PHOTOTRANSFER METHOD OF DETERMINING ARCHAEOLOGICAL DOSE OF POTTERY SHERDS

by

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1. INTRODUCTION

In the evaluation of the archaeologically accumulated dose by quartz inclusions in TL dating, three different methods are employed viz. conventional method of calibration with beta/gamma doses [Fleming, 1970], the pre-dose sensitisation method [Fleming, 1971] and phototransfer TL (PTTL) technique [Bailiff, 1977]. The latter two methods have an advantage in that they avoid any TL measurements at high temperature regions where interference due to black body radiation and spurious thermoluminescence are prominent.

The pre-dose method is generally applicable only to young samples because of saturation effects beyond a few hundred rads whereas the PTTL method as brought out in this paper is extendable to older samples with archaeological doses of the order of a few thousand rads. Besides, the PTTL method suffers no drawback even in samples exhibiting anamolous fading characteristics [Bailiff, 1976]. This paper deals with various aspects of the phototransfer property of quartz with particular emphasis to its application in TL dating.

2. EXPERIMENTAL

Detailed studies on PTTL characteristics were made on a pink variety of Indian quartz [David, et al. 1977] The sample was prepared by powdering and selecting grains in the range of 125-150 μm. Four Pottery sherds with widely varying archaeologic ages were selected for the studies (see Table 2). The quartz inclusions of grain size 106-180 μm were extracted from the pottery by the well known method of Fleming [1970]. The TL reader used for the experiments is described elsewhere [Samant et al. 1974]. A heating rate of 10°C/second was selected for the measurements. For artificial laboratory irradiation a Co-60 source was used. An unfiltered light beam from a germicidal mercury lamp, predominantly of wavelength 250 nm was used for the UV exposure. The procedure of recording PTTL was standardised by the following steps: (1) pre-heat the sample in the reader upto about 300°C and allow to cool down to room temperature, (2) shine with UV light for 2 min and (3) record the PTTL glow curve after an interval of 30 seconds from the end of the UV irradiation. Fig.1 shows the representative glow curves for gamma induced TL and PTTL in quartz.

3. FEASIBILITY STUDIES

The dependance of PTTL of quartz on its thermal history was studied in detail. Aliquots of the pink quartz sample were heated in a muffle furnace at various temperatures for 2 hours

and then quenched to room temperature. The standard PTTL measurements were done on these after giving two different gamma doses. The plot of height of the first PTTL peak (around 70°C) versus the temperature of treatment exhibits two maxima, around 575°C and 900°C (fig.2). The pattern of the curve resembles the one obtained by David et al [1977] correlating TL sensitivity and temperature of treatment with two inversion points. The change in TL sensitivity was attributed to the phase changes occuring in quartz with the temperature of treatment. Hence it is reasonable to assume that the same type of centres responsible for gamma induced TL are responsible for the PTTL.

It may be noted that inspite of being given two different doses, the PTTL peak height does not change with the temperature of treatment upto about 350°C.

The growth of the 65°C PTTL peak with pre-dose was studied. The 800°C treated sample was used for this and it was seen that the PTTL peak at first increases linearly with dose (fig.3) and tends to saturate beyond about 4 Krads.

To study the feasibility of the application of PTTL to dose evaluation, a portion of the 800°C treated quartz was given a known dose and then recalibrated by the PTTL method. The irradiated sample was given additional doses and the PTTL recorded. The height of the 65°C peak was plotted against dose and extrapolated to evaluate the dose given earlier. The calibrated value came within

±3% of the actual dose. This type of calibration dispenses with the bleaching of the sample by UV light for prolonged periods (16 hrs) as was done by Bailiff [1977].

The technique was applied on quartz extracted from a few ancient pottery samples and the results are presented in table 1. The equivalent dose values evaluated by the conventional calibration method and the PTTL method fall within ±10%. The sample M2 did not have its first peak at 65°C, but only at 110°C. Fig.4 shows the calibration curves for sample PQ1 by both the methods. Supralinearity correction if any, was found out for the PTTL case exactly in the same way as is done in the conventional calibration procedure i.e. using NTL erased samples. After NTL erasure in the TL reader by heating upto 450°C, a constant feeble residual UV sensitivity was always registered and this has been subtracted from readings obtained for various doses in fig.4.

Table 1: Comparison of the archaeological doses obtained by different methods

Sr. No.	Sample Code Name	Archaeological age (years)	ED_r, rads (Conventional method)	ED_r(rads) (PTTL method)
1.	Meg 2	100 BC	4040	3600
2.	Meg 3	"	3520	3280
3.	M2	100 AD	1690	2025
4.	PQ-1	1400-1700 AD	330	330

4. CONCLUDING REMARKS

The method of PTTL dating works satisfactorily over a very wide range of archaeological doses and the upper limit seems to be around 4000 rads. The first TL peak generally occurs at 65°C or 110°C in different varieties of quartz and both seem to be satisfactory for PTTL dating if the reading procedure is standardised to take care of the fast fading of these peaks at room temperature.

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LIST OF FIGURES

1. Typical glow curves of quartz.

2. Change of PTTL with temperature of treatment in pink quartz.

3. Growth of PTTL with pre-dose.

4. Archaeological dose calibration by conventional and PTTL methods.

TABLE 1: COMPARISON OF THE ARCHAEOLOGICAL DOSES OBTAINED BY DIFFERENT METHODS

SR. NO.	SAMPLE CODE NAME	ARCHAEOLOGICAL AGE (YEARS)	ED_r (RADS) (CONVENTIONAL METHOD)	ED_r (RADS) (PTTL METHOD)
1.	Meg 2	100 BC	4040	3600
2.	Meg 3	100 BC	3520	3280
3.	M 2	100 AD	1690	2025
4.	PQ-1	1400-1700 AD	330	330

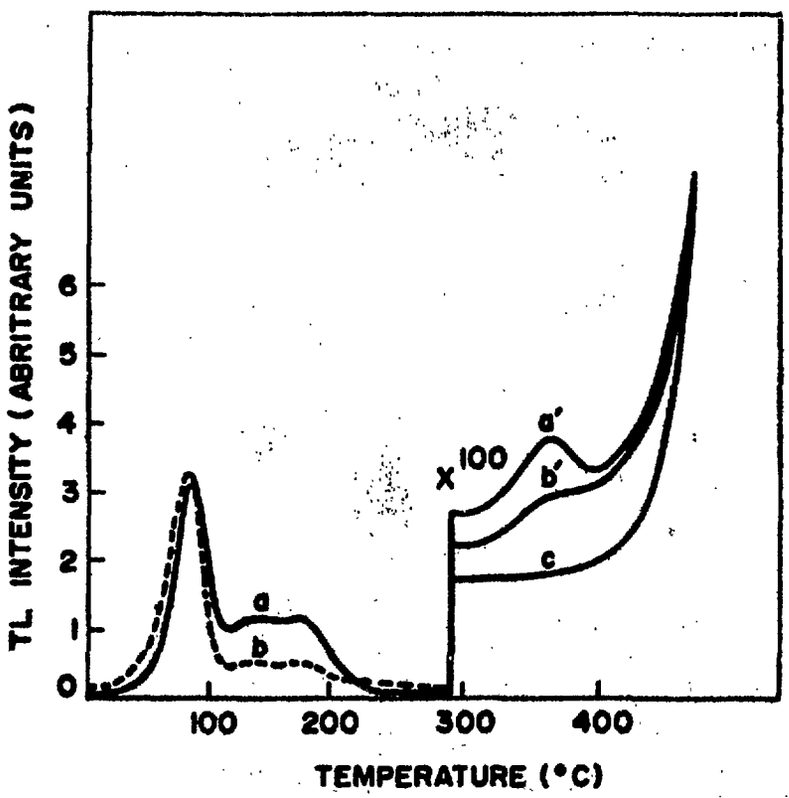

FIG. 1. TYPICAL GLOW CURVES FOR QUARTZ (a) GAMMA INDUCED TL (a') RESIDUAL TL BEFORE PHOTOTRANSFER (b) PTTL (b') RESIDUAL TL AFTER PHOTOTRANSFER (c) BLACK BODY RADIATION.

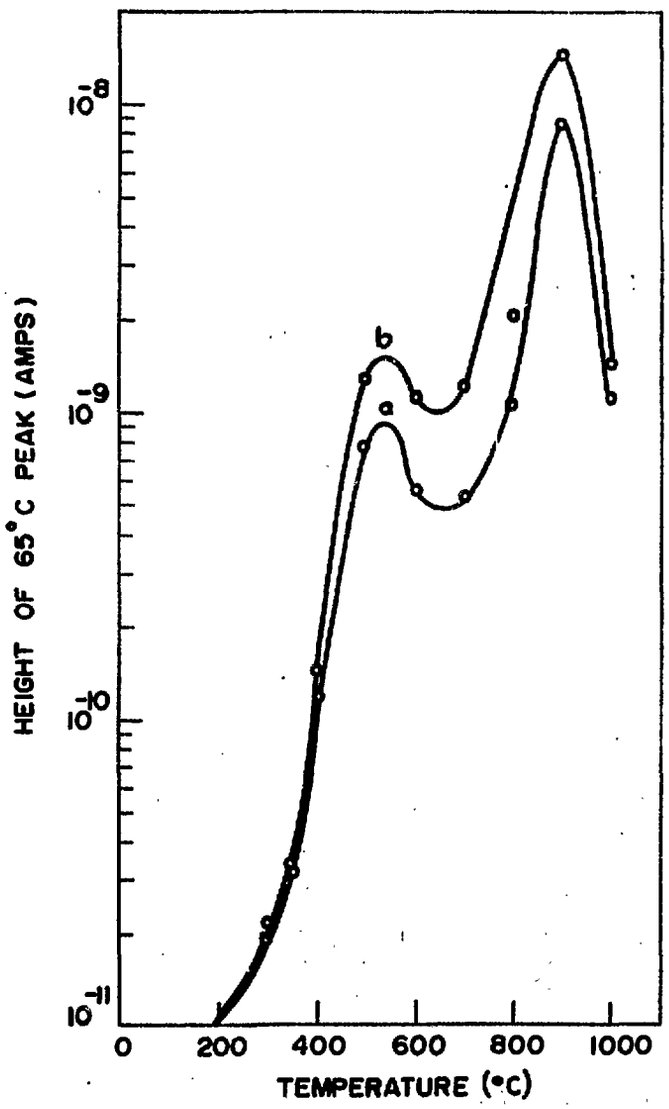

FIG. 2. CHANGE OF PTTL EFFICIENCY WITH THE TEMPRATURE OF TREATMENT IN PINK QUARTZ

a, after 500rads gamma b, after 1000 rads gamma

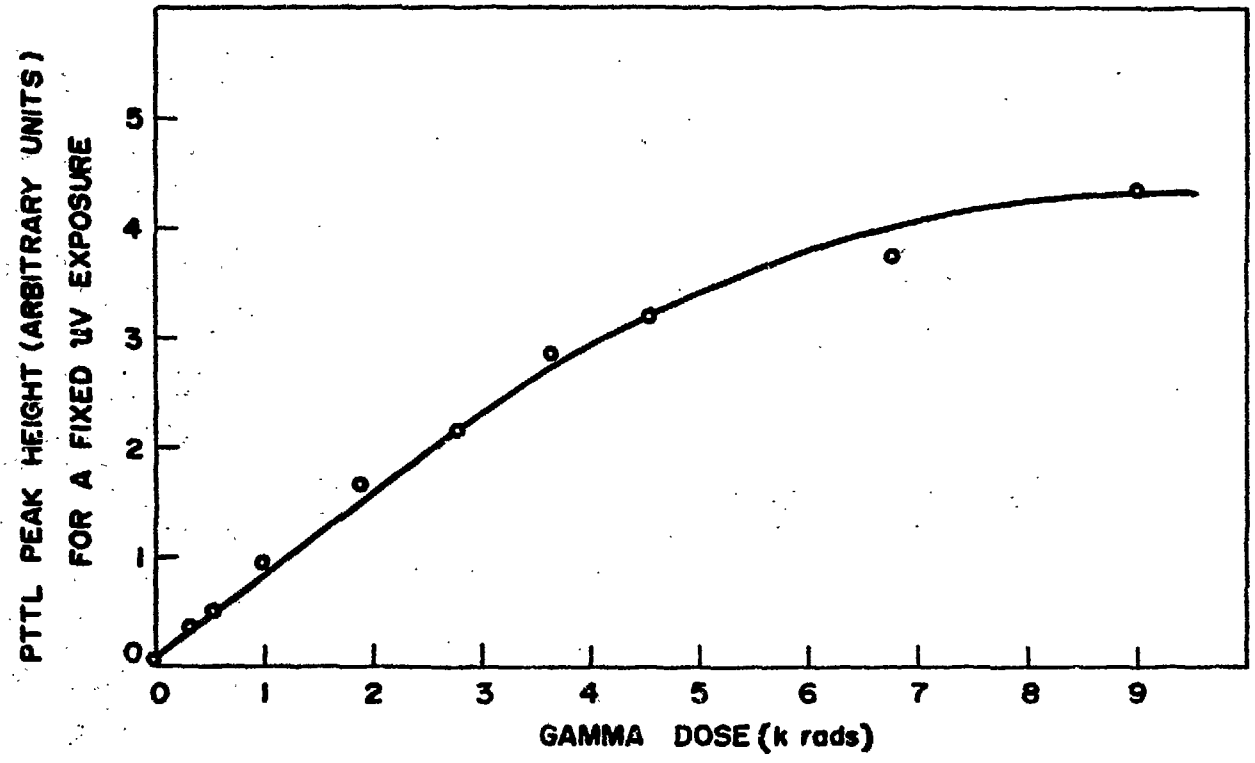

FIG. 3. GROWTH OF PTTL WITH PRE-DOSE IN INDIAN PINK QUARTZ

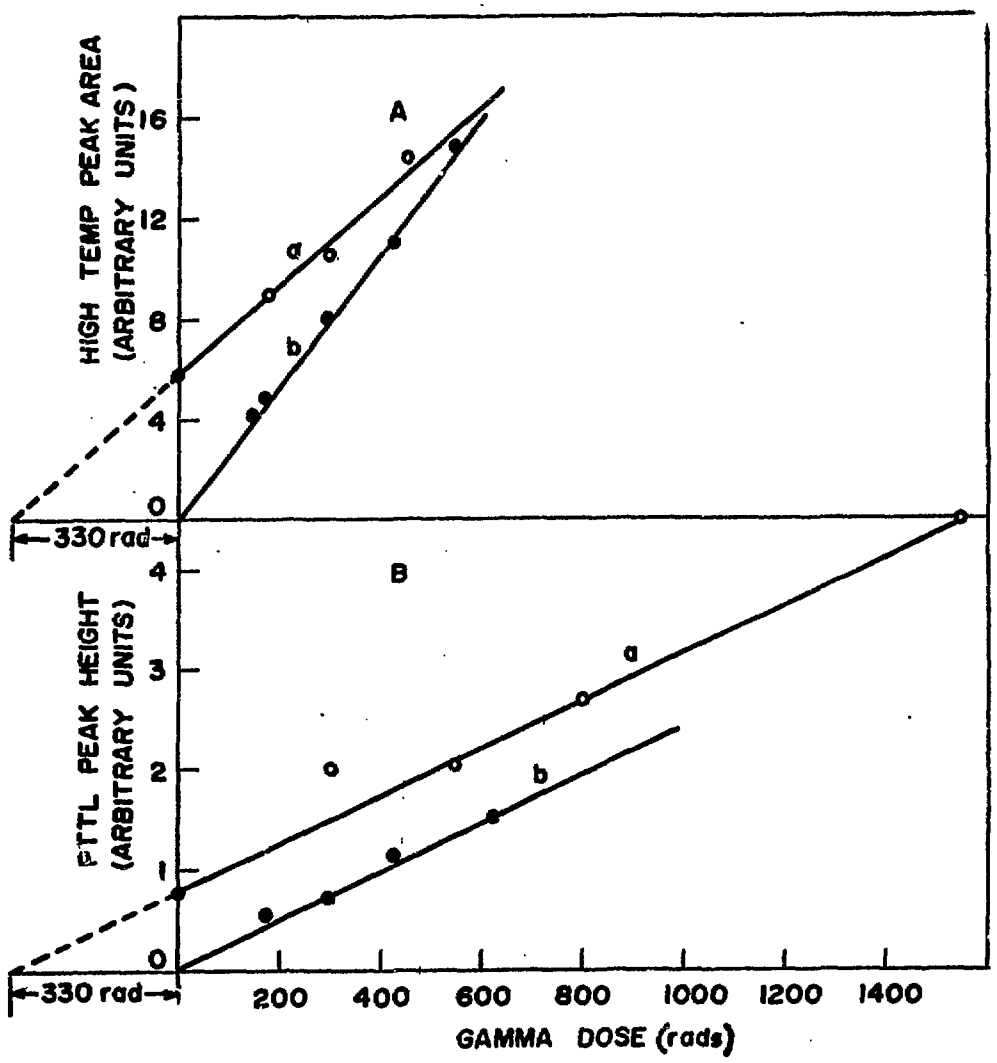

FIG. 4. ARCHAEOLOGICAL DOSE CALIBRATION: COMPARISON OF THE CONVENTIONAL AND PTTL METHODS (A) CONVENTIONAL METHOD (B) PTTL METHOD (a) NTL + DOSE (b) NTL ERASED + DOSE (SAMPLE: PQ1)