COMPLEX REFRACTORY CAIs FROM THE NWA 3118 AND EFREMOVKA CV3 CHONDRITES. M. A. Ivanova[1,2], C. A. Lorenz[1], A. N. Krot[3], and G. J. MacPherson[2], [1]Vernadsky Institute, Kosygin St. 19, Moscow 119991, Russia. e-mail: meteorite2000@mail.ru, ivanovama@si.edu; [2]Department of Mineral Sciences, National Museum of Natural History, Smithsonian Institution, Washington, DC. 20560; [3]University of Hawai'i at Mānoa, Honolulu, HI 96822, USA.

Introduction: Several complex and compound refractory inclusions were discovered among a new suite of CAIs (~0.5 to 2 cm) from the Efremovka and NWA 3118 CV3 chondrites. The structures and bulk compositions of these CAIs record not only the effects of high temperature volatility-controlled processes during the first 1-2 million years of solar system history [1,2], but also a complex history of multiple melting events interspersed with collisions and merging.

Analytical procedure: Polished sections of CAIs were studied using an FEI Nova NanoSEM 600 scanning electron microscope, equipped with a Thermo Electron energy dispersive X-ray spectrometer. Minerals were analyzed using a JEOL JXA-8900R electron microprobe at the Smithsonian and a Cameca-SX100 at the Vernadsky Institute.

Results and Discussion: The complex CAIs ("E" and "N" denote Efremovka and NWA 3118, respectively) include:

(a) a heterogeneous, possibly composite object (*27bE)*, whose bulk composition is intermediate between Types B and C CAIs;

(b) an unusual compact Type A inclusion *(7N)* whose core is nearly-pure melilite, and which is surrounded by two different mantles. The bulk composition of the core is typical of Type As, the porous inner mantle lies in the field of Type Bs, and the outermost mantle lies in the field of Type Cs [3];

(c) a clearly-composite Type B1 + Type B2 CAI (*10Na*, *10Nb*) whose respective bulk compositions match typical Type B CAIs;

(d) a fluffy Type A CAI (*33E-1*) that contains both an amoeboid olivine inclusion (AOA) and a Zr,Sc,Y-rich CAI (Figs. 1, 2) [4];

(e) a large composite object *(3N)* (Fig. 3) that consists of many CAIs of different types including a unique Zr,Sc,Y-rich CAI (*3N-24*) (Fig. 3, 5) [4].

During section preparation of the CAI *3N* as well as several other CAIs, we established that they have round shapes only in one section. Other sections indicate that the natural shapes of the inclusions are flat to even bowl-like (i.e., possibly aerodynamic). Based on this observation and chemical and (as yet undone) isotopic properties it may be possible to model the CAI movements through the protoplanetary disk, including velocities and ablation processes.

CAI *3N* is remarkable relative to any other composite CAI we have ever seen. The rounded 1.7×1.7 cm object encloses 26 separate CAIs of different types and textures (Fig. 3). Several have a sharp boundary with the CAI-host material, but others have poorly-defined margins that merge with surrounding material. Although the mineralogy of all the CAIs is similar – melilite, spinel, pyroxene, and anorthite, with minor FeNi metal, secondary nepheline and sulfide – the distribution of minerals is highly variable. The textures and bulk compositions (Fig. 4) of some identified objects within CAI *3N* match known types of CAIs, *e.g.*, a compact Type A and many Type Bs; their bulk compositions lie near the trend defined by equilibrium condensation of a gas of solar composition. However, the bulk compositions of several "CAIs" inside the host object are grouped near the liquidus minima within this portion of the CMAS system system (Fig. 4), near the field of pyroxene+liquid, and away from the fields of typical Types B and C CAIs and also Al-chondrules. They include object *3N-24* (described in [4]), *3N-7*, and *3N-26* (Fig. 5). All these objects are coarse-grained and their textures indicate melt solidification. Their bulk compositions are unexpected, because there should be no relationship between nebular CAI compositions and any features on liquidus diagrams. We suggest that these particular objects within CAI *3N* are not separate CAIs at all but, rather, local zones of partial melting of the host CAI. Their compositions represent the composition of eutectic and peritectic melting. This interpretation will be tested by additional investigations of mineral chemistry and isotopic investigations.

References: [1] MacPherson G. J. (2003) *In Treatise on Geochemistry*, 1 (ed. A. M. Davis), 201–247. [2] Krot A. N. et al. (2005) *Nature*, *434*, 998–1001. [3] Ivanova M. A. et al. (2010) *Meteorit. Planet. Sci.*, *45*, Abstract #5266. [4] Ivanova M. A. et al. (2011) *LPS XLII*, (this volume).

Fig. 1. Combined elemental map in Mg (red), Ca (green), and Al (blue) of a complex CAI *33E-1* from Efremovka (CV). The CAI is composed of three major types of materials: fluffy Type A CAI, Zr-rich CAI *33E*-1A, and forsterite-rich accretionary rim (red), which is mineralogically similar to amoeboid olivine aggregates. fo = forsterite; mel = melilite; px = Al,Ti-diopside; sp = spinel.

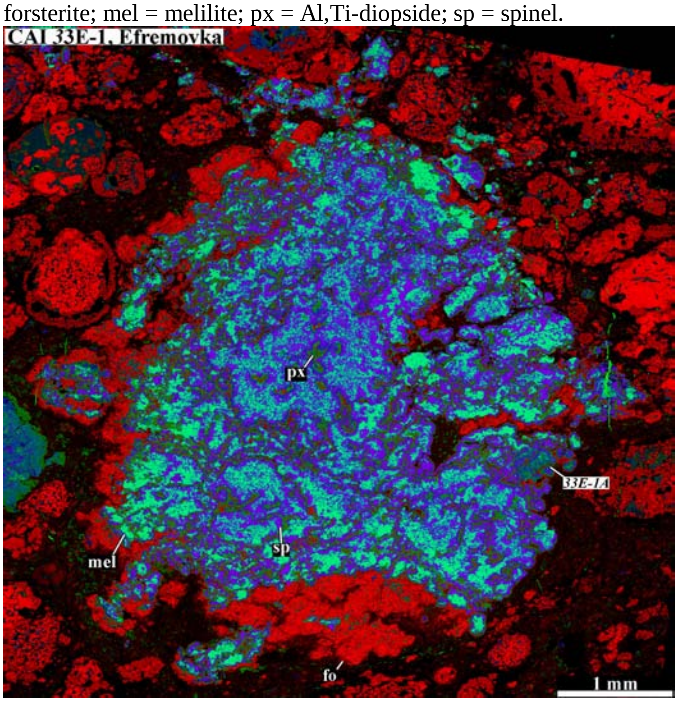

Fig. 3. Combined elemental map in Mg (red), Ca (green), and Al (blue) of a complex CAI *3N* from the CV carbonaceous chondrite NWA 3118. The CAI is composed of 26 CAIs of different types. CAIs *3N-7*, *3N-24*, and *3N-27* described in the text are indicated. an = anorthite.

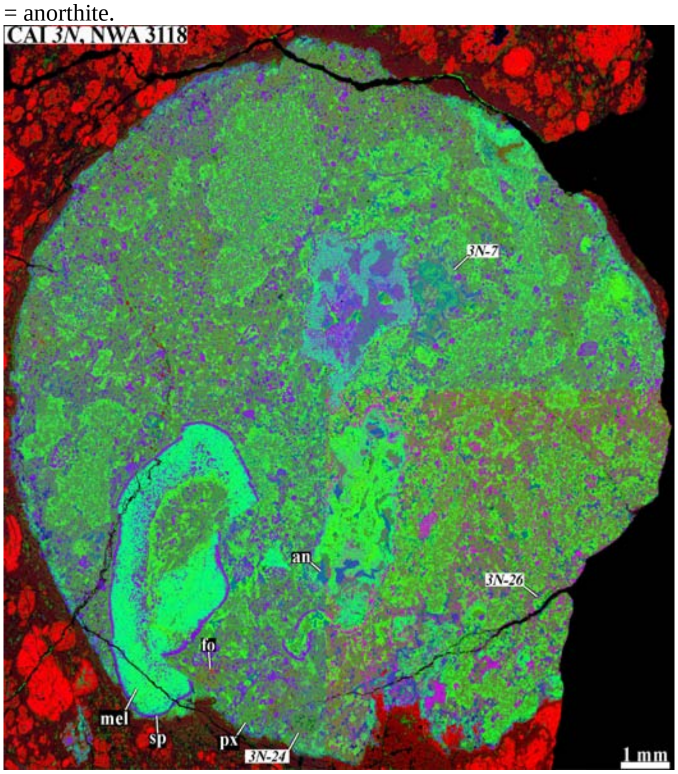

Fig. 2. BSE image of a compound CAI *33E-1* composed of fluffy Type A CAI, Zr-rich CAI, and forsterite-rich accretionary rim (red), which is mineralogically similar to amoeboid olivine aggregates. The Zr-rich CAI *33E-1A* is indicated (see [4] for details).

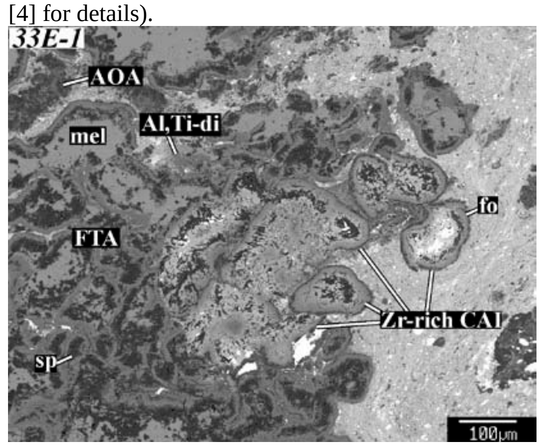

Fig. 4. Bulk chemical compositions of individual CAIs within a complex inclusion *3N* from NWA 3118.

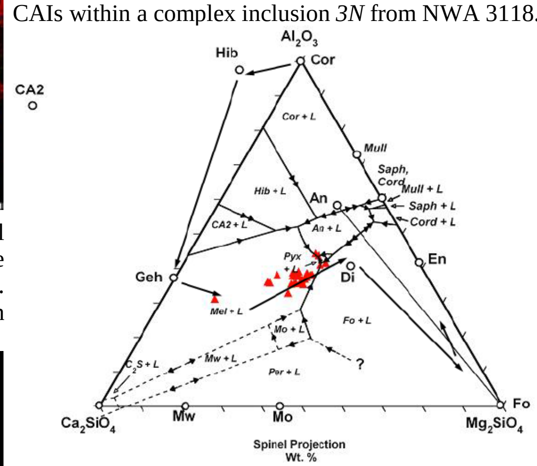

Fig. 5. BSE images of CAIs *3N-24*, *3N-7* and *3N-26*.