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Irradiation of loess samples at elevated temperatures

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Introduction

In some recent TL studies of loess from western Europe, it has not been possible to achieve ages greater than about 100 ka (Debenham, 1985) or 150 ka (Wintle, Shackleton and Lautridou, 1985; Wintle, 1985). Systematic underestimation of the TL ages occurs when the TL from mixed fine grain minerals is observed in the ultraviolet part of the spectrum, as observed using a Schott UG-11 filter, and when the regeneration method is used for ED determination for samples older than about 50 ka. Typical European loess samples of this age will have an ED of around 200 Gy and their natural TL signal will occur in a part of the glow curve which is clearly non-linear. It should be pointed out that no such underestimation has been reported by Zöller, Stremme and Wagner, 1988), who employ the regeneration method on fine grains but use a Corning 5-58 filter and a strong thermal wash before TL measurement.

Several causes have been hypothesized, but none proven.

1) The apparent saturation of the TL age obtained for progressively older samples led Debenham (1985) to suggest a time-dependent loss of luminescence centres. This would effect all methods of ED determination, not just the regenerative method.

2) A sensitivity change after bleaching. No sensitivity changes are apparent for young samples, and it is difficult to determine such changes for older samples which show non-linear growth curves. However, it has been hypothesized that the sensitivity change is dose-dependent (Wintle, 1985; Rendell and Townsend, 1988).

The hypothesis

There is also another difference between irradiation in nature which produces the natural TL signal and irradiation of the laboratory-bleached sample discs which results in the matching regenerated signal - the traps which are responsible for the TL signal up to 200 °C are kept empty at ambient temperature in the natural environment. Let us hypothesize that the trapping cross section for these traps is higher than for the traps between 280 °C and 380 °C, where the ED determinations are made. Then during natural irradiation free charge carriers will go preferentially to the shallower traps and the deeper traps will fill more slowly than during the laboratory irradiation after bleaching when the shallower traps fill and stay filled. This would result in an apparent increase in TL sensitivity after bleaching and thus an underestimated ED.

To see whether this is occurring irradiations need to be carried out at elevated temperatures. In the literature there have been several instances of sensitivity changes being reported as a result of irradiations at different temperatures; for example for LiF (TLD-100) (Chandra et al, 1982). Aitken et al (1974) found a 40% decrease in the TL signal for the 325 °C peak in quartz when irradiated at 200 °C compared with irradiation at 20 °C. Durrani et al (1977) found a large decrease in the intensity of the TL signal from several quartzes as they decreased the irradiation temperature from room temperature to 113 K.

Experiment

A tube oven was placed in the beam of the ^{60}Co gamma source in the Biochemistry Department in Oxford. Five discs (fine grains deposited onto 1 cm aluminium discs in the usual way) were placed in identical positions in an aluminium container in the oven for each temperature. The container was allowed to reach equilibrium temperature before the irradiation was performed. Temperatures of 18, 60, 100 and 123 °C were used. An irradiation time of one hour, giving about 130 Gy, was used for each experiment. The discs were unfortunately

not able to be measured until 8 weeks after the irradiation. The results are shown in figure 1 and show no difference in the TL signal above 270 °C. As well as irradiating bleached discs, a comparison was made between irradiation at 18 and 100 °C using the same dose but adding it on top of the natural dose. Again no difference was observed.

Conclusion

The similarity of the glow curves above 270 °C does not confirm the hypothesis outlined in the previous section.

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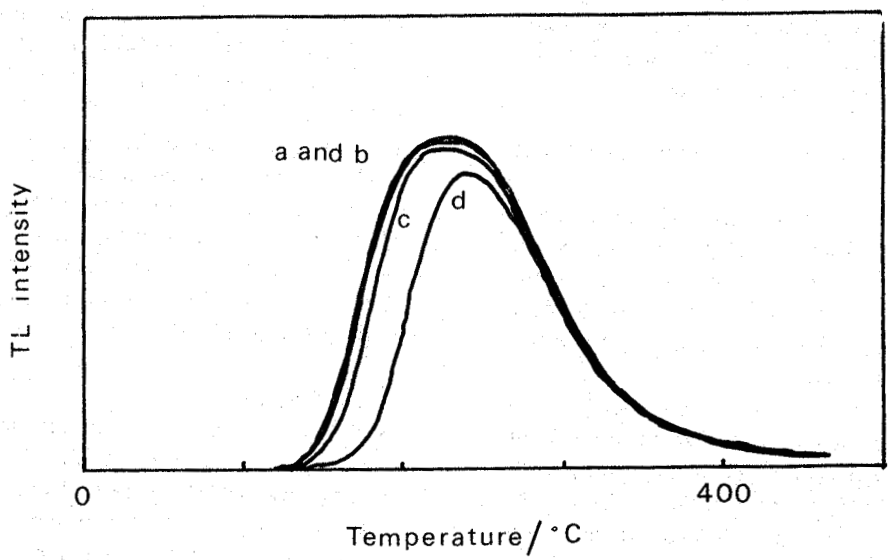

Figure 1. Glow curves of fine grains for a sample of Hungarian loess (QTL85DB) which had been bleached and then given a gamma dose of 130 Gy at temperatures of a) 18 °C, b) 60 °C, c) 100 °C, and d) 123 °C. Measurement was with a Schott UG-11 filter at a heating rate of 5 °/s.

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