# SPECULATIONS ON THE FORMATION OF METALLIC METEORITE PHASES

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A new interpretation of the formation of metallic phases in pallasites and nickel-iron meteorites can be made using a non-equilibrium microgravity solidification hypothesis. This hypothesis implies that meterorites were initially large, weightless melts which solidified by radiative cooling.

Current theories do not satisfactorily explain the coexistence of equilibrium and metastable metallic phases. The proposed hypothesis accounts for the composition, morphology and coexistence of kamacite, plessite and pearlite within these same meteorites.

The solidification of metallic meteorite phases can be compared with that of low alloy steels. The relevant phase diagram for this process is approximated by the Ni-Fe phase diagram above 1400°C. Phase diagram boundaries can be significantly altered by minor elements in a melt. Solidification begins with the growth of delta ferrite dendrites, a BCC phase which can be retained at room temperature. The next expected transformation is a peritectic reaction in which ($\delta$ + L) ⧫ $\gamma$. It is not generally recognized that during cooling, the peritectic reaction stops after only a few atom layers of $\gamma$ are formed on the solid $\delta$ phase (peritectic walling). The balance of the solute-enriched liquid solidifies as a remote alloy system of $\gamma$ and ($\gamma + \alpha$).

It is proposed that swathing kamacite and Widmanstatten kamacite are both derivative phases of retained delta ferrite. Swathing kamacite forms by heterogeneous nucleation on high temperature solids such as olivine in pallasites. Widmanstätten kamacite lamellae are delta ferrite dendrites. Their octahedral growth morphology is a response to non-equilibrium solidification, or oriented dendritic growth. Their relatively large size is due to enhanced crystal growth in microgravity. This phenomenon is documented by materials processing experiments conducted in space.

Solute elements rejected by the growing kamacite collect in liquid pools which solidify in a complex manner producing a wide variety of compounds and microstructural features commonly termed plessite. Since plessite is formed at lower temperatures from cubic system metals, it exhibits similar octahedral morphology but on a finer scale. This morphology is generically termed Widmanstätten structure.

It is shown that a broader and more consistent interpretation of miocrostructrural features can be made by combining concepts from casting theory and the results of materials processing in space research.

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