THE FORMATION OF PALLASITIC CHONDRULES: EVIDENCE FOR RAPID SOLIDIFICATION UNDER MICROGRAVITY CONDITIONS

P.Z. Budka, *Dept. of Mechanical Engineering and Materials Science, Union College, Schenectady, NY 12308*

The microstructural features of pallasitic chondrules are clues to conditions in effect during solidification. We employ surface energy theory, analytical welding metallurgy, the findings of solidification experiments done under microgravity conditions, and past works on meteoritics to reexamine the formation of pallasite chondrules.

Previous investigators have overlooked the powerful influence of microgravity (or free fall) on chondrule formation. Springwater pallasite, a stony-iron meteorite whose microstructure has been characterized as remarkably smooth and undisturbed since crystallization occurred, is used as a model in this study. The similarities of morphologies between Springwater olivine chondrules and soap bubble aggregates suggest that chondrules solidified in an environment where surface energy forces dominated gravity forces, i.e., microgravity. This factor successfully explains the apparent contradiction of the co-existence of angular and rounded olivine features not only within the same sample, but also in one and the same olivine. Both rounded and angular morphologies can be generated within weightless molten olivine aggregates. These forms have been frozen in by rapid solidifcation.

Rapid solidification is the second important factor in pallasite formation. Non-equilibrium metal phases such as martensite in the pallasite microstructure attest to non-equilibrium formative conditions. Thus solidification was probably on a time scale of tens or hundreds of Centigrade degrees per minute or per day.

The picture of a pallasite melt solidifying rapidly in microgravity successfully answers "the pallasite problem." Under microgravity, density differences do not exist and the close association between olivine and metal phases is unremarkable.

The classic Kokscharow paper on the Pallas Iron chondrules includes a detailed description of the Pallas Iron by Pallas. This description closely matches that of Springwater. However, a careful reading indicates that Kokscharow's familiarity with goniometry influenced his interpretation of his observations. It can be shown that what Kokscharow characterized as crystal faces are olivine-to-olivine contact planes (or bubble-to-bubble interfaces).

Possible scenarios for pallasite formation consistent with rapid solidification under microgravity conditions include the breakup of a molten body or the spalling off of molten pieces from a body which is at least partially molten.

Rapid solidification under microgravity conditions is a simple, consistent, successful hypothesis for pallasite formation.

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