APOLLO 14 OLIVINE VITROPHYRES: GEOCHEMICAL EVIDENCE FOR HETEROGENEOUS TARGET MATERIALS. A. L. Fagan[1], C. R. Neal[2], and A. Simonetti[3] [1,2,3] Dept. of Civil Eng. and Geo. Sci., University of Notre Dame, 156 Fitzpatrick Hall, Notre Dame, IN, 46556, abacasto@nd.edu; neal1@nd.edu; Antonio.Simonetti.3@nd.edu.

Introduction: Olivine vitrophyres are impact melts, consisting of Lunar highlands and KREEP-rich materials, that are primarily composed of olivines in an opaque glass, sometimes with lath-like plagioclase crystals [e.g. 0-2]. Petrographically, these are similar to vitrophyric Apollo 14 high-Al basalts [11]. The purpose of this study was to use olivine chemistry and petrographic evidence in order to distinguish between Apollo 14 impact-generated olivine vitrophyres and pristine mare basalts. Thus, we conducted textural and chemical analyses of vitrophyre and basalt samples from breccia 14321 (Table 1).

Table 1: Details of samples analyzed in this study. *Basalt "groups" were previously determined by [8] based on compositional differences

Sample Type	Thin Section #	Whole Rock #	Whole Rock Ref.
Olivine Vitrophyre	14321,1305	14321,1180	[1]
Olivine Vitrophyre	14321,1471	14321,1416	[2]
Olivine Vitrophyre	14321,1486	N/A	[9]
Olivine Vitrophyre	14321,1602	14321,1539	[2]
Group "A" Basalt*	14321,1246	14321,1161	[1]
Group "C" Basalt*	14321,9057	14321,9057	[3]
Group "C" Basalt*	14321,9080	14321,9080	[3]

Textural Analysis: Crystal size distributions (CSDs) are used as a complement to compositional analyses and to quantitatively investigate igneous processes. CSDs were determined for four high-alumina basalts, and four olivine vitrophyres all originating from lunar breccia 14321 [eg. 4]. Each sample was digitally photographed and the images imported into *Adobe Photoshop*, where each olivine was crystal was outlined and filled. The image was then converted into a bitmap and imported into *Imagetool* [5], which measured the major and minor axes, roundness, and area of each crystal as well as the entire sample. These major and minor axes were imported into *CSDslice* [6] to determine the 3-D crystal habit: short, intermediate, and long axes. This data, in conjunction with the major axis, minor axis, individual crystal area, avg. crystal roundness and total sample area, were used in *CSDcorrections 1.37* [5] to determine the 3-D crystal size distribution. Finally, crystal size distributions were plotted as the natural log of the population density against the crystal size length [7].

Chemical Analysis: *Major Elements***.** Major element analyses were conducted on all samples (with the exception of 14321,1486) using a JEOL JXA-8600 Superprobe electron microprobe (EMP) at the University of Notre Dame. Analyses were performed using mineral standards, a 3μm spot, a probe current of 30nA, 15 second on-peak counting time, and 2 background measurements per peak. Matrix effects were corrected using an online ZAF correction method. Major element analyses for sample 14321,1486 were conducted on a JEOL JXA-8200 Washington University using similar operating procedures as with previous samples.

Trace Elements. Mn abundance obtained by EMP for ,1486 was used as the internal standard for laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) analyses to determine Sc, Ti, V, Cr, Co, Ni, and Y contents of the olivines; NIST SRM 610 glass was used as the external standard. LA-ICP-MS analyses were conducted at the University of Notre Dame using a New Wave UP 213 laser ablation system and a ThermoFinnigan Element2 ICP-MS, with a repetition rate of 5 Hz, spot diameter of 25μm, and a corresponding fluence of ~17 J/cm^2. Elemental abundances were determined using *GLITTER©* software. Secondary Ionization Mass Spectrometry (SIMS) trace element analyses for the remaining vitrophyres and the Group "C" basalts were conducted at the University of new Mexico using the Cameca ims 4f using primary O^- ions accelerated through a nominal potential of 10.0 kV, a primary beam current of 20 nA, and a spot diameter of 20μm.

Preliminary Results: *Textural Analysis (CSDs):* Some previous work has shown that plagioclases in impact melts may exhibit systematically different CSD shapes than in basalts [10]. This study complements earlier work and illustrates that the difference holds true for olivines as well (Fig. 1). The three basalts exhibit lower slopes than the olivine vitrophyres and are approximately linear indicating a difference in crystal growth rates. Group C basalts (,9057 and ,9080) exhibit different CSDs than the Group A basalt (,1246) sample. This is also consistent with the findings of [10] that plagioclases from the different basalt groups exhibit different CSD shapes. CSD analyses are ongoing for Group B basalts as well as more Group A basalts.

Composition: In general, olivines from the vitrophyres and basalts have comparable major element compositions. However, our results indicate that trace elements abundances define distinct compositional fields for both vitrophyres and basalts (Fig. 2). The olivines from basalts have higher V, Co, Sc, Cr, and Mn values than most of the olivines from the vitrophyres. Some of the vitrophyric olivines, which tend to be rounded and embayed, plot near the basalt or troctolite fields (Fig. 2) and suggests that these may be inherited; in contrast, euhedral olivines likely crystallized from the impact melt. In Fig. 2a, the trends exhibited by the olivine data from ,1486 indicate the influence of at least 3 different components: low-Ti basalts (lower R corner), high-Ti basalts (upper R corner) and highlands material (lower L corner).

Sample 14321,1486. Sample 1486 was previously interpreted as a basalt [9], but our results suggest otherwise. The CSD for ,1486 has a similar slope to the other three olivine vitrophyres than for the basalts analyzed and thus indicates analogous crystal growth rates. In addition, most of the olivine crystals from ,1486 (blue circles in Fig. 2) are chemically distinct from the olivines in the Group C basalts (,9057 & ,9080) and plot in the general vicinity of the other vitrophyre samples (,1305; ,1471; & ,1602). There are two olivine crystals in ,1486 that are compositionally distinct (14 & 24). These crystals appear cloudy and rounded in thin section (Fig. 3) indicating that they did not crystallize from the impact melt, but were inherited from the target material. Compositionally, crystal 14 may be inherited from a troctolite while crystal 24 may be inherited from a basalt, given their close proximity to those fields in Fig. 2b.

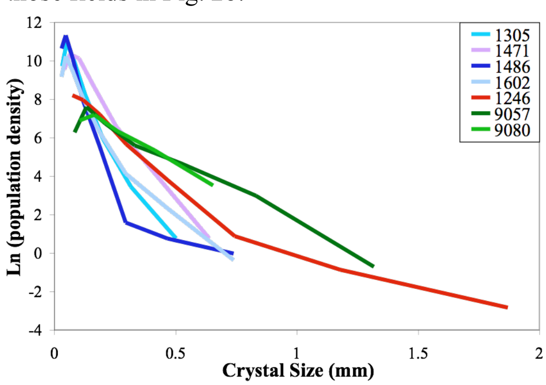

Fig. 1: CSD analyses of olivines in this study (Table 1)

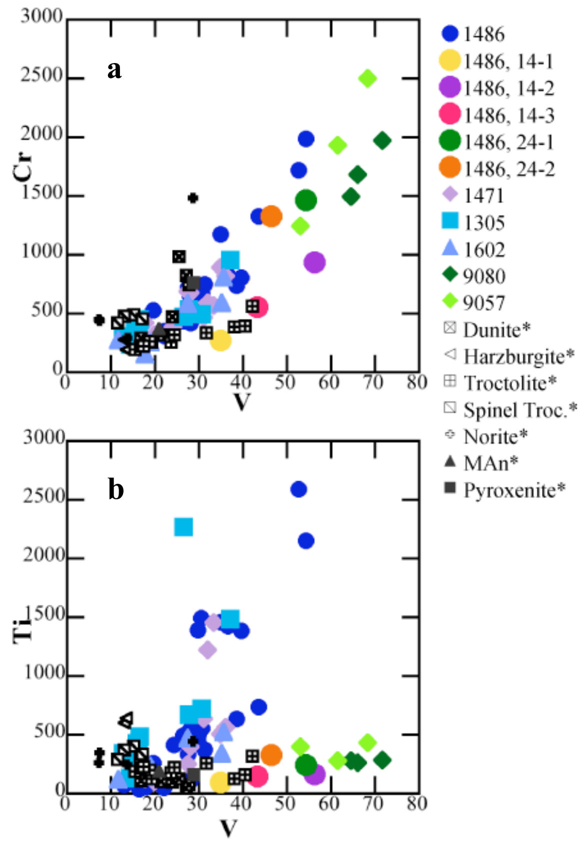

Fig. 2: Trace element data (in ppm) from olivines in various lunar materials. Materials with an * are taken from [12] for purposes of comparison.

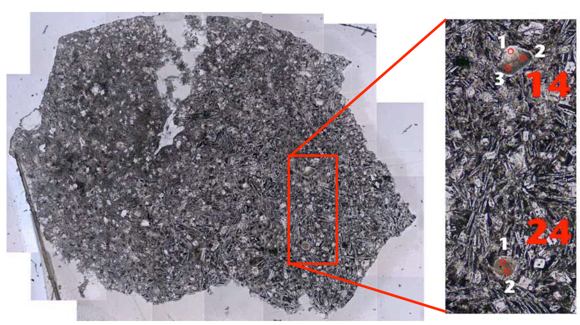

Fig. 3: Photograph of thin section 14321,1486 with zoom image of crystals "14" and "24," which are visually and compositionally distinct. The small red circles indicate the locations of microprobe and laser data.

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