PETROLOGY AND MINERAL CHEMISTRY OF THE ANTARCTIC FERRAR DOLERITE: IMPLICATIONS FOR MARTIAN METEORITES. Justin D. Kennedy and Ralph P. Harvey. Dept. of Geological Sciences, Case Western Reserve University, 10900 Euclid Ave., Cleveland, OH 44106-7216. E-mail: jdk40@case.edu

Introduction: The study of terrestrial analogs to Martian igneous rock compositions and surface features is important in order to gain insight into past and present dynamic processes experienced on Mars. Previous Martian analog studies have been performed on materials from various terrestrial environments [e.g., 1-3]. For this study, we investigated petrological and mineralogical properties of the Ferrar dolerite as an analog to the Martian basaltic meteorites. The Ferrar dolerite is a shallow intrusive, forming well-exposed cliffs along the length of the Transantarctic Mountains [4]. Outcrops of the Ferrar are exposed to some of the coldest and driest weathering environments on Earth. As a result, these rocks are an excellent terrestrial analog to Martian igneous lithologies and their weathering on a variety of scales. In thin section, they show mineralogical and petrological similarities to the Martian Shergottite-Nakhlite-Chassignite (SNC) meteorites [4]. On the outcrop scale, they display similar cm-scale weathering features observed in rocks at numerous Viking [5], Pathfinder [6], and MER [7] mission sites. Here, we provide mineralogical analyses from a suite of Ferrar dolerite samples, ranging from relatively fresh (unexposed) gray-green specimens to ones displaying distinctively advanced weathering features (e.g., cavernous weathering pits, desert varnish). Comparisons of these to numerous SNC meteorites are also presented.

Approach and Results: Samples for this study were collected during Antarctic Search for Meteorite (ANSMET) fieldwork in the austral summer of 2001. Thin sections from three hand samples were analyzed using electron microprobe analysis (EMPA). The three samples represent a range of weathering stages: (1) relatively unaltered, fresh samples (dense, hard, gray-green in color with minimal red mottling); (2) slightly weathered samples (thin sections that traverse a pronounced boundary from “green” interiors to “red” exteriors); (3) highly weathered samples (cm-scale etch pits on hand sample surfaces with distinctive desert varnish present). Sections from unaltered and intermediately weathered samples were cut from interiors of hand samples; those from highly weathered ones cross-cut desert varnish surfaces.

Quantitative microprobe results confirm the presence of two pyroxenes (augite and pigeonite), two feldspars, and a variety of Fe- and Ti-oxides (e.g., ilmenite, titanomagnetite). The Ferrar pyroxene assemblage is a very good match to Shergottite pyroxenes in terms of both range and average composition. The feldspar assemblage is also quite similar, but the Ferrar contains minor, but significant, alkaline-rich feldspars. The modal abundance of pyroxenes and feldspars in the Ferrar dolerite differs from that of the Shergottites; feldspar is more abundant than pyroxene in the former, while the reverse is generally true in the Shergottites. An important difference between the Shergottites and the Ferrar Dolerite is that the latter contains quartz in the mesostasis.

Backscatter electron images from Ferrar thin sections reveal subhedral pyroxene and plagioclase crystals, with the pyroxenes showing a range of zoning styles and fracturing. Most of these crystals display normal zoning (Mg-rich cores with Fe-rich rims), while the remainder show more complex and intricate zoning. In the least altered samples, pigeonite overgrowths are common on larger augite crystals. The pyroxenes in these samples display extremely pronounced exsolution weathering features, with pigeonite overgrowths “peeling” away from augites (Figure 1). Pigeonite is rare in samples with the highest degree of alteration. Many of the above features are commonly observed in the SNC meteorites [8, 9].

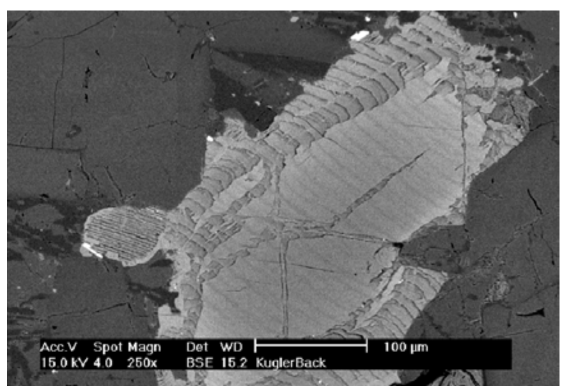

Figure 1. Backscatter electron image of a pyroxene grain surface prominently displaying a “peeling” texture of exsolution lamellae, which are common in the least weathered samples.

Alkaline feldspars almost always occur as bladed crystals in the presence of quartz in mesostasis regions; they are much finer grained than plagioclase grains. Oxide phases show a variety of microstructures, including trellis lamellae and sandwich textures. Ilmenite is unaltered in fresh samples, while titanomaghemite replacement of titanomagnetite is common. Highly weathered samples are void of titanomagnetite and titanomaghemite altogether, while ilmenite grains consist of skeletal segments.

Initial Conclusions and Discussion: Augite in weathered Ferrar samples appears deficient in FeO compared to unweathered samples. Augites from these samples cluster around ^{30}Wo^{56}En^{14}Fs, while those from unexposed samples form a typical igneous fractionation trend, ranging from about ^{30}Wo^{40}En^{30}Fs to ^{30}Wo^{25}En^{45}Fs (Figure 2). The likely cause of this FeO deficiency is oxidation to Fe_2O_3, resulting in the prevalent green-to-red color transition observed in more weathered samples. Furthermore, titanomaghemite replacement of titanomagnetite is consistent with low-temperature oxidation of FeO to Fe_2O_3 [10].

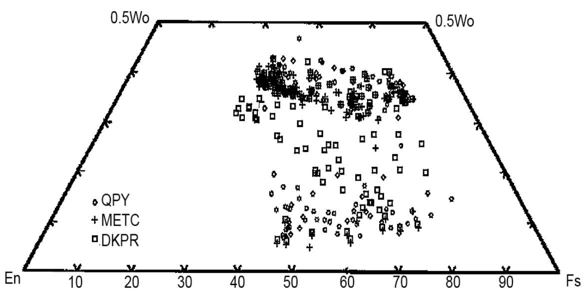

Figure 2. Pyroxene quadrangle showing compositions of least weathered (QPY), intermediate (METC), and most weathered (DKPR) samples.

Plagioclase compositions from highly altered samples cluster around $^{50\text{-}80}$An, while those in least weathered samples show a greater range, from $^{45\text{-}90}$An (Figure 3). Compositions from intermediately weathered samples follow a transitional trend, displaying an intermediary range. K-rich feldspars are found in all Ferrar samples (in mesostasis regions), but in minor abundances compared to plagioclase. These compositions cluster around $^{60\text{-}80}$Or.

Future Work: Mössbauer spectroscopy spectra from three Ferrar samples are being collected in order to determine the amount of ferric iron is present in the silicate phases. We are also conducting X-ray diffraction with thermal analysis on another group of samples collected by the ANSMET team during the 2004 field season. These rocks have been kept at ambient temperatures (~ -15^{o}C) during transport and storage, and will be prepared for and introduced to the XRD at these temperatures. These analyses take place over temperatures ranging from ~ -15^{o} to 10^{o} C.

References: [1] Gibson E. K., et al. 1983. *Proc. of LPSC*, 88, p. A912. [2] Allen C. C. 1981. *Icarus*, 45, p. 347. [3] Morris R. V., et al. 2001. *JGR*, 106, p. 5057. [4] Harvey R. P. 2001. Field Trip and Workshop on the Martian Highlands and Mojave Desert Analogs, LPI Contribution 1101, 25. [5] Allen C. C. and Conca J. L. 1991. *Proc. of LPSC* 21, p. 711. [6] Rodriguez-Navarro C. 1998. *Geophys. Res. Lett.* 25, p. 3249. [7] Rice J. W. 2004. *Abstracts with Programs – GSA* Vol. 36, no. 5, p. 21. [8] Harvey R. P. and McSween H. Y. 1991. *Geochim. Cosmochim.* 56, p. 1655. [9] McSween H. Y. and Treiman A. H. 1998. in *Rev. Min.* 36, p. 6.1. [10] Haggerty, S. E. 1991. in *Rev. Min.* 25, p. 129.

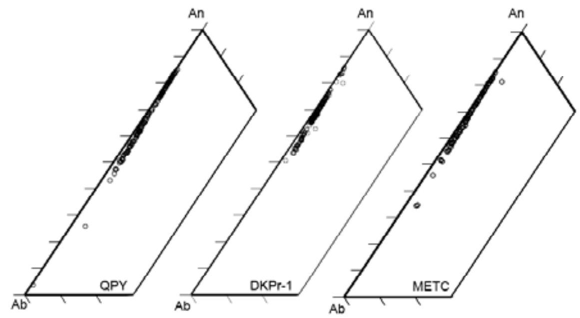

Figure 3. Feldspar ternary plots (cropped) showing compositions from least weathered (QPY), most weathered (DKPr-1), and intermediate (METC) samples.