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A Survey of Archaeological Samples Dated in 1987

Vagn Mejdahl

The Nordic Laboratory for Thermoluminescence Dating

Risø-M-2715

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Abstract: A survey is given of archaeological samples dated in 1987 at the Nordic Laboratory for Thermoluminescence Dating. A total of 74 samples were dated. The results were corrected for short-term fading of feldspars as measured for samples stored at room temperature for four weeks or at 100^oC for two weeks. The beta dose from potassium and rubidium in feldspar, and the alpha dose from uranium and thorium in quartz and feldspar were included, assuming alpha efficiency factors of 0.1 for quartz and 0.2 for feldspar.

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INTRODUCTION

TL dating results for archaeological materials from the Nordic countries completed in 1987 are presented. The dated materials included ceramics, bricks, burnt clay and burnt stones. A total of 74 samples are discussed (Table 1): 35 from Denmark, 31 from Sweden, 5 from Norway and 3 from Finland. Results for samples dated in the four previous years are described in Mejdahl (1984, 1985, 1986, 1987a).

Table 1. Archaeological samples from the Nordic countries dated in 1987 at the Nordic Laboratory for TL dating.

Material	No. of samples	Percent
Ceramics	37	50
Bricks	11	15
Burnt clay	4	5
Burnt stones	22	30
Total	74	100

TL DATING TECHNIQUE

The additive dose technique as described by Aitken (1985) was used. Three groups of minerals: K-feldspar ($\sim 10\%$ K), Na-feldspar ($\sim 4\%$ K) and quartz were separated by means of the heavy liquid technique. The liquids were aqueous solutions of sodium metatungstate. Grain sizes used were in the 0.1-1 mm range. Our dating technique, including methods for estimating dose contributions from internal Rb, U and Th in the grains are outlined in Mejdahl (1986, 1987b). Some sources of error are discussed in Mejdahl (1988 a,b).

In 1987, the TL dosimetry technique for measuring beta dose rate (Mejdahl 1978) was replaced by the faster and more convenient beta counting technique (Bøtter-Jensen and Mejdahl 1988).

Short-term fading was measured for all samples, in most cases by storing irradiated samples at 100°C for two weeks (Mejdahl 1988a), and the results were corrected accordingly. A few samples for which the fading exceeded 15% were discarded.

COMMENTS ON THE PRESENTATION OF RESULTS

In the following, tables with gamma (including cosmic ray) and beta dose rates are given. The beta dose rates are infinite-matrix values, usually measured on dry samples for ceramics and clay, and wet samples for burnt stones. For the new beta counting technique, all samples were measured dry. The tables also include U contents of feldspar grains, measured by delayed neutron counting (Kunzendorf et al. 1980), and fading factors for feldspar grains.

Additional tables list the TL dates obtained and an uncertainty value including random and systematic errors at the 1σ level. The calculation of the uncertainty is described in Mejdahl (1988a,b).

TL DATING RESULTS, DENMARK

1. Farvergade 7-9, Næstved

The excavation, carried out in 1986 by Næstved Museum (j.no. NEM 86:200) under the direction of Jens Erik Petersen, (Petersen 1988) comprised some massive sand layers with ceramics and a few hearths. The ceramics were uncharacteristic, but certain features pointed to the period 300 - 500 AD. The 1986 campaign was a continuation of earlier excavations that had uncovered layers from 1600 - 1000 AD. (Hansen 1986, Mejdahl 1986, Vegger et al. 1982).

The TL dating was made on six samples of ceramics from sandy layers. The environmental radiation was measured on site during the excavation. Dose rate data and fading either over four weeks at room temperature or two weeks at 100^oC, are given in Table 2 and the TL dates are listed in Table 3.

Table 2. Water uptake W (wet weight over dry weight), gamma and beta dose rates, U content of grains and fading of feldspars over four weeks at room temperature, or two weeks at 100^oC for samples of ceramics from Farvergade 7-9, Næstved.

Risø TL no.	W	Dose rate (Gy/ka)		U Content (ppm)	Fading
		Gamma	Beta		
R-862601	1.10	0.81	3.30	0.35	0.94 (1)
R-862602	1.11	0.89	3.73	0.20	1.00 (2)
R-862603	1.09	0.82	3.77	0.30	0.87 (2)
R-862604	1.11	0.81	3.43	0.20	0.88 (2)
R-862605	1.10	0.89	3.54	0.50	0.89 (2)
R-862606	1.12	0.89	3.71	0.30	0.90 (1)

(1) Four weeks at room temperature

(2) Two weeks at 100^oC

Table 3. TL dates for ceramics from Farvergade 7-9, Næstved.

Rise TL no.	Sample No.	TL age (a)	TL date
R-862601	1, AFA	1642	340 AD +/- 90 a
R-862602	2, ACD	1416	570 AD +/- 90 a
R-862603	3, CA	1683	300 AD +/- 100 a
R-862604	4, ACR	1609	380 AD +/- 80 a
R-862605	5, AEA	1674	310 AD +/- 140 a
R-862606	6, AEF	1487	500 AD +/- 80 a

Average TL age: 1585 +/- 45 a (statistical mean error)

Average TL date: 400 AD +/- 45 a +/- 80 a

Except for R-862602, the results are all within the expected period 300 - 500 AD. It is conceivable that the scatter of the results reflects real age differences. However, since age differences were not evident from stratigraphy, an average TL age and TL date have been calculated. The statistical mean error is only 45 years (less than 3%), whereas the total error of the average TL date is 80 years.

2. Havmosegård, St. Musse, Lolland

The excavation at Havmosegård (j. no. LFS 800-1986-9) was carried out in 1986 by Lolland-Falsters Stiftsmuseum under the direction of Karen Løkkegaard Poulsen (Poulsen 1987a,b). The site was an Iron Age habitation place, which, on the basis of the ceramics found, was estimated to date from the period 150 BC to 200 AD. One house (house VI) had features that were alien to prehistoric as well as medieval periods and would thus be expected to date from a more recent period.

Seven samples of ceramics, burnt clay and burnt stones were submitted for TL dating. The environmental radiation was measured on site during the excavation. Dose rate data and fading over two weeks at 100 °C, are given in Table 4, and the TL dates are listed in Table 5.

Table 4. Water uptake W (wet weight over dry weight), gamma and beta dose rates, U content of grains and fading over two weeks at 100 °C for samples from Havmosegård. C = ceramics, L = burnt clay and S = burnt stone.

Risø TL no.	Matl.	W	Dose rate (Gy/ka)		U content (ppm)	Fading 100 °C
			Gamma	Beta		
R-871801	C	1.12	0.80	2.97	0.40	0.88
R-871802	C	1.09	0.80	2.98	0.15	0.92
R-871803	C	1.17	0.90	2.87	0.15	0.97
R-871804	L	1.23	0.90	2.32	0.20	0.98
R-871806	S	1.02	0.95	5.12	0.20	0.94
R-871807	C	1.11	0.89	3.17	0.20	0.86

Table 5. TL dates for samples from Havmosegård. C = ceramics, L = burnt clay and S = burnt stone.

Risø TL no.	Matl.	Feature	TL date
R-871801	C	Pit IV/25	180 AD +/- 90 a
R-871802	C	"	320 AD +/- 90 a
R-871803	C	Pit I/58	320 AD +/- 90 a
R-871804	L	"	50 AD +/- 90 a
R-871806	S	Posthole I/90	80 AD +/- 90 a
R-871807	C	Postholes VI/1,3,7	150 AD +/- 110 a

R-871802 and R-871803 are somewhat more recent than expected, whereas the other four results fall in the expected range. It is possible that the age difference between R-871801 and R-871802 is real, because the two samples were taken from different parts of the pit. Also, the difference between R-871803 and R-871804 could be correct, because the burnt clay probably originates from an older burnt-down house.

The result, 150 AD, for R-871807, ceramics from postholes in House VI, is remarkable, because, as mentioned above, this House apparently is much later than the period (Roman Iron Age) indicated by the TL age as well as by the appearance of the ceramics. It appears, therefore, that Roman Age ceramics lying on the ground or in the soil were accidentally shovelled into the post-holes when House VI was built.

3. Baldershøj near Taastrup

The excavation at Baldershøj (j.no. SØL 226), comprising two longhouses called I and II, was carried out in 1986 by Søllerød Museum under the direction of Preben Rønne. House typology and a small number of potsherds indicated that House I was from the Early Bronze Age, and House II possibly from the Late Bronze or Early Iron Age.

The environmental radiation was measured on site during the excavation. The dating was based on ceramics, burnt clay and burnt stones from three pits: W, BN and BØ. The archaeological interpretation of the pits was:

BN = hearth / cooking pit in house I

W = waste pit for house I

BØ = waste pit for house II.

Dose rate data and fading over two weeks at 100^oC, are given in Table 6, and the TL dates are listed in Table 7.

Table 6. Water uptake W (wet weight over dry weight), for ceramics and clay, gamma and beta dose rates, U content of grains and fading over two weeks at 100°C for samples from Baldershøj. C = ceramics, L = burnt clay and S = burnt stone.

Rise TL no.	Matl.	W	Dose rate (Gy/ka)		U Content (ppm)	Fading 100°C
			Gamma	Beta		
R-863901	C	1.13	0.90	3.72	.20	0.96
R-863902	L	1.22	0.90	2.42	.20	0.92
R-863903	C	1.11	0.94	3.51	.30	0.97
R-863906	S	-	1.07	5.34	.20	0.98
R-863907	S	-	1.07	0.91	.20	0.88

Table 7. TL dates for samples of ceramics, burnt clay and burnt stones from Baldershøj. C = ceramics, L = burnt clay and S = burnt stone.

Rise TL no.	Matl.	House	Pit	TL date
R-863901	C	II	B0	350 BC +/- 120 a
R-863902	L	II	B0	540 BC +/- 150 a
R-863903	C	I	W	540 BC +/- 150 a
R-863906	S	I	BN	1010 BC +/- 180 a
R-863907	S	I	BN	420 BC +/- 150 a

The results for R-863901 and R-863902 show that House II dates to about 450 BC, in accordance with the archaeological estimate. The result for R-863906 (1010 BC) indicates that House I dates to the older Bronze Age, as suggested by the archaeological evidence. However, the results for R-863903 and R-863907 show that the pits associated with House I also contained material from the Late Bronze Age phase.

4. Gl. Hviding, south of Ribe

The excavation (j.no. ASR 440) was carried out in 1986 by the Antiquarian Collection, Ribe, under the direction of Stig Jensen (Jensen 1987a,b,c,d). It comprised a farm estimated to date to the Viking or Early Medieval period. The main building was a 35 m longhouse of the Trelleborg type.

The dating was made on ceramics from the longhouse and from an adjacent well. The environmental radiation was measured on site during the excavation. Dose rate data and TL dates are given in Tables 8 and 9.

Table 8. Water uptake W (wet weight over dry weight), gamma and beta dose rates, U content of grains and fading over two weeks at room temperature, for ceramic samples from Gl. Hviding.

Rise TL no.	W	Dose rate (Gy/ka)		U Content (ppm)	Fading 100 °C
		Gamma	Beta		
R-870401	1.09	0.56	3.26	0.15	0.96
R-870402	1.09	0.49	3.24	0.20	0.90

Table 9. TL dates for ceramics from Gl. Hviding.

Rise TL no.	Feature	Sample	TL date
R-870401	Well	I	1110 AD +/- 70 a
R-870402	Longhouse	II	1010 AD +/- 50 a

The TL dates are in good agreement with the expected age of the site.

5. Sct. Nicolajgade 8, Ribe.

In the last few years, the Antiquarian Collection, Ribe, has excavated cultural layers at a trading place on the north bank of Ribe River (j.no. ASR 440). The layers were estimated to date from Late Germanic / Viking Age, constituting perhaps the oldest city-like habitation in the Nordic Region. The excavation was directed by Lene Frandsen and Stig Jensen (Frandsen and Jensen, 1988).

TL dating was made on ceramics from the different layers. The environmental radiation was measured on site during the excavation in 1985. Dose rate data and TL dates are listed in Tables 10 and 11.

Table 10. Water uptake W (wet weight over dry weight), gamma and beta dose rates, U content of grains and fading over two weeks at 100 °C for ceramics from Sct. Nicolajgade 8.

Risø TL no.	W	Dose rate (Gy/ka)		U Content (ppm)	Fading 100 °C
		Gamma	Beta		
R-870403	1.10	0.47	3.65	0.20	0.75
R-870404	1.09	0.53	3.24	0.20	0.97
R-870405	1.09	0.53	3.16	0.20	0.87
R-870406	1.08	0.53	3.48	0.20	0.95

Table 11. TL dates for ceramics from Sct. Nicolajgade 8. The archaeological estimates were based on typology, stratigraphy and coin finds.

Risø TL no.	Layer	TL date	Expected age
R-870403	Village	770 AD +/- 70 a	710 - 720 AD *)
R-870404	Workshop, VH1	530 AD +/- 90 a	720 - 755 AD *)
R-870405	" , VH5, VH6	790 AD +/- 60 a	750 AD
R-870406	Ditch 2	1150 AD +/- 70 a	800 AD

*) From coin finds.

Within the uncertainty, two of the TL dates, R-870403 and R-870405, agree well with the archaeological estimates. Marked differences were found, however, for the other two samples. R-870404 is distinctly older than the estimated age, whereas R-870406 is younger. On stratigraphical grounds, layer VH1 must be more recent than the village layer, and the TL date is, therefore, too old. At the present time, we have no explanation for this discrepancy. For the ditch layer, stratigraphy defines no boundaries for the age, but it appears from typology that the TL date is too recent. Fading can hardly explain a too recent date, since the fading over two weeks at 100°C was only 5% (fading factor 0.95). The discrepancies found in these two cases are unusually large.

6. Staghøj, Billund.

The excavation at Staghøj was carried out in 1986 by Esbjerg Museum (j.no. ESM 1520) under the direction of Palle Siemen. Remains of about ten houses or farms constituting a village from about 800 AD were found. The age estimate was based on typology of houses and ceramics.

In addition to the houses, a number of oblong pits containing burnt stones were found. The pits were of a construction rarely found on Viking Age sites, and TL dating was undertaken to clarify whether the pits were contemporaneous with the village. TL dating was made on burnt stones from two pits. The environmental radiation was measured on site in connection with sample taking. Dose rate data and TL dates are listed in Tables 12 and 13.

Table 12. Gamma and beta dose rates, U content of grains and fading over two weeks at 100 °C for burnt stones from oblong pits at Staghøj.

Risø TL no.	Dose rate (Gy/ka)		U Content (ppm)	Fading 100 °C
	Gamma	Beta		
R-862036	0.59	4.64	0.20	0.78
R-862039	0.59	4.38	0.20	0.82
R-862941	0.81	1.66	0.05	0.88
R-862043	0.81	6.03	0.30	0.95

Table 13. TL dates for burnt stones from oblong pits at Staghøj.

Risø TL no.	Pit no.	TL date
R-862036	2	1200 e.Kr. +/- 120 a
R-862039	2	1260 e.Kr. +/- 60 a
R-862041	3	670 e.Kr. +/- 100 a
R-862043	3	1050 e.Kr. +/- 90 a

For some of the samples, considerable variations in results obtained with different grain sizes has resulted in rather large uncertainties. Furthermore, for R-862036 and R-862039, the fading correction (Table 12) is high, about 20%. In spite of these reservations, the most probable interpretation of the results is that the pits represent activities that were later than the village. However, some burnt stones from the village period could easily have ended up in the pits, as evidenced by R-862041.

7. Sdr. Novrupvej near Esbjerg.

The excavation of the site at Sdr. Novrupvej was carried out in 1986 by Esbjerg Museum (j.no. ESM 1525), under the direction of Ulla Mejdahl. The site comprised houses and other elements from four periods: Single grave period, Late Bronze Age, Pre-Roman Iron Age, Period Ia and Younger Germanic Iron Age.

The dating was based on ceramics and burnt stones from three houses. The environmental radiation was measured on site during the excavation. Dose rate data and TL dates are listed in Tables 14 and 15.

Table 14. Water uptake W (wet weight over dry weight) for ceramics, gamma and beta dose rates, U content of grains and fading over two weeks at 100°C for samples from Sdr. Novrupvej.

Risø TL no.	W	Dose rate (Gy/ka)		U Content (ppm)	Fading 100°C
		Gamma	Beta		
R-862044	1.12	0.45	2.86	0.20	0.89
R-862045	1.12	0.45	2.62	0.30	0.87
R-862946	1.11	0.60	2.60	0.20	0.86
R-862049	-	0.60	4.91	0.30	0.87
R-862050	-	0.70	5.36	0.40	0.87
R-862051	-	0.70	4.94	0.15	0.91

Table 15. TL dates for ceramics and burnt stones from Sdr. Novrupvej. C = ceramics, S = burnt stone.

Risø TL no.	Matl.	House	Sample	TL date
R-862044	C	Pithouse C	X17,1	770 AD +/- 100 a
R-862045	C	"	X17,2	540 AD +/- 100 a
R-862946	C	III	Dung channel	420 BC +/- 120 a
R-862049	S	VI	X43	1030 BC +/- 150 a
R-862050	S	"	X44	1020 BC +/- 180 a
R-862051	S	"	X44	620 BC +/- 150 a

Based on the ceramics, Pithouse C was estimated to be from the Younger Germanic Iron Age, 600-800 AD. The mean value of the two TL dates (R-862044 and R-862045), 660 AD +/- 80 a, is in good agreement with this estimate. House III was estimated to date from Pre-Roman Iron Age, Period Ia (400-500 BC) on the basis of its construction and the presence of an adjacent cemetery with urns from that period. The TL date 420 BC +/- 120 a (R-862046), confirms the archaeological estimate.

House VI was presumed to be from the Younger Germanic Iron Age, because of the finds of other elements on the site from that period. However, the house type and the occurrence of cooking pits inside the house were alien to the Germanic period, whereas the latter feature is common for Bronze Age houses. The three TL dates for stones from pits in House VI indicate a Bronze Age date for the house. The stones were taken from six different pits, which might explain the TL age variation. The mean value of the three dates for House VI is 890 BC, with a statistical mean error of 130 years.

8. Tvedemosegård, Snesere, South Zealand.

The excavation at Tvedemosegård, comprising a burnt-down pit-house, was carried out in 1986 by the National Museum (j.no. NMI 6464/86) under the direction of Jens-Aage Pedersen. The finds included ceramics of the Slavic type. On the basis of typological features, Jens-Aage Pedersen estimated the ceramics to date from the second half of the 12th century. Radiocarbon dating of charred wattle (K-5027) gave the calibrated result 970-1025 AD.

TL dating was made on burnt clay from house walls. The environmental radiation was measured on site during the excavation. The dose rate data were: water uptake 10%, gamma dose rate 1.03 Gy/ka, beta dose rate 2.68 Gy/ka, U content of grains 0.20 ppm, and the fading over two weeks at 100°C was 13%. The TL date obtained was

R-862802: 1180 AD +/- 50 a

The TL date is not consistent with the radiocarbon date, even when considering that different events are dated by the two methods. However, the TL date agrees well with the archaeological estimate for the ceramics.

9. Argisbrekka, The Faroe Islands.

Excavations carried out in 1985 and 1986 at Argisbrekka, Eidi, Eystoroy, by Føroya Fornminnisavn (j.no. 4765), under the direction of Ditlev Mahler (Mahler 1986a,b, 1989a,b, Mahler and Malmros 1989), have revealed remains of at least 17 houses. The houses were estimated to be from the period 850 - 1050 AD. Three burnt stones of basalt were submitted for the TL dating, but only one was suitable. The stone came from house 3 (no. 4765/I.736), which was joined to House 1.

Radiocarbon dating of a sample of juniper (K-4622) gave the calibrated results 1000-1015 AD, the youngest of five radiocarbon dates obtained so far from the area (K-5065, K-5064, K-5066 and K-5100). Since the layer from which K-4622 was taken stretched underneath House 1, it can be concluded that House 1 and thereby House 3 were built in the beginning of the 11th century and might have been in use into the second half.

The environmental radiation was obtained from gamma spectrometry made on a sample of the soil surrounding the stone. The dose rate data were: gamma 0.32 Gy/ka (assuming a water content of 20%), beta 0.49 Gy/ka, U content of grains 0.03 ppm (assumed), and fading over two weeks at 100 °C was 18% (factor 0.82). The total dose rate for the grain size used (0.1-0.3 mm) was only 0.93 Gy/ka. The TL date obtained was:

R-870302: 1080 AD +/- 50 a

Within the uncertainty, the result agrees well with the archaeological estimate and shows that also basaltic stones can be useful for TL dating.

TL DATING RESULTS, SWEDEN

1. Mølner/Gullarve and Ajvide, Gotland

Four samples from Mølner/Gullarve, Väte Parish and eight samples from Ajvide, Eksta Parish were received for TL dating from Inger Osterholm. All samples were ceramics. but some were tempered with crushed limestone.

A number of radiocarbon dates are available for the two sites and are listed below.

Radiocarbon dates (uncalibrated) from Mølner/Gullarve

St-7271	5560 +/- 155 BP
St-9471	6870 +/- 100 BP
St-9472	7180 +/- 100 BP

Radiocarbon dates from Ajvide

Sample	C-14 age BP uncalibrated	C-14 age BC calibrated *)	Coordinates (x,y)
St-9033 **)	3065 +/- 75	1200 - 1430	(-0.65, -171.80)
St-9053	4270 +/- 170	2620 - 3090	(-80.17, 0.43)
St-9247 **)	2835 +/- 215	800 - 1370	(-0.65, -171.80)
St-10788	4140 +/- 130	2400 - 2900	(-9.55, -116.25)
St-11206	3615 +/- 70	1890 - 2130	(-2.35, -172.0)

*) Stuiver and Becker (1986)

***) Charcoal from a Bronze Age hearth

The environmental radiation was measured on site in 1986, before the start of the excavation. The radiation, therefore, could not be measured precisely where the samples for dating were taken, but since the level was very uniform, the measurements are assumed to be representative.

Dose rate data and fading at 100°C over two weeks are given in Table 16, and the TL dates are listed in Table 17.

Table 16. Water uptake W (wet weight over dry weight) gamma and beta dose rates, U content of grains and fading at 100°C over two weeks for ceramics from Mølner/Gullarve (the first four samples) and Ajvide.

Rise TL no.	W	Dose rate (Gy/ka)		U content (ppm)	Fading 100°C
		Gamma	Beta		
R-870601	1.13	0.73	4.09	0.33	0.96
R-870602	1.09	0.73	4.03	0.20	0.92
R-870603	1.13	0.73	4.37	0.20	0.99
R-870604	1.12	0.73	4.06	0.40	0.92
R-870605	1.12	0.65	2.69	0.30	0.96
R-870606	1.11	0.65	2.90	0.20	0.91
R-870607	1.12	0.65	3.45	0.20	0.94
R-870608	1.17	0.65	4.71	0.30	1.00
R-870609	1.15	0.65	3.21	0.20	0.91
R-870610	1.12	0.65	3.12	0.20	0.89
R-870611	1.10	0.65	2.86	0.30	0.90
R-870612	1.11	0.65	2.94	0.20	1.00

Table 17. TL dates for ceramics from Mølner/Gullarve (M/G) and Ajvide (Aj). For some of the Ajvide samples, the coordinates Y, X are given as sample number.

Rise TL no.	Locality	Sample no.	Layer	TL date
R-870601	M/G	D3,50		2930 BC +/- 250 a
R-870602	"	F5,50		2440 BC +/- 400 a
R-870603	"	105D:10D		3040 BC +/- 250 a
R-870604	"	110D:25b		3230 BC +/- 250 a
R-870605	Aj	-118.15,-0.30	2	2840 BC +/- 400 a
R-870606	"	-120,-1	2	2240 BC +/- 300 a
R-870607	"	-169,+2	2	1750 - 3730 BC
R-870608	"	-81,+0	2	1340 BC +/- 180 a
R-870609	"	Grave 13		2550 BC +/- 250 a
R-870610	"	Grave 14		1810 BC +/- 200 a
R-870611	"	-120,-1	4	2460 BC +/- 270 a
R-870612	"	-120,-3	4	2390 BC +/- 430 a

The results for the samples from Mølner/Gullarve are consistent within the uncertainty and agree well with archaeological expectations. The youngest C-14 age agrees with the TL-dates whereas the other two are older. It should be noted, however, that the TL and C-14 results may not be directly comparable for this site.

The samples from Ajvide were more difficult to date, because the tempering material was predominantly crushed limestone. Even though the samples were rather large, they yielded only a small amount of alkali feldspar grains larger than 0.1 mm. Therefore, some of the dates have a rather large uncertainty. For R-870607, only an age range of 2000 years could be given. The results for the majority of the samples are quite consistent and agree with the expected age. Two results, R-870608 and R-870610, indicate Bronze Age, thus supporting the archaeological evidence of Bronze Age activities on the site. There is excellent agreement between TL and C-14 ages for this site.

2. Vadbron and Sotmyra near Uppsala.

Ceramics from the sites Vadbron and Sotmyra in Uppland have been submitted for dating by Ann Segerberg, Gustavianum, Uppsala. The environmental radiation was measured during a visit to the sites in 1985. The excavation had then been completed, but at Vadbron a burnt stone was found in one of the holes made for background measurement.

Dose rate data are given in Table 18. For two of the samples (R-853612 and R-863603) the beta dose contributions from uranium and thorium were exceptionally high, 49% and 65%, respectively, and the beta dose contribution from potassium correspondingly low. Because our beta TLD (TL dosimetry) technique overestimates the beta dose rate when the contribution from potassium is low (Haskell 1983), the measured dose rates for the two samples have been reduced by 15%. The TL ages obtained are listed in Table 19.

Table 18. Water uptake W (wet weight over dry weight), gamma and beta dose rates, U content of grains and fading of feldspars over two weeks at 100^o C for ceramics and burnt stones from Vadbron (Vad) and Sotmyra (Sot). C = ceramics, S = stone.

Risø TL no.	Matl.	Locality	W	Dose rate (Gy/ka)		U content (ppm)	Fading 100 ^o C
				Gamma	Beta		
R-853612	S	Vad	-	1.50	9.99	0.6	0.84
R-863601	C	"	1.14	1.80	7.14	0.4	0.82
R-863602	C	Sot	1.15	1.37	5.04	0.2	0.94
R-863603	C	"	1.07	1.37	4.56	0.2	0.91

Table 19. TL dates for ceramics and burnt stones from Vadbron and Sotmyra. C = ceramics, S = stone.

Risø TL no.	Material	Locality	TL date
R-853612	S	Vadbron	430 BC +/- 120 a
R-863601	C	"	2040 BC +/- 250 a
R-863602	C	Sotmyra	2000 BC +/- 250 a
R-863603	C	"	2300 BC +/- 400 a

The TL dates for Vadbron may be compared with two radiocarbon dates made on charcoal at the accelerator laboratory, Uppsala:

Ua-387: 2350 +/- 115 a BP

Ua-388: 2280 +/- 115 a BP

The corresponding calibrated values (Stuiver and Becker 1986) are:

Ua-387: 240 - 760 BC

Ua-388: 210 - 410 BC

The TL date 430 BC for the burnt stone from Vadbron is in good agreement with the radiocarbon dates. The TL date for the ceramics from Vadbron points to Late Stone Age, as do the two TL results for ceramics from Sotmyra.

3. Veda, north of Stockholm

The ancient hill-fort at Veda is being investigated by Michael Olausson, the University of Stockholm, as part of a comprehensive study of hill-forts in the Angarnsjö area. The TL dating project is a continuation of earlier projects (Mejdahl 1986, 1987).

A number of burnt stones were taken in 1987 from the site at Veda and five were found suitable for dating. The samples were taken from two layers in the section, called upper and lower. The environmental radiation was measured on site during sample taking. Dose rate data and fading over four weeks are given in Table 20, and the TL dates obtained are listed in Table 21.

Table 20. Water uptake W (wet weight over dry weight), gamma and beta dose rates, U content of grains and fading over two weeks at 100 °C for burnt stones from the ancient hill-fort at Veda.

Rise TL no.	W	Dose rate (Gy/ka)		U content (ppm)	Fading 100 °C
		Gamma	Beta		
R-874401	1.01	2.61	6.13	0.50	0.92
R-874403	1.02	2.61	6.74	0.60	0.91
R-874404	1.02	2.61	6.03	0.80	0.96
R-874406	1.04	2.79	4.82	0.60	0.92
R-874407	1.02	2.79	4.81	0.60	0.94

Table 21. TL dates for burnt stones from the ancient hill-fort at Veda.

Rise TL no.	Layer	TL date
R-874401	Upper	30 AD +/- 180
R-874403	"	790 AD +/- 60
R-874404	"	860 AD +/- 60
R-874406	Lower	90 AD +/- 100
R-874407	"	560 BC +/- 200

The TL dates indicate that the hill-fort contains stone layers from at least two and possibly three different periods: Viking Age, Early Roman Iron Age, and Late Bronze or Early Celtic Iron Age. It is intended to take an additional set of TL samples from Veda in order to establish the number of phases present at the site.

4. Sct. Mikael 5, Lund

The excavation, comprising a brick kiln, was carried out in 1986 by Kulturen, Lund under the direction of Torvald Nilsson. Torvald Nilsson has given the following information concerning the kiln:

The kiln was situated on a site which from 1329 belonged to the Dominican monastery. Some ten metres to the east of the kiln a floor was found, belonging to a building which, judging from the level, could be contemporaneous with the kiln. The floor has been dated by two coins stamped during the time of King Magnus Smek (1332-1260). A small well situated between the kiln and the coin-dated floor was partly filled with crossed bricks and, under these, coarse wooden branches. One of the branches has been dated in Lund by dendrochronology to 1367 +/- 5 AD (DE 70.627). From these concurrent sources of evidence, it can be concluded that the kiln must have been built around 1360 AD.

Two bricks from the kiln, one from the wall and one from the bottom, were submitted for TL dating. The environmental radiation was measured on site during the excavation. Dose rate data and fading over two weeks at 100^o C are given in Table 22, and the TL dates are listed in Table 23.

Table 22. Water uptake W (wet weight over dry weight), gamma and beta dose rates, U content of grains and fading over two weeks at 100^o C for bricks from Sct. Mikael 5, Lund.

Rise TL no.	W	Dose rate (Gy/ka)		U content (ppm)	Fading 100 ^o C
		Gamma	Beta		
R-861701	1.13	1.22	3.95	0.15	0.94
R-861702	1.12	1.16	4.64	0.15	0.95

Table 23. TL dates for bricks from the brick kiln at Sct. Mikael 5, Lund.

Rise TL no.	Locality	TL date
R-861701	Wall	1390 AD +/- 40 a
R-861702	Bottom	1420 AD +/- 40 a

Considering that the TL results relate to the last firing in the kiln, the TL dates are consistent with the conclusion stated above that the kiln was built around 1360 AD.

5. Stockholm Castle

As part of a study of Stockholm Castle, Anders Odman, the University of Lund, submitted eight bricks and two samples of burnt stones for TL dating. All samples were taken from the basement of the castle. The two latter samples were taken from granitic stones in the wall that had been cracked by fire. It turned out, however, that the heating had not been sufficient to remove the geological TL signal. The expected age was 1250-1400 AD.

The environmental radiation was measured by scintillation counting, and by placing TL dosimeters ($\text{CaSO}_4:\text{Dy}$) in holes in the wall where bricks were taken for dating. The dosimeters were left for five months. The dose rate obtained by scintillation counting was generally somewhat lower than that obtained by TL dosimetry (Table 24) because the counting geometry was not totally 4 pi. An especially large discrepancy was found for sample R-865004 (see Table 24). Comparison with results for the other samples indicate that the dosimetry value for R-865004 might be an overestimate.

Dose rate data and fading over two weeks at 100^oC are given in Table 24, and the TL dates obtained are listed in Table 25. The beta dose rate was measured by TL dosimetry on samples with their natural water content. The U content of the grains could be measured for only some of the samples, because of contamination from clay particles. The value found, 0.10 ppm, was used for all samples.

Table 24. Gamma dose rate obtained by TL dosimetry (G1) and scintillation counting (G2), beta dose rate, U content of grains and fading over two weeks at 100 °C for bricks from Stockholm castle. G1 was used for dating. For R-865004, a gamma dose rate of 2.1 Gy/ka has been used, because the stated value, 2.78 Gy/ka, appears to be in error.

Rise TL no.	Room	Dose rate (Gy/ka)			U content (ppm)	Fading °C 100 C
		G1	G2	Beta		
R-865002	611A	1.93	1.83	4.69	.10	0.90
R-865003	616	2.06	1.73	4.12	.10	0.91
R-865004	616	(2.78)	1.75	5.30	.10	0.91
R-865005	608	2.19	1.80	5.13	.10	0.98
R-865007	615	2.17	2.03	4.90	.10	0.89
R-865008	613	2.23	2.01	4.37	.10	0.88
R-865009	613	1.93	1.74	5.03	.10	0.92
R-865010	608	2.10	1.69	4.39	.10	0.90

Table 25. TL dates obtained for bricks taken from the basement of Stockholm Castle.

Rise TL no.	Sample no.	Room	TL date
R-865002	2	611A	1480 AD +/- 40 a
R-865003	3	616	1510 AD +/- 40 a
R-865004	4	616	1540 AD +/- 80 a
R-865005	5	608	1270 AD +/- 80 a
R-865007	7	615	1640 AD +/- 40 a
R-865008	8	613	1580 AD +/- 40 a
R-865009	9	613	1680 AD +/- 40 a
R-865010	10	608	1570 AD +/- 40 a

Anders Ödman has made a careful evaluation of the results in the light of historical, architectural and archaeological evidence (Olsson 1940, Ödman 1988) and his conclusion was that the TL dates (except R-865005) are too recent by around 200 years.

There is at present no apparent explanation for this discrepancy. Short-term fading of feldspars cannot be the reason because the fading was small and results obtained for quartz and feldspar from the same brick were identical.

TL DATING RESULTS, NORWAY

1. Bergen

Five samples have been submitted for dating by Siri Myrvoll, Riksantikvarens Utgravningskontor, Bergen; one from a 1985 excavation at Kroken 3, directed by Alexander Rory Dunlop, and four from an excavation in 1986 at Dreggsalmenningen 14/16 directed by Andrzej Golembnic (Myrvoll 1988). The latter excavation included the remains of the Katarina Hospital.

The environmental radiation was measured on site during the excavations. Dose rate data and fading over four weeks at room temperature are given in Table 26, and the TL dates are listed in Table 27.

Table 26. Gamma and beta dose rates, U content of grains, and fading over four weeks at room temperature for samples from excavations in Bergen.

Risø TL no.	Dose rate (Gy/ka)		U content. (ppm)	Fading ⁰ 100 °C
	Gamma	Beta		
R-863401	0.90	3.22	0.25	0.88
R-863403	1.03	4.05	0.25	0.89
R-863404	1.03	3.70	0.10	0.91
R-863406	0.83	3.60	0.50	0.95
R-863408	1.48	1.55	0.20	0.99

Table 27. TL dates for samples from Kroken 3 and Dreggsalmenningen (Dregg) 14-16, Bergen. C = ceramics, S = burnt stones and B = brick.

Risø TL no.	Material	Locality	Layer	TL date	Expected date
R-863401	C	Kroken 3	88/83	1280 AD +/- 50 a	Med. 1200
R-863403	S	Dregg.	20	1190 AD +/- 40 a	Ca. 1170
R-863404	S	"	283	1340 AD +/- 40 a	1170-1200
R-863406	S	"	46A	1280 AD +/- 70 a	Med. 1200
R-863408	B	"	313	1260 AD +/- 70 a	*)

*) Late Medieval.

One of the results for Dreggsalmenningen, R-863404 is more recent than expected, and the heating of the sample was apparently unrelated to two known fires in 1170 and 1198 AD. The other four results agree well with expected ages.

TL DATING RESULTS, FINLAND

1. Pieksämäki.

Three samples from Pieksämäki were dated in 1987; two burnt stones submitted by Torsten Edgreen and a sample of burnt clay submitted by Markus Hiekkanen, both Museiverket, Helsinki. Three possible dates were suggested for the latter sample: (A) Kiln from Early Neolithic, (B) Lining from Iron Age iron smelting place, and (C) Clay from a burnt-down hunting hut, 1600-1800 AD.

The environmental radiation was measured on the site by Högne Jungner. The result, 1.70 Gy/ka, has been used for the three samples, even though the measurements were not made precisely where these samples were taken. Dose rate data and fading are given in Table 28 and the TL dates are listed in Table 29.

Table 28. Gamma and beta dose rates, U content of grains and fading over four weeks at room temperature (R-861301), or two weeks at 100 °C (R-861302 and R-861308) for samples from Pieksämäki. Water content of clay (R-871308) 11%.

Risø TL no.	Dose rate (Gy/ka)		U content (ppm)	Fading 100 °C
	Gamma	Beta		
R-861301	1.70	3.83	0.30	0.95
R-861302	1.70	1.74	0.30	0.92
R-861308	1.70	2.90	0.15	0.91

Table 29. TL dates for samples from Pieksämäki. S = burnt stone, L = burnt clay.

Risø TL no.	Material	Sample no.	TL date
R-861301	S	TL1	1630 AD +/- 40 a
R-861302	S	TL2	1090 AD +/- 60 a
R-861308	L	-	1860 AD +/- 50 a

Expected ages were not stated for the first two samples. R-861302 agrees well with an earlier result (R-851306: 1030 AD +/- 100 a) for ceramics from the site (Mejdahl 1986). The result for R-871308 shows clearly that interpretation (C), hunting hut, is the correct one.

CONCLUSION

A total of 74 dates representing 19 sites are discussed. In most cases, the TL dates were in agreement with other dating evidence, even though marked differences were found for samples of ceramics from Ribe and bricks from Stockholm castle.

It has been possible to identify those samples that show excessive short-term fading by storing irradiated samples at 100 °C for two weeks. About five percent of the samples received were discarded because their short-term fading exceeded 15%.

With the new beta counting technique, the time required for measuring the beta dose rate has been reduced considerably. Because samples for beta counting were unsealed, there is a possibility of radon escape. However, for nearly all samples, the contribution from uranium to the external beta dose rate was less than 20%. The effect of radon escape was, therefore, assumed to be negligible.

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Abstract (Max. 2000 char.)

A survey is given of archaeological samples dated in 1987 at the Nordic Laboratory for Thermoluminescence Dating. A total of 74 samples were dated. The results were corrected for short-term fading of feldspars as measured for samples stored at room temperature for four weeks or at 100°C for two weeks. The beta dose from potassium and rubidium in feldspar, and the alpha dose from uranium and thorium in quartz and feldspar were included, assuming alpha efficiency factors of 0.1 for quartz and 0.2 for feldspar.

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