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TREE-RING ANALYSIS OF TIMBERS FROM SHREWSBURY ABBEY CHURCH

N Nayling

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Summary

The tower of Shrewsbury Abbey, founded in the late-eleventh century, is presently undergoing repair. Recording of surviving timbers in both the bell-chamber floor and tower roof suggests that some medieval timbers may survive, in contrast to the rest of the building. This report covers the dendrochronological analysis of a series of oak timbers within the roof and bell-chamber floor to clarify the dating of the surviving timbers so as to inform repair decisions. Few timbers from the floor proved suitable for tree-ring dating, but a single timber dated with a felling range of AD 1365-95. A single timber dates underpinning of this floor with diagonally oriented beams to the late-seventeenth century, probably AD 1667. The tower roof, previously interpreted as a single-phase construction dated to the seventeenth century, contains surviving elements of the original roof dated to AD 1380-95. The present roof dates to AD 1641. The results suggest that substantial elements of the bell-chamber floor and the tower roof date to the primary construction of the tower.

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Introduction

This document is a technical archive report on the tree-ring analysis of oak timbers from the roof and floor of the belfry tower of Abbey Church, Shrewsbury (NGR SJ50591222). It is beyond the dendrochronological brief to describe the building in detail or to undertake the production of detailed drawings. As part of a multifaceted and multidisciplinary study of the building, 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. The conclusions may therefore have to be modified in the light of subsequent work.

Substantial elements of the Abbey Church, Shrewsbury, and much of its overall plan date to the late-eleventh or early-twelfth century. Subsequent alterations include westward extension of the bays of the three-aisled nave in the thirteenth or fourteenth century, the addition (probably in the late-fourteenth century) of a massive three-stage tower which now dominates the west end, the insertion of numerous Decorated elements, and extensive nineteenth-century restoration. The oldest surviving elements in the nave roof probably date to the fifteenth or sixteenth century and it would appear that the west tower contains the only surviving medieval timber-work. Baker (1998) suggests a late fourteenth-century date for the western tower on both architectural grounds and the heraldic content of the great west window.

The western tower of Shrewsbury Abbey is presently undergoing a substantial programme of repairs, grant-aided by English Heritage. Ancient timbers survive in both the lead-covered roof and the bell-chamber floor. Recent detailed recording of the bell-chamber floor has identified a possible medieval floor with later underpinning, along with remnants of bell-frames (Baker 1998). A tree-ring dating programme of timbers from the tower roof and bell-chamber floor of Shrewsbury Abbey was requested by John Wheatley, the English Heritage commissioned architect, to provide precise dates for their construction, and hence inform the programme of repairs.

Methodology

Methods employed at the Lampeter Dendrochronology Laboratory in general follow those described in English Heritage (1998). Details of the methods used for the dating of this building are described below.

A brief survey identified those oak timbers with the most suitable ring sequences for analysis. Those with more than 50 annual rings and some survival of the original sapwood and bark-edge were sought. The dendrochronological sampling programme attempted to obtain cores from as broad a range of timbers, in terms of structural element types, scantling sizes, and carpentry features, 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 left open. The ring sequences in the cores were revealed by sanding.

The complete sequences of growth rings in the samples that were selected for dating purposes were measured to an accuracy of 0.01mm using a micro-computer based travelling stage (Tyers 1997a). The ring sequences were plotted onto semi-log graph paper to enable visual comparisons to be made between sequences. In addition cross-correlation algorithms (Baillie and Pilcher 1973; Munro 1984) were 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 satisfactory visual matching supports these positions.

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 11 and maximum of 41 annual rings, following sapwood estimates given by Miles (1997). 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 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

Indications of reuse of timbers in the tower roof, including redundant mortises in the ridge beam, and differential erosion of timbers in the surviving truss, implied greater chronological complexity in the roof

than had been anticipated before scaffolding provided access for detailed assessment of the surviving structure. Samples were taken from a variety of timber elements to test whether the surviving roof was indeed of a single phase, as previously assumed.

Identification of suitable samples from the bell-chamber floor was hampered by the highly eroded condition of the upper surface of its timbers, and the application of paint to their undersides. On-site assessment of cores as they were taken indicated that the timbers were borderline in terms of ring count. Samples were also taken from two of the diagonally situated timbers underpinning the floor. Possible remnants of bell-frames, both reused within the floor and *in situ* timbers, were deemed unsuitable for analysis.

A total of 19 timbers were selected as most suitable for sampling (Table 1; Figs 1-3). The samples were numbered **1-19** inclusive.

Three of the 19 samples, when examined in the laboratory were rejected due to an insufficient number of rings for reliable analysis (Table 1). The remaining 16 series were initially compared with each other. Three sets of sequences matched together to form three internally consistent groups (Table 2). Three mean chronologies were calculated: a 122-year five-timber mean named SACM1; a 119-year two-timber mean named SACM2; and a 165-year five-timber mean named SACM3. These means were then compared with dated reference chronologies from throughout the British Isles and northern Europe. Table 3 shows the correlation of the mean sequences with dated series at the dating position identified for each sequence: AD 1257-1378, AD 1375-1493, and AD 1477-1641 respectively. Table 4 lists the mean chronologies and the dated timbers are indicated graphically in Figure 4.

The four measured samples that did not match the rest of the material, all from the bell-chamber floor, were compared with dated reference chronologies from throughout the British Isles and northern Europe without any dating being obtained.

Interpretation

Only a single timber (sample **13**; timber T11) from the bell-chamber floor produces a felling range of AD 1365-95. The heartwood/ sapwood boundary of sample **11**, from the underpinning of this floor dated to AD 1626. The sapwood on this sample consisted of 15 very narrow and unmeasurable sapwood rings following on from the heartwood/sapwood boundary, and a detached fragment of 26 sapwood rings with bark edge. Although little or no loss of sapwood rings is considered likely, beetle damage makes it impossible to be certain. Given sapwood estimates for Shropshire (Miles 1997), interpretation of the dating of this sample as indicative of a probable felling date of AD 1667? is favoured. The results are consistent with construction of the original floor in the latter half of the fourteenth century followed by underpinning in the late-seventeenth century.

Four of the sampled timbers from the roof (**3,4,5**, and **9**) gave unexpectedly early dates in the late-fourteenth or early-fifteenth century. These timbers, along with other unsampled elements such as the

crude, lapped-truss posts exhibited eroded surfaces in contrast to other visible roof timbers. It seems most probable that these timbers represent partial survival of an earlier (original?) roof and could still be in their original location. If the four dated timbers are considered contemporary then the combined estimated felling range for this group can be estimated to AD1380-95. None of this group of timbers exhibited any evidence for reuse such as redundant joints. Both this group and the bell-chamber floor could therefore represent the original timber-work contemporary with the construction of the tower.

Both of the sampled ridge pieces (**1** and **2**), which exhibited redundant mortices indicating reuse, probably derived from the same tree and possibly the same original timber (Table 2a). The felling date of AD 1493 could indicate a repair to the original roof, or perhaps more likely the reuse of this timber during the seventeenth-century rebuild of the roof.

Four timbers (**6**, **7**, **8** and **10**), two rafters and two wall plates, dated to the mid-seventeenth century, with sample **6** giving a felling date of AD1641 for construction of the present roof, consistent with the felling date ranges of the other dated timbers.

Conclusion

The dendrochronological analysis of timbers from Shrewsbury Abbey tower appears to support the hypothesised fourteenth-century date for the bell-chamber floor. The majority of timbers contained barely sufficient rings for analysis, and hence this interpretation is based on only a single timber. Associated bell-frame elements proved unsuitable for analysis. The floor was underpinned in the late-seventeenth century.

The roof proved more complex than anticipated and whilst the present roof appears to date to AD1641, there are clearly elements of an earlier, fourteenth-century, roof present along with timbers originally felled at the end of the fifteenth century.

The results suggest that substantial elements of the bell-chamber floor and the tower roof date to the primary construction of the tower. The tower roof underwent a major rebuild in AD 1641, and the bell-chamber floor was underpinned in the late-seventeenth century, possibly in AD 1667.

Acknowledgements

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Figure 1 Plan of the tower roof at Shrewsbury Abbey Church showing position and orientation of elevation and indicating sample locations. See Fig 2 for elevation (after Catterall Morris Jaboor Chartered Architects diagram)

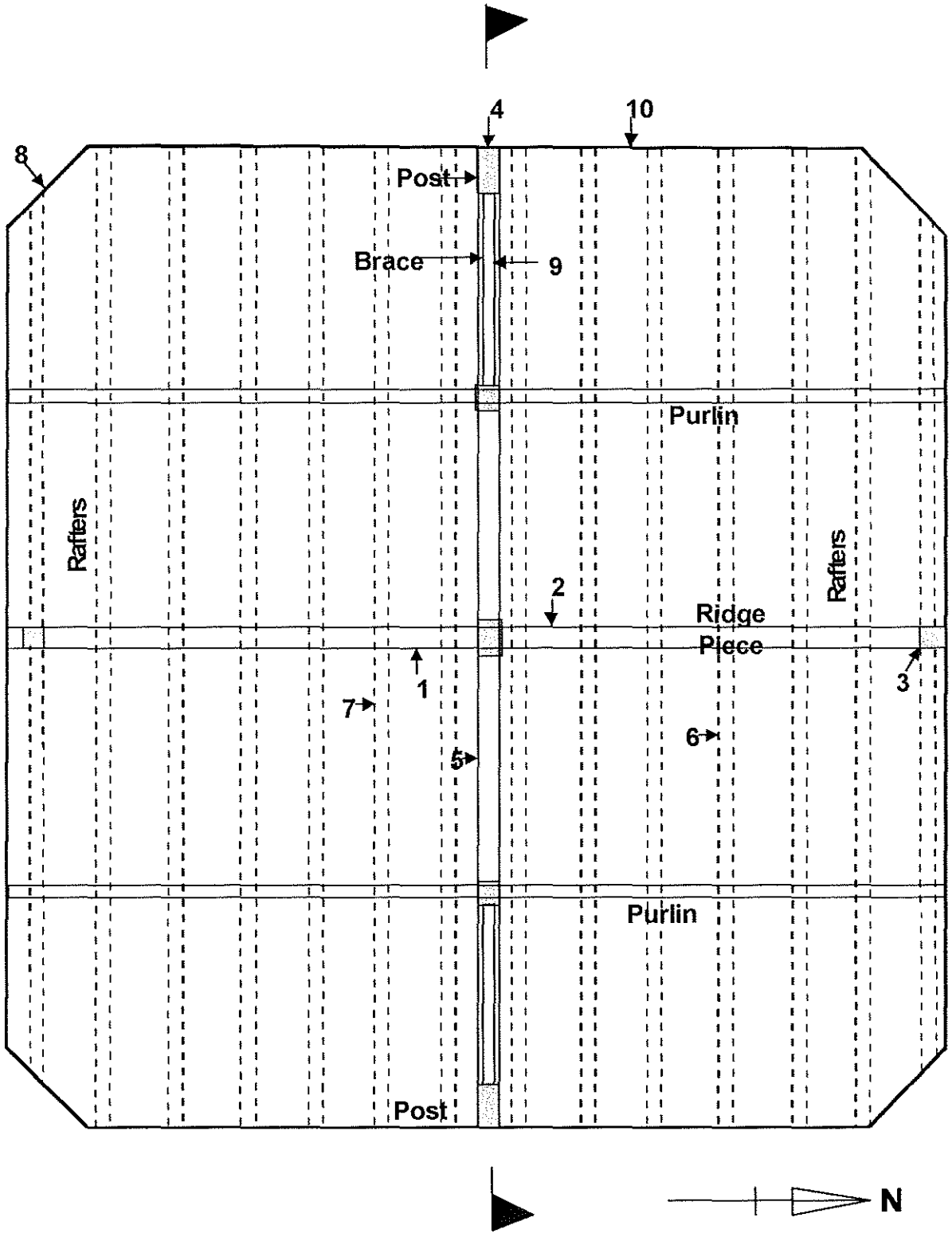


Figure 2 Central truss of tower roof showing sample locations (after Catterall Morris Jaboor Chartered Architects diagram)

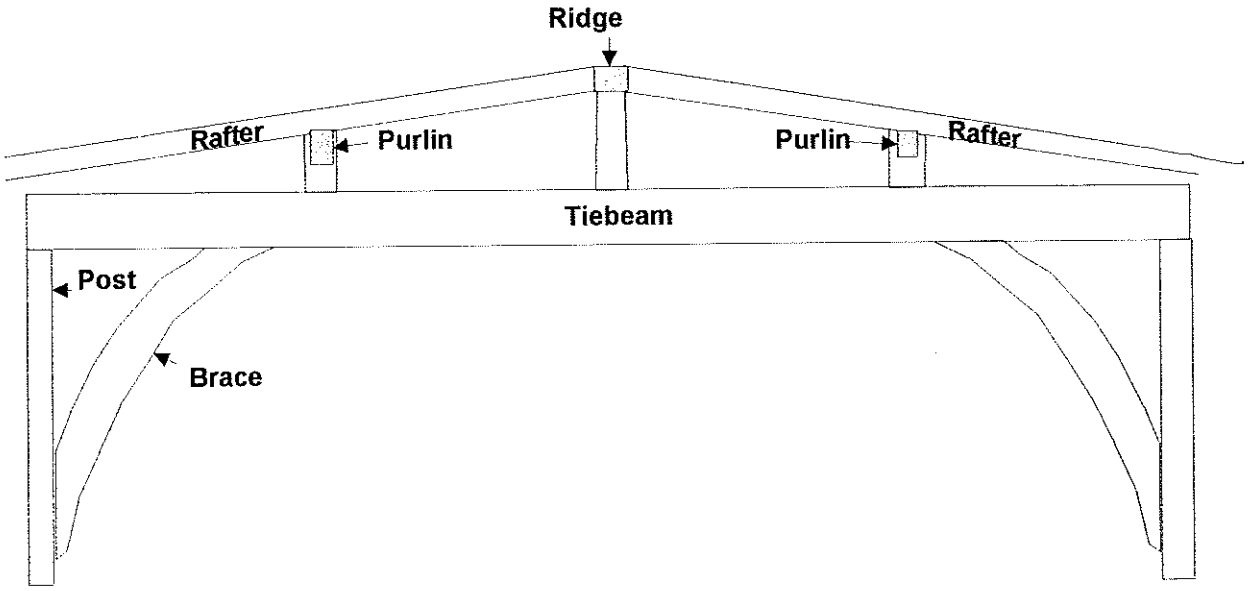


Figure 3 Bell-chamber floor and underpinning showing sample locations (after Baker 1998)

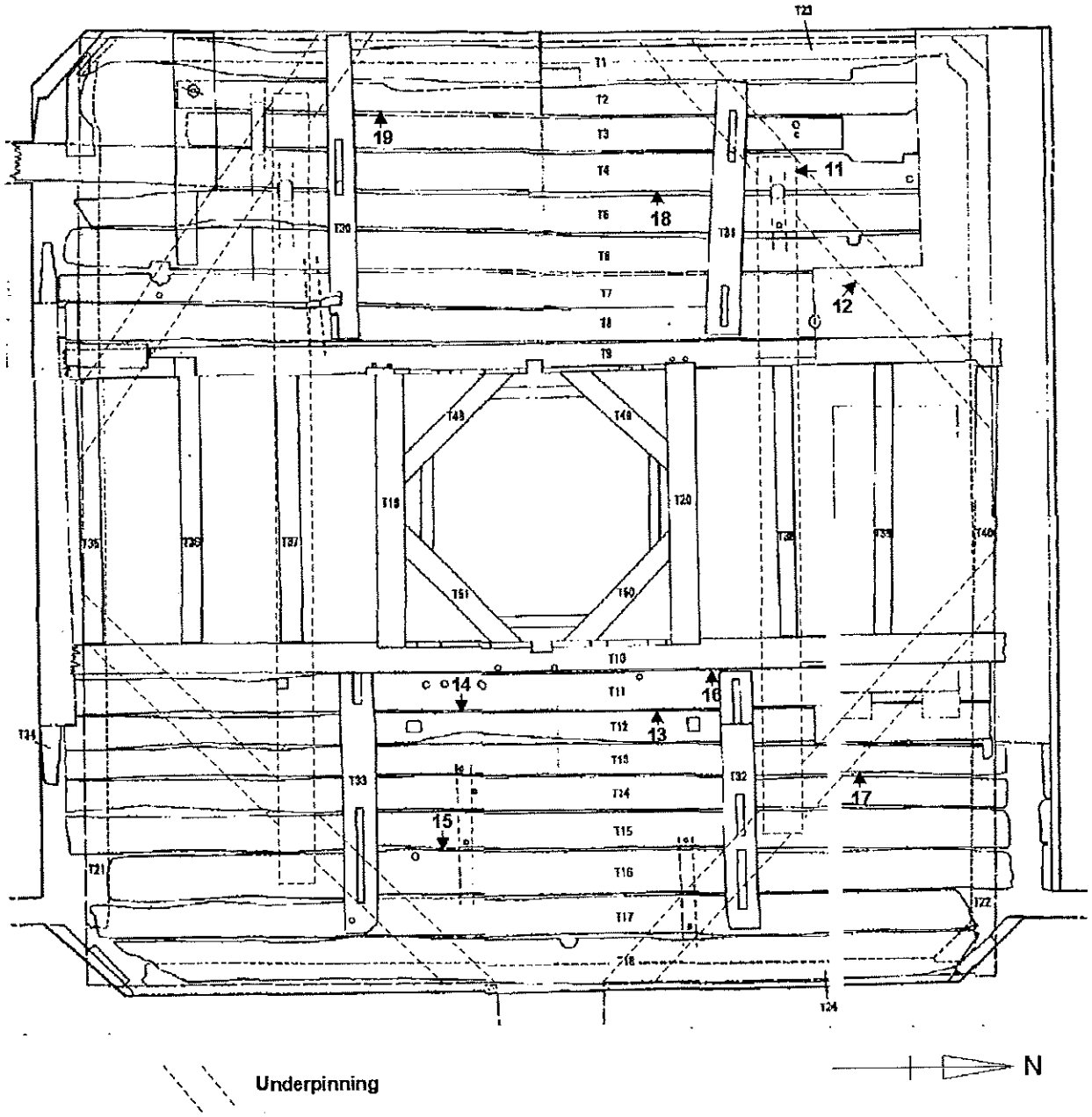
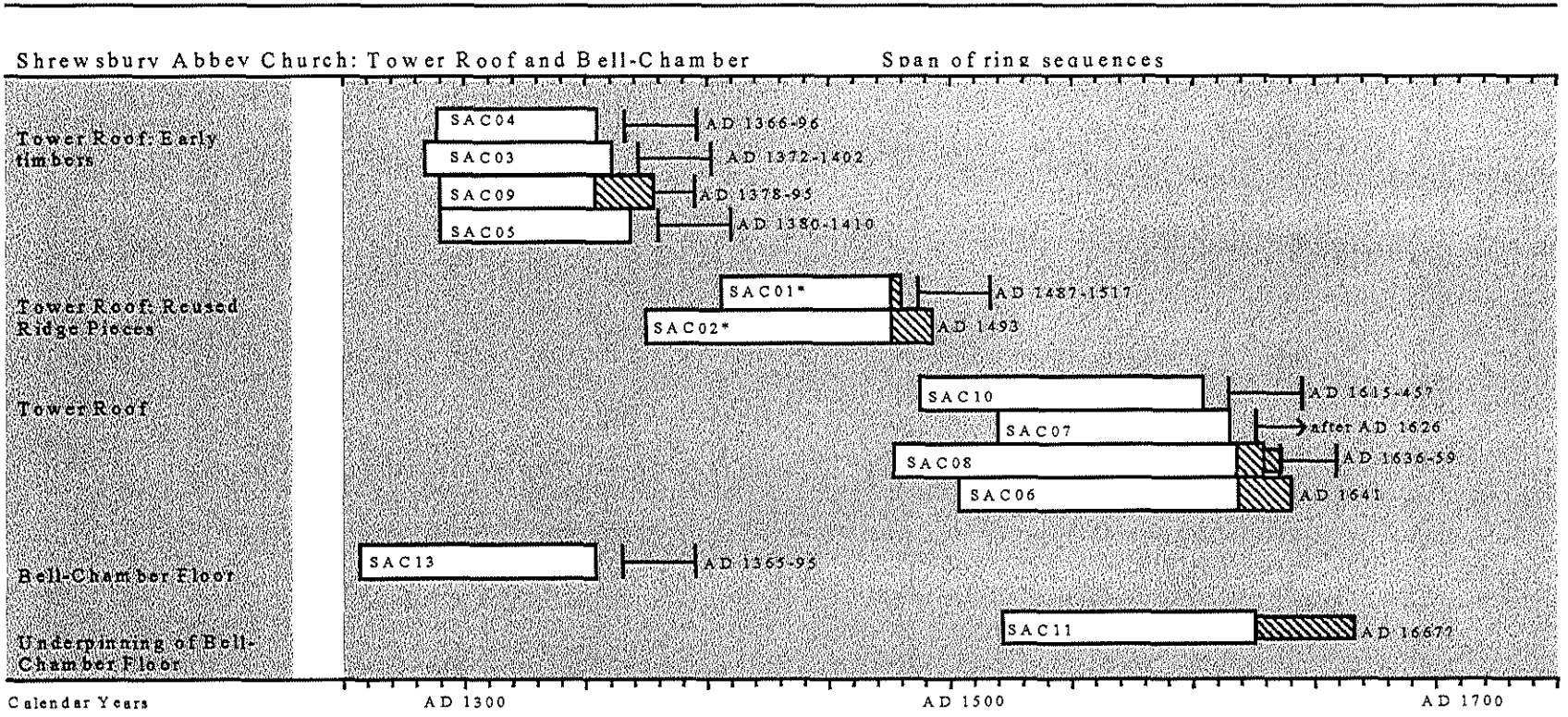


Figure 4 Bar diagram showing the chronological positions of the 12 dated timbers. The felling period for each sequence is also shown.



KEY

	heartwood
	sapwood
	unmeasured heartwood
	unmeasured sapwood
?HS	possible heartwood/sapwood boundary
B	bark boundary
*	re-used timber

Table 1

List of samples

Core No	Origin of core	Cross-section size (mm)	Cross-section of tree	Total rings	Sapwood rings	ARW mm/year	Date of sequence	Felling period
01	Tower roof: eastern ridge piece	350 x 260	Quarter	75	4	1.36	AD 1406-80	AD 1487-1517
02	Tower roof: western ridge piece	340 x 280	Half	119	17+b	1.84	AD 1375-1493	AD 1493
03	Tower roof: western post	295 x 270	Half	78	h/s	2.81	AD 1284-1361	AD 1372-1402
04	Tower roof: southern post	250 x 175	Half?	67	h/s	2.72	AD 1289-1355	AD 1366-96
05	Tower roof: tiebeam	360 x 250	Half	80	h/s	3.45	AD 1290-1369	AD 1380-1410
06	Tower roof: rafter	170 x 150	Quarter?	138	22+b	1.05	AD 1504-1641	AD 1641
07	Tower roof: rafter	160 x 160	Quarter	96	-	1.25	AD 1520-1615	after AD 1626
08	Tower roof: wall plate south-east corner	230 x 150	Half	153	11+7	1.11	AD 1477-1629	AD 1636-59
09	Tower roof: brace	300 x 280	Whole	89	24	1.49	AD 1290-1378	AD 1378-95
10	Tower roof: southern wall plate	280 x 150	Half	117	h/s?	1.15	AD 1488-1604	AD 1615-45?
11	Bell-chamber floor underpinning: T47	280 x 270	Whole	146	15+26+bw	1.69	AD 1522-1626	AD 1667?
12	Bell-chamber floor underpinning: T42	300 x 290	Whole	63	h/s+4	2.67	Undated	
13	Bell-chamber floor T11	300 x 300	Whole	98	h/s	2.24	AD 1257-1354	AD 1365-95
14	Bell-chamber floor T12	220 x 220	Quarter	58	h/s?	2.95	Undated	
15	Bell-chamber floor T16	340 x 220	Half	63	h/s?	2.56	Undated	
16	Bell-chamber floor T10	410 x 220	Half	<50	-	-	Unmeasured	
17	Bell-chamber floor T13	240 x 220	Whole	68	h/s?	2.59	Undated	
18	Bell-chamber floor T4	280 x 220	Whole	<50	-	-	Unmeasured	
19	Bell-chamber floor T2	240 x 220	Quarter?	<50	-	-	Unmeasured	

'Total rings' = all measured rings, +value means additional rings were only counted, the felling period column is calculated using these additional rings.
'sapwood rings': h/s heartwood/sapwood boundary, ?h/s possible heartwood/sapwood boundary, +bw = bark-edge winter felled, +bs = unmeasured spring growth also present
'ARW' = average ring width of the measured rings

Table 2

a) *t*-value matrix for the timbers forming the chronology SACM2.
KEY: - = *t*-values under 3.0, \ = no overlap

	2
1	9.99

b) *t*-value matrix for the timbers forming the chronology SACM1.
KEY: - = *t*-values under 3.0, \ = no overlap

	4	5	9	13
3	-	4.66	4.46	3.95
4		3.26	3.44	3.90
5			8.69	6.07
9				7.79

c) *t*-value matrix for the timbers forming the chronology SACM3.
KEY: - = *t*-values under 3.0, \ = no overlap

	7	8	10	11
6	5.68	3.40	3.53	3.70
7		5.15	4.90	3.89
8			8.68	-
10				-

Table 3

a) Dating the mean sequence SACM2, AD 1375-1493 inclusive. *t*-values with independent reference chronologies

Area	Reference chronology	*t*-values
Buckinghamshire	Claydon House (Tyers 1995)	5.01
East Midlands	East Midlands (Laxton and Litton 1988)	5.79
Gloucestershire	26 Westgate Street Gloucester (Howard *et al* 1998a)	5.19
Gloucestershire	Gloucester Mercer's Hall (Howard *et al* 1996)	5.79
Herefordshire	Widemarsh St Hereford (Tyers 1996)	5.07
Herefordshire	Woodhouse Farm Staplow (Tyers pers comm)	5.22
Staffordshire	Sinai Park (Tyers 1997b)	5.13
Welsh Border	Welsh Border (Siebenlist-Kerner 1978)	5.90
Yorkshire	Calverley Hall (Hillam pers comm)	6.48
Yorkshire	Nostell Priory (Tyers 1998)	6.11

b) Dating the mean sequence SACM1, AD 1257-1378 inclusive. *t*-values with independent reference chronologies

Berkshire	Windsor Castle (Hillam pers comm)	4.73
Essex	Fyfield (Bridge 1998)	4.74
Essex	St Martins Colchester (Tyers pers comm)	4.94
Gloucestershire	Withington (Howard *et al* 1998b)	4.80

Herefordshire	Kings Pyon barn (Groves and Hillam 1993a)	4.97
Leicestershire	Owston Church (Howard *et al* 1998c)	4.50
Worcestershire	Worcester Commandery (Pilcher pers comm)	4.72
Worcestershire	Manor Farm, Lower Wick (Bridge 1981)	5.00
Worcestershire	Droitwich Upwich 2 (Groves and Hillam 1997)	5.50
Yorkshire	Nostell Priory (Tyers 1998)	4.87

c) Dating the mean sequence SACM3, AD 1477-1641 inclusive. *t*-values with independent reference chronologies

Cheshire	Old Abbey Farm, Risley (Nayling 1998)	5.12
Devon	Berry Pomeroy Castle (Groves and Hillam 1993b)	5.18
Dorset	Lodge Farm Kingston Lacy (Groves 1994)	4.12
Herefordshire	Pembridge Bell Tower C (Tyers 1999)	4.21
Herefordshire	Widemarsh St Hereford (Tyers 1996)	3.40
Lincolnshire	Main Street - South Rauceby (Tyers pers comm)	4.84
Staffordshire	Sinai Park (Tyers 1997b)	4.53
Welsh Border	Welsh Border (Siebenlist-Kerner 1978)	3.54
Worcestershire	Droitwich Upwich 3 (Groves and Hillam 1997)	3.49
Yorkshire	York, King's Manor (King pers comm)	4.44

Table 4

Ring-width data from site master s a) SACM1, b) SACM2, and c) SACM3 dated to AD 1257-1378, AD 1375-1493, and AD 1477-1641 inclusive respectively.

a) Shrewsbury Abbey SACM1

Date	Ring widths (0.01mm)										No of samples									
AD 1257							195	304	100	233							1	1	1	1
	203	225	290	266	313	279	337	267	223	276	1	1	1	1	1	1	1	1	1	1
	321	266	351	290	277	256	340	330	336	339	1	1	1	1	1	1	1	1	1	1
	286	318	289	348	233	379	267	308	316	349	1	1	1	2	2	2	2	2	3	5
	305	359	388	369	318	318	248	270	222	278	5	5	5	5	5	5	5	5	5	5
AD 1301	298	305	194	182	241	251	255	256	207	179	5	5	5	5	5	5	5	5	5	5
	182	220	219	274	352	324	316	258	284	258	5	5	5	5	5	5	5	5	5	5
	275	265	273	288	287	164	286	297	226	174	5	5	5	5	5	5	5	5	5	5
	136	224	265	266	312	262	163	271	296	244	5	5	5	5	5	5	5	5	5	5
	244	203	205	171	271	272	254	252	257	168	5	5	5	5	5	5	5	5	5	5
AD 1351	189	200	218	262	159	192	175	158	227	172	5	5	5	5	4	3	3	3	3	3
	189	275	222	197	172	185	153	196	264	111	3	2	2	2	2	2	2	2	2	1
	104	115	115	106	165	139	174	135			1	1	1	1	1	1	1	1		

b) Shrewsbury Abbey SACM2

Date	Ring widths (0.01mm)										No of samples									
AD 1375					300	273	238	281	324	240					1	1	1	1	1	1
	174	207	201	270	188	347	328	356	268	224	1	1	1	1	1	1	1	1	1	1
	206	210	255	113	118	193	227	247	244	252	1	1	1	1	1	1	1	1	1	1
AD 1401	169	238	310	224	246	251	194	137	177	250	1	1	1	1	1	2	2	2	2	2
	185	267	192	207	200	128	138	195	143	209	2	2	2	2	2	2	2	2	2	2

	212	162	276	189	159	83	135	209	177	178	2	2	2	2	2	2	2	2	2	2
	220	219	161	168	225	139	155	121	94	140	2	2	2	2	2	2	2	2	2	2
	137	101	115	124	116	138	108	141	140	139	2	2	2	2	2	2	2	2	2	2
AD 1451	158	138	183	173	144	177	179	129	152	188	2	2	2	2	2	2	2	2	2	2
	100	86	100	68	103	86	125	120	112	105	2	2	2	2	2	2	2	2	2	2
	118	74	97	101	128	138	144	123	145	118	2	2	2	2	2	2	2	2	2	2
	182	140	154	157	162	152	223	174	140	127	1	1	1	1	1	1	1	1	1	1
	132	96	113								1	1	1							

c) Shrewsbury Abbey SACM3

Date	**Ring widths (0.01mm)**										**No of samples**									
AD 1477							467	210	247	359							1	1	1	1
	332	261	262	319	322	274	306	202	187	272	1	1	1	1	1	1	1	2	2	2
	238	296	230	220	252	345	245	174	187	265	2	2	2	2	2	2	2	2	2	2
AD 1501	431	617	465	424	341	263	208	234	250	171	2	2	2	2	2	2	2	2	2	2
	165	176	135	135	107	112	106	127	110	181	2	2	2	2	2	2	2	2	2	4
	170	175	139	157	111	124	137	138	123	108	4	5	5	5	5	5	5	5	5	5
	169	107	111	110	125	120	126	124	121	107	5	5	5	5	5	5	5	5	5	5
	127	102	113	138	127	95	95	111	158	187	5	5	5	5	5	5	5	5	5	5
AD 1551	182	141	117	133	67	52	71	88	101	94	5	5	5	5	5	5	5	5	5	5
	118	92	76	74	69	65	76	83	104	118	5	5	5	5	5	5	5	5	5	5
	83	74	75	127	117	78	70	64	74	76	5	5	5	5	5	5	5	5	5	5
	91	72	97	107	94	104	73	58	75	63	5	5	5	5	5	5	5	5	5	5
	71	67	74	83	83	82	91	101	97	86	5	5	5	5	5	5	5	5	5	5
AD 1601	87	74	99	89	70	78	84	101	85	95	5	5	5	5	4	4	4	4	4	4
	71	66	54	54	67	89	81	80	74	89	4	4	4	4	4	3	3	3	3	3
	68	68	59	41	49	52	79	76	96	138	3	3	3	3	3	3	2	2	2	1
	70	88	73	54	77	81	91	133	117	111	1	1	1	1	1	1	1	1	1	1
	93										1									