A COMPARISON OF GLASSES ON AIRLESS BODIES: THE MOON VS. VESTA S. A. Singerling[1] and H. Y. McSween[1], [1]Dept. of Earth & Planetary Sciences, University of Tennessee, Knoxville, TN 37996. E-mail: ssingerl@utk.edu.

Introduction: Glasses are often minor components of rocks primarily due to the nature of their genesis—rapid quenching of a melt. This most often occurs in a terrestrial setting from fire-fountaining, which takes place in mildly explosive volcanic eruptions. Another mechanism for rapid quenching of a melt comes in the form of shock metamorphism from meteorite impacts. Surface lithologies of airless bodies have a rather significant, though still minor, abundance of glass in comparison to deeper lithologies on those bodies and any terrestrial counterparts. There are two flavors of glasses formed by the aforementioned mechanisms: impact melt clasts, formed by meteorite impacts, and pyroclasts, formed by fire-fountaining.

The Moon provides a suitable case-study for these glass types since there is substantial evidence for the presence of both [1]. The following table outlines differences between lunar impact melt clasts and pyroclasts.

	Impact Melt Clasts	Pyroclasts
composition	-heterogeneous -felsic to mafic -non-peritectic	-homogeneous -ultramafic -peritectic
texture	-vitric/vitrophyric -dendritic/skeletal -partly resorbed clasts -schlerin -Fe metal droplets	-vitric/vitrophyric -dendritic/skeletal -vesicular

Theoretical calculations predict that explosive eruptions ought to have occurred on volatile-bearing asteroids of sufficient size [2, 3]. The resulting deposits, pyroclastics, should then be preserved in surfical samples derived from these asteroids. The large asteroid 4 Vesta is one candidate that might have experienced explosive volcanism, but pyroclastic material has not yet been definitively identified in meteorite samples (HEDs) from this body [4]. Preliminary work by David Mittlefehldt has identified what may be pyroclasts in several howardite samples (personal communication). The purpose of this research is to analyze glasses in howardites and distinguish their origin (impact melt-derived or pyroclastic) based on textural and chemical differences observed in lunar glasses.

Methods: 39 glasses in 8 polished thin sections of howardites were analyzed for textures with a petrographic microscope. Major-element compositions were determined using the WDS of the CAMECA SX-100 microprobe analyzer with an accelerating potential of 15keV, a beam current of 10nA, a 5–10μm beam size, and peak and background counting times of 20s. The number of analyses per glass varied from 5 to 13 depending on the size. Only analyses with wt% totals of 98.5–101 were used. When calculating bulk composition of a partly crystalline glass, a weighted average of glass and crystals was calculated.

Trace-element compositions were determined using an Agilent 7500ce ICP-MS combined with an Excimer 193nm ArF GeoLasPro LA system. Depending on the size of the glass, beam sizes ranged from 16–32μm and dwell times from 30–40s. For an external standard, NIST 610 glass was used a total of four times before and after an analysis. For an internal standard, all elements were summed to 100%. Analysis Management System (AMS) software was used for data reduction with a 3σ LOD [5].

Results and Discussion: Howardite glasses vary from homogeneous to heterogeneous. Fig. 1 shows common textures expected of impact melt clasts and pyroclasts.

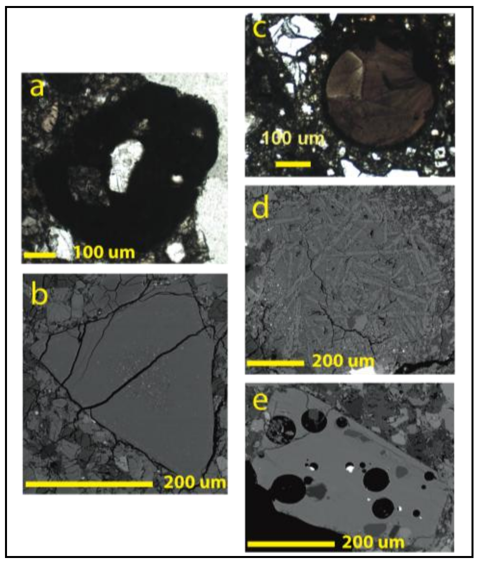

Fig. 1. Common textures of impact melt clasts: a. partly resorbed clasts (PPL), b. Fe metal droplets (BSE); and pyroclasts: c. spherical shape (PPL), d. skeletal (BSE), e. vesicular (BSE).

Data concerning major- and minor-element compositions can be displayed using a variety of methods. In this work, variation diagrams, spider diagrams normalized to basaltic eucrite composition (BE), and Q-Ol-An ternary diagrams are used. The purpose of normalizing to BE is to amplify any differences between the glasses and their expected starting composition. Figs. 2–4 are examples of these plots.

If the differences between impact melt clasts and pyroclasts on the Moon can be extended to what we would expect to see on Vesta, only glasses with the appropriate textures, high Mg content, and low Al content could be tentatively classified as punitive pyroclasts. The textural overlap between the two glass types is significant. Any texture that is considered pyroclastic in nature could also be seen in impact melts, so the defining difference between the two glass types lies in their compositions.

Lunar glasses display distinct Mg- and Al-contents (e.g., Fig. 2). If howardite glasses follow the trends seen in lunar glasses, only those with an enrichment in Mg and a depletion in Al with respect to basaltic composition could be considered to be putitive pyroclasts. Glass 9a in Fig. 3 shows one such pattern.

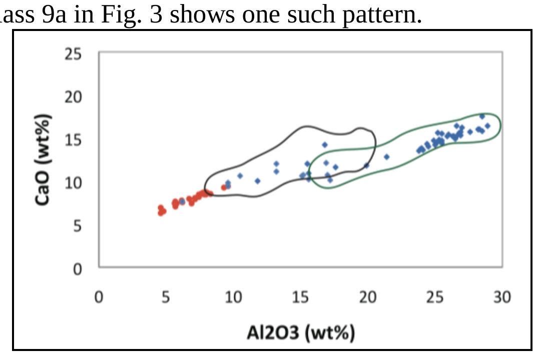

Fig. 2. Variation diagram depicting compositional differences in lunar impact melt clasts (blue) and pyroclasts (red). Envelopes: black=basalt, green=highland.

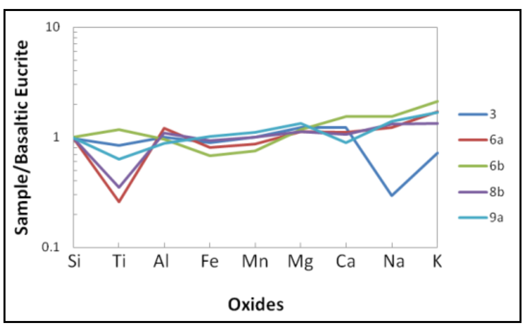

Fig. 3. Major-element spider diagram of glasses in howardite EET 87532 normalized to basaltic eucrite.

A pyroclast represents the initial melt, and as such, should have a peritectic-like composition. In the ternary diagram illustrated in Fig. 4, the peritectic is located at the join between the pyroxene, olivine, and anorthite fields. Glasses that plot at this point could be considered to be punitive pyroclasts.

Lunar data show pyroclasts to be of ultramafic composition. The difficulty with extending this line of reasoning to Vestan samples lies in the fact that, unlike on the Moon, Vesta has ultramafic lithologies at its surface in the form of diogenites. Any punitive pyroclast in howardites could, in reality, be an impact melt of diogenitic material.

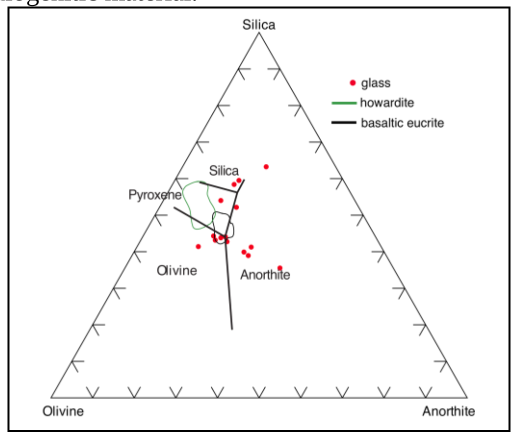

Fig. 4. Q-Ol-An ternary diagram of glasses in howardite LAP 04838. Envelopes: black=basaltic eucrite, green=howardite.

Future work will focus on trace-element compositions of glasses in howardites using lunar data as a proxy. Fig. 5 is an example of a trace-element diagram normalized to a eucrite, Juvinas. Notice the enrichments and depletions in volatile elments Rb and K.

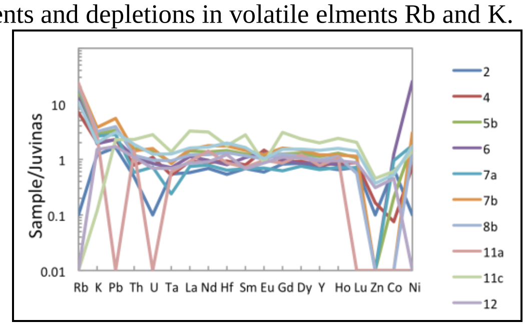

Fig. 5. Trace-element diagram of glasses in howardite LAP 04838 normalized to Juvinas.

Conclusions: Only a combination of textures and compositions expected of pyroclasts could allow for the classification of a glass as a punitive pyroclast. On Vesta, a glass that meets these criteria could actually be a diogenitic impact melt clast. In conclusion, the criteria used to distinguish impact melt clasts from pyroclasts on the Moon cannot be extended to Vesta as far as textures and major- and minor-elements are concerned. Trace elements may provide a better distinction between the two glass types.

References: [1] Delano J.W. 1986. *Journ. Geophy. Research* 91:D201–D213. [2] Wilson L. and Keil K. 1997. *Met. & Planet. Sci.* 32:813–23. [3] Wilson L. et al. 2010. *Met. & Planet. Sci.* 45:1284–301. [4] Keil K. 2002. In *Asteroids III*, p. 573–85. [5] Mutchler et al. 2008. In *Laser Ablation ICP-MS in the Earth Sciences: Current Practices and Outstanding Issues*, 40:318–27.