NEAR SURFACE GEOCHEMISTRY AND MINERALOGY AT THE MCMURDO DRY VALLEYS, ANTARCTICA, SERVES AS AN ANALOG FOR SOME NEAR SURFACE SITES ON MARS. P. Englert[1], J. L. Bishop[2], Z. F. M. Burton[3], E. K. Gibson[4], C. Koeberl[5,6], D. Tirsch[7], J. D. Toner[8], and B. Sutter[4], [1]University of Hawaii (penglert@hawaii.edu), [2]SETI Institute & NASA Ames (Mountain View, CA), [3]Stanford University (Stanford, CA), [4]NASA Johnson Space Center (Houston, TX), [5]University of Vienna (Vienna, Austria), [6]Natural History Museum (Vienna, Austria), [7]German Aerospace Center (Berlin, Germany), [8]University of Washington (Seattle, WA).

Cold and arid conditions at the McMurdo Dry Valleys (MDV) in Antarctica enable investigation of geochemical processes and sediment alteration in one of the closest Earth environments to that of Mars [1]. A large collection of sediments is under study from surface environments [2], sediment cores [3], soil pits [3] and lake bottom sediments [4-5]. Current work is focusing on trends in geochemistry and mineralogy with depth at several cores and soil pits collected during the 1979-1980 season [3].

Introduction : Sediments from multiple settings in the Wright and Taylor Valleys (Fig. 1) are available for this study. Surface sediments are characterized primarily by physical alteration based on analyses of mineralogy and Chemical Index of Alteration (CIA) trends [2]. However, subsurface sediments include salts and alteration minerals from chemical processes [e.g. 3,6].

Shallow salty ponds in Wright Valley include Don Quixote pond and VXE-6 pond. Near surface sediments at each of these sites exhibit elevated Cl and S contents [7,8]. Don Quixote represents a briny pond dominated by surface inputs of salts from surrounding soils by snowmelt and transport to the basin by shallow groundwater flows. Sediment chemistry in these sites is thought to be dominated by the accumulation of surface salts (S, Cl) in a closed basin, and concentration of a Mg-Na-Cl brine through evaporation [9].

Don Juan pond, located in the south fork of Wright Valley (Fig. 1), contains one of the most unique surface waters on Earth. This pond is composed of up to 40 % salt by weight, 95 % of which is $CaCl_2$, and occasionally precipitates Antarcticite ($CaCl_2 \cdot 6H_2O$), a mineral identified only here [10]. Ca-Cl-rich brines are of particular interest in a Mars context because such brines are extremely hygroscopic and only freeze near -50°C [11]. Numerous studies of nutrient and ion chemistry of lake waters in the MDV have shown that chemical weathering is an important process in the Dry Valleys and that both biotic and abiotic processes shape the biogeochemistry of the deep groundwater environments [e.g. 12-14]. Views of Don Juan pond from 1980 illustrate the near surface alteration layers (Fig. 2). We focus here on changes in the mineralogy and chemistry of sediments from the surface to the subsurface.

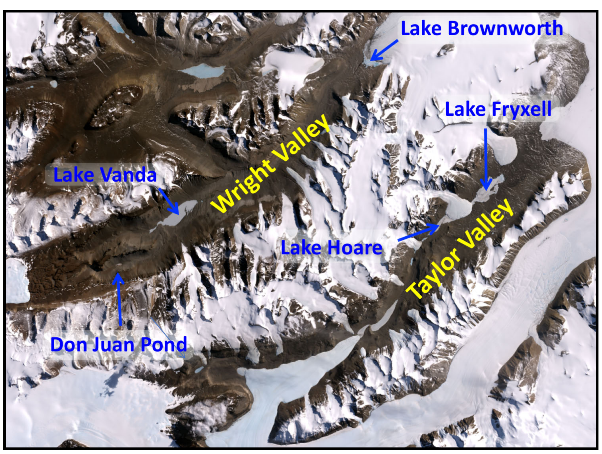

Fig. 1. View of McMurdo Dry Valleys showing the locations of the Wright and Taylor valleys and several sites where samples were collected.

Methods: VNIR reflectance spectra were collected at Brown University's RELAB from 0.3 to 50 µm in a H_2O-purged environment [e.g. 2] and using an ASD spectrometer from 0.35-2.5 µm under ambient conditions. Raman spectra were also collected at the DLR. Major element chemistry was measured by XRF at the Bureau Veritas and minor and trace elements were measured using Instrumental Neutron Activation Analysis (INAA) at the University of Vienna. XRD has been run on selected sediments using a Terra instrument as well as an advanced laboratory instrument at JSC.

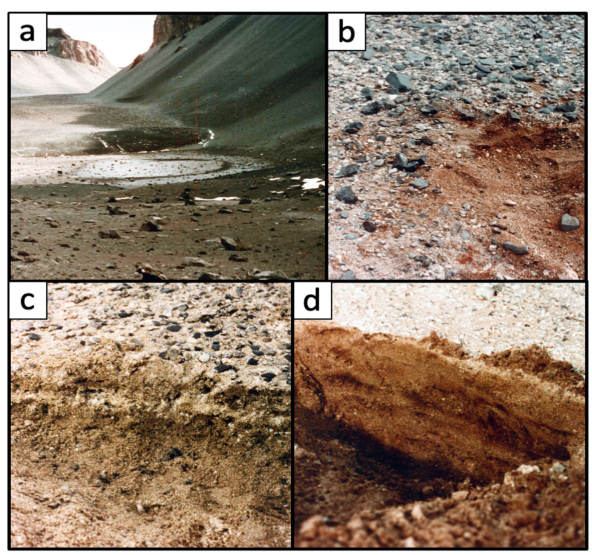

Fig. 2. Views of Wright Valley sediments and soils. a) Don Juan pond, b) reddish altered soil 1-4 cm below sediment surface, c) bright layer 3-4 cm below surface, d) reddish altered material and light-toned layer ~2 cm subsurface on margin of Don Juan pond.

Results: VNIR spectra (Fig. 3) and XRD (Fig. 4) of selected sediments in a salty region east of Don Juan pond illustrate the presence of hydrated phases including gypsum and poorly crystalline materials such as ferrihydrite, imogolite and opal. The dominant minerals in the surface sediments are quartz, pyroxene and feldspar. Calcite is also frequently observed in the lake bottom sediments. CIA trends for surface sediments are shown

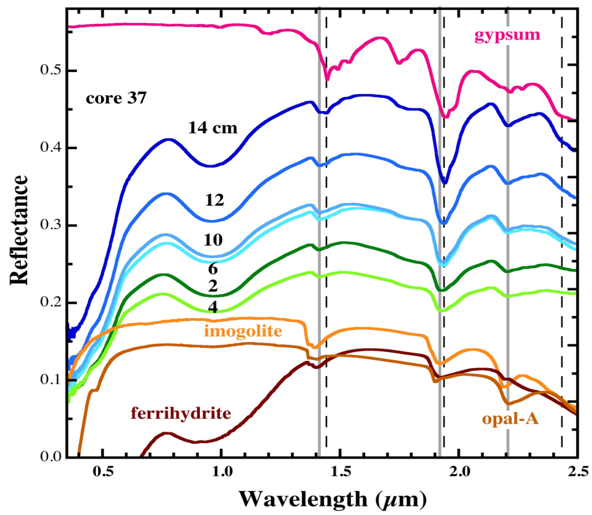

Fig. 3. VNIR spectra of sediments from core 37 collected from the eastern margin of Don Juan pond. Features are observed at ~1.40, 1.91 and 2.20 μm in spectra of samples in the upper layers that are attributed to hydrated amorphous material (e.g. opal, imogolite, and/or ferrihydrite). At 6 cm depth, shifts were observed for the water bands towards ~1.45 and 1.94 μm and a drop in reflectance near 2.43 μm started occurring, all of which are consistent with gypsum.

in Fig. 5. These are consistent with primarily physical weathering. Geochemical analyses are currently underway on our data sets for MDV subsurface samples.

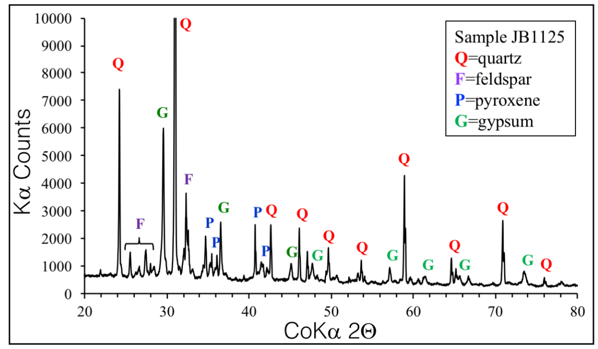

Fig. 4. XRD analyses of sediment JB1125 at the edge of Don Juan pond. The dominant minerals in the sample are quartz, pyroxene, feldspar and gypsum.

References : [1] McKay C. et al. (2005) in *Water on Mars and Life* (Springer, Berlin) 219. [2] Bishop J. et al. (2014) *Phil.Trans.R.Soc.A*, **372**, 20140198. [3] Gibson E. et al. (1983) *JGR, 88,* A912. [4] Bishop J. et al. (1996) *GCA,* **60**, 765. [5] Bishop J. et al. (2001) *GCA,* **65**, 2875-2897. [6] Claridge G. & I. Campbell (1977) *Soil Sci., 123,* 377-384. [7] Englert et al. (2015) *LPSC*, #2297. [8] Burton Z. et al. (2018) *LPSC*, #1086. [9] Cartwright K. & H. Harris (1981) in *Dry Valley Drilling Project, Ant. Res.* 193. [10] Torii T. & J. Osaka (1965) *Science,* **149**, 975. [11] Marion G. (1997) *Ant. Sci.*, **9**, 92. [12] Green W. & D. Canfield (1984) *GCA*, **48**, 2457. [13] Welch K. et al. (1996) *J. Chromatography A*, **739**, 257. [14] Lyons W. et al. (2005) *GCA*, **69**, 305.

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ADV Source Rock Averages	CIA	$(Al_2O_3/TiO_2)_{molar}$
Basement	48.7	17.6
Lower Beacon	64.6	18.6
Ferrar Dolerite	42.4	15.0
McMurdo Volcanic Group	33.9 & 43	2.8 & 8.7
Lashley Formation	63.7	18.8

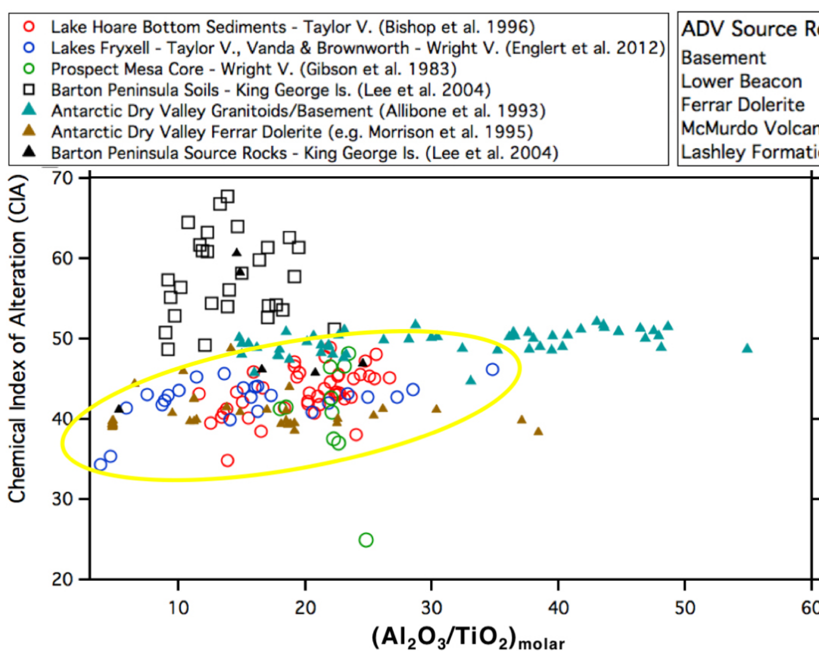

Fig. 5. Chemical Index of Alteration (CIA) vs. molar Al_2O_3/TiO_2 ratio for several MDV soils and sediments (circles) from the bottom of Lake Hoare, Taylor Valley and several sites in Wright Valley compared to Barton Peninsula soils (squares) and source rocks (triangles).
The yellow oval marks trends for most sediments in our study. The Barton Peninsula soils exhibit higher CIA values and the granitoid basement rocks have elevated Al_2O_3/TiO_2 ratios compared to the MDV soils and sediments.