Apparently Kreepy Lunar Meteorite Dhofar 287a: The Residual Melt Tapped from a Fractionating Magma Chamber.

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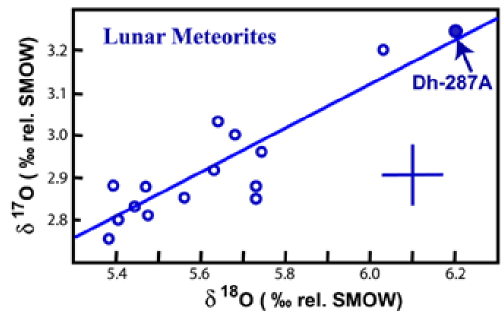
Introduction: Dhofar 287 (Dh-287) is a new lunar mare-basalt meteorite found in the Dhofar region of Oman on January 14, 2001. The classification and preliminary min-pet description of the meteorite was given by Taylor et al. [1]. The rock consists mainly of phenocrysts of olivine (>2mm) and pyroxene (up to 0.5 mm) set in a finer-grained matrix, which is composed of elongated pyroxene and plagioclase crystals, radiating from common nuclei. Accessory minerals include ilmenite, chromite rimmed by ulvöspinel, troilite, and FeNi metal. This rock is unusually rich in late-stage mesostasis that is composed largely of fayalite, K-rich glass, and Cl-apatite. In appearance, this is a low-Ti mare basalt, with similarities to Apollo 12 and 15 basalts; however, all plagioclase is now present as maskelynite, and its composition is atypical for such basalts. In addition, its oxygen isotopes of $\delta^{18}O$ of +6.20 and $\delta^{17}O$ of +3.24 is at the high-end of the range for lunar meteorites (Fig. 1), but well within the range seen for Apollo samples.

Figure 1. Oxygen Isotopes of Dh-287A.



Petrography and Mineral Chemistry: The modal mineralogy of Dh-287, as determined by EMP mapping [2], is about: olivine = 21%; pyroxene = 47%; Maskelynite = 26%; mesostasis = 3%; and opaque minerals = 3%. The majority of the olivine grains are chemically zoned. Many olivine grains show asymmetrical zoning with extreme iron enrichment within 50µm of the rims. Cooling-rate estimations [3], based on variation in Fo content in several olivine grains along orthogonal profiles, yield values of 0.2-0.8 °C/hr for the lava. Pyroxene compositions show extreme variation in chemistry following a typical mare-basalt fractionation trend (Fig. 2), albeit with the notable absence of early-crystallized pyroxene (e.g., Mg-Pig). A similar trend is depicted on the Ti vs Al graph (Fig. 3), again with the missing early pyroxene. As just noted, the early olivines and pyroxenes Fo >70 and mg# >60, resp., are conspicuously missing from this basalt. Maskelynite in Dh-287 shows a restricted range of An 74-84. One of the most striking petrographic features of Dh-287 is the disproportionate abundance (3%) of late-stage mesostasis throughout the sample. These areas are typically 300 x 300 µm in size and are composed mainly of fayalite, both Si-rich and K-Ba-rich glasses, ilmenite, apatite, and tranquilityite. Pyroxene grains surrounding

Figure 2. Olivines and pyroxenes in Dh-287

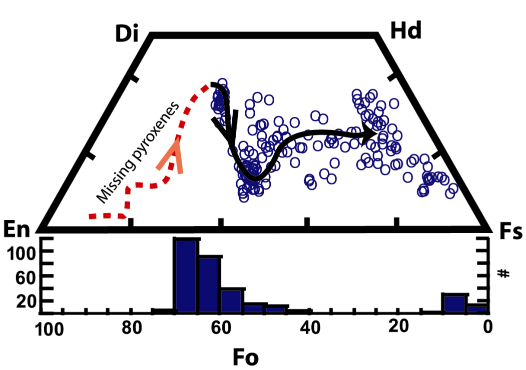


Figure 3. Ti vs Al plot of Dh-287 pyroxenes.

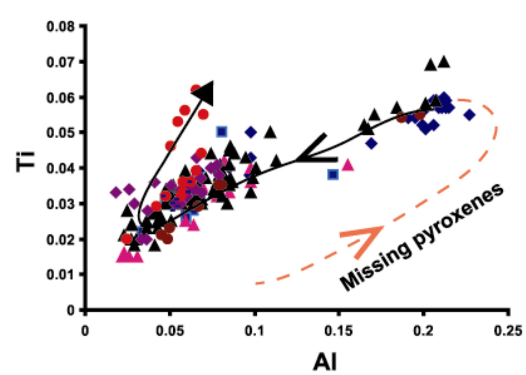


Figure 4. Mesostasis in Dh-287

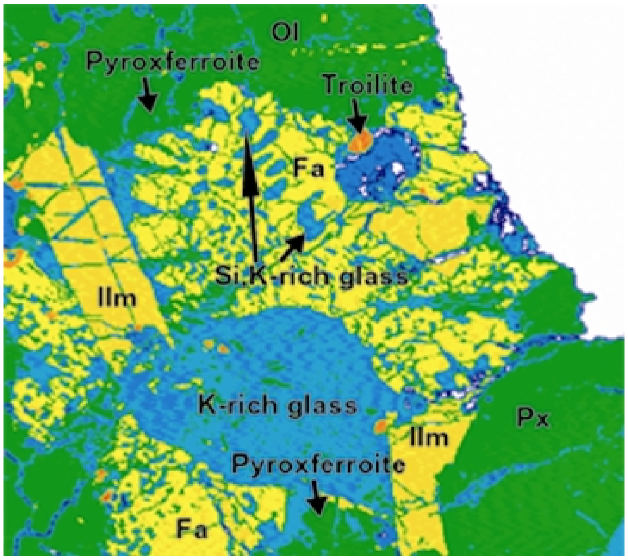
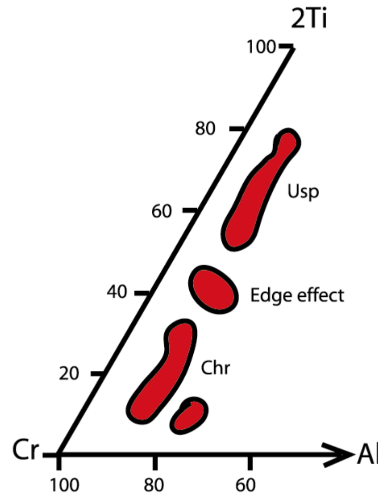


Figure 5. Dh-287 Spinels



mesostasis areas show extreme iron enrichment, all the way to pyroxferroite. Figure 4 shows a typical mesostasis area with a large bleb of K-Ba-rich glass. In the upper half of the picture, two stages of intergrowth between fayalite and K-rich glass are present. Needles of apatite occur randomly throughout the mesostasis areas.

Opaque minerals are abundant (i.e., 3%) throughout Dh-287. Ilmenite is most common, as lath-shaped grains, followed by spinels that occur in the form of chromite rimmed by ulvöspinel. Ilmenite and the spinels are only rarely in contact. No evidence for typical subsolidus reduction of ulvöspinel is present, as occurs in most mare basalts. Dh-287 spinels show fractionation trends similar to those of low-Ti mare basalts.

Discussion: Dh-287 is a lunar low-Ti mare basalt that contains an over-abundance of late-stage mesostasis. In particular, the absence of high-mg# pyroxene suggests that the early fractionate of these minerals is not evident here. Instead, the residual melt from a fractionating magma chamber was tapped and extruded. This fractionated magma possibly represented the melt after >20% of the olivine and pyroxene had crystallized and settled. This could account for the disproportionately high abundance of the late-stage KREEP-rich mesostasis within this basalt and the relatively high Na-content of the maskelynite, similar to that reported from lunar meteorite EET96008 [4].

In summary, the overly abundant mesostasis, with its concentration of incompatible elements, strongly suggests that this rock was derived from a residual melt. This late-stage fractionated melt would have been highly enriched in KREEPy components that, upon cooling, gave rise to pockets of KREEP-rich mesostasis areas. Indeed, there is no need for assimilation of KREEP by a primitive magma, as suggested by [5] for such a rock; however, the radiogenic data on Dh-287A [6] leaves this suggestion open.

References: [1] Taylor et al., (2001) Met Bull, No85, A204; [2] Taylor et al., 1996, Icarus; [3] Taylor et al., 1977, PLSC 8th; [4] Snyder et al., 1998, LPSC XXX, CD-ROM 1499; [5] Ringwood & Kesson, 1976, PLSC 7th; [6] Shih et al, this volume.