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Note

Thermoluminescence studies of some silicate minerals

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The application of the thermoluminescence technique to geology and related phenomena has been discussed by several authors[1,2]. The usefulness of this method in comparative studies of geological samples is well recognised. Its application to age determinations of both geological[3] and archeological[4] specimens has been seriously investigated with several instances of success at least in the latter case. Attempts have also been made to determine the nature of traps and emission centres in rock materials[5]. The effect of temperature and pressure on thermoluminescence has also been studied[6–8]. Thermoluminescence as a tool in mineral prospecting, particularly radioactive minerals U, Th, etc. has also been tried for this purpose but without much success[9]. This paper reports on the thermoluminescence of some silicate minerals taken from various localities of pre-cambrian age. Most of the results presented here are characterised by being negative, some contrary to expectations as per the classification of McDaugall[10].

EXPERIMENTAL

The minerals were crushed to powder of particle size 80–200 mesh. Only 5 mg of powder were used for the recording of the thermoluminescence glow curve.

TL glow curves were recorded with a linear heating rate of about 70°C min^{-1} and the light intensities were measured with a EMI 69514 S photomultiplier. A stainless-steel plate with a small central hole just sufficient to keep the 5 mg powder sample on a Kanthal heater plate in full sight of the photomultiplier tube, was used along with a chance HA_3 filter to reduce the thermal noise of the photomultiplier when the sample is being heated. The flow-rate of N_2 in the sample–photomultiplier housing was about 2.5 l/min^{-1}. The instrument is described in detail elsewhere[11]

In recording the natural thermoluminescence (NTL), N_2 flow was not used each time. It is our experience that N_2 does not remove the spurious thermoluminescence completely. Therefore, if a high NTL was observed in any sample this was read in N_2 atmosphere as happened with our feldspar sample. The large NTL shown in

Fig. 1 almost completely disappeared. The ^{60}Co gamma exposure values and the heating rates are indicated for each sample in the figure.

RESULTS AND DISCUSSION

Silicate minerals of different types were taken to study their thermoluminescence response. The minerals chosen included both types, viz., those expected to exhibit thermoluminescence and those expected not to show any thermoluminescence or only very weakly as per the classification of McDaugall[10]. Thus, we have feldspar, zircon and quartz of the former type and aquamarine, tourmaline, hornblende, garnet, kyanite, serpentine, etc. of the latter variety. Studies on carbonates are being reported separately[12].

Among the samples of the first type, i.e., expected to give NTL, it is surprising to see that practically no NTL was observed in feldspar and three specimens of zircon, collected from igneous rocks. The only sample which has NTL is the zircon sand obtained from separation of the monazite containing sands of Kerala coast.

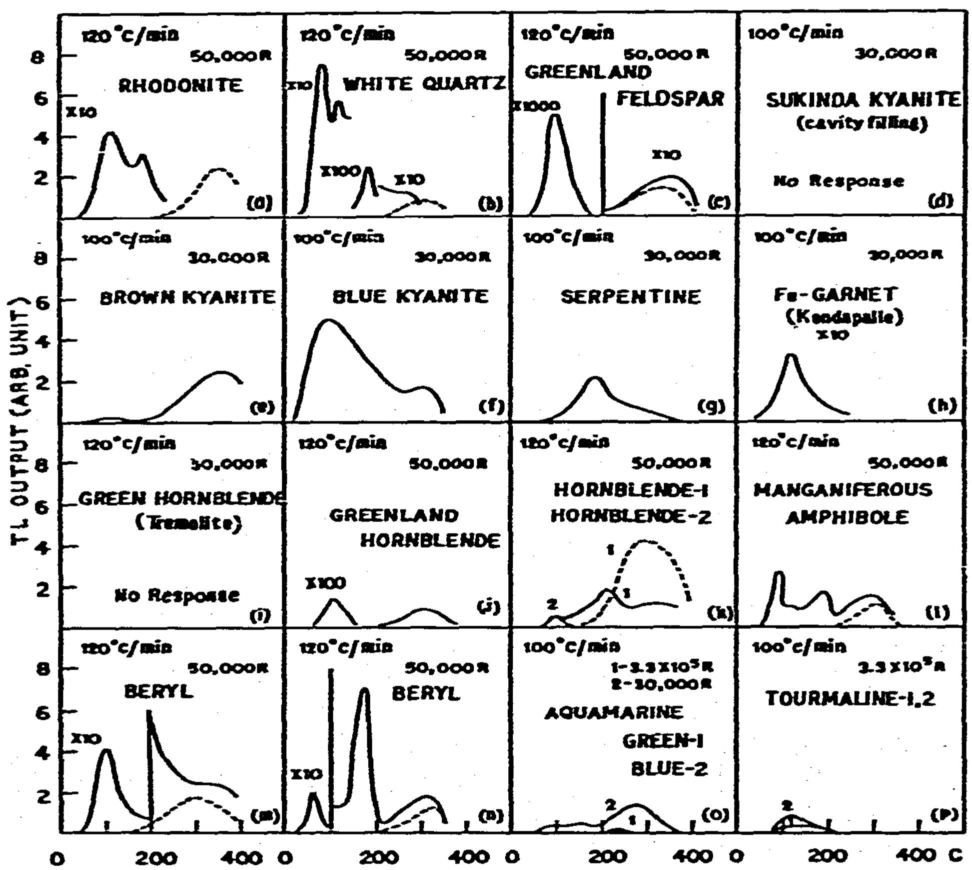

Fig. 1. Thermoluminescence of some silicate minerals. — — —, NTL spurious; ———, after exposures.

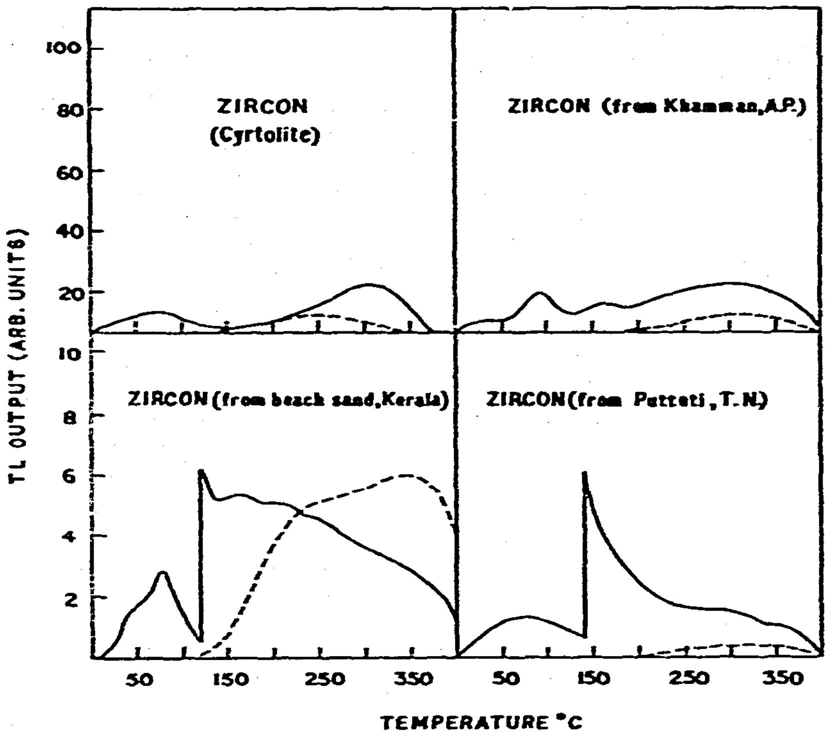

Fig. 2. Thermoluminescence glow curves of zircon samples. – – –, natural thermoluminescence; ———, after irradiation to 50,000 *R* of ^{60}Co. Heating rate, 80°C min^{-1}.

The results are shown in Figs. 1 and 2 with details of the sample, radiations and heating marked. The large NTL seen in the feldspar sample disappears for the greater part when the sample is heated in N_2 atmosphere. This has also been reported by Aitkin[4] and others. The little amount remaining, we believe, is also NTL but spurious TL which cannot be removed even with N_2. This is our experience with synthetic phosphors like LiF and CaF_2 where spurious TL is well documented. For the zircon samples (Fig. 2) the little NTL could be reintroduced in the heated samples by shaking them a little. The NTL of zircon sand appears to be only about 20% of the saturation value. On irradiation too the three mineral samples of zircon show very little thermoluminescence whereas the sensitivity of the sand is very high as indicated in Fig. 2. It is difficult to say whether radiation damage due to α-particles in the sand has anything to do with the sensitivity. One reason for the absence of NTL in zircon samples could be their extreme insensitivity to TL response, viz., 50,000 *R* give very small peaks. Similarly the feldspar sample on irradiation showed only a very sensitive low temperature peak but no high temperature response. And this might be the reason for its not showing any NTL. However, it might be mentioned here that this is quite contrary to the reported results on TL of feldspar.

Among the weakly sensitive or insensitive silicates aquamarines and tourmalines appear to be the most TL insensitive mineral. We tested (1) green aquamarine (from Chakai, Simultala, Bihar), (2) blue aquamarine (from M.P.), and (3 & 4)

Tourmalines (from Chakai). None of these samples showed any NTL. This is not surprising because even after an irradiation of 3.3×10^5 R no TL is observed.

Next several samples of hornblende were tested. Again no NTL was observed, even on irradiation very little TL was seen. One sample of hornblende was collected from the S. W. Greenland (Fisknaesset area) feldspar rock which contained hornblende to a good extent. On irradiation both showed a single peak at about the same temperature (Fig. 1). But the response of hornblende is about 1/50th that of Feldspar. Other hornblende samples tested included: (i) green hornblende (tremolite) from Bichaburu, S. Singhbhum Dt., Bihar; (ii) hornblende in quartz-amphibolite from Saladipura, Rajasthan; (iii) purple amphibole (winchite) from M.P.; and another (iv) Mn-amphibole (Tirodite) from M.P. The responses of these were found to be different. The first showed little TL sensitivity, the second only a low temperature peak, the third a high temperature peak and the fourth showed three peaks.

Iron-garnet (from granulitic acid rocks from Kondapalle, A.P.) was also seen for TL response on irradiation. This showed a low temperature peak but more sensitive than the hornblende.

Three samples of kyanite—blue, green and brown (with Fe^{3+})—were also read for their NTL and TL on irradiation. Again no NTL was observed and only the brown kyanite showed a little response after 30,000 R. A very hard variety of serpentine again showed no NTL and a small low temperature peak after 30,000 R exposure.

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