Trap spectroscopy of microcline in the temperature range 77-600 K

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Trap spectroscopy of microcline (KAlSi$_3$O$_8$) has been determined by deconvoluting two monochromatic (435 and 285 nm) glow curves. Unlike most studies performed in the range LNT to RT and RT to 400°C separately, in this work thermal scan of the trapping levels has been done right from LNT (77 K) to 600 K. As many as 15 trapping levels could be identified. The most remarkable finding of this analysis is that in microcline, practically all the glow peaks follow second order kinetics, a point that will be discussed critically. For 77K to RT, the frequency factor ($s$) lies in the range $10^5 \leq s \leq 10^8$ while in the range RT and $\approx 300$°C, it lies in the range $10^7 \leq s \leq 10^{12}$. $E \sim T_m$ plot both for UV and blue emission fit to similar equations:

\[ E_{\text{blue}}=0.12 \exp (0.0045 T_m) \quad \ldots(1) \]
\[ E_{\text{UV}}=0.11 \exp (0.0049 T_m) \quad \ldots(2) \]

The lifetime ($\tau$) of electrons trapped in the trap of depth $\approx 1.5$ eV (300°C glow peak) is more than $10^7$ years justifying the use of feldspar in long range dating.

**Keywords**: Trap spectroscopy, Microcline, Thermoluminescence

1 Introduction

Thermoluminescence (TL) of feldspar including that of microcline (KAlSi$_3$O$_8$) is an interesting and rewarding field of study for many reasons. They typically exhibit TL that is 10-50 times brighter than that of quartz; having a substantially greater dose range extending to around 2000 Gy. Hence, one can study the physics of TL in these materials easily. It also makes these materials attractive candidate for long range TL dating. Feldspars are present in crystalline/disordered form in rocks, meteorites and lunar materials making them ideal candidate to study geology by their TL. Most of the feldspars exhibit natural TL (NTL) in the region 200-700°C indicating the presence of deep traps where the electron lifetime is more than millions of years. No doubt, this helps in the use of feldspar in dating archaeological and geological objects/events. In this work we establish the trap spectroscopy of microcline [KAlSi$_3$O$_8$] the triclinic form of the potash feldspar by deconvoluting the complex monochromatic glow curves recorded in the temperature range 77--600K. TL of feldspar has been studied by our group in quite details that has been reported in numerous published/unpublished thesis/papers.

2 Experimental Details

Bluish green variety of microcline of Indian origin is used in the present study. Prior to any experiment, the samples are annealed at 550°C to erase natural TL if any. In order to create radiation defects the sample is irradiated at 80 K with X-rays from a TEG 50 Machlette tube operated at 30kV and 8 mA. TL is recorded keeping the sample in a vacuum chamber (vacuum $\sim 10^{-2}$ Torr) using a heating rate of 0.5 K/s. The TL output is detected by an RCA 1P28B photomultiplier tube (PMT). The resulting photocurrent amplified by an electrometer amplifier is fed to a recorder. The temperature of the sample is simultaneously recorded. The TL spectrum is recorded by scanning the emitted light with the help of a Jarrel Ash 1/4 m monochromator and detected with the same PMT. The spectrum is corrected for PMT response and monochromator dispersion.

3 Results and Discussion

Monochromatic TL curves of microcline using 435 nm and 285 nm filters are presented in Fig. 1. The selection of the emissions is based on the reason that the sample exhibits strong blue TL emission (435 nm) as well as UV (285 nm) in addition to the presence of...
about four other emissions. The glow curves presented in Fig. 1 clearly show that the curves are quite complex consisting of large number of overlapped glow peaks.

In order to locate the glow peak temperature \( T_m \), we have plotted the second derivative of the intensity which reveals the existence of about twelve peaks (Fig. 2). The glow curves are subjected to rigorous Computerised Glow Curve Deconvolution (CGCD) and one of the deconvolution along with the histogram of error distribution is shown in Fig. 2. The fitting passes \( \chi^2 \)-test. The glow peak temperatures \( (T_m) \) of the best fit peaks show quite good agreement with that revealed in the second derivative plot.

Trapping parameters obtained by CGCD of the glow curves of microcline are presented in Table 1.

Similar results have been reported by other researchers for TL peaks that occurred in microcline in the range 300-650 K. The most remarkable observation is that all the glow peaks of microcline follow practically second order kinetics, a fact demonstrated for the glow peaks in the range 300-650 K. A plot of trapping levels of \([\text{KAlSi}_3\text{O}_8]\) determined by the present deconvolution along with some other researchers are shown in Fig. 3.

Fig. 2 — CGCD of glow curve (285 nm emission) of microcline

Table 1 — Trapping parameters of microcline

<table>
<thead>
<tr>
<th>( T_m ) (K)</th>
<th>435nm emission</th>
<th></th>
<th>285nm emission</th>
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<tr>
<td></td>
<td>( E ) (eV)</td>
<td>( s ) (1/s)</td>
<td>( b )</td>
<td>( E ) (eV)</td>
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<tr>
<td>101.0</td>
<td>0.19</td>
<td>( 1.7E+08 )</td>
<td>( 2.0 )</td>
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<tr>
<td>111.5</td>
<td>0.20</td>
<td>( 9.4E+07 )</td>
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<td>111.9</td>
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<tr>
<td>127.3</td>
<td>0.22</td>
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<td>132.1</td>
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<td>148.2</td>
<td>0.24</td>
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<td>( 1.9 )</td>
<td>153.0</td>
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<td>174.5</td>
<td>0.29</td>
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<td>( 1.8 )</td>
<td>171.2</td>
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<td>200.8</td>
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<td>( 1.9 )</td>
<td>196.8</td>
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<tr>
<td>237.6</td>
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<td>267.5</td>
<td>0.45</td>
<td>( 1.1E+07 )</td>
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<td>305.9</td>
<td>0.49</td>
<td>( 3.4E+06 )</td>
<td>( 1.7 )</td>
<td>286.5</td>
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<tr>
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<td>( 3.4E+11 )</td>
<td>( 1.5 )</td>
<td>587.5</td>
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</table>
Fig. 3 — Spectroscopy of traps in microcline as revealed by analysis of TL data

●●●●● : UV emission result; oooooo : Blue emission result
xxxxxx : Ref. 4; XXXXX : Ref. 7

The entire set of data can be fitted to an equation.

\[ E = 0.12 \exp(0.004t T_m) \]  \quad \ldots (3)

Thus, we summarize that TL is a spectroscopic technique capable to locate the trapping levels present in an insulator/semiconductor materials. The concept in principle can be extended to other TL emitting materials. Once it is done TL will get its right place as a structure sensitive spectroscopic tool.

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**References**