Oxford Dendrochronology Laboratory
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THE TREE-RING DATING OF BRON Y FOEL ISAF, LLECHEIDDIOR ISAF, TAL Y BONT, GWYNEDD (NGR SH 603 246)

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Summary
A number of samples from this site contained knots, only revealed after preparation of the samples, meaning that only parts of the series could be dated. One timber appears to have come from a managed tree, and could not be dated. Between samples cross-matching was generally poor, and independent dating of individual trees suggests some may have been imported into the area from southern England. A felling date range for the roof timbers of **1595–1614** was derived, and it is thought likely that construction most likely took place in the closing years of the sixteenth-century.

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BACKGROUND TO DENDROCHRONOLOGY

The basis of dendrochronological dating is that trees of the same species, growing at the same time, in similar habitats, produce similar ring-width patterns. These patterns of varying ring-widths are unique to the period of growth. Each tree naturally has its own pattern superimposed on the basic 'signal', resulting from genetic variations in the response to external stimuli, the changing competitive regime between trees, damage, disease, management etc.

In much of Britain the major influence on the growth of a species like oak is, however, the weather conditions experienced from season to season. By taking several contemporaneous samples from a building or other timber structure, it is often possible to cross-match the ring-width patterns, and by averaging the values for the sequences, maximise the common signal between trees. The resulting 'site chronology' may then be compared with existing 'master' or 'reference' chronologies.

This process can be done by a trained dendrochronologist using plots of the ring-widths and comparing them visually, which also serves as a check on measuring procedures. It is essentially a statistical process, and therefore requires sufficiently long sequences for one to be confident in the results. There is no defined minimum length of a tree-ring series that can be confidently cross-matched, but as a working hypothesis most dendrochronologists use series longer than at least fifty years.

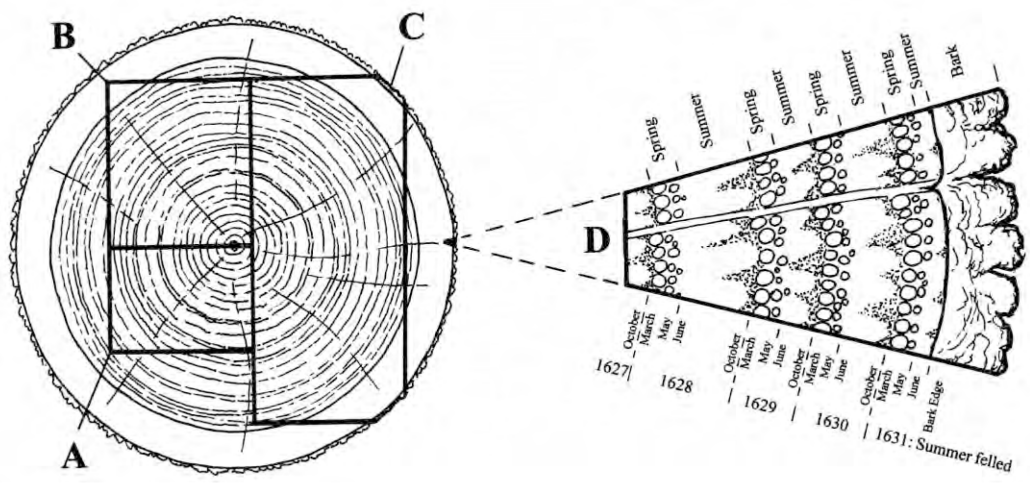
The dendrochronologist also uses objective statistical comparison techniques, these having the same constraints. The statistical comparison is based on programs by Baillie & Pilcher (1973, 1984) and uses the Student's *t*-test. The *t*-test compares the actual difference between two means in relation to the variation in the data, and is an established statistical technique for looking at the significance of matching between two datasets that has been adopted by dendrochronologists. The values of '*t*' which give an acceptable match have been the subject of some debate; originally values above 3.5 being regarded as acceptable (given at least 100 years of overlapping rings) but now 4.0 is often taken as the base value. It is possible for a random set of numbers to give an apparently acceptable statistical match against a single reference curve – although the visual analysis of plots of the two series usually shows the trained eye the reality of this match. When a series of ring-widths gives strong statistical matches in the same position against a number of independent chronologies the series becomes dated with an extremely high level of confidence.

One can develop long reference chronologies by cross-matching the innermost rings of modern timbers with the outermost rings of older timbers successively back in time, adding data from numerous sites. Data now exist covering many thousands of years and it is, in theory, possible to match a sequence of unknown date to this reference material.

It follows from what has been stated above that the chances of matching a single sequence are not as great as for matching a tree-ring series derived from many individuals, since the process of aggregating individual series will remove variation unique to an individual tree, and reinforce the common signal resulting from widespread influences such as the weather. However, a single sequence can be successfully dated, particularly if it has a long ring sequence.

Growth characteristics vary over space and time, trees in south-eastern England generally growing comparatively quickly and with less year-to-year variation than in many other regions (Bridge, 1988). This means that even comparatively large timbers in this region often exhibit few annual rings and are less useful for dating by this technique.

When interpreting the information derived from the dating exercise it is important to take into account such factors as the presence or absence of sapwood on the sample(s), which indicates the outer margins of the tree. Where no sapwood is present it may not be possible to determine how much wood has been removed, and one can therefore only give a date after which the original tree must have been felled. Where the bark is still present on the timber, the year, and even the time of year of felling can be determined. In the case of incomplete sapwood, one can estimate the number of rings likely to have been on the timber by relating it to populations of living and historical timbers to give a statistically valid range of years within which the tree was felled. For this region the estimate used is that 95% of oaks will have a sapwood ring number in the range 11 – 41 (Miles 1997a).



Section of tree with conversion methods showing three types of sapwood retention resulting in **A** *terminus post quem*, **B** a felling date range, and **C** a precise felling date. Enlarged area **D** shows the outermost rings of the sapwood with growing seasons (Miles 1997, 42)

<u>BRON Y FOEL ISAF (Notes from Smith 2001)</u>

This house has a standard end-chimney, cross-passage plan, a two storeyed latrine block opening off both ground-floor cold parlour and first-floor chamber and discharging over a stream running past the house. Nothing like this block has been found in other houses in Merioneth. It is , however, very similar to the two-storeyed latrine blocks attached to the back of fifteenth-century lodgings at St Cross Hospital, Winchester. William Lewis who inherited the Bron y Foel Isaf from his uncle, was Master at St Cross. The winding stone fireplace stair extends through the first floor to the loft – an unusual feature indicating a house of some ambition, confirmed by two tall fine square chimneys. The long axis of the house lies north-south. There are three main trusses in the roof, each supporting two tiers of purlins with a ridge piece. The two end trusses have raking struts, whilst the central truss has a collar, with a boarded partition between the collar and apex.

SAMPLING

Sampling took place in August 2011. All the samples were of oak (*Quercus* spp.). Core samples were extracted using a 15mm diameter borer attached to an electric drill. They were numbered using the prefix **byf**. The samples were removed for further preparation and analysis. Cores were mounted on wooden laths and then these were polished using progressively finer grits down to 400. The samples were measured under a binocular microscope on a purpose-built moving stage with a linear transducer, attached to a desktop computer allowing the measurement of ring-widths to the nearest 0.01 mm using DENDRO for WINDOWS, written by Ian Tyers (Tyers 2004), which was also used for subsequent analysis, along with other programs written in BASIC by D Haddon-Reece, and re-written in Microsoft Visual Basic by M R Allwright and P A Parker.

RESULTS AND DISCUSSION

Basic information about the samples and their origins are shown in Table 1, and illustrated in Figure 1. The interpretation at this site is complicated by the fact that several cores contained knots, which prevented a complete series being measured, and the sapwood on most samples disintegrated on coring, or became detached from the main core. This meant that sometimes only the inner part of the series could be dated. One series (**byf09**) showed very atypical growth (Fig 2), with a number of sudden declines in growth, followed by slow recovery – potentially the result of management of the tree. This series could not be dated, and no further analysis was undertaken on it.

Also, the cross-matching between samples was generally poor (Table 2). Individual pairs of series matched well, e.g. **byf04** and **byf05**, two principal rafters from the same truss, which may even be from the same tree; and **byf01** and **byf03**, another pair of principal rafters from a second truss. When these series were combined and matched to the remaining samples, better matching was found. As a result of the overall poor matching, independent verification of the dates of individual series was sought, and the results for the best three matches for various series are shown in Table 3a. It is of interest that the best matches for **byf54m** are against material from southern England, perhaps indicating that these timbers were brought in from some distance, and partially explaining the poor between series matches found. Nevertheless, a site master series was formed from the dated series, the 141-year series **BRONFOEL** dating to the period 1438–1578. The strongest matches for this series are shown in Table 3b. The relative positions of overlap of the dated series are shown in Fig 3, along with their likely felling date ranges.

With the uncertainty in some ring patterns resulting from distortion by knots, one cannot often be certain about the felling dates, especially when adding rings and sapwood to a series for which only the inner part is dated. Nevertheless, series **byf08** from the cellar beam, which retained complete sapwood, but for which only the inner rings were dated, appears to have been from a tree most likely felled around 1576. Many series go beyond this date and have later likely felling date ranges later still, so if the interpretation is correct, this may imply the re-use of some timbers, stockpiling before use, or an earlier phase for the cellar than the rest of the house. Taking the mean heartwood-sapwood boundary date of

1573 for all the uninterrupted dated series produces a likely felling date range of 1584–1614, which can be modified in light of the rings found on sample **byf05**, to **1595–1614**. Given that not many rings are thought to have been lost before the detached sapwood section on this sample, it is likely that construction actually took place in the final years of the sixteenth-century.

ACKNOWLEDGEMENTS

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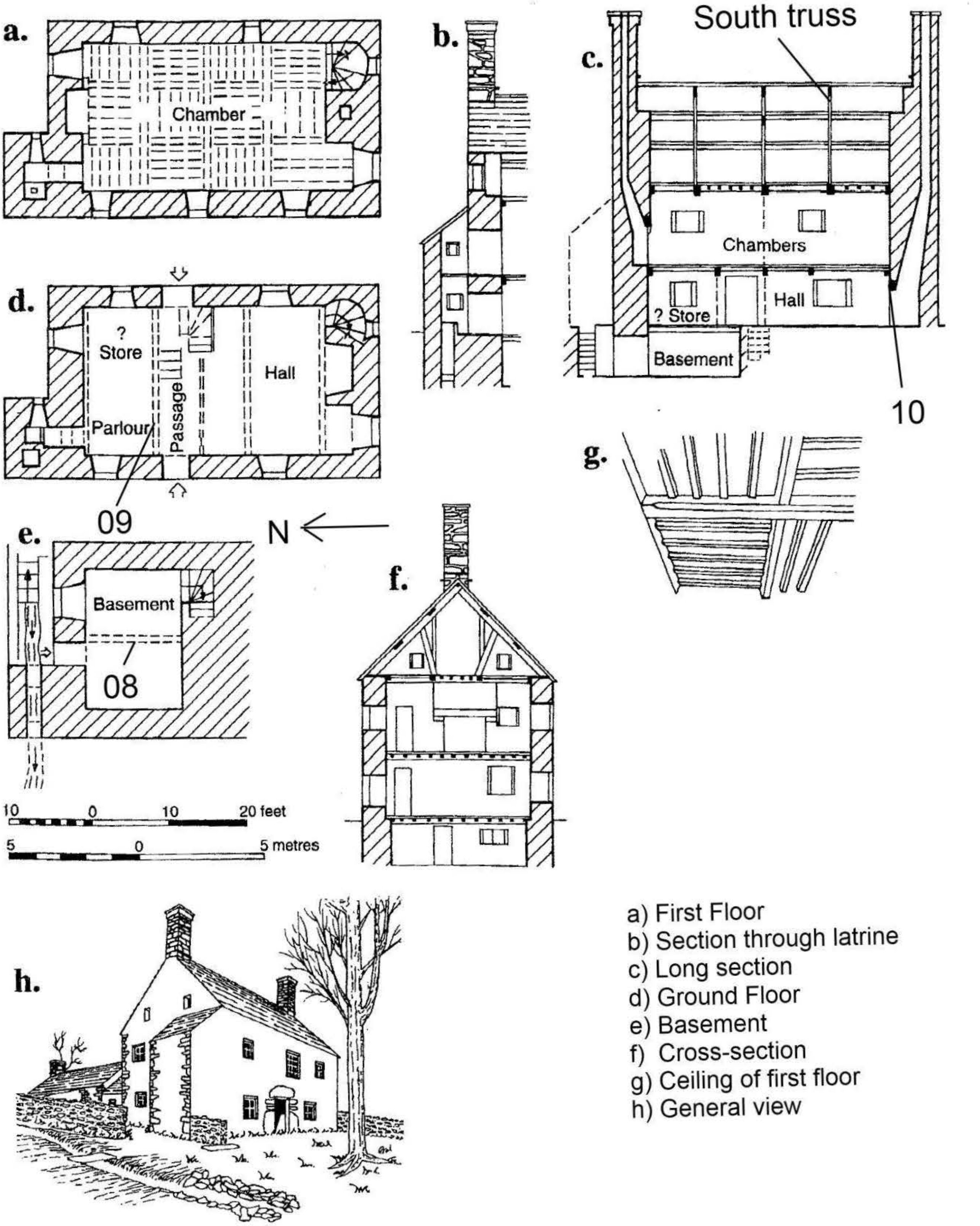

Figure 1: Drawings of the building adapted from Smith 2001 (Fig 10.44) to show some of the timbers sampled for dendrochronology

Table 1: Details of samples taken from Bron y Foel Isaf, Tal y Bont.

Sample number	Timber and position	Date of series	H/S boundary date	Sapwood complement	No of rings	Mean width mm	Std devn mm	Mean sens	Felling date range
* **byf01i**	West principal rafter, south truss	1462-1547	-	-	86	1.40	0.44	0.24	
byf01ii	*ditto*	undated	-	H/S +22	17	NM	-	-	after 1586
* **byf02i**	West raking strut, south truss	1464-1526	-	-	63	1.69	0.51	0.21	
byf02ii	*ditto*	undated	-	14	*50*	*0.47*	*0.16*	*0.22*	after 1576
* **byf03**	East principal rafter, south truss	1453-1574	1572	2	122	1.54	0.49	0.21	1583–1613
* **byf04**	West principal rafter, central truss	1491-1578	1577	1	88	1.59	0.67	0.28	1588–1618
* **byf05**	East principal rafter, central truss	1489-1577	1576	1 +18	89	1.58	0.66	0.23	1595–1617
* **byf06**	West principal rafter, north truss	1528-1577	1577	H/S	50	2.32	0.76	0.21	1588–1618
* **byf07**	West raking strut, north truss	1469-1569	1567	2	101	1.16	0.43	0.20	1578–1608
* **byf08i**	Main N-S beam, cellar	1491-1545	-	-	55	2.20	0.97	0.26	
byf08ii	ditto	undated	-	23C					*c*1576
* **byf09**	Ceiling beam, N side entrance hall	undated	-	34¼C	147	0.98	0.61	0.24	unknown
* **byf10i**	Fireplace lintel, south end	1459-1505	-	-	47	2.09	0.74	0.23	
byf10ii	*ditto*	undated	-	1	*59*	*1.15*	*0.38*	*0.24*	after 1564
* = included in Site Master	**BRONFOEL**	**1438-1578**	**1573**		**141**	**1.54**	**0.42**	**0.20**	**1595–1614**

Key: H/S bdry = heartwood/sapwood boundary - last heartwood ring date; C = complete sapwood, winter felled; std devn = standard deviation; mean sens = mean sensitivity; NM = not measured;

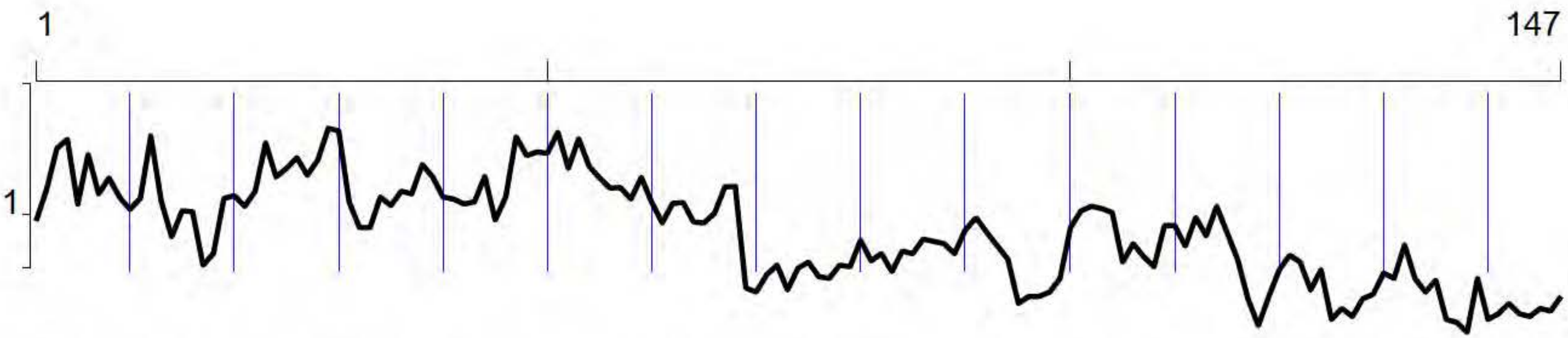

Figure 2: Plot of the ring-width series (semi-logarithmic scale) for sample byf09, showing atypical growth changes

Table 2: Cross-matching between the dated samples

	t-values							
Sample	**byf02i**	**byf03**	**byf04**	**byf05**	**byf06**	**byf07**	**byf08i**	**byf10i**
byf01i	3.3	7.0	1.0	1.4	*	4.4	1.2	4.3
byf02i		3.2	2.6	3.2	*	2.2	3.8	3.4
byf03			1.9	3.4	2.9	3.9	2.0	4.0
byf04				8.8	5.4	2.2	3.9	*
byf05					3.2	2.0	3.5	*
byf06						1.6	*	*
byf07							1.3	5.0
byf08i								*

* = overlap less than 20 years, *t*-value not calculated

Table 3a: Best three matches for individual series

Series; end date	t-value; Site name; (yrs of overlap)	t-value; Site name; (yrs of overlap)	t-value; Site name; (yrs of overlap)
byf31m 1574	8.7 LLANABR1 (57)	6.6 GWYNEDD1 (83)	5.5 CEFNCAR1 (73)
byf02i 1526	4.6 BEDD_T6 (63)	4.3 CEFNCAR1 (62)	4.3 BDGLRT6 (63)
byf54m 1578	6.0 NEWDIG2 (87)	6.0 STLENBN1 (62)	5.9 CROWSHL2 (63)
byf06 1577	5.4 brfa7 (50)	5.1 DENBY1 (50)	4.9 LNYDLOS1 (50)
byf07 1569	6.4 BDGLRT22 (101)	6.1 BDGLRT7 (79)	5.8 PENGWERN (53)
byf08i 1545	5.9 LLWYN (55)	5.5 CHERGTN (55)	5.5 ALKINGTN (55)
byf10i 1505	8.5 BDGLRT13 (47)	7.6 BDGLRT22 (47)	6.9 BDGLRT7 (47)

Table 3b: Dating evidence for the site master **BRONFOEL AD 1438–1578** against dated reference chronologies

County or region:	*Chronology name:*	*Short publication reference:*	*File name:*	*Spanning:*	*Overlap (yrs):*	*t-value:*
Wales	Vaynol Old Hall	(Miles *et al* 2010)	GWYNEDD2	1448-1628	131	9.4
Wales	Oxwich Castle	(Miles *et al* 2006)	OXWICH	1459-1630	120	8.3
Wales	Cefn Caer Pennal	(Miles and Worthington 1999)	CEFNCAR1	1404-1525	88	7.5
Wales	Ffinnant, Llansantffraid-ym-Machain	(Miles *et al* 2010)	FFINNANT	1437-1609	141	7.6
Wales	Welsh Master Chronology	(Miles 1997b)	**WALES97**	404-1981	141	7.3
Hampshire	South Barn, Great Posbrook Farm	(Miles *et al* 2009)	PSBROOK1	1476-1600	103	6.8
Wales	Plas Mawr House	(Miles and Haddon-Reece 1996)	PLASMWR1	1428-1556	119	6.8
Wales	Gelli, Llanfrothen	(Miles *et al* 2006)	BDGLRT8	1391-1662	141	6.7
Wales	Old Market Hall, Llanidloes	(Miles *et al* 2003)	LNYDLOS1	1424-1589	141	6.5
Wales	Bwthyn Cae-glas, Llanfrothen	(Miles *et al* 2006)	BDGLRT7	1386-1547	110	6.4
Wales	Tydynn Lwydion	(Miles and Haddon-Reece 1996)	TYDDYN	1385-1601	141	6.3
Lincolnshire	Fenton Church	(Arnold *et al* 2005)	FENASQ02	1434-1617	141	6.3
Wales	Plas y Dduallt, Maentwrog	(Miles *et al* 2011)	GWYNEDD5	1355-1604	141	6.2
Wales	Cae'nycoed-uchaf, Maentwrog	(Miles *et al* 2006)	BDGLRT17	1407-1592	141	6.0
Wales	Dylasau Ichaf, Caernarfonshire	(Miles *et al* 2011)	DYLASAU1	1412-1592	141	6.0

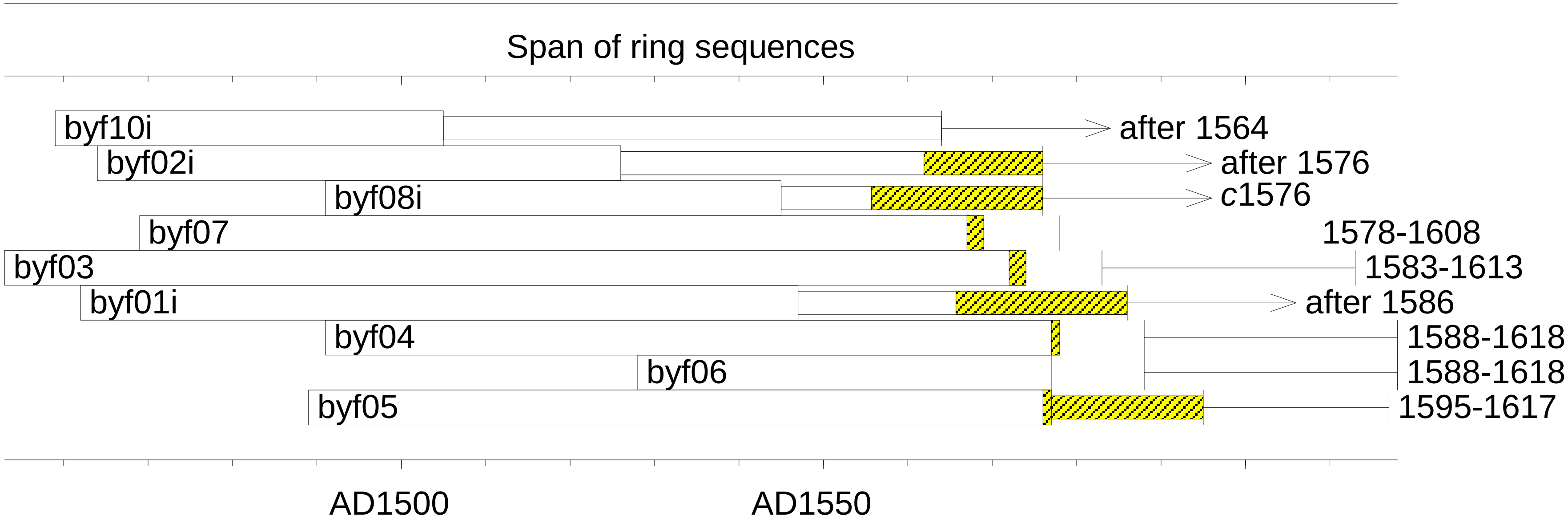

Figure 3: Bar diagram showing the relative positions of overlap of the dated series, along with their interpreted likely felling date ranges. Hatched yellow sections represent sapwood rings, and narrow sections of bar represent additional unmeasured rings