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ST PETER'S CHURCH,
PIRTON,
WORCESTERSHIRE;
TREE-RING ANALYSIS OF SAMPLES FROM
THE TIMBER-FRAMED TOWER AND BELL FRAME

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SEPTEMBER 2013

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SUMMARY

A total of 25 core samples were obtained from a variety of wall and bell frame timbers of the wooden tower at St Peter's Church, Pirton. Following analysis by dendrochronology of these samples it would appear that much of the tower is constructed of trees felled in 1507, this phase being represented by 10 dated timbers. Two further timbers could, *possibly*, also be part of this phase, but it is more likely that they were felled earlier, some time in the period, say, 1480–90. Another timber is certainly earlier than these, this being felled sometime between 1390 at the earliest and 1415 at the latest.

There are, however, some later timbers, the sill or base beam to the north wall for example, this being felled some time between 1600–25. A still later phase of felling is represented by the middle 'outriggers' to the east and west lean-tos, these timbers being felled in 1747, and the possibility that these lean-tos are of mid-eighteenth century date might perhaps be considered.

Two timbers of the bell frames, two 'short heads', are likely to have been felled between 1585 at the earliest and 1610 at the latest.

From the analysed samples three dated site chronologies can be formed, the first of 12 samples, being 161 rings long overall, these rings dated as spanning the years 1347–1507. The second dated site chronology is formed of three samples, this being 101 rings long overall, with these rings being dated as spanning the years 1485–1585. The third dated site chronology is formed of two samples, is 131 rings long, and spans 1617–1747. A further single sample is dated individually.

A further two site chronologies comprising two samples each can be formed, these having overall length of 82 and 64 rings respectively, but neither of them can be dated. Three other samples (two of which were not measured due to having insufficient rings) remain ungrouped and undated.

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Introduction

The church of St Peter, at Pirton, Stands in an isolated position, a little way south of the village of the same name (SO 885 468, Figs 1a/b). It comprises a chancel, nave, and a timber tower north of the nave.

It is believed that the side walls of the nave date from the early-twelfth century, when the church had a central tower, of which the present chancel arch formed the eastern support. The church remained unaltered till the early-fourteenth century, when the chancel and the west end appear to have been rebuilt. In the fifteenth century a window was inserted in the south wall of the nave, and early in the sixteenth century, it is believed, the central tower was taken down. This alteration involved the removal of the western arch and the construction of a passage in the wall from the former tower stair to the new rood loft, which must have stood against the eastern arch. It is also believed that the timber tower was then erected, and not long after the brick mullions and tracery appear to have been added in the side windows of the chancel. The church has been restored in modern times, and the west wall entirely rebuilt slightly within the old lines.

The timber tower is built against the north nave wall near its western end. The ground stage forms three bays, the side ones being covered by pent roofs resting against the framing of the central portion. The central portion then rises one stage higher and is covered with a modern pyramidal roof. The framing of the ground stage has diagonal braces on each face and a square headed door on the north. The bell-chamber has a small light with a rounded head in each face and the tower is finished externally in black and white work (Figs 2a-d).

Pevsner describes the tower as having narrowly spaced studs and big diagonal braces, and internally, between nave and aisles, double scissor braces of a formidable scantling. The Victorian County History (VCH) calls the tower early-sixteenth century, but its timbering, with great cruck forms as braces and its proportions would suggest, says Pevsner, a date in the fourteenth century or earlier.

Sampling

Sampling and analysis by tree-ring dating was commissioned by Nick Joyce of Nick Joyce Architects Ltd, of Worcester, on behalf of the Church, as part of a Heritage Lottery Fund application for grant-aided repairs. It was hoped that sampling would more accurately and reliably establish the date of the tower as being either fourteenth century (or earlier), as Nikolaus Pevsner suggests, or early-sixteenth century as the VCH suggests. It was also hoped that tree-ring dating would determine the date of the east and west 'lean-to' aisles to the tower and establish if they were coeval or later additions. It was also hoped that a date for the bell frame might also be established.

Thus, from the timbers available a total of 25 samples was obtained by coring. Each sample was given the code PIR-A (for Pirton, site 'A'), and numbered 01–25. In some cases, as with PIR-A03, A12, and A14 for example, it was necessary to take more than one core per timber in order to obtain the optimum sample with the maximum number of rings and some sapwood or the heartwood/sapwood boundary. In such cases the cores were combined to produce a single sample for the respective source timber.

An attempt to identify and locate the sampled timbers is given on plans made and kindly provided by Nick Joyce, reproduced here as Figures 3a–d), or on annotated photographs taken at the time of coring, these being given here as Figures 4a–m. Details of the samples are given in Table 1, including the timber sampled and its location, the total number of rings each sample has, and how many of these, if any, are sapwood rings. The individual date span of each dated sample is also given. In this Table, and on the drawings, the trusses, bays, and individual timbers, have been located on a site north–south/east–west basis as appropriate.

The Nottingham Tree-ring Dating Laboratory would like to take this opportunity to thank St Peter's Church, particularly in the form of Mr Derek Skeys, Church Warden, for their enthusiasm and help with this programme of analysis. In particular, we would like to them for their generous funding of this project. The Laboratory would also like to thank Nick Joyce, Church Architect, for promoting and supporting this programme of dating, for his help in interpreting the possible phases of the building, and for the provision of high quality drawings on which to locate sampled timbers.

<u>Tree-ring dating</u>

Tree-ring dating relies on a few simple, but quite fundamental, principles. Firstly, as is commonly known, trees (particularly oak trees, the timber most commonly used in building construction until the introduction of pine from the late eighteenth century onwards) grow by adding one, and only one, growth-ring to their circumference each, and every, year. Each new annual growth-ring is added to the outside of the previous year's growth just below the bark. The width of this annual growth-ring is largely, though not exclusively, determined by the weather conditions during the growth period (roughly March–September). In general, good conditions produce wider rings and poor conditions produce narrower rings. Thus, over the lifetime of a tree, the annual growth-rings display a climatically influenced pattern. Furthermore, and importantly, all trees growing in the same area at the same time will be influenced by the same growing conditions and the annual growth-rings of all of them will respond in a similar, though not identical, way (Fig 5).

Secondly, because the weather over a certain number of consecutive years (the statistically reliable minimum calculated as being 54 years) is unique, so too is the growth-ring pattern of the tree. The pattern of a shorter period of growth, 20, 30, or even 40 consecutive years, might conceivably be repeated two or even three times in the last one thousand years, and is considered less reliable. A short pattern might also be repeated at different time periods in different parts of the country because of differences in regional micro-climates. It is less likely, however, that such problems would occur with the pattern of a longer period of growth, that is, anything in excess of 45 years or so. In essence, a short period of growth, anything less than 45 rings, is not reliable, and the longer the period of time under comparison the better.

Tree-ring dating relies on obtaining the growth pattern of trees from sample timbers of unknown date by measuring the width of the annual growth-rings. This is done to a tolerance of 1/100 of a millimeter. The growth patterns of these samples of unknown date are then compared with a series of reference patterns or chronologies, the date of each ring of which is known. When the growth-ring sequence of a sample 'cross-matches' repeatedly at the same date span against a series of different reference chronologies the sample can be said to be dated. The degree of cross-matching, that is the measure of similarity between sample and reference, is denoted by a '*t*-value'; the higher the value the greater the similarity. The greater the similarity the greater is the probability that the patterns of samples and references have been produced by growing under the same conditions *at the same time*. The statistically accepted fully reliable minimum *t*-value is 3.5.

However, rather than attempt to date each sample individually it is usual to first compare all the samples from a single building, or phase of a building, with one another, and attempt to cross-match each one with all the others from the same phase or building. When samples from the same phase do cross-match with each other they are combined at their matching positions to form what is known as a 'site chronology'. As with any set of data, this has the effect of reducing the anomalies of any one individual (brought about in the case of tree-rings by some non-climatic influence) and enhances the overall climatic signal. As stated above, it is the climate that gives the growth pattern its distinctive pattern. The greater the number of samples in a site chronology the greater is the climatic signal of the group and the weaker is the non-climatic input of any one individual.

Furthermore, combining samples in this way to make a site chronology usually has the effect of increasing the time-span that is under comparison. As also mentioned above, the longer the period of growth under consideration, the greater the certainty of the cross-match. Any site chronology with less than about 55 rings is generally too short for reliable dating.

Having obtained a date for the site chronology as a whole, the date spans of the constituent individual samples can then be found, and from this the felling date of the trees represented may be calculated. Where a sample retains complete sapwood, that is, it has the last or outermost ring produced by the tree before it was cut, the last measured ring date is the felling date of the tree.

Where the sapwood is not complete it is necessary to estimate the likely felling date of the tree. Such an estimate can be made with a high degree of reliability because oak trees generally have between 15 to 40 sapwood rings. For example, if a sample with, say, 12 sapwood rings has a last sapwood ring date of 1400 (and therefore a heartwood/sapwood boundary ring date of 1388), it is 95% certain that the tree represented was felled sometime between 1403 (1400+3 sapwood rings (12+3=15)) and 1428 (1400+28 sapwood rings (12+28=40)).

<u>Analysis</u>

Each of the 25 samples obtained from the various timbers of the tower and bell frame of St Peter's Church was prepared by sanding and polishing. It was seen at this time that two of these, samples, PIR-A24 and A25, both from the bell frame, had too few rings for reliable dating, ie, less than 50, and they were rejected from this programme of analysis. The annual ring widths of the remaining 23 samples were, however, measured and the data were then compared with each other as described in the notes above. By this process five different groups, comprising a total 21 measured samples, could be formed.

The first group comprises 12 samples, PIR-A01, A02, A03, A04, A06, A07, A09, A14, A16, A17, A18, and A19, from a wide range of different timbers, these samples cross-matching with each other at the relative positions as shown in the bar diagram Figure 6. These 12 samples were combined at their indicated off-set positions to form PIRASQ01, a site chronology with an overall length of 161 rings. This site chronology was then satisfactorily dated by repeated and consistent comparison with a large number of relevant reference chronologies for oak as spanning the years 1347 to 1507. The evidence for this dating is given in the *t*-values of Table 2.

The second group comprises three samples, A20 and A21, from the short heads to bell frames 2 and 3 (counting from the north), and sample A12, from the basal sill beam to the north wall of the tower. These samples cross-match with each other at the relative positions as shown in the bar diagram Figure 7. These three samples were combined at their indicated off-set positions to form PIRASQ02, a site chronology with an overall length of 101 rings. This site chronology was then satisfactorily dated by repeated and consistent comparison with a large number of relevant reference chronologies for oak as spanning the years 1485 to 1585. The evidence for this dating is given in the *t*-values of Table 3.

The third group comprises two samples, A10 and A11, from the middle ‘outriggers’ to the east and west lean-tos. These samples cross-match with each other at the relative positions as shown in the bar diagram Figure 8. These two samples were combined at their indicated off-set positions to form PIRASQ03, a site chronology with an overall length of 131 rings. This site chronology was then satisfactorily dated by repeated and consistent comparison with a large number of relevant reference chronologies for oak as spanning the years 1617 to 1747. The evidence for this dating is given in the *t*-values of Table 4.

The fourth group also comprises two samples, A08 and A13, respectively from the lower east and west struts of the south wall of the tower. These two samples cross-match with each other at the relative positions shown in the bar diagram Figure 9, and were combined to form PIRASQ04, a site chronology with an overall length of 82 rings. However when compared with the reference chronologies there was no cross-matching, and these samples must, therefore, remain undated, at least for the moment.

The fifth and final group again comprises two samples, A22 and A23, both from the braces of bell frame 1 (counting from the north). These two samples cross-match with each other at the relative positions shown in the bar diagram Figure 10 and were combined to form PIRASQ05, a site chronology with an overall length of 64 rings. However when compared with the reference chronologies there was again no cross-matching, and these samples must also remain undated.

The two remaining measured but ungrouped samples, PIR-A05 and A15, were then compared individually with the full corpus of reference data, this indicating a cross-match only for sample PIR-A05 when the date of the first ring is 1280 and the date of the last ring is 1375. The evidence for this dating is given in the *t*-values of Table 5.

This analysis may be summarised thus:

Site chronology / sample	Number of samples	Ring length	Date span (where dated)
PIRASQ01	12	161	1347–1507
PIRASQ02	3	101	1485–1585
PIRASQ03	2	131	1617–1747
PIRASQ04	2	82	undated
PIRASQ05	2	64	undated
PIR-A05	1	96	1280–1375
ungrouped	1	---	undated
unmeasured	2	---	undated

Interpretation

Tree-ring analysis of the 23 measured samples from the wooden tower of St Peter's Church would indicate that, as possibly intimated by the structural evidence, timbers with different felling dates are to be found here.

Phase 1

The earliest timber would appear to be that represented by sample PIR-A05, from the north lower brace to the inner west wall. Although its precise felling date cannot be determined because the sample does not retain complete sapwood (the outermost or most recent growth ring produced be the tree before it was felled), it does retain the heartwood/sapwood boundary, this meaning that only the sapwood rings are missing. Given that this boundary ring is dated to 1375, and that most oak trees have between a minimum of 15 sapwood rings and a maximum of 40 sapwood rings, this means that the tree is very likely to have been felled between 1390 at the earliest and 1415 at the latest.

Phase 2

The next phase of felling may be represented by samples PIR-A16 and A17, from diagonal braces to the east wall of the tower at bell stage level, these having heartwood/sapwood boundary dates of 1451 and 1453 respectively. Again taking into account the minimum and maximum number of sapwood rings the trees represented are likely to have had (15–40), and allowing that the latest extant ring on either sample is dated to 1470, this would suggest that these timbers were felled sometime between 1471 at the earliest to 1492 at the latest. There is, however, just a possibility that these timbers were cut as part of the phase 3 felling (in 1507, see below), but they would have required 54 and 56 sapwood rings respectively, a higher than usual number. While such a high number of sapwood rings on oak is not altogether unknown, it is very unusual.

Phase 3

A subsequent major phase of felling is represented by a larger number of samples, 10 in total. One of these 10 samples, PIR-A19, from the main south-west corner post at bell stage level, retains complete sapwood, the last ring produced by the tree before it was felled (this is denoted by upper case 'C' in Table 1 and the bar diagram, Figure 6). This last ring, and thus the felling of the tree, is dated to 1507.

Another of these 10 samples, PIR-A01, is from a timber, main north-east post at ground floor level, which has complete sapwood on it, but from which, due to the soft and fragile nature of this part of the wood, a small amount of sapwood, about 5mm, was lost during coring (this is denoted by lower case 'c'). Given that the last extant ring on this sample is dated to 1501, the lost amount of sapwood would suggest that it too represents a timber felled in 1507.

The remaining eight samples of this group either have a heartwood/sapwood boundary, or cross-match with each other to such a degree, that make it likely that they too represent timbers felled in 1507.

Phase 4

A further phase of felling appears to be represented by samples PIR-A20 and A21, from the 'short heads' to bell frames 2 and 3 (counting from the north). These two samples match well together, with one of them having a heartwood/sapwood boundary date of 1570. Again allowing for a minimum of 15 sapwood rings and a maximum of 40 sapwood rings, this means that the source trees are is very likely to have been felled between 1585 at the earliest and 1610 at the latest.

Also approximately of this date is the north sill or base beam, represented by sample PIR-A12. This sample has a heartwood/sapwood boundary date of 1585. Allowing for the usual 15–40 sapwood rings would indicate that the timber represented was felled between 1600 and 1625.

Phase 5

The latest phase of felling detected in this programme of analysis is represented by samples PIR-A10 and A11, from the middle outriggers to the east and west lean-tos. Again both timbers cross-match well with each other and both have a heartwood/sapwood boundary at a very similar, if not identical position. One of these samples, PIR-A11, retains complete sapwood, the last ring produced by the tree before being felled. In this case the last growth ring, and thus the felling of the tree, is dated to 1747.

Conclusion

It would appear, therefore, that much of the tower, particularly the central main body, is constructed of timber felled in 1507. Given that a good number of timbers date to this time, this is likely to be the original construction date. The tower does, though, use some timbers which were felled earlier, one timber felled in the period 1390–1415, and others probably in the period 1471–92. It is likely that these represent the reuse of timbers salvaged or saved from other buildings, or pieces which were held in stock, and simply utilised as part of the 1507 build.

The tower also utilises timber felled later, the north sill or base beam for example, this estimated to have been felled between 1600-25. Although it would have been very difficult, and not a little awkward, to insert such a timber into an existing structure, it would be possible (the sill beams of the east and west outer wall (of the lean-tos), for example, half-lap over the north sill), and this timber may represent the replacement of an original base beam which, for some reason, had failed.

If the 1600-25 north sill beam represents an exact copy of an already existing beam here, a beam which extended beyond the inner walls of the central tower to the outer walls of the lean-tos, this would imply that the lean-tos were already in existence, and were presumably part of the 1507 structure.

However, one might thus consider the possibility that the 1600–25 sill beam is not an exact copy of the original (which may have been shorter and which fitted only beneath the central main body of the tower), but was an alteration, designed to carry the lean-tos, which were to be newly built at this time.

An alternative interpretation is that the lean-tos were not constructed till 1747, the date of the outriggers, and that the 1600–25 sill is simply another older timber reused at this time because it was of sufficient length to accommodate the new side additions. Such an interpretation might be tentatively supported by there appearing to be no early-sixteenth century or early-seventeenth century style timbers in either lean-to, but both appear to be constructed of eighteenth century timber, the main timbers being well squared and having regular saw marks, while much of the infill structure is built of very small, lightweight, timbers.

The bell frame also retains some late-sixteenth or early-seventeenth century timber.

Undated samples

Two grouped samples, PIR-A08 and A13, in site chronology PIRASQ04, remain undated. While both samples, and the overall chronology, have sufficient rings for reliable dating, it is noticeable that both samples have two bands of compacted, or narrow, rings. The first band last for almost a decade, the second band for about five or six years. It is likely that this is caused by some non-climatic influence, such as pollarding or coppicing, but the effect is to disrupt the climatic signal and make the samples undatable. The fact that both samples are the same would indicate that source timbers, the lower east and west braces of the south wall, are of the same date, and indeed, are almost certainly derived from the same tree.

Two grouped samples, PIR-A22 and A23, in site chronology PIRASQ05, also remain undated. While this time the samples are a little short, the overall chronology does have sufficient rings for reliable dating. It is again noticeable that both samples have bands of compacted, or narrow, rings, again possibly disrupting the climatic signal. Again, the fact that both samples are the same would indicate that source timbers, the east and west braces of bell frame 1 (counting from the north), are of the same date, and are again almost certainly derived from the same tree.

The single remaining measured but ungrouped and undated individual sample, PIR-A15, is similarly afflicted by a band of compressed rings, and also shows some signs of distortion to its rings, perhaps caused by a knot.

Woodland sources

As may be seen from Table 2 which lists a selection of the best cross-matches with the reference chronologies, site chronology PIRASQ01 produces a series of unusually high *t*-values, most into double figures. It may be noted that, despite being compared with references from every part of Britain, the best matches are found with data made up of material from other 'western England' sites, particularly in Worcestershire, Herefordshire, and Gloucestershire. Although the exact location of the woodland sources for these sites is themselves not known, this would suggest, perhaps not unexpectedly, that the timber used at St Peter's is relatively local.

Although the *t*-values of the cross-matches with the other site chronologies, and with the individual sample, are not quite so strong, they too are very high, and again suggest a local source for these timbers.

Bibliography

Arnold, A J, Howard, R E, Laxton, R R, and Litton, C D, 2002 – *The Urban Development of Newark-on-Trent: A Dendrochronological Approach*, Centre for Archaeol Rep, **95/2002**

Arnold, A J, Howard, R E, and Litton, C D, 2004 *Tree-ring analysis of samples from the roof of the 'Red Wing' Croome Court, Croome D'Abitot, near Upton upon Severn, Gloucestershire*, Centre for Archaeol Rep, **80/2004**

Arnold, A J, and Howard, R E 2005 unpubl Tree-ring analysis of timbers from Lower Bean Hall, Bradley Green, Feckenham, Worcestershire – Nottingham Tree-ring Dating Laboratory unpubl computer file *LBHASQ01 & 2*

Arnold, A J, and Howard, R E, 2006 *The Commandery, Worcester: Tree-ring analysis of timbers*, EH Res Dep Rep Series, **71/2006**

Arnold, A J, and Howard, R E, 2006 unpubl Tree-ring analysis of timbers from The Master's House, St Katherines's Hospital, Ledbury, Herefordshire – Nottingham Tree-ring Dating Laboratory unpubl computer file *LDBASQ01*

Arnold, A J, and Howard, R E, 2007 *Tree-ring analysis of timbers from Polesworth Abbey Gatehouse, Polesworth, Warwickshire*, Centre for Archaeol Rep, **6/2007**

Arnold, A J, and Howard, R E, 2008 *Church of St Nicholas, Bromham, Wiltshire: Tree-ring analysis of timbers from the Roof of the Beauchamp or 'Bayntun' Chapel*, EH Res Dep Rep Ser, **37/2008**

Arnold, A J, Howard R E, and Litton, C D, 2008a List 197 no 25 – Nottingham Tree-ring Dating Laboratory, Vernacular Architect, **39,** 119–28

Arnold, A J, Howard, R E, and Litton, C D, 2008b – Nottingham Tree-ring Dating Laboratory: additional dendrochronology dates, no 16, Vernacular Architect, **39**, 107–11

Arnold, A J and Howard, R E, 2009 List 210 no 8 – Nottingham Tree-Ring Dating Laboratory: results, *Vernacular Architect,* **40**, 111–17

Arnold, A J and Howard, R E, 2011 *Church of St James, Whitson Street, Bristol: Tree-ring analysis of timbers of the Nave and Chancel Roofs*, EH Res Dep Rep Ser, **86/2011**

Arnold, A J, and Howard, R E, 2011 unpubl Tree-ring analysis of timbers from Avebury Manor, Avebury, Wiltshire – Nottingham Tree-ring Dating Laboratory unpubl computer file *AVBMSQ01*

Arnold, A J, and Howard, R E, forthcoming a *Apethorpe Hall, Apethorpe, Northamptonshire: Tree-ring analysis of timbers*, EH Res Dep Rep Ser

Arnold, A J, and Howard, R E, forthcoming b *Oakham Castle, Oakham, Rutland: Tree-ring analysis of timbers*, EH Res Dep Rep Ser

Arnold, A J, and Howard, R E, forthcoming c *The Bede House, Lyddington, Rutland: Tree-ring analysis of timbers*, EH Res Dep Rep Ser

Bridge, M C, 2001 *Tree-ring analysis of timbers from the church of St George of England, Toddington, Bedfordshire*, Centre for Archaeol Rep, **77/2001**

Bridge, M C, 2002 *Tree-ring analysis of timbers from Ashleworth Tithe Barn, Quay Lane, Ashleworth, Gloucestershire*, Centre for Archaeol Rep, **17/2002**

Fletcher, J, 1978 unpubl computer file MC10---H

Groves, C, Hillam, J, and Pelling-Fulford, F, 1997 Dendrochronology in Excavations on Reading Waterfront sites 1979–1988 (eds J W Hawkes and P J Fasham), Wessex Archaeol Rep, **5**, 64–70

Howard, R E, Laxton, R R, and Litton, C D, 1996 *Tree-ring analysis of timbers from Mercer's Hall, Mercer's Lane, Gloucester,* Anc Mon Lab Rep, **13/1996**

Howard, R E, Laxton, R R, and Litton, C D, 1998 *Tree-ring analysis of timbers from 26 Westgate Street, Gloucester,* Anc Mon Lab Rep, **43/1998**

Howard, R E, Laxton, R R, and Litton, C D, 2000 *Tree-ring analysis of timbers from Stoneleigh Abbey, Stoneleigh, Warwickshire*, Anc Mon Lab Rep, **80/2000**

Hurford, M, Arnold, A J, Howard, R E, and Tyers, C 2008 *Tree-ring analysis of timbers from Flore's House, High Street, Oakham, Rutland,* EH Res Dep Res Rep, **94/2008**

Hurford, M, Howard, R E, and Tyers, C, 2010 *The Old House, Main Street, Norwell, Nottinghamshire: Tree-ring analysis of timbers,* EH Res Dep Rep Ser, **52/2010**

Hurford, M, and Tyers, C, forthcoming *The Old Manor, West Lavington, Wiltshire: Tree-ring analysis of timbers*, EH Res Dep Rep Ser

Laxton, R R, Litton, C D, Simpson, W G, and Whitley, J P, 1982 Tree-ring Dates for some East Midlands Buildings: Table 1, no 2, *Transaction of the Thoroton Society of Nottinghamshire*, **86**, 76–7

Miles, D, and Worthington, M, 2006 *The Tree-Ring Dating of the Bell Tower and Cloister Door, New College, Oxford*, EH Res Dep Rep Ser, **56/2006**

Pilcher, J R 1990 pers comm

Table 1: Details of tree-ring samples from St Peter's Church, Pirton, Worcestershire

Sample number	Sample location	Total rings	Sapwood rings*	First measured ring date (AD)	Heart/sap boundary (AD)	Last measured ring date (AD)
	Ground level timbers					
PIR-A01	Inner wall, main north-east corner post	145	21c	1357	1480	1501
PIR-A02	Inner east wall, middle main post	80	no h/s	1381	------	1460
PIR-A03	Inner east wall, lower south cross-rail	83	no h/s	1370	------	1452
PIR-A04	Inner east wall south lower brace	88	no h/s	1371	------	1458
PIR-A05	Inner west wall, north lower brace	96	h/s	1280	1375	1375
PIR-A06	North wall, east brace	87	h/s	1399	1485	1485
PIR-A07	North wall, west brace	86	h/s	1400	1485	1485
PIR-A08	South wall, lower east brace	82	h/s	------	------	------
PIR-A09	South wall upper east brace	52	no h/s	1367	------	1418
PIR-A10	West outrigger	87	11c	1649	1724	1735
PIR-A11	East outrigger	131	19C	1617	1728	1747
PIR-A12	North sill beam	101	h/s	1485	1585	1585
PIR-A13	South wall, lower west brace	78	h/s	------	------	------
PIR-A14	Inner east wall, lower north cross-rail	95	no h/s	1347	------	1441
PIR-A15	South sill beam	65	no h/s	------	------	------
	Bell stage timbers					
PIR-A16	East wall, north diagonal brace	80	19	1391	1451	1470
PIR-A17	East wall, south diagonal brace	72	h/s	1382	1453	1453
PIR-A18	Main north-west corner post	98	no h/s	1373	------	1470
PIR-A19	Main south-west corner post	115	26C	1393	1481	1507

Table 1: continued

Sample number	Sample location	Total rings	Sapwood rings*	First measured ring date (AD)	Heart/sap boundary (AD)	Last measured ring date (AD)
	Bell frame timbers					
PIR-A20	Head beam to frame 2 (from north)	71	h/s	1500	1570	1570
PIR-A21	Head beam to frame 3	72	no h/s	1488	------	1559
PIR-A22	West brace, frame 1	48	h/s	------	------	------
PIR-A23	East brace, frame 1	57	13	------	------	------
PIR-A24	Crown post, frame 1	nm	---	------	------	------
PIR-A25	Sill beam, frame 2	nm	---	------	------	------

h/s = heartwood/sapwood boundary, i.e., only the sapwood rings are missing

C = complete sapwood is retained on the sample, the last measured ring date is the felling date of the timber represented

c = complete sapwood is found on the timber, but all or part has been lost from the sample in coring

nm = sample not measured

Table 2: Results of the cross-matching of site chronology PIRASQ01 and the reference chronologies when the first ring date is 1347 and the last ring date is 1507		
Reference chronology	*t*-value	
The Master's House, Ledbury, Herefs	14.4	(Arnold and Howard 2006 unpubl)
The Commandery, Worcester	12.1	(Arnold and Howard 2006)
Ashleworth Tithe Barn, Ashleworth, Glos	10.9	(Bridge 2002)
Mucknell Farm, Stoulton, nr Pershore, Worcs	10.4	(Arnold *et al* 2008a)
The Old Manor, West Lavington, Wilts	10.3	(Hurford *et al* forthcoming)
Church of St Nicholas, Bromham, Wilts	9.7	(Arnold and Howard 2008)
Mercer's Hall, Mercer's Lane, Gloucester	9.4	(Howard *et al* 1996)
Abbots Lodge, Ledbury, Herefs	8.8	(Arnold and Howard 2009)

Table 3: Results of the cross-matching of site chronology PIRASQ02 and the reference chronologies when the first ring date is 1485 and the last ring date is 1585		
Reference chronology	*t*-value	
26 Westgate Street, Gloucester	8.2	(Howard *et al* 1998)
Polesworth Abbey Gatehouse, Warwicks	8.0	(Arnold and Howard 2007)
Avebury Manor, Avebury, Wilts	7.9	(Arnold and Howard 2011 unpubl)
Apethorpe Hall, Apethorpe, Northants	7.9	(Arnold and Howard forthcoming a)
Oakham Castle, Oakham, Rutland	7.9	(Arnold and Howard forthcoming b)
Flore's House, Oakham, Rutland	7.8	(Hurford *et al* 2008)
Lower Bean Hall, Feckenham, Worcs	7.6	(Arnold and Howard 2005 unpubl)
MC10---H	6.9	(Fletcher 1978 unpubl)

Table 4: Results of the cross-matching of site chronology PIRASQ03 and the reference chronologies when the first ring date is 1617 and the last ring date is 1747		
Reference chronology	*t*-value	
Croome Court, Croome, Worcs	5.5	(Arnold *et al* 2004)
Lyddington Bede House, Lyddington, Rutland	5.3	(Arnold and Howard forthcoming c)
Stoneleigh Abbey, Stoneleigh, Warwicks	5.2	(Howard *et al* 2000)
Green's Mill, Snenton, Nottingham	5.2	(Laxton *et al* 1982)
Quenby Hall, Quenby, Leics	5.0	(Arnold *et al* 2008b)
The Old House, Norwell, Notts	5.0	(Hurford *et al* 2010)
Old Barn, Shottery, Warwicks	4.8	(Howard *et al* 1996)
12 Chain Lane. Newark, Notts	4.8	(Arnold *et al* 2002)

Table 5: Results of the cross-matching of sample PIR-A05 and the reference chronologies when the first ring date is 1280 and the last ring date is 1375		
Reference chronology	*t*-value	
Wick at Worcester	8.7	(Pilcher 1990)
Reading Waterfront, Berks	8.2	(Groves *et al* 1997)
St George's Church, Toddington, Beds	6.9	(Bridge 2001)
Mucknell Farm, Stoulton, nr Pershore, Worcs	6.7	(Arnold *et al* 2008a)
Church of St James, Bristol	6.5	(Arnold and Howard 2011)
New College, Oxford	6.5	(Miles and Worthington 2006)
Abbots Lodge, Ledbury, Herefs	6.3	(Arnold and Howard 2009)
The Old Manor, West Lavington, Wilts	6.2	(Hurford *et al* forthcoming)

Site chronologies PIRASQ01–SQ03 are composites of the data of the relevant cross-matching samples as seen in the bar diagrams Figures 6–8 below. This composite data produces an 'average' tree-ring pattern, where the possible erratic variations of any one individual sample are reduced and the overall climatic signal of the growth of the group is enhanced. These 'average' site chronologies are then compared with several hundred reference patterns covering every part of Britain for all time periods, cross-matching with a number of these only at the time spans indicated in Tables 2–4. These tables give only a small selection of the very best matches as represented by '*t*-values' (ie, degrees of similarity). Sample PIR-A05 (Table 5) has been compared individually with the full corpus of reference data.

It may be noticed from these Tables that the resultant *t*-values are well in excess of the *t*=3.5 value usually taken as the minimum acceptable level for satisfactory dating. These values, along with the many other slightly lower, unlisted, cross-matches, indicate very firm and reliable dates for the timbers.

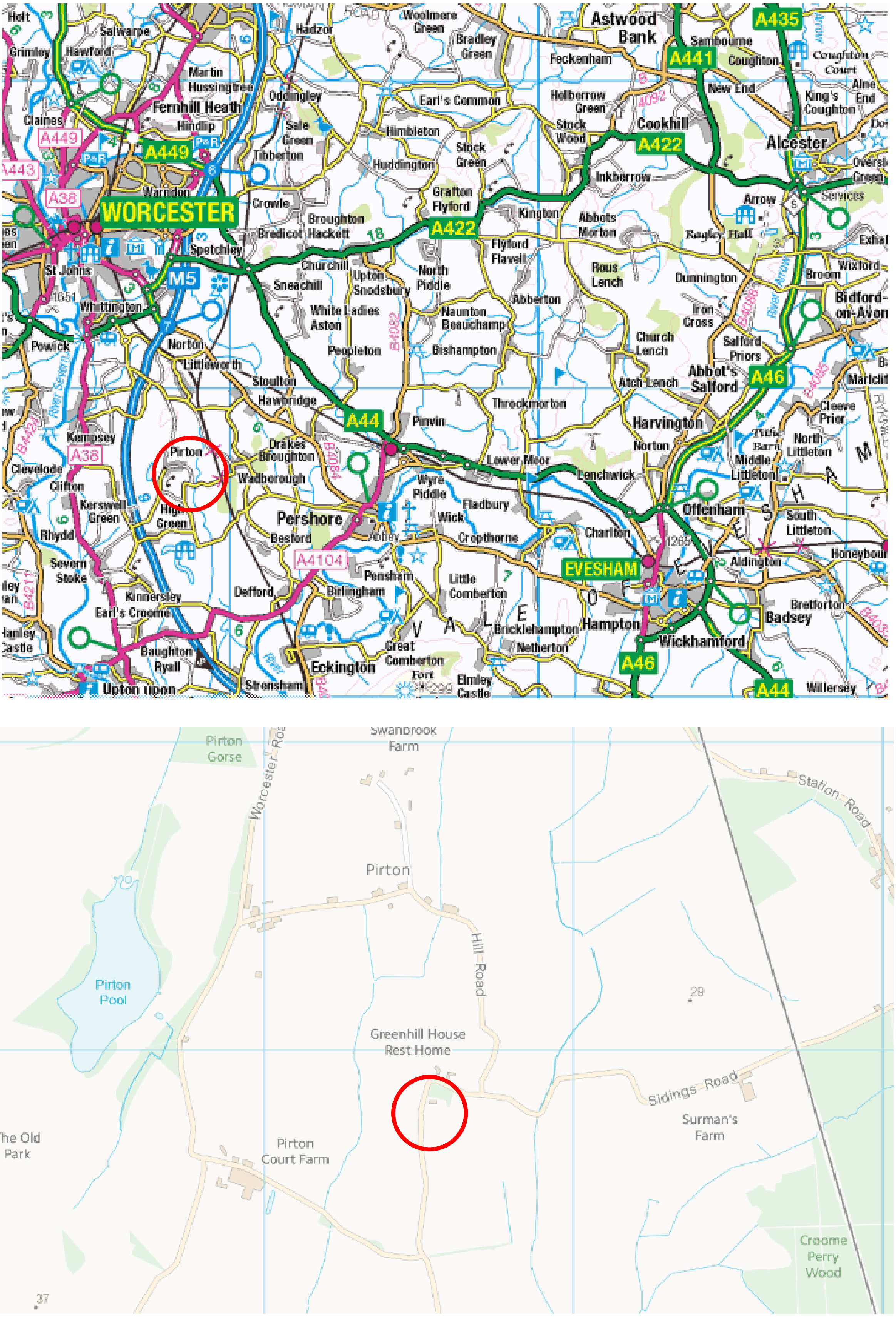


Figure 1a/b: Maps to show location of Pirton (top) and St Peter's Church (bottom)

Figure 2a/b: Views of the internal framing of the tower, looking east (top) and south (bottom)

Figure 2c/d: Views of the upper timbers, looking east (top), and the bell frame, looking northwest (bottom)

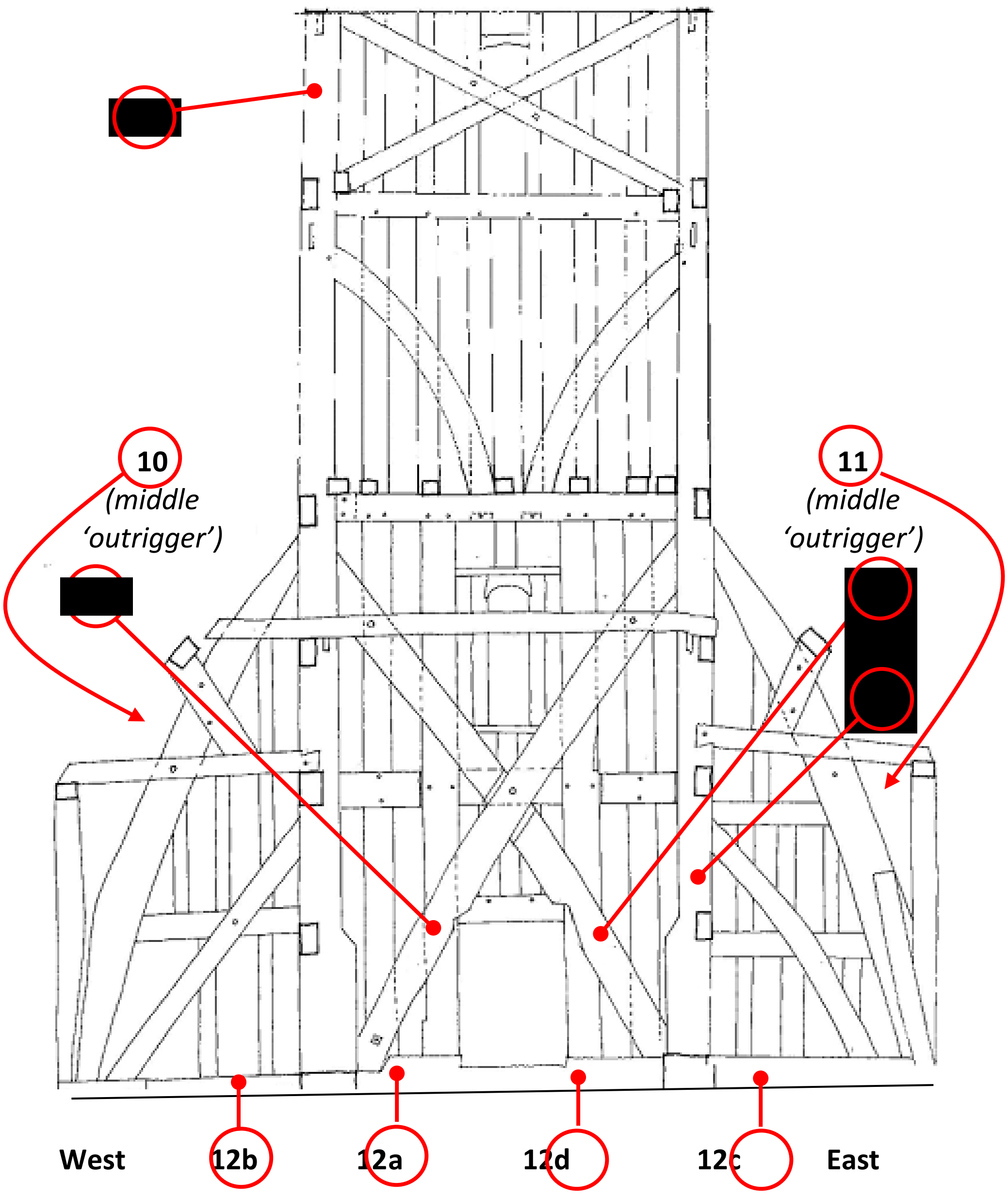


Figure 3a: Section looking north to locate sampled timbers (after Nick Joyce Architects)

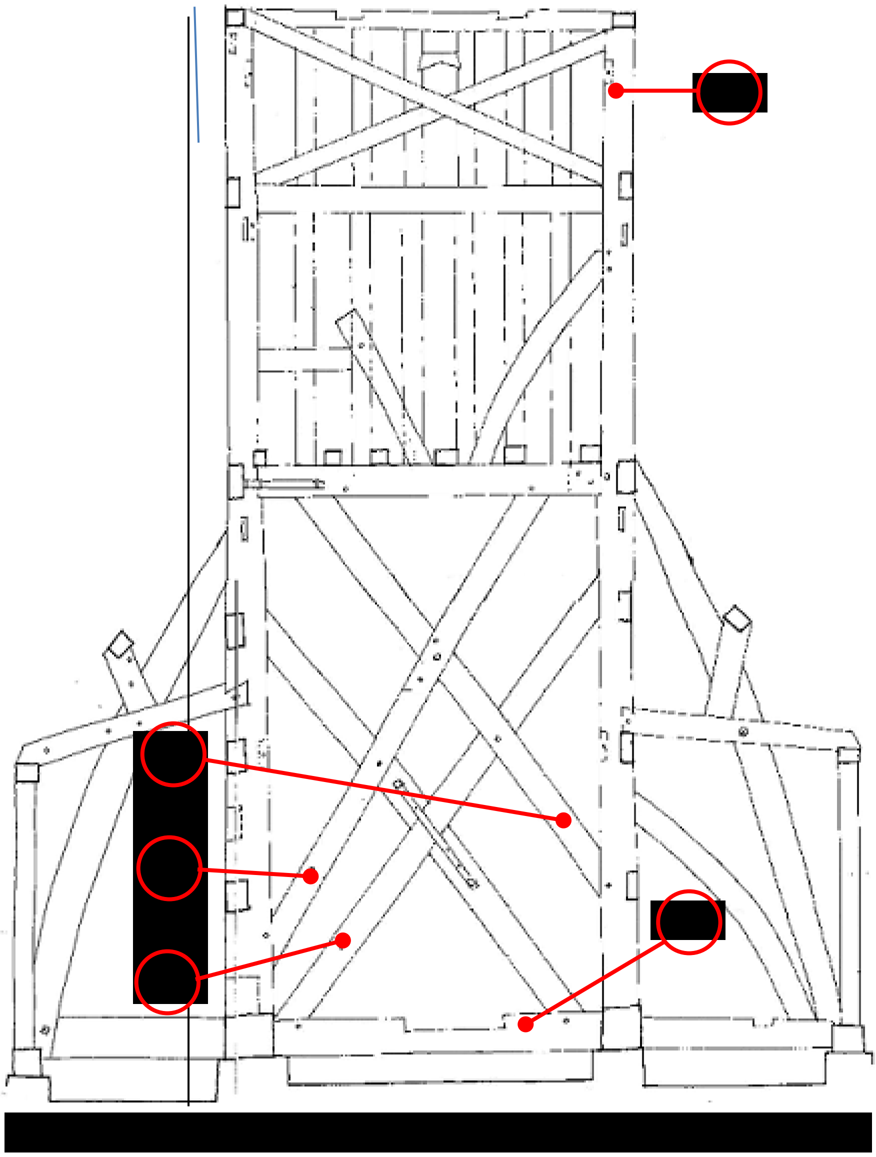


Figure 3b: Section looking south to locate sampled timbers (after Nick Joyce Architects)

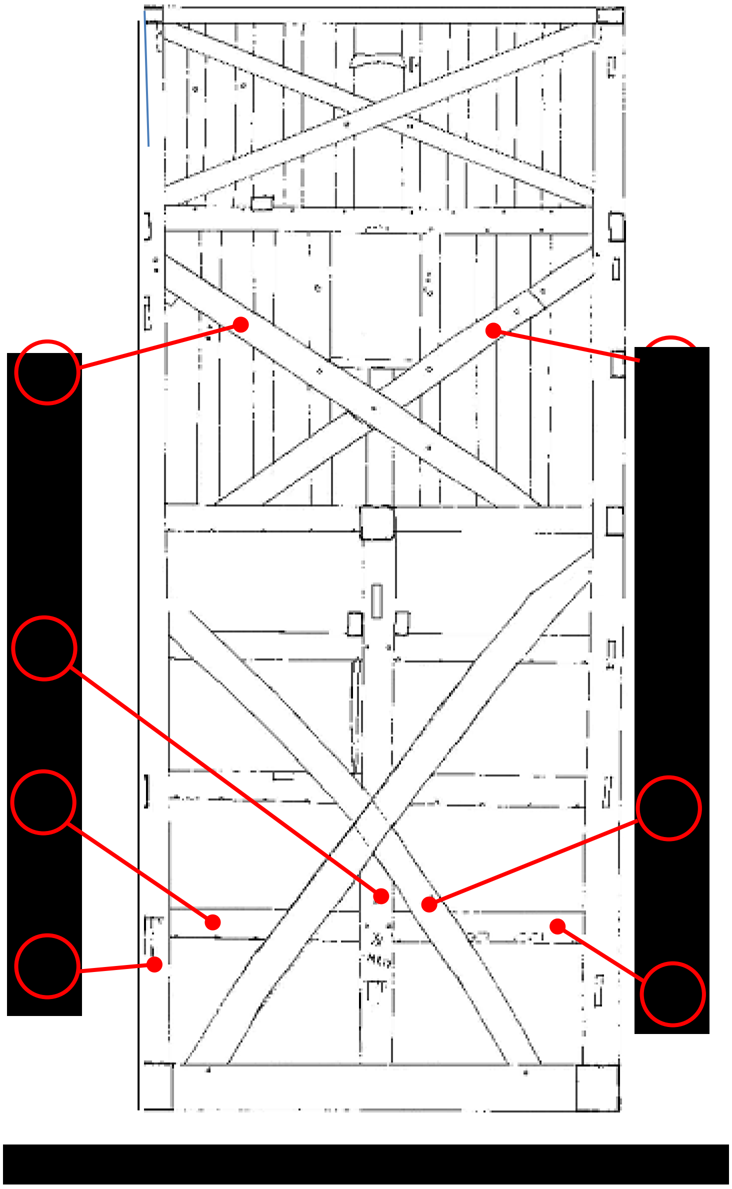
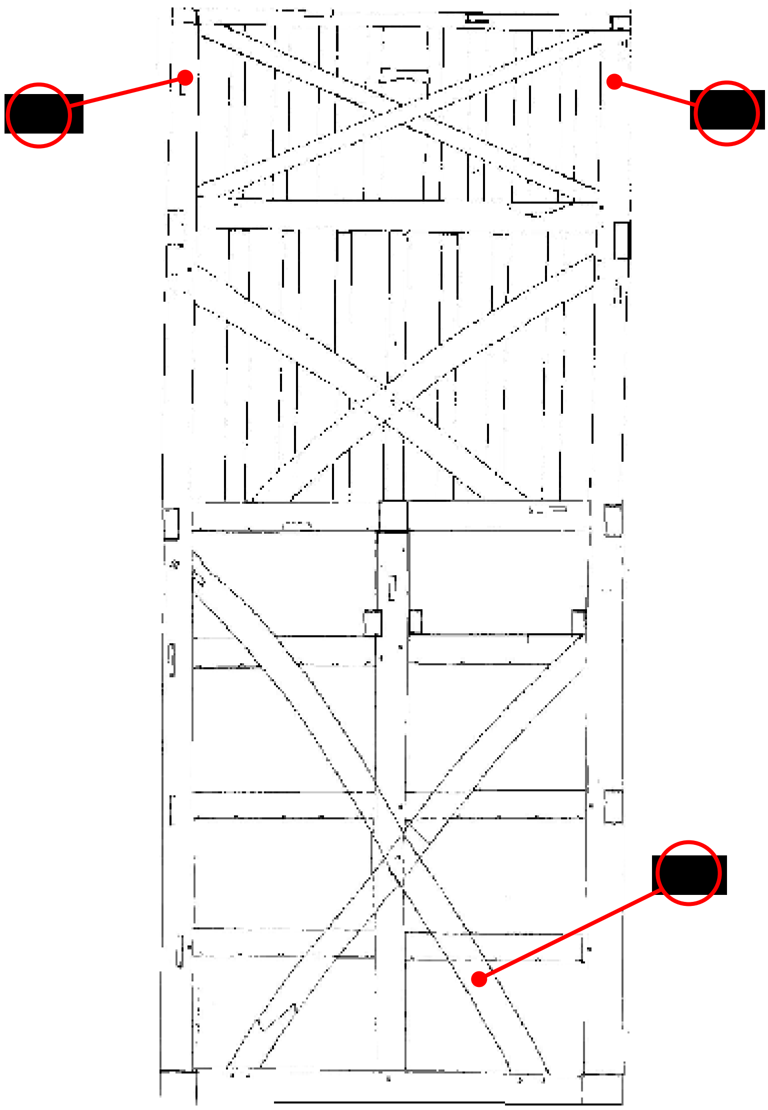


Figure 3c: Section looking east to locate sampled timbers (after Nick Joyce Architects)



[redacted]

Figure 3d: Section looking west to locate sampled timbers (after Nick Joyce Architects)

Figure 4a–c: Annotated photographs to help locate sampled timbers

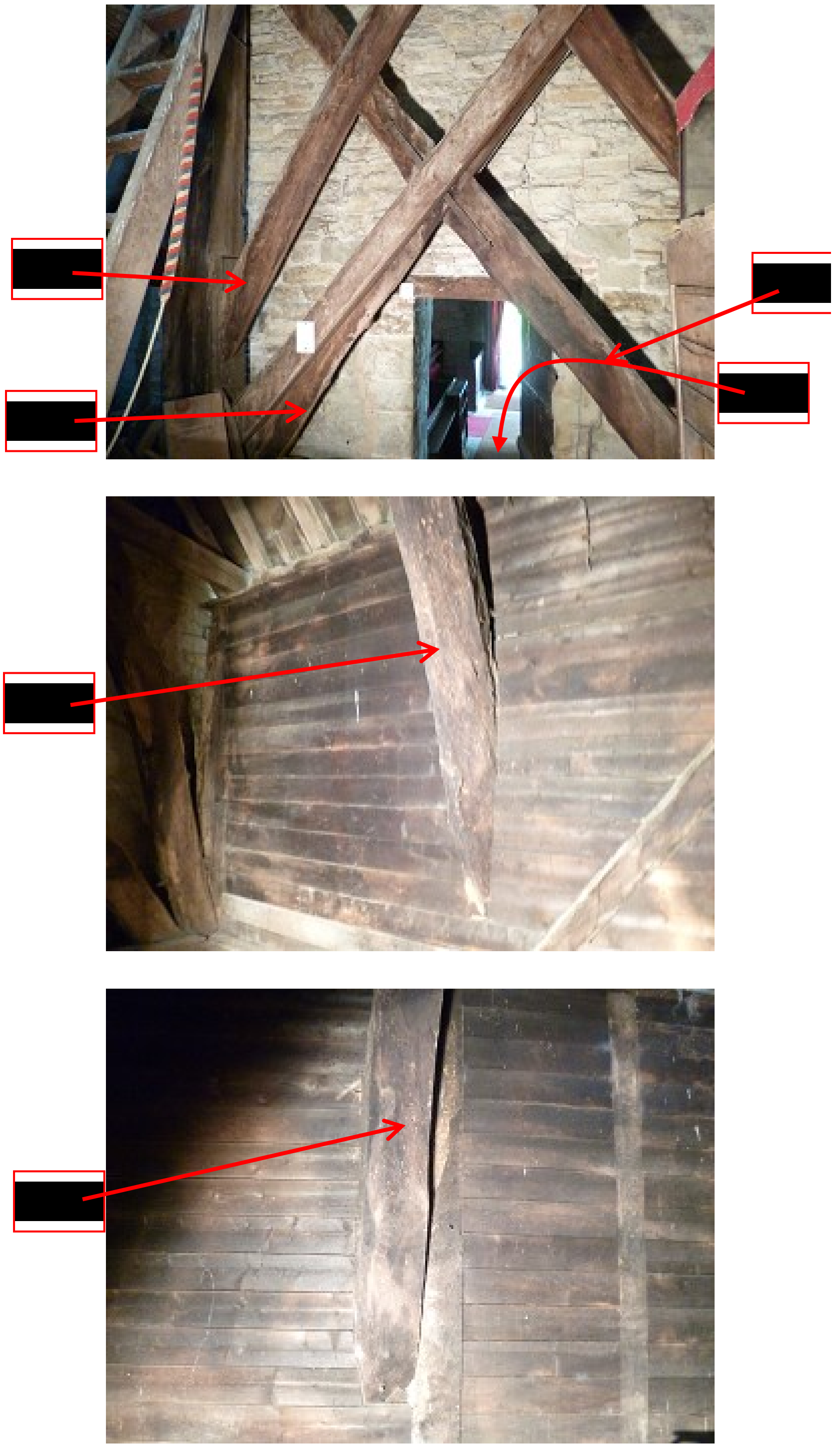


Figure 4d–f: Annotated photographs to help locate sampled timbers

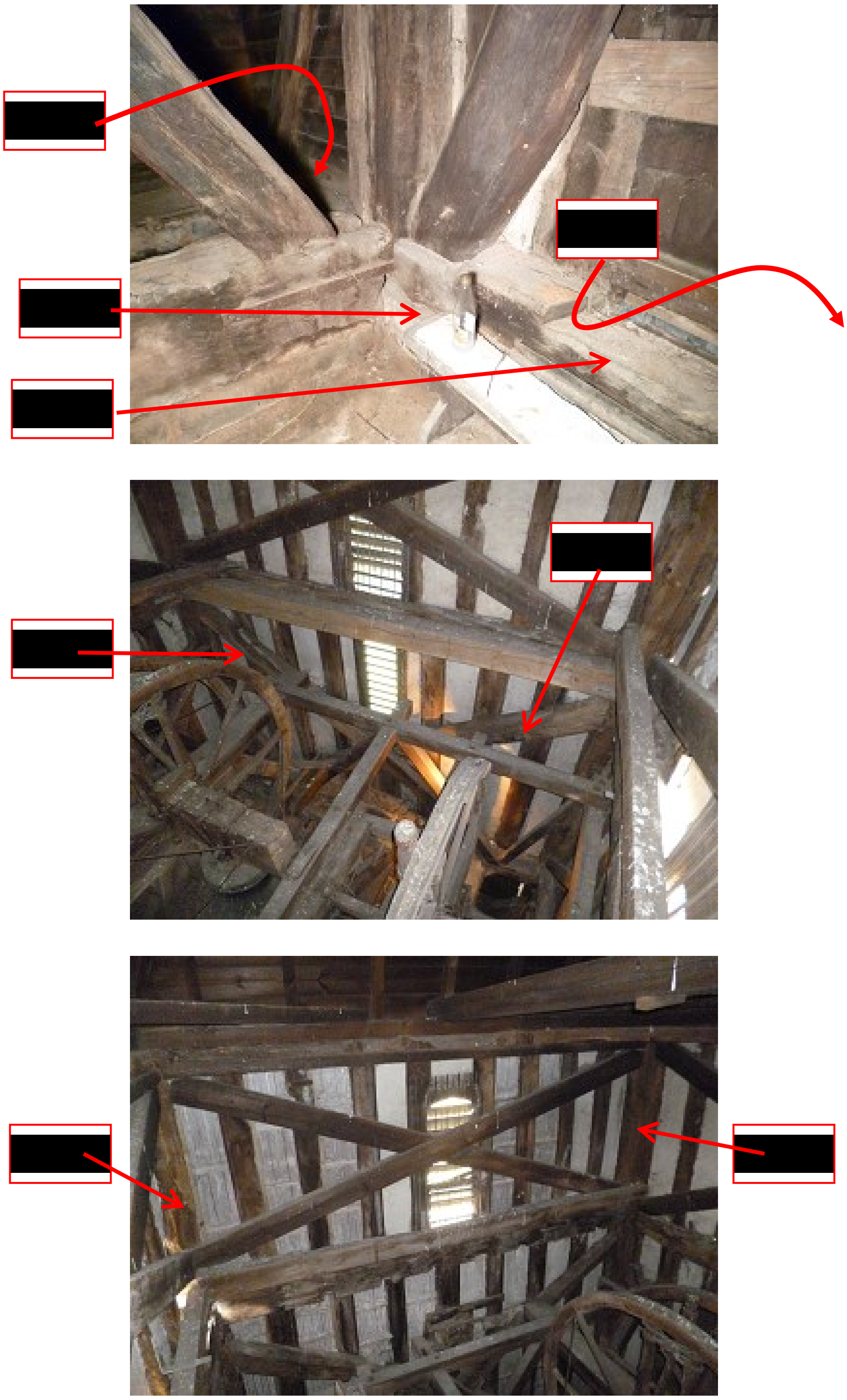


Figure 4g–i: Annotated photographs to help locate sampled timbers

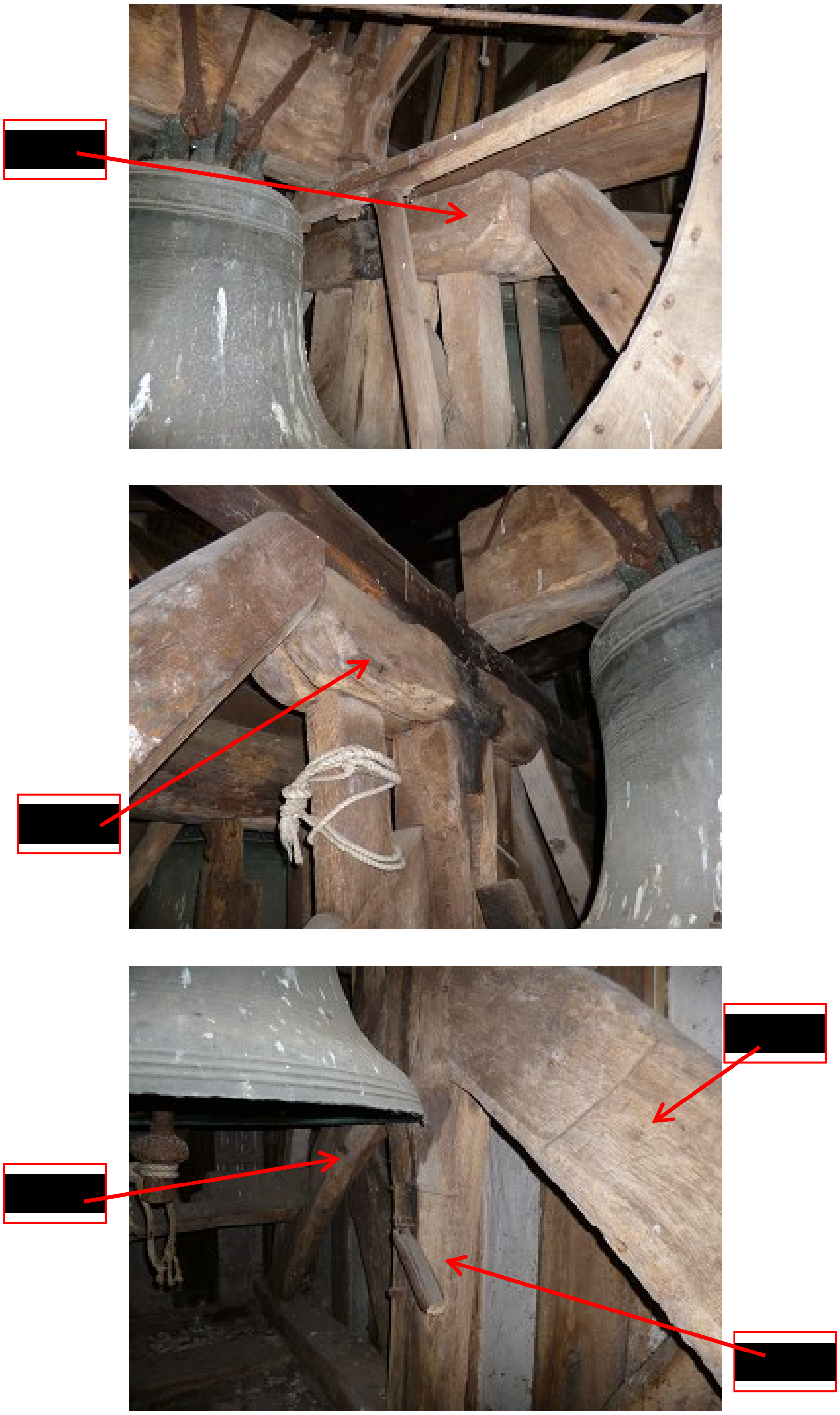


Figure 4j–l: Annotated photographs to help locate sampled timbers

Figure 4m: Annotated photograph to help locate sampled timber

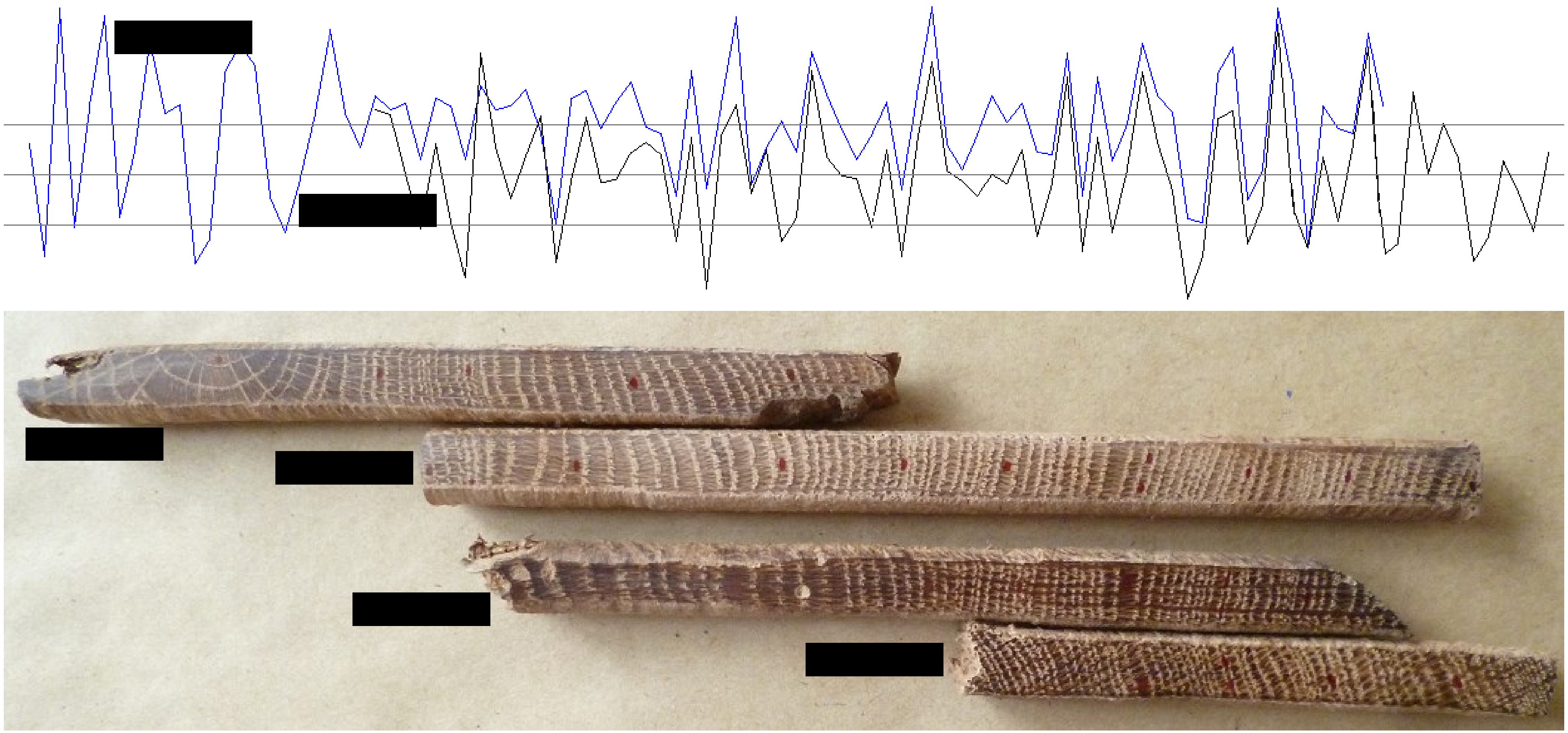
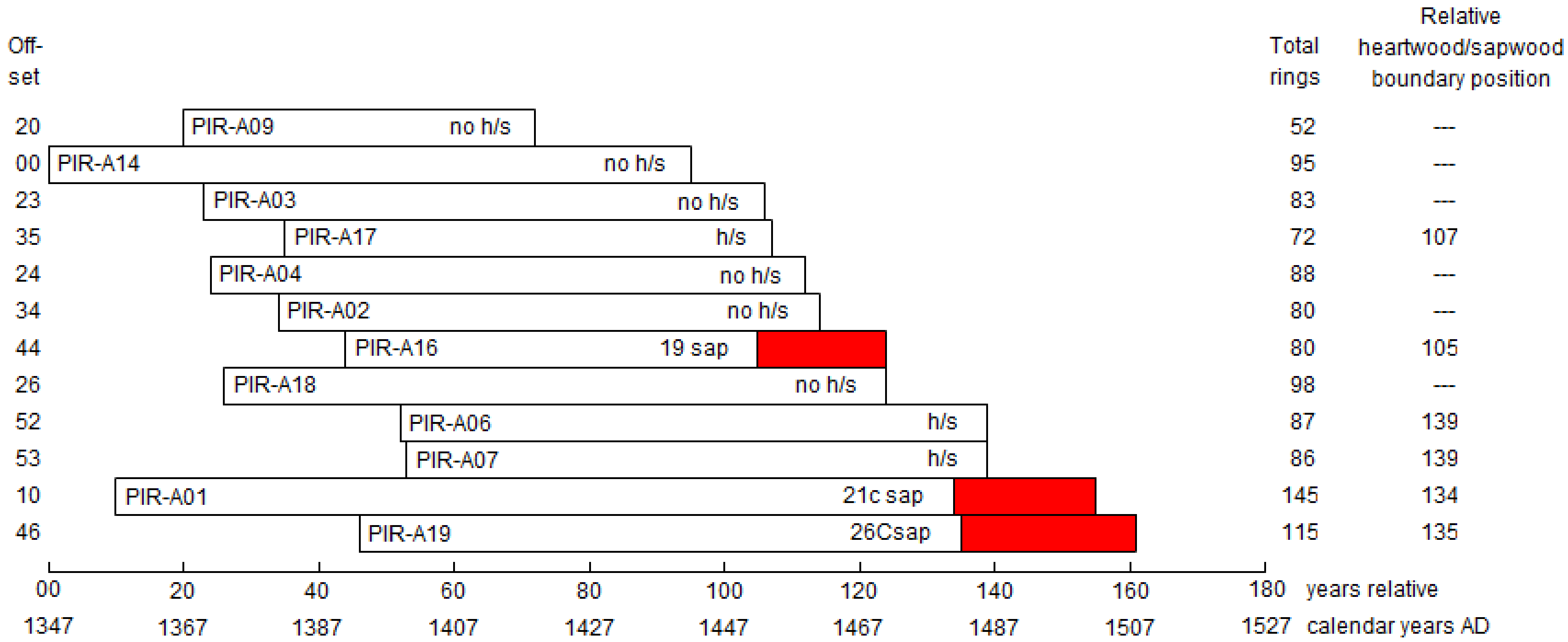


Figure 5: Graphic representation of the cross-matching of two samples, PIR-A03 and A14

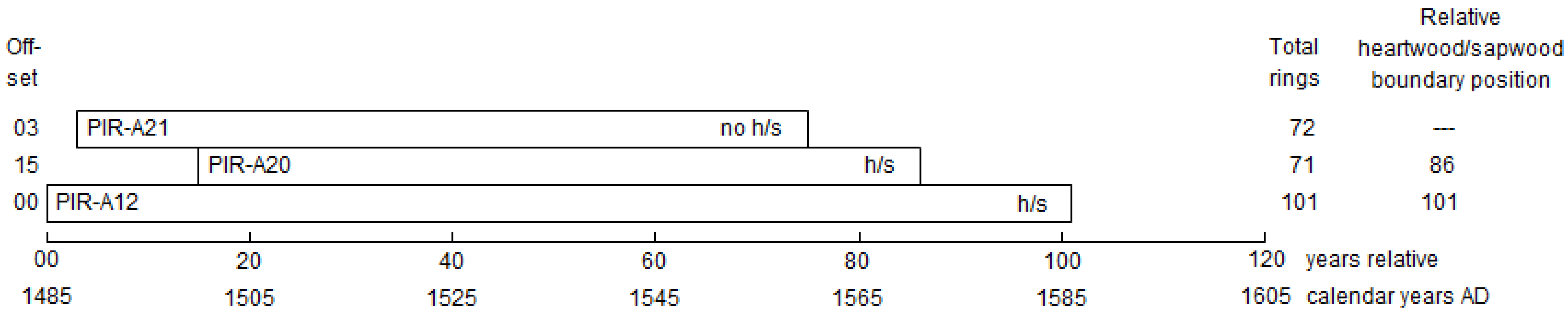
When cross-matched at the correct positions, as here, the variations in the rings of these two samples (each sample made up in this case of 2 cores) correspond with a high degree of similarity. As the ring widths of one sample increase (represented by peaks in the graph), or decrease (represented by troughs), so too do the annual ring widths of the second sample. This similarity in growth pattern is a result of the two trees represented having grown at the *same time* in the *same place.* The growth ring pattern of two samples from trees grown at different times would never correspond so well.



blank bars = heartwood rings, shaded bars = sapwood rings; C = complete sapwood is retained on the sample, the last ring date is the felling date of the tree represented; h/s = heartwood/sapwood boundary, i.e., only the sapwood rings are missing

Figure 6: Bar diagram of the samples in site chronology PIRASQ01. The samples are shown in the form of bars at positions where the ring variations cross-match with each other, this similarity being produced by the trees represented growing in the same place as each other. The samples are combined to form a 'site chronology', dated by comparison with the 'reference' chronologies with a last ring of 1507 (Table 2).

It will be of interest to note that samples PIR-A01 and A19 have complete, or near complete, sapwood on them ('C' and 'c'), both probably being felled in 1507 along, probably, with several other timbers represented by this chronology. However, on two samples, PIR-A16 and A17, the heartwood/sapwood boundary ('h/s') is at a much earlier position. If these timbers had also been felled in 1507, they would have required 54 and 56 sapwood rings. While such a high number of sapwood rings on oak is not altogether unknown, it is very unusual, and the inference is that these two timbers were felled earlier than the others, perhaps in the period 1480–90. The timbers may, therefore, be reused pieces, or from stock.



blank bars [ ] = heartwood rings
h/s = heartwood/sapwood boundary, i.e., only the sapwood rings are missing

Figure 7: Bar diagram of the samples in site chronology PIRASQ02. The samples are again shown in the form of bars at positions where the ring variations of the samples cross-match with each other, this similarity being produced by the trees represented growing in the same place as each other. The samples are again combined to form a 'site chronology', which is then dated by comparison with the 'reference' chronologies with a last ring date of 1585 (Table 3).

The difference between the position of the heartwood/sapwood boundary ('h/s') on the two samples which retain it, PIR-A12 and A20, is 15 years. Thus, while it is possible that the two timbers represented were felled at the same time as each other, between, it is estimated, 1600 – 1610, it is also quite possible that they were felled at slightly different times to each other. Individually, sample PIR-A20 given an estimated felling date of 1585 – 1610, while sample PIR-A12 gives an individual estimated felling date of 1600 – 25 (these ranges calculated on a 95% probability limit that the trees had between 15 and 40 sapwood rings).

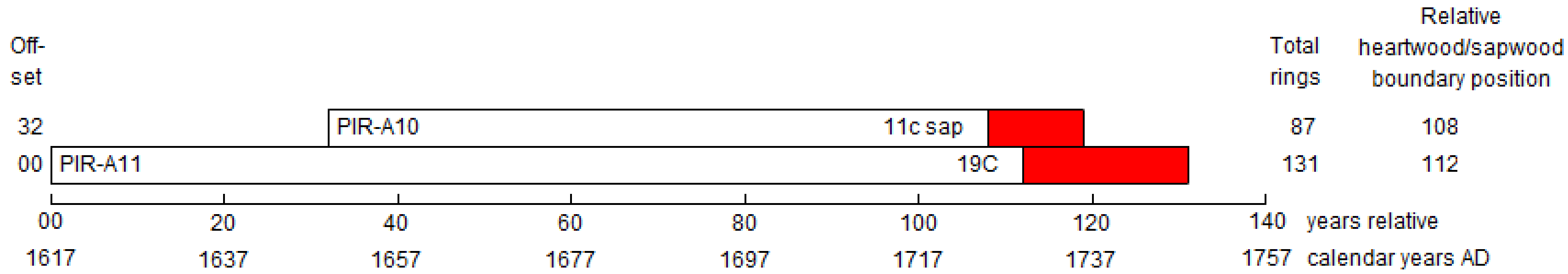
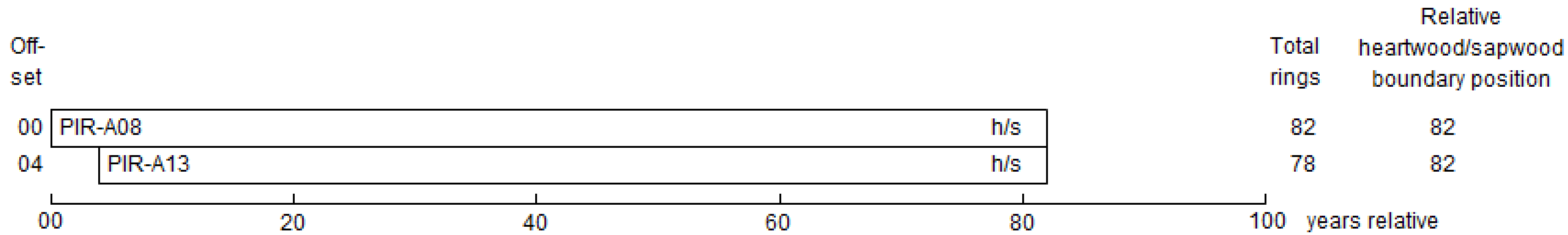
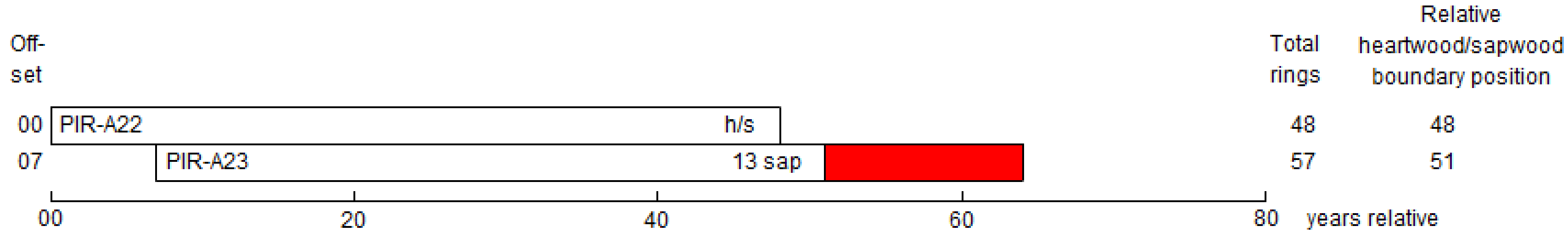


Figure 8: Bar diagram of the samples in site chronology PIRASQ03. It will again be seen that samples PIR-A10 and A11 have complete, or near complete, sapwood on them (‘C’ and ‘c’), both probably being felled in 1747 (Table 4).



blank bars = heartwood rings, shaded bars = sapwood rings
C = complete sapwood is retained on the sample, the last ring date is the felling date of the tree represented
h/s = heartwood/sapwood boundary, i.e., only the sapwood rings are missing

Figure 9: Bar diagram of the samples in site chronology PIRASQ04. Although compared to the full database of oak reference chronologies, these two samples could not be dated. It is almost certain, however, that the two timbers were felled at the same time as each other.



blank bars [white box] = heartwood rings, shaded bars [red box] = sapwood rings
h/s = heartwood/sapwood boundary, i.e., only the sapwood rings are missing

Figure 10: Bar diagram of the samples in site chronology PIRASQ05. Although compared to the full database of oak reference chronologies, these two samples could not be dated. It is almost certain, however, that the two timbers were felled at the same time as each other.