TRACE ELEMENT DISTRIBUTION BETWEEN MINERALS OF NODULES, VEINS AND FINE-GRAINED METAL PARTICLES FROM SOME ORDINARY CHONDRITES. S. N. Teplyakova[1], M. Humayun[2], C. A. Lorenz[1], M. A. Ivanova[1], A. V. Korochantsev[1], and D. A. Sadilenko[1] , [1]Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Sciences, Moscow, Kosygina st.19, 119991 (elga.meteorite@gmail.com), [2]National High Magnetic Field Laboratory and Department of Earth, Ocean & Atmospheric Science, Florida State University, 1800 E. Paul Dirac Drive, Tallahassee, FL 32310, USA.

Introduction: It is known that ordinary chondrites occasionally contain large (>3mm in size) metallic Fe-Ni particles which are called "metal nodules", distinct from fine-grained metal particles (<2 mm) [1]. Nodules are often depleted in Re, Os, Ir, Ru, Pt, Rh and Cu compare to fine-grained metal (FGM) and enriched in W, Mo, Ni Co, Au, As, and Sb [1-2]. The different origin of nodules and fine-grained chondrite metal is suggested [1-4]. Here we report preliminary results on major and trace element distribution in FGM, nodules and metal veins from four ordinary chondrites.

Samples and methods: We have studied four meteorites - Ash Creek (L6), Timochin (H5), Kunya-Urgench (H5), and NWA 1588 (H3.8) that belong to meteorite collection of Russian Academy of Sciences. We had a chance to explore large slabs of chondrites Kunya-Urgench and Timochin and observe large metal veins and nodules in macroscopic scale. Major and trace elements were determined in thick polished sections of separated metal objects and host chondrite samples by LA-ICP-MS [5] at Florida State University.

Results: Ash Creek contains the FGMs ranging from 0.5 to 2 mm in size and metal nodules. The FGMs mainly consist of taenite (up to 22.3 % Ni), kamacite with minor troilite and metallic copper. The nodules range from 3.1-17 mm in size and consist of kamacite and troilite only.

The taenite from FGMs is enriched in Re, Os, Ir, Ru, Pt, Rh and Cu, Au, W, Mo, up to 7-12xCI and volatile siderophiles such as Sb, Ga, Ge, Sn (1-3xCI) relative to bulk CI chondrite abundances. The element distribution patterns of kamacite show complementary depletions in Re, Os, Ir, and Pt with a higher concentration of Ru among these refractory siderophiles over W and Mo. The kamacite from FGMs contains refractory siderophiles and As with enrichment 5-10xCI, Co -17xCI and Cu, Ge, Sn - 5-0.7xCI. The kamacites from nodules contain less refractory siderophile element abundances (0.01-3xCI) than the FGMs, and are similar to the FGMs in As, Cu, Ge, Ga, and Sn. The troilite is strongly depleted in all trace elements (0.1-0.005xCI) with the exception of Cu and Mo relative to Fe-Ni metal (Fig 1).

NWA 1588 contains FGM ranging in size from 0.5 to 2 mm. The FGMs consist of taenite (up to 11.6 % Ni) and kamacite. One isometric nodule, 35 mm in size, was found in the section. The taenites and kamacites are enriched in refractory siderophiles and Ni, Co relative to CI. The kamacite from nodules are more depleted in Re, Os, Ir, Ru, Pt, Rh, Sb 0.1-1xCI than kamacite from the FGM particles (Fig. 2).

The FGMs of Timochin range in size from 0.5 to 1.5 mm. A noticeable feature of Timochin is a straight metal vein of 2 mm thickness, intersecting the whole meteorite. The FGMs consist of taenite (up to 24.5 % Ni) or kamacite (Fig. 3). The large vein consists of kamacite and troilite. The FGM taenites are enriched in all trace elements and Ni, Co, up to 2-12xCI. The FGM kamacite shows a smooth pattern with depression in Re, Os, Ir, Ru, Pt, Rh and As in the range of 2-10xCI. A relative abundance of Co is 9xCI; Cu, Ga, Ge, Sn - 0.3-0.9xCI. The kamacite of metal vein (Fig. 3) is similar to that from several FGMs.

Kunya-Urgench (H5) contains FGMs ranging from 0.5 to 2 mm in size and metal nodules interconnected by metal veins.

The FGMs consist of taenite (up to 23.6 % Ni) or kamacite. Nodules (up to 200 mm in size) consist of kamacite and troilite. Observed part of vein is up to 20 cm in long dimension, and it contains kamacite and oriented minor troilite inclusions with metallic copper. The taenites are more enriched in trace siderophile elements, up to 2-12xCI. The kamacite from FGMs has a smooth pattern with depression in Re, Os, Ir, Ru, Pt, Rh and As in the range 3-9xCI, and depleted in Cu, Ga, Ge, and Sn (0.6-1xCI). The kamacite from veins is similar to that from FGMs in volatiles - As, Co, Cu, Ga, Ge, Sn and depleted in refractory siderophiles compare to FGMs. The kamacite from nodules is depleted in Re, Os, Ir, Ru, Pt, Rh compared to FGMs and vein kamacites. Troilites are extremely depleted in all trace siderophile elements compared with FeNi metal (Fig. 4).

Discussion: The distribution of trace elements in mineral phases is not dependent on petrological type of chondrite. Among investigated phases the positive correlation is observed between refractory siderophiles and Ni. It was shown [6, 7] that the large atoms of siderophiles will partition preferentially into taenite. Associated metal and sulfide phases in all studied objects have complementary distribution patterns.

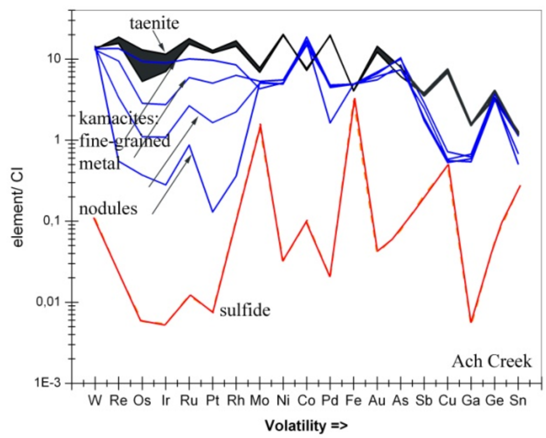

Fig. 1. The distribution of siderophile elements in minerals of Ash Creek (L6) metal phase.

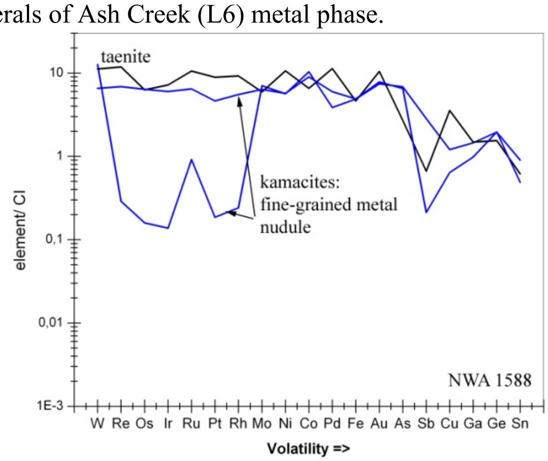

Fig. 2. The distribution of siderophile elements in minerals of NWA 1588 (H3.8) metal phase.

The distinct depletion in compatible siderophiles in nodules and the Timochin vein are consistent with extraction of a Fe-Ni-S melt formed on the chondrite parent body, perhaps by impact heating [1, 4], as indicated by experimental partitioning in the Fe-S system [8,9]. Our textural observations of Kunya-Urgench confirm that nodules were formed by filling of cavities in the host chondrite by metal flowing through fractures forming veins. Further siderophile fractionation may have taken place during cooling of melt flowing through fractures and led to formation of nodules, the most-depleted in siderophiles, as pools of residual liquids. Unlike Kunya-Urgench veins, the large vein in Timochin demonstrates a moderate fractionation relative to the FGMs that could correspond to initial stage of partial melting of source metal. This small fractionation is inconsistent with the large size of vein in Timochin. The FGMs should be linked to bulk H chondrite metal composition [2].

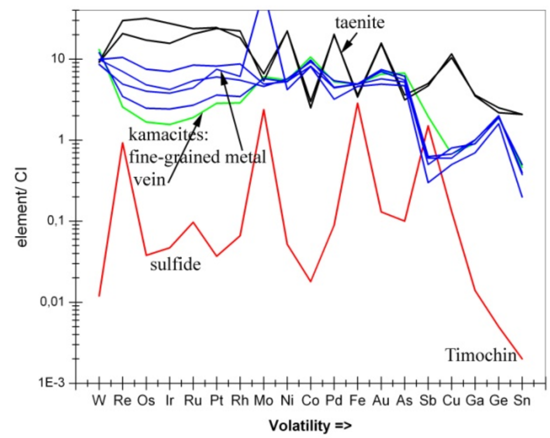

Fig. 3. The distribution of siderophile elements in minerals of Timochin (H5) metal phase.

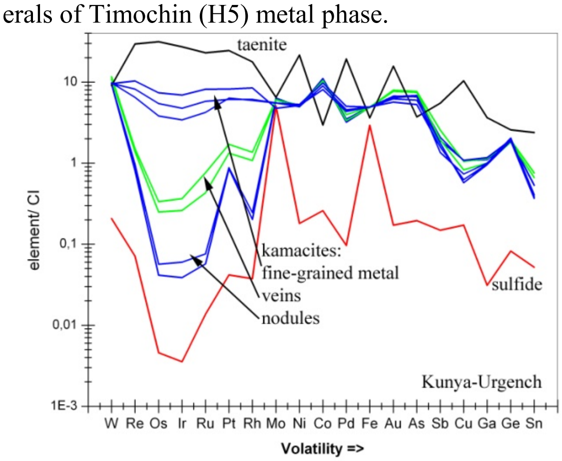

Fig. 4. The distribution of siderophile elements in minerals of Kunya-Urgench (H5) metal phase.

Consequent depletion in refractory siderophiles in order: FGMs→veins→nodules was observed. Probably the metal in the vein was formed by high-degree partial melting of FMGs without significant separation and removal of the sulfide-rich portion. The nodules appear to be liquids formed by parent-body processes that concentrated Fe-S liquids into small pools (nodules).

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