GEOCHEMISTRY OF A UNIQUE LUNAR METEORITE FROM OMAN, A CRYSTALLINE IMPACT-MELT BRECCIA DOMINATED BY MAGNESIAN ANORTHOSITE. R. L. Korotev (Department of Earth & Planetary Sciences, Washington University, C/B 1169, Saint Louis, MO 63130; korotev@wustl.edu)

What we did: We have obtained compositional data by INAA for 2–4 small (18–34 mg) subsamples each of seven feldspathic lunar meteorite stones from Oman, Dhofar stones 303, 305, 306, 309, 908, 911, and 1085 (analyses of Dhofar 302, 310, 489, and 733 are pending). We rely here on published major-element data for some of these stones and other related stones (1–4).

Background: Of the 45 numbered lunar meteorite stones from the Dhofar region of Oman, ~15 of them (Table 1) appear to be paired with each other on the basis of petrographic and compositional similarity, appearance of sawn faces, as well as find location [1,2, 3,5,6]. Together these stones are unique among the feldspathic lunar meteorites for the following reasons. (1) They are impact-melt breccias [1,2,4] or crystalline matrix breccias [5], not regolith or fragmental breccias. On average, (2) they are on the feldspathic end of the compositional range (mean Al_2O_3: 29% = 85% modal plagioclase; Fig. 1), (3) they are the most magnesian (mean bulk *Mg´* = 75%; Fig 1), (4) they have the highest Cr/Sc ratios (Fig. 2), and they have the lowest concentrations of both (5) incompatible elements (Fig. 3) and (6) siderophile elements (Fig. 4). Normatively, the meteorite is a magnesian troctolitic anorthosite [2,3,5,7], although mean normative olivine (9%) is only slightly greater than pyroxene (8%). (More and better major-element data may prove this observation to be incorrect.)

Extraneous info. Trace element data for some of the stones have been presented previously [3,7]. Except for Dhofar 489 [4], all available major-element data are not from whole-rock analyses but from analysis by electron microprobe of the melt matrix [1–3]. Dhofar 302 may be related, but it is more ferroan than the others [1,2]. Our data for Dhofar 305 do not suggest that it is distinct from the others [2]. Dhofar 489 [5], although found 24 km away [6], is indistinguishable in composition [4] from the others (point J on figures). Most of the subsamples we analyzed are strongly contaminated with U (Fig. 5) as well as Sr and Ba, as noted earlier [3,7].

Significance: Among feldspathic lunar meteorites, concentrations of siderophile elements tend to increase with those of incompatible elements (Fig 4; [7]). The correlation likely occurs because, in the FHT (Feldspathic Highlands Terrane [8]), material beneath the regolith has low concentrations of both suites of elements. Surface regolith accumulates micrometeorites with time, leading to accumulation of siderophile elements [9,10]. Also with time, regolith at the surface of the FHT accumulates material from impacts into the maria and Procellarum KREEP Terrane. Because the surface of the Moon is more mafic and richer in incompatible elements, on average, than the igneous rocks of the FHT, regolith of the feldspathic highlands can only become richer with time in Fe, Mg, and incompatible elements as well as siderophile elements. The otherwise unlikely correlation [7] between siderophile and incompatible elements is a consequence of surface exposure. Lunar meteorites that are richest in siderophile and incompatible elements are regolith breccias (Fig. 4). Those with low concentrations of these elements tend to be fragmental breccias and impact-melt breccias, which derive from material deeper in the crust. The Dhofar magnesian anorthosite is extreme and likely represents melted material from well below the regolith. The meteorite gives credence to the hypothesis that that surface material of the FHT is more mafic than deeper material [11].

The Dhofar magnesian anorthosite cannot be composed mainly of ferroan anorthosite such as that typical of the Apollo missions (Fig. 1). It is a breccia composed in large part of some type of magnesian anorthosite that is not well represented by samples in the Apollo collection. As a crystalline impact melt breccia, the meteorite represents a significant volume of material.

Mg/Fe ratios of feldspathic lunar meteorites vary greatly and average higher than those of ferroan anorthosites from the Apollo missions (Fig. 1). As samples from random locations, feldspathic lunar meteorites indicate that regions of the crust in the feldspathic highlands do not derive from ferroan anorthosite such as that common at the Apollo 16 landing site and that magnesian anorthosites are common at some locations [9].

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References: [1] Nazarov et al. (2002) *LPS XXXII*, #1293. [2] Demidova et al. (2003) *LPS XXXIV*, #1285. [3] Nazarov et al. (2004) *LPS XXXV*, #1233. [4] Karouji et al. (2004) *Antarctic Meteorites XXVIII*, p. 29–30. [5] Takeda et al. (2003) *LPS XXXIV*, #1284. [6] Korotev (this volume); [7] Nazarov et al. (2003) *LPS XXXIV*, # 1636. [8] Jolliff et al. (2000) *J. Geophys. Res.* **105**, 4197–4416. [9] Korotev et al. *Geochim. Cosmochim. Acta* **67**, 4895–4923. [10] Korotev (2005) *Chemie der Erde* **65**, 297–346. [11] Hawke et al. (2003) *J. Geophys. Res.* **108** (doi 10.1029/2002JE001890). [12] Warren (1993) *Am. Mineralogist* **78**, 360–376.

Table 1. Dhofar feldspathic lunar meteorite stones of magnesian-anorthositic composition.

stone	g	note	plot	stone	g	note	plot	stone	g	note	plot
303	4		B	**310**	11	2,3		**908**	245	2,4	M
305	34		C	**311**	4	3	I	**909**	4	2,3	
306	13		D	**489**	34	1	J	**911**	194	2,4	O
307	50	3	E	**730**	108	3	K	**950**	22	3	P
309	81	2	G	**731**	36	3	L	**1085**	197	2,4	R

g: Total mass in grams. Note: (1) Found distant from others [6]; (2) No major-element data; (3) No trace-element data; (4) Multiple stones. Plot: Symbol on Figs. 1–5..

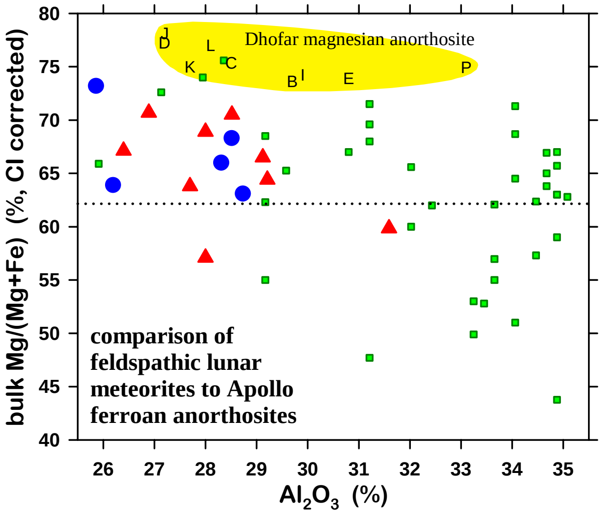

Figure 1. Comparison of FLMs from cold deserts (blue circles) and hot deserts (red triangles; each point represents a meteorite) with the Dhofar magnesian anorthosite stones of Table 1 (letters in yellow field, each point represents a stone; data of [1–4]) and pristine FAns (ferroan anorthosites) from the Apollo collection (green squares; data of [12]). The plot compares whole-rock *Mg´* for meteorites with mafic mineral *Mg´* for FAns. The horizontal dotted line is the FAn mean. For the lunar meteorites, Mg and Fe concentrations have been corrected for contributions of chondritic material.

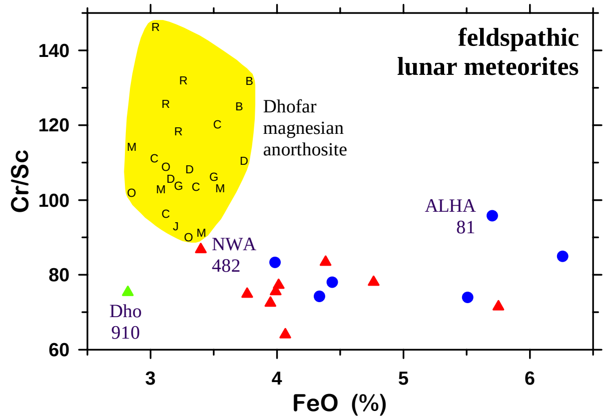

Figure 2. The Dhofar magnesian anorthosite (each letter point represents a subsample) is characterized by high Cr/Sc compared to other FLMs. Cr/Sc tends to correlate with Mg/Fe among FLMs [10]. The green triangle represents Dhofar 910 [6], a regolith or fragmental breccia of ferroan composition that is probably not paired with the stones of Table 1 (see also Figs. 3, 4, and 5).

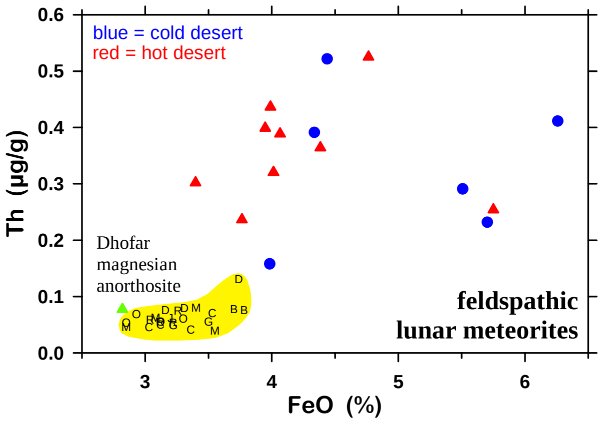

Figure 3. Comparison of concentrations of FeO and Th in subsamples of the Dhofar magnesian anorthosite with mean concentrations for other FLMs.

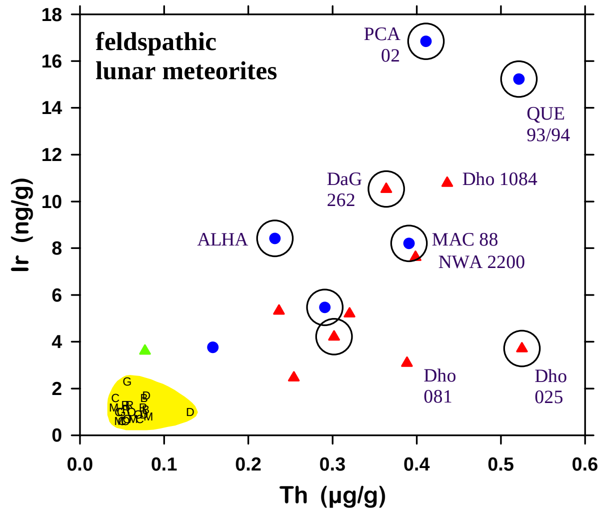

Figure 4. Among FLMs, those with high concentrations of siderophile elements like Ir tend to be regolith breccias (circled) that also have high concentrations of incompatible element like Th. The Dhofar magnesian anorthosite (yellow field) is an impact-melt breccia. Dhofar 1084 and NWA 2200 [6] are not yet well characterized and may be regolith breccias.

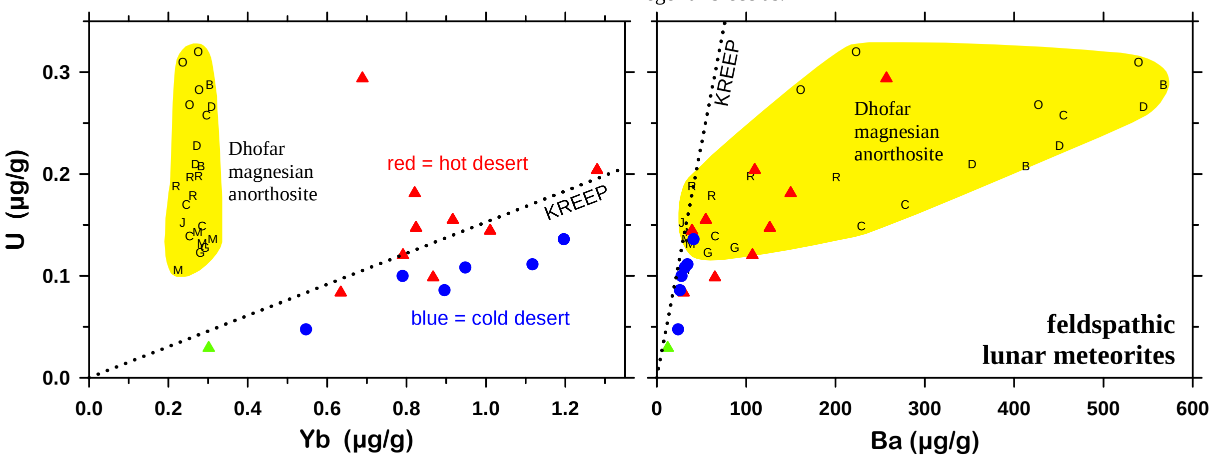

Figure 5. Hot-desert lunar meteorites are contaminated with Sr (not shown) and Ba compared to cold-desert FLMs [5,9] and Apollo samples [9]. Uranium is also affected. U concentrations correlate weakly (r^2=0.56, *N*=23) with those of Ba among the Dhofar magnesian anorthosites.