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TREE-RING ANALYSIS OF TIMBERS FROM THE ABBOT'S LODGE, CHURCH LANE, LEDBURY, HEREFORDSHIRE

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SUMMARY

Tree-ring analysis of 14 samples obtained from the roofs of The Abbot's Lodge, Ledbury, has produced a single site chronology, LDBBSQ01, this comprising 12 samples, and having an overall length of 246 rings. These rings were dated as spanning the years 1274 to 1519.

Interpretation of the sapwood on the dated samples indicates that two phases of timber felling are represented. The earlier phase is represented by six samples, all from trusses 1 – 8 (these trusses appearing to represent one single and distinct structural element of the building), the timbers for which all appear to have been felled in 1480.

The later phase is represented by six samples from trusses 9 – 12 (which appear to represent a second distinct structural element). These timbers all appear to have been felled in 1519.

It is apparent, therefore, that the building began life in 1480 as a three-bay, east–west, range with a three-bay north–south wing attached at its east end. In 1519 a three-bay addition was built attached to the south end of the east wing.

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Introduction

The Abbot's Lodge, Ledbury, is situated at the east end (off to the south side) of Church Lane, narrow, cobbled, and retaining a number of other fine black-and-white timber-framed

buildings. The lane connects the church of St Michael and All Angels with the market place at a point just above the town's iconic Market House (Map Fig 1).

The site comprises a number of elements forming a complicated and irregular building, parts of it built in brick (a substantial range to the south east for example), along with a number of brick additions to the west; other parts of it are timber-framed. A basic plan of the site is given in Figure 2. Of particular interest to this report, however, are the two main timber-framed ranges which together produce an L-shaped plan. The first is the east wing, aligned north–south, with its gable end towards Church Lane to the north. The second is the north range, projecting westwards from near the north end of the east wing, and fronting the entrance courtyard.

The house has undergone investigation by the Royal Commission on the Historic Monuments of England (RCHME), although no detailed measured drawings were made. More recently it has been studied by Duncan James, consultant buildings archaeologist with a specialism in the buildings of Herefordshire and Shropshire. It has also been the subject of the BBC television programme, 'The House Detectives' and subsequent book (Austin *et al* 197; pp.202 – 7). These various examinations have produced conflicting interpretations of the sites development and a variety of possible dates for its stages of construction.

It was believed, for example, that as originally constructed, not only was the east wing shorter than it now is, but that The Abbot's Lodge had another matching wing, also aligned north–south, at the west end of the present north range (where Church House now stands), making the original building H-shaped in plan. It was thought that this building was of a single phase of construction dating to the mid- to late-fifteenth century. It was thought, furthermore, that the west wing was later dismantled and then re-erected as an attachment at the southern end of the east wing (see Figs 3a and 3b); where the two parts of this range now abut each other may be found two adjacent trusses (Fig 4a/b), trusses 9 and 8 in Figure 2. Other interpretations have suggested that parts of the house date to the late-fourteenth century.

In the alternative interpretation (Fig 3b) it is believed that the earliest part of the house is formed by the whole of the north range and by the three northern bays of the east wing. Both elements are three bays long, although it would seem that the north range has bays of different lengths. It is virtually certain that these two parts are contemporary, this being intimated by the fact that where they meet the struts and principal rafters of truss 4, and the wall plate and studs of the west wall of the east wing all appear to be framed together, the west wall plate of the east wing forming the tie-beam of truss 4 of the north range. Significantly, where the north range joins the east wing, the latter's wall plate has no rafter housings, suggesting that as originally built, the northern end of the east wing was covered by the roof of the north range. Judging by the decorative nature of the timberwork to the spere truss, truss 3, with its cusped struts, it is possible that the north range originally contained a 'hall', open from the ground-floor to the roof. Other bays may have had two floors, a ground and first floor, the first floor again open to the roof.

As to the date of the original building, this is intimated by the probable layout of the rooms, the form of the wall framing, and, in particular, by the decorative features of the open trusses in comparison to other dated examples. The first open truss, truss 3, has a tie-beam, collar and principal rafters. It also has V-set struts both between the tie-beam and the collar, and above the collar to the principal rafters (Fig 5a). The cusps and foils occur only on the

V-struts, and form two foiled panels, one above the other. The other panels of this truss are undecorated. Such decoration is comparable to that seen at the Master's House, Ledbury (part of the former St Katherine's Hospital) (Fig 5b), which has recently been dated by tree-ring analysis to 1487 (Arnold and Howard 2006 unpubl). Significantly, truss 3 has not been blackened by the smoke from the fire of an open hall, as might be expected were the building of, say, late-fourteenth century date. The second open truss, truss 7, is found in the east wing. This has a cambered, arch-braced, collar which is again indicative of a date in the late-fifteenth century (Fig 6a).

Such a possible date is also intimated by the box-framed construction of the walls and the form of the roof of both ranges. These have single wind braces (Fig 6b) to the purlins and roof trusses, with raked struts (Fig 6c). The timber-framing of the north range consists of posts studs and rails. In bay A there are two studs in each bay of the side walls (the north and south walls), forming an arrangement three panels long. The side walls in bay B retain less of the original framing but the form is similar to bay A, although each wall has a long curved downward brace from the posts beneath truss 3. The framing in bay C has been altered and partly removed.

This alternate interpretation then proposes that some time later, probably in the sixteenth century, a timber-framed three-bay range was built immediately adjoining the south end of the east wing. It is noticeable that there is some weathering on the south face of truss 8, demonstrating that this truss formed the south end of the original, supposedly late-fifteenth century, building for some time prior to addition of the new three-bay range. Truss 9, the first truss of the 'new' range, is positioned virtually abutting the weathered south face of truss 8. Significantly, truss 9 has no evidence of ever having been a closed truss, the original closure of truss 8 continuing to form the division between the two phases.
The form of construction of the addition is, however, close to that of the original ranges. There are, though, some differences which might suggest a different phase of construction. Trusses 9, 10, 11, and 12 have higher collars (Fig 4b), the purlins do not have wind braces, and the principal rafters are set to a slightly steeper pitch. The struts are also longer and set at a steeper angle.

Sampling

Sampling and analysis by tree-ring dating of timbers within The Abbot's Lodge were commissioned by the owners Mr and Mrs Tombs. This analysis was undertaken out of personal interest, and as part of a general enquiry into the background history and development of the site, the various features of the site having engendered much discussion and debate. It was hoped that tree-ring analysis might indicate the dates at which certain timbers had been felled and, if possible, establish a likely primary construction date for the building and demonstrate something of its developmental history. In short, it was hoped that tree-ring dating would clearly establish not only the date, or dates, of the two main timber-framed elements, but also show whether or not the southern three bays of the east wing were part of the original build, and therefore almost certainly dismantled and reconstructed, or if it was a later addition.

Thus, from the roof timbers available a total of 14 core samples was obtained. Each sample was given the code LDB-B (for Ledbury, site "B") and numbered 01 – 14. Eight samples, LDB-B01 – B08, were obtained from the timbers of the north range and the northern 3

bays of the east wing, trusses 1 – 8, with a further six samples, LDB-B09 – B14, being obtained from the southern three bays of the east wing, trusses 9 – 12. The position of the samples, along with other relevant information about the timber, was carefully recorded at the time of sampling, the position of the samples also being marked on the plan from the 1998 RCHME report. This is reproduced here as Figure 7. Details of the samples are given in Table 1. In these figures, and in Table 1, the trusses and bays have been numbered following the schema of this plan and further identified on a north–south or east–west basis as appropriate. In all cases the timbers sampled appeared to be integral to each other and to be representative of their respective structural phase. Whilst one or two timbers showing possible evidence for re-use or later insertion are present, these were not sampled.

The Nottingham Tree-ring Dating Laboratory would like to take this opportunity to thank Mr and Mrs Tombs for their enthusiasm and help with this programme of analysis and for their hospitality during sampling. We would also like to thank Duncan James, not only for his help with the introduction above but for much other useful information on the site besides.

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 these annual growth-rings 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. Trees growing at the same time and in the same place thus have a very similar ring pattern.

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. In the Tables and bar diagrams of this report, the retention of complete sapwood on a sample is denoted by upper case 'C'.

Sometimes, complete sapwood is found on a timber, but, because of its soft condition, some, or all of it, crumbles as the sample is cored. It is possible to measure how much of the sapwood part of the core has been lost and from this it is sometimes possible to estimate the number of rings the lost portion might have represented. From this it is possible to make a reasonable estimate the felling date of the timber. Such a state is represented by lower case 'c' in the Tables and bar diagrams.

Where the sapwood is not complete it is necessary to calculate a likely felling date range for 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% probable 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 have almost certainly been cut in a single felling operation especially for that building, it is usual to calculate the average date of the heartwood/sapwood boundary, not on the basis of each single individual sample, but from *all* the dated samples from each phase of a building and add 15 to 40 rings to this average to get the likely overall felling date range of all the timbers used. In this calculation, wide variations in the position/date of the heartwood/sapwood boundary (possibly suggesting different felling dates) must be noted and taken into consideration.

Analysis

In the case of the 14 samples obtained from The Abbot's Lodge each was prepared by sanding and polishing, and its annual growth-ring widths measured. The data of these measurements were then compared with each other. At a minimum value of t=4.5 a single group comprising 12 samples could be formed, cross-matching with each other at the positions indicated in the bar diagram, Figure 8. The 12 cross-matching samples were combined at these indicated off-set positions to form a site chronology, LDBBSQ01, this having an overall length of 246 rings. Site chronology LDBBSQ01 was then satisfactorily dated by repeated and consistent comparison with a number of relevant reference chronologies for oak as spanning the years 1274 to 1519. The evidence for this dating is given in the t-values of Table 2.

Site chronology LDBBSQ01 was then compared with the two remaining measured but ungrouped samples, LDB-B01 and B06, but there was no further satisfactory cross-matching. Samples LDB-B01 and B06 were then compared individually with the full range of reference chronologies but, again, there was no further cross-matching and these two samples must remain undated.

Interpretation and conclusion

Analysis by dendrochronology of 14 measured samples from the roofs of The Abbot's Lodge has resulted in 12 of these being combined to form a single site chronology, LDBBSQ01. This site chronology is 246 rings long, these rings being satisfactorily dated as spanning the years 1274 to 1519.

Interpretation of the sapwood would indicate that two phases of felling appear to be represented by the 12 grouped and dated samples of site chronology LDBBSQ01. The earlier phase of felling is evidenced by samples LDB-B02, B03, B04, B05, B07 and B08 (samples LDB-B01 and B06 being undated), all of which are from trusses 1 – 8, these trusses appearing to represent one distinct structural element of the building.

One of these samples, LDB-B04, retains complete sapwood. This means that it has the last ring produced by the tree it represents before it was felled. In this case the last measured ring, and thus the felling of the tree, is dated to 1480. Two other samples in this sub-group, samples LDB-B05 and B08, are from timbers which do retain complete sapwood, but from

which, due to the soft nature of this part of the wood, small portions of the sapwood were lost during coring. In each case the lost portion of the sapwood is small and probably accounts rings which would almost certainly indicate that the trees they represent were felled in 1480 as well.

Given the cross-matching between samples LDB-B04, B05, and B08, and the remaining three of this sub-group (LDB-B02, B03, and B07), and the structural integrity of the sampled beams, there is no reason to suspect that these latter were not also felled in 1480, despite their having either only the heartwood/sapwood boundary (h/s in Table 1 and the bar diagram), or no heartwood/sapwood boundary at all.

The later phase of felling is evidenced by samples LDB-B09 – B14, all of which are from trusses 9 – 12. These trusses appear to represent a second distinct structural element of the building. One of these samples, LDB-B10, again retains complete sapwood, this meaning that it too has the last ring produced by the tree it represents before it was felled. In this case the last measured ring, and thus the felling of the tree, is dated to 1519. One other sample in this sub-group, LDB-B14, is also from a timber which retains complete sapwood, but from which a portion of the sapwood was lost during coring. Again the lost portion of the sapwood is small and accounts for rings which would almost certainly indicate that the tree represented was also felled in 1519.

Two other samples of this sub-group, LDB-B09 and B12, retain the heartwood/sapwood boundary. The relative position and date of this would suggest that they too represent timbers felled in 1519. Indeed, again given the cross-matching between all the samples of this sub-group and the structural integrity of the beams, there is no reason to suspect that all the samples, including samples LDB-B11 and B13, represent trees felled in 1519.

Even without the presence of complete sapwood on any of the samples it would be possible to show, using the relative position/date of the heartwood/sapwood boundaries, that the timbers represented by the two sub-groups were probably felled at different times. The average date of the heartwood/sapwood boundary of the four samples (LDB-B03, B05, B07 and B08) where it exists in the earlier group is dated to 1451. If we were to add the usual complement of sapwood rings that the trees might have had, between 15 and 40 rings (as mention in the notes on tree-ring dating above), the estimated felling date would lie in the range 1466 to 1491.

The average date of the heartwood/sapwood boundary of the four samples (LDB-B09, B10, B12, and B14) where it exists in the later group is dated to 1490. If we were to add the same complement of sapwood rings as above, between 15 and 40 rings, the estimated felling date would lie in the range 1505 to 1530. It will be seen that the actual felling dates obtained for both groups lies close to the middle of their respective ranges.

A certain corresponding dichotomy may also be seen in the timber used for the respective structural elements of the building (trusses 1 – 8 and trusses 9 – 12). Although the beams are approximately the same size in both elements, the trees used in the later phase of construction, trusses 9 – 12 and felled in 1519, had lived longer when felled, and had a tighter series of growth-rings, than did the trees used in the earlier phase, trusses 1 – 8 and felled in 1480. The samples of these earlier timbers have an average of 80 rings per core, whilst those of the later timbers have an average of 144 rings per core.

It is not possible to demonstrate by dendrochronology exactly where the source woodland for the timbers used at The Abbot's Lodge was situated. Indeed, it is very likely that the trees used for the two phases come from two different woodlands This is suggested by the fact that although there is very good cross-matching between the samples within each respective phase, suggesting that the trees used for each element were growing close together in the same stand or copse, the intra-phase matching is not quite so good, suggesting there was some distance between the two source woodlands.

It would appear, however, as one might expect, that wherever they were, both woodlands were reasonably local. As will be seen from Table 2, which shows the reference chronologies with which site chronology LDBBSQ01 has cross-matched and dated, many of the best matches, ie, the highest *t*-values and thus the greatest degree of similarity, are with material from other sites in the west of England (this despite site chronology LDBBSQ01 having been compared with reference material from all parts of England). Some of the best values are found in comparison to other sites in Worcestershire, Gloucestershire, and indeed Herefordshire, the nearby Master's House at Ledbury also being listed. There is, however, a slight trend for the highest cross-matches to be found against sites to the south of Ledbury, suggesting the possibility that the source woodlands lay in this general direction.

Two samples, LDB-B01 and B06, remain undated. While it is not unknown for such samples to cross-match and date, it is possible that in this case sample B06, with only 50 rings, is too short, the minimum number of rings usually required being about 54. Sample LDB-B01, on the other hand, has 76 rings, quite sufficient for dating. There appears to be no problem with the rings, such as compression or distortion, which might make cross-matching difficult and it is simply a frequent feature of tree-ring analysis that some samples remain undated.

Despite this, tree-ring dating has thus clearly demonstrated the construction date of the two timber-framed ranges, showing that the north range and the three bays of the east wing are of one date, 1480, whilst the southern three bays of the east wing are later, dating to 1519.

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Table 1: Details of tree-ring samples from The Abbot's Lodge, Church Lane, Ledbury, Herefordshire

Sample number	Sample location	Total rings	Sapwood rings*	First measured ring date (AD)	Last heartwood ring date (AD)	Last measured ring date (AD)
	North range / east wing (north end)					
LDB-B01	South upper purlin, truss 2 – 3	76	17c	------	------	------
LDB-B02	South principal rafter, truss 3	73	no h/s	1351	------	1423
LDB-B03	North principal rafter, truss 4	105	no h/s	1339	------	1443
LDB-B04	South principal rafter, truss 4	77	23C	1404	1457	1480
LDB-B05	East principal rafter, truss 6	83	29c	1393	1445	1475
LDB-B06	West principal rafter, truss 6	50	h/s	------	------	------
LDB-B07	East principal rafter, truss 7	90	h/s	1361	1450	1450
LDB-B08	West principal rafter, truss 7	85	15c	1384	1453	1468
	east wing (southern end)					
LDB-B09	East principal rafter, truss 9	124	h/s	1358	1481	1481
LDB-B10	West principal rafter, truss 9	190	18C	1330	1501	1519
LDB-B11	East principal rafter, truss 10	107	no h/s	1330	------	1436
LDB-B12	West principal rafter, truss 10	146	h/s	1330	1475	1475
LDB-B13	West principal rafter, truss 11	145	no h/s	1274	------	1418
LDB-B14	Collar, truss 11	150	5c	1357	1501	1506

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

c = complete sapwood is present on the timber, a portion has been lost from the sample during coring

C = complete sapwood is retained on the sample; where dated, this is the felling date of the tree represented

Table 2: Results of the cross-matching of site chronology LDBBSQ01 and relevant reference chronologies when the first-ring date is 1274 and the last-ring date is 1519

Reference chronology	*t*-value	Reference
Hampshire county chronology	10.1	(Miles 2003)
The Commandery, Worcester	8.2	(Arnold and Howard 2006)
England Master chronology	8.2	(Baillie and Pilcher 1982 unpubl)
Kingswood Abbey Gatehouse, Glos	8.1	(Arnold *et al* 2003)
The Master's House, Ledbury, Herefs	7.9	(Arnold and Howard 2006 unpubl)
East Midlands Master Chronology	7.7	(Laxton and Litton 1988)
England, London	7.5	(Tyers and Groves 1999 unpubl)
Thatched Cottage, Hill Wootton, Warwicks	7.1	(Alcock *et al* 1989)