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TREE-RING ANALYSIS OF TIMBERS FROM THE CHAPTER ROOM ROOF, ROCHESTER CATHEDRAL, ROCHESTER, KENT

October 2013

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SUMMARY

Dendrochronological analysis was undertaken on timbers of the Chapter Room roof, resulting in the construction and dating of two site sequences and one single sample.
Interpretation of the sapwood on these samples suggests felling of all dated timber in the second half of the fourteenth century with construction likely to have occurred shortly after.

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INTRODUCTION

Rochester Cathedral, the second oldest cathedral in England after Canterbury, was founded in 604 by Bishop Justus. Located in the Medway town of Rochester (TQ 74273 68521; Figs 1–3), this early cathedral fell into disrepair and the present building was begun by Bishop Gundulf in the eleventh century. Elements of Gundulf's cathedral survive although there are disagreements as to how much of the fabric can be attributed to him. Work to improve and enlarge the cathedral continued throughout the next few centuries, culminating with the extension of the Lady Chapel in *c* 1490.

To the east of the south transept is the Chapter Room (Fig 4) which has housed the cathedral library for many years. Access to this room is through a highly decorated doorway, generally thought to be the work of Bishop Hamo de Hythe and dating to the mid-fourteenth century. The roof over this part of the building consists of seven king post trusses; each king post has braces rising up to the ridgepiece (Fig 5). A single tier of purlins to each side are supported on posts; there are further braces from these posts to the purlins (Fig 6). There have been later modifications in the form of softwood bracing, thought to have been carried out in the eighteenth century.

Principles of Tree-ring Dating

Tree-ring dating relies on a few simple, but fundamental, principles. Firstly, as is commonly known, trees (particularly oak trees) 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 to 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 determined 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.

Secondly, because the weather over any number of consecutive years is unique, so too is the growth pattern of the tree. The pattern of a short period of growth, 20 or 30 consecutive years, might conceivably be repeated two or even three times in the last one thousand years. 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 60 years or so. In essence, a short period of growth, anything less than 50 rings, is not reliable, and the longer the period of time under comparison the better.

The third principal of tree-ring dating is that, until the early-to mid-nineteenth century, builders of timber-framed houses usually obtained all the wood needed for a given structure by felling the necessary trees in a single operation from one patch of woodland or from closely adjacent woods. Furthermore, and contrary to popular belief, the timber was used "green" and without seasoning, and there was very little long-term storage as in timber-yards of today. This fact has been well established from a number of studies where tree-ring dating has been undertaken in conjunction with documentary studies. Thus, establishing the felling date for a group of timbers gives a very precise indication of the date of their use in a building.

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 a sample "cross-matches" repeatedly at the same date against a series of different relevant 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 the 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 phases 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 satisfactory analysis.

SAMPLING

A total of 13 timbers was sampled from the timbers of the roof with each sample being given the code RCH-C and numbered 01–13. Trusses were numbered from east to west (Fig 7) and the location of all samples noted at the time of sampling and marked on Figures 8–14. Further details can be found in Table 1.

ANALYSIS & RESULTS

During the initial assessment it was thought that the timbers utilised within the roof structure were generally quite fast grown and unlikely to have high growth ring numbers; this was found to be the case once the samples had been taken. It is normal practice to prepare and measure only those samples with more than 50 growth rings. However, as the roof appears to be intact with a high probability that all timbers would be the same date, it was decided to measure all samples over 40 growth rings in the hope that they would match each other and could be combined into a site sequence of sufficient length to make successful dating a possibility.

Four samples were found to have less than 40 rings and so were discarded prior to preparation and measurements. The remaining 9 samples were prepared by sanding and polishing and their growth-ring widths measured. These growth-ring widths were then compared with each other resulting in the formation of two groups.

Three samples matched each other and were combined to form RCHCSQ01, a site sequence of 64 rings (Fig 15). This site sequence was compared against a series of relevant reference chronologies for oak where it was found to match securely and consistently to a first ring date of 1278 and a last-measured ring date of 1341. The evidence for this dating is given by the *t*-values in Table 2.

Three further samples matched each other and were again combined at the relevant offset positions to form RCHCSQ02, a site sequence of 84 rings (Fig 16). When compared against the reference material this site sequence was found to span the period 1264–1347. The evidence for this dating is given by the *t*-values in Table 3.

Finally, attempts were made to date the remaining ungrouped samples by comparing them individually against the reference chronologies resulting in sample RCH-C11 being found to span the period 1274–1337. The evidence for this dating is given by the *t*-values in Table 4.

INTERPRETATION

Tree-ring analysis has resulted in the successful dating of seven of the samples taken from this roof. All seven of these dated samples have the heartwood/sapwood boundary, the position of which suggests two separate groups (Fig 17). Four of the samples (the three dated within RCHCSQ01 and RCH-C11) have similar heartwood/sapwood boundary ring dates, the average of which is 1323. This allows an estimated felling date to be calculated for the four timbers represented to within the range 1342–63. This takes into consideration that sample RCH-C03 has the last-measured ring date of 1341 with incomplete sapwood. The other three dated samples have slightly later heartwood/sapwood boundary ring date. The average of these is 1340, giving the slightly later felling date range of 1355–80.

Felling date ranges have been calculated using the estimate that mature oak trees from this region have between 15 and 40 sapwood rings.

DISCUSSION

The dendrochronology has successfully dated timbers of the roof over the Chapter Room to 1342–63 and 1355–80. These two felling date ranges can be seen to overlap, giving rise to the possibility that all timber was felled in a single operation in 1355–63. Alternatively, the slightly different felling date ranges may indicate the use of stockpiled timber, something which is not uncommon, especially amongst large and wealthy institutions such as cathedrals.

Whether the roof was constructed in or soon after felling of timbers in 1355–63 or in 1355–80, utilising some stockpiled timber, these results point to it belonging to the same scheme of work (or one immediately succeeding it) as the magnificent doorway through which access to the Chapter Room is gained.

It can be seen (Tables 2–4) that the reference chronologies match the site sequences at a series of values which, although secure, are not especially high. Due to the excellent growing conditions in Kent, fast grown trees are a feature of this county and more particularly from the fourteenth century here. This greatly reduces the number of buildings suitable for tree-ring dating which in turn has led to reference chronologies covering this period in Kent being under-represented in our databanks when compared to other areas/over different periods. Additionally, neither of the site sequences relating to this roof are particularly well replicated (both only containing three samples) or long (RCHCSQ02 is the longest sequence with 84 rings) and it can generally be said that the better replicated or longer the ring width sequences you have to compare against the reference material the better the chance of a good match. With this in mind, these two dated site sequences, although short, are important additions to our reference database, and will hopefully assist in the future dating of other Kent buildings.

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Acknowledgements

This work was commissioned by Graham Keevill, of Keevill Heritage Limited, on behalf of the Dean and Chapter of Rochester Cathedral and kindly funded by Russell Race. The Laboratory would like to thank Graham Keevill for facilitating access and his *on-site* advice and the cathedral staff for their assistance during sampling and the initial assessment.

Table 1: Details of samples taken from the Chapter Room roof, Rochester Cathedral, Rochester, Kent

Sample number	Sample location	Total rings	*Sapwood rings	First measured ring date (AD)	Last heartwood ring date (AD)	Last measured ring date (AD)
RCH-C01	South post, truss 1	78	05	1270	1342	1347
RCH-C02	North purlin, truss 1–2	NM	--	----	----	----
RCH-C03	North post, truss 2	52	16	1290	1325	1341
RCH-C04	East brace, south post to purlin, T3	41	h/s	1282	1322	1322
RCH-C05	East brace, king post to ridge, T3	55	h/s	----	----	----
RCH-C06	North principal rafter, T3	41	h/s	1300	1340	1340
RCH-C07	South post, T3	47	01	1278	1323	1324
RCH-C08	South principal rafter, T5	NM	--	----	----	----
RCH-C09	South post, T5	NM	--	----	----	----
RCH-C10	King post, T4	74	h/s	1264	1337	1337
RCH-C11	West brace, king post to ridge, T5	64	14	1274	1323	1337
RCH-C12	South principal rafter, T6	NM	--	----	----	----
RCH-C13	South post, T7	47	02	----	----	----

*NM = not measured

**h/s = the heartwood/sapwood boundary ring is the last-measured ring on the sample

Table 2: Results of the cross-matching of site sequence RCHCSQ01 and relevant reference chronologies when the first-ring date is 1278 and the last-measured ring date is 1341

Reference chronology	*t*-value	Span of chronology	Reference
Walnut Tree Cottage, East Sutton, Kent	6.2	1219–1393	Laxton and Litton 1989
Blackmore Church, Essex	5.0	1266–1399	Miles *et al* 2005
Home Farm, Newdigate, Surrey	5.0	1283–1411	Bridge 1998
Thaxted Church (chancel), Essex	4.7	1212–1404	Bridge 2005
8–9 The Parade/St Margaret's Street, Canterbury, Kent	4.7	1247–1374	Arnold and Howard 2007a
St George's Church, Bedfordshire	4.7	1226–1392	Bridge 2001a
Reading Waterfronts, Berkshire	4.7	1160–1407	Groves *et al* 1997

Table 3: Results of the cross-matching of site sequence RCHCSQ02 and relevant reference chronologies when the first-ring date is 1264 and the last-measured ring date is 1347

Reference chronology	*t*-value	Span of chronology	Reference
Polesworth Abbey Gatehouse, Warwickshire	6.6	1095–1342	Arnold and Howard 2007b
Priory Barn, Little Wymondley, Hertfordshire	5.9	1283–1364	Bridge 2001b
St George's Church, Bedfordshire	5.7	1226–1392	Bridge 2001a
Turret Close, High Street, Long Wittenham, Oxfordshire	5.6	1272–1351	Alcock *et al* 1989
Blackmore Church, Essex	5.6	1266–1399	Miles *et al* 2005
Thorley Hall, Bishops Stortford, Hertfordshire	5.4	1275–1375	Arnold *et al* 2001
Kenilworth Castle Gatehouse, Warwickshire	5.4	1282–1374	Arnold and Howard 2007c

Table 4: Results of the cross-matching of sample RCH-C11 and relevant reference chronologies when the first-ring date is 1274 and the last-measured ring date is 1337

Reference chronology	*t*-value	Span of chronology	Reference
Blackfriars Priory, Gloucester, Gloucestershire	6.0	1168–1347	Howard *et al* 2002
The Old Manor, West Lavington, Wiltshire	5.9	1264–1497	Hurford and Tyers forthcoming
83 The Causeway, Steventon, Oxfordshire	5.6	1281–1365	Arnold *et al* 2008
Culm Davy Farm, Hemyock, Devon	5.4	1265–1392	Tyers *et al* forthcoming
Aisled barn, Newark, Nottinghamshire	4.9	1249–1399	Laxton *et al* 1984
Church of St James, Bristol, Somerset	4.5	1209–1396	Arnold and Howard 2011
Turret Close, High Street, Long Wittenham, Oxfordshire	4.5	1272–1351	Alcock *et al* 1989

Figure 1: Map to show the general location of Rochester in Kent, arrowed (based on the Ordnance Survey map with permission of the Controller of Her Majesty's Stationery Office, ©Crown Copyright)

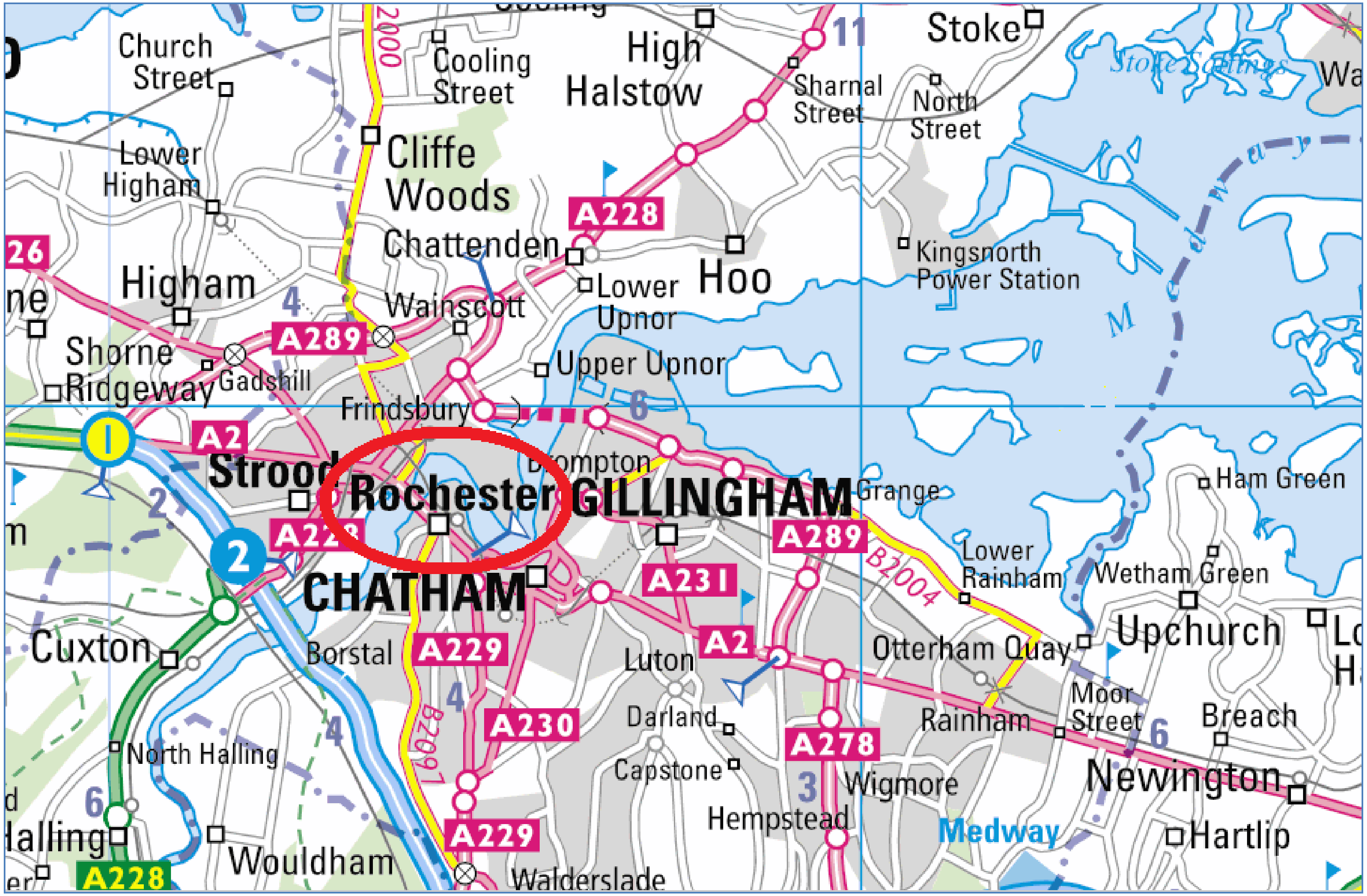

Figure 2: Map to show the Rochester, Kent (based on the Ordnance Survey map with permission of the Controller of Her Majesty's Stationery Office, ©Crown Copyright)

Figure 3: Map to show the location of Rochester Cathedral, arrowed (based on the Ordnance Survey map with permission of the Controller of Her Majesty's Stationery Office, ©Crown Copyright)

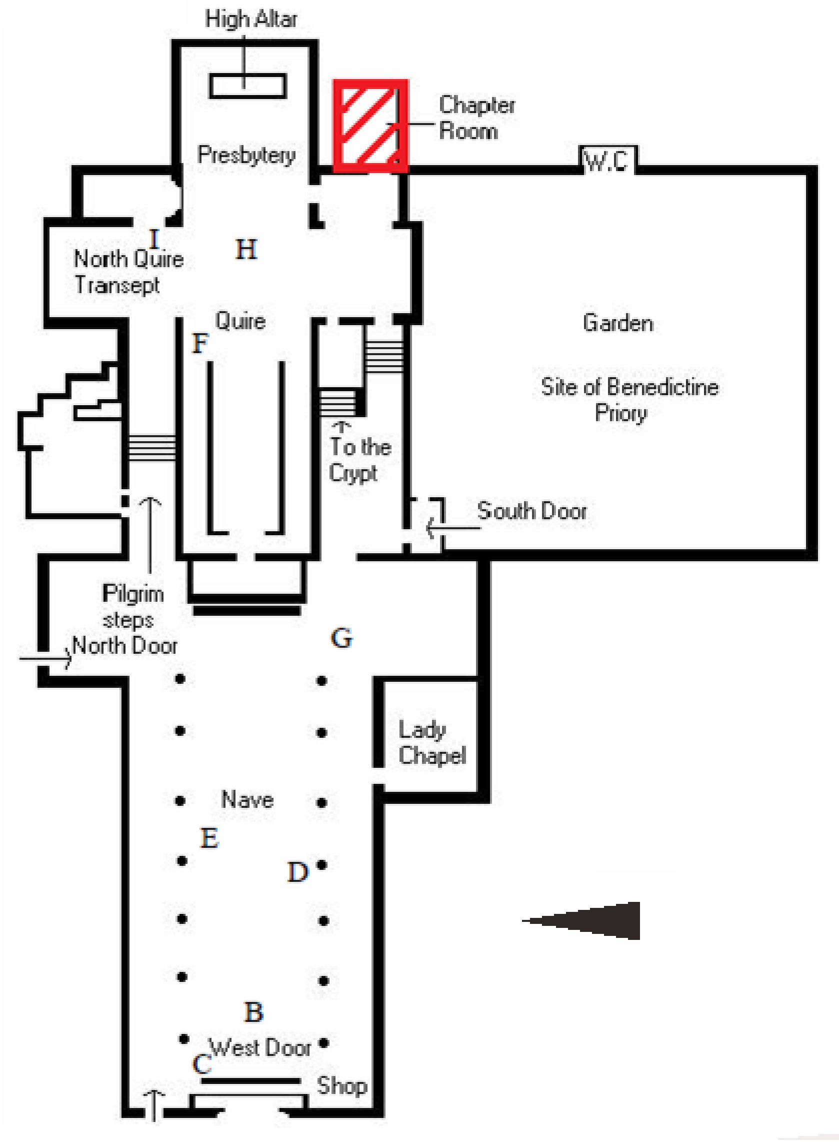

Figure 4: Plan of Rochester Cathedral with the Chapter Room hashed in red (www.rochestercathedral.org)

Figure 5: Chapter Room roof, truss 6 in foreground

Figure 6: Chapter Room roof, south side

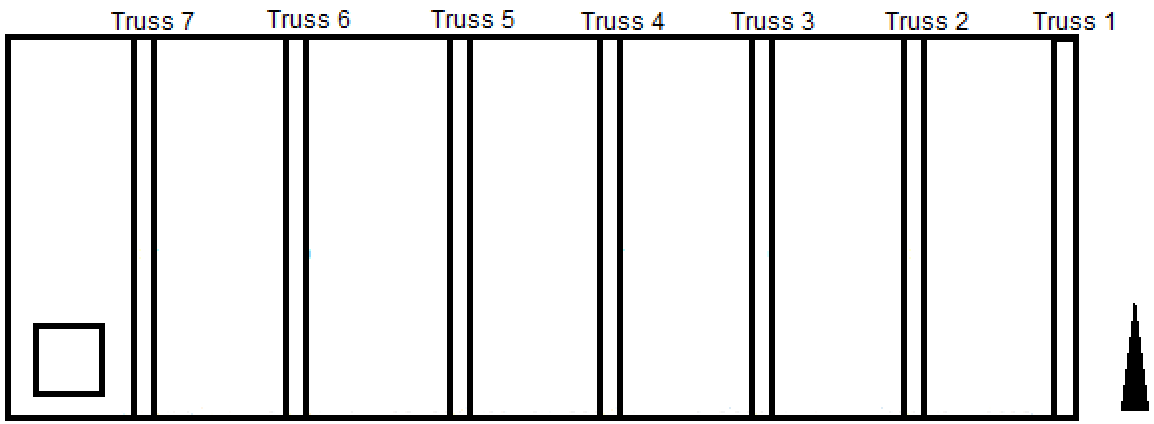

Figure 7: Sketch plan, showing truss numbering.

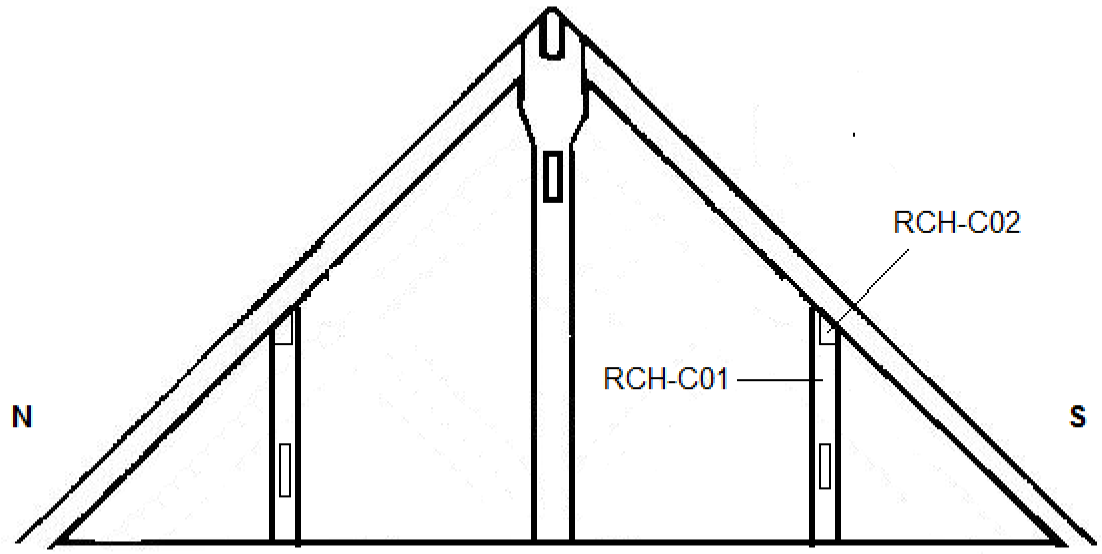

Figure 8: Sketch of truss 1, showing the location of samples RCH-C01 and RCH-C02

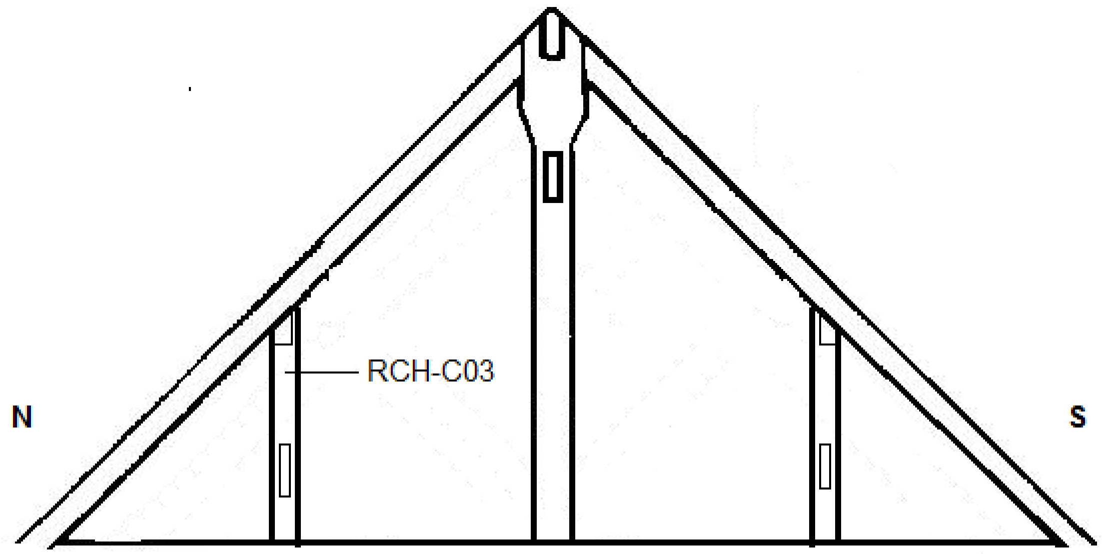

Figure 9: Sketch of truss 2, showing the location of sample RCH-C03

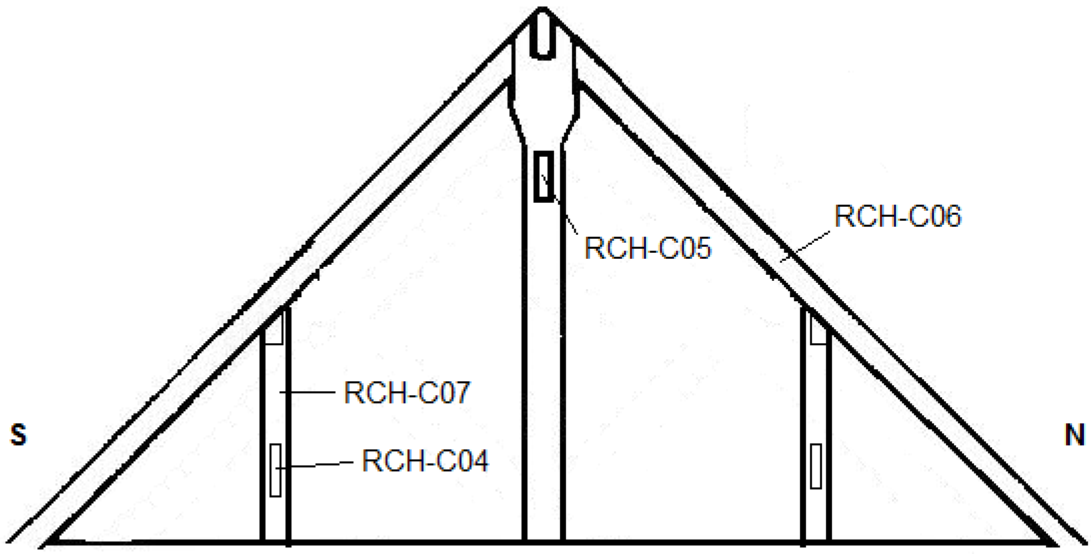

Figure 10: Sketch of truss 3, showing the location of samples RCH-C04-07

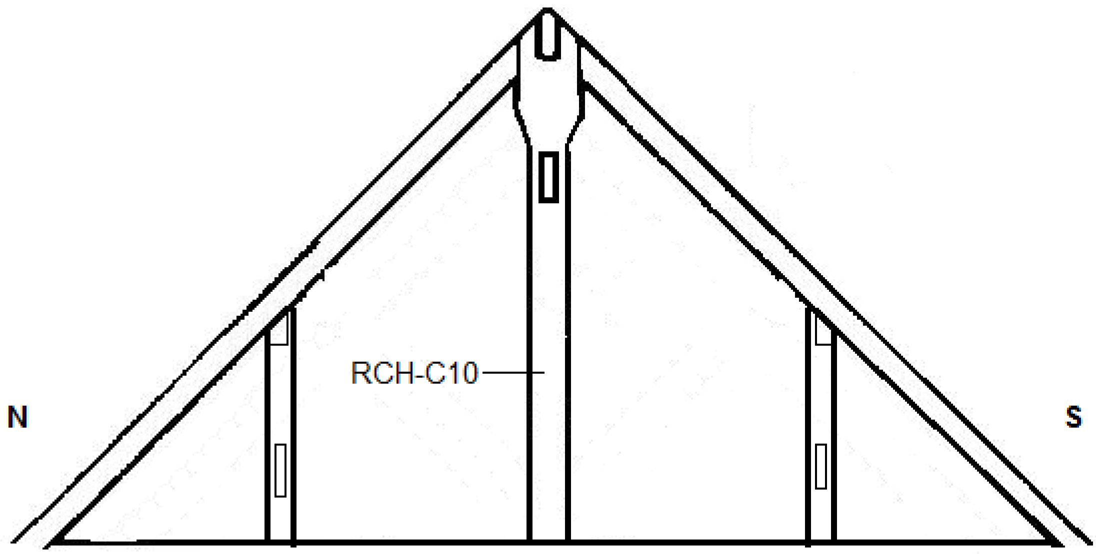

Figure 11: Sketch of truss 4, showing the location of sample RCH-C10

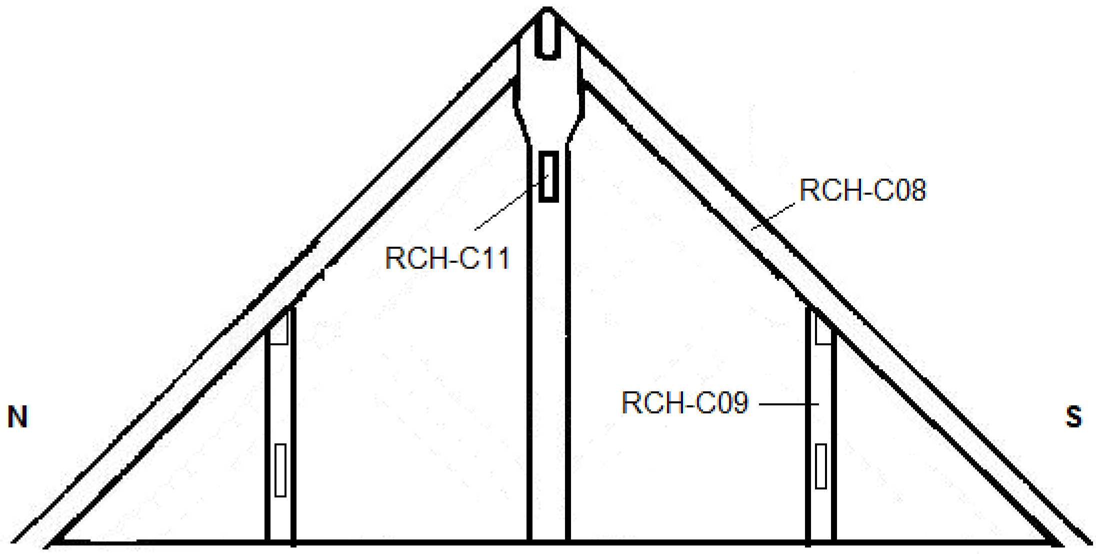

Figure 12: Sketch of truss 5, showing the location of samples RCH-C08-09 and RCH-C11

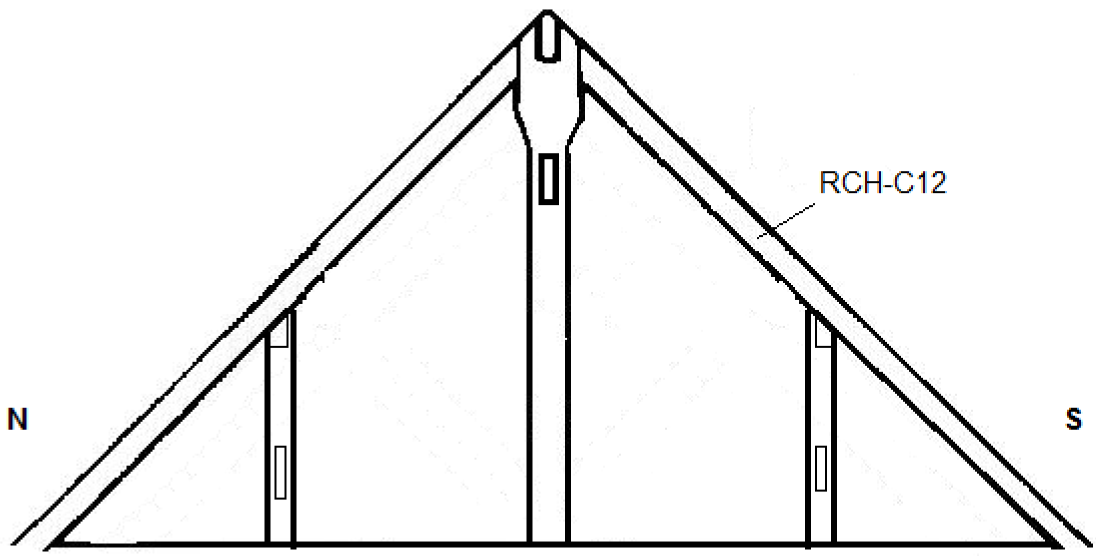

Figure 13: Sketch of truss 6, showing the location of sample RCH-C12

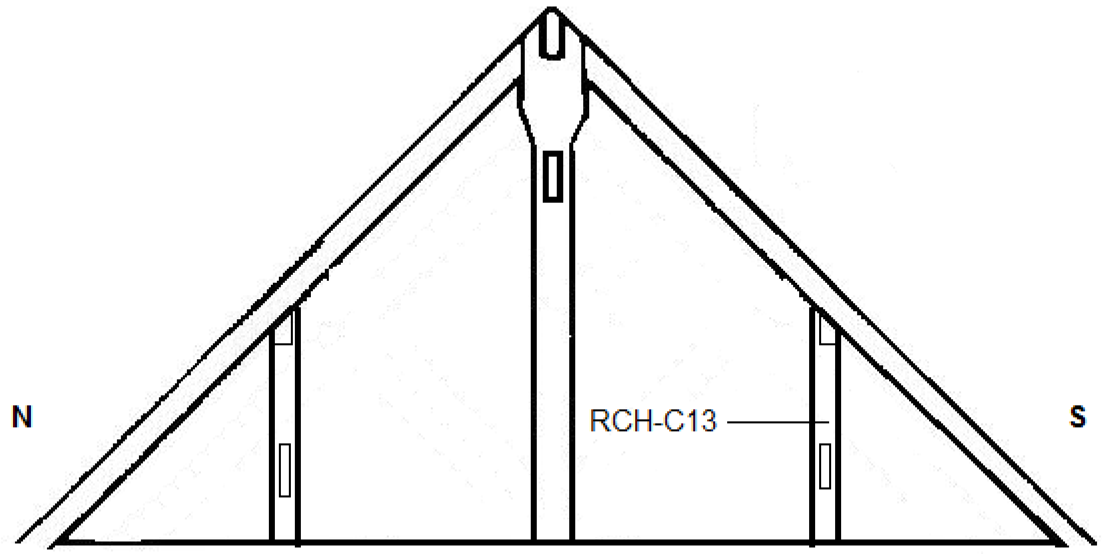

Figure 14: Sketch of truss 7, showing the location of sample RCH-C13

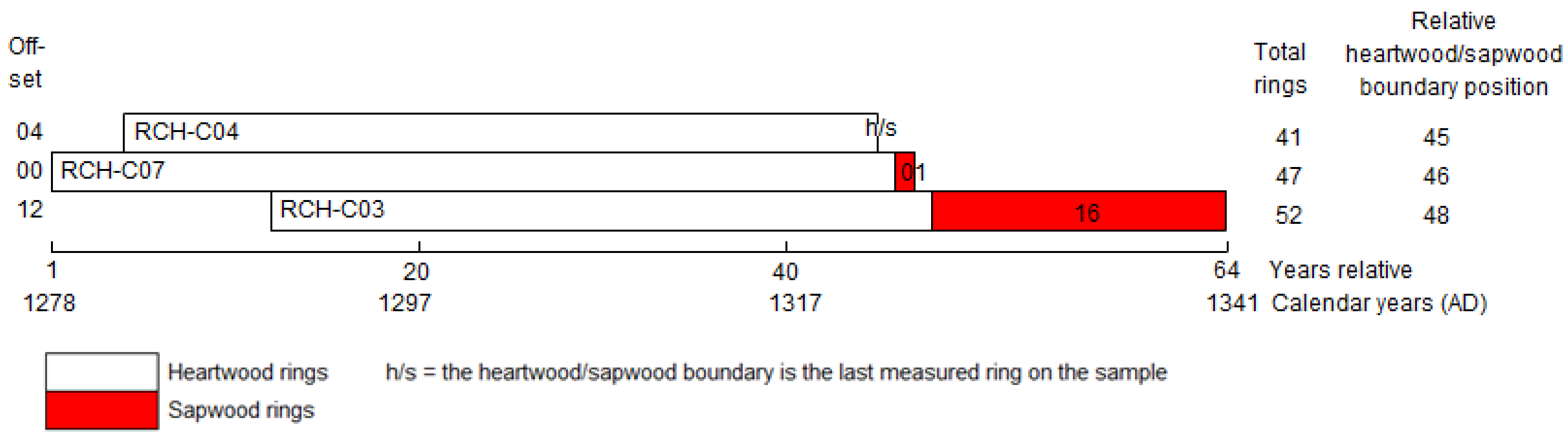

Figure 15: Bar diagram of samples in site sequence RCHCSQ01

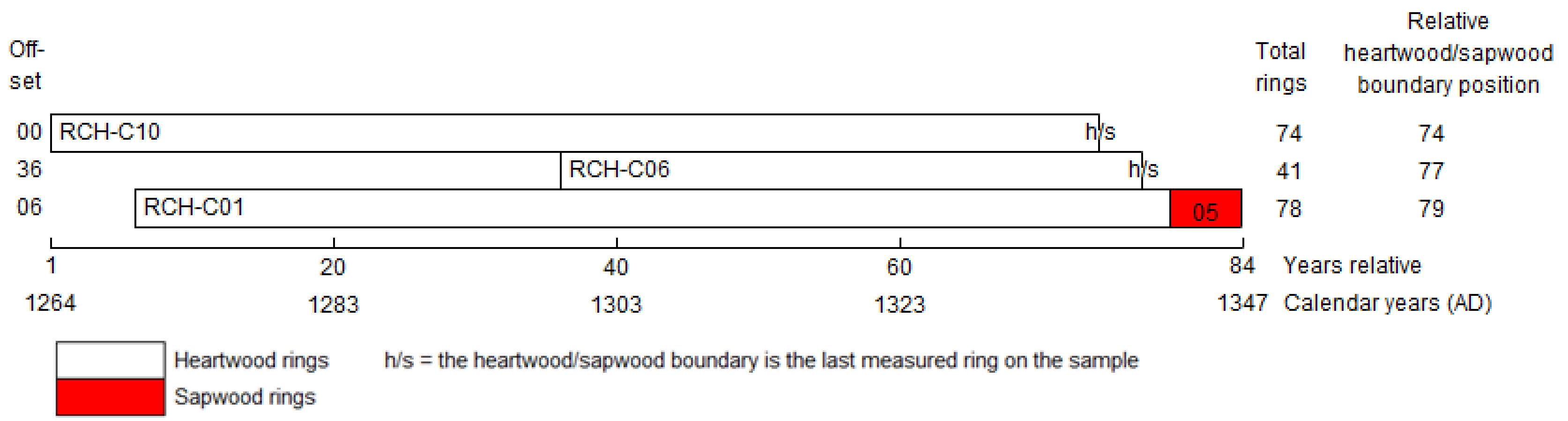

Figure 16: Bar diagram of samples in undated site sequence RCHCSQ02

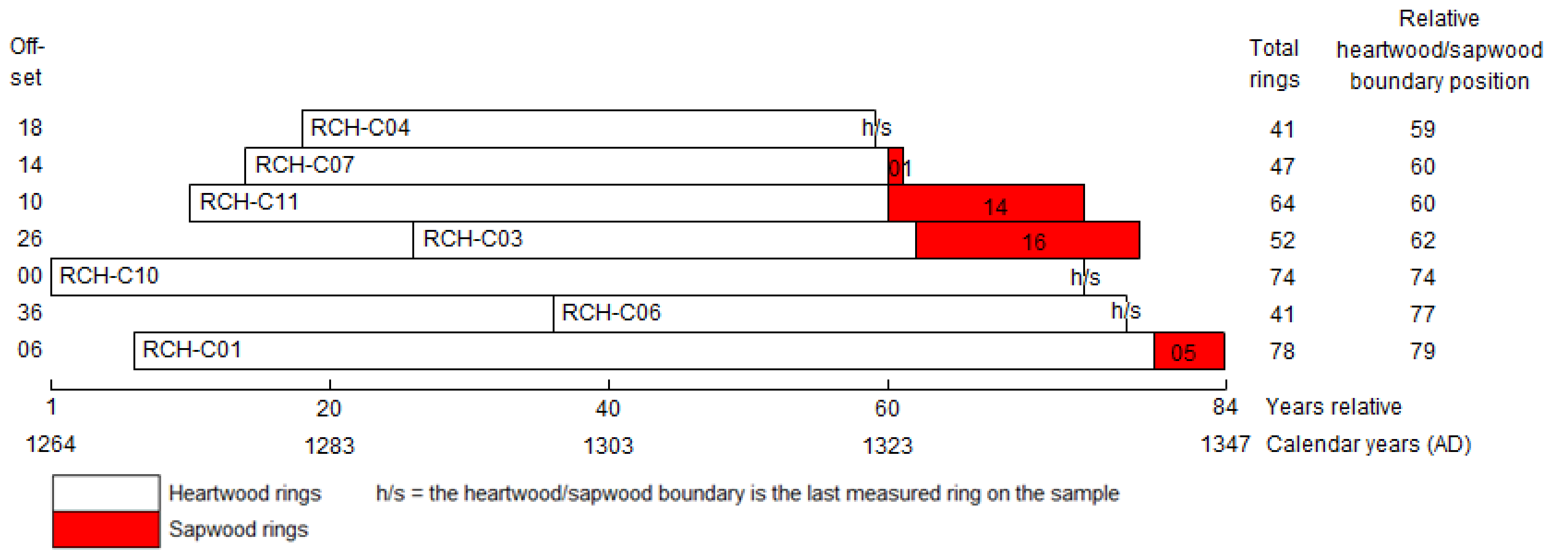

Figure 17: Bar diagram of all dated samples, sorted by heartwood/sapwood boundary ring