METEORITE HILLS (MET) 00526: AN UNEQUILIBRATED ORDINARY CHONDRITE WITH HIGH PRESOLAR GRAIN ABUNDANCES. C. Floss[1,2] and P. Haenecour[1,3]. [1]Laboratory for Space Sciences, [2]Physics Department, [3]Department of Earth & Planetary Sciences, Washington University, St. Louis, MO, USA. (Email: floss@wustl.edu)

Introduction: Presolar grain abundances can serve, along with other parameters, as indicators of the degree of alteration experienced by extraterrestrial materials [e.g., 1, 2]. Presolar silicate grains, in particular, are highly labile and only occur in meteorites that have experienced little or no secondary processing. To date the highest abundances (150–200 ppm) have been found in unequilibrated carbonaceous chondrites, particularly samples from the CR and CO groups [e.g., 3].

However, far less work has been done on other chondrite groups. For example, there have been few in situ searches for presolar silicates in unequilibrated ordinary chondrites. Initial investigations suggest very low abundances, on the order of ~10 ppm or less [4, 5]. Somewhat higher abundances (60–90 ppm) have been found in fine-grained rims around chondrules occurring in so-called 'cluster chondrite clasts' [6] from Krymka and NWA 1756 [7]. MET 00526 is an unequilibrated ordinary chondrite that was originally thought to be an H chondrite [8], but was subsequently reclassified as an L/LL chondrite [9]. Here we present the results of a systematic search for presolar grains in the fine-grained matrix of this meteorite.

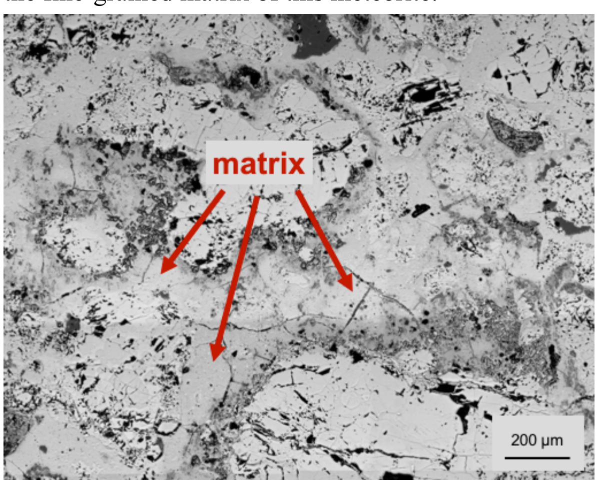

Figure 1. Reflected light image of matrix material in MET 00526.

Experimental: MET 00526 contains abundant fine-grained matrix material interspersed between chondrules and other inclusions (Fig. 1). We carried out NanoSIMS C and O ion imaging measurements in several different matrix areas of this meteorite. The measurements were made in semi-automated mode and involved rastering a ~1 pA Cs^+ ion beam over 10 x 10 µm sized areas within larger (12 x 12 µm) areas presputtered to remove the carbon coat. Presolar grains were identified from ratio images processed using L'Image. The total area measured was 19,200 μm^2.

Results: We identified both O-rich and C-rich presolar grains in all of the matrix areas measured. We found seven SiC grains; all are mainstream grains, with $^{12}C/^{13}C$ ratios between 23 and 75. We also found five grains with $^{12}C/^{13}C$ ratios between 102 and 112; these may be disordered carbonaceous grains similar to those found in other primitive meteorites [e.g., 10], but this needs to be confirmed by Auger analysis. Finally, 32 O-rich presolar grains were found. The isotopic compositions of the grains are similar to those observed in other studies (Fig. 2). Most of the grains are ^{17}O-enriched with close-to-solar $^{18}O/^{16}O$ ratios, characteristic of Group 1 grains [e.g., 11]. One grain is strongly depleted in ^{18}O and probably belongs to Group 2, and two grains exhibit the enrichments in both ^{17}O and ^{18}O of Group 4 grains.

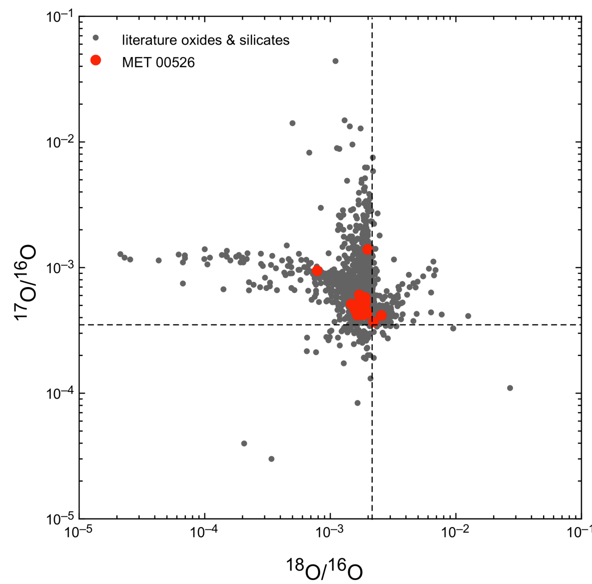

Figure 2. Oxygen three-isotope plot of presolar grains from MET 00526, compared with literature data.

We calculated abundances based on the grain areas and the total area measured. The overall abundance for O-rich grains is 275 ± 50 ppm and for SiC is 65 ± 25 ppm. The abundances are more or less uniform among the different matrix areas analyzed, ranging from 215 to 335 ppm for O-rich grains, and from 55 to 85 ppm for SiC.

Discussion: As Fig. 3 shows, the abundance of O-rich presolar grains in MET 00526 is comparable to (indeed, slightly higher than) the abundances observed in the most primitive carbonaceous chondrites. Notably, it is significantly higher than abundances determined for other unequilibrated ordinary chondrites.

The most commonly used scheme for determining the petrologic type of unequilibrated ordinary chondrites is based on the distribution of Cr in Fe-rich olivine [9]. According to this scheme, MET 00526 is of petrologic type 3.05, making it one of the most unequilibrated ordinary chondrites known. Only Semarkona is considered to be less equilibrated, and is classified as a type 3.00. Similarly, a Raman spectroscopy study of insoluble organic matter in primitive meteorites suggests that Semarkona is less thermally altered than MET 00526 [12].

Despite the fact that MET 00526 and Semarkona both appear to have experienced very limited thermal metamorphism, the abundance of O-rich presolar grains in Semarkona (~4–8 ppm [4, 5]) is almost two orders of magnitude lower than in MET 00526 (Fig. 3). The abundance of SiC, between 10–30 ppm [1, 13] is also lower in Semarkona than in MET 00526, although the difference is not as striking.

Although it has experienced little thermal metamorphism, Semarkona has undergone extensive aqueous alteration; both chondrule rims and matrix are dominated by smectite, and metal and sulfide phases show ubiquitous evidence of alteration [14]. In contrast, a transmission electron microscopy study of MET 00526 indicates that its matrix material consists of a mixture of amorphous silicates and unequilibrated crystalline phases [15]. These authors noted that, although MET 00526 does show signs of aqueous alteration, the effects are minimal compared to those observed in Semarkona. Phyllosilicates are present, but they are heterogeneously developed and not well-crystallized. Moreover, the observation of unaltered Mg-silicates and Ni-poor sulfides indicates that a significant fraction of the primary pre-accretionary assemblage remains in MET 00526 [15].

Past studies have demonstrated that presolar silicates are easily altered or isotopically re-equilibrated by relatively modest degrees of thermal metamorphism and/or aqueous alteration [e.g., 3]. Although Semarkona and MET 00526 have both undergone little thermal metamorphism, the degree of aqueous alteration they have experienced is very different, and this factor likely accounts for the large difference in abundance of O-rich presolar grains between the two meteorites.

Conclusions: MET 00526 is the first non-carbonaceous chondrite with high presolar silicate abundances, comparable to those of the most primitive meteorites studied to date. Our study demonstrates that chondrites of similar petrologic type can have vastly different presolar grain abundances, and emphasizes the need for more systematic presolar grain searches among unequilibrated ordinary chondrites.

References: [1] Huss and Lewis (1995) *GCA* 59, 115-160. [2] Floss and Stadermann (2012) *MAPS* 47, 992-1009. [3] Floss and Haenecour (2016) *Geochem. J.*, in press. [4] Mostefaoui et al. (2004) *LPS XXXV*, #1593. [5] Tonotani et al. (2006) *LPS XXXVII*, #1539. [6] Metzler (2012) *MAPS* 47, 2193-2217. [7] Leitner et al. (2104) *LPS XLV*, #1099. [8] Connolly et al. (2008) *MAPS* 43, 571-632. [9] Grossman and Brearley (2005) *MAPS* 40, 87-122. [10] Floss and Stadermann (2009) *Ap. J.* 697, 1242-1255. [11] Nittler et al. (1997) *Ap. J.* 483, 475-495. [12] Busemann et al. (2007) *MAPS* 42, 1387-1416. [13] Davidson et al. (2014) *GCA* 139, 248-266. [14] Alexander et al. (1989) *GCA* 53, 3045-3057. [15] Dobrica and Brearley (2011) *LPS XLII*, #2092.

This work is supported by NASA grant NNX14AG25G.

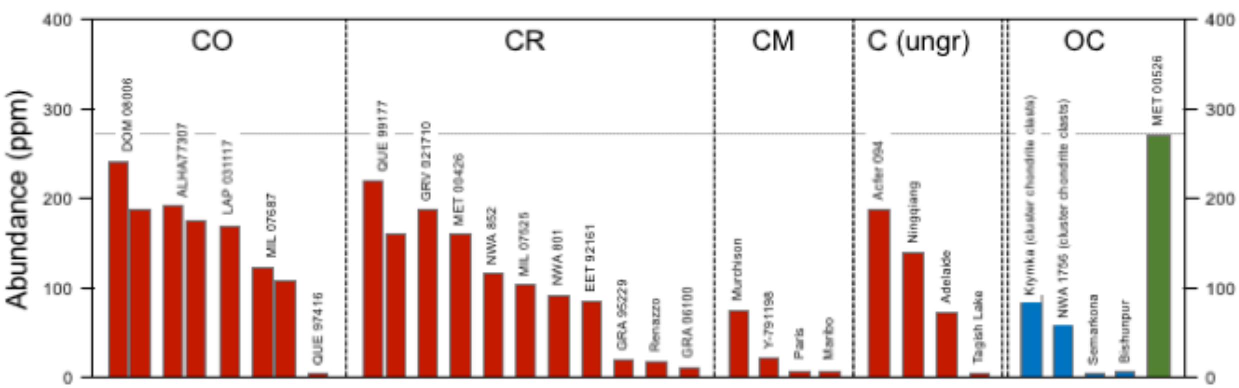

Figure 3. Abundance of O-rich presolar grains in MET 00526 compared with other primitive carbonaceous and ordinary chondrites. Adapted from [3].