

The Ar-Ar Age and Petrology of Miller Range 05029: An Impact Melt Created Before Earth's Moon

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Miller Range 05029 is a slowly cooled, clast free melt rock with metal/sulfide depletion and an Ar-Ar age of 4515 ± 10 Ma. Oxygen isotopes and mineral composition suggest an L-chondrite impact melt, and a well equilibrated igneous rock texture with a lack of clasts suggest a melt pool instead of a melt dike. A metallographic cooling rate of $\sim 10^\circ\text{C}/\text{Ma}$ indicate the impact occurred before the Ar-Ar closure age of 4515 Ma, possibly even shortly after accretion of its parent body. A metal grain with Widmannstätten-patterns further substantiates slow cooling. The formation age of MIL 05029 is at least as old as the Ar-Ar age of unshocked L and H chondrites, indicating metamorphism was still occurring at the time of

impact. This age is also older than the formation of the Earth-Moon system ~ 4.5 Ga, indicating the impact occurred before this late accretionary episode in the Solar System. Its metallographic cooling rate of $\sim 10^\circ\text{C}/\text{Ma}$ is similar to what is typical for L6 chondrites, suggesting an impact on the L-chondrite asteroid that excavated and buried the sample in a region 5-12 km below the surface. The inferred minimum crater size of 25-60km may have shattered the 100-200 km diameter L-chondrite asteroid. Therefore, MIL 05029 records the timing and petrogenetic setting for the observed lack of correlation of cooling rates with metamorphic grades in many L-chondrites.