The abundance and distribution of chondrules in the main asteroid belt: evidence from micrometeorites

Conference or Workshop Item

CHONDRULES IN THE PARENT ASTEROIDS OF MICROMETEORITES. M. J. Genge and M. M. Grady, [1]Department of Mineralogy, The Natural History Museum, Cromwell Road, London SW7 5BD, UK (mjg@nhm.ac.uk).

Introduction: Two main types of unmelted micrometeorite are recognised: (1) fine-grained micrometeorites (fgMMs), dominated by phyllosilicates, and (2) coarse-grained micrometeorites (cgMMs), dominated by anhydrous silicates and glass with magmatic textures [1]. Fine-grained MMs have close affinities to the matrices of CI, CM2 and CR2 chondrites, however, the other major components of these meteorites, chondrules, are exceedingly rare amongst micrometeorites [2]. Kurat et al., [3] described one particle that, on the basis of shape, texture and minor element chemistry, is probably a chondrule fragment. Genge and Grady [1] have further proposed, on the basis of texture and mineralogy, that most cgMMs represent fragments of chondrules. The preservation of glass in the mesostases of most cgMMs, however, is not consistent with derivation from a parent asteroid that has experienced hydrous alteration to the extent of the CM2 or CI parent bodies. We report the first discovery of a chondrule fragment from within a fgMM.

Texture and mineralogy: Particle SP96-100-001 was collected from the South Pole water well [4] and is dominated by a core of porous fine-grained matrix. The matrix consists of micron-sized subhedral anhydrous silicate grains embedded in a network-like structure of much-finer grained materials which probably represent the thermal decomposition products of phyllosilicates. Several large (<10 μm) anhedral olivine grains are also present in the matrix and appear to be clastic fragments. The unmelted core is surrounded by a <30 μm thick melted rim consisting of sub-micron fayalitic olivine grains in a glassy matrix and evidently formed during entry heating.

Adjacent to the unmelted matrix is a large 50 μm diameter igneous object consisting of euhedral zoned forsterite phenocrysts within a glassy mesostasis. Some of the euhedral forsterites are truncated at the interface with the fine-grained matrix indicating that this is a fragment of a larger grain. Close to the external surface sub-micron fayalitic olivine phenocrysts occur in the mesostasis and are similar to those in the melted rim surrounding the fine-grained matrix. These suggest remobilisation of the mesostasis during entry heating and indicate that the igneous texture predates atmospheric entry.

Implications: The texture and mineralogy of the igneous object found within particle SP96-100-001 is similar to that of Fe-poor cgMMs and of Type I chondrules [5]. The occurrence of this object embedded in fine-grained matrix closely resembles that of chondrule fragments and thus implies that cgMMs are derived as fragments of chondrule-like components of primitive asteroids. Hydrous alteration of the matrix of the particle is suggested by the presence of the thermal decomposition products of phyllosilicates. The porous nature of the matrix and the presence of sub-micron anhydrous silicates, however, implies a lower degree of alteration than in CM2 and CR2 chondrites. Similar porous fine-grained micrometeorites are relatively common and likewise differ from CM2 materials. The survival of glassy mesostasis within the chondrule fragment is also consistent with a lower degree of parent body aqueous alteration.

Conclusions: Particle SP97-100-001 suggests that glass-bearing cgMMs may have originated as fragments of chondrules from the same primitive asteroids as some fgMMs. The survival of glass and the textures of porous fgMMs imply that these parent asteroids experienced degrees of aqueous alteration intermediate between the CM2 and CV3 parent bodies.

Because micrometeorites a more representative sample than meteorites [6], the presence of chondrule fragments as a major component of the micrometeorite flux therefore suggests that these objects are widely distributed throughout the main belt.

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