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Further comparisons of quartz OSL additive dose palaeodoses generated using long and short duration pre-heats

Stephen Stokes

Research Laboratory for Archaeology and the History of Art
and School of Geography
Oxford University

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Introduction

Over approximately the past year there has been some debate on the potentially malign effects of long duration pre-heat procedures on OSL palaeodoses (P) generated for coarse-grained quartz samples. This position has, for the most part, been championed by Roberts and colleagues (Roberts et al., 1993a,b, Roberts, 1994). They have specifically suggested that short (duration of minutes) pre-heats at temperatures above 200°C produce correct palaeodoses, whereas long (duration of hours) pre-heats at temperatures below 200°C result in palaeodose underestimation (Roberts et al., 1993a). This has been demonstrated by Roberts et al. for a series of five samples (one from North Africa, and four from Australia). While small in number, their analyses for these samples are used as a basis for hypothesising that long duration, relatively low temperature pre-heats cause dose-dependent sensitivity changes which influence additive dose growth curves.

Being an advocate of long duration pre-heat procedures in quartz optical dating (Stokes, 1992) I find their data of interest. I have accordingly undertaken a somewhat more extensive intercomparison on a series of 45 samples collected from Australia, South Africa, Botswana, Egypt, England, Holland, Mexico, the United States, and Zimbabwe (described in more detail in Stokes (1994)). Sample ages range from a few hundred to approximately 125 000 years. Clearly the samples are of varied provenance, and were collected from a range of depositional environments. The sampling of such a variety of materials was undertaken to attempt to facilitate measurement of as wide a range as possible of the 'spectrum' of quartz OSL behaviour. This paper describes the results of the intercomparison.

Experimental Procedures

All measurements were made on the quartz fraction as routinely refined from bulk sediment samples (e.g. Stokes, 1992). Cleaning procedures included HCl (1N) treatment, wet sieving (90-150 μm), magnetic and heavy liquid (ρ = 2.75 gm.cm^{-3}) separations, and etching using both HF (48%) and H_2SiF_6 (40%). All separation procedures took place under subdued red light. Cleaned samples were mounted as monolayers on 9.9 mm dia. stainless steel discs using a silicone oil (aliquot masses c. 5 mg). Typically 26 aliquots were prepared for the construction of each growth curve. In a small number of cases 50 aliquots were used (Stokes, 1994).

Optical stimulation was by an Ar^+ laser (λ = 514 nm) as described elsewhere (e.g., Smith et al. 1990), operated at a power level of 125 mW.cm^{-2}. OSL of UV-violet wavelengths was detected using an EMI 9635Q photomultiplier; other wavelengths being blocked by the presence of Corning 7-51 and Schott BG-39 glass filters (Stokes, 1992).

Prior to dosing and pre-heating, aliquots were exposed to the laser for a brief (< 20 mJ) period to facilitate normalisation using the so-called 'natural normalisation method'. Samples were then subjected to varying amounts of beta ($^{90}Sr/^{90}Y$) radiation and pre-heated either using a 160°C, 16 hour or 220°C, 5 minute procedure. All samples were stored for a period of at least 24 hours prior to OSL measurement.

The resulting additive dose measurements had the OSL collected late in the laser exposures subtracted as a background (c.f., Aitken and Xie, 1992), and palaeodoses were extrapolated using either a linear least squares or saturating exponential fitting algorithm. The saturating exponential fitting algorithm was provided by B.W. Smith (details in

Smith, 1983), and is known to produce somewhat more conservative errors on estimated palaeodoses than many other algorithms currently in use elsewhere.

The palaeodoses calculated for each pre-heat are plotted in Figure 1.

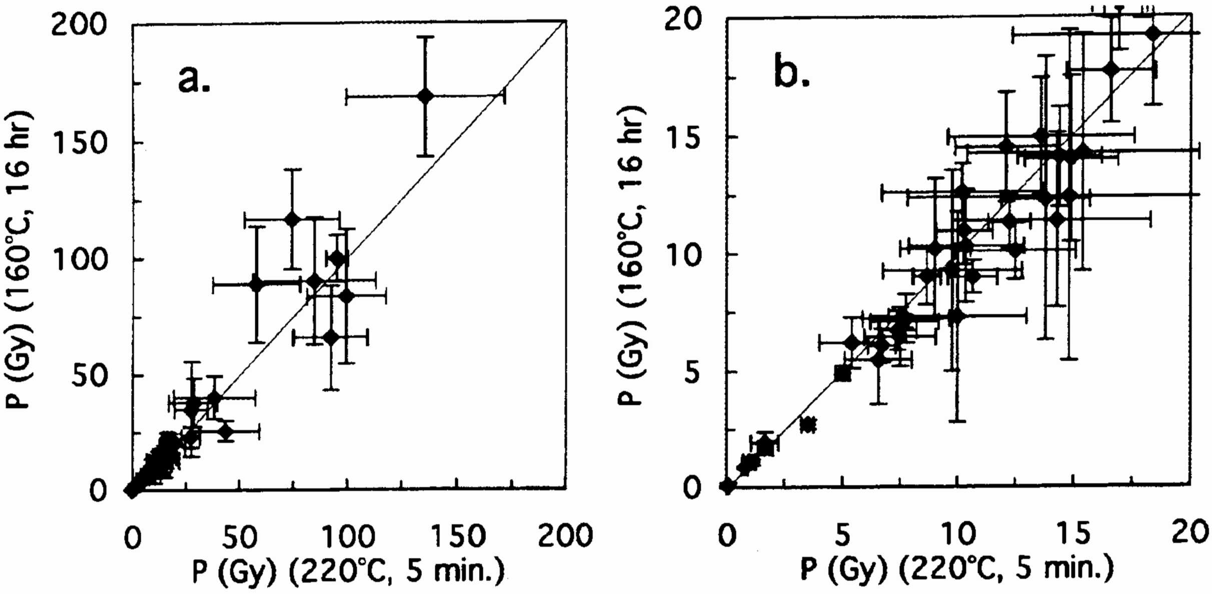

Figure 1

Comparison of palaeodoses (in Gy) generated using 160°C, 16 hour and 220°C, 5 minute pre-heat treatments. a. all data, b. data plotted for a restricted range of palaeodoses (0 - 20 Gy). Errors plotted are one sigma

Summary

Palaeodose estimates are found to be in close agreement independent of which pre-heat treatment is employed. This appears to be the case over an age range from a few hundred to over a hundred thousand years. Average ratios of the palaeodoses generated for each of the pre-heats were calculated for all samples. The unweighted mean ratio (220°C, 5 minute/160°C, 16 hour) was 1.02±0.20, whilst the mean ratio weighted inversely proportionally to the scatter in each palaeodose assessment yielded a value of 0.95±0.14. Standard errors on the mean ratios are estimated at 0.03 and 0.02 respectively.

It is inferred from this analysis that there is no consistent contrast in palaeodoses caused by using either a 160°C, 16 hour or 220°C, 5 minute pre-heat treatment. While the corpus of observations remains too small for a robust statisical analysis, there is no specific evidence to suggest any influence of geographical locality, depositional environment, quartz provenance or sample age.

Although Roberts et al. (1993, 1994b) describe contrasts in palaeodoses caused by pre-heating for a small number of high sensitivity samples, it does not appear to be the norm in most quartz varieties. The cause of the apparent contrasts noted by Robert et al. (1994b) remains to be established.

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Rewievers
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