**CHARACTERIZING THE EFFECT OF SHOCK ON ISOTOPIC AGES I: FERROAN ANORTHOSITE MAJOR ELEMENTS.** J. Edmunson[1], B. A. Cohen[2], and M. N. Spilde[3], [1]NASA Postdoctoral Program, Marshall Space Flight Center (National Space Science and Technology Center, Huntsville AL 35805, Jennifer.E.Edmunson@nasa.gov), [2]Marshall Space Flight Center (Huntsville AL 35812, Barbara.A.Cohen@nasa.gov), [3]Institute of Meteoritics (University of New Mexico, Albuquerque NM 87131, mspilde@unm.edu).

**Introduction:** A study underway at Marshall Space Flight Center is further characterizing the effects of shock on isotopic ages. The study was inspired by the work of L. Nyquist et al. [1, 2], but goes beyond their work by investigating the spatial distribution of elements in lunar ferroan anorthosites (FANs) and magnesium-suite (Mg-suite) rocks in order to understand the processes that may influence the radioisotope ages obtained on early lunar samples. This abstract discusses the first data set (major elements) obtained on FANs 62236 and 67075.

**Background:** This study was designed to investigate peculiarities of a selection of lunar highland rocks: 62236 and its FAN geochemistry would imply origin during primary lunar crust formation, but its $^{147}$Sm-$^{143}$Nd isotopic age is relatively young (4.29 ± 0.06 Ga [3]); isotopic ages for 67075 range from 3.66 ± 0.63 Ga [4] to 4.47 Ga [5], and the calculated initial $\varepsilon_{Nd}^{143}$ of approximately +8 [6] indicates derivation of this FAN from a LREE-depleted source (unlike expected primary FAN compositions [7]); Mg-suite troctolite 76535 has contradictory $^{87}$Rb-$^{87}$Sr (4.57 ± 0.07 Ga, $\lambda_{87}$ = 1.402 x10$^{-11}$y$^{-1}$ [8]) and $^{147}$Sm-$^{143}$Nd (4.26 ± 0.06 Ga [9]) ages of formation; and no $^{87}$Rb-$^{87}$Sr isochron could be discerned for Mg-suite troctolite 76335 [10].

Apollo 16 sample 62236 is classified as a ferroan noritic anorthosite, despite the fact that it has both noritic and troctolitic biases depending on the thin section viewed [11, 12]. Warren and Wasson [11] concluded that 62236 is pristine, and Nord and Wandless [12] argue that 62236 is a monomict breccia. However, Shearer et al. [13] found two distinct populations of olivine characterized by differences in their Ni and Co abundances, indicating a polymict nature. They further state that the relatively young age of 62236 [3] may suggest metamorphic re-equilibration of the sample, and that "the extent and scale of re-equilibration determines the significance of the Sm-Nd data". Thus, any re-equilibration of the sample must be quantified – one of the goals of this study.

Sample 67075 is a friable brecciated anorthosite, containing minor amounts of olivine, pyroxene, and chromite [14, 15]. Like 62236, variations in the distribution of mafic minerals produced different estimated modal mineralogies for 67075. In the case of 67075, the modal mineralogy of the thin section viewed likely reflects the proportions of three components, with slightly different chemical compositions, that make up this sample [14]. The three components are a polygonal microanorthosite, a coarse-grained cataclastic anorthosite, and a pyroxene-dominated constituent [14]. This sample is thought to be the result of brecciation and mixing of layers from a single igneous pluton [15, 16], which should be ideal in the case of an isotopic analysis. However, isotopic studies have produced a range in ages for 67075 [4, 5], and a significantly positive calculated initial $\varepsilon_{Nd}^{143}$ [6]. Further study of 67075 has indicated regions of annealing [15, 17], which could influence the age of the sample. Investigating the geochemistry of this sample will help establish the extent of shock and annealing, as well as the validity of the ages and the calculated LREE-depleted source for this FAN.

**Methodology:** The methods employed in this study mirror that of [18]; imaging and initial identification of phases through scanning electron microscopy (SEM), major element analysis by electron microprobe, and trace element abundance determination with secondary ion mass spectrometry (SIMS). Ultimately, 153 quantitative major element microprobe analyses were collected on 5 phases in both thin sections. These points were selected for the following reasons: (1) large mineral grains, core to rim, to look for diffusion or igneous crystallization trends; (2) small mineral grains, grain center analysis, to compare to larger grains in major and trace element abundances; (3) inclusions within the large mineral grains to show high silica phase production and equilibration or diffusion within adjacent related minerals; and (4) inclusion host grains, core to inclusion, to note any changes in chemistry associated with proximity to the inclusion. These points were also selected to be suitable for subsequent analysis by SIMS.

**Expectations:** Given the relatively low shock pressures for 62236 (estimated at 200-300 kilobars [12]) and 67075 (see below), any changes in major element chemistry due to shock are expected to be below detection limits of the microprobe, but ppm-level changes should be observed with SIMS. In situ melting of anorthite and olivine at grain boundaries has been observed in 62236, but maskelynite formation has not [12]. Maskelynite is thought to be a diaplectic glass implying that the structure, but not the chemistry, of the feldspar has been altered. Thus, samples such as 62236 and 67075 likely would not show significant changes to their major element chemistry.

**Observations:** Thin section observations of 62236 are fairly consistent with those of Nord and Wandless [12], who estimated that three shock events were necessary to create this breccia. These observations include multiple episodes of mechanical faulting and undulatory extinction in plagioclase (found by [12] to be deformation in 62236 anorthite on a <1μm scale). However, no melting of "particulate olivine" was observed in thin sections ,40 and ,58 (exceedingly fine-grained olivine was observed, but did not appear under SEM to be melted).

A study of thin section 67075 ,51 revealed planar deformation features in a few plagioclase grains (after [18]), as well as annealed clasts (e.g., Figure 1). Neither maskelynite, nor melting of "particulate olivine", was present in the thin section. Thus, the constraints of 300 or 200 kilobars shock pressure, respectively, that were applied to 62236 by [12] cannot be applied to this portion of 67075. Also, no evidence of (001) augite shock-induced twinning was found in section ,51, and without contradictory evidence, an upper bound of 50 kilobars [19] can be established.

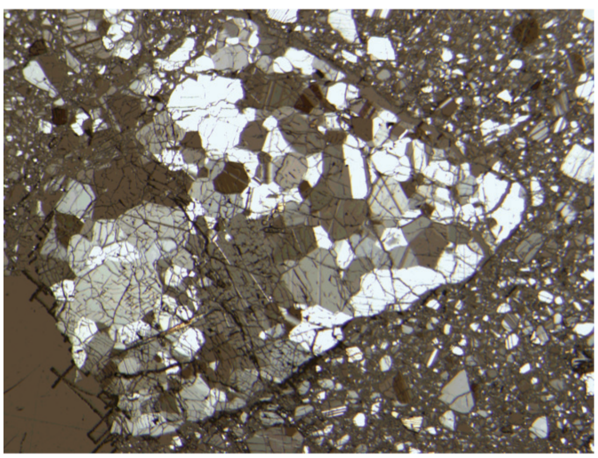

**Figure 1:** Annealed clast in 67075 ,51. Note polygonal grains and abundance of 120° grain junctions.

Electron microprobe results were studied with respect to spatial location and grain size to determine whether diffusion of highly volatile elements occurred readily in relatively small grains when compared to larger grains. No relationship between the size of a grain and its volatile major element content could be established.

Low-resolution microprobe element maps for 67075 indicated a difference in the Na content of different plagioclase clasts. In fact, a plot of CaO versus $Na_2O$ abundances in individual microprobe points show scatter in $Na_2O$ outside that explainable by microprobe error. However this scatter is well within the natural variations in terrestrial anorthosite complexes such as the Bushveld Complex [19] or the Laramie Complex [20], calculations indicate that the plagioclase grains are stoichiometric, and the An content of both 62236 and 67075 only varies from $An_{98-99}$ which is similar to other FANs. Therefore, it will be important in the next phase of this study to further investigate Na, K, and Rb abundances in the individual grains to verify whether or not shock has influenced the volatile content of the mineral grains.

**Study Status:** There is currently no evidence to suggest that the major elements of 62236 and 67075 have been redistributed due to shock. Scatter shown in the $Na_2O$ content of plagioclase does not exceed scatter in natural terrestrial anorthosites, but does suggest that further study with more precise techniques of similar volatile trace elements in these lunar samples is necessary. An estimated shock pressure of <50 kilobars is implied by the petrography of 67075 ,51.

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