Ancient Monuments Laboratory
Report 43/87

TREE-RING ANALYSIS OF ROMAN TIMBERS FROM CAERLEON, MUSEUM SITE, 1983-5.

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Summary

Tree-ring analysis was carried out on 26 oak samples from the Museum site. Thirteen were from the earliest timber building, dated archaeologically to AD 75, and thirteen were from piles which had been driven into a disused well of about AD 90-100. Eight timbers from the original construction were dated, producing a short master curve, 33BC- AD62. The timbers were felled after AD61 and probably before AD 98. The well timbers, however, proved difficult to date with poor crossmatching between the individual ring sequences, even though many of them had bark or bark edge. Two of the timbers were dated, one firmly and the other tentatively. The former had a felling date of about AD 72-73, suggesting that felling was contemporary with the original construction of the fortress.

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Tree-ring analysis of Roman timbers from Caerleon, Museum site, 1983-5

Introduction

Two groups of tree-ring samples from the Museum site were examined in 1986-7. The first group of thirteen was from the earliest timber building on the site which is thought to date to about AD 75. The sampled oak timbers (*Quercus* spp) were all uprights which had been cleft to rectangular section from complete or halved logs. None of the timbers retained bark.

In contrast to these timbers from the earliest period of construction at the legionary fortress, the second group of thirteen samples was from a phase dating to about AD 90-100. They were from oak piles which had been driven into a well (well 2) to consolidate the soft infilling prior to the construction of a stone building. Most of the piles were complete stems with bark or bark edge present, and they did not appear to be re-used.

The dendrochronological work was undertaken to provide precise dates for the two phases. Whilst the establishment of the fortress is thought on historical and archaeological grounds to be about AD 74-78, the timbers could have been robbed at this time from the then disused fortress at nearby Usk. It was hoped that the tree-ring dates would provide either a precise date for the Caerleon fortress or show that the timbers had been

robbed from the Usk fortress which was constructed around AD 55.

A secondary reason for the Caerleon study was that it offered a chance to examine timbers of Roman date from outside the London area. The majority of sites with Roman timbers examined during the last ten years have been in the City of London (eg Hillam 1985a; Sheldon & Tyers 1983). The Caerleon timbers therefore had the potential of producing a tree-ring chronology from a non-London area.

Methods

The samples were frozen for at least 48 hours. The cross-sections were then cleaned, whilst still frozen, with a surform plane which leaves the boundaries of the rings clearly visible. The annual rings were measured on a travelling stage connected to an Apple II microcomputer which automatically records the widths after each ring has been traversed (Hillam 1985b, Fig 4). Usually only one set of measurements was made per sample, but where crossmatching proved difficult, a second set was made along a different radius. The two sets of measurements were then averaged (these ring sequences are labelled M in Appendix D).

The ring sequences were plotted as graphs, known as tree-ring curves, on transparent semi-logarithmic paper to facilitate comparison between the ring patterns (Eckstein et al 1984). As well as the manual comparison of one graph with another, a

computer program was used as an aid to crossmatching. The program (Baillie & Pilcher 1973) calculates the degree of similarity between two curves at each position of overlap, the results being expressed as values of Student's t. Values of 3.5 or above represent a match provided that the visual match between the two curves is acceptable (Baillie 1982).

When a group of curves crossmatch, their ring widths are averaged to produce a site master curve against which any unmatched sequences are tested. The master curve is also used for comparisons with dated reference curves since masters are usually easier to date than individual sequences.

Once calendar years have been asigned to the ring sequences, it is necessary to interpret the tree-ring dates. Where bark or bark edge is present, the date of the outer measured ring represents the year in which the timber was felled. In its absence, the amount of missing wood must be estimated. The presence of sapwood makes this process more precise since the number of oak sapwood rings in the British Isles is relatively constant at 10-55 rings (This range represents 95% confidence limits; for further details, see Hillam et al 1986). If this sapwood estimate is added to the date of the heartwood-sapwood transition, the likely felling date range is obtained. Where sapwood is absent, the felling date is quoted as a terminus post quem.

Results

Timbers from the original construction

Samples 21, 30 and 31 were rejected prior to measurement as they had less than 40 rings. The remainder had 44-88 rings (Appendix A). Samples 25 and 29 had 9 and 10 sapwood rings respectively, whilst the heartwood-sapwood transition may be present at the outer corner of 20.

The curves from seven timbers (20, 23, 24, 26, 27, 28, 29) crossmatched to give a total sequence of 95 years (Fig 1; Table 1), and their ring widths were averaged to produce a master curve, Caerleon1. When the unmatched curves were tested against this, 25 was also found to match (t = 4.7), but 22 and 32 remain undated. 25 was incorporated into the master to give a final master curve, Caerleon3 (Appendix D).

Caerleon3 was compared with all the available dated reference chronologies covering the Roman period, details of which are given in Appendix C. Relatively high t-values were obtained when the master dated to 33BC-AD62 (Table 2). The Caerleon chronology matched particularly well with chronologies from London (City-Southwark - Tyers, pers comm) and from Walton-le-Dale in Lancashire (Groves, in prep). These results were confirmed when the visual matching was checked (eg Fig 2).

The end dates of the ring sequences vary from AD 34 for 23 to AD 62 for 29 (Appendix B). The date of the heartwood- sapwood transitions of 25 and 29 is AD 53, and the possible sapwood

transition for 20 is AD 43. The range of end dates for 20, 23, 24, 26, 27 and 28 (Fig 1) is characteristic of a group of timbers from which only the sapwood rings have been removed (Baillie 1982 56), so it is probable that the outer ring of 20 is the sapwood transition. Using the sapwood estimate of 10-55 rings (see above), the probable felling date range is AD 62-97. (This would become AD 62-107 if the sapwood transition was not present on 20).

Timbers from well 2

Since most of the samples had sapwood and bark edge, all of them were included for measurement. Sample 2, however, was rejected because its rings were very narrow and could not be measured with accuracy. The outer rings of some of the other samples (eg 7, 11) were also very narrow so that the outer rings had to be counted rather than measured to avoid distorting the accuracy of the ring record. The narrow rings often made it difficult to determine in which season the timbers were felled, but in most cases the outer ring was complete indicating that the trees were felled in winter or early spring. (Details of the samples and the results are given in Appendices A and B, whilst the ring width data are listed in Appendix D).

The samples appeared more suitable for tree-ring dating than the group from the original construction: many had bark edge, and they tended to have more rings. However, attempts to crossmatch the tree-ring curves met with little success. There was certainly no similarity between the curves when the various

bark edges were aligned as would be expected if the timber had been felled at the same time from the same area. Second radii were measured on samples with the longest ring sequences (1, 6, 7, 8, 9 and 13), but there was still no apparent matching, either visually or when the computer program was used.

The curves were next tested against the master Caerleon3 but there were no obvious high correlations. When they were compared with other reference chronologies, 9 and 13 showed relatively high t-values with some of the chronologies (Table 3). There is no doubt about the dating of 9; its rings cover the period 47BC-AD72 and it matches well the chronologies from London, Mancetter and Walton-le-Dale (Fig 2), although the match with Caerleon3 is weak (t = 3.3). Bark edge is present but there could be a measurement error of +/-1 ring in the outer few rings because of the narrowness of the rings. Timber 9 therefore was felled, probably in winter or early spring, in AD 72/3 +/- 1.

The dating of 13 is less secure. It gives t-values over 3.5 with Droitwich, southern Germany and two chronologies from London when its rings cover the period 24BC-AD32 (Table 3). It matches the master Caerleon3 and timber 9 with t-values of 3.3 and 3.4 respectively so, although the correlations are not particularly high, they are consistently greater than 2.5, and may indicate that the sequence dates to 24BC-AD32. However further proof is needed before this result can be accepted without reservation, especially as the ring sequence is relatively short (56 rings). If

it is correct, the timber was felled in AD 37-40/41 since an additional 5-9 rings were present but not measured.

No consistent results were found for the remaining timbers.

Discussion

The probable felling date range of AD 62-97 for the timbers from the original construction is consistent with historical and archaeological evidence which suggests a construction date of about AD 74-78. Despite their lack of precision, the tree-ring results show that the timbers could not have been removed from the fortress at Usk, which was built around AD 55, since they were still growing in AD 62.

The well timbers are dated on archaeological grounds to about AD 90-100. Timber 9 was in fact felled in AD 71/2 - 73/4, which suggests that it is contemporary with the building of the fortress. It is possible that the well timbers were cut at that time and stored, to be used later as infilling of the well. (If the dating of 13 is correct, the timber was felled in AD 37-40/1, which would imply some form of stockpiling for over 30 years.)

The lack of correlation between the individual well sequences, and between the well sequences and the master Caerleon3, is interesting. It suggests that the well timbers either came from different sources or from trees which were responding to different local conditions of growth. It seems unlikely that the two groups of timbers from Caerleon came from the same

woodland or even the same area. Similar results were obtained for the Roman timbers at Carlisle where difficulty in crossmatching was probably due to timbers being brought from different sources (Baillie pers comm). Timber transport has also been identified at Walton-le-Dale where timbers of fir (Abies alba) were identified from a well (Groves in prep). These must have been imported from the Continent, although there is no indication from the tree-rings that the Caerleon timbers were brought from abroad.

The Caerleon rings sequences obtained from this study are not very long (33BC-AD62 for Caerleon3; 47BC-AD72 for timber 9), but they could form the basis for dating future timbers from the Caerleon excavations and, in view of the somewhat surprising results from the well timbers, further work would be worthwhile.

Conclusion

The timbers for the original building of Caerleon fortress were probably felled in the period AD 62-97, indicating that they could not have been taken from the fortress at Usk. The one timber from well 2 that was firmly dated was felled in AD 71/2 to 73/4 at a time when it is thought the Caerleon fortress was built. The remaining well timbers do not appear to match each other or the reference chronologies, except for 13 which is tentatively dated to 24BC-AD32. The lack of dating is surprising since most of the timbers had bark edge and did not appear to have been re-used. If available, further timbers should be

examined from Caerleon as they may help to date more of the well timbers and possibly provide information about the use of timber in the Roman period.

Acknowledgements

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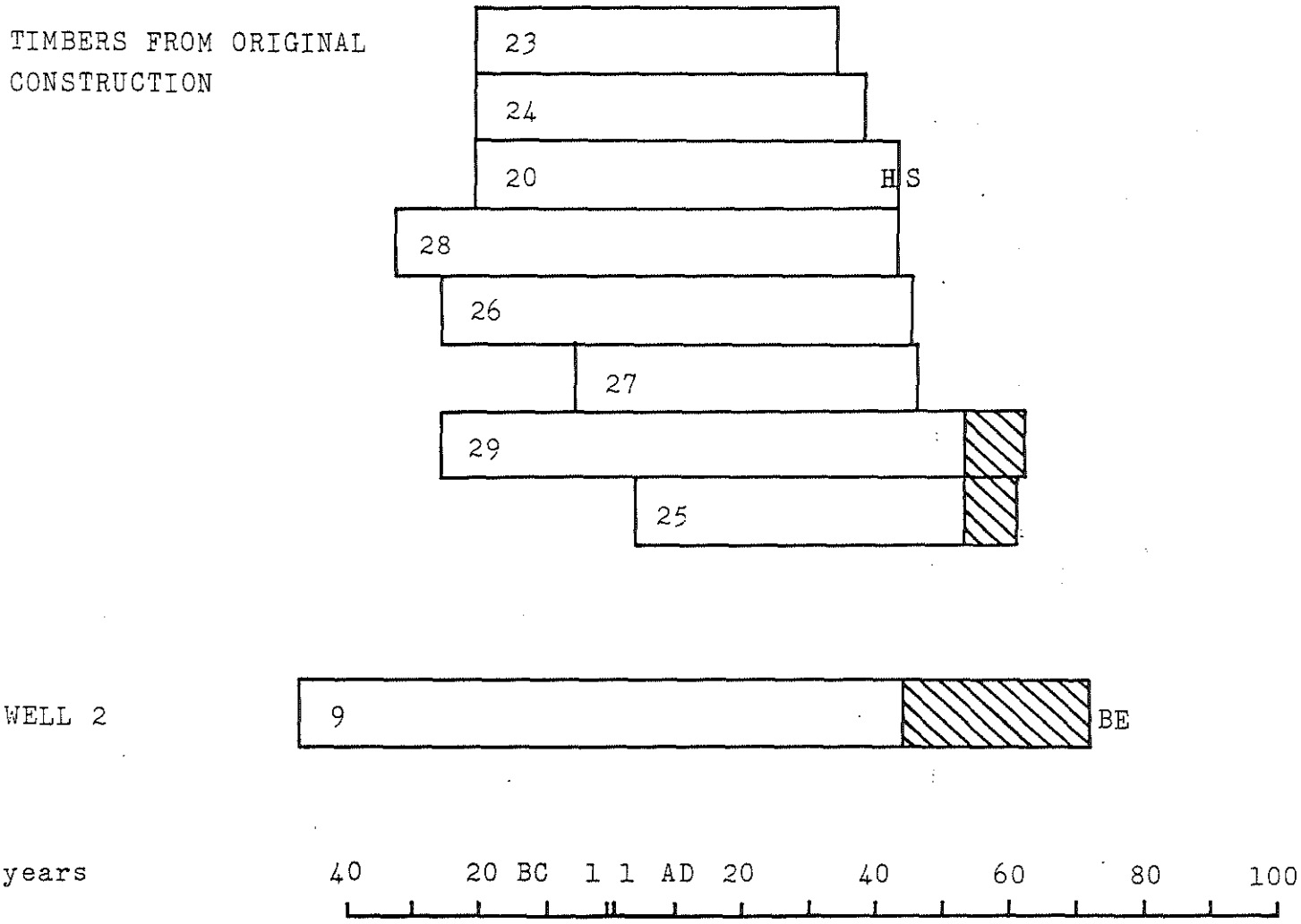


Fig 1: Bar diagram showing the relative positions of the dated Caerleon ring sequences. White bar - heartwood rings; hatching - sapwood; BE - bark edge; HS - heartwood-sapwood transition.

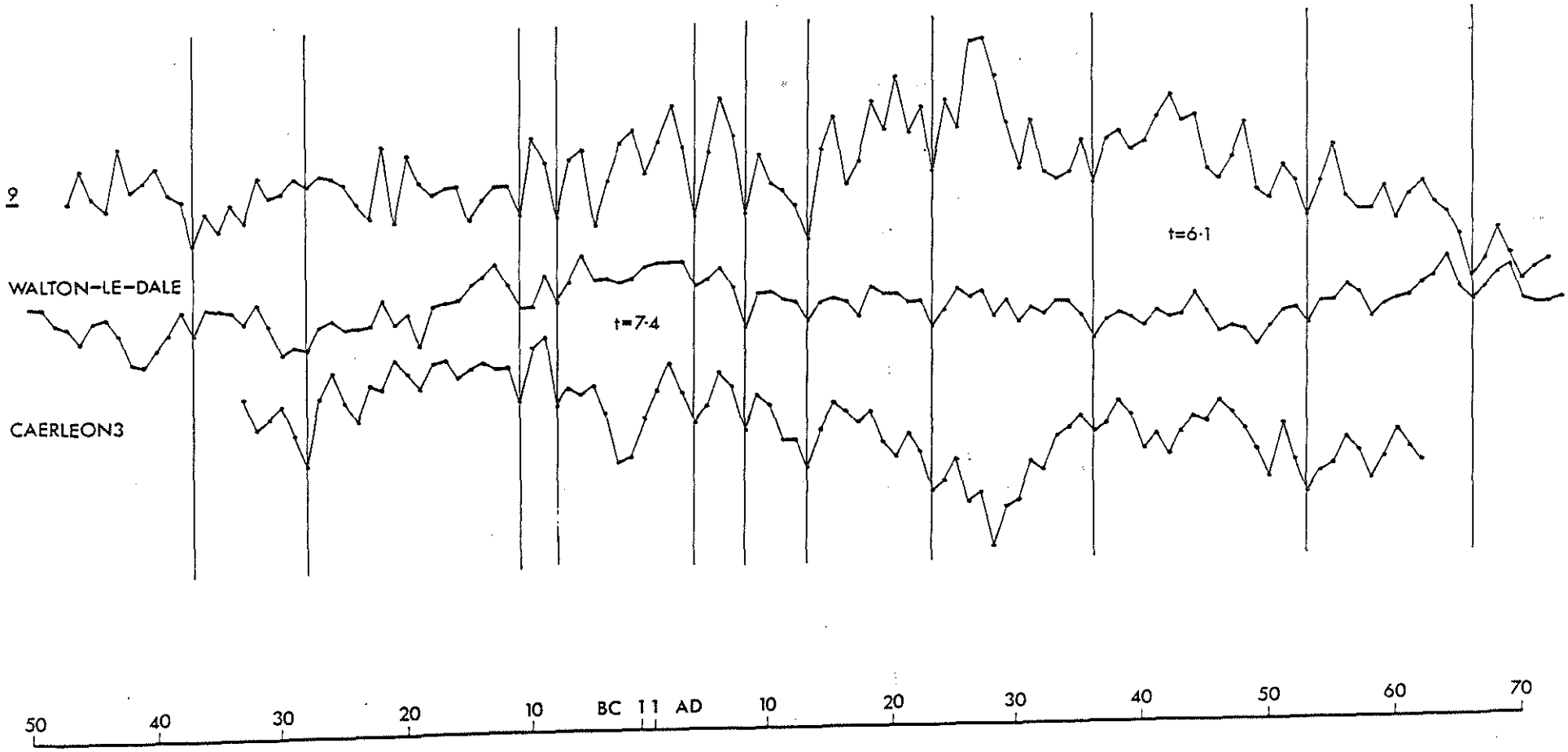


Fig 2: Matching tree-ring curves. The matches between Caerleon3, timber 9 and the Walton-le-Dale chronology are illustrated. The vertical scale is logarithmic, and the widths are in units of C.02mm.

Table 1: Matrix of t-values for the ring sequences from the original construction.

	20	23	24	26	27	28	29
20	-						
23	5.1	-					
24	7.2	5.9	-				
26	4.8	4.5	3.6	-			
27	3.2	3.8	4.8	2.7	-		
28	6.4	4.5	4.5	3.1	2.6	-	
29	4.0	4.0	7.6	4.5	4.8	3.6	-

Table 2: Dating the timbers from the original construction. t-values between Caerleon3, 33BC-AD62, and dated reference chronologies (see Appendix C for details of the chronologies).

chronology	t-value
Alcester	2.3
Carlisle	2.5
Droitwich, Friar Street	3.1
Germany, south	1.8
Germany, west	3.0
Ireland, Mill Lough	3.0
London, City-Southwark	5.8
London, Swan Lane	3.5
Mancetter	3.3
Nantwich	2.9
Walton-le-Dale	7.4

Table 3: Dating well timber 9, 47BC-AD72. t-values are also given for the tentative dating of timber 13 to 24BC-AD32.

chronology	t-value 9	13
Alcester	2.9	2.5
Caerleon3	3.3	3.3
Carlisle	3.5	1.9
Droitwich, Friar Street	2.6	3.6
Germany, south	1.5	3.6
Germany, west	3.2	3.3
Ireland, Mill Lough	3.8	1.4
London, City-Southwark	5.0	3.8
London, Swan Lane	3.4	3.6
Mancetter	4.7	2.9
Nantwich	1.8	1.8
Walton-le-Dale	6.1	3.2

APPENDIX A

Details of the tree-ring samples

(i) well 2 timbers

(ii) timbers from the original construction

Key

TIMBER - timber number

RINGS - total number of rings

SAPWOOD - number of sapwood rings

AV WIDTH - average ring width in mm

SIZE - maximum dimensions of the cross-section in mm

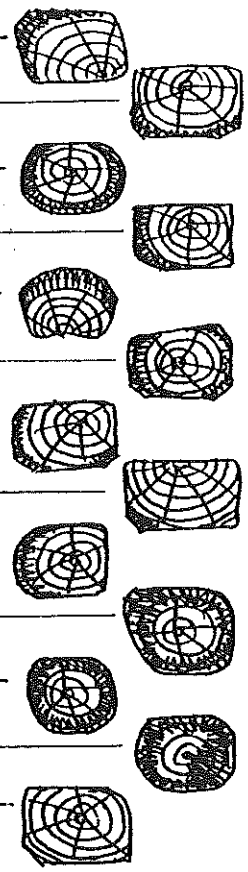
+ - indicates the presence of rings which could not be measured accurately

Sketches of the cross-sections are not drawn to scale; the shading on the sketches represent sapwood

WELL 2 TIMBERS

Report: SAMPLE DETAILS

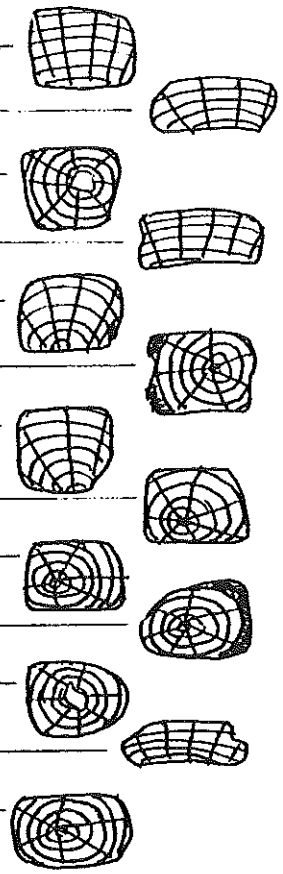
TIMBER	RINGS	SAPWOOD	AV WIDTH	SIZE
1	124	17-21	1.33	185 x 165
2	-	-	-	170 x 155
5	42	15	2.16	185 x 140
6	83	39	1.45	155 x 140
7	59+	30+	1.56	125 x 110
8	79	31	0.71	115 x 85
9	119	29	0.79	165 x 120
10	70	20	1.48	175 x 90
11	40+	15+	2.14	130 x 110
12	55	23-40	1.72	170 x 150
13	56+	26+	1.09	135 x 125
14	34	17-34	1.17	105 x 90
17	54	-	1.58	180 x 135



PRIMARY CONSTRUCTION TIMBERS

Report: SAMPLE DETAILS

TIMBER	RINGS	SAPWOOD	AV WIDTH	SIZE
20	64	?1	2.08	180 x 150
21	–	–	–	130 x 70
22	82	–	0.96	125 x 110
23	55	–	1.40	140 x 80
24	59	–	1.79	175 x 115
25	58	9	1.76	180 x 145
26	71	–	1.71	165 x 120
27	52	–	1.83	155 x 115
28	76	–	1.08	145 x 115
29	88	10	1.36	170 x 130
30	–	–	–	190 x 65
31	–	–	–	190 x 65
32	44	–	1.91	135 x 95



APPENDIX B

Results

(i) well 2 timbers

(ii) timbers from the original construction

Unless bark edge is present, felling date ranges are calculated using the sapwood estimate of 10-55 rings. This represents the 95% confidence limits for the number of oak sapwood rings in the British Isles (Hillam *et al* 1986).

WELL 2 TIMBERS

Report: RESULTS

TIMBER	RESULT	FELLED	COMMENT
1	undated	winter	-
2	rejected	-	rings too narrow
5	undated	winter	-
6	undated	?bark edge	-
7	undated	10-12 rings to bark	-
8	undated	near bark edge	-
9	47BC - AD72	approx AD72/3	?error in outer 6 rings
10	undated	?winter	-
11	undated	about 15 rings to bark	-
12	undated	winter	knotty
13	?24BC - AD32	5-8 rings to bark	-
14	undated	winter	-
17	undated	-	knotty

PRIMARY CONSTRUCTION TIMBERS

Report: RESULTS

TIMBER	RESULT	FELLED	COMMENT
20	21BC - AD43	?AD52-97/after 53	-
21	rejected	-	less than 40 rings
22	undated	-	-
23	21BC - AD34	after AD 44	-
24	21BC - AD38	after AD48	-
25	AD 4-61	AD 62-107	-
26	26BC - AD45	after AD65	-
27	6BC - AD46	after AD56	-
28	33BC - AD43	after AD53	-
29	26BC - AD62	AD 62-107	-
30	rejected	-	less than 40 rings
31	rejected	-	less than 40 rings
32	undated	-	-

APPENDIX C

Details of dated reference chronologies used in the Caerleon study. SDL - Sheffield Dendrochronology Laboratory unpublished data.

Alcester, Warwickshire (Baillie pers comm)
184BC-AD95

Carlisle (Baillie pers comm)
247BC-AD90

Droitwich, Friar Street (SDL)
141BC-AD44

Germany, south (Becker 1981)
370BC-present

Germany, west (Hollstein 1980)
700BC-present

Ireland, Mill Lough (Baillie & Pilcher pers comm)
13BC-AD390

London, City-Southwark (Tyers pers comm)
252BC-AD255

London, Swan Lane (SDL)
56BC-AD169

Mancetter, Warwickshire (SDL)
139BC-AD33

Nantwich, Cheshire (Simpson pers comm)
134BC-AD132

Walton-le-Dale, Lancashire (SDL)
235BC-AD119

Appendix D

Ring width data. Widths in units of 0.02mm are listed for all the measured samples and for the master curve, Caerleon3.

Key

HS - heartwood-sapwood transition

F - felled

FW - felled winter or early spring

BE - bark edge

M - after the timber number, indicates at least two radii have been measured

The figures on the right of the Caerleon3 ring widths show the number of samples per year.

CAERLEON
CAER1M
124

1	-	32	70	56	104	62	59	24	42	72	54
11	-	101	80	84	81	82	75	78	104	135	117
21	-	81	67	86	58	84	87	67	96	101	66
31	-	108	62	61	83	101	104	57	75	116	104
41	-	57	46	59	51	35	43	43	70	54	64
51	-	71	39	34	24	18	24	25	30	22	30
61	-	37	29	50	49	60	48	63	67	77	110
71	-	80	82	87	86	67	69	34	46	60	76
81	-	88	130	133	102	79	48	56	58	44	60
91	-	44	65	62	49	61	74	87	74	96	102
101	-	75	61	57	75	79	71	63	63	63	93
111	-	92	75	38	49	51	75	73	75	53	25
121	-	18	29	42	35						

COMMENT - NR PITH - HS104-8 - FW - MEAN OF 3 RADII

MEAN RING WIDTH IN MM = 1.32806452

CAERLEON
CAER5
42

1	-	113	189	169	203	85	119	78	71	84	64
11	-	101	121	170	189	131	188	141	112	82	96
21	-	129	120	59	104	120	81	77	133	145	149
31	-	108	89	77	44	23	30	45	69	106	99
41	-	99	117								

COMMENT - PITH - HS28 - FW

MEAN RING WIDTH IN MM = 2.15666667

CAERLEON
CAER6M
83

1 - 119 132 139 108 99 102 111 116 145 166

11 - 146 164 188 163 82 32 47 49 70 86

21 - 97 95 107 148 142 171 136 82 93 172

31 - 159 114 118 120 124 113 113 118 48 71

41 - 52 22 32 43 30 19 15 21 36 23

51 - 26 32 20 48 33 44 31 33 18 22

61 - 19 35 47 72 95 62 83 52 47 25

71 - 43 18 32 48 28 24 17 15 11 15

81 - 11 17 15

COMMENT - PITH - HS45 - 7F

MEAN RING WIDTH IN MM = 1.45445783

CAERLEON
CAER7M
59

1 - 107 82 161 140 218 253 191 162 234 226

11 - 145 159 118 157 127 105 71 66 80 57

21 - 71 73 85 79 94 60 68 64 101 66

31 - 92 59 94 48 36 50 51 44 49 55

41 - 39 38 53 36 25 21 24 15 14 18

51 - 24 14 20 16 15 12 10 10 8

COMMENT - PITH - HS30 - PLUS C 10-12 TO BE

MEAN RING WIDTH IN MM = 1.56271186

CAERLEON
CAER8M
79

1	-	55	92	36	37	40	42	75	78	105	141
11	-	104	90	60	72	63	59	49	53	55	43
21	-	39	27	21	26	35	21	33	33	34	56
31	-	34	23	12	27	27	27	18	38	35	52
41	-	28	20	28	24	21	16	18	36	28	26
51	-	31	25	24	41	30	42	27	21	26	20
61	-	18	17	14	17	15	22	15	16	14	12
71	-	22	19	14	15	20	10	9	10	15	

COMMENT - PITH - KNOT AT YRS 9-10 - ERRORS IN LAST FEW RINGS - HS42
-49 - NR BE

MEAN RING WIDTH IN MM = .707088608

CAERLEON
CAER9M
119

1	-	34	45	35	31	54	37	40	45	35	33
11	-	22	29	25	31	27	40	34	35	39	37
21	-	40	39	37	31	27	51	26	47	37	33
31	-	35	35	26	31	35	35	27	54	43	26
41	-	43	47	24	35	49	55	38	50	69	47
51	-	25	45	73	52	26	43	33	31	27	20
61	-	45	60	33	40	69	53	85	51	64	36
71	-	69	53	118	119	85	56	36	55	35	33
81	-	35	46	31	46	49	42	45	56	68	54
91	-	56	35	32	38	53	28	26	35	30	22
101	-	30	41	26	23	23	28	21	26	29	24
111	-	22	18	11	14	19	15	8	11	12	

COMMENT - NR PITH - HS91-101 - ?ERRORS IN LAST FEW RINGS

MEAN RING WIDTH IN MM = .786218487

CAERLEON
CAER10
70

1	-	120	133	110	94	85	74	84	54	44	33
11	-	38	59	90	70	69	84	103	51	26	47
21	-	55	53	116	132	108	89	65	64	85	109
31	-	118	89	70	87	42	52	69	69	84	75
41	-	96	104	86	91	67	89	69	48	74	84
51	-	75	78	84	75	67	57	81	62	81	91
61	-	79	24	15	23	41	49	88	74	77	44

COMMENT - HS51 - 61-2 COULD BE ONE - F ?W

MEAN RING WIDTH IN MM = 1.47771429

CAERLEON
CAER11
40

1	-	156	143	128	111	103	129	143	109	204	170
11	-	227	200	147	157	121	134	152	167	131	148
21	-	112	93	102	129	110	153	121	93	48	71
31	-	45	32	43	34	30	21	13	18	13	14

COMMENT - PITH - HS26 - PLUS C15 TO BE

MEAN RING WIDTH IN MM = 2.1375

CAERLEON
CAER12
55

1	-	153	105	121	87	158	147	130	146	104	148
11	-	115	74	75	88	105	100	42	34	24	24
21	-	20	28	22	21	25	34	46	39	74	48
31	-	81	55	80	91	74	57	103	90	68	36
41	-	24	16	13	14	12	14	18	37	52	86
51	-	163	262	330	322	306					

COMMENT - NR PITH - HS16- 33 (KNOT) - FW

MEAN RING WIDTH IN MM = 1.72036364

CAERLEON
CAER13M
56

1	-	119	85	131	89	61	67	115	97	65	36
11	-	48	42	46	42	75	89	48	52	32	37
21	-	36	43	41	42	37	61	53	49	75	73
31	-	83	63	76	69	71	59	40	53	47	45
41	-	50	61	42	60	40	49	25	45	40	31
51	-	26	26	17	15	12	8				

COMMENT - NR PITH - HS30 - PLUS 5-8 TO BE

MEAN RING WIDTH IN MM = 1.08535714

CAERLEON
CAER14
34

1 - 116 62 77 117 70 147 51 82 69 52

11 - 34 71 33 32 43 88 41 44 20 31

21 - 18 16 15 11 20 55 70 51 56 78

31 - 60 82 70 105

COMMENT - PITH - HS1-18 - FW

MEAN RING WIDTH IN MM = 1.16882353

CAERLEON
CAER17
54

1 - 94 54 74 47 61 36 40 53 53 32

11 - 45 39 42 54 32 38 34 21 24 36

21 - 30 45 26 19 16 23 14 21 19 26

31 - 48 35 101 119 58 32 106 156 301 330

41 - 202 175 156 128 96 108 132 120 110 139

51 - 88 138 139 105

COMMENT - NR PITH

MEAN RING WIDTH IN MM = 1.58148148

CAERLEON
CAER2Ø
64

1	-	248	219	220	278	254	213	186	198	193	197
11	-	160	203	219	122	148	136	158	118	101	83
21	-	86	98	154	99	72	69	73	111	54	92
31	-	91	64	84	53	75	100	76	82	93	62
41	-	50	70	68	63	50	51	30	44	27	38
51	-	38	58	56	60	71	68	51	51	72	68
61	-	49	66	48	70						

COMMENT - LAST RING = HS

MEAN RING WIDTH IN MM = 2.0809375

CAERLEON
CAER22M
82

1	-	61	50	62	48	74	86	67	84	64	38
11	-	53	66	38	40	53	99	109	115	75	99
21	-	71	49	35	36	40	28	38	47	34	32
31	-	43	60	68	58	51	36	62	73	82	60
41	-	78	48	38	31	40	39	34	42	40	45
51	-	59	49	31	47	43	35	36	52	36	28
61	-	34	32	33	26	46	37	30	48	35	31
71	-	25	36	30	36	26	28	34	28	25	25
81	-	26	21								

COMMENT - NEAR PITH - MEAN OF 2 RADII

MEAN RING WIDTH IN MM = .957804878

CAERLEON
CAER23
55

1 - 167 123 60 118 153 114 132 135 119 109

11 - 72 160 194 77 92 58 70 38 21 29

21 - 45 61 72 72 47 53 76 65 50 60

31 - 41 38 37 30 43 50 66 75 100 61

41 - 51 62 55 45 38 43 30 25 23 28

51 - 30 48 51 61 84

COMMENT -

MEAN RING WIDTH IN MM = 1.40254546

CAERLEON
CAER24
59

1 - 110 138 113 109 127 109 139 152 163 174

11 - 106 190 248 117 161 122 121 90 37 40

21 - 70 152 196 116 62 104 117 141 66 74

31 - 96 53 67 44 78 113 104 81 65 68

41 - 38 58 48 35 26 35 24 26 19 27

51 - 33 45 42 64 60 73 56 77 68

COMMENT -

MEAN RING WIDTH IN MM = 1.79220339

CAERLEON
CAER25
58

1	-	123	136	207	95	107	185	156	124	63	45
11	-	97	110	137	123	129	92	106	92	93	62
21	-	84	86	70	58	32	40	49	76	59	109
31	-	90	96	94	133	147	114	74	84	78	72
41	-	102	82	90	87	76	52	35	71	43	37
51	-	51	50	74	59	48	64	75	73		

COMMENT - NR PITH - LAST 9 RINGS SAPWOOD

MEAN RING WIDTH IN MM = 1.75724138

CAERLEON
CAER26
71

1	-	180	150	129	172	185	174	171	149	175	176
11	-	170	116	129	162	150	122	193	190	106	99
21	-	128	118	95	66	90	87	78	112	87	80
31	-	74	93	74	50	58	66	61	72	63	58
41	-	76	60	66	73	42	50	66	43	25	36
51	-	39	26	31	18	45	39	45	32	50	45
61	-	31	41	32	50	38	43	47	32	57	43
71	-	52									

COMMENT -

MEAN RING WIDTH IN MM = 1.71295775

CAERLEON
CAER27
52

1	-	108	117	108	61	56	118	181	194	168	142
11	-	163	181	159	132	165	134	85	94	82	93
21	-	108	92	79	90	79	64	67	51	28	48
31	-	54	31	39	20	21	38	49	50	63	98
41	-	120	122	80	88	92	69	90	78	77	68
51	-	73	92								

COMMENT - PITH

MEAN RING WIDTH IN MM = 1.82653846

CAERLEON
CAER28
76

1	-	102	79	85	96	73	55	103	128	95	71
11	-	80	66	60	34	28	36	42	61	113	94
21	-	70	59	52	84	108	58	40	50	59	37
31	-	44	49	59	47	73	75	30	41	68	80
41	-	36	51	55	44	59	48	71	87	76	45
51	-	50	29	24	41	53	34	38	36	27	28
61	-	18	14	21	23	27	23	33	42	25	32
71	-	40	41	32	35	33	45				

COMMENT - NR PITH

MEAN RING WIDTH IN MM = 1.07894737

CAERLEON
CAER29
98

1	-	73	51	49	88	79	86	73	94	109	87
11	-	68	100	112	78	97	73	94	99	75	98
21	-	104	106	98	46	38	89	98	121	92	61
31	-	78	127	113	75	87	74	46	40	30	37
41	-	62	56	53	51	61	56	76	42	24	29
51	-	37	47	50	30	37	39	59	98	84	60
61	-	89	75	82	131	108	75	54	44	70	78
71	-	75	68	64	54	55	48	63	53	35	35
81	-	43	45	45	32	35	49	36	47		

COMMENT - NR PITH -`LAST 10 RINGS SAPWOOD

MEAN RING WIDTH IN MM = 1.35954546

CAERLEON
CAER32
44

1	-	69	97	79	93	65	92	63	90	47	63
11	-	69	59	54	83	88	77	79	59	66	60
21	-	100	95	113	111	124	105	81	188	209	118
31	-	179	139	120	132	59	58	80	122	135	117
41	-	86	84	115	62						

COMMENT - PITH

MEAN RING WIDTH IN MM = 1.91045455

MASTER CHRONOLOGY

CAERLEON
CAERLEON3

MASTER STORED IN FILE CALLED CAERLEON3
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CAERLEON
CAERLEON3
95

102	79	85	96	73	55	103	127	98	83	1	1	1	1	1	1	1	3	3	3
113	110	140	126	110	137	139	122	131	136	3	3	6	6	6	6	6	6	6	6
130	131	97	154	176	92	106	100	107	83	6	6	6	6	6	6	6	7	7	7
53	55	79	102	130	101	76	89	117	104	7	7	7	7	7	7	8	8	8	8
71	95	88	63	63	49	69	88	82	74	8	8	8	8	8	8	8	8	8	8
80	61	54	65	56	39	42	50	35	37	8	8	8	8	8	8	8	8	8	8
23	33	35	49	46	63	67	73	65	69	8	8	8	8	8	8	8	7	7	7
84	76	56	62	52	64	72	70	83	75	7	6	6	6	6	6	4	4	3	2
65	53	41	67	48	36	43	46	59	52	2	2	2	2	2	2	2	2	2	2
40	49	62	54	47	.	2	2	2	2	1									

MASTER DATES TO 33BC-AD62