REVISITING THE NOMENCLATURE OF APOLLO 16 IMPACTITES. M. E. Mechem[1], J. W. Hostrawser[1], and G. R. Osinski[1], [1]Department of Earth Sciences, University of Western Ontario, 1151 Richmond St., London, ON, N6A 5B7, Canada

Introduction: During the NASA-led Apollo missions, lunar impactites were brought to Earth where they were classified based on the knowledge of the impact cratering process and impactites at the time [1]. Since then our knowledge of impact cratering processes and products has progressed based on 50 years of study of hypervelocity impact craters on Earth [2], thus said classifications of lunar rocks have the potential of being outdated [3]. Here, we report on the results of a detailed study of Apollo 16 lunar impactite samples 67455, 47 and 62255, 37 and discuss their nomenclature based on an updated proposed lunar impactite classification scheme outlined by Osinski et al. [3]. This work is part of an ongoing project with the goal of updating and streamlining the classification scheme for lunar impactites.

Methods: Polished thin sections were studied using various methods, including optical microscopy, micro X-ray fluorescence (XRF), electron microprobe analysis (EPMA), and image analysis using the program ImageJ.

Results:

Sample 67455, 47. The 942 g Apollo sample 67455 has been classified as a fragmental breccia. It was collected from the top of a white breccia boulder on the southern rim of North Ray Crater [4] and may have been excavated from the buried Descartes formation [e.g., 5, 6]. Thin section 47 is a poorly-sorted mix of fine-grained predominantly anorthositic groundmass and larger clasts. The clasts are generally either fragments of anorthositic material or of clast-rich impact melt glass, which is likely allochthonous. Anorthositic clasts feature extensive albite twinning; they range from unshocked to weakly-shocked (patchy, undulatory extinction). Also present are minor pyroxenes and olivines. Two ~0.1mm Si-rich grains with low Ca, Al, Mg, or Fe stand out in EDS mapping.

In plane polarized light (PPL), glassy clasts in 67455 vary from pale to dark brown (**Fig. 1**). They range from indistinguishably small clasts up to ~2 mm, with two prominent large clasts >3mm. The glassy clasts vary in appearance and content; some have sharp boundaries, while others appear to merge into the groundmass, suggesting they may be of different source and/or age. Glassy clasts have no clear evidence of flow. Entrained clasts and fragments range up to ~1mm; small, skeletal laths of plagioclase were also observed in some of the glass. One rounded glassy clast encases a distinct hexagonal, shocked and cracked, anorthosite crystal.

The groundmass itself is divided into a darker-coloured region (relatively enriched in Mg, Fe, and Ti) and a lighter region (slightly enriched in Si and Al and containing almost all of the glassy clasts). As 67455 may be excavated material, glasses in this thin section were analyzed via EDS spot analysis in comparison to a thin section of an Apollo 16 regolith breccia collected several km away, near the lander (60016, 170). Spots were chosen in the matrix of over 27 glassy clasts of each thin section. It was found that glasses in 67455 are relatively enriched in Ca, Na, Mg, and Al, when compared to 60016, and likewise depleted in Si. Major-element composition in glasses of both thin sections was observed to vary widely across the matrix of any single clast. Plotting Al_2O_3 vs CaO for all EDS points together revealed a positive trend for glass in 67455 that matches the trend for highland rocks in Fig. 8.3d of [7]. However, in the glasses a second population of higher-Al composition was also observed. Comparison with 60016 revealed a similar higher-Al population. A mechanism for enrichment of the melt glass in this way is unknown.

Sample 67455 was originally classified as a fragmental breccia. While this classification is correct based on the original lunar nomenclature, this is a term that is no longer used in the nomenclature of terrestrial impactites [2]. The term "fragmental" is also somewhat confusing, as in older terrestrial nomenclature this would imply no melt content. Based on the modern nomenclature for terrestrial impactites [2], the best term for this rock is an impact melt-bearing breccia, given the presence of impact glass clasts.

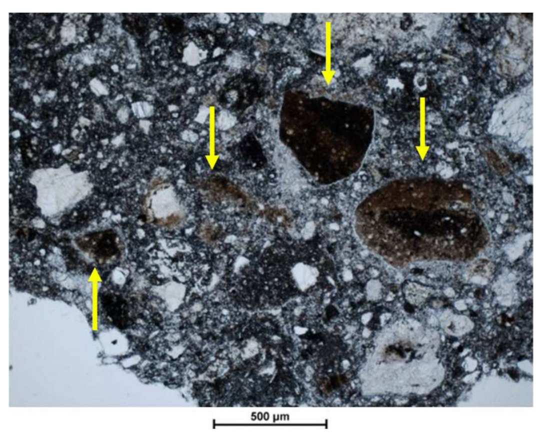

Figure 1: PPL view of glassy clasts in 67455,47, showing variation of colour and visual appearance.

Sample 62255, 37. Sample 62255 was found perched along the south rim of Buster crater [8]. Weighing approximately 1239 g, the rock has been described as crushed anorthosite containing veins of mafic melt [8]. Thin section 37 of the sample contains these distinct lithologies with a clear boundary; the anorthosite, comprising about 80% of the sample, and impact melt rock, comprising about 20%.

The anorthositic portion is composed mostly of plagioclase ranging from angular to subangular in shape with many regions displaying a cataclastic texture. The plagioclase content is corroborated by XRF element maps of the sample that show a relative abundance of Al and Ca in this portion when compared to the impact melt rock. Many plagioclase crystals exhibit shock effects in the form of fractures, offset albite twinning, and undulatory extinction. Small amounts of mafic minerals such as pyroxenes are also present within the anorthosite.

The impact melt rock portion exhibits various degrees of crystallization including aphanitic and microcrystalline textures. Mineral and lithic clasts (plagioclase and anorthosite respectively) are present throughout the melt. In PPL, the melt surrounding some of these clasts is darker than the rest of the melt. XRF element maps demonstrate that the impact melt has high relative concentrations of Mg, S, Ti, Cr, Fe, Co, and Ni compared to the anorthosite. Furthermore, opaques are strewn throughout the impact melt portion of the sample; many of which appear brightly under reflected light, suggesting that they are metals.

Using backscattered electron (BSE) imagery via EPMA, three main textures were identified in the melt: homogenous glass, needle-like laths, and thicker laths (**Fig. 2**). Needle-like laths were found at the anorthosite-impact melt boundary and surrounding pockets of smooth glass (**Fig. 2c**). Shorter laths can also be observed branching off from some of the needle-like laths. The most common texture observed was the thicker laths. Found surrounding needle-like laths as well as mineral and lithic clasts, the thicker laths have three main habits: randomly oriented, radial growths, and groups of laths with a preferred orientation (**Fig. 2c**). Using electron dispersive spectroscopy (EDS) the laths appear to be plagioclase as they are relatively more concentrated in Al and Ca when compared to areas in the melt without lath growth.

Sample 62255 was originally classified as a dilithologic breccia [8]. This is a term that is unique to the Moon and is not used in the terrestrial nomenclature [2]. Because of the lack of surrounding context for this sample, it is unclear whether it represents a large mass of anorthosite with injected impact melt, or whether it is a clast of anorthosite in an impact melt rock – but for which little of the impact melt rock was sampled. It is, thus, not possible to reclassify the naming of this impactite at present. We can rule out, however, that this sample is not pseudotachylite (i.e., an in situ melt vein) given the difference in composition between the anorthosite and the melt phase.

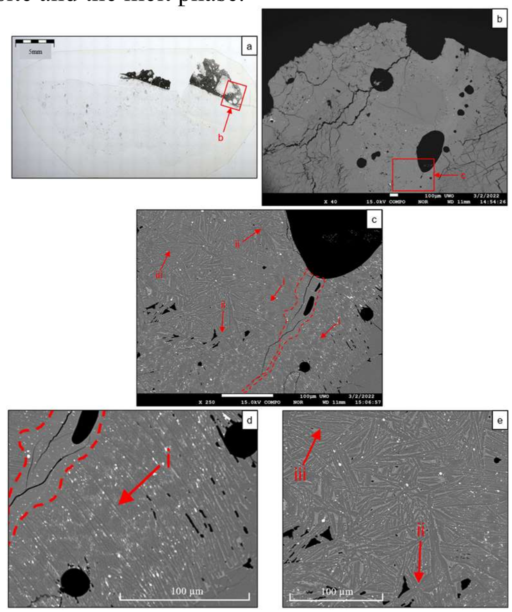

Figure 2: BSE imaging of the three textures in the impact melt portion of sample 62255, 37. (a) Mosaic of sample 62255, 37 with area b labeled. (b) BSE imaging of area denoted in a; area c is shown. (c) The dotted lines outline smooth glass texture. (i) Needle-like laths. (ii) Radial growths of thicker laths. (iii) Group of thicker laths in preferred orientation. (d) Zoomed-in image of image c including the homogenous glass and i. (e) Zoomed-in image of image c including ii and iii.

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