LUMINESCENCE DATES OF THE IRON AGE CEMETERY AT MØLLEGÅRDSMARKEN, FYN, DENMARK

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Abstract

The Iron Age cemetery at Møllegårdsmarken on the island of Funen is described briefly and the principle of luminescence dating is outlined. Dates for a number of cremation urns and for a potsherd found on a road running close to the site are presented. The dating was carried out with the OSL method SARA applied to quartz.

Møllegårdsmarken

The cemetery in the field "Møllegårdsmarken" near Gudme in East Funen (Figs. 1–2) is famous not only for its size, being the biggest Danish cemetery with 2230 excavated graves and an estimated original total of c. 2500 burials (Albrectsen, 1971). As part of the Gudme research project on the Iron Age settlement (Nielsen et al., 1994) the latest series of excavation campaigns was undertaken by the archaeological museum at Hollufgård. The result was i.a. new observations on grave ritual (Madsen, 1995) and, more surprisingly – the examination of bits of roads, a ford and what is regarded as mortuary houses (Madsen & Thrane, 1995). The cemetery we see as belonging to the central settlement during the late Roman Iron Age near Lake Gudme (Thrane, 1991).

The latest excavations confirmed Albrectsen's statement on the detrimental effect of modern agriculture on the state of the Iron Age cremation graves. We noted quite a few cases where just the base of the urn was left in situ, the major part of urn (35–40 cm) and bones and possible metal objects having been ploughed away.

In this situation there was no alternative dating technique to luminescence available. It is impossible to date an urn by its base alone (Fig. 3) as the diagnostic elements are rim, proportions and decoration (Jensen, 1977), clay and ware so far being too little studied to be of much assistance in spite of Ole Stilborg's interesting analysis of potsherds from Lundeborg and Møllegårdsmarken in 1997. All we can tell from archaeological knowledge alone is that these pots belong to the earlier Iron Age (100 BC – c. 400 AD). As we know the lifespan of the cemetery to be exactly this time range, such a statement does no lead us forward and is clearly insufficient when we want to estimate the evolution of the cemetery (what archaeologists somewhat misleading call "horizontal stratigraphy"). However, we thought that maybe the ploughed out urns could belong to the final part of the cemetery when the cremation rite seems to have changed towards poorer burials. Their higher position in the soil could account for their having suffered more serious plough damage.

This hypothesis could only be evaluated by luminescence analyses. The dates obtained (Fig. 4) do not support the hypothesis, however. The dates do, none the less,

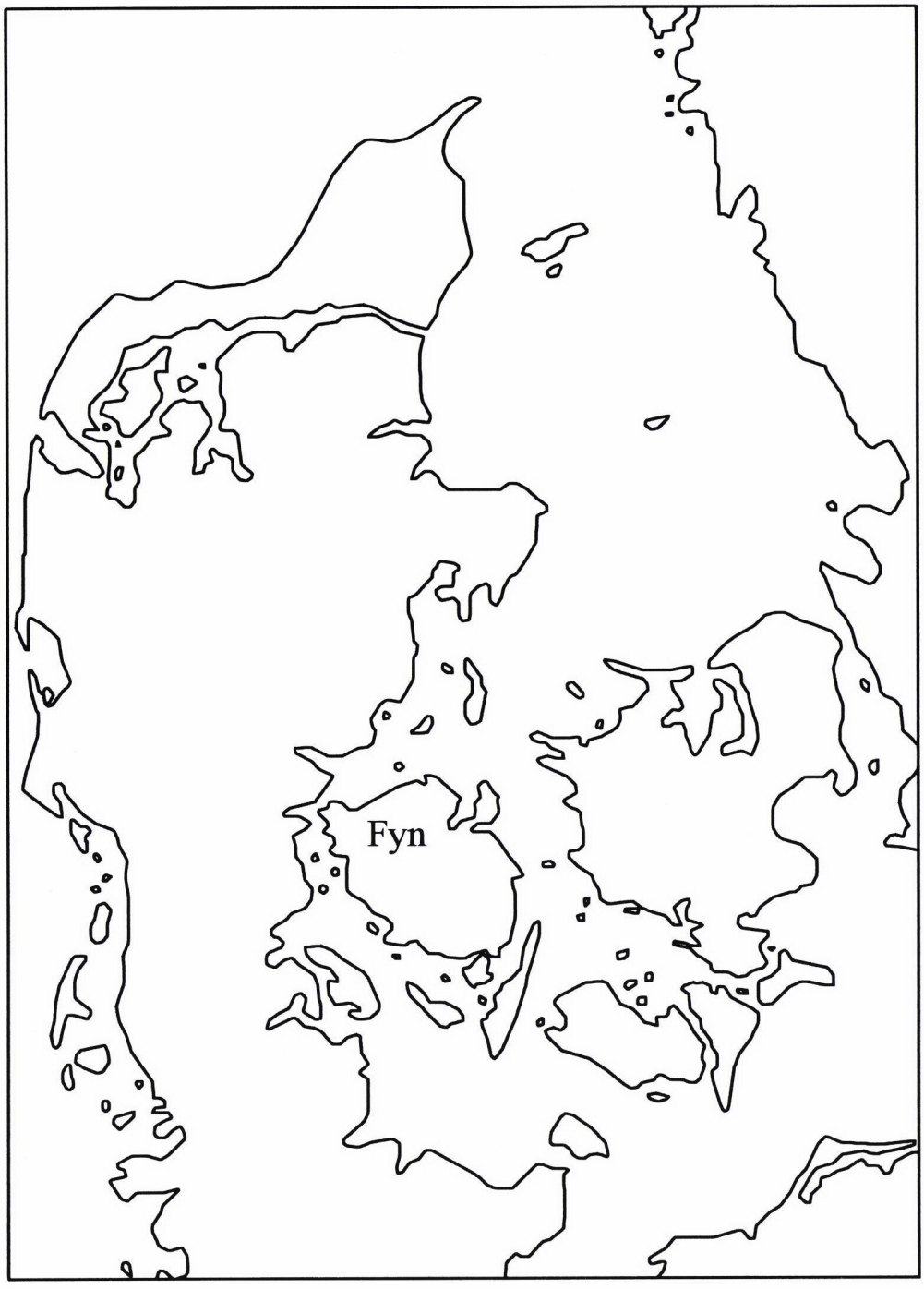

Fig. 1. Map of Denmark showing the location of the island of Funen (Fyn).

help us in the study of the development of the cemetery. The "horizontal stratigraphy" is not a simple one, but seems to have been determined by family or farm groups.

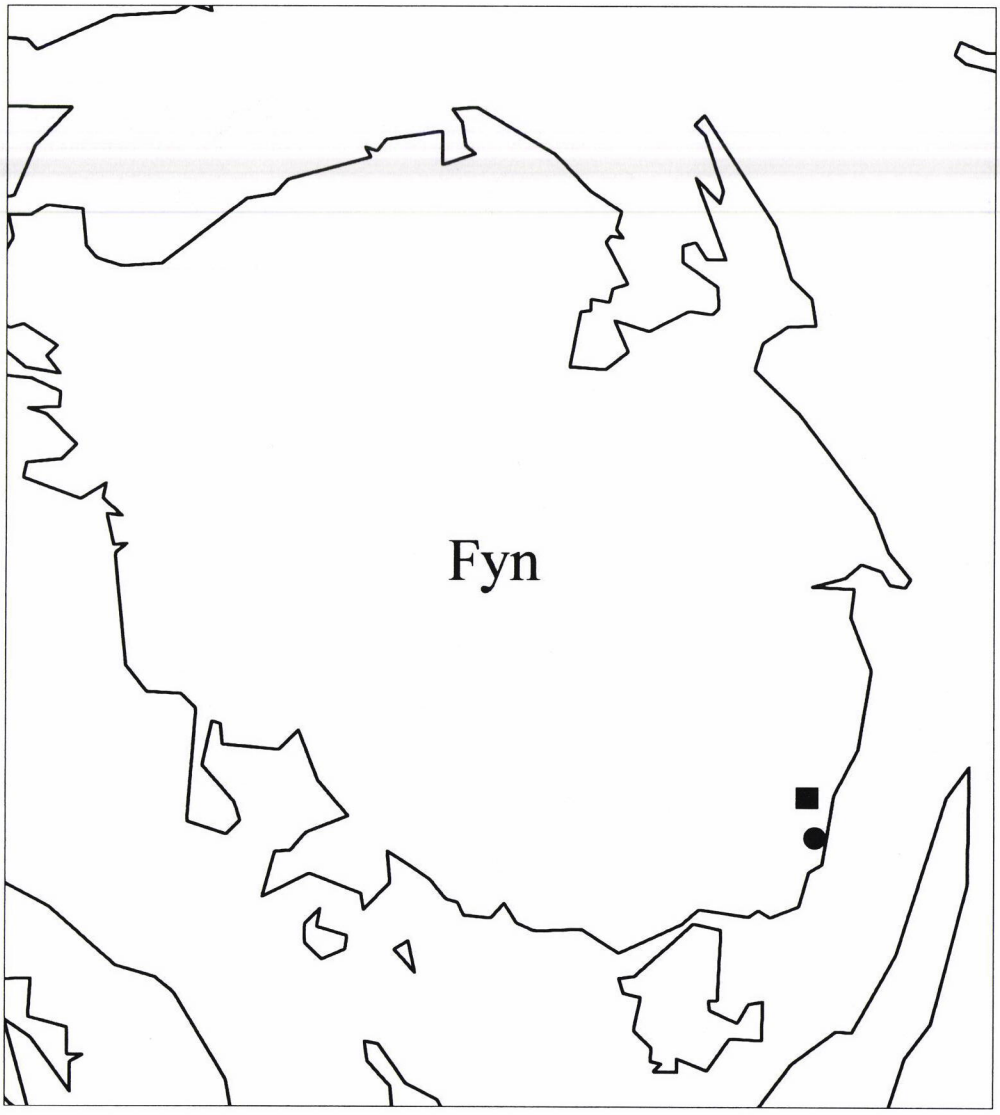

Fig. 2. Map of Funen showing the location of Gudme ■ and Møllegårdsmarken ●.

One potsherd was found on the pavement of one of the roads (Fig. 3, x821). Even if the roads seemed to shun the graves we had no way of providing a precise relative date of the road system then, so a luminescence date seemed the only way to help. The potsherd was deemed to be contemporary with the use of this particular bit of road. The luminescence date indicates that the road here may be later than the cemetery.

Since then we have obtained stratigraphical evidence that the roads were active when the cemetery was in use (Madsen & Thrane, 1995). Further fieldwork in 1996 has underlined the intensive use of the ford across the Tange river with at least three parallel roads hollowed out in the left bank. The road system as such was apparently used during the Roman period and was finally closed in the Middle Ages (around 1210: Mad-

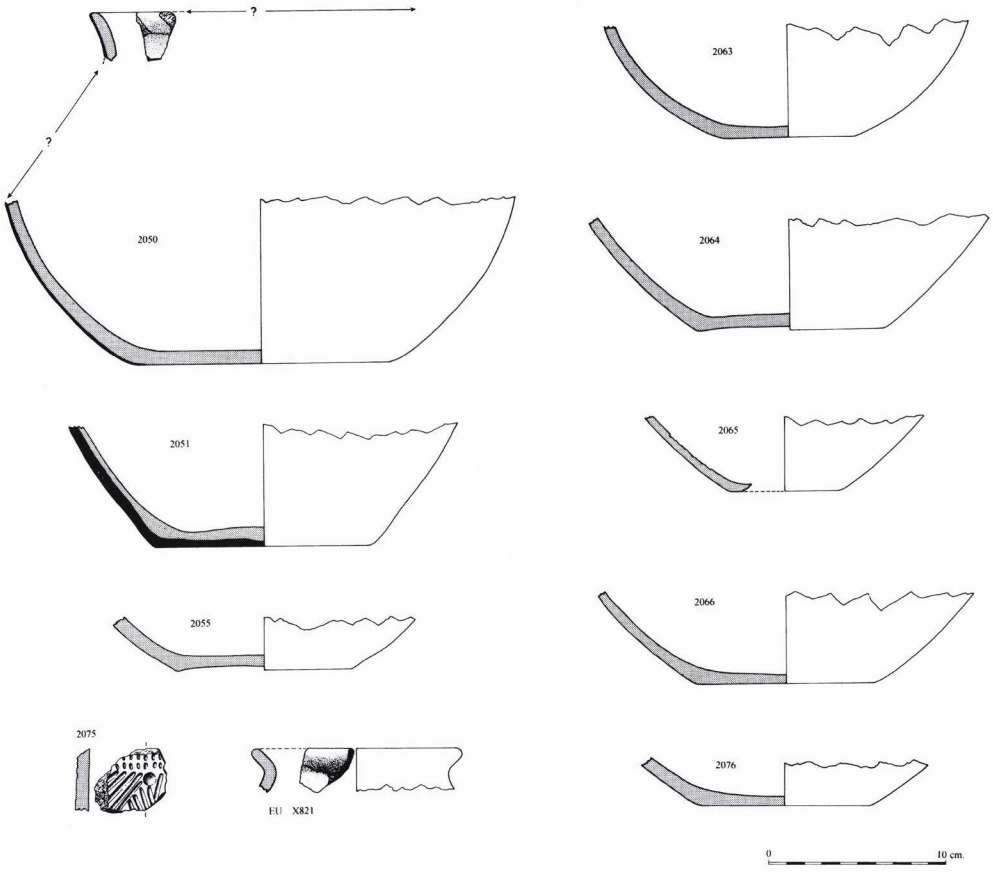

Fig. 3. Wall shapes of the dated urns from Møllegårdsmarken. Del. Claus Madsen.

sen & Thrane, 1995, 81). The luminescence dates are useful where the archaeological context is unambiguous and where answer to a clear question is wanted. If the luminescence dates do not answer the question, the blame may rest with the archaeologist more than with the luminescence method.

Luminescence dating

Luminescence dating methods are based on the minerals quartz and feldspar which are able to store radiation energy when they are exposed to ionizing radiation (alpha, beta and gamma). The stored energy can be released as a luminescence signal by (1) heating the minerals to a temperature of 500°C or (2) exposing the minerals to light, usually green or infrared (Bøtter-Jensen and Duller, 1992). In the first case the signal is called thermoluminescence (TL) and in the second it is called optically stimulated luminescence (OSL). Dating of archaeological materials (ceramics, bricks or heated stones) is possible when the materials have been heated in the past, usually in the firing process; this will empty the stored signal thus providing a zero point for the dating. Subsequently, the mineral in the materials will be accumulating a new signal because they are irradiated by the natural background radiation from uranium, thorium and

Fig. 4. Plan of the cemetery with the location of the dated urns. The numbers are grave numbers except for X821 which is a potsherd found on road EU.

potassium in the environment and cosmic radiation. This signal will now be a measure of the time elapsed since the zeroing. For dating, the luminescence signal is measured in the laboratory by TL or OSL and converted to accumulated radiation dose.

When the annual dose has also been measured, the age can be calculated from the equation.

$$\text{Age} = \frac{\text{Accumulated dose}}{\text{Annual dose}}$$

The dating methods will not be described further here, but the reader is referred to Aitken (1985), Mejdahl (1988) and Mejdahl and Christiansen (1994).

Dating of burial urns from Møllegårdsmarken

The dating was carried out with the OSL method SARA applied to quartz (SARA = Single Aliquot, Regeneration, Added dose). This method was proposed by Mejdahl

Table 1. Luminescence dates for cremation urns from Møllegårdsmarken. The dating was carried out with the OSL method SARA applied to quartz. A single TL measurement (Run No. B5097) was made on feldspar. Sample X821 was a burnt stone. St = standard deviation, Stm = statistical mean error.

Lab. No.	Grave	Run No.	Age (years)	Mean value (years) St (%), Stm (%)
R-952601	2050	CG6105	2155 ± 120	2152 ± 120
"	"	CG6115	2149 ± 120	0.14, 0.10
R-952602	2051	B5097	1628 ± 100	
"	"	CG5396	1580 ± 100	1617 ± 100
"	"	CG5403A	1643 ± 100	1.7, 1.0
R-952603	2055	CG5403B	1745 ± 100	
"	"	CG5382	1648 ± 100	1697 ± 100
"	"	CG5397	1697 ± 100	2.3, 1.3
R-952604	2064	CG5388	1817 ± 120	
"	"	CG5397	1804 ± 120	1912 ± 120
"	"	CG5406	1804 ± 120	5.4, 2.7
"	"	CG5471	1987 ± 120	
R-952605	2064	CG5404	1836 ± 120	
"	"	CG5422	2005 ± 120	2069 ± 120
"	"	CG5471	2366 ± 140	10.7, 6.2
R-952606	2065	CG5390	1757 ± 120	1757 ± 120
R-952607	2066	CG5390	1670 ± 100	
"	"	CG5428	1682 ± 100	1688 ± 100
"	"	CG5476	1706 ± 100	0.8, 0.4
"	"	CG5482	1694 ± 100	
R-952608	2075	CG5488	1723 ± 100	
"	"	CG6006	1803 ± 100	1954 ± 100
"	"	CG6062	2077 ± 100	10.2, 5.1
"	"	CG6066	2213 ± 120	
R-952609	2076	CG5409	1766 ± 100	
"	"	CG5476	1752 ± 100	1848 ± 100
"	"	CG5484	1917 ± 110	4.1, 1.8
"	"	CG5488	1931 ± 110	
"	"	CG6006	1876 ± 100	
R-952610	X821	DG5166	1477 ± 100	
"	"	DG5180	1491 ± 100	1531 ± 100
"	"	DG5212		4.3, 2.5

Table 2. Dose rate (Gy/ka) for quartz samples extracted from cremation urns from Møllegårdsmarken. Beta radiation was corrected for water absorption and grain attenuation. An alpha effectiveness factor of 0.1 was used for alpha radiation from uranium and thorium embedded in the crystals.

Lab. No.	Water (1) content (%)	Gamma+ cosmic	Beta	Alpha	Total
R-952601	9.9	0.71	2.54	0.13	3.38 ± 0.13
R-952602	7.2	0.71	2.35	0.13	3.19 ± 0.12 (2)
R-952603	10.9	0.70	2.48	0.12	3.30 ± 0.12
R-952604	3.0	0.74	2.19	0.13	3.06 ± 0.11
R-952605	8.6	0.74	2.90	0.13	3.77 ± 0.14
R-952606	5.6	0.72	3.02	0.13	3.87 ± 0.14
R-952607	8.2	0.72	2.48	0.13	3.33 ± 0.12
R-952608	9.0	0.72	2.91	0.13	3.76 ± 0.14
R-952609	9.8	0.72	2.06	0.12	2.90 ± 0.11
R-952610	2.2	0.72	2.75	0.13	3.60 ± 0.13

(1) At saturation

(2) A K-feldspar sample (13.0% K) was included in the dating of R-952602. To obtain the dose rate for feldspar a dose rate of 1.87 Gy/ka from potassium and rubidium embedded in the crystal lattice must be added to the value 3.19 Gy/ka in the table.

and Bøtter-Jensen (1994). It is based on the single aliquot procedure introduced by Duller (1991). With this method the accumulated dose is determined from one aliquot (10 mg). SARA is not quite a single aliquot method because it requires at least three aliquots, but it has the same advantages:

(1) Very small samples can be dated.
(2) The dating precision is high, 3–4%.
(3) No normalization of signals is required as is the case when the dating is based on a larger number of aliquots (usually 24).

The dates are presented in Table 1 and Table 2 lists the annual doses for the urns. The dates were obtained as mean values from a number of measurements for each urn. The standard deviation and the mean statistical error (standard deviation divided by the square root of the number of measurements) are also stated as well as the resulting error of the mean values (one sigma).

Conclusion

OSL dates were obtained for ten cremation urns and a potsherd from the pavement of a road running close to the cemetery. The dates were in agreement with the archaeological age estimate for the cemetery 100 BC – c. 400 AD. However, the dates do not allow an estimate of the evolution of the cemetery. The age of the potsherd found on the road indicates that it remained in use later than the cemetery.

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