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# THERMOLUMINESCENCE AND KINETICS OF GAMMA IRRADIATED BHUTANESE STONE

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**Abstract.** The present paper reports the photoluminescence (PL) and thermoluminescence (TL) studies of natural Bhutanese stone (Biotite) collected from Bhutan. The sample was Bhutanese stone irradiated with $Co^{60}$ gamma source giving a dose from 0.5 kGy to 2 kGy. The heating rate used for TL measurements was 6.7 ºC/s. The heating rate used for TL measurements was 6.7 ºC/s. The samples shows good TL peaks, the corresponding activation energy (E) values are calculated. Structural characteristics were showed by XRD spectrum of the sample. The value of trap depth of Bhutanese stone was evaluated by different methods. Also the annealing quenching effect was studied for gamma exposure of the sample.

## 1. Introduction

Bhutan is a magic country with magic geology – metamorphic, structural, thermal and rock magnetic history. There have been small scale mining activities in Bhutan for over a thousand years. Slags are found in many parts of country. They point to mining of lead-zinc and iron ores for production of artifacts, weapons, and most notably a series of iron-chain suspension bridges which were constructed in the 14th century by Saint Thangthong Gyalpo (1385-1464).

Mineral exploration began only in the early 1960s. Less than 30 % of total area of the country has been mapped geologically. Geological surveys are carried out jointly by Survey of India and Department of Geology and Mines of the Royal Government. So far surveys have shown that there are deposits of coal, limestone, dolomite, talc, marble, gypsum, slate, lead, zinc, copper, tungsten, graphite, iron, mica, phosphate, pyrite, asbestos, and gold.

It has been variously claimed by different authors that the thermoluminescence of meteorites can be used to provide data on their shock/reheating history, cosmic ray exposure age, orbit, preatmospheric shape, ablation rate, terrestrial age and petrologic type [1-5]. Thermoluminescence dosimetry is a field of recent origin which has proved to be special importance in the estimation of radiation doses. Special attention has been paid to the

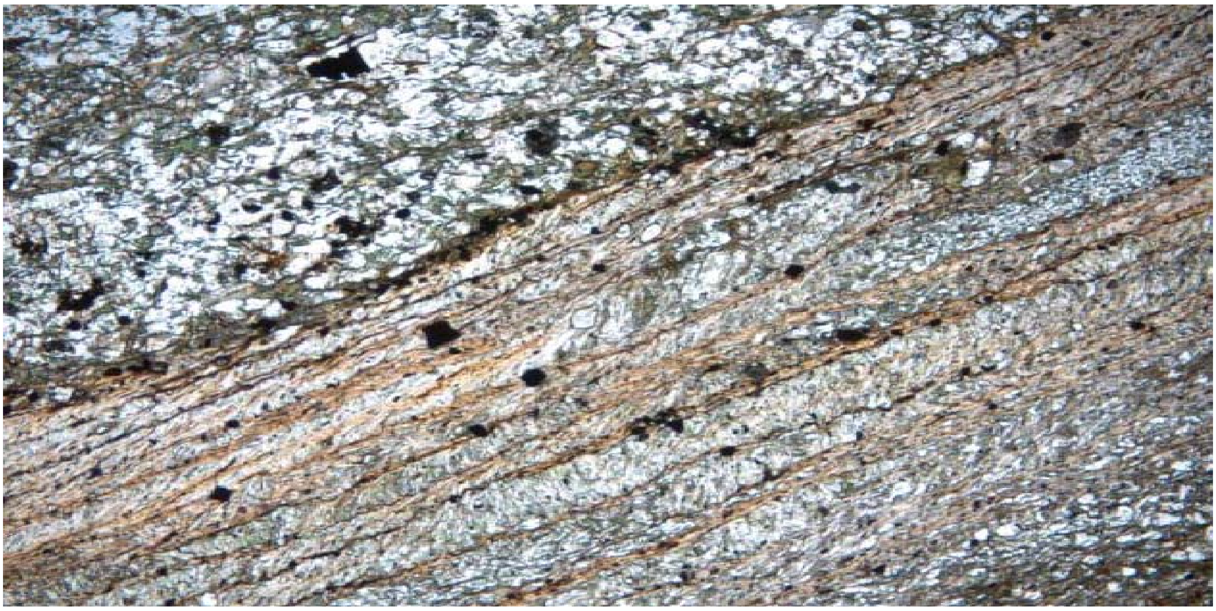

**Fig. 2.** Fine laminated clayey and sand metasediment with crenulation and oblique schistosity.

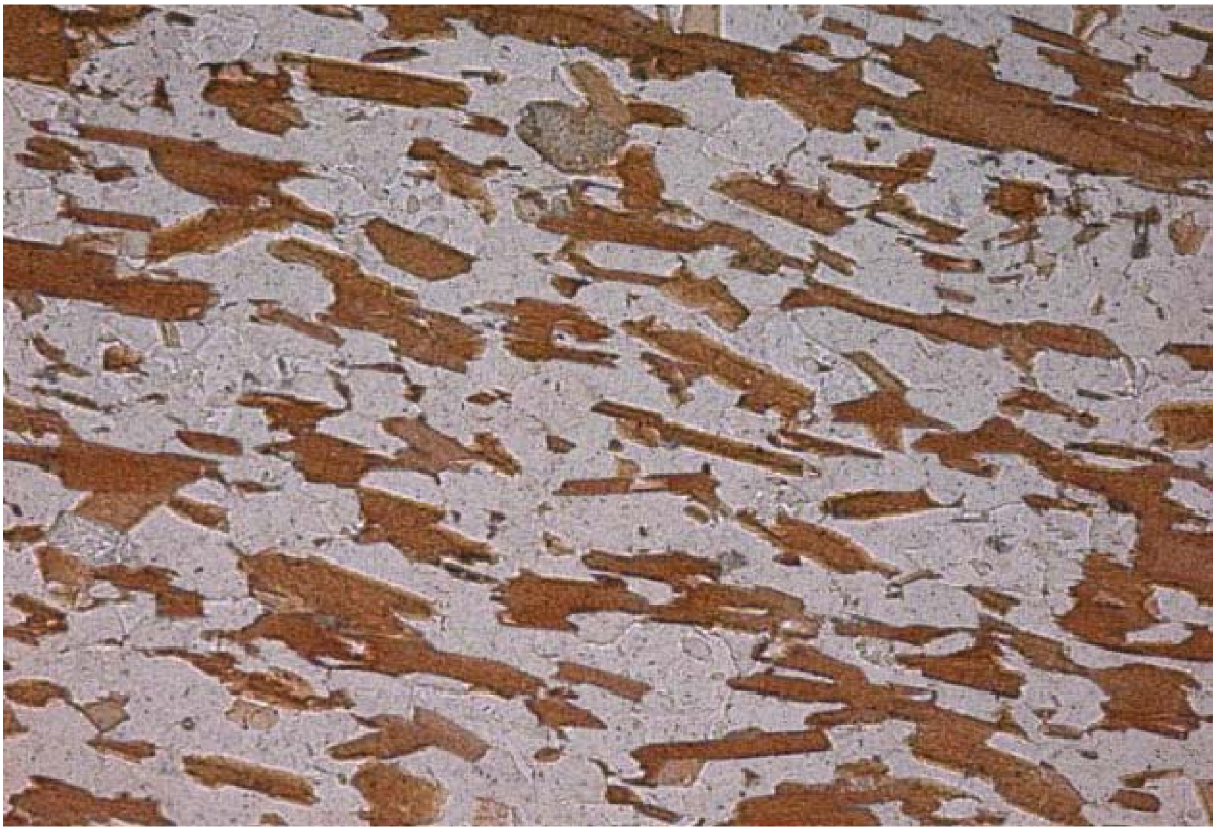

**Fig. 3.** Biotite schist with well developed crystals (B7).

**2. Experimental**

The natural Bhutanese samples were collected from Bhutan. The TL glow curve was recorded by TLD Reader. The photoluminescence (PL) emission and excitation spectra were recorded at room temperature using Spectrofluorophotometer RF-5301 PC of SHIMADZU make. The excitation source is a xenon lamp. The chemical characterization was done by NGRI Hyderabad with the instrument Perkin Elmer Sciex ELAN DRC II. For gamma irradiation

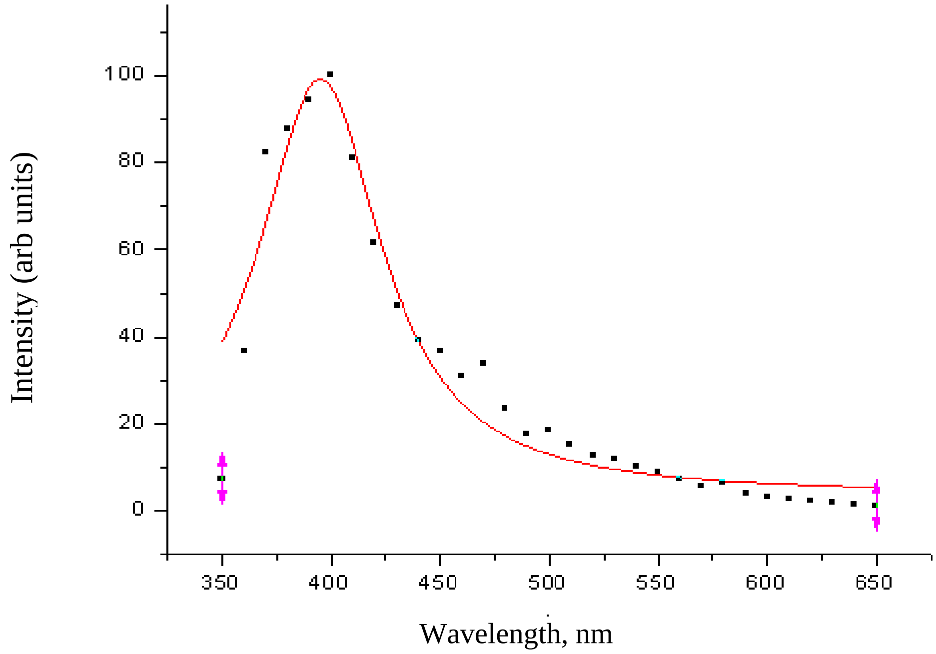


**Fig. 5.** PL spectra of Bhutanese stone (Biotite).

**3.2. Gamma irradiated Bhutanese stone.** Figure 6 shows the variation with TL glow curve as a function of gamma dose.

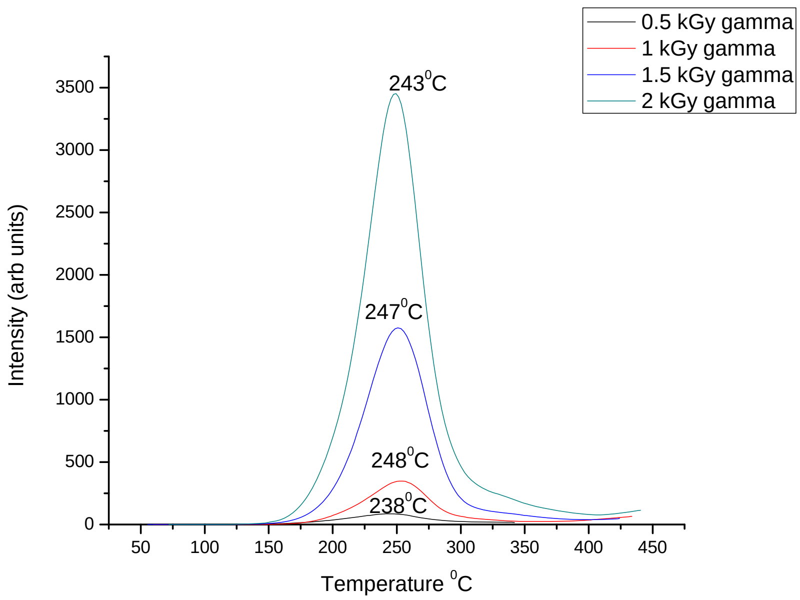


**Fig. 6.** Gamma irradiated Bhutanese stone as a function of gamma dose.

The sample was irradiated with $Co^{60}$ gamma source giving a dose from 0.5 kGy to 2 kGy and the heating rate used for TL measurements was 6.7 ºC/s. The samples displayed good TL peaks at 238 ºC, 243 ºC, 244 ºC, and 246 ºC respectively. The corresponding

$Co^{60}$ source. Heating rate used for TL measurement was 6.7 ºC/s. The powdered Bhutanese stone was annealed in air atmosphere in the temperature range 400 ºC, 600 ºC, and 800 ºC at atmospheric pressure. Samples show TL glow peaks at 254 ºC, 248 ºC, and 257 ºC respectively as a function of annealing quenching temperature. Corresponding activation energy and frequency factor are shown in Table 2. TL glow curve shows first order kinetics for AQ effect. The activation energy lies between 0.7 and 1.0 eV. The frequency factor is between $8\times10^7$ and $7\times10^{11}$ $s^{-1}$.

Table 4. Chemical composition of Bhutanese stone (Biotite) tracing elements.

| ANALYTE | MASS | CONV. MEAN | |
|---|---|---|---|
| Sc | 45 | 293.315 | 0.0293315 |
| V | 51 | 2588.618 | 0.2588618 |
| Cr | 52 | 550.763 | 0.0550763 |
| Co | 59 | 423.278 | 0.0423278 |
| Ni | 60 | 142.317 | 0.0142317 |
| Cu | 63 | 1892.395 | 0.1892395 |
| Zn | 66 | 850.855 | 0.0850855 |
| Ga | 71 | 445.775 | 0.0445775 |
| Rb | 85 | 24739.466 | 2.4739466 |
| Sr | 88 | 119.136 | 0.0119136 |
| Y | 89 | 1051.556 | 0.1051556 |
| Zr | 90 | 915.092 | 0.0915092 |
| Nb | 93 | 4951.254 | 0.4951254 |
| Cs | 133 | 1521.964 | 0.1521964 |
| Ba | 137 | 444.534 | 0.0444534 |
| La | 139 | 1886.374 | 0.1886374 |
| Ce | 140 | 4305.023 | 0.4305023 |
| Pr | 141 | 555.407 | 0.0555407 |
| Nd | 146 | 1730.689 | 0.1730689 |
| Sm | 147 | 350.874 | 0.0350874 |
| Eu | 151 | 13.297 | 0.0013297 |
| Gd | 157 | 308.414 | 0.0308414 |
| Tb | 159 | 40.758 | 0.0040758 |
| Dy | 163 | 332.292 | 0.0332292 |
| Ho | 165 | 49.491 | 0.0049491 |
| Er | 166 | 102.417 | 0.0102417 |
| Tm | 169 | 29.466 | 0.0029466 |
| Yb | 172 | 162.494 | 0.0162494 |
| Lu | 175 | 36.527 | 0.0036527 |
| Hf | 178 | 40.65 | 0.004065 |
| Ta | 181 | 790.906 | 0.0790906 |
| Pb | 208 | 164.515 | 0.0164515 |
| Th | 232 | 509.497 | 0.0509497 |
| U | 238 | 2.274 | 0.0002274 |
| Rh | 103 | | |
| Total | | | 5.2341683 |

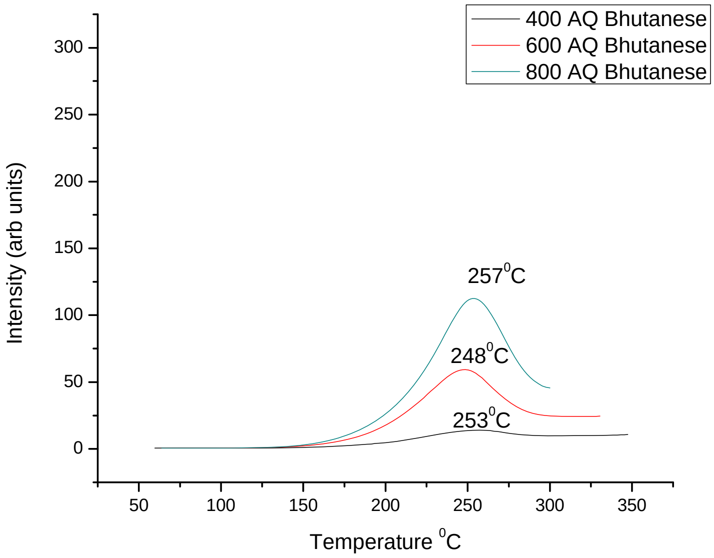


**Fig. 7.** Annealing effect of gamma irradiated Bhutanese stone (at dose 0.5 kGy).

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**References**
[1] S.W.S. McKeever, *Thermoluminescence of solids* (Cambridge University Press, Cambridge, 1985).
[2] Vikas Dubey, Jagjeet Kaur, N.S. Suryanarayana // *International Journal of Industrial Engineering and Technology* **2** (2010) 383.
[3] Vikas Dubey, N.S. Suryanarayan, Jagjeet Kaur // *Journal of Minerals & Materials Characterization & Engineering* **9** (2010) 1101.
[4] P.C. Choubey, Jagjeet Kaur, N.S. Suryanarayana, V. Dubey, G. Das // *Mater. Phys. Mech.* **10** (2010) 47.
[5] J.T. Randall, M.H.F. Wilkins // *Proc. Roy. Soc. A* **184** (1945) 366.
[6] F. Urbach // *Wiener Ber. IIa* **139** (1930) 363.
[7] L.I. Lushihik // *Sov. Phys. - JETP* **3** (1956) 390
[8] R. Chen // *J. Electrochem. Soc.* **116** (1969) 1254.
[9] R. Chen, S.W.S. McKeever, *Theory of Thermoluminescence and Related Phenomenon* (World Scientific, Singapore, New Jersey, London, Hong Kong, 1997).
[10] M. Martini, F. Meinardi // *La Rivista del Nuovo Cimento* **20 (8)** (1997) 1.
[11] M. Martini, S. Paravisi, C. Liguori // *Radiation Protection Dosimetry* **66 (4)** (1996) 447.