Widmanstätten Pattern Growth in a Dynamic Early Solar System

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Iron meteorites come from the cores of differentiated planetesimals. The Widmanstätten pattern found in these samples developed from the exsolution of kamacite from taenite as the core cooled. Modeling the formation of these minerals and the diffusion of Ni within them as the core cooled allows us to estimate the cooling rates that these iron meteorites experienced. To date, cooling in such bodies has been assumed constant with time, a prediction consistent with onion-shell models of planetesimal thermal evolution [1]. These models assumed there would be no disturbances to the parent body as it cooled; however impacts are expected to be common in the early Solar System [2], and in fact, some iron meteorite groups are thought to be the products of collisions stripping the mantle and exposing the metallic cores to space [3]. The net effect of such collisions is to accelerate the cooling of heated planetesimals [4].

Here we examine how changes in cooling rates would affect the formation of the Widmanstätten pattern in impacted planetesimals. We follow [5] and start cooling at a slow, constant rate but then increase the cooling rate at various temperatures prior to when Ni diffusion ceases. We find that a given taenite half-width in our "disturbed" cases can be matched by distinct models with constant cooling rates (rates that differ significantly from the pre- and post-disturbance cooling rates). However, the Ni-concentration within the taenite band differs from this constant cooling rate prediction. Thus, the structure of the Widmanstäten pattern in these disturbed bodies would differ from those in undisturbed planetesimals, and can be analyzed to look for records of collisions. Combining this information with models for the changes in cooling rates expected in these events [6] would give insights into the frequency and timing of impacts in the early Solar System, providing important constraints on its early dynamical evolution.

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