ARGON-40-ARGON-39 GEOCHRONOLOGY OF LUNAR METEORITE IMPACT MELT CLASTS.

B. A. Cohen[1], T. D. Swindle, and D. A. Kring, The University of Arizona, Tucson AZ 85721 [1]Now at The University of Tennessee, Knoxville TN 37996 (bcohen@utk.edu)

Introduction: The idea that the impact cratering rate in the Earth-Moon system was particularly high ~4 Ga ("terminal lunar cataclysm") has existed since the early 1970's [1, 2]. Apollo and Luna samples have been examined by multiple isotopic methods [1, 3, 4, 5] and no impact melts from these samples have ages older than ~3.85Ga, implying that the majority of impact melt was created during this short, intense bombardment. However, these samples come from a restricted geographical region on the near side of the Moon and may all have been affected by the basin-forming impacts. The lunar meteorites represent a random sampling of the lunar surface and provide additional samples with which to test the cataclysm hypothesis [6].

Methods: We have previously shown [7] that impact melt clasts within the lunar highlands regolith breccias MAC88105, QUE93069, DaG262, and DaG400 are chemically dissimilar to each other and to Apollo samples. Typical impact melt clasts were crystalline, fine-grained, microporphyritic, and plagioclase-rich, containing ~0.01 wt % K_2O. Samples extracted from each melt clast had masses ranging from 30-150 μg. We used a continuous laser system to step-heat 30 samples in 3-7 steps.

Results: Figure 1 is an ideogram of the impact melt clast ages. No clasts have ages older than 3.9 Ga. Based on age and chemistry, 6-10 different impact events are represented. Though the young ages of some clasts preclude their formation in basin-forming events, their crystalline and clast-free nature imply that they were created in large craters. A similar age distribution is seen in the oldest lunar spherules [8]

Implications: The lack of impact melt >3.9 Ga in lunar meteorite samples supports a cataclysm in the Earth-Moon system. On the Moon, this produced more than a thousand large (>20 km diameter) craters, including basins and swarms of secondary craters [9]. The number of impacts occurring on Earth would have been an order of magnitude larger, implying >10,000 large impact events in a brief time. The largest of these probably produced immense quantities of ejecta, temporarily charged the atmosphere with silicate vapor, and boiled away large quantities of surface water [10]. Interestingly, the earliest isotopic evidence of life on Earth comes from this same period of time [11]. Impact events of these sizes on Earth would have affected the environment and most likely any life that had arisen (e.g. [12]).

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Figure 1: Each clast age is represented by a Gaussian curve with a unit area. The ideogram is the addition of all impact melt clast Gaussians.