ntrdl the nottingham tree-ring dating laboratory

Dendrochronology, timber analysis, and historic building consultants

VAUGHAN'S MANSION, MARKET SQUARE, SHREWSBURY, SHROPSHIRE:

TREE-RING ANALYSIS OF TIMBERS

A J ARNOLD
R E HOWARD

SEPTEMBER 2012

VAUGHAN'S MANSION, MARKET SQUARE, SHREWSBURY, SHROPSHIRE: TREE-RING ANALYSIS OF TIMBERS

A J ARNOLD
R E HOWARD

SUMMARY

Analysis by dendrochronology of three oak samples from the single remaining truss of a late-medieval replacement roof to the first-floor hall range of Vaughan's Mansion, and of three oak samples from the roof of the cross-wing range, has resulted in the production of two separate site chronologies.

The first site chronology comprises all three samples from the timbers of the medieval replacement roof to the hall range, and has an overall length of 201 rings. These rings are dated as spanning the years 1269–1469. Interpretation of the sapwood on the samples would indicate that all three timbers are derived from trees felled very early in the spring of 1470.

The second site chronology comprises all three samples from the roof timbers of the cross-wing. This site chronology has an overall length of 182 rings, these dated as spanning the years 1441–1622. Interpretation of the sapwood on these samples would indicate that all three timbers are derived from trees felled very early in 1623.

NTRDL, 20 Hillcrest Grove, Sherwood, Nottingham, NG5 1FT
Telephone 0115 960 3833 (laboratory);
07980 305583 / 07913 427987 (Mobiles)
roberthoward@tree-ringdating.co.uk
alisonarnold@tree-ringdating.co.uk

Introduction

The Old Music Hall in Shrewsbury, Shropshire, is situated to the south side of the Market Place at the heart of the earliest part of the town (SJ 490 124, Figs 1a/b). The Old Music Hall site is a complex of buildings and now comprises a number of structures which have been built, added to, and altered over many years, and is one of the most important parts of Shrewsbury, being strategically positioned at its centre. It is a unique collection of buildings and includes, to the rear of the Music Hall proper, the stone-built, Grade II* listed, thirteenth century, Vaughan's Mansion, a rare example of an urban first-floor town house.

The 'Mansion' is believed to have originally been built for a wealthy local merchant in 1290, and is thought to have had cross-wings to either end of its main hall range. These medieval wings have been long-demolished, possibly in 1623 when the present replacement west cross-wing is thought to have been built.

The form of the original, thirteenth century, roof of the hall range (along with the original roof form of the cross-wings) is unknown (though believed to possibly have been of crown-post form), this having been replaced at some time in the late medieval period by a hammer-beam roof. This late medieval roof of unknown date was in turn largely destroyed by a fire in 1917, being replaced by what is believed to be the faithful replica seen today. Although the fire if 1917, and the subsequent repair and reconstruction, destroyed virtually all the medieval timber of the hall range, a small fragment of this period, in the form of a single, largely original close-studded cross-frame at the west end of the hall, until now hidden and long forgotten, was left in place. This single truss forms the basis of the partition wall between the hall and the west cross-wing (Fig 2a).

The present roof of the western cross-wing (really the radical remodelling of the west end of the hall range complete with a roof at right-angles to the medieval alignment), which survived the fire of 1917, appears to have originally comprised four (though possibly five) principal rafter with tiebeam and collar trusses, the trusses supporting double purlins to each pitch of the roof. The roof of the cross-wing is part of what has recently been identified as a much more important space than had previously thought, and is associated with the extremely rare coved ceiling and surviving timber framing (Fig 2b).

Sampling

Sampling and analysis by tree-ring dating of the timbers within the hall range of Vaughan's Mansion and the west cross-wing were commissioned by Oliver Heighway on behalf of S J Roberts Construction Ltd, main contractors for a programme of repair and conservation of the Old Music Hall complex, this redevelopment work being undertaken for the owners of the site, Shropshire Council. It was hoped that this programme of tree-ring analysis would establish the date of the recently rediscovered truss, and thus a date for the replacement roof of the hall range, and confirm the date of the cross-wing roof and test the validity of the carved dates on the building. This analysis was undertaken as an adjunct to a historic building survey and interpretation undertaken by Richard K Morriss & Associates of Bromlow, Shropshire.

With the aim of fulfilling this brief, core samples were obtained from six different suitable oak timbers, three from the single remaining truss of the hall range, and three from the timbers of the cross-wing roof. Each sample was given the code SRW-A (for Shrewsbury – site 'A'), and numbered 01–06. The positions of the sampled timbers were located and recorded at the time of coring, the details of these samples being given in Table 1. These details include the specific 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. The sample locations are also recorded on simple drawings made at the time of sampling or based on the plans provided (Figs 3 & 4). For the purposes of this report, the hall range is taken as running east–west, with the cross-wing (at its west end) running north–south. The single remnant truss of the hall range is taken to be in the west wall of the hall range. The trusses of the cross-wing have been numbered from north (or front, facing onto the Market Square) to south.

Although in theory other timbers might have been available for sampling, some studs to the partition wall for example, these appeared to be of very mixed assemblage. Although the scantling of the timbers varied, they were mostly small, and all of them were derived from fast-grown trees. As such, it is very unlikely that any of them would have provided samples with sufficient rings, 50+, for reliable analysis. None of these timbers were sampled.

Acknowledgements

The Nottingham Tree-ring Dating Laboratory would like to take this opportunity to thank Oliver Heighway of S J Roberts Construction Ltd, for commissioning and generously funding this programme of tree-ring analysis. We would also like to thank John McStay and his on-site team who most kindly cooperated, and who helped in every way possible, during sampling. Finally, we would like to thank Richard K Morriss & Associates for the help and information given about the phasing of the timbers.

Tree-ring dating

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 54 years or so. In essence, a short period of growth, anything less than 54 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)).

Analysis of the Vaughan's Mansion samples

Each of the six samples obtained from the timbers within the two parts of Vaughan's Mansion was prepared by sanding and polishing, and the widths of their annual growth rings were measured. The data of these measurements then compared with each other, as described in the notes above, by which process two separate groups of cross-matching samples could be formed.

The first group comprises all three samples from the timbers of the replacement roof to the original hall range, the three samples cross-matching with each other as shown in the bar diagram, Figure 6. The three samples were combined at their indicated off-set positions to form SRWASQ01, a site chronology with an overall length of 201 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 1269 to 1469. The evidence for this dating is given in the *t*-values of Table 2.

The second group comprises all three samples from the timbers of the roof to the cross-wing range, the three samples cross-matching with each other as shown in the bar diagram, Figure 7. The three samples were combined at their indicated off-set positions to form SRWASQ02, a site chronology with an overall length of 182 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 1441 to 1622. The evidence for this dating is given in the *t*-values of Table 3.

This analysis may be summarised as below:

Site chronology	Number of samples	Number of rings	Date span
SRWASQ01	3	201	1269–1469
SRWASQ02	3	182	1441–1622

Interpretation

Site chronology SRWASQ01 (Fig 6)

Site chronology SRWASQ01 comprises all three samples from the timbers of the replacement roof to the original hall range. One of these samples, SRW-A03 retains complete sapwood, that is, it has the last growth ring produced by the tree represented before it was cut down (this being denoted by upper case 'C' in Table 1 and the bar diagram). This last, complete, sapwood ring is dated 1469. However, although this last full sapwood rings was produced in 1469 it is possible, under the microscope, to see that the spring-cell growth for the following year is just about to start (the colour and size of the spring cells of each year being distinguishable from the cells laid down during the later, summer, growth). This would indicate that this tree was felled just as spring was commencing in the year 1470, perhaps in March or maybe in April.

Given that the number of sapwood rings on any given tree usually lie within certain known limits (the usual maximum number on any tree being about 40 sapwood rings), it is possible to tell if two or more trees are likely to have been felled at the same, or at least at a similar, time, this being indicated by the degree of similarity or divergence in the relative position of the heartwood/sapwood boundary on the trees/samples. Where the heartwood/sapwood boundaries on samples are at widely different positions, it would be suspected that the trees were felled at different times to each other, and where they are at similar positions, it would be believed that the trees were felled at a similar, if not identical, times.

It will be seen from the bar diagram, Figure 6 (and from Table 1), that the relative position and date of the heartwood/sapwood boundary on the three samples in site chronology SRWASQ01 is very similar, varying by only two years from relative position 175 (1443) on sample SRW-A03, to relative position 177 (1445) on samples SRW-A01 and A02. Such similarity would strongly suggest that the trees were cut at the same time as each other, in-keeping with the usual method of building construction in the medieval period, when all trees required for all but the largest building projects were cut as part of a single programme of felling.

The interpretation that the trees were cut at one and the same time is further supported by the degree of cross-matching between all three samples which is sufficiently high to suggest that the three trees were growing close to each other in the same copse or stand of woodland. They were each affected in a similar way by the same growing conditions, this producing a very similar growth pattern in each tree. Had the trees been felled at different times it is very unlikely that each would come to be used in the same part of the building.

Site chronology SRWASQ02 (Fig 7)

Site chronology SRWASQ02 also comprises three samples, all of them from the timbers of the cross-wing roof. One of these samples, SRW-A06, again retains complete sapwood, this last, complete, sapwood ring in this case being dated 1622. Once again, although this last full sapwood ring was produced in 1622 it is possible to see, under the microscope, that the spring-cell growth for the following year is just about to start. This would indicate that this tree was felled just as spring was commencing in the year 1623, again perhaps in March or maybe in April.

It will again be seen from the bar diagram, Figure 7 (and from Table 1), that the relative position and date of the heartwood/sapwood boundary on the three samples in site chronology SRWASQ02 is very similar, varying by only five years from relative position 146 (1586) on sample SRW-A06, to relative position 151 (1591) on sample SRW-A05. Such similarity would again strongly suggest that the trees were cut at the same time as each other.

The interpretation that the trees were cut at one and the same time is again further supported by the degree of cross-matching between all three samples which is sufficiently high to suggest that the three trees were growing close to each other in the same copse or stand of woodland.

Conclusion

Analysis by dendrochronology of the six samples obtained from this site shows that the original, thirteenth century, roof of the hall range was replace in 1470, and that the western cross-wing was built, as was believed, in 1623.

Bibliography

Arnold, A J, Howard, R E, and Litton, C D, 2005 – Nottingham Tree-Ring Dating Laboratory: *Tree-ring analysis of timbers from the Gazebo, Shifnal Manor, Shifnal, near Telford, Shropshire*, Cent for Archaeol Rep, **60/2005**

Arnold A J, and Howard, R E, 2006 unpubl Tree-ring analysis of timbers from Old Hall Farmhouse, Mayfield, Staffordshire – Nottingham Tree-Ring Dating Laboratory unpubl computer file *MAYASQ02*

Arnold, A J, Howard, R E, and Litton, C D, 2008 List 197 no. 11 – Nottingham Tree-ring Dating Laboratory, Vernacular Architect, **39,** 119–28

Arnold, A J, and Howard, R E, 2011a unpubl Tree-ring analysis of timbers from The Old Ship Inn, Bridge Street, Worksop, Nottinghamshire – Nottingham Tree-ring Dating Laboratory unpubl computer file *WKSSSQ02*

Arnold, A J, and Howard, R E, 2011b unpubl Tree-ring analysis of timbers from Wytheford House, Great Wytheford, Shawbury, Shropshire – Nottingham Tree-ring Dating Laboratory unpubl computer file *WYTASQ01*

Bridge, M, C, 1983 unpubl St Cuthbert's Church, Wick, Worcestershire. The use of tree-ring widths as a means of dating timbers from historical sites. Unpubl PhD Thesis. CNAA

Esling, J, Howard, R E, Laxton, R R, Litton, C D, and Simpson, W G, 1990 List 33 no 11c – Nottingham University Tree-ring Dating Laboratory results, *Vernacular Architect*, **21**, 37–40

Hadden-Reece, D, and Miles, D, 1989 *The Tree-Ring Dating of the New Inn, 26–28 Cornmarket, Oxford*, Anc Mon Lab Rep, 1989

Howard, R E, Laxton, R R, and Litton, C D, 2003 *Tree-ring analysis of timbers from Combermere Abbey, Whitchurch, Cheshire,* Anc Mon Lab Rep, **83/2003**

Laxton, R R, and Litton, C D, 1988 An East Midlands master tree-ring chronology and its use for dating vernacular buildings, University of Nottingham, Dept of Classical and Archaeol Studies, Monograph Series, **III**

Miles, D W H, 1996 *Tree-ring dating of 2 Milk Street, Shrewsbury, Shropshire*, Anc Mon Lab Rep, **25/1996**

Miles, D W H, 2001 *The Tree-Ring Dating of the Galleried Building and 'Dairy', 40 Broad Street, Leominster, Herefordshire*, Cent for Archaeol Rep, **38/2001**

Miles, D W H, 2003 Dating Buildings and Dendrochronology in Hampshire in *Hampshire Houses 1250–1700: Their Dating and Development* (E Roberts), 220–26

Siebenlist-Kerner, V, 1978 *Chronology, 1341-1636, for hillside oaks from Western England and Wales*, in Dendrochronology in Europe (ed J M Fletcher), BAR Int Ser, **51**, 295-301

Tyers, I, 2010 *Boscobel House, near Brewood, Shropshire, dendrochronological analysis of oak timbers,* EH Res Dep Rep Ser, **12/2010**

Table 1: Details of tree-ring samples from the hall range and cross-wing, Vaughan's Mansion, the Old Music Hall, Shrewsbury, Shropshire

Sample number	Sample location	Total rings	Sapwood rings*	First measured ring date (AD)	Heart/sap boundary (AD)	Last measured ring date (AD)
	Original Hall Range, replacement truss					
SRW-A01	North principal rafter to west truss	170	19	1295	1445	1464
SRW-A02	South principal rafter to west truss	177	h/s	1269	1445	1445
SRW-A03	Tiebeam to west truss	175	26C	1295	1443	1469
	Cross-wing roof					
SRW-A04	West principal rafter, truss 2 (from N or front)	168	22	1444	1589	1611
SRW-A05	West principal rafter, truss 3	149	16	1459	1591	1607
SRW-A06	East principal rafter, truss 4	182	36C	1441	1586	1622

*h/s = the last ring on the sample is at the 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

Table 2: Results of the cross-matching of site chronology SRWASQ01 and the reference chronologies when the first ring date is 1269 and the last ring date is 1469

Reference chronology	***t*-value**	
Milk Street, Shrewsbury, Shropshire	7.9	(Miles 1996)
Boscobel House, Brewood, Shropshire	6.1	(Tyers 2010)
Zacharius, Oxon	5.7	(Hadden-Reece and Miles 1989)
Winchcombe Abbey House, Winchcombe, Glos	5.6	(Arnold *et al* 2008)
St Cuthbert's, Wick, Worcs	5.6	(Bridge 1983)
Lacock Abbey, Wilts	5.3	(Esling *et al* 1990)
Hampshire County Chronology	5.2	(Miles 2003)
Broad Street, Leominster, Herefs	4.9	(Miles 2001)

Table 3: Results of the cross-matching of site chronology SRWASQ02 and the reference chronologies when the first ring date is 1441 and the last ring date is 1622

Reference chronology	***t*-value**	
East Midlands Master Chronology	7.8	(Laxton and Litton 1988)
Wales and West Midlands Master Chronology	7.7	(Siebenlist-Kerner 1978)
Old Ship Inn, Worksop, Notts	7.3	(Arnold and Howard 2011a unpubl)
Old Hall Farmhouse, Mayfield, Staffs	7.1	(Arnold and Howard 2006 unpubl)
Shifnal Manor Gazebo, Shifnal, Shropshire	6.9	(Arnold *et al* 2005)
Hampshire County Chronology	6.5	(Miles 2003)
Wytheford House, Shawbury, Shropshire	6.5	(Arnold and Howard 2011b unpubl)
Combermere Abbey, Cheshire	6.4	(Howard *et al* 2003)

Site chronologies SRWASQ01 and SRWASQ02 are composites of the data of the relevant cross-matching samples as seen in the bar diagrams Figures 6 and 7. This composite data produces 'average' tree-ring patterns, where the overall climatic signal of the growth is enhanced, and the possible erratic variations of any one individual sample are reduced. These 'average' site chronologies are then compared with several hundred reference patterns covering every part of Britain for all time periods. Each site chronology dates only at the time periods indicated, each table giving only a small selection of the very best matches as represented by '*t*-values' (ie, degrees of similarity).

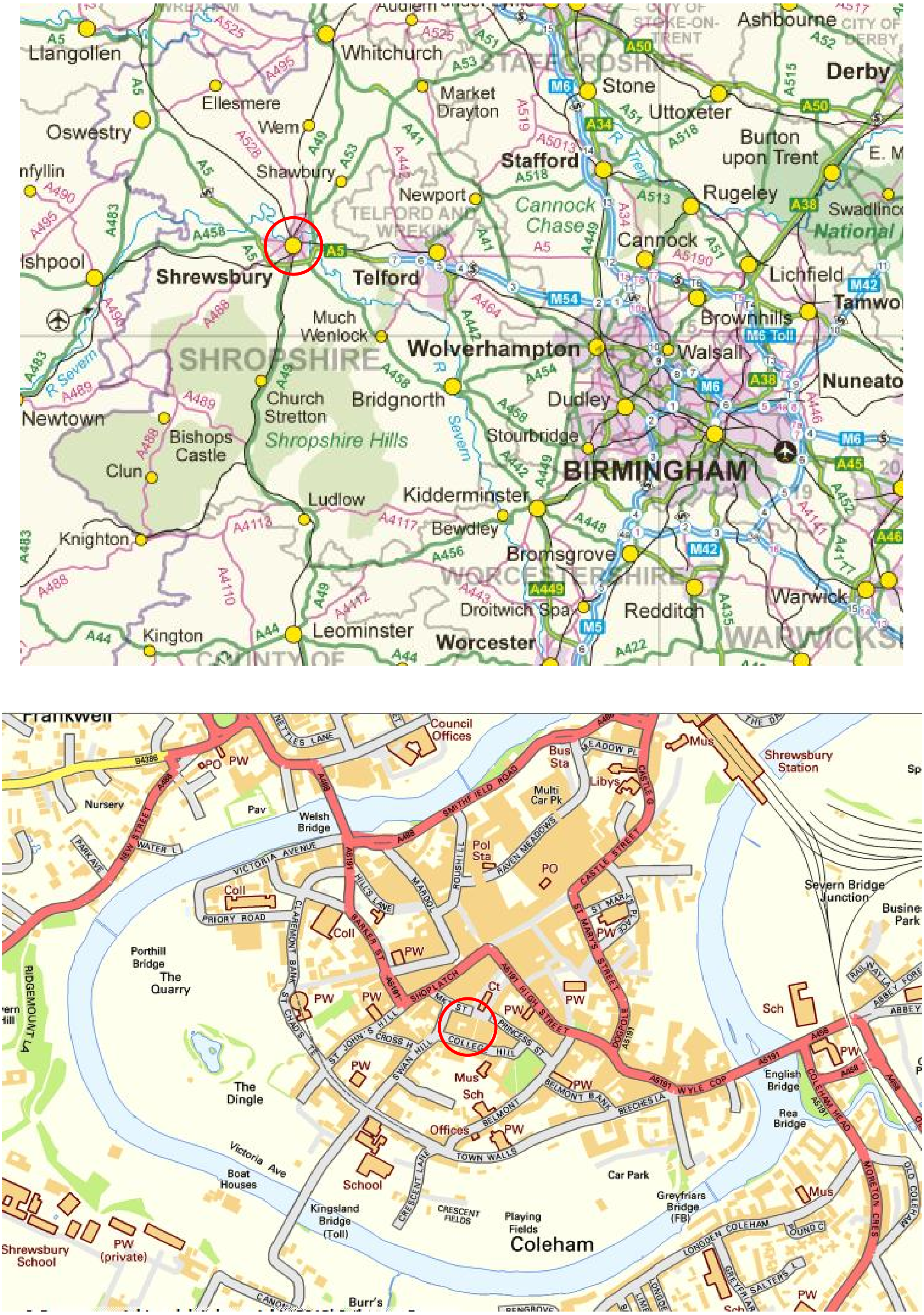


Figure 1a/b: Maps to show location of Shrewsbury (top) and the Old Music Hall (bottom)

Figure 2a/b: View of the remnant west truss of the hall range, hidden by later studs (top), and the trusses of the west cross-wing (bottom)

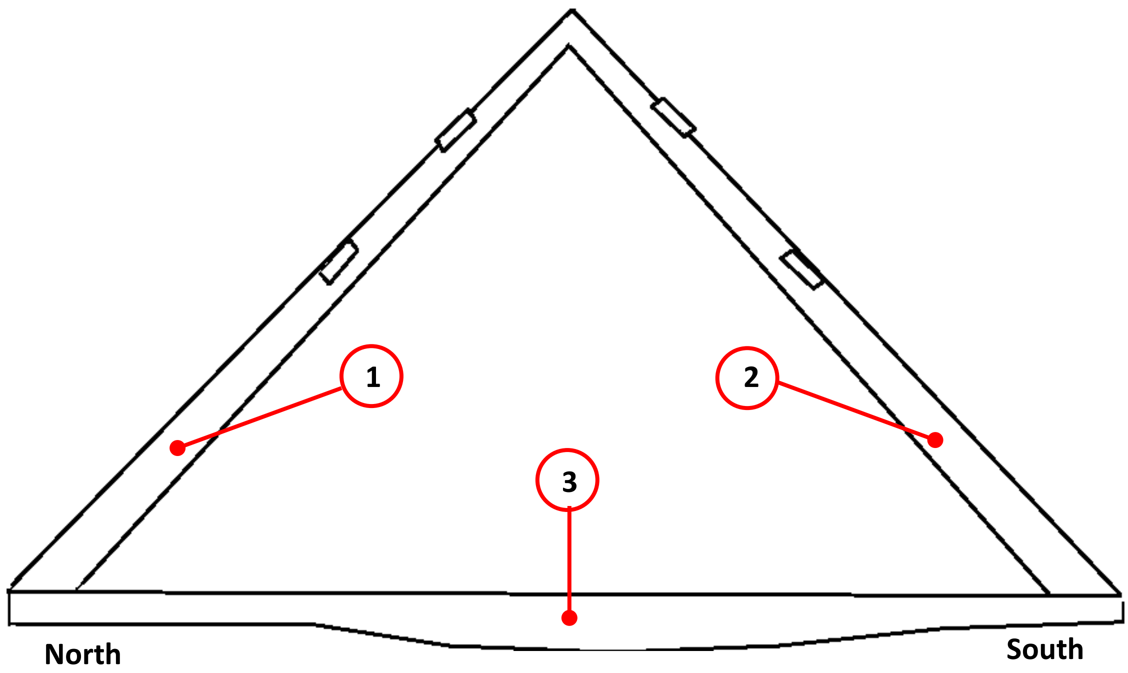


Figure 3: Drawing of the remnant west truss of the hall range to show sample locations

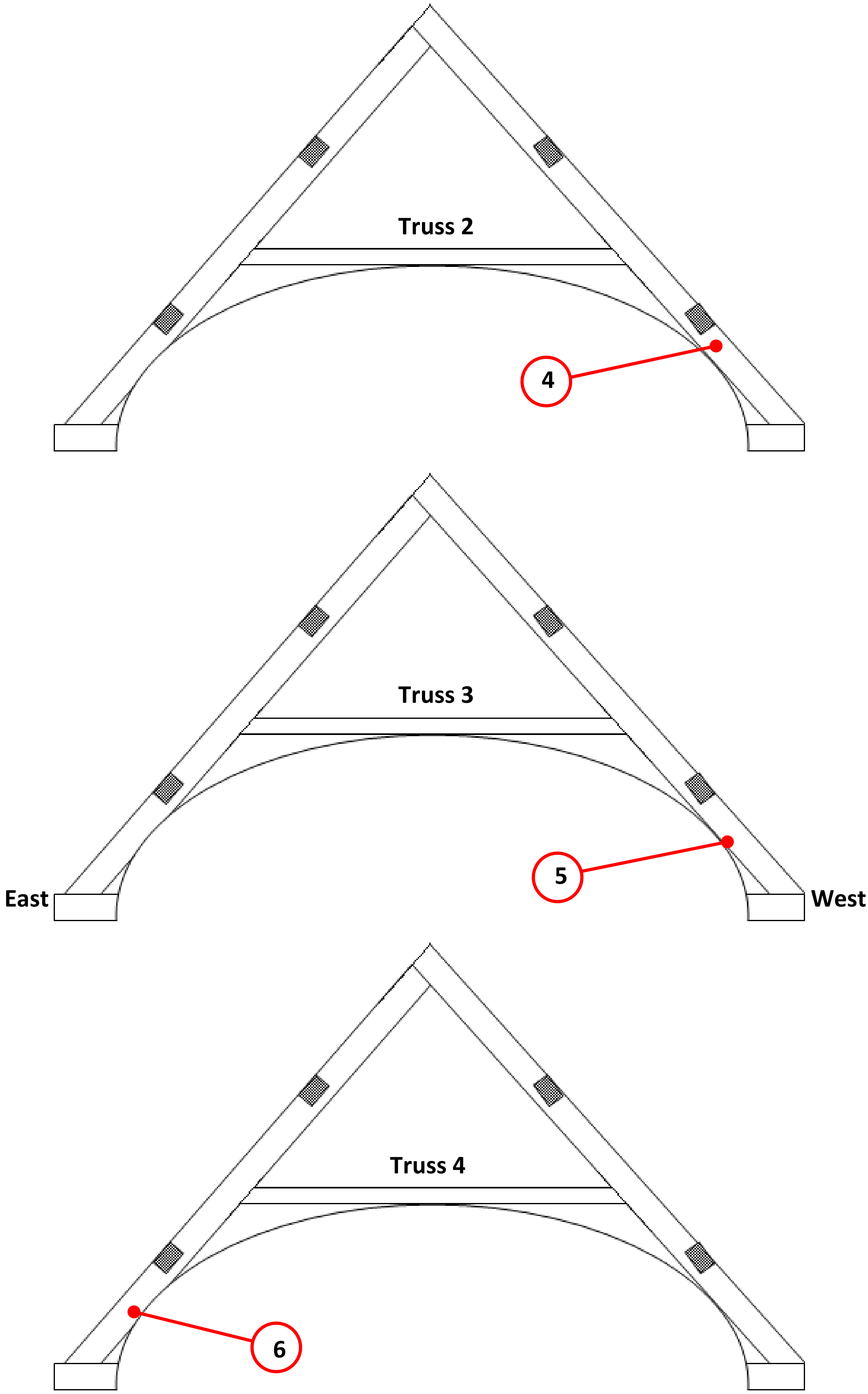


Figure 4: Drawing of the cross-wing trusses to show sample locations

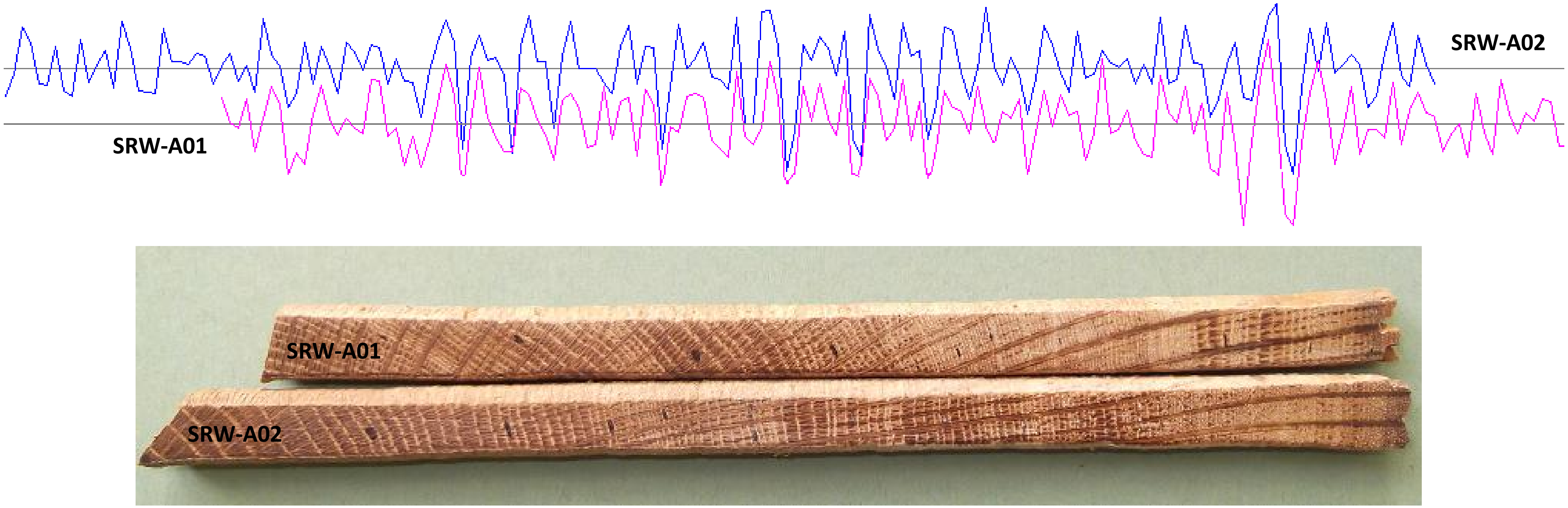
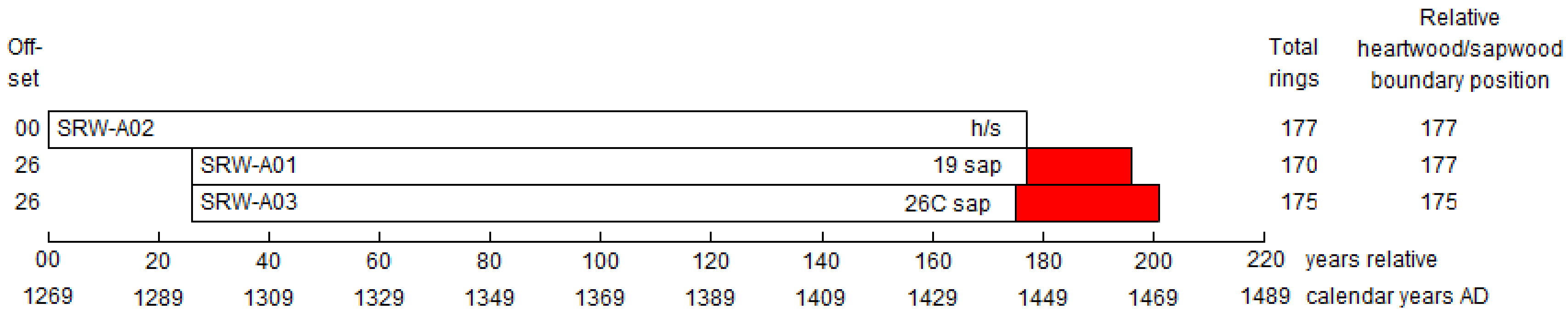


Figure 5: Graphic representation of the cross-matching of two samples, SRW-A01 and A02. It can be seen from the graph that when cross-matched at the correct off-set positions, as here, the variations in width of the annual growth rings of these two samples correspond with a high degree of similarity. As the annual rings 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 other sample. This similarity in growth pattern is a result of the two trees represented having grown in the same area *at the same time.* The growth ring pattern of two samples from trees grown at different times should never cross-match significantly at any position.

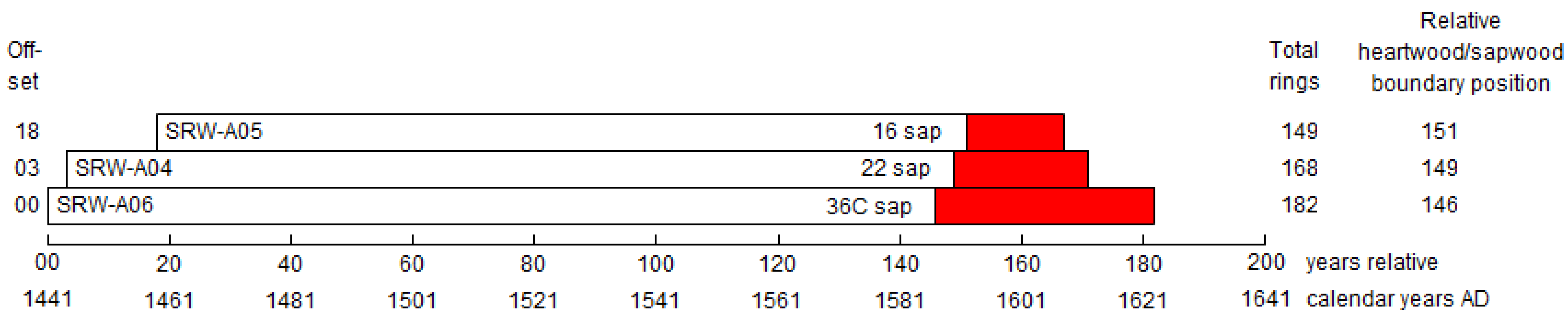


Blank bars = heartwood rings. Filled bars = sapwood rings
C = complete sapwood is retained on the sample, the last measured ring date is the felling date of the timber
h/s = the last ring of the sample is at the heartwood/sapwood boundary, ie, only the sapwood rings are missing

Figure 6: Bar diagram of the samples in site chronology SRWASQ01

The three samples of this site chronology are shown here in the form of a 'bar diagram' at positions where the ring variations of the three samples cross-match with each other, this similarity being produced by the trees represented sharing periods of growth in common (ie, where the bars overlap). The samples are combined at these offsets to form a 'site chronology', SRWASQ01, which is then compared with a large database of 'reference chronologies' for all time periods for all parts of England. Site chronology SRWASQ01 cross-matches only with a date span of 1269–1469 (see Table 2).

One of these three samples, SRW-A03, retains complete sapwood, that is, it has the last full ring produced by the source tree before it was cut down (denoted by upper case 'C'), this last, complete, sapwood ring being dated to 1469. Under the microscope, however, it is possible to see that the spring-cell growth for the following year is just about to start, indicating that the tree was felled in the first few months of 1470. The amount of sapwood remaining on the other two samples, and the relative position/date of the heartwood/sapwood boundary on them, would suggest that the trees these samples represent were also felled in 1470. Such an interpretation is further supported by the high degree of cross-matching between all three samples which suggests that the three trees were growing close to each other, and it being unlikely, if they had been felled at different times, they would come to be used in the same part of the building as each other.



Blank bars = heartwood rings. Filled bars = sapwood rings
C = complete sapwood is retained on the sample, the last measured ring date is the felling date of the timber

Figure 7: Bar diagram of the samples in site chronology SRWASQ02

The three samples of this site chronology are also shown in the form of a 'bar diagram' at positions where the ring variations of the three samples cross-match with each other. The samples have again been combined at these offsets to form a 'site chronology', SRWASQ02, which was again compared with a large database of 'reference chronologies'. Site chronology SRWASQ02 cross-matches only with a date span of 1441–1622 (see Table 3).

Again, one of these three samples, SRW-A06, retains complete sapwood, the last full ring produced by the source tree before it was cut down, this last, complete, sapwood ring being dated to 1622. Again, under the microscope, it is possible to see that the spring-cell growth for the following year is just about to start, indicating that the tree was felled in the first few months of 1623. The amount of sapwood remaining on the other two samples, and the relative position/date of the heartwood/sapwood boundary on them, would suggest that the trees these samples represent were also felled in 1623. This interpretation is, once again, further supported by the high degree of cross-matching between all three samples which suggests that all three trees were growing close to each other, and it would be unlikely, if they had been felled at different times, they would come to be used in the same part of the building as each other.