RESEARCH OF SHOCK-THERMAL HISTORY OF THE ENSTATITE CHONDRITES BY TRACK, THERMOLUMINESCENCE AND NEUTRON-ACTIVATION (NAA) METHODS.

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The results of complex search of the bulk samples and separate fractions selected from the enstatite chondrites Abee EH4 (a sample № 15832), Adhi Kot EH4 (№ 15059), Atlanta EL6 (№ 2611) and Pillistfer EL6 (№ 1864) are presented. The study of these samples was carried out with help of thermoluminescence (TL), track and neutron-activation (NAA) methods. The purposes of the given work consist in definition of sensitivity of various methods for an estimation of the quantitative characteristics of a thermal and/or shock-thermal influence on substance of these meteorites during formation and subsequent evolution of their parent bodies.

Thermoluminescence

Investigations of natural and X-ray induced TL were carried out both in the bulk samples and separate fractions selected from some enstatite chondrites. The last were presented by the Abee and Pillistfer samples, differing by the grain sizes: < 45, 45-71, 71-100, 100-160, 160-260, 260-360 and > 360 µm. The natural TL intensity, saved by meteorites in cosmic space, in samples Atlanta and Pillistfer was close to background glow of apparatus. However, natural TL registered in 9 bulk samples of Abee and 6 bulk samples of Adhi Kot has shown a luminescence of various intensity in the region of ≥200 ^oC (see Fig. 1a, curves Ad-1, Ad-5, Ab-3 and Ab-7). So, for example, in the temperature interval of 190-250 ^oC the precise peak is sometimes observed. The height of the TL-peak (I_{TL}) in different samples lies in ~200 times interval: from ~0,004 rel. un. for a sample Ab-7 up to ~0,8 rel. un. for a sample Ad-1. At that time as, for all investigated samples in the temperature region of ~ 250-380 ^oC the luminescence intensity of a TL peaks changes only within the limits of 15%. Measurements of TL in various fractions of the Abee meteorite has shown, that the fraction with the size of particles < 45 µm (curve Ab-1L in Fig. 1a) gives the greatest contribution to a TL luminescence in the region of 190-250 ^oC in comparison with luminescence in 250-350 ^oC interval.

The value of the relation of the areas under TL glow-curves in interval of 190-250 ^OC (S_1) and 250-350 ^OC (S_2) for this sample makes S_1/S_2 = 1,26. In other fractions this value is much lower: ~0,4 for a sample 8L (160-260 µm) and less than 0,1 for all other size fractions. Thus, there are all grounds for supposing, that natural TL in the relatively low-temperature interval (190-250 ^OC) was maintained, mainly, in the fraction of size particles < 45 µm. The various parts of this fraction in the different bulk samples explain change of intensity of a natural TL in this temperature region.

The glow-curves of TL, induced by X-ray irradiation, are shown in a Fig. 1b. It is seen, that for meteorites Atlanta and Pillistfer the wide peak of a luminescence (50-350 ^oC) is observed with temperature of the maximal intensity near the 100 ^oC (curves At-3 and Pl-1). However, for Adhi Kot the high-temperature peak is observed in the region of 270 ^oC (curve Ad-1). The feebly marked peak at same temperature is observed also in meteorites Abee (Ab-6) and Atlanta (At-3). Accounts of the areas under glow-curves in the regions of 50-220 ^oC (S_1) and 220-350 ^oC (S_2) indicate, that the values of S_1/S_2 in the searched meteorite samples is equal to (1.31 ± 0.15) for Abee, (1.40 ± 0.03) for Atlanta and (1.61 ± 0.14) for Pillistfer, that is essentially differ from the value received for Adhi Kot: (0.40 ± 0.02).

Research of tracks

Track density (ρ) statistical distributions of the enstatite (*En*), olivine (*Ol*) and plagioclase (*Pl*) micro-crystals (size fraction of 100 - 200 µm), extracted from researched meteorites are given in Table 1. As it seen, the values of ρ for each meteorite vary in nearly the same interval of about ($10^4 \div 10^6$) cm^{-2}. However, the portions of the crystals with different ρ-values indicate on the appreciable distinction in the region of the two specific statistical track parameters: first, for the very low irradiated ($\rho \leq 2\cdot10^4$ cm^{-2}) crystal grains, and second, for the highly irradiated ($\rho \geq 2\cdot10^5$ cm^{-2}) grains. Note, that for Abee about 30% of searched crystals contained the first statistical group. In the second highly irradiated group there are near 15% of all crystals for Abee and Atlanta meteorites, ~7% for Pillistfer and only ~3% for Adhi Kot. So, it can be constituted the some different radiation-thermal history for the searched enstatite meteorites.

The Cu and Ir contents in the metal particles

The results of NAA measurements in Adhi Kot and Pillistfer are given in Table 2. Observed distinctions in the Cu and Ir contents in metal particles caused by processes existent on the pre-accretion stage of evolution of EH- and EL- group chondrite matter. Whereas the features of the variation trends in the contents of these elements respectively to the size of metal grains (see Fig. 2) reflect higher intensity of post-accretion metamorphic processes in the parent body for Adhi Kot in comparison with Pillistfer. Probably, these processes are caused both thermal and shock-thermal influences.

On the petrology-chemical data [5] in a meteorite Adhi Kot the signs of strong (up to melting of separate phases) shock-thermal processing of matter are observed. It is possible, the metal of this meteorite also could be changed and, in particular, in it could be an additional redistribution of elements. It is obvious, that the size of secondary shock-thermal effects resulting in enrichment of metal by sierophile elements firstly depends on the size of metal particles.

Conclusions.

Complex analysis of the received data in comparison with results of our TL researches in olivine, quartz and calcite [1-3], results in the following basic conclusions.

Chondrites Adhi Kot and Abee have undergo the strongest shock loading that is resulted in practically complete melting and subsequentrecristallization of his matter. This assumption is coordinated well to conclusions of petrography researches [4], and as by reference of this meteorite in the group of the enstatite chondrites with features of shock-melting breccias [5].

The meteorite Atlanta also, probably, has undergoes loading, which has resulted in partial melting and subsequent re-crystallization of enstatite. The matter of a meteorite Pillistfer was under vented to the lowest (in comparison with other searched by us meteorites) shock loading.

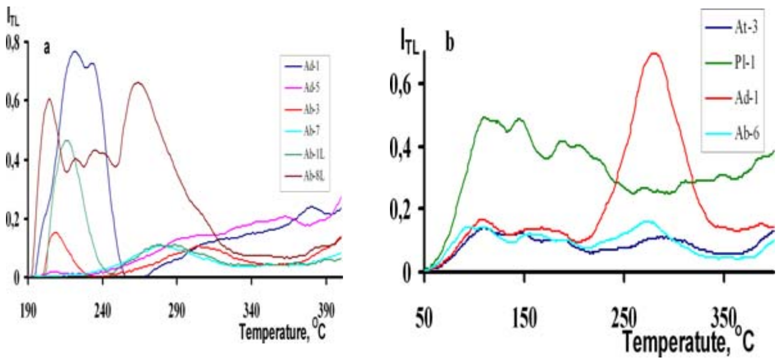

Fig. 1 Glow curves of natural (a) and artificially induced by X-ray irradiation (b) TL in bulk samples from Atlanta (*At-3*), Abee (*Ab-3, 6 and 7*), Pillistfer (*Pl-1*) and Adhi Kot (*Ad-1, and 5)* enstatite chondrites, and in separated fractions with grain size from Abee (*Ab-1L < 45 µm and Ab-8L – 160-260 µm*) .

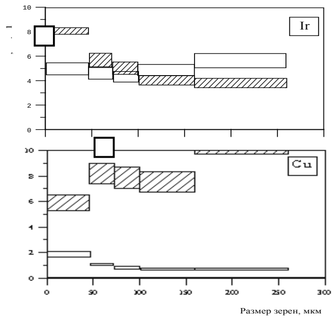

Fig. 2 Grain-sized distribution of Cu and Ir in the metal of Adhi Kot EH4 ■ and Pillistfer EL6 chondrites □.

Table 1. Track-density distribution in the silicate crystals from enstatite chondrites Abee, Adhi Kot, Atlanta and Pillistfer.

No	Chondrite	Crystals		Part of crystals with track density, cm^{-2}			$N_{\rho\geq 2\ 10^5}/N_{tot}$
		Minerals	Numbers	$\rho\leq 2\ 10^4$	$P2\ 10^4 \leq 2\ 10^5$	$\rho\geq 2\ 10^5$	
1	Abee	Pl, Ol	48	0.29	0.40	0.31	0.17
2	Adhi Kot	En	64	~0	0.85	0.15	0.03
3	Atlanta	En	53	~0	0.65	0.35	0.15
4	Pillistfer	En	71	~0	0.69	0.31	0.07

Table 2. The contents Ir and Cu in metal particles of the different sizes from enstatite chondrites Adhi Kot EH4 and Pillistfer EL6.

№	Size of metal particles, µm	Adhi Kot EH4				Pillistfer EL6			
		10^6 g/g		Relation to CI		10^6 g/g		Relation to CI	
		Cu	Ir	Cu	Ir	Cu	Ir	Cu	Ir
1	260 – 160	1195	1,76	9,88	3,82	85	2,6	0,71	5,65
2	160 – 100	910	1,84	7,52	4	85	2,28	0,71	4,96
3	100 – 71	960	2,32	7,93	5,05	95	2,3	0,79	5
4	71 – 45	990	2,6	8,18	5,65	125	2,1	1,03	4,6
5	< 45	710	3,5	5,87	7,6	225	2,3	1,86	5

References

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