TRACE ELEMENTS IN SMALL VLT BASALT CLASTS FROM 72235. David J. Lindstrom[1] and Rene R. Martinez[2]. [1]SN4, Johnson Space Center, Houston TX 77058, [2]Lockheed Engineering and Sciences Co. 2400 NASA Rd. 1, Houston TX 77058.

Basaltic clasts in highlands breccias are the best samples of old, pre-mare lunar volcanics. For example, basalt clasts in boulder 1, station 2 breccia 72235 may be among the oldest mare basalts [1], yet because the clasts are so small no trace element data are available on these samples, and their relationship to basaltic glasses and lithic fragments in soils and other breccias [e.g., 2] are unknown. This work utilizes a new micro-coring technique to extract microgram-sized samples of these basalt clasts from thin sections, and micro-INAA techniques [3] to obtain trace element data. Results show that these clasts are similar in composition to LOCo or MECo Apollo 17 VLT basaltic glasses [2].

Sampling and Analytical Methods. The clasts sampled in this work were those described in [4] as "olivine-normative pigeonite basalts," in contrast to the more common quartz normative pigeonite basalts. The former are members of the VLT (Very Low Titanium) basalt clan, while the latter are the Apollo 17 KREEP basalts. Clasts in polished thin section 72235,59 were identified from the map in [4], and attempts were made to confirm the defocused-beam electron microprobe analyses (DBAs) of [4] by doing our own DBAs, and/or by calculations using modes from analyses of digital backscattered electron images and mineral analyses. Samples ranging in diameter from about 140-400 µm were drilled with a micro-coring device mounted on a petrographic microscope [5]. Multiple samples of the larger clasts were taken, and attempts were made to sample typical regions, while still saving some of the clast area for future microbeam work. Photomicrographs were taken before and after drilling to document the sampling as well as possible. Samples were irradiated with about 10^{20} neutrons in the Missouri University Research Reactor and gamma-ray spectroscopy was done using large intrinsic Ge detectors in the low-background counting facility at JSC. Multiple glass standards weighing a total of 120 µg were used for the INAA. The samples are too small to weigh accurately, so their masses (most ~1-3 µg) were estimated from the microprobe estimates of the FeO concentrations and the INAA data for the total amounts of FeO in the samples.

Discussion. Choosing the areas of the thin section to sample is difficult. Several of the clasts contain large olivines with sulfide veins in them, suggesting that they may be xenocrysts rather than phenocrysts, so these grains were avoided. Other clasts contain clusters of olivines or opaques that make representative sampling difficult. Estimates of major element compositions from modal recombination or rastered beam DBAs utilized the entire area of each clast. Thus, multiple samples were assumed, for the purpose of sample mass determination, to have the same FeO content. Clasts are referred to according to their clast suffix on Table III-3 of [4], i.e. clasts C1, C4, C7, C9, and C10 of 72235,59 (the thin section which [4] referred to as SAO 803).

The left side of the figure shows the rare earth patterns of all 9 micro-cores. Dotted lines in the vicinity of Eu indicate that the size of Eu anomalies are not well constrained by the data. The two samples of C9 are shown in dashed lines for legibility. **C1** is clearly the most fractionated, having the highest abundances of rare earths (especially LREE), Th, and K_2O. This alkali enrichment is apparent in the DBA of [4] and is confirmed by high abundances of the heavy alkalies Rb (25 ppm) and Cs (1.6 ppm). One of the subsplits of **C4** has almost identical rare earth concentrations, although it is not as enriched in the other excluded elements. Still, the fact that the other subsplit, C4a, is so similar to the other lithic VLTs suggests that C4b and C1 are simply more mesostasis-rich samples of the same type of basalt. C7 consists of abundant phenocrysts and xenocrysts in a very fine-grained matrix, which our drill core attempted to sample. Although we consider it most likely that this is an impact-generated melt rock, this clast has a perfectly ordinary Apollo 17 VLT composition, and there is no evidence of meteoritic contamination. The two samples of clast **C9** are quite similar to each other in composition. **C10** is the largest, coarsest-grained basalt. We obtained two cores of typical material (270 and 235 µm in diameter), and a smaller (145 µm) core of sulfide-rich mesostasis. Unlike C1 and C4b, this mesostasis shows no significant enrichment in

LREE or alkalies, although it is strongly enriched in Zn (4400 ppm!), W (2.8 ppm), Ni (370 ppm) and Co (215 ppm). In retrospect, we should have obtained larger samples of this clast to minimize sampling difficulties.

The right side of the figure illustrates the rare earth patterns of the other lithic VLT samples for which trace element data are available: 3 clasts from the 73255 breccia [6], 3 lithic fragments from the deep drill core [7], and the largest sample of Apollo 17 VLT composition, the green impact melt 78526 [7]. All samples have positive-sloping REE patterns with small, often poorly determined, Eu anomalies. The microcores studied in this work were ~1000x smaller than these other particles, so it is not surprising that they span a larger range in REE. Other trace element abundances also scatter considerably, at least in part also due to sampling problems. Nonetheless, the moderately high Sc and low Co contents, along with the rare earth patterns, suggest that none of these are compositional equivalents of the HICo pyroclastic (?) glasses we studied previously, but instead resemble the LOCo or MECo Apollo 17 VLT glasses [2].

We believe that the minor compositional differences among the necessarily small samples of lithic VLT basalt at Apollo 17 are outweighed by their similarities, and we suggest that VLTs in the station 2 and station 3 boulders, as well as lithic fragments in the soils and the LOCo and MECo glasses, all had the same source. The tight compositional groupings of the LOCo and MECo glasses suggest that they were the products of melting of much larger volumes of the VLT source region than the typical sizes of lithic fragments, and that therefore they were emplaced by different events than the lithic fragments. Whether the lithic VLT particles weathered out of breccias or were transported separately remains to be determined, but clearly the emplacement history of VLTs at Taurus-Littrow was more complex than a single event.

References

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