University of Cologne
Institute of Geography

CRC 806 - Our Way to Europe
Application of Luminescence and ESR Dating Techniques in Geoarchaeological Studies

Using R for TL dating of heated flints

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Introduction

R is a highly extensible language and environment for statistical computing and graphics. It provides a wide variety of statistical and graphical tools. A package for luminescence dating is available, but it mainly includes tools for OSL dating with the single aliquot regenerative dose (SAR) protocol [1, 2].

The aim of this project is to implement new functions specifically designed for Thermoluminescence dating (TL), including the multiple aliquots additive dose (MAAD) and the SAR protocol [3].

These functions were used to estimate the palaeodose of 5 heated silex artefacts coming from the Palaeolithic site of Taibeh, Jordan. These artefacts were associated with the Masraqan technocomplex, currently dated between 16 and 20 ka BC (MIS 2).

Data pretreatment

Each TL measurement is preceded by a preheat procedure and includes the measurement of the background (BG) signal. Both additive and regenerative dose measurements are followed by a testdose to normalize the results. Therefore, the data pretreatment is identical for SAR-TL and MAAD-TL.

First, the preheat curves, which are not needed for the palaeodose estimation, are plotted and removed (Fig. 1). Then, the BG signals are subtracted from the TL signals (Fig. 2). Finally, the peak maxima are aligned using the average of the testdose signals as reference (Fig. 3). Indeed, the scatter of the peaks is random and therefore not linked to second order kinetics

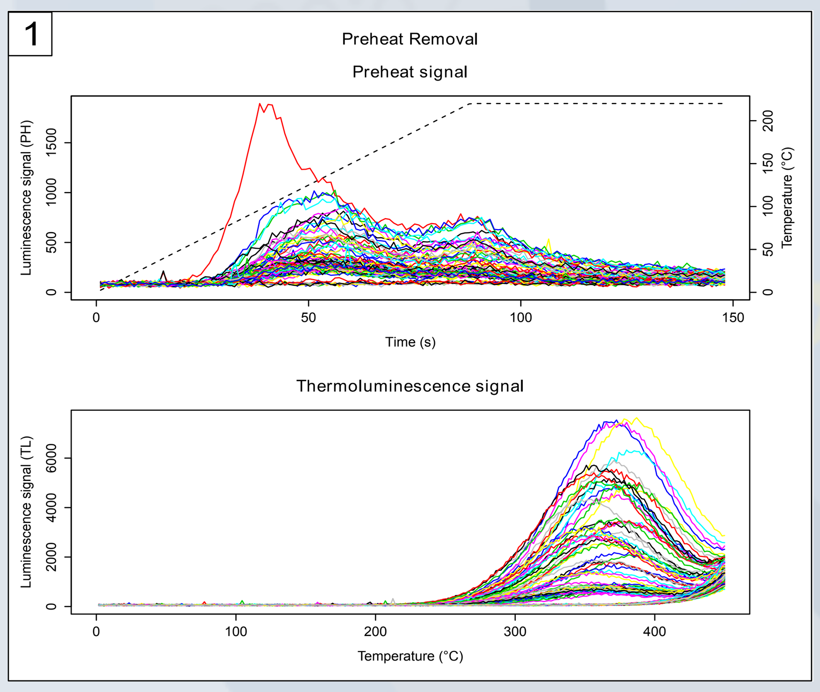


Fig.1, Sample TAI 19 (MAAD): Identification and removal of the preheat curves.

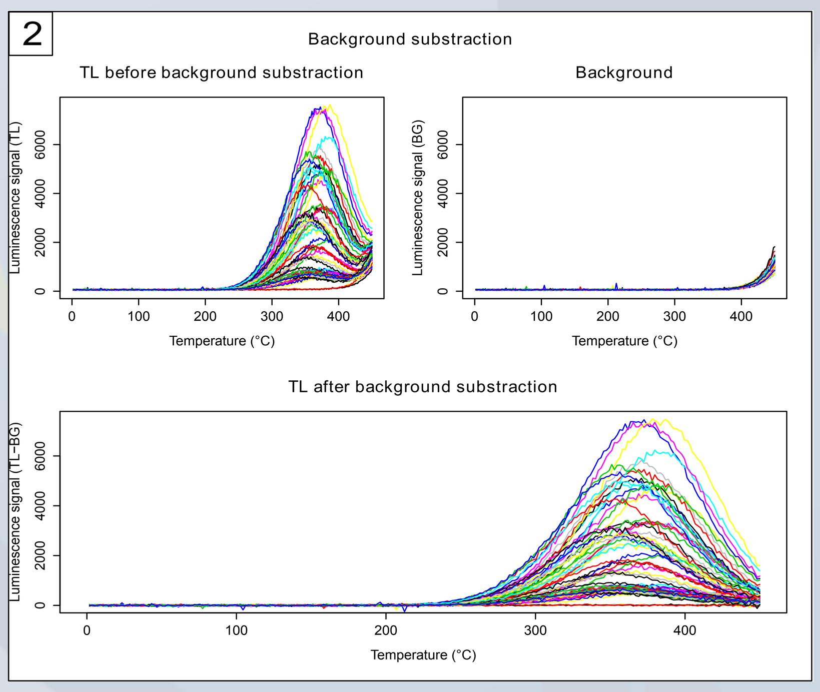


Fig.2, Sample TAI 19 (MAAD): Subtraction of the background signal from the TL signal.

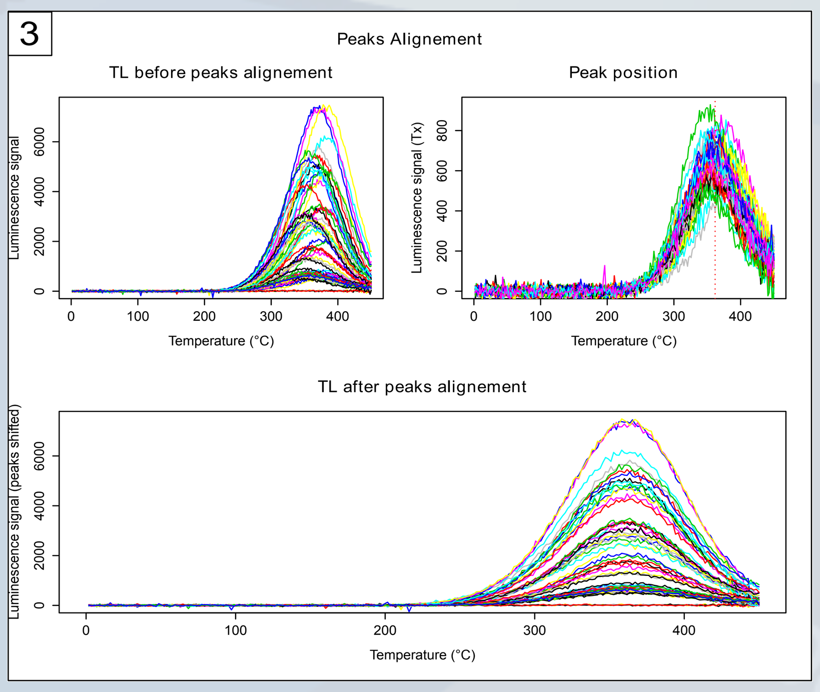


Fig.3, Sample TAI 19 (MAAD): peak maxima alignment.

Palaeodose estimation

Three parameters can be modified to provide the best estimation for the D_e: (1) fitting, including if it is weighted or unweighted ; (2) dose interval (D_{min}, D_{max}) ; and (3) temperature interval (T_{min}, T_{max}). Four rejection criteria can be used to select the best disks: (1) recycling ratio ; (2) recuperation rate ; (3) maximum error on L_x ; (4) and on T_x. For now only the linear fitting is fully supported. However, exponential, lin+exp, and exp+exp can be easily added.

For **MAAD-TL**, 6 additive dose steps were used. Each one was applied on 4 discs and the average was used for the D_e estimation. The discs used for the palaeodose estimation (Q) were reused for the sublinearity correction (I). L_x, T_x, L_x/T_x and their plateau tests were plotted for the additive (Fig. 4) and the regeneratice doses. D_e was estimated using the growth curve (GC) and the dose plateau (DP) approach (Fig. 5). Combining the plateau tests with the DP allows for a better selection of the temperature interval used.

For **SAR-TL**, each disc was irradiated by 10 different regenerative dose steps, including a 0 and a repeated dose. Once again, L_x, T_x, L_x/T_x and their plateau tests were plotted and D_e was estimated using a GC and a DP approach (Fig. 6a). The measurement was repeated on 12 discs and the results were plotted using an abanico plot to estimate the average D_e (Fig. 6b). Due to the way the BG is subtracted, the recuperation rate is always very close to zero. Therefore, it is probably not a rejection criterion as reliable as for SAR-OSL.

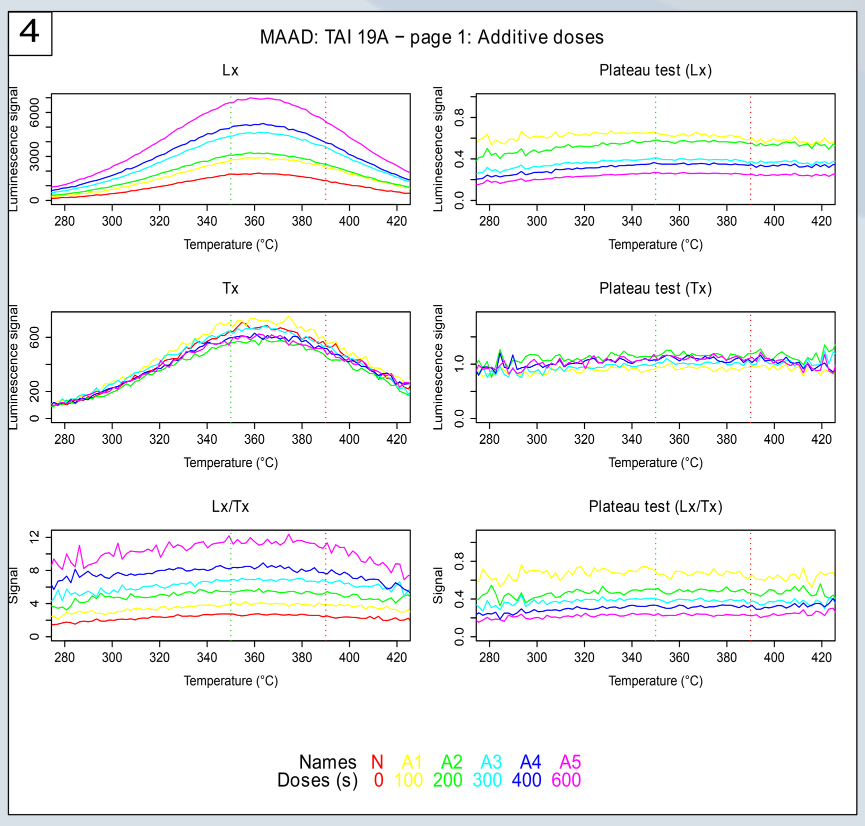


Fig. 4, Sample TAI 19 (MAAD): (i) Lx and L_X plateaus, (ii) T_X and T_X plateaus, (iii) L_X/T_X and L_X/T_X plateaus for the additive doses.

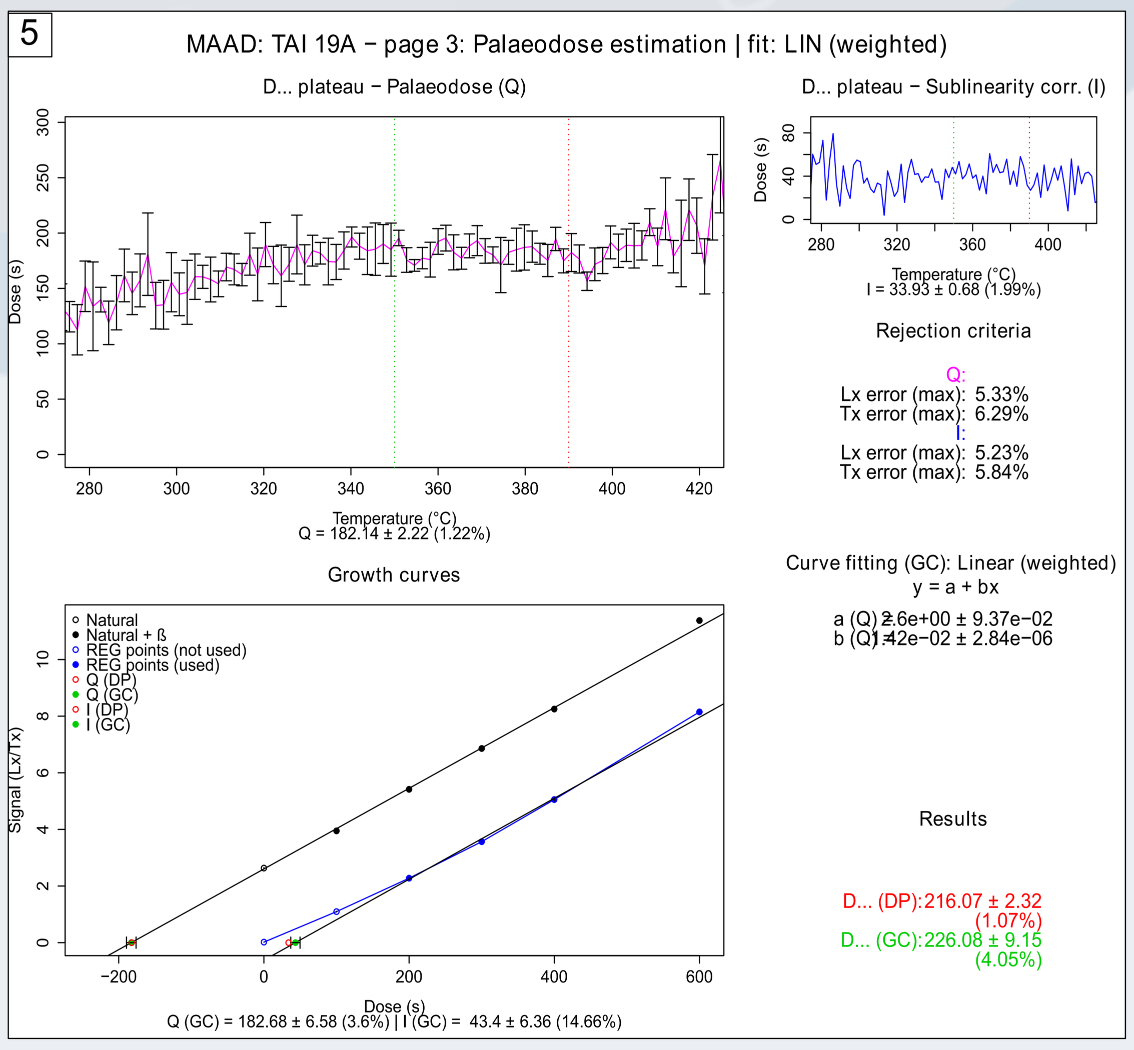
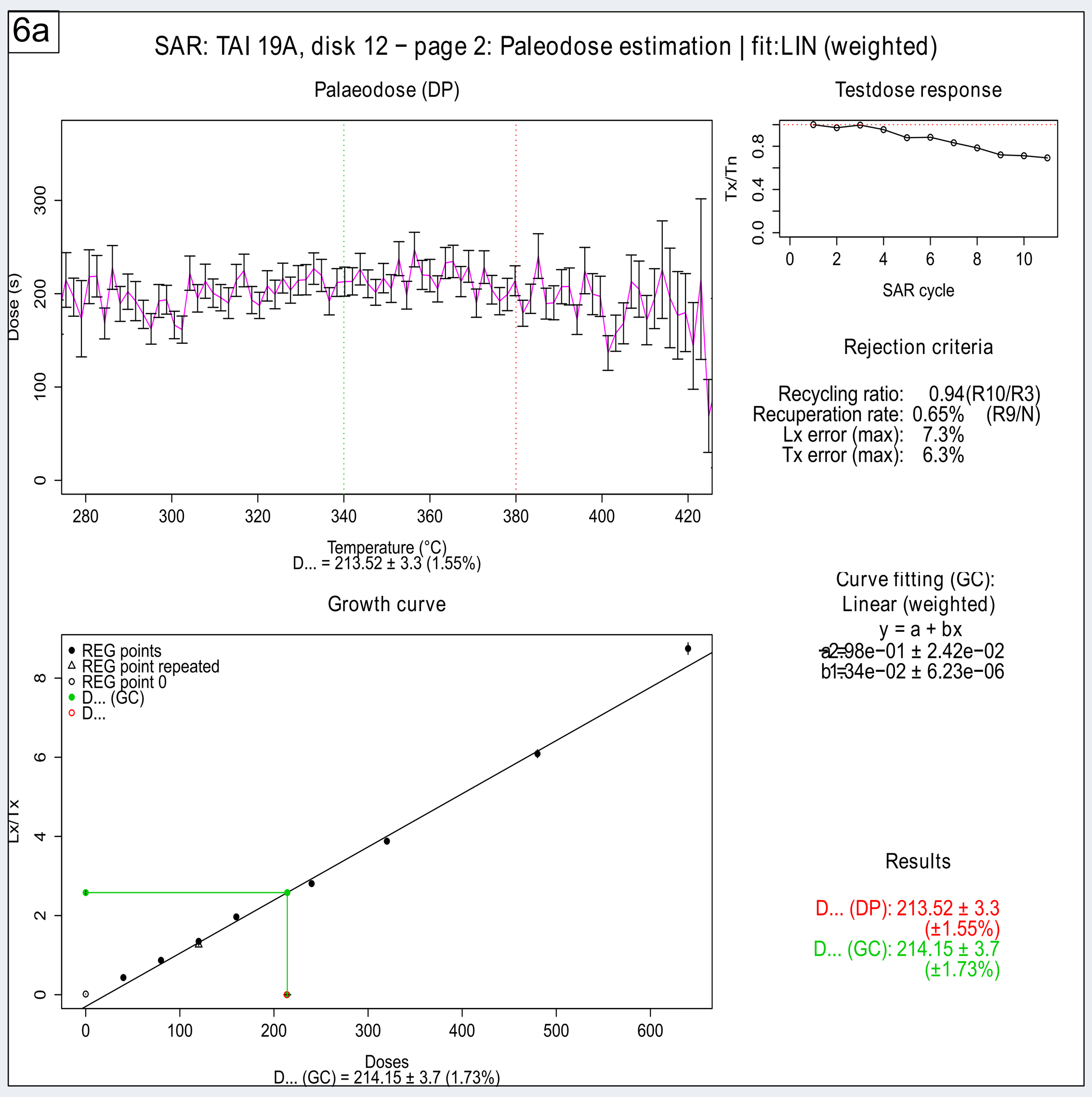


Fig 5, sample TAI 19 (MAAD): Estimation of the palaeodose (Q) and the sublinearity correction (I) using the dose plateau and the growth curve approaches.



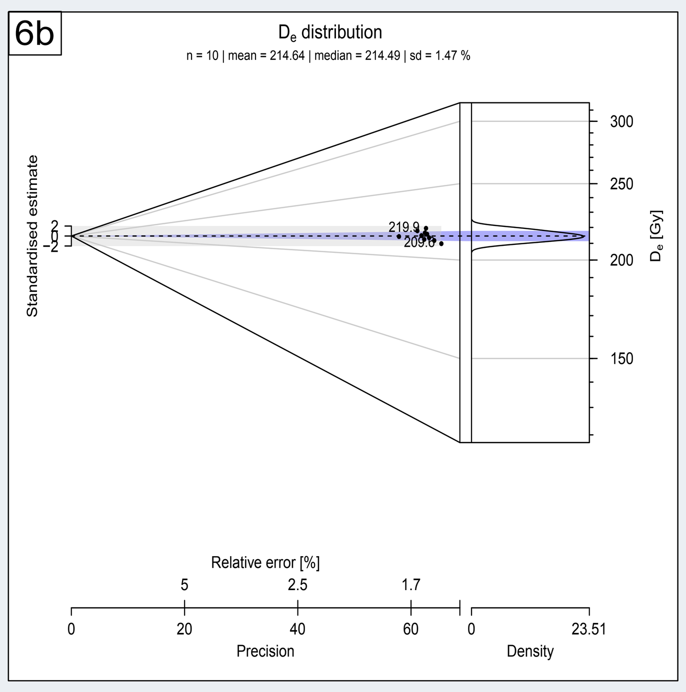


Fig. 6a, Sample TAI 19, disc 12 (SAR): D_e estimation using the dose plateau and the growth curve approaches.
Fig 6b, sample TAI 19 (SAR): Abanico plot of the D_e obtained using the growth curve approach.

Results and discussion

The difference between SAR-TL and MAAD-TL is generally below ±5 %. For SAR-TL, the variation between the growth curve (GC) and the dose plateau (DP) approaches and between a weighted and an unweighted linear fitting are below ±2 %. For MAAD-TL, these variations go from ±1 up to ±20 %. The primary source for these huge variations seems to be the sublinearity correction (I). They can also be explained by a relatively low maximum additive dose.

Both the SAR-TL and the MAAD-TL are able to provide reliable results. SAR-TL is more time consuming, but needs 2 to 4 times less material and seems to be more precise. For MAAD-TL, the sublinearity correction stays problematic. It should be done on separately annealed material. The dose steps should also be carefully selected, since those used for the fitting have to be in the linear part of the growth curve.

The DP clearly helps to select the best temperature interval. A divergence between the DP and the GC results for MAAD-TL generally means a divergence between SAR-TL and MAAD-TL.

Bibliography

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You can find more information about the CRC 806 on: http://www.sfb806.uni-koeln.de