DATING OF MORTAR AND BRICKS FROM THE CASTLE OF KASTELHOLM

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Abstract

In connection with the excavation and restauration works at Kastelholm radiocarbon dating of mortar from the walls of the castle has been attempted. Except for a date clearly affected by old carbonate and a few samples of modern age, the calibrated samples date back to the 14th century.

Four bricks from different parts of the tower of the castle dated by the thermoluminescence method gave ages between 1490 and 1600 AD. The TL measurements are made on feldspar inclusions extracted from the bricks. The dating results are in agreement with those from the archaeological investigations.

Introduction

When the restauration works of the castle of Kastelholm started in 1980 the need for application of physical dating methods became evident as the chronology for the different building periods were not clearly found from historical records. Since no organic material directly connected to the castle was available, we decided to try radiocarbon dating of mortar from the walls together with TL dating of some bricks.

Dating of mortar is based on the fact that at time of hardening the mortar absorbs carbon dioxide from the air. The radiocarbon content in the mortar at this occasion is therefore comparable to the radiocarbon content in the air (see table 1). The reliability of mortar dating has been questioned by different authors. The mixing of old carbonate, i.e. unburned limestone, into the lime during the preparation or exchange of carbon in the carbonate after hardening can affect the rehability to use mortar for dating. In the literature results in agreement with known ages can be found as well as

Table 1. The main reactions in preparing of mortar (White 1939).

$CaCO_3 \rightarrow CaO + CO_2 \uparrow$	Limestone is heated to above 1000°C to liberate carbon dioxide and give quicklime (calcium oxide).
$CaO + H_2O \rightarrow Ca(OH)_2$	Quicklime is slaked with water to form calcium hydroxide, which is mixed with water and sand to form mortar.
$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$	Calcium hydroxide in mortar reacts with carbon dioxide from the air forming calcium carbonate and making mortar hard.

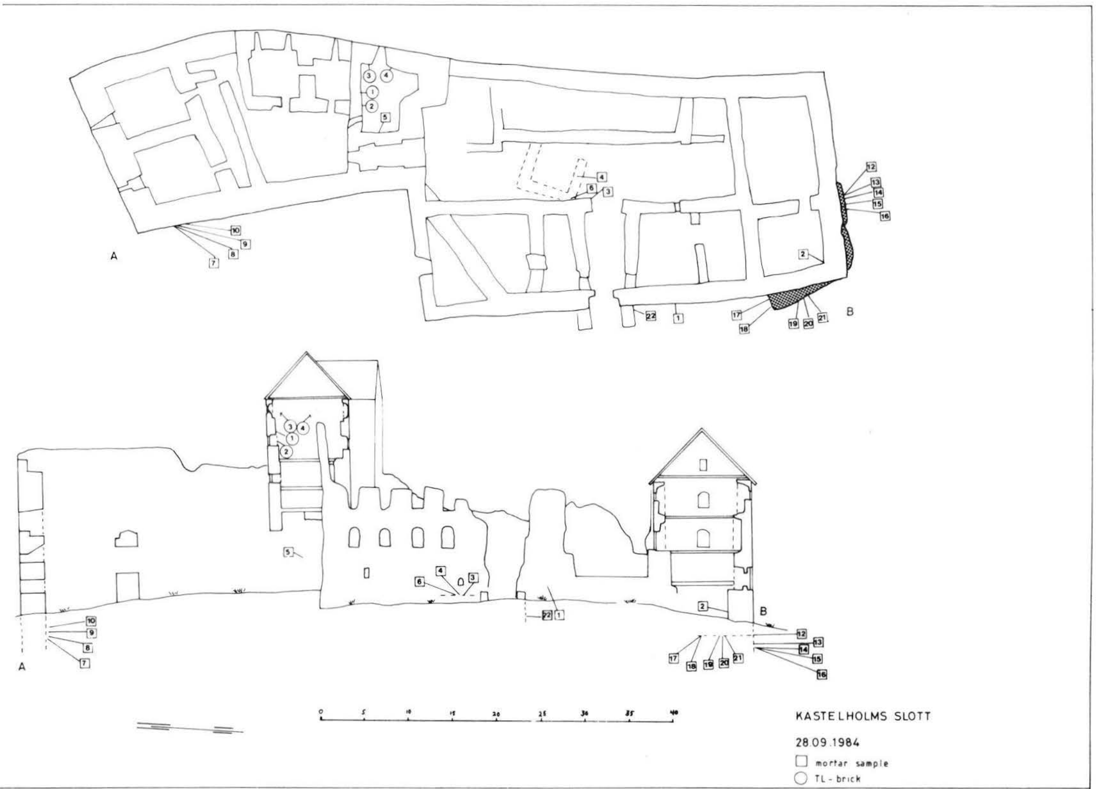

Fig. 1. The castle of Kastelholm with the sampling sites indicated.

results deviating from expected dates (Delibrias et al. 1964, Delibrias and Labeyrie 1964, 1965, Stuiver and Smith 1965, Baxter and Walton 1970a, 1970b, Folk and Valastro 1976, 1979, Malone et al. 1980, Van Strydonk et al. 1983, Willaime et al. 1983).

Sample treatment and results

The first mortar samples were collected in 1981 from different parts of the castle. The promising dating results encouraged us to proceed, and further information provided by archaeological investigations helped us to collect samples more systematically. A total of 21 mortar samples have now been dated. The sample collecting points, as well as the position of the four bricks dated by TL can be seen from figure 1.

The pretreatment of the mortar samples is mainly based on the principles suggested by Folk and Valastro (1979). The sample is gently crushed, mixed with water and shaken to form suspension, which is then wet-sieved to give particles less than 74 microns, and dried. Carbon dioxide is released by hydrochloric acid. The collected carbon dioxide is then converted to methane and the radiocarbon content determined through gas counting (Jungner 1979). The radiocarbon dates obtained are collected in table 2. For five samples giving a modern age the corresponding $d^{14}C$ values are included in parenthesis. The table also contains $\delta^{13}C$ values measured at the Laboratory for Isotope Geology, Swedish Museum of Natural History, Stockholm (sample 1—5) and at the Department of Marine Geology, University of Gothenburg (sample 7—22). The spread in the obtained $\delta^{13}C$ values is considerable, the values varying from -22.3 to -9.7 ‰. As a shift of 10 ‰ in the $\delta^{13}C$ value results in an age shift of 160 years isotope fractionation is a noticeable source of error in the relatively young dates arrived at. To make the use of Stuiver's (1982) calibration curve possible, all results are corrected for isotopic fractionation to a $\delta^{13}C$ value of -25 ‰. The results obtained after this correction and calibration are included in table 2.

Table 2. Radiocarbon data from mortar samples. The calibration is based on the curve given by Stuiver (1982).

Sample no	Laboratory no Hel-	Age uncorrected BP	$\delta^{13}C$ ‰	Age calibrated	
				BP	AD
1	1631	350 ± 90	− 9.2	520—690	1260—1430
2	1625	340 ± 70	−14.8	480—640	1310—1470
3	1576	580 ± 90	−17.9	540—710	1240—1410
4	1630	850 ± 90	−17.9	740—980	970—1210
5	1617	390 ± 90	−14.7	500—670	1280—1450
6	1832	580 ± 90	—		
7	1833	(+95 ± 15 ‰)	−17.1		
8	1834	(+233 ± 13 ‰)	−15.4		
9	1835	(+233 ± 15 ‰)	−13.2		
10	1836	1610 ± 110	−21.0	1400—1720	230—550
12	1893	630 ± 90	−20.5	540—720	1230—1410
13	1894	670 ± 70	−22.1	570—720	1230—1380
14	1895	490 ± 90	−20.1	500—680	1270—1450
15	1896	560 ± 90	−21.9	510—690	1260—1440
16	1897	490 ± 90	−21.4	490—670	1280—1460
17	1898	630 ± 80	−19.8	550—720	1230—1400
18	1899	540 ± 80	−20.4	520—680	1270—1430
19	1900	80 ± 80	−22.3	0—200	1750—1950
20	1901	(+49 ± 17 ‰)	−21.8		
21	1902	(+35 ± 11 ‰)	−22.8		
22	1903	1010 ± 70	−20.0	930—1090	860—1020

The use of the calibration curve is based on the condition that the drying of the mortar took place in a few years. Normally a mortar surface dries in a few weeks. But inside thick walls the drying process may slow down considerably. Based on ^{14}C measurements Baxter and Walton (1970b) reported that the setting of mortar from repair work at London Tower had reached an advanced stage within the first few years. White (1939) mentions that soft mortar has still been found in thick walls after 100 years.

For TL dating we used feldspar grains separated from the bricks. The grain size was 0.2—0.3 mm. The annual gamma dose-rate was measured during the winter 1981—1982 using TL dosimeters (Mejdahl 1978). The beta dose-rates are calculated from the uranium, thorium and potassium content of the bricks using conversion values given by Bell (1979) and dose attenuation factors given by Mejdahl (1979). The relatively high content of the radioactive elements in the bricks leading to high dose-rate levels (see table 3) made the use of the inclusion method on these comparatively young samples more easy.

The TL results are collected in table 3. The errors indicated are based on the statistical uncertainty when determining the equivalent dose value and an assumed 10 % un-

Table 3. Thermoluminescence data of the bricks.

Sample no	Annual dose mGrey	Age	
		before 1980	AD
1	6.47	390 ± 70	1520—1660
2	6.72	430 ± 60	1490—1610
3	5.59	490 ± 60	1430—1550
4	6.01	380 ± 70	1530—1670

certainty in the annual dose rate. An influence of fires, which have caused damage to the castle, on the TL dates can not be found from plateau data when determining the equivalent dose.

Discussion

The dated samples are from the north, east and south wing, the courtyard and the tower of the castle.

According to the archaeologists the north wing has been built during different periods up to the 17th century. Samples 12—16 are taken from the outer surface of a part of the wall assumed to represent an older building period. Sample 2 is taken from the inner NE corner of the wing. The calibrated results for 12—16 covers a region AD 1230—1460 and the age for sample 2 is of the same order. Samples 17—21 are from an extension of the wall situated under the main wall. The results for sample 17 and 18 are in good agreement with the previous results where sample 19—21 give a modern age. There is no clear explanation for the modern ages. The three samples were harder to their consistence than the other samples. Sample 20 was also very strongly alkaline and this may have caused an adsorption of modern carbon dioxide.

Three samples are taken from the east wing of the castle. Sample 1 is from the outer surface of the eastern wall. The wall has been built on an older encircling wall presumably at the later half of the 16th century. The date obtained indicates an older age. The influence of isotopic fractionation is exceptionally prominent for this sample as can be seen from table 2. Sample 22 is from a constructionally younger part of the encircling wall close to the entrance, and sample 3 is from the western wall, which probably was built earlier than the east wing. The result for sample 22 is clearly older than the archaeological estimate and the main group of results obtained. Together with the results from sample 4 this date could indicate an earlier stage of the castle. Further investigations are, however, needed to exclude the possibility of mixing of older carbonates into the mortar as is apparently the case for sample 10. This sample was taken from a level about 4.5 meters above the present sea level and, assuming a constant land-uplift rate of 0.56 cm/year, this point rose above sea level in the 12th century.

Two samples were collected from the large courtyard of the castle. Sample 4 is taken from the ground wall in which there are traces of a door or window opening. The stone-pavement covering the wall presonably dates to the later part of the 15th century. The wall seems older than the surrounding constructions and it apparently had lost its importance before the 16th century. Sample 6 is taken from the joint between the western wall of the east wing and the ground wall. Unfortunately no $\delta^{13}C$ value was measured for this sample and the date has therefore not been calibrated.

Sample 7—10 were collected in 1976 from the south wing of the castle in connection with drainage work outside the castle. The samples have since then been kept at the

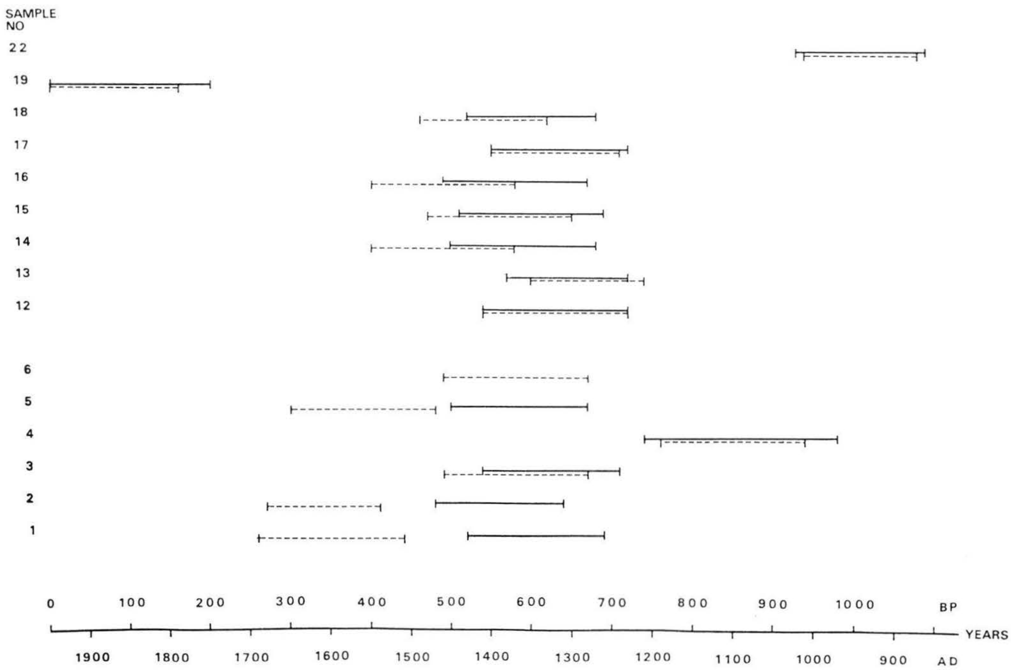

Fig. 2. The distribution of the calibrated (———) and uncorrected (------) radiocarbon ages.

museum. Proper archaeological excavations have not yet been carried out at this area. This part of the castle is, however, traditionally considered a medieval construction. The results for the four samples differ completely from the expected ages, sample 7—9 being modern and sample 10 clearly too old.

From the tower of the castle only one mortar sample, 5, was dated. It was collected from the eastern wall at ground level, where there are indications of several building periods from the Middle Ages to 17th century. The TL samples were all collected from the upper part of the tower. The dates arrived at are well grouped together and correspond to a construction time in the 16th century. This agrees with historical data telling that during the time of Gustav Wasa was some brickmaking at the castle. From there are, however, documents about transportation of older bricks from Turku. Palamarz and Palamarz (1983) suggest a 14th century date.

Figure 2 illustrates the radiocarbon dates except those of modern ages (7—9, 20—21) and the one too old (10). In general the calibrated dates group around a mean value of 600 B.F.. This corresponds to the 14th century when historical sources first mention the castle as a property left by Bo Jonson Grip 1388 but not in his testament 1384. The question of earlier building stages, hinted at by the two samples dated to around 800—1000 B.P., will be the aim of the forthcoming investigations at the castle.

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