**REFRACTORY INCLUSIONS IN MET 00426, A CR3 CHONDRITE.** Benjamin E. Lin[1,2], Michael K. Weisberg[1,3] and Denton S. Ebel[1] [1]American Museum of Natural History, Manhattan, NY 10024, [2]Amherst College, Amherst, MA 01002 (blin12@amherst.edu), [3]Kingsborough Community College, CUNY, Brooklyn, NY 11235 (mweisberg@kbcc.cuny.edu).

**Introduction:** Meteorite Hills (MET) 00426 is a carbonaceous chondrite found in Antarctica in 2000, and initially classified as a CR2 [1,2]. The fine-grained matrix of MET 00426 was later studied using TEM, which revealed amorphous FeO-rich silicate material and nanosulfide particles that were interpreted as evidence for reclassification as one of two known pristine CR3 chondrites [3].

We obtained a thin section of MET 00426, 46 from the MWG and studied the refractory inclusions and chondrules. This was an opportunity to characterize the inclusions in a pristine CR3 chondrite, look for any evidence of alteration, and test the type 3 classification. If the CR3 designation is correct, the CR chondrites are the only chondrite group that spans the range of petrologic types 1-3. Here we present a petrologic description of inclusions in the MET 00426 CR3 chondrite.

**Methods:** We studied a thin-section of MET 00426 using the petrologic microscope, Hitachi S-4700 FE-SEM equipped with EDS, and SX100 Electron Microprobe at the AMNH.

**Petrography:** *Ca-Al-rich Inclusions (CAI):* Eight refractory inclusions were identified and studied. They range in size from 10 - 100 µm in longest dimension. Textures vary and they can be characterized as three types: (1) spinel-rich, (2) melilite-rich (type A) and (3) spinel-melilite inclusions. **(1) Spinel–rich inclusion:** The largest inclusion is dominated by Mg-Al spinel, containing 1-4 µm inclusions of perovskite. The spinel is associated with laths of hibonite and surrounded by a melilite rim (Fig. 1, 2). We found Cl-bearing sodalite in the melilite rim, presumably a secondary alteration product. The sodalite runs across the rim in a vein-like structure but does not cross into the matrix (Fig. 2). **(2) Melilite-rich (type A) inclusions:** Three inclusions were predominantly melilite with inclusions of perovskite and Mg-Al spinel. These inclusions are similar to compact type A inclusions. One of these inclusions has a fine rim of micron to submicron perovskite and spinel (Fig. 3). **(3) Spinel-melilite inclusions:** Four small (≤10 µm) spinel-melilite inclusions were found, which have spinel cores and melilite rims. Three of these have thin rims of Ca-rich pyroxene surrounding the melilite.

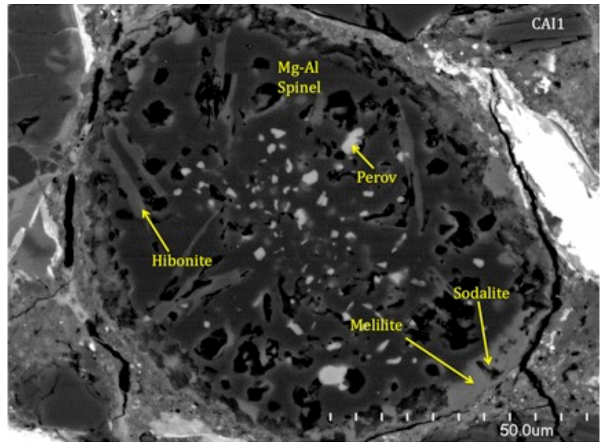


**Fig. 1: BSE image of the largest inclusion in MET 00426, 46 dominated by spinel with small perovskite, minor laths of hibonite and melilite rim.**

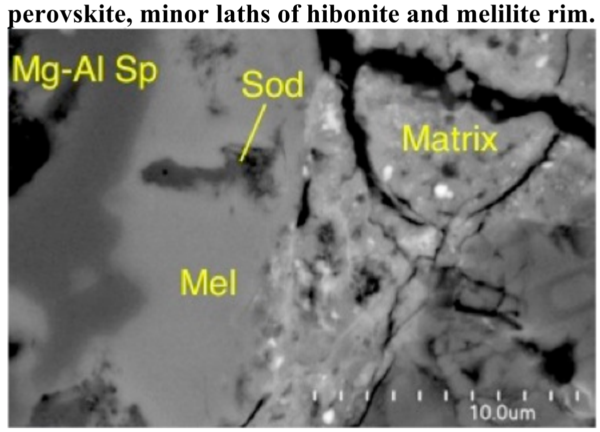


**Fig. 2: Rim of spinel-rich inclusion of Fig. 1 (BSE)**

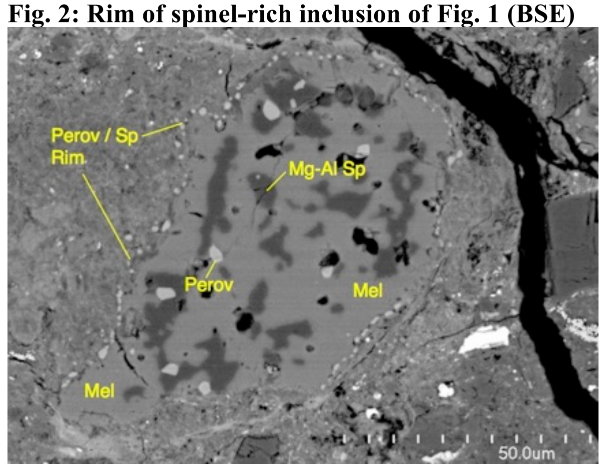


**Fig. 3: BSE image of a melilite-rich CAI in MET 00426, 46. It shows inclusions of Mg-Al spinel and perovskite within melilite, but also a very fine-grained perovskite and Mg-Al spinel rim.**

*Amoeboid Olivine Aggregates (AOA)*: Two AOAs were found, one 50 by 100 µm, the other ~120 µm across. Both AOAs consist of relatively coarse-grained forsterite and Ca-Al-rich minerals. They did not contain the Cal-Al-rich nodules described in AOAs from other CR chondrites [4]. Instead, Ca-Al-rich minerals are equally distributed throughout the inclusions. In one AOA, the Ca-Al-rich minerals are anorthite and very fine-grained diopside (less than 1 µm) (Fig. 4). The other AOA contains anorthite and Ti-bearing Ca-pyroxene.

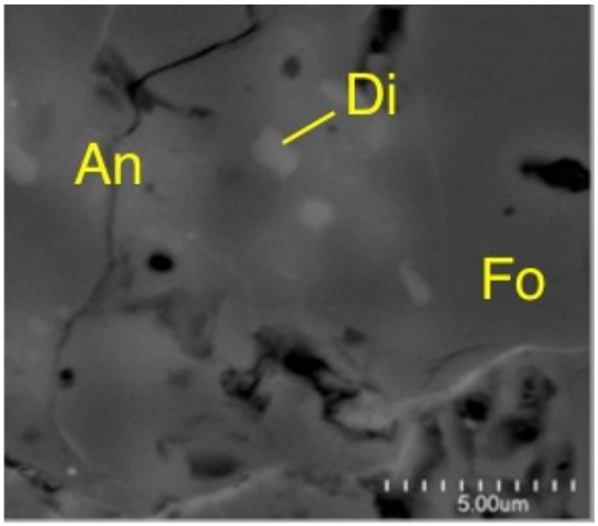


**Fig. 4: BSE image of the interior of an AOA from MET 00426, primarily of coarse-grained forsterite, with anorthite inclusions. Numerous, very fine (<1 µm) diopside grains occur in contacts between anorthite and forsterite.**

*Chondrules:* Chondrules in MET 00426 are similar to those described in CR2 chondrites. They are about 1 mm in diameter and show variations in texture. Most are type I chondrules. However, they differ from the chondrules in CR2 chondrites in lacking phyllosilicates. Chondrules contain forsterite, enstatite, unaltered mesostasis, and Fe,Ni-metal in varying proportions. Barred olivine chondrules are rare. Fe,Ni-metal commonly appears in distinct zones, with some chondrules having a metal rim around them as is characteristic of CR chondrites [e.g., 6]. Only one Type-2 chondrule was found, consisting of two 50-100 µm fayalite grains, which sit next to several spinel-melilite inclusions, and a grain of chromite.

*Fragments:* Near one cluster of spinel-melilite inclusions we found an isolated 10 µm grain of albite , a mineral not found elsewhere in the meteorite. Also near this cluster were several grains of calcite, though calcite was also found in other parts of the sample embedded within the fine-grained matrix. One 1 mm wide, round dark inclusion with several sulfide phases and abundant calcite was also found. In addition, an 80 µm isolated nearly pure forsterite grain was found.

**Discussion:** The inclusions found in MET 00426 are similar to inclusions described previously in other chondrites. Most of the CAIs and AOAs in MET 00426 have compact textures suggesting that they experienced post-formation heating and recrystallization and/or small degrees of melting. No fluffy varieties were found. The textural relationship between mineral phases in the CAIs is also indicative of a more complex formation history. For example, in one CAI, perovskite is concentrated in the center and hibonite laths are found outside near the rims, but thermodynamic calculations predict hibonite should crystallize first if the CAI forms from the cooling of nebular gas [5]. Additionally, the fine-grained spinel and perovskite rim found on one of the melilite-rich inclusions indicates at least a second growth period for those two phases.

The Fe-enrichment and Cl-bearing sodalite found in the melilite rim of the largest CAI is interpreted to result from a metasomatic reaction between the CAI and hydrous fluids, since sodalite is a volatile-bearing secondary phase. Because the alteration does not appear to crosscut into the matrix, and because [3] concluded that the fine-grained matrix is extremely pristine, we infer that the inclusion was altered prior to its accretion into the parent body.

MET 00426 represents an extremely unequilibrated assemblage of different mineral and fragments. We found both end-member forsterite and end-member fayalite, refractory inclusions, and isolated non-refractory grains such as albite and calcite. The rock is a mixture of minerals formed in very different conditions, and the borders between inclusions and matrix are well-defined. The glassy mesostasis in chondrules is pristine and does not show any evidence of alteration, unlike most other CR chondrites [6]. Petrological classification as a type 3 is, however, complex, considering the presence of calcite and secondary minerals in some refractory inclusions and in dark inclusions.

**References:** [1] McCoy, T. and Welzenbach, L. (2001) *Antarctic Meteorite Newsletter, Vol. 24, No. 2,* Sept 2001: 18. [2] Russell, S. S. et al. (2002) *Meteoritics & Planet. Sci., 37,* A157-A184. [3] Abreu, N. and Brearley, A. (2010) *Geochimica et Cosmochimica Acta, 74,* 1146-1171. [4] Weisberg, M. K. et al. (2004) *Meteoritics & Planet. Sci., 39, No. 10,* 1741-1753. [5] Ebel, D. S. (2006) *Meteorites & the Early Solar Sys. II,* 253-277. [6] Weisberg, M. K. et al. (1993) *Geochimica et Cosmochimica Acta, 57,* 1567-1586.