Oxford Dendrochronology Laboratory
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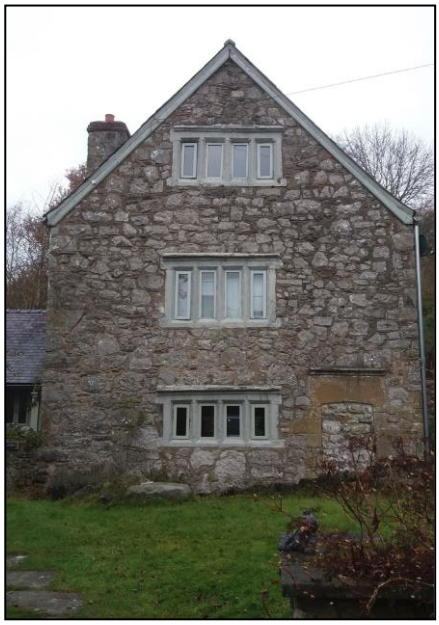
THE DENDROCHRONOLOGICAL DATING OF TIMBERS FROM HAFOD BILSTON, LLANDEGLA DENBIGHSHIRE (SJ 207 512)



Summary

Several of the primary timbers at this site retained complete sapwood, but many of them exhibited unusually narrow rings in the final decades of growth, making them impossible to measure. One timber was found to have come from a tree felled in **Spring 1638**, and it seems likely the others were felled at around this time too. One timber, a ground floor ceiling beam, may well have had more sapwood rings than is normal. The whole building appears to be of the same date, although an offset purlin in the bathroom appears to be a re-used timber, from a tree most likely felled in the period 1561-91.

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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. These include chronologies made by colleagues in other countries, most notably areas such as modern Poland, which have proved to be the source of many boards used in the construction of doors and chests, and for oil paintings before the widespread use of canvas.

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.

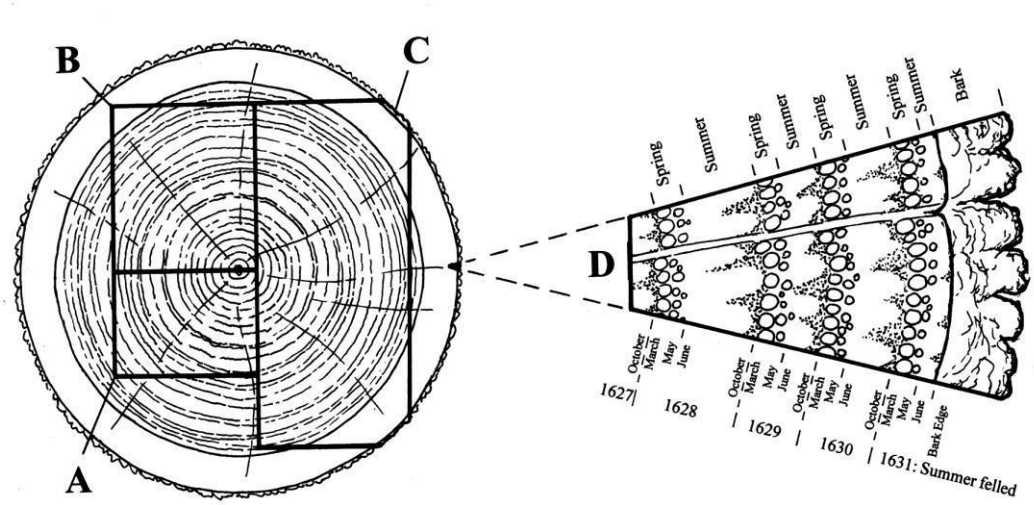
The dendrochronologist also uses objective statistical comparison techniques, these having the same constraints. The statistical comparison is based on programs by Baillie & Pilcher (1973, 1984) and uses the Student's *t*-test. The *t*-test compares the actual difference between two means in relation 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 in oak studies. Higher values are usually found with matching pine sequences. 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 1997).



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)

Hafod Bilston

An early 17th-century gentry house, formerly belonging to the estates of the Puleston family. The house is of two-storeys and an attic; originally gable-entry with a lateral-chimney. Rubble stone walls with a slate roof and stone stack. The W gable front has 4-light stone mullion windows with splayed mouldings and dripmoulds. A dressed-stone Tudor-arched doorway to the ground-floor right is now blocked. To the left of the lateral stack on the N side, a later single-storey gabled wing forms the modern entry to the house. The E gable has a 20th-century casement-pair with a blocked 1-light 17th-century opening to the right; below a 3-light mullion on first floor. The ground floor has a casement-pair to the right, and a double casement-pair with central mullion, both with big rectangular stone lintels. The interior is generally much modified. The ground-floor hall has chamfered beams with straight-cut stops and a deep fireplace recess.
Source: DE/DOM/SJ25SW, from the Cadw listed buildings database. J. Archer, RCAHMW, 2.11.2004
Additional Note. Hafod-Bilston is a mid-17th century, stone-built, 2½ storey, gentry house with lateral fireplace to ground-floor and a first-floor great- chamber. The ground–floor was once divided into three

units. This consisted of a central hall/kitchen with timber lintel to a lateral fireplace, between an entry-lobby room at the west gable-end (partition removed), and a service-room to the east end. The east end service-room was divided from the hall/kitchen by a framed wattle and daub partition (mortice pegs for studs remain in ceiling-beam). A rearranged 17th century stair with moulded balusters and hand-rail rises against this partition within the hall/kitchen.
The first-floor originally had a great-chamber (now sub-divided) extending from the west gable-end up to a small chamber at the rear east gable-end. The great chamber's fireplace (recently revealed) is of dressed stone with a 'Tudor' headed lintel and 'ovolo' mouldings. The smaller chamber has evidence for a former, secondary exterior end loading doorway (now a window) probably for later storage of farm produce.
The attic-floor is open to the roof, supported by a pair of collar trusses, two pairs of side-purlins and a ridge piece. It was probably used as accommodation for servants and storage.
A later, probably 18th century single-storey wing adjoins the rear service-room, at right angles. Inside its gable-end there are two internal arched openings (probably for coppers) and an oven with a corbelled flue.
The main range has dressed stone details throughout, including mullion windows some of three and four light, and the former gable-end entrance doorway (blocked) has a 'Tudor' head and drip mould. Throughout there are fine oak ceiling-beams with medium chamfer 'ogee' or straight-cut stops, and square joists. The early 17th century rearranged stair has turned balusters and moulded hand-rails, but appears to be reset.
There are diagonally set, assumed corner fireplaces to the entry-lobby and above in the sub divided great-chamber, probably relating to late-18th century alterations, indicated by lathe and plaster partitions here and elsewhere. The site of the end lobby-entry partition is indicated by a later ceiling-beam and short joists that do not align. It is possible that the original stair was in this area, but was resited in the late 18th century when there must have been a change of use.
Visited at the request of Phil Ebrill, Denbigh conservation officer, Geoff Ward, 06/09/2012.

SAMPLING

Samples were taken in November 2016. The locations of the samples are described in Table 1, and shown in Fig 1. Core samples were extracted using a 15mm diameter borer attached to an electric drill. They were labelled (prefix **hbil**) and were polished with progressively finer grits down to 400 to allow the measurement of ring-widths to the nearest 0.01 mm. The samples were measured under a binocular microscope on a purpose-built moving stage with a linear transducer, attached to a desktop computer. Measurements and subsequent analysis were carried out using DENDRO for WINDOWS, written by Ian Tyers (Tyers 2004).

RESULTS AND DISCUSSION

Details of the samples are given in Table 1. Many of the timbers showed very narrow outer rings, and it was often not possible to adequately distinguish individual rings, many having an approximate number of remaining unmeasured rings estimated. It seems likely the timbers would have been from trees felled at or around the same time. Two samples matched well (**05** and **06**) and were thought likely to have come from a single tree – their measurements being meaned to produce a new series used in subsequent analysis. Five series were cross-matched (Table 2) and a 183-year long site chronology (**HFDBLSTN**) was produced. This was dated to the period 1455–1637, the strongest matches being shown in Table 3b.
A single timber (**10**) from a reset purlin in the bathroom was found to have come from a tree most likely felled earlier (1561-91), and is probably a re-used timber. The date of construction of the building is likely to be 1638, or within a year or two after this date.

ACKNOWLEDGEMENTS

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Table 1: Details of samples taken from Hafod Bilston.

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
* **hbil01**	North ceiling beam, ground floor	1506–1622	1602	20+15NM	117	1.07	0.55	0.24	1637–43
hbil02	Joist 3rd from E, north bay, ground floor	-	-	3+25NM	55	1.53	0.58	0.24	-
* **hbil03**	Central ceiling beam, ground floor	1455–1617	1603	14+16NM	163	1.61	0.93	0.19	1633–44
hbil04	South ceiling beam, ground floor	1476–1570	1570?	H/S?	95	1.18	0.67	0.26	1581–1611
hbil05	S joist, 6th from E, first floor	1483–1618	1597	21	136	1.02	0.38	0.22	1619–39
hbil06	N joist, 5th from E, first floor	1474–1585	-	-	112	1.19	0.50	0.26	*1619–39*
hbil07	Upper E purlin, N attic room	-	-	H/S	108	1.06	0.50	0.19	-
hbil08i	Lower W purlin, N attic room	-	-	-	*40*	*0.63*	*0.14*	*0.18*	
hbil08ii	*ditto*	-	-	H/S	*64*	*0.89*	*0.32*	*0.20*	-
hbil09	Central ceiling beam, first floor	-	-	H/S	47	2.63	0.47	0.15	-
hbil10	**West purlin in bathroom (re-used?)**	1467–1550	**1550**	**H/S**	**84**	**2.10**	**1.42**	**0.26**	**1561–91**
* **hbil11**	2nd joist from W, ground floor rear	1512–1604	1604	H/S+30NM	93	1.13	0.49	0.26	1634-45
* **hbil12**	5th joist from E, boot room	1510-1637	1606	31¼C	128	0.84	0.32	0.18	Spring 1638
* **hbil65m**	Mean of **05** and **06**	1474–1618	1597	21	145	1.06	0.41	0.22	1619–39
hbil13	South window lintel, ground floor	-	-	-	-	NM	-	-	-
* = included in site master **HFDBLSTN**		**1455–1637**			**183**	**1.26**	**0.66**	**0.19**	

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.

Table 2: Cross-matching between the dated samples from Hafod Bilston included in the site master

	***t*-values**				
Sample	**hbil03**	**hbil04**	**hbil65m**	**hbil11**	**hbil12**
hbil01	4.4	2.5	3.4	2.3	2.3
hbil03		4.1	5.8	4.6	5.5
hbil04			6.2	1.6	2.0
hbil65m				6.0	5.0
hbil11					3.2

* = overlap too short to produce meaningful value

NB **hbil05** *v* **hbil06**, *t* = 9.8 with 103 years overlap – considered to be the same tree, and combined for subsequent analysis

Table 3a: Dating evidence for the site sequence **hbil10** **AD 1467–1550** against dated reference chronologies

County or region:	*Chronology name:*	*Reference*	*File name:*	*Spanning*	*Overlap: (yrs)*	*t-value:*
Regional Chronologies						
North Wales	North Wales Master Chronology	(Bridge 2016)	**NWALES**	1306–1758	84	5.9
Shropshire	Shropshire Master Chronology	(Miles 1995)	**SALOP95**	881–1745	84	5.6
Site Chronologies						
Shropshire	Church Farm, Ditton Priors	(Miles *et al* 2004)	DITTON5	1437–1578	84	7.7
Denbighshire	Berain, Llannefydd	(Bridge *et al* 2014)	BERAIN	1469–1553	82	7.5
Caernarvonshire	Fedw Deg Old House, Penmachno	(Bridge *et al* 2015)	FEDWDEG	1417–1587	84	7.2
Lancashire	Worden Old Hall, Chorley	(Bridge 2003)	OLDWORD2	1415–1531	65	6.8
Denbighshire	Rose and Crown, Gwyddelwern	(Miles and Worthington 2000)	GWYDWN	1411–1571	84	6.7
Caernarvonshire	Blaen Glasgwm Uchaf, Penmachno	(Bridge *et al* 2013)	GLASGWM2	1468–1518	51	6.5
Montgomeryshire	Kerry Church	(Miles *et al* 2011)	KERRY	1402–1567	84	6.4
Montgomeryshire	Old Market Hall, Llanidloes	(Miles *et al* 2003)	LNYDLOS1	1424–1589	84	6.2
Denbighshire	Ty Mawr, Druid, Corwen	(Miles *et al* 2010)	DENBY1	1440–1583	84	6.1

Table 3b: Dating evidence for the site chronology **HFDBLSTN** **AD 1455–1637** against dated reference chronologies

County or region:	*Chronology name:*	*Reference*	*File name:*	*Spanning*	*Overlap: (yrs)*	*t-value:*
Regional Chronologies						
Shropshire	Shropshire Master Chronology	(Miles 1995)	**SALOP95**	881–1745	183	8.6
England	Southern Central England	(Wilson *et al* 2012)	**SCENG**	663–2009	183	8.1
Wales/borders	Hillside oaks	(Siebenlist-Kerner 1978)	**GIERTZ**	1341–1636	183	7.6
Site Chronologies						
Herefordshire	Dore Abbey	(Tyers and Boswijk 1998)	DORE2	1363–1612	158	9.6
Shropshire	High Ercall Hall	(Miles and Worthington 2002)	HIERCALL	1390–1607	153	9.3
Gloucestershire	26 Westgate Street, Gloucester	(Howard *et al* 1998)	GLOBSQ01	1399–1622	168	9.3
Breconshire	Hay Castle gate	(Miles *et al* 2008)	HAYGATE1	1445–1603	149	8.9
Herefordshire	Mynde, Dewchurch	(Nayling 2001)	MYNDEt10	1392–1619	165	8.7
Shropshire	Reader's House, Ludlow	(Bridge and Miles 2011)	READERS1	1406–1615	161	8.4
Denbighshire	Glas Hirfryn,	(Bridge *et al* 2014)	GHN	1404–1557	103	8.3
Montgomeryshire	St Idloes Church, Llanidloes	(Miles *et al* 2003)	LNYDLOS2	1384–1593	139	8.2
Worcestershire	Hartlebury Castle Saloon Roof	(Tyers 2008)	HARTSALN	1339–1608	154	8.2
Denbighshire	Caerfallen, Ruthin	(Bridge *et al* 2015)	CAERFLLN	1415–1559	105	8.0
Rutland	Oakham Castle	(Arnold and Howard 2013)	OKMCSQ02	1383–1620	166	7.9
West Sussex	Danny House, Hurstpierpoint	(Miles and Bridge 2010)	DANNY1	1389–1589	135	7.9
Herefordshire	White House, Vowchurch	(Nayling 2000)	VOWCH	1364–1602	148	7.9

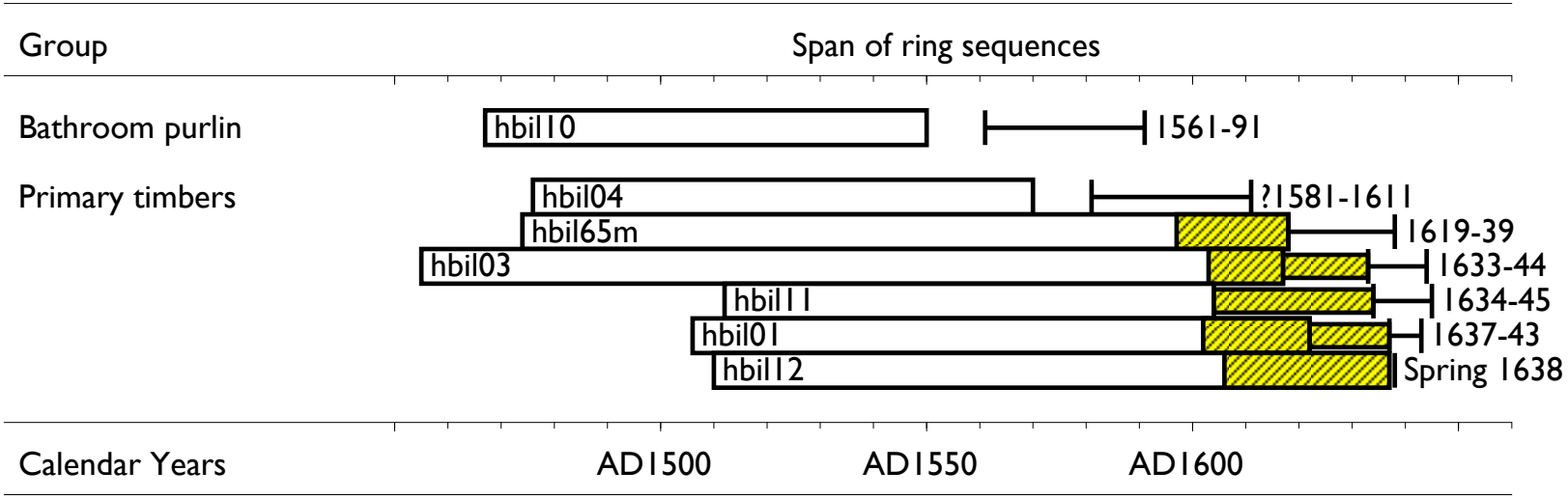

Figure 1: Bar diagram showing the relative positions of overlap of the dated samples, with their actual or likely felling dates / date ranges. White sections represent heartwood rings and yellow hatched sections represent sapwood, narrow bars represent additional unmeasured rings.