FORMATION OF Ca-PHOSPHATES DURING AQUEOUS ALTERATION OF TYPE IIA CHONDRULES IN THE Y-791198 CM2 CARBONACEOUS CHONDRITE

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Introduction: The CM2 chondrites are a primitive group of meteorites that record a complex history of early solar system processes [1]. The CM2s show evidence of significant aqueous alteration that has resulted in the replacement of primary nebular phases by a variety of secondary alteration products [1]. An understanding the nature of the alteration reactions provides important insights into the composition of aqueous fluids and elemental mass transfer during alteration. To address the issue of elemental mobility during alteration, we have examined the behavior of Ca and P in type IIA chondrules [2,3] that results in the formation of Ca-phosphates during aqueous alteration.

Method: Several type IIA chondrules and their associated fine-grained rims from the weakly altered CM2 chondrite, Y-791198 were characterized by SEM/BSE imaging and elemental X-ray mapping by EPMA. Selected regions from the interface between these chondrules and their fine-grained rims were extracted using FIB techniques and were studied in detail by TEM.

Results and Discussion: X-ray maps of type IIA chondrules show that, in all cases, a narrow zone of Ca and P enrichment is present at the interface between altered mesostasis and the fine-grained rim [2]. The zone of Ca and P enrichment has been characterized in detail using TEM. These observations show that the Ca and P-bearing phase is well-crystallized apatite, but with a highly unusual morphology. The apatite occurs as continuous, elongate, but curved plates, that extend for several microns, but are clearly single crystals. In some locations, the apatite crystals resemble a wishbone with straight segments that may be 2-3 μm in length, linked by a short, curved segment. The apatites range from <0.1 to 0.8 μm in width. The TEM data show that the apatites are not located exactly at the interface between the chondrule and fine-grained rim, but are contained completely within the altered chondrule mesostasis, 2-3 μm from the edge of the chondrule. The altered mesostasis consists of fine-grained phyllosilicates and material that appears to be amorphous. EDS analysis of this material show that it is SiO_2- (~ 40 wt%) and FeO-rich (40 wt%), but also contains significant concentrations of Al_2O_3, (~7 wt%) MgO (~8 wt%) and, notably, K_2O (~4 wt%).

The occurrence of apatite in Y-791198 type IIA chondrules is remarkably similar to textures observed in partially altered glass in a type IIA chondrule in the CR2 chondrite EET92015 [3]. We have argued that Ca and P leached from chondrule mesostasis during aqueous alteration are precipitated as apatite at a geochemical reaction front on the edge of the chondrule. Precipitation is promoted by an increase in pH, stabilizing apatite [4]. The Y791198 phosphates appear to share a similar origin, except that the degree of alteration in Y791198 is much more extensive. This suggests that early formed phosphates are stable to relatively advanced degrees of alteration, but do eventually undergo dissolution in more heavily altered CM2s [4].

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