RARE EARTH ELEMENT ABUNDANCES & CHEMICAL ALTERATION IN MICROENVIRONMENTS OF THE McMURDO DRY VALLEYS. A. Foerder¹, P. Englert¹, J. L. Bishop²,³, C. Koeberl⁴, E.K. Gibson⁵, ¹University of Hawai'i at Mānoa (Honolulu, HI; afoerder@hawaii.edu, pengler@hawaii.edu), ²SETI Institute (Mountain View, CA), ³NASA Ames Research Center (Moffet Field, CA), ⁴Natural History Museum (Vienna, Austria), ⁵Department of Lithospheric Research, University of Vienna (Vienna, Austria), ⁶NASA Johnson Space Center (Houston, TX).

Introduction: The McMurdo Dry Valleys (MDV) region are the Earth’s coldest and driest desert; the mean annual air temperatures range from -25 to -20°C and the mean annual precipitation, in the form of snowfall, is 15 g/cm²/yr [2,5]. The region is desolate and liquid water is scarce. Investigations of chemical and mineralogical alteration of MDV soils have found more extensive physical alteration than chemical alteration. This is not to say that chemical alteration is not occurring, and possibly more so than previously thought. The aim of this study is to investigate soil provenance and the extent of chemical weathering by examining Rare Earth Element (REE) abundance in soils and their corresponding source rocks in the extreme conditions of the MDV. Because MDV conditions are not conducive to chemical alteration, special focus is given to microenvironments exhibiting data different from expected abundances and patterns.

Rare Earth Elements: A rare-earth element is one of 17 elements, 15 of which are known as lanthanides, the other two being scandium and yttrium. They are of particular interest to geologists because of their immobility during chemical alteration processes, largely attributed to the small relative size of their ionic radii. Elements with larger ionic radii, such as potassium, are more mobile and soluble whereas elements with smaller ionic radii, such as REEs, tend to be more immobile and less soluble. These characteristics permit REEs to be effective tools for tracing soil provenance. Our work focuses on the abundance of ten REEs (La, Ce, Nd, Sm, Eu, Gd, Tb, Tm, Yb, and Lu).

Methods: For this study, we analyzed surface samples collected on or near lakes Vanda (V), Brownworth (B), and Fryxell (F) [8], and cores from ponds in Upper Wright Valley (UWV) [9]. These samples are compared to potential source rocks in the MDV, based on the availability of REE data. Source rock data include REEs from granitoids [1], Beacon Sandstone [4], and Ferrar Dolerite [3]. Minor and trace elemental abundances of the samples for our study were determined using standard Instrumental Neutron Activation Analysis (INAA) [7]. REE abundances were normalized to Solar System averages as in [6].

Results: Figure 1 shows variations in Th, La, and Ce for the source rocks and collected samples. All of the source rock data points overlap, displaying comparable abundances of Th, La, and Ce, with Granitoids exhibiting slightly lower abundances and Ferrar Dolerite slightly higher. The surface sediments collected near lakes all group in a similar region of the diagram, as do the core samples from UWV, with the exception of the Don Juan Pond samples, which are in the same region as the surface sediments. These consistent trends across the surface sediments indicate that similar geologic histories governed processes at these very different sites in both Wright Valley and Taylor Valley. The separate cluster for all of the Wright Valley core samples indicates that subsurface processes are distinct from surface processes. Variations of REE abundances between different core samples are attributed to the local geologic setting of cores. Core 39, for example, is located farthest from Don Juan pond at the base of an alluvial fan. Core 33 sits in the path of a wet encrustation, and Core 2074, the anomaly, sits in the center of Don Juan pond where the highest salinity and lowest REE abundance is reported.
cm and 7 cm depths experience comparatively low (4 cm) and high (7 cm) REE abundances, with the sample at 4 cm not experiencing a negative Eu anomaly, which is likely due to Na$_2$O enrichment. Generally, a negative Eu anomaly is attributed to CaO and Na$_2$O depletion [10]. A horizon of elevated elemental abundance in the 4-7 cm depth range suggests a clay layer undergoing active alteration [11]. Elevated REE abundance in the 4-7 cm depth range corroborates these findings.

**Implications:** Due to the extreme cold and aridity of both the McMurdo Dry Valleys and Martian landscape, terrestrial analysis of REE rock and soil data in the MDV could be compared to Martian rover rock and soil data to test the efficacy of microenvironments in the MDV as analogs for martian microenvironments.

Additionally, due to their immobility, REEs could be well-suited for tracing soil provenance in terrestrial and martian landscapes. Coordinating REE analyses with geochemical and mineralogical analyses of MDV microenvironments could aid in understanding alteration in the Dry Valleys and also help constrain and reconstruct Mars’ geochemical history. From this, the scientific community could move closer to answering questions regarding the potential of life and habitability outside of Earth.


**Acknowledgements:** We thank the NASA Astrobiology Institute, the SETI Institute, The Hawai‘i Institute of Geophysics and Planetology, and the Department of Earth Science at the University of Hawai‘i at Mānoa for their support.