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Note

Thermoluminescence characteristics of USGS standard basaltic rock BCR-1

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Thermoluminescence (TL) investigations on lunar and meteorite samples are on the increase and it is necessary for the laboratories to work with some reference standard sample of similar behaviour before taking up actual measurements on precious samples of limited availability. The different rock samples of the United States geological survey standards can fill this need and measurements made on BCR-I, a standard basalt of the Columbia river bed are presented here.

EXPERIMENTAL

The TL instrument used is described elsewhere[1]; however, instead of the motor-driven autovariac for the heater voltage supply, an indigenously made temperature programmer was used in the present investigations. All TL measurements were normalised to 5 mgm weight of the sample on the TL heater pan. The TL emission spectra were determined by recording monochromatic TL glow curves through band pass filters[2].

RESULTS AND DISCUSSION

The natural TL (NTL) glow curve of the virgin sample and that obtained after artificial gamma irradiation in the laboratory (ATL) are shown in Figs. 1 and 2. It is clearly seen that the TL glow curve is characterised by three peaks at 170°C (I), 283°C (II) and 377°C (III) with the first peak having completely decayed in the NTL.

From the known U, Th and K concentrations in BCR-I, it can be computed that the total beta, gamma annual self-irradiation rate is of the order of 300 mR yr^{-1}. (The alpha irradiation can be neglected as its TL effectiveness is very low.) The TL calibration obtained by incremental artificial gamma irradiations in the laboratory reveals that the NTL exhibited by BCR-I is equivalent to about 4×10^4 R of beta, gamma irradiation. This leads to a TL age estimate (upper limit, as the cosmic component of the irradiation is neglected) of about 1.4×10^5 years which is quite low

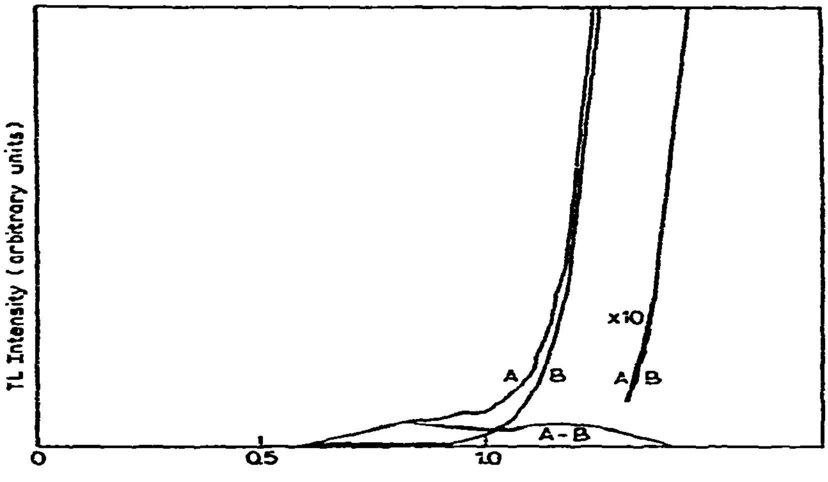

Fig. 1. NTL glowcurve of USGS standard basalt BCR-I: A, NTL curve; B, thermal background. A − B = NTL signal. Heating rate 300°C min^{-1}.

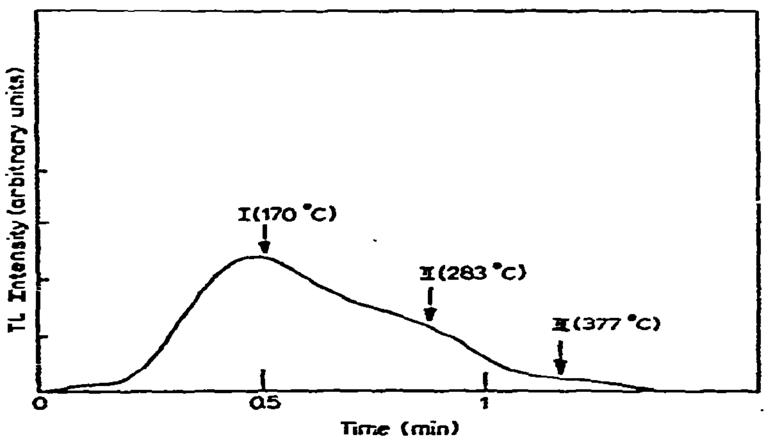

Fig. 2. ATL glowcurve of USGS standard basalt BCR-I. Gamma exposure given = 8.6 × 10^5 R. Heating rate 300°C min^{-1}.

compared to 20–30 million years, known[2] to be the age of BCR-I. It is also known[3] that, in dating up to about 50 million years, an NTL peak at more than 300°C coupled with an activation energy nearer to about 2 eV is necessary; otherwise the peak is drained considerably even at 20°C. Although the NTL peak of BCR-I is at a temperature well above 300°C, the low TL age obtained may be indicative of a rather shallow trap (< 2 eV) with a mean life much shorter than the actual geological age involved. Experimental determination of the activation energy by the "initial rise method" has indeed yielded values of 0.73 eV and 1.42 eV respectively for the peaks II and III which constitute the NTL.

The TL emission spectra are presented in Fig. 3 and it is seen that peak I is emitted predominantly in the 500–560 nm region while peaks II and III (corresponding

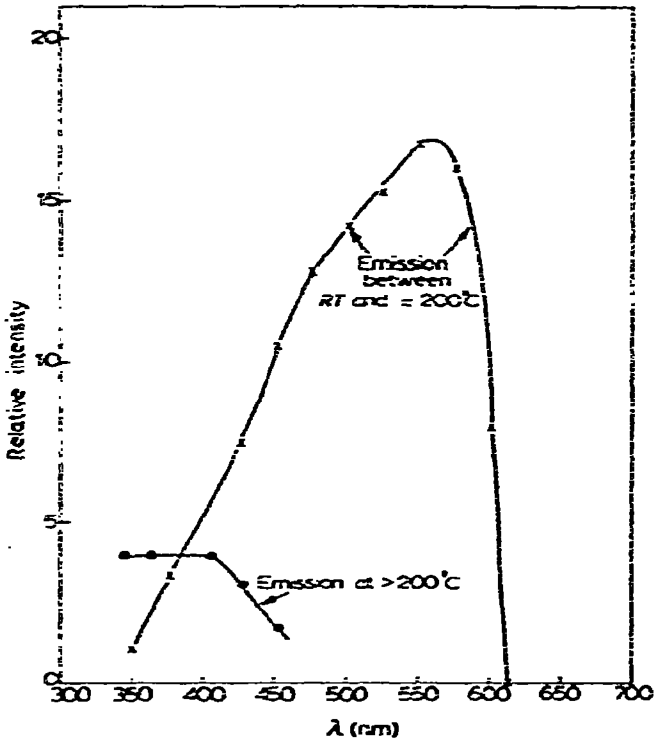

Fig. 3. TL emission spectra of USGS standard basalt BCR-I.

to NTL) are emitted predominantly in the 350–400 nm region. The bands could not be well resolved because of low levels of emission and the use of band pass filters to register the spectrum. However, these bands coincide remarkably with the emissions of Mn^{2+} and Ce^{3+} ions which are well known TL emitters (at ~ 1% by weight and trace quantities respectively) in a variety of host lattices such as CaF_2, $CaSO_4$, $CaCO_3$, CaO, CaS etc. Available analytical reports[4] reveal that BCR-I has about 0.2% by weight of Mn and among the rare earths Ce is present in the highest concentration range of around 50 ppm. The predominance of the manganese emission at lower temperatures and cerium emission at higher temperatures lends further support to the conclusion that Ce and Mn impurities cause the TL emission in BCR-I.

ACKNOWLEDGEMENT

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