Sun bleaching of the red TL of quartz: preliminary observations

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Introduction

Since the pioneer observations of Hashimoto et al., (1987) on a remarkable orange-red TL peak for some volcanogenic quartz samples, this signal has been found to be widespread on quartzes from various origins and well adapted to long range dating for samples zeroed by heat in the past, e.g., Hashimoto et al., (1991), Pilleyre et al. (1992), Montret et al. (1992), Miallier et al. (1993; 1994). Thereafter, the question arose, whether the red TL of quartz was also available for dating sediments; if it was the case, a very wide field of applications would be open to it. A preliminary attempt by Hashimoto et al. (1989) was encouraging; however the weak sensitivity of the red TL of quartz to sun exposure that they found and which was confirmed by further laboratory experiments (Miallier et al., 1991) suggested that the method would have a poor precision. This was investigated in the present work, where the sun bleaching properties of the red TL were compared to those of the blue one - which is actually routinely used for sediment dating. Two experiments were carried out. In the first one, the "zero level" of quartz from dune sands was checked; in the second one the sun bleaching kinetics of red TL and blue TL were compared to each other.

Checking the 'zero level' of the red TL

Quartz grains in the size range 200-315 μm were sampled (during spring-time) at the top surface of La Dune du Pyla, Atlantic coast, France. Their preparation included diluted HCI etching, heavy liquid separation and hexafluorosilicic acid etching (3 days). Some of the grains were given various additive doses of gamma radiation, (i.e., 32.5, 65 and 97.5 Gy) using a ^{137}Cs gamma source, in order to compare the natural signal to the artificially induced ones. The grains were then measured for TL using alternatively a red or a blue filter (Sharp cut-off Schott long-pass RG610 red filter and red-cut Leitz blue BG12 filter).

Fig. 1, curve a, shows the blue glow-curves; the natural glow-curve N was the usual residual TL observed after prolonged bleaching; it was composed of one major peak, centred at ~390°C. The induced glow-curves comprised this latter peak, however it was largely overlapped by strong peaks at ~290 and ~330 °C; other peaks appeared at 150 and 220 °C. It can be verified that the residual TL under the peaks of interest for sediment dating, at 290 and 330 °C, is very low; probably most of the signal in this area is in fact the left slope of the 390°C peak. The dose response curve plotted at 330°C showed the good sensitivity of the blue TL (Fig. 2); with an added dose of 35.5 Gy, the 330°C peak was 5 times higher than N (measured at the same temperature).

For the same added doses, the increase of the red TL peak, at 385-390 °C, was very weak (Fig. 1, curve b); above ~320 °C the shape of the peak was nearly the same for natural and induced glow-curves. On those latter curves, other peaks appeared at ~140 and ~220 °C; they are probably "red wings" of the strong peaks centred in the blue region of the spectrum. The growth of the peak with added dose was nearly linear (Fig. 2). An added dose of around 950 Gy would be necessary for the signal to be 5 times higher than the residual background (as evidenced by N).

If the observed natural red signal was at a steady residual level, easily reached under sun bleaching, the red TL would also be available for evaluating

paleodoses for sediments. Hence it was necessary to verify whether or not the red TL had an "easy-to-bleach" component.

Bleaching the red TL with sun

This was performed using quartz grains extracted from a sediment layer baked by a lava flow around 14 ka ago, having a palaeodose of around 70 Gy (Sample of Neschers, in Pilleyre et al., 1992). This sample was selected because it showed a clean red peak; on the other hand, we wanted to bleach a "fossil" TL, as would happen for sediments. The preparation was as for inclusion dating. The grains of quartz, in the size range 100-200 μm, were simply exposed to sunlight, inside perspex boxes, for various lengths of time; afterwards they were measured for TL, all at the same time, in the same conditions as above.

With the blue filter, the natural TL showed a strong single peak around 330°C, accompanied by a weak peak at ~220°C (Fig. 3, curve a). The main peak decreased very rapidly to around 25% of its initial intensity during the first 3 days of bleaching (Fig. 4); afterwards, the decrease was much slower and the height of the peak stabilised at around 15-16% after the 20th day. This behaviour is well known.

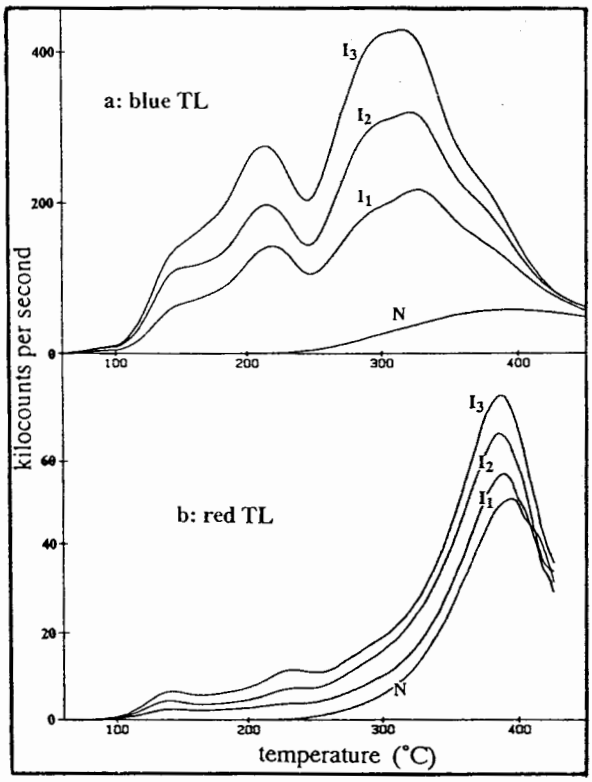

Figure 1.
Additive glow-curves for dune quartz grains. N: natural signal; I_j: N + added doses (35.5, 65 and 95.5 Gy). Heating rate: 4.85 °C s^{-1} atmosphere: nitrogen flowing at 1.5 l h^{-1}; other conditions as in text. Background has been subtracted. a: blue TL; b: red TL.

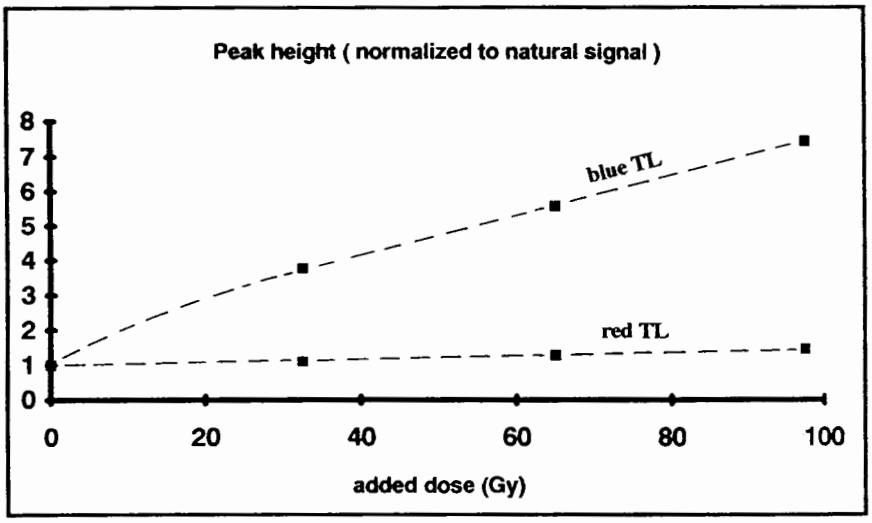

Figure 2.
Dose response curves, plotted for height of the 330°C peak for blue TL and of the 385°C peak for red TL.

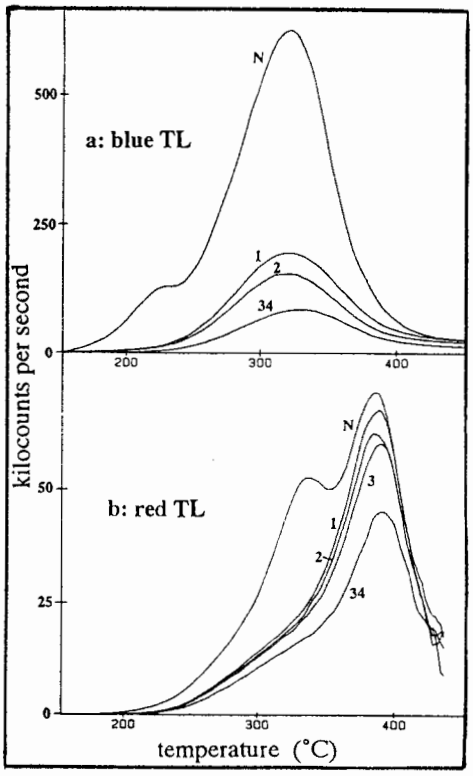

Figure 3.
Glow-curves for quartz samples having a palaeodose of ~70 Gy, after various durations of sun exposure (indicated on the curves, in days). Conditions: as in Fig. 1 and text. a: blue TL; b: red TL.

The red TL very rapidly lost its "shoulder" around 340°C; however, the main peak, at 385-390 °C, decreased slowly to around 82% of its initial intensity during the first 3 days of bleaching (Fig 3, curve b, and Fig 4). The peak ceased to decrease after 20 days of sunlight, at a level of around 62%. Roughly similar values - in percentage of the initial height of the red TL - had been obtained by Hashimoto et al. (1989).

Discussion

The above results indicate, that the red TL of quartz resists sun bleaching much more firmly than the blue TL. Not only is the residual level of the red TL very high, but the decrease is slow. Moreover, the precision on the residual level estimated for the red TL will be very bad, since, for a short period, it depends strongly on the duration of sun exposure; also its "equivalent dose level" varies largely with the origin of the quartz; this level being around 340 Gy for the Japanese samples (Hashimoto et al., 1989), 50 Gy for Neschers and 200 Gy for Le Pyla (from linear extrapolation of the dose response curve). Therefore, the availability of the red TL for dating sediments appears to be very poor. If we take a factor of 10 for the ratio of the natural signal to the residual signal (as indicated by the surface sample) as an arbitrary criterion for getting reasonable accuracy, the red TL is not able to give paleodoses below ~19 kGy for La Dune du Pyla; this would

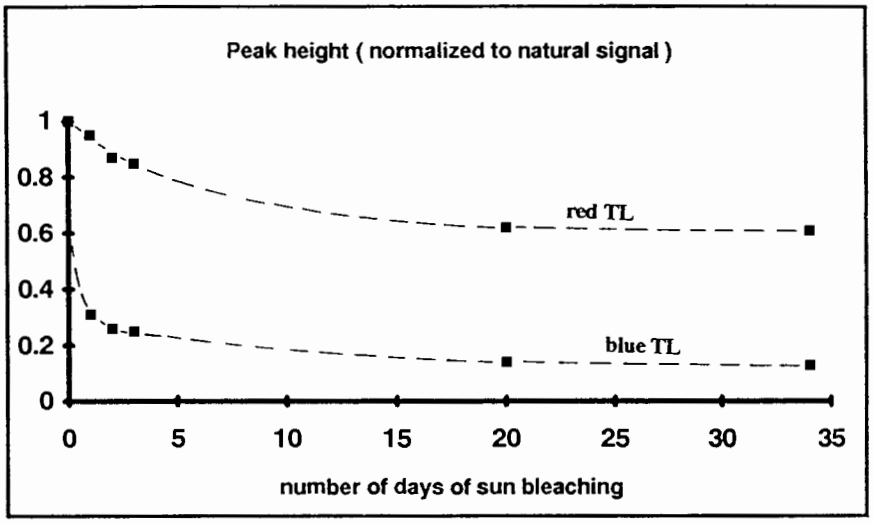

Figure 4.
Plot of the peak heights vs the bleaching time for the blue and the red TL peaks.

correspond to a minimum age of 3 Ma (!), using the dose rate of ~0.65 mGy a^{-1} measured by Smith et al. (1990) for this site. (This is a very crude estimation, assuming linear growth of the red TL to high levels as previously observed) .

Conclusion

The red TL of quartz is not very sensitive to solar radiation; the estimation of the initial level of the signal, prior to burial, will be affected by large uncertainties. Thus, the red TL is only available for dating very old sediments, provided that fresh surface samples of the same origin are available to permit evaluation of zero level of the signal.

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It is good to have this study (particularly as the relevant Hashimoto paper is in Japanese) even though it is a sad result for sediment dating - it would have been good to be able to use this far-reaching peak.