THERMOLUMINESCENCE OF NATURAL GLASSES: 1. PARAMETERS FOR THE GLASSES OF DIFFERENT ORIGIN

Kashkarov L.L., Ivliev A.I., Kalinina G.V.
Vernadsky Institute of Geochemistry and Analytical Chemistry RAS (GEOKHI RAS)
ugeochem@geochem.home.chg.ru; phone: (8-252-219-88)

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Introduction

The research of thermoluminescence (TL) in the natural silicates, in particular, of glasses is one of the most sensitive methods of determination of their formation age [1, 2]. At that the glasses most precisely reflect a time interval, past from the moment of their formation or last event of high-temperature (up to 300 – 400°C) heating, till now. In this connection the detailed study of the TL characteristics for glasses of a different origin is a paramount task at them dating.

The basic characteristics of natural glasses determining probability of formation and safety of TL in time are: 1) processes of formation and subsequent melt-quench; 2) petrology-chemical characteristics of a glass; 3) presence or absence of a different sort of micro-inclusions and dislocations. Besides, depending on duration of a presence of glasses at certain temperature and light exposure conditions in them can be a process of partial or complete crystallization that results in essential increase of probability of TL accumulation.

In the given work the results of experimental TL study of a number of natural glasses, which were differing in as by process of formation, and subsequent history of cooling in conditions of an environment, are resulted. The basic task on the first of investigation phase was reception of quantitative parameters of TL in glasses of a different origin. Comparison of TL accumulation and safety in glasses will be carried out.

The measurements of the TL characteristics are executed for a number of tektite samples (moldavite, indoshinite, phillipinite, tailandite), obsidians (Djervlar, Armenia and Liparite glass) and also glass connected to a shock crater Smerdyachee (Shatura region).

Technique of research

In the crystal matter of different sort defects and inclusions of impurity atoms in a crystal lattice form charge-defective conditions with intermediate energy levels, on which the free electrons can be captured. Natural glasses, except for samples with traces of partial or complete crystallization, it is practically completely amorphous matter. Therefore, as against crystal matter, the process of TL accumulation in glasses has specific features: the electrons capture in metastable states or in "traps" in glass basically is connected to micro-structural defects. Further as a result of heating these electrons with the certain probability can recombine with the luminescence centers that give a TL-luminosity. The TL-intensity of researched samples is proportional to quantity of a different sort of "traps", and also to doze of an ionizing radiation right up to a saturation level.

The measurement of the natural TL_{NAT}, saved from the moment of last heating of investigated sample, and also TL_{REN} formed under action of X-radiation, was carried out on a high-sensitivity apparatus described in [3]. For the received TL glow-curves the following parameters were measured: 1) TL-intensity in the low- and high-temperature intervals; 2) minimal temperature of heating of a sample, at which occurs a very faint TL-luminosity, at least, in some times exceeding a level of a registered apparatus background; 3) peaks on a glow-curves, for which are measured: temperature of peak (T_{PEAK} , °C), height of peak (I_{TL}, rel. un.) and its full width on half of maximum (FWHM, °C).

Results and discussion

Some received results are given in the Table. As it is seen, investigated samples of natural glasses have both identical and specific features partially reflecting process of their formation:

(1) TL_{NAT} - luminosity is observed for all investigated glasses only in high-temperature (≥200 °C) section. The value of intensity lays in limits from ~0.003 up to ~0.67 rel. un. For all four investigated tektite samples in a rather narrow interval of temperature (360 - 400 °C) are observed peaks of a luminosity, which intensity on one - two order of magnitude exceeds a level of a background luminosity (~0.001 rel. un. at temperature up to ~400 °C). For all these peaks the value of FWHM parameter does not exceed 20 °C.

(2) Unlike of tektites for obsidians the most highly intensive precise peaks of TL_{NAT} with the much greater value of parameter FWHM = (60 - 90) °C are observed. Apparently, it can be connected, mainly, to their volcanic origin and slower (in comparison with tektites and glasses of an impct origin)

cooling. Thus, in volcanic glasses with the greater probability of formation the local micro-sites with the crystal structure resulting in further in more highly effective formation «of electronic traps «with the certain energy characteristics can be formed.

(3) For investigated sample of an impacted glass Smerdyachee two poorly intensive peaks in a TL_{NAT} glow-curve with parameter FWHM = (60 - 80) ^oC are precisely traced.

(4) Artificially induced by X-radiation in the investigated glasses TL_{REN} is characterized by presence from one up to two-three precisely expressed peaks of different width. Parameter FWHM varies in very wide limits: from ~ (10 - 20) ^oC for high-temperature T = (390 - 420) ^oC of peaks in moldavites and indoshinite, up to ~120 ^oC (peak at T = 120 ^oC for liparite glass). The peaks with parameter FWHM ~ (50 - 60) ^oC are the most distributed.

Conclusions

- The intensity of a TL_{NAT} in the majority of the investigated glasses is at a level of a limit of sensitivity of TL measuring apparatus;
- The investigated glass samples can be divided on some groups, differing among themselves as on TL intensity, and presence of several peaks into a TL glow-curve;
- One of the determining factors influencing on the character of a formed TL spectrum of luminosity, are the micro-structural features and, mainly, presence or absence in glass of local sites with crystal structure. In this connection, it is possible to assume that the glasses, which have undergone during all of their geological history of existence, shock and/or shock-thermal influence, also, should have essential specific features of TL parameters.

The registered TL_{NAT} intensity depends as on probability of accumulation, and safety of electrons in "traps". Note, this characteristic for each glass sample is defined with the help of artificial induced TL_{ART} under action of ionizing radiation (β, γ or X-ray) of the certain doze.

The carried out researches have shown a wide variation of the basic TL parameters, being, in particular, by result of distinction of processes of formation of these glasses. Detailed study of dependence TL from the petrology-chemical characteristics of various natural glasses, quantitative analysis of a TL_{NAT} / TL_{ART} ratio, and also safety of TL_{NAT} under various conditions of an environment - all these questions are the purpose of our further researches.

Table. Thermoluminescence parameters for the natural glasses of different origin

Glass type	Sample	TL_{NAT}			TL_{REN}		
		T_{PEAK} ^oC	I_{NAT} (*)	FWHM (**)	T_{PEAK} ^oC	I_{REN} (*)	FWHM (**)
Tektite	Moldavit	-	0.005	-	110	0,15	85-145
		385	0,085	380-395	390	0,09	380-400
	Indoshinit	-	0,008	-	360	0.010	350-370
		-	0,02	-	395	0,12	390-400
	Filippinit	-	0.005	-	125	0.004	110-150
		-	0.01	-	250	0.003	200-300
		380	0.1	370-390			
	Tailand	–	0,004	-	140	0,003	90-190
		–	0,008	-	395	0,12	385-405
		360	0,015	350-370			
Obsidian	Djervlar	340	0,24	295-360	130	0,011	100-150
	Liparit	350	0,674	310-400	120	0,008	95-215
Impaktit	Smerdyachee	190	0,003	160-220	110	0,10	85-135
		320	0.01	280-360	320	0,065	280-360

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