Introduction: The CM carbonaceous chondrites have experienced extensive secondary processing that has overprinted the primary nebular characteristics of this group of meteorites. The most widely recognized form of alteration that has affected these meteorites is aqueous alteration that has resulted in partial to complete alteration of the primary nebular components. As a consequence CM chondrites consist of mixtures of anhydrous and hydrated materials. One of the main unresolved questions concerning the aqueous alteration of CM carbonaceous chondrites is the location where the aqueous alteration occurred. It has been suggested that some of the hydrous alteration must have occurred prior to accretion into the final CM2 parent body asteroid, a process that has been termed preaccretionary alteration [1,2]. Several lines of evidence have been presented to support this argument, most notably, the presence of unaltered metal grains juxtaposed against hydrous silicate phases in the fine-grained rims around chondrules [2]. However, there is a significant body of evidence pointing to parent body alteration as a very important process in the evolution of CM chondrites [3,4]. This evidence includes the consistent bulk composition for all CM chondrites, irrespective of their degree of alteration, the common occurrence of carbonate assemblages [5], the presence of undisrupted Fe-rich aureoles [6], and the systematic redistribution of elemental constituents over millimeters, e.g., Mg\textsuperscript{2+} into the matrix and Fe\textsuperscript{2+} into the chondrules, inclusions and aggregates [5,7].

One of the objectives of this study is to assess whether aqueous alteration took place on the parent body asteroid or in a preaccretionary environment as suggested by [1]. A key element of the parent body alteration model is that chemical exchange must occur between chondrules and matrix as alteration proceeds. According to the model of [3,5], progressive alteration should result in a systematic evolution of the altering fluid from an early Fe-rich fluid to more Mg-rich at more advanced degrees of alteration.

In order to test the parent body model, we have determined the compositions of altered chondrule mesostasis from Y-791198 and compared them to those from ALH 81002. These two meteorites enable the effects of aqueous alteration to be studied without the complication of brecciation. Both Y-791198 and ALH 81002 are primary accretionary rocks [1,8], but ALH 81002 is much more highly altered than Y-791198. In Y-791198, hydration is mainly restricted to matrix materials and fine-grained rims whereas in ALH 81002 the primary chondrule silicates show evidence of significant alteration [8]. If the model for progressive aqueous alteration is correct, we would expect to observe a systematic change in the mesostasis composition as alteration becomes more advanced. Mesostasis glass is highly susceptible to alteration and alters first during progressive alteration. Because the composition of chondrule mesostasis is variable, the early-formed alteration products are likely to have heterogeneous compositions from one chondrule to another. However, with more advanced alteration one would expect to find a general homogenization in the composition of the alteration products.

Methodology: In order to test the parent body model, compositional data was gathered from two thin sections of Y-791198. First the sections were mapped and observed in BSE on a JEOL JSM5800LV SEM. 64 chondrules in two separate thin sections of Y-791198 were identified and chosen for study on the basis of their well-developed fine-grained rims. 20 of these chondrules had large patches of mesostasis. Compositional data (12 elements) were collected using a JEOL Superprobe electron microprobe. These data was then compared to analyses obtained by [9].

Results: The studied chondrules are mostly type IA (PO) and type IIA (PO) with a type IA (BO) in each thin section of Y-791198. These chondrules range in size from 37µm x 23µm 667µm x 400µm. They range in shape from rounded to irregular.

In all the chondrules studied the chondrule glass has been entirely replaced by secondary phases and no evidence of relict chondrule glass is present. Altered mesostasis in Y-791198 is interstitial to the silicate minerals (e.g. olivine, pyroxene) or occurs on the exterior of the chondrule between the silicate minerals and the fine-grained rim. It has low contrast in BSE imaging and ranges in texture from smooth and featureless to containing dendritic crystals of serpentine (Fig 1).

When plotted on a ternary diagram, the SiO\textsubscript{2}, MgO and FeO data from altered mesostasis in the two thin sections of Y-791198 are nearly identical. The data from the two sections overlap each other with

![Figure 1. Type II chondrule in Y-791198 fragments. The mesostasis contains dendrites of serpentine.](https://example.com/figure1.png)
chondrule mesostasis in one thin section being slightly more FeO-rich than the second. This is most likely due to sampling statistics. The altered mesostasis data from type IIA chondrules are more FeO-rich than those from type IA chondrules in both sections of Y-791198. The average MgO/(MgO+FeO) values are 0.466 and 0.390 for type IA and IIA chondrules, respectively.

The altered mesostasis compositions for ALH 81002 [9] make a much tighter cluster (Fig 2) than those for Y-791198. The overall average MgO/(MgO+FeO) value for both sections of Y-791198 is 0.428, with a standard deviation of 0.092, whereas as the average for ALH 81002 is 0.332 with a standard deviation of 0.039.

Figure 2. Ternary plot of wt% SiO₂, MgO and FeO from chondrule mesostasis from the CM chondrites Y-791198 and ALH 81002.

Discussion. [9] studied the alteration of chondrule mesostasis in type I and II chondrules from several CM chondrites showing variable degrees of aqueous alteration. In all these chondrites, there appeared to be no compositional differences between the alteration products of mesostasis in different chondrule types. However, this is not the case in Y-791198, where there is a distinct difference in the MgO/(MgO+FeO) ratio of mesostasis alteration products in type IA and IIA chondrules. This suggests that either the mesostasis in type IIA chondrules initially had more Fe than that in type IA chondrules or that the alteration took place when the fluid had a higher Fe-content (earlier). Although [10-13] found that type IIA chondrules contain more Fe in their mesostasis than do type IA chondrules, the Fe contents are not nearly as high as they are in serpentinized mesostasis in CM chondrules. Therefore, the higher Fe content is probably due to a combination of both.

A comparison of the data for chondrule mesostasis alteration products in Y-791198 with the more highly altered ALH 81002 shows that there is a distinct decrease in the compositional range of the alteration products with higher degrees of alteration. This seems to indicate that compositional homogenization has occurred with increasing degrees of alteration, which is consistent with parent body alteration. However, the fact that the ALH 81002 data are generally more Fe-rich than the Y-791198 data does not support the parent body alteration model as it currently stands. If this model were correct, then one would expect the alteration phases in ALH 81002 to be more Mg-rich than those of Y-791198 because it sustained more advanced alteration. The relatively Mg-rich compositions of mesostasis serpentines in Y-791198 could indicate that in the earliest stages of alteration, the fluid was actually Mg-rich, but became more Fe-rich once significant alteration of Fe-bearing phases took place. This is supported by the survival of Fe-Ni metal grains in the fine-grained rims of Y-791198. Because they were not completely consumed, they had no control over the Mg/Fe ratio of the fluid. In addition, the effect of local compositional controls should not be neglected, i.e. chondrule mesostasis with initially higher FeO concentrations.

Preliminary data for individual chondrules hints that there is a positive correlation between the MgO/(MgO+FeO) values for the chondrule mesostasis and the associated fine-grained rims. This relation supports the theory that the fine-grained rims and their associated chondrules altered as a closed system, but involved local exchange between altering chondrules and their enclosing rims.

Further evidence for elemental exchange between chondrules and matrix or rime materials comes from the compositions of serpentines that have replaced mesostasis. These mesostasis serpentines contain up to 2 wt% NiO and SO₃ and up to 11 wt% Al₂O₃. This indicates that Ni and S were mobile during the aqueous alteration. There is no correlation between these elements which suggests that they are not residing in a particular mineral phase.