ntrdl the nottingham tree-ring dating laboratory

ORIEL COTTAGE
AVON VIEW
(OFF CASTLE STREET)
SALISBURY
WILTSHIRE

TREE-RING ANALYSIS OF TIMBERS

Alison Arnold and Robert Howard

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ORIEL COTTAGE, AVON VIEW (OFF CASTLE STREET), SALISBURY, WILTSHIRE; TREE-RING ANALYSIS OF TIMBERS

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SUMMARY

Analysis by dendrochronology was undertaken on 10 of the 15 samples obtained from Oriel Cottage (five samples having too few rings for reliable dating). This analysis produced two dated site chronologies, each of two samples, and dated a further single sample individually.

The earliest material is represented by a tiebeam (sample SOC-T11) to the eastern truss in the range set back from Avon View, this timber being cut in 1246. A later phase of felling is represented by sample SOC-T07, from a common rafter to the roof of the front range facing on to Castle Street, this timber felled at some point between 1305 at the earliest and 1330 at the latest.

A subsequent felling is represented by samples SOC-T09, from the east-most tiebeam of the Avon View range, and SOC-T12, from a principal rafter to the set-back range. These timbers were probably felled together at some point between 1456 at the earliest and 1475 at the latest.

The latest material is taken from a floorboard (sample SOC-T15). The felling date of this timber is unknown, but is unlikely to be any earlier than the early seventeenth century.

The five remaining measured samples remain ungrouped and undated.

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Introduction

Although from the Castle Street frontage (probably rebuilt/refaced in the eighteenth century, and re-roofed parallel with Castle Street) there is scant evidence, Oriel Cottage, Salisbury (SU 14362 30346, maps Figs 1a/b) is part of a range of timber-framed houses, believed to probably originally date from the fifteenth century. It is only from Avon View to the south side of the building, and from the rear to the west, that the full evidence for such an interpretation can be appreciated.

On account of its subsequent developmental history, the Grade II* listed building now has a slightly complicated layout. While the original medieval timber framing to the east half (the end nearest Castle Street end) of the range facing directly on to Avon View was lost in the eighteenth century rebuild, the west end of the range retains three slender archbraced collar trusses, with delicately curved windbraces from wallplates to purlins. There are further curved braces from wall beams to the main wall posts.

At the west end of this Avon View range, but set back from it and slightly overlapping with it, is a short, single bay, section of what may once have been a parallel range, perhaps also extending eastwards as far as Castle Street (see plan Figure 2). This single bay, of slightly broader dimension than the Avon View range, retains two archbraced collar trusses (here described as either the east truss or the west truss), with windbraces from the principal rafters to the purlins.

The roof to the eighteenth century rebuilt range facing on to Castle Street mostly comprises a series of common rafter frames, although there is one truss with a collar.

Sampling

Wiltshire Buildings Record as a group has been investigating historic buildings in Wiltshire and charting their evolution since 1979, the archive now containing over 20,000 records including reports, photographs, plans, drawings, newspaper articles etc. A series of informative and accessible books have also been published. Since 2013 an on-going dendrochronology project has been looking at early roof types in particular, this having considerably increased the understanding of their development.

As furtherance of this programme of tree-ring dating, a funding application was made to the Vernacular Architecture Group to continue to study key Wiltshire buildings with early or unusual carpentry, and relating them to other buildings in the County. Amongst those selected was Oriel Cottage, Salisbury, a timber-framed building forming part of a collection of historic buildings along this part of Castle Street. Although part of the present ground floor to the Castle Street frontage has been used as commercial premises, and much other alteration work has been undertaken over the years, it retains a good quantity of its original timber frame structure to the rear ground floor and to certain parts of the first floor.

In this context it is hoped the Wiltshire Buildings Record would add interest and value to the VAG conference in Wiltshire in April 2025, the intention being to complete the dating project in advance in order that the results may be presented at that meeting.

Thus sampling and analysis by dendrochronology of timbers were commissioned by the Wiltshire Buildings Record, the work being funded with the aid of a generous grant from the Vernacular Architecture Group. It was hoped that tree-ring analysis might more accurately and reliably determine the date of the building, and perhaps demonstrate its relationship to others in the locality.

An initial examination of the parts of the building under consideration here showed that all the remaining timbers were of oak. However, it was also noted that the majority of timbers to the first floor were derived from moderately fast-grown trees. This, and the fact that many of the timbers had been reduced in size by chamfering and shaping, potentially reduced the numbers of rings some of the timbers might contain. The timbers to the roof of the front range, parallel to Castle Street, also appeared to be very mixed as to their potential rings counts. It was also observed that these roof timbers possibly did not comprise an integral single structure, there being some evidence that timbers of varying sizes and shapes, and thus of potentially different dates had been used, or possibly re-used, in this roof. Indeed, it was noted that a few rafters appear to be composed of two timbers spliced together.

However, from the suitable timbers available to the roof and first floor a total of 14 samples was obtained by coring. Each sample was given the tree-ring code SOC-T (for Salisbury, 'Oriel Cottage), and numbered 01–14. A fifteenth sample was also obtained as a cross-sectional slice of a floorboard, lifted during the current programme of repair and conservation.

Details of the samples are given in Table 1, including the timber sampled, 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 report the 'front' of the building is deemed to face east onto Castle Street, with Avon View being to the south. What is now taken to be the rear of the property is to the west. The approximate positions of the core-sampled timbers are shown in the plan, Figure 2, with the individual core-sampled timbers being identified in a series of annotated photographs, shown here as Figures 3a–h.

The Nottingham Tree-ring Dating Laboratory would firstly like to very much thank the owner of Oriel Cottage, Dr Suzanne Keene, for so willingly accommodating this programme of tree-ring dating and for her help on the days of sampling. The Laboratory would also like to thank the Wiltshire Buildings Record for supporting this programme of work, in particular Dorothy Treasure, for helping with gaining access to the building. Finally, we would like to thank the Vernacular Architecture Group for their generous support for this project.

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. 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.

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 millimetre. 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

Each of the 15 samples obtained from the timbers to this building was prepared by sanding and polishing to clearly show the individual annual growth rings. It was seen at this time that, as feared, some of the samples had too few rings for reliable dating, and five cores had to be rejected from this programme of analysis. The annual growth-ring widths of the remaining 10 samples were, however measured, these measured data then being compared with each other as described in the notes on tree-ring dating above.

This comparative process indicated that two groups of cross-matching samples could be formed.

The first group comprises two samples, SOC-T07, from a timber in the front range roof, and sample SOC-T11, from the tiebeam to the east truss in the range set back from Avon View, these two samples cross-matching with each other at relative positions as shown in the bar diagram, Figure 4. The measured data of the two cross-matching samples were combined at their indicated off-set positions to form SOCTSQ01, a site chronology with an overall length of 143 rings. This site chronology was then satisfactorily dated by repeated and consistent cross-matching with a high number of relevant reference chronologies for oak as spanning the years 1148 to 1290. The evidence for this dating is given in the *t*-values of Table 2.

The second group also comprises two samples, SOC-T09 from the east-most tiebeam of the three trusses in the Avon View range, and SOC-T12, from a principal rafter to the east truss of the set-back range. These two samples cross-match with each other at relative positions as shown in the bar diagram, Figure 5. The measured data of the two cross-matching samples were also combined at their indicated off-set positions to form SOCTSQ02, a site chronology with an overall length of 68 rings. This site chronology was then satisfactorily dated by repeated and consistent cross-matching with a high number of relevant reference chronologies for oak as spanning the years 1388 to 1455. The evidence for this dating is given in the *t*-values of Table 3.

The two site chronologies thus created were then compared with the six remaining measured but ungrouped samples. There was, however, no further satisfactory cross-matching. The six remaining ungrouped samples were, therefore, compared individually with the full corpus of reference data for oak, this indicating a cross-match and date for only one further sample, SOC-T15, from the floorboard. This sample contains 151 rings, these rings dated as spanning the years 1437–1587. The evidence for this dating is given in the *t*-values of Table 4.

Interpretation

The earliest material detected in this programme of tree-ring analysis appears to be represented by sample SOC-T11 from a tiebeam to the eastern truss in the range set back from Avon View. This sample retains complete sapwood, this meaning that it has the last full growth ring produced by the tree represented before it was cut (this denoted by upper case 'C' in Table 1 and the bar diagram). This last growth ring, and thus the felling of the tree, is dated 1246, the cell growth for the final ring suggesting it was cut in the early summer of that year.

A later phase of felling is represented by sample SOC-T07, from a common rafter to the roof of the re-built front range facing onto Castle Street. This sample has a last measured ring date of 1290. This sample, however, retains only the heartwood/sapwood boundary (denoted by 'h/s' in Table 1 and the bar diagram), this meaning that all the sapwood rings the sample might have had have been lost (possibly having been removed by the original carpenters, and/or decayed away over the years). Given that most oak trees have between a minimum of 15 sapwood rings, and a maximum of 40 sapwood rings (the 95% confidence interval), this would suggest that this timber was cut at some point between 1305 at the earliest and 1330 at the latest.

A further phase of felling is represented by samples SOC-T09, from the east-most tiebeam of the Avon View range, and SOC-T12, from a principal rafter to the set-back range. Both samples retain some sapwood, but it is not complete. Given that the relative position and date of the heartwood/sapwood boundary on the two samples are almost identical, it is likely that they originally had similar amounts of sapwood, this suggesting that they were felled at the same, or at least similar, time as each other. The average heartwood/sapwood boundary ring of

these two samples is dated 1435. Allowing for the same sapwood limits as above, a minimum of 15 sapwood rings, and a maximum of 40 sapwood rings, but also taking into account that the latest extant ring on sample SOC-T09 is dated 1455, this would suggest that these two timbers was cut at some point between 1456 at the earliest and 1475 at the latest.

The latest material detected in this programme of tree-ring analysis is represented by sample SOC-T15, the offcut from a floorboard. Unfortunately, this samples retains no sapwood, nor the heartwood/sapwood boundary, this meaning that not only has it lost all its sapwood rings, but an unknown number of heartwood rings as well. As such, it is impossible to say when the timber might have been felled. However, what might be said is that, with a last extant heartwood ring date of 1587, and allowing for a minimum of 15 sapwood rings, this felling is unlikely to have taken place any earlier than 1602.

Conclusion

Unfortunately, in this instance, only a small portion of the 15 sampled timbers have been dated, with dates being obtained for only five of the samples which were measured.

The results appear to show that an older timber, the tiebeam of the eastern truss to the set-back range, represented by sample SOC-T11, which was felled in 1246, has been reused here. A further, presumably also reused timber is a common rafter to the front range roof, represented by sample SOC-T07, this having a felling date of 1305–20.

Two timbers, the east-most tiebeam of the Avon View range (SOC-T09) and a principal rafter to the set-back range (SOC-T12), date to the later fifteenth century, 1456–75, these probably relating to the construction of the primary phase of the present building here.

A floorboard, perhaps relating to the some phase of later flooring, is unlikely to be any earlier than the early seventeenth century.

The inference, therefore, is that while Oriel Cottage does indeed probably date to the later fifteenth century, it (perhaps unsurprisingly given its potential sequence of development and alteration) containing timbers of different dates.

Woodland sources

As may perhaps be seen from Tables 2 and 3, although site chronologies SOCTSQ01 and SOCTSQ02 have been compared with reference material from all parts of England, there is possibly something of a trend for them to match best with reference sites in the southwest, with other sites in Wiltshire being listed. While the woodland source(s) of the timbers used at these other sites are themselves not known, the matching seen here would suggest that the timbers used at Oriel Cottage came from a similar regional source.

Undated samples

Five measured samples, SOC-T01, T03, T04, T05, and T08 (all from the front range roof), remain ungrouped and undated. Although two of them, SOC-T04 and T08, are perhaps a little low on ring numbers, the others certainly have quite sufficient numbers of rings for dating. None of these samples show any particular problems such as compression or distortion of the rings, which might make cross-matching and dating difficult, and the reason for the failure to date is unknown. It is, however, a common feature of most programmes of tree-ring analysis to fine that some samples, for whatever reason, do not date.

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Table 1: Details of tree-ring samples from Oriel Cottage, Avon View (off Castle Street), Salisbury, Wiltshire

Sample number	Sample location	Total rings	Sapwood rings*	First measured ring date (AD)	Heart/sap boundary (AD)	Last measured ring date (AD)
SOC-T01	Common rafter	124	23	------	------	------
SOC-T02	Common rafter	nm	---	------	------	------
SOC-T03	Common rafter	83	10	------	------	------
SOC-T04	Purlin	47	no h/s	------	------	------
SOC-T05	Collar	91	h/s	------	------	------
SOC-T06	Common rafter	nm	---	------	------	------
SOC-T07	Common rafter	143	h/s	1148	1290	1290
SOC-T08	Common rafter	49	no h/s	------	------	------
SOC-T09	Tiebeam 1	68	19	1388	1436	1455
SOC-T10	Wall plate	nm	---	------	------	------
SOC-T11	Tiebeam 2	51	18C	1196	1228	1246
SOC-T12	Principal rafter	61	20	1393	1433	1453
SOC-T13	Principal rafter	nm	---	------	------	------
SOC-T14	Wall post	nm	---	------	------	------
SOC-T15	Floorboard (off-cut piece)	151	no h/s	1437	------	1587

*C = Complete sapwood is retained on the sample, the last measured ring date is the felling date of the timber
h/s = heartwood/sapwood boundary, i.e., only the sapwood rings are missing
nm = sample not measured

Table 2: Results of the cross-matching of site chronology SOCTSQ01 and the reference chronologies when the first ring date is 1148 and the last ring date is 1290		
Reference chronology	*t*-value	
Abbey Barn, Glastonbury, Somerset	6.4	(Bridge 1983)
Pitt's Mead, Stratford-sub-Castle, Wiltshire	6.2	(Arnold and Howard 2017 unpubl)
Exeter Cathedral, Exeter, Devon	6.2	(Arnold *et al* 2003)
Meare Farmhouse, Somerset	6.1	(Bridge 2002)
Salisbury Cathedral, Wiltshire	6.0	(Arnold *et al* 2003 unpubl)
7 - 9 Stourport Road, Bewdley, Worcestershire	5.8	(Arnold *et al* 2005)
SARUM (Salisbury Cathedral), Wiltshire	5.8	(Miles and Worthington 2001)
9 Queen Street, Salisbury, Wiltshire	5.8	(Arnold and Howard 2018 unpubl)

Table 3: Results of the cross-matching of site chronology SOCTSQ02 and the reference chronologies when the first ring date is 1388 and the last ring date is 1455		
Reference chronology	*t*-value	
White Tower, Tower of London, London	6.8	(Miles 2007)
Mucknell Farm, Stoulton, Worcestershire	6.3	(Arnold *et al* 2008)
London, England	6.3	(Tyers and Groves 1999 unpubl)
Fulham Palace, London	6.1	(Bridge and Miles 2004)
Church of St Nicholas, Bromham, Wiltshire	5.8	(Arnold and Howard 2008)
St Andrew's Church, Pixley, Worcestershire	5.5	(Bridge 2006)
Church of St John The Baptist, Latton, Wiltshire	5.4	(Miles and Worthington 1997)
Abbots Lodge, Ledbury, Herefordshire	5.3	(Arnold and Howard 2009)

Table4: Results of the cross-matching of sample SOC-T15 and the reference chronologies when the first ring date is 1437 and the last ring date is 1587		
Reference chronology	*t*-value	
London, England	9.8	(Tyers and Groves 1999 unpubl)
Guildhall, High Street, Worcester,	8.7	(Arnold *et al* 2006)
Avebury Manor, Avebury, Wiltshire	8.3	(Arnold and Howard 2011 unpubl)
26 Westgate Street, Gloucester	8.3	(Howard *et al* 1998)
SOUTH 1	8.2	(Howard 2002 unpubl)
Town Hall, Alcester, Warwickshire,	8.1	(Arnold and Howard 2014 unpubl)
Whitewebbs Farm, Enfield, London	7.7	(Arnold *et al* 2019)
Lower Bean Hall, Feckenham, Worcestershire	7.5	(Arnold and Howard 2005 unpubl)

Site chronologies SOCTSQ01 and SOCTSQ02 are composites of the data of the pairs of cross-matching samples as seen in the bar diagrams, Figures 4 and 5, below. These composite data sets produces 'averaged' tree-ring patterns, where the possible erratic variations of individual samples are reduced and the overall climatic signal of the pairs 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 date spans indicated. The Tables gives only a small selection of the very best matches as represented by '*t*-values' (ie, degrees of similarity). It may be noticed from this 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.

Sample SOC-T15 has been compared with the reference material individually.

It may perhaps be noted that although these data of the two site chronologies SOCTSQ01 and SQ02, and perhaps for the individually dated sample SOC-T15, have been compared with reference material from all parts of England, there is perhaps something of a slight trend for them to match best with reference sites in south central/western England, with other sites in Wiltshire appearing quite often. The matching seen here would suggest that the few dated timbers used at Oriel Cottage came from a similar, and probably local, regional source.

Figure 1a/b: Maps to show location of Salisbury (top) and Oriel Cottage (bottom)

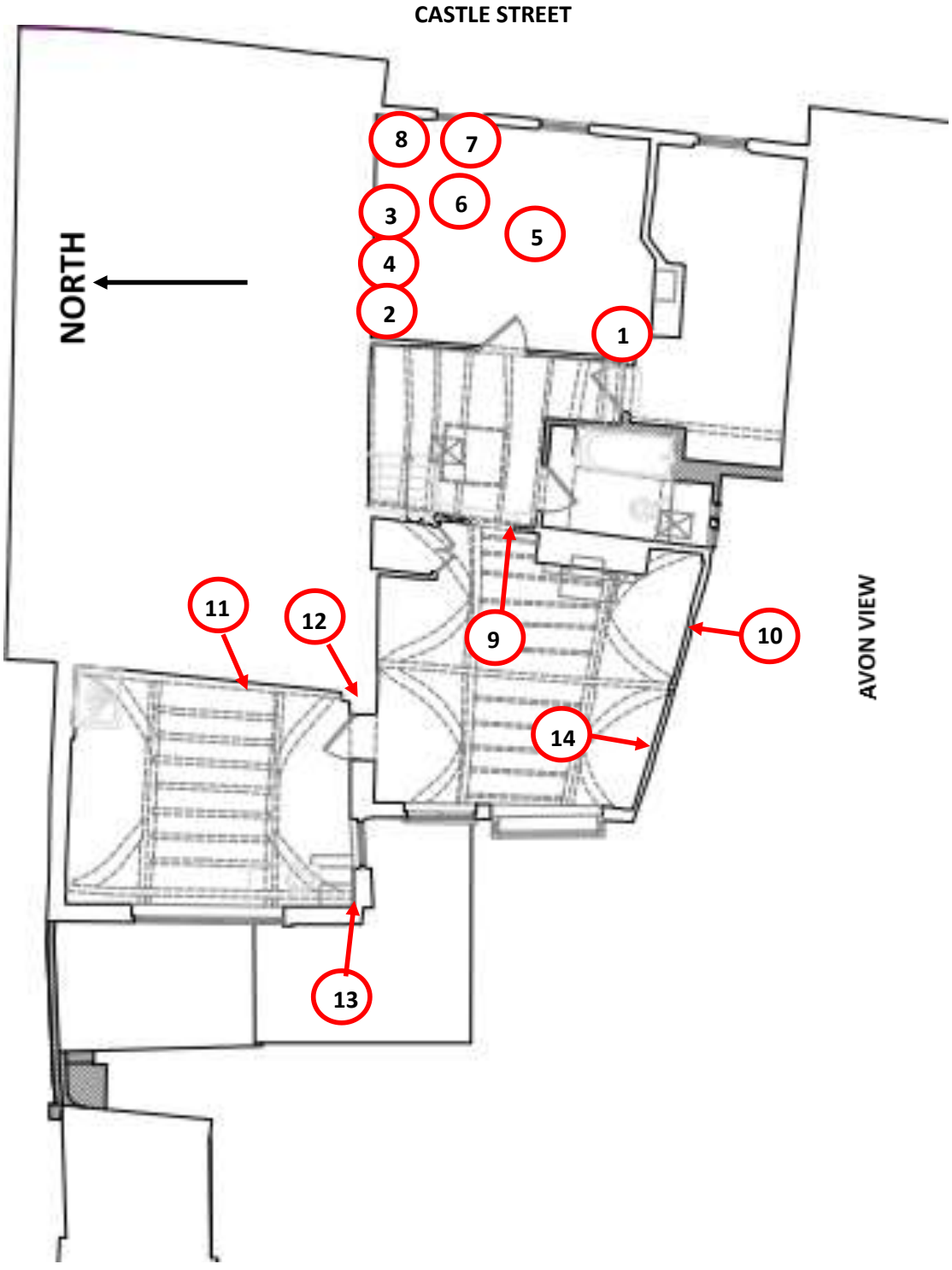
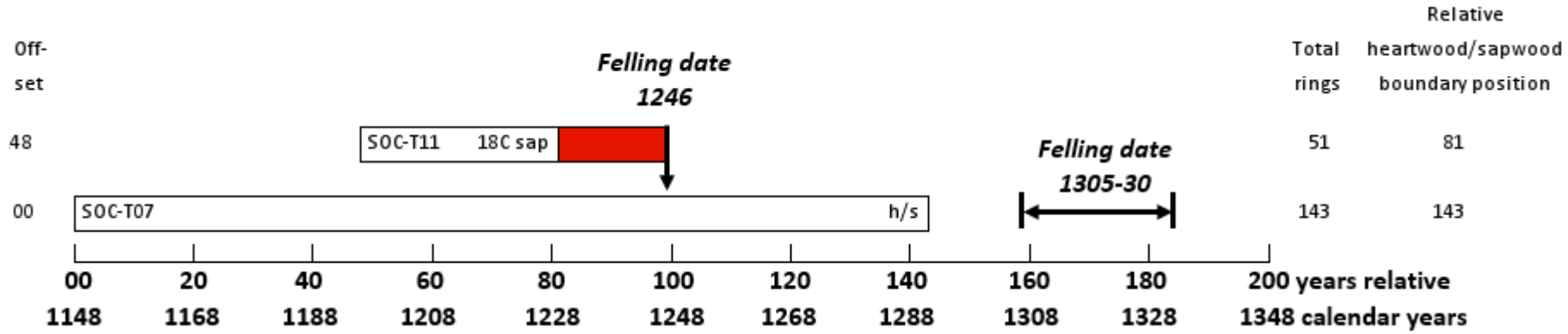


Figure 2: Plan (at first floor level) to show the approximate position of the sampled timbers (see Table 1 and Figures 3a–h) (after Gerald Steer)

Figures 3a–c: Front range roof - annotated photographs to help identify sampled timbers (see table 1 and Figure 2)

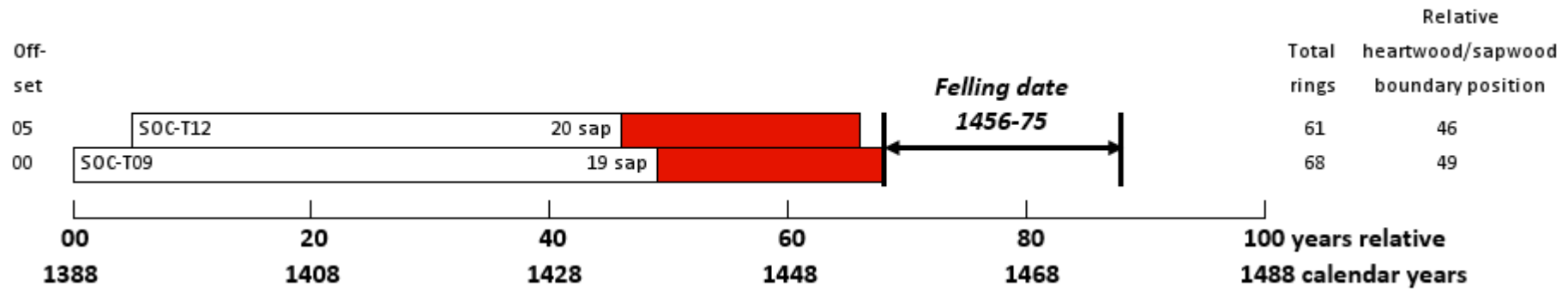
Figures 3d/e: Front range roof - annotated photographs to help identify sampled timbers (see table 1 and Figure 2)

Figure 3f–h: First floor - annotated photographs to help identify sampled timbers (see table 1 and Figure 2)



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

Figure 4: Bar diagram of the samples in site chronology SOCTSQ01



blank bars = heartwood rings; filled bars = sapwood rings

Figure 5: Bar diagram of the samples in site chronology SOCTSQ02

The constituent samples of site chronologies SOCTSQ01 and SOCTSQ02 are shown above in the form of 'bars' at positions where the pattern of their growth rings cross-match with each other, the similarity being caused by the trees used for the beams sharing common periods of growth which overlap with each other, and having grown in the same area as each other. The data of the measured rings widths of each pair of samples have been combined to form two 'site chronologies' which have then been dated by comparison with the 'reference' chronologies (see Tables 2 and 3).