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Alternative laboratory illumination: 'gold' fluorescent tubes

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Introduction

In the process of arranging a laboratory for TL work, initially concerned with quartz, consideration was given to the appropriate illumination, taking account of recent reports on the variability in the optical transmission properties found in different batches of nominally identical filters (Spooner and Prescott 1986, Smith 1988). In order to avoid using filters around 'white' fluorescent tubes, a search through technical specifications provided by manufacturers was made for a fluorescent tube which emitted light only within the wavelength range found to be satisfactory by Spooner and Prescott (1986), that is with no significant emission at wavelengths shorter than about 500 nm. 'Gold' tubes supplied by Thorn EMI Lighting were selected. According to the manufacturer's data (Thorn EMI Lighting 1987) they do not emit at wavelengths shorter than 510 nm, which compares well with the commonly used 'Cinemoid No. 1' filter with a cut off at 470 nm and with the 'Chris James No. 179' filter recommended by Spooner and Prescott (1986) with a cut off about 490 nm. The emission spectrum from these 'gold' tubes is peaked at 590 nm falling to zero on either side at about 510 nm and 750 nm (Thorn EMI Lighting 1987). While initially the concern was with quartz TL which determined the choice of fluorescent tube type, later work concerned feldspars and optically stimulated luminescence and these are also considered below.

Illumination conditions

The samples investigated were illuminated in two different ways. In one arrangement the samples were placed at a distance of 1 m below a single 1200 mm long 40 W gold fluorescent tube. From the data on the tube, Thorn EMI Lighting (1987), the illumination intensity in this situation is calculated to be about 0.1 W m^{-2} (neglecting any reflection from walls or ceiling). In the other arrangement, the normal room lighting comprising 6 pairs of ceiling mounted 1500 mm white tubes was replaced by gold tubes of the same length rated at 65/80 W. The 'off-white' painted room measured 6 m x 7.5 m x 3 m high and the samples were exposed on a table surface 0.75 m above the floor. A relative measurement of the level of illumination in the latter situation showed it to be about twice that in the former.

The samples investigated

Quartz, feldspar and a mixed mineral sediment were used in the tests. The quartz samples were prepared from 'acid washed sand' (supplied by BDH Ltd., Broom Road, Poole BH12 4NN, England) which was ground down, separated by sedimentation to nominally 2 - 10 μm size and deposited on stainless steel discs 12 mm in diameter by 0.2 mm thick with about 3 mg of material per disc. The feldspar samples were prepared similarly from a microcline feldspar of Norwegian origin. The mixed mineral material came from a French lake sediment with standard fine grain preparation.

The TL fading tests

For all the TL measurements, sample heating and application of beta dose the equipment described recently (Galloway 1990) was used. The sample heating rate was 5 °C/s. The TL was detected by an RCA 8575 photomultiplier preceded by a 2.5 mm thick 5-58 filter and a 4 mm thick HA-3 heat absorbing filter.

For the TL fading tests on the gold lighting, each sample was drained of natural TL by heating to 500 °C and exposed to a ^{90}Sr beta source for a set time. Different beta exposure times were set for quartz, feldspar and the sediment to account for their different sensitivities. After exposure to the gold light for a chosen time each sample was pre-heated at 200 °C for 60 s and the TL glow curve recorded to 500 °C. Reference glow curves for no exposure to gold light were obtained using the same sequence of measurements. Samples were also stored in the dark for the duration of each test and then measured to ensure that no fading was taking place regardless of the influence of the light. Sample to sample normalisation was based on similarly measured TL, integrated over the temperature range 210-500 °C, resulting from equal radiation doses given to all members of the set of samples used for a particular sequence of tests.

An overall indication of fading due to exposure to the gold light is provided by the dependence of the 210 - 500 °C integrated TL intensity on the duration of the exposure and is shown in fig.1. The error bars drawn on the points in fig. 1 correspond to ±3% uncertainty in the normalised TL intensities, the value indicated by tests on sets of 10 identically treated samples not exposed to the light. Exposure to the gold light has no noticeable effect on quartz although both feldspar and the

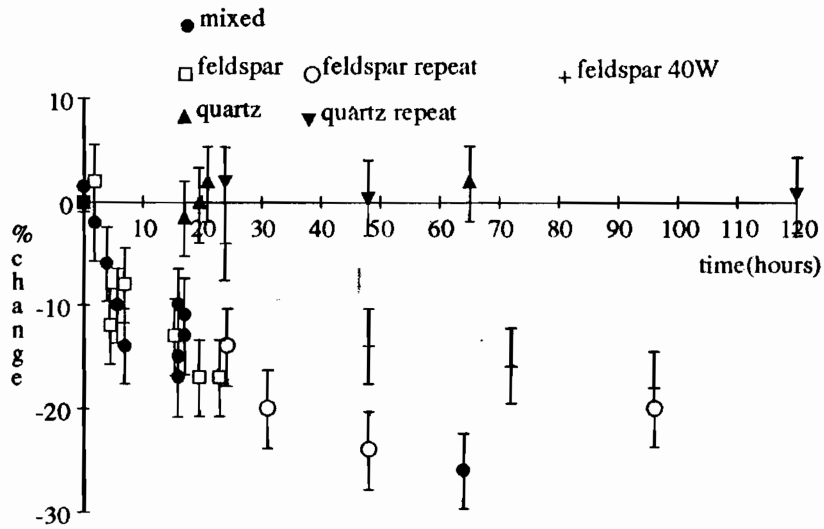

Figure 1.
Percentage change in TL intensity related to duration of exposure of quartz, feldspar and mixed mineral sediment samples to gold fluorescent lighting. The points labelled 'repeat' were measured 4 months later than the original ones.

sediment which has a feldspar component are significantly bleached by prolonged exposure.

As would be expected for the feldspar samples exposed to the single 40 W gold tube at 1 m, the halving of light intensity compared with the room lights results in about half the fading. Indeed for exposure times of up to 6 hours to the 40 W tube at 1 m fading effects cannot be clearly distinguished from random fluctuations in the measurements, fig. 2, although least squares fitting of a straight line to this set of data indicates a fall of about 4 % in TL intensity over the 6 hour period in accord with the trend in fig.1.

Four months after the first tests on the gold room lights a repeat set of tests on samples of quartz and of feldspar were carried out with results consistent with the first set, fig. 1.

Gold light exposure and glow curve shape

Looking at the recorded glow curves in more detail, no significant change in shape was observed due to exposure to the gold light. Such small variations as did occur were no more than could be seen in the comparison of glow curves from identically treated samples, due possibly to variations in thermal conductivity from heater to sample material. A quantitative investigation of possible change in glow shape for both quartz and feldspar is illustrated in fig. 3.

Consider first the case of quartz. Spooner, Prescott and Hutton (1988) studied the wavelength dependence of the bleaching of quartz TL and found the 325 °C peak to be bleached by visible light and the 370 °C and 480° peaks to be sensitive only to UV. Fig. 3a concerns the TL intensity from these three peak regions of the glow curves (integration ranges 320-335 °C, 365-380 °C, 475-490 °C respectively) for up to 5 days exposure to the gold room lights. No statistically significant change in intensity is observed, the percentage changes being -2±3 for the 325 °C region, +4±8 for the 370 °C and +13±11 for the 480 °C region. Spooner, Prescott and Hutton (1988) indicate that for 590 nm light, the peak in the emission spectrum from the gold tubes, complete bleaching of the 325 °C quartz TL should require about 10^4 J m^{-2} and so for our estimated intensity of 0.1 W m^{-2} should take about 30 hours. That substantial bleaching of the 325 °C region is not observed in fig. 3a even in 120 hours could have three possible explanations, now considered in turn.

One is simply that our estimate of gold light intensity is substantially too high. Unfortunately absolute measurement of the light intensity was not possible but it seems unlikely that calculation from the manufacturer's data should be in error by as much as a factor of 2. Even an order of magnitude lower intensity than calculated should still, on the basis of the Spooner, Prescott and Hutton (1988) measurements, show an effect within the 5 days covered by fig. 3a. An attempt to observe some bleaching of quartz TL by the gold light was made by placing samples at a distance of only 5 cm from the 40 W gold tube for 24 hours. The light intensity incident on samples at 5 cm from the 120 cm long tube is calculated to be 40 times that at a distance of 1 m when allowance is made for the extended nature of the light source.

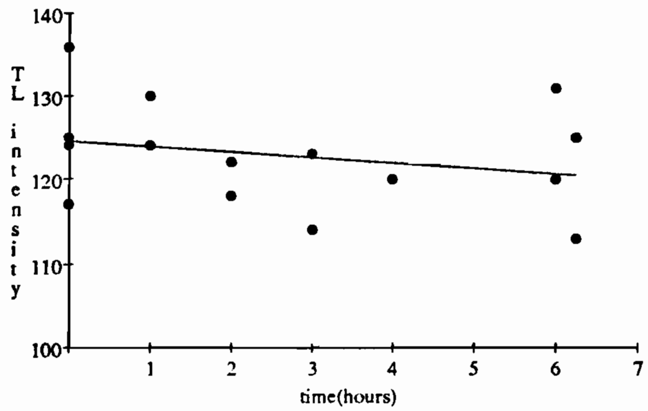

Figure 2.
Normalised TL intensity in arbitrary units for feldspar samples exposed for various lengths of time to a single 1200 mm 40 W gold fluorescent tube at a distance of 1 m. The straight line least squares fit to the data indicates a fall of TL intensity of 4% in 6 hours.

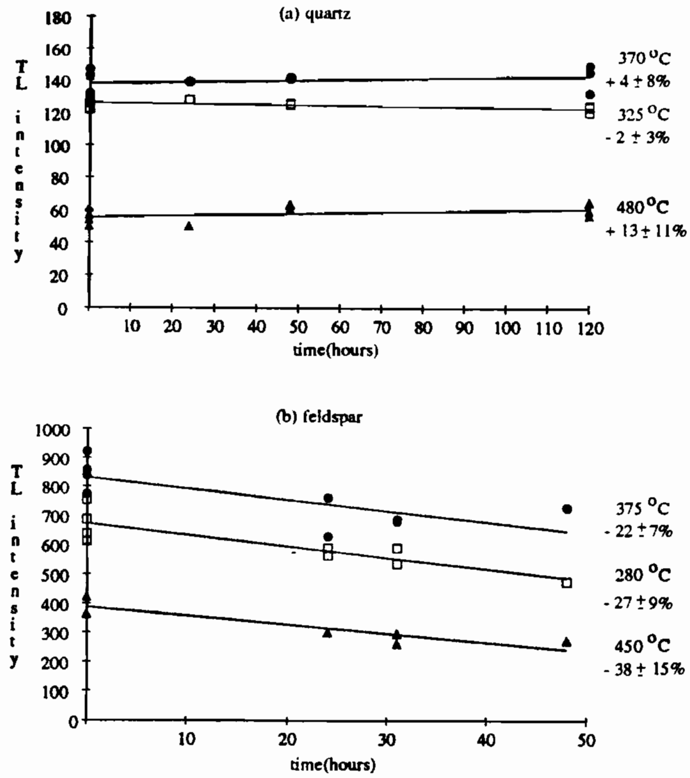

Figure 3.
(a) Normalised TL intensity in arbitrary units at 325 °C, 370 °C and 480 °C from the glow curves for quartz samples exposed for up to 120 hours to the gold room lights.
(b) Normalised TL intensity in arbitrary units at 280 °C, 375 °C and 450 °C from the glow curves for feldspar exposed to the gold room lights for up to 48 hours.

For each temperature there are 10 measured points in (a) and 9 in (b) although not all individually distinguishable on the plot. The lines are least squares fits to the measurements and the percentage change in normalised TL intensity indicated by each best fit line over the maximum exposure period is given to the right of the line.

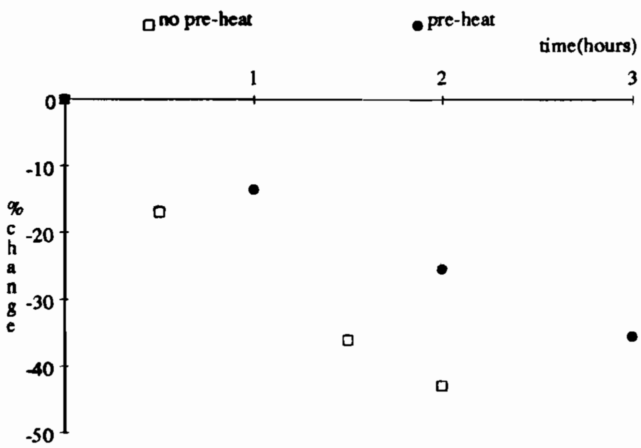

Figure 4.
Percentage change in intensity of infra red stimulated luminescence from feldspar related to the duration of exposure of the samples to the 40 W gold fluorescent tube at 1 m. The pre-heated samples were heated for 60 s at 200 °C prior to luminescence measurement.

Comparing the TL emission of 3 samples exposed for 24 hours at 5 cm with 3 samples stored in the dark indicates a percentage change of -10±7 at 325 °C, -6±4 at 370 °C and -4±4 at 480 °C. Thus bleaching of the quartz TL requires a considerably higher light intensity than arises in the laboratory illumination under test. Qualitative observation of the effect of exposure of our BDH quartz to white fluorescent light does clearly show the preferential bleaching of the 325 °C region of the glow curve.

A second possible explanation is that this quartz is less sensitive to light than the samples of quartz from several Australian sources used by Spooner, Prescott and Hutton (1988). All that can be added in this connection is that one set of tests at the 5 cm exposure position on a quartz of quite different origin gave similar results to those quoted above.

A third possibility is that the rate of bleaching is intensity dependent, being slower at low intensity. The intensity used in the measurements at a comparable wavelength by Spooner, Prescott and Hutton (1988) was about 250 times the calculated intensity for the 40 W gold tube at a distance of 1 m, but only about 6 times the intensity at 5 cm from the tube.

It is not certain which of these possible explanations is dominant or whether more than one applies. In relation to laboratory lighting it would be prudent to bear the second possibility in mind. *(see postscript)*

Similar data on feldspar is provided in fig. 3b along with least squares fitted lines, although restricted to 48 hours exposure to the room lights as fig. 1 indicates that linear fitting may not be appropriate for longer times. Allowing for the uncertainty in the slopes of the fitted lines the shape of the glow curves do not change significantly, the observed percentage changes over the 48 hour period being -27±9 for 275-290 °C, -22±7 for 370-385 °C and -38±15 for 445-460 °C.

Gold light and OSL

Infra red stimulated luminescence from feldspar is much more rapidly bleached by exposure to the gold light than is the TL signal as shown in fig. 4 for samples exposed for up to 3 hours to the 40 W tube at a distance of 1 m. Results are shown both for samples which were heated at 200 °C for 60 s to empty thermally unstable traps prior to luminescence measurements and for samples which received no pre-heat treatment. The latter show a larger bleaching effect than those pre-heated. The luminescence has been integrated over a period of 100 s, a time sufficient for most of the luminescence to be included in the integration. Sample to sample normalisation was based on the intensity of 1 s OSL from each sample prior to exposure to the gold light. Samples stored in the dark over several hours showed no loss of OSL intensity.

Conclusions

The gold fluorescent tubes provide a useful alternative to the use of filters around white tubes with greater convenience and no possibility of problems from filters overheating. Quartz TL, in relation to which the tubes were selected, is unaffected by long exposure to the gold light, up to 5 days having been tested with full room illumination. Feldspar TL is much more affected and exposure must be limited in time and intensity for negligible bleaching, say to no more than 2 or 3 hours under a 40 W tube at 1 m. Infra red stimulated luminescence is quite rapidly bleached by the gold light and for samples pre-heated to empty unstable traps, a 1% reduction occurs in only 4 minutes for light from a 40 W tube at a distance of 1 m. It is worth noting from the shape of the bleaching curves that simple linear interpolation from the effect of a long light exposure to estimate the effect of a short exposure will under-estimate the short exposure effect. Comparison with past work suggests that not all quartz is equally sensitive to gold light.

Postscript

Prescott and Fox (1990) have now shown that the TL emission at 325 °C from quartz is at a shorter wave-length than the TL at neighbouring temperatures and that the 325 °C TL may be emphasised by use of a combination of UG-11 and 7-59 filters. Measurements with this filter combination show a bleaching of 35% at 325 °C for 4 hours exposure to the gold room lights, whereas measurements with 7-59 filter show only 5 % bleaching and the 5-58 filter used in the work above shows no significant effect. The original purpose of the investigation of the gold tubes was for high temperature TL work on quartz which had been zeroed thermally and for which they are suitable. However, they are not appropriate for use while handling quartz extracted from sediments when the 325 °C TL peak is the predominant interest.

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