LUNAR IMPACT GLASSES AS CLUES TO THE MOON'S BOMBARDMENT HISTORY. N. E. B. Zellner[1] and J. W. Delano[2], [1]Department of Physics, Albion College, 611 E. Porter St., Albion, MI 49224, nzellner@albion.edu, [2]Department of Atmospheric and Environmental Sciences, University at Albany (SUNY), Albany, NY 12222 USA

Introduction: Lunar impact glasses provide important information not only about the Moon's impact rate over the past ~4.5 billion years, but also about its composition. These glasses are small (~200 μm), numerous in the Apollo regolith samples, and homogeneous (e.g., xenocryst-free). Analyses of hundreds of impact glasses from the Apollo 14, 16, and 17 landing sites have allowed us new insights not only into when and how often the Moon has suffered impact events but also into which lunar glasses have compositions that should be suitable for obtaining reliable ages via $^{40}Ar/^{39}Ar$ dating.

Compositions: As described in [1], melt structure (i.e., fraction of non-bridging oxygen atom, X(NBO); [2,3]) of a lunar glass affects the diffusivity of radiogenic ^{40}Ar. Additionally, this diffusivity depends on temperature variations resulting from diurnal heating of the lunar surface. Essentially, glasses with feldspathic highlands compostions are more likely to suffer diffusive loss of radiogenic ^{40}Ar during extended residence in the shallow (<2-cm depth; [1]) regolith compared to glasses with more mafic compositions.

X(NBO) values were calculated for all lunar impact glasses with $^{40}Ar/^{39}Ar$ ages. As seen in Figure 1, glass shards are more likely to retain argon compared to (large or small) glass spherules and more likely to report old ages [4]. Impact glass spherules, on the other hand, are short-lived, perhaps because spherules are prone to shattering during impact gardening of the lunar regolith as a result of thermal stresses in those impact glasses acquired during quenching from hyperliquidus temperatures [4,5].

Chronology: The lunar impact flux is uncertain [e.g., 6,7,8], but specific lunar impact glasses can elucidate some of the details of the Moon's bombardment history. In particular, the results of this study show that shape, size, and composition of an impact glass matter for determining its formation age via $^{40}Ar/^{39}Ar$ dating. Figure 1 shows the distribution of currently available ages among lunar impact glasses of sufficient size to have retained at least 90% of radiogenic ^{40}Ar depending on X(NBO) value [4]. Many of the impact episodes have been documented elsewhere (e.g., ~500 Ma [e.g., 9]; ~800 Ma [e.g., 10]; ~3700 Ma [11]), and there are others that may be statistically significant. See Figure 8 in [4] for details.

Conclusions: As reported in [4] and as seen in Figure 1, several trends become apparent:

(1) Impact glass spherules are more likely to have young ages. Therefore, an increase in the recent impact flux may not be the correct interpretation.

(2) Impact glass shards are more likely to have old ages. Their large compositional ranges and multiple old ages (Figure 1) suggest that these glasses are products of multiple impact events into compositionally diverse terrains, including at least one that has not been documented elsewhere [lmHKFM; 11].

(3) The oldest impact glass shards could represent the last remnants of an initially large population of impact glasses generated during the tail end of the late heavy bombardment. Additionally, the absence of lunar impact glasses with $^{40}Ar/^{39}Ar$ ages >3900 Ma could reflect either an increased rate of shattering of glasses during intense gardening of the regolith and/or higher rates of diffusive Ar loss from impact glasses when the regolith had a steeper thermal gradient than the present one.

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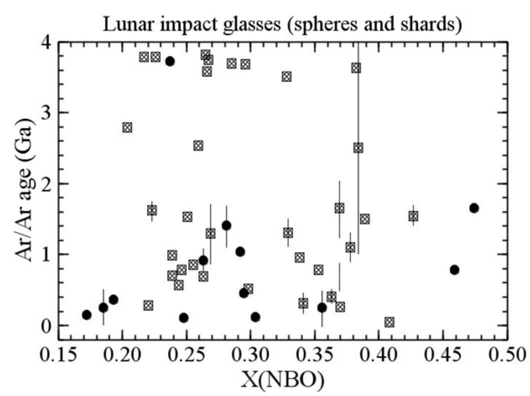

Figure 1. Lunar impact glass spherules (circles) and shards (squares) that would have likely retained at least 90% of their radiogenic ^{40}Ar during 750 Ma of residence at a time-integrated temperature of ~290K. Uncertainties in age that are larger than the size of the symbols are shown. From [4].