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Ancient Monuments Laboratory
Report 94/88

BILLINGSGATE LORRY PARK, CITY OF LONDON, 1982. TREE-RING ANALYSIS OF THE PERIOD V TIMBERS.

Jennifer Hillam

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Summary

The analysis and dating of the Periods II and III (Roman) and the 10th-11th century Period IV timbers have already been described (Hillam 1986, 1987). This report gives the results for the study of the 202 oak timbers from Period V, thus continuing the chronological history of the development of the medieval Thames waterfront at Billingsgate. Many of the dates proved to be earlier than expected, resulting in a revision of the site phasing and the provision of a precise date for the construction of a Period IV structure. The application of a new computer program for tree-ring research is also described.

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Billingsgate Lorry Park, City of London, 1982. Tree-ring analysis of the Period V timbers

Introduction

Approximately 600 oak timbers at Billingsgate were sampled for dendrochronology by the Museum of London's Department of Urban Archaeology. It was hoped that, with this relatively large number of timbers, dendrochronology would provide a detailed and precise dating framework for the site.

The timbers from Periods II and III were Roman in date (Hillam 1986), but the remainder were medieval. The results from the 137 samples already analysed from Period IV provided information on the first stages of development of the medieval waterfront (Hillam 1987). They indicated that both sides of the inlet were developed using timber felled in AD 1039/40 and reusing timbers felled in the late 10th century (phase IV.1 and IV.2). A stave front was then added to the west side of the inlet, the timbers being felled in the period 1047-1070 (phase IV.4).

The Period V contexts represent a further development of the inlet. On the west side of the inlet, the stave front of IV.4 was replaced by a new frontage (V.1), and the IV.1 bank behind it was consolidated first with gravel (V.2) and then with a timber and clay feature (V.3). The addition of the timber and clay structure to the gravel consolidation caused a break in the slope of the bank, where there was some structural activity or consolidation in phase V.4. Further development followed (V.5), and in V.6 there is evidence for the construction of a revetted bank at the west side of the inlet surmounting the earlier Period V embankment. This consisted of a series of gravelly dumps containing rough timber breastwork at intervals to contain the gravel. The revetted bank also contained piles which were used to form an informal frontage.

Development was also evident on the east side of the inlet where the original IV.2 bank was reconstructed to form a new V.8 bank. This was similar to the structure on the west side, except that it reused timbers from the Period IV frontage. The final phase of Period V represents the use and repair of the V.8 bank (V.9).

Two hundred and two timbers from Period V were sampled for tree-ring dating, the bulk of the samples coming from the V.3 bank, where about 10% of the unworked and most of the worked timbers were sectioned. In addition, two samples came from V.1, seven from V.4, 19 from V.6 and 27 from V.8. The samples were analysed in 1987, those from phases V.1, V.4, V.6 and V.8 being examined first, followed by the 147 samples from V.3.

The samples

Two timbers were sampled from the V.1 revetment, one of which was an upright squared post (6788). The function of the other (7530) is unknown.

The V.3 timbers were aligned N/S, parallel to the inlet, changing to E/W at the south end following the main direction of the frontage. The timbers tended to become larger towards the bottom of the layers. With the exception of 7074, which was recorded as a boat or house timber, the V.3 timbers were not recorded separately. Some were worked and others unworked, but these details were not available until towards the end of the study.

The V.4 timbers were all worked. Three (5714, 5765, 5812) were planks with 5659 above. 6026 and 6027 were found a little to the east, whilst 5626 was one of five robbed out stakes scattered to the north.

The V.6 timbers were either worked horizontal timbers or upright stakes or piles. A group of the piles were set in clusters around N/S horizontal timbers and extending beyond them to the south. Twelve piles (3269, 4635, 4643, 4645, 4646, 5304, 5334, 5388, 5389, 5392, 5394, 5394B) and two horizontals (4771, 5387) were sampled. 4771 was recorded as a reused domestic baseplate. Five other timbers were sampled: two horizontals (5625, 5750) and three stakes (5423, 5424, 5981).

The clay and timber consolidation of the V.8 east bank was mostly represented by N/S horizontal timbers, 27 of which were sampled.

Methods

The samples were prepared, measured and crossdated following the method given in Hillam (1985). They were examined phase by phase in groups of

about ten. Any samples with less than 40 rings were rejected, along with any that had knots obscuring the ring pattern or had very narrow, unreadable rings (Appendices A, C). Usually the rings along only one radius per sample were measured, but occasionally two or even three radii were measured. This might be done if 1) the ring sequence was particularly knotty or difficult to measure; 2) the ring sequence was relatively short but had sapwood or bark edge; or 3) if the sequence was undated but was considered particularly important, such as when there were only a few samples from a particular phase (eg V.4).

The measured ring sequences were plotted as graphs to facilitate visual comparison, and each sequence was compared by computer with other medieval reference chronologies from London. At the start of the study, the three chronologies used for comparison were CITY MED - made up of tree-ring data from the City of London (Hillam unpubl), SOUTHWARK - tree-ring data from Southwark (Tyers unpubl), and BIG - the chronology produced during the study of the Billingsgate conservation samples (Hillam & Groves 1985). As the work progressed, various working masters were constructed from the Period IV and V samples. These were also used for dating purposes. Although the computer program CROS (Baillie & Pilcher 1973) was used to save time, the results were checked visually. Each ring sequence was checked against the other ring sequences as well as against the reference chronologies. A match was only accepted if the ring sequence crossmatched at least two others. Such careful checking prevents the inclusion of spurious matches which may occur, especially if the initial matching is done by computer.

A new computer program SORT-STRING (Crone 1987; Okasha 1987) was also used in an attempt to handle the large number of data from V.3 more efficiently. Based on the original CROS program, it compares each sequence from a group against each other and calculates the highest t-value per pair. (A simple explanation of the t-test as applied to dendrochronology is given by Baillie, 1982 82.) The results are then sorted so as to find internally consistent groups of sequences based on the highest t-value. Thus, if a group A-E was selected, B would crossmatch A, C would match A and B, and so on, with "match" in this case being equivalent to the highest t-value. Since SORT-STRING is still

under development, traditional methods were used first, and any new results which were indicated by SORT-STRING were checked visually.

The program was designed chiefly for short oak and non-oak ring sequences, and has been used successfully on prehistoric tree-ring data (Crone pers comm). This was the first time that it had been used on a large group of samples from a complex urban context. Although it was used initially on the sequences from phase V.3, it was later applied to the remaining ring sequences from Period V.

The results from the visual and computer crossmatching were set out as a bar diagram (Figs 2,3) to make it easier to estimate felling dates (see Appendix C). It was not always necessary to estimate felling dates because a few of the samples had bark or bark edge, so that the felling date is exact to the year, eg 6340, or occasionally the season, eg 5904. (If the outer ring is completely formed, the tree was felled in winter or early spring whilst it was dormant, but if there is only spring wood present, then it was felled in late spring or early summer.) On some samples, eg 6732, the bark edge was present but the outer rings were too narrow to measure. Instead a rough count of the unmeasured rings was made, and an approximate felling date given. Where the sapwood was incomplete, a sapwood estimate of 10-55 rings was used to calculate the 95% confidence limits for the period of felling (Hillam et al 1987). In the total absence of sapwood, the probable terminus post quem for felling is given by adding ten years to the date of the last measured heartwood ring.

Results

Details of the samples are provided in Appendix A, whilst sketches of the cross-sections showing how the timbers were cut are illustrated in Appendix B. Full details of the results are given in Appendix C, but they are summarised in Figs 2 and 3, and will be described below phase by phase. Because of the complexity of the site, it is not possible to give full details of how each sample was dated. However, the ring width data from all the measured samples are stored in the Sheffield Dendrochronology Laboratory, and can be consulted on request. A site

master curve (or curves) will be produced when all the Billingsgate timbers have been examined.

Phase V.1

The two V.1 timbers had relatively few rings. 7530, with 36 rings, was rejected, but 6788 was dated, its 47 rings spanning the period 1024-1070. Even though the sequence is relatively short, the dating is reliable since the visual matching was good, and the t-values produced by CROS relatively high, eg 6.7 with City Med, 5.2 with Southwark and 6.0 with BIG4.2, the Billingsgate master derived from the IV.2 samples. The timbers of the V.1 revetment therefore are unlikely to have been felled before 1080. Because of lack of sapwood, a more precise felling date cannot be given, but the result may be refined once the tree-ring dates for Period VI become available.

Phase V.3

After preparation of the cross-sectional surfaces, 32 of the samples were rejected. One, 5871, was not oak, but was identified as Populus spp; nine had insufficient rings; and 22 had rings which were either too narrow for accurate measurement or were obscured by knots.

The samples were very variable in size, shape, number of rings, and ring pattern (Appendices A, B). Contrary to information recorded at the time of excavation, most of the timbers appeared to have been worked to some degree, and were often sections cut from larger tree trunks. If the section was taken from towards the outside of the trunk, then the sapwood was often left on (eg 5904, 5912). Other timbers were wedge-shaped segments covering the complete radius of a smaller trunk (eg 6312), indicating that trees of variable diameter were used to produce the timbers for the V.3 structure. 5909A and 6726 came from trees with diameters less than 180mm, whilst 5914B and 6709 were cut from a tree, probably the same tree (see below), with a diameter more than 500mm.

Age of tree used is difficult to determine with any accuracy. 6635 had well over 254 rings because many inner rings were too narrow to measure. Even then the centre of the trunk was not present so that it must be from a tree over 300 years when felled. By contrast, the tree producing

6719, was under 100 years old. Between these extremes there are many samples from trees with varying ages. This variety is reflected by the number of rings per sample (Fig 1), although the bulk of the samples had between 60 and 100 rings. The number of rings does not seem to affect whether a sample is dated or not.

The average ring widths of the measured samples tended to be narrow (Table 1; Appendix A). Three samples (6635, 6704, 6726) had average widths under 0.5mm. This is extremely narrow, and in the past it has not been possible to measure such rings with any accuracy. Several other V.3 samples were rejected for just this reason (see above). Two of the samples were successfully dated, but the third (6726) remains undated, probably because of errors during measurement (Appendix A). Of the remaining samples, 87 had average widths in the range 0.5 - 1.49, and 24 were greater than 1.5mm. This is much lower than, for example, timbers from the waterfront site at Dundas Wharf, Bristol (Nicholson & Hillam 1987) (Table 1).

During measurement of the rings, it became apparent that, not only were the rings generally narrow, but also that some of the ring patterns were almost identical. The patterns of 6623, 6674 and 6731B, for example, were recognisable by a very wide ring, which was later dated to AD 837. Other ring patterns were also found to be similar, and on the basis of the high t-values between them, as well as the similarity of the samples themselves, it is suggested that as many as 14 timbers were cut from the same tree (Table 2). Another possibility is that the 14 samples come from one or two trees which were growing close together, but the three named above are definitely from the same tree, and some of the other comparisons give higher t-values.

Comparison of the 115 measured samples with dated reference chronologies resulted in the dating of 81 ring sequences, and the SORT_STRING program confirmed the tentative dating of three others (5913B, 5931A, 6664) (Fig 2). The degree of correlation with the reference chronologies was very variable (Table 3). Some of the samples gave the highest agreements, as expressed by t-values, with non-Billingsgate chronologies, but the majority were dated by comparison with master curves made up from Billingsgate data as well as by City Med and Southwark. As the study

continued, various V.3 masters were constructed which contained an inceasing number of ring sequences (BIG5.3 mark 1-6, and finally BIG5.3). However it was noticeable that some V.3 sequences matched better with the period IV master (BIG4) than with any of the V.3 masters.

There is little evidence from the tree-ring results that any of the timbers were re-used. The only obvious exception is 6312 which has a felling date of 1039/40, and was probably re-used from phase IV.1, the timbers for which were also felled at this time (Hillam 1987). Eleven of the remaining samples probably had bark edge. Ten of these were felled either in the winter-early spring of 1054/55 (eg 6340) or in the late spring/summer of 1055 (5904). This could in fact represent a difference in felling of only a few weeks. It seems likely therefore that the structure was constructed in the latter part of 1055, since the timbers would probably have been used green (eg Baillie 1982, 138, 167).

Two timbers were definitely felled after this date. 6635 was felled in the winter of 1061/2, and 6316 has an end date of 1057. The latter was probably felled some time after this, since the date of its heartwood-sapwood transition ranges from 1040 to 1054, giving a likely felling date range of 1063-1094.

Of the 83 measured samples without sapwood, the end dates show a gradual fall-off from 1034 (7074) to 818 (5927B). These probably represent timbers with sapwood removed or, in the case of the earlier date spans, timbers taken from the inner part of the trunk. For example, of the timbers which may have come from the same tree (Table 2), 5914B dates to 649-866 and 6679B to 893-1005, thus representing two portions of a trunk. 6701, 6709 and 6625B have similar end dates to 6679B (1015, 1014 and 1008 respectively), suggesting that these all come from the outer part of the tree from which the sapwood has been removed.

Thirty one samples remain undated. Although tentative dates were obtained for some of these samples, they could not be confirmed either by reference to other chronologies or to other V.3 ring sequences.

Phase V.4

Six samples were measured from this phase, of which four had sapwood (5659, 5714, 5765, 5812). A seventh sample was rejected because its rings were too narrow. Initially only one sample (5626) was dated. A second set of ring measurements was therefore taken from the other samples, and the two sets of data averaged. Attempts to date 5765 were made more difficult because the sample was broken in the middle, but eventually it and 5714 were dated against various Billingsgate masters (Fig 3).

Both 5714 and 5765 had bark edge, but the outer one or two rings were damaged and could have been missing on sections of the sample's edge. The last measured rings of 5714 and 5765 were 993 and 1053 respectively. Their felling dates are therefore 994-6 and 1054-6, and it seems likely that 5765 is contemporary with the V.3 timbers which were felled in 1055, whilst 5714 was reused. A similar result was found for the phase IV.2 timbers, except that the fresh timbers in that structure were felled in 1039/40 and the reused timber probably felled in about 983-990 (Hillam 1987).

Tentative matches were found for 5812 and 6026, but both sequences appeared to match in more than one position, ie their ring sequences were not unique. 5812, for example, could end at 955, 998 or 1039 (Table 4). Whilst the SORT-STRING program favoured the 1039 position, none of the visual matches looked acceptable. As there is no way of distinguishing from the tree-rings which is the correct position, both 5812 and 6026 (possible end dates 992, 988, 1008) must remain undated at the moment. (A few other Billingsgate sequences have matched the reference chronologies at two tentative positions but it has always been possible to distinguish the correct match by looking at the quality of the visual match, both with the master chronologies and with other individual sequences from Billingsgate.)

Phase V.6

Sixteen out of the 19 samples were measured, giving sequences of 51-143 years in length. 5625 had complete sapwood, and the outer edge of 4635 may have been the heartwood-sapwood transition, but the remainder had

heartwood rings only. Nine sequences dated (Fig 3), most of them matching with Southwark, City Med and BIG4. The t-values for the matches were very variable, ranging from 3.5 to 8.5. 5394B did not match well with Southwark or City Med but gave t-values of 4.4 and 6.4 with BIG4 and BIG53 respectively.

Tentative matches were found for 5334, 5392 and 5394 but these could not be confirmed either visually or using the SORT-STRING program.

The end dates for the dated samples without sapwood range from 947 (5981) to 1013 (4771, 5424). 4635 ends at 981, with a possible heartwood-sapwood transition date of 982, and 5625 ends at 1049. However about 10-15 sapwood rings on 5625 were too narrow to measure accurately. The latter was therefore felled in about 1059-64, making it slightly later than the V.3 and V.4 timbers but earlier than V.1. 4635 was probably felled after 991 or, if the sapwood transition is present, in the period 991-1036, indicating that late 10th century timbers might also have been used in V.6.

Phase V.8

All but two timbers were measured from this phase, 6432 and 7987 being rejected because their rings were too narrow for accurate measurement. The remainder had measurable ring sequences between 51 and 162 years in length. Nine had sapwood, and two others either ended near the sapwood boundary or had a queried boundary. All but 7969, 7970, 7979, 7984 and 8031 were dated. As with the V.3 and V.6 timbers, there was great variation in the values of t for comparisons with the dated chronologies. 6435, for example, matched well with BIG4 (t = 6.4) but not with City Med or Southwark; 8041 matched with all the chronolgies but especially well with Southwark (t = 6.0); and the dating of 7940 was not confirmed until it was tested against the final version of BIG5.3, with which it gave a t-value of 6.9.

Eight of the dated samples had sapwood, with the sapwood transition queried on a ninth (Fig 3). The dates of the heartwood-sapwood transitions range from 1002 (6433B) to 1046 (7914). However none of the samples had bark edge so that it is not possible to give precise felling dates. The probable felling date range for 6433B is 1011-1056, whilst

that for 7914 is 1056-1101, indicating that there are probably at least two felling phases amongst the phase V.8 timbers. The first felling phase presumably represents reused timbers since timbers from Period IV were found in this phase.

The period V timbers, excluding V.3

Because there are relatively few samples from V.1, V.4, V.6 and V.8, as compared to V.3, it is difficult to draw any conclusions about the timbers. All of the them have been worked in some way, although the degree of working was variable (Appendix B). Like V.3, the shape and size of the cross-section, and the age of tree from which they were taken, are very variable. Sapwood was removed more often from the phase V.6 timbers than from those in V.4: five out of eight V.4 timbers had sapwood, compared to two or three out of 19 in V.6.

The chronology of periods IV and V

The sequence of events in these two periods when examined phase by phase (Table 5), indicates that the timber for the V.1 revetment was felled considerably later than the timbers for phases V.3 and V.4, and this result has led to a reinterpretation of the site's stratigraphy (Vince pers comm) (Table 6). Following the construction of the IV.1 and IV.2 banks in 1039/40, the IV.4 plank frontage was added to the IV.1 bank in 1055. At roughly the same time, timbers were added behind the frontage (V2, V3, V4), and to the structure east of the inlet (IV.2). More timbers were added at a later date on both sides of the inlet: in 1059-64 on the west side (V.6), and some time in the second half of the 11th century on the east (V.8). Finally a new revetment was constructed on the west bank some time after 1080. This latter event could be contemporary with the activity on the V.8 bank.

Discussion

The analysis was successful in that 117 out of 163 measured timbers were dated. Most of these were dated using traditional methods, but about five tentative matches were confirmed using the new SORT-STRING program. The latter was not strong enough however to confirm other tentative

dates, or to distinguish between several possible dates for the same sample (eg 5812, 6026 from V.4), and these remain undated. The use of SORT-STRING on the large group of phase V.3 samples indicated that, if it had been used instead of traditional methods, then fewer samples would have been dated. It is less useful therefore for use on large complex urban sites than perhaps it would be for a timber assemblage from a prehistoric site, for example, but further tests will be carried out on data from the later phases at Billingsgate.

The precision obtained for some of the phases is encouraging and it is hoped that, just as the analysis of the period V timbers produced a more exact date for phase IV.4, so the precision of the results for V.1 and V.8 will be refined after the analysis of timbers from later phases.

Conclusion

The tree-ring analysis of 202 samples from Billingsgate period V resulted in a reinterpretation of the site's phasing. It is now known that, following the construction of the IV.1 and IV.2 structures in 1039/40 or just after, timbers for a plank frontage and the consolidation of the bank behind were felled in 1055. Other structural timbers were felled after this, but precise felling dates are not yet available. The V.1 revetment, which was originally thought to be earlier than the V.3 bank, is in fact later since the timber for its construction were not felled before 1080.

Use of a new computer program for crossmatching confirmed some tentative results, but could not be used to replace traditional methods.

Acknowledgements

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Legends to Figs

Fig 1: Diagram showing the distribution of ring sequence length in relationship to the number of samples dated and undated.

Fig 2: Bar diagram showing the relative positions of the dated ring sequences from phase V.3.

Fig 3: Bar diagram showing the relative positions of the dated ring sequences from all phases except V.3.

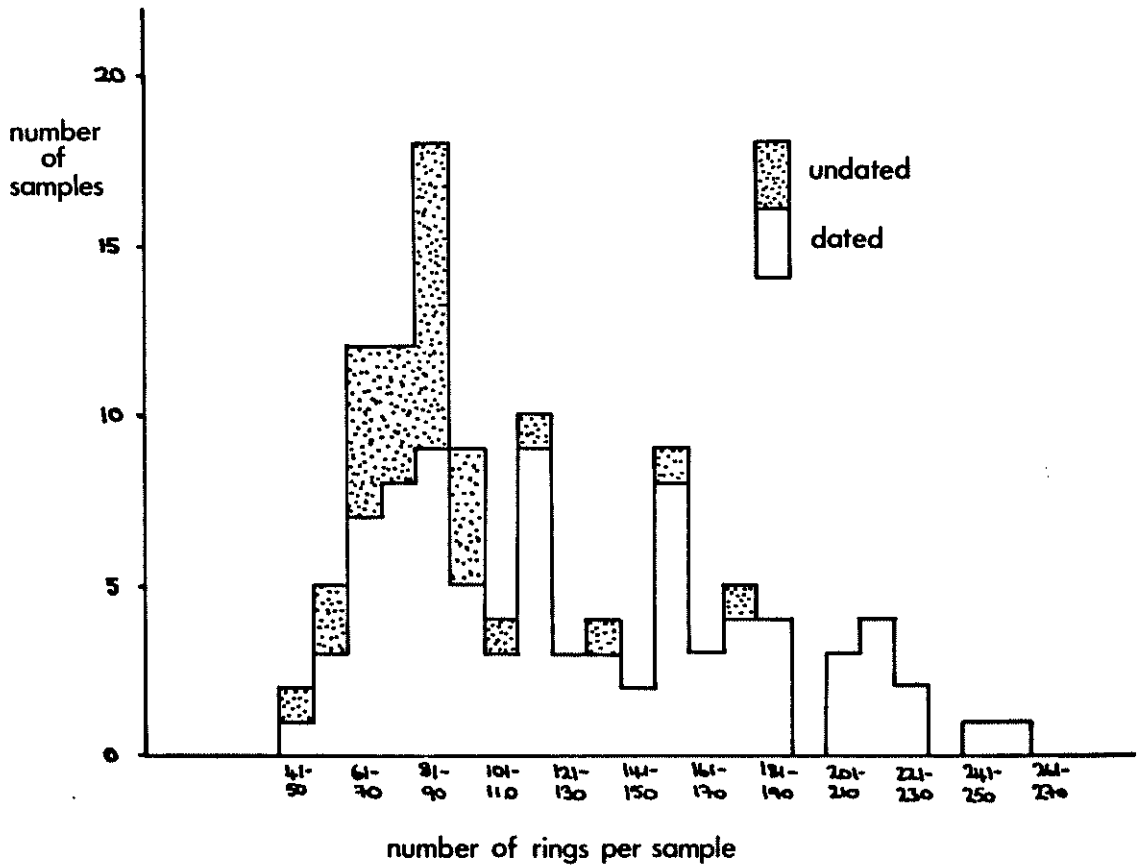

number of samples
20
15
10
5
0
undated
dated
41-50
61-70
81-90
101-110
121-130
141-150
161-170
181-190
201-210
221-230
241-250
261-270
number of rings per sample

FIG 1

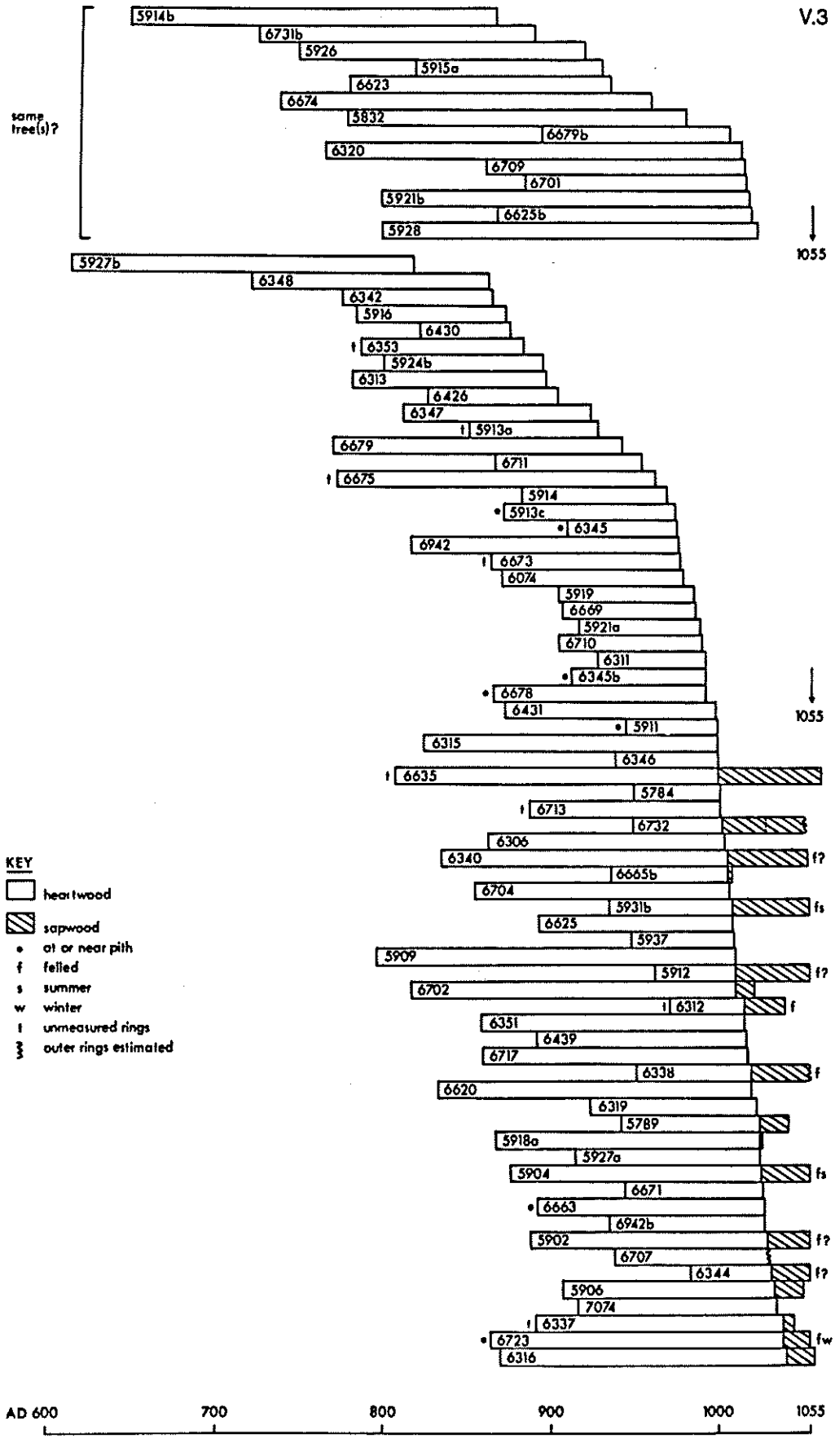

V.3
same tree(s)?
5914b
6731b
5926
5915a
6623
6674
5832
6679b
6320
6709
6701
5921b
6625b
5928
1055
5927b
6348
6342
5916
6430
t 6353
5924b
6313
6426
6347
t 5913a
6679
6711
t 6675
5914
• 5913c
• 6345
6942
t 6673
6074
5919
6669
5921a
6710
6311
• 6345b
• 6678
6431
• 5911
6315
6346
t 6635
5784
t 6713
6732
6306
6340
6665b
6704
5931b
6625
5937
5909
5912
6702
t 6312
6351
6439
6717
6338
6620
6319
5789
5918a
5927a
5904
6671
• 6663
6942b
5902
6707
6344
5906
7074
t 6337
• 6723
6316
1055
KEY
heartwood
sapwood
• at or near pith
f felled
s summer
w winter
t unmeasured rings
outer rings estimated
f?
fs
f?
f
f
fs
f?
f?
fw
AD 600
700
800
900
1000
1055

FIG 2

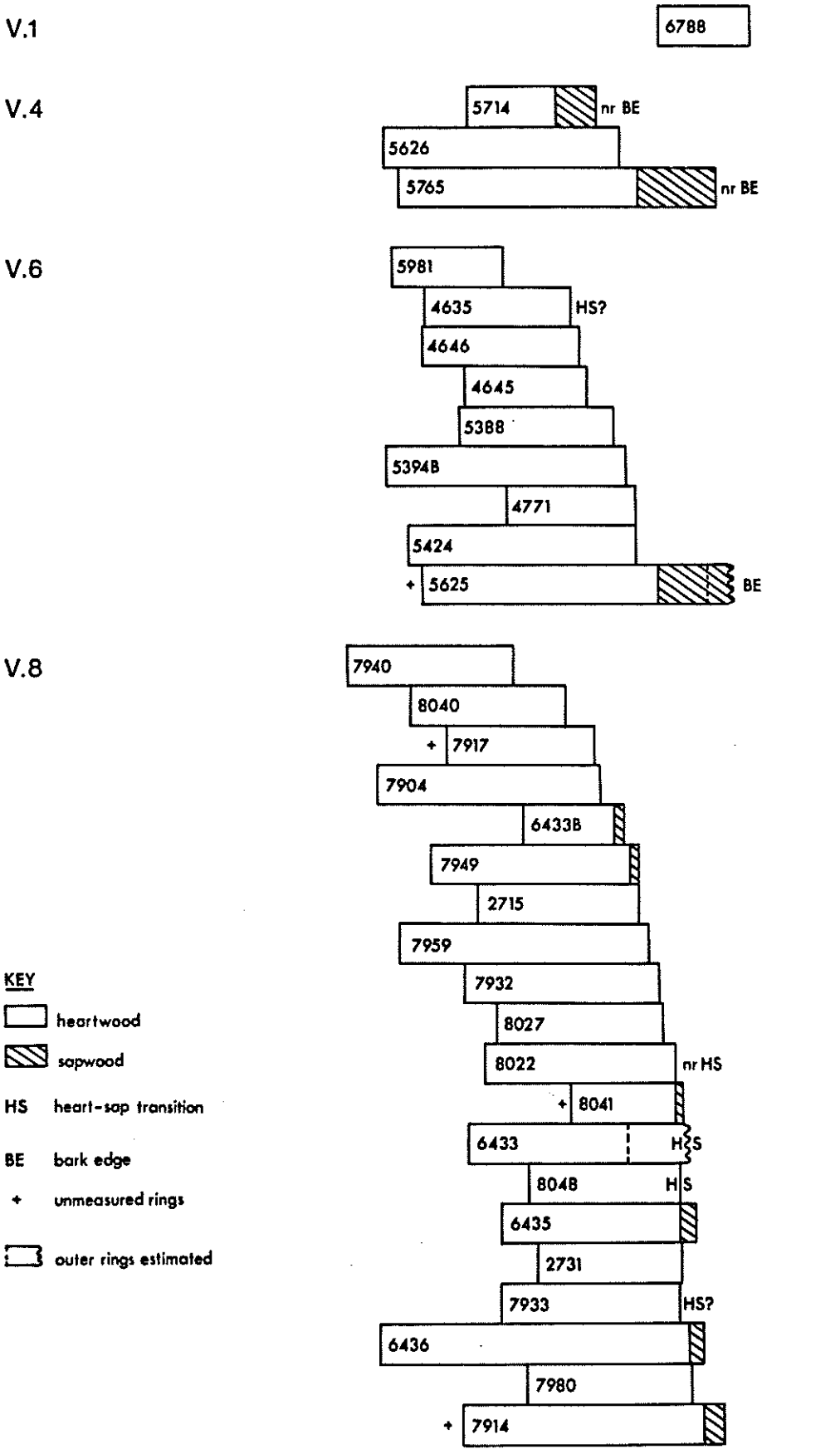

V.1
6788
V.4
5714
nr BE
5626
5765
nr BE
V.6
5981
4635
HS?
4646
4645
5388
5394B
4771
5424
+ 5625
BE
V.8
7940
8040
+ 7917
7904
6433B
7949
2715
7959
7932
8027
8022
nr HS
+ 8041
6433
HS
8048
HS
6435
2731
7933
HS?
6436
7980
+ 7914
KEY
heartwood
sapwood
HS heart-sap transition
BE bark edge
+ unmeasured rings
outer rings estimated
AD 800
900
1000
1100

FIG 3

Table 1: Phase V.3 - distribution of the average ring widths from the 114 measured samples. Those for the 61 measured samples from the medieval waterfront site at Dundas Wharf, Bristol (Nicholson & Hillam 1987), are given for comparison.

average widths(mm)	number of samples (%)	
	London	Bristol
0.5	3	0
0.5-0.99	34	21
1.0-1.49	42	25
1.5-1.99	15	21
2.0-2.49	4	11
2.5-2.99	2	7
3.0	0	15

Table 2: t-values between those samples which are probably from the same tree. 5832S and 5832E are the inner and outer portions of sample 5832 which was broken. * - overlap length is less than 50 years. (Note that 6623, 6674 and 6731B are definitely from the same tree.)

	5832S	5832E	5914B	5915A	5921B	5926	5928	6320	6623	6625B	6674	6679B	6701	6709	6731B
mean t	8.2	7.3	6.9	8.6	6.6	7.3	7.3	10.7	6.9	8.3	8.6	8.2	6.8	8.1	8.4
5832S	-	*	8.5	6.9	5.2	7.9	7.0	11.0	6.9	*	11.4	*	*	*	8.4
	5832E	-	*	8.1	5.7	*	5.6	10.4	4.8	9.4	6.7	8.4	6.3	7.8	*
		5914B	-	*	3.0	6.7	3.7	9.7	6.2	*	8.5	*	*	*	8.8
			5915B	-	9.2	6.6	8.1	11.9	6.9	7.7	10.8	*	*	9.5	8.3
				5921B	-	8.5	9.0	7.8	7.5	5.3	7.9	5.6	5.4	6.1	6.6
					5926	-	8.3	9.0	9.4	3.6	8.5	*	*	3.9	8.0
						5928	-	10.0	6.8	8.3	10.5	7.1	4.8	6.4	6.6
							6320	-	9.1	14.2	11.9	11.7	8.9	13.9	9.7
								6623	-	4.6	9.4	*	4.6	4.6	8.9
									6625B	-	6.7	10.1	8.0	12.8	*
										6674	-	4.5	5.6	6.6	10.7
											6679B	-	9.2	8.8	*
												6701	-	8.2	*
													6709	-	5.0
														6731B	-

Table 3: Dating the V.3 timbers. Examples of t-values for comparisons with master chronologies. * - value less than 3.5.

		t-value			
sample	date	Southwark	City Med	Big 4	Big53MK2
5784	950-1001	*	*	4.9	3.9
5902	888-1054	5.9	4.7	5.6	6.1
5926	749-919	*	5.9	5.2	9.6
6312	971-1039	4.3	*	6.0	5.2
6316	870-1057	7.6	5.6	9.2	9.2
6320	765-1012	5.3	6.9	8.8	10.8
6337	891-1044	*	*	4.2	4.1
6351	859-1026	4.8	*	4.3	*
6353	787-884	3.5	3.8	3.6	4.5
6669	907-986	4.4	5.4	3.5	*

Table 4: Tentative dating of 5812. t-values with reference chronologies for three possible positions of crossmatching. It is impossible to determine the correct match from the tree-ring evidence.

	end date (AD)		
chronology	955	998	1039
Southwark (Tyers pers comm)	3.6	4.2	2.8
City Med (Hillam unpubl)	2.3	4.1	1.0
England (Baillie & Pilcher pers comm)	1.7	1.5	3.1
Ref6 (Fletcher 1977)	2.1	2.2	3.7
Big58 (Billingsgate V.8)	1.3	0.7	3.8
Big45 (" IV/V)	4.9	2.7	3.8
Big53 (" V.3)	4.1	1.6	3.9

Table 5: Sequence of felling events phase by phase, based on the original archaeological interpretation. * - also includes timbers re-used from an earlier phase.

west of inlet				east of inlet			
IV.1		1039/40	*	IV.2	(i)	1039/40	*
IV.4		1049-1071			(ii)	1047-1070	
V.1		1080+					
V.3	(i)	1055	*	V.8		1011-1056	
	(ii)	1061/2				to	
	(iii)	1063-1094				1056-1101	
V.4		1054-6	*				
V.6	(i)	1023+	?*				
	(ii)	1059-64					

Table 6: Sequence of events in chronological order as indicated by the tree-ring results.

date	west of inlet	east of inlet	comment
1039/40	IV.1 bank	IV.2 bank	late 10th century timbers reused in both banks
1055	IV.4 frontage V.3 bank V.4 timbers	more IV.2 timbers	reuse of timbers felled in late 10th century (V.4) and in 1039/40 (V.3) on west bank
1059-64	V.6 timbers, 1 or 2 timbers from V.3	-	-
1056-1101	-	V.8 bank	may also contain timbers reused from IV.2; date may refined after the analysis of timbers from VI and VII
1080+	new V.1 revetment	-	could be contemporary with V.8 bank

Appendix A

Details of the tree-ring samples

Context - context number

Accn - accession number

Rings - total number of rings

Sapwood - number of sapwood rings

Av. width - Average ring width in mm

Dimensions - maximum dimensions of cross-section in mm

BE - bark edge

+ - rings present but not measured

5.1 - phase V.1

APPENDIX A - DETAILS OF SAMPLES

CONTEXT	ACCN	PHASE	RINGS	SAPWOOD	AV.WIDTH	DIMENSIONS	COMMENTS
6788	4905	5.1	47	-	2.64	155 X 150	meas by CG
7530	4919	5.1	36	-	-	170 x 130	-
5784	4508	5.3	52	-	2.00	175 x 65	-
5789	4656	5.3	100	18	1.48	170 x 105	-
5799	4891	5.3	-	-	-	250 x 125	-
5832	4670	5.3	-	-	1.05	215 x 60	in 2 pcs 96, 105 rings
5861	4689	5.3	87	8	0.91	140 x 95	-
5871	4393	5.3	-	-	-	230 x 185	poplar type
5873	4516	5.3	68	-	1.24	125 x 85	-
5901	4797	5.3	-	yes	-	100 x 100	narrow rings
5902	4807	5.3	167	26	1.19	190 x 190	?f 1054/5
5904	4811	5.3	-	30	0.89	155 x 65	fs 1055; in 2 pcs 70,95 rings
5906	4584	5.3	144	18	1.25	185 x 70	-
5908	4804	5.3	100	-	0.83	145 x 75	?errors
5909A	4690	5.3	+74	2	0.82	135 x 130	-
5909B	4384	5.3	214	-	0.80	215 x 190	-
5911	4700	5.3	55	-	1.25	140 x 125	-
5912	4036	5.3	93	45	0.64	85 x 65	?fw 1054/5
5913A	4335	5.3	+77	-	2.03	255 x 150	-
5913B	4765	5.3	48	-	1.88	85 x 80	-
5913C	4595	5.3	103	-	0.78	100 x 70	-
5914	4649	5.3	87	-	1.03	115 x 95	-
5914B	4657	5.3	218	-	0.75	180 x 55	-
5915A	4655	5.3	112	-	0.89	115 x 50	-
5915B	4232	5.3	81	26	1.16	190 x 100	felled ?summer
5916	4739	5.3	90	-	1.56	170 x 55	-
5917	4302	5.3	34	11	-	175 x 90	-
5918A	4684	5.3	160	3	0.77	140 x 100	-
5918B	4664	5.3	-	-	-	130 x 105	narrow rings
5919	4292	5.3	81	-	1.32	105 x 55	-
5920	4672	5.3	156	-	1.10	190 x 75	-
5921A	4297	5.3	73	-	1.35	110 x 100	-
5921B	4759	5.3	220	-	0.74	200 x 80	knot at outside
5922	4600	5.3	61	-	1.53	110 x 70	-
5924A	4336	5.3	-	yes	-	130 x 70	narrow rings
5924B	4640	5.3	90	-	1.94	200 x 80	-
5925	4671	5.3	-	-	-	155 x 85	very knotty
5926	4695	5.3	171	-	0.90	190 x 100	-
5927A	4738	5.3	110	-	0.87	105 x 60	-
5927B	4656	5.3	204	-	1.02	215 x 75	-
5928	4230	5.3	225	-	0.63	145 x 55	-
5931A	4350	5.3	65	-	1.10	80 x 30	-
5931B	4220	5.3	120	42-7	0.78	125 x 115	f ?summer 1055
5932	4547	5.3	50+	-	1.25	100 x 100	+ about 40
5934	4231	5.3	-	-	-	215 x 85	broken; knotty
5937	4037	5.3	62	-	2.84	220 x 125	-
6045	4691	5.3	-	-	-	200 x 180	very knotty
6074	4680	5.3	109	-	0.69	170 x 95	-
6305	4806	5.3	-	yes	-	170 x 110	narrow rings; included sapwood
6306	4764	5.3	140	-	1.21	190 x 55	-
6307	4630	5.3	-	-	-	110 x 75	narrow rings

APPENDIX A - DETAILS OF SAMPLES

CONTEXT	ACCN	PHASE	RINGS	SAPWOOD	AV.WIDTH	DIMENSIONS	COMMENTS
6307B	illeg	5.3	-	-	-	110 x 90	narrow rings
6309	4692	5.3	73	-	2.36	260 x 250	pith
6310	4583	5.3	102	22-6	1.58	175 x 75	fw
6311	4803	5.3	65	-	1.95	130 x 100	-
6312	4683	5.3	+69	16-25	1.29	250 x 115	f ?w
6313	4599	5.3	116	-	1.49	185 x 175	-
6314	-	5.3	-	-	-	-	-
6315	4888	5.3	175	nr bs	1.39	310 x 90	-
6316	4810	5.3	188	4-18	0.76	165 x 95	-
6319	4699	5.3	100	-	1.23	215 x 50	-
6320	illeg	5.3	248	-	0.99	260 x60	-
6334	6486	5.3	46	-	-	280 x 145	-
6335	4651	5.3	86	-	1.59	165 x 105	-
6337	4585	5.3	+154	7	1.01	225 x 85	knot at inside
6338	4665	5.3	69+	yes	1.40	120 x 115	+ about 34 to be: f c1053
6340	3366	5.3	219	49	0.52	125 x 90	fw (but narrow rings)
6341	4041	5.3	75	6	2.26	205 x 65	-
6342	4614	5.3	90	-	1.12	110 x 45	-
6344	4232	5.3	72	24	1.77	135 x 85	?fw 1054/5
6344B	4913	5.3	18	10	-	140 x 130	pith
6345	4808	5.3	66	-	1.10	140 x 130	pith
6345B	4685	5.3	81	-	1.04	160 x 155	pith
6346	illeg	5.3	63	-	2.01	135 x 110	-
6347	4565	5.3	113	-	0.99	130 x 90	-
6348	3365	5.3	142	-	0.92	130 x 90	-
6349	4351	5.3	41	-	-	85 x 45	-
6350	4677	5.3	-	-	-	140 x 70	narrow rings
6351	4757	5.3	168+	12+	0.73	130 x 90	20-30 to BE
6352	4299	5.3	91	-	1.64	165 x 115	-
6353	4758	5.3	+98	-	0.96	130 x 75	-
6419	4564	5.3	95	-	1.63	170 x 130	knotty at inside
6420	4637	5.3	-	-	-	140 x 75	narrow rings
6421	4653	5.3	49	-	-	135 x 90	-
6424	4693	5.3	-	-	-	150 x 125	narrow rings
6426	4601	5.3	78	-	1.69	145 x 55	-
6427	3367	5.3	-	-	-	110 x 35	narrow rings
6428	4591	5.3	84	21	1.74	155 x 70	-
6430	4629	5.3	55	-	1.91	115 x 55	-
6431	4732	5.3	126	-	0.98	150 x 80	-
6434	4648	5.3	60	-	2.59	170 x 55	-
6439	4636	5.3	125	-	1.28	175 x 45	-
6615	4669	5.3	86+	-	0.90	180 x 80	+ about 103
6619	4042	5.3	+90	25	1.19	225 x 140	nr pith
6619B	4752	5.3	-	yes	-	130 x 70	knotty
6620	4801	5.3	187	-	0.89	200 x 105	-
6623	4760	5.3	156	-	0.84	145 x 75	same tree as 6674
6624	4049	5.3	90	-	1.35	220 x 115	knotty
6625	4050	5.3	116	-	1.57	205 x 70	-
6625B	4754	5.3	152	-	1.07	190 x 60	-
6627	4039	5.3	-	-	-	155 x 70	knotty
6629	4694	5.3	-	yes	-	120 x 40	narrow rings; knotty

APPENDIX A - DETAILS OF SAMPLES

CONTEXT	ACCN	PHASE	RINGS	SAPWOOD	AV.WIDTH	DIMENSIONS	COMMENTS
6631	4095	5.3	-	-	-	165 x 70	knotty
6632	4733	5.3	83?	50?	0.59	145 x 80	near BE but ?errors
6634	4092	5.3	-	-	-	135 x 95	knotty
6635	4296	5.3	+254	62	0.41	130 x 45	NB av width
6663	4643	5.3	136	nr hs	1.07	230 x 155	pith
6664	4802	5.3	77	-	1.17	110 x 50	-
6665	4038	5.3	68	-	1.61	285 x 145	knotty
6665B	4755	5.3	73	4	1.07	85 x 45	-
6666	4610	5.3	68	-	1.36	185 x 150	v nr pith
6667	4762	5.3	72	-	1.37	125 x 115	knotty
6668	4661	5.3	-	-	-	180 x 90	narrow rings; knotty
6669	4679	5.3	80	-	1.45	160 x 155	pith
6671	illeg	5.3	83	-	1.44	195 x 55	-
6671B	4242	5.3	85	-	1.43	200 x 55	-
6671C	4093	5.3	173	-	0.91	180 x 55	-
6673	4043	5.3	+112	-	0.72	150 x 95	-
6674	4688	5.3	221	-	0.83	215 x 80	same tree as 6623
6675	4659	5.3	+190	-	0.71	165 x 60	-
6677	4559	5.3	112	-	1.19	140 x 90	-
6678	4560	5.3	127	-	1.38	200 x 130	-
6679	4676	5.3	172	-	1.04	205 x 85	-
6679B	4639	5.3	113	-	1.06	140 x 65	-
6700	4650	5.3	88	-	1.51	160 x 75	-
6701	4536	5.3	133	-	0.72	110 x 70	-
6702	4766	5.3	205	12	0.61	140 x 65	-
6704	4561	5.3	152	-	0.49	245 x 65	-
6706	4675	5.3	139	-	1.24	205 x 50	-
6707	4652	5.3	83+	-	1.45	155 x 60	about 10 unmeasd heart rings
6708	4658	5.3	-	-	-	120 x 40	very narrow rings
6709	4033	5.3	155	-	1.25	220 x 50	-
6710	4702	5.3	86	-	1.04	105 x 40	-
6711	4645	5.3	88	-	1.51	150 x 65	-
6713	4696	5.3	+114	-	1.12	150 x 90	-
6715	-	5.3	-	-	-	-	-
6717	4096	5.3	158	-	0.80	150 x 55	difficult to measure
6719	4673	5.3	67	5	0.81	135 x 105	pith
6721	4740	5.3	45	-	-	80 x 60	-
6722	4089	5.3	49	-	-	100 x 40	-
6723	4698	5.3	190	17	0.68	180 x 135	near pith; f 1054/5
6726	4615	5.3	+96	71	0.46	170 x 105	many rings unmeasd; BE; ?error
6728	4654	5.3	-	-	-	195 x 145	knotty
6731	4602	5.3	-	-	-	110 x 90	narrow rings
6731B	4604	5.3	165	-	0.84	160 x 60	same tree as 6623/6674
6732	4090	5.3	80+	27+	1.00	125 x 95	about 22 to BE
6942	4731	5.3	160	-	0.68	135 x 90	-
6942B	4730	5.3	93	-	1.00	110 x 75	-
6965	4982	5.3	55	16	1.96	170 x 140	fs; knotty; 2 centres
6983	4753	5.3	43	-	-	175 x 165	-
7074	4452	5.3	119	-	1.03	280 x 130	-
5626	4576	5.4	119	-	1.37	175 x 105	-
5659	4366	5.4	54	37	1.06	110 x 60	near BE; 2 radii

APPENDIX A - DETAILS OF SAMPLES

CONTEXT	ACCN	PHASE	RINGS	SAPWOOD	AV.WIDTH	DIMENSIONS	COMMENTS
5661	-	5.4	-	-	-	-	-
5714	4487	5.4	65	21	1.88	135 x 50	near BE; 2 radii
5765	4492	5.4	159	40	-	120 x 35	near BE; meas in 2 sections
5812	4490	5.4	121+	6+	0.60	115 x 85	-
6026	4661	5.4	179+	-	0.86	165 x 120	+ about 30 rings
6027	4736	5.4	-	-	-	165 x 95	rings too narrow
3269	4557	5.6	64	-	0.86	115 x 50	-
4635	3378	5.6	74	?HS 982	1.36	140 x 80	-
4643	4556	5.6	-	-	-	80 x 75	broken
4645	4291	5.6	62	-	1.16	85 x 65	-
4646	4668	5.6	79	-	1.44	110 x 110	-
4771	4697	5.6	65	-	2.19	180 x 95	-
5304	4641	5.6	124	-	0.66	135 x 75	-
5334	4606	5.6	79	-	1.07	100 x 70	-
5387	4496	5.6	93	-	1.02	240 x 70	knotty
5388	5388	5.6	78	-	1.03	90 x 45	-
5389	4809	5.6	89	-	2.56	245 x 60	-
5392	4293	5.6	51+	-	1.51	90 x 85	-
5394B	4593	5.6	120	-	0.81	115 x 100	-
5394	4592	5.6	100	-	0.62	90 x 45	-
5423	4674	5.6	39	-	-	150 x 85	-
5424	4567	5.6	114	-	0.87	135 x 85	-
5625	3314	5.6	+143+	26+	1.04	200 x 135	10-15 rings to BE
5750	4520	5.6	-	yes	-	330 x 150	knotty
5981	4760	5.6	56	-	1.72	140 x 75	-
2715	4626	5.8	81	-	2.18	210 x 115	-
2731	4378	5.8	73	-	0.86	110 x 65	-
6432	4681	5.8	-	-	-	200 x 140	rings too narrow
6433	4881	5.8	80+	yes	1.32	135 x 70	25-30 rings to hs
6433B	4097	5.8	51	6	1.15	115 x 75	-
6435	4594	5.8	98	9	1.28	145 x 65	-
6436	4734	5.8	162	8	1.27	225 x 95	knotty
7252	-	5.8	-	-	-	-	-
7904	4971	5.8	112	-	2.12	280 x 85	knotty
7914	4958	5.8	+128+	18+	0.92	190 x 70	at least 3 rings not measd
7917	4957	5.8	+74	-	1.03	200 x 80	-
7932	4938	5.8	98	-	1.28	140 x 75	-
7933	4932	5.8	90	-	1.24	120 x 40	hs visible
7940	4940	5.8	83	-	1.86	195 x 170	-
7949	4920	5.8	104	5	0.83	100 x 85	-
7959	4916	5.8	125	-	0.77	110 x 80	-
7969	4893	5.8	87+	-	1.56	175 x 95	+ 15 rings
7970	4930	5.8	73+	1+	1.29	100 x 100	+ 20 sap rings
7979	4502	5.8	117	-	1.08	165 x 90	knotty
7980	4928	5.8	83	-	1.74	160 x 40	-
7984	4943	5.8	76	-	1.69	165 x 145	-
7987	4944	5.8	-	yes	-	115 x 65	rings too narrow
8022	4894	5.8	96	-	1.33	150 x 70	near hs
8027	4937	5.8	84	-	1.30	120 x 60	-
8031	4971	5.8	54	2	1.23	90 x 85	-
8040	4979	5.8	78	-	2.01	165 x 80	-

APPENDIX A - DETAILS OF SAMPLES

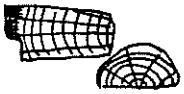
CONTEXT	ACCN	PHASE	RINGS	SAPWOOD	AV.WIDTH	DIMENSIONS	COMMENTS
8041	4924	5.8	+57	4	1.40	150 x 100	-
8048	4988	5.8	76	1	1.58	140 x 75	-

Appendix B

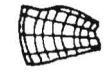
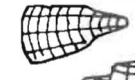
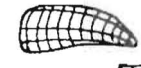
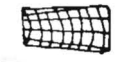
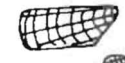
Cross-sectional sketches

These are not drawn to scale, and are intended as a rough guide to the way in which the timbers were cut or split. Sapwood is represented by shading.

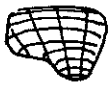
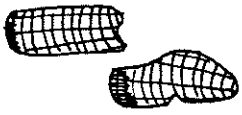
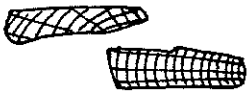
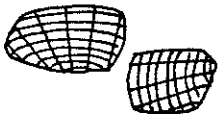
APPENDIX B - CROSS-SECTIONAL SKETCHES AND DIMENSIONS (MM)

PHASE	CONTEXT	ACCN		DIMENSIONS
5.1	6788	4905		155 X 150
5.1	7530	4919		170 x 130
5.3	5784	4508		175 x 65
5.3	5789	4656		170 x 105
5.3	5799	4891		250 x 125
5.3	5832	4670		215 x 60
5.3	5861	4689		140 x 95
5.3	5871	4393		230 x 185
5.3	5873	4516		125 x 85
5.3	5901	4797		100 x 100
5.3	5902	4807		190 x 190
5.3	5904	4811		155 x 65
5.3	5906	4584		185 x 70
5.3	5908	4804		145 x 75
5.3	5909A	4690		135 x 130
5.3	5909B	4384		215 x 190
5.3	5911	4700		140 x 125
5.3	5912	4036		85 x 65
5.3	5913A	4335		255 x 150
5.3	5913B	4765		85 x 80
5.3	5913C	4595		100 x 70
5.3	5914	4649		115 x 95
5.3	5914B	4657		180 x 55
5.3	5915A	4655		115 x 50
5.3	5915B	4232		190 x 100

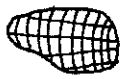
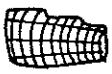
APPENDIX B - CROSS-SECTIONAL SKETCHES AND DIMENSIONS (MM)

PHASE	CONTEXT	ACCN		DIMENSIONS
5.3	5916	4739		170 x 55
5.3	5917	4302		175 x 90
5.3	5918A	4684		140 x 100
5.3	5918B	4664		130 x 105
5.3	5919	4292		105 x 55
5.3	5920	4672		190 x 75
5.3	5921A	4297		110 x 100
5.3	5921B	4759		200 x 80
5.3	5922	4600		110 x 70
5.3	5924A	4336		130 x 70
5.3	5924B	4640		200 x 80
5.3	5925	4671		155 x 85
5.3	5926	4695		190 x 100
5.3	5927A	4738		105 x 60
5.3	5927B	4656		215 x 75
5.3	5928	4230		145 x 55
5.3	5931A	4350		80 x 30
5.3	5931B	4220		125 x 115
5.3	5932	4547		100 x 100
5.3	5934	4231		215 x 85
5.3	5937	4037		220 x 125
5.3	6045	4691		200 x 180
5.3	6074	4680		170 x 95
5.3	6305	4806		170 x 110
5.3	6306	4764		190 x 55

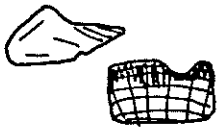
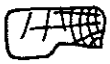
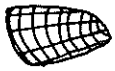
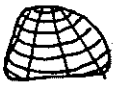
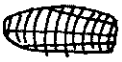
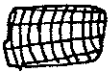
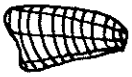
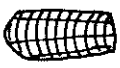
APPENDIX B - CROSS-SECTIONAL SKETCHES AND DIMENSIONS (MM)

PHASE	CONTEXT	ACCN		DIMENSIONS
5.3	6307	4630		110 x 75
5.3	6307B	illeg		110 x 90
5.3	6309	4692		260 x 250
5.3	6310	4583		175 x 75
5.3	6311	4803		130 x 100
5.3	6312	4683		250 x 115
5.3	6313	4599		185 x 175
5.3	6314	-	-	-
5.3	6315	4888		310 x 90
5.3	6316	4810		165 x 95
5.3	6319	4699		215 x 50
5.3	6320	illeg		260 x60
5.3	6334	6486		280 x 145
5.3	6335	4651		165 x 105
5.3	6337	4585		225 x 85
5.3	6338	4665		120 x 115
5.3	6340	3366		125 x 90
5.3	6341	4041		205 x 65
5.3	6342	4614		110 x 45
5.3	6344	4232		135 x 85
5.3	6344B	4913		140 x 130
5.3	6345	4808		140 x 130
5.3	6345B	4685		160 x 155
5.3	6346	illeg		135 x 110
5.3	6347	4565		130 x 90

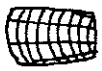
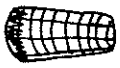
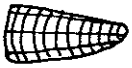
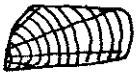
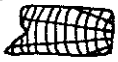
APPENDIX B - CROSS-SECTIONAL SKETCHES AND DIMENSIONS (MM)

PHASE	CONTEXT	ACCN		DIMENSIONS
5.3	6348	3365		130 x 90
5.3	6349	4351		85 x 45
5.3	6350	4677		140 x 70
5.3	6351	4757		130 x 90
5.3	6352	4299		165 x 115
5.3	6353	4758		130 x 75
5.3	6419	4564		170 x 130
5.3	6420	4637		140 x 75
5.3	6421	4653		135 x 90
5.3	6424	4693		150 x 125
5.3	6426	4601		145 x 55
5.3	6427	3367		110 x 35
5.3	6428	4591		155 x 70
5.3	6430	4629		115 x 55
5.3	6431	4732		150 x 80
5.3	6434	4648		170 x 55
5.3	6439	4636		175 x 45
5.3	6615	4669		180 x 80
5.3	6619	4042		225 x 140
5.3	6619B	4752		130 x 70
5.3	6620	4801		200 x 105
5.3	6623	4760		145 x 75
5.3	6624	4049		220 x 115
5.3	6625	4050		205 x 70
5.3	6625B	4754		190 x 60

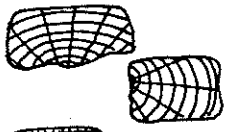
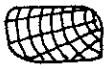
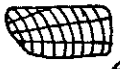
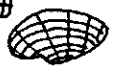
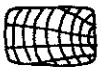
APPENDIX B - CROSS-SECTIONAL SKETCHES AND DIMENSIONS (MM)

PHASE	CONTEXT	ACCN		DIMENSIONS
5.3	6627	4039		155 x 70
5.3	6629	4694		120 x 40
5.3	6631	4095		165 x 70
5.3	6632	4733		145 x 80
5.3	6634	4092		135 x 95
5.3	6635	4296		130 x 45
5.3	6663	4643		230 x 155
5.3	6664	4802		110 x 50
5.3	6665	4038		285 x 145
5.3	6665B	4755		85 x 45
5.3	6666	4610		185 x 150
5.3	6667	4762		125 x 115
5.3	6668	4661		180 x 90
5.3	6669	4679		160 x 155
5.3	6671	illeg		195 x 55
5.3	6671B	4242		200 x 55
5.3	6671C	4093		180 x 55
5.3	6673	4043		150 x 95
5.3	6674	4688		215 x 80
5.3	6675	4659		165 x 60
5.3	6677	4559		140 x 90
5.3	6678	4560		200 x 130
5.3	6679	4676		205 x 85
5.3	6679B	4639		140 x 65
5.3	6700	4650		160 x 75

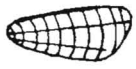
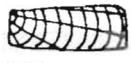
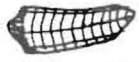
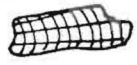
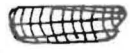
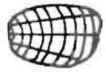
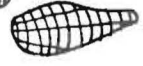
APPENDIX B - CROSS-SECTIONAL SKETCHES AND DIMENSIONS (MM)

PHASE	CONTEXT	ACCN		DIMENSIONS
5.3	6701	4536		110 x 70
5.3	6702	4766		140 x 65
5.3	6704	4561		245 x 65
5.3	6706	4675		205 x 50
5.3	6707	4652		155 x 60
5.3	6708	4658		120 x 40
5.3	6709	4033		220 x 50
5.3	6710	4702		105 x 40
5.3	6711	4645		150 x 65
5.3	6713	4696		150 x 90
5.3	6715	-	-	-
5.3	6717	4096		150 x 55
5.3	6719	4673		135 x 105
5.3	6721	4740		80 x 60
5.3	6722	4089		100 x 40
5.3	6723	4698		180 x 135
5.3	6726	4615		170 x 105
5.3	6728	4654		195 x 145
5.3	6731	4602		110 x 90
5.3	6731B	4604		160 x 60
5.3	6732	4090		125 x 95
5.3	6942	4731		135 x 90
5.3	6942B	4730		110 x 75
5.3	6965	4982		170 x 140
5.3	6983	4753		175 x 165

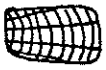
APPENDIX B - CROSS-SECTIONAL SKETCHES AND DIMENSIONS (MM)

PHASE	CONTEXT	ACCN		DIMENSIONS
5.3	7074	4452		280 x 130
5.4	5626	4576		175 x 105
5.4	5659	4366		110 x 60
5.4	5661	-	-	-
5.4	5714	4487		135 x 50
5.4	5765	4492		120 x 35
5.4	5812	4490		115 x 85
5.4	6026	4661		165 x 120
5.4	6027	4736		165 x 95
5.6	3269	4557		115 x 50
5.6	4635	3378		140 x 80
5.6	4643	4556		80 x 75
5.6	4645	4291		85 x 65
5.6	4646	4668		110 x 110
5.6	4771	4697		180 x 95
5.6	5304	4641		135 x 75
5.6	5334	4606		100 x 70
5.6	5387	4496		240 x 70
5.6	5388	5388		90 x 45
5.6	5389	4809		245 x 60
5.6	5392	4293		90 x 85
5.6	5394B	4593		115 x 100
5.6	5394	4592		90 x 45
5.6	5423	4674		150 x 85
5.6	5424	4567		135 x 85

APPENDIX B - CROSS-SECTIONAL SKETCHES AND DIMENSIONS (MM)

PHASE	CONTEXT	ACCN		DIMENSIONS
5.6	5625	3314		200 x 135
5.6	5750	4520		330 x 150
5.6	5981	4760		140 x 75
5.8	2715	4626		210 x 115
5.8	2731	4378		110 x 65
5.8	6432	4681		200 x 140
5.8	6433	4881		135 x 70
5.8	6433B	4097		115 x 75
5.8	6435	4594		145 x 65
5.8	6436	4734		225 x 95
5.8	7252	-	-	-
5.8	7904	4971		280 x 85
5.8	7914	4958		190 x 70
5.8	7917	4957		200 x 80
5.8	7932	4938		140 x 75
5.8	7933	4932		120 x 40
5.8	7940	4940		195 x 170
5.8	7949	4920		100 x 85
5.8	7959	4916		110 x 80
5.8	7969	4893		175 x 95
5.8	7970	4930		100 x 100
5.8	7979	4502		165 x 90
5.8	7980	4928		160 x 40
5.8	7984	4943		165 x 145
5.8	7987	4944		115 x 65

APPENDIX B - CROSS-SECTIONAL SKETCHES AND DIMENSIONS (MM)

PHASE	CONTEXT	ACCN		DIMENSIONS
5.8	8022	4894		150 x 70
5.8	8027	4937		120 x 60
5.8	8031	4971		90 x 85
5.8	8040	4979		165 x 80
5.8	8041	4924		150 x 100
5.8	8048	4988		140 x 75

Appendix C

Results

Context - context number
Accn - accession number
BE - bark edge
+ - rings present but not measured
5.3 - phase V.3

Dates of heartwood-sapwood transitions, where present, are given in brackets. 95% confidence limits for the felling date range can be obtained by adding 10-55 rings to this date. In the absence of sapwood, add 10 to the date of the last measured heartwood ring to obtain the probable terminus post quem for felling. (Note that one in twenty samples are likely to have either more than 55 or less than 10 sapwood rings - see Hillam et al 1987 for further details on sapwood estimates).

Where bark or bark edge is present, the felling date is known exact to the year, and does not have to be estimated.

APPENDIX C - RESULTS

CONTEXT	ACCN	PHASE	RESULT 1	RESULT 2	COMMENTS
6788	4905	5.1	dated	1024-1070	meas by CG
7530	4919	5.1	rejected	-	-
5784	4508	5.3	dated	950-1001	-
5789	4656	5.3	dated	942-1041(1024)	-
5799	4891	5.3	rejected	-	-
5832	4670	5.3	dated	778-979	in 2 pcs 96, 105 rings
5861	4689	5.3	undated	-	-
5871	4393	5.3	rejected	-	poplar type
5873	4516	5.3	undated	-	-
5901	4797	5.3	rejected	-	narrow rings
5902	4807	5.3	dated	888-1054(1029)	?f 1054/5
5904	4811	5.3	dated	876-1054(1025)	fs 1055; in 2 pcs 70,95 rings
5906	4584	5.3	dated	907-1050(1033)	-
5908	4804	5.3	undated	-	?errors
5909A	4690	5.3	undated	-	-
5909B	4384	5.3	dated	797-1010	-
5911	4700	5.3	dated	945-999	-
5912	4036	5.3	dated	962-1054(1010)	?fw 1054/5
5913A	4335	5.3	dated	+852-928	-
5913B	4765	5.3	dated	949-996	-
5913C	4595	5.3	dated	872-974	-
5914	4649	5.3	dated	883-969	-
5914B	4657	5.3	dated	649-866	-
5915A	4655	5.3	dated	818-929	-
5915B	4232	5.3	undated	-	felled ?summer
5916	4739	5.3	dated	784-873	-
5917	4302	5.3	rejected	-	-
5918A	4684	5.3	dated	867-1026(1024)	-
5918B	4664	5.3	rejected	-	narrow rings
5919	4292	5.3	dated	905-985	-
5920	4672	5.3	undated	-	-
5921A	4297	5.3	dated	917-989	-
5921B	4759	5.3	dated	798-1017	knot at outside
5922	4600	5.3	undated	-	-
5924A	4336	5.3	rejected	-	narrow rings
5924B	4640	5.3	dated	801-895	-
5925	4671	5.3	rejected	-	very knotty
5926	4695	5.3	dated	749-919	-
5927A	4738	5.3	dated	915-1024	-
5927B	4656	5.3	dated	615-818	-
5928	4230	5.3	dated	798-1022	-
5931A	4350	5.3	dated	823-887	-
5931B	4220	5.3	dated	935-1054(1008-13)	f ?summer 1055
5932	4547	5.3	undated	-	+ about 40
5934	4231	5.3	rejected	-	broken; knotty
5937	4037	5.3	dated	948-1009	-
6045	4691	5.3	rejected	-	very knotty
6074	4680	5.3	dated	871-979	-
6305	4806	5.3	rejected	-	narrow rings; included sapwood
6306	4764	5.3	dated	864-1003	-
6307	4630	5.3	rejected	-	narrow rings

CONTEXT	ACCN	PHASE	RESULT 1	RESULT 2	COMMENTS
6307B	illeg	5.3	rejected	-	narrow rings
6309	4692	5.3	undated	-	pith
6310	4583	5.3	undated	-	fw
6311	4803	5.3	dated	928-992	-
6312	4683	5.3	dated	+971-1039(1015-24)	f ?w
6313	4599	5.3	dated	782-897	-
6314	-	5.3	still to c	-	-
6315	4888	5.3	dated	825-999	-
6316	4810	5.3	dated	870-1057(1040-54)	-
6319	4699	5.3	dated	923-1022	-
6320	illeg	5.3	dated	765-1012	-
6334	6486	5.3	rejected	-	-
6335	4651	5.3	undated	-	-
6337	4585	5.3	dated	+891-1044(1038)	knot at inside
6338	4665	5.3	dated	951-1019+	+ about 34 to be: f c1053
6340	3366	5.3	dated	835-1053(1005)	fw (but narrow rings)
6341	4041	5.3	undated	-	-
6342	4614	5.3	dated	776-865	-
6344	4232	5.3	dated	983-1054(1031)	?fw 1054/5
6344B	4913	5.3	rejected	-	pith
6345	4808	5.3	dated	910-975	pith
6345B	4685	5.3	dated	912-992	pith
6346	illeg	5.3	dated	939-1000	-
6347	4565	5.3	dated	812-924	-
6348	3365	5.3	dated	722-863	-
6349	4351	5.3	rejected	-	-
6350	4677	5.3	rejected	-	narrow rings
6351	4757	5.3	dated	859-1026(1015)+	20-30 to BE
6352	4299	5.3	undated	-	-
6353	4758	5.3	dated	+787-884	-
6419	4564	5.3	undated	-	knotty at inside
6420	4637	5.3	rejected	-	narrow rings
6421	4653	5.3	rejected	-	-
6424	4693	5.3	rejected	-	narrow rings
6426	4601	5.3	dated	827-904	-
6427	3367	5.3	rejected	-	narrow rings
6428	4591	5.3	undated	-	-
6430	4629	5.3	dated	822-876	-
6431	4732	5.3	dated	873-998	-
6434	4648	5.3	undated	-	-
6439	4636	5.3	dated	892-1-16	-
6615	4669	5.3	undated	-	+ about 103
6619	4042	5.3	undated	-	nr pith
6619B	4752	5.3	rejected	-	knotty
6620	4801	5.3	dated	833-1019	-
6623	4760	5.3	dated	779-934	same tree as 6674
6624	4049	5.3	undated	-	knotty
6625	4050	5.3	dated	893-1008	-
6625B	4754	5.3	dated	867-1018	-
6627	4039	5.3	rejected	-	knotty
6629	4694	5.3	rejected	-	narrow rings; knotty

CONTEXT	ACCN	PHASE	RESULT 1	RESULT 2	COMMENTS
6631	4095	5.3	rejected	-	knotty
6632	4733	5.3	undated	-	near BE but ?errors
6634	4092	5.3	rejected	-	knotty
6635	4296	5.3	dated	+808-1061(1000)	NB av width
6663	4643	5.3	dated	892-1027(1028)	pith
6664	4802	5.3	dated	830-906	-
6665	4038	5.3	undated	-	knotty
6665B	4755	5.3	dated	936-1008(1005)	-
6666	4610	5.3	undated	-	v nr pith
6667	4762	5.3	undated	-	knotty
6668	4661	5.3	rejected	-	narrow rings; knotty
6669	4679	5.3	dated	907-986	pith
6671	illeg	5.3	dated	944-1026	-
6671B	4242	5.3	undated	-	-
6671C	4093	5.3	undated	-	-
6673	4043	5.3	dated	+866-977	-
6674	4688	5.3	dated	738-958	same tree as 6623
6675	4659	5.3	dated	+773-962	-
6677	4559	5.3	undated	-	-
6678	4560	5.3	dated	866-992	-
6679	4676	5.3	dated	771-942	-
6679B	4639	5.3	dated	893-1005	-
6700	4650	5.3	undated	-	-
6701	4536	5.3	dated	883-1015	-
6702	4766	5.3	dated	817-1021(1010)	-
6704	4561	5.3	dated	855-1006	-
6706	4675	5.3	undated	-	-
6707	4652	5.3	dated	938-1020+	about 10 unmeasd heart rings
6708	4658	5.3	rejected	-	very narrow rings
6709	4033	5.3	dated	860-1014	-
6710	4702	5.3	dated	905-990	-
6711	4645	5.3	dated	867-954	-
6713	4696	5.3	dated	+888-1001	-
6715	-	5.3	still to c	-	-
6717	4096	5.3	dated	860-1017	difficult to measure
6719	4673	5.3	undated	-	pith
6721	4740	5.3	rejected	-	-
6722	4089	5.3	rejected	-	-
6723	4698	5.3	dated	865-1054(1038)	near pith; f 1054/5
6726	4615	5.3	undated	-	many rings unmeasd; BE; ?errors
6728	4654	5.3	rejected	-	knotty
6731	4602	5.3	rejected	-	narrow rings
6731B	4604	5.3	dated	725-889	same tree as 6623/6674
6732	4090	5.3	dated	949-1028(1002)+	about 22 to BE
6942	4731	5.3	dated	817-976	-
6942B	4730	5.3	dated	935-1027	-
6965	4982	5.3	undated	-	fs; knotty; 2 centres
6983	4753	5.3	rejected	-	-
7074	4452	5.3	dated	916-1034	-
5626	4576	5.4	dated	887-1005	-
5659	4366	5.4	undated	-	near BE; 2 radii

CONTEXT	ACCN	PHASE	RESULT 1	RESULT 2	COMMENTS
5661	-	5.4	still to c	-	-
5714	4487	5.4	dated	929-993(973)	near BE; 2 radii
5765	4492	5.4	dated	895-1053(1014)	near BE; meas in 2 sections
5812	4490	5.4	undated	-	-
6026	4661	5.4	undated	-	+ about 30 rings
6027	4736	5.4	rejected	-	rings too narrow
3269	4557	5.6	undated	-	-
4635	3378	5.6	dated	908-981	-
4643	4556	5.6	rejected	-	broken
4645	4291	5.6	dated	928-989	-
4646	4668	5.6	dated	907-985	-
4771	4697	5.6	dated	949-1013	-
5304	4641	5.6	undated	-	-
5334	4606	5.6	undated	-	-
5387	4496	5.6	undated	-	knotty
5388	5388	5.6	dated	925-1002	-
5389	4809	5.6	undated	-	-
5392	4293	5.6	undated	-	-
5394B	4593	5.6	dated	889-1008	-
5394	4592	5.6	undated	-	-
5423	4674	5.6	rejected	-	-
5424	4567	5.6	dated	900-1013	-
5625	3314	5.6	dated	+907-1049(1024)+	10-15 rings to BE
5750	4520	5.6	rejected	-	knotty
5981	4760	5.6	dated	1015-1070	-
2715	4626	5.8	dated	934-1014	-
2731	4378	5.8	dated	963-1035	-
6432	4681	5.8	rejected	-	rings too narrow
6433	4881	5.8	dated	929-1008+	25-30 rings to hs
6433B	4097	5.8	dated	957-1007(1002)	-
6435	4594	5.8	dated	945-1042(1034)	-
6436	4734	5.8	dated	885-1046(1039)	knotty
7252	-	5.8	still to c	-	-
7904	4971	5.8	dated	884-995	knotty
7914	4958	5.8	dated	+926-1053(1046)+	at least 3 rings not measd
7917	4957	5.8	dated	+919-992	-
7932	4938	5.8	dated	927-1-24	-
7933	4932	5.8	dated	945-1034(1035)	hs visible
7940	4940	5.8	dated	870-952	-
7949	4920	5.8	dated	911-1014(1010)	-
7959	4916	5.8	dated	895-1019	-
7969	4893	5.8	undated	-	+ 15 rings
7970	4930	5.8	undated	-	+ 20 sap rings
7979	4502	5.8	undated	-	knotty
7980	4928	5.8	dated	958-1040	-
7984	4943	5.8	undated	-	-
7987	4944	5.8	rejected	-	rings too narrow
8022	4894	5.8	dated	937-1032	near hs
8027	4937	5.8	dated	943-1026	-
8031	4971	5.8	undated	-	-
8040	4979	5.8	dated	901 x 978	-

APPENDIX C - RESULTS

CONTEXT	ACCN	PHASE	RESULT 1	RESULT 2	COMMENTS
8041	4924	5.8	dated	+980-1036(1032)	-
8048	4988	5.8	dated	959-1034(1034)	-