2750

Ancient Monuments Laboratory
Report 73/98

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Summary

Ten samples were taken from the roof of the library (former refectory) at Forde Abbey, Chard, Dorset (ST 3594 0514) during repairs executed during 1997. Four timbers were found to originate from the same tree and were combined to form a 184-ring site master which was dated, spanning the years AD 1292-1475 and giving an estimated felling date range of AD 1483-1515. Three other samples matched together to form a second site master of 100 rings which also dated, spanning the years AD 1386-1485 and giving a felling date range of AD 1492-1524 and two termini post quem of after AD 1483 and after AD 1494. An eighth timber of 87 rings dated individually, spanning the years AD 1390-1476 and giving a felling date range of AD 1481-1513. All the estimated felling date ranges are consistent with a very late fifteenth or early sixteenth century date, and whilst it is just possible that the Refectory roof may have been part of the alterations instigated by Abbot Chard in AD 1521, it is more likely to have been constructed by his immediate predecessor.

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THE TREE-RING DATING OF THE REFECTORY ROOF, FORDE ABBEY, CHARD, DORSET

1. INTRODUCTION AND OBJECTIVES

Forde Abbey, Chard, Dorset (ST 3594 0514) originated as a Cistercian monastery founded by AD 1141 (Fig 1). In AD 1521 the last Abbot, Thomas Chard, succeeded and embarked on an ambitious programme of restoration and improvements to the buildings. This however was cut short by the Dissolution in AD 1539 when the Abbey was appropriated by the Crown and leased to Richard Pollard. During the following century the buildings were plundered for their materials until AD 1649 when it was sold to Edmund Prideaux, Attorney-General to Oliver Cromwell. He spent the next decade transforming the Abbey into the house which largely survives today (Fig 2). Subsequent owners have made minor alterations to the house and created the gardens, but the Abbey still retains most of Prideaux's work (Tyler and Roper nd).

In 1997 repairs commenced to the roof structure of the Library, converted from the monastic Refectory or Frater. This roof structure comprises 13 arch-braced collar-trusses with curved V-struts alternating with straight cross-bracing above, sitting on inner and outer wall-plates above which are four tiers of bare-faced butt purlins and a ridge piece (Fig 3). The high quality of the carpentry is emphasised by the liberal use of mouldings and chamfers on all exposed structural members, with the unusual feature of three tiers of straight cross-bracing between the purlins with the collars, arch-braces, and ashlars all having their faces elaborately carved with sunk blind-tracery. The dendrochronological analysis was commissioned by Rebecca Child, English Heritage architect for the South-west Region, to establish the date of construction of the existing roof structure. Typically, the date of the roof has been ascribed to the fifteenth century on stylistic grounds, but because of its unusual design, this dating was tentative at best.

2. METHODOLOGY

Ten samples taken were from what appeared to be primary first-use oak (*Quercus* spp.) timbers with complete sapwood, heartwood/sapwood transitions, or with reasonable number of rings. Sections of timbers removed during the course of repairs were first assessed and five sections were selected for analysis (***frd6*** - ***frd10***). Unfortunately none of these had any surviving sapwood, and only one of these retained a heartwood/sapwood transition boundary. Therefore, it was necessary to selectively sample *in situ* from the standing roof structure. However, because of the highly finished nature of the timberwork, virtually all of the sapwood had been trimmed off through the cutting of mouldings and chamfers. Only one timber (***frd5***) retained complete sapwood, which was a common rafter severed in forming access to the roof of the north-east part of the cloisters adjacent. Sampling was further complicated by the fact that most of the timbers were wide-ringed and therefore unsuitable for dendrochronology. The highly moulded and carved surface of the majority of timbers greatly reduced the areas of timbers accessible to coring. Nevertheless, three collars exhibited substantial ring counts (***frd2*** - ***frd4***), with two retaining a visible heartwood/sapwood boundary. Another common rafter (***frd1***) with a heartwood/sapwood boundary was cored twice to ensure a complete sequence of rings. The samples taken *in situ* were accomplished with a 16mm hollow coring bit, the holes plugged with ramin doweling stained where necessary to match the surrounding timberwork.

The dry samples were sanded on a linisher using 60 to 1200 grit abrasive paper, and were cleaned with compressed air, to allow the ring boundaries to be clearly distinguished. They were then measured under a x10/x30 microscope using a travelling stage electronically

displaying displacement to a precision of 0.001mm, rounded to the nearest 0.01mm. After measurement, the ring-width series for each sample were plotted as a graph of width against year. The graphs of each of the samples in the phase under study were then compared visually at the positions indicated by the computer matching and, when found satisfactory and consistent, were averaged to form a mean curve for the site or phase. This mean curve and any unmatched individual sequences were then compared against dated reference chronologies to obtain an absolute calendar date for each sequence.

Here this was accomplished by using a combination of both visual matching and a process of qualified statistical comparison by computer. The samples were first matched by computer, and then independently visually checked with graphs. When an undated sample or site sequence is compared against a dated sequence, known as a reference chronology, an indication of how good the match is must be determined. Although it is almost impossible to define a visual match, computer comparisons can be accurately quantified. Whilst it may not be the best statistical indicator, Student's t-value has been widely used amongst British dendrochronologists. The cross-correlation algorithms most commonly used are derived from Baillie and Pilcher's Belfast CROS programme (Baillie and Pilcher 1973), compared on an IBM compatible PC. A version of this and other programmes were written in BASIC by D Haddon-Reece, and latterly re-written in Microsoft Visual Basic by M R Allwright and P A Parker.

In comparing one sample or site master against other samples or chronologies, t-values over 3.5 are considered significant, although in reality it is common to find demonstrably spurious t-values of 4 and 5 because more than one matching position is indicated. For this reason, dendrochronologists prefer to see some t-value ranges of 5, 6, and higher, and for these to be well replicated from different, independent chronologies with local and regional chronologies well represented. Where two individual samples match together with a t-value of 10 or above, this may suggest they originated from the same tree.

Once a tree-ring sequence has been firmly dated in time, a felling date, or date range, is ascribed where possible. With samples which have sapwood complete to the underside of, or including bark, this process is relatively straight forward. Depending on the completeness of the final ring, ie if it has only the spring vessels or early wood formed, or the latewood or summer growth, a precise felling date and season can often be given, although this is more problematical with narrow-ringed samples. If the sapwood is partially missing, or if only a heartwood/ sapwood transition boundary survives, then an estimated felling date range can be given for each sample. The number of sapwood rings can be estimated by using a statistically derived sapwood estimate with a given confidence limit. An accepted sapwood estimate for British and Irish oaks is given as between 10 and 55 rings with a 95% confidence range (Hillam.*et al* 1987). A recent review of the geographical distribution of dated sapwood data from historic building timbers has shown that a 95% range of 9-41 rings is more appropriate for historic building timbers in the southern counties (Miles 1997a), and this sapwood estimate has been used throughout this report. If a dated sample has no evidence of a heartwood/sapwood transition, then only a *terminus post quem (tpq)* or felled after date can be given. This is derived by adding the minimum number if sapwood rings from the appropriate sapwood estimate to the last measured or counted heartwood ring.

3. RESULTS

The ten samples obtained from various elements of the roof were designated ***frd1***, ***frd2***, etc. The sample locations are located on the plan and sections in Figures 4, 5, and 6. Details of each sample, including locations, date ranges, sapwood, number of rings, and other characteristics are summarised in Table 1. Section drawings of each sample are shown in Figure 7.

Three samples (***frd2***, ***frd3***, and ***frd4***) from the collars of trusses T3, T4, and T7 respectively were found to match together with a section of the east wall plate from bay 1 (***frd9***). The extremely high *t*-values produced between these samples (Table 2) strongly suggest these originated from the same tree. The four samples were combined to form the 184-ring site master ***FRDABBY1***. This was compared with the reference chronologies and was found to match with the first ring of the sequence at AD 1292, and the final ring at AD 1475 (Table 3). As the two samples with sapwood or heartwood/sapwood boundaries both produced a last heartwood ring date of AD 1474, a felling date range of AD 1483-1515 has been given.

Three other samples (***frd7***, ***frd8***, and ***frd10***) from the east principal rafter of T 7, the west wall plate from bay 1, and the east wall plate from bay 9 respectively were found to match together (Table 4). These were combined to form the 100-ring site master ***FRDABBY2***. This was compared with the reference chronologies and was found to match with the first ring of the sequence at AD 1386 and the final ring at AD 1485 (Table 5). Neither sample ***frd7*** or ***frd8*** had a heartwood/sapwood boundary evident, so only *termini post quem* of after AD 1483 and after AD 1494 could be given. Sample ***frd10*** did have a heartwood/sapwood boundary evident, thus allowing a felling date range of AD 1492-1524 to be given.

An eighth sample from a common rafter above T 10 had a heartwood/sapwood boundary and was sampled twice. The two sequences of 81 (***frd1a***) and 79 rings (***frd1b***) were found to match with $t = 6.89$ and were combined to form the sequence ***frd1*** of 87 rings. This was compared with the reference chronologies and was found to match with the first ring of the sequence at AD 1390, and the final ring at AD 1476. It also matched with $t = 4.19$ with the site master ***FRDABBY1***, but the match with ***FRDABBY2*** was very poor (Table 6). An average heartwood/sapwood boundary date of AD 1472 for the two samples gives a felling date range of AD 1481-1513.

Sample ***frd5*** was cut from an exposed rafter end, and was the only sample from the site to retain complete sapwood and bark. However, as the sample had only 57 rings, no conclusive or consistent dating was obtained either individually or against the other dated or undated samples. Sample ***frd6*** had 66 rings but no heartwood/sapwood transition. This too failed to date, either with the other samples or site masters, or individually against the reference chronologies.

4. CONCLUSION

Four samples were identified as having originated from a single tree, two of which had heartwood/sapwood boundaries at AD 1474, thereby producing a felling date range of AD 1483-1515. All four samples were from timbers which were heavily moulded such as collars or wall plates. Given that most of the other less-decorated timbers assessed for tree-ring dating were from faster-grown trees, the evidence here would suggest that slow-grown trees were specifically selected for those members with the finest carving. This is because the slower-grown trees would have a higher ratio of porous spring cells in relation to dense summer growth, more conducive to executing intricate carving and moulding work. Often fine-grain oak was imported from the Baltic for this purpose, but the material used at Forde Abbey was clearly relatively local in origin. The tree from which the three collars and wall-plate were cut was between 200 and 250 years old when felled.

Four other samples have dated, two giving felling date ranges of AD 1481-1513 and 1492-1524, and two *termini post quem* of after AD 1483 and after AD 1494. As all of the dated samples are from well-provenanced timbers which are clearly coeval, a presumed construction period of shortly after AD 1500 is most likely (Fig 8). Whilst it is just possible that the

Refectory roof may have been part of the alterations instigated by Abbot Chard in AD 1521, it is more likely to have been constructed by his immediate predecessor. Only through the further analysis of samples from other early-sixteenth phases at Forde Abbey might there be a chance of matching the only sample with complete sapwood, ***frd5***, and thus substantially narrow down the construction period of the Refectory roof.

Of the eight timbers dated, it has been shown that four of these originated from a single tree. While three of these exhibited similar growth patterns suggesting a similar source, the extremely poor match with the other two trees suggests that these were obtained from diverse sources and under different growing conditions. Given the size of the Abbey's holdings, this is not unusual, and illustrates the wide area over which the Abbot could draw on in procuring materials for his building programme.

Three dated sequences were produced: ***FRDABBY1*** of 184 rings spanning the years AD 1292-1475, ***FRDABBY2*** of 100 rings spanning the years AD 1386-1485, and ***frd1*** of 87 rings spanning the years AD 1390-1476 (Table 7). These should prove useful in dating other Dorset buildings in the future.

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6. REFERENCES

Baillie, M G L, and Pilcher, J R, 1973 A simple cross-dating program for tree-ring research, *Tree-Ring Bulletin*, **33**, 7-14

Bridge, M C, 1983 *The use of tree-ring widths as a means of dating timbers from historical sites*, unpubl PhD thesis, CNAA (Portsmouth Polytechnic)

Bridge, M C, 1988 The dendrochronological dating of buildings in southern England, *Medieval Archaeol*, **32**, 166-74

Haddon-Reece, D, and Miles, D H, 1992a List 43 - Tree-ring dates, *Vernacular Architect*, **23**, 48-51

Haddon-Reece, D, and Miles, D H, 1992b *The Tree-ring dating of Acton Court, Avon*, Anc Mon Lab Rep, **11/94**

Hillam, J, 1983 Tree-ring analysis of timbers from four buildings, in Millett 1983

Hillam, J, Morgan, R A, and Tyers, I, 1987 Sapwood estimates and the dating of short ring sequences, in *Applications of tree-ring studies: current research in dendrochronology and related areas* (ed R G W Ward), BAR Int Ser, **333**, 165-85

Laxton, R R, and Litton, C D, 1988 *An East Midlands Master Tree-Ring Chronology and its use for dating Vernacular Buildings* Univ Nottingham, Dept of Classical and Archaeol Studies, Monograph Ser, **3**

Laxton, R R, and Litton, C D, 1989 Construction of a Kent Master Chronological Sequence for Oak, 1158-1540 AD *Medieval Archaeol*, **33**, 90-98

Miles, D H, 1996 *Tree-ring dating of Mottisfont Abbey, Romsey, Hampshire*, Anc Mon Lab Rep, **23/96**

Miles, D H, 1997a The interpretation, Presentation, and Use of Tree-ring Dates, *Vernacular Architect* **28**, 40-56

Miles, D H, 1997b *Working compilation of 55 reference chronologies centred around Hampshire by various researchers*, unpubl computer file *HANTS97*, the author

Miles, D H, 1997c *Working compilation of 58 reference chronologies centred around Wales by various researchers*, unpubl computer file *WALES97*, the author

Miles, D H, and Haddon-Reece, D, 1993 List 54 - Tree-ring dates, *Vernacular Architect*, **24**, 54-60

Miles, D H, and Haddon-Reece, D, 1995 List 64 - Tree-ring dates, *Vernacular Architect*, **26**, 60-74

Miles, D H, and Haddon-Reece, D 1996 List 72 - Tree-ring dates, *Vernacular Architect*, **27**, 97-102

Miles, D H, and Worthington, M J, 1997 Lists 81-85 - Tree-ring dates, *Vernacular Architect*, **28**, 159-181

Millett, M, 1983 The History, Architecture and Archaeological of Johnson's Corner, Alton, *Proc Hampshire Field Club Archaeol Soc*, **39**, 77-109

Mills, C M, 1988 Dendrochronology of Exeter and its application, unpubl PhD thesis, Sheffield Univ

Tyers, I, 1996 *Tree-ring analysis of six secular buildings from the City of Hereford*, Anc Mon Lab Rep, **17/96**

Tyers, I, Groves, C, Hillam, J, and Boswijk, G, 1997 List 80 - Tree-ring dates, *Vernacular Architect*, **28**, 138-158

Tyler, R, and Roper, M, nd Forde Abbey - Home of the Roper Family, privately printed

Table 1: Summary of tree-ring dating

Sample number	Type	Timber and position	Dates AD spanning	H/S bdry	Sapwood	No of rings	Mean width mm	Std devn mm	Mean sens mm	Felling seasons and dates/date ranges
FORDE ABBEY - REFECTORY ROOF										
frd1a	c	E rafter above T 10	1396-1476	1476	h/s	81	1.11	0.48	0.206	
1b	c	ditto	1390-1468	1468	h/s	79	1.24	0.47	0.221	
frd1		Mean of *frd1a* + *frd1b*	*1390-1476*	*1472*	*h/s*	*87*	*1.19*	*0.45*	*0.201*	*1481-1513*
**frd2*	c	Collar T 3	1341-1475	1474	1	135	0.97	0.29	0.239	1483-1515
**frd3*	c	Collar T 4	1325-1474	1474	h/s	150	1.11	0.40	0.211	1483-1515
**frd4*	c	Collar T 7	1319-1470			152	1.16	0.40	0.216	
frd5	s	E rafter bay 12	-		22C	57	1.73	0.50	0.176	
frd6	s	E wall plate bay 5	-			66	3.48	0.79	0.177	
†*frd7*	s	E principal rafter T 7	1395-1474			80	2.52	0.90	0.138	after 1483
†*frd8*	s	W wall plate bay 1	1386-1485			100	2.24	0.73	0.155	after 1494
**frd9*	s	E wall plate bay 1	1292-1414			123	1.47	0.64	0.223	
†*frd10*	s	E wall plate bay 9	1420-1483	1483	h/s	64	2.42	0.98	0.166	1492-1524
* = ***FRDABBY1* Site Master**			**1292-1475**			**184**	**1.28**	**0.51**	**0.212**	***1483-1515***
† = ***FRDABBY2* Site Master**			**1386-1485**			**100**	**2.39**	**0.79**	**0.146**	

Key: *,† = sample included in site-master; c,s = core, slice; = within 5 rings of centre; = within 10 rings of centre; C = bark edge present
winter felling (ring measured); h/s bdry = heartwood/sapwoodboundary - last heartwood ring date; std devn = standard deviation; mean sens = mean sensitivity

Table 2: *t*-values and overlaps for components of ***FRDABBY1***

Sample:	*frd3*	*frd4*	*frd9*
dated at:	1474	1470	1414
frd2	12.78 / 134	9.05 / 130	8.22 / 74
frd3		15.41 / 146	9.51 / 90
frd4			12.35 / 96

Table 3: Dating of ***FRDABBY1*** against reference chronologies at AD 1475

Reference chronology	Spanning	Overlap	t-value
HANTS97 *(Miles 1997b)*	1041-1972	180	7.17
* SHERFLD *(Miles and Haddon-Reece 1993)*	1251-1390	95	6.87
MDM11X *(Miles and Haddon-Reece 1993)*	1401-1454	50	5.77
* ALTON *(Hillam 1983)*	1348-1504	124	5.54
HALSTON *(Miles and Worthington 1997)*	1322-1437	112	5.49
SENGLAND *(Bridge 1988)*	1083-1589	180	5.45
CHILVRTN *(Tyers et al 1997)*	1351-1488	121	5.12
BRUTON5 *(Miles and Worthington 1997)*	1365-1453	85	5.09
* KINGST1 *(Miles and Haddon-Reece 1996)*	1169-1447	152	5.04
WALES97 *(Miles 1997c)*	404-1981	180	5.03

* = Component of HANTS97

Table 4: *t*-values and overlaps for components of ***FRDABBY2***

Sample:	*frd8*	*frd10*
dated at:	1485	1483
frd7	7.26 / 80	3.62 / 55
frd8		6.48 / 64

Table 5: Dating of ***FRDABBY2*** against reference chronologies at AD 1485

Reference chronology	Spanning	Overlap	t-value
OVERTON3 *(Miles and Worthington 1997)*	1397-1543	85	6.05
KENT88 *(Laxton and Litton 1989)*	1158-1540	96	5.47
HANTS97 *(Miles 1997b)*	1041-1972	96	5.44
MARTIN *(Bridge 1983)*	1379-1534	96	5.30
SENGLAND *(Bridge 1988)*	1083-1589	96	5.08
* EXTON *(Miles and Haddon-Reece 1995)*	1376-1546	96	4.89
EASTMID *(Laxton and Litton 1988)*	882-1981	96	4.75
WALES97 *(Miles 1997c)*	404-1981	96	4.24
CHILVRTN *(Tyers et al 1997)*	1351-1488	96	3.67
* KINGST1 *(Miles and Haddon-Reece 1996)*	1169-1447	58	3.61

* = Component of HANTS97

Table 6: Dating of ***frd1*** against reference chronologies at AD 1476

	Reference chronology	Spanning	Overlap	t-value
	EXMED *(Mills 1988)*	1367-1616	83	5.50
	CEELY *(Haddon-Reece and Miles 1992a)*	1377-1472	79	4.74
*	ALTON *(Hillam 1983)*	1348-1504	83	4.35
	SENGLAND *(Bridge 1988)*	1083-1589	83	4.31
	FRDABBY1	1292-1475	82	4.19
	ACTON *(Haddon-Reece and Miles 1992b)*	1328-1575	83	4.18
	WINIFRED *(Haddon-Reece and Miles 1992a)*	1301-1473	80	4.18
	HEREFC *(Tyers 1996)*	1313-1617	83	4.17
	MARTIN *(Bridge 1983)*	1379-1534	83	4.15
*	MOTISFNT *(Miles 1996)*	1388-1538	83	4.14
	HANTS97 *(Miles 1997b)*	1041-1972	83	4.08
	KENT88 *(Laxton and Litton 1989)*	1158-1540	83	3.78
	WALES97 *(Miles 1997c)*	404-1981	83	3.35
	FRDABBY2	1386-1485	83	1.73

* = Component of HANTS97

Table 7: Ring-width data for site master curves

FRDABBY1 AD 1292-1475 Refectory Roof, Forde Abbey, Chard - ***frd2+3+4+9***

ring widths (0.01mm)										number of samples in master									
212	189	160	180	252	242	158	102	115	192	1	1	1	1	1	1	1	1	1	1
250	91	96	202	246	309	363	229	310	230	1	1	1	1	1	1	1	1	1	1
245	257	165	147	164	190	172	155	183	165	1	1	1	1	1	1	1	2	2	2
172	232	99	122	91	179	221	194	130	146	2	2	2	3	3	3	3	3	3	3
159	163	140	141	233	119	142	145	111	102	3	3	3	3	3	3	3	3	3	4
128	118	144	139	105	112	80	90	99	110	4	4	4	4	4	4	4	4	4	4
113	115	104	98	86	104	109	87	92	114	4	4	4	4	4	4	4	4	4	4
103	138	129	76	57	75	89	96	97	96	4	4	4	4	4	4	4	4	4	4
78	41	60	79	65	80	73	103	77	88	4	4	4	4	4	4	4	4	4	4
75	85	81	91	109	93	80	60	63	67	4	4	4	4	4	4	4	4	4	4
68	116	85	136	181	153	137	128	163	170	4	4	4	4	4	4	4	4	4	4
124	144	124	132	127	74	111	112	97	104	4	4	4	4	4	4	4	4	4	4
112	118	112	118	62	82	99	108	124	118	4	4	4	3	3	3	3	3	3	3
109	204	142	126	65	60	90	107	122	150	3	3	3	3	3	3	3	3	3	3
173	141	121	152	119	108	104	90	118	124	3	3	3	3	3	3	3	3	3	3
106	139	114	89	102	145	138	146	106	106	3	3	3	3	3	3	3	3	3	3
124	91	143	127	154	92	120	89	62	107	3	3	3	3	3	3	3	3	3	3
128	169	101	124	148	115	79	69	95	92	3	3	3	3	3	3	3	3	3	2
98	111	109	145							2	2	2	1						

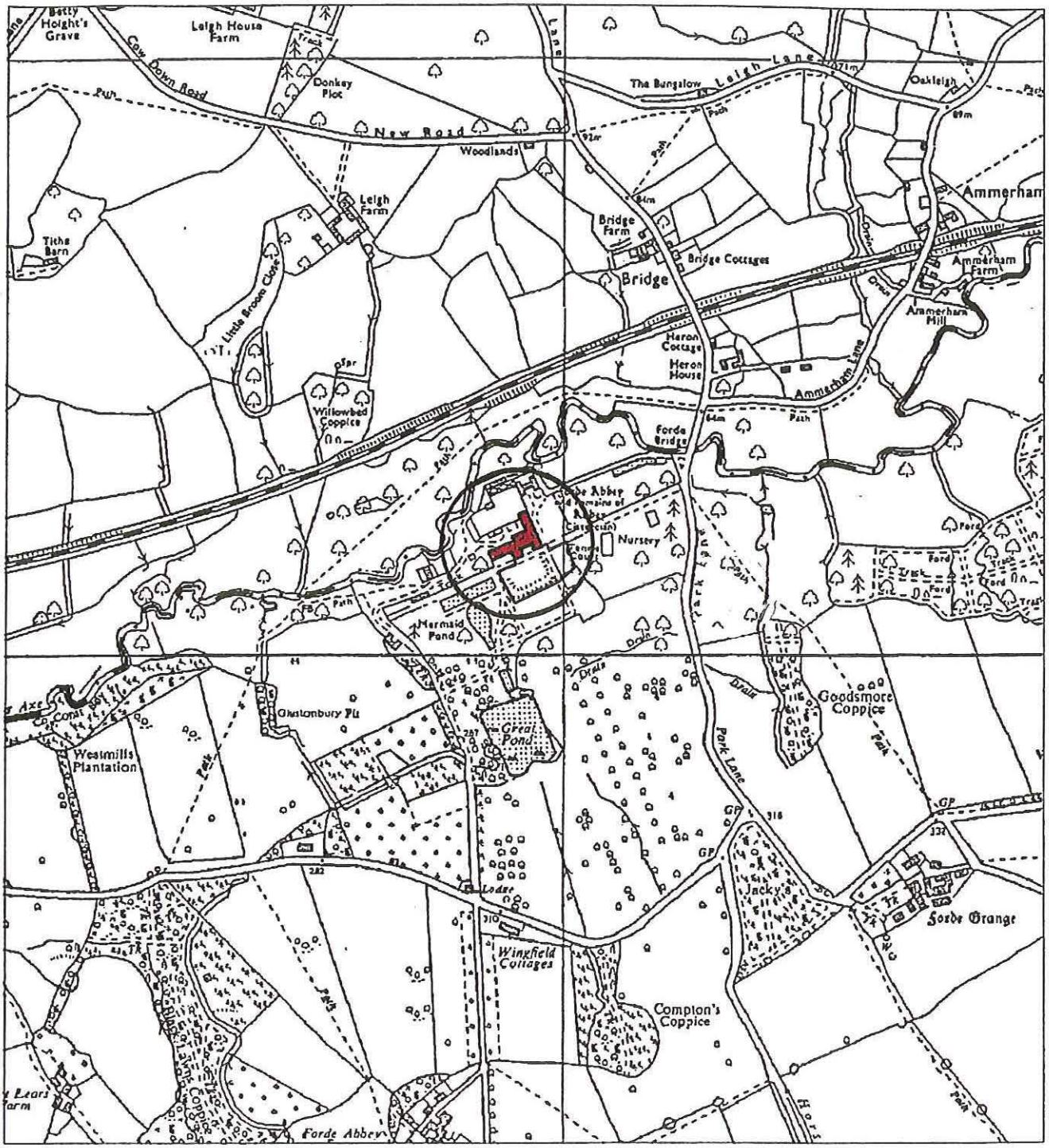
FRDABBY2 AD 1386-1485 Refectory Roof, Forde Abbey, Chard - ***frd7+8+10***

ring widths (0.01mm)										number of samples in master									
196	181	136	118	155	200	170	142	194	256	1	1	1	1	1	1	1	1	1	2
305	439	423	372	470	310	256	325	309	381	2	2	2	2	2	2	2	2	2	2
363	344	273	294	327	253	286	320	303	342	2	2	2	2	2	2	2	2	2	2
279	266	260	281	378	335	286	400	427	370	2	2	2	2	3	3	3	3	3	3
299	202	250	277	287	272	299	269	258	272	3	3	3	3	3	3	3	3	3	3
235	245	251	190	215	187	216	210	186	152	3	3	3	3	3	3	3	3	3	3
151	176	209	204	225	193	186	196	194	169	3	3	3	3	3	3	3	3	3	3
168	149	156	130	163	163	157	156	172	154	3	3	3	3	3	3	3	3	3	3
160	163	285	164	165	180	157	173	204	311	3	3	3	3	3	3	3	3	3	2
229	160	154	181	191	234	223	236	214	175	2	2	2	2	2	2	2	2	1	1

frd1 AD 1390-1476 Refectory Roof, Forde Abbey, Chard - ***frd1a + b***

ring widths (0.01mm)										number of samples in master									
156	181	147	169	186	158	251	179	259	221	1	1	1	1	1	1	2	2	2	2
225	194	157	214	183	180	213	139	135	101	2	2	2	2	2	2	2	2	2	2
138	111	105	117	109	148	131	104	99	96	2	2	2	2	2	2	2	2	2	2
84	111	90	144	165	130	81	91	86	78	2	2	2	2	2	2	2	2	2	2
81	84	97	93	82	131	81	79	86	60	2	2	2	2	2	2	2	2	2	2
81	84	82	64	64	85	99	121	79	122	2	2	2	2	2	2	2	2	2	2
100	116	121	95	103	84	87	93	88	49	2	2	2	2	2	2	2	2	2	2
47	80	73	140	91	81	159	138	133	94	2	2	2	2	2	2	2	2	2	1
119	108	96	91	86	132	101				1	1	1	1	1	1	1			

Figure 1: Site location plan



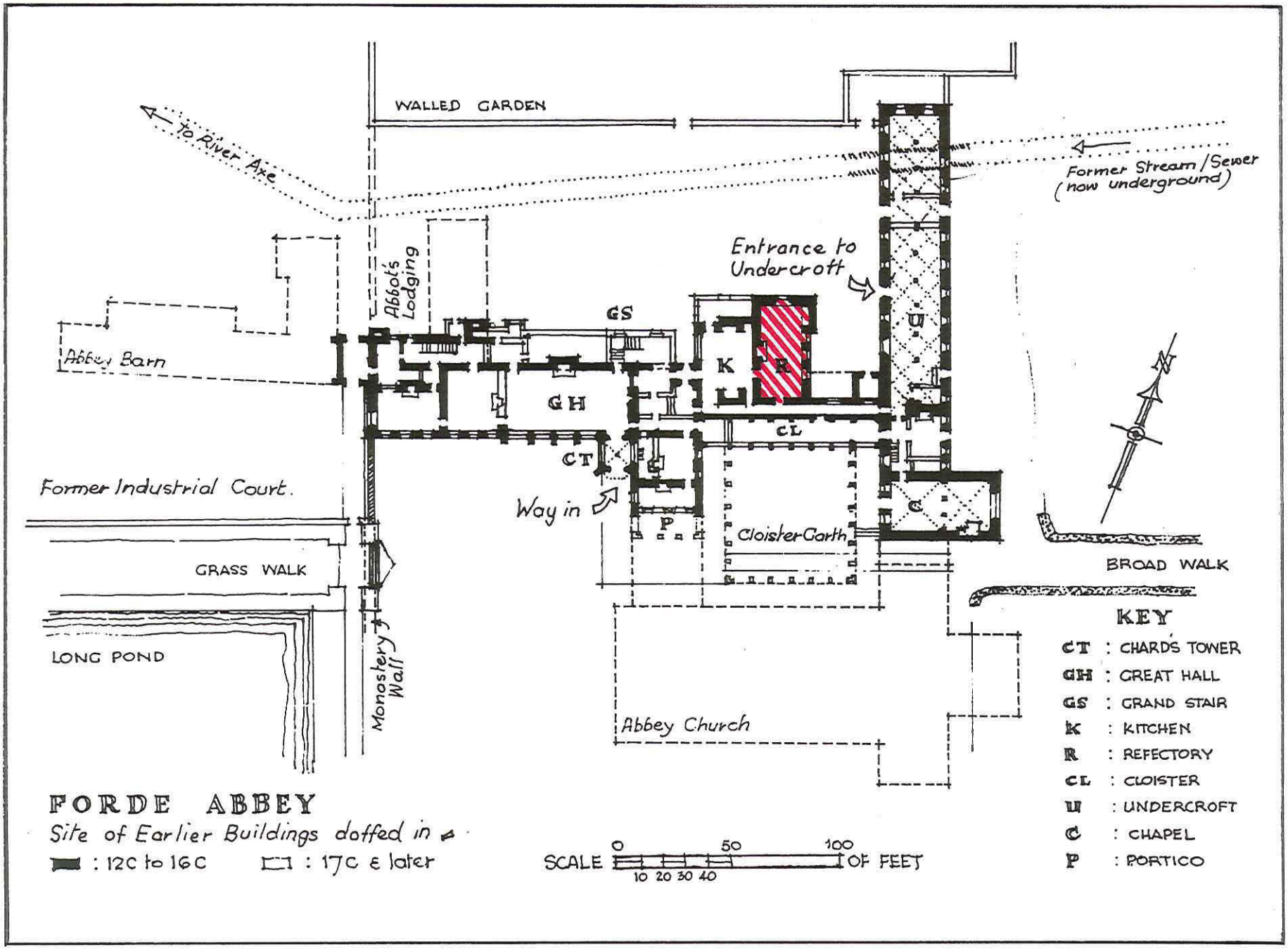


Figure 2: Site plan *(after Tyler and Roper)*

Figure 3: Isometric exploded view of Refectory roof structure *(after Philip Hughes Associates)*

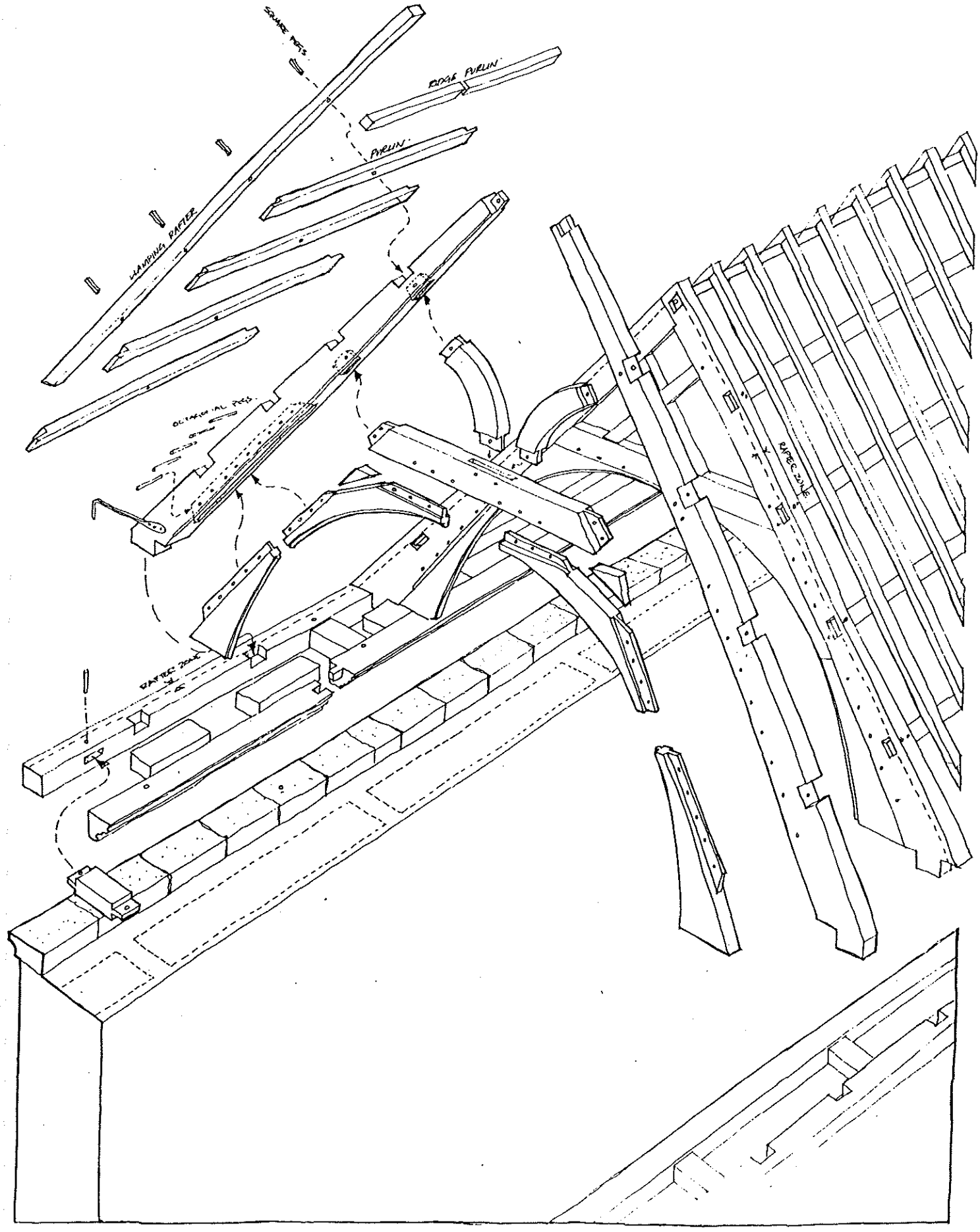


Figure 4: East longitudinal section of roof showing location of timbers sampled *(after Philip Hughes Associates)*

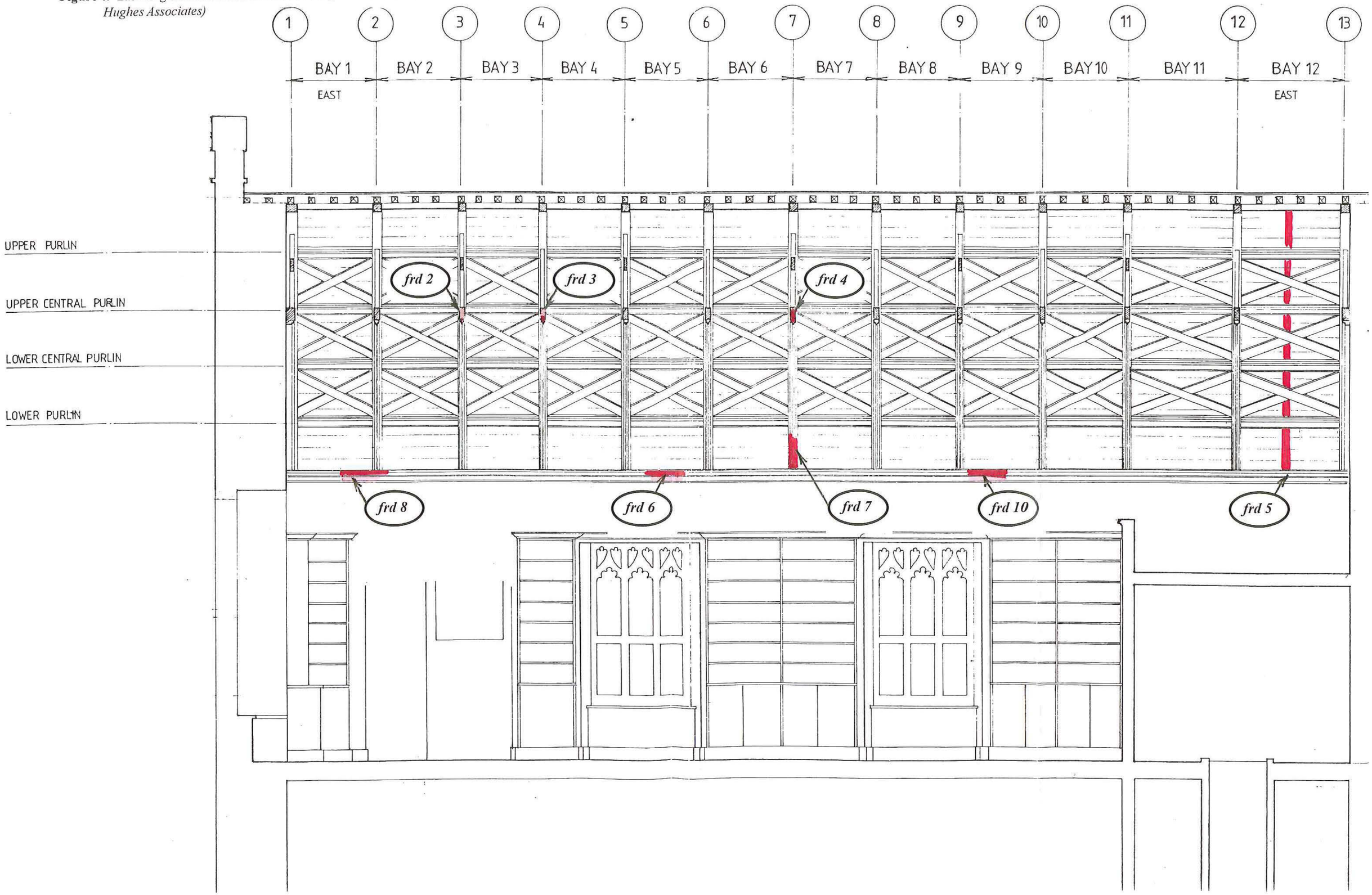


Figure 5: West longitudinal section of roof showing location of timbers sampled *(after Philip Hughes Associates)*

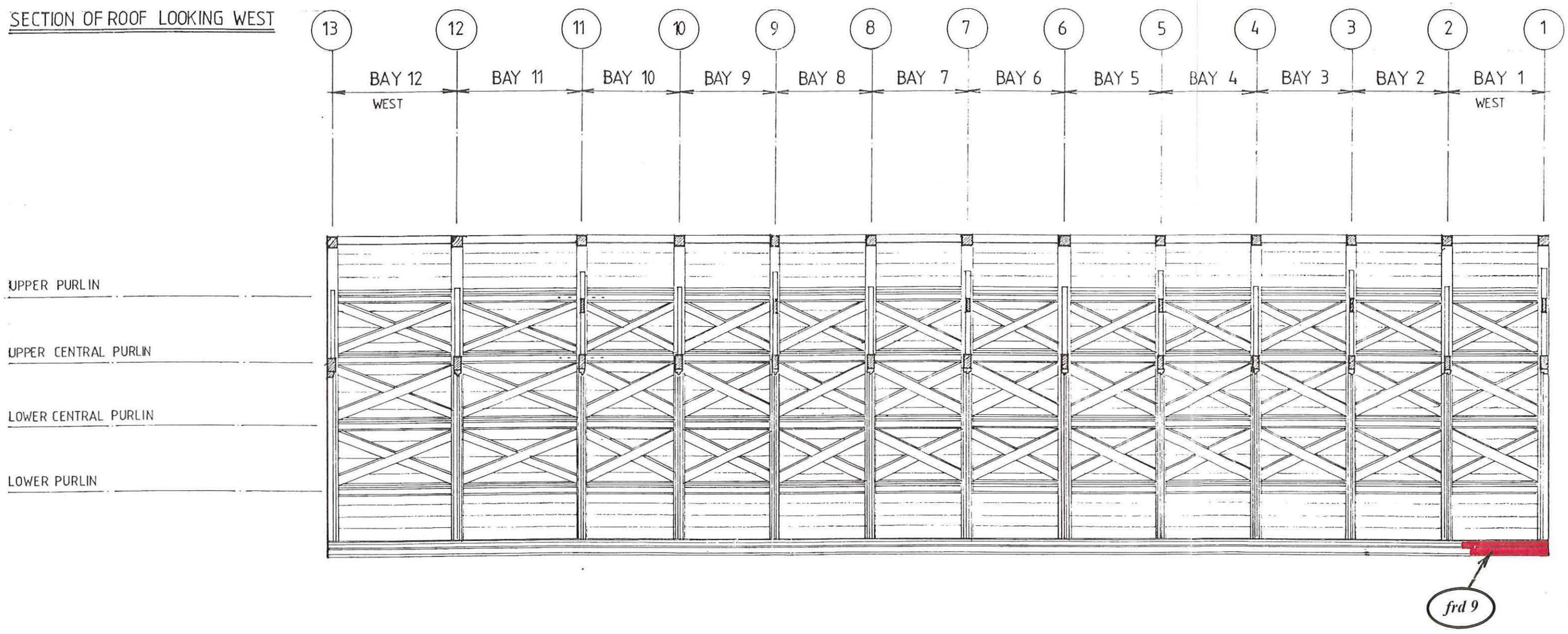
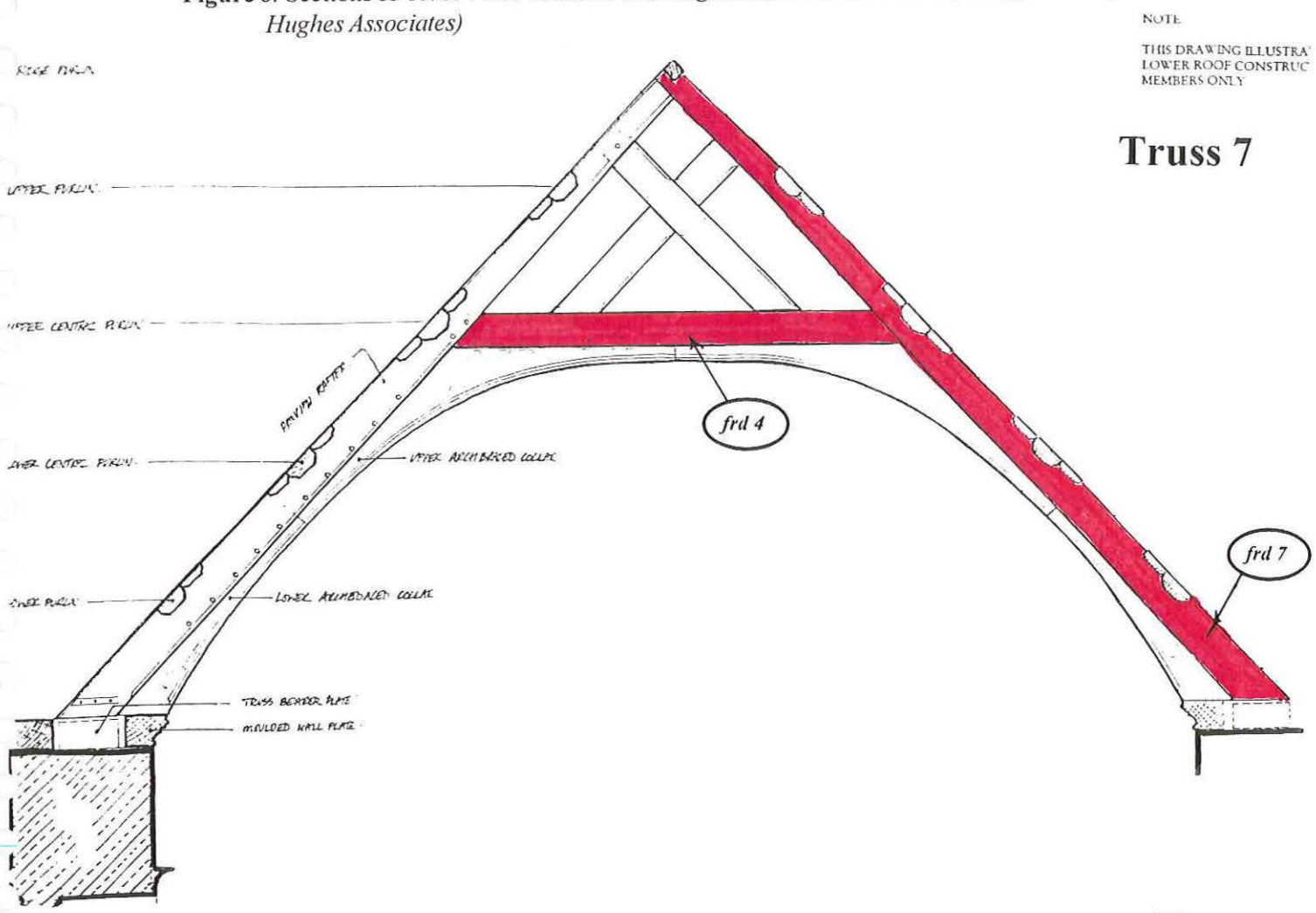


Figure 6: Sections of Truss 7 and Truss 10 showing location of timbers sampled *(after Philip Hughes Associates)*



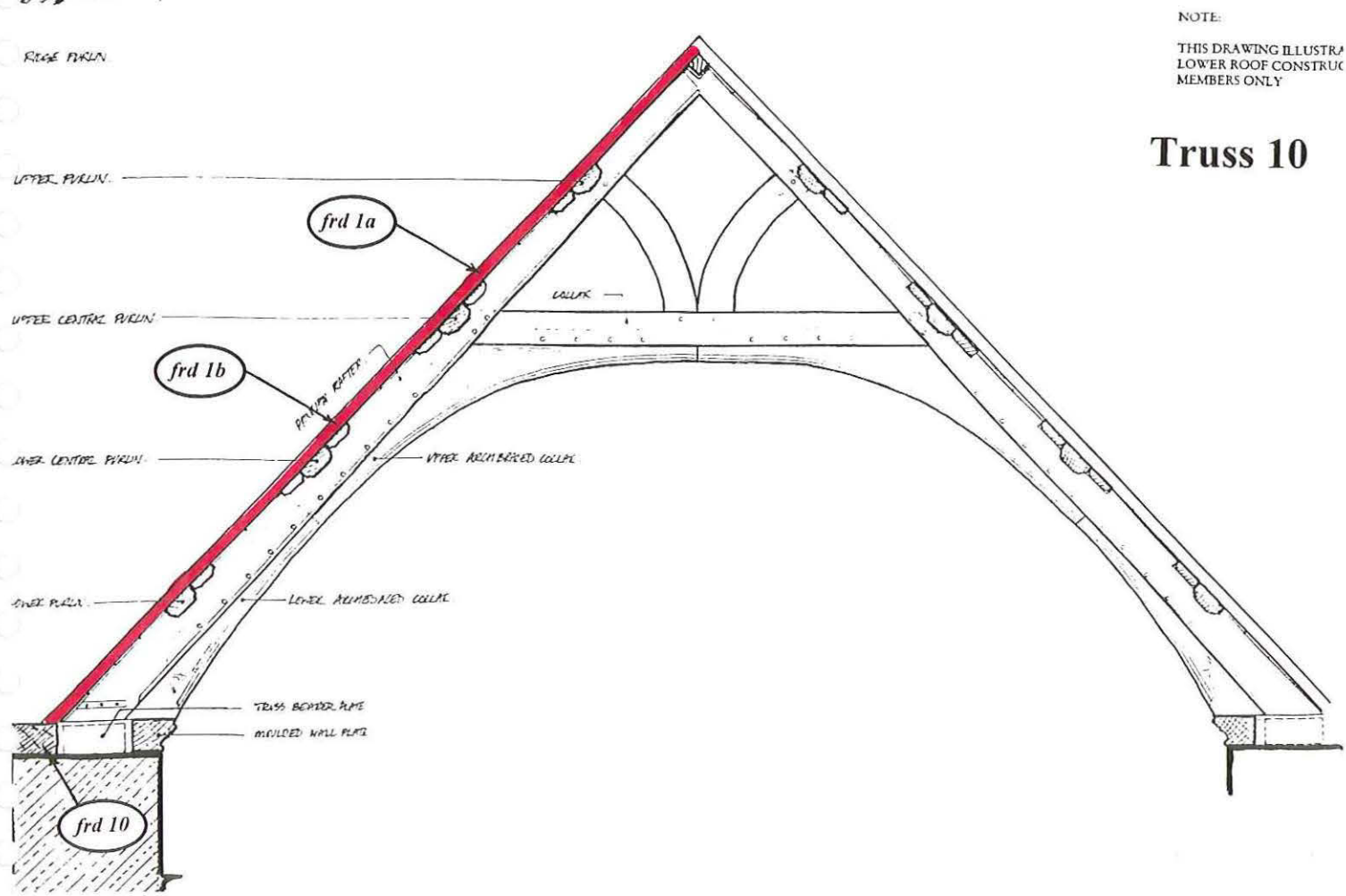
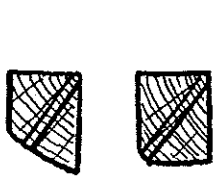


Figure 7: Sections of timbers sampled *(scale 1:8)*



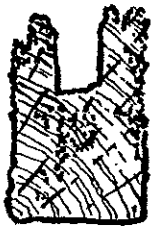
frd1a frd1b

frd2

frd3

frd4

frd5



frd6

frd7

frd8

frd9

frd10

Key: = Sapwood
[ ] = Bark edge

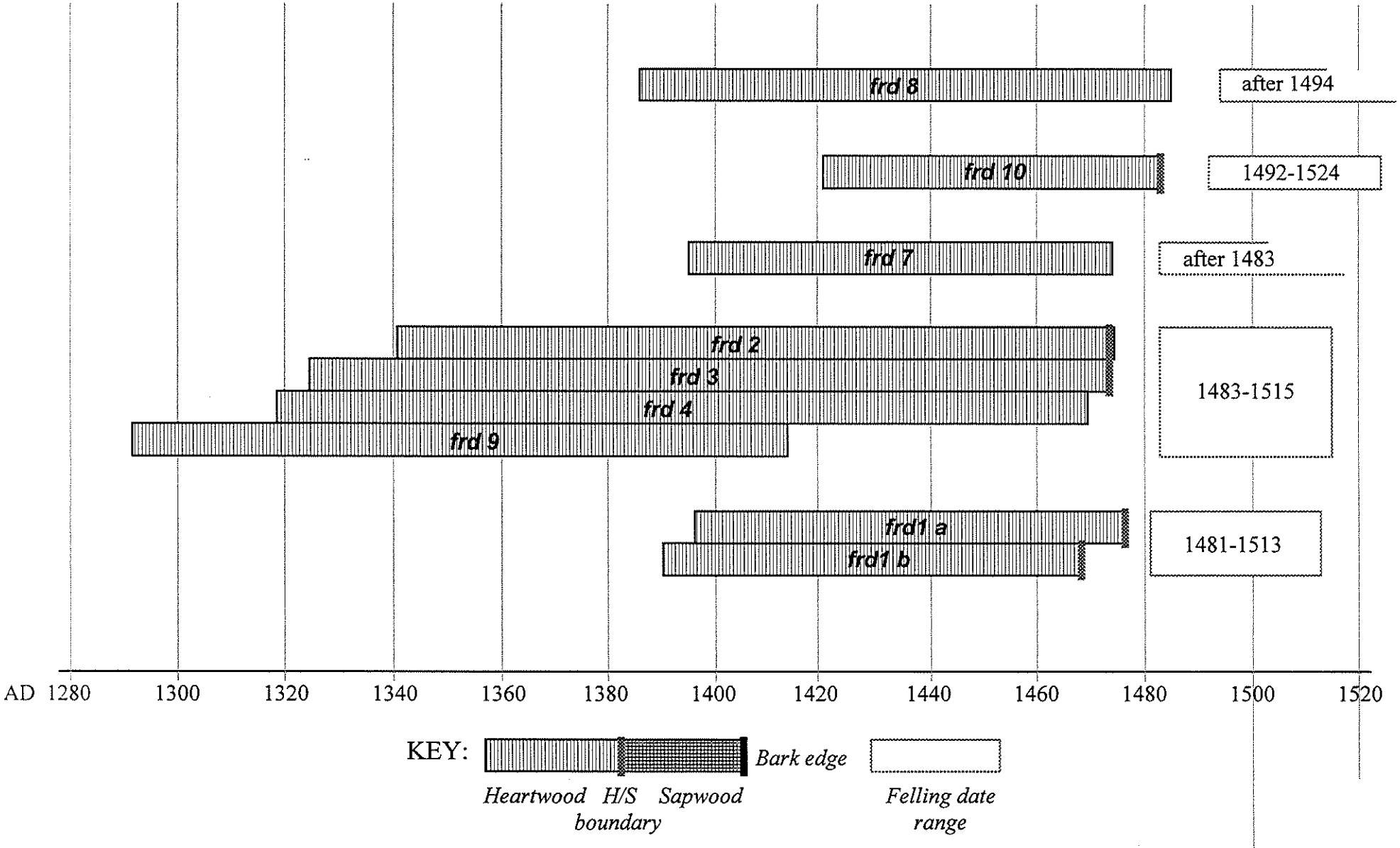


Figure 8: Bar diagramme showing relative positions of dated samples and date ranges