Lunar Meteorite PCA 02 007: A Feldspathic Regolith Breccia with Mixed Mare/Highland Components

L. A. Taylor[1] (lataylor@utk.edu), M. Anand[1], C. Neal[2], A. Patchen[1] and G. Kramer[2]; [1]Planetary Geosci. Inst., Univ. of Tennessee, Knoxville-37996, [2]Department of Civil Eng. & Geological Sci., Univ. of Notre Dame, IN 46556

Introduction: Lunar meteorite PCA 02 007 was recently discovered in the Pecora Escarpment in Antarctica. We were allocated one thin section (PCA 02 007,27), one polished thick section (PCA 02 007,24), and 0.535 g powdered rock sample (PCA 02 007,13) by the Meteorite Working Group (MWG) for carrying out mineral and geochemical investigations. This sample was originally described as a basaltic lunar breccia [1]. However, the polished thick- and thin-sections that we have examined are of a regolith breccia consisting of many highland clasts and a few basalt clasts of VLT affinity and a multitude of monomineralic basaltic clasts, all set within a fine-grained, brownish glassy matrix, made almost opaque by myriads of native Fe grains. Several regolith clasts are also present containing partially devitrified glass spheres and a network of fine-grained native Fe grains from the accompanying agglutinates.

Mineralogy and Petrography:

Clasts: The majority of the lithic clasts have high plagioclase contents, mostly representing highland impact-melt products, but a few basaltic clasts also exist, sans appreciable ilmenite – i.e., VLT (Figure 1). Few troctolitic and noritic clasts are also present. Some of the clasts are of metamorphosed regolith, as evidenced by the glass beads and abundant 1-2 μm native Fe grains throughout. The remaining clasts are mostly pyroxene and a few olivines from coarse-grained basalts. In terms of appearance and clast compositions, PCA 02 007 is similar to QUE 94281 [2].

Pyroxenes: The compositions of the pyroxenes shown in Fig. 2 are misleading in that the majority of them come from single pyroxene grains as clasts. The points that are in the ferropyroxene region come from 5 monomineralic clasts (50-100 μm in size). Some of the suspected highland clasts have the most Ca- and Mg-rich pyroxene compositions, common for HMS highland rocks. Some of the pyroxene grains possess exsolution lamellae. Fig. 3 depicts a traverse across one such grain. Notice the Wo contents of the two pyroxenes and the thickness of the lamellae. Such features are interpreted to be indicative of slow cooling, such as may occur in a thick (~10 m) flow or shallow hypabyssal situation.

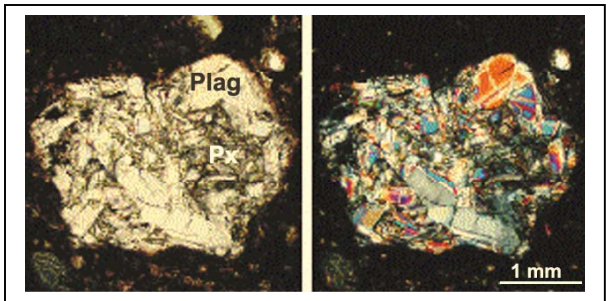
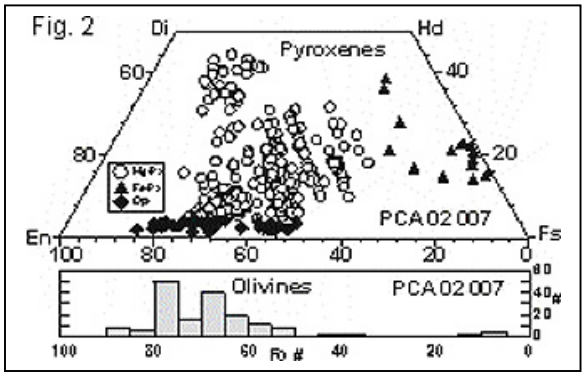


Fig. 1. VLT Basaltic Clasts



Olivine: The olivine compositions (Fig. 2) are mostly from clasts of comminuted basalt. The Fo content in the majority of the cases varies between 50 and 80, with some values below Fo 40 down to Fo 5. Similarly, there are some olivine grains that occur in partially melted HMS clasts with Fo content ranging between 80 and 90. The Fe to Mn ratios in the olivines and pyroxenes (Fig. 4, after [3]), presence of a myriad of FeNi metal grains, and agglutinates are indicative of lunar source for this sample.

Plagioclase: The plagioclase compositions are all extremely rich in An component, most above An 95 and in the range of 95-99. Only in one case, An contents of 70-75 have been measured from a plagioclase grain. The high An contents in plagioclases are common for highland rocks, but also for VLT basalts.

Other Minerals and lithologies:

Spinels and ilmenite are rare in PCA 02 007. Spinels have both chromite and ulvöspinel

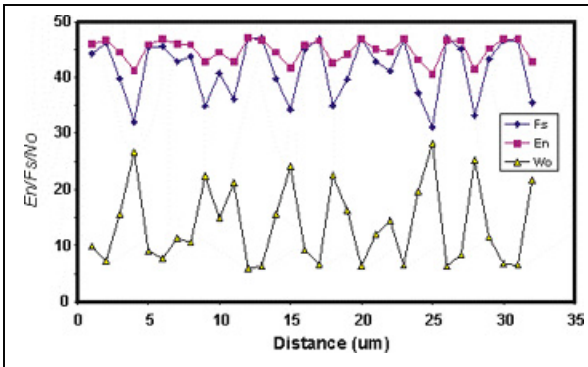
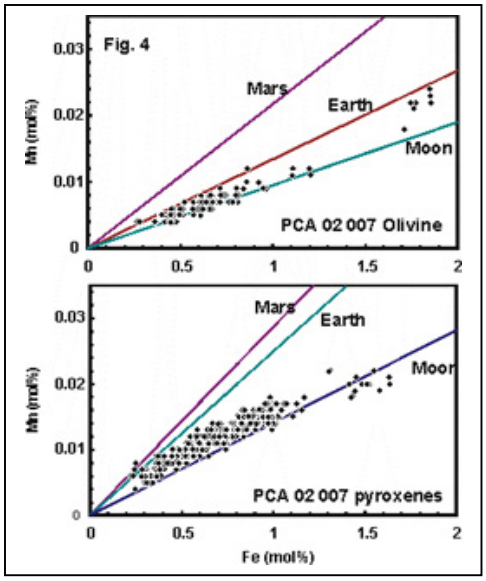
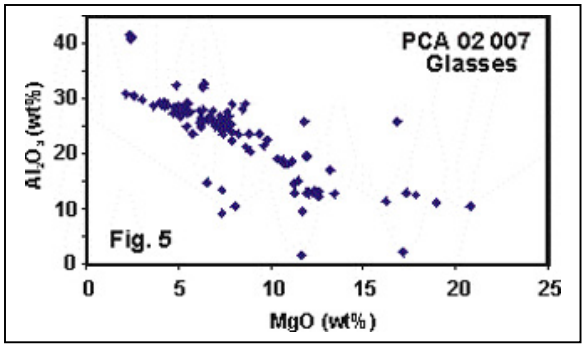


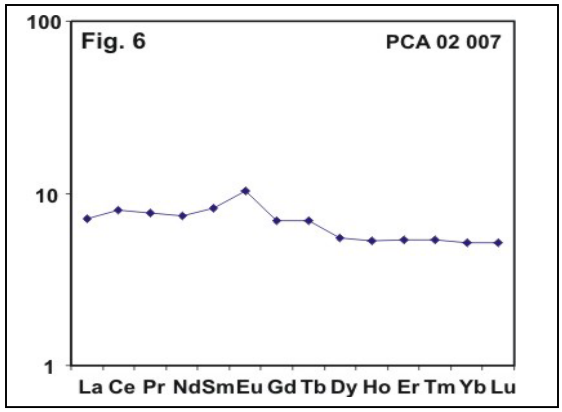
Fig3. Traverse across exsolved pyroxene



compositions. The MgO content in ilmenites is as high as 4.76 wt% but in general it varies between 0.1 to 2.8 wt%. Similarly, the ZrO_2 content in ilmenite varies from < 0.03 to 0.17 wt%. FeNi metal grains show wide variation in terms of Ni and Co compositions (Ni –0.6-13 wt%; Co- 0.05-0.7 wt%) and plot within the compositional range defined by A-14 and 16 polymict rocks [4]. Glass compositions also exhibit significant variations. In general, they show a linear mixing trend between feldspathic-highland material and basaltic mare/HMS material (Fig. 5).

Bulk-Rock Major- & Trace-Element Chemistry: The whole-rock, major- and trace-element compositions of PCA 02 007 were determined on a 50 mg powered sample using solution ICP-MS following the procedure of [5]. Major-element compositions (Table 1) clearly reveal the predominance of FAN-type material in PCA 02 007 (29 wt% Al_2O_3). However, there is appreciable MgO content in the sample, which may have been contributed from the mare/HMS sources. The rarity of ilmenite, combined with low TiO_2 content of the bulk-rock, strongly suggests VLT basalt as the contributor from the mare regions. The REE contents of PCA 02 007 are about 10 times





chondrite with a flat chondrite-normalized pattern (Fig. 6) and a positive Eu anomaly.

Summary: PCA 02 007 is a mixed mare and highland regolith breccia, with a number of clasts derived from a thick mare-basalt flow (i.e., VLT basalts), possibly from a gabbro-norite and HMS suite of rocks. In terms of texture, mineral and bulk-rock composition, this rock appears similar to QUE 94281 and could be paired with it.

References: [1] Ant. Met. News Lett., 26(2); [2] Jolliff et al., MAPS, 33, 581-601; [3] Papike et al., 2003, Am. Min., 88, 469-472; [4] Papike et al., 1991, Lunar Source Book, p.152. [5] Neal 2001, JGR, 106, 27865-27885.

Table1: Major- and Trace-elements in PCA 02 007,13

Majors	wt%	Traces	ppm	REEs	ppm
SiO_2*	38.6	Be	0.50	La	2.67
TiO_2	0.28	Sc	11.8	Ce	7.69
Al_2O_3	29.06	V	50.6	Pr	1.06
FeO	6.80	Co	29.8	Nd	5.28
MnO	0.09	Ni	353.67	Sm	1.89
MgO	7.40	Ga	3.86	Eu	0.90
CaO	17.26	Rb	0.82	Gd	2.13
Na_2O	0.38	Sr	151.5	Tb	0.40
K_2O	0.05	Y	9.77	Dy	2.10
P_2O_5	0.08	Zr	40.2	Ho	0.45
Total	100.0	Nb	2.5	Er	1.33
		Cs	0.09	Tm	0.19
		Ba	34.8	Yb	1.29
		Ta	0.24	Lu	0.20
		W	0.20		
		Pb	1.16		
		Hf	1.33		