Accurate $^{40}Ar/^{39}Ar$ MDD Thermal Histories of Extraterrestrial Samples

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One of the most significant concepts to emerge from the Apollo-era lunar exploration is the hypothesis that a late, heavy bombardment (the LHB) occurred in the inner solar system at ~3.9 Ga, possibly caused by a sudden massive delivery of planetesimals from the outer solar system. The nature of the LHB has profound implications for the emergence of life on Earth [1], the role of giant planet migration in mitigating habitability [2], and the calibration of 'crater counting' chronologies [3]. Unfortunately, the majority of the evidence for the LHB comes from misinterpretations of apparent plateau ages on thermally disturbed Apollo samples and appears to contradict bombardment histories inferred from lunar meteorites [4].

In the present study we undertake a thermochronologic investigation of Apollo 16 samples from North Ray Crater to examine their post-crystallization thermal histories. In contrast to practice over the past 40 years, we conducted high-resolution $^{40}Ar/^{39}Ar$ step-heating analyses using both isothermal duplicate heating steps and temperature cycling to maximize resolution of kinetic information needed to couple with high precision age measurements to reveal accurate thermal histories. Data are modelled using a refined formulation of the multi-diffusion domain [5] model that incorporates multiple phases and activation energies to estimate episodic loss thermal histories. This approach demonstrates the significant limitations inherent in arbitrary selection of plateau ages. The highly variable initial ages recorded in our age spectra demonstrate a more protracted bombardment history than generally believed.

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