AGE RESETTING IN SMALL LUNAR IMPACTS: CASE STUDY OF APOLLO 17 STENO CRATER BASALTS.

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Introduction: The Apollo Next Generation Sample Analysis (ANGSA) program investigated specially curated Apollo 17 mission samples [1]. As part of this effort, we have conducted a coordinated geochronologic study of a suite of Apollo 17 basalts collected from a prominent boulder on the rim of Steno Crater (~0.5 km diameter). Upon return to Earth, three samples were normally curated (71035, 71037, 71055), and one was frozen in N_2 (71036). Previous geochronology efforts on this suite of basalts include Rb/Sr dating of 71055, which yielded an age of 3.56 ± 0.09 Ga (corrected for new decay constants) [2], and an unsuccessful attempt to measure the U-Th-Pb age of 71035 [3]. [4] measured Kr-Kr exposure ages of 71035 and 71055 of 106 ± 4 and 101 ± 7 Myr, respectively. Combining exposure ages of other Apollo 17 samples and crater morphology at this landing site, [4] suggested these exposure ages correspond to the age of Tycho crater.

Sample Petrology: All four samples are high-titanium, type B vesicular basalts collected from a single 1-meter boulder at Apollo 17 Station 1A [5]. The basalts are fine to medium-grained with accessory phosphates, Zr-bearing minerals, mesostasis glass, metal, and troilite [6,7]. Coupled 2-D petrology and 3-D tomography by [8] provided evidence that all four samples are cogenetic and formed within the upper crustal region of a mare flow.

Geochronology: A suite of geochronologic analyses was collected for all four basalt samples, including in-situ Pb-Pb isochron ages, $^{40}Ar/^{39}Ar$ ages, and cosmogenic Ar exposure ages. The Pb-isochrons (collected by Secondary Ion Mass Spectrometry) of all four samples are consistent with crystallization from the same basaltic reservoir at 3730 ± 27/39 Ma (2σ). $^{40}Ar/^{39}Ar$ data reveal that all samples have experienced Ar-loss since initial cooling, and the fraction of gas loss is variable between the samples and between different aliquots of the same sample. The highest temperature/laser power steps are consistent with the crystallization age inferred from the Pb-isochrons. The exposure histories derived from Ar-isotopes suggest similar exposure histories for all four samples and are comparable to Kr-Kr ages of [4].

Discussion: The crystallization age of the Steno Crater basalts agrees with the Pb-isochron ages of other Apollo 17 Group A, B, and C basalts [9]. The $^{40}Ar/^{39}Ar$ data likely reflect Ar-loss and age disturbance during the formation of Steno Crater and excavation of the source boulder. The exposure ages constrain the ages of Steno Crater to within the last ~ 100 Myr.

This coordinated geochronology study highlights the potential of relatively small (less than 1 km) craters to disturb the main isotopic systems used to date planetary samples. As is evident from the Ar-data and the previous Rb-Sr [2] and U-Th-Pb [3] analyses, it can be challenging to discern a timeline of events from a single geochronometer, even in the simple case of lava emplacement followed by a small impact excavation event. However, our results are promising in that the detailed petrology of [8], combined with multiple geochronometers including systems with a range of thermal sensitivities, successfully refined the history of the Steno Crater basalts. Furthermore, the variability in Ar-loss within a single boulder and between aliquots of the same sample demonstrates the heterogeneity of impact heating and the need for future lunar sample return missions (e.g., Artemis and Endurance-A) to collect multiple large samples to increase the likelihood of successful and interpretable geochronologic information.

References:

[1] Gross J. et al. (2025) *Journal of Geophysical Research: Planets* 130: e2024JE008585 [2] Tera F. et al. (1974) *LS V,* 792-794. [3] Chen J. H. et al. (1979) *LPS X,* 195-197. [4] Arvidson R. (1976) *7th LSC,* 2817-2832. [5] Neal C. R. & Taylor L. A. (1992) *Geochimica et Cosmochimica Acta* 56:2-77-2211. [6] Brown G. M. et al. 1974) *5th LSC,* 89-91. [7] Dymek R. F. et al. (1975) *6th LSC*, 49-77. [8] Wilbur Z. E. et al. (2023) *Meteoritics and Planetary Science* 58:1600-1628. [9] Snape J. F. et al. (2019) *Geochimica et Cosmochimica Acta* 266:29-53.

Acknowledgements: We acknowledge Leah Morgan and Cameron Mercer, who collected noble gas data at the Denver USGS, and we appreciate their continued collaboration on this project. Samples and funding for this project were provided through the NASA ANGSA program (Grant 80NSSC19K0803). We thank Beth Ann Bell and Ming-Chang Liu for their assistance with SIMS.