PLASTIC DEFORMATION OF CHONDRULES IN ORDINARY AND ENSTATITE CHONDRITES: EVIDENCE OF HOT ACCRETION OR IMPACT-RELATED REGOLITH PROCESSING?

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Introduction: While chondrites and their constituent components are among the most primitive Solar System materials available for study, the period between the formation of chondrules and the accretion of the chondrite parent bodies remains poorly constrained. Unequilibrated ordinary chondrites (UOCs) are known to exhibit textures that apparently record post-accretionary brecciation and reconsolidation of clasts [1]. These clasts may represent several provenances of their components, thereby providing context for the period between chondrule formation and the final assemblage of chondritic components onto parent bodies. Although well established for UOCs, the history of brecciation and mixing of disrupted chondritic components in the enstatite chondrite (ECs) class of meteorites remains less well understood and constrained.

The hot accretion of chondritic components has been described throughout the literature [e.g. 2]. Recently, work on cluster chondrite clasts having highly compact structures with deformed and undeformed chondrules has strongly supported the hypothesis of rapid accretion of nascent chondrules [3]. Our goals are to expand upon our previous work [4, 5] on Watonga (LL3.1) in order to examine deformed and indented chondrule components, as well as examine from some of the least equilibrated ECs for evidence of deformation textures.

Results: Watonga contains a wide range of chondrule textural types, many of which are rimmed by fine-grained material, as well as chondrule fragments mixed with lithic and mineral fragments. In particular, fine-grained interchondrule matrix (<5 µm, [6]) represents a minor component (~3 vol%), whereas chondrules and chondrule fragments are the most abundant (~71 vol%). Coarse-grained matrix (5 – 100 µm) is composed of mineral fragments, which include olivine, pyroxene, metal and sulfide grains, and extends up to 15 vol%. The degree of deformation was determined in a total of 88 examined chondrules following procedures outlined in [3]. Of those chondrules examined, ~20% showed considerable degrees of deformation. Deformation extends over all chondrule textural types.

Petrologic Type 3 ECs examined for deformation include Elephant Moraine (EET) 90992, Queen Alexandra Range (QUE) 93351, both EL3s, and Pecora Escarpment (PCA) 91383, an EH3. The EL3s both have comparably less fine-grained interchondrule matrix (<3 vol%) than PCA 91383 (~5 – 10 vol%). Preliminary findings reveal that ~16 vol% and ~11 vol% of chondrules from EET 90992 and QUE 93351, respectively, show considerable degrees of deformation, with some that are indented around each other. PCA 91383 has far fewer examples (<10 vol%). The matrix from PCA 91383 is also coarser-grained than the predominantly fine-grained matrix in the EL3s, with the former composed mostly of enstatite fragments embedded in FeO-rich material. Indented chondrule clusters are numerous in the EL3s, yet are lacking in the PCA 91383 EH3.

Discussion: Previous work on Watonga has shown it to contain deformed and indented chondrules and chondrule/lithic fragments [5]. Cluster chondrite clasts have been previously found to occur as higher percentages in UOCs with minimal modal abundances of matrix (i.e. < 10 vol%) [3]. Like UOCs, the EL3 chondrites also show chondrule deformation and clustering and have low matrix. EET 90992 has also previously been shown to have a shock stage S3 [7], which we interpret to be a likely influence on deformation textures. PCA 91383, however, contains matrix that we interpret to be derived from cataclasis and the disruption of precursor material. Such mechanical processing evident in EH3s, coupled with the paucity of deformation textures, might instead record post-accretion comminution and fracturing in a regolith setting.

Implications: Two plausible models for the formation of deformation textures include deformation via hot accretion in the solar nebula, and impact-related deformation on the parent body regolith. For the hot accretion model, at least 2 distinct events are posited to have occurred prior to final lithification: 1) rapid assemblage of ephemeral planetesimals that accreted chondrules hot, and 2) subsequent disruption and brecciation to produce the clasts of cluster chondrites and the cataclastic portions common throughout Type 3 chondrites. Alternatively, compaction from impacts on the parent bodies could also have contributed to the deformation textures without the formation of cluster chondrites as demonstrated for friable ordinary chodnrites [8]. Further work is required to test the viability of each model for UOCs and Type 3 ECs.

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