CHONDRULES AND AGGREGATES: SOME DISTINGUISHING CRITERIA. Glenn J. MacPherson and Lawrence Grossman*, Department of Geophysical Sciences, University of Chicago, Chicago, IL 60637. *Also Enrico Fermi Institute.

If the term chondrule is to be reserved for any object in a meteorite which was once an independent molten droplet, objective criteria must be recognized for distinguishing between such objects and things which do not satisfy this definition. We are particularly interested in distinguishing between chondrules and aggregates, *i.e.* mechanical mixtures of particles that are not necessarily related to one another. Our purpose here is to point out that such criteria exist and to describe what some of them are, using objects in the Allende meteorite as examples.

The presence of glass is almost universally accepted as evidence for a pre-existing liquid. As a result, virtually everyone would agree that those objects in Allende and other unequilibrated chondrites which contain glass, are olivine- and/or pyroxene-rich and which have barred or excentroradial textures were once molten. The term chondrule as defined herein can be applied with certainty only to the above objects which are spheroids, ellipsoids or fragments of these, as such shapes are a clear indication that the objects were once independent droplets. Ambiguity arises in applying the term chondrule to rounded, porphyritic, glass-bearing objects because some could conceivably be abraded fragments of much larger igneous bodies. Some features may be present that can be used to distinguish such objects from chondrules. For example, any mineralogical or chemical zonation that might be present in an abraded fragment would not be expected to be concentric with the external shape of the object, as it would in a chondrule. Also, a chilled margin would be a good indicator of a chondrule. We now turn our attention to glass-free objects which may have been neither independent droplets nor even molten in some cases.

If the shapes and/or sizes of crystals were constrained by their neighbors during growth, then it can be concluded that they solidified *in situ* and the host object did not form by random aggregation of independent crystals that formed elsewhere. An example of such growth interference is found in a Type B1 coarse-grained inclusion (1) in which melilite laths project from the margin of the object inward. The longest ones are at high angles to the inclusion surface, whereas shorter, stubbier ones at lower angles abut against and terminate at the sides of the longer ones.

Showing that the crystals in an object solidified *in situ*, however, is not even sufficient to demonstrate that it was molten, let alone that it is a chondrule. Because droplets solidify due to heat loss from their surfaces, unique features characteristic of such an origin may sometimes be produced which, if seen in an object, would indicate that it is a chondrule. It is reasonable to assume that chondrules were volatile-free, closed systems during solidification. Therefore, in cases where cooling from the outside of a droplet caused solidification to begin on its surface and to proceed inward with falling temperature, the phases nearest the margin should be those predicted to crystallize first from known phase equilibrium relations for the chondrule's bulk composition. Furthermore, the phase rule requires that the number of phases increase toward the center of such an object, unless quenching to a glass has occurred, reaction relationships can be demonstrated or the composition of the object is that of a eutectic. Minerals exhibiting solid solution might, in some cases, be richer in their high-temperature components in the outer mantle of such a chondrule than in the core of the object. An example of a chondrule like this is the Type B1 inclusion mentioned above (1) which has a mantle of spinel + melilite, the first phases predicted (2) to crystallize from a liquid having the bulk composition of this inclusion, and a core of the same minerals + fassaite + anorthite, phases predicted to crystallize later. Furthermore, the cores of individual melilite laths become progressively richer in åkermanite along their lengths toward the center of this inclusion. In contrast, a consequence of the above phase rule argument is that the concentric, multi-layered rims around coarse-grained inclusions (3) and spinel nodules in fine-grained inclusions (3) did not result from progressive crystallization of a liquid, since several of the layers are monomineralic. Some inclusions in Allende (4) have ophitic textures similar to those of terrestrial basic igneous rocks and, by analogy, have been interpreted as products of solidification of a melt. While this is a reasonable inference, it must be pointed out that it is not known that such textures could not also be produced by condensation of a gas. Other arguments, such as those developed above, would help to confirm the interpretation.

Aggregates are conglomerates: their primary constituents did not form in contact with one another and need not be in chemical equilibrium with one another. All would agree that the Allende meteorite fits this definition in that it consists of many diverse inclusions which accumulated with their matrix into a common body. Indeed, the texture of the matrix itself indicates that it is an aggregate (5): euhedral olivine plates which touch one another but are not intergrown and which are separated by abundant voids. Clastic rims (5) that mantle inclusions and chondrules are also aggregates, as their textures are similar to that of the matrix, though their mineral proportions are different. Another example is the amoeboid olivine aggregates (6) in which clumps of Ca-, Al-rich phases are separated from one another by material whose mineralogy and texture are like those of clastic rims. A further example is the fluffy Type A coarse-grained inclusions (7) which are composed of clumps of melilite + spinel + hibonite that are separated from one another by Allende matrix material, clastic rims or Wark-Lovering rims. Finally, the mineral grains and spinel-centered nodules in pink, fine-grained inclusions are not intergrown with one another and are separated by voids, indicating that these inclusions are also aggregates (8), although the above textures are sometimes obscured by post-aggregation alteration products.

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