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RED GABLES COTTAGE,
BOYNE HILL,
CHAPELTHORPE,
CRIGGLESTONE,
WEST YORKSHIRE;

TREE-RING ANALYSIS OF TIMBERS

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SUMMARY

Analysis by dendrochronology of 15 samples obtained from the remnant timbers of Red Gables Cottage (part of a complex of three buildings to this site) has resulted in the production of a single dated site chronology comprising seven samples. All these dated samples are from the frame of the ground floor ceiling to the room extending westwards of the main timber-framed structure of Red Gables Cottage. Interpretation of the sapwood on these seven dated samples would indicate that the timbers (main beams and common joists) were all cut as part of a single programme of felling in 1590 specifically for the construction of this floor.

The remaining eight samples, all of them from various beams of the timber-framed building, are ungrouped and undated.

Thus, although the present building was constructed by one Thomas Boyne in 1623, it would appear possible that an earlier building, dating to 1590, may have already existed on the site.

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Introduction

Red Gables Cottage is one of an integral complex of three dwellings to the south side of Boyne Hill close to its junction with Wood Lane, in Chapletown, West Yorkshire, the three buildings being centred on SE 322 155 (Figs 1a/b). The other two dwellings are known as Gable Cottage and Red Gables Annexe (Fig 2), although, up to the early twentieth century, Red Gables Cottage and Gable Cottage were known collectively as Boyne Hill House. It is believed that that Boyne Hill House was constructed by one Thomas Boyne in 1623, this event being commemorated by a carved stone to the front gable of Gable Cottage inscribed *'TB AD 1623'*.

Red Gables Cottage appears to be an east-west oriented west wing of the main structure to this site. Like the other elements of the building, it has a pitched roof of stone slates with a coped western gable with a gable stack and projecting kneelers. A central door opening is present on the south side, this flanked by windows at ground and first floor levels. The roof of Red Gables Cottage is of simple construction, with one truss near the west side having only a collar and tie-beam. The purlins are staggered and trenched into the blades of this truss. Much of the timber used in this roof is re-used; however, one re-used wall-plate was also identified.

Sampling

The complex of buildings to this site has been the subject of a detailed survey and recording by Pre-Construct Archaeological Services Ltd of Saxilby, Lincolnshire (Savage and Tann 2011), who were commissioned by Ursula Bradwell Architects Ltd to prepare a Statement of Significance for submission with a planning application for proposed alterations to Red Gables Cottage, Gable Cottage/Red Gables Annexe. As part of this work a request was made that tree-ring dating be attempted on the timbers of the single remaining truss and the fragmentary remaining in-situ timbers which were uncovered during demolition of Red Gables Cottage, these comprising a few wall posts, two wall plates, and one or two other timbers (Fig 3a/b).

In addition to these structural timbers a series of timbers forming the frame of a ground floor ceiling also existed in rooms extending to the west side of the main structural frame (Fig 3c). While it appeared possible that some of the beams from the timber-framed structure might have been reused or might represent repairs or alterations, the timbers of the floor frame all appeared to be of a single phase of construction with no evidence of reuse or repair.

With the aim of fulfilling this brief, core samples were obtained from a number of different timbers which appeared suitable for tree-ring dating by reason of having sufficient rings for reliable analysis, and by appearing to be pertinent to the construction and development of Red Gables Cottage. Each sample was given the code CRG-A (for Crigglestone – site 'A'), and numbered 01–15. The sampled timbers are located on a plan provided by Pre-Construct archaeological Services Ltd, this being given as Figure 4. 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, following the schema of the survey drawings, the front of the house is taken to be facing north, the rear to be facing south.

Although there were other timbers potentially available for sampling, particularly a collection of *ex-situ* beams stored on site, these were all seen to be derived from very fast-grown trees and to have very low numbers of annual growth rings. Such timbers were not sampled. There were also a series of trusses and other timbers to the roofs of the other buildings to this site, but they were not included in the immediate request for tree-ring dating reported upon here.

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

Each of the 15 samples obtained from the timbers of both the cruck element and the rear floor-frame part of Red Gables Cottage was prepared by sanding and polishing. It was seen at this time that two of these, CRG-A12, A14, and A15, had less than the 40 rings here considered necessary to providing meaningful data and a reliable result, and these three samples were rejected from this programme of analysis. The annual growth ring widths of the remaining 12 samples were, however, measured, the data of these measurements then being compared with each other as described in the notes above.

This comparative process indicated that seven of the 12 samples (CRG-A01–A07) cross-matched with each other and could be formed into one single group, the length, relative position, and overlap of the samples being shown in the bar diagram Figure 6. These seven samples were combined at their indicated off-set positions to form CRGASQ01, a site chronology with an overall length of 207 rings. This site chronology was then satisfactorily dated by repeated and consistent comparison with a number of relevant reference chronologies for oak as spanning the years 1384 to 1590. The evidence for this dating is given in the *t*-values of Table 2.

Site chronology CRGASQ01 was then compared with the five remaining measured but ungrouped samples, but there was no further satisfactory cross-matching. Each of the five remaining measured but ungrouped samples was then compared individually with the full corpus of reference data for oak, but again there was no cross-matching, and these five individual samples must, therefore, remain undated.

Interpretation

Site chronology CRGASQ01

One of the seven dated samples, CRG-A05, in site chronology CRGASQ01, retains complete sapwood. This means that it has the last growth ring produced by the tree it represents before it was cut down, and is indicated by upper case 'C' in Table 1 and the bar diagram Figure 6. In this case the last growth ring, and thus the felling date of the tree, is dated to 1590.

Three other dated samples, CRG-A03, A06, and A07, also come from timbers which appear to have complete sapwood on them but from which (due to the soft and fragile nature of this part of the timbers) part of the sapwood has been lost from the core in sampling (this is indicated by lower case 'c' in Table 1 and the bar diagram, Figure 6). Under such circumstances it is possible, at the time of sampling, to note, in millimetres, the approximate amount lost from each core. Upon analysis at the laboratory, it is then possible to make some approximation of the number of sapwood rings the lost portion of core might have contained. In each case the estimated missing number of lost sapwood rings would strongly suggest that the three trees represented by these samples were also felled in 1590.

The exact felling date of the three final samples in site chronology CRGASQ01 cannot be precisely determined. This is either because they have no heartwood/sapwood boundary (samples CRG-A01 and A02) and are thus are missing not only all their sapwood rings but an unknown number of heartwood rings as well (and in theory could have gone on growing for many years after their last extant, heartwood, ring date), or because the sampled timber did not retain complete sapwood (CRG-A04). However, the cross-matching between these three samples and all the others is very high, suggesting that all the trees used for this floor frame were growing very close to each other in the same copse or stand of woodland. In such circumstances it might be considered unlikely that trees, originally growing close to each other, but felled at different times, would come to be used for the same sort of beam in the same building. The inference of this analysis, therefore, is that all these timbers were felled at one and the same time in 1590, specifically for the construction of this floor frame.

Ungrouped/undated samples

Five of the 12 samples which were measured remain ungrouped (that is their growth patterns do not match each other), and are undated (that is, their growth patterns do not match with any of the tree-ring reference patterns). As may be seen from Table 1 three of these ungrouped/undated samples (CRG-A08, A09, and A13) have very low numbers of rings, well below the usual minimum of 50+ rings needed for reliable matching. Samples CRG-A07 and A11, on the other hand, while having sufficient numbers of rings for reliable dating, do in fact show bands of compressed and distorted growth rings, perhaps as a result of the trees being coppiced or pollarded. It is likely that these factors interfere with the climatic input into the growth of the trees by which the tree-ring patterns are determined. It is also possible, though this cannot be proven by tree-ring analysis, that the trees have come from different locations (and are thus affected by different weather and thus have different growth patterns, and or they may be of different dates, having been salvaged from other buildings and possible reused at Red Gables Cottage.

This analysis and interpretation may be summarised as below:

Site chronology / samples	Number of samples	Number of rings	Date span	Felling date
CRGASQ01	7	207	1384–1590	1590
Undated	5	---	---	---
Unmeasured	3	---	---	---

Woodland sources

Although it is not possible to be certain as the location of the woodland source of the timbers used at Red Gables Cottage it is likely to have been relatively local. As may be seen from Table 2, which lists the sites against which site chronology CRGASQ01 has been cross-matched and dated, some of the highest t-values, ie, the greatest degrees of similarity, are found with reference data made up of timbers from some other nearby sites West Yorkshire. Most notably there is a match with an unusually high value of t=13.4 with the reference chronology from All Hallows Church, Kirkburton, about 8 miles to the southwest of Crigglestone, as well as with Peny's Hey site in Huddersfield, a little further on. It is probable that the timbers for all these sites have come from the same locality.

Conclusion

The conclusion of the tree-ring analysis undertaken here would indicate that all the dated timbers were felled at one and the same time in 1590 specifically for the construction of the floor frame. As such, this date is somewhat earlier than that, 'AD 1623' given on the inscribed stone to the front of Gable Cottage and ascribed to the builder, Thomas Boyne. Perhaps the tree-ring results obtained here suggest that there was an earlier building on the plot, which Thomas Boyne then extended and enlarged, this possibly also being represented by the un-sampled timbers of the other buildings to this complex.

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Table 1: Details of tree-ring samples from Red Roofs Cottage, Chapelthorpe, Crigglestone, West Yorkshire

Sample number	Sample location	Total rings	Sapwood rings*	First measured ring date (AD)	Heart/sap boundary (AD)	Last measured ring date (AD)
CRG-A01	Ground floor main ceiling beam, north	154	no h/s	1384	------	1537
CRG-A02	Ground floor main ceiling beam, south	120	no h/s	1388	------	1507
CRG-A03	Ground floor ceiling joist 2, north bay	124	30c	1460	1553	1583
CRG-A04	Ground floor ceiling joist 5, north bay	110	20	1468	1557	1577
CRG-A05	Ground floor ceiling joist 5, middle bay	131	39C	1460	1551	1590
CRG-A06	Ground floor ceiling joist 7, middle bay	104	20c	1485	1568	1588
CRG-A07	Ground floor ceiling joist 2, south bay	117	7c	1437	1546	1553
CRG-A08	Post 1	42	h/s	------	------	------
CRG-A09	Post 2	42	11	------	------	------
CRG-A10	Post 3	74	4	------	------	------
CRG-A11	Tiebeam 1	65	13	------	------	------
CRG-A12	Lintel	nm	---	------	------	------
CRG-A13	Wall plate 1	45	11	------	------	------
CRG-A14	Wall plate 2	nm	---	------	------	------
CRG-A15	Wall plate 3	nm	---	------	------	------

*h/s = the sample has 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 tree represented
c = complete sapwood exists on the sampled timber but all or part of the sapwood has been lost from the core in sampling
nm = sample not measured

Table 2: Results of the cross-matching of site chronology CRGASQ01 and the reference chronologies when the first ring date is 1384 and the last ring date is 1590

Reference chronology	*t*-value	
All Hallows Church, Kirkburton, W Yorks	13.4	(Arnold and Howard 2007)
East Midlands Master Chronology	9.7	(Laxton and Litton 1988)
Offerton Hall, Offerton, Derbys	9.2	(Howard *et al* 1995)
Bramall Hall, Stockport, Cheshire	8.5	(Arnold and Howard 2013 unpubl)
The Governor's House, Newark, Notts	8.5	(Arnold *et al* 2002)
Peny's Hey, Huddersfield, W Yorks	8.3	(Arnold *et al* 2008)
Tithe Barn, Bolton Abbey, W Yorks	8.1	(Arnold and Howard 2006 unpubl)
Old Durham Farm, Durham	8.1	(Howard *et al* 1995)

Site chronology CRGASQ01 is a composite of the data of the cross-matching samples as seen in the bar diagram Figure 6. This composite data produces an 'average' tree-ring pattern, where the overall climatic signal of the growth is enhanced, and the possible erratic variations of any one individual sample are reduced. This 'average' site chronology is then compared with several hundred reference patterns covering every part of Britain for all time periods. The site chronology dates only at the time span indicated, the table giving only a small selection of the very best matches as represented by '*t*-values' (ie, degrees of similarity). It may be noticed that all the *t*-values are, by standards, very high, with the match with the reference pattern made up of samples from Kirkburton (8 miles to the south-west of Crigglestone) being particularly pronounced, suggesting that the timbers used at both sites came from woodlands close to each other, and possibly from the same woodland.

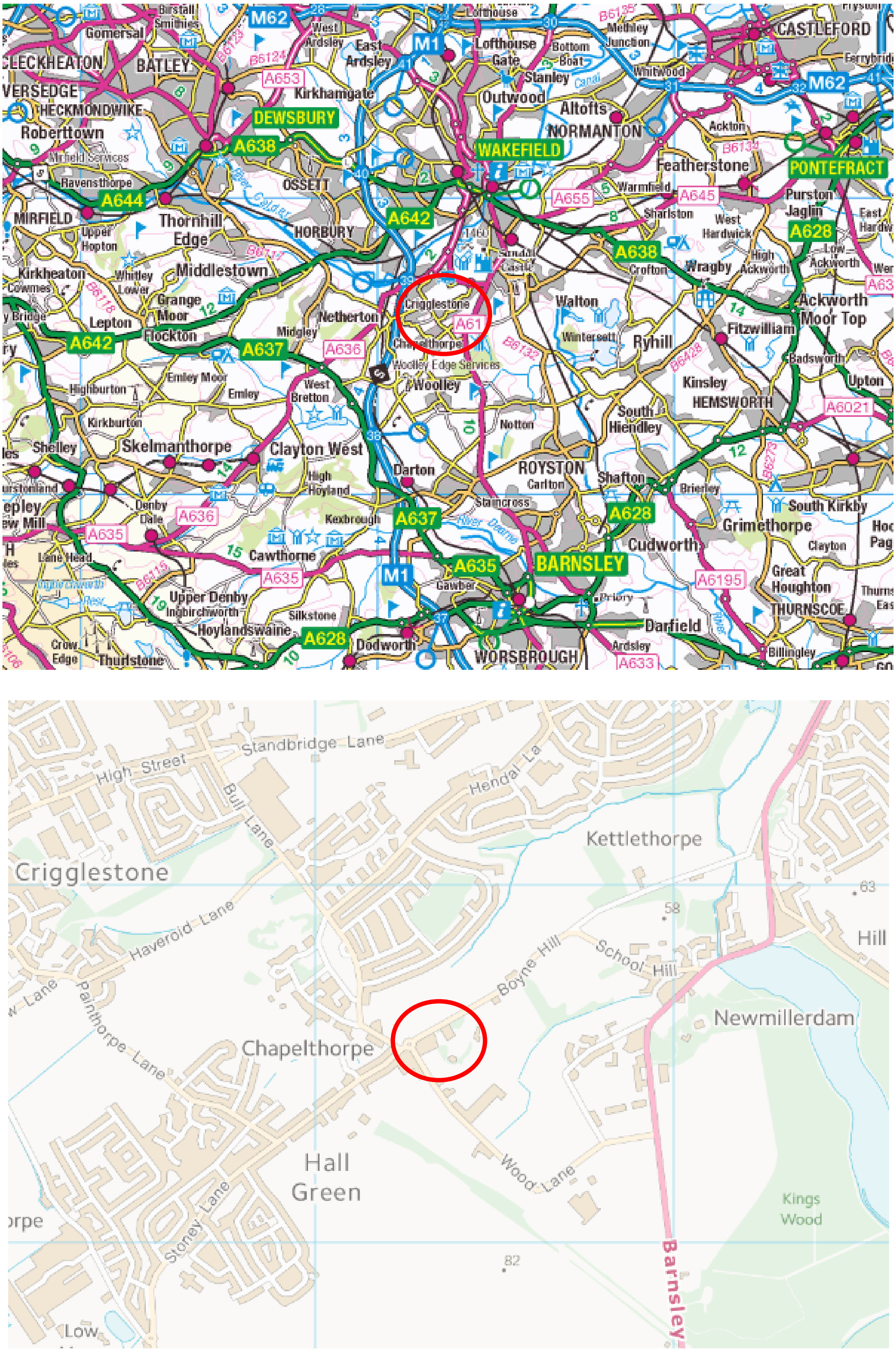


Figure 1a/b: Maps to show general location of Crigglestone (top) and the site of Red Gables Cottage (bottom)

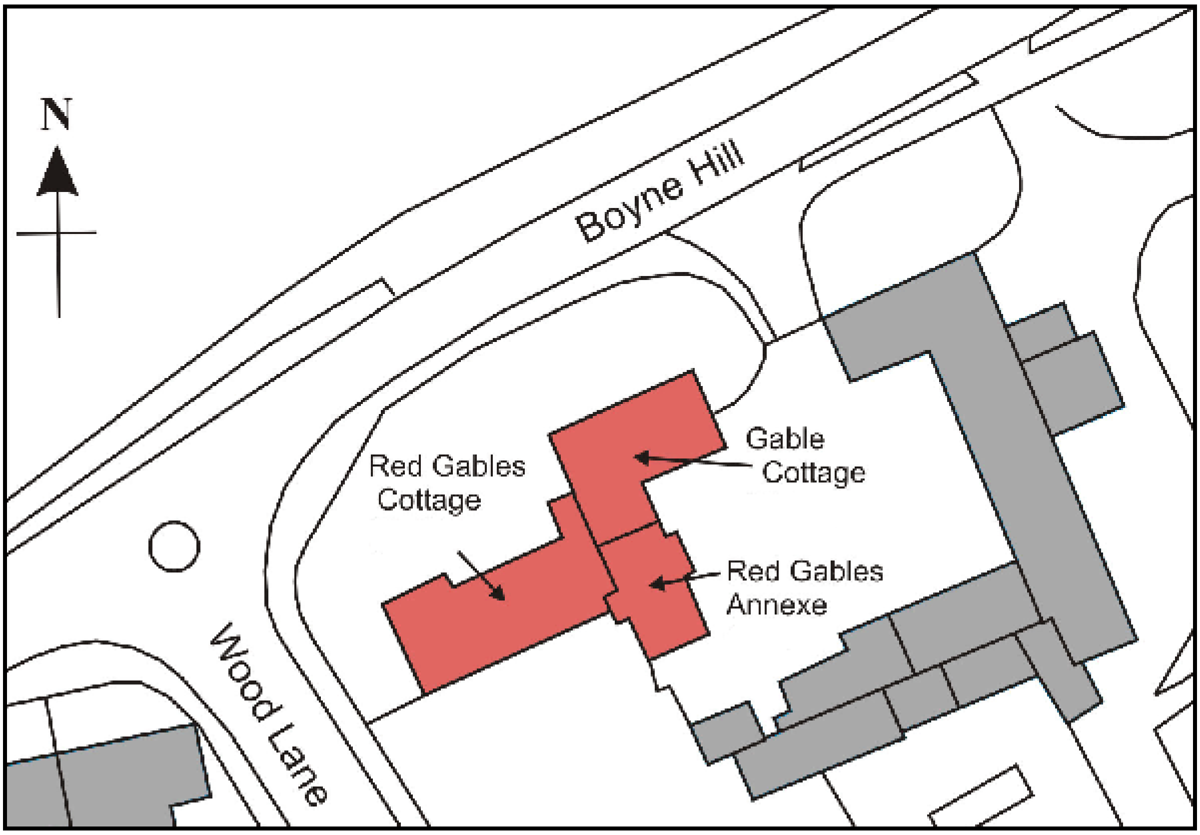


Figure 2: Plan to show layout and arrangement of the Red Gables Cottage site (after Pre-Construct Archaeological Services Ltd report Ref 716)

Figure 3a-c: Views of the fragmentary remains of the timbers and the ground floor ceiling frame

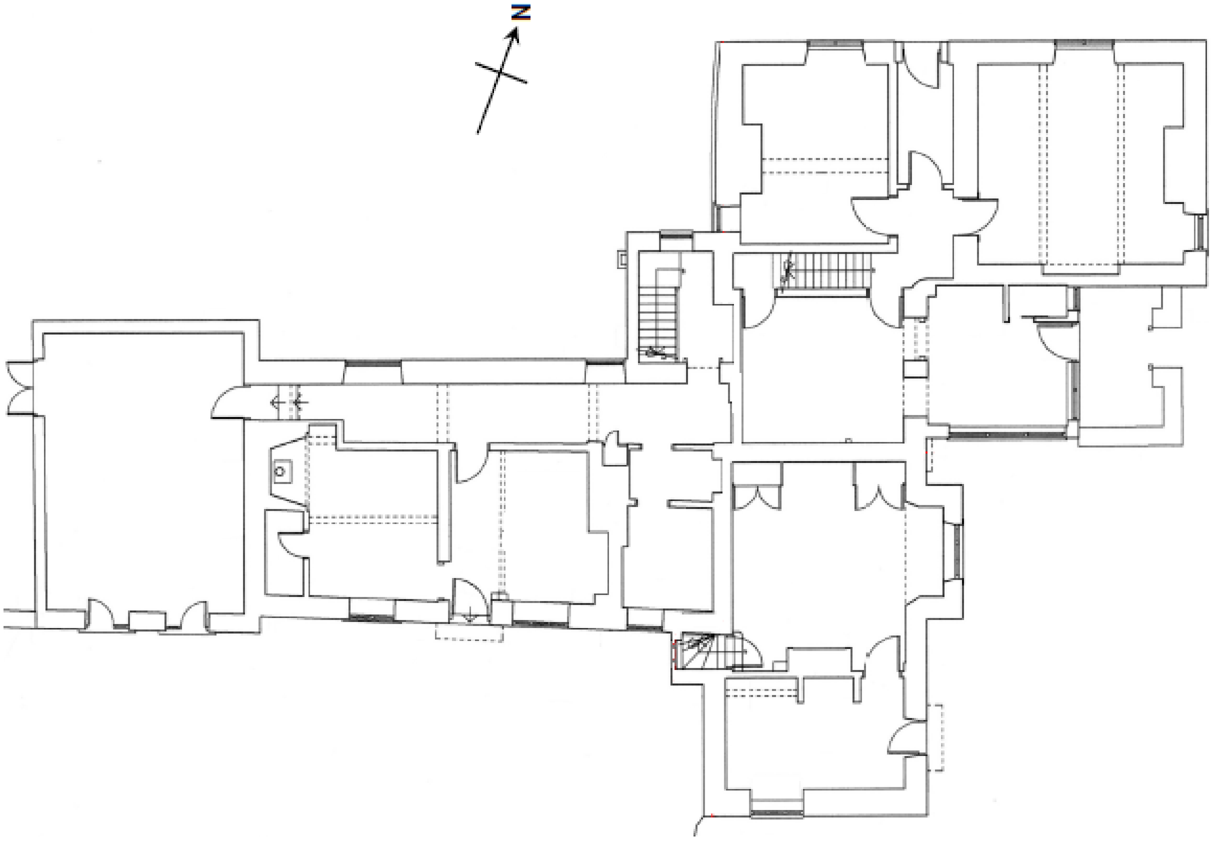


Figure 4: Plan to show approximate position of the sampled timbers
(after Pre-Construct Archaeological Services Ltd report Ref 716)

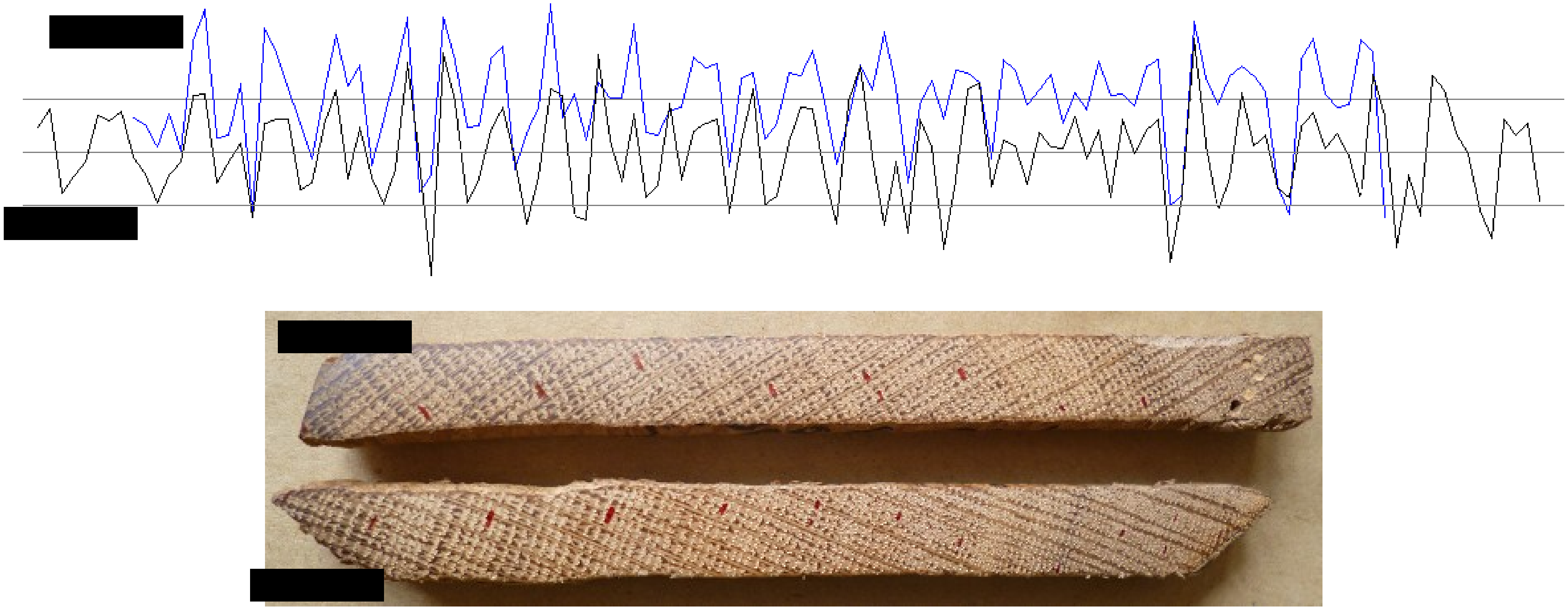
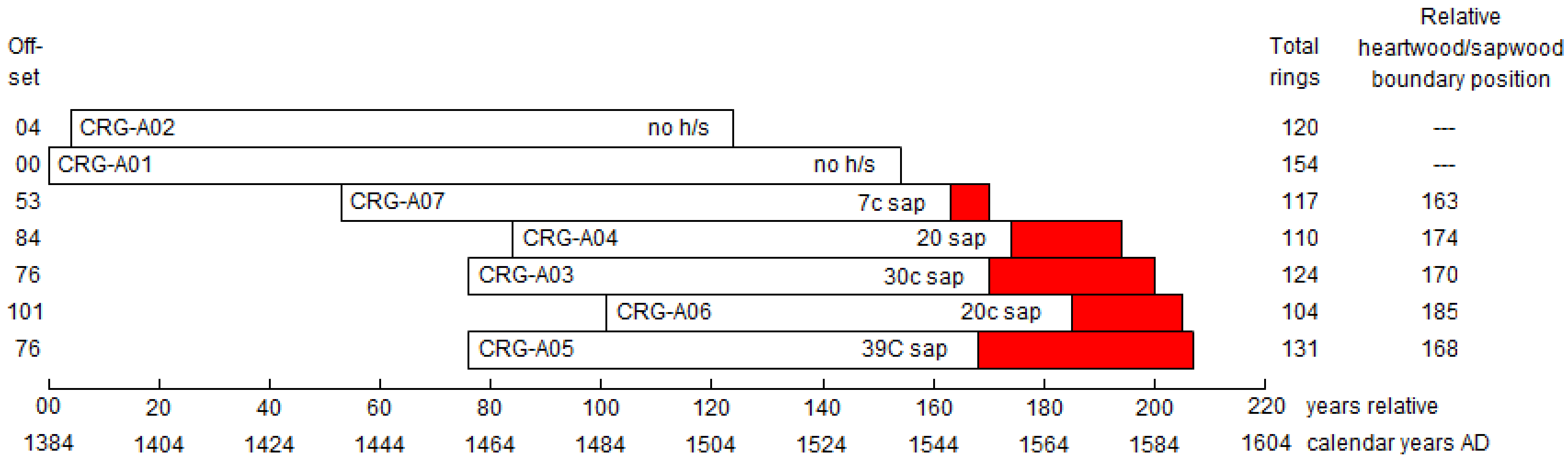


Figure 5: Graphic representation of the cross-matching of two samples, CRG-A04 and A05

When cross-matched at the correct positions, as here, the variations in the rings of the two samples 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 samples from trees grown at different times would never correspond so well.



Blank bars [ ] = heartwood rings, shaded bars [ ] = sapwood rings
h/s = heartwood/sapwood boundary, i.e., only the sapwood rings are missing
c = complete sapwood exists on the sampled timber but all or part of the sapwood has been lost from the core in sampling
C = complete sapwood is retained on the sample, the last measured ring date is the felling date of the tree represented

Figure 6: Bar diagram of the samples in site chronology CRGASQ01 at positions indicated by their grouping. The samples are 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 at the *same time* as each other in the *same place.* The samples are combined to form a 'site chronology', which is dated by comparison with the 'reference' chronologies (Table 2). One sample, CRG-A05 retains complete sapwood, the last ring produced by the tree before it was cut down, this last ring, and thus the felling of the tree, being dated to 1590. Three others (CRG-A03, A06, and A07) are from timbers which had complete sapwood but from which a small portion of this was lost from the samples in coring. An estimate of the number of rings the lost portions of sapwood contained suggests that these samples represent timbers felled in 1590 as well.

The cross-matching between these four and the remaining three samples would suggest that all the trees were growing at the same time and the same place, and are thus likely to have been felled in 1590 as well (it being unlikely that trees growing in the same place but felled at different times would eventually come to be used for the same sort of timber in the same building).