**COMPARATIVE TRANSMISSION ELECTRON MICROSCOPY STUDIES OF PRESOLAR SILICATE AND OXIDE GRAINS FROM THE DOMINION RANGE 08006 AND NORTHWEST AFRICA 5958 METEORITES.**

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**Introduction:** The abundance of isotopically identifiable presolar grains contained in primitive chondritic materials decreases with increasing levels of parent body alteration [1, 2]. Presolar silicate abundances are significantly higher in the most primitive interplanetary dust particles (IDPs) than in meteorites, and only a few of the most primitive meteorites contains presolar silicates at levels comparable to typical anhydrous IDPs. Even at modest levels of alteration for which a clear extra-solar O isotope composition is retained, indications of possible parent body alteration of the grains' elemental composition are sometimes observed. For example, Auger electron spectroscopy of presolar silicate grains identified in the Adelaide show elevated Fe contents due to infiltration of Fe from the matrix [2]. Transmission electron microscopy (TEM) of silicates from Acfer 094 suggests that high Fe may be a primary condensation feature, but does not rule out the possibility of diffusion of Fe from the matrix into the interior of amorphous presolar silicates [3]. More *in situ* TEM studies of O-rich presolar grains are needed for meteorites of varying petrographic grades, to deconvolve the parent body or other, e.g., interstellar medium or nebular, processing signatures from primary condensation features.

We have initiated coordinated secondary ion mass spectrometry (SIMS) and TEM studies of two primitive meteorites Dominion Range 08006 (CO3) and Northwest Africa 5958 (C-ung.). The former shows the highest yet-reported meteoritic O-rich presolar grain abundance (>200 ppm), comparable to many IDPs [4]. The later has a lower presolar grain abundance than most unequilibrated carbonaceous chondrites (~ 50 ppm) [5]. NWA 5958 has a CI-like bulk composition, and bulk O isotope and petrographic studies suggested it had experienced little parent body alteration (type 3), albeit significant terrestrial weathering [6]. However, further analysis indicated a lower petrographic grade (type 2) based on the presence of abundant phyllosilicates, inferred from low temperature magnetic succeptibility measurements [7]. Through comparative *in situ* TEM characterization of the O-rich presolar grains in these two meteorites, we seek to address whether specific parent body alteration or terrestrial weathering signatures on the presolar grain surrounding matrix can be identified; and whether preferential preservation or loss of specific grain types (single crystal vs. nanocrystalline, olivine vs. pyroxene) can be identified.

**Experimental:** Presolar grains were identified by NanoSIMS isotope imaging [4, 5]. Matrix cross-sections were extracted from DOM 08006 and NWA 5958 by focused ion beam (FIB) lift-out with a FEI Nova 600 FIB-SEM at the Naval Research Laboratory (NRL). Analytical transmission electron microscopy studies were performed with a JEOL 2200FS field-emission scanning transmission electron microscope at NRL, equipped with a Noran System Six energy dispersive X-ray spectrometer. EDS spectra of individual grains were quantified with Cliff-Lorimer routines, with K factors calibrated from San Carlos olivine and Tanzanian hibonite standards.

**Results and Discussion:** Three matrix sections containing two O-rich presolar grains were extracted from NWA 5958. TEM analysis of the matrix (Fig. 1) reveals it contains fine-grained, sub-micron nominally anhydrous silicates, phyllosilicates, Fe- and Fe-Ni sulfides, with little glass. Cronstedtite was identified in one section. These results support the conclusions of [7] that NWA 5958 is better classified as petrographic type 2 than as type 3.

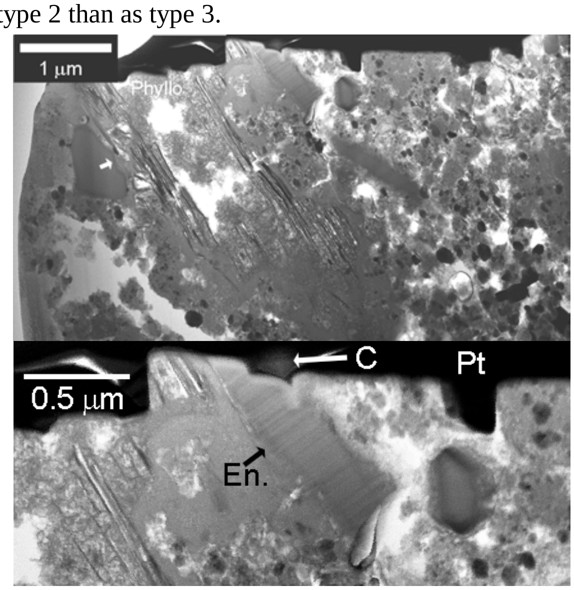


Figure 1. (top) Bright field scanning TEM image of NWA 5958 matrix. Abundant phyllosilicates (Phyllo) are present; some olivines show Fe-rich rims (white arrow), and the sulfides are partially equilibrated. (bottom) Enlargement showing presolar enstatite grain e1-5.

The two O-rich presolar grains, NWA e1-5 and NWA e2-15, are identified as enstatite, possibly hydrated, and polycrystalline AlMg-spinel, respectively (Table 1). Although the pyroxene grain exhibited lamellar contrast indicative of clino-orthopyroxene intergrowth in bright-field TEM and STEM imaging (Fig 1, bottom) it rapidly amorphized during high resolution imaging. Attempts to directly image the lattice prior to amorphization were unsuccessful. This rapid susceptibility to amorphization is presumably due to parent-body hydration, although pre-accretion radiation processing in the ISM could also play a role. The spinel grain (Fig. 2) was stable under high resolution image conditions, and we obtained electron diffraction and lattice images confirming the polycrystalline nature.

Four matrix sections of DOM 08006 were extracted, containing four presolar silicates (Table 1), including two olivine grains and two amorphous grains, e.g., Fig. 3. The matrix is an unequilibrated mixture of amorphous silicate, sub-micron olivine and pyroxenes, metal and sulfides. Some Fe oxhydride is also found, consistent with terrestrial weathering. More comprehensive petrography studies [9] confirm that DOM 08006 is minimally thermally or aqueously altered.

Table 1. Summary of presolar grain data.

| grain | $\delta^{17}O$ (‰) | $\delta^{18}O$ (‰) | Composition and Structure |
|---|---|---|---|
| NWA e1-5 | +796 ±102 | -1 ±36 | $MgSiO_3$ enstatite, amorphized in TEM |
| NWA e2-15 | +628 ±70 | -12 ±23 | $Mg_{0.97}Cr_{0.11}Al_{1.91}O_4$ polycrystalline spinel |
| DOM A2C-15 | +1290 ±44 | -15 ±12 | $Mg_{1.61}Fe_{0.33}Ni_{0.03}Al_{0.02}Si_{1.00}O_4$ olivine (tentative) |
| DOM A2C2-25a | +5034 ±145 | 13 ±25 | $Mg_{0.33}Fe_{0.86}Ca_{0.03}Al_{0.06}Si_{0.84}O_3$ amorphous |
| DOM A2C2-25b | +763 ±54 | -334 ±17 | $Mg_{1.85}Fe_{0.14}Ni_{0.01}Si_{1.00}O_4$ olivine |
| DOM A2-18 | +1554 ±45 | -87 ±11 | $Mg_{0.45}Fe_{0.74}Ni_{0.07}Ca_{0.03}Al_{0.05}Si_{0.82}O_3$ amorphous |

**Conclusions:** Although the total number of grains analyzed is too small to make meaningful statistical comparisons of the grain populations in each meteorite, some inferences are possible. For DOM 08006, where glass remains abundant in the matrix, amorphous presolar grains are also abundant (2 of 5 grains analyzed to-date, including a previously reported CAI-like grain [8]). In contrast, NWA 5958 has abundant phyllosilicates and little glass, and the one silicate identified is a single crystal has signs of incipient hydration. The low abundance of O-rich presolar silicates (~ 50 ppm) in this meteorite is likely due loss of amorphous and weakly crystalline grains as result of hydrothermal alteration on the parent body.

**References:** [1] Huss G. R. and Lewis R. S. (1995) *GCA*, 59, 115–160. [2] Floss C. and Stadermann F. J. (2012) *MAPS*, 47, 992-1009. [3] Vollmer C. et al.. (2009) *ApJ*, 700, 774-782. [4] Nittler L. R., Alexander C. M. O'D. and Stroud R. M. (2013) *LPS XLIV*, Abstract #2367. [5] Nittler L. R. et al. (2012) *MAPS Suppl.* 75, #5233. [6] Bunch T. E.. et al. (2011) *LPS XLII*, Abstract #2343. [7] Elmaleh A. et al. (2012) *MAPS Suppl.* 75, #5389. [8] Stroud R. M., Nittler L. R. and Alexander C. M. O'D. (2013) *LPS XLIV*, Abstract #2315. [9] Davidson J. et al. (2014) *LPS XLV (this volume).*

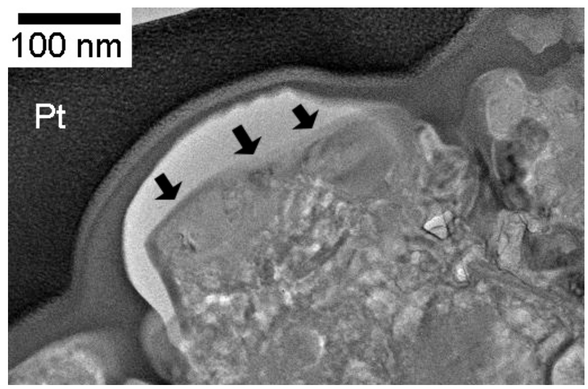


Figure 2. Bright field TEM image of NWA e2-15. Black arrows indicate the top of the grain.

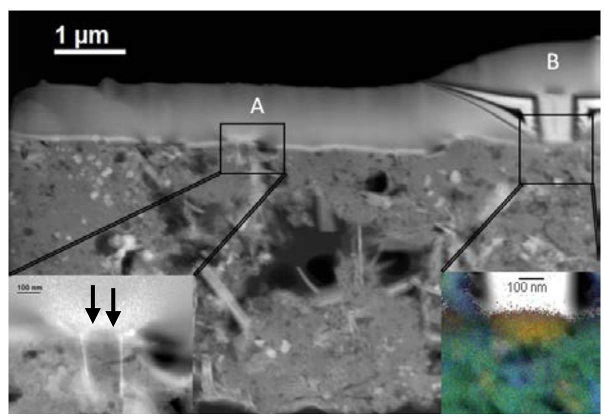


Figure 3. Dark field STEM image of DOM 08006 matrix containing presolar grains A2C2-25a and b**.** (left inset) bright field TEM of A2C2-25a (black arrows). (right inset) RGB composite, MgSiFe EDS map of Mg-rich grain A2C2-25b.