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Summary

A tree-ring dating programme was commissioned of timbers in the Frater roof of Cleeve Abbey, near Washford, Somerset, by English Heritage in AD 2003. The tree-ring results indicate that timbers felled in the second quarter of the fifteenth century are present in the roof. The absence of surviving sapwood prevents a precise felling or construction date from being obtained.

Keywords
Dendrochronology
Standing Building

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Introduction

This document is a technical archive report on the tree-ring analysis of oak timbers from the Frater roof of Cleeve Abbey, near Washford, Somerset (NGR ST 047 406). It is beyond the dendrochronological brief to describe the building in detail or to undertake the production of detailed drawings. Elements of this report may be combined with detailed descriptions, drawings, and other technical reports at some point in the future to form either a comprehensive publication or an archive deposition on the building.

Cleeve Abbey lies 0.5 km south of Washford, 3 km south of the north Somerset coast, and just to the east of the Exmoor National Park (Figs 1 and 2). The decorated wagon roof of the Frater is undergoing English Heritage grant-aided repairs. This roof consists of five bays. It is constructed of 11 decorated, bossed, and arch braced trusses, six of which are principal trusses and five of which are the somewhat slighter and less decorated intermediate trusses (Figs 3 and 4). In between these are 30 common rafter trusses that were originally invisible above a ceiling. These trusses are arranged in threes between each principal and intermediate truss. This roof is thought to date from the fifteenth or early sixteenth century. Tree-ring analysis was commissioned by Francis Kelly, the local English Heritage inspector, to inform the repair programme.

Methodology

The general methodology and working practises used at the Sheffield Dendrochronology Laboratory are described in English Heritage (1998). The methodology used for this building was as follows.

The building was initially visited in AD 1999 by the author and an assessment of the dendrochronological potential of the building was undertaken (Tyers 1999a). This assessment aimed to identify whether oak timbers with suitable ring sequences for analysis existed in the structure. This assessment identified that the roof contained suitable material, although it was noted that sapwood had mostly been removed in an earlier restoration programme. Access during the assessment was confined to the eastern end of the roof.

In early AD 2003 a lightweight scaffold structure was erected providing access to the entire roof. The dendrochronological sampling programme attempted to cover the suitable material by obtaining samples from as broad a range of timbers, in terms of structural element types, scantling sizes, carpentry features, and surface condition as was possible within the terms of the request.

The most promising timbers were sampled using a 15mm diameter corer attached to an electric drill. The cores were taken as closely as possible along the radius of the timbers so that the maximum number of rings could be obtained for subsequent analysis. The core holes were subsequently filled by the repair team. The ring sequences in the cores were revealed by sanding.

The complete sequences of growth rings in the cores were measured to an accuracy of 0.01mm using a micro-computer based travelling stage (Tyers 1999b). The ring sequences were plotted onto semi-log graph paper to enable visual comparisons to be made between sequences. In addition a cross-correlation

algorithm (Baillie and Pilcher 1973) was employed to search for positions where the ring sequences were highly correlated. These positions were checked visually using the graphs and, where these were satisfactory, new mean sequences were constructed from the synchronised sequences. The *t*-values reported below are derived from the original CROS algorithm (Baillie and Pilcher 1973). A *t*-value of 3.5 or over is usually indicative of a good match, although this is with the proviso that high *t*-values at the same relative or absolute position must be obtained from a range of independent sequences, and that these positions are supported by satisfactory visual matching.

All the measured sequences from this assemblage were compared with each other and any found to cross-match were combined to form a site master curve. These, and any remaining unmatched ring sequences, were tested against a range of reference chronologies, using the same matching criteria: high *t*-values, replicated values against a range of chronologies at the same position, and satisfactory visual matching. Where such positions are found these provide calendar dates for the ring-sequence.

The tree-ring dates produced by this process initially only date the rings present in the timber. The interpretation of these dates relies upon the nature of the final rings in the sequence. If the sample ends in the heartwood of the original tree, a *terminus post quem (tpq)* for the felling of the tree is indicated by the date of the last ring plus the addition of the minimum expected number of sapwood rings which are missing. This *tpq* may be many decades prior to the real felling date. Where some of the outer sapwood or the heartwood/sapwood boundary survives on the sample, a felling date range can be calculated using the maximum and minimum number of sapwood rings likely to have been present. The sapwood estimates applied throughout this report are a minimum of 10 and maximum of 46 annual rings, where these figures indicate the 95% confidence limits of the range (Tyers 1998). These figures are applicable to oaks from England and Wales. Alternatively, if bark-edge survives, then a felling date can be directly utilised from the date of the last surviving ring. The dates obtained by the technique do not by themselves necessarily indicate the date of the structure from which they are derived. It is necessary to incorporate other specialist evidence concerning the re-use of timbers, seasoning, and the repairs of structures before the dendrochronological dates given here can be reliably interpreted as reflecting the construction date of phases within the structure.

Results

The timbers were carefully examined for the presence of suitable numbers of tree-rings and the presence of possible heartwood/sapwood boundaries. All the timbers in the roof are oak (*Quercus* spp.). Ten timbers were selected for sampling. Following discussion with Francis Kelly and with due regard to the high levels of decoration on the principal and intermediate trusses all the sampling was concentrated on the undecorated timbers of the common rafter trusses. Samples were obtained from each bay and from a variety of elements of the common rafter trusses; seven samples are from the upper braces, one is from a lower brace, one is from a rafter, and one is from a collar. The samples were numbered **1-10** (Table 1). The timbers selected for sampling are quartered trees and are all of similar scantling size (*c* 150 x 120 mm). The cores contain large numbers of rings.

There have been two different numbering schemes used for this structure, the AD 1953-57 restoration project used a relatively complicated scheme but the most recent descriptive report (Parker and Watts 1999) used another. Following discussion on site with Francis Kelly and Tony Harcourt, the project archaeologist, the sample locations throughout the roof were recorded using the AD 1953-57 restoration project numbering scheme (where the principal decorated trusses starting at the east of the roof are labelled P1 to P6, with the intermediate decorated trusses labelled I1 to I5, and the common rafter trusses between the principal trusses labelled by bay number 1 to 5 and C1 to C6 between each principal truss, see Fig 3), and an agreed structural element nomenclature (see Fig 4).

The tree-ring series from the ten sampled timbers were measured and the resultant series were then compared with each other. A group of six sequences, and a further group of four sequences, were found to match together to form two internally consistent groups (Table 2) with a series of tentative matches between the two groups. Two interim site mean chronologies were calculated, named CAFA_T6 and CAFB_T4. These site means were then compared with dated reference chronologies from throughout the British Isles and northern Europe. A single well correlated position was identified for each CAF sequence, and these confirmed the tentative links between the groups previously identified. Consequently a final site mean chronology, named CLEEVE10, was calculated by combining all ten sequences. Table 3 shows example correlations at its identified dating position against independent reference chronologies. Table 1 provides the chronological dates identified for each component sample by this process and their interpretation. Figure 5 graphically shows the chronological position identified for each component sample. Appendix 1 lists the individual sample series.

Discussion

The 171-year chronology CLEEVE10 is dated AD 1250 to AD 1420 inclusive. It was created from ten timbers. The major interpretative problem with the samples is the identification of their original heartwood/sapwood boundaries. The timbers were extensively repaired during the period AD 1953-57 and this repair programme appears to have included the defrassing of all the timbers. No sapwood was observed on any timber in the roof, although is not clear whether this is a result of the defrassing programme or a product of the dereliction of the roof prior to the earlier restoration programme. Some of the repairs certainly removed the corners where the heartwood/sapwood boundaries would have been and inserted replacement sections of new timber. It is most likely that all the surviving curving surfaces on the edges of the roof timbers are the original heartwood/sapwood boundaries, however it is possible that some are a secondary surface caused by the earlier restoration works. Following careful examination of these outer curving surfaces four of the samples were confidently identified as complete to the original heartwood/sapwood boundary, another was possibly complete to the boundary, for the other five it was concluded the ends of the samples were not necessarily adjacent to the original heartwood/sapwood boundary (Table 1).

Applying the estimate for the number of missing sapwood rings to the four samples with firmly identified heartwood/sapwood boundaries indicates the material was felled between AD 1430 and AD 1459. Applying the same estimate to the more tentatively identified heartwood/sapwood boundary on sample 1 suggests the felling of these timbers may have occurred between AD 1430 and AD 1441.

Conclusion

Assuming the timbers were felled for immediate usage, and this was normal practice in the medieval period (Charles and Charles 1995), the structure is likely to date from the second quarter of the fifteenth century, or shortly thereafter.

The material from Cleeve Abbey has provided a data set from the northern part of Somerset well away from other contemporaneous data. The composite series matches data particularly from Gloucestershire as well as sequences from further away. The two internally consistent groups of samples from the same structure are possibly a reflection of different woodland sources being exploited for its construction and may indicate that the timber requirements for the roof, and in particular for the curving bracing, could not be supplied by a single source.

Acknowledgements

The sampling and analysis programme was funded by English Heritage. Tony Harcourt and Francis Kelly discussed their observations on site, provided practical assistance, and helped determine nomenclature and numbering schemes. Stuart Blaylock supplied a copy of the Exeter Archaeology report. Tony Leach facilitated access to the site and discussed the details of the AD 1953-57 restoration programme. Peter Marshall from English Heritage put together the request documentation, and Cathy Groves provided useful discussion of the results.

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Figure 1 Location of Cleeve Abbey, near Washford, Somerset, within England and Wales.

Figure 2 Location of Cleeve Abbey, near Washford, Somerset

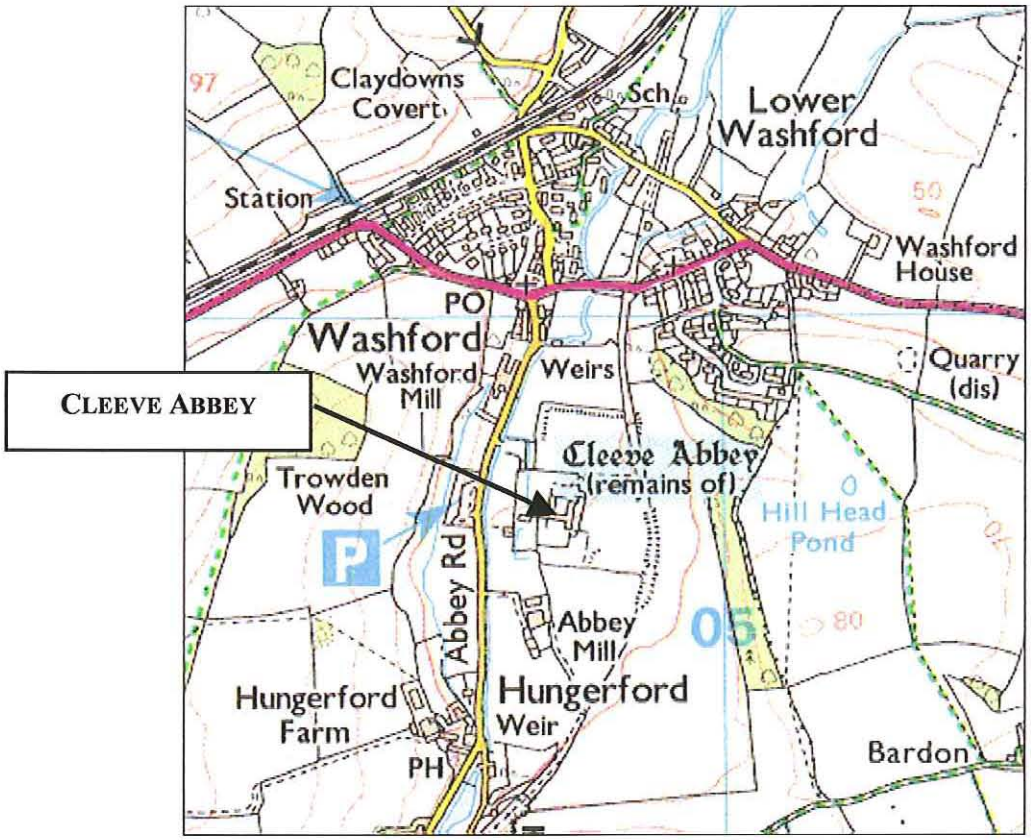


Figure 3 Plan of the Frater at Cleeve Abbey, near Washford, Somerset showing the truss numbering scheme adopted for this report (based on a figure supplied by English Heritage). The smaller arrows indicate the approximate sampling locations

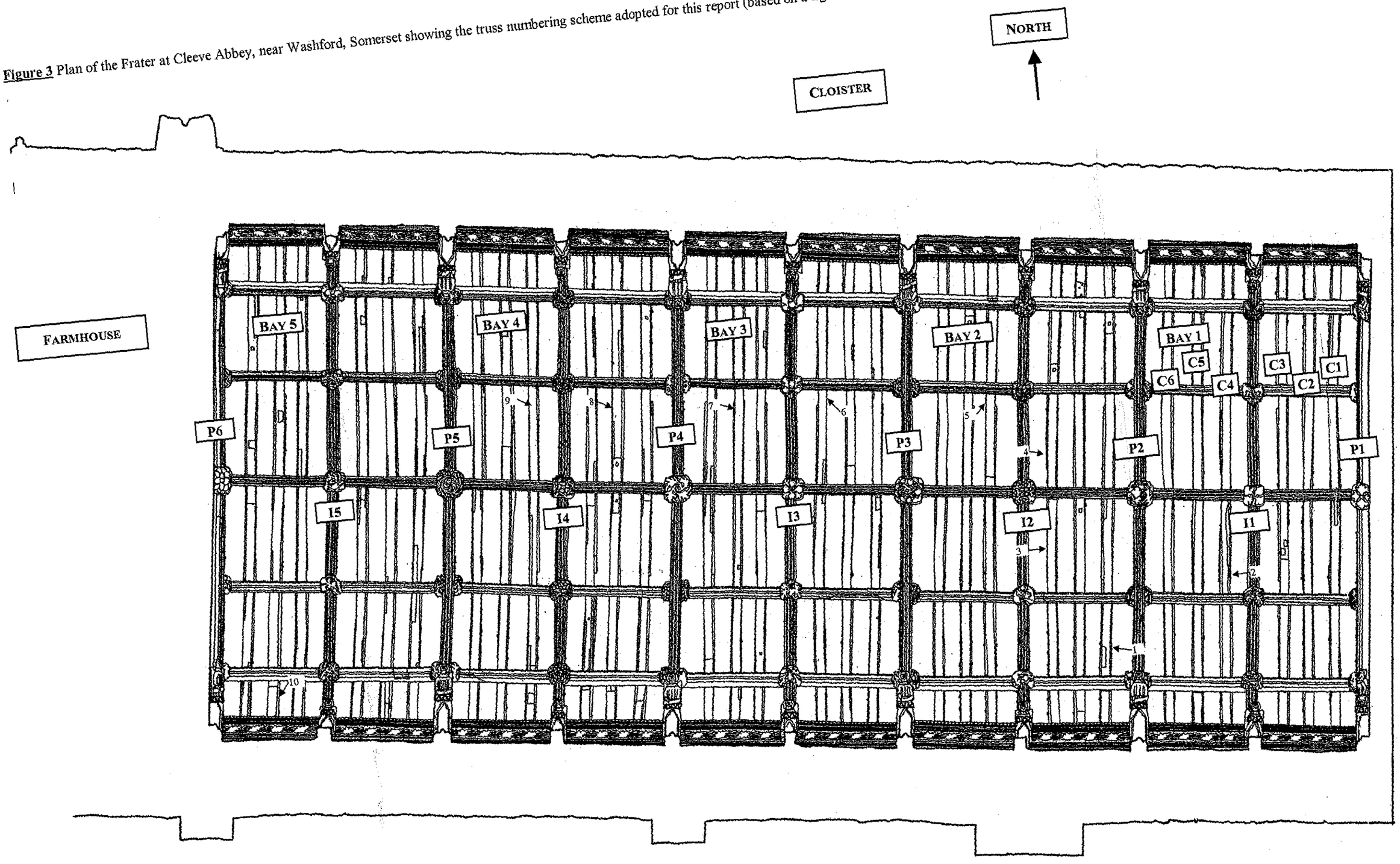


Figure 4 Elevation of the three truss types from the Frater roof at Cleeve Abbey, near Washford, Somerset showing the structural element nomenclature followed in this report, based on figures derived from the Ministry of Works, Ancient Monuments Department, survey AD 1953

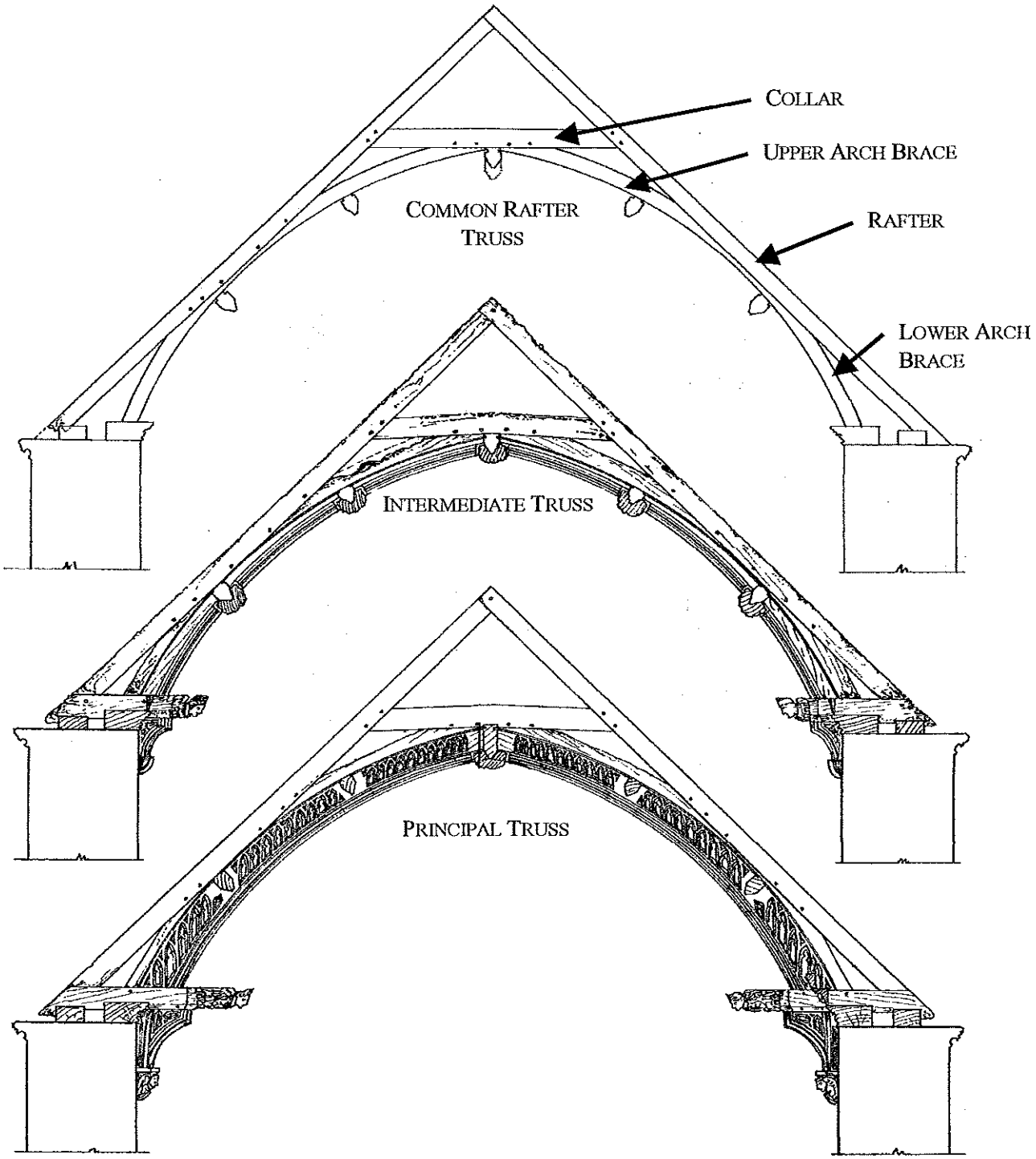
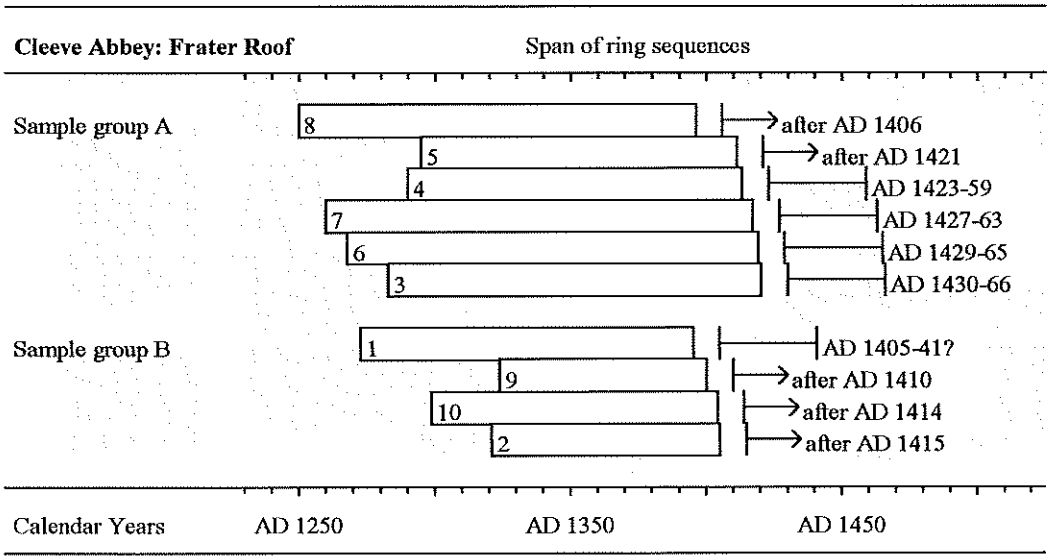


Figure 5 Bar diagram showing the chronological positions of the dated timbers from the Frater roof at Cleeve Abbey, near Washford, Somerset. The timbers are divided into the groups identified during the analysis. The estimated felling period for each sequence is also shown



KEY for figure 5

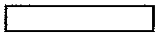


Table 1 List of samples from timbers from the Frater roof at Cleeve Abbey, near Washford, Somerset

Core No	Origin of core	Cross-section size (mm)	Total rings	Sapwood rings	ARW (mm/year)	Date of sequence	Felling period
1	Bay 2 C1 south rafter	150 x 130	123	?H/S	1.12	AD 1273-AD 1395	AD 1405-41?
2	Bay 1 C4 south upper arch brace	150 x 100	85	-	1.39	AD 1321-AD 1405	after AD 1415
3	Bay 2 C3 south upper arch brace	150 x 120	138	H/S	1.09	AD 1283-AD 1420	AD 1430-66
4	Bay 2 C3 north upper arch brace	150 x 120	124	H/S	1.27	AD 1290-AD 1413	AD 1423-59
5	Bay 2 C4 north upper arch brace	150 x 120	117	-	0.86	AD 1295-AD 1411	after AD 1421
6	Bay 3 C3 north upper arch brace	150 x 120	152	H/S	1.10	AD 1268-AD 1419	AD 1429-65
7	Bay 3 C5 north upper arch brace	150 x 120	158	H/S	0.99	AD 1260-AD 1417	AD 1427-63
8	Bay 4 C2 collar	160 x 140	147	-	1.11	AD 1250-AD 1396	after AD 1406
9	Bay 4 C4 north upper arch brace	150 x 120	77	-	1.51	AD 1324-AD 1400	after AD 1410
10	Bay 5 C5 south lower arch brace	150 x 120	106	-	1.08	AD 1299-AD 1404	after AD 1414

KEY for Table 1 Total rings = all measured rings. Sapwood rings: H/S heartwood/sapwood boundary. ARW = average ring width of the measured rings

Table 2

t-value matrix for the timbers forming the chronology CLEEVE10. The matrix is divided into sample groups A and B which probably derive from different, although still local, sources

	4	5	6	7	8	1	2	9	10
3	11.87	11.90	8.92	8.01	9.06	-	3.07	-	-
4		10.25	8.44	8.33	7.22	-	-	-	-
5			7.08	6.60	7.06	-	-	-	-
6				11.75	7.63	3.11	3.56	3.33	-
7					7.87	-	3.24	-	-
8						-	-	-	-
1							4.23	3.26	6.14
2								3.89	4.61
9									4.96

Table 3

Dating the mean sequence CLEEVE10, AD 1250-1420 inclusive. Example *t*-values with independent reference chronologies

Area	Reference chronology	*t*-values
Berkshire	Reading (Groves *et al* 1997)	5.86
Gloucestershire	Ashleworth, Tithe Barn (Bridge 2002)	7.12
Gloucestershire	Kempley, St Marys Church (Miles *et al* 1999)	7.02
Gloucestershire	Twyning, Bellframe (Tyers 1996)	8.05
London	City of London, Trig Lane (Tyers 1992)	5.65
Nottinghamshire etc	East Midlands region (Laxton and Litton 1988)	6.03
Surrey	Wanborough, Barn (Tyers 1997)	6.31
Worcestershire	Worcester, Commandery (Pilcher 1998)	7.43
Worcestershire	Wick, St. Cuthberts (Bridge 1981)	6.52
Yorkshire	Wakefield, John Bunny House (Morgan 1988)	7.28

Appendix 1 Ring width data for measured samples from the Frater roof at Cleeve Abbey, near Washford, Somerset, 100 = 1mm

CAF01

115	98	67	72	61	43	32	35	34	41
138	115	124	134	86	122	108	108	127	174
242	211	166	170	110	126	128	99	125	129
160	114	137	109	164	151	157	181	171	189
145	135	134	121	160	133	127	147	148	148
170	106	98	90	94	114	121	119	100	109
132	133	129	97	65	56	106	99	102	128
113	130	138	132	120	122	119	79	82	67
51	74	83	74	84	77	115	81	92	70
101	100	82	124	101	109	136	122	103	120
128	130	124	80	110	77	167	105	87	106
89	91	97	136	118	105	105	92	110	88
64	98	86							

CAF02

320	218	253	262	161	146	140	143	131	123
119	98	112	134	163	94	93	77	141	112
102	138	133	147	120	145	144	153	218	192
202	97	61	90	70	60	118	142	133	70
113	165	172	197	126	157	149	102	112	117
117	109	108	137	132	104	92	110	199	181
145	166	130	171	155	162	105	117	143	111
130	106	126	130	160	220	156	138	114	129
91	104	143	152	234					

CAF03

315	329	320	332	149	65	174	299	132	121
216	160	141	79	44	54	120	185	127	152
59	61	58	81	79	50	49	60	52	73
65	85	97	148	124	77	122	70	97	83
61	57	58	36	110	85	85	49	47	60
57	99	150	74	60	60	179	147	102	100
151	66	86	175	119	93	133	42	33	23
30	30	22	28	45	39	45	42	41	118
71	53	51	44	86	124	168	142	75	56
42	45	57	55	47	50	104	67	71	98
63	76	101	131	142	123	83	65	86	62
140	125	153	171	115	157	86	86	202	175
225	136	136	249	182	217	261	171	207	231
215	114	144	135	99	131	96	111		

CAF04

361	173	196	512	344	230	118	74	73	97
130	123	179	107	140	156	122	136	100	102
124	153	108	90	80	90	181	183	121	159
145	174	161	94	52	57	39	102	113	119
162	143	111	114	135	143	120	75	52	148
166	129	94	125	93	110	295	232	168	203
99	43	40	46	37	27	37	35	32	32
38	37	99	106	69	57	34	129	161	232
112	112	83	60	41	42	48	57	52	127
61	93	99	70	91	180	228	273	223	90
73	158	76	192	107	187	209	122	161	195
114	300	202	150	101	94	153	139	207	132
120	132	134	94						

CAF05

247	150	55	51	90	105	84	121	56	59
87	107	115	89	59	73	84	77	84	66
73	131	104	87	110	91	121	77	84	70
72	53	132	123	105	109	104	119	89	116
215	144	104	71	156	158	140	97	128	79
88	125	131	93	88	44	36	37	54	35
24	32	58	45	33	46	43	78	58	71
55	36	81	135	128	122	43	46	49	47
36	42	48	36	56	48	63	81	56	61
66	99	118	113	64	71	105	65	104	82
95	76	79	76	73	66	98	106	114	67
80	98	127	111	99	94	102			

CAF06

178	140	222	261	219	260	261	183	227	194
129	116	91	111	138	173	158	164	132	83
67	93	106	79	100	151	144	113	97	87
80	81	90	104	96	67	71	86	102	98
90	80	109	107	107	67	86	87	152	137
76	84	78	78	74	55	62	63	38	54
71	54	64	59	50	59	83	89	71	54
35	84	79	65	56	69	59	52	91	80
66	86	63	93	73	65	64	30	53	86
63	63	56	63	78	99	83	48	47	80
109	150	111	85	126	75	70	89	90	91
78	102	88	86	106	86	88	123	144	110
129	122	104	139	100	123	113	112	133	120
100	115	113	132	142	163	132	89	163	151
195	299	251	221	202	196	191	150	206	157
216	170								

CAF07

190	149	150	141	123	160	108	52	78	61
73	132	114	135	171	92	104	95	75	65
60	87	76	156	115	133	122	90	49	70
76	45	66	71	75	66	82	73	72	81
79	72	71	63	64	75	97	95	113	88
111	142	102	76	82	76	121	107	94	95
100	126	96	81	100	77	45	77	79	68
71	75	72	64	71	93	72	64	42	73
80	85	58	64	53	54	111	92	65	80
78	99	61	77	53	38	40	74	70	75
50	63	83	113	64	64	44	75	83	114
97	90	125	81	71	82	80	79	75	114
80	96	126	82	78	103	139	117	107	140
143	172	112	119	99	103	125	82	117	135
146	260	204	204	155	108	122	164	212	201
182	181	194	105	125	145	147	140		

CAF08

365	230	120	118	88	184	175	195	129	225
198	115	108	101	84	217	168	82	41	48
64	59	50	55	75	83	128	102	102	143
79	57	81	128	81	150	123	100	46	145
200	83	91	269	168	169	55	23	41	67
92	73	75	59	35	68	65	56	98	106
172	127	101	64	76	127	296	232	97	190
153	168	85	100	101	89	55	209	160	161
93	93	57	54	96	142	73	44	36	55
54	38	34	74	46	62	182	77	30	74
209	123	64	116	90	26	45	135	116	61
74	68	200	188	140	96	51	171	194	130
152	103	129	88	74	76	53	90	71	191
70	47	63	83	85	109	129	322	93	77
77	68	52	261	138	240	190			

CAF09

202	118	110	112	172	159	144	142	167	193
194	208	200	136	108	159	132	142	139	151
180	191	173	168	171	250	161	193	124	93
79	70	69	177	187	280	205	207	135	236
251	160	112	111	129	151	178	164	115	115
146	149	122	117	97	113	147	139	106	96
172	125	157	147	179	161	127	193	127	121
144	165	168	96	83	126	148			

CAF10

171	139	144	204	172	136	112	106	134	178
175	138	103	134	91	52	60	84	129	98
99	106	130	115	130	107	95	122	94	100
67	64	84	96	101	108	102	112	58	66
103	74	68	73	87	91	107	111	91	90
92	101	96	71	49	51	42	42	61	51
93	65	79	66	86	106	78	96	84	78
114	126	124	91	95	131	106	89	109	92
141	107	95	114	123	133	119	177	127	181
155	160	179	98	121	115	156	136	105	106
94	107	108	122	135	209				