Apollo 15 Green Glass Phenocryst Growth and Compositional Inhomogeneity D. C. Barker[1] and J. E. Snow[2], [1,2] University of Houston, Department of Earth and Atmospheric Sciences Science, Research Bldg. 1, Houston, TX, 77204.

Introduction: Pyroclastic green volcanic glasses are a prominent component of the regolith at the Apollo 15 landing site. An ongoing interest in these glasses centers around their being sources of pristine, unaltered magma and their volatile content [1] specifically associated with the primordial water content of the moon. Enhancing the understanding of lunar evolution combined with the future need for lunar resources warrants continued examination of the petrography and compositions of these materials. Ultimately, an understanding of the variations in internal compositions, phase equilibria and the trace element partitioning of the phases preserved within glass provides a unique insight into the structure and evolution of the moon as well as the processes associated with the differentiation of lunar materials.

Here we report on the geochemistry of glassy spherules collected from the regolith fines collected on the north rim of Spur Crater, Station 7, during the Apollo 17 mission. These glasses have been well characterized to be the result of volcanic fire-fountains and are associated with dark mantle deposits [2, 3]. Lunar glasses demonstrate a degree of crystallization (e.g., olivine phenocrysts) controlled either by plume optical density segregation (i.e., quenching environment) and bead size [4, 5] or by devitrification processes [6]. The exposure ages of nearby green glasses are between 275 and 300 Ma and the eruption age is estimated to range from 3.41 to 3.35 Ga [7]. A preliminary examination of 41 volcanic glass beads from soil aliquot 15421,67 has been completed using both Field Emission Scanning Electron Microscopy (FESEM) and Energy Dispersive Spectrometry (EDS) instruments – as a prelude to future EPMA analysis.

Methods: Handpicked glass beads were mounted in epoxy within 3 mm stainless steel cylinders, and were then hand polished using 25 µm diamond paste to expose an internal cross section of each bead. The grain mounts were then cleaned and carbon coated for analysis.

FESEM: Initial analysis began with the JEOL JSM 6330F Field Emission instrument. The SEM used a 15.0 kV accelerating voltage, a beam emission current of 12 µA, and a working distance of 15 mm. Beads were imaged in both secondary electron (SEI) and backscattered electron (BSE) compound modes showing distinct population differences between homogeneous glass spherules and beads exhibiting crystal growth. Of 41 beads examined 21 (51%) show crystalline growth structures at the polished surface to sub-micron scales. Two distinct crystal forms occur in these green glasses, dendritic/feathery and barred. Beads containing crystals are comprised of a mixture of fully opaque beads (24.4%) and clear green glass beads that contain various amounts of crystalline inclusions (36.6%), which may or may not be exposed on the polished surface. Textural categorizations (See Fig. 1) are based on the amount and type of crystallization observed in the beads. Three categories are generally assigned as being either completely transparent and free of crystals or inclusions (A), as containing clear glass with opaque inclusions (B) or completely opaque and exhibiting barred crystal growths visible in transmitted light. Glasses with barred crystalline (Figs. 2-4) structures exhibit repeatable patterns across similarly categorized beads. The opaque beads (C) contain olivine phenocrysts that range from ~5-200 µm in length. We continue herein by examining one group C bead in more detail.

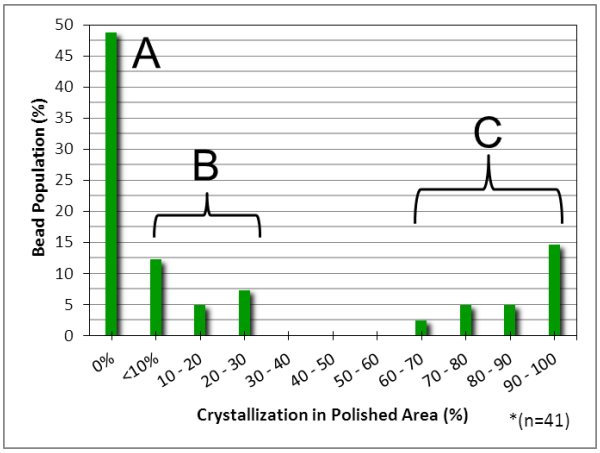

Fig. 1: Degree of individual bead crystallization

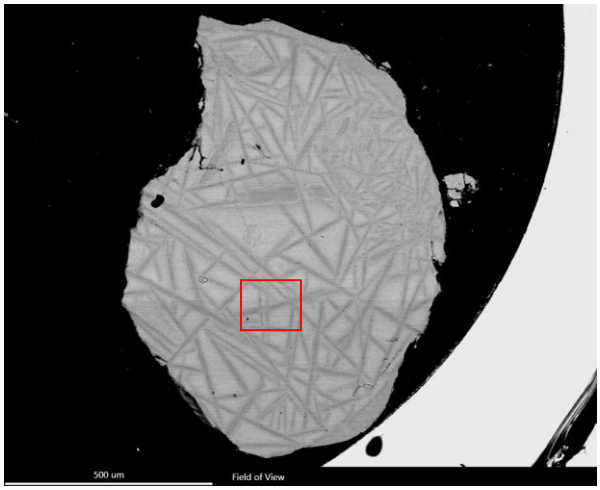

Fig. 2: BSE image of whole bead S8B2 - a representative opaque green bead showing crossing barred olivine crystalline structures emanating from different nucleation sites.

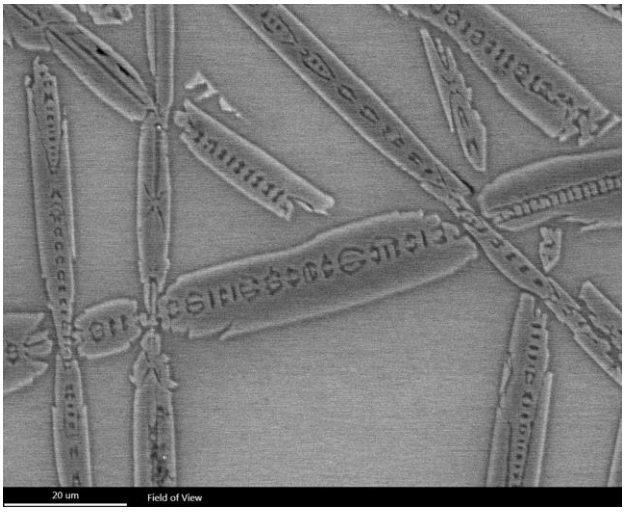

Fig. 3: BSE image of the boxed region in Fig. 2 showing unique barred olivine crystalline structures in a glass matrix.

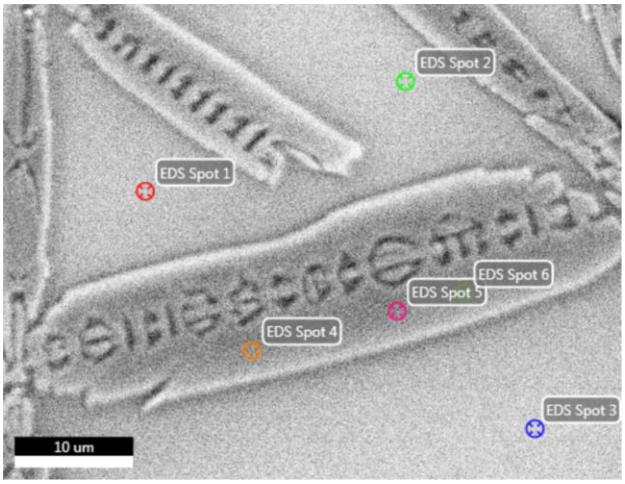

Fig. 4: EDS targeting on a single barred crystal.

EDS: Figure 5 provides two analyses from the JEOL JSM 6330F showing distinctive and repeatable chemical variations between the glass and crystals at scale. Image analysis shows chemical variations between the outer rim of and internal crystal structures (darker indicating higher Mg content and lighter indicating lower content).

Discussion: The crystallization of olivine phenocrysts are known to be a function of the undercooling of the magma post eruption [8], and of the location of settling of molten droplets within the volcanic gas plume surrounding the vent site (i.e., homogenous glasses cooling and quenching quickly away from the effects of venting gasses) [4].

As noted by Delano [2], most authors publish average compositional analyses for lunar glasses, and do not take into account fractionation trends or the post eruptive crystallization as documented here. This may be especially relevant for nonconservative volatile elements. The homogenous glasses, on the other hand, may be better suited for average composition reporting, and the investigation of lunar mantle evolution. Ongoing microprobe evaluations will provide quantitative values for our glass and olivine compositions.

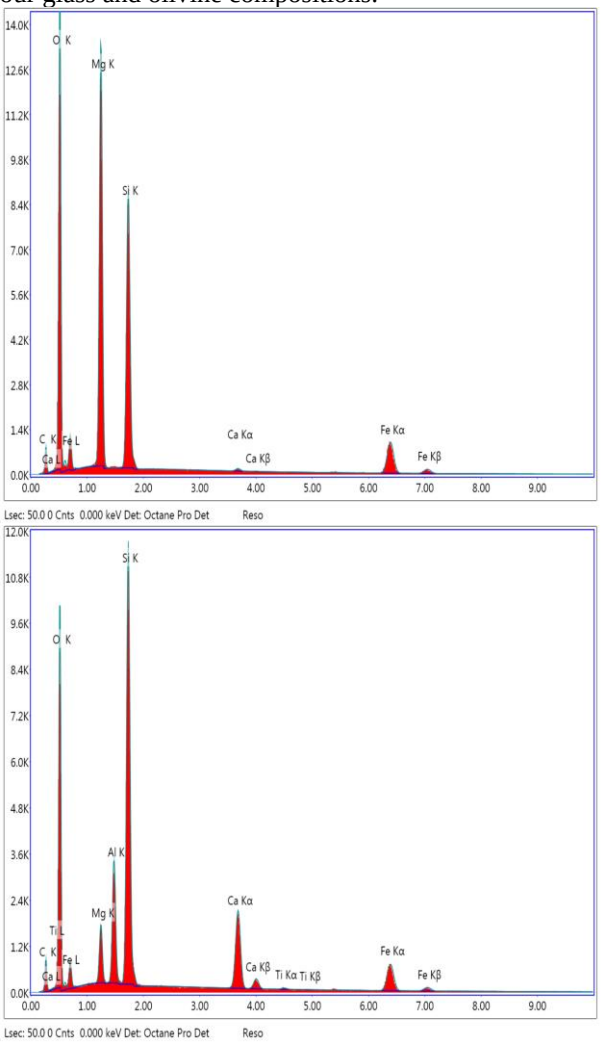

Fig. 5: EDS compositions of spot 5 (top) and spot 2 (bottom) in Fig. 4 illustrating chemical differences between olivine crystals and the glassy matrix respectively.

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References: [1] Saal et al. (2008) *Nature Letters*, 454, 192-196, [2] Delano (1986) *Journal Geophys Rsch*, 91, D201-D213, [3] Delano (1979) *Proc. Lunar Planet. Sci. Conf.*, 10, 275– 300, [4] Elkins-Tanton et al. (2003) *Geophys Rsch. Letters*, 20, 1513, [5] Heiken et al. (1974) *Geochim. Cosmochim. Acta*, 38, 1703-1718, [6] Haggerty, S. (1974) *Proc. 5th Lunar Conf.*, 1, 193-205, [7] Spangler et al. (1984) *Proc. 14th Lunar Planet Conf.*, B478-B486, [8] Faure et al. (2003) *Contrib. Mineral Petrol.*, 145, 251-263.