Lunar impact histories from zircon (U-Th)/He thermochronometry

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Differences in interpretation of radiometric ages for lunar rocks and impact melts limit our ability to fully characterize the impact history of the Moon, such as the extent of early bombardment flux and the nature of flux decay through time. Implementing more thermally-sensitive radiometric systems provides a means to further document the timing and extent of lunar impacts, and that of the inner solar system.

New research on lunar impact-melt breccia samples integrates existing U-Pb zircon ages of pre-impact lunar crust with new low-temperature zircon (U-Th)/He (ZHe) thermochronometry from the same grains. The diffusion of ^{4}He from zircon closes at temperatures between ~220 and <100°C depending on accumulated radiation damage to the crystal structure [1]. As such, the ZHe method is sensitive to peak temperature and rate of cooling during and following impact events, with more damaged grains susceptible to He loss during lower temperature thermal events.

We present new ZHe results from Apollo 14 breccia 14311, interpreted to have formed in the Imbrium impact at c. 3.95 Ga [2,3]. ZHe dates range from c. 4250-3500 Ma at low eU (= $U + 0.235*Th$ < 100 ppm), dropping to a consistent population of younger dates at higher eU. The date-eU correlation is typical of that observed in normal terrestrial zircon samples. Forward modeling performed using the HeFTy software [4] indicates a best-fit thermal history dominated by two thermal events, corresponding to the age of Imbrium impact (~3.95 Ga) and a second, more recent event.

ZHe thermochronometric results from this study yield new insights into solar system chronology and underscore the utility of low-temperature thermochronometers in ancient samples. Data show that zircon grains with long histories of accumulated radiation damage can nevertheless retain He over ~4 Gyr timescales and still yield meaningful ZHe dates.

References: [1] Guenthner et al. (2013) *American J. Sci.* **313**, 145-198. [2] Simonds et al. (1977) *LPS VIII* 1869-1893. [3] Wilshire & Jackson (1972) *USGS Prof. Paper* **785**, pp. 26. [4] Ketcham (2005) *Reviews Min. Geochem.* **58**, 275–314.