TREE-RING ANALYSIS OF TIMBERS FROM THE SHIP INN, 14 MARKET PLACE, COCKERMOUTH, CUMBRIA

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SUMMARY

Analysis by dendrochronology of 40 samples obtained from various timbers in this building has resulted in the production of a single site chronology comprising 28 of the 36 samples which were measured (four samples having insufficient rings for reliable analysis). This site chronology has an overall length of 115 rings, these rings dated as spanning the years 1584–1698.

Interpretation of the sapwood on the samples would indicate that all the dated timbers were cut in 1698 as part of a single programme of felling specifically for works on this building.

Eight measured samples remain ungrouped and undated.

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Introduction

Number 14, Market Place, Cockermouth, the building now occupied by the Ship Inn, stands to the north side of the street (NY 123 307, Figs 1a/b), and is one of a short row of buildings forming an historic group in this part of the town. The Ship Inn presents a broad three-storied front of four bays with a dentilled cornice and quoins beneath a slate roof (hereafter referred to as building 1), to the rear of which projects a second, narrower, building also of three floors (building 2). Attached to the rear of building 2 is a third and final building (building 3), this being of two floors only.

Within, the ceilings of the ground and, to buildings 1 and 2 only, the second floors, comprise three substantial main joists between which run smaller common joists (the timbers to both ground and first floor ceilings of building 2 are, however, modern replacements). The roofs to buildings 1 and 3 are each formed by two principal rafter-with-tie-beam trusses, the two roof trusses to building 2 also being of principal rafter and tie-beam form but in addition also having a collar. In all cases the trusses carry double purlins to each pitch of the roof along with a ridge beam (Figs 2a–c). There are no wall plates visible, and apart from a few door and window lintels, there is no timber framing to the walls. Building 1 has a cellar beneath it, this containing a single beam to its ceiling.

Although the facade to the street frontage is clearly of late-seventeenth or early-eighteenth century date, the stonework within, and the form of some of the door and window openings, would suggest that the building is substantially older. There is also a spiral stone staircase. The architectural details of these features, however, are not sufficiently clear to indicate a specific date for its construction.

Sampling

Thus, in an attempt to establish a more reliable date for the building, sampling and analysis by tree-ring dating of the timbers within were commissioned by Philip Cracknell, consulting archaeologist. This programme of tree-ring dating was undertaken in conjunction with a survey and drawn record of the building, and as part of a research project on its history and development. It was hoped that tree-ring analysis would determine the date of each of the three parts of the building and establish how the buildings had developed over time.

A further aim of this programme of analysis was to help with the establishment of a reliable, well-replicated, tree-ring reference chronology for this region. As indicated in the notes on tree-ring dating below, dendrochronology relies on having a corpus of reference material with wide temporal and geographical application against which site chronologies from undated buildings can be compared and matched, and thus be dated. Recent research on timber framed buildings in other parts of Cumbria has intimated, however, that many of the reference chronologies currently available for the region appear to be of limited applicability. This may perhaps be as a result of the small number of samples each of the currently available reference chronologies contains, but may also be a result of the varied Cumbrian geography which divides the region into several small micro-climate zones, making it more difficult to create a set of regional reference chronologies here than might be the case in other parts of England. It was hoped that by obtaining a large number of samples from a single building a well replicated, widely applicable reference chronology could be created.

With the aim of fulfilling this double brief, core samples were obtained from 40 different seemingly suitable timbers located in all parts of the three buildings. Each sample was given the code CKM-B (for Cockermouth – site 'B'), and numbered 01–40. The sampled timbers are located on plans made and provided by Philip Cracknell/Alpha Designs, on simple schematic drawings based on sketches made at the time of sampling, or on photographs of the relevant timbers. These locations are shown here as Figures 3a–4d. 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, and on the drawings, the trusses, bays, and individual timbers, have been located on a site north–south/east–west basis as appropriate.

The Nottingham Tree-ring Dating Laboratory would like to take this opportunity to thank the owner of the Ship I n Cusack, along with his staff, for his help, cooperation, and enthusiasm with this programme of tree-ring analysis. We would also like to acknowledge his generous hospitality. The Laboratory would also like to thank the Cumberland and Westmorland Antiquarian and Archaeological Society for their generous funding of this programme of research. Finally, we would like to thank Philip Cracknell not only for organising this research project and for putting considerable effort into both the financial and practical arrangements for sampling, but also for the very prompt provision of plans and drawings.

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 found preserved in archaeological excavations) 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 any number of consecutive years is unique, so too is the growth-ring pattern of the tree. The pattern of a short 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. 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 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 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

All 40 samples obtained from the various timbers of the Ship Inn were prepared by sanding and polishing. It was seen at this time that four samples had fewer than 50 rings, the minimum here deemed necessary for reliable dating, and these were rejected from this programme of analysis. The annual growth ring widths of the remaining 36 samples were, however, measured, the data of these measurements then being compared with each other as described in the notes above. By this process a single group of 28 samples could be formed, the samples cross-matching with each other at the positions as shown in the bar diagram Figure 6. The 28 cross-matching samples were combined at these off-set positions to form CKMBSQ01, a site chronology with an overall length of 115 rings. This site chronology was then satisfactorily dated by repeated and consistent comparison with a large number of relevant reference chronologies for oak as spanning the years 1584 to 1698. The evidence for this dating is given in the *t*-values of Table 2.

Site chronology CKMBSQ01 was compared with the eight remaining measured but ungrouped samples, but there was no further satisfactory cross-matching. The eight ungrouped samples were then compared individually with the full corpus of reference data, but again there was no further satisfactory matching, and all eight samples must, therefore, remain undated.

Interpretation

Analysis of 36 of the 40 samples obtained from this site (four samples having insufficient rings for reliable dating) has produced a single dated site chronology, CKMBSQ01, comprising 28 samples, all of them from the roof. This site chronology has a last measured ring date of 1698.

No fewer than 18 of the 28 cross-matching and dated samples in site chronology CKMBSQ01 retain complete sapwood on their respective cores. This means that such samples have the last growth ring produced by the trees they represent before they were cut down (this indicated by upper case 'C' in Table 1 and the bar diagram Fig 6). In each case the date of this last growth ring, and thus the felling date of the tree, is identical at 1698.

The ten remaining dated samples in site chronology CKMBSQ01 retain some sapwood or at least the heartwood/sapwood boundary, indicated by 'h/s' in Table 1 and the bar diagram (this latter meaning that all the sapwood rings, but *only* the sapwood rings, have been lost from the timbers). This means that it is not possible to obtain a precise felling date for the timbers these 10 samples represent. However, given that the relative position of the heartwood/sapwood boundary on these further samples is at a very similar position to that on the 18 samples from the timbers whose felling date is known, there is little reason to suspect that the timbers they represent were not all felled in, or very close to, 1698 as well.

Undated timbers

Eight measured samples remain ungrouped and undated. Although one of these samples has the minimum number of rings, 50, required for reliable dating, all the others are longer, the longest having 119 rings. It is noticeable that a number of these ungrouped/undated samples have bands or sections of compressed and narrow rings (Fig 7). It is possible, but not at all certain, that this has been caused by some abiotic input other than the weather, such as shredding, pollarding or coppicing, this disturbing the climate pattern in the growth by which the rings are cross-matched and dated. The fact that a number of different timbers show this effect, however, would suggest that the trees represented had been grown in the same general woodland area under the management regime, and are therefore likely to be of the same date as each other. It is noticeable that the largest number of ungrouped/undated samples is to be found concentrated in the roof of building 2, again suggesting that they had all been felled at the same time as each other specifically for this part of the building.

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Table 1: Details of tree-ring samples from the Ship Inn, 14 The Market Place, Cockermouth, Cumbria

Sample number	Sample location	Total rings	Sapwood rings*	First measured ring date (AD)	Heart/sap boundary (AD)	Last measured ring date (AD)
	Building 1, first-floor					
CKM-B01	West ceiling beam	114	26C	1585	1672	1698
CKM-B02	Middle ceiling beam	107	26C	1592	1672	1698
CKM-B03	East ceiling beam	107	42C	1592	1656	1698
CKM-B04	Lintel to kitchen door	nm	---	------	------	------
CKM-B05	Lintel to stair passage	108	22	1585	1670	1692
	Building 1, roof					
CKM-B06	North (rear) principal rafter, truss II (east)	76	24	1619	1670	1694
CKM-B07	North lower purlin, truss II – east gable	96	29C	1603	1669	1698
CKM-B08	North lower purlin, truss I – II	nm	---	------	------	------
CKM-B09	North upper purlin, truss I – II	61	13	------	------	------
CKM-B10	South (front) principal rafter, truss II	104	18	1588	1673	1691
CKM-B11	South lower purlin, truss I – II	61	no h/s	------	------	------
CKM-B12	North principal rafter, truss I (west)	73	21	1618	1669	1690
CKM-B13	South principal rafter, truss I	102	23C	1597	1675	1698
	Building 1 – 2					
CKM-B14	West purlin	57	h/s	1616	1672	1672
CKM-B15	East purlin	57	20	1636	1672	1692

Table 1: continued

Sample number	Sample location	Total rings	Sapwood rings*	First measured ring date (AD)	Heart/sap boundary (AD)	Last measured ring date (AD)
	Building 1, ground floor (front bar)					
CKM-B16	East ceiling beam (over bar)	115	29C	1584	1669	1698
CKM-B17	Middle ceiling beam	58	h/s	1619	1676	1676
CKM-B18	West ceiling beam (adj door)	107	23C	1592	1675	1698
	Building 3, ground floor (rear room)					
CKM-B19	North ceiling beam (to rear/far end)	110	33C	1589	1665	1698
CKM-B20	Middle ceiling beam	107	35C	1592	1663	1698
CKM-B21	South ceiling beam (by entry)	113	36C	1586	1662	1698
	Building 3, roof					
CKM-B22	East lower purlin, truss II – south gable	96	34C	1603	1664	1698
CKM-B23	Tiebeam, truss II (south truss)	103	41C	1596	1657	1698
CKM-B24	East principal rafter, truss I (north truss)	60	21C	1639	1677	1698
CKM-B25	Tiebeam, truss I	105	22C	1594	1676	1698
CKM-B26	East lower purlin truss I – north gable	82	48C	1617	1650	1698
CKM-B27	West principal rafter, truss II	94	27C	1639	1671	1698
CKM-B28	West principal rafter, truss I	109	23C	1590	1675	1698
CKM-B29	East principal rafter, truss II	114	21C	1585	1677	1698

Table 1: continued

Sample number	Sample location	Total rings	Sapwood rings*	First measured ring date (AD)	Heart/sap boundary (AD)	Last measured ring date (AD)
	Building 2, roof					
CKM-B30	East principal rafter, truss II (south truss)	80	14	1607	1672	1686
CKM-B31	East lower purlin, truss I – II	71	10	1614	1676	1686
CKM-B32	East lower purlin, truss II – south gable	101	22	------	------	------
CKM-B33	East principal rafter, truss I (north truss)	119	40C	------	------	------
CKM-B34	West principal rafter, truss I	nm	---	------	------	------
CKM-B35	East upper purlin, truss I – II	75	24	------	------	------
CKM-B36	West principal rafter, truss II	62	17	1630	1674	1691
CKM-B37	West lower purlin, truss I – II	75	h/s	------	------	------
	Miscellaneous timbers					
CKM-B38	Window lintel 21	nm	---	------	------	------
CKM-B39	Lintel to ground floor doorway	95	h/s	------	------	------
CKM-B40	Cellar ceiling beam	50	h/s	------	------	------

*h/s = the last measured ring on the sample is at the heartwood/sapwood boundary, ie, only the sapwood rings are missing

C = complete sapwood is retained on the sample; where dated the last measured ring date is the felling date of the tree represented

nm = sample not measured

Table 2: Results of the cross-matching of site chronology CKMBSQ01 and relevant reference chronologies when the first ring date is 1584 and the last ring date is 1698

Reference chronology	***t*-value**	
England Master Chronology	9.8	(Baillie and Pilcher 1982 unpubl)
Turton Tower, Blackburn with Darwen, Lancs	7.8	(Arnold and Howard 2008)
Cromford Bridge House, Cromford, Derbys	7.0	(Arnold and Howard 2007 unpubl)
Staircase House, Stockport, Greater Manchester	6.9	(Howard *et al* 2003)
Bolsover Castle (Little Castle) Bolsover, Derbys	6.4	(Arnold *et al* 2003)
Bolsover Castle (Riding House) Bolsover, Derbys	6.3	(Arnold *et al* 2005)
Brewhouse Yard Museum, Nottm	6.3	(Howard *et al* 1994)
15/17 St John's Street, Wirksworth, Derbys	6.0	(Howard *et al* 1995)

Site chronology CKMBSQ01 is a composite of the data of the 28 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 ring 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. As can be seen here, CKMBSQ01 matches only when its 115 rings span the years 1584–1698, the table above giving only a small selection of the very best matches with reference chronologies as represented by '*t*-values' (ie, degrees of similarity).

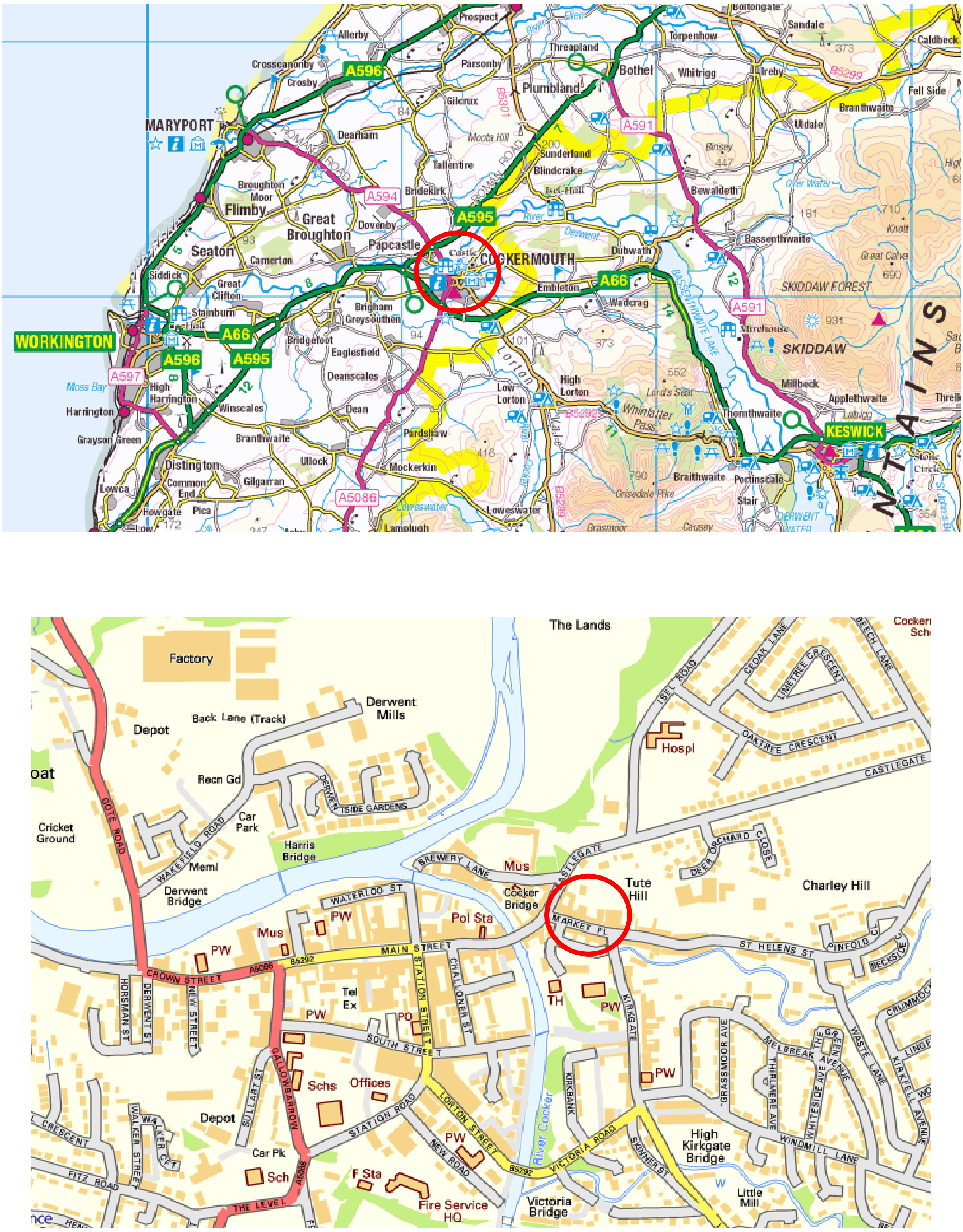


Figure 1a/b: Maps to show location of Cockermouth (top) and the Ship Inn on the Market Place (bottom)

Figure 2a-c: Views of the roof trusses: building 1 (top), 2 (middle) and 3 (bottom)

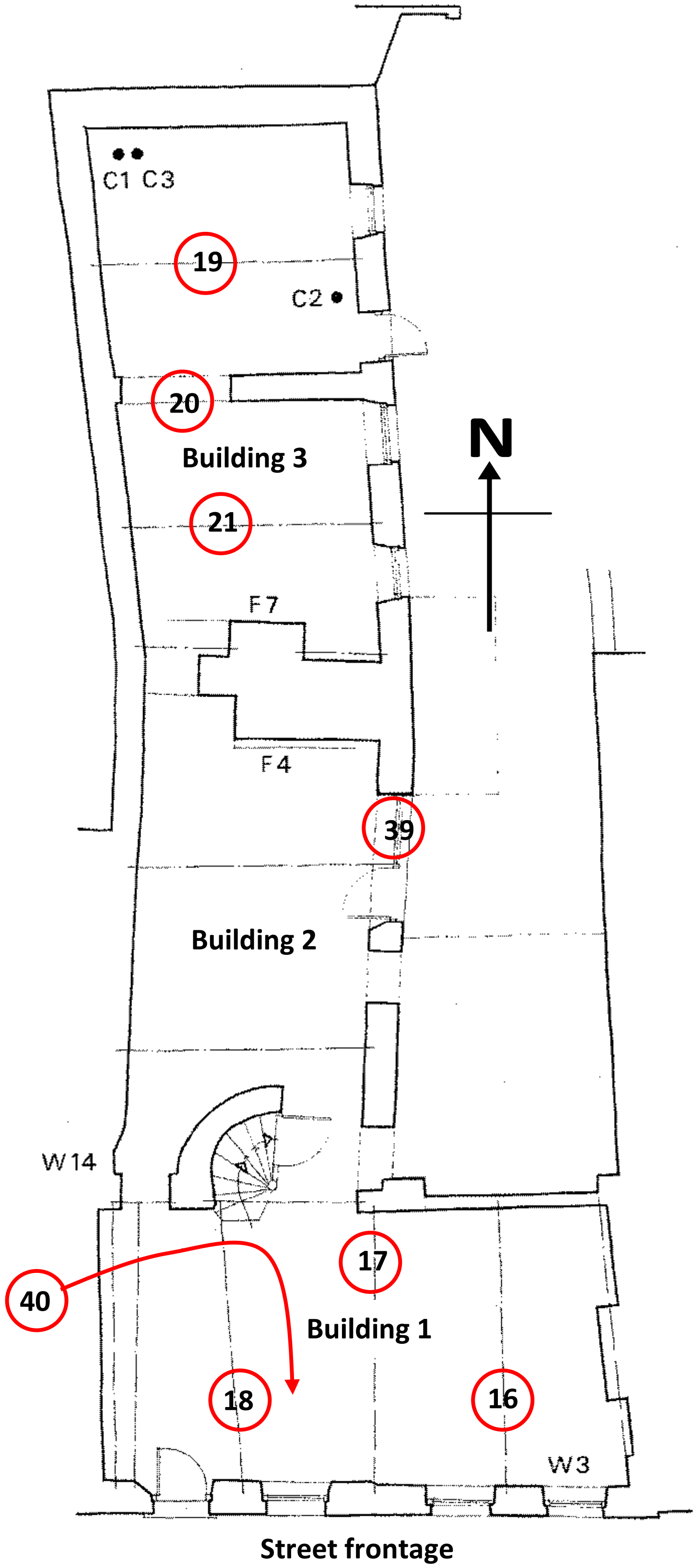


Figure 3a: Plan of the Ship Inn at ground floor level to show arrangement of the buildings and the locations of the sampled timbers (see Table 1) (after Phillip Cracknell/Alpha Design)

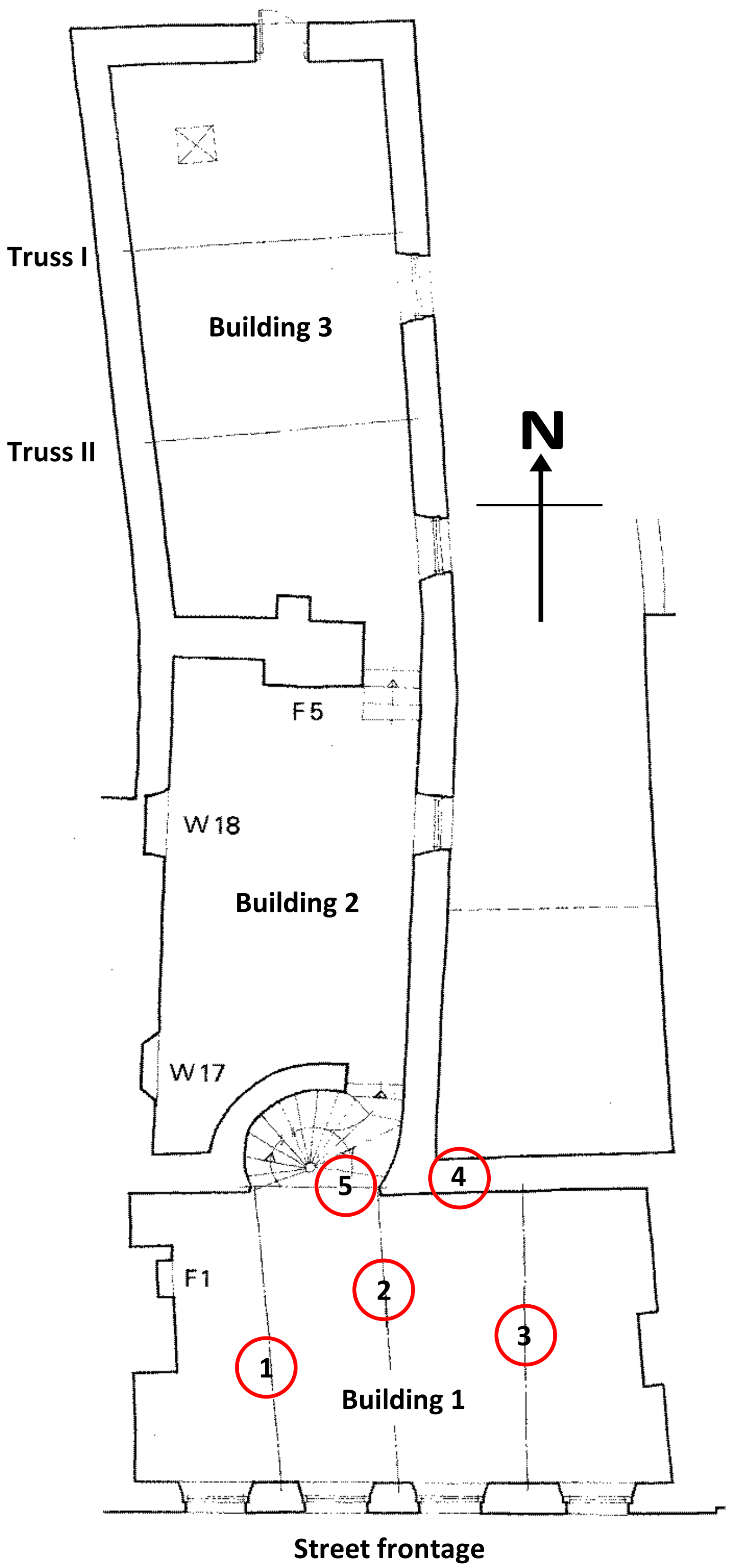


Figure 3b: Plan of the Ship Inn at first floor level to show arrangement of the buildings and the locations of the sampled timbers (see Table 1) (after Phillip Cracknell/Alpha Design)

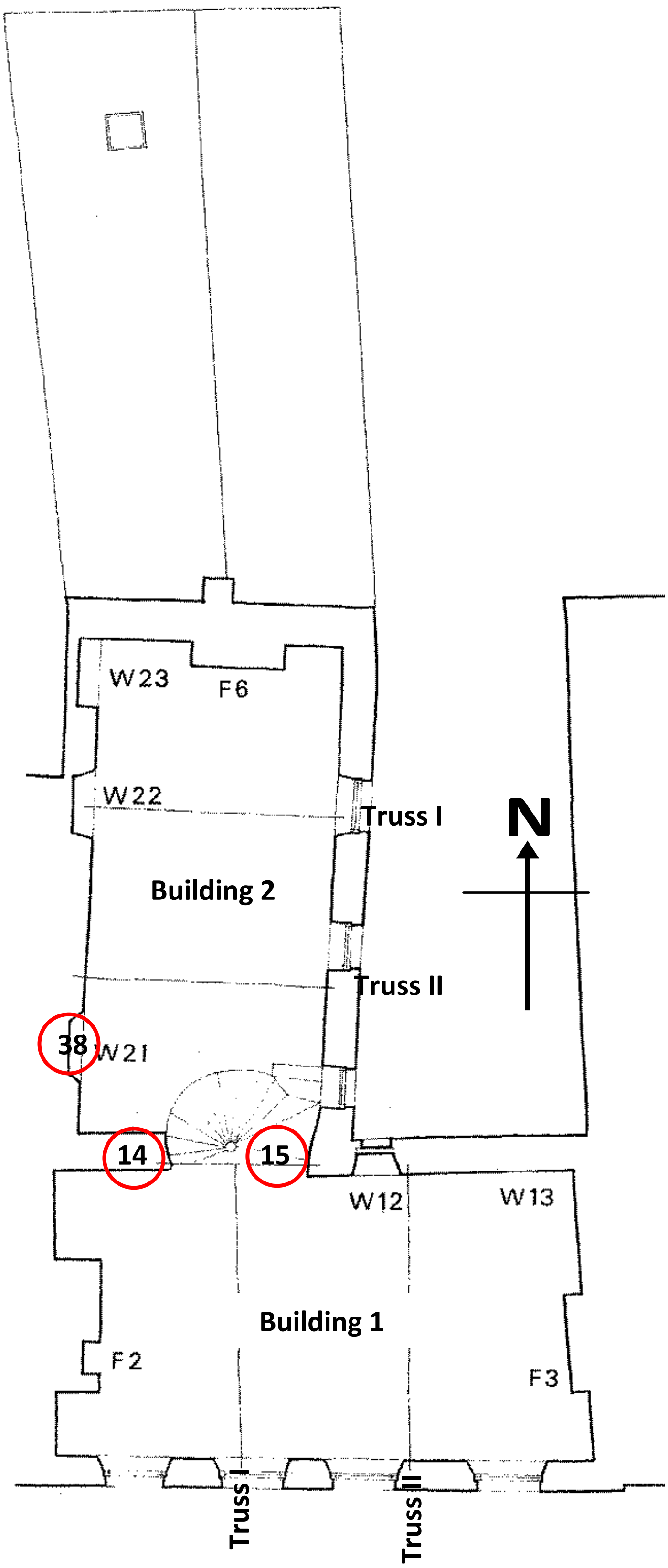
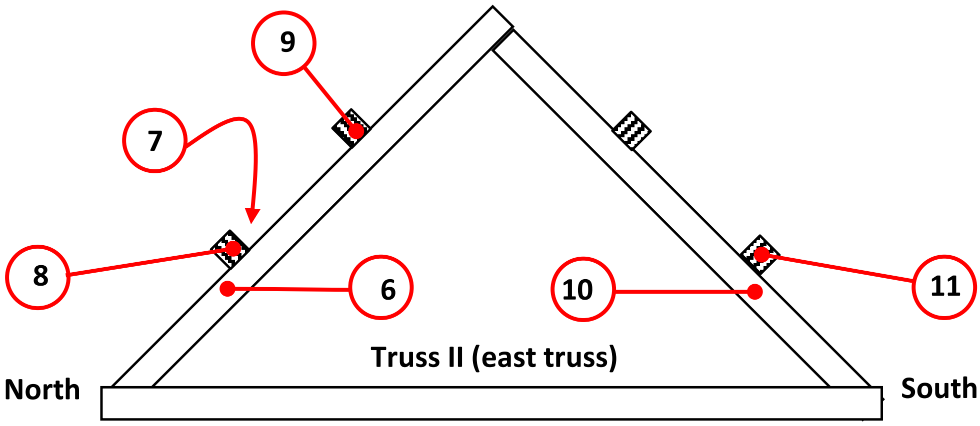


Figure 3c: Plan of the Ship Inn at second floor level to show arrangement of the buildings and the locations of the sampled timbers (see Table 1) (after Phillip Cracknell/Alpha Design)



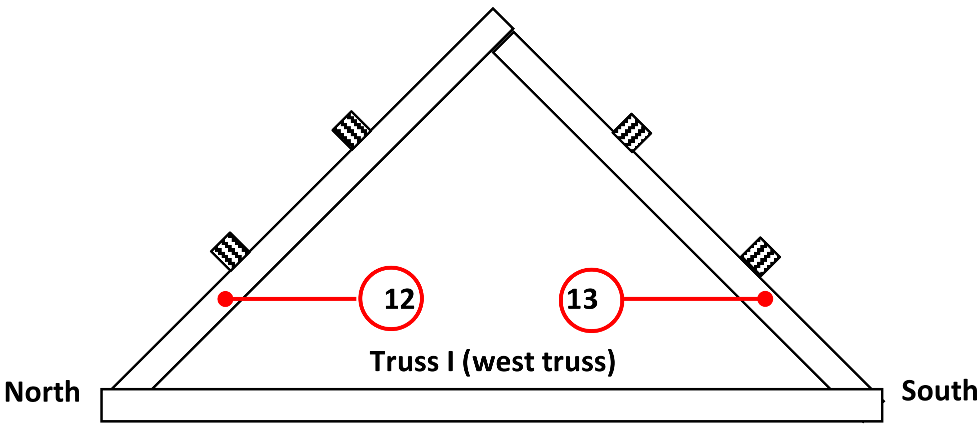
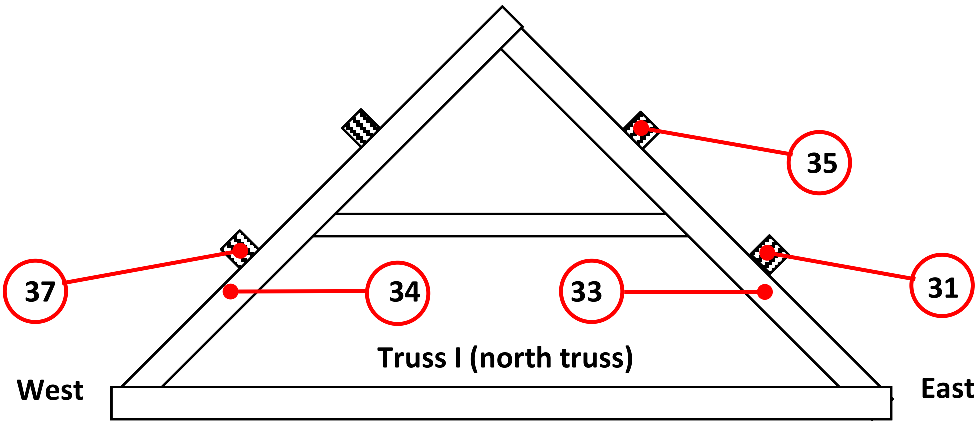


Figure 4a: Sections through the roof trusses of building 1 to locate sampled timbers (see Table 1)



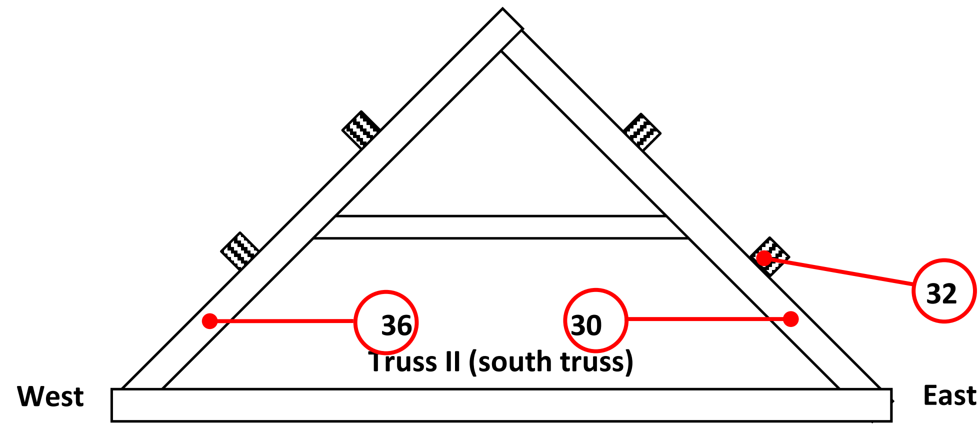
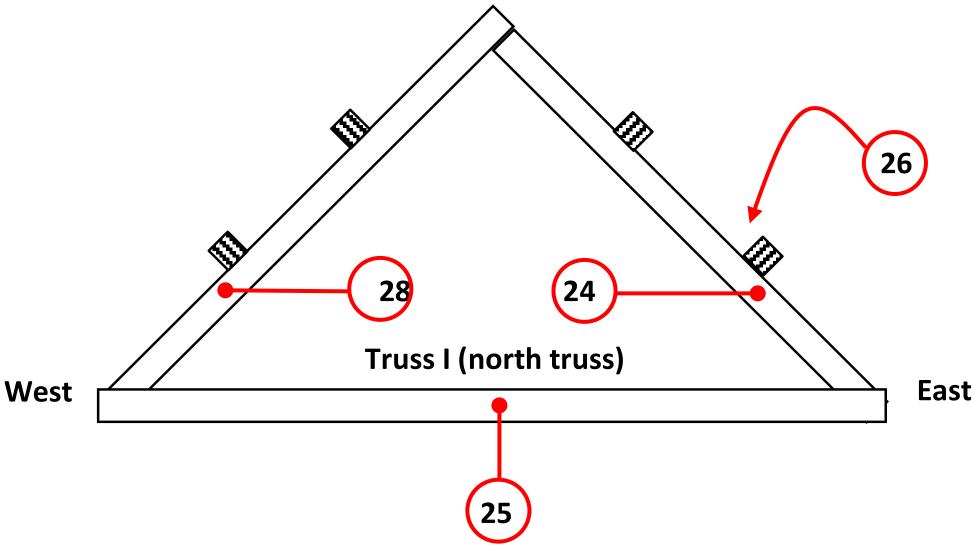


Figure 4b: Sections through the roof trusses of building 2 to locate sampled timbers (see Table 1)



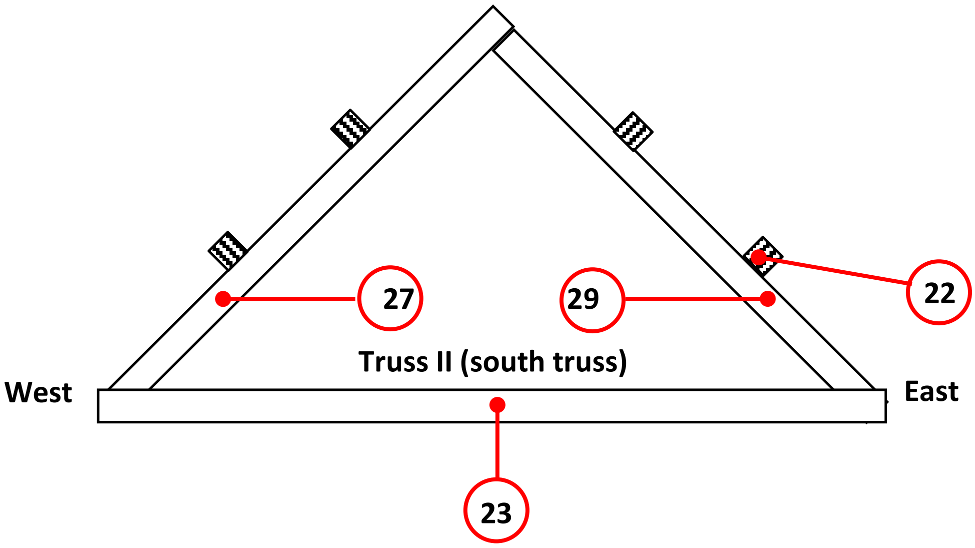


Figure 4c: Sections through the roof trusses of building 3 to locate sampled timbers (see Table 1)

Figure 4d: View of the timbers in the roof between buildings 1 and 2

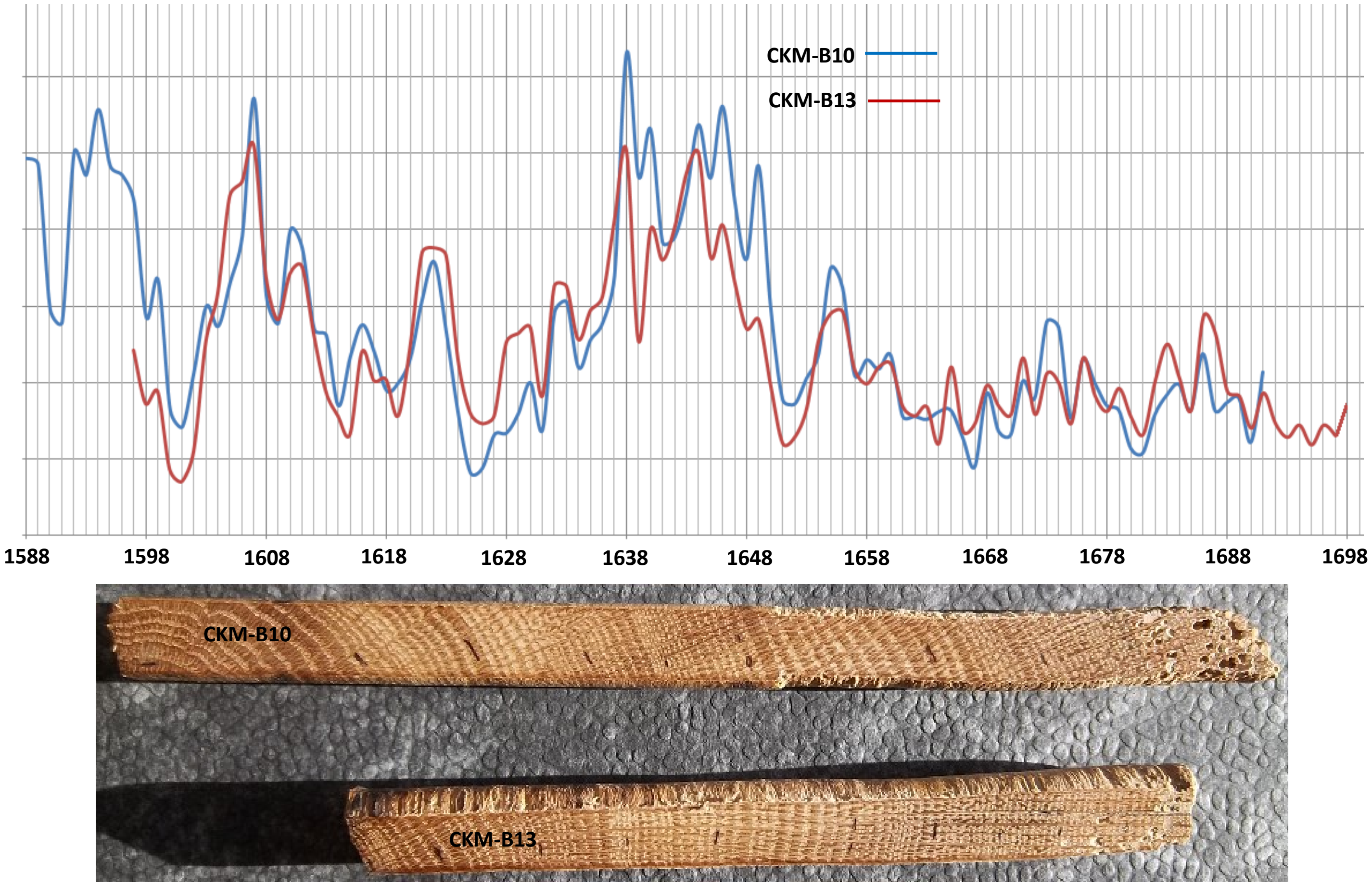
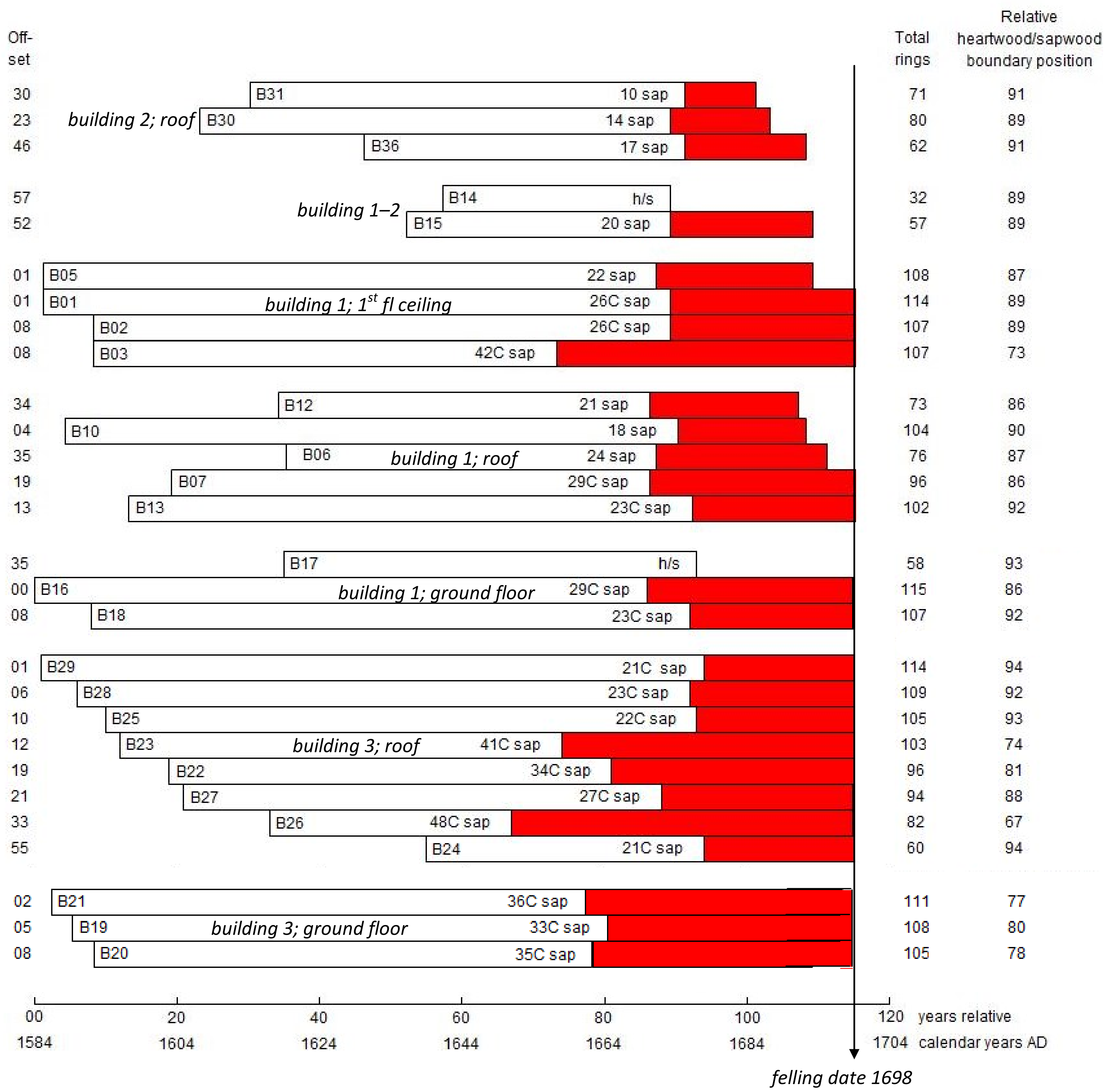


Figure 5: Graphic representation of the cross-matching of two samples, CKM-B10 (blue) and B13 (red). It can be seen that when cross-matched at the correct off-set positions, as here, the variations in width of the annual growth rings of these two samples correspond with a high degree of similarity. As the annual rings widths of one sample increase (represented by peaks in the graph), or decrease (represented by troughs), so too do the annual ring widths of the second sample. This similarity in growth pattern is a result of the two trees represented having grown in the same area *at the same time.* The growth ring pattern of samples from trees grown at different times should never cross-match at any position. This matching process is carried out with all samples from the same building in an attempt to form a 'site chronology'.



White bars [ ] = heartwood rings, shaded bars [ ] = sapwood rings
h/s = the last measured ring on the sample is at the heartwood/sapwood boundary, ie, only the sapwood rings are missing
C = complete sapwood is retained on the sample; where dated, the last measured ring date is the felling date of the tree represented

Figure 6: Bar diagram of the samples in site chronology CKMBSQ01

This figure shows the samples in the form of 'bars', at the positions where the variations in the growth rings cross-match with each other, this similarity being produced by the trees from which the sampled beams were derived all growing in the same place, *at the same time.* The measured data of the annual growth rings are combined to form a 'site chronology', and it is this 'average' which is dated by comparison with the 'reference' chronologies. As can be seen from this figure, and from Table 1, a number of samples retain complete sapwood (the last ring produced by the tree before it was felled), this being denoted by 'C', and that in each case the relative position, and date, of this last ring is identical at 1698. This indicates that all such timbers were felled at the same time as each other. Given that, as can be seen from this bar diagram and Table 1, the relative position and date of the heartwood/sapwood boundary (h/s) on the samples without complete sapwood are at a very similar positions to those on the timbers whose felling date is known, there is little reason to suspect that the timbers represented were not felled in, or at least very close to, 1698 as well.

Figure 7: View of three ungrouped and undated samples showing the bands of compressed and narrow rings. It is not known for certain what has caused these bands but it is possibly as a result of the trees represented being pollarded, coppiced or shredded, this restricting the growth for a number of years before it returns to 'normal'. Whatever the cause, it appears to have negated the climatic signal of the growth pattern. An attempt to cross-match and date these samples was made by measuring up to, and where possible beyond, the point of disturbance, but without success. The phenomenon of ungrouped and/or undated samples is very common in tree-ring analysis and is one of the reasons why several samples are taken from each building or phase of building.