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CRAG COTTAGE
MASTILES LANE
KILNSEY
NORTH YORKSHIRE

TREE-RING ANALYSIS OF TIMBERS

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July 2017

This report was commissioned and funded by the Upper Wharfedale Heritage Group as part of their Kilnsey Landscape Research Project - 2016/17.

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CRAG COTTSGE, MASTILES LANE, KILNSEY, NORTH YORKSHIRE; TREE-RING ANALYSIS OF TIMBERS

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SUMMARY

Analysis by dendrochronology of 10 cores from this building produced three separate site chronologies, each comprising two samples, and dated two further samples individually. It would appear that different phases of felling are represented.

The earliest felling may be represented by the rear brace of the west truss, its last extant ring being dated 1168. The sample does not have any sapwood or even the heartwood/sapwood boundary, and the source tree could thus have gone on growing for a long time after this date. It is unlikely, however, to have been felled before, say, 1183

The next felling is represented by the front stub tie and post of the east truss which are probably of the same date, both timbers being felled in 1370. It is possible that the front rafter of this truss is also of this date.

The next felling is represented by the north and south stub ties of the west truss, the timber being felled at some point between 1454 at the earliest and 1479 at the latest.

The final felling is represented by the north and south posts of the west truss (these two timbers probably being cut from the same tree). It is likely that this tree was felled at some point between 1493 at the earliest and 1518 at the latest.

Two timbers, the south braces of both the west and east trusses, are undated.

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Introduction

Grade II listed Crag Cottage stands to the north side of Mastiles Lane, near the centre of Kilnsey (Fig 1a/b). The listing entry for it describes the building as a house of mid- to late-seventeenth century date, constructed of limestone rubble with gritstone dressings beneath a graduated stone slate roof. It is of two storeys and three bays of lobby entrance plan. The walling has quoins. There is a half-glazed door between bays 2 and 3, with dressed stone jambs and lintels; there are traces of a quoined jamb to right. Fenestration to the ground floor comprises, left to right: a 4-pane sash in plain stone surround, a 4-light recessed and chamfered mullion window, 2 mullions removed; far right the same, with moulded string course over. To first floor: 2-, 3-, and 3-light recessed and chamfered mullion windows directly below the eaves line. The house has stone coped gables with stacks to far left, and to ridge opposite the door (restored).

Crag Cottage has been the subject of a survey by the Upper Wharfedale Heritage Group (UWHG Report KB 08, 2015), the upstairs described as having two roof trusses, one over the housebody, and one over the parlour (Fig 2). These trusses are of interest since they are of a medieval style, perhaps of late fifteenth century date. The upper parts need to be inspected through the hatches, but the bottoms of the trusses are wall posts on shaped stone corbels. The wall post and base of the principal rafter are both mortised into a short tie spur which is braced into a timber pegged to the post and the principal rafter. There are carpenters scribed-on markings including a very large “butterfly” hewing mark. At ceiling level a collar is bolted on to reinforce the structure, but there are original pegholes and mortice for the original collar. The truss would have simple decorative arch-bracing and an upper kingpost and was designed to be part of an open hall. It may be re-used since the walling has lines of heightening and the stonework of the windows seems awkwardly put together as if re-used.

Sampling

Currently in private ownership, sampling and analysis by dendrochronology of the timbers within Crag Cottage were commissioned and generously funded by the Upper Wharfedale Heritage Group. It was hoped that tree-ring analysis might accurately and reliably determine the date of the reused timbers and demonstrate that they were of greater antiquity than the house itself and were possibly reused from one of the demolished local monastic buildings.

Thus, from the timbers available, a total of 10 samples was obtained by coring. Each sample was given the tree-ring code KLN-A (for Kilnsey, site ‘A’), and numbered 01–10. 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. The sampled timbers are located on annotated photographs taken at the time of sampling, these shown here as Figure 3a–c. In this report the front of Crag Cottage is taken to be facing site south, onto the lane, with the rear facing site north. The trusses have been numbered from east (truss 1) to west (truss 2). Although not

accessible as part of this episode of analysis, there is a substantial amount of further timbering to the roof void, much of it apparently reused.

The Nottingham Tree-ring Dating Laboratory would firstly like to thank the Owners of Crag Cottage, Pat and Rob Harrison, for agreeing to this programme of work, and for being so helpful and cooperative at the time of sampling. We would also like to thank the Upper Wharfedale Heritage Group for commissioning and funding this programme of tree-ring analysis, for arranging access to the house, and for their considerable help during sampling, appreciation particularly due to Alison Armstrong and Philip and Patricia Carroll. We would also like to thank the UWHG for providing their survey report from which introductory information above is taken, and for the use of their plans and cross-sections elsewhere in this report).

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 (see Fig 4).

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 10 samples obtained from the various timbers of Crag Cottage were prepared by sanding and polishing, and the widths of their annual growth rings were measured. The data of these measurements were then compared with each other as described in the notes

above, this comparative process indicating that three separate groups of cross-matching samples could be formed, each group comprising two samples. The cross-matching samples of each group were combined at their indicated off-set positions to form site chronologies KLNASQ01, KLNASQ02, and KLNASQ03.

Each site chronology was then compared with the full corpus of reference chronologies for oak, this indicating a repeated and consistent series of cross-matches. Each of the three site chronologies was then compared with the four remaining ungrouped samples, but there was no further cross-matching. The four ungrouped samples were, therefore, compared individually with the full corpus of reference material, this indicating cross-matches and dates for two of these individuals, KLN-A04 and A05, with date spans of 1164 – 1308 and 1026 – 1168, respectively.

This analysis may be summarised thus:

Site chronology	Samples	Length	Date span
KLNASQ01	KLN-A01 & A03	117	1254 – 1370
KLNASQ02	KLN-A07 & A10	59	1387 – 1445
KLNASQ03	KLN-A06 & A09	57	1427 – 1483
------	KLN-A04	145	1164 – 1308
------	KLN-A05	143	1026 – 1168
------	KLN-A02 & A08	---	undated

Interpretation

Sample KLN-A05

The earliest felling is possibly represented by sample KLN-A05 from the north (rear) brace of truss 2 (the west truss), the earliest ring on the sample being dated 1026, the last extant ring being dated 1168. This sample, however, does not have any sapwood or even the heartwood/sapwood boundary, and the tree could thus have continued growing for many years after this date. It is possible that it was felled in the late fourteenth century (see below), but if it were, it would have been approaching 400 years of age when cut. While such an age is not unknown in tree ring analysis in this country, it is somewhat rare. In any case, in round terms, the tree is unlikely to have been felled before, say, 1185.

Site chronology KLNASQ01

The next felling is represented by the south stub tie and post of truss 1, the east truss (respectively samples KLN-A01 and A03). Sample KLN-A01 has complete sapwood on it (ie, it has the last growth ring produced by the tree before it was felled), this last ring, and thus the felling of the tree, being dated to 1370. Sample KLN-A03 is also from a timber with complete sapwood, and although this disintegrated during coring because of its soft and fragile nature,

it is estimated that the amount of sapwood lost would give this timber a felling date of, or about, 1370 as well.

Sample KLN-A04

It is possible that the south principal rafter of truss 1 (sample KLN-A04) is also of, or about, 1370. The sample has a last ring date of 1308, but again does not have any sapwood on it, and again it could have gone on growing for many more years. However, given the size of the timber and its likely age at felling (it would have been about 250 years of age when cut), it is perhaps more likely to be of late-fourteenth century date than not.

Site chronology KLNASQ02

The next felling is represented by samples KLN-A07 and A10, respectively the north and south stub ties of truss 2. Taking the date of the heartwood/sapwood boundary on the two samples, and allowing for likely amounts of missing sapwood it is likely that the timber used for them (it being possible that these two pieces have been cut from the same tree) was felled at some point between, say, 1455 at the earliest and 1480 at the latest

Site chronology KLNASQ03

The final phase of felling is represented by samples KLN-A06 and A09, respectively the north and south posts of truss 2 (it again being highly likely that these two timbers have been cut from a single tree). Again taking the date of the heartwood/sapwood boundary on the two samples and allowing for likely missing sapwood, it is probable that the tree was felled at some point between 1493 at the earliest and 1518 at the latest.

The relative positions of all eight cross-matched and dated samples are shown in the bar diagram, Figure 5.

Woodland source

It is occasionally possible in programmes of tree-ring analysis to make some comments about the possible location of the woodland source, or sources, of the timber used in a building. This is usually done by noting with which reference chronologies a site chronology cross-matches; sometimes the best cross-matches (that is the closest similarities) appear to be concentrated in one particular district or region (despite the site chronology having been compared with reference data from all parts of England).

In the case of Crag Cottage, however, although as may be seen from Tables 2 – 6 there are indeed a good number of relatively local, regional, reference chronologies listed, with sites in Cumbria, Co Durham, Lancashire, and perhaps particularly Yorkshire, appearing often, there are no especially close local cross-matches. As will also be seen, sites from as far away as Derbyshire, Leicestershire, and Warwickshire are also listed.

This is in part due to the fact that are still relatively few reference chronologies available for the region of North Yorkshire under study in this programme of tree-ring dating, meaning that cross-matches must be sought further afield. The lack of more local cross-matching is also possibly due to the slightly more 'scattered' nature of the dates obtained at Crag Cottage, with most dates represented by only two timbers, and on some cases, single timbers. This means that the data under comparison has a weaker climatic signal might otherwise be the case if each date were represented by several timbers. This slight lack of multiple-timber dates may also account for the slightly lower than usual t-values which are listed, which, although not particularly high, are maximum values and are repeated and consistent. Taking these factors into account, however, it is still possible to suggest, perhaps not unexpectedly, that the timbers used at Crag Cottage are of regional origin.

Undated samples

Two samples, KLN-A02 and A08, remain ungrouped and undated. As may be seen from Table 1, both samples have sufficient numbers of rings for reliable dating. However, while sample KLN-A08 shows no such problems, sample KLN-A04 does have a short band of slightly distorted rings in the early years of its growth. It is possibly this which makes cross-matching and dating of this sample impossible. It is, however, a common feature of most programmes of tree-ring analysis to have some samples which remain undated.

Table 1: Details of tree-ring samples from Crag Cottage, Kilnsey, North Yorkshire

Sample number	Sample location	Total rings	Sapwood rings*	First measured ring date (AD)	Heart/sap boundary (AD)	Last measured ring date (AD)
KLN-A01	South (front) stub tie, truss 1 (east truss)	117	19C	1254	1351	1370
KLN-A02	South hanging brace, truss 1	87	2	------	------	------
KLN-A03	South post, truss 1	89	h/s c	1261	1349	1349
KLN-A04	South principal rafter, truss 1	145	no h/s	1164	------	1308
KLN-A05	North (rear) brace, truss 2 (west truss)	143	no h/s	1026	------	1168
KLN-A06	North post, truss 2	57	6	1427	1477	1483
KLN-A07	North stub tie, truss 2	53	h/s	1387	1439	1439
KLN-A08	South hanging brace, truss 2	79	no h/s	------	------	------
KLN-A09	South post, truss 2	50	1	1429	1477	1478
KLN-A10	South stub tie, truss 2	52	6	1394	1439	1445

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

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

c = complete sapwood is found on the timber but a portion has been lost from the sample in coring

Table 2: Results of the cross-matching of site chronology KLNASQ01 and the reference chronologies when the first ring date is 1254 and the last ring date is 1370

Reference chronology	*t*-value
Merchant Taylor's Hall, York, West Yorkshire	6.1
Lancaster Castle, Lancashire	5.6
'Westroyd', Hunsworth, West Yorkshire	5.3
Carlisle, Cumbria – composite chronology	5.2
Tithe Barn, Carlisle, Cumbria	4.9
Kirkby Thore Hall, Kirkby Thore, Cumbria	4.8

Table 3: Results of the cross-matching of site chronology KLNASQ02 and the reference chronologies when the first ring date is 1387 and the last ring date is 1445

Reference chronology	*t*-value
Governor's House, Newark, Nottinghamshire	4.8
Tithe Barn, Bolton Abbey, North Yorkshire	4.3
35 Church Street, Eckington, Derbyshire	4.1
Thatched Barn, Tow House, Northumberland	4.0

Table 4: Results of the cross-matching of site chronology KLNASQ03 and the reference chronologies when the first ring date is 1427 and the last ring date is 1483

Reference chronology	*t*-value
Church of St Nicholas, Stanford, Northamptonshire	5.1
St Mary's Church, Neen Savage, Shropshire	4.9
Kingsbury Hall, Kingsbury, Warwickshire	4.9
Buildwas Abbey, Shropshire	4.9
St Thomas a Becket, Tugby, Leicestershire	4.7
Mansfield Woodhouse Priory, Nottinghamshire	4.5

Table 5: Results of the cross-matching of sample KLN-A04 and the reference chronologies when the first ring date is 1164 and the last ring date is 1308

Reference chronology	*t*-value
Finchale Priory, Brasside, Durham	5.3
Manor House, Medbourne, Leicestershire	5.0
Chapter House, York Minster, York	4.7
Ling Bob Farm, Horseforth, West Yorkshire	4.7
33 Goodramgate, York	4.5
Lancaster Castle, Lancashire	4.4
Kirkby Thore Hall, Kirkby Thore, Cumbria	4.3
Seaton Holme, Easington, County Durham	4.3

Table 6: Results of the cross-matching of sample KLN-A05 and the reference chronologies when the first ring date is 1026 and the last ring date is 1168

Reference chronology	*t*-value
St Hugh's Choir, Lincoln Cathedral	7.5
Dacre Hall, Lanercost Priory, Cumbria	6.9
Timber loft, The College, Durham Cathedral	5.9
33 Goodramgate, York	5.2
All Hallow's Church, Kirkburton, West Yorkshire	4.8
Seaton Holme, Easington, County Durham	4.8
Angel Choir, Lincoln Cathedral	4.8
Carlisle, Cumbria – composite chronology	4.7

Site chronologies KLNASQ01 – SQ03 are composites of the data of the relevant cross-matching samples as seen in the bar diagrams below. The composite data produces 'average' tree-ring patterns, where the possible erratic variations of any one individual sample are reduced and the overall climatic signal of the group is enhanced. These 'average' site chronologies are then compared with several hundred reference patterns covering every part of Britain for all time periods, cross-matching with a number of these only at the date spans indicated. The Table 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 although the resultant *t*-values are sometimes lower than might be expected, they are repeated and consistent and are well in excess of the *t*=3.5 value usually taken as the minimum acceptable level for satisfactory dating.

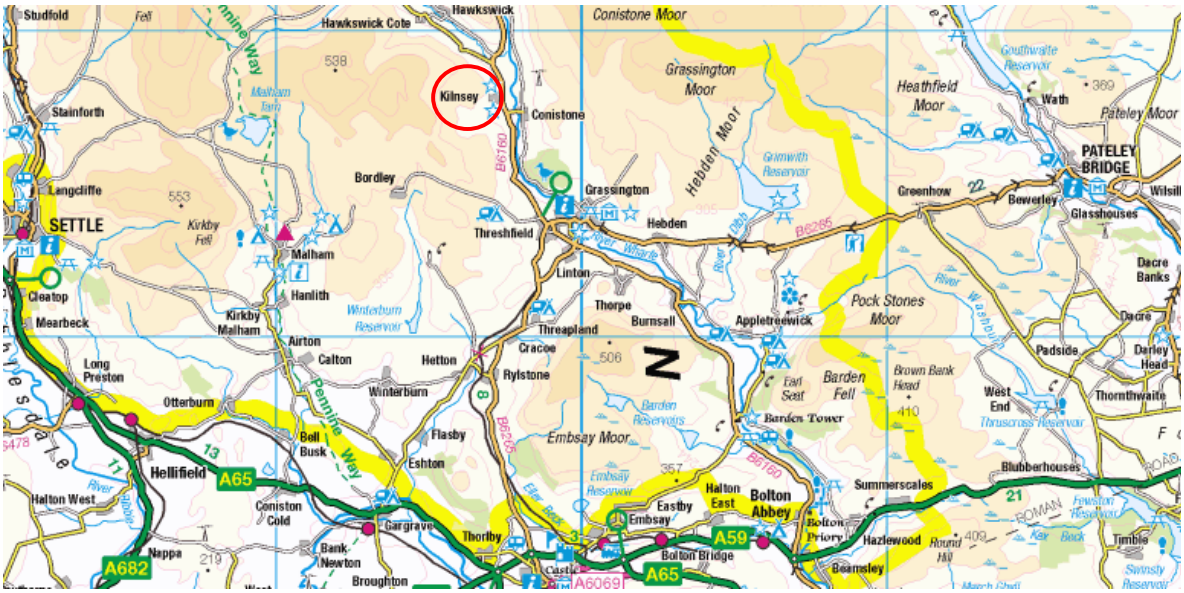


Figure 1a/b: Maps to show the location of Kilnsey (top) and Crag Cottage (bottom)

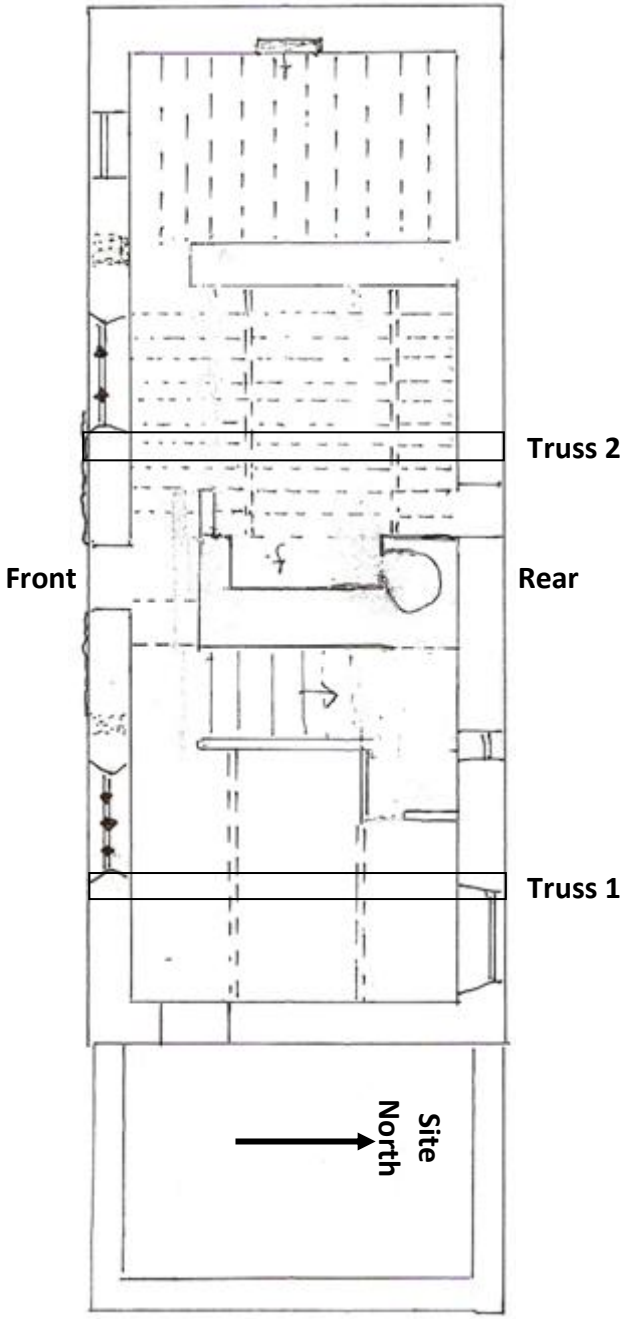
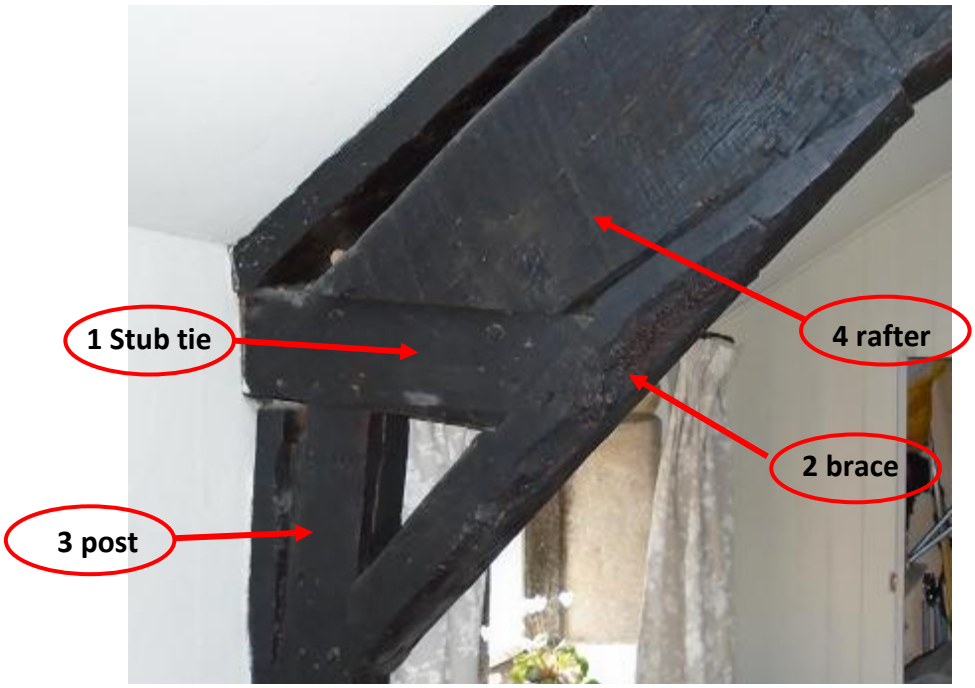


Figure 2: Ground floor plan of Crag Cottage to show layout and arrangement of the trusses (after Upper Wharfedale Heritage Group report KB 08)



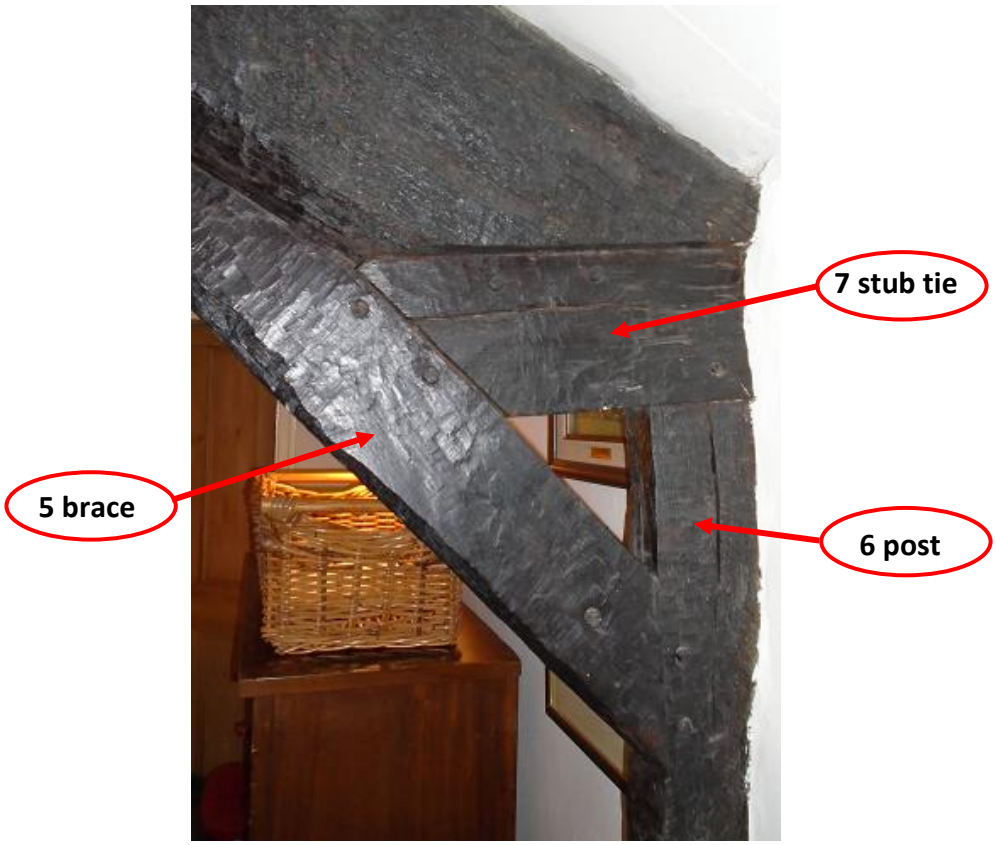


Figure 3a/b: Photographs to help locate sampled timbers. Truss 1 (east truss), south side/front (top). Truss 2 (west truss), north side/rear (bottom)

Figure 3c: Photograph to help locate sampled timbers. Truss 2 (west truss), south side/front

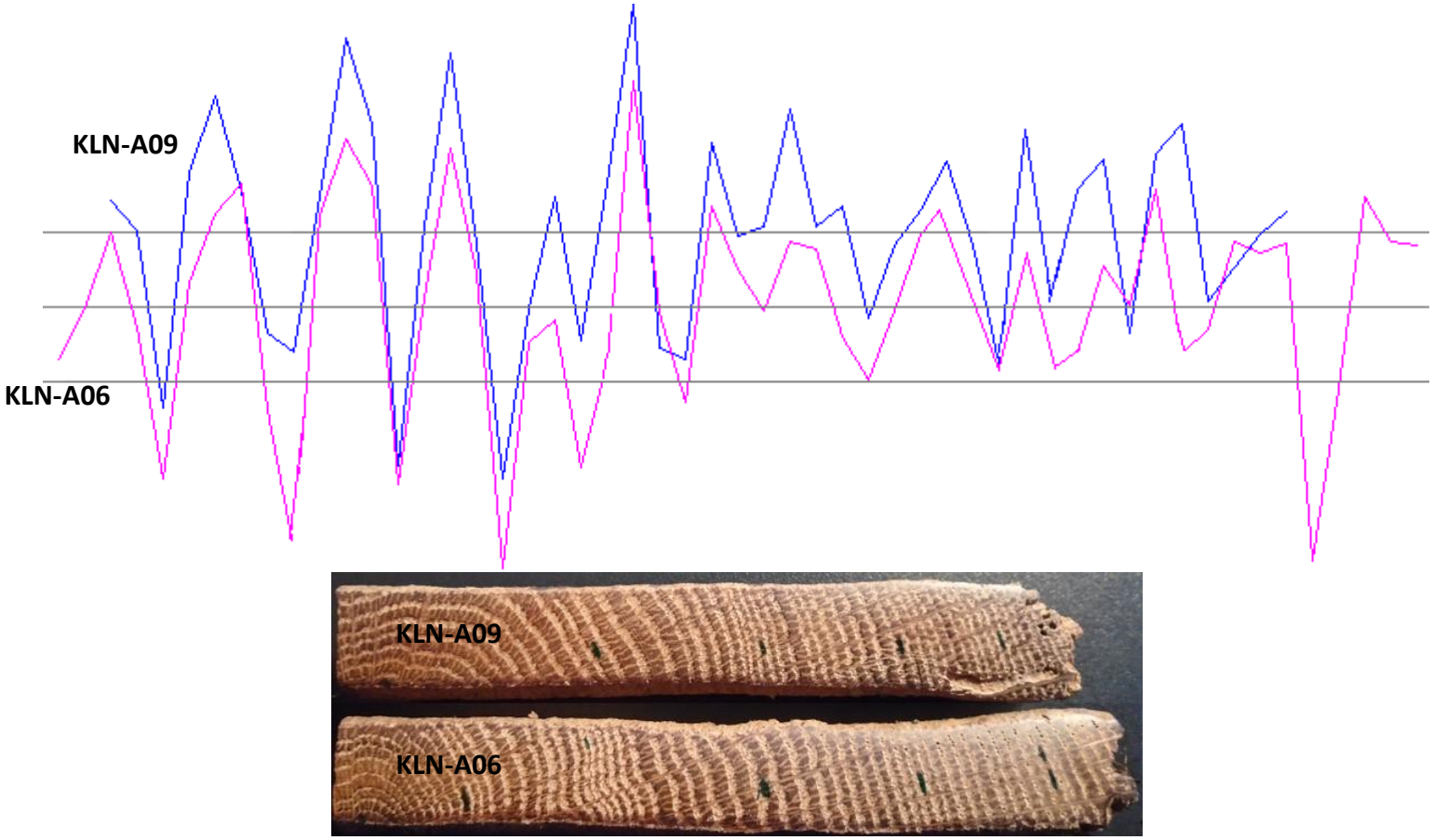
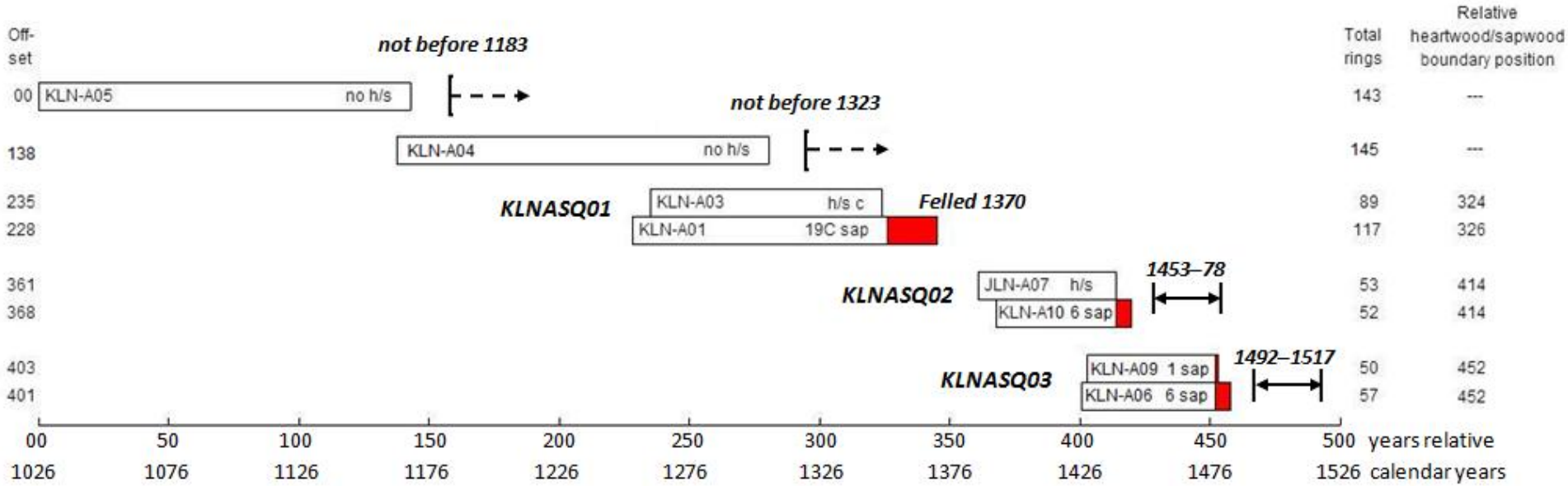


Figure 4: Graphic representation of the cross-matching of two samples, KLN-A06 and A09

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



blank bars = heartwood rings, shaded bars = sapwood rings
h/s = heartwood/sapwood boundary, i.e., only the sapwood rings are missing
C = complete sapwood is retained on the samples, the last measured ring date is the felling date of the tree represented
c = complete sapwood is found on the timber but a portion has been lost from the sample in coring

Figure 5: Bar diagram of all cross-matched samples the in last measured ring date order

The samples of the three site chronologies, KLNASQ01, SQ02, and SQ03, are shown here in the form of bars at positions where their ring variations 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 of each cross-matching group are combined to form a 'site chronology', which is dated by comparison with the 'reference' chronologies (see Tables 2–4). Samples KLN-A04 and A05 have been dated individually (Tables 5 & 6).