The bleaching of latent optically stimulated luminescence

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Introduction

The very nature of optically stimulated luminescence (OSL) ensures that samples are liable to bleaching by even short exposure to laboratory illumination during preparation. The results are reported here of tests on quartz and feldspar samples exposed to 1200 mm long 40 W fluorescent tubes at a distance of 1 m. Three colours of fluorescent light were investigated, red which has a long history of use in the preparation of samples for thermoluminescence measurement, gold which was the subject of a recent report in relation to thermoluminescence (Galloway and Napier, 1991) and white which served to indicate the extent of any benefit from the use of coloured light. The red tube emits a continuous distribution of wavelengths from 600-800 nm peaked at 640 nm and provides 20 mW m^{-2} at a distance of 1 m, the gold tube emits a continuous distribution of wavelengths from 510-750 nm peaked at 580 nm and provides 100 mW m^{-2} at a distance of 1 m, while the white tube emits over the wavelength range 310-720 nm with emission lines particularly noticeable at 610, 550, 440, 405 and 360 nm and provides 500 mW m^{-2}, Thorn EMI Lighting (1987). Fine grain samples of quartz were prepared from 'acid washed sand' (BDH Ltd., Broom Road, Poole BH12 4NN, England) and fine grain felspar samples from Norwegian microcline material. They were drained of natural luminescence either by heating to 500 °C or by exposure in a SOL-2 solar simulator for 30 minutes. Each sample was exposed to a $^{90}Sr/^{90}Y$ beta source to provide a radiation dose of 240 Gy and then pre-heated at 200 °C for 60 s to empty thermally unstable traps. An OSL measurement of 1s duration (which released less than 1% of the latent signal) was made on each sample for normalisation prior to exposure of the sample to light. Similarly normalised samples were measured without light exposure for reference before each sequence of exposures while samples were stored in the dark for the duration of the sequence and measured subsequently to ensure that no fading occurred which was unrelated to light exposure.

For the infra red stimulated luminescence of feldspar the LED system described by Galloway (1991) was used, providing an estimated 50 mW cm^{-2} at the sample and with luminescence detection being by EMI 9635QA photomultiplier preceded by 2 mm Schott BG 39, 4 mm Corning 7-59 and 4 mm Chance HA3 filters, providing a transmittance peak around 370 nm. For the green light stimulated luminescence of both quartz and feldspar a similar arrangement was used but of green LEDs, type TLMP 7513 manufactured by III-V, with a maximum in their emission spectrum at 565 nm and providing about 0.2 mW cm^{-2} at the sample. In this case the filters used were Schott 0.5 mm BG39, 4 mm UG 11, Corning 4 mm 7-59, 4 mm 7-60 and Chance 4 mm HA3 which provided a sharper transmittance peak at 360 nm.

Quartz

Preliminary measurements with the green LED system on quartz samples showed that the samples zeroed by heating to 500 °C had a much greater sensitivity to the beta dose than the samples zeroed in the solar stimulator, table 1. Because of this substantial difference in behaviour bleaching tests were carried out on samples zeroed in both ways. The percentage reduction in OSL intensity is plotted against duration of light exposure in fig.1 which however shows no distinction between method of zeroing despite the difference in sensitivity. Fig. 1 does show that there is a marked dependence of rate bleaching on the colour of the light even when allowance is made for the different intensities from the three colours of fluorescent tube used, as noted above. That comparison of the red and gold light data indicates greater bleaching for a given energy absorbed by the sample as the wavelength is reduced suggests that the short wavelength components in the white light are responsible for its rapid bleaching. The reduction in bleaching effect with increasing wavelength in fig. 1 is similar to the wavelength dependence of the bleaching of the 325 °C thermoluminescence peak in quartz reported by Spooner *et al.* (1988).

Feldspar

The sensitivity of the feldspar samples as measured with the green LEDs was less dependent on the method of zeroing than in the case of quartz, table 1, the heated feldspar being only about 30% more sensitive than the optically zeroed feldspar. Nevertheless for completeness bleaching tests were carried out on samples zeroed in both ways, with the results displayed in fig. 2. As was the case with quartz, the rate of bleaching is not significantly dependent on the method of zeroing. However in marked contrast to the quartz results the energy required form the bleaching light to produce a particular reduction in OSL intensity is not significantly dependent on the colour of the light.

Similar measurements were made on the bleaching of the infra red stimulated luminescence of feldspar samples, fig. 3. In this case the material zeroed by heating showed about 40% greater sensitivity than the optically zeroed material although again the method of zeroing did not influence the rate of bleaching. As with the green OSL, the degree of bleaching is not obviously dependent on the colour of the bleaching light but only on the energy absorbed. Indeed the dependence of degree of bleaching on energy from the fluorescent light is essentially the same in figs. 2 and 3, i.e. for both green and infra red stimulated luminescence from feldspar.

Conclusions

While the bleaching of green OSL from quartz is dependent on the colour of the light, the bleaching of both green and infra red OSL from feldspar is essentially similarly dependent on the energy absorbed from the bleaching light independent of colour over the visible range. As a guide to a maximum acceptable exposure of samples to light, table 2 lists the energy per unit area which produces a 1% bleaching of OSL. Also listed is the time required for a 40 W 1200 mm long red, gold or white tube at a distance of 1 m from the sample to produce 1% bleaching. Except for quartz exposed to red light, the times are all very short. For feldspar the longer times for gold and red light simply relate to the lower light intensity from the coloured fluorescent tubes rather than to the colour as such. In so far as the same light sensitive traps in the sample crystals may be relevant to both OSL and recently described thermoluminescence techniques for the dating of sediments, Franklin and Hornyak (1990), Prescott and Fox (1990), the limitations of table 2 may apply also to sediment samples for such thermoluminescence dating, even though the TL signal is generally considerably less sensitive to light than the OSL signal from the same material (Godfrey-Smith et al, 1988).

Acknowledgements

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Table 1.
Relative OSL intensity for samples of comparable mass and given the same beta dose (240 Gy) and pre-heat (60s at 200°C).

sample zeroing	quartz SOL-2	feldspar SOL-2	feldspar 500 °C	quartz 500 °C
rel.int.	1	29	37	77

Table 2.
Best estimate from the data of the energy per unit area and exposure times for a 1 % reduction in OSL intensity. The exposure times refer to a 40 W 1200 mm fluorescent tube at a distance of 1 m from the sample.

fluorescent light colour	Green LEDs quartz J m^{-2}		feldspar J m^{-2}		Infra red LEDs feldspar J m^{-2}	
red	350	5 Hrs	7	6 min	10	8 min
gold	60	10 min	7	1 min	10	2 min
white	5	10 s	7	15 s	10	20 s

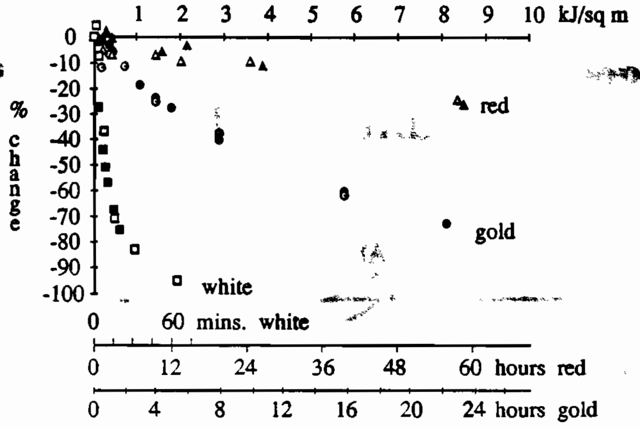

Figure 1. The dependence of the percentage reduction in green LED stimulated luminescence from quartz on the energy per unit area delivered by the fluorescent tubes to the sample (upper axis, based on the manufacturer's data and duration of exposure). The corresponding duration of exposure to white, red and gold fluorescent tubes (40 W 1200 mm long) at a distance of 1 m is given on the lower axes. The solid symbols refer to samples zeroed by heating to 500 °C and the open symbols to optically zeroed samples.

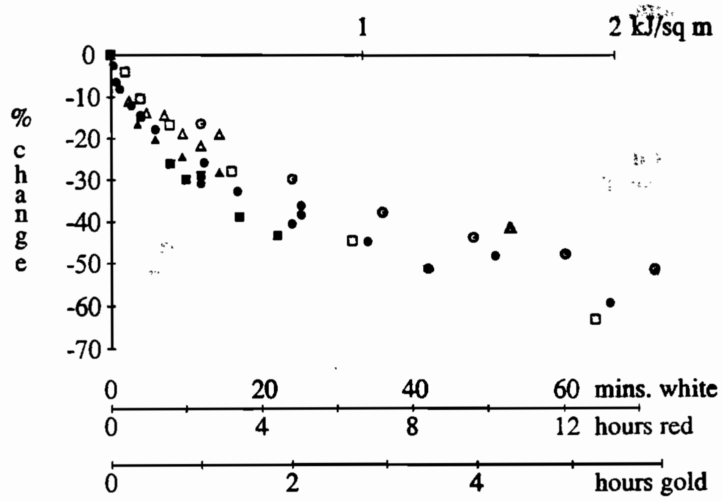

Figure 2. Data on the bleaching of feldspar luminescence stimulated by green LEDs in the same format as figure 1. Squares refer to white light, triangles to red light and circles to gold light, solid symbols to samples zeroed by heating to 500 °C and open symbols to samples optically zeroed.

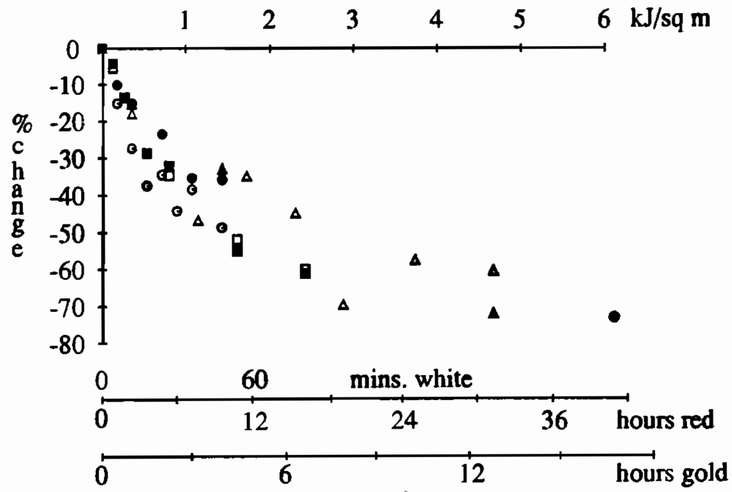

Figure 3. Data on the bleaching of feldspar luminescence stimulated by infra red LEDs in the same format as the previous figures.