THE EFFECT OF PRE-ANNEALING ON SEDIMENT TL

A.G. Wintle

The Godwin Laboratory
Free School Lane
Cambridge CB2 3RS

Post-irradiation pre-readout anealing is used extensively to remove low-temperature peaks in dosimeters such as LiF:Mg,Ti and CaF_2:Dy. These peaks are not required because they are thermally unstable at ambient temperature. The extension of such a pre-heat procedure to minerals being used for dating was first reported by Mejdahl and Winther-Nielsen (1982). They applied it to 100-300μm alkali feldspars extracted from pottery and it has more recently been used for 100-300 μm potassium feldspar and quartz grains separated from sediments (Mejdahl, 1985). Valladas and Valladas (1982) used a preheat procedure in their study of quartz.

The application of a preheat procedure (230°C for 1 minute on the TL oven plate or more recently 150°C for 16 hours on a separate hot plate) to fine grain polymineral sediments (Wintle, 1985) was introduced to reduce the response of the TL between 150 and 280°C (heating rate = 5°C/s). When a Schott UG-11 filter is used, the TL in this part of the glow curve is enhanced relative to that above 280°C. The latter is the temperature region where stability of the trapped electron signal might be expected, and indeed onset of the plateau region before 300°C was reported by Debenham (1985) for a large number of sediments of different ages. I therefore wished to eliminate the high response of the TL in the 150-280°C region since this, combined with small amounts of thermal lag, gave rise to considerable scatter in the growth curves obtained for 10°C temperature intervals. This was reduced by the preheating.

The preheat procedure (230°C for 1 minute) was chosen such that after its application both the natural TL and a matching TL signal regenerated by irradiation after optical bleaching have the same glow peak temperature. This is at about 290°C. As shown in Fig. 4(a) of Wintle (1985) this is not achieved by preheating at lower temperatures. When such a match is achieved an ED plateau is often obtained throughout the region from 220-400°C. The presence of a well-defined peak has the added advantage that any curves which have been apparently shifted to a higher temperature due to thermal lag (eg caused by grains beneath the disc) can be shifted down by an amount corresponding to the diference in peak position.

It is clear from the shape of the glow curves that one is not dealing with a single glow peak obeying either first or second order kinetics. However the glow curves may be interpreted as being due to distributions of electron traps, with increasing trap depths found for increasing glow curve temperatures (as found by Strickertsson (1985) for separated potassium feldspars). If these curves are thought of as being composed of such distributions, then holding at 230°C for 1 minute (by analogy with the decay of the pure first order 110°C peak in quartz) will remove about half of the TL which would have a peak at 280°C and all of that with a peak at 230°C.

The more general approach taken by Debenham (1987) is an interesting one in which only two component signals (designated A and B) are fitted to the natural glow curves of a sample; they are applied to curves obtained after two different sample preparation procedures and when two different parts of the emission spectra are observed. This empirical aproach is totally separate from any kinetic behaviour. It implies that the higher peak (330°C for 5°C/s) from a sample treated with H_2SiF_6 for 3 days at ambient temperature is the same as that of the dominant TL signal above 300°C obtained for a polymineral signal. It should be pointed out that although this treatment does not attack the quartz (Chapman et al (1969) obtained 97% recovery of 2-20 μm quartz) it may not totally eliminate all the feldspars. Chapman et al (1969) found a 48% recovery for albite (high Na feldspar), 34% for microcline (a K feldspar) but less than 0.1% for anorthite (a high Ca feldspar) in the same grain size. This treatment was first used by Berger et al (1980) and subsequently by Berger and Huntley (1982) and Wintle (1982). The drastic change in shape of the glow curves that results from this treatment indicates a change in the mineralogical composition.

Wintle (1982) thought that the peak given by the H_2SiF_6 treated sample was not totally responsible for the upper peak of the natural TL of the untreated sample when observed with the same filter (a Corning 5-58 blue glass). It appeared to occur some 30°C lower. A similar temperature difference has been reported for the glow peaks of separated 100-300 μm quartz and potassium feldspar (Mejdahl, 1986). In this context it is interesting to note that these two peaks have been shown to have different behaviour eg the bleaching of the TL by visible light is more rapid for potassium feldspars than for quartz and the TL signal of quartz saturates at a lower radiation dose level than does the feldspar. Since these differences in response are also observed for the two extreme sets of glow curves (I and IV of Debenham (1986)), it may cast doubt on the more widespread application of the two signal approach.

REFERENCES

Berger, G.W., Mulhern, P.J. and Huntley, D.J. (1980) Isolation of silt-sized quartz from sediments. *Ancient TL*, **11,** 8-9.

Berger, G.W., and Huntley, D.J. (1982) Thermoluminescence dating of terrigenous sediments. *PACT J*, **6**, 495-504.

Chapman, S.L., Syers, J.K. and Jackson, M.L. (1986) Quantitative determination of quartz in soils, sediments and rocks by pyrosulfate fusion and hydrofluosilicic acid treatment. *Soils Science*, **107**, 348-355.

Debenham, N.C. (1985) Use of U.V. emissions in TL dating of sediments. *Nuclear Tracks*, **10**, 717-724.

Debenham, N.C. (1987) Study of the effect of pre-annealing on sediment TL using a technique of glow curve analysis. *Ancient TL*, this vol.

Mejdahl, V. (1985) Thermoluminescence dating of partially bleached sediments. *Nuclear Tracks*, **10**, 711-715.

Mejdahl, V. (1986) *Thermoluminescence dating of sediments.* In press.

Mejdahl, V. and Winther-Nielsen, M. (1982) TL dating based on feldspar inclusions. *PACT J*, **6**, 426-437.

Strickertsson, K. (1985) The thermoluminescence of potassium feldspars - glow curve characteristics and initial rise measurements. *Nuclear Tracks*, **10**, 613-617.

Valladas, G. and Valladas, H. (1982) Influence du debit de dose sur la thermoluminescence du quartz (II). *PACT J*, **6**, 281-291.

Wintle, A. G. (1982) Thermoluminescence properties of fine-grain minerals in loess. *Soil Science*, **134**, 164-170.

Wintle, A.G. (1985) Stability of TL signal in fine grains from loess. *Nuclear Tracks*, **10**, 725-730.

PI Reviewer's Comments (Martin Aitken)

It is useful to have this paper following soon after Debenham's on the same topic since the author makes clear that the genesis of her pre-heat procedure was the practical desirability of obtaining TL glow curves for natural and artificial that had the same peak temperature. It is reassuring to note that Debenham (fig 3a) finds the same peak temperature (290°C) for the same pre-heat procedure. He interprets this glow curve as a composite of the two basic shapes, A and B, and he concludes that A contributes despite the pre-heat. While this calls into question the statement in Wintle (1985), that the pre-heat totally removes the TL from the lower peak it does not detract from the practical advantages of the pre-heat indicated in the present paper.

In all this discussion we are hampered by inadequacy of nomenclature. Does 'a peak at 290°' mean a maximumin a composite glow curve or a signal from a single trap type? In the latter case how do we indicate trap type having a distribution of depths? We need a TL lexicographer - if that's the right word!