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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.

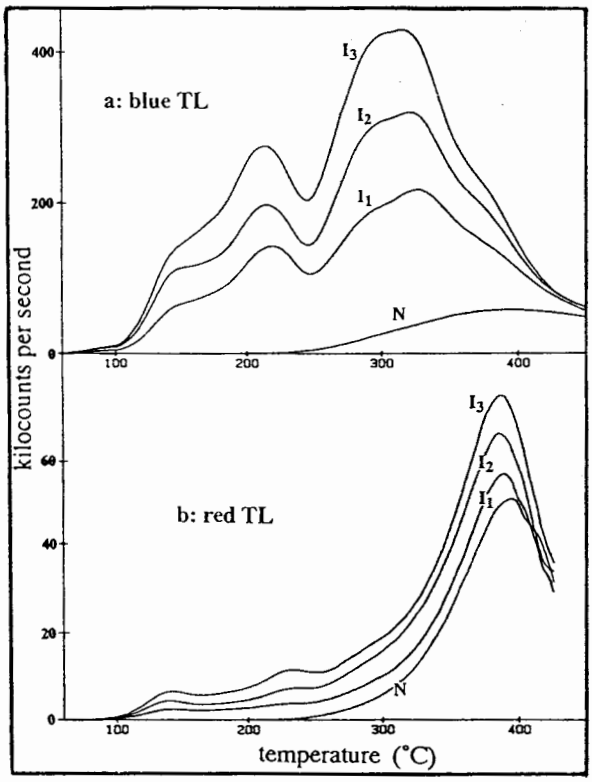

Figure 1.
Additive glow-curves for dune quartz grains. N: natural signal; I_j: N + added doses (35.5, 65 and 95.5 Gy). Heating rate: 4.85 °C s^{-1} atmosphere: nitrogen flowing at 1.5 l h^{-1}; other conditions as in text. Background has been subtracted. a: blue TL; b: red TL.

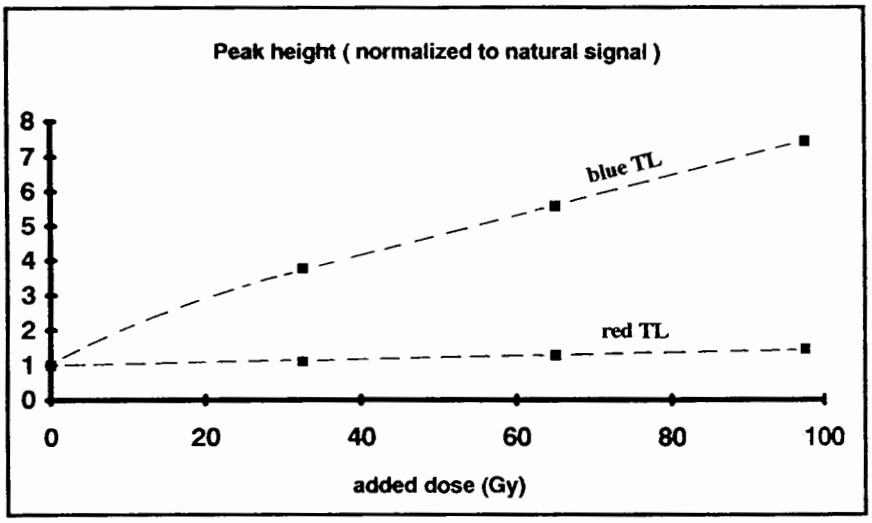

Figure 2.
Dose response curves, plotted for height of the 330°C peak for blue TL and of the 385°C peak for red TL.

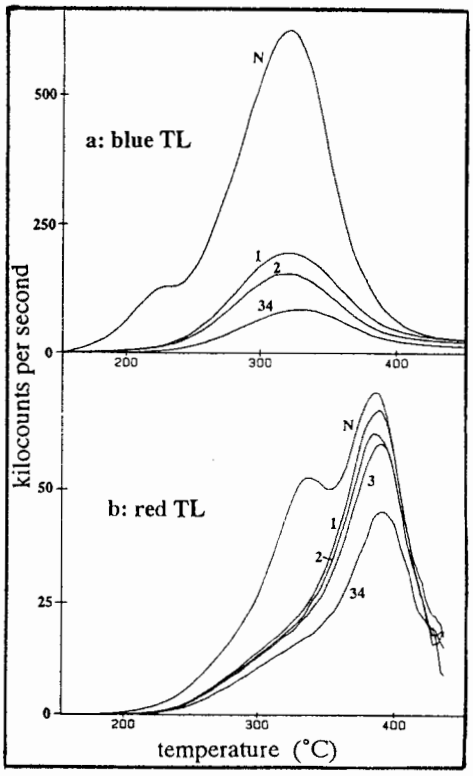

Figure 3.
Glow-curves for quartz samples having a palaeodose of ~70 Gy, after various durations of sun exposure (indicated on the curves, in days). Conditions: as in Fig. 1 and text. a: blue TL; b: red TL.

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

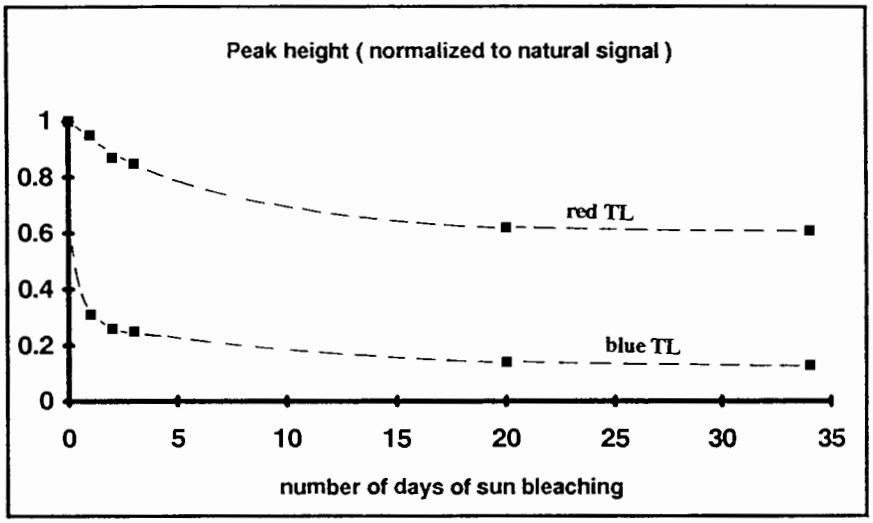

Figure 4.
Plot of the peak heights vs the bleaching time for the blue and the red TL peaks.

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.

References

Hashimoto, T., Yokosaka, K. and Habuki, H. (1987) Emission properties of thermoluminescence from natural quartz. Blue and red response to absorbed dose. *Nucl. Tracks Radiat. Meas.* **13**, No. 1, 57-66.

Hashimoto, T., Habuki, H., Tanabe, I. Sakai, T. and Takahashi, S. (1989) Dating using red thermoluminescence from quartz grains in strata related to fossil bones of Elephas Naumanni. *Chikyukagaku (Geochemistry)* **23**, 35-43 (in Japanese, abstract in English).

Hashimoto, T., Kojima, M. and Sakai, T. (1991) Age determination of prehistorical sites in Japan using red thermoluminescence measurements from quartz grains. *Archaeology and Natural Science* **23**, 13-25 (in Japanese, abstract in English).

Miallier, D., Sanzelle, S., Falguères, C., Faïn, J., Montret M., Pilleyre, T.H., Soumana, S., Laurent, M., Camus, G. and De Goër de Hervé, A. (1993a) Intercomparisons of red TL and ESR signals from heated quartz grains. *Radiation Measurements*, in press.

Miallier, D., Faïn, J., Sanzelle, S., Pilleyre, T.H., Montret, M., Soumana, S. and Falguères, C. (1994) Attempts at dating pumice deposits around 580 ka by use of red TL and ESR of xenolithic quartz inclusions. *Radiation Measurements*, **23**, in press

Miallier, D., Faïn, J., Montret, M., Pilleyre, Th., Sanzelle, S. and Soumana, S. (1991) Properties of the red TL peak of quartz relevant to thermoluminescence dating. *Nucl. Tracks Radiat. Meas.* **18**, Nos. 1/2, 89-94.

Montret, M., Miallier D., Sanzelle, S., Faïn, J., Pilleyre, Th. and Soumana, S. (1992) TL dating in the holocene using the red TL of heated quartz grains. *Ancient TL* **10**, 33-36.

Pilleyre, Th., Montret, M., Faïn, J., Miallier, D. and Sanzelle, S. (1992) Attempts at dating ancient volcanoes using the red TL of quartz. *Quaternary Science Reviews* **11**, 13-17.

Smith, B.W., Rhodes, E.J., Stokes, S., Spooner, N.A. and Aitken, M.J. (1990) Optical dating of sediments: initial quartz results from Oxford. *Archaeometry* **32**, 19-31.

PR Martin Aitken

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.

Lack of interaction between the rapidly and slowly bleaching TL peaks in an Australian quartz

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The second glow growth curve for the Rapidly Bleaching Peak (RBP, at 325°C for a ramp rate of 20°C s^{-1}) is shown to be independent of the state of bleaching of the Slowly Bleaching Peak (SBP, 375°C). This result validates the usual TL and OSL dating procedures using this second glow growth curve for the Australian sand dune quartz studied, and probably for others. Furthermore, it suggests that the corresponding two electron trap/luminescence centre systems do not interact. This raises the question whether the conduction and/or valence bands constitute the path for charge carrier transport for the thermoluminescence process for both systems in this quartz.

Introduction

Much archaeological quartz in the natural state, unexposed to laboratory irradiation, exhibits either or both of two major TL peaks, the "325°C" or Rapidly Bleaching Peak (RBP) and the "375°C" or Slowly Bleaching Peak (SBP). The temperatures describing these peaks are shown in quotes because they apply only to a ramp rate of 20°C s^{-1}. For the lower ramp rate used in this work the peaks occur at lower temperatures.

Spooner et al. (1998) have shown that even with light of wavelength greater than about 400 nm and up to about 700 nm the RBP bleaches very rapidly and apparently completely. On the other hand, the SBP is essentially unaffected unless the wavelength is less than about 400 nm, and then it bleaches much more slowly than does the RBP. Furthermore the SBP appears to bleach down only to a residual level (Wintle and Huntley, 1979). These characteristics have led to some concentration of sediment dating work, where solar bleaching is the clock resetting mechanism, on the RBP, both with TL (Prescott and Fox, 1990; Franklin and Hornyak, 1990) and with OSL (Smith et al., 1986).

For dating with either TL or OSL the second glow growth curve of the RBP is critically important, the necessary assumption being made that this curve is the same after laboratory resetting as it was at the time of deposition. There are both experimental and theoretical reasons to be cautious about this assumption. The RBP was long ago dubbed the "malign" peak (Aitken, 1985, p.20) because of sensitivity changes after thermal resetting. There have also been reports of sensitivity changes after bleaching of OSL in quartz (Smith et al., 1990) and of TL in loess (Li and Wintle, 1992 and references therein), although loess is a complex mixture and may reflect for the most part properties of minerals other than quartz.

On the theoretical side, a number of kinetic studies have shown that the glow growth curve of a TL peak may be influenced by the state of other systems which could compete for charge carriers during irradiation (Chen and Bowman, 1978; McKeever and Chen, 1982) or for thermally-released charge carriers during heating (Kristianpoller et al., 1974; Chen et al., 1938). Thus in particular if the RBP and the SBP used the same pathways for charge transport (e.g. the conduction and valence bands) during irradiation or heating the level of occupancy of the traps and luminescence centres associated with the SBP might be expected, on the basis of such models of competition, to influence the glow growth curve of the RBP. If this were so, in order to obtain the correct second glow growth curve for the RBP the resetting procedure would have not only to eliminate the RBP but also to return the SBP to the

same state it was in on deposition (Franklin et al., 1992), a condition that might be hard to meet.

In this paper I report on an experiment designed to test in the most direct fashion possible whether the state of the SBP influences the glow growth curve of the RBP, using a reasonably typical Australian dune sand quartz. The negative result not only strengthens confidence in current dating procedures with the RBP but may also raise interesting questions for models of the TL processes in similar quartz. These implications are briefly discussed.

Experimental

The material studied was approximately 100 μm quartz, extracted by the usual procedures (Aitken, 1985, p.18) including HF treatment and density separation, from sediment from the Puritjarra rock shelter in central Australia (Smith, 1987). The extraction was done by the Archaeometry Group of the Department of Physics and Mathematical Physics at Adelaide University and the sample kindly made available by Prof. John Prescott. The intention was to compare the first glow growth curve of the RBP with second glow growth curves starting with large and small SBPs. Therefore three batches were used. In batch #1 the SBP was at its natural level, which was quite close to saturation. With batch #2 a preliminary exposure of 45 minutes to sunlight reduced the SBP to a very low level. Both of these batches were then subjected to a preheat for 1 minute at 240°C followed by a 30 minute bleach under an Oriel solar simulator using a high pass filter cutting off to 1% transmission at 475 nm. This yellow bleach was found in preliminary experiments to eliminate entirely the RBP with no measurable effect on the SBP. The preheat removed lower-lying peaks, including a small one at about 280°C. These two batches were used to produce second glow growth curves. The third batch was material in the natural state except for a 240°C preheat, and was used to produce the first glow growth curve.

All measurements were of 2.0 mg aliquots deposited on Al disks that had first been sprayed with a Silkospray silicone coating (Willy Rusch AG), using a Risø automatic TL reader with a 9635QA PM tube fitted with a UG11 filter. The ramp rate was 3.1°C s^{-1}. A preheat of 1 minute at 240°C was used before all glow curve heats. The glow curves were normalised using the integrated counts over the central 20°C of the second-glow peak at about 310°C induced by a small test dose, this peak being a combination mostly of the RBP with some SBP. This normalisation signal was found to be independent of the treatment the specimen had received prior to the test dose. Irradiations were performed with a Sr-90 beta source and are given in terms of minutes of exposure, at a dose rate of about 1 Gy min^{-1} The starting levels of the SBP for batches #1 and #2, for the second glow growth curves, are illustrated in fig. 1. The peak height of the SBP was increased by only about 20% over the natural curve by an additional 100 Gy beta dose.

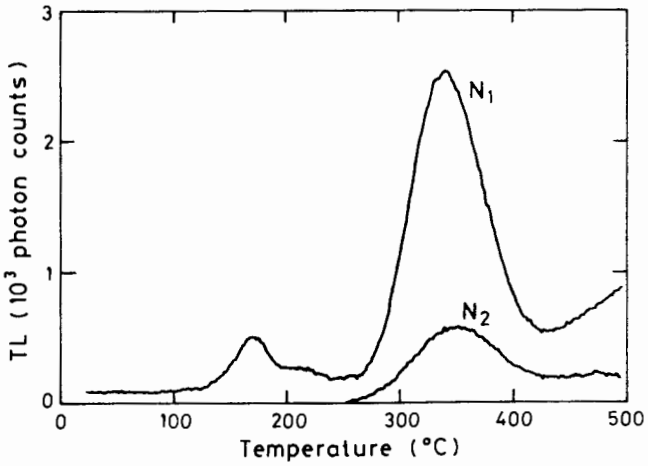

Figure 1.
Initial glow curves of batches #1 and #2 of material. N_1= N+P+YB; N_2 = N + SB+P+YB. N = Natural, P = Preheat for 1 min at 240°C; YB = 30 min Yellow Bleach; and SB = 45 min Solar Bleach.

Samples of all three batches were then given a series of beta doses and each sample divided in half, one half being measured directly and the other measured after a yellow bleach to remove the RBP, as described above. At least 5 replicates of each measurement were made. The replicate glow curves were adjusted along the temperature axis to eliminate the temperature jitter in the apparatus, as described in a previous paper (Franklin et al., 1987). For each dose the temperature standard was the most centrally-located (in terms of temperature) glow curve measured with yellow bleach, exhibiting

only the SBP. For other yellow-bleached specimens these SBP peaks all had essentially the same shape and matching on the temperature axis by overlaying curve upon curve was straight-forward and unequivocal. For specimens given doses but no yellow bleaches the glow curves were the sum of the RBP and the SBP, with the former dominating and the overall peak shape changing slightly with dose. Temperature matching for most of these specimens was done with the same temperature standard, matching on the high temperature side only of the SBP.

For the data with the highest accumulated dose (96 min beta dose for the first glow growth curve) this procedure was not satisfactory. In this case the yellow-bleached data were treated as above but the data without the yellow bleach were temperature shifted using the overall TL peak (dominated by the RBP) with a standard consisting of the average over the temperature-corrected glow curves for the zero-dose specimens not receiving a yellow bleach. The rationale for this procedure is based on observation that the peak temperatures of the RBP glow curves produced by the standard procedure outlined above were independent of dose. The temperature-shifted replicate glow curves for each treatment were then averaged among themselves and the yellow bleached average curve, containing only the SBP, was subtracted from the corresponding unbleached curve, containing both the RBP and the SBP. This procedure produces the RBP glow curve by difference, and is illustrated in fig. 2. As shown by fig. 3, the RBP glow curves so produced do not vary in peak shape or peak position with dose, as expected for a first order peak (Wintle, 1975). A value of 0.42-0.43 for the geometric symmetry factor (Chen and Kirsh, 1981) is also consistent with first-order kinetics. On the other hand the SBP glow curves exhibited the small drop in peak temperature with increasing dose expected for a peak with some higher-order character (Hornyak et al., 1992)

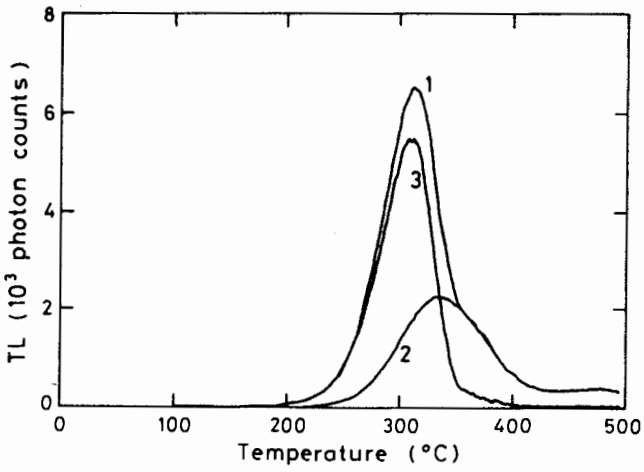

Figure 2.
Example of glow curves used to obtain RBP by subtraction. 1 = without YB, 2 = with YB, and 3 = RBP by difference.

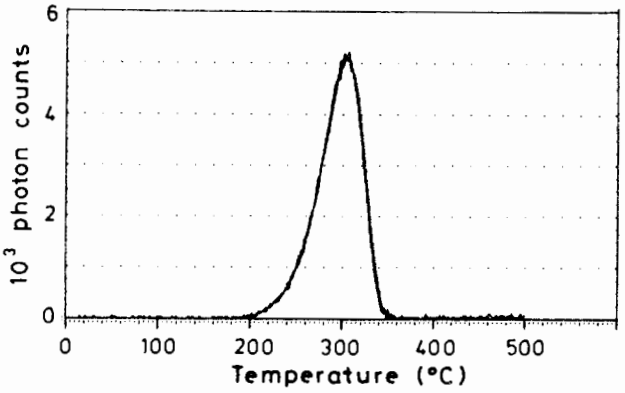

Figure 3.
RBP glow curves for first glow growth. Curves for 0, 24, 48 and 72 min beta doses are scaled to the same height and plotted together. $N_3 = N + P$.

Results

The integrated sum of counts over an 11°C interval centred at the peak was taken as the measure of intensity of the RBP. These intensities are plotted for all three batches as a function of dose in fig. 4. The solid line is a best fit to the second glow growth data by a saturating exponential. The first glow growth data have been shifted along the dose axis by +73 min as an estimate of the ED to illustrate the consistency of the first and second glow growth curves. The result is clearly that the variation in the initial state of the SBP has had no observable influence on the glow growth curve of the RBP. Because the experiment was so arranged that the lower-temperature peaks below the

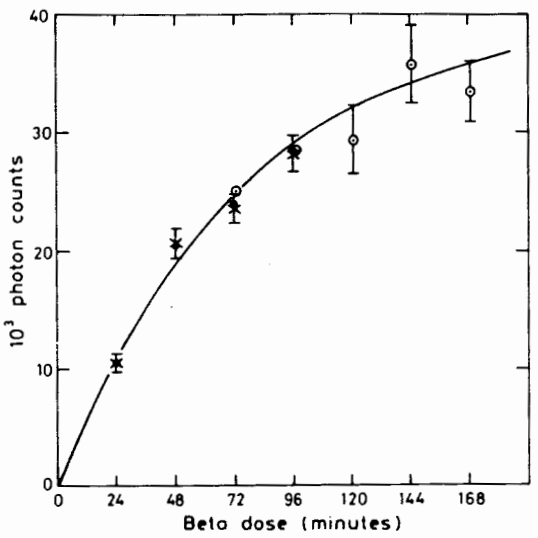

Figure 4.
Glow growth curves for the three batches of material. Data points are identified as: • = N_1, × = N_2 and o =N_3, with N_1 and N_2 as in caption to fig. 1 and N_3 as in caption to fig.3. The error bars represent two standard deviations for N_2 (up to 96 min beta dose) and N_3 (above 96 min beta dose), the errors for N_1 being about the same as those for N_2. The solid line is the unweighted least squares fit of a saturated exponential to the N_1 data.

RBP were very small or absent, it has not tested interaction between these peaks and the RBP. However, in the field at the time of deposition the traps associated with these peaks are reasonably certain to be empty so that this interaction should not be a problem in any event.

Discussion

The result shows that there is no observable change in the glow growth curve of the RBP in this quartz when it is solar-bleached and one can conclude that for dating purposes it does not matter how bleaching is done, provided it eliminates the RBP, before the second glow growth curve is obtained. This conclusion certainly applies to this particular quartz and probably also to a wide range of Australian quartz and perhaps other quartz exhibiting primarily the RBP and the SBP. The situation is sufficiently complex, however, that the present conclusion of no interact ion between the RBP and SBP should be extended to other materials only with caution, particularly in the light of mention by Smith et al. (1990) that sensitivity changes in the OSL of quartz have been observed as a result of bleaching.

The apparent lack of interaction between the RBP and the SBP in this quartz raises the question whether the two systems use the same pathways for charge transport. Different pathways would certainly account for the observed apparent lack of interaction. Perhaps both systems do not transfer charge carriers through the conduction and valence bands, but rather at least one involves transfer in some other way, in the sense describe by Townsend and Kirsh (1989). Kinetic treatments of the irradiation and glow-out processes in this latter system would then have to take this into account.

Acknowledgement

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References

Aitken, M. J.. (1985) *Thermoluminescence Dating,* Academic Press, London, p. 20.

Chen, R. and Bowman, S.G.E. (1978) Superlinear growth of thermoluminescence due to competition during irradiation, *Eur. PACT* **2**, 216-230.

Chen, R. and Kirsh, Y. (1981) *Analysis of Thermally Stimulated Processes,* Pergamon Press, Oxford.

Chen, R., Yang, X.H., and McKeever, S.W.S. (1988) The strongly superlinear dose dependence of thermoluminescence in synthetic quartz. *J. Phys. D: Appl. Phys.* **21**, 1452-1457.

Fox, P. J. (1990) Optical studies of thermoluminescence materials. Unpublished Ph.D thesis, Department of Physics and Mathematical Physics, University of Adelaide.

Franklin, A.D., Hornyak, W.H., and Tschirgi, A. (1987) Experimental TL techniques for the inclusion method, *Ancient TL* **5**, 9-10.

Franklin, A.D. and Hornyak, W.F. (1990) Isolation of the rapidly bleaching peak in quartz TL glow curves, *Ancient TL* **8**, 29-31.

Franklin, A.D., Hornyak, W.F., and Dickerson, W. (1992) TL estimation of paleodose of dune-sand quartz, *Quat. Sci. Revs.* **11**, 75-78.

Hornyak, W.H., Chen, R., and Franklin, A.D. (1992) Thermoluminescence characteristics of the 375°C electron trap in quartz, *Phys. Rev. B* **46**, 8036-8049.

Hashimoto, T., Koyanagi, A., Yokosaka, K., Hayashi, Y., and Sotobayashi, T. (1986) Thermoluminescence colour images from quartzes of beach sand. *Geochem. J.* **20**, 111-118.

Huntley, D.J., Godfrey-Smith, D.I., Thewalt, M.L.W., Prescott, J.R., and Hutton, J.T. (1988) Some quartz thermoluminescence spectra relevant to thermoluminescence dating, *Nucl. Tracks Radiat. Meas.* **14**, 27-33.

Kristianpoller, N., Chen, R., and Israeli, M. (1974) Dose dependence of thermoluminescence peaks. *J. Phys. D: Appl. Phys.* **7**, 1063-1072.

Li , S. H. and Wintle, A.G. (1992) Luminescence sensitivity change due to bleaching of sediments, *Nucl. Tracks Radiat. Meas.* **20**, 569-573.

McKeever, S.W.S. (1991) Mechanisms of thermoluminescence production: some problems and a few answers? *Nucl. Tracks Radiat. Meas.* **13**, 5-12.

McKeever, S.W.S. and Chen, R. (1982) TL response to dose: numerical solution of the equations describing the build-up of the TL during irradiation, *Eur. PACT* **6**, 243-251.

Prescott, J.R. and Fox, P.J. (1990) Dating quartz sediments using the 325°C TL peak: new spectral data, *Ancient TL* **8**, 32-35.

Smith, M.A. (1987) Pleistocene occupation in Central Australia, *Nature* **328**, 710-711.

Smith, B.W., Aitken, M.J., Rhodes, E.J., Robinson, P.D, and Geldard, D.M. (1986) Optical dating: methodological aspects, *Rad. Prot. Dos.* **17**, 229-233.

Stokes, S., Spooner, N.A., and Aitken, M.J. (1990) Optical dating of sediments: initial quartz results from Oxford, *Archaeometry* **32**, 19-31.

Spooner, N.A., Prescott, J.R., and Hutton, J.T. (1988) The effect of illumination wavelength on the bleaching of the thermoluminescence (TL) of quartz, *Quat. Sci. Revs.* **7**, 325-329.

Townsend, P.D. and Kirsh, Y. (1989) Spectral measurements during thermoluminescence - an essential requirement, *Contemporary Physics* **30**, 337-354.

Wintle, A.G. (1975) Thermal quenching of thermoluminescence in quartz, *Geophys. J. Res. Astro. Soc.* **41**, 107-113.

Wintle, A.G. and Huntley, D.J. (1979) Thermoluminescence dating of a deep-sea sediment core, *Nature* **279**, 710-712.

PR Steve McKeever

The author poses an important and interesting question, namely does the degree of bleaching of the slowly bleached TL peak (SBP) in quartz affect the growth curve (i.e. sensitivity) of the rapidly bleached peak (RBP)? The data presented clearly indicate that it does not, for the particular sample of quartz under study. However, since the mechanism that causes the bleaching of the TL signals in quartz is still uncertain, and under considerable debate, we should be cautioned about extending this conclusion to all quartz samples (a point noted by the author). Similarly, we should also be careful about the inferences that may be drawn from these data concerning kinetic models.

Nevertheless, models aside, the present data are clearly relevant to general concerns regarding possible sensitivity differences between samples that have received only a selective bleach in the laboratory (e.g. "yellow bleach" referred to in this paper) versus other less selective bleaches (e.g. a solar bleach, or a natural sunlight bleach). It would perhaps be fruitful for all laboratories engaged in this type of research to carry out similar tests and in this way the question regarding the generality of the results, raised by the author in the Discussion section, could be examined in greater depth.

Bibliography

Galloway, R.B. (1993) Correction for sample thickness in activity determination by gamma-ray spectrometry. *Radioactivity and Radiochemistry* **4**, 32-41.

Goër de Hervé, A., de Camus, P., Miallier, D., Sanzelle, S., Falguéres, C., Faïn, J., Montret, M. et Pilleyre, T. (1993) Le puy de Gravenoire et ses coulées dans l'agglomeration de Clermont Ferrand (Massif Central, français). *Bulletin de la Societé Geologique de France* **164**, 783-793.

Hashimoto, T., Yokosaka, K., Notoya, S., Ojima, T. and Sakaue, S. (1993) Dependence of red thermoluminescence on Eu-anomaly in natural quartzes. *Nuclear Tracks and Radiation Measurements* **21**, 209-215.

Hashimoto, T., Yokosaka, K., Shirai, N. and Ichino, M. (1993) Activation energies from blue- and red-thermoluminescence (TL) of quartz grains and mean lives of trapped electrons related to natural red-TL. *Nuclear Tracks and Radiation Measurements* **21**, 217-223.

Huntley, D.J., Hutton, J.T. and Prescott, J.R. (1993) Optical dating using inclusions within quartz grains. *Geology* **21**, 1087-1090.

Luff, B.J. and Townsend, P.D. (1993) Correction. High sensitivity thermoluminescence spectrometer. *Measurement Science Technology* **4**, 1186.

Muller, P. and Schvoerer, M. (1993) Factors affecting the viability of thermoluminescence dating of glass. *Archaeometry,* **35**, 299-304.

Prescott, J.R. and Fox, P.J. (1993) Three-dimensional thermoluminescence spectra of feldspars. *J. Phys. D: Appl. Phys.* **26**, 2245-2254.

Rendell, H.M., Townsend, P.D., Luff, B.J., Wintle, A.G. and Balescu, S. (1993) Spectral analysis of thermoluminescence in the dating of potassium feldspars. *Phys. Stat. Sol. (a)* **138**, 335-341.

Rendell, H. M., Khanlary, M.-R., Townsend, P.D., Calderon, T. and Luff, B.J. (1993) Thermoluminescence spectra of minerals. *Mineralogical Magazine* **57**, 217-222.

Robertson, G.B., Prescott, J.R. and Hutton, J.T. (1993) Bleaching of the thermoluminescence of feldspars by selected wavelengths present in sunlight. *Nuclear Tracks and Radiation Measurements* **21**, 245-251.

Vandiver, P.B., Kaylor, R., Feathers, J., Gottfried, M., Yener, K.A., Hornyak, W.F. and Franklin, A. (1993) Thermoluminescence dating of a crucible fragment from an early tin-processing site in Turkey. *Archaeometry* **35**, 295-298.

TL and ESR ages in

Clarke, P.U. plus fifteen other authors including Berger, G.W. and Lamothe, M. (1993) Initiation and development of the Laurentide and Cordilleran ice sheets following the last interglaciation. *Quaternary Science Reviews* **12**, 79-114. This includes an appendix by G.W. Berger entitled Comments on TL ages.

Forman, S.L., Smith, R.P., Hackett, W.R., Tullis, J.A. and McDaniel, P.A. (1993) Timing of late Quaternary glaciations in the western United States based on the age of loess on the eastern Snake River Plain, Idaho. *Quaternary Research* **40**, 30-37.

Lees, B.G., Hayne, M. and Price, D. (1993) Marine transgression and dune initiation on western Cape York, northern Australia. *Marine Geology* **114**, 81-89.

Nanson, G.C., East, T.J. and Roberts, R.G. (1993) Quaternary stratigraphy, geochronology and evolution of the Magela Creek catchment in the monsoon tropics of northern Australia. *Sedimentary Geology* **83**, 277-302.

Sherman, C.E., Glenn, C.R., Jones, A.T., Burnet, W.C. and Schwarcz, H.P. (1993) New evidence for two highstands of the sea during the last interglacial, oxygen isotope substage 5e. *Geology* **21**, 1079-1082.

Patton, P.C., Pickup, G. and Price, D. (1993) Holocene palaeofloods of the Ross River, Central Australia. *Quaternary Research* **40**, 201-212.

Young, R.W., Bryant, E.A. and Price, D.M. (1993) Last Interglacial sea levels on the south coast of New South Wales. *Australian Geographer* **24**, 72-75.

Young, R.W., Bryant, E.A., Price, D.M., Wirth, L.M. and Pease, M. (1993) Theoretical constraints and chronological evidence of Holocene coastal development in central and southern New South Wales. *Geomorphology* **7**, 317-329.

Compiled by Ann Wintle

Notices

JOHN THOMAS HUTTON

John Hutton graduated in Chemistry from the University of Adelaide, with additional qualifications in Industrial Chemistry from the South Australian School of Mines, just before the Second World War. His first employment was in Australian munitions production. After the war he joined the Soil Division of the Council for Scientific and Industrial Research (afterwards the Commonwealth Scientific and Industrial Research Organisation, CSIRO). He began as chemist in charge of soil surveys and then as chemist in soil mineralogy. With Norrish, he developed the use of XRF for elemental analysis of soils and plants. After taking early retirement from CSIRO, he was persuaded, without too much urging, to join the Physical Archaeometry Research group in the Physics Department at the University of Adelaide where he was appointed a visiting Research Fellow. At CSIRO he had been unique in his insistence on taking part in the field work associated with his chemical analyses. This proved particularly valuable to the Adelaide Archaeometry group because when we began work on a new site, he had either been there before or knew someone who had. John Hutton may not have been well known personally to northern hemisphere workers in luminescence dating but his name will be familiar as co-author on most of the publications of the Adelaide group in the last ten years. In addition, he published in his own right on the application of chemistry to archaeology. He died on 13 December aged 72, after the return of cancer for which he was treated several years ago. He will be sorely missed.

J. R. Prescott
New Years Day 1994

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