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A Cautionary Note On The Measurement of Quartz TL Immediately after Irradiation

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Observations have been made of the TL from coarse grain quartz immediately after a laboratory beta-irradiation. It has been found that the scatter in the measurements decreases with time after the irradiation. More important, several observations were made which indicate that in some cases there is an apparent fading immediately after a laboratory irradiation. It is suggested that this may not necessarily be due to the loss of charges from deep traps, but could be due to a transfer of some charges associated with the 100° peak to higher temperature traps during heating.

The effect was originally observed whilst coarse-grain dating an aboriginal ovenstone (EB1/F2-L). The first and second growth curves at 340° are shown in figure 1. It can be seen that the discs which were left for several days showed linear growth with good reproducibility between discs. On the other hand, discs which were glowed out within a few hours of beta-irradiation had a high TL in all cases and greater scatter. This was thought at first to be a change in instrumental efficiency, but further measurements in which all TL outputs were measured on the same day showed the effect to be real.

Not all quartz samples appear to be subject to this phenomenon. Measurements carried out on a sample of baked sand (SC3/6) showed that the TL after six days was within one standard error of the TL after fifteen minutes, for all temperatures between 270° and 460°.

A marine sediment sample (RED42-40) also shows the effect. The TL was measured for a range of time intervals after irradiation of from ten minutes to eight weeks, with all glow-outs made on the same day to minimize errors introduced by equipment sensitivity changes. The sample discs were initially glowed out to give the natural TL, and then given a 37.7 Gy beta dose. The discs were normalized using three methods: natural TL, weight and dose. The dose normalization involved giving each disc a further 37.7 Gy dose and measuring the TL (3rd glow) after one week. All of the normalization methods gave similar results.

Figure 2 shows the TL response for discs left for more than twenty hours compared with those left for less than six hours. These are typical time periods that would apply if the samples were either glowed on the same day as irradiation or left until the next day. The TL was integrated over sixty degree intervals to minimize errors introduced by small temperature shifts in the glow curve. The boundary between the 250° and 310° intervals was in a region where the TL was increasing at a fast rate, which led to the errors for these intevals being larger than those for the higher temperatures. The data are consistent with an average fading of about 5% and the uncertainties are such that no conclusion can be drawn about whether fading depends on glow temperature.

There are very few references to the fading of quartz. Indeed, most researchers have reported no fading. One exception is a series of measurements by Mejdahl (1983) which showed the same fading of between eight and ten per cent for three, six and nine month periods, when compared with control samples that had just been irradiated. Mejdahl does not mention how much time elapsed between irradiation and measurement of the controls, but it was presumably the same day. His results would then be consistent with our measurements. Further evidence has been obtained by Readhead (1982) who also had difficulty obtaining a flat age plateau for quartz if the low temperature TL was not allowed to decay thermally before glowing.

It is thought that the apparent fading is due to charge transfer from 110° peak to higher temperature (deeper) traps during the glow out. Trap competition during heating has been described by Paige (1957), Aitken et al. (1968) and more recently Levy (1983), who produced expressions which clearly show that the higher temperature peaks depend on the initial trapped charge concentration in the lowest temperature trap. Levy now suspects that some of his previous measurements on quartz (e.g. Fuller and Levy, 1978) have produced physically unrealistic kinetic parameters due to charge transfer between different types of traps.

An interesting conclusion from the present measurements is that ambient temperature decay of the 110° peak does not transfer the same amount of charge as does heating the sample (at say 10°C s^{-1}) during TL measurement.

The dependence of TL output on heating rate was checked for sample EB1/F2-L. All discs were glowed out (with a 10°C s^{-1} heating rate) fifteen minutes after irradiation, but one set was given a preliminary heating to 150°C at 2.5°C s^{-1}. The latter set gave a 350°C peak area 7 (±6)% less than the other. This is consistent with a reduction in charge transfer but unfortunately, as is common with quartz, the uncertainties are large. It does, however, suggest that the phenomenon is not anomalous fading - rather the contrary: anomalous early excess.

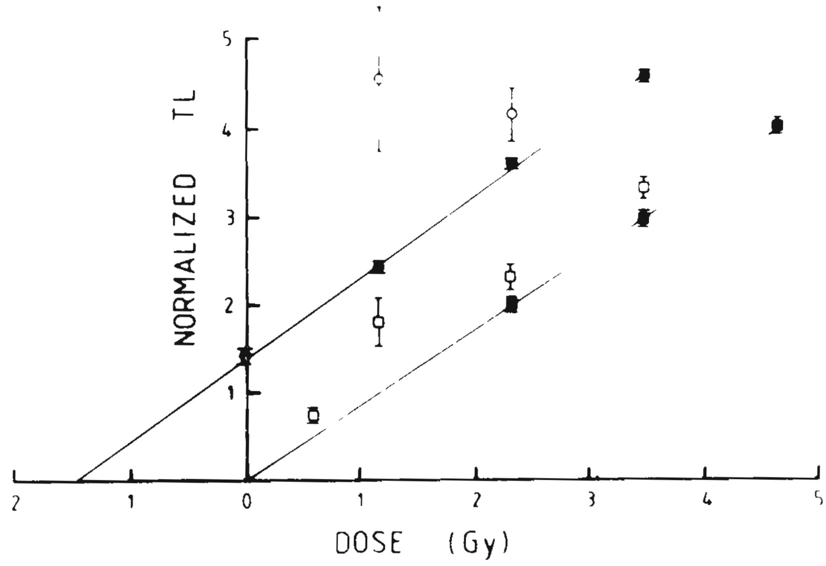

Figure 1. First and second glow TL growth curves at 340°C for sample EB1/F2-L
Error bars show sample standard deviations.
Open circles: 1st glow same day as irradiation.
Filled circles: 1st glow two days after irradiation.
Open squares: 2nd glow same day as irradiation.
Filled squares: 2nd glow five days after irradiation.

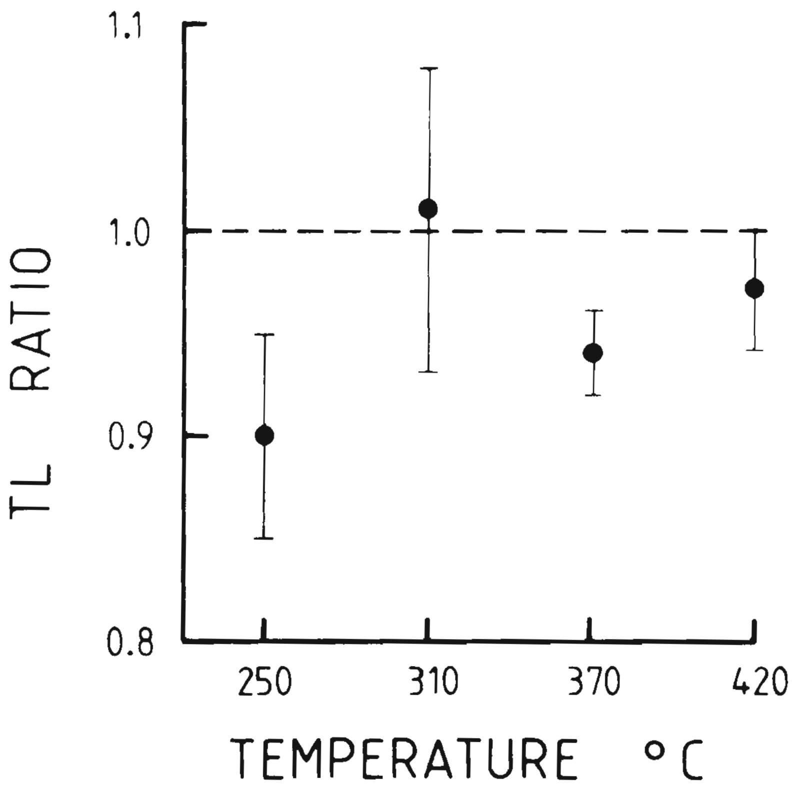

Figure 2. Sample RED 42-40. The ratio of TL for discs left at least twenty hours after irradiation to that for discs glowed after intervals of less than six hours. Sample standard deviations are shown.

It is stressed that anomalous excess may not occur for all quartz samples. We have found it most prominent in quartz which has been recently prepared from the field sample. Repeat measurements on sample EB1/F2-L after it had been sitting in a sample bottle for two years showed that rapid fading after irradiation still occurred, but to a lesser extent than is shown in figure 1. The reason why this made any difference cannot be explained.

Even when anomalous excess was not apparent, a better disc-to-disc reproducibility was obtained if the discs were not glowed for at least a day after irradiation. This is shown in the following table which gives the standard deviations for measurements on identical discs at 350°C (1) immediately after irradiation, (2) at least one day after irradiation, and (3) after the 110°C peak has been removed by an extremely slow heating rate.

SAMPLE	STANDARD DEVIATION (%)		
	(1)	(2)	(3)
EB1/F2-L	10.1	6.8	8.4
RED42-40	11.5	5.8	
SC3/6	23	22	
BPG	6.5	4.7	

The large scatter in measurements of SC3/6 has been discussed in detail elsewhere (Smith, 1983).

If only for the improved precision, we recommend that quartz is left for at least one day after irradiation. If this is not practical, the 110°C peak should first be removed using a very slow heating rate.

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