

**THE ADHI KOT EH4 ENSTATITE CHONDRITE: TRACE ELEMENT DISTRIBUTION AMONG ACCESSORY MINERALS.** Lavrentjeva Z.A., Lyul A.Yu. V. I. Vernadsky Institute of Geochemistry and Analytical Chemistry RAS, Moscow, lavza@mail.ru

**Introduction:** Enstatite chondrites (EC) are proposed to have formed in the inner regions of the disk, in an environment that was highly reducing (i.e. low oxygen fugacity), in contrast to the oxidizing conditions seen in many other meteorite groups [1,2]. This inference is supported by the high  $Mg/(Mg + Fe)$  of olivine and pyroxene, presence of Si in Fe,Ni metal, and occurrence of typically lithophile elements, such as Ca, Mg, Mn and K, in sulfide minerals in enstatite chondrites [3]. EC classified into the high-siderophile group EH and low-siderophile group EL [4]. This work reports data on the composition of mineral fractions on the Adhi Kot EH4 enstatite chondrite which are considered from the viewpoint of cosmochemical history of EH chondrites. The Adhi Kot EH4 enstatite chondrite breccia consist of silica-rich clasts (12+5 vol %), chondrule-rich clasts (55+10 vol %) and matrix (35+10 vol %). The silica – rich clasts are new kind of enstatite chondritic material, which contains more cristobalite (18 – 28 wt%) than enstatite (12 – 14 wt%), as well as abundant niningerite and troilite [5]. We studied following fractions of accessory minerals: cristobalite, olivine, yellow pyroxene, sphalerite, osbornite and schreibersite from unequilibrated Adhi Kot EH4. The mineral fractions were selected by particle – size analysis and handpicking under microscope. The elemental composition of fractions was analyzed at the Central Laboratory of GEOKHI RAS using optimized version of neutron-activation analysis developed for analyzing extraterrestrial material [6].

**Results and discussion:** Under consideration are peculiarities of trace element composition of accessory minerals extracted from unequilibrated Adhi Kot EH4 enstatite chondrite. The analysis of the chemical composition of the obtained data showed that: The Ca content in the *light-green* olivine (fraction C) is an order of magnitude higher than that in the *dark-green* olivine (fraction D) (Fig 1.). The siderophile element contents in low-calcium olivine higher than in high-calcium olivine. Perhaps, that the Ca content is indicator of the thermal history of olivines. The fractions C and D are enriched in REE with the prominent predominance of heavy REE  $[(Lu/La)_{C,D}/(Lu/La)_{CI}] = 1.4$  and  $3.3$ , respectively, with negative and positive Eu anomalies  $[(Eu/Sm)_{C,D}/(Eu/Sm)_{CI}] = 0.8$  and  $1.6$ , respectively. The light-green olivine are characterized more high ration of lanthanum to samarium  $[(La/Sm)_C/(La/Sm)_{CI}] = 1.4$ , than dark-green olivine –  $0.9$ . The light-green olivine and dark-green olivine D are characterized by LREE depletion

in with regard to HREE  $[(La/Lu)_{C,D}/(La/Lu)_{CI}] = 0.7$ ;  $0.3$  respectively.

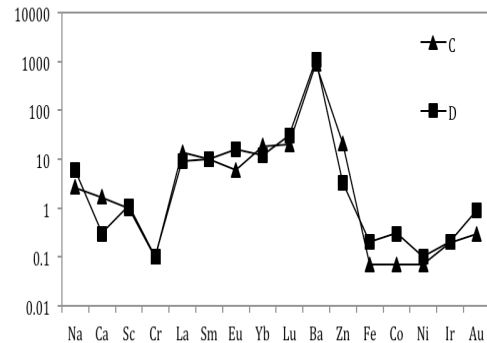


Fig.1. CI chondrite-normalized of trace element abundance patterns in olivine from Adhi Kot EH4 enstatite chondrite: fraction C (light-green olivine); fraction D (dark-green olivine).

In cristobalites A and B (Fig 2) are large variations in compositions of lithophile and siderophile elements.

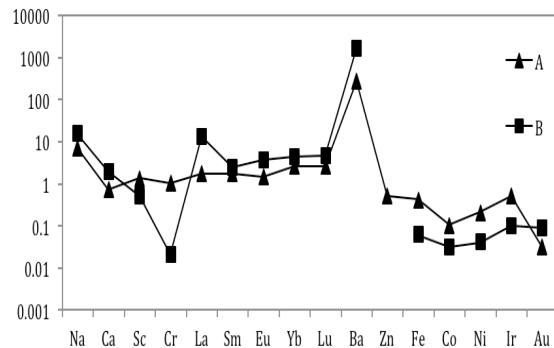


Fig.2. CI chondrite-normalized of trace element abundance patterns in cristobalite from Adhi Kot EH4 enstatite chondrite: fraction A (“fine-grained” cristobalite); fraction B (“coarse-grained” cristobalite).

Cristobalite A (“fine-grained” fraction) is enriched in REE with the prominent predominance of HREE  $[(Lu/La)_A/(Lu/La)_{CI}] = 1.5$  and negative Eu anomaly  $[(Eu/Sm)_A/(Eu/Sm)_{CI}] = 0.8$ . Cristobalite B (“coarse-grained”) is enriched in LREE  $[(La/Lu)_B/(La/Lu)_{CI}] = 2.9$  and have positive Eu anomaly  $[(Eu/Sm)_B/(Eu/Sm)_{CI}] = 1.5$ . Lanthanum show fractionation to samarium with enrichment La in cristobalite B -  $[(La/Sm)_B/(La/Sm)_A] = 5.4$ . The  $[(Ir/Au)_{A,B}/(Ir/Au)_{CI}]$  ratio in cristobalites A, B varies from 1.1 to 16.6. This fact supports the opinion that, the main

processes controlling of composition cristobalites was nebular fractionation. Cristobalite A (“fine - grained” fraction has the ratio  $[(\text{Ir}/\text{Ni})_A / (\text{Ir}/\text{Ni})_{\text{CI}}] / [(\text{Au}/\text{Ni})_A / [(\text{Au}/\text{Ni})_{\text{CI}}] = 16.6$ , more than cosmic (cosmic is 3.44). The superabundant in Ir to Au witness as to formation of “fine - grained” cristobalite by agglomeration of components enriched in refractory metal (Ir) with components enriched in no refractory metal (Au).

*Yellow pyroxene* (fraction E) (Fig. 3) is the high abundances of scandium relative the calcium in comparison with their content in other accessory minerals. Pyroxene is enriched in REE with the prominent predominance of HREE  $[(\text{Lu}/\text{La})_E/(\text{Lu}/\text{La})_{\text{CI}}] = 2.0$  and lowest negative Eu anomalie  $[(\text{Eu}/\text{Sm})_E/(\text{Eu}/\text{Sm})_{\text{CI}}] = 0.3$ . One of the feature of yellow pyroxene is characterized by CI chondrite ratio of siderophile elements with different condensation temperature  $[(\text{Fe}, \text{Co}, \text{Ir}, \text{Au} / \text{Ni})_E] / [(\text{Fe}, \text{Co}, \text{Ir}, \text{Au} / \text{Ni})_{\text{CI}}] = 1.0$ , which indicates the even distribution Fe, Co, Ir, Au, Ni in this fraction.

*Sphalerite* (fraction F) (Fig. 3) are enriched in refractory lithophile Ca, Sc, REE, Ba and non-refractory Na. One of the feature of sphalerite is characterized the high contents Cr, Au и REE in comparison with their content in other accessory minerals. Sphalerite is enriched in REE with the prominent predominance of HREE  $[(\text{Lu}/\text{La})_F/(\text{Lu}/\text{La})_{\text{CI}}] = 2.0$  and negative Eu anomalie  $[(\text{Eu}/\text{Sm})_F/(\text{Eu}/\text{Sm})_{\text{CI}}] = 0.95$ . Other feature of element distribution in the sphalerite is the high abundances Co, Ir and Au relative to Ni -  $[(\text{Co}, \text{Ir}, \text{Au}/\text{Ni})_F/(\text{Co}, \text{Ir}, \text{Au} / \text{Ni})_{\text{CI}}] = 2.5; 5.0; 12$ , respectively.

One of the features of element distribution in *osbornite* (fraction G) (Fig. 3.) is the low contents of Cr, Fe, Ni, Co and Au relative to those in other accessory minerals. The osbornite have the highest refractory siderophile Ir abundance relative to non-refractory siderophile Ni, Co и Au. Other feature of element distribution in osbornite is the high abundance Ca relative to Sc -  $[(\text{Ca}/\text{Sc})_G/(\text{Ca}/\text{Sc})_{\text{CI}}] = 15.5$ ; Ni relative to Co -  $[(\text{Ni}/\text{Co})_G/(\text{Ni}/\text{Co})_{\text{CI}}] = 4.5$ ; Ir relative Au -  $[(\text{Ir}/\text{Au})_G / (\text{Ir}/\text{Au})_{\text{CI}}] = 3.7$  and the low abundance Na relative K -  $[(\text{Na}/\text{K})_G/(\text{Na}/\text{K})_{\text{CI}}] = 0.06$ ; Fe relative Ni -  $[(\text{Fe}/\text{Ni})_G/(\text{Fe}/\text{Ni})_{\text{CI}}] = 0.09$ .

*Schreibersite* (fraction H) (Fig. 3) are enriched in siderophile Fe, Ni, Co, Au and depleted in Ir. In schreibersite from Adhi Kot EH4 have observed negative Sm anomaly where it is associated with negative Eu and Yb anomalies. The similar distributions of Sm, Eu and Yb have been observed in enstatite from unequilibrated enstatite chondrites [Hsu, 1998]. Perhaps, the fraction H has enstatite grains. One of

the feature of schreibersite is the fact that the ytterbium to europium ratio corresponds to that in CI chondrites  $[(\text{Yb}/\text{Eu})_H / (\text{Yb}/\text{Eu})_{\text{CI}}] = 1.0$ .

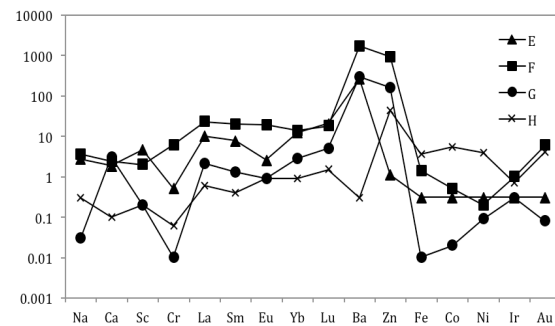


Fig.3. CI chondrite-normalized of trace element abundance patterns in mineral fractions from Adhi Kot EH4 enstatite chondrite: fraction E (yellow pyroxene); fraction F (sphalerite); fraction G (osbornite); fraction H (schreibersite).

The enrichment factors of *siderophile* Fe, Ni, Co, Ir and Au in all fractions are less than 1, with exception of sphalerite. *Cristobalites* A and B, *yellow pyroxene* (E) and *osbornite* (G) are enriched in refractory Ir relative to more volatile Au -  $(\text{Ir}/\text{Au})_{A,B,E,G}/(\text{Ir}/\text{Au})_{\text{CI}} = 1.0 - 16.6$ . This fact supports the opinion that, the main processes controlling of composition these accessory minerals was nebular fractionation. The distribution of these elements (0.17 – 0.66) in olivines (C, D), sphalerite (F) and schreibersite (H) indicate that was fractionation in situ probably result from thermal metamorphism.

**Conclusions.** Based on the study of the features of lithophile and siderophile trace element distributions in the accessory minerals from Adhi Kot EH4 enstatite chondrite a conclusion has been made that these peculiarities probably result from mixing effects of nebular fractionation, thermal metamorphism and shock.

**References.** [1] McSween H. Y. (1988) *Thermal metamorphism in meteorites and the early solar system* (eds. J. F. Kerridge and M. S. Matthews), 102 - 113. [2] Brearley A. J. and Jones R.H. (1998) *Chondritic meteorites*. In : *Papike J.J. (Ed.). Reviews in mineralogy, planetary materials*, 36. Mineralogical society of America. [3] Weisberg M. K. et al. (2009) *LPS XL*, Abstract # 1886. [4] Sears D.W. et al. (1982). *GCA*, 46, 597 - 608. [5] Rubin A.E. (1983) *Earth Planet. Sci. Lett.*, 64, 201 – 212. [6] Kolesov G. M. et al. (2001) *J. Anal. Chem.*, 56, 1169 – 1172.