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Dendritic core crystallization of iron meteorites parent bodies

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Although it is clear that most iron meteorites crystallized from cores of small planetoids, the solidification mode and its relations with the chemistry of iron meteorites are still poorly understood. Available data for liquid iron suggest that, at the low pressures of the cores of iron meteorites parent bodies, the adiabatic gradient is steeper than the liquidus gradient: crystallization may have initiated at the core-mantle boundary and progressed inward. We modelled the thermal evolution of cores of planetesimals of radius 10 to 100 km, describing the cooling and crystallization of the core. These calculations allow the estimation of the solidification rate and of the chemical and thermal gradient at the solidification front, which determine the solidification regime (dendritic or planar) of the core. Under such conditions, we found from a linear stability analysis that the interface is likely to be morphologically unstable, and that most of the solidification of the core must have been dendritic. Interdendritic spacing is estimated from our stability analysis and estimates of thermal profiles in the core. Reasonable agreement is found between our estimates for the IIIAB group parent body and those from chemical analysis of the Cape York meteorite (Esbensen and Buchwald, 1982) within their (large) respective uncertainty ranges.

The question arises of how the large range in trace element concentration measured in iron meteorites, which is usually thought to reflect fractional crystallization approaching ideal conditions, can be understood in a model of inward crystallization involving a stably stratified dendritic zone.