THE FERRAR DOLERITE: AN ANTARCTIC ANALOG FOR MARTIAN BASALTIC LITHOLOGIES AND WEATHERING PROCESSES. R. P.. Harvey[1] [1]Dept. of Geological Sciences, Case Western Reserve University, Cleveland OH 44106-7216 (rph@po.cwru.edu).

Introduction: The Ferrar Dolerite is one of the most prominent rocks of East Antarctica, forming well-exposed cliffs along the length of the Transantarctic Mountains. The Ferrar serves as an excellent analog for martian igneous lithologies on a number of scales, from planetary (global concepts of its origin) to the outcrop and hand specimen (cm-scale weathering features) to the microscopic (thin-section scale petrologic similarities to martian meteorites).

Planetary scale: The Ferrar dolerite is a shallow intrusive exposed on a scale seldom seen among terrestrial igneous rocks. Together with its contemporaneous extrusive counterpart in Antarctica (the Kirkpatrick Basalt) and coeval lithologies of Australia (the Tasmanian and Victoria dolerites) and South Africa (the Karoo dolerites and basalts) they represent a significant event in planetary history and one of the largest effusive events. The event in question is the breakup of Gondwanaland in the early to mid-Jurassic, contemporaneous with Ferrar intrusion approximately 177 Ma [1,2].

While not all localities offer supporting evidence, most authors suggest that the association between the Ferrar and the disassembly of Gondwanaland is not coincidental. The tectonic extension and rifting associated with the breakup of Gondwanaland (and Pangea before it) is typically considered a response to significant mantle upwelling beneath a singularly large and insulating continental mass [1, 3, 4]. Similar plumes are almost ubiquitously cited as the driving force behind large volume Martian magmatism, with the production of large volumes of mantle-derived magma at localized sites beneath thick immobile crust [e.g., 5]. The Ferrar may or may not be a good analogy in this regard; some isotopic studies of suggest an origin from very "fertile" mantle, while others prefer a mantle strongly influenced by assimilation of subducted crust [e.g., 6].

Outcrop Scale: The Ferrar is extremely well exposed in spite of its occurrence on the Earth's only ice-covered continent. Because it is stratigraphically young and one of the most resistant rocks within the heavily glaciated Transantarctics, at most localities it is exposed as cliffs, often several hundred meters high (Fig. 1) . The sills that make up the Ferrar therefore typically show very complete cross-sections of varying thickness and intrude among the older (Devonian-Triassic) sedimentary sequences of the Beacon Supergroup. Often these sills assimilate large lenses of the intruded sequences. Feeder dikes are rarely exposed, and in most localities (but not all) emplacement of the Ferrar appears to have been a single event contiguous across the Transantarctics. The sills are commonly differentiated, showing significant compositional and crystal settling features. Sills also show significant grain size variation from interior to exterior and around included lenses of sedimentary formations. Thick exposures of the Ferrar typically show columnar jointing and outcrop surfaces commonly show a pattern of strong exfoliation around the joints, creating rounded surfaces with developing adjacent regolith (Fig. 2). Although cross sections of the martian crust are typically not as well exposed as the Ferrar, studies of outcrop slopes and stability in Valles Marineris suggest

Figure 1, Typical occurrence of the Ferrar Dloerite as the major cliff-forming unit of the Transantarctic Moutains.

Figure 2. Typical weathering on exposed Ferrar surfaces.

the behavior of the Ferrar is analogous to that of massive martian volcanics [7, 8].

Hand Specimen Scale: Fresh Ferrar dolerite is a gray-green color because of the abundant mafic mineral content; upon weathering the Ferrar becomes a rich reddish-brown. In sawn or broken section coarse-grained interior Ferrar strongly resembles both the basaltic and lherzolitic shergottites, exhibiting cm-scale dark and light patches corresponding to relative abundance of pyroxene or feldspar petrologic texture. As is seen on the outcrop scale, smaller specimens are often rounded by exfoliation. However, finer-grained specimens exhibit a variety of classic desert habits including ventifaction, salt encrustations, desert varnish development and cavernous weathering [9, 10] (Fig. 3). Ferrar dolerite cobbles found in moraines or scree slopes are typically angular while cobbles found resting on ice are severely rounded, suggesting that the balance between chemical and mechanical weathering varies significantly between local sites.

Figure 3. Ferrrar Dolerite hand sample, showing cavernous weathering on exterior while dense fracture-free interior remains unaltered. Specimen is approximately 22

The variety of weathering features exhibited by the Ferrar strongly resemble those seen in images returned by the Mars Pathfinder lander mission [11]. By analogy they show that the textural features observed at the Pathfinder landing site have plausible origins as the product of desert weathering of rocks of basaltic composition.

Thin-section Scale: the Ferrar dolerite bears broad geochemical and mineralogical similarities to Martian igneous lithologies. The Ferrar is an intrusive gabbroic rock containing two pyroxenes (both ortho- and clino-, with a third pyroxene commonly present in exsolution), two feldspars (plagioclase and alkaline) and a significant vol. percent of Fe and Ti oxides. Texturally the rock resembles the coarser basaltic shergottites in terms of mode, average grain size and a general cumulate appearance. Often pyroxene and feldspar grains are elongated and zoned in a manner similar to that seen in the coarser shergottites. Weathered examples of the Ferrar exhibit brown iron-staining of the mafic minerals as well as dissolution of feldspars and pyroxenes, and development of minor amounts of secondary quartz, clays and other poorly crystalline phases. A brown surface varnish deposit, a cryptocrystalline amalgam of silica and iron oxide, often protects the interior of specimens below. The Kirkpatrick basalt has been less extensively studied and is identical in terms of bulk chemistry and mineralogy but with a much finer texture, producing a much more resistant rock. It also can commonly be found in a vesicular texture with zeolites filling the vesicles, and both rocks commonly exhibit significant salt deposits in highly weathered specimens.

Summary The small amount of study completed so far suggests that the Ferrar dolerite (and Kirkpatrick basalt) is an excellent terrestrial analog for the basaltic martian meteorites in many ways. Currently we are in the process of testing this analogy in more detail, which requires study of the Ferrar with the extraordinary and exhaustive focus commonly turned toward Martian meteorites. Like the Munro Township basalts commonly used as an analogy to the nakhlites, the Ferrar should provide new insight into the origins of an important group of martian meteorites. This time, however, the rocks are unmetamorphosed, younger, and well-exposed, making it easier to explore not only petrologic similarities but also petrogenetic similarities. This should in turn provide new insight into the evolution of the martian crust and the distinctions between geological processes on Mars and Earth.

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