RESEARCH OF THE SHOCK METAMORPHISM OF ORDINARY CHONDRITES BY THE THERMOLUMINESCENCE METHOD. A.I. Ivliev, V.A Alexeev, N.S Kuyunko Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Sciences, 119991, Kosygin str. 19, Moscow, Russia; e-mail: cosmo@geokhi.ru.

Introduction. Since the time of formation, the solar system matter has been affected by various evolution processes both in the protoplanetary nebula or meteorite parent bodies and at the stage of existence of meteorite as independent cosmic bodies. The collision processes obviously played a leading role in the formation of meteorites. Shock and thermal metamorphism accompanying the collisions is considered therefore as the most fundamental process in the evolution of the primordial matter. The experimental study of this process has undoubtedly the crucial importance, especially with respect to the search for quantitative criteria in the estimation of the effects of shock-thermal metamorphism. One of the most sensitive methods of determination of the degree of structural changes in a matter is the thermoluminescence (TL). The intensity of a TL glow in equilibrium ordinary chondrites (peak height of glow or area under peak) changes more than on two orders of magnitude [1]. The main TL phosphor in these meteorites is feldspar, which one is present at all H, L, and LL chondrites approximately in identical proportions and has a similar composition (Ab_{74}, An_{20}, and Or_6) [2]. The investigations of TL in minerals affected by experimental loading in spherically converging shock waves [3-5] have shown that TL characteristics were highly sensitive to changes in the crystal lattice. The shock stage of ordinary chondrites usually is determined by a petrographic method [6, 7]. The purpose of the present investigation was carrying out of the TL investigations of chondrites with a petrographically identified shock stage. And, on the basis of obtained results, carrying out of an estimation of a degree of a shock metamorphism in chondrites with a unknown degree of a shock load.

Experimental method. The method of the sample preparation and the TL measuring is similar to a procedure surveyed in [3-5, 8].

Results of TL measurements. As an example, the Fig. 1 shows the glow curves of the Kunya-Urgench chondrite obtained at the registration of natural TL (curve *1*), TL induced by X-ray (curve *2*), and by γ-radiation of a ^{137}Cs source (curve *3*). The shapes of all curves are typical for ordinary chondrites. A glow peak at a temperature of 260°C characterizes the intensity of natural TL accumulated in the meteorite in cosmic space. The maximum intensity of the TL accumulated after sample irradiation by X-rays is registered at a temperature of ~170°C. The irradiation by γ-quanta gives the maximum intensity at the temperature of ~190°C.

On the results of recording of X-rays and γ-rays induced TL, there were calculated the temperature of a peak, the full width at half maximum, and also peak height of glow (Ip) and intensity of glow TL (Sp). The obtained results were compared to a degree of a shock load [6,7]. The dependence of values Ip and Sp from a shock class of meteorites was found. However, at examination of TL induced by a X-rays, it was found, that the most sensing indicators of a degree of a shock load are the value of a peak height (Ip) and area under a curve of glow in a temperature region 40 -350 ^{O}C (Sp). The results of these calculations are listed in table and in Fig. 2. In accordance with these data, the increase of values Ip and Sp is observed at the increase of shock pressure up to 10 GPa (stages S1-S2), and subsequent their sharp decrease up to two orders of magnitude is seen at further increase of shock pressure from ~10 up to 90 GPa (stages S3-S6). Using the results of our measurements and values of shock pressures of different classes of meteorites [6,7], we have received the approximate formulas for an estimation of a value of a shock load, which one have undergone chondrites at collisions in space. For shock classes S1-S2 it was obtained: $P = 1.93 \times \ln (Sp) - 5.57$, and for S3-S6: $P = -12.28 \times \ln (Sp) + 91.74$. The results of evaluations under these formulas are given in the last column of the table.

Conclusions. The investigation of the TL induced by X-rays in equilibrium ordinary chondrites has shown a high response of values Ip and Sp on a shock load, which one was undergone by these meteorites in space.

However for precise identification of shock classes S1 - S3 under the TL data, the preliminary petrographic examinations is necessary. The estimation of a shock load of 17 meteorites was executed. The shock classes of meteorites of Kunya-Urgench (S2), Dalgety Downs (S4), and Pervomaisky (S6) were determined.

References. [1] Sears D.W.G. (1988) *Nucl. Tracks Radiat. Meas 14*. 5-17. [2] Dodd, R., (1981) *Meteorites. A Petrologic-Chemical Synthesis*, Cambridge (UK): Cambridge Univ. Press. [3] Ivliev, A.I. et al. (1995) *Geokhimiya*. 9. 1368-1377. [4] Ivliev, A.I. et al. (1996) *Geochemistry International* 34. P. 912-919. [5] Ivliev A.I. et al. (2002) *Geochemistry International*. 40. 739-750. [6] Stöffler D. et al. (1991) *Geochim. et Cosmochim. Acta*, 55. 3845-3867. [7]. Dodd R.T. and Jarosewich E. (1979) *Earth and Planet. Sci. Lett*., 44. 335-340. [8] Alexeev V.A. et al. (2001) *Geochemistry International*. 39. 1043-1055.

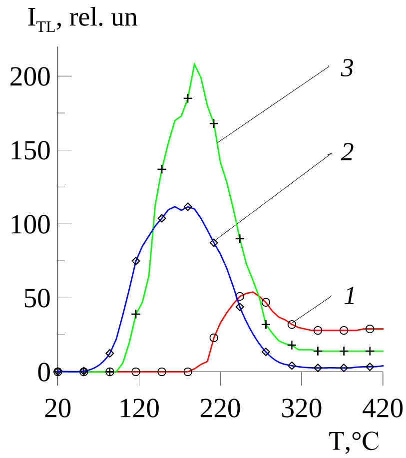

Fig. 1. Glow curves of the Kunya-Urgench chondrite obtained at the registration of natural TL (curve *1*) and TL induced by X-ray (*2*) and gamma γ-radiation (*3*). I_{TL} - the intensity of TL in relative units and T is the sample temperature.

Table. Results of calculations of a peak height (Ip), area under the peak of glow (Sp) and value of a shock load (P).

N п/п	Meteorite	Shock klass	Ip	Sp	P, GPa
1	Dhajala H3	S1	0.97±0.09	222±13	4.9±0.3
2	Pribram H5	a-b	2.1±0.1	261±10	5.2±0.2
3	Saratov L4	S2	2.3±0.1	310±16	5.5±0.3
4	Biurboele L4	S1	2.5±0.1	326±20	5.6±0.3
5	Elenovka L5	S2	2.6±0.1	355±9	5.8±0.1
6	Tugalin-Bulen H6	S1	4.9±0.2	575±25	6.7±0.6
7	Nikolskoe L4-5	S2	5.2±0.5	671±67	7.0±0.7
8	Kunya-UrgenchH5		7.7±0.7	928±100	7.6±0.8
9	Barwell L5	S3	4.8±0.3	590±35	13.5±0.8
10	Kunashak L6	e	2.1±0.1	300±28	21±2
11	Pultusk H5	S3	2.3±0.1	285±24	22±2
12	Ochansk H4	S3	2.3±0.3	279±32	23±3
13	Kilabo LL6	S3	2.3±0.1	262±10	23±1
14	Dalgety Downs L5		1.3±0.1	142±14	31±3
15	Malakal L5	e	0.27±0.01	45±2	44±2
16	Kyushu L6	S5	0.25±0.03	34±3	46±5
17	Pervomaisky L6		0.047±0.002	7.6±0.6	60±5

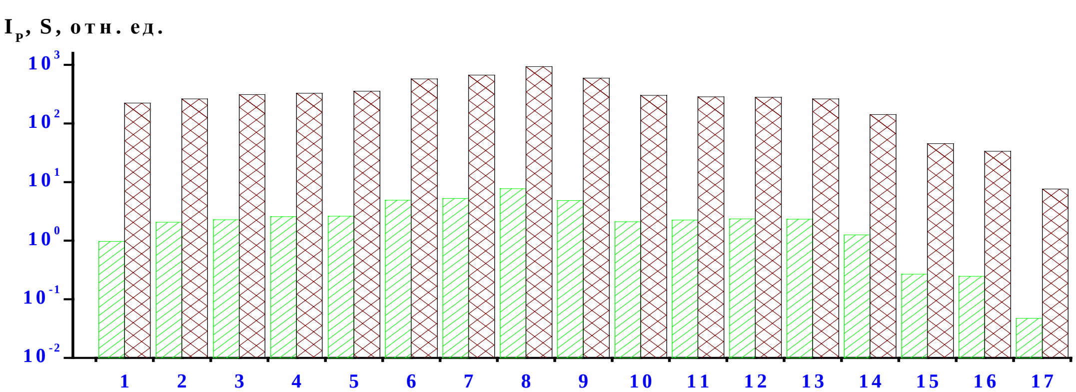

Fig. 2. Values of Ip and Sp in ordinary chondrites of a different shock classes (see table). The numbers on an abscissa axis correspond to the numbers of meteorites in the table.