MILLER RANGE FELDSPATHIC LUNAR METEORITES. R. L. Korotev, B. L. Jolliff, and P. K. Carpenter, Department of Earth and Planetary Sciences and McDonnell Center for the Space Sciences, Campus Box 1169, Washington University, Saint Louis MO 63130; korotev@wustl.edu

Introduction: We report on the composition and petrography of four lunar meteorite stones (137–244 g) found during the 2009–2010 ANSMET field season in the Miller Range (MIL) of Antarctica and compare the new meteorites to the other feldspathic lunar meteorites from Antarctica.

Samples: We were allocated three ~100-mg chips of each of the four stones (Fig. 1). We analyzed one or two 30–35-mg subsamples of each chip by INAA (instrumental neutron activation analysis). Polished thin sections (NASA-JSC) of a different chip of each of the MIL 09 stones and a chip of MIL 07006 were examined using optical and electron microprobe analyses.

Petrography: All of the MIL 09 stones are glassy-matrix, clast-rich, feldspathic breccias. Clasts are rounded and include a wide range in sizes. The largest clasts are anorthositic and contain relict, cataclasized areas that did not completely melt. Lithic clasts in all four of the MIL 09 specimens have diffuse boundaries that grade into glassy-to-very finely crystalline matrix. Mineral clasts are all extremely fine-grained, more so in MIL 090070 and MIL 090075. MIL 090034,7 and MIL 090036,6 contain a more diverse set of clasts, including mineral and lithic clasts, compared to MIL 090070,7 and MIL 090075,6. The latter two stones, which are paired [1,2], are very similar to each other texturally and contain nearly identical matrix melt compositions. Our section of MIL 090034 contains several clasts of magnesian, feldspathic impact-melt (MgO ≈ 6%, *Mg´* ≈ 71) and MIL 090036 contains a suite of ferroan lithic clasts (FeO ~10%, *Mg´* ≈ 66. (Fig. 3). The glassy matrix, rounded lithic clasts, and very fine-grained mineral clasts indicate that these meteorites are regolith breccias although we have not found glass spherules or relict agglutinates among the clasts.

All four MIL 09 breccias differ from tiny MIL 07006 (1.4 g), which has clasts with distinct and sharp boundaries (Fig. 1). Section MIL 07006,13 appears to be composed entirely of the dark aphanitic matrix. It appears to contain agglutinates or a bit of vesicular glass associated with fusion crust along one edge (Fig. 2, right side). Clasts of mare origin have been reported in MIL 07006 [2,3]. We did not observe clasts of mare basalt in any of the MIL 09 sections, however.

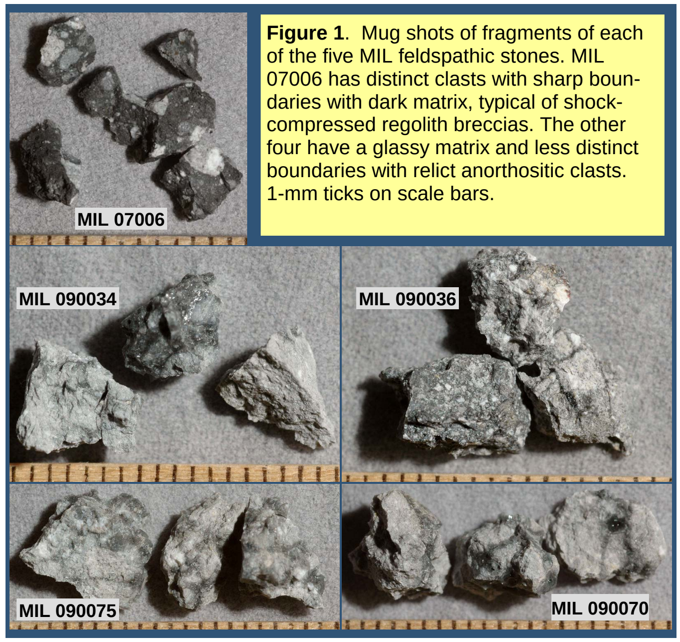

Figure 1. Mug shots of fragments of each of the five MIL feldspathic stones. MIL 07006 has distinct clasts with sharp boundaries with dark matrix, typical of shock-compressed regolith breccias. The other four have a glassy matrix and less distinct boundaries with relict anorthositic clasts. 1-mm ticks on scale bars.

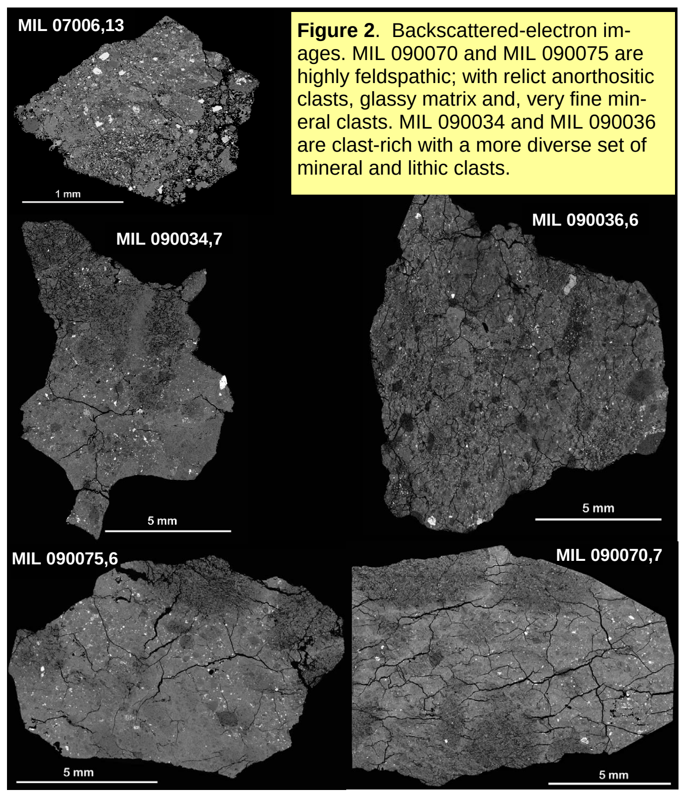

Figure 2. Backscattered-electron images. MIL 090070 and MIL 090075 are highly feldspathic; with relict anorthositic clasts, glassy matrix and, very fine mineral clasts. MIL 090034 and MIL 090036 are clast-rich with a more diverse set of mineral and lithic clasts.

Bulk Composition: None of the new stones is a compositional match to MIL 07006, which is significantly richer in Sc (Fig. 4) presumably because of the mare component [2,3]. MIL 090034, MIL 090070, and MIL 090075 are at the low-FeO, low-Sc (i.e., most feldspathic) end of the range of feldspathic lunar meteorites and most similar to GRA 06157 and LAR 06638 among those from Antarctica. MIL 090036 is compositionally more mafic and is richer in Na, incompatible elements, and siderophile elements, although one of the six MIL 090070/75 subsamples is comparably rich in Sm (Fig. 4). MIL 090036 is richer in incompatible elements than any feldspathic lunar meteorite from Antarctica and in the range of Apollo 16 soils. Among lunar meteorites, it is most similar in composition to paired stones Northwest Africa 4936/5406 [Fig. 4]. We previously noted that MIL 07006 is similar in composition to Y-791197 [5], but in detail there are some differences, e.g., in Na (Fig. 4).

Pairing: On one hand, focusing on the differences, the four MIL 09 stones might represent three meteorites. If so, then it is a coincidence that MIL 090034 is so similar to MIL 090070/75 and together different from most other lunar meteorites from Antarctica. On the other hand, centimeter-sized clasts occur in all four stones [1] and our thin sections and INAA samples are not large compared to a centimeter (Figs. 1 and 2). Subsample scatter for breccias composed of mature regolith is small (e.g., QUE and PCA of Fig. 4). If the MIL 09 stones are regolith breccias, then the regolith was immature. A great deal of lithologic and compositional (Al/Fe, Mg/Fe, Na, Sm, etc.) diversity occurs among the rocks and

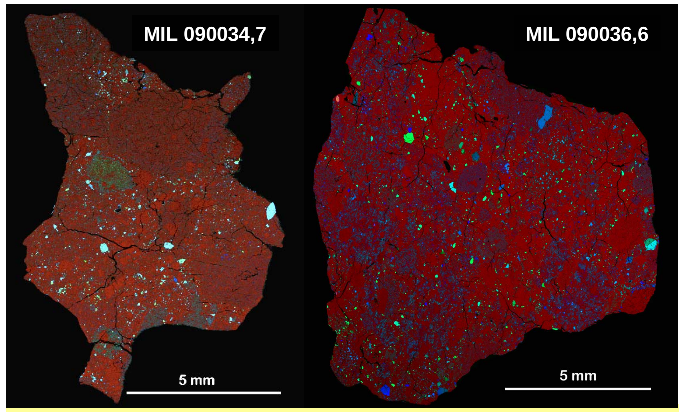

Figure 3. X-ray RGB composites with Al in the red channel, Mg in green, and Fe in blue. MIL 090034,7 contains several magnesian (green) lithic clasts whereas those in 090036,6 are distinctly more ferroan than any of the other MIL samples.

(immature) regolith samples collected, for example, on the rim of North Ray Crater at Apollo 16 [5,6,7]. Thus, in light of our Apollo experience, petrography and chemistry do not argue strongly that the course grained MIL 09 breccias are not all from the same meteorite. All derive from a highly feldspathic region of the lunar highlands.

Acknowledgements: Thanks NASA, ANSMET, Kathleen, and Cecilia.

References: [1] Corrigan et al. (2010) *Antarctic Meteorite Newsletter* **33**(2). [2]. Liu et al. (2009) *LPSC40*, #2105. [3] Joy et al. (2010) *LPSC41*, #1793. [4] Korotev et al (2009) *M&PS* 44, 1287–1322. [5] Korotev et al. (2009) *LPSC40*, #1137. [6] Stöffler et al. (1981) *LPSC12*, 185–207. [7] Lindstrom & Salpas (1983) *PLPSC13*, A671–A683 [8] Korotev (1996) *M&PS* **31**, 403–412.

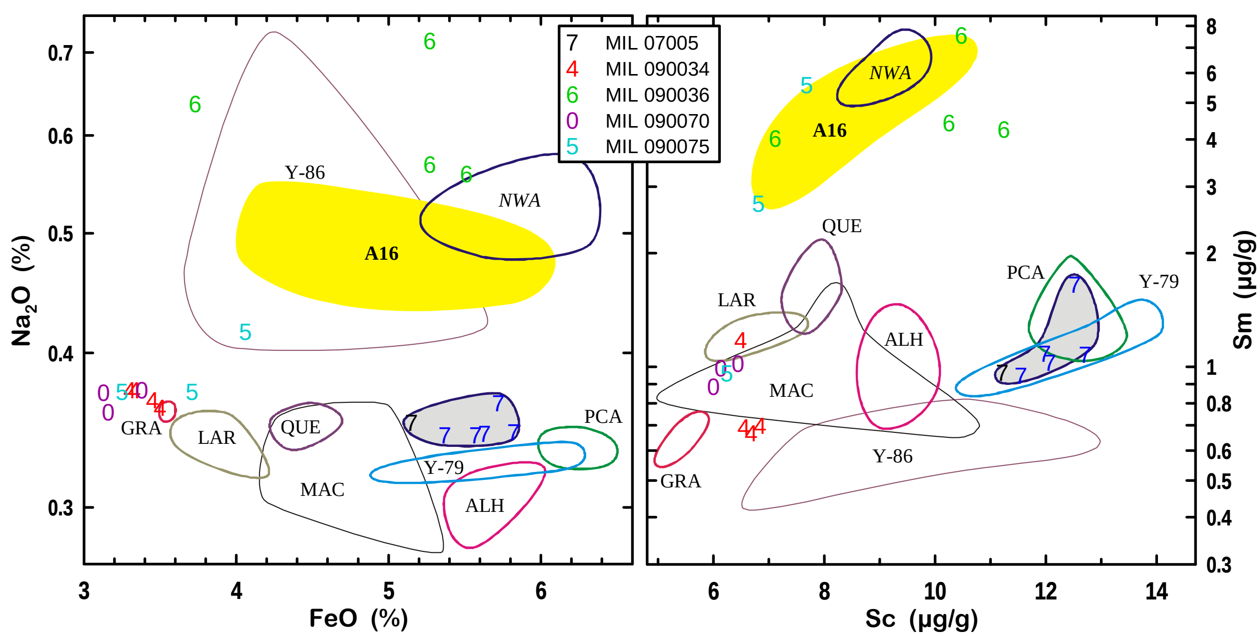

Figure 4. Compositional comparison of feldspathic lunar meteorites from Antarctica. Numeric symbols represent ~35-mg subsamples of the 5 MIL meteorites. Fields represent range of concentrations of subsamples of typical composition of non-MIL meteorites. ALH = ALHA 81005 (9); GRA = GRA 06157 (2), LAR = LAR 06638 (10), MAC = MAC 88104 & 88105 (16); PCA = PCA 02007 (14), QUE = QUE 93069 & 94269 (14), Y-79 = Yamato 791197 (7), Y-86 = Yamato 86192, 82193, and 86032 (21) (values in parentheses indicate number of subsamples defining the field). Also shown is the field for submature and mature soils from Apollo 16 (yellow) and lunar meteorite NWA 4936/5406 (16) [4]. Data from many sources.