

CONTRASTING EARLY AND LATE SHOCK EFFECTS ON THE L CHONDRITE PARENT BODY: EVIDENCE FROM AR AGES AND OLIVINE MICROSTRUCTURES FOR TWO METEORITES.

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Introduction: ⁴⁰Ar/³⁹Ar ages for L chondrites show two frequency maxima, a predominant late event (~470 Ma) that indicates a major impact at this time, and earlier ages between ~4.4-4.5 Ga [1]. The former age may correspond to the break-up of the parent body [e.g., 1-3], whereas the latter corresponds either to early impacts or metamorphism of the parent body [1]. We obtained Ar age data for two L6 chondrites, Park and Morrow County, which were studied for olivine microstructures with TEM and optical methods [4]. This combined approach provides a case study of contrasting shock effects in similar chondritic materials deformed in different epochs and under different conditions.

Methods: We conducted ⁴⁰Ar/³⁹Ar age dating of small (4-5 mg) neutron-irradiated aliquots of Park and Morrow County using a Thermo Scientific™ Argus MC mass spectrometer coupled to a CO₂ laser for step-heating at the University of Manchester. Olivine microstructures were studied in ion-milled 3-mm-diameter disks using an FEI Technai G3 TEM at PSU.

Results: *Chronology.* Park gave a plateau age of 4525.8 ± 4.6 Ma comprising 80% of the ³⁹Ar released over 15 steps. Morrow County showed significant disturbance in the low-temperature steps giving reset ages of ~450-470 Ma for two samples, with high-temperature steps recording ages of up to ~2 Ga. *Olivine microstructures.* Olivine in Park is lightly deformed (shock stage S1, geometric average dislocation density $\rho = 3.3 \times 10^8 \text{ cm}^{-2}$) whereas in Morrow County it is strongly deformed (shock stage S5, $\rho = 4.9 \times 10^9 \text{ cm}^{-2}$). Neither meteorite shows evidence for appreciable post-deformation annealing. **b**=[001] dislocations are prevalent in both meteorites, but **b**=[100] dislocations are somewhat common in Park and are common in Morrow County. Morrow County olivine also contains a low proportion of dislocations in **b**=[001] screw orientation. These features suggest high-temperature deformation for both meteorites, especially for Morrow County [4].

Discussion: The ⁴⁰Ar/³⁹Ar age of Park is one of the oldest for an L chondrite and implies the meteorite escaped significant late shock disturbance. Olivine microstructures in Park suggest weak shock at elevated temperature (syn-metamorphic shock) followed by excavation to a cool parent body surface [4]. For Morrow County, the ~450-470 Ma reset age is consistent with strong heating in the parent body break-up event. Olivine in Morrow County shows TEM evidence for high temperatures that is best explained by dynamic heating during intense shock, and evidence for minimal post-shock annealing that can be explained by cooling near the surface of a parent body break-up fragment [4].

References: [1] Swindle T.D. et al. (2014) Geological Society of London, Special Publication, 378: 333-347. [2] Haack H. et al. (1996) *Icarus* 119: 182-191; [3] Schmitz B. et al. (1997) *Science* 278: 88-90; [4] Ruzicka A. et al. (2015) *Geochimica et Cosmochimica Acta*, In Press, doi:<http://dx.doi.org/10.1016/j.gca.2015.04.030>.