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CALCULATION OF THE ACTIVATION ENERGY IN A CONTINUOUS TRAP DISTRIBUTION SYSTEM OF A CHAROITE SILICATE USING INITIAL RISE AND TL GLOW CURVE FITTING METHODS

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This work focuses on the study of the thermoluminescence (TL) emission of a charoite silicate with a very complex lattice structure: $[K_4NaCa_7Ba_{0.75}Mn_{0.2}Fe_{0.05}(Si_6O_{15})_2(Si_2O_7)Si_4O_9(OH) \cdot 3(H_2O)]$.

The activation energy, E , has been calculated for samples of charoite preheated at different temperatures (T_{STOP}) in the range 240–340°C, by means of (i) initial rise (IR) method and (ii) glow curve fitting (GCF). As it is showed in Fig 1, the TL maximum (peaked at 370°C) shifts towards higher temperatures as T_{STOP} is increased.

Figure 1. TL glow curves of natural charoite samples, preheated up to different temperatures (T_{stop})

The IR method (Chen and McKeever, 1997) is based on the premise that occupancies of the relevant states remain almost constant for the lowest temperature side of the TL peak and, consequently, this side of the peak will follow an exponential dependence regardless of the kinetic order and the applicability of the quasi-equilibrium approximation, i.e.

$$I_{TL} \propto \exp(-E/kT)$$

So, in the Arrhenius plot ($\ln I_{TL}$ vs $1/T$), the activation energy E can be obtained from the slope $-E/k$, irrespectively of any other kinetic parameter.

When the IR method is applied to a continuous distribution (Gómez-Ros et al. 2006), the obtained activation energy corresponds to an 'effective' activation energy, E_{eff} , depending on the actual energy distribution of active traps.

Curves in Figure 1 can be well fitted assuming an exponential distribution, as it could be expected for

the TL glow curves obtained after thermal cleaning of the shallowest trapping levels, i.e.

$$n_{exp}(E) = \frac{n_0}{\sigma} \exp\left(-\frac{E-E_0}{\sigma}\right) \quad [1]$$

In such case, the effective activation energy is related to parameters in equation [1] by:

$$E_{eff}^{(exp)} = E_0 + kT \log(1 + \sigma/kT) \quad [2]$$

Figure 2. Arrhenius plot of the low-T side of the 300°C preheated TL curve of charoite.

As it can be seen in Table 1, E values calculated by IR are in good agreement with the E_{eff} corresponding to the fitted parameters for the exponential distribution [1]. Moreover, dependence of [2] on kT is not significant in the IR range. Changes in the E values when T_{STOP} increases are consistent with the gradual emptying of trapping levels during preheatings.

Table 1. E values (in eV), calculated by IR and GCF methods for preheated charoite silicate samples.

T_{STOP}	IR range	E (IR)	(GCF)		
			E_0	σ	E_{eff}
240	280-320	1.16	1.13	0.15	1.18
260	282-334	1.23	1.21	0.16	1.26
280	292-338	1.29	1.27	0.16	1.32
300	300-338	1.30	1.25	0.19	1.30
320	314-352	1.31	1.26	0.20	1.32
340	336-372	1.36	1.24	0.26	1.31

References:

- Chen, R. and McKeever, S.W.S. 1997, *Theory of Thermoluminescence and Related Phenomena* (World Scientific Publishing, Singapore).
 Gómez-Ros, J.M. et al. 2006, Nucl. Instrum. Meth. A 566, 727-732

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Calculation of the activation energy in a continuous trap distribution system of a charoite silicate using initial rise and TL glow curve fitting methods

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Abstract

The blue thermoluminescence (TL) emission of a complex charoite silicate $[K_4NaCa_7Ba_{0.75}Mn_{0.2}Fe_{0.05}(Si_6O_{15})_2(Si_2O_7)Si_4O_9(OH) \cdot 3(H_2O)]$, exhibits a continuum in the trap structure similar to that observed in other natural materials; i.e., the glow curve, that consists of a single broad peak at 350 °C, continuously shifts towards higher temperatures when the sample is preheated up to increasing temperatures. This behaviour could be attributed to the charoite strained structure including possible non-bridging oxygen, silicon vacancy–hole centres and Si–O bonding defects which seem to be responsible for this UV–blue emission typical of stressed silicates. The calculation of the activation energy from the TL glow curve performed by the initial rise and the TL glow curve fitting methods are fairly well correlated. The evolution of both the activation energy values and the parameters describing the width of the exponential distribution tends to get larger when increasing the annealing temperatures owing to the emptying of the shallower energy traps.

Keywords: Thermoluminescence; Initial rise; Glow curve analysis; Continuous trap distribution

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CALCULATION OF THE ACTIVATION ENERGY IN A CONTINUOUS TRAP DISTRIBUTION SYSTEM OF A CHAROITE SILICATE USING INITIAL RISE AND TL GLOW CURVE FITTING METHODS

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This work focuses on the study of the thermoluminescence (TL) emission of a charoite silicate $[K_4NaCa_7Ba_{0.75}Mn_{0.2}Fe_{0.05}(Si_6O_{15})_2(Si_2O_7)Si_4O_9(OH) \cdot 3(H_2O)]$ with a very complex lattice structure

The activation energy, E , has been calculated for samples of charoite preheated at different temperatures (T_{STOP}) in the range 240–340°C, by means of (i) initial rise (IR) method and (ii) glow curve fitting (GCF). As it is showed in Fig 1, the TL maximum (peaked at 370°C) shifts towards higher temperatures as T_{STOP} is increased.

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