KEEPING UP WITH THE LUNAR METEORITES – 2008. R. L. Korotev[1], A. J. Irving[2], and T. E. Bunch[3], [1]Campus Box 1169, Dept. of Earth and Planetary Sciences, Washington University, Saint Louis MO 63130; [2]Dept. of Earth & Space Sciences, University of Washington, Seattle, WA 98195; [3]Dept. of Geology, Northern Arizona University, Flagstaff, AZ 86011; korotev@wustl.edu

The number of lunar meteorites has increased by 9 to a total of about 55 in the last year. We have obtained compositional data by INAA (instrumental neutron activation analysis) for 197 subsamples (20–30 mg each) of 29 lunar meteorite stones since our last reports here [1–5]. In Table 1 we present mass-weighted mean concentrations of some key elements.

New Data Confirm Previously Known or Suspected Pairings. Our samples of **Dhofar 081** and **Dhofar 910** are compositionally indistinguishable from each other. As we noted earlier [6], our sample of **Dhofar 280**, which is presumably paired with Dhofar 081/910 is different. The analysis of Dhofar 081 of [7] on a large mass (0.41 g), however, is intermediate (3.0% FeO, 0.6 µg/g Sm), suggesting that the meteorite is heterogeneous and our small sample of Dhofar 280 is anomalous.

Dhofar 490 and **Dhofar 1084** [6] are compositionally indistinguishable from each other (i.e., subsamples overlap). **DaG 1042** is compositionally indistinguishable from **DaG 262** and **DaG 996** [6].

We have analyzed samples of seven stones from different sources that are compositionally indistinguishable from **NWA 2995** (Table 1; O's in Fig. 1). The meteorite is a heterogeneous, fragmental breccia [8] consisting of subequal proportions of feldspathic and mafic (presumably mare) material with some KREEP-like lithic component. NWA 2995 et al. is compositionally most similar to **Yamato 983885** (Z) and, to a lesser extent, **Dhofar 1180** (3), but different in detail.

Subsamples of **NWA 4483** (¢) overlap in composition with those of **NWA 3163** ($) [9], although our sample of NWA 4483 is a bit more feldspathic on average than our sample of NWA 3163. The stones are paired.

Possible Launch Pairings. An unnamed mare basalt from the Sahara is compositionally and texturally indistinguishable from the LAP mare basalts from Antarctica, i.e., **LAP 02205** et al. [10]. The meteorites are almost certainly launch paired.

Regolith breccia **NWA 4884** is compositionally indistinguishable from **QUE 94281** and appears to be another stone in the launch-pair group that also includes **Yamato 793274/981031** [11] and, possibly, **EET 87521/96008** [12].

Although texturally different, **NWA 2998** (#) and Dhofar 081/280/910 (8) are nearly identical in composition. The two meteorites are the most feldspathic of lunar meteorites (85–90% normative plagioclase). They may be launch paired but, given that they are so feldspathic, the compositional similarity may just be a coincidence.

Compositionally and texturally, impact-melt breccia **NWA 4932** (&) is similar to **SaU 300** (S). Both derive

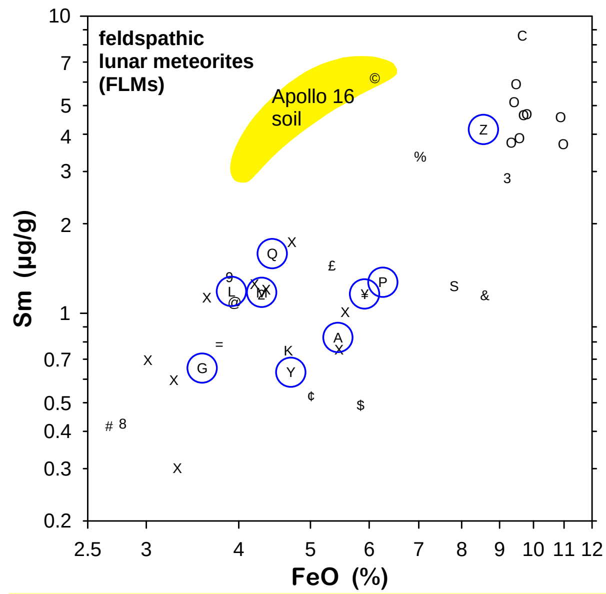

Figure 1. X = FLM's not mentioned in text; all others are mentioned; key in Table 1. Meteorites from Antarctica are circled.

from mafic anorthosite with low Sm/Sc [13].

Other New Data. Neither new lunar meteorite from Antarctica is obviously paired with any other from Antarctica (symbols AGLMQPY¥Z in Fig. 1). Tiny **GRA 06157** (G, 0.8 g) is at the low-FeO, low-Sm end of the range of FLMs (feldspathic lunar meteorites). Compositionally, it is most similar to texturally different **NWA 482** (= in Fig. 1). **LAR 06638** (L) is a more typical FLM but is still more feldspathic than most FLMs from Antarctica. We observe little difference in composition between the light clasts and dark matrix in LAR. Overall, the composition is most similar to Dhofar 490/1084 (9) and **NWA 2200** (@) [6].

Despite its distinct petrography, **NWA 5000** (£) is a typical FLM in composition and not obviously paired with any other NWA lunar meteorite [14]. **NWA 4819** (%) is an FLM that differs from others of similar FeO in being richer in incompatible elements. In this regard it resembles some feldspathic breccias from the Apollo missions. **NWA 4936** (©) is an FLM with even greater concentrations of incompatible elements. With 6.1% FeO and 6.2 µg/g Sm, it is the first lunar meteorite that could pass for a sample of regolith from Apollo 16.

NWA 4898 is a new mare basalt [15] with a unique composition, one at the low-FeO (17%) end of the range for mare basalts (17–23%). REE concentrations (Fig. 2) most closely match those of **Yamato 793885**, but the new meteorite is otherwise distinct.

We analyzed a mass of **Calcalong Creek** >3 times that of the previous analysis [16], but obtain a similar mean composition. Subsamples vary considerably (8.2–

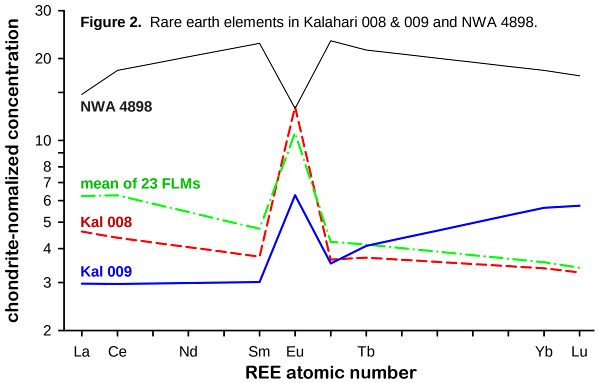

Figure 2. Rare earth elements in Kalahari 008 & 009 and NWA 4898.

11.7% FeO, 6.6–10.6 µg/g Sm) but there is no correlation of incompatible elements with “mafic” elements (Fe, Sc, Cr), indicating that simple “plagioclase dilution” is not the cause of the variation in incompatible elements as it is in many brecciated lunar meteorites.

With 4.7% FeO and 0.75 µg/g Sm **Kalahari 008** (K) is a typical FLM. For **Kalahari 009**, a basaltic breccia, we obtain only 16.4% FeO (8 subsamples range from 14.0% to 17.7%) compared to 18.5% reported by [17]. As others have noted [17,18], it has extraordinarily low concentrations of incompatible elements. Concentrations of trivalent REE are so low that pyroxene and plagioclase, not phosphates, are the major carriers of the incompatible elements. Eu^{2+} carried in the plagioclase leads to a positive Eu anomaly and the heavy REE are carried mainly by pyroxene (Fig. 2).

Caveat emptor. We previously reported that the “regolith breccia” lithology of Dhofar 287 “is highly dissimilar in composition to the basalt lithology … and, in fact, to any Apollo regolith.” [2]. Further investigation reveals, however, that the analyzed sample does instead have the composition of a howardite, so we must conclude that the sample we acquired from a dealer as “Dhofar 287B” [19] was not, in fact, a sample of lunar meteorite Dhofar 287.

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References: [1] Jolliff et al. (2007) *LPSC38*, #1489. [2] Korotev & Zeigler (2007) *LPSC38*, #1340. [3] Kuehner et al. (2007) *LPSC38*, #1516. [4] Zeigler et al. (2007) *LPSC38*, #2109. [5] Zeigler et al. (2007) *LPSC38*, #2110. [6] Korotev (2006) *LPSC37*, #1404. [7] Warren et al. (2005) *M&PS* **40**, 989–1014. [8] Bunch et al. (2006) 69th MetSoc, #5254. [9] Irving et al. (2006) *LPSC37*, #1365. [10] Zeigler et al. (2005) *M&PS* **40**, 1073–1102. [11] Arai & Warren (1999) *M&PS* **34**, 209–234. [12] Korotev et al. (2003) *Ant. Met. Res.* **16**, 152–175. [13] Korotev et al. (2007) 70th MetSoc., #5006. [14] Irving et al. (this conf.). [15] Greshake et al. (this conf.). [16] Hill & Boynton (2003) *M&PS* **38**, 595–626. [17] Schulz et al. (2007) 70th MetSoc, #5151. [18] Terada et al. (2007) *Nature* **450**, 849–853. [19] Demidova et al. (2003) *M&PS* **38**, 501–514. [20] Jolliff et al. (1998) *M&PS* **33**, 581–601.

Table 1. Results of INAA – Mass-weighted mean concentrations of *N* subsamples of each stone, with total analyzed mass. *Preliminary data. Data for QUE 94281 from [20].

	plot	Na_2O, %	FeO, %	Sc, ppm	Cr, ppm	Ni, ppm	Sm, ppm	Eu, ppm	Th, ppm	mass, mg	*N*
Calc. Creek	C	0.434	9.66	22.3	1260	113	8.59	1.056	3.95	208	11
DaG 996	2	0.357	4.25	7.81	618	187	1.21	0.776	0.44	234	9
DaG 1042		0.342	4.31	7.69	643	294	1.12	0.738	0.45	204	8
GRA 06157*	G	0.36	3.6	5.5	550	90	0.66	0.84	0.2	57	2
Dhofar 280	8	0.352	3.57	6.92	460	103	0.900	0.776	0.39	103	4
Dhofar 081		0.326	2.75	4.80	372	77	0.324	0.751	0.08	252	8
Dhofar 910		0.328	2.50	4.45	323	49	0.322	0.761	0.08	227	10
NWA 2998	#	0.344	2.67	4.89	356	60	0.416	0.761	0.13	224	8
NWA 2200	@	0.330	3.95	6.95	504	175	1.09	0.796	0.40	209	10
LAR 06638*	L	0.34	3.9	6.7	560	270	1.2	0.82	0.4	282	10
Dhofar 490	9	0.323	3.89	6.61	488	250	1.28	0.754	0.43	98	4
Dhofar 1084		0.344	4.00	6.93	525	250	1.33	0.787	0.44	135	5
Kalahari 008	K	0.561	4.67	10.9	710	60	0.747	1.014	0.17	278	9
Kalahari 009	none	0.485	16.4	53.2	2880	<150	0.603	0.479	0.06	265	8
NWA 2995	O	0.467	9.80	19.3	1560	217	4.66	1.045	1.90	246	8
pair 1	O	0.475	9.70	18.3	1580	184	4.63	1.097	1.57	253	8
pair 2	O	0.447	9.58	18.7	1510	194	3.89	1.045	1.38	210	7
pair 3	O	0.463	11.7	22.0	1920	156	4.58	1.053	1.51	148	6
pair 4*	O	0.43	11.0	22.	1800	200	3.7	0.96	1.2	119	4
pair 5*	O	0.50	9.4	18.	1600	200	5.1	1.12	1.7	168	6
pair 6*	O	0.48	9.5	18.	1600	200	5.9	1.20	2.4	54	2
pair 7*	O	0.46	10.9	20.	1700	200	4.6	1.03	1.8	60	2
Y-983885	Z	0.365	8.56	19.4	1490	530	4.15	0.831	2.10	107	9
Dhofar 1180	3	0.384	9.22	26.8	1040	130	2.84	0.899	0.90	196	9
NWA 3163	$	0.288	5.84	12.6	1025	38	0.489	0.658	0.10	304	10
NWA	¢	0.292	5.01	11.2	890	54	0.526	0.682	0.12	314	10
LAP, 6 stones	none	0.373	22.0	59.2	2140	<200	7.53	1.22	2.06	1237	37
unnamed NWA	none	0.371	21.7	59.7	2330	<200	7.13	1.15	1.98	199	8
NWA 4819	%	0.363	7.03	13.0	1420	288	3.36	0.824	1.50	275	9
QUE 94281	none	0.396	13.3	28.9	1780	295	3.17	0.839	1.03	464	28
NWA 4884	none	0.365	13.7	30.1	2090	161	3.06	0.786	0.93	181	6
NWA 4898	none	0.296	17.2	65.4	3020	<180	4.55	0.997	0.44	133	6
SaU 300	S	0.329	7.8	17.9	1470	440	1.23	0.631	0.53	321	11
NWA 4932*	&	0.31	8.6	20.	1510	600	1.2	0.65	0.5	210	6
NWA 4936*	©	0.50	6.1	9.0	800	680	6.2	1.4	2.0	178	6
NWA 5000*	£	0.43	6.4	10.	920	860	1.4	0.9	0.4	296	9