VARIATION IN AQUEOUS ALTERATION IN THE MURRAY CM CHONDRITE. E. E. Palmer[1] , D. S. Lauretta[1], K. J. Domanik[1] [1] Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721; epalmer@lpl.arizona.edu.

Introduction: While most researches believe that CM chondrites experienced aqueous alteration after accretion, this is not universally accepted. We studied metal grains in the Murray CM chondrite to determine if grains were out of equilibrium with the matrix and what they would tell us about the alteration history of the meteorite.

Metal grain alteration in CM chondrites occured when S-bearing fluids corroded metal into tochilinite, a mixed layer sulfide-hydroxide [1]. Continued alteration converted tochilinite into what used to be known as poorly characterized phase, PCP [2]. PCP has been characterized as fine-grained mixture of tochilinite and cronstedtite. During late-stages of alteration, the PCP further reacted with silicates to form serpentine [2].

Method: We used the LPL Cameca SX-50 Electron Microprobe to evaluate eight different assemblages. We used a focussed beam for point analysis. In order to analyse the matrix, we broadened the beam to 10 μm. We generated back scatter electron (BSE) and elemental map images, and microprobe point analyses in order to determine the composition of the chondrules and their surrounding matrix. From this, we inferred the amount of alteration and estimated the original mineralogy.

Results: We found that the chemical composition of our Murray sample matches the results of previous studies [1,2]. The matrix is comprised of hydrated silicates forming serpentine. Altered metal grains have compositions consistent with tochilinite.

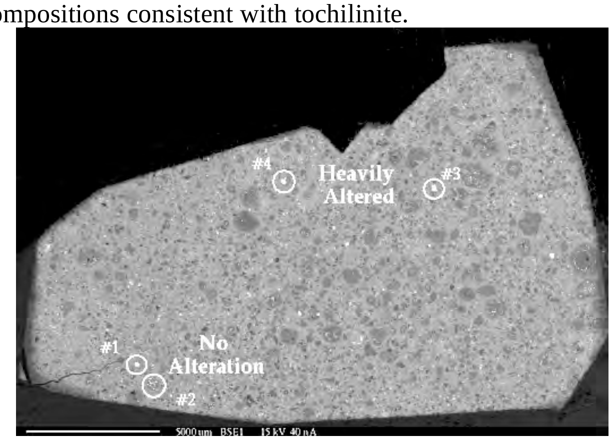

Figure 1: Overview of the Murray sample and shows the two regions with the most difference in alteration.

Additionally, we found that the meteorite has vast variations in the level of aqueous alteration over short distances, Fig. 1. This is significant because it indicates how evenly distributed fluid was during alteration.

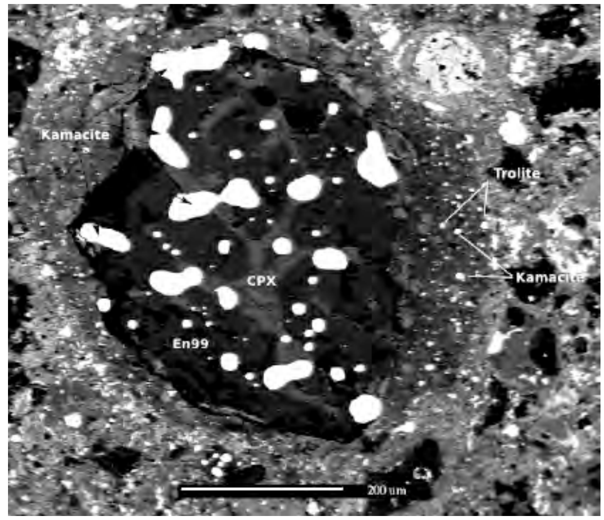

Figure 2: Unaltered chondrule, mix of kamacite, enstatite and augite.

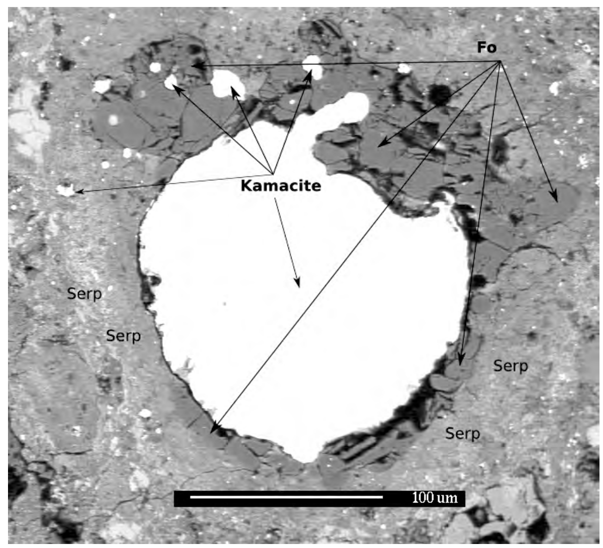

Figure 3: Unaltered kamacite grain partially enclosed by forsterite.

Unaltered Chondrules. Figures 2 and 3 show chondrules that have no noticeable alteration of their metal or silicate grains. The metal inclusions, including some which are exposed to the matrix itself, remain pure unaltered, kamacite.

The surrounding matrix has a bulk composition that is similar to the other sampled matrix regions in the chondrite. However, small kamacite grains, less than 5 um, are present in the matrix. These small grains should have been susceptible to aqueous alteration since they have a high surface area and were exposed to the porous matrix.

Alteration. Figure 4 shows a large kamacite grain that has been partially converted into tochilinite. The center of the grain remained unaltered. Within the silicate portion of the grain, all but a few of the kamacite inclusions have been converted into tochilinite. Some of the kamacite inclusions have begun to interact with the silicates forming an intermediate mixture composition between tochilinite and cronstedtite (PCP). It appears that the dark rim material has been breached by tochilinite both near the top and at the upper left. Further, as the iron moved away from its original location, nickel, phosphorus and chromium were left behind and concentrated, similar to those found by [3]. The matrix no longer has any small metal grains, which were likely converted into PCP or serpentine.

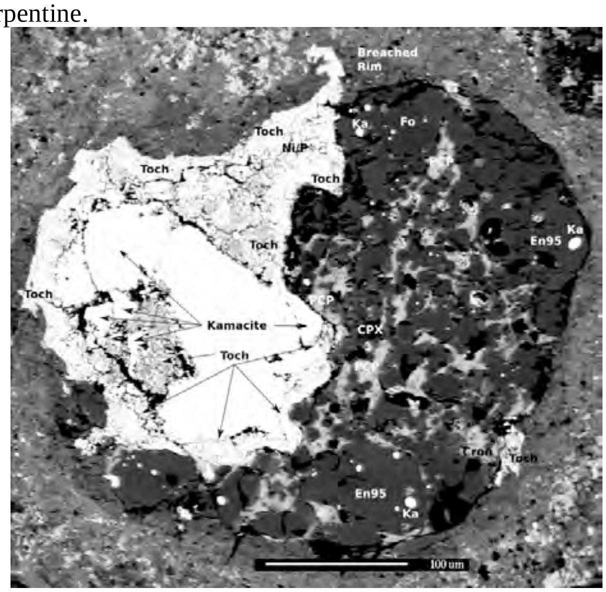

Figure 4: Heavily altered kamacite and silicate chondrule. Large portions of the kamacite has been converted into tochilinite.

Figure 5 is a troilite grain that has undergone extensive alteration along grain boundaries. Microprobe data show that the fracture zones are veins of tochilinite. Grain boundaries between the troilite and the silicates show wider regions of alteration. PCP were not detected within the grain itself, but in the nearby matrix. Of note is a large grain of nickel and phosphorous on the left side of the troilite. It is less altered due to the very high nickel content (25 to 30%). Finally, the mobilized iron may have flowed out of the grain, breaching the fine grained rim (top of Fig. 5).

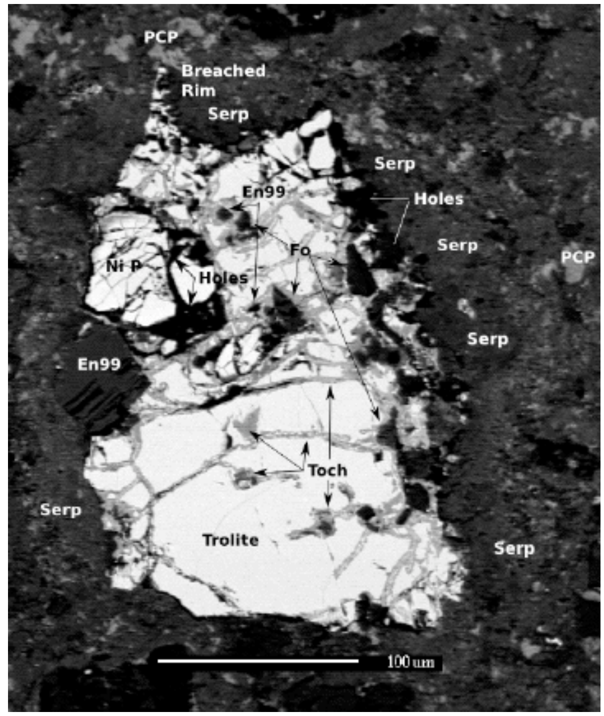

Figure 5: Highly altered troilite grain. The alteration in fractures is tochilinite.

Conclusion: We find that there are several regions in the meteorite that experienced extensive aqueous alteration, while there are others that did not see any. If alteration occured post accretion, one would expect the fluid to fill pore spaces evenly, resulting in similar alteration over short distances. Finding such drastic differences in alteration leads us to question whether alteration phases in CM chondrites formed in the parent body. Alternatively, the chondrule may have experienced this alteration in the solar nebula, before accretion [4]. An alternate explanation is that ice was entrained into the matrix during accretion.

In order to better understand the relationship between unaltered and altered regions, a more systematic evaluation is required. A map showing altered and unaltered regions will help us determine if the alteration happened in the solar nebula or the parent body. If altered chondrules are randomly scattered around the meteorite with immediate neighbors showing no alteration, then one can deduce the alteration happened in the solar nebula. Alternatively, if alteration radiates away from focal points, then ice entrained in the parent body is more likely source of aqueous alteration.

References: [1] McSween H. Y. (1987) *GCA*, 51, 2469-2477. [2] Tomeko, K and Buseck P R (1985) *GCA*, 49, 2149-2163. [3] Goreva S Lauretta D S (2006) *LPS XXXVII*, abstraction #2422. [4] Metzler K, Bischoff A and Stoffler D (1992) *GCA, 64, 2873-2897.*