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Dating phosphates of the strongly shocked Suizhou chondrite

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Abstract

Impacts on undifferentiated asteroidal bodies provide invaluable information for understanding the solar system evolution. Nevertheless, dating early and small-scale impact events is technically challenging. Uranium–lead (U–Pb) systematics of U-bearing phases within shock-induced melt veins (SMVs) of chondrites may be significantly disturbed by localized heating, thus providing opportunities to date these impact events. As one of the major U hosts in chondrites, apatite in the Suizhou (L6) chondrite has been compositionally and structurally modified to varying degrees by shock metamorphism. Apatite grains in the host remained largely intact during the impact and have recorded the initial thermal cooling time (~4550 Ma) on their parent body. Apatite grains in regions less than 100 μm bordering the SMVs or in relatively "cold" regions within the SMVs were partly decomposed to tuite, driven by the localized transient heating within the SMVs. Their U–Pb systematics were disrupted to varying extents. Apatite in regions close to the center of the SMVs has been completely transformed to tuite, which yields an age of 4481 ± 30 Ma (2σ), providing an upper limit to the impact event. This study clearly demonstrates that by integrating in situ U–Pb isotope analysis with detailed microstructural and compositional analysis of phosphates, it is possible to deduce the timing of early and small-scale celestial impact events, and hence create a more comprehensive understanding of the impact history of the solar system.

Keywords: Apatite, tuite, L chondrite, in situ U–Pb dating, early impacts in the solar system