PETROGRAPHY AND GEOCHEMISTRY OF LUNAR METEORITE DHOFAR 1442. R. A. Zeigler, R. L. Korotev, and B. L. Jolliff. Department of Earth and Planetary Sciences and the McDonnell Center for Space Sciences, Washington University, 1 Brookings Dr., C/B 1169, St. Louis MO 63130 zeigler@levee.wustl.edu

Introduction: Dhofar 1442 is a lunar meteorite collected in the Dhofar region of the Sultanate of Oman in 2005 [1]. Although initially described as an impact-melt breccia, Dhofar 1442 is a glassy-matrix regolith breccia that is rich in clasts, including basaltic, granulitic, and felsic lithic clasts. With the exception of the impact-melt breccia lithology of SaU 169 [2], Dhofar 1442 is the most KREEP-rich lunar meteorite to date [3]. The provenance of Dhofar 1442 is almost certainly within the Procellarum KREEP Terrane (PKT), likely in the vicinity of a low-Ti mare.

Results: Dhofar 1442 is a clast-rich lunar breccia containing a variety of mineral, glass, and lithic clasts set in a glassy matrix that contains abundant vesicles (Fig. 1b). The most abundant mineral clasts are pyroxene, plagioclase, and olivine, with minor to trace amounts of ilmenite, silica, chromite, FeNi metal, and troilite also observed. The compositions of the most abundant mineral clasts show considerable range: pyroxene ($Fs_{15-61}Wo_{2-40}$), plagioclase ($An_{73-97}Or_{0.1-2.3}$), and olivine (Fo_{12-83}) (Fig. 2). Impact-derived glass clasts are relatively minor in abundance, and typically have compositions similar to the bulk meteorite (e.g., ~14 wt% FeO, ~14 wt% Al_2O_3). Additionally, a single pyroclastic glass bead was found (Fig. 1c). It has a composition (5 wt% TiO_2, 8 wt% Al_2O_3, 25 wt% FeO, 11.5 wt% MgO, 0.3 wt% K_2O) that is broadly similar to the yellow glasses found in the Apollo collection, albeit not an exact match for any one variety [5]. Terrestrial alteration products such as calcite and Ca-sulfate are observed in the section, but are not pervasive (Fig. 3).

A wide variety of lithic clasts are observed in Dhofar 1442, including basalts, granophyres, impact-melt clasts and breccias, granulites, norites, agglutinates, and anorthosite. Crystalline basalt clasts vary somewhat in texture from subophitic to equigranular (Fig. 1a), but are all dominated by pyroxene, with lesser plagioclase, minor ilmenite, and in rare cases fayalite or silica. Pyroxene compositions vary widely with low-Ca pyroxene, pigeonite, and augite all present over a range of Mg/Mg+Fe ratios. Plagioclase is typically Na-rich (An_{55-84}), although more calcic cores (An_{92}) are found in a single clast. There are numerous small (<200 µm) granophyre clasts scattered throughout the section. Typically these consist of intergrowths of silica and Na-rich feldspar ($An_{55}Or_{5-8}$) and/or K-feldpsar. Minor amounts of Fe-rich pyroxene and olivine are also found in these clasts (Fig. 1c). Dhofar 1442 contains a high proportion of impact-melt breccias that typically have mineral clasts set in a glassy matrix. The most interesting impact-melt clasts are those that appear to have been formed by the melting of basalt clasts (Fig. 1a) or silica-rich materials (Fig. 1e). Two clasts appear to be agglutinates, as they are composed of vesicular glass containing schlieren and partially resorbed mineral clasts. A number of well-equilibrated granulite clasts also occur. They typically consist of pigeonite grains ($Fs_{32–42}Wo_{9–15}$), Na-rich plagioclase grains (An_{70-75}), and a Si,K-rich glass (70-75 wt% SiO_2, 2-3 wt% K_2O), with minor amounts of ilmenite, phosphates, FeNi metal, troilite, and even zircon present (Fig. 1c). A few norite clasts are found, with well equilibrated low-Ca pyroxene ($Fs_{35}Wo_4$) and moderately Na-rich plagioclase (An_{80}) present in approximately equal amounts (Fig. 1d). Minor amounts of apatite, ilmenite, and trace amounts of zircon are also observed. A single large (~600 µm across) anorthosite clast was observed. It consists nearly entirely of plagioclase (An_{96}), with a few small grains of augite also present ($Fs_{18-24}Wo_{30-40}$).

Table 1	
SiO_2	48.4
TiO_2	2.74
Al_2O_3	13.6
Cr_2O_3	0.25
FeO	13.9
MnO	0.18
MgO	8.25
CaO	9.73
Na_2O	0.83
K_2O	0.70
P_2O_5	0.64
Total	99.23
Mg'	51.4

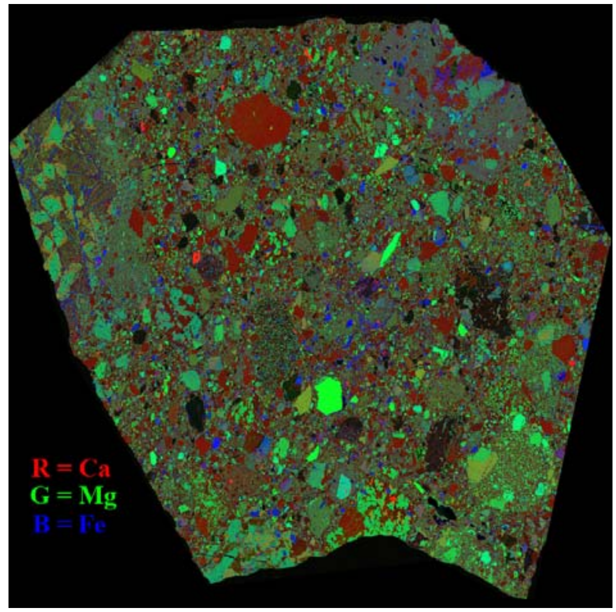

Figure 3: RGB image combining x-ray maps of Ca (red), Mg (green), and Fe (blue). This shows the wide variety of materials present in Dhofar 1442.

Compositionally, Dhofar 1442 is most similar to the Apollo 14 regolith but is richer in elements associated with mare basalt (Ti, Fe, Sc) and incompatible elements (1.15–1.25×). *Mg´* is low (51, Table 1) compared to Apollo 14 soil (62). We can, in fact, match the composition of Dhofar 1442 remarkably well with a simple mixture of 72.5% high-K KREEP [6], 24% basaltic lunar meteorite LAP 02005, and 3.5% CI chondrite, although a basalt with a greater TiO_2 concentration (~5.4%) would provide a better fit.

Discussion: The vesicular nature of the matrix glass, the presence of suspected agglutinates, and especially the presence of spherules indicates that Dhofar 1442 is a glassy matrix regolith breccia according to the classification scheme of Stöffler et al. [8]. Dhofar 1442 has the distinctions of being both the second most KREEPy lunar meteorite (after the SaU 169 IMB) and the lunar regolith sample with the highest concentrations of incompatible elements. The provenance of Dhofar 1442 is almost certainly within the PKT as that is the only area of the Moon with incompatible element concentrations that are elevated enough to account for the composition of Dhofar 1442. Moreover, the abundance of low-Ti mare basaltic material in Dhofar 1442 suggests that it originated near the boundary of a low-Ti mare and the highlands within the PKT.

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References: [1] Ivanova M.A. et al. (2009) *MAPS, 44,* 429-462. [2] Zeigler R.A. et al. (2006) *LPS 37,* abstract #2366. [3] Korotev R.L. et al. (2009) *MAPS,* 44, 1287-1322. [4] Zeigler R.A. et al. (2006) *MAPS, 41,* 263-284. [5] Papike J. J et al. (1998) *Reviews in Mineralogy, 36,* 5-213 to 5-215. [6] Warren P. H. (1989) 149–153, LPI Tech. Rpt. 89-03. [7] Zeigler R. A. et al. (2005) M&PS 40, 1073-1102. [8] Stöffler D. et al. (1980) *Proc. Conf. Lunar Highland Crust,* 51-70.

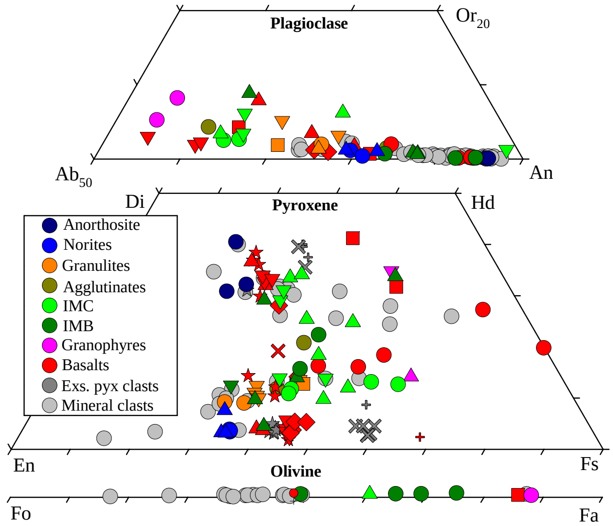

Figure 3: Mineral compositions in Dhofar 1442. Different colors represent different lithologies, whereas different symbols within the same color represent different clasts of that type.

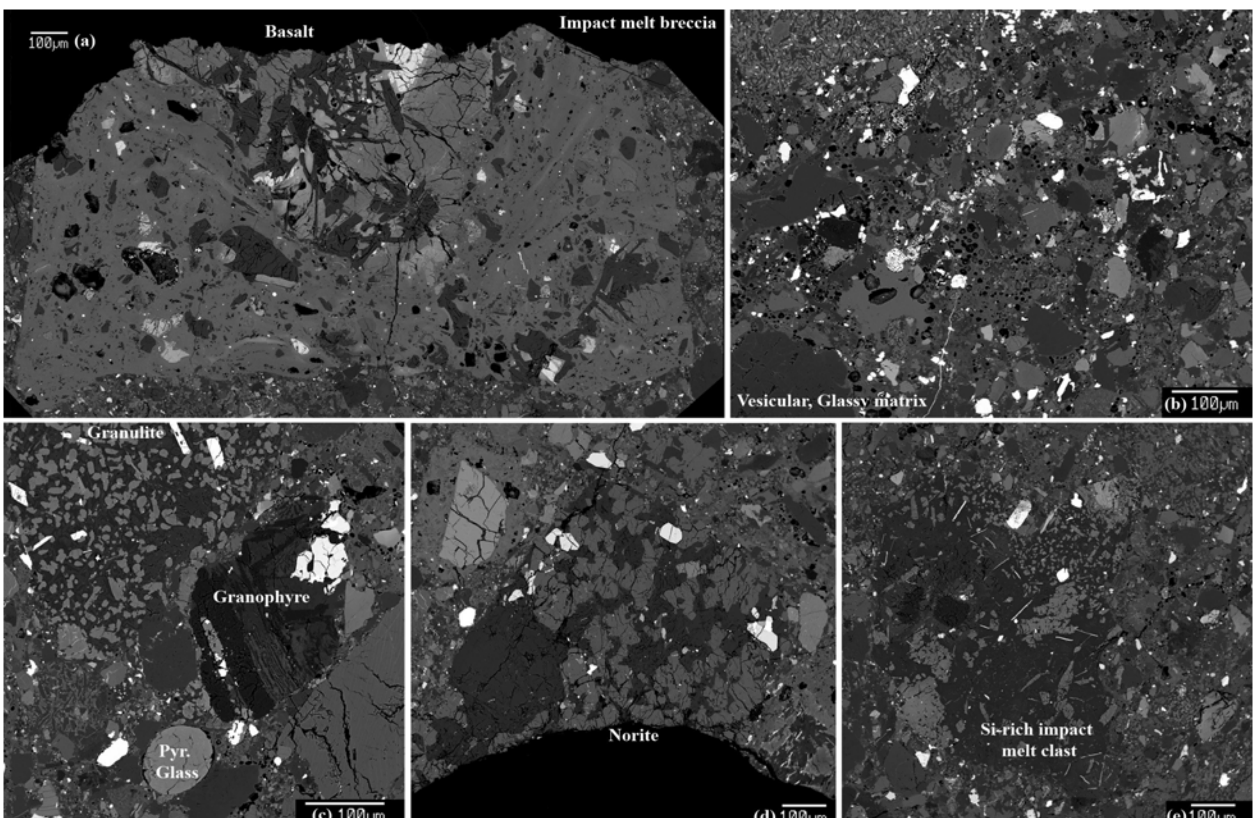

Figure 1: Back scattered electron images of selected petrographic features within Dhofar 1442.