

EFFECTS OF SECONDARY PROCESSING ON PRESOLAR GRAIN ABUNDANCES AND COMPOSITIONS IN THE UNIQUE CARBONACEOUS CHONDRITE MILLER RANGE 07687. C. Floss¹ and A. J. Brearley². ¹Laboratory for Space Sciences and Physics Department, Washington University, St. Louis, MO, USA; ²Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM, USA. (Email: floss@wustl.edu)

Introduction: Presolar silicates are easily altered or isotopically re-equilibrated by relatively modest degrees of thermal metamorphism and/or aqueous alteration [1–3], and have been found in abundance only in certain primitive extraterrestrial materials. As a result, they can be useful tracers of secondary nebular and parent body processes [e.g., 4, 5].

MIL 07687 is classified as a CO3 chondrite [6], but contains unique features that distinguish it from typical CO chondrites [7, 8]. Specifically, the abundance of refractory inclusions is lower in MIL 07687 than in CO chondrites, the amount of matrix (~68%) is higher, and fine-grained chondrule rims, which are common in COs are essentially absent in MIL 07687 [7]. However, the most unusual feature of this meteorite is that it appears to have undergone a unique style of highly localized aqueous alteration [7, 8]. The matrix is texturally complex, consisting of irregularly-shaped Fe-rich (altered) and Fe-poor (unaltered) regions separated by distinct boundaries (Fig. 1).

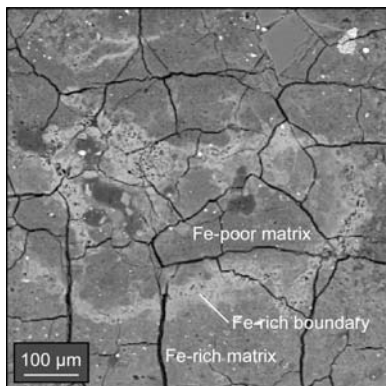


Figure 1. Back-scattered electron image of matrix from MIL 07687.

In other primitive carbonaceous chondrites, high abundances of presolar silicates are typically found in fine-grained matrix regions dominated by amorphous silicates. We are carrying out ion imaging searches in MIL 07687, with the goal of evaluating how the abundances and compositions of presolar grains in the matrix of this meteorite have been affected by the secondary alteration it has experienced.

Experimental: We used the Cameca NanoSIMS 50 to carry out C and O raster ion imaging of matrix areas in MIL 07687 that experienced varying degrees of aqueous alteration. The total area we analyzed is 33,900 μm^2 ; approximately 1/3 of this is Fe-rich

altered matrix, while the remainder is relatively unaltered Fe-poor matrix.

Following isotopic identification of the grains, we used Auger spectroscopy to determine the major element compositions of the grains, following standard procedures developed for presolar silicate analysis [9].

Results: We found a total of 53 O-rich presolar grains and 21 SiC grains. The overall abundances are 110 ± 15 ppm for O-rich grains and 85 ± 19 ppm for SiC, in good agreement with the abundances determined by [10] for the same meteorite. Most grains belong to either Group 1 or Group 4, but three grains have more elevated $^{17}\text{O}/^{16}\text{O}$ ratios, typically referred to as extreme Group 1 grains (Fig. 2).

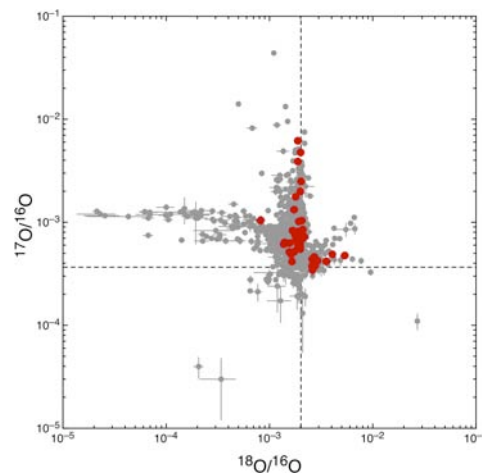


Figure 2. O three-isotope plot showing O-rich presolar grains from MIL 07687 (red symbols). Other data are from the Presolar Grain Database [11].

Auger analysis of the grains shows that virtually all of them are ferromagnesian silicates; only one oxide grain is present. Elemental compositions are broadly consistent with those of other presolar silicates, with Fe+Mg/Si ratios that are close to either olivine (2.0) or pyroxene (1.0) or are intermediate between these two. Iron concentrations in the grains range from 6 to 32 at.%, with a median of 16 at.%, similar to the ranges and medians observed for presolar silicates from primitive meteorites such as Acfer 094, ALHA77307 and the CR3 chondrites QUE 99177 and MET 00426 [e.g., 1 and references therein].

Discussion: The Fe-poor matrix regions of MIL 07687 consist of amorphous Mg-Fe-bearing silicates and Fe-sulfides, and resemble matrix from

other highly primitive carbonaceous chondrites (Fig. 3a). In contrast, the Fe-rich matrix areas are extensively altered and are dominated by fibrous Fe oxyhydroxides (Fig. 3b), possibly ferrihydrite or akaganéite [7, 8].

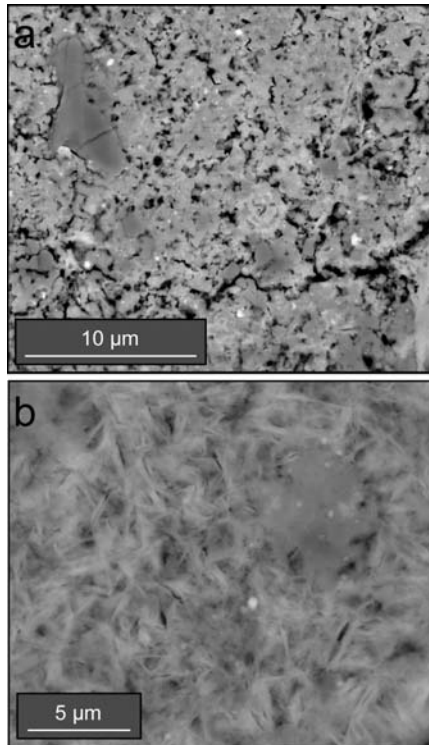


Figure 3. Back-scattered electron images of (a) Fe-poor, unaltered and (b) Fe-rich, altered matrix from MIL 07687.

The results of our imaging survey indicate that presolar grains are found in both the more pristine Fe-poor areas and in the altered Fe-rich ones. Thus, the aqueous alteration experienced by MIL 07687 has not resulted in complete destruction of the presolar grains. However, we do see some differences in the presolar grain abundances between the two types of matrix. Figure 4 shows grain densities in the Fe-rich and Fe-poor matrix areas. Overall we observe 2.6 grains per 1000 μm^2 in the unaltered matrix areas and only 1.7 grains per 1000 μm^2 in the Fe-rich altered regions. Considering just the presolar silicates, abundances are again lower in the altered areas than in the unaltered ones. However, the difference is not as large as might be expected given that presolar silicates are more susceptible to secondary alteration than most presolar grain types.

In addition to the difference in abundance, we observe compositional differences in the presolar silicates from the altered and unaltered areas. Grains from the altered areas have a lower median Fe content than grains from the unaltered areas, 12.5 at.% vs. 17.5

at.%. This differs from the presolar silicates in the ungrouped carbonaceous chondrite Adelaide, which have a factor of two higher median Fe content than presolar silicates from other primitive meteorites [1]. In Adelaide this difference was attributed to an influx of Fe into the grains due to the thermal processing experienced by that meteorite. The lower median Fe content observed here in grains from the Fe-rich matrix areas may also be due to secondary processing. In this case, loss of Fe may have occurred through leaching of Fe from the grains during aqueous alteration and subsequent formation of the Fe oxyhydroxides.

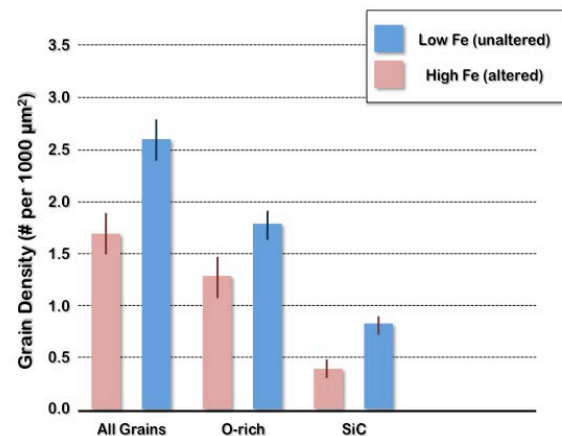


Figure 4. Presolar grain densities (in # of grains per 1000 μm^2) in MIL 07687.

Finally, there is a factor of two difference in the SiC grain density between altered and unaltered matrix areas, 0.4 vs. 0.8 grains per 1000 μm^2 . This difference is somewhat surprising, since SiC should be more resistant to secondary processing than presolar silicate grains. A possible explanation is suggested by the fact that Fe oxyhydroxides rather than phyllosilicates are the dominant alteration product in the Fe-rich matrix areas, indicating that alteration occurred under highly oxidizing conditions [7]. This may have contributed to the partial destruction of presolar SiC grains in those matrix areas affected by aqueous alteration.

References: [1] Floss and Stadermann (2012) *MAPS* 47, 992. [2] Floss and Stadermann (2009) *GCA* 73, 2415. [3] Leitner et al. (2012) *LPSC XLIII*, #1835. [4] Haenecour and Floss (2012) *LPSC XLIII*, #1790. [5] Haenecour et al. (2013) *LPSC XLIV*, #1150. [6] *Ant. Met. Newslett.* (2009) 32, No. 1. [7] Brearley (2012) *LPSC XLIII*, #1233. [8] Brearley (2013) *MAPS Suppl.*, #5206. [9] Stadermann et al. (2009) *MAPS* 44, 1033. [10] Davidson et al. (2014) *LPSC XLV*, #1376. [11] Hynes and Gyngard (2009) *LPSC XL*, #1198.

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