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Thermoluminescence Dating of Loess Deposition in Normandy

Vagn Mejdahl
Nordic Laboratory
for TL Dating
Risø National Labs.
4000 Roskilde
Denmark

Debenham concluded from a recent TL dating study (Debenham, 1985) of loess deposits in N.W. Europe that the time period accessible by the TL method used was limited by the decay of luminescence centres in the material. The decay was found to have an associated mean life close to 100 ka. Debenham suggests that also the results obtained by Wintle et al (1984) in a study of loess deposits from Normandy would be affected by decay.

In view of the growing recognition of the great potential of the TL technique for dating Quaternary deposits I feel it is important to point out that a decay phenomenon of that nature is not a general observation in TL dating of sediments. I suggest that it may be related to the particular mineral fraction (polymineral, 4-11 μm grains) used by Debenham.

In figures 1 and 2 I present some results of a TL dating study (Funder et al, 1985) of marine sediments from Kap København, Peary Land, Greenland, estimated to date from Late Tertiary/Early Quaternary. The dating was based on potassium feldspar grains, 0.1-0.3 mm, extracted from the sediment. Linear extrapolation from the points in the TL growth curve in figure 1 yields an equivalent dose of 4160 Gy, while polynomial regression based on all four points yields 3060 Gy. The latter, combined with a dose-rate of 2.86 Gy/ka, gives a TL age of about 1.07 Ma (assuming the residual dose at deposition to be zero). It is obvious that the TL properties of the mineral used here are not affected by the decay phenomenon described by Debenham.

The upper limit of the time period that can be assessed by the TL dating method has not yet been established with certainty. The limiting factors can be expected to be either saturation of the TL level, when all trapping centres in the material are occupied, or decay (untrapping of charges at ambient temperatures) that will result in a dynamic equilibrium where the rate of untrapping equals the rate of trapping. In potassium feldspar saturation appears to occur at a dose level of about 4500 Gy corresponding to ages of 1-5 Ma, depending on the dose rate.

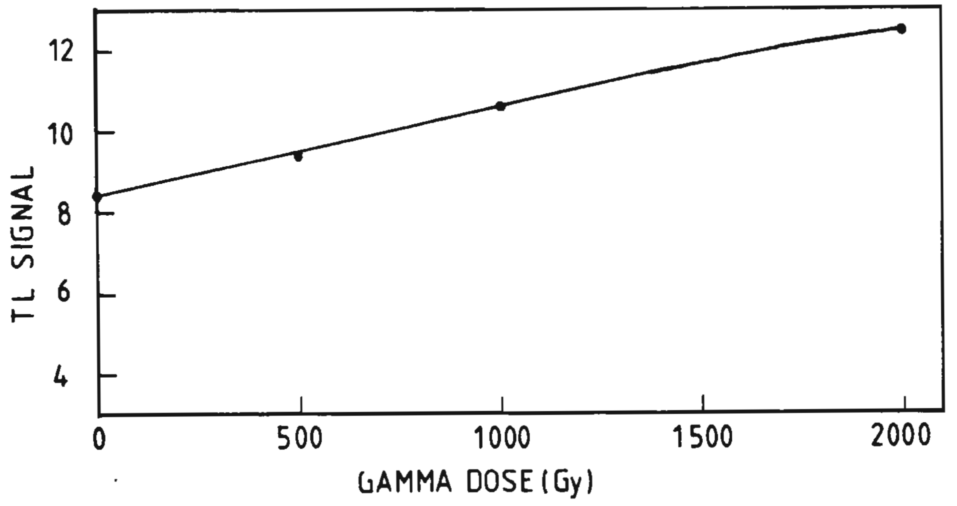

Figure 1. TL growth curve for potassium feldspar, grain size 0.1-0.3 mm (lab. no. 841008), extracted from a marine sediment at Kap København, Peary Land, Greenland. Glow curve region 325-380°C. Blue filter Corning 5-58.

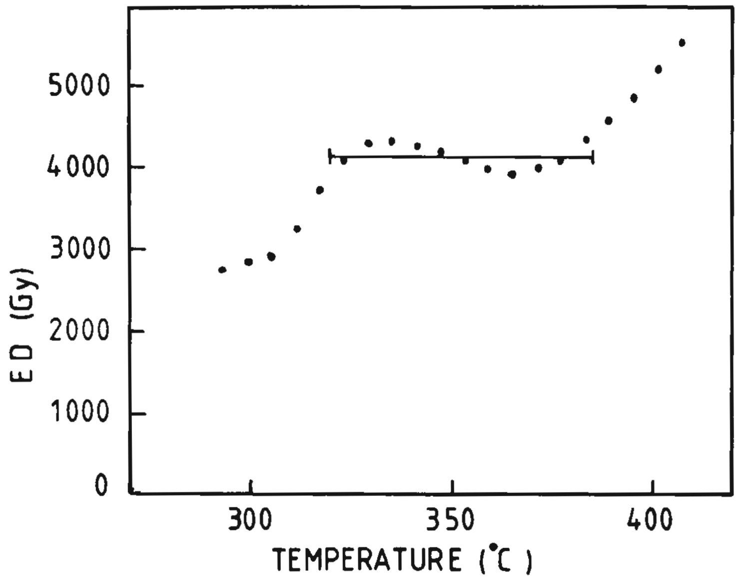

Figure 2. Equivalent dose (linear regression) vs. glow curve temperature for sample no. 841008. A plateau is seen over the region 320-380°C. With a heating rate of 8°C/s the glow peak occurs at 370°C. At temperatures beyond 400°C saturation of the TL level precludes the determination of an equivalent dose. Polynomial regression gave a plateau of only 25°C centered at 370°C.

While it is clear from the TL growth cruve in figure 1 that the natural TL level is not in saturation, one cannot exclude the possibilities of dynamic equilibrium and fading, which would make the TL age an underestimate. The stability of the trapped charges and the upper limit of the TL method can be studied by measuring the TL level in very old sediments to see whether it is in saturation or has reached a dynamic equilibrium. Studies of Tertiary deposits, 20-30 Ma old, are in progress in our laboratory and preliminary results for one of these indicate that the TL level may not be in saturation.

Concerning the loess deposits in question, the result presented above suggest that it would be important to extract larger grains from the loess and separate out specific minerals for TL dating rather than using a mixture of fine-grain minerals with different properties. Only in this way can one hope to clarify the cause of the unexpected decay phenomenon encountered for these loess deposits.

References

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Reviewer's comments (by M.J.A.) on the three contributions by Debenham, Wintle and Mejdahl

It is good news that coarse-grain potassium feldspar, from Greenland at any rate, can break the 100 ka barrier that is indicated by Debenham's polymineral fine-grain results from N.W. Europe. Although Wintle presumes that the fine-grain signal, in her case and that of Debenham too, comes from potassium feldspar I think this is only on the basis that this mineral is likely to dominate over the plagioclase because of its brightness. Hence extraction of the potassium feldspar from the loess of N.W. Europe might yield a more stable signal. It should also be noted that Strickertsson's lifetime may not be applicable to the fine-grain signal. However, the limit noted by Debenham is unlikely to be due simply to thermal fading because good plateaux are obtained and it is not a sharp peak; indeed for this and other reasons Debenham hypothesises that it is due to decay of luminescence centres. Whatever the cause of the decay, if correction is to be made for it, one important question is the degree of dependence on burial temperature.