PRESOLAR O- AND C-ANOMALOUS GRAINS IN PRISTINE ORDINARY CHONDRITE MATRICES

J. Barosch[1*], L. R. Nittler[1], E. Dobrică[2], A. J. Brearley[3], D. C. Hezel[4] and C. M. O'D. Alexander[1], Carnegie Institution for Science, EPL (Washington, DC; *jbarosch@carnegiescience.edu), [2]University of Hawai'i at Mānoa (Honolulu, HI), [3]University of New Mexico (Albuquerque, NM), [4]Goethe-Universität Frankfurt (Frankfurt, Germany).

Introduction: The matrices of chondrites contain presolar grains as trace components. These nm- to low µm-sized grains formed in dying stars before the birth of the solar system and are identified by their highly anomalous isotopic compositions. O- and C-anomalous presolar grains have been shown to be present in all classes of chondrites [1], but most previous in-situ studies have focused on carbonaceous chondrites (CC). However, the growing evidence for an outer/inner solar system dichotomy reflected in bulk isotopic compositions of meteorites [2] suggests that CC and non-CC may carry distinct populations of the presolar grain carriers of bulk isotope anomalies. The few in-situ studies conducted on unequilibrated ordinary chondrites (UOC) revealed very diverse abundances of presolar O-anomalous grains (mostly silicates) – from 4–15 ppm in Semarkona [3, 4] up to 275 ppm in Meteorite Hills 00526 [5]. Presolar silicates are easily destroyed by secondary aqueous alteration and only the most pristine matrices may preserve these primary constituents in their original abundances. Most of the Semarkona matrix is much more hydrated than that of MET 00526 [6]; however, a recent transmission electron microscopy (TEM) study detected matrix domains in Semarkona that are dominated by amorphous silicates, which indicates that minimal alteration has occurred [7]. Such pristine areas are prime targets to examine the pre-alteration inventory of presolar grains in UOCs. Here, we investigate the abundances, compositions and characteristics of presolar O- and C-anomalous grains in pristine matrix of Semarkona (LL3.00), MET 00526 (L(LL)3.05), and Northwest Africa 8276 (L3.00).

Methods: We used the Carnegie NanoSIMS 50L ion microprobe for in-situ identification of presolar O- and C-anomalous grains. $^{12,13}C^-$, $^{16,17,18}O^-$, $^{28}Si^-$ and $^{27}Al^{16}O^-$ ion images were recorded in multi-collection mode with a Cs^+ primary beam (~0.5 pA), rastering contiguous 10×10 µm^2-sized frames, and were analyzed via standard methods [8]. Target areas were selected with the SEM to avoid clast-rich and/or visibly altered domains. In Semarkona, we specifically targeted the same matrix areas that showed minimal evidence of aqueous alteration reported in [7].

Results: We mapped a total area of 26,300 µm^2 in Semarkona, 63,300 µm^2 in MET 00526 and 32,600 µm^2 in NWA 8276. We found 42, 73, and 11 O-anomalous grains, as well as 20, 28, and 12 C-anomalous grains, respectively. These yield preliminary matrix-normalized O- and C-anomalous grain abundances of 150^{+27}_{-23} and 45^{+13}_{-10} ppm in Semarkona, 46^{+6}_{-6} and 20^{+5}_{-4} ppm in MET 00526 and 8^{+3}_{-3} and 14^{+6}_{-4} ppm in NWA 8276. The isotopic compositions of the identified presolar grains span similar ranges to those seen in situ in prior studies. For example, most O-anomalous grains are Group 1 silicates [7] with ^{17}O enrichments and slightly sub-solar $^{18}O/^{16}O$ ratios. C-anomalous grains are mostly associated with Si signals and are hence likely SiC; most are ^{13}C-rich and thus likely mainstream grains. TEM data are reported for an unusual compound presolar oxide/silicate grain in Semarkona in a companion abstract [9].

Discussion: Many presolar grains originally present in NWA 8276, and possibly most other UOCs previously studied [3, 4], were likely destroyed by secondary aqueous alteration. Phyllosilicates are visually recognizable in this sample. We found significantly higher abundances of presolar O-anomalous grains in Semarkona than in any previous study, demonstrating the importance of identifying and targeting pristine matrix. The same sample may produce vastly different results due to locally distinct degrees of alteration affecting its matrix. This might also be the case for MET 00526 where individual areas showed variable abundances ranging from 10 ppm up to as much as 137 ppm in a single section. The highest local abundance in MET 00526 is comparable to the pre-alteration abundances detected in Semarkona matrix (150 ppm) and the 145 ±30 ppm from Queen Alexandra Range 97008 (L3.05) [10]. However, we found no evidence for abundances of O-anomalous grains within reach of the 275 ppm previously reported from MET 00526 [5]. This may either indicate a very heterogeneous distribution of presolar grains in MET 00526, and/or a failure to consistently target the most pristine matrix areas in our run. Alternatively, our data may be more representative of MET 00526's presolar grain inventory, as our total mapped area is more than three times larger than [5] and yielded results that seem more in line with abundances determined in other primitive UOCs (i.e., Semarkona and QUE 97008). Our results show that pristine matrix in UOCs contain presolar O-anomalous grain abundances and isotopic compositions comparable to those of lightly altered CCs [1]. However, even the most primitive UOCs (i.e., petrologic type 3.00) may be unable to preserve their most fragile primary constituents, such as presolar silicates. Thus far, there is no definitive evidence for isotopic differences between presolar silicates from outer and inner solar system reservoirs.

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