Ar-Ar Thermochronology of Apollo 12 Impact-Melt Breccia 12033,638-1. C. A. Crow1, W. S. Cassata1, B. L. Jolliff2, R. A. Zeigler3, L. E. Borg1, and C. K. Shearer4, 1Lawrence Livermore National Laboratory, 7000 East Avenue (L-231), Livermore, CA 94550s (crow7@llnl.gov); 2Washington University, St. Louis, MO; 3NASA Johnson Space Center, Houston, TX; 4University of New Mexico, Albuquerque, NM.

Introduction: We have undertaken an Ar-Ar thermochronology investigation as part of a coordinated multichronometer analysis of a single Apollo 12 impact-melt breccia to demonstrate the wide range of information that can be obtained for a single complex rock. This has implications for the age of formation, component makeup, and subsequent impact/shock and exposure history of the sample. This study also serves as a capabilities demonstration for the proposed MoonRise Mission [1]. The goal of this investigation is to elucidate the history of this sample through coordinated Ar/39Ar, Sm-Nd, Rb-Sr and zircon 207Pb-206Pb ages along with geochemical and petrographic context on a relatively small (~450 mg) sample. Here, we report preliminary results of the Ar-Ar thermochronology.

Sample: Apollo soil 12033 is characterized by high concentrations of KREEP-rich impact melt glass thought to be ejecta from the Copernicus impact event at ~800 Ma [2, 3, 4]. 40Ar/39Ar thermochronology was conducted on a high-Th, mafic impact-melt breccia fragment separated from this soil sample, 12033,638-1 [5]. The average matrix grain size is 20-30 µm, with occasional larger plagioclase grains and lithic classes ranging between ~100 µm to 1 mm (Figure 1) [5, 6]. Zircons identified in 12033 thin sections yield 207Pb-206Pb ages between 3888 ± 25 and 4171 ± 7 Ma, which define a weighted average age of 3920 ± 13 Ma [5].

Analytical Procedures: An aliquot of 12033,638-1 weighing 1.8 mg was co-irradiated with fluence monitors for 52 hours at the Oregon State University TRIGA reactor in the Cadmium-Lined In-Core Tube (CLICIT). Noble gas extractions were conducted in the Livermore Noble Gas Lab using temperature-controlled diode laser-heating following procedures similar to those described in [7]. Released gases were analyzed using a Nu Instrument Noblesse mass spectrometer equipped with six Faraday cup detectors and four ion-counting, discrete dynode multiplier detectors. Ages were calculated using the decay constants and standard calibration of [8].

Results:

Chronology. The age spectrum obtained from 12033,638 (Figure 2c) defines a “young” average 40Ar/39Ar age of 939 ± 86 Ma (1σ) over 74% of the released gas, with a minimum measured age of 828 ± 4 Ma. These data are similar to other 40Ar/39Ar ages obtained from Apollo 12 KREEP-rich glasses [2, 3, 4].

The higher 40Ar*/39Ar ratios observed in low temperature releases most likely reflect excess 40Ar, which have previously been reported in Apollo 12 soil samples [9]. High temperature releases have significantly older ages and likely reflect degassing of clasts and lithic fragments (based on the apparent Ca/K ratios; see Figure 2a). A maximum age of 4177 ± 102 Ma is observed at high temperatures and represents a lower limit on the oldest clast ages. This age is older than the 3920 ± 13 Ma age from [5], however it is within error.
samples spend some time shallowly buried ± 5 Ma (1 Figure 2b and defines an average exposure age of 136 K of \( \frac{39}{40} \)Ar/K of CRE procedures described in [10], producing exposure rates lower than at the surface. Thus, the 136 Ma exposure age indicates that 12033,638 has remained relatively shielded since it’s exhumation at ~ 900 Ma, most likely as a result of the Copernicus impact event (refs from before). Measurements of un-irradiated fragments are underway.

**Discussion:** The agreement between the maximum \( \frac{40}{39} \)Ar and \( \frac{207}{206} \)Pb ages suggests that oldest clasts within 12033,638-1 date to at least 4177 ± 102 Ma. The young \( \frac{40}{39} \)Ar age observed over 74% of the released gas (minimum measured age of 828 ± 4 Ma) suggests either (1) the formation age of the impact melt breccia is associated with the Copernicus impact event, or (2) extensive resetting of an older impact melt breccia occurred at that time. A similarly young, <1Ga, Pb-loss event was observed in discordant zircons from this sample [5]. Liu et al. [5] interpret the ~3.9 Ga \( \frac{207}{206} \)Pb ages of matrix hosted zircons as the matrix crystallization or breccia formation age. Alternatively, the \( \frac{207}{206} \)Pb-Pb ages could reflect inherited ages of target rock or local zircons that were incorporated into the melt matrix. The ~800-900 Ma age could therefore represent the matrix crystallization age, at which time only large clasts retained ancient Ar components and the U-Pb system of small zircons was disturbed. Ultimately, combining multiple chronometers, along with modeling of ejecta conditions (efforts currently underway), will lead to a better understanding of the thermochronologic history of this complex sample.

**References:**


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