Timing of Rapid Core Cooling Events in the Early Solar System Revealed by the Pd-Ag Chronometer

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Rapid cooling of planetesimal cores was inferred for several iron meteorite parent bodies including the IIAB, IIIAB and IVAs based on fast and variable metallographic cooling rates [e.g., 1-2]. This was linked to the loss of insulating mantles during hit-and-run impacts [2]. The short-lived ^{107}Pd-^{107}Ag decay system can constrain core crystallisation, and hence the timing of disruptive events. We use Pd-Ag ages for the IAB, IIAB and IIIAB iron meteorites from [3] to constrain the causes of these events.

The solar system initial (SSI) ^{107}Pd/^{108}Pd remains ambiguous and ages relative to CAI are calculated using both (5.9±2.2) x10^{-5} [4] and (3.5±0.1) x10^{-5} [5]. The IABs yield an isochron with a slope of (1.51±0.16) x10^{-5} [3], corresponding to ~12.8 or 7.9 Myr after CAI. This likely dates cooling after an impact break-up and reassembly of the body [e.g., 6]. However, an age of ~7.9 Myr cannot easily be reconciled with resetting of the Hf-W system [7], while cooling at ~12.8 Myr can.

Data for the IIABs and IIIABs define slopes of (1.78±0.44) and (2.20±0.57) x10^{-5} [3], respectively. The IVA irons yield a similar slope of (2.57±0.07) x10^{-5} [5]. Cooling ages for these three bodies calculated using a ^{107}Pd/^{108}Pd SSI of (3.5±0.1) x10^{-5} suggest a highly energetic inner solar system between ~2.9-6.3 Myr after CAI. This corresponds with the suggested outward migration of Jupiter after ~5 Myr [e.g., 8]. However, this SSI is at odds with thermal events on the IAB parent body. Closure times relative to a ^{107}Pd/^{108}Pd SSI of (5.9±2.2) x10^{-5} equate to cooling in the later timeframe ~7.8-11.2 Ma after CAI, and may instead date the dissipation of gas in the disk. After this, the damping effect of gas drag ceases and energetic collisions capable of disrupting planetesimals are predicted [e.g., 9]. This age coincides with observations of the lifetime of gas in stellar disks [e.g., 10].

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