Nottingham Tree-ring Dating Laboratory
Dendrochronology, timber analysis, and historic building consultants

TREE-RING ANALYSIS OF TIMBERS FROM WAKELYN OLD HALL, MAIN STREET, HILTON, SOUTH DERBYSHIRE

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Sample HLT-A02 from the tiebeam of truss 2 in the east cross-wing

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SUMMARY

Tree-ring analysis of 15 measured samples from a range of locations within Wakelyn Hall produced a single site chronology, HLTBSQ01, comprising 12 samples, and having an overall length of 159 rings. These rings were dated as spanning the years 1415 – 1573. Interpretation of the analysis indicates that all the dated timbers represent a group of trees cut in a single felling operation in 1573, with the building being constructed immediately thereafter, or within a year or two at the very most.

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Introduction

Wakelyn Old Hall, in Hilton, South Derbyshire, presents a delightful H-plan house (Fig 1), the gabled cross-wings at each end projecting forward from the linking hall range only very slightly to the front of the house, but to a somewhat greater degree to the rear (see Fig 2a). The ground floor level is now encased in brick but presumably (though perhaps not certainly) originally comprised close-set vertical studs to the sides and rear, and decorated panels to the front, as the first-floor level still is.

To the road frontage, this first floor timber decoration is arranged in two courses. The rectangular panels of the lower course, below the horizontal mid-rail and formed by more widely spaced vertical studs, are filled by a quatrefoil motif, there being simple curved pieces to the corners of each panel forming a central 'diamond'. This design is given some variation with two panels of the 'hall' range being divided by a vertical stud and a horizontal beam to form four smaller panels. Each of these smaller panels is then filled by trefoil cusped timbers to again make a quatrefoil, or 'cusped cross' design. In its basic form this is not an uncommon form of decoration.

The panels of the upper course of decoration, above the mid-rail, present a lozenge-shape within an oval, within a rectangular timber block formed by a vertical stud and a horizontal rail. This design is much more unusual and may well be unique.

The front, or north, gables of the cross-wings are again formed of rectangular panels by vertical studs, the panels then decorated with diagonal struts to each corner. The diagonal struts are then linked by curved and cusped timbers which form a four-lobed floret, or flower petal, shape To the rear, the gables of the cross-wings appear to have been more simply filled with less ornate close-set vertical studs (now only visible to the rear of the west gable (right-hand side as viewed from the road)). This west cross-wing has two further gables to the west pitch of its roof, these filled with wide-set vertical studs and diagonal struts. It is not certain if these gables are original, or are a later addition (Fig 2b).

Internally the building was presumably arranged around its central hall on the ground floor of the hall range. At one cross-wing end, probably the unheated east end given the position of the chimney, there would have been storage rooms (a buttery and pantry), with more convivial domestic accommodation in the heated western cross-wing, perhaps a kitchen, and a parlour or other living room. It is possible that this hierarchical arrangement of the rooms is reflected in the more highly decorated gables of this western cross-wing. The rooms to the first floors would have been given over to family accommodation and further storage, while some of the attic rooms may have been used as accommodation for domestic servants (this is not certain however as there is no clear evidence as to which attic rooms might have been originally floored).

At first floor level and particularly in the roof space, the original division of the building can be clearly seen (see simple plan Fig 3). This shows that the cross-wings are of two bays each, being formed by three principal rafter with collar and tiebeam trusses, with the hall range comprising three bays formed by four similar trusses. All the trusses support double purlins to each roof pitch, there being wind braces from the principal rafters to the lower purlins. Of particular note here is the observation that two of the trusses in the hall range roof, trusses 5 and 7, contain timbers which, judging by the empty mortices and peg-holes etc, are reused from somewhere else (it is possible that the trusses were filled by close-set studding, but this would appear to make little sense in their present positions).

Structurally, Wakelyn Hall appears to be of a single phase of construction, all timbers seemingly integral to each other and part of the original building. There is no clear evidence of any additions or of any major alterations. As originally built, it would have been the substantial and comfortable home of a reasonably wealthy individual, a person able to afford the considerable quantity of quality timber required for this particular style of timber framing, and a person who had some interesting concepts about the design they wished to present on the visible street frontage.

Sampling

Sampling and analysis of timbers from Wakelyn Hall were commissioned by Philip Heath of South Derbyshire District Council, this being undertaken during later stages of repair and conservation to the building. The Hall had in recent years fallen into some neglect and disrepair, a state of affairs corrected at considerable expense by the new owner. It was hoped that tree-ring analysis would firmly and reliably establish the date of the building and confirm that, as the structural evidence suggested, it was all of one phase.

Thus, from the timbers available a total of 16 core samples was obtained. Each sample was given the code HLT-B (for Hilton, site "B") and numbered 01 – 16. The great majority of samples, HLT-B01 – B14, were obtained from the roof space, or attic rooms, with a further two samples, HLT-B15 and B16, being taken from ground-floor ceiling beams. The positions of these samples were marked on a simple plan made at the time of sampling, this being reproduced here as Figure 3. Details of the samples are given in Table 1. In this Table, and on the plan, all trusses and the individual timbers have been numbered and/or identified on a north – south, or east – west basis, as appropriate.

It will be seen from Table 1 that only one sample, HLT-B14, has been obtained from either truss 5 or truss 7, the two trusses which contain possibly reused timbers. It was noticeable at the time of sampling that both trusses were constructed entirely of timbers derived from very fast-grown trees (unlike the timbers of all the other trusses where the trees grew more slowly). As such, although the timbers of trusses 5 and 7 are large, they would not have provided samples with the required minimum number of rings for reliable dating. This difference in timber type suggests that they are from a different source to all the other timbers, this reinforcing the possibility that they are of a different date, and have been reused here.

The Nottingham Tree-ring Dating Laboratory would like to take this opportunity to thank the owner of Wakelyn Hall, Mr Bobbi Sodhi, for his enthusiasm for and help with this programme of tree-ring analysis, and for his generous part-funding of analysis. The Laboratory would also like to thank Philip Heath, for arranging access and for help with the interpretation of this building, and South Derbyshire District Council for funding the remaining part of this programme of analysis.

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 most frequently used building timber in England) 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.

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.

The third principle 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 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, 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)).

Given that in a timber-framed building the trees required for each phase are almost certainly to have been cut in a single felling operation especially for that building, it is usual to calculate the average date of the heartwood/sapwood boundary of *all* the dated samples from each phase of a building and add 15 to 40 rings to get the overall likely felling date of the group.

Analysis

Each of the 16 samples obtained from Wakelyn Hall was prepared by sanding and polishing. It was seen at this point that one sample, HLT-B14 had too few rings for reliable dating, ie, less than 54, and it was rejected from this programme of analysis. The annual growth-ring widths of the remaining 15 samples were, however, measured, and all 15 were then compared with each other.

At a minimum value of t=3.8 a single group comprising 12 samples could be formed, cross-matching with each other at the positions indicated in the bar diagram Figure 4. The 12 samples were combined at these indicated off-set positions to form HLTBSQ01, a site chronology of 159 rings. Site chronology HLTBSQ01 was then satisfactorily dated by repeated and consistent comparison with a number of relevant reference chronologies for oak as spanning the years 1415 to 1573. The evidence for this dating is given in the *t*-values of Table 2.

Site chronology HLTBSQ01 was then compared with the three remaining single samples, HLT-B03, A05, and A16 but there was no further satisfactory cross-matching. The three single samples were then compared individually with the full range of reference chronologies but there was, again, no further cross-matching and these samples must, therefore, remain undated.

Interpretation and conclusion

Analysis by dendrochronology of 15 of the 16 samples obtained from a range of locations within Wakelyn Hall (one sample having too few rings), has resulted in 12 of these being combined to form a single site chronology, HLTBSQ01. This site chronology is 159 rings long, these rings being satisfactorily dated as spanning the years 1415 – 1573.

Four of the samples in this dated site chronology, HLT-B07, B10, B11, and B12, retain complete sapwood (denoted by 'C' in the Table and bar diagram). This means that they each have the last ring produced by the tree they represent before it was felled. In each case the last measured ring, and thus the felling date of the tree represented is the same, at 1573. It may be seen from the bar diagram, Figure 4, that all four of these samples end at the same time.

It may also be seen from the bar diagram, and from Table 1, that the relative position of the heartwood/sapwood boundary on all the dated samples varies by 15 years, from relative position 131 (1545), on sample HLT-B09, to relative position 146 (1560), on sample HLT-B04; the variation on most of the samples is generally even less than this. Given that the number of sapwood rings on oak trees falls within a fairly limited range, 15 – 40 sapwood rings, such consistency of this boundary position is strongly indicative of a group of trees being felled at one time and it is virtually certain that all the dated timbers were felled in 1573, and that Wakelyn Hall is of a single phase of construction, despite the probability that older timbers have been salvaged from elsewhere and reused here (were the sapwood boundary position more varied, it might suggest more than one phase of felling).

It may be of interest to note that the actual felling date of 1573 for the timbers, as provided by the samples with complete sapwood, falls well within what would otherwise be the estimated felling date range based on the heartwood/sapwood boundary dates only. As can be calculated from Table 1, the average heartwood/sapwood boundary of all 12 dated samples is 1553. To this can be added the minimum number of sapwood rings, 15, the trees are likely to have had and the maximum number, 40, they might have had. This would have given the timbers an estimated felling date of sometime between 1568 (1553+15) and 1593 (1553+40).

It is not possible to be certain where the trees used at Wakelyn Hall were originally growing. However, as indicated by Table 2, which shows the reference chronologies against which site chronology HLTBSQ01 has been dated, the highest *t*-values are found against material from other sites in the Midlands. The East Midlands Master

Chronology in particular contains data from other sites in Derbyshire – from Melbourne for example, as does the 'England' Master Chronology. It will be seen from Table 2 that other near-by sites in Derbyshire and Staffordshire are also listed. It may also be seen from Table 2 that all the *t*-values given are all notably high, two in excess of *t*=11.0 and 2 in excess of *t*=10.0 (anything higher than *t*=7.0 would be of note). All these indicators suggest that, not unexpectedly, the timber used at Wakelyn is of local origin.

Judging by the *t*-values of the cross-match between some of the samples (some values in excess of *t*=5.0 being seen), it is likely that many of the trees used were growing generally dispersed in the same patch of woodland. Indeed, given that values in excess of *t*=7.0 and 9.0 are seen, it is likely that some trees were probably growing adjacent to each other. Some of the trees may have been more widely dispersed.

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Table 1: Details of tree-ring samples from Wakelyn Hall, Hilton, South Derbyshire

Sample number	Sample location	Total rings	Sapwood rings*	First measured ring date (AD)	Last heartwood ring date (AD)	Last measured ring date (AD)
HLT-B01	East upper purlin, truss 1 – 2	130	12	1434	1551	1563
HLT-B02	Tiebeam, truss 2	133	no h/s	1415	------	1547
HLT-B03	North brace from east principal rafter, truss 2	67	h/s	------	------	------
HLT-B04	South principal rafter, truss 6	54	4	1511	1560	1564
HLT-B05	Collar, truss 6	63	25	------	------	------
HLT-B06	North purlin, truss 6 – 7	75	h/s	1482	1556	1556
HLT-B07	South purlin, truss 6 – 7	73	19C	1501	1554	1573
HLT-B08	Tiebeam, truss 9	97	h/s	1454	1550	1550
HLT-B09	East principal rafter, truss 9	70	8	1484	1545	1553
HLT-B10	West principal rafter, truss 9	71	20C	1503	1553	1573
HLT-B11	East lower purlin, truss 9 – 10	143	24C	1431	1549	1573
HLT-B12	West upper purlin, truss 9 – 10	87	15C	1487	1558	1573
HLT-B13	Brace from east principal rafter, truss 10	88	h/s	1463	1550	1550
HLT-B14	South principal rafter, truss 7 ®	nm	---	------	------	------
HLT-B15	Ground-floor entry hall, ceiling joist 5 (from N)	80	h/s	1476	1555	1555
HLT-B16	Ground-floor entry hall, ceiling joist 7 (from N)	56	15C	------	------	------
				Avrg 1553		

*h/s = The last ring on the sample is at the heartwood/sapwood boundary
C = Complete sapwood is retained on the sample, the last measured ring date is the felling date of the timber
nm = sample not measured
® = timber sampled is possibly reused in its present location

Table 2: Results of the cross-matching of site chronology HLTBSQ01 and relevant reference chronologies when the first-ring date is 1415 and the last-ring date is 1573

Reference chronology	*Span of reference*	*t-value*	*Reference*
England	401 – 1981	11.3	(Baillie and Pilcher 1982 unpubl)
Sinai Park, Burton on Trent, Staffs	1227 – 1750	11.1	(Tyers 1997)
East Midlands	882 – 1981	10.8	(Laxton and Litton 1988)
Wales and West Midlands	1341 – 1636	10.7	(Siebenlist-Kerner 1978)
Kingsbury Hall, Kingsbury, Warwicks	1391 – 1564	9.7	(Arnold & Howard 2006)
MC10---H	1386 – 1585	9.1	(Fletcher 1978)
Combermere Park, Cheshire	1363 – 1564	8.8	(Howard *et al* 2003)
Hardwick Old Hall, Doe Lea, Derbys	1375 – 1590	8.2	(Howard *et al* 2002)