DENDROCHRONOLOGICAL ANALYSIS OF OAK TIMBERS FROM TY-LLWYD, LLANHILLETH, NEAR PONTYPOOL, MONMOUTHSHIRE, WALES

Tree-Ring Services Report: NPTY/22/24

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SUMMARY

A stone-built listed building containing a cruck with a type C apex and some re-used crucks. Major modifications, including the addition of upper crucks (with a type E apex) and a stud-and-panel partition, are evident.

The majority of timbers assessed in Ty-Llwyd contained more than 80 rings, making them suitable for tree-ring analysis. Three timbers from cruck blades and a re-used cruck are dated and indicate that the initial construction occurred in 1485, or soon after. Four timbers dated from upper crucks and a stud-and-panel partition identify that the building was significantly modified in 1624, or soon after.

Two samples from upper crucks in the added parlour failed to date, likely due to periodic management of the trees.

KEYWORDS

Dendrochronology, 15th & 17th Century, Standing buildings, Monmouthshire, Llanhilleth

Tables

Photos

INTRODUCTION

More and more people wish to know precisely when ancient buildings were constructed in order to better understand the history of their occupants and land in which we live. Although it is sometimes possible to date a building on stylistic grounds, a precise date is rare except when there is a date-stone or documentary evidence. However, the increasing use of dendrochronology (tree-ring dating) has changed this scenario, at least for buildings with timbers containing sufficient rings for analysis. The science is simple in concept. The width of a tree's growth rings varies from year to year, so that each series of years has a unique pattern of narrow and wide rings. We now know in detail the pattern of rings shown by oak trees in England for at least the last 2000 years, and there is some work in progress on other species, such as pine, beech and yew. Tree-ring dating typically involves small cores of wood being taken from the structural timbers of a building. Once sanded to a polished finish, these samples show the pattern of rings laid down during the lifetime of the trees from which the timbers were cut. If this pattern is then compared with "master chronologies" it is often possible to identify the felling date of the trees with astonishing accuracy. Where bark is present, it is possible to give a precise year, sometimes even the season of the year. We know that oak for building was almost always used "green", (unseasoned, not having been felled and prepared until required), so construction dates can be determined in which we can place considerable confidence.

Recording Timber-Framed Buildings

National trends in building activity inevitably conceal regional differences that can only be explained by detailed local studies. In the first county project the Royal Commission on the Historical Monuments of England (RCHME) analysed 53 medieval buildings in Kent (Pearson 1994). Since then studies have been published in Hampshire County Council has analysed well over 100 buildings in the county (Roberts 2003). These projects utilize the specific dates provided by tree-ring analysis to refine the typological and stylistic dating of buildings.

Tree-Ring Services is committed to the development of date-range spans for stylistic features to help refine the dating of timber-framed buildings. Buildings are recorded using a ‘Tick-Box’ sheet (available at www.buildingarchaeology.co.uk) which is used to summarize the most common and distinctive ‘key features’. This information is entered into a purpose-built Building Archaeology Research Database (BARD), a resource then available for further analysis (Moir *et al.* 2012). BARD has been used to analyse 177 dwellings in Surrey and establish date ranges for 52 key features (Wild and Moir 2013). Since then major studies using BARD have been published for Shropshire (Moir *et al.* 2019) and Gloucestershire (Moir 2023c). Each additional building tree-ring dated by Tree-Ring Services adds to this research and should eventually allow date ranges to be extended to other counties.

Harris (1978) provides a useful introduction to the study of timber-framed buildings, while Brunskill (2000) details the study of vernacular architecture. Alcock's (1996) glossary provides illustrative drawings which are particularly useful in facilitating the naming of timbers in a building.

Ty-Llwyd (NGR: SO 2180 01667)
A stone-built building listed as dating from the early to mid 17th century, but possibly with earlier origins (**Photo 1**). The cruck blades in truss 1 in the cowshed originally had a tenoned collar and a type C apex (Alcock *et al.* 2019). Trusses 4 and 5 are of upper cruck form. Truss 4 has a type E apex (**Photo 2**) and the collar has notched-lap halved joints with simple entry (**Photo 3**). Truss 4 has a post-and-panel partition (**Photo 4**) and diagonal stops.

Photo 1: Ty-Llwyd – south aspect

Photo 2: Truss 4: upper cruck with type E apex

Photo 3: A notched-lap halved joint with simple entry

Photo 4: A stud-and-panel partition

Objective of the Analysis
The main objective of this analysis was to provide dendrochronological evidence to date the primary, secondary and tertiary phases of construction at Ty-Llwyd.

Dendrochronological Assessment
Ty-Llwyd was visited on the 13th March 2024 and the timbers assessed for their potential use in dendrochronological study. Oak timbers with more than 50 rings, traces of sapwood or bark, and accessibility were the main considerations.

In the cowshed, the main cruck blades in truss 1 and one re-used cruck (used as a lintel) were assessed to contain more than 80 rings. The lintel also retained full sapwood. One transverse beam at the east end of the cowshed and in truss 4, together with the upper cruck blades in truss 4, were all identified as likely containing more than 80 rings and had traces of sapwood. In truss 5 in the parlour, the upper cruck blades were also assessed to contain more than 80 rings.

METHODOLOGY

Methods employed by Tree-Ring Services in general are those described in English Heritage guidelines (Hillam 1998). Part 2 of the Guidelines is designed for large projects in conjunction with other specialist disciplines and is not applicable to the type of privately commissioned dendrochronological analysis generally conducted by Tree-Ring Services and is therefore not used. Details of the methods employed for the analysis of this building are described below.

Sampling and Preparation

Photo 5: Extraction of a core in progress

Whenever possible, timbers with more than 50 annual growth rings are selected for sampling. This is necessary to provide a pattern of rings of sufficient length to be unique to the period of time when the parent tree was growing. Timbers are sampled using purpose-made 12mm diameter corers attached to an electric drill. Sampling is located as discreetly as possible in what appear to be original timbers and is orientated in the most suitable direction to maximize the numbers of rings for subsequent analysis. Extracted core samples are immediately taped and glued onto wooden laths on site and then labelled, ready for subsequent analysis.

Tree-ring series are revealed through sanding with progressively finer grits to a 800 abrasive grit finish to produce results suitable for measuring, see **Photo 6**. When required, for example where bands of narrow rings occur, further preparation is performed manually. Where requested, extraction holes are "made good", employing pine dowelling, wood-glue, sawdust and wood stains to restore the timbers to their original appearance.

Photo 6: An example of the tree-ring series revealed through the sanding of cores

Tree-ring series are measured under a ×20 stereo microscope to an accuracy of 0.01mm using a microcomputer-based travelling stage. All samples are measured from the centremost ring to the outermost. Samples considered unsuitable for dating purposes are then rejected. These include samples with disturbed ring series which cannot be measured due to knots or bands of extremely narrow rings, and samples with to few rings.

Samples of fewer than 50 rings are sometimes rejected from dendrochronological analysis because their ring patterns may not be unique (Hillam *et al.* 1987). Although this is

certainly true of all ring series of fewer than 30 rings, which should not be used in dating (Mills 1988), samples with 30 to 50 rings may be dated in some circumstances (Hillam 1998). It has been felt wise to maximize the recorded amount of data, and therefore in general series of more 35 rings are included in analysis and considered for dating, usually when they match well with a number of other series. Samples are measured twice and the two sets of measurements cross-matched and plotted visually as a check. Where series match satisfactorily they are averaged and the resulting series are used in subsequent analysis. Series containing fewer than 50 rings are suffixed '-S', and series from managed trees '-M' to help indicate that additional caution must be exercised in dating.

Cross-correlation algorithms are then employed to search for the positions where tree-ring series correlate and therefore possibly match. All statistical correlations are reported as *t*-values derived from the original CROS73 algorithm (Baillie and Pilcher 1973). A value of 3.5 or over is usually indicative of a good match as it represents the value of *t* which should occur by chance only once in every 1000 mismatches (Baillie 1982), and the higher the *t*-value the closer to congruency in the cross-matching. However, due to the remaining small risk of high *t*-values being produced by chance, all indicated correlations are further checked to ensure that corroborative high results are obtained at the same relative position against a range of independent tree-ring series. Visual comparisons of series are also employed to support or reject possible cross-matches and serve as a means of identifying measuring errors.

Timber Groups

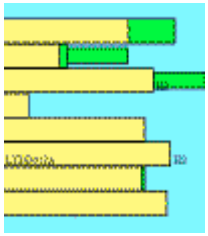
A further element of the tree-ring analysis of buildings and archaeological assemblages is the grouping of timbers within the sampled material. Inspection of *in situ* timbers may indicate that samples derive from a common timber, while common arrangements of anatomical features (knots & branching) may also indicate that samples are derived from a single tree.

Tree-ring analysis is used to support suggestions of same-tree groups between samples based on a combination of information. Timbers derived from the same tree are generally expected to have *t*-values over 10, although lower *t*-values may be produced when different radii measured from the same tree are compared. Tree-ring series producing *t*-values of 10 or above are examined to identify same-tree groups. Good comparisons of visual matching, growth rates, short and longer-term growth patterns, are combined with pith information, sapwood boundaries, bark and anatomical anomalies, to help decide whether timbers are likely to come from the same tree. Where timbers are assessed as deriving from the same tree, to avoid bias the series are averaged to produce a single tree-ring series before inclusion in the final site chronology, but inevitably some same-tree samples go undetected by dendrochronology.

Chronology Building and Cross-dating

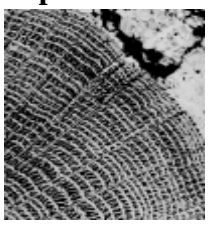
The process of cross-matching compares all tree-ring series against one another and those found to cross-match satisfactorily together are combined to create an average series. The site mean(s) and individual ring series which remain unmatched with the site mean are then tested against a range of established reference series (reference chronologies). Significant *t*-values replicated against a range of series at the same position with satisfactory visual matching are similarly used to establish cross-matches with reference chronologies. Where cross-matching is established against dated reference chronologies, calendar dates can be assigned to the site series. The dates of the first and last rings of dated series are produced as date spans. These dates should not be confused with felling dates.

Felling Dates



Series dated by the cross-dating process provide calendar year dates for the final tree-ring present in the measured timber sample. The interpretation of these dates then relies upon the nature of the final rings in the series. Where bark survives intact on a sample a felling date is given as the date of the last ring measured on the tree-ring series. Based on the completeness of the final ring it is sometimes even possible to distinguish between spring, summer or winter fellings, corresponding to approximately March to May, June to September and October to February, respectively. Where timbers were felled in either spring or summer and the final ring is incomplete and therefore not measured, allowance has to be made for the one-year discrepancy between the end of a measured series and the actual year of felling.

Sapwood Estimates



Where bark is missing from oak samples, as long as either sapwood or the heartwood/sapwood boundary have been identified, an estimated felling-date range can be calculated using the maximum and minimum number of sapwood rings that were likely to have been present. Sapwood estimates have varied over time with different data sets, geographical location and researchers. A general trend identified is that the number of sapwood rings in oak decreases from north to south and from west to east across Europe.

However, simply not enough is yet understood about sapwood variations and the mechanisms responsible for them. A generally accepted sapwood estimate of between 10 and 55 rings for British and Irish oaks (at 95% confidence) was given in 1987 (Hillam *et al.* 1987). Analysis of the increased data set available ten years later indicates a range of 10 to 46 rings to be more appropriate for England (Tyers 1998). Currently, as research in areas improves, sapwood estimates are refined and new estimates applied. Therefore, when dendrochronological dates are produced, the reference to the sapwood estimate used in its calculation should always follow.

This report applies a sapwood estimate of a minimum of 11 and maximum of 41 annual rings, which means that 19 out of every 20 trees examined is expected have between 11 and 41 sapwood rings. This sapwood estimate is currently applied to most of Wales and the Borders region and has been arrived at by Oxford Dendrochronology Laboratory (Haddon-Reece *et al.* 1990; Miles 1997). Felling-date ranges have been calculated by adding the sapwood estimate of minimum and maximum missing rings to the date of the

heartwood/sapwood boundary. Felling-date ranges have been refined by the presence of surviving sapwood where appropriate, see **Table 5**. Where samples ending in heartwood were dated, "felled after dates" have been calculated by adding the minimum expected number of missing sapwood rings to the samples' final ring dates. These dates represent the earliest probable felling dates. However, the actual felling date of a tree may be decades later due to an unknown number of missing heartwood rings. Where bark is present within a group of timbers and other evidence does not dispute the date, it is assumed that all the trees within a felling group were felled in the same year.

Date of Construction

It is vitally important to understand that dendrochronological analysis provides dates for when trees were felled and not necessarily when their timbers were used. Green or freshly felled wood is, however, far easier to work and it is standard practice to assume that medieval timbers were felled as required and used green (Rackham 1990; Miles 1997). However, the use of previously felled timbers in vernacular construction was not uncommon, with short-term stockpiling of usually not more than 1 to 2 years (Miles 1997), and the use of leftovers or re-used timbers may certainly give rise to differences between felling dates and the date of construction where samples are analysed in isolation. A number of samples having a close range of felling dates are required from different elements of a building either to strongly indicate a single date of construction or to identify separate phases of construction.

Tree-Ring Services - Methods and Criteria

Tree-ring analysis and graphics are achieved via a dendrochronological programme suite developed by Ian Tyers of Sheffield University (Tyers 1999). Alcock's (1996) timber-framed building nomenclature has been adopted throughout to facilitate regional comparisons. Summary features of most buildings dated, are made available on the Building Archaeology Research Database (Moir *et al.* 2012). Tree-Ring Services reports are published with tree-ring data to enable independent verification and allow their use in dating. Report may be ordered through the website at www.tree-ring.co.uk.

For the analysis of a building an initial assessment is conducted with the owner and recommendations in line with English Heritage guidelines on sampling strategies made, (i.e., that a minimum of 8 to 10 samples are obtained per building or per phase). However, the final decision concerning the number of samples taken for analysis rests with the individuals who commission the analysis. It is generally beyond the scope of an analysis to describe a building in detail or to undertake the production of detailed drawings. Without the benefit of other specialist disciplines there is always the danger that re-used timbers may be inadvertently selected, and the conclusions presented in a report may be modified in the light of subsequent work.

RESULTS

Nine core samples were taken from Ty-Llwyd on the 13th March 2024. The samples were labelled with a site code 'NPTY' and numbered sequentially from 1 to 9. The sampling locations of the cores are indicated on a sketch plan of the building (see **Appendix I**) and the locations of cores 1 to 7 are shown in the photographs below.

Photo 7: Core NPTY01

Photo 8: Core NPTY02

Photo 9: Core NPTY03

Photo 10: Core NPTY04

Photo 11: Core NPTY05

Photo 12: Cores NPTY06 & NPTY07

All nine samples were confirmed as oak (*Quercus* spp). Samples NPTY08 and NPTY09 contained sudden and sustained periods of ring-width reduction characteristic of direct management and were identified by the suffix '-M'. Two samples were recovered with complete sapwood.

Three series were found to match together (see **Table 1**) and were combined to form a 162-year site chronology named LLANH-T1.

Table 1: Cross-matching between the series in the site chronology LLANH-T1

Filenames	Start dates	end dates	NPTY02	NPTY04
NPTY01	AD1324	AD1459	3.11	4.88
NPTY02	AD1366	AD1463		4.25
NPTY04	AD1323	AD1484		

KEY: - = *t*-values less than 3.00. \ = overlap < 30 years.

Series LLANH-T1 was found to produce consistently high *t*-values against reference chronologies (**Table 2**), with the first ring of the series at AD 1323 and the final ring of the series at AD 1484.

Table 2: Dating evidence for the series LLANH-T1 against reference chronologies

LLANH-T1 dated AD 1323 to AD 1484					
File	**Start Date**	**End Date**	***t*-value**	**Overlap (yr.)**	**Reference chronology**
EXETR-HS	AD1309	AD1491	6.42	162	46 High St - Exeter - Devon (Arnold and Howard 2009)
STANDREW	AD1253	AD1490	6.08	162	St Andrew's Church - Alwington - Devon (Arnold *et al.* 2009)
POUND7	AD1316	AD1441	5.82	119	Pound Farm - Kington - Herefordshire (Nayling 2002)
STJLICH	AD1356	AD1494	5.72	129	St John the Baptist - Lichfield - Staff (Worthington and Miles 2002)
NEENS-SM	AD1227	AD1532	5.66	162	St Marys - Neen Savage - Shropshire (Arnold and Howard 2014)
WALES18	AD1156	AD1977	5.62	162	Wales reference chronology (Author, unpublished)
COLWALL-3	AD1354	AD1509	5.57	131	Church Hse - Colwall - Herefordshire (Hillam and Groves 1991)
HERE-57	AD994	AD2003	5.44	162	Herefordshire reference chronology (Author, unpublished)
WIGMOR-3	AD1261	AD1484	5.37	162	Abbots Parlour - Wigmore Abbey - Herefordshire (Tyers 2002)
EASBY-AH	AD1374	AD1494	5.09	111	Abbey House - Easby - N Yorkshire (Moir 2023b)
ORLET-OH	AD1371	AD1627	5.08	114	Orleton House - Orleton - Herefordshire (Moir 2020b)
PENTREH	AD1189	AD1465	5.05	143	Timber Croft - Shropshire (Worthington and Miles 2001)

KEY: **Bold** = indicates a composite reference chronology consisting of multiple site chronologies.

Four other series were found to match together (see **Table 3**) and were combined to form a 133-year site chronology named LLANH-T2.

Table 3: Cross-matching between the series in the site chronology LLANH-T2

Filenames	Start dates	End dates	NPTY05	NPTY06	NPTY07
NPTY03	AD1498	AD1577	7.95	3.37	3.93
NPTY05	AD1509	AD1623		6.09	3.86
NPTY06	AD1509	AD1597			8.84
NPTY07	AD1491	AD1598			

KEY: - = *t*-values less than 3.00. \ = overlap < 30 years.

This site chronology was found to produce consistently high *t*-values against reference chronologies (**Table 4**), with the first ring of the series at AD 1491 and the final ring of the series at AD 1623.

Table 4: Dating evidence for the series LLANH-T2 against reference chronologies

LLANH-T2 dated AD 1491 to AD 1623					
File	**Start Date**	**End Date**	***t*-value**	**Overlap (yr.)**	**Reference chronology**
SHROP45	AD1058	AD1810	7.72	133	Shropshire county chronology (Author, unpublished)
MOUSEHOL	AD1374	AD1613	6.67	123	No 1-7 Keigwin Place - Mousehole - Cornwall (Arnold and Howard 2011)
RUTHN-36	AD1225	AD1734	6.53	133	Ruthin - Wales (Moir 2023a)
BELFAST	AD1001	AD1970	6.39	133	Belfast - N Ireland (Baillie 1977)
ORLET-OH	AD1371	AD1627	6.37	133	Orleton House - Orleton - Herefordshire (Moir 2020b)
PORCHBC	AD1416	AD1564	6.23	133	Porch House - Bishops Castle - Shrops (Worthington and Miles 2000)
RUTH-UC1	AD1479	AD1605	6.04	133	7 Upper Clwyd St - Ruthin - Denbighshire - Wales (Moir 2022)
WIGMR-C2	AD1367	AD1632	5.90	133	Chapel Farmhouse barn - Wigmore - Herefordshire (Moir 2016a)
WINTN-W1	AD1435	AD1618	5.83	133	West wing - Winton Court - Winton - Shropshire (Moir 2016b)
LLANG-LB	AD1468	AD1622	5.73	132	Llanerch-y-Beudy - Llangynid - Powys (Moir 2018)
LYDNY-MR	AD1359	AD1585	5.66	95	Crump Farm and Barn - Lydney - Glouc (Moir 2020a)
RUTH-CC1	AD1452	AD1604	5.33	114	Plas-Coch - Ruthin - Denbighshire - Wales (Moir 2023a)

KEY: **Bold** = indicates a composite reference chronology consisting of multiple site chronologies.

All other series failed to cross-match and therefore remain undated at this time.

INTERPRETATION

Felling Dates

The sapwood allowance used to calculate the felling dates now discussed is presented in **Table 5**, and the bar diagram (see **Figure 1**) helps to demonstrate the findings visually.

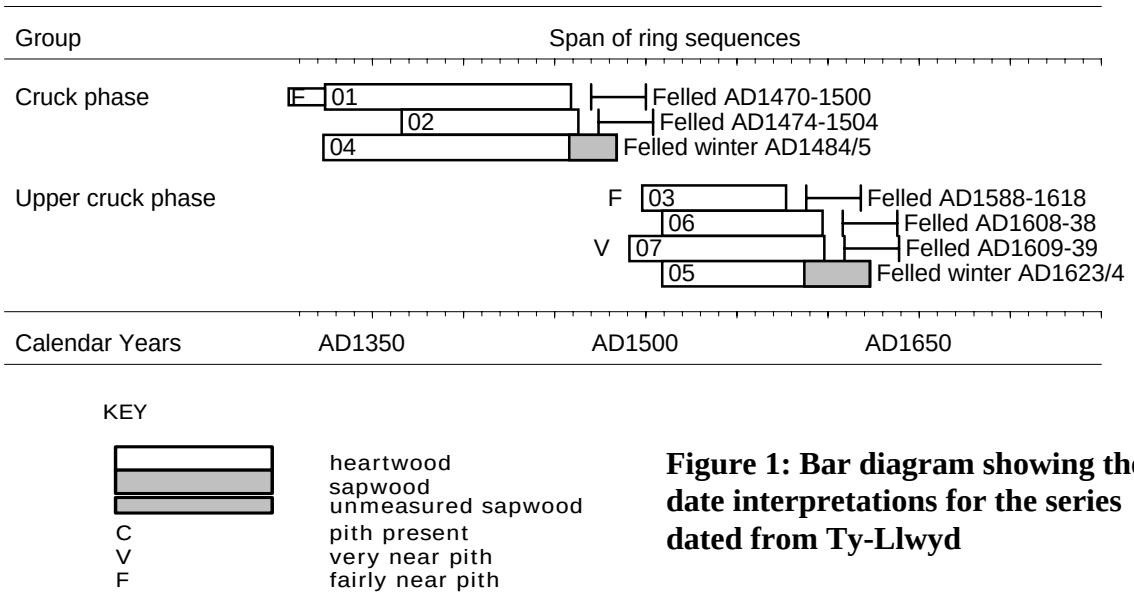


Figure 1: Bar diagram showing the date interpretations for the series dated from Ty-Llwyd

The re-used cruck timbers in Ty-Llwyd produces one precise felling date in the winter of 1484/5. This precise felling date is consistent with the felling-date ranges produced from two other timbers dated, providing good evidence that cruck construction occurred in 1485, or soon after.

The upper cruck timbers produce one precise felling date in the winter of 1623/24. This precise felling date is consistent with the felling-date ranges produced from three other timbers dated, providing good evidence that construction of the upper crucks occurred in 1624, or soon after.

CONCLUSIONS

The majority of timbers assessed in Ty-Llwyd contained more than 80 rings, making them suitable for tree-ring analysis. Three timbers from cruck blades and a re-used cruck are dated and indicate that the initial construction occurred in 1485, or soon after. Four timbers dated from upper crucks and a stud-and-panel partition identify that the building was significantly modified in 1624, or soon after.

Two samples from upper crucks in the added parlour failed to date, likely due to periodic management of the trees.

Table 5: Summary of dendrochronological analysis

Sample	Timber and Position	Timber Conversion	Timber Dimensions (mm)	Rings	Sapwood	Average Growth Rate (mm/yr)	Sequence Date Range	Felling Date Range
NPTY01	North cruck - truss 1	B2	370 x 210	(20+)136	+HS	0.80	AD1324-AD1459	Felled AD1470-1500
NPTY02	South cruck - truss 1	B2	400 x 200	98	+HS	1.87	AD1366-AD1463	Felled AD1474-1504
NPTY03	Transverse bean - cowshed between truss 2 & 3	A2	230 x 170	80	+HS	1.36	AD1498-AD1577	Felled AD1588-1618
NPTY04	Re-used cruck - cowshed north lintel	B2	170 x 360	162	26+Bw	0.85	AD1323-AD1484	Felled winter AD1484/5
NPTY05	Transverse beam - truss 4	A2	260 x 200	115	36+Bw	1.22	AD1509-AD1623	Felled winter AD1623/4
NPTY06	South upper cruck - truss 4	B2	370 x 150	89	+HS	1.65	AD1509-AD1597	Felled AD1608-38
NPTY07	North upper cruck - truss 4	B2	380 x 160	108	+HS	1.19	AD1491-AD1598	Felled AD1609-39
NPTY08-M	South upper cruck - truss 5	B2	350 x 160	(66+)57	+HS	1.31		
NPTY09-M	North upper cruck - truss 5	B2	350 x 160	(16+)92	+HS	0.66		

KEY	
+	= additional information not measured on the core
(+)	= unmeasured heartwood rings at the beginning or end of the core
HS	= heartwood/sapwood boundary
?B	= probable bark
¼B	= spring bark
½B	= summer bark
Bw	= winter bark
A2	= boxed heartwood & trimmed
B2	= halved & trimmed
C2	= quartered & trimmed
E2	= tangential & trimmed

Note: Timber dimensions were generally taken at the core sample location and are not necessarily the maximum dimensions of the timber

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REFERENCES

Alcock, N W, Barley, M W, Dixon, P W, and Meeson, R A, 1996 *Recording timber-framed buildings: an illustrated glossary*, York (CBA)

Alcock, N W, Barnwell, P S, and Cherry, M, 2019 *Cruck Building: a survey*, Donington (Shaun Tyas)

Arnold, A J and Howard, R E, 2009 *46 High Street, Exeter, Devon: Tree-ring analysis of timbers.*, Research Department Report Series, **71/2009**

Arnold, A J and Howard, R E, 2011 *The Old Standard (Nos 1 and 2), Little Keigwin (No 5), and Keigwin (No 7), Keigwin Place, Mounsehole, Cornwall: Tree-ring Analysis of timbers.*, Research Department Report Series, **10/2008**

Arnold, A J and Howard, R E, 2014 *Church of St Mary, Neen Savage, Shropshire: Tree-ring Analysis of timbers.*, Research Department Report Series, **75/2014**

Arnold, A J, Howard, R E, and Hurford, M, 2009 *Church of St Andrew, Feniton Court, Feniton, Devon: Tree-ring Analysis of timbers.*, Research Department Report Series, **4/2009**

Baillie, M G L, 1977 The Belfast oak chronology to AD1001, *Tree-ring Bulletin*, **37**, 1-12

Baillie, M G L, 1982 *Tree-ring dating and archaeology*, London (Croom-Helm)

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

Brunskill, R W, 2000 *Vernacular Architecture: an illustrated handbook*, London (Faber and Faber)

Haddon-Reece, D, Miles, D H, and Munby, J T, 1990 List 38 - Tree-Ring Dates from the Ancient Monuments Laboratory, HBMC, *Vernacular Architect*, **21**, 46-50

Harris, R, 1978 *Discovering timber-framed buildings*, Princes Risborough (Shire Publications)

Hillam, J, 1998 *Dendrochronology: Guidelines on producing and interpreting dendrochronological dates*, London (Historic England)

Hillam, J and Groves, C, 1991 *Tree-ring dating of timbers from the Church Ale House, Colwall, Herefore and Worcester*, Centre for Archaeology Report, **106/91**

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, **S333**, 165-85

Miles, D H, 1997 The interpretation, presentation, and use of tree-ring dates, *Vernacular Architect*, **28**, 40-56

Mills, C M, 1988 Dendrochronology: the long and short of it, in *Science and archaeology* (eds E A Slater, and J O Tate), Glasgow, BAR Int Ser, **196**, 549-65

Moir, A K, 2016a *Dendrochronological analysis of oak timbers from Chapel Farmhouse and Barn, Wigmore, Leominster, Herefordshire, England.*, Tree-Ring Services, Dendro Rep, **HRCF/32/16**

Moir, A K, 2016b *Dendrochronological analysis of oak timbers from the west wing of Whitton Court, Whitton, Shropshire, England.*, Tree-Ring Services, Dendro Rep, **SYWC/53/16**

Moir, A K, 2018 *Dendrochronological analysis of oak timbers from Llanerch-y-Beudy Farm, Llangynidr, Crickhowell, Powys, Wales.*, Tree-Ring Services, Dendro Rep, **NPLB/13/18**

Moir, A K, 2020a *Dendrochronological analysis of oak timbers from Crump Farmhouse and barn, Lydney, Gloucestershire, England*, Tree-Ring Services, Dendro Rep, **GLMR/01/20**

Moir, A K, 2020b *Dendrochronological analysis of oak timbers from Orleton House, Orleton, Herefordshire, England*, Tree-Ring Services, Dendro Rep, **SYOH/07/20**

Moir, A K, 2022 *Dendrochronological analysis of oak timbers from Fifteen Buildings in Ruthin, Denbighshire, Wales*, Tree-Ring Services, Dendro Rep, **LLRA/23/22**

Moir, A K, 2023a *Dendrochronological analysis of buildings for the Vale of Clwyd Dendrochronology Project*, Tree-Ring Services, Dendro Rep, **LLRA/11/23**

Moir, A K, 2023b *Dendrochronological analysis of oak timbers from Abbey House, Easby, Richmond, North Yorkshire, England*, Tree-Ring Services, Dendro Rep, **DLAH/32/23**

Moir, A K, 2023c *Dendrochronological analysis of oak timbers from Chateau Clerbaud, Paizay le Sec, France*, Tree-Ring Services, Dendro Rep, **FRCC/42/23**

Moir, A K, Nash, G, and Reid A, 2019 New Insights into timber-framing in Shropshire: Findings from the Tilley Timber Project, *Vernacular Architecture*, **50**, 40-52

Moir, A K, Wild, R, and Haddlesey, R, 2012 An Internet-Accessible Building Archaeology Research Database (BARD), *Vernacular Architecture*, **43**, 1-6

Nayling, N, 2002 *Tree-ring analysis of timbers from Pound Farm, Kington, Herefordshire*, Centre for Archaeol Rep, **28/2002**

Pearson, S, 1994 *The Medieval Houses of Kent, An Historical Analysis*, London (RCHME)

Rackham, O, 1990 *Trees and woodland in the British Landscape*, London (J M Dent & Sons Ltd)

Roberts, E, 2003 *Hampshire Houses 1250 - 1700: Their dating & Development*, (Hampshire County Council)

Tyers, I, 1998 *Tree-ring analysis and wood identification on timbers excavated on the Magistrates Court Site, Kingston upon Hull, East Yorkshire*, ARCUS Rep, **410**

Tyers, I, 1999 *Dendro for Windows Program Guide 2nd Edition*, ARCUS Rep, **500**

Tyers, I, 2002 *Tree-ring analysis of oak timbers from the abbot's hall and parlour at Wigmore Abbey, near Adforton, Herefordshire* , Centre for Archaeol Rep, **112/2002**

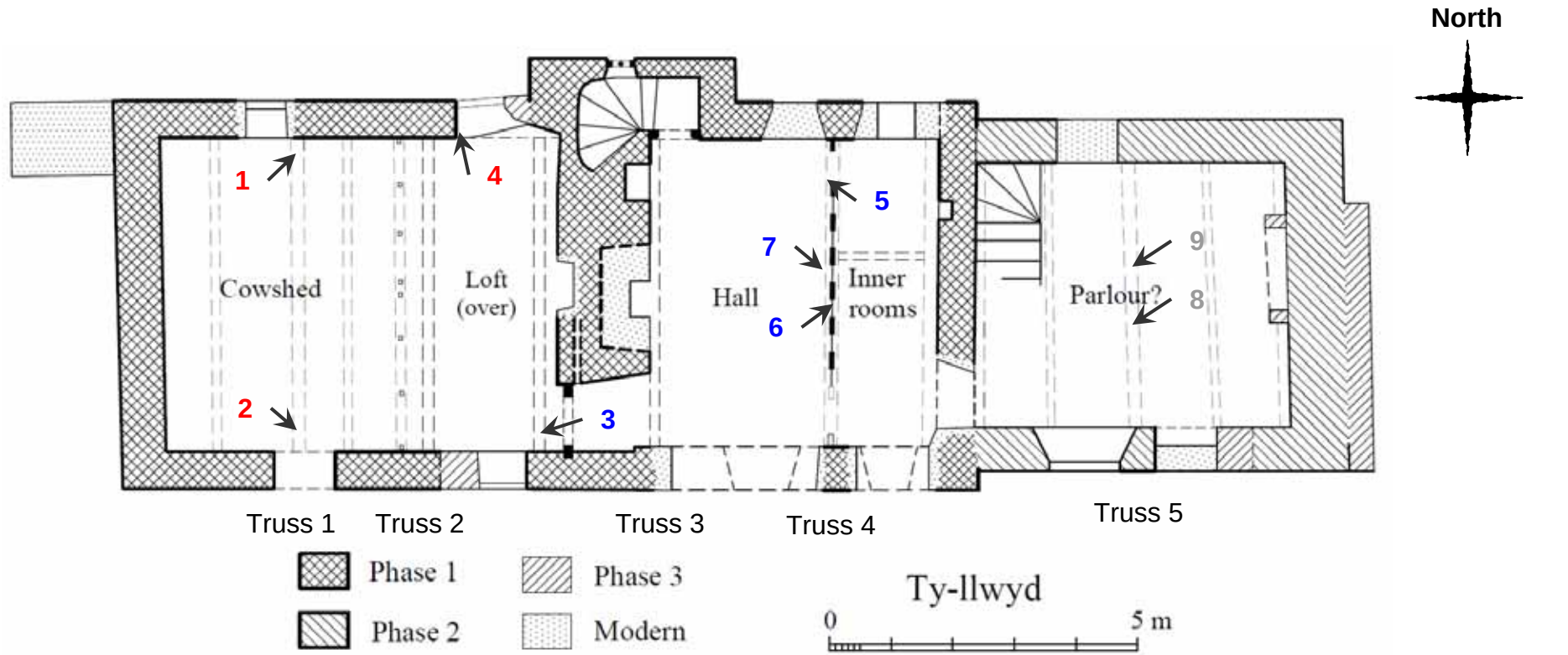
Wild, R and Moir, A K, 2013 Key dating features for timber-framed dwellings in Surrey, *Vernacular Architecture*, **44**, 46-61

Worthington, M J and Miles, D H, 2000 *The tree-ring dating of the Porch House, 33-5 High Street, Bishop's Castle, Shropshire*, AML Report, **72/2000**

Worthington, M J and Miles, D H, 2001 *The tree-ring dating of Timber Croft, Pentre Hodre, Clun, Shropshire*, Centre for Archaeol Rep, **58/2001**

Worthington, M J and Miles, D H, 2002 *The tree-ring dating of the Hospital of St John the Baptist, Lichfield, Staffordshire*, Centre for Archaeol Rep, **62/2002**

APPENDIX I: Plan of Ty-Llwyd



KEY:
Not to scale
Numbers identify location of the cores taken.
Red = Dated to AD 1485
Blue = Dated to AD 1624
Grey = Undated

APPENDIX II: Ring-width data

Title : Cruck - Ty-Llwyd - Llanhilleth - Monmouthshire - Wales [LLANH-T1]
Timber mean with signatures Ring-width QUSP data of 162 years length
Unit of Measurement 0.01mm
Dated AD1323 to AD1484
3 timbers raw data mean
Average ring width 102.57 Sensitivity 0.18

AD1323			71	73	69	72	82	72	84	88
	86	104	146	80	71	56	79	56	78	56
	52	58	62	66	61	55	92	79	120	101
AD1351	165	103	119	97	121	137	117	132	107	72
	111	152	141	173	133	206	189	153	175	143
	136	168	124	154	115	72	105	137	183	128
	116	108	116	140	160	178	170	163	184	152
	142	119	111	107	193	179	153	140	152	160
AD1401	128	146	161	142	131	114	100	119	124	125
	92	97	88	107	100	95	112	116	72	77
	99	86	144	114	84	97	83	81	81	118
	86	145	96	110	132	83	116	94	61	74
	74	71	89	106	95	85	104	117	96	76
AD1451	79	62	78	96	75	81	78	77	73	65
	94	89	86	66	56	70	91	57	69	55
	53	50	56	67	70	51	49	52	62	66
	55	55	55	56						

Title : Upper Cruck - Ty-Llwyd - Llanhilleth - Monmouthshire - Wales [LLANH-T2]
Timber mean with signatures Ring-width QUSP data of 133 years length
Dated AD1491 to AD1623
Unit of Measurement 0.01mm
4 timbers raw data mean
Average ring width 139.78 Sensitivity 0.18

AD1491	212	153	211	188	199	210	194	148	167	170
AD1501	152	134	146	229	175	177	107	136	160	155
	160	137	114	122	91	121	132	130	133	114
	155	135	114	122	135	142	137	153	140	113
	174	133	140	128	121	144	138	99	137	175
	140	93	123	130	144	129	110	108	105	92
AD1551	145	107	136	109	121	95	110	92	114	105
	120	137	108	141	99	77	79	80	105	86
	115	122	128	182	144	108	102	112	122	192
	164	144	159	188	140	146	179	122	216	142
	151	182	170	150	153	138	144	130	171	147
AD1601	234	157	143	172	128	145	148	161	141	157
	163	116	155	138	223	121	128	158	127	127
	95	106	133							