THE ORIGIN OF ROUND PHYLLOSILICATE AGGREGATES IN CR2 AND CI1 CHONDRITES

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Abstract: We have characterized round phyllosilicate aggregates in Orgueil and Al Rais, and conclude that they formed from aqueous alteration of glassy spheres.

Introduction: The CI1 chondrites, while having the most solar-like, or primitive, composition of any sizable solar system material available for laboratory analysis, have also been considerably altered by asteroidal processes including aqueous alteration [1]. It is therefore of fundamental importance to determine the pre-alteration mineralogy of the CI1s, so that the state of matter in the early Solar System can be better determined. In the course of a study of separated components of the Orgueil and Alais CI1 chondrites, we noted numerous rounded, yellowish-brownish objects. These varied in shape from spheres to oblate spheroids, and ranged in size up to 100μm in greatest dimension (Figure 1). Now, without engendering any undo prejudice for the current work, we point out that these objects are similar to some of the so-called "organized elements" reported from carbonaceous chondrites by Nagy many years ago [2]. We prepared ultramicrotomed slices of two of these rounded objects, and characterized the mineralogy by transmission electron microscopy (TEM). Inspection of numerous thin sections of CI1 chondrites (Orgueil, Alais and Ivuna) shows that these rounded objects are common, although generally of smaller size (10-60μm) than the ones we examined by TEM.

Results: We found that these rounded objects consist mainly of two components (Figure 2): (1) Rather fine-grained, flaky phyllosilicate with basal lattice spacings (~7 and 11-14Å) and compositions indicating intergrown serpentine and saponite (Figure 2). (2) Very poorly-crystalline ferromagnesian material, with the same approximate composition as the phyllosilicate. This could be ultra-fine grained phyllosilicate damaged by the electron beam. These two materials in fact dominate the bulk of the host CI1 chondrites as well [3&4]. In any case, saponite clearly predominates over serpentine in the crystalline, flaky material. Also present in the slices we examined were a few sub-micrometer sized grains of chromite and magnetite. These spinels are common byproducts of the aqueous alteration of ultramafic material when the resultant phyllosilicates cannot accommodate all of the available Fe and Cr. In fact, with the exception of these sparse spinels, the rounded phyllosilicate objects are remarkably free of other minerals. This suggests that the precursor from which the phyllosilicates were derived was a simple, homogeneous material as well.

Some time ago two of us (MEZ and MKW) examined by the same techniques the mineralogy of yellow and brown spherules noted in CR2 chondrites. These spherules, generally smaller than 1 mm, are found within and rimming chondrules, and scattered loosely within matrix. They are particularly abundant in Al Rais. We show a view of these in Figure 3. We found that some spherules were totally non-crystalline (glass), some consisted almost entirely of serpentine with accessory saponite, and some spherules contained mixtures of non-crystalline material and phyllosilicates. The former of these spherules were remarkable in their homogenous texture, consisting almost entirely of flaky phyllosilicates (Figure 4), with only a few inclusions of submicron sized olivine. Such large aggregates of "pure" phyllosilicate are quite unusual in chondrites, in our experience.

Discussion and Conclusions: The spherules in the CR2 chondrites are almost undoubtedly glassy, pre accretionary-aged objects caught in various stages of aqueous alteration. The extremely homogeneous texture of phyllosilicates supports the contention that they derive from such a homogeneous glass, as opposed to merely a fine-grained assemblage of anhydrous, crystalline silicates. Further, we suggest that the rounded phyllosilicate aggregates in the CI1 chondrites had a similar origin as glassy spherules. The only difference between the objects in the CR2 and CI1 chondrites is the less spherical nature of those in the latter, attributable to physical deformation of the softer, less stable CI1 regolith during frost-driven physical weathering and impact-produced distortion.

If we are correct, then we know one component of the pre-alteration CI1 mineral assemblage: glassy spherules. It is interesting that glassy spherules (GEMS: glass with metal and sulfides) [5] are also abundant in the other "most primitive" material, anhydrous chondritic interplanetary dust particles. It is critical to determine whether the CI1 glassy material was more like the GEMS, or the simpler, larger glassy bodies in CR2 chondrites.

References: [1] Zolensky and McSween (1988) In *Meteorites and the Early Solar System*, pp. 114-143; [2] Nagy (1975) *Carbonaceous Meteorites*, pp.624-634; [3] Bass (1971) *GCA* **35**, 139-147; [4] Tomeoka and Buseck (1988) *GCA* **52**, 1627-1640; [5] Bradley (1994) *Science* **265**, 925-929.

Figure 1: Spherules (arrowed) in Orgueil, view measures 1 mm across

Figure 2: Low-magnification TEM image of an Orgueil phyllosilicate spherule

Figure 3: Spherules (arrowed) in Al Rais, view measures 2 mm across

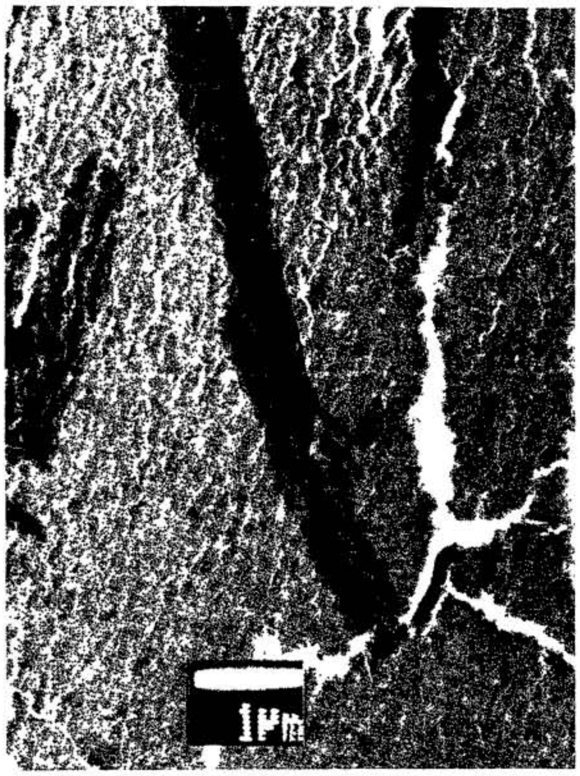

Figure 4: Low-magnification TEM image of an Al Rais phyllosilicate spherule