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Report 93/90

TREE-RING ANALYSIS OF OAK TIMBERS FROM QUEEN'S HOTEL, YORK, YORKSHIRE, 1988-89.

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Summary

Tree-ring analysis was carried out on twenty-three oak timbers from three medieval-early post medieval structures at the Queen's Hotel site in York. A master chronology was produced for the period AD1061-1271. The timbers from context 1051 were felled after AD1193, and those from context 2030 have a probable terminus post quem for felling of AD1281. The ring sequence of a single sample from context 1066 was dated to AD897-978 and has a felling date range of AD978-1008.

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Tree-ring analysis of oak timbers from Queen's Hotel, York, Yorkshire, 1988-89

Introduction

Timber remains of medieval-early post medieval structures were revealed during excavations at the Queen's Hotel site (site code 1988/89.17) in York, by the York Archaeological Trust in 1988-89. A total of twenty-three samples were taken for tree-ring analysis. Context 1051, area 1, consisted of a double row of timber piles and provided eight samples. Other archaeological dating evidence suggested a late medieval or early post medieval date for context 1051. Context 1066, area 1, was an extensive layer of black organic silty loam of approximately twelfth/thirteenth century date which was excavated by machine. Archaeological evidence suggests that the three timbers sampled from context 1066 may have been part of context 1051 which were either missed or not apparent higher up in the stratigraphy. The remaining twelve samples were all from context 2030 in area 2. This was a double row of timber piles driven into medieval and Anglo-Scandinavian deposits. The piles supported a limestone wall of late medieval-early post medieval date. This structure was on the same alignment as context 1051 from area 1 and may be part of the same building.

It was hoped that dendrochronological analysis would provide more precise dates for the structures and determine whether all three contexts are likely to be part of the same building. Additionally it was hoped to extend the coverage of reference chronologies available for the York area.

Method

The samples were prepared by freezing them for a minimum of 48 hours and then cleaning their cross-sectional surface with a surform plane. Any unsuitable samples were rejected before measurement. These are usually samples with unclear ring sequences or samples with less than 50 rings. Ring patterns with

fewer than 50 rings are generally unsuitable for absolute dating as they may not be unique (Hillam et al 1987). However samples with 30-49 rings and bark or bark edge are usually included for measurement as these have the potential to provide precise felling dates.

The growth rings of the selected samples were measured on a travelling stage connected to an Apple II microcomputer (see Hillam 1985: Figure 4). The ring width data were transferred to an Atari ST microcomputer with hard disk drive via the Sheffield University Prime mainframe computer. The ring sequences were plotted on semi-logarithmic paper, using a graphing program on the mainframe (Okasha 1987), to facilitate visual comparison of the patterns. The process of crossmatching and dating was carried out on the Atari microcomputer with software written and developed by Ian Tyers of the Museum of London, although visual matching was still used to check the computer results. The crossdating programs are based on versions of CROS (Baillie & Pilcher 1973, Munro 1984) and measure the amount of correlation between two ring sequences. The Student's t test is then used as a significance test on the correlation coefficient. All t values quoted in this report are identical to those produced by the original CROS program (Baillie & Pilcher 1973). Generally a t value of 3.5 or over represents a match, provided that the visual match is acceptable (Baillie 1982: 82-85).

The samples were analysed structure by structure and the ring patterns which crossmatched from all three contexts were combined to give a site master curve. The master curve and all unmatched ring sequences were tested against reference chronologies to obtain absolute dates. A master curve is more likely to produce a date than the ring sequence of a single sample when compared with dated reference chronologies. This is because the master curve enhances the common climatic signal and reduces the "background noise"

resulting from the local growth conditions of individual trees.

The results only date the rings present in the timber and therefore do not necessarily represent the felling date. If the bark or bark edge is present on a sample the exact felling year can be determined. A study of oak sapwood data showed that 19 out of every 20 samples from British trees older than 30 years had 10-55 sapwood rings (Hillam et al 1987). These 95% confidence limits are used to estimate felling dates in the absence of complete sapwood. In the total absence of sapwood, the addition of 10 rings (the minimum number of sapwood rings expected) to the date of the last measured heartwood ring produces a probable *terminus post quem* for felling. As the number of missing heartwood rings is unknown, the actual felling date could be much later.

At this stage of tree-ring analysis, factors such as stockpiling or timber re-use must also be considered, since they might affect the interpretation of the tree-ring dates. Thus, whilst the production of dates is a completely independent process, their interpretation can be refined by studying other archaeological evidence.

Results

The number of rings, their orientation and the size of the cross-section of every sample was noted (Table 1). The tree-ring results are described structure by structure below. The ring width data from individual samples are stored at the Sheffield Dendrochronology Laboratory, where they may be consulted.

Context 1051

None of the eight samples had retained any sapwood and sample 13 was rejected as it contained only 41 rings. The remaining seven samples had 56-123 annual growth rings, although it was only possible to measure 54 rings on sample 07

as the outer eight rings were too narrow and degraded for reliable measurement. The ring patterns from the timbers were compared with each other and 08 and 09 were found to match (t = 8.0). No other consistent results were obtained for the other five samples.

Context 1066

Sample 43 had 25 sapwood rings and 28 and 42 had bark edge indicating that they had both retained their full complement of sapwood. Sample 28 had only eight sapwood rings but the 95% confidence limits quoted above indicate that one out of every twenty samples is likely to have less than 10 or more than 55 sapwood rings. All three samples were measured, although the ring pattern of 43 was partly distorted due to knots. The sequences contained 55-92 rings but no reliable crossmatching was obtained when they were tested against each other.

Context 2030

Six (17, 18, 19, 24, 25, 26) of the twelve samples, including both timbers with sapwood still present, were rejected. They all had less than 50 rings and the ring patterns of 18 and 24 were also badly distorted by knots. The six measured samples had 65-102 growth rings. The ring sequences were compared against each other and four samples (15, 16, 21, 21A) crossmatched (Figure 1; Table 2). These matching sequences were combined to produce a master curve QHY/T4.

The unmatched individual ring patterns from all three contexts were tested against QHY/T4 and a further two samples, 08 and 09, were found to match (Figure 1; Table 2). These were combined with QHY/T4 to produce a new master curve QHY/T6. No further reliable crossmatching was obtained, so the master sequence QHY/T6 and all unmatched individual sequences were compared initially

with reference chronologies from northern England and then from elsewhere in the British Isles. An excellent match was obtained for QHY/T6 when it spanned the period AD1114-1271 (Table 3). Two individual samples, 20 and 43, were also absolutely dated to AD1061-1157 and AD897-978 respectively (Table 3; 4). No other consistent crossdating was produced for any of the other individual sequences. These were also compared with reference chronologies from the rest of Europe but remain undated.

Sample 20 has only a short overlap with ring sequences from the six timbers that are included in QHY/T6 (Figure 1). However it extends the master curve back in time by 55 years and was therefore combined with QHY/T6 to produce a final site master chronology, QHY/T7 (Table 5). QHY/T7 dates to AD1061-1271 and matches particularly well with reference chronologies from York Coppergate (Hillam 1989) and other northern England sequences (Table 3).

Interpretation

The outermost rings of samples 08 and 09, from context 1051, date to AD1183 and 1182 respectively (Table 6). The results suggest that they are likely to be contemporary and therefore both have a *terminus post quem* for felling of AD1193. This indicates that the double row of timber piles could not have been erected before AD1193.

The single dated sample from context 1066 had retained 25 sapwood rings. Its outermost measured ring dates to AD978 which therefore indicates that it was felled during the period AD978-1008. If 43 is a primary timber (ie not re-used) it could not have been used in the building of the structure from context 1066 before AD978 but was probably used before AD1009.

None of the five dated samples from context 2030 have any sapwood. The dates of the outermost measured heartwood rings range from AD1157 (20) to 1271 (16).

The *termini post quem* for felling of the timbers therefore vary between AD1167 and 1281 (Table 6). If the five timbers are contemporary they were probably all felled after AD1281 which implies that the double row of piles could not have been built before AD1281. This also suggests that samples 20 and 21 in particular had lost a large number of rings during conversion. Alternatively the wide variation in the date of the outermost measured ring may be due to some of the timbers having been re-used from earlier structures. Additional archaeological information may be able to determine the more likely of the two interpretations suggested by the tree-ring results.

The *termini post quem* for felling obtained for the timbers from contexts 1051 and 2030 range from the mid 12th century to the late 13th century. Although there is no precisely defined limit, individual samples which match with *t* values over approximately 10.0 are likely to have originated from the same tree. If comparisons between timbers from context 1051 and context 2030 had given such high *t* values a positive link would have been indicated between the two structures. However the *t* values produced between the timbers from the two contexts were all less than 5.4 (Table 2). Consequently this information, combined with the lack of precise felling dates due to the absence of sapwood, means that it is not possible to determine from the tree-ring results whether the double row of timber piles from context 1051 in area 1 and context 2030 in area 2 represent the same structure.

The felling date range given by 43 from context 1066 is earlier than the twelfth/thirteenth century date expected from the loam. The results for 43 show that it cannot be contemporary with the dated timbers from context 1051 unless other archaeological evidence indicates that it has been re-used from a previous structure.

The Timbers

All of the timbers from contexts 1051 and 2030 had been trimmed or worked in some way. Approximately 60% are from halved (eg 07, 13) or quartered (eg 15, 20) trunks which had been hewn into the required shape. The remaining timbers from contexts 1051 and 2030, although virtually intact, were shaped or trimmed on one or more sides (eg 06, 19). By contrast sample 28 from context 1066 is a complete trunk with bark still intact and 42 is just over half of a trunk with a full complement of sapwood. Sample 43 also from context 1066 is from a quartered trunk which had retained much of its sapwood. The three timbers from context 1066 therefore appear to have been converted in a slightly different way, though the presence of sapwood could be due to more ideal conditions for preservation. Additionally the apparent differences may be due to such a small number of samples being available.

The age and size of the parent trunks are difficult to assess due to the lack of sapwood and/or pith on many of the samples. However it seems likely that the vast majority of timbers were less than 150 years old when felled and the three from context 1066 were all probably under 100 years old. The parent trunks ranged from circa 140mm to over 400mm diameter when felled. The average ring width of the timbers ranges from 1.0mm to 2.2mm. Slow grown timbers have narrow ring widths and originate from trees that grew under conditions that were limiting, possibly in dense woodland. Faster grown timbers with wider average ring widths had more favourable conditions and perhaps experienced less competition. Although it is as yet impossible to source timber using dendrochronology with any detail, the results produced by the dated samples suggest that these timbers are of British origin and probably from a local source.

Conclusion

A total of 16 samples were suitable for measurement of which eight were absolutely dated. The construction of a further chronology for York was achieved but this does not extend the periods covered by existing oak chronologies for this area. The timbers from context 1051, area 1, could not have been felled before AD1193 indicating a construction date for the piling of after AD1193. A felling date range of AD978-1008 was obtained for a timber from context 1066 in area 1. This indicates some building activity in the late 10th-early 11th century, although it is possible for the timber to have been re-used at a later date. The *termini post quem* obtained for the timbers from context 2030, area 2, imply that this double row of timber piling was erected after AD1281.

It has not been possible from the tree-ring results to determine whether the timbers from contexts 1051 and 2030 represent the same building. However the timber from context 1066 cannot be contemporary with those from context 1051 unless it has been re-used from an earlier structure.

Acknowledgements

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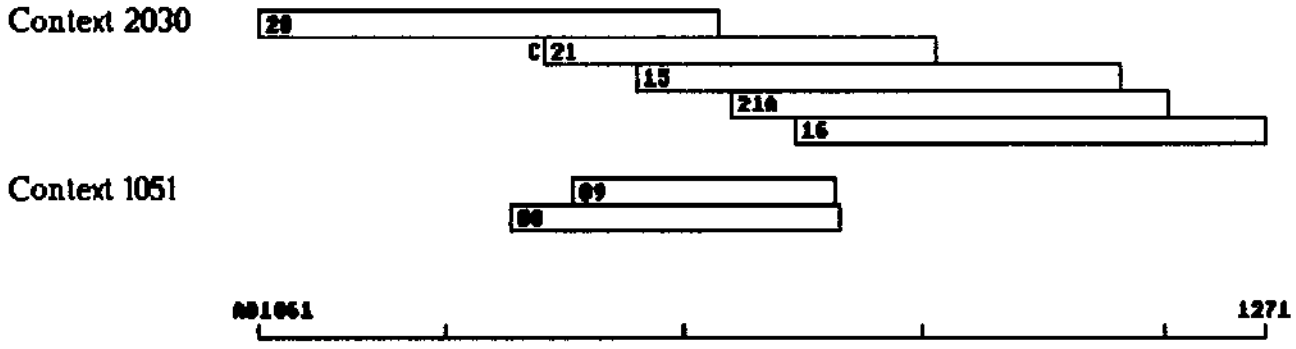
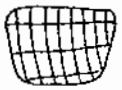
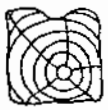
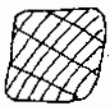
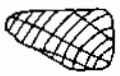


Figure 1: Bar diagram showing the reltaive positions of the dated samples from Queen's Hotel, York. C - indicates that the centre of the tree was present.

Table 1: Details of the samples. Sketches are not to scale; sapwood is indicated by shading.

Timber number	Number of rings	Sapwood rings	Average ring width	Maximum dimensions	Sketch	Comment
context 1051						
06	88	-	1.3	165x160		
07	54+	-	2.5	180x130		+8 rings
08	70	-	1.5	105x70		
09	56	-	1.9	105x80		
10	87	-	1.5	185x165		
12	123	-	1.7	185x175		
13	41	-	2.7	165x115		rejected
14	79	-	1.3	140x70		+20 rings
context 1066						
28	55	8	2.2	220x210		felled summer
42	92	12	1.0	160x110		bark edge
43	82	25	1.3	160x100		knots

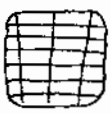
Timber number	Number of rings	Sapwood rings	Average ring width	Maximum dimensions	Sketch	Comment
context 2030						
15	102	-	1.0	100x100		
16	99	-	2.0	155x145		
17	33	-	3.2	195x180		rejected
18	40	-	2.4	190x160		rejected, knots
19	24	2	3.1	135x125		rejected
20	97	-	1.7	140x140		
21	83	-	2.2	155x155		
21A	92	-	1.2	125x115		
23	65	-	2.1	165x145		
24	35	-	2.1	145x125		rejected, knots
25	26	-	4.2	180x160		rejected
26	45	9	1.9	130x130		rejected

Table 2: Matrix of t values obtained between the samples included in the master chronology QHY/T6. \ = overlap of less than 30 years; - = t is less than 3.0.

	08	09	15	16	21	21A
08	*	8.0	4.2	\	3.7	-
09		*	4.4	\	5.3	-
15			*	3.9	3.1	4.5
16				*	5.9	6.3
21					*	3.8
21A						*

Table 3: Dating the master curves QHY/T6 (AD1114-1271), QHY/T7 (AD1061-1271) and samples 20 (AD1061-1157) and 43 (AD897-978) from Queen's Hotel, York. \ = overlap is less than 30 years; - = t of less than 3.0; * = composite chronologies of data from many sites.

reference chronology	t value			
	QHY/T6	QHY/T7	20	43
Beverley: Eastgate (Groves 1990)	5.07	6.49	6.30	4.97
Hall Garth (Hillam 1981)	5.34	6.22	-	\
Lurk Lane (Groves & Hillam 1987)	-	3.79	4.21	5.74
Bristol: Dundas Wharf (Nicholson & Hillam 1987)	3.25	4.31	4.40	-
Carlisle medieval (Baillie & Pilcher pers comm)	5.02	5.60	4.06	-
*East Midlands (Laxton & Litton 1988)	7.59	7.57	3.75	5.88
*England (Baillie & Pilcher pers comm)	7.27	7.37	3.66	3.23
Hull: Chapel Lane (Hillam 1979)	6.69	6.75	-	\
Nantwich (Leggett 1988)	6.28	6.51	3.22	-
Reading (Groves et al 1985)	4.94	4.92	\	\
Shackerley, Salop (Hillam 1984)	4.63	5.02	3.74	\
Stafford (Groves unpubl)	3.53	6.37	6.45	6.00
York: Coppergate medeival (Hillam 1989)	6.42	7.35	5.02	\

Table 4: Sample 43 from Queen's Hotel, York, AD897-978.

years	ring width data (units of 0.02mm)									
AD897							136	121	80	107
AD901	90	96	96	69	88	139	80	105	64	74
	69	108	79	71	46	63	47	67	63	69
	72	75	82	80	72	44	57	41	81	88
	70	87	65	97	93	122	105	110	102	130
	83	38	40	69	81	84	86	133	99	108
AD951	58	42	39	45	56	41	27	28	19	18
	17	11	19	21	18	19	19	17	19	14
	16	16	16	20	18	23	21	19		

Table 5: The site master chronology QHY/T7 from Queen's Hotel, York, AD1061-1271.

years	ring width data (units of 0.02mm)										number of samples per year									
AD1061	83	71	60	101	95	124	168	97	111	150	1	1	1	1	1	1	1	1	1	1
	100	77	74	87	126	111	123	122	104	191	1	1	1	1	1	1	1	1	1	1
	104	101	153	105	116	90	63	70	80	66	1	1	1	1	1	1	1	1	1	1
	145	136	158	76	89	105	80	53	43	52	1	1	1	1	1	1	1	1	1	1
AD1101	33	55	100	72	106	84	88	79	56	39	1	1	1	1	1	1	1	1	1	1
	66	82	101	75	65	69	72	75	47	61	1	1	1	2	2	2	2	2	2	2
	66	84	95	77	83	77	85	78	63	84	3	3	3	3	3	3	4	4	4	4
	80	76	79	98	114	77	90	83	81	131	4	4	4	4	4	4	4	4	4	5
	119	98	88	76	80	85	83	97	113	108	5	5	5	5	5	5	5	5	5	5
AD1151	111	131	134	126	112	99	86	86	92	100	5	5	5	5	5	5	5	4	4	5
	74	74	88	82	81	62	83	91	105	87	5	5	5	5	5	5	5	5	5	5
	72	57	56	53	67	85	74	85	95	79	5	5	6	6	6	6	6	6	6	6
	64	97	98	79	80	72	98	82	79	113	6	6	5	4	4	4	4	4	4	4
	94	88	120	82	100	94	105	82	79	59	4	4	4	4	4	4	4	4	4	4
AD1201	70	52	58	58	69	85	80	71	78	91	4	4	4	3	3	3	3	3	3	3
	78	60	71	66	67	82	106	79	91	80	3	3	3	3	3	3	3	3	3	3
	80	80	63	64	74	57	44	44	51	54	3	3	3	3	3	3	3	3	3	3
	50	62	53	65	70	43	58	58	83	71	3	3	3	3	3	3	3	3	3	3
	64	79	91	66	62	75	69	41	52	59	3	2	2	2	2	2	2	2	2	2
AD1251	57	63	61	35	49	41	52	39	40	48	2	1	1	1	1	1	1	1	1	1
	36	54	48	32	34	42	37	49	69	37	1	1	1	1	1	1	1	1	1	1
	43										1									

Table 6: Details of the tree-ring dates. The date of the sapwood transition, if present, is given in brackets.

Context	Timber	No of rings	Date	Comment
1051	08	70	1114-1183	felled after 1193
1051	09	56	1127-1182	felled after 1192
1066	43	82	897-978 (954)	felled 978-1008
2030	15	102	1140-1241	felled after 1251
2030	16	99	1173-1271	felled after 1281
2030	20	97	1061-1157	felled after 1167
2030	21	83	1121-1203	felled after 1213
2030	21A	92	1160-1251	felled after 1261