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PREDOSE DATING OF A SWEDISH VITRIFIED FORT

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1. Introduction

This paper describes work on the TL dating of Swedish vitrified Fort material using the quartz inclusion predose method. A subsequent paper will describe results of the conventional method, and will compare the two.

While it is hoped that the dating will be of archaeological interest, the main feature of each paper is the interpretation of results. In this investigation, there was apparently a discrepancy comparing unetched samples with those etched in HF. This problem has been resolved.

2. Material investigated

The material was provided by F. Sandstedt of Alvsjo, Sweden, and consisted primarily of limestone from a calcinated core in a wall in a vitrified Fort. This Fort is being excavated at Torsburgen E. Gotland. It was estimated by the supplier that this core had been heated to about 1000°C.

3. Sample preparation

Samples were obtained by careful crushing in a vice, and selection of the required grain size by sieving. The whole product was used for α-counting, and for estimation of K_2O content. The next step with samples for TL measurement was to remove the limestone using dilute HCl. After washing and drying, some samples were sieved again and studied at that stage, others were treated in 40% (cold) HF for 45 to 60 minutes.

4. Dose rate

The total sample had a low K_2O content, 0.13% reference (1). α-counting was carried out using a ZnS powder screen on cellotape, with an α-thick layer of sample of diameter 42 mm, working at an efficiency of 0.85. The α-counting was carried out in this laboratory by D. C. W. Sanderson using a 4-channel counter which also had provision for pairs counting (in course of publication). The total count was 5.2 per Ks unsealed and 6.8 sealed. The pairs count is not very accurate at this stage, but indicated a Th/U ratio well below the typical pottery value of the order 3/1. A ratio of unity has therefore been assumed, which is the typical value for limestone. The unsealed α-count leads to the following dose rates, using Bell's (1976) figures:

Table 1

	β-dose rate	γ-dose rate
U	33 mrad/yr.	26 mrad/yr.
Th	6 " "	11 " "
K	9 " "	3 " "
Total	48	40

The corresponding α-dose rate for two values of the efficiency Factor k is:

	Fines	100μ
k = 0.15	102	21
k = 0.04	27	5

For grains larger than 100μ, or grains etched in HF, the α-dose rates will be still smaller.

The β-dose rates in Table 1 will also be dependent on grain size, in the manner described by Mejdahl (1978).

5. Results by Predose method

(a) The first samples investigated had been treated in dilute HCl but not HF. Subsequent X-ray analysis (2) showed that the main constituents were quartz and feldspar (plagioclase). Samples 4e, 8a, 12 and 14 were of this type; grain sizes and results are summarised in Table 2.

The procedure was as in Aitken and Murray, 1976. Some of the plots of TL against β-dose were linear to at least 600 rad, others had a slight curvature. Typical plots are shown in Fig. 1. The TL/temp. plots had a characteristic feature in that the TL signal after the first test dose, before activation, was as in Fig. 2a. There is a plateau commencing at the same temperature as that at which the quartz peak appears after activation. This plateau is present at all subsequent stages, as in Fig. 2 b, c.

It was concluded that the correct method of determining the archaeological dose in this situation was to subtract the plateau height from the total height of the quartz (100°) peak. This implies that S_o associated with quartz itself can be neglected.

(b) Samples 6, 7, 10, 11 and 13 were treated for 45-60 minutes in 40% HF following one hour in dilute HCl. These gave "clean" 100°C quartz peaks as in Fig. 3. With most samples S_o was small but with 6, S_o was 35% of S_n, and with 6a it was 8%. In determining the archaeological dose with these two, the full value of S_n was used, not $S_n - S_o$. The values deduced were in agreement with the other samples.

X-ray analysis showed that after the HF treatment, there was no detectable feldspar. CaF_2 was, however, present, in samples 6, 11 and 13 and was evidently produced by the action of HF on the feldspar. There was no detectable fluorite in 8 or 12.

It is concluded that it was the feldspar present under the conditions of section 5 (a) which led to the plateau in Fig. 2. This represents sensitivity to the test dose. It gives a spurious contribution which must be subtracted from S_n. When the 100° peak is clean, however, as in Fig. 3, any value of S_o due to partial activation can be disregarded.

It will be noted (Table 2) that samples 9 and 10 consisted of large grains selected by hand. There is then no need to use HF to remove the feldspar. Sample 9 was, therefore, simply washed and dried after the HCl treatment. The peaks were clear as for 6 and 7. 10 was etched in HF for 45 minutes to give a comparison, and there was no significant difference between 9 and 10. If there was any residue of CaF_2 after HF etching of the quartz, there is no evidence of its effects on predose results.

From the results in Table 2, the average of the intercepts representing the archaeological dose in terms of β-irradiation time is 76 minutes, with a standard deviation of 12.9 which is 17%. The last three results for the large grains are above average, and if they are omitted, the mean is 71 and the standard deviation is 10.6 or 15%.

Table 2

Sample	Grain size	HF	Plot linear to	S_o/S_n	Equiv. Arch. Dose
4e	90-106μ	none	350 rad	23%	82 min.
8a	150-355μ	"	200	26	90
8b	"	"			
12	"	"	> 600	11	77
14	"	"	> 350	9	60

In the above, the TL/temp. plots are as in Fig. 2. S_o is the plateau height, and is attributed to feldspar, not quartz. S_o is subtracted from S_n, etc. in deriving figures in the final column.

6	150-355μ	45 min.	> 600	35	64
6a	"	"	> 400	8	62
6c	"	"	200	4	75
7a	106-150μ	"	> 400	0	60
11	150-355μ	"	> 350	0	74
9	1 mm	none	> 350	0	84
10a	1 mm	45 min.	250	2	94
10b	0.5 mm	45 min.	> 100	3	95
					917

In the last eight samples, the TL/temp. plots have symmetrical 100 °C peaks, as in Fig. 3. S_o is the height of the peak before activation. Values of S_o are disregarded in deriving figures in the final column and plots as in Fig. 1.

8b received a dose of 600 rad before taking a glow-curve, and there was then partial saturation preventing a predose estimation of archaeological dose.

Mean of the twelve results	76.4
Standard deviation	12.9
Mean of first nine results (small grains)	71.1
Standard deviation	10.6

6. Age of samples

Calibration of the β-source was carried out by Dr. A. F. McKinlay of the Scottish Radiological Protection Board using LiF phosphors 1 mm thick. The dose-rate deduced for 100μ grains of quartz is 2.5 rad/min. This is based on the calibration data together with the grain-size corrections (Wintle and Aitken, 1977). These corrections are not very sensitive to grain-size in the range 100 to 300μ, so that this figure applies to all but the last three samples. For 1 mm grains the figure will, however, be reduced to 2.1 rad/min. The archaeological dose-rates in Table 1 must be multiplied by the following factors: 100μ, 0.90; 300μ, 0.82; 1mm, 0.61. These figures have been deduced from Mejdahl's tables (1978) allowing for the K_2O, U and Th concentrations determined in paragraph 4 above. The ages deduced are consequently as follows:

Samples	4 e and 7 a -	1820 years
"	6, 8, 11, 12, 14 -	1940 years
"	9 and 10 -	2130 years

It appears that agreement comparing different grain sizes would be better if, relative to the 100μ figures, the multiplying factors for the larger grains were either larger for the Mejdahl correction or smaller for the Wintle-Aitken correction. Taking into account the number of samples with the different sizes, the best figure for the age is 1950 years. The standard deviation is, however, not less than ± 280 years.

REFERENCES

(1) K_2O determinations were made by R. Coult of the Chemistry Department, University of Durham, using atomic absorption spectrophotometry .

(2) X-ray analysis was carried out by R. G. Hardy, Geology Department, University of Durham.

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Fig.1

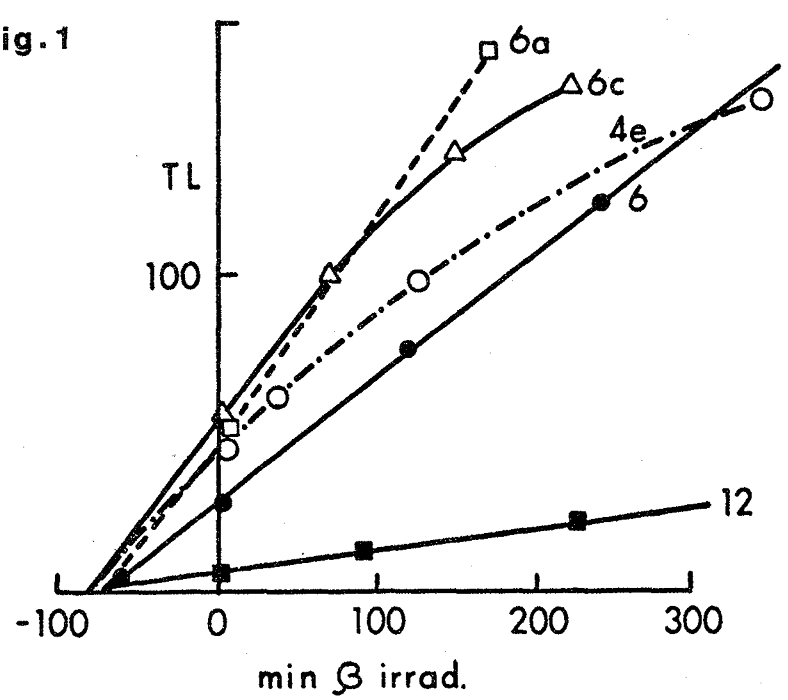


Fig. 2

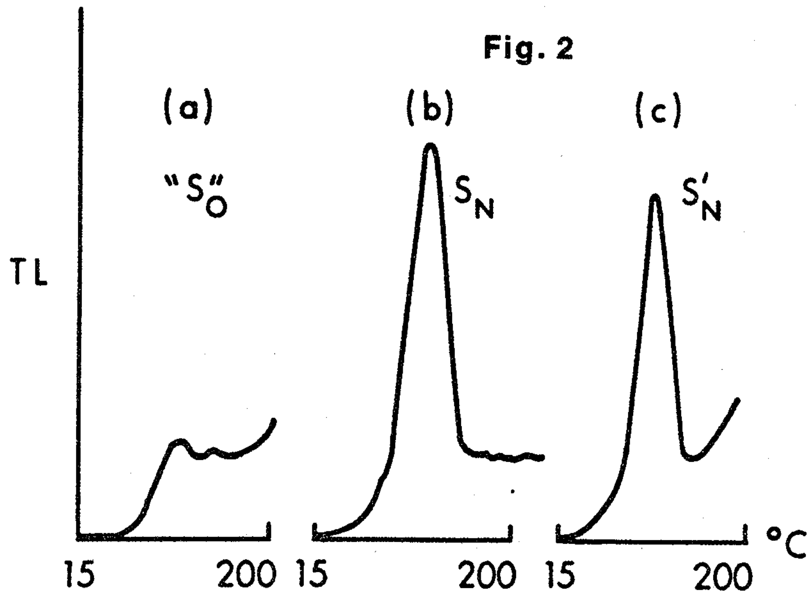
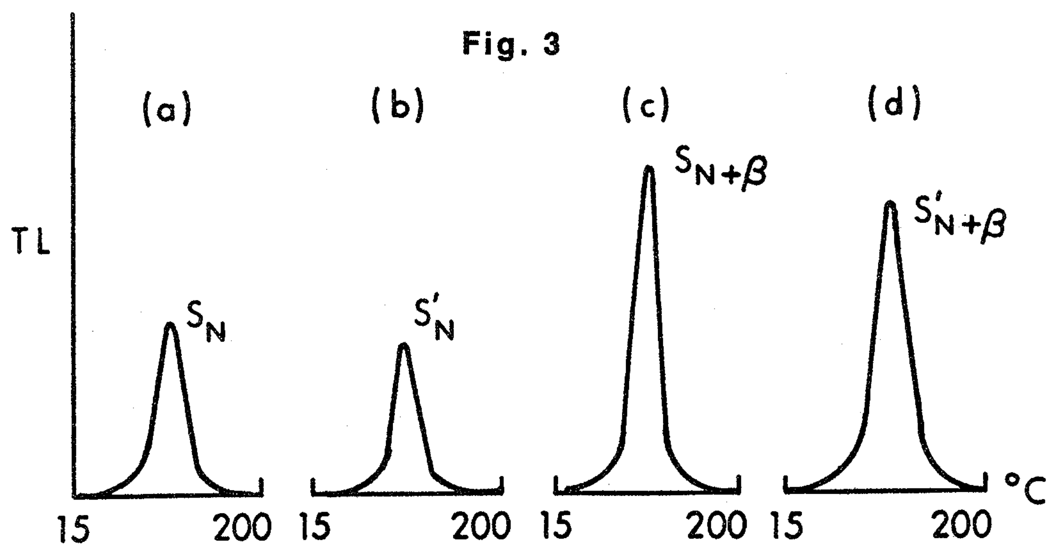


Fig. 3



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