METAL-RICH CAI's IN EFREMOVKA (C3); Nazarov M.(1),F. Brandstätter(2), A.A.Ulyanov(1), G.M.Kolesov(1), and G.Kurat(2). (1) Vernadsky Institute of Geochemistry and Analytical Chemistry, Moscow 117975, USSR. (2) Naturhistorisches Museum, A-1014 Vienna, Austria.

Calculations of the condensation sequence of chemical elements from a gas of solar composition show that after the formation of Ca-Al-rich inclusions (CAI's) FeNi should condense, closely followed by forsterite (1). Although there are abundant CAI's rimmed by olivine, those enveloped by FeNi metal are missing. Generally CAI's contain rare metal nuggets which are extremely enriched in refractory siderophile elements (RSE's) such as Os, Ir, Re, W, Mo and others (2-7). We describe here two CAI's from Efremovka (E38 and E61) which are very rich in metal and compare these with normal CAI's described in the literature and one from Efremovka analyzed by us (E49).

E38 is a type B inclusion with well developed core-mantle structure. The core consists of melilite (Ak 42-76), Ti-Al pyroxene, spinel, and anorthite. The mantle (500 µm thick) consists only of melilite (Ak 11-32). The whole object is thinly enveloped by spinel followed by pyroxene and covered by a thick (100 µm) olivine layer. E38 contains 0.8 vol.-% FeNi nuggets ranging in size from a few um up to 1 mm. They are concentrated in the core with the largest nuggets at the core-mantle boundary. Small nuggets (up to 10 µm) are also present in the rim, mainly at the base of the olivine layer. Large metals are rounded, small are irregular in shape. They normally consist of kamacite (k) and taenite (t) but individual k and t particles are also present. Mainly the large metals are accompanied by schreibersite, daubreelite, chromite and V-rich magnetite. Commonly they are rimmed by thin Ca-phosphate (inner) and V magnetite (outer) layers. Compositions of k and t are plotted in Fig.1. INAA of the largest metal nugget (~1 mm) shows high and fractionated RSE contents (up to 500xCI), fairly unfractionated medium volatile siderophile elements (~15 - 29xCI for Pt, Ni, Co) and a depletion in Fe (3.5xCI)(Fig.2).

E61 is a type A inclusion consisting of melilite (Ak 15-24), perovskite, spinel, and trace amounts of secondary minerals. It is rimmed by successive (thin) layers of hibonite+perovskite, melilite (Ak 8), and diopside. It contains 1.4 vol.-% metal ranging in size from a few µm up to 70 µm. The shapes are mostly irregular, commonly elongated and controlled by the silicates and oxides. However, some silicate areas contain very abundantly, very small (1-4 µm) metal droplets. The metals are not rimmed but their surfaces are commonly decorated by small crystals of V magnetite. The individual metal particles consist of k and t which are poorer in Co than the E38 metals (Fig.1). The bulk metal composition estimated by integration is Fe 78.2, Ni 21.2, Co 0.92 (wt.-%). There is no metal in the rims.

E49 is a type A inclusion consisting of melilite (Ak 15-59), perovskite, and spinel. It is rimmed by a sequence of "Wark-Lovering" layers and contains more secondary phases than E38 and E61. The metal content is only 0.0016 vol.-%, typical for CAI's.

METAL-RICH CAI's
Nazarov, M. et al.

The metal nuggets are very small (3-6 µm) and consist mainly of t. Only one k - t intergrowth could be analyzed (Fig.1).

Discussion and conclusions. The abundances of major and trace elements of Efremovka CAI metal are volatility controlled and indicate vapor-solid exchange reactions under oxidizing conditions (Fig.2). A depletion of the most refractory RSE's Os and Re relative to Ir indicates a high-T solid-vapor fractionation and strongly suggests that the metal of metal-rich CAI's in Efremovka was formed as a condensate from a fractionated, super RSE-depleted vapor. Since FeNi should not be stable during the high-T destillation event which led to the formation of CAI's its presence in large amounts in E38 and E61 can only be explained by mixing. Simple mixing of refractory silicates and oxides with FeNi (the ingredients must be made separately) is possible for E61 but impossible for E38. The latter has a core mantle structure which implies that it suffered a partial volatilization event after accretion which the FeNi should not have survived. We have to conclude, that the metal must have been added to the CAI's after their silicate and oxide compositions have been established. The trace element signature of the metal indicates a condensation event. This could have taken place at the coolest locations of the cooling CAI's, the interior vesicles and pore space (8).

References: (1) Grossman,L. and J.W.Larimer (1974) Rev.Geophys.Space Phys. 12, 71. (2) Palme,H. and F.Wlotzka (1976) Earth Planet.Sci.Letts. 33, 45. (3) Wark,D.A.and J.F.Lovering (1976) Lunar Planet.Sci.VII, 912. (4) Fuchs,L.H. and M.Blander (1980) Proc.Lunar Planet.Sci.Conf.11th, 929. (5) ElGoresy,A.et al.(1978) Proc.Lunar Planet.Sci.Conf.9th, 1279. (6) Wark,D.A.(1986) Earth Planet.Sci.Letts. 77, 129. (7) Fegley,B. and H.Palme (1985) Earth Planet.Sci.Letts. 72, 311. (8) Arrhenius,G. and B.R.De (1973) Meteoritics 8, 297.

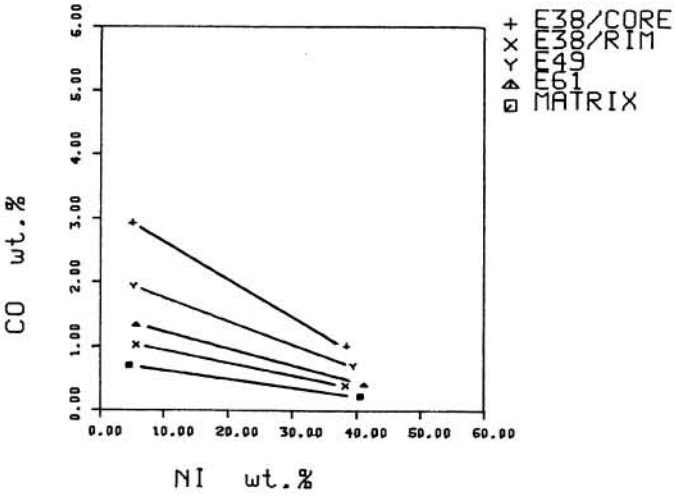

Fig.1: Average compositions of metals in Efremovka CAI's and matrix.

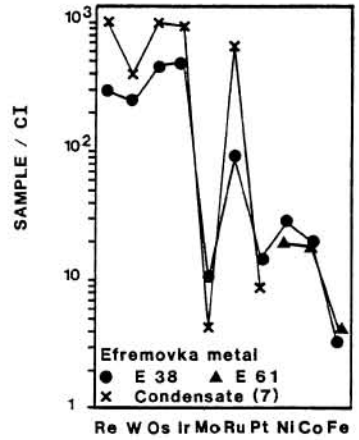

Fig.2: Composition of metal in Efremovka CAI's normalized to CI_3 and calculated metal alloy condensate (fraction in solid $x10^3$) (7).