University of Cologne
Institute of Geography

CRC 806 - Our Way to Europe

Application of Luminescence and ESR Dating Techniques in Geoarchaeological Studies

TL dating of heated flint using MAAD and SAR protocols

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Introduction

The Single Aliquot Regenerative dose (SAR) protocol introduced by Murray & Wintle [1] is routinely used for OSL dating sediments. The use of a SAR-TL protocol to date heated silex was proposed by Richter & Krbetschek [2]. However, up to now, the Multiple Aliquot Additive Dose (MAAD) protocol remains the reference for TL dating of heated flint.

To investigate the usability of SAR-TL, we estimated the palaeodose of 5 heated silex samples using the SAR and the MAAD protocol, and compared the results when varying the way the data are processed.

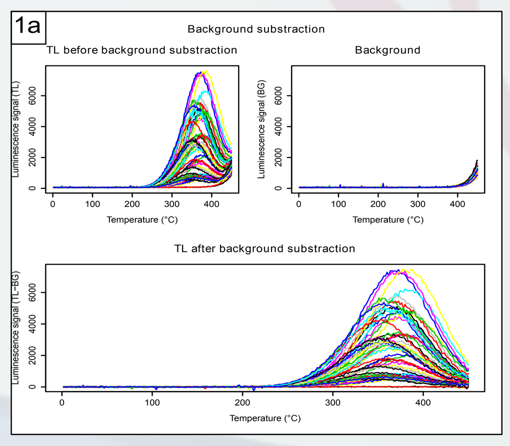
The heated silex come from the Palaeolithic site of Taibeh in the Wadi Sabra, Jordan. These artefacts were associated with the Masraqan technocomplex which is currently dated between 16 and 20 ka BC (MIS 2).

All measurements were made on a Risø TL/OSL reader with a TL unit and a combination of 4 filters to only record the UV-blue signal (HA-3,7-59, GG400 and BG39).

Measurement procedure and data pretreatment

Each TL measurement (0°C to 450°C at 2°C/s) was precedeted by a preheat (0°C to 220°C at 2°C/s then held for 60s) and followed by the measurement of the background signal (0°C to 450°C at 2°C/s again). Both additive and regenerative measurements were followed by testdose measurements to normalize the results.

The data pretreatment is identical for the SAR and the MAAD protocols. First, preheat curves are removed. Then, BG signals are substracted from TL signals (Fig. 1a). Finally, peak maxima are aligned using the average of the testdose signals as reference (Fig. 1b). Since the scatter of the peaks is random, it should not be linked to second order kinetics.



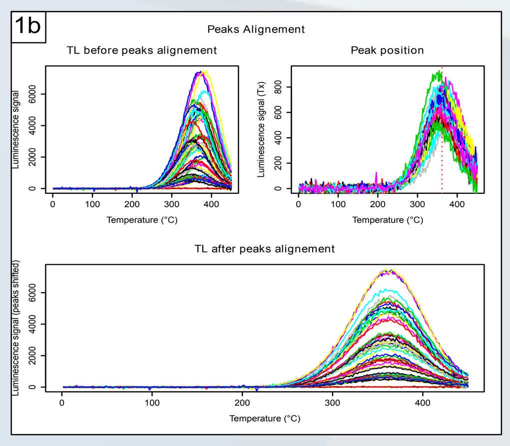


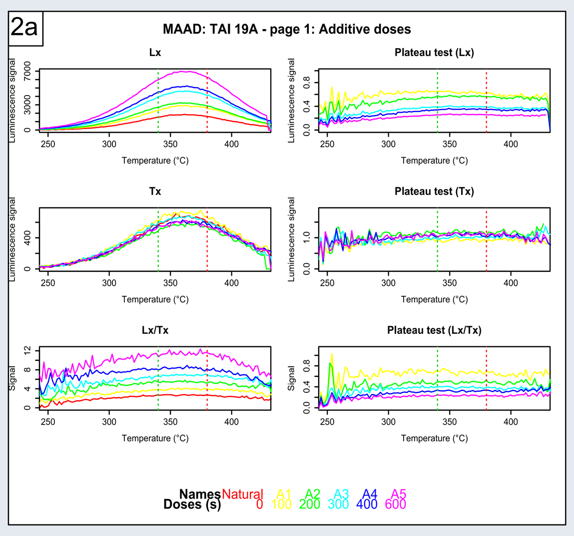
Fig 1a: Background substraction (sample TAI 19A, SAR protocol).
Fig 1b: Peak alignment (sample TAI 19A, SAR protocol).

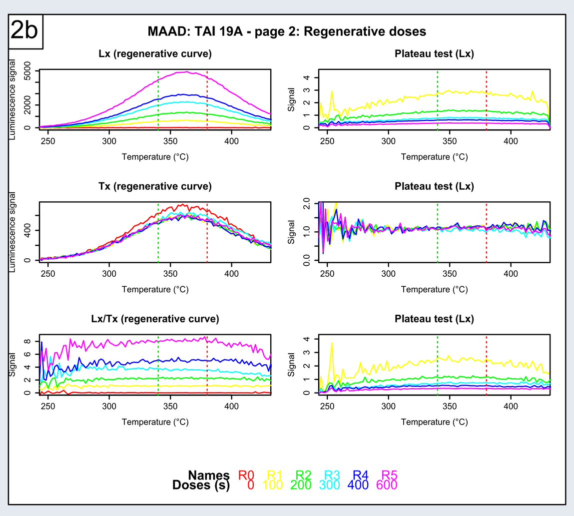
MAAD protocol

The used MAAD protocol includes a testdose step after each TL measurement. It allows to normalize the results. Moreover, rather than annealing extra material and making the regenerative curve separately, we reused the disks from the palaeodose (Q) estimation to determine the sublinearity correction (I). The sequence is as follows: (1) additive dose, (2) L_x measurement, (3) BG measurement, (4) testdose, (5) T_x measurement, (6) BG measurement, (7) regenerative dose, (8) L_x measurement, (9) BG measurement, (10) testdose, (11) T_x measurement, and (12) BG measurement.

We used 6 additive dose steps. Each one was applied on 4 disks. The average is used for the D_e estimation.

For the additive and the regenerative doses, we plot L_x, T_x, L_x/T_x and their plateau tests in order to facilitate the selection of the temperature interval (Figs. 2a, 2b). Finally, the D_e is estimated using a *dose plateau* (DP) approach and a *growth curve* (GC) approach (Fig. 2c).





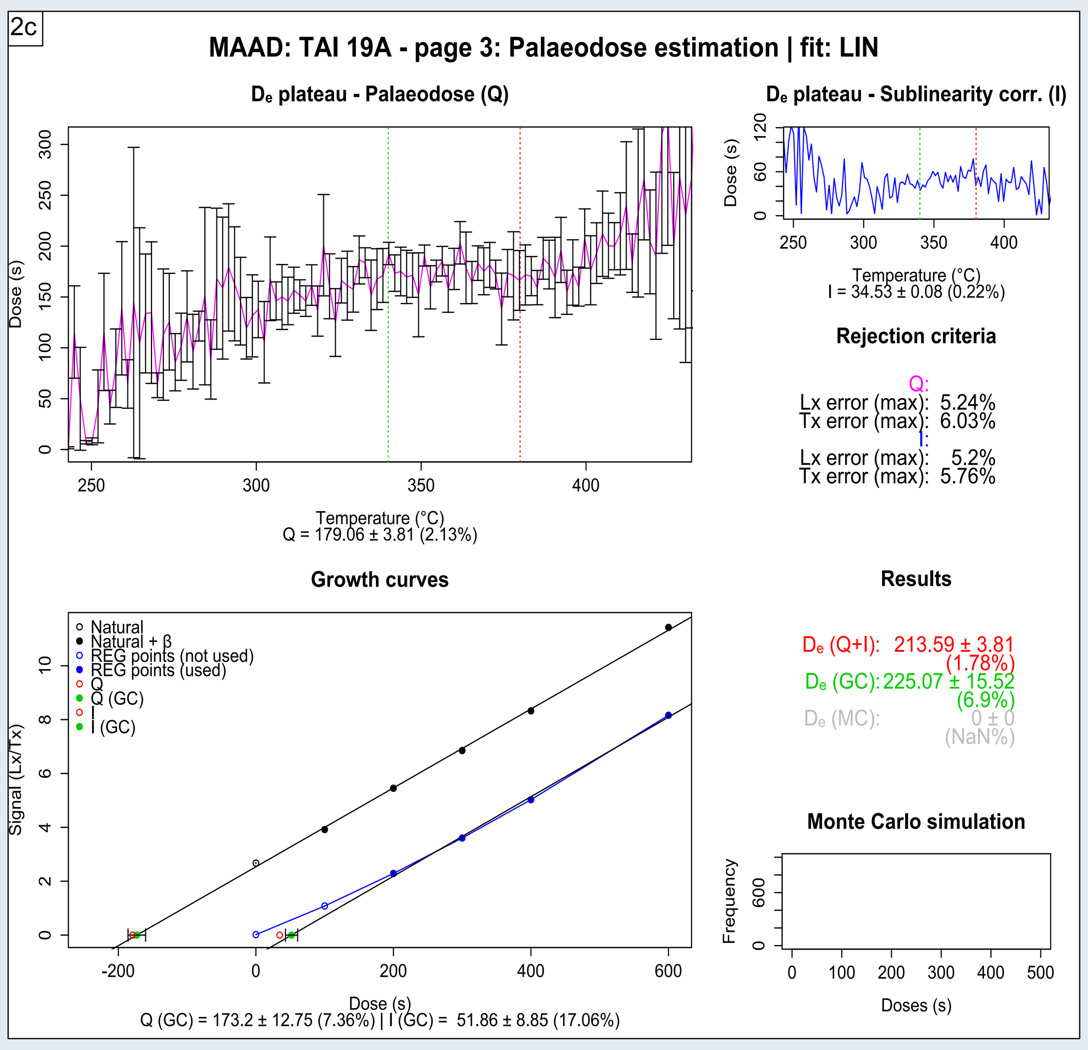


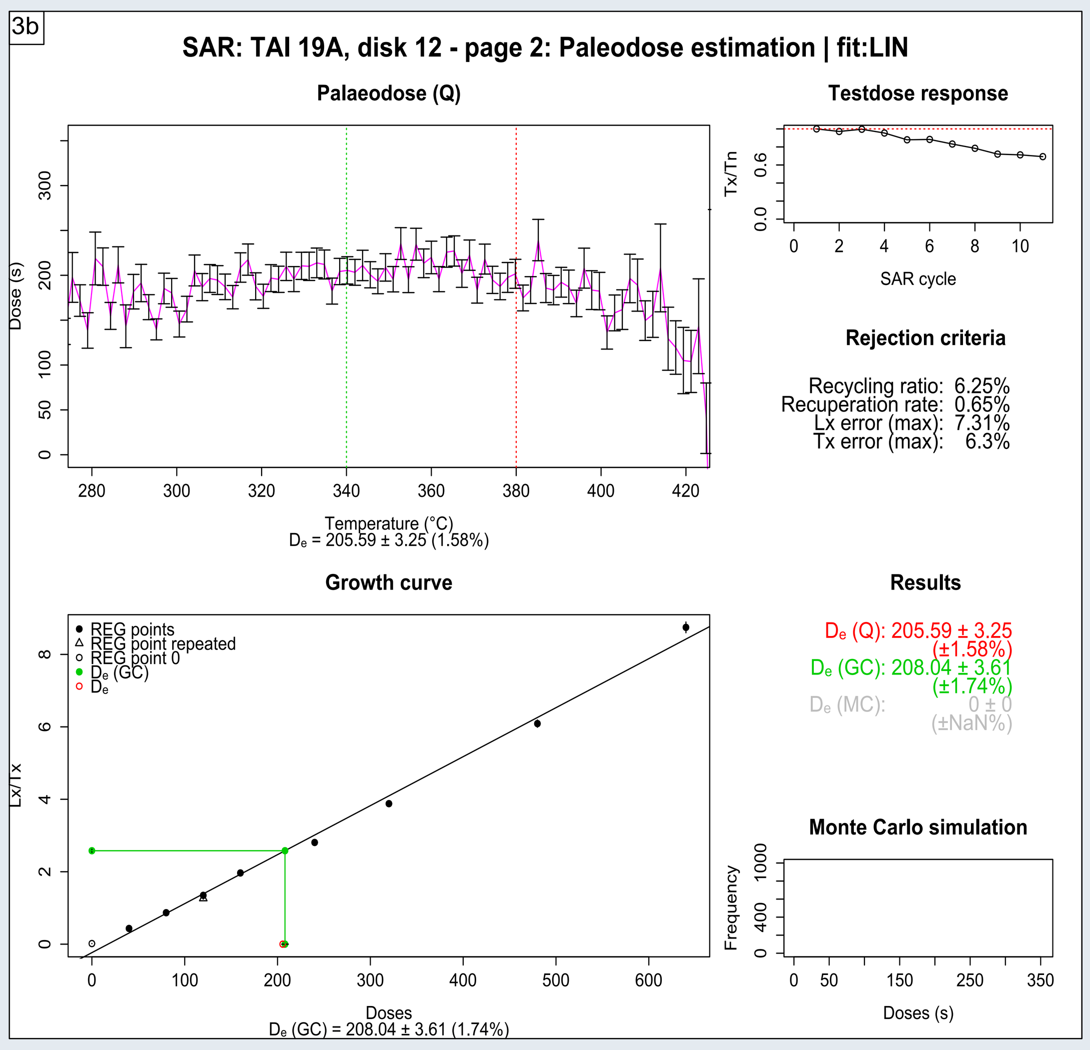
Fig 2a & 2b: L_x, T_x, L_x/T_x and theirs plateaux for the additives (a) and the regeneratives (b) doses (sample TAI 19A, MAAD protocol).
Fig 2c: Estimation of the paleodose (Q) and the sublinearity correction (I) for the dose plateau and the growth curve approaches (sample TAI 19A, MAAD protocol).

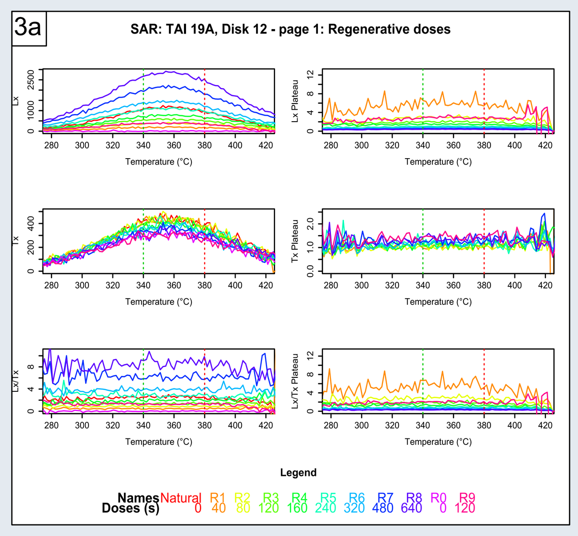
SAR protocol

The used SAR protocol is identical to the classical one, exept that each TL measurement is followed by a BG measurement. The sequence is as follows: (1) regenerative dose, (2) L_x measurement, (3) BG measurement, (4) testdose, (5) T_x measurement, (6) BG measurement.

Once again, we first plot signals and plateau tests for L_x, T_x and L_x/T_x to facilitate the selection of the temperature interval (Fig. 3a). Then, once again, we used a *dose plateau* (DP) and a *growth curve* (GC) approach to estimate the De of each disk (Fig. 3b). These measurements were repeated for 12 disks and the results were plotted using the new Abanico plot to estimate the average D_e (Fig. 3c).

Due to the way the background signal is substracted, the recuperation rate is always very closed to zero. Therefore, it is probably not a rejection criteria as reliable as for SAR-OSL. Further more, the testdose response can vary up to -30% at the end of the cycle. However, it does not seem to have an influence on the TL age.





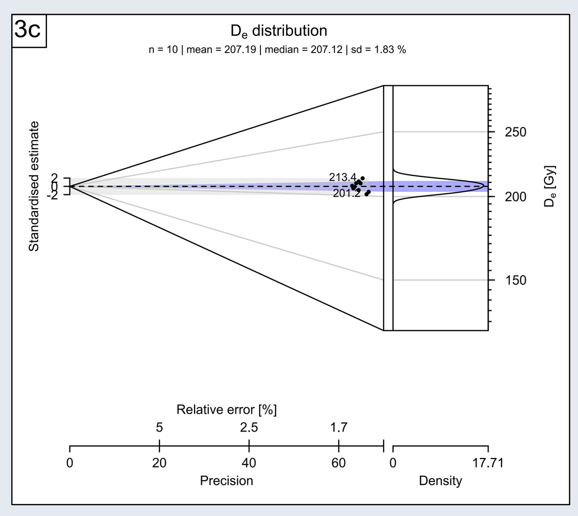


Fig 3a: L_x, T_x, L_x/T_x and theirs plateaux for the regeneratives doses (sample TAI 19A, SAR protocol).
Fig 3b: Estimation of the paleodose for the dose plateau and the growth curve approaches (sample TAI 19A, SAR protocol).
Fig 3c: Abanico plot of the D_e obtained using the dose plateau approach (sample TAI 19A, SAR protocol).

Results and discussion

If the difference between the *SAR-D_e* and the *MAAD-D_e* goes from -17% to +17%, it mainly stays below ±5% (Tabs. 4a, 4b). Using a *weighted* rather than an *unweighted* linear regression can also make a difference up to 17%. Although, if the difference between a DP and a GC approach is generally below ±2%, it can rise up to 27%. However, the most influential parameter, on the D_e estimation, is the temperature interval selection.

In general, a GC approach seems less sensitive to the temperature interval, but more to the use of a weighted regression than a DP approach. It also provides, quite systematically, higher D_e values.

Even if more samples are needed for a final conclusion, it seems that both SAR-TL and MAAD-TL provide reliable results for heated flint.

4a. Average equivalent dose (Gy)

Sample	protocol	DP (LIN)	DP (LIN weighted)	GC (LIN)	GC (LIN weighted)
TAI 1	MAAD	22.88	23.66	23.93	24.32
	SAR	23.46	24.63	23.70	24.75
TAI 15	MAAD	20.33	23.80	21.48	23.72
	SAR	22.32	25.00	22.61	25.07
TAI 18	MAAD	25.23	25.74	25.50	25.73
	SAR	27.11	27.24	29.98	30.07
TAI 19A	MAAD	22.70	23.16	23.92	24.04
	SAR	22.02	23.37	22.35	23.52
TAI 20	MAAD	13.92	13.31	16.87	17.03
	SAR	13.60	13.97	13.89	14.03

4b. Average uncertainty (1σ)

Sample	protocol	DP (LIN)	DP (LIN weighted)	GC (LIN)	GC (LIN weighted)
TAI 1	MAAD	2.00%	1.16%	7.05%	4.25%
	SAR	1.56%	1.37%	1.51%	1.41%
TAI 15	MAAD	5.28%	2.79%	27.61%	14.30%
	SAR	1.65%	2.71%	1.81%	2.62%
TAI 18	MAAD	1.69%	0.83%	10.59%	5.55%
	SAR	1.88%	1.99%	1.87%	1.96%
TAI 19A	MAAD	1.78%	1.04%	6.90%	4.77%
	SAR	1.83%	1.58%	1.85%	1.56%
TAI 20	MAAD	4.00%	1.77%	10.22%	5.24%
	SAR	4.70%	4.91%	4.48%	4.80%

Tab 4a & 4b: D_e values (a) and uncertainties (b) for SAR and MAAD protocol using a dose plateau (DP) or a growth curve (GC) approach with an unweighted (LIN) or a weighted (LIN weighted) linear regression.
For each sample, the lower D_e is in blue and the higher in red.

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

[1] Murray, A.S. & Wintle, A.G. (2000). Luminescence dating of quartz using a improved single-aliquot regenerative-dose protocol. Radiation Measurements 32, 57-73.
[2] Richter, D. & Krbetschek, M. (2006). A new Thermoluminescence dating technique for heated flint. Archaeometry 48 (4), 695-705.

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