PETROGRAPHY AND CHEMISTRY OF IMPACT-MELT CLASTS IN APOLLO 16 BRECCIAS. B.A. Cohen[1], S.J. Symes[2], and T.D. Swindle[3]. [1]Institute of Meteoritics, University of New Mexico, Albuquerque NM 87131 (bcohen@unm.edu); [2]University of Tennessee-Chattanooga, Chattanooga TN 37403; [3]University of Arizona, Tucson AZ 85721.

Introduction: The preponderance of 3.9 Ga lunar impact-melt rock ages and the dearth of older samples of unequivocal impact origin, from either the Apollo collection or lunar meteorites, suggest an extraordinary bombardment event in the Earth-Moon system at ~3.9 Ga. We have begun to study another set of samples, impact melts and crystalline lunar spherules (CLS) within demonstrably old Apollo breccias, to search this untapped reservoir for evidence of pre-3.9 Ga lunar impacts.

The impact-melt rocks that form the basis of the cataclysm hypothesis are predominantly mafic, KREEP-rich samples, affording enough radiogenic elements to be feasibly dated, but possibly dominated by the large volume of melt created in the stratigraphically young, nearside basins. In contrast, the feldspathic lunar meteorite breccias have low (≤1 ppb) Th contents; consistent with an origin in the feldspathic lunar highlands, far from the incompatible element-rich Procellarum KREEP terrain (PKT) or mafic South Pole-Aitken basin [1]. Alternatively, the components of these breccias could have formed from the nearside feldspathic crust prior to the widespread distribution of material from these areas.

Our previous work showing the relatively young ^{40}Ar-^{39}Ar ages of impact-melt clasts in feldspathic lunar meteorite breccias supports the former interpretation that the breccias formed in the feldspathic lunar highlands [2]. However, discrepancies in the age distribution between the lunar meteorite impact-melt clasts and Apollo impact-melt rocks [e.g. 3, 4] may reveal a bias in selection techniques that merits further investigation.

In contrast to the apparent youth of the meteorite breccias, high amounts of trapped ^{40}Ar and excess fission Xe present in many Apollo 16 feldspathic breccias indicates that they acquired their noble gases, including solar wind exposure, very early in lunar history [5]. These breccias lack mature regolith components such as agglutinates, indicating that following exposure, the breccia components were shielded for some time. Despite their recovery location near several large, nearside basins, the breccias lack the ubiquitous KREEPy impact-melt clasts found throughout the Apollo collection, indicating that these rocks were lithified and closed to new input before the exposure and dissemination of KREEP material. These characteristics make the Apollo 16 breccias attractive targets for a) searching for evidence of impact events that may pre-date formation of the large, nearside basins, and b) repeating identification and analysis techniques used for the lunar meteorite dataset on well-studied rocks from the lunar near side.

Methods: 66075 is a feldspathic fragmental breccia and 60016 and 66035 are feldspathic regolith breccias. All are subcompact with low shock and rare occurrences of agglutinates and glass spheres [5]. We obtained 100-µm thick sections of each breccia to conduct petrologic, geochemical, and geochronological studies on crystalline lunar spherules (CLS) [6] and impact-melt fragments.

We identified and characterized impact-melt clasts in these rocks using previously-described

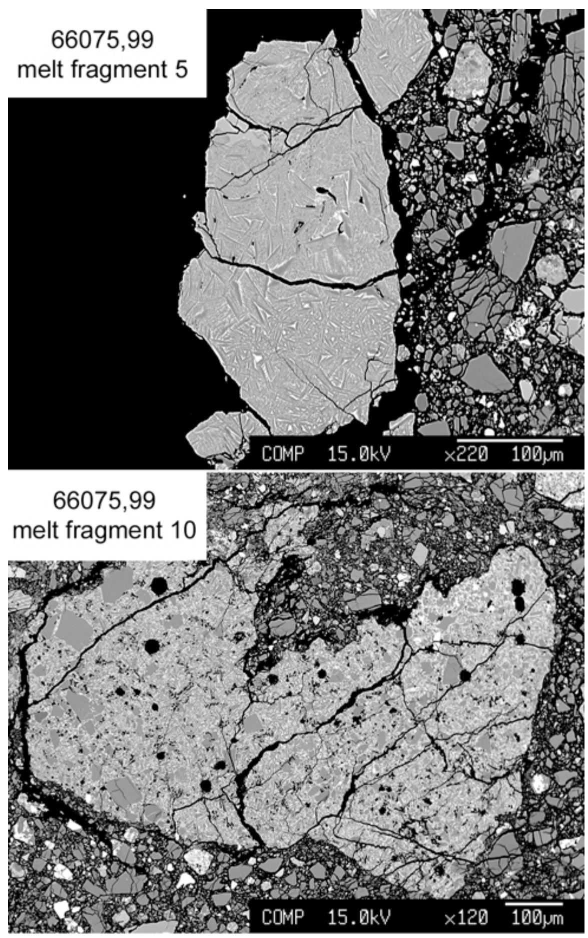

Fig. 1: Backscattered electron images of two feldspathic impact-melt clasts in 66075,99: mf5 has a quench texture; mf10 is microporphyritic. Scale bars in both images is 100 µm.

techniques for lunar meteorite breccias [2]. We identified 18 large (>100 μm) melt fragments (mf) and two glass fragments (gl) in the three thick sections based solely on their textures in the petrographic and scanning electron microscopes. The melt fragments are fully crystalline and generally microporphyritic or quench-textured (Fig. 1), though several of the clasts have a better-defined igneous texture and may not be impact melt. We obtained bulk chemistry of each clast by averaging multiple defocused-beam electron-microprobe analyses (DBA). The DBA technique yields values for low-Z elements that may be systematically low by a few percent, but this does not affect comparison among grossly similar clasts analyzed using the same conditions, as is the case here. We extracted the clasts from the rock matrix using a Medenbach microcorer for irradiation and future ^{40}Ar-^{39}Ar analyses.

Results: Figure 2 compares the major-element compositions of the clasts with the feldspathic lunar meteorites and typical KREEP-rich impact-melt rocks. About half the impact-melt clasts in 66075 and 60016 have high Al_2O_3 and low K_2O contents and plot in the same area as the feldspathic lunar meteorites and the average Apollo 16 soil (indicated with an asterisk). Their normative compositions are ≥80% plagioclase by volume. These clasts may indeed be derived from the pre-Imbrium feldspathic highlands of the Moon. Diversity in the clasts' Mg' (molar Mg/(Mg+Fe)) suggest that these breccias sample multiple impact events.

Several clasts plot in the area between the KREEP and meteorite fields. Most of the A16 breccia bulk compositions lie in this area [5], indicating admixture of a less aluminous component, such as basalt [7]. If these clasts are impact melts, they may have formed from a similar mix of target materials, or these clasts may actually be lithic fragments. One high-K, high-Na glass fragment was identified in 66035 that may be quite exotic to the A16 site.

The clasts in these breccias have total MgO+FeO contents and Mg' consistent with other lunar rocks of similar lithology. However, the majority of clasts have FeO contents ≥4.5 wt.% (the remotely-sensed lunar highlands mean [8]), possibly suggesting that the pre-PKT nearside crust had a more ferroan composition than current far side highlands.

References: [1] Jolliff, B.L., *et al.* (2000) *JGR* 105, 4197. [2] Cohen, B.A., *et al.* (2005) *MAPS* 40, 755. [3] Dalrymple, G.B. and G. Ryder (1996) *JGR* 101, 26. [4] Dalrymple, G.B. and G. Ryder (1993) *JGR* 98, 13. [5] McKay, D.S., *et al.* (1986) *JGR* 91, D277. [6] Symes, S.J. and C.M. O'D. Alexander (2004) *LPSC* 35, #1917. [7] Korotev, R.L. (1997) *Meteoritics* 32, 447. [8] Lucey, P.G., *et al.* (1995) *Science* 268, 1150.

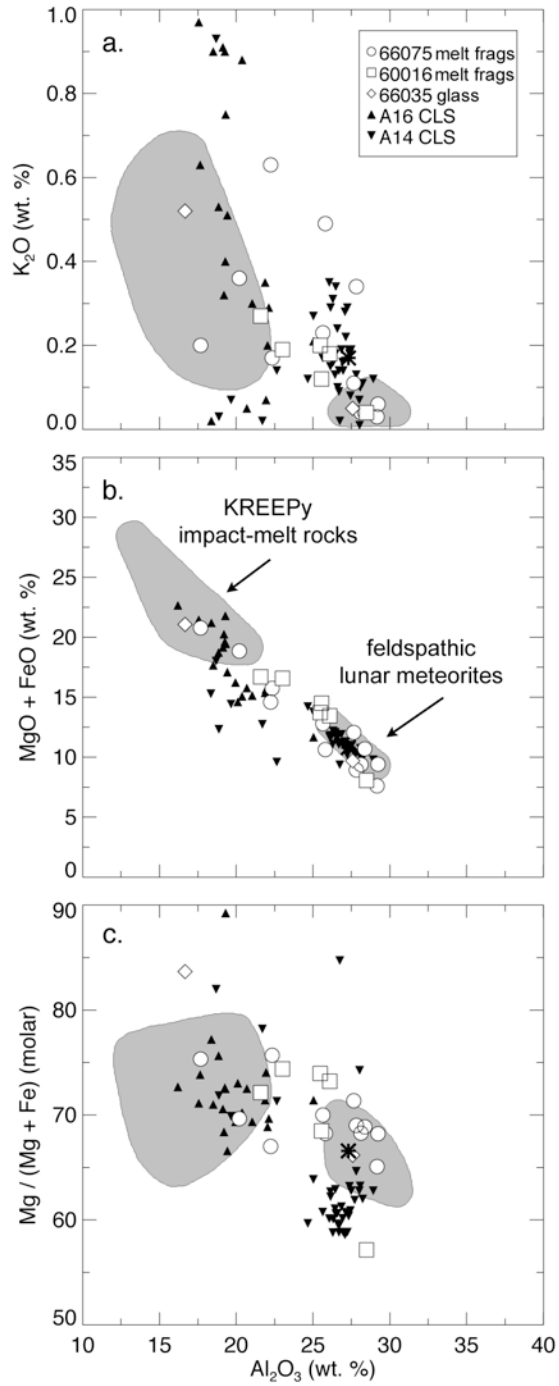

Fig. 2. Major-element chemistry of A16 melt fragments and glass compared with A14 and A16 crystalline lunar spherules, lunar meteorites, and KREEPy impact-melt rocks. Asterisk is the average A16 soil composition.