Preliminary study of the thermoluminescence behaviour of quartz from a Dutch cover sand

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Introduction

The object of this study was to determine wheter it is possible to obtain reproducible and meaningful TL measurements on quartz grains from cover sands before embarking on a dating study. Therefore we examined the bleaching characteristics of quartz. A similar study was presented at the Fourth Specialist Seminar on TL and ESR dating by Jungner (1985) on post-glacial sand dunes.

The sample discussed here is a well sorted wind-blown sand with a mean grain size of 150-210 micron taken at a depth of 2.45 m at Loozerheide, near Weert in the southern part of The Netherlands and covered by several paleopodzols developed during the Holocene in aeolian sands (fig. 1). A radiocarbon date of the lower soil, approximately 60 cm above the sample, will be available soon, but is expected to be around 7,000 years. Based on lithostratigraphic criteria the underlying aeolian sand is considered to be part of the Younger Cover sand II deposit of post Allerod age. The expected age of the sample therefore is in the range of 7-11,000 years. For a preliminary study the 125-150 micron grain size fraction was treated with 30% H_2O_2 for 24 hours, although hardly any organic matter was present, and subsequently with 40% HF for 1 hour at room temperature to remove any feldspars as well as to etch the quartz grains. The resulting grains were washed thoroughly and dried. Aliquots of 4-6 mg were weighed and evenly spread onto 1 cm aluminium discs, which had to be sprayed with a silicone-base spray to prevent sample removal during measurement. The glow curves were weight-normalised for a 4 mg aliquot.

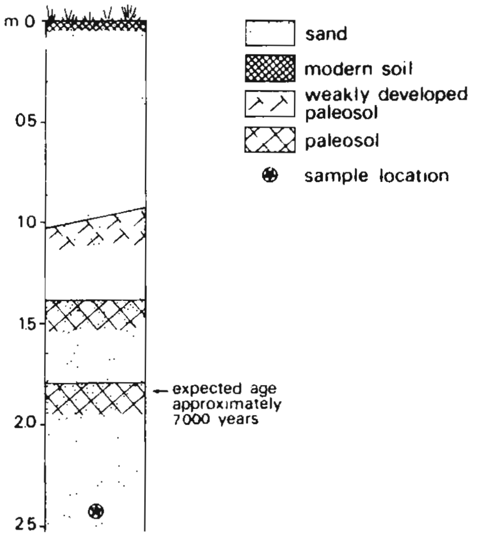

Figure 1 *Schematic diagram of the section at Loozerheide.*

TL Measurements

Measurements were made at $5^oC/s$ using an EMI 9635 photomultiplier tube and a Corning 5-58 filter to enhance the quartz signal. Wakefield thermal compound was found to be essential for thermal contact between the disc and the heating plate at this heating rate, otherwise disc-to-disc shifts of up to 20^oC occurred.

Curve 2 in figure 2A is the natural TL (N.B. all black body signals have been subtracted) and curve 1 shows the effect of 28.3 Gy additional dose. These are similar to the graphs of Jungner (1985). Curve 3 is the TL that is measured after the grains containing their natural TL have been exposed to an unfiltered mercury sunlamp for 60 hours at 35 cm distance. A phototransfer peak occurs at 170^oC. Comparison of the glow curves at 360^oC indicates that the natural TL is equivalent to the TL induced by some 30 Gy which is at least an order of magnitude greater than expected for this sample. This is caused by laboratory overbleaching with wavelengths not present in the original bleaching spectrum. This was supported by attempts to measure the ED by the R - beta method using a 30 minute partial bleach which resulted in the intersection of the two growth curves occurring at a negative TL intensity value.

Using a Black Light lamp from Philips, Jungner (1985) found that the natural TL bleached faster for quartz than a similarly treated feldspar sample. However, his use of natural TL would have incorporated a UV bleachable component not bleached at the time of deposition. We felt that it was more appropriate to obtain the bleaching characteristics for quartz which has been well bleached and given a known laboratory radiation dose (in this case 60 hours UV exposure followed by 31.4 Gy dose). Weight normalization gave rise to less scatter than second glow normalization (as used by Jungner) but reproducibility better than about 10% could not be achieved. The results are given in figures 2B and 3.

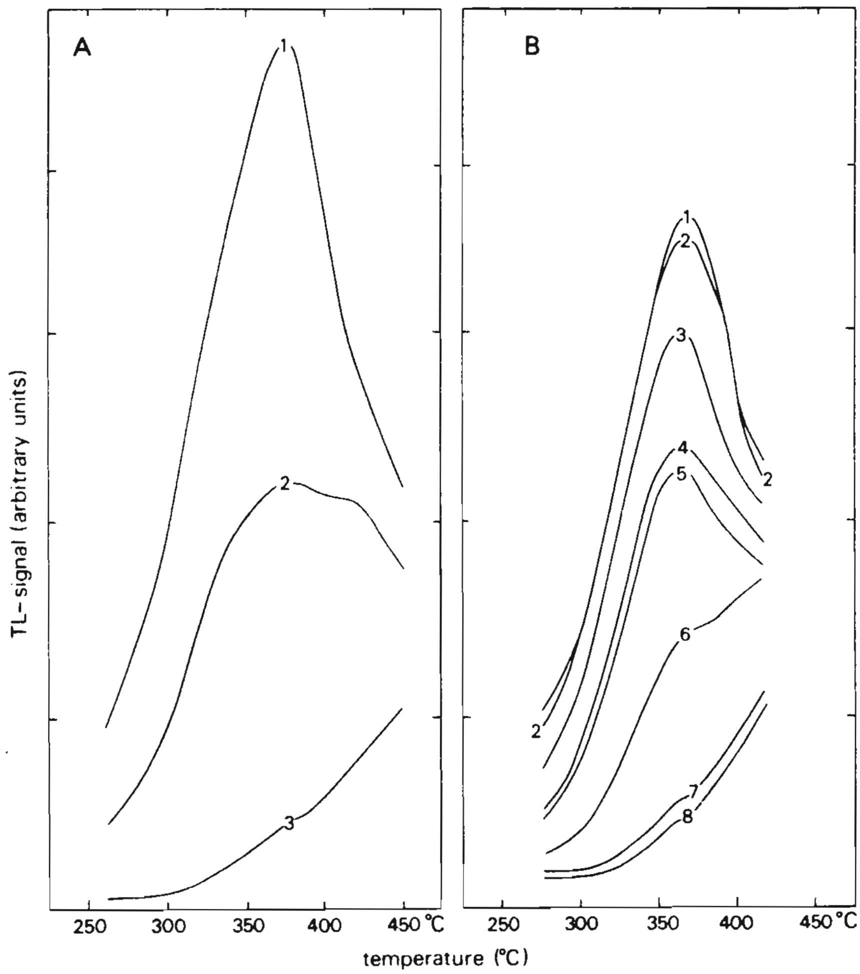

Figure 2: *(A) Glow curves of the 360°C quartz peak for 1. Natural TL + 28.3 Gy beta dose, 2. Natural TL, 3. Natural TL + 60 hours bleaching.*

(B) Glow curves (scale is identical to that of (A)) of the radiation induced 360°C quartz peak with the following subsequent bleaching times: 1) 0 minutes, 2) 5 minutes, 3) 15 minutes, 4) 30 minutes, 5) 1 hour, 6) 2 hours, 7) 8 hours and 8) 20 hours.

In figure 3 the percentage of bleachable TL as a function of bleaching time (the 0% level is the TL as shown in fig. 2A, curve 3) is compared with that obtained for the 330°C TL of a separated feldspar (Kronborg, 1983) and that obtained for 300°C TL of polymineral fine grained sediment (Wintle and Huntley, 1979). Kronborg (1983) found that if the data were plotted on a log-log scale, an almost straight line could be drawn through them, but this is not the case for the present data (fig. 4). We found some 40% reduction in the radiation induced signal is attained after about 30 minutes exposure and this would be a reasonable exposure time to select for the partial bleach (R - beta) method as long as the original spectrum was similar. Much slower bleaching was achieved for this sample with a Corning 3-67 filter directly in front of the discs during the 60 hours sunlamp exposure as suggested by Huntley et al. (1983). Moreover no phototransfer peak occurred when this filter was used. Other bleaching curves have been obtained with an ultraviolet lamp for natural and gamma induced TL from sand (Vlasov et al., 1979); they concluded that the TL is reduced to less than 1% of its initial value by a light exposure of 70 kcal/cm, equivalent to 1 polar day.

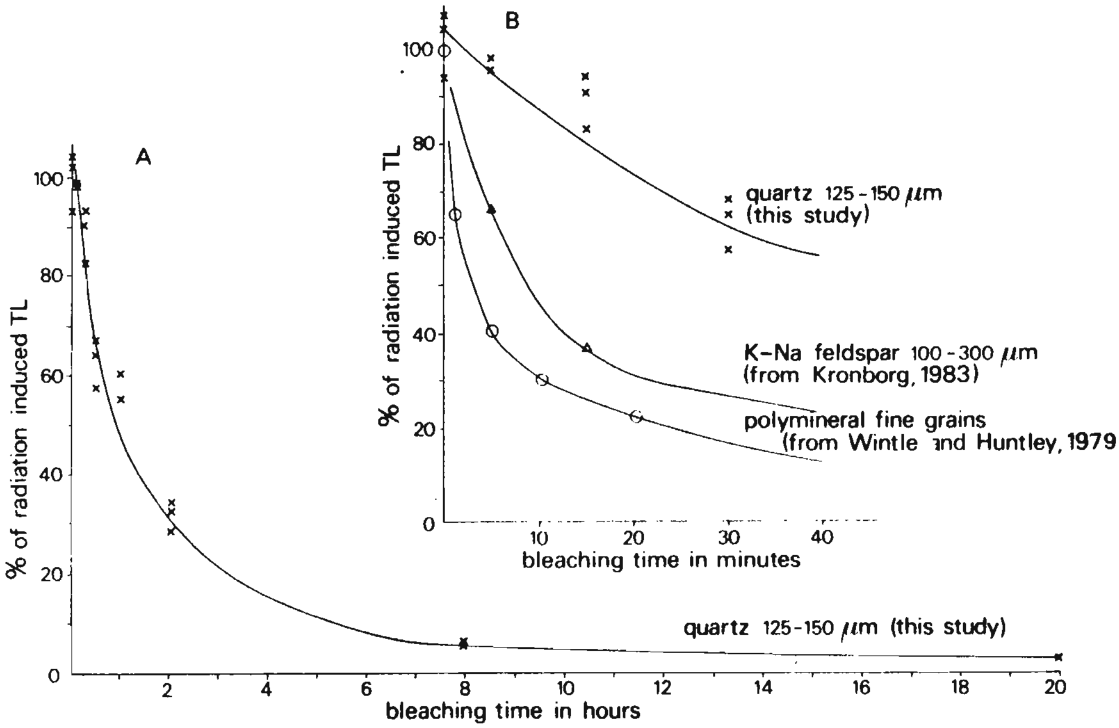

Figure 3: *(A) Bleaching curve of the 360°C quartz peak showing the loss of radiation induced TL with increasing bleaching time. To obtain radiation induced TL all samples were bleached for 60 hours (0% level) and were subsequently given a 31.4 Gy beta dose (100% level).*

(B) Same bleaching curve as (A) compared with other studies.

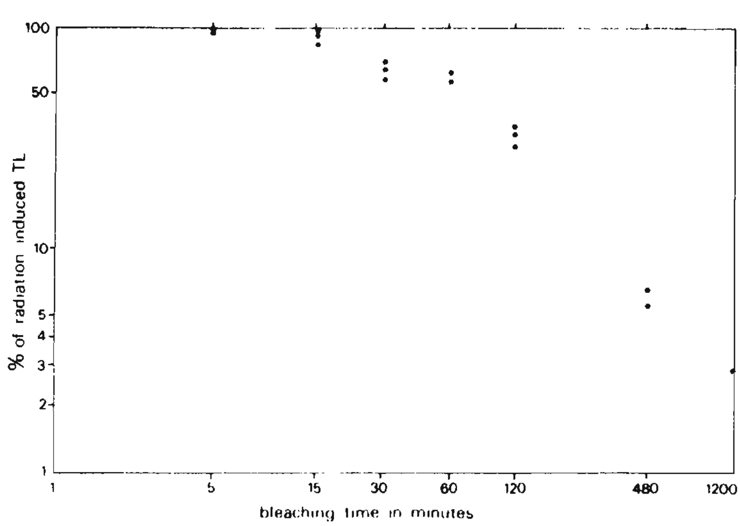

Figure 4: *As figure 3 (A) but plotted on a log-log scale.*

Conclusions

(A) Most of the 360°C quartz TL signal is bleachable provided that long enough exposure times are used with a broad spectrum source.

(B) Use of an unfiltered medium pressure mercury lamp is unsuitable for the regeneration, total bleach and R - beta methods for the quartz from this kind of sediment, because it induces overbleaching. It should be noted that this problem was not encountered by Singhvi, et al. (1983) who studied quartz extracts from sand dune in Rajasthan, India.

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Reviewer's comments (V. Mejdahl)

An important problem in TL dating of sediments is to define those types that are suitable for dating. Considerable success has been achieved in dating loess (Debenham, 1985 and Wintle et al., 1984), and aeolian sand deposits such as dune and cover sands also appear promising.

The present study of quartz from cover sand brings out one of the difficulties in dating quartz from a young sediment, namely, that it has been deposited with a residual TL level that constitutes a large proportion of the present natural level. Determination of the residual level by prolonged laboratory sunlamp bleaching (or sun bleaching) therefore results in severe overbleaching.

I have two specific comments on the paper:

1. The discussion related to Figure 2(A) is unclear. It is true that the natural TL level corresponds to about 30 Gy as estimated from the figure, but the laboratory overbleaching must relate to the TL accumulated since deposition, that is the difference between curves 2 and 3, which corresponds to about 21 Gy. Assuming a dose rate of 1.2 Gy/ka, 21 Gy yields an age of 18 ka. If the expected age, 7-11 ka, is correct, then the true residual TL would be roughly 3 times that in curve 3 or about 60% of the natural level. This agrees well with the residual levels that I found for quartz from cover sand from Jutland (Mejdahl, 1985). Considering this high residual level, it is uncertain whether quartz from such young sediments can be dated with sufficient accuracy. However, it can be used together with K feldspar to determine the much lower residual level in feldspar (Mejdahl, 1985).

2. Bleaching experiments. It is important to note that the bleaching rate depends strongly on the initial TL level when the residual level is expressed as percentage of the initial level. Therefore, a comparison of bleaching rates is meaningful only when the minerals have the same initial level. It should further be stressed (and the authors are well aware of this) that laboratory bleaching using an unfiltered sunlamp does not reflect correctly the bleaching taking place in nature; this is particularly true for quartz.

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