THERMOLUMINESCENT DATING OF THE REMAINS OF ANCIENT ESTONIAN SETTLEMENTS BY MEANS OF FELDSPAR INCLUSION METHOD

G. HÜTT, A. MOLODKOV and T. MOORA*

Institute of Geology,
* Institute of History
Estonia Puiestee 7, Tallinn 200101, ESSR

Abstract

K-feldspars were extracted from burnt sand from under the hearths of ancient settlements. Energetical trap parameters with T_m = 320°C (heating rate 2.5 grad/sec) were determined: E = 1.7 eV; T = $3.2 \cdot 10^8$ years. Fading was not observed within the limits of reproducibility (< 5 %). The impact of etching with acids on TL and dosimetric properties of feldspars were studied. As quartz proved unapplicable to TL-dating K-feldspars were used for determining the age of some ancient Estonian settlements. The results obtained are in good agreement with radiocarbon dates and archaeological suppositions.

Introduction

Feldspars have attracted the attention of investigators as natural dosimeters applicable to TL-dating of archaeological and geological objects (Wintle 1973, 1978; Valladas et al., 1979; Mejdahl et al 1982, 1983; Hütt et al 1982, 1983, Jungner, 1983). In comparison with quartz they have several advantages: TL intensity is about 20—100 times higher, the linear region of dose response curve permits to date objects up to $7 \cdot 10^5$—10^6 years in age. One cannot forget either that in some cases feldspars are the only material enabling to determine the age of an object.

We attempted the study of some pecularities of K-feldspars from different geological areas. We also performed the dating of the remains of ancient Estonian fireplaces by means of the feldspar inclusion method where the quartz inclusion method didn't serve for dating purposes.

Separation, thermoluminescent and dosimetric pecularities of K-feldspars

K-feldspars were separated by treating them in heavy liquids (bromoform + xylol d = 2,59 g/cm^3), subsequently they were etched in 10 % HF for 15 minutes. Ultrasonic treatment was also used. By checking the weight it was established that about 15—20 % of the sample was removed. The separation in heavy liquids was carried out in columns or by means of a centrifuge. Microscopical studies and microprobe analysis showed that in the majority of cases the extracted samples contained over 70 % of feldspars, the rest being quartz occurring as ballast against the brightness of feldspars. However, in case of higher quartz content the maximum of TL glow curves shifts into

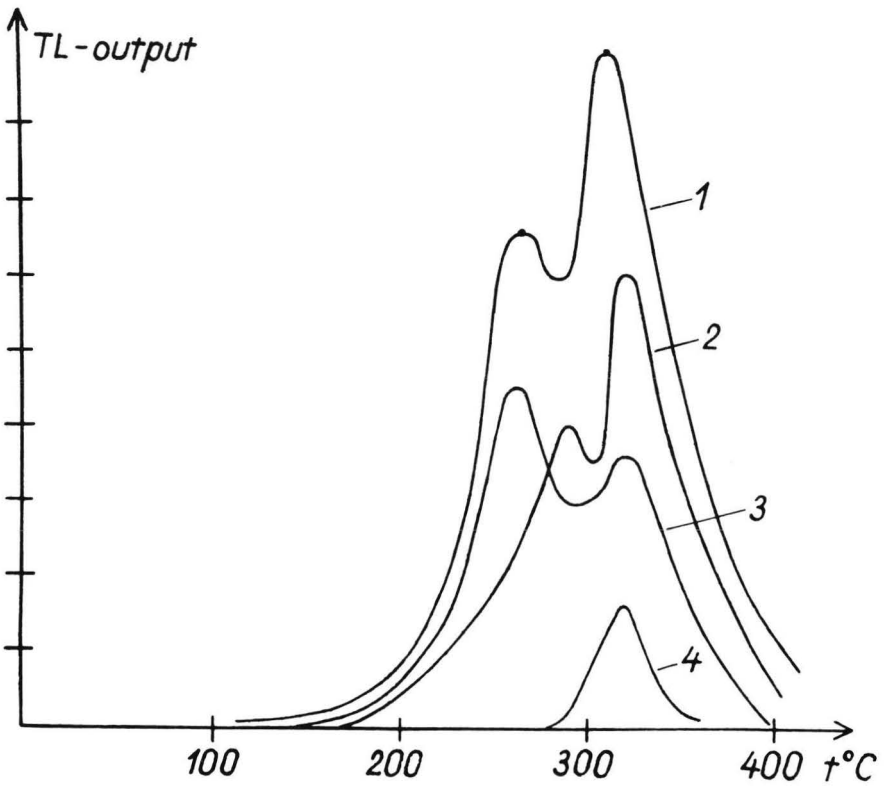

Fig. 1. TL-glow curves of feldspars from different regions: 1 — Middle-Asia, 2 — Belorussian, 3 — Black Sea profile, 4 — Estonian archaeological sample.

the higher temperature region, the dose response curve changes as well (early saturation is observed).

Our studies on quartz which was extracted from deposits of different genesis revealed the characteristic TL glow curve for quartz with T_m = 350°C (Hütt et al., 1982).

The preliminary studies on feldspars showed that the TL glow curve maintains its regional character (Fig. 1).

We studied the energetical trap parameters responsible for the peak T_m = 320°C in archaeological feldspar according to earlier described methods (Hütt et al., 1979) (Fig. 2). On the basis of dose response curve it was shown earlier that this trap level permits to date events up to $7 \cdot 10^5$—10^6 years in age (Hütt et al., 1982). However, feldspars with T_m = 310°C reach saturation considerably earlier ($\leq 10^5$years).

The impact of etching with acids on TL properties of feldspars was also studied. For a vast majority of samples the etching with acids has no influence on the morphology of TL glow curves. It is understandable as the TL of feldspars is usually higher than the potential TL of the surface contaminating components (it does not concern quartz).

Our investigations proved the suitability of the trap with T_m = 320°C for TL-dating.

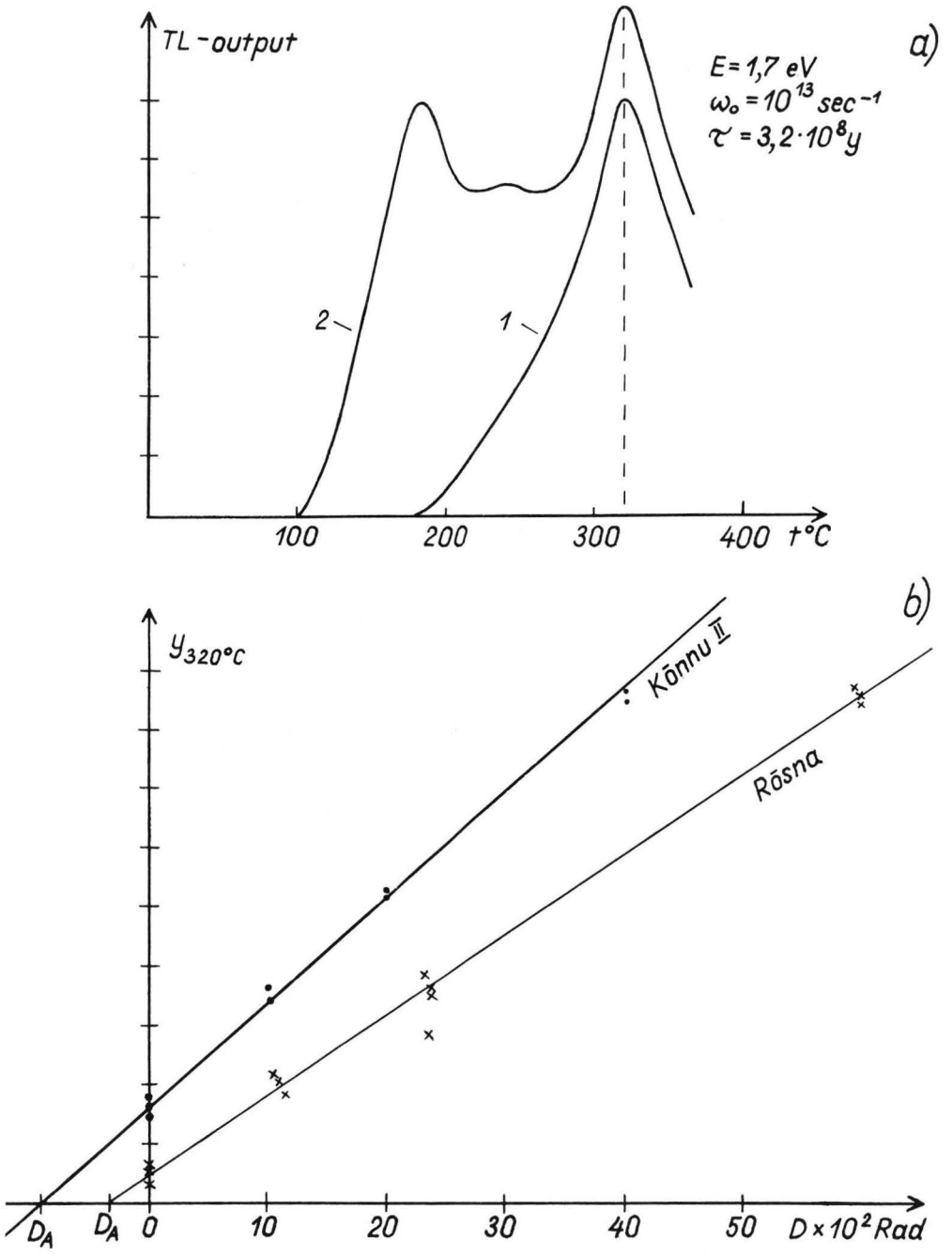

Fig. 2. The TL-dating procedure. a) 1. — NTL, 2. — NTL + γ-dose, b) Dose response curves.

TL-dating

As the study object served sand with prominent traces of the impact of high temperatures (from red to dark colour) collected from under the hearths of ancient Estonian

Table 1.

Sample	^{238}U (p.p.m.)	^{232}TH (p.p.m.)	K %	D_r (rad/a)	D_A (rad)	TL-age (years)	
Pada I	3.7	6.4	1.5	0.365	340	930 ± 93	11550*
Pada II	4.32	7.56	1.8	0.421	510	1210 ± 120	16704*
Rõsna	2.94	2.98	0.95	0.251	340	1355 ± 135	14500*
Rõsna	2.36	3.28	1.0	0.244	340	1390 ± 140	
Kõnnu I	1.68	5.94	1.71	0.323	1527	4210 ± 400	11805*
Kõnnu II	0.54	3.92	0.93	0.197	927	4705 ± 400	
Kõnnu III	1.28	7.55	2.8	0.438	2084	4760 ± 400	

* TL-datings by quartz inclusion method
D_r — annual doserate;
D_A — accumulated dose;

$$\text{TL-age} = \frac{D_A}{D_r}.$$

settlements. Datings were performed according to the quartz inclusion method (Fleming, 1978). The size of feldspar grains was 120—160 μ.

Figure 2 a shows glow curve for feldspars, figure 2 b presents dose response curves of some samples.

Laboratory radiation was performed by means of a ^{60}Co (100 rad/min) γ-source according to the added dose method. The absence of fading was fixed within the limits of reproducibility by measuring TL immediately after irradiating the natural sample and after 4 weeks. The content of ^{238}U, ^{232}Th and K in the sample was determined by γ-spectrometry (the sample being 1 kg in weight). Initial water content of the sample was preserved.

The contribution from ^{40}K comprised in feldspar grains to the annual dose was calculated proceeding from the chemical formula (35 mrad/year), and taking the content of K-feldspars in the sample equal to 100 % — actually it was considerably less.

In parallel with feldspars also quartz was separated from samples. We performed TL dating of the first four samples using the quartz inclusion method (dates with asterisks).

Description of samples and discussion of results

1. The samples were collected in the Pada Village, Rakvere District, from the place where an ancient Pada settlement existed since the Iron Age (7—8th cent.) up to the 11th century as is confirmed by the finds of ceramics and artifacts. The major part of ceramics is hand-made, from the last period there are potsherds produced by potter's wheel.

Pada I — the sample is collected from the upper part of the cultural layer immediately from the hearth (strongly burnt sand, with ash and coal).

Pada II — the sample is taken from the bottom of a natural hole (1 × 3 × 0,6 m).

The dates obtained: Pada I — 930 ± 93 years and Pada II — 1210 ± 120 years agree with archaeological suppositions. The age of Pada II evidences the earlier stage of the settlement.

The radiocarbon datings were performed in the territory of the Pada settlement on burnt wood remains: TA-1463: 1330 ± 80 years; Tln-567: 1100 ± 45 years; Tln-528: 1250 ± 30 years, which are also in good agreement with the TL dates.

2. Samples from Rŏsna were collected at the foot of a long barrow (the type of Krivichi), Suure-Rŏsna settlement, Pŏlva District. The sand was strongly burnt, up to the colour of dark ochre. The barrow is dated to the 7—8 centuries through the find of a spear head. Two TL datings were carried out in parallel on samples collected approximately from one and the same place, the dates obtained were in good agreement: 1355 ± 135 years and 1390 ± 140 years, confirming archaeological suppositions.

3. In the Kŏnnu settlement, Kingissepa District samples were collected from the remains of hearths of a Neolitic settlement. Kŏnnu I is collected from the lower part of the untouched cultural layer. In this place there occur only single finds, consequently, here we have to do with the peripheral part of the settlement. The TL-date obtained is 4210 ± 420 years.

Kŏnnu II and III are sampled from the place where the cultural layer has suffered under constructions; for this reason the identification of different layers and parts of settlements, from where the sand was sampled, is impossible. The dates obtained: 4705 ± 400 years, 4460 ± 400 years agree with archaeological suppositions. From geological point of view (fluctuation of sea level in the vicinity of the settlements) a part of this ancient village might be even older (dr. H. Kessel, private communication).

Conclusion

TL-dates obtained by the feldspar inclusion method are in good agreement with archaeological suppositions. On dating the remains of ancient hearths feldspars serve as the only mineral suitable for TL dating.

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