THERMOLUMINESCENCE IN ASH CREEK AND TAMDAKHT CHONDRITES. A.I. Ivliev and N.S. Kuynko. Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Sciences (GEOKHI RAS), 119991 Kosygin str. 19, Moscow, Russia. e-mail: cosmo@geokhi.ru.

Introduction: The Ash Creek chondrite fell in the morning of February 15, 2009, witnessed by numerous onlookers, not far from the town of West (for which the meteorite was originally named) in McLennan County, Texas, United States. The fall was videotaped from the town of Austin, at a distance of 180 km from the fall site and was also traced by two radars. The chondrite is classed with ordinary chondrites of L6 group, shock stage S3 [1].

The Tamdakht meteorite fell on December 20, 2008, in Morocco, in a mountainous terrain between Marrakesh and Ouarzazate, not far from the village of Tamdakht. The chondrite is classed with ordinary chondrites of H5 group, shock stage S3 [2].

Experimental: The cosmic history of ordinary chondrites suggests that a universal process that formed meteorites as individual cosmic bodies was collision, and one of the most sensitive techniques applicable in studying shock metamorphism is thermoluminescence (TL).

The Ash Creek (L6) and Tamdakht (H5) meteorites are equilibrium ordinary chondrites, whose TL provides insight into the character of their shock metamorphism and make it possible to quantify the sizes of their orbits [3]. Our data on the TL "stored" during the irradiation of samples in the laboratory (TL_{IND}) in oligoclase, quartz, and calcite affected by various shock pressures in our experiments led us to conclude that the significant variations in the intensity of TL_{IND} were caused [4-6], first of all, by various grades of shock metamorphism of the meteorites but not by differences in the TL characteristics of feldspar, a mineral contained in all H, L, and LL chondrites in roughly equal proportions and having roughly similar composition in these meteorites ($Ab_{74}An_{20}Or_6$) [7]. Our TL data on more than 30 meteorite samples confirm this conclusion [8]. It was demonstrated that the intensity of TL_{IND} increases with increasing shock pressure in equilibrium ordinary chondrites of shock stages S1 and S2 and decreases with the transition from shock stage S3 to S6. These data were utilized to derive formulas for evaluating shock pressure that affected the meteorites at their collisions in space. In order to evaluate the perihelia of the orbits of the Ash Creek and Tamdakht meteorites, we have measured their TL accumulated in space (TL_{NAT}), whose intensity can be controlled (in the opinion of the authors of the method [9-10]) by certain characteristics of the orbits. Obviously, the smaller the perihelion, the higher the temperature to which the meteorite body is heated and, accordingly, the lower the stored T_{LNAT}. To conduct the calculations, we normalized TL_{NAT} of each sample to its sensitivity by measuring the TL_{IND} perdose unit induced by the radiogenic source. This ratio, which is referred to as the equivalent dose (ED) can be calculated for a certain temperature value on the glow curve as:

$$\mathbf{ED = (TL_{NAT}/TL_{IND}) \times D,} \quad (1)$$

where D is the radiation dose of the meteorite in the laboratory. The reader can find more detailed descriptions of the ED technique in our earlier papers [11-13]. The ED value calculated for TL at 250°C lies within 200–1500 Gy (20–150 krad) for most ordinary chondrites whose fall dates are known, and this corresponds to perihelion values of ~0.8–1.0 AU [9, 10].

The methods applied for sample preparation and TL measurements are analogous to those described in [11, 12]. It is only pertinent to mention that the meteoritic material was utilized to prepare three 2-mg samples of each meteorite. The TL values were calculated from the averages of the three measurements. Figure 1 shows the glow curves obtained by registration the TL of the samples of the Ash Creek and Tamdakht chondrites, and the numeral *1* corresponds the TL_{NAT} glow curves, *2* - to TL_{IND} induced by X-ray radiation, and *3* marks TL_{IND} induced by β/γ-radiation from ^{137}Cs. It should be mentioned that the radiation dose of Ash Creek was 1.49 kGy, and that of Tamdakht was 3.12 kGy. As was mentioned above and in [26], the TL_{IND} intensity increases with the transition from the shock stage S1 to S2 and decreases with the transition from the shock stage S3 to S6. For the shock stages S1–S2, the shock pressure P was calculated by the formula

$$\mathbf{P = 1.93 \times \ln(S_P) - 5.57,} \quad (2)$$

and that for the shock stages S3—S6 by the formula

$$\mathbf{P = -12.28 \times \ln(S_P) + 91.74,} \quad (3)$$

where P is GPa, and S_P is the TL_{IND} intensity induced by X-ray radiation, whose value is calculated as the surface below the glow curve within the sample heating region of 40– 350°C. In order to elucidate as to which of the formulas [(2) or (3)] is more suitable for the calculations, one can use the results of petrographic studies. Our preliminary results indicate that the shock stage of meteorites can be identified in certain instances from measured TL_{NAT}. Figure 2 shows TL_{NAT} glow curves of meteorite samples of various shock stages: Bjurboeole L4, S1 (glow curve *1*); Nikol'skoe L4, S2 (*2*); Pultusk H5, S3 (*3*); and Dalgety Downs L4, S4

(*4*). It can be readily seen that the TL_{NAT} intensities for meteorites of different shock stages are also notably different: the maximum height of the peak is typical in the Nikolskoe meteorite of shock stage S2 (curve *2*). The T_{LNAT} of Bjurboele (shock stage S1) is less intense, and the further transition to shock stages S3 and S4 is accompanied by the decrease in the TL_{NAT} intensity (curves *3* and *4* for the Pultusk and Dalgety Dawns meteorites). The comparison of the TL_{NAT} glow curves in Fig. 1 (curves *3*) with the glow curves in Fig. 2 led us to classify the Ash Creek and Tamdakht meteorites with shock stage S2. This implies that the shock pressure that affected the meteorites in space should be calculated by formula (3). The calculations yielded the following shock pressure values: 15 ± 2GPa for Ash Creek and 20 ± 2 GPa for Tamdakht. The evaluated shock pressures classify these meteorites with shock stage S3, which is consistent with the estimates from petrographic data [1, 2].

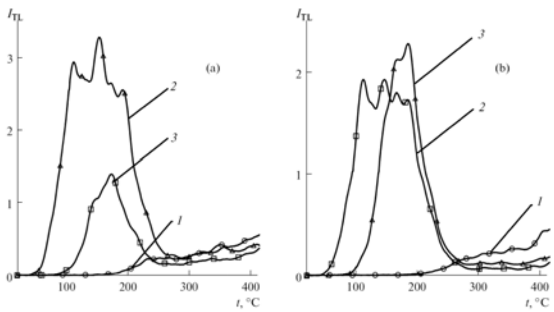

Fig. 1. Glow curves of the (a) Ash Creek and (b) Tamdakht chondrites due to natural TL_{NAT} (line *1*) and TL_{IND} induced by (*2*) X-ray and (*3*) β/γ - radiation; I_{TL} is the TL intensity expressed in relative units, t is the heating temperature of the sample.

As was mentioned above, the perihelia of the orbits of the meteorites can be estimated from the equivalent dose *D* [see formula (1)]. Our calculations yielded the following values: D = 600 ± 10 Gy for Ash Creek and D = 1200 ± 100 Gy for Tamdakht. As was demonstrated in [9,10], such *D* values correspond to the perihelion region typical of most meteorites: 0.8–1 AU

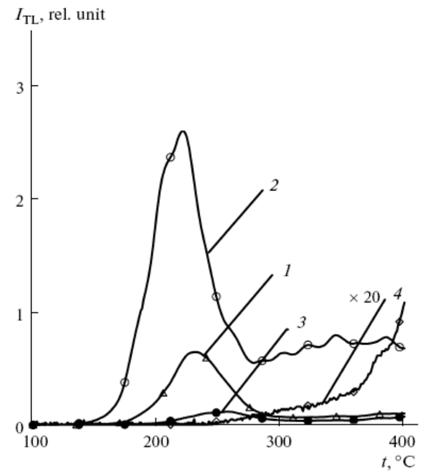

Fig. 2. Glow curves obtained by registering natural TL_{NAT} in the Bjurboele (line *1*), Nikolskoe (*2*), Pultusk (*3*), and Dalgety Downs (*4*) meteorites. The I_{TL} values of (4) are shown in the diagram 20 times greater.

References:

[1] Weisberg M. K. at al., (2009) *Meteoritics & Planet. Sci*., 44, 1355–1397. [2] Weisberg M. K. at al., (2009) *Meteoritics & Planet. Sci*., 44, 1–33. [3] Sears D. W. G. (1988) *Nucl. Tracks Radiat. Meas.,* 14, 5–17. [4] Ivliev A. I. et al., (1995) *Geokhimiya,* 9, 1368–1377. [5] Ivliev A. I. et al., (1996) *Geokhem. Int*., 34, 912–919. [6] Ivliev A. I. et al., (2002) *Geokhem. Int.,* 40, 739–750. [7] Dodd R.T. (1981) *Meteorites. A Petrologic_Chemical Synthesis* (University Press, Cambridge). [8] Ivliev A. I. and Kuyunko N. S. (2008) *LPS XXXIX,* Abstract #1053. [9] Melcher C. L. and Walker R. M. (1977) *Meteoritics*, 12, 309–310. [10] Melcher C. L. (1981) *Earth Planet. Sci. Lett.,* 52 (1), 39–54. [11] Alexeev V. A. et al., (2001) *Geochem. Int.* 39, 1043–1055. [12] Alexeev V. A. et al., (2008) *Geokhem. Int*., 46, 849–866. [13] Ivliev A. I. et al., (2006) *LPS. XXXVII,* Abstract #1047.