DISTRIBUTION OF TRACE ELEMENTS IN GRAIN-SIZED FRACTIONS FROM ATLANTA EL6 EQUILIBRATED ENSTATITE CHONDRITE. Lavrentjeva Z.A., Lyul A.Yu. V. I. Vernadsky Institute of Geochemistry and Analytical Chemistry RAS, Moscow (lavza@mail.ru).

Introduction: Mineralogical and isototopic data indicate that enstatite chondrites formed in a nebular region distinct from the other main belt asteroids possibly in the inner part of the solar system [1,2]. Enstatite chondrites are thought to have formed in highly reducing environment. 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]. Enstatite chondrites are divided into two main groups, EH and EL, based on high and low abundances of Fe,Ni metal: both groups show a metamorphic sequence from type 3 to 6 similar to that observed in ordinary chondrites [4,5]. The Atlanta meteorite is classified as an EL6 enstatite chondrite. In order to obtain more information about the features of the composition of the EL group of chondrites, to evaluate the influence of nebular fractionation and metamorphism, in the non-magnetic size fractions of the enstatite chondrite Atlanta EL6, the contents of trace elements were determined by the INNA method and their distribution in the material of the studied meteorite was analyzed [6].

Results and its discussion: The features of the microelement composition of granulometric fractions isolated from the equilibrium enstatite chondrite Atlanta EL6 are considered. All non-magnetic fractions in the Atlanta meteorite are depleted in light REE relative to heavy ones - $[(La/Lu)_F / (La/Lu)_{CI}] = 0.5 - 0.8$ and have both positive and negative Eu anomalies - $[(Eu/Sm)_F / (Eu/Sm)_{CI}] = 0.6 - 1.5$. The main part of rare earth elements was concentrated in non-magnetic fractions with a grain size of 1<d<45 µm. The concentrators of rare earth elements, apparently, are accessory minerals, which are most enriched in ultrafine fractions. (Fig.1.)

The fine-grained non-magnetic fraction is enriched in lithophile - Sc, Cr, La, Sm, Eu, Tb, Yb, Lu and depleted in siderophile - Ni, Co, Au, Ir – elements. A characteristic feature of the distribution of trace elements in this fraction is the increased content of both light (1.5 x CI) and heavy (2.0 x CI) rare earth elements with positive Eu anomalies. The enrichment of fine-grained REE fractions with positive Eu-anomalies is possibly due to the fact that they contain the accessory mineral plagioclase, which is a concentrator of many rare elements. Only in the fine-grained fraction is there a strong fractionation between siderophile elements - the abundance of Au and Ir is an order of magnitude lower than that for Ni and Co. In the fine-grained fraction, a typical igneous distribution pattern of siderophile elements is observed with Ir depleted in comparison with Ni, Co, and Au. Such a distribution of siderophile elements can only be explained by evaporation and recondensation of fine-grained metal particles in the matrix material. The fine-grained fraction differs from other size fractions in higher REE content, which may also be associated with evaporation processes matrix material. This fraction differs from other size fractions in the increased content of REE, which can also be associated with the processes of evaporation and recondensation of fine-grained silicate particles in the matrix substance as a result of impact processes. The volatile element Se (2.9 x CI) shows a distinct tendency to concentrate in the fine grained fraction, which indicates the interaction of this fraction with the gas phase at a relatively low temperature.

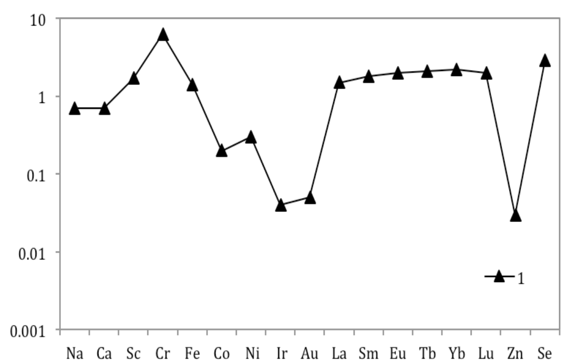

Fig. 1. Element contents normalized to CI chondrites (1<d < 45 µm) from Atlanta enstatite chondrite. in the "fine-grained" non-magnetic fraction.

Medium-grained, and coarse-grained non-magnetic fractions (Fig. 2, 3) are depleted in light La (0.6 – 0.8 x CI) and enriched in heavy Lu (1.0 – 1.5 x CI) rare earth elements and have positive Eu anomalies: $(Eu/Sm)_{fraction} / (Eu/Sm)_{CI} = 1.0 - 1.5$. At the same time, Eu anomalies, as well as depletion in light REE, cannot be explained by nebular condensation. It is possible that positive Eu-anomalies in particle-size fractions are associated with plagioclase, since oldhamite is absent in the meteorite. The same abundances (0.2 x CI) for the "normal" siderophile elements Ni, Co, Au and refractory Ir are observed in all medium-grained fractions, indicating the absence of fractionation between siderophile which is typical for particles that have not undergone fractional crystallization. Such a prevalence of siderophile elements indicates the primacy of the composition of the metal included in the silicates of these fractions.

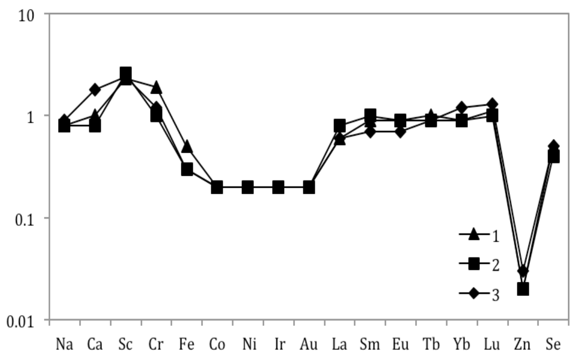

Fig. 2. Normalized to CI chondrite element contents in “medium-grained” non-magnetic fractions from Atlanta enstatite chondrite. 1 – (45<d <71 µm); 2 – (1<d<100 µm); 3 - (100<d<160 µm).

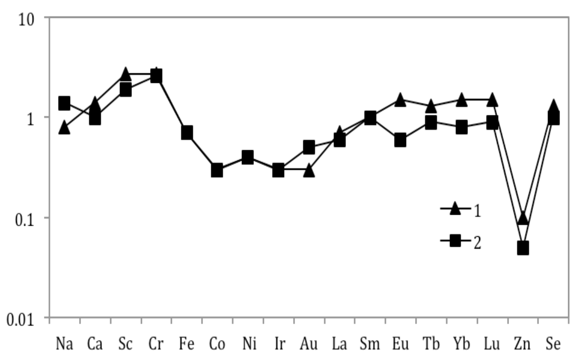

Fig. 3. Normalized to CI chondrite element contents in “coarse-grained” non-magnetic fractions from Atlanta enstatite chondrite. 1 - (160<d <260 µm); 2 - (260<d<360 µm).

In all medium-grained fractions, depletion of the volatile element Se (0.4 – 0.5 x CI) is observed, which indicates the absence of interaction of these fractions with the gas phase. In coarse-grained fractions, in contrast to other fractions, when fractionating REE towards enrichment in heavy rare earth elements, both positive and negative Eu anomalies are observed. In these nonmagnetic fractions, the abundances of Ni relative to Co, Au, Ir, and CI chondrites are higher than the cosmic value, while in magnetic fractions, they are lower than the cosmic value. Such fractionation of siderophile elements is probably associated with metal sulfirization. The coarse-grained fractions are enriched in Se (1.0 – 1.3 x CI), but to a much lesser extent than the fine-grained fraction (2.9 x CI). REE fractionation towards enrichment in heavy rare earth elements is manifested in all non-magnetic fractions of the Atlanta chondrite - $(Lu/La)_{Atlanta}/(Lu/La)_{CI}$ = 1.2 – 2.2. This is obviously due to the fact that enstatite dominates in the meteorite, in which similar REE distribution spectra are observed. Except for the largest fraction, in all other size fractions of the meteorite, the REE distribution spectra have positive Eu anomalies – $(Eu/Sm)_{Atlanta}/(Eu/Sm)_{CI}$ = 1.0 – 1.5. In non-magnetic fractions, variations in the ratios $(Ni/Co)_{Atlanta}$ $/(Ni/Co)_{CI}$ =1.0 – 1.5; $(Ni/Au)_{Atlanta}$ $/(Ni/Au)_{CI}$ = 0.8 – 6.0; $(Ni/Ir)_{Atlanta}$ $/(Ni/Ir)_{CI}$ = 1.0 – 7.5 indicate the presence of both metal particles that have not undergone fractional crystallization and particles with strong fractionation of siderophilic elements - fine-grained and coarse-grained fractions.. In the medium-grained non-magnetic fractions, the abundances of refractory Ir relative to the medium-volatile Au and CI of chondrites are equal to the cosmic one, and in the fine-grained and coarse-grained fractions they vary within (0.6 – 1.0 x CI). This indicates the presence in the silicates of metal particles that have not undergone fractional crystallization. The coexistence of fractions with different elemental variations in the Atlanta chondrite is consistent with the model of impact fracture of the primary parent body of enstatite meteorites [7]. The study of the distribution of trace elements in size fractions from the Atlanta enstatite meteorite showed that their distribution was affected by the agglomeration nature of the chondrite parent bodies, as well as the processes that led to structural changes in the meteorite.

Conclusion: Based on the features of the distribution of siderophile and rare earth elements in the size fractions of the Atlanta EL6 enstatite chondrite, it was assumed that the meteorite material was subjected to partial remelting due to impact processes, which also caused brecciation. It is assumed that these features of the distribution of elements were acquired as a result of the crystallization of impact melts. The origin of such melts could be as a result of impact melting in situ or impact melt ejections.

References: [1] Kallemeyn G.W. and Wasson J.T. (1986) GCA. V.50. P. 2153 – 2164. [2] Shukolyukov A. and Lungmair G.W. (1998) LPSC XXIX. # 1208. [3] Weisberg M. K., et al. (2009) LPSC XL2009. # 1886. [4] Baedecker P.A. and Wasson J.T. (1975). GCA V.38, pp.735 - 765. [5] Sears D.W.. (1980) . Jcarus. 43, pp.184-202. [[6] Kolesov G. M. et al. (2001). J. Anal. Chem. 2001. V.56. P. 1022 – 1028. [7] Okada A. et al, (1988). Meteoritics,V. 23, pp. 59 – 74.