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Summary

Oak timbers from two wells were examined and dated by dendrochronology. The first well, context 0630, was lined with timbers from a hollowed-out oak tree, the ring sequence of which spanned the period AD585-688. The second, context 0697, was lined with reused barrel staves. The rings from these timbers spanned the period 539-744, and a high correlation with German chronologies indicated that the timbers were probably imported from Germany.

Author's address :-

Jennifer Hillam

Department of Archaeology And Prehistory
University of Sheffield
Sheffield
S.Yorks
S10 2TN

Tree-ring dating of well timbers from Greyfriar's Road, Ipswich, Suffolk

Oak timbers from two wells excavated at the Greyfriar's Road site (IAS5203) by the Suffolk Archaeological Unit were examined at the Sheffield Dendrochronology Laboratory in 1989. The first well (context 0630) was lined with five timbers from what was originally a hollowed-out tree trunk (Fig 1). Associated finds suggested a 7th century date for the well. The second well was lined with 19 barrel staves (Fig 2) and was thought to be 8th/9th century in date.

Methods

Sections were sawn from the ends of timbers A-E from 0630, and from the widest part of staves 1-19 from 0697. The samples were frozen for at least 24 hours before the cross-sections were prepared with a surform plane. The boundaries of the annual rings of the barrel staves were distinct and ready for measurement after this treatment, but those from the hollowed-out tree were still indistinct. Surfacing the cross-sections with a sharp knife improved the quality of the surface to a certain extent, but as an extra precaution each sample was measured twice to ensure that the measurements were accurate.

Once the samples had defrosted, the ring widths were measured on a travelling stage which was linked to an Apple II microcomputer (Hillam 1985, Fig 4). The ring width data were then transferred to the University's Prime computer which plotted the ring sequences as graphs using software written by Okasha (1987). The data were then transferred to an Atari 1040ST where the remaining tree-ring processes of matching, making master sequences and dating were carried out. The software for the Atari was written and developed by Ian Tyers of the Museum of London (Tyers pers comm). The crossdating routines are based on the original CROS programs (Baillie & Pilcher 1973; Munro 1984), and all the t

values in this report are identical to those produced by the first CROS program (Baillie & Pilcher 1973). Generally t values of 3.5 or above indicate a match provided that the visual match between the graphs is acceptable (see Baillie 1982, 82-85). All results from the computer comparisons were therefore checked using graphs.

The ring sequences from each context were compared one against the other. When as many as possible had been matched, their ring widths were averaged to produce a master sequence for each context. The masters were then tested against dated reference chronologies from Britain and Europe.

This process produced dates for the rings of each master and therefore for each individual ring sequence. The relationship between the tree-ring dates and the felling date of the timber still has to be determined. Where bark or bark edge is present, precise felling dates are obtained. If some sapwood has been preserved, the 95% confidence limits for the felling date range can be determined by adding 10 and 55, the likely minimum and maximum number of sapwood rings, to the date of the heartwood-sapwood transition (Hillam *et al* 1987). If heartwood rings only are present, the felling date is given as a *terminus post quem* by adding 10 to the date of the last measured ring or in this case to the last ring of the master sequences. This takes into account the absence of the minimum 10 sapwood rings, but there could be up to 55 rings missing and possibly heartwood rings as well. There may also be an unknown time interval between the felling of the timber and its use in the wells. The timber from the hollowed-out tree may not have been seasoned, but the barrel staves would have been dried for some time. In the latter case, some time must also be allowed for the life span of the barrel before it was reused in the well.

Results

a) well 0630

Sample A was rejected because the ring boundaries were so unclear that the two sets of measurements did not correspond. The two sets of measurements from the remaining samples were averaged to produce a single sequence for each sample. Samples B-E had 71-104 rings with average ring widths of approximately 1mm (Table 1). The ring sequences matched each other to give a master sequence of 104 rings (Table 2). Although there was no doubt from the pattern of rings on the timbers that they were from the same tree, the *t* values between the ring sequences were not particularly high (Table 3). Whilst the barrel staves give a *t* value range of 2.2 to 18.9, those from 0630 range from 4.0 to 6.6. These relatively low values are probably due to the difficulties in measurement described above.

When the master sequence from 0630 was tested against reference chronologies, consistently good *t* values were found when the sequence spanned the period 585-688 (Table 4). It matched particularly well with sequences from Barking Abbey (Tyers pers comm) and Hamwic (Hillam 1984). It also matched other sequences such as Smart Street, Ipswich, and Mersea Strood, but there was no agreement with chronologies from Germany.

Since the outer ring of the sequence is 688, the *terminus post quem* for felling is 698. The timber is likely to have been used in the 8th century but exactly when is not determinable from the tree-rings.

b) barrel well 0697

Three of the staves (5, 10, 13) were rejected because they were broken and did not have enough rings for dating. The remaining 16 staves had 87-173 rings with average ring widths well under 1mm (Table 1). The ring sequences crossmatched to give a master sequence of 206 rings. The *t* values between

them were generally very high (Table 5), although samples 14 and 19 seemed to match less well than the remainder and were not included in the master. The master chronology from 0697 is therefore constructed from 14 ring sequences (Table 6).

The *t* values between the ring sequences suggest that many of the staves came from the same tree, although it was not possible to verify this from the ring patterns on the timbers themselves because the cross-sections were too small. It is generally not reliable to use *t* values as a measure of whether timbers come from the same tree (Milsom 1979), but it is unusual for pairs of timbers from different trees to produce *t* values greater than 12.

When the master was compared with dated reference chronologies, *t* values of 6.5 and 7.6 were obtained with chronologies from the Munich and Trier areas of Germany when the sequence covered the period 539-744 (Table 7). Low *t* values were obtained at this date with English chronologies: Barking and Hamwic, for example, which had matched so well with the 0630 timbers, gave *t* values of 2.9 and 1.9 respectively. There was no match between the master sequences from the two wells.

The barrel timbers are unlikely to have been felled before 754. Allowing for the possibilities of missing sapwood and possibly heartwood, seasoning and the life span of the barrel, it is unlikely that the well would have been lined until the late 8th-early 9th century.

Discussion

As well as providing dates for the two sets of well timbers, information on the origins of the timber can also be inferred from the tree-ring results. The ring sequences from the 0630 timbers match best with chronologies from England, particularly those from the London and Southampton areas (Fig 3), but

do not match with chronologies from Germany. A southern English origin is therefore suggested for these timbers.

The barrel timbers give very different results. Table 8 shows the *t* values for comparisons between the ring patterns from each barrel stave and chronologies from the Munich, Trier and Schleswig-Holstein areas of Germany plus a chronology made up from English regional chronologies (Baillie & Pilcher pers comm). The highest *t* values are those obtained from comparisons with Trier (Hollstein 1980), although the *t* values with the Munich area chronology (Becker 1981) are almost as high. *t* values with the Schleswig-Holstein chronology (Eckstein pers comm) and England on the other hand are considerably lower, which suggests that the barrel timbers had an origin in mid-southern Germany.

The reuse of barrels from this area of Germany has been noted elsewhere. Excavations at Dorestadt in the Netherlands revealed several reused barrels. Eckstein *et al* (1975) deduced from the archaeological and tree-ring evidence that the barrels, which had contained wine, had been transported down the Rhine from the Mainz area. On the basis of the tree-ring evidence, it is possible that the Ipswich barrel also came from this area.

Conclusion

Tree-ring analysis of the oak timbers from wells 0630 and 0697 has produced chronologies for the periods 585-688 and 539-744 respectively. The timbers for well 0630 came from the same tree, which was probably English in origin and was not felled before 698. The reused barrel timbers may also have come from one tree, probably felled some time after 754, but they were imported from Germany. The barrel may have been transported down the Rhine from the Mainz area and across to Ipswich.

Acknowledgements

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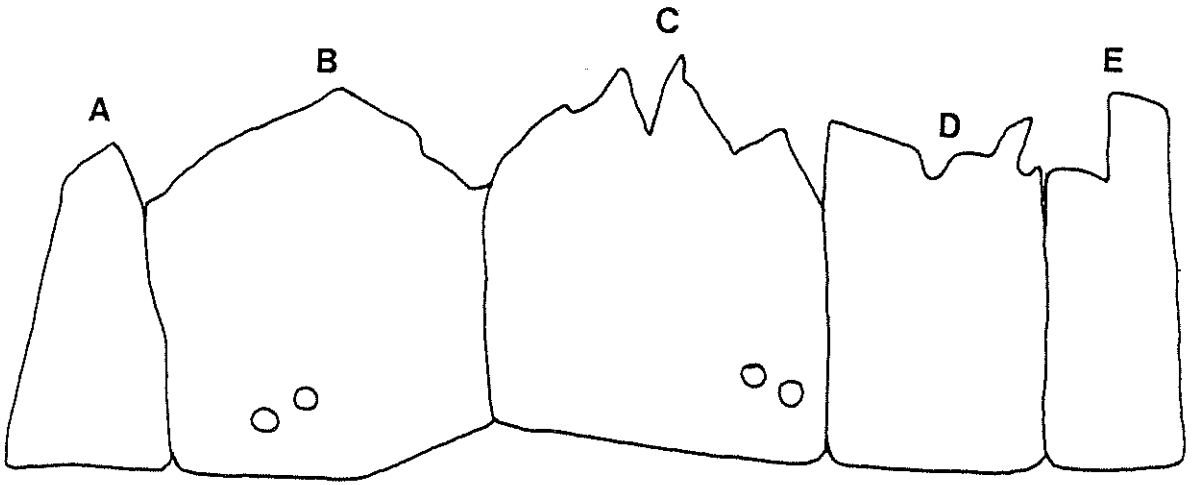


Fig 1: Well timbers elevation: well context 0630. Scale 1:10.

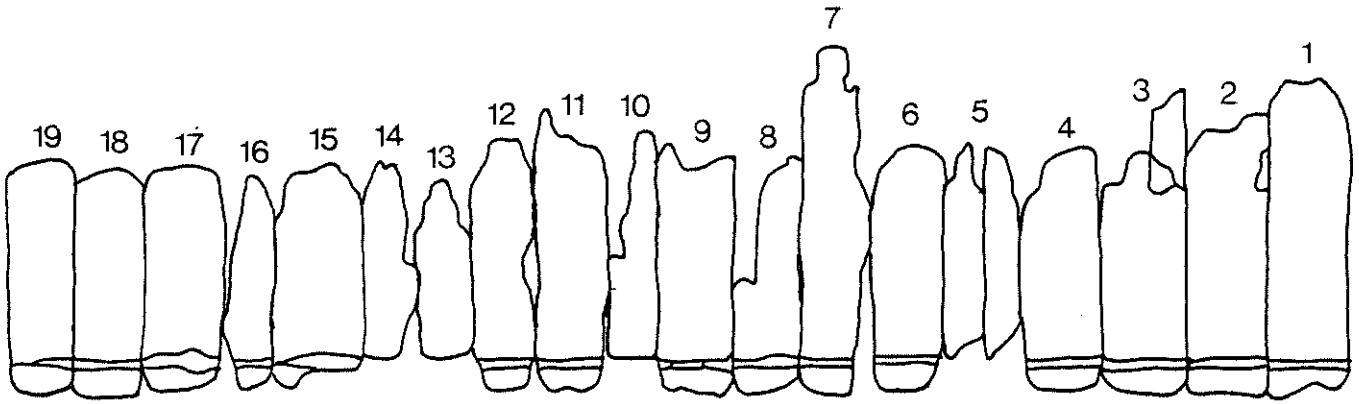


Fig 2: Well timbers elevation: barrel well context 0697. Scale 1:10.

Table 1: Details of the tree-ring samples. Cross-sectional sketches are not to scale; "+" - unmeasured rings present.

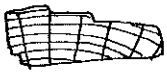
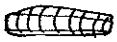
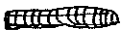
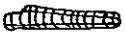
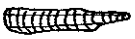
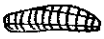
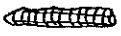
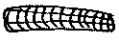
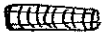
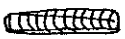
sample	no of rings	average ring width(mm)	sketch	maximum dimensions(mm)	AD date
a) well 0630					
A	66+	0.73		180x75	-
B	71	1.29		430x90	602-672
C	104	0.97		425x105	585-682
D	72	1.06		295x80	616-687
E	72+	0.92		150x70	615-686
b) barrel well 0697					
1	153	0.66		115x20	556-708
2	163	0.68		115x15	539-701
3	164	0.65		110x20	552-715
4	142	0.72		105x15	578-719
6	127	0.73		95x15	548-674
7	+123	0.65		100x15	585-707
8	109	0.84		95x10	590-698
9	+135	0.62		110x10	590-724
11	90	0.92		90x15	595-684
12	97	0.78		80x10	590-686
14	87	0.65		65x20	590-676
15	173	0.68		125x20	572-744
16	94	0.90		60x10	610-703
17	133	0.72		105x20	573-705
18	112	0.81		95x20	605-716
19	109	0.81		90x15	620-728

Table 2: Ipswich 5203 0630 master chronology, AD585-688.

years	ring widths (0.02mm)										number of samples									
AD585					77	86	93	70	61	50					1	1	1	1	1	1
	43	36	53	38	39	44	49	39	46	57	1	1	1	1	1	1	1	1	1	1
AD601	80	61	53	39	58	61	60	67	53	65	1	2	2	2	2	2	2	2	2	2
	60	69	52	91	63	55	68	74	49	51	2	2	2	2	3	4	4	4	4	4
	66	69	89	65	82	79	74	80	59	45	4	4	4	4	4	4	4	4	4	4
	56	62	44	32	32	41	48	48	47	48	4	4	4	4	4	4	4	4	4	4
	49	56	57	60	63	56	63	56	71	73	4	4	4	4	4	4	4	4	4	4
AD651	60	64	62	52	58	46	40	35	39	46	4	4	4	4	4	4	4	4	4	4
	46	52	59	53	53	49	53	52	63	46	4	4	4	4	4	4	4	4	4	4
	33	31	37	42	41	25	28	32	27	28	4	4	3	3	3	3	3	3	3	3
	34	33	33	38	40	48	51	35			3	3	3	3	3	3	2	1		

Table 3: *t* value matrix for samples from well 0630.

	B	C	D	E
B	*	6.6	5.0	4.0
C		*	4.1	4.3
D			*	4.4
E				*

Table 4: Dating well 0630 - *t* values with dated reference chronologies.

chronology	*t* value
Barking Abbey (Tyers pers comm)	6.6
Hamwic (Hillam 1984)	6.6
Ipswich, Smart Street (Groves 1987)	4.8
London, New Fresh Wharf boat (Tyers pers comm)	3.6
Mersea Strood (Hillam 1981)	3.3
Ref 8 (Fletcher 1977)	4.2
Germany, Munich (Becker 1981)	no match
Germany, Trier (Hollstein 1980)	no match

Table 5: *t* value matrix for samples from barrel well 0697.

	1	2	3	4	6	7	8	9	11	12	14	15	16	17	18	19
1	*	18.9	16.9	14.6	14.0	10.4	12.5	12.3	10.9	5.7	5.0	7.0	10.9	16.7	11.9	4.8
	2	*	17.2	14.7	15.3	9.6	10.9	12.8	10.3	5.6	3.8	6.6	9.5	16.4	13.0	3.1
		3	*	15.4	15.5	10.3	9.7	10.6	9.8	5.9	4.6	7.5	10.8	16.7	11.3	3.6
			4	*	14.5	11.1	12.6	10.4	9.8	5.7	3.8	6.5	9.4	17.3	12.5	2.4
				6	*	8.8	8.2	10.1	7.7	7.4	2.8	6.5	6.9	11.2	10.3	2.5
					7	*	10.6	9.4	10.0	4.7	4.8	5.6	6.5	8.6	9.7	3.6
						8	*	12.5	10.2	7.1	4.6	5.0	10.6	10.0	10.6	4.4
							9	*	8.1	8.0	4.5	4.3	10.3	11.8	9.1	4.1
								11	*	3.7	3.4	5.6	7.0	8.0	14.6	2.7
									12	*	2.8	4.3	5.7	4.7	4.5	5.6
										14	*	2.1	2.8	4.3	3.4	3.8
											15	*	3.1	5.8	4.6	2.2
												16	*	10.7	10.6	3.7
													17	*	12.9	3.2
														18	*	3.1
															19	*

Table 6: Ipswich 5203 0697 master chronology, AD539-744.

years	ring widths (0.02mm)										number of samples									
AD539									38	25									1	1
	51	55	53	42	53	34	35	36	49	62	1	1	1	1	1	1	1	2	2	2
AD551	51	33	33	40	23	33	25	44	43	35	2	3	3	3	3	4	4	4	4	4
	42	41	55	27	24	21	30	46	40	47	4	4	4	4	4	4	4	4	4	4
	30	51	44	50	34	31	44	33	35	28	4	5	6	6	6	6	6	7	7	7
	33	58	33	26	32	49	44	32	56	60	7	7	7	7	8	8	8	8	8	11
	32	38	26	38	49	33	45	29	55	57	11	11	11	11	12	12	12	12	12	12
AD601	77	84	53	48	47	40	40	55	40	28	12	12	12	12	13	13	13	13	13	14
	39	33	46	44	49	42	35	50	47	44	14	14	14	14	14	14	14	14	14	14
	29	53	47	26	30	35	27	39	40	39	14	14	14	14	14	14	14	14	14	14
	31	43	46	49	36	46	57	35	37	52	14	14	14	14	14	14	14	14	14	14
	51	30	20	31	37	27	39	33	23	26	14	14	14	14	14	14	14	14	14	14
AD651	23	37	21	38	33	23	22	39	24	36	14	14	14	14	14	14	14	14	14	14
	26	24	38	33	37	34	37	25	31	28	14	14	14	14	14	14	14	14	14	14
	32	43	41	43	35	39	30	36	30	28	14	14	14	14	13	13	13	13	13	13
	31	29	24	30	31	26	29	23	27	33	13	13	13	13	12	12	11	11	11	11
	36	25	35	26	28	26	33	22	28	23	11	11	11	11	11	11	11	11	10	10
AD701	23	27	34	23	34	27	27	27	23	22	10	9	9	8	8	7	7	6	5	5
	24	24	23	30	27	20	32	23	24	27	5	5	5	5	5	4	3	3	3	2
	28	29	24	22	33	37	42	31	39	29	2	2	2	2	1	1	1	1	1	1
	41	22	30	35	21	31	47	37	23	25	1	1	1	1	1	1	1	1	1	1
	28	32	26	26							1	1	1	1						

Table 7: Dating barrel well 0697 - *t* values with dated reference chronologies.

chronology	*t* value
Barking Abbey (Tyers pers comm)	2.9
Hamwic (Hillam 1984)	1.9
Ipswich, Smart Street (Groves 1987)	0.9
London, New Fresh Wharf boat (Tyers pers comm)	2.2
Mersea Strood (Hillam 1981)	3.1
Ref 8 (Fletcher 1977)	3.2
Germany, Schleswig-Holstein (Eckstein pers comm)	3.6
Germany, Munich (Becker 1981)	6.5
Germany, Trier (Hollstein 1980)	7.6

Table 8: *t* values for comparisons between the individual barrel staves and chronologies from Germany (Munich - Becker 1981; Trier - Hollstein 1980; Schleswig-Holstein - Eckstein pers comm) and England (Baillie & Pilcher pers comm).

stave	Trier	Munich	Schleswig	England
1	7.6	6.7	5.0	4.4
2	6.5	6.8	4.2	4.1
3	7.5	5.3	4.0	3.1
4	5.4	4.8	4.2	3.7
6	5.9	5.0	3.4	2.9
7	6.9	4.2	3.8	2.4
8	5.3	5.2	2.7	1.6
9	3.9	3.7	2.4	2.7
11	5.0	4.4	4.1	2.0
12	5.0	3.4	0.8	1.5
14	7.3	5.0	1.2	1.4
15	6.2	4.3	1.9	1.6
16	4.3	5.2	3.6	3.0
17	6.7	7.0	3.5	3.9
18	6.1	5.2	3.4	2.8
19	5.3	4.5	1.1	1.7