Oxford Dendrochronology Laboratory
Report 2018/25

The Tree-Ring Dating of the South Door and Chest at the Church of St Peter, Laneham, Nottinghamshire

Dr D W H Miles FSA and Dr M C Bridge FSA

Summary:

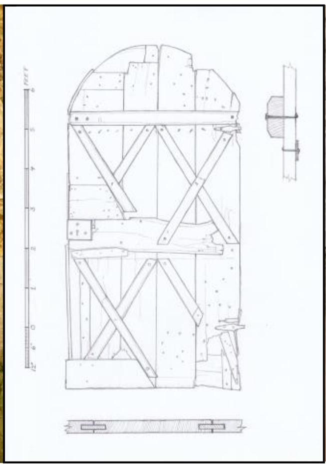
LANEHAM, Church of St Peter, Main Street, Church Laneham (SK 81480 76566)

(a) South door *Felling date range (OxCal Modelled):* ***1157-78*** (Unrefined 1156-89)

(b) Large chest *Felling date range:* **After 1240**

(a) Boards (2/3) 1140(H/S), 1147(H/S); Ledge 1030; Braces (0/2); (b) Stiles 1228, 1210; Board (0/1). *Site Masters* (a) LANEHAM1 969-1147 (t = 12.02 PETERC; 10.06 NORTH; 9.09 EASTMID); (b) LANEHAM2 1107-1228 (t = 8.57 BISHWTHM; 8.22 HANTS02; 7.59 SARUM14).

This Norman church still retains its south door case and the door, whilst replaced, has been hung on display internally. It features butt-edged boards with stopped loose tongues and two tiers of saltire bracing. The ironwork is of two strap hinge bands with thin tendrils with Cs ending in split curls. The dating of 1157-78 is a generation earlier than the previously thought date of *circa* 1200. The chest is of a stile type with three trefoil lancet openings cut into the foot of each stile, and three circular chip-carved stars carved on the top of the stiles and front board. No sapwood or heartwood/sapwood boundary resulted in a *terminus post quem* of 1237, but it was likely to have been constructed in the third quarter of the thirteenth century.


Date sampled:	June 2018
Owner:	Church of St Peter, Laneham
Commissioners:	Gavin Simpson and Chris Pickvance
Summary published:	Miles, D H, and Bridge, M C, 2019 Tree-ring dates, *Vernacular Architecture* **50**, (forthcoming)

Oxford Dendrochronology Laboratory
Mill Farm, Mapledurham, South Oxfordshire, RG4 7TX
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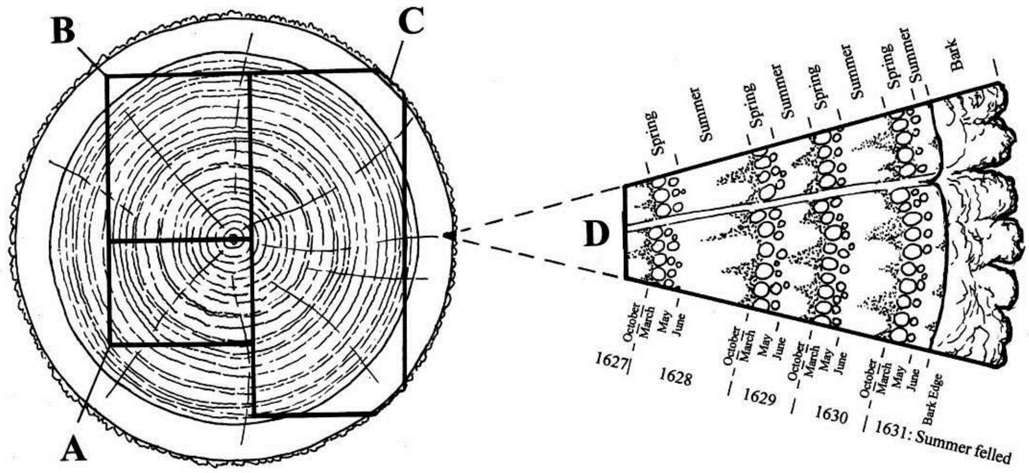
How Dendrochronology Works

Dendrochronology has over the past 30 years become one of the leading and most accurate scientific dating methods. Whilst not always successful, when it does work, it is precise, often to the season of the year. Tree-ring dating is well known for its use in dating historic buildings and archaeological timbers to this degree of precision. However more ancillary objects such as doors, furniture, panel paintings, and wooden boards in medieval book-bindings can sometimes be successfully dated.

The science of dendrochronology is based on a combination of biology and statistics. Fundamental to understanding how dendrochronology works is the phenomenon of tree growth. Essentially, trees grow through the addition of both elongation and radial increments. The elongation takes place at the terminal portions of the shoots, branches, and roots, while the radial increment is added by the cambium, the zone of living cells between the wood and the bark. In general terms, a tree can be best simplified by describing it as a cone, with a new layer being added to the outside each year in temperate zones, making it wider and taller.

An annual ring is composed of the growth which takes place during the spring and summer until about November when the leaves are shed and the tree becomes dormant for the winter period. For the European oak (*Quercus robur* and *Q. petraea*), as well as many other species, the annual ring is composed of two distinct parts - the spring growth or early wood, and the summer growth, or late wood. Early wood is composed of large vessels formed during the period of shoot growth which takes place between March and May, which is before the establishment of any significant leaf growth, and is produced by using most of the energy and raw materials laid down the previous year. Then, there is an abrupt change at the time of leaf expansion around May or June when hormonal activity dictates a change in the quality of the xylem and the summer, or late wood is formed. Here the wood becomes increasingly fibrous and contains much smaller vessels. Trees with this type of growth pattern are known as ring-porous, and are distinguished by the contrast between the open, light-coloured early wood vessels and the dense, darker-coloured late wood.

Dendrochronology utilises the variation in the width of the annual rings as influenced by climatic conditions common to a large area, as opposed to other more local factors such as woodland competition and insect attack. It is these climate-induced variations in ring widths that allow calendar dates to be ascribed to an undated timber when compared to a firmly-dated sequence which has shared a common period of growth with the sample being dated. If a tree section is complete to the bark edge, then when dated a precise date of felling can be determined. The felling date will be precise to the season of the year, depending on the degree of formation of the outermost ring. Therefore, a tree with bark which has the spring vessels formed but no summer growth can be said to have been felled in the spring, although it is not possible to say in which particular month the tree was felled.



Section of tree with conversion methods showing three types of sapwood retention resulting in A *terminus post quem*, B a felling date range, and C a precise felling date. Enlarged area D shows the outermost rings of the sapwood with growing seasons (Miles 1997, 42)

Another important consideration in dendrochronological studies is the presence (or absence) of sapwood. This is the band of growth rings immediately beneath the bark and comprises the living growth rings which transport the sap from the roots to the leaves. This sapwood band is distinguished from the heartwood by the prominent features of colour change and the blocking of the spring vessels with tyloses, the waste products of the tree's growth. The heartwood is generally darker in colour, and the spring vessels are blocked with tyloses. The heartwood is dead tissue, whereas the sapwood is living, although the only really living, growing, cells are in the cambium, immediately beneath the bark. In European oak (*Quercus* spp), the difference in colour is generally matched by the change in the spring vessels. Generally the sapwood retains stored food and is therefore attractive to insect and fungal attack once the tree is felled and therefore is often removed during conversion.

Sapwood in European oaks tends to be of a relatively constant width and/or number of rings. By determining what this range is with an empirically or statistically-derived estimate is a valuable aspect in the interpretation of tree-ring dates where the bark edge is not present (Miles 1997). The narrower this range of sapwood rings, the more precise the estimated felling date range will be.

Methodology: The Dating Process

All timbers sampled were of oak (*Quercus* spp.) from what appeared to be primary first-use timbers, or any timbers which might have been re-used from an early phase. Those timbers which looked most suitable for dendrochronological purposes with reasonably long ring sequences were selected. As the surface of the door planks was too abraded or damaged to allow the rings to be accurately measured, and cleaning the surface would cause unacceptable visual damage to the timberwork, a micro-borer was used to extract the samples. This system uses a small 8mm outside diameter hollow drill bit which extracts a 5mm diameter core. The drill bit is cooled and cleared of dust with the aid of compressed air which is channelled through the inside of the cutting tube and clears the waste from around the outside of the bit. The drill bit is accurately aligned by the use of a series of guides fitted to a jig which is clamped to the face of the door. In this manner the drill can be used to bore through a number of boards as thin as 15mm thick and as wide as one metre or longer. Thus three of the original boards could be drilled in succession with the need to make only a single hole, which is afterwards plugged with an oak pellet and stained. The cores thus extracted were mounted on grooved timber mounts and prepared by being sanded on a linisher using 60 to 1200 grit abrasive paper, and cleaned with compressed air to allow the ring boundaries to be clearly distinguished. They were then measured under a x10/x45 variable-focus microscope using a travelling stage electronically displaying displacement to a precision of 0.001mm, rounded to the nearest 0.01mm.

Details and locations of the samples are detailed in the summary Table 1.

The principle behind tree-ring dating is a simple one: the seasonal variations in climate-induced growth as reflected in the varying width of a series of measured annual rings is compared with other, previously dated ring sequences to allow precise dates to be ascribed to each ring. When an undated sample or site sequence is compared against a dated sequence, known as a reference chronology, an indication of how good the match is must be determined. Although it is almost impossible to define a visual match, computer comparisons can be accurately quantified. Whilst it may not be the best statistical indicator, a variant of the Student's (a pseudonym for W S Gosset) *t*-value has been widely used amongst British dendrochronologists. The cross-correlation algorithms most commonly used and published are derived from Baillie and Pilcher's CROS programme (Baillie and Pilcher 1973), although a faster version (Munro 1984) giving slightly different Baillie-Pilcher *t*-values is sometimes used for indicative purposes.

Generally, *t*-values over 3.5 should be considered to be significant, although in reality it is common to find demonstrably spurious t-values of 4 and 5 because more than one matching position is indicated. For this reason, dendrochronologists prefer to see some *t*-value ranges of 5, 6, or higher, and for these to be well replicated from different, independent chronologies with local and regional chronologies well represented. Users of dates also need to assess their validity critically. They should not have great faith in a date supported by a handful of *t*-values of 3's with one or two 4's, nor should they be entirely satisfied with a single high match of 5 or 6. Examples of spurious *t*-values in excess of 7 have been noted, so it is essential that matches with reference chronologies be well replicated, and that this is confirmed with visual matches between the two graphs. Matches with *t*-values of 10 or more between individual sequences usually signify samples having originated from the same parent tree.

In reality, the probability of a particular date being valid is itself a statistical measure depending on the *t*-values. Consideration must also be given to the length of the sequence being dated as well as those of the reference chronologies. A sample with 30 or 40 years growth is likely to match with high *t*-values at varying positions, whereas a sample with 100 consecutive rings is much more likely to match significantly at only one unique position. Samples with ring counts as low as 50 may occasionally be dated, but only if the matches are very strong, clear and well replicated, with no other significant matching positions. This is essential for intra-site matching when dealing with such short sequences. Consideration should also be given to evaluating the reference chronology against which the samples have been matched: those with well-replicated components which are geographically near to the sampling site are given more weight than an individual site or sample from the opposite end of the country.

It is general practice to cross-match samples from within the same phase to each other first, combining them into a site master, before comparing with the reference chronologies. This has the advantage of averaging out the 'noise' of individual trees and is much more likely to obtain higher *t*-values and stronger visual matches. After measurement, the ring-width series for each sample is plotted as a graph of width against year on log-linear graph paper. The graphs of each of the samples in the phase under study are then compared visually at the positions indicated by the computer matching and, if found satisfactory and consistent, are averaged to form a mean curve for the site or phase. This mean curve and any unmatched individual sequences are compared against dated reference chronologies to obtain an absolute calendar date for each sequence. Sometimes, especially in urban situations, timbers may have come from different sources and fail to match each other, thus making the compilation of a site master difficult. In this situation samples must then be compared individually with the reference chronologies.

Therefore, when cross-matching samples with each other or against reference chronologies, a combination of both visual matching and a process of qualified statistical comparison by computer is used. The ring-width series were compared on an IBM compatible computer for statistical cross-matching using a variant of the Belfast CROS program (Baillie and Pilcher 1973). A version of this and other programmes were written in BASIC by D Haddon-Reece, and re-written in Microsoft Visual Basic by M R Allwright and P A Parker.

Ascribing and Interpreting Felling Dates

Once a tree-ring sequence has been firmly dated in time, a felling date, or date range, is ascribed where possible. For samples which have sapwood complete to the underside of, or including bark, this process is relatively straightforward. Depending on the completeness of the final ring, i.e. if it has only the early wood formed, or the latewood, a *precise felling date and season* can be given. If the sapwood is partially missing, or if only a heartwood/sapwood transition boundary survives, then an *estimated felling date range* can be given for each sample. The number of sapwood rings can be estimated by using a statistically derived sapwood estimate with a given confidence limit. A review of the geographical distribution of dated sapwood data from historic building timbers has shown that a 95% range of 12-45 rings is most appropriate for the northern counties of England, which will be used here. However, in the case of the chest, a 9-41 year range was used as more appropriate for the south of England (Miles 1997) If no sapwood or heartwood/sapwood boundary survives, then the minimum number of sapwood rings from the appropriate sapwood estimate is added to the last measured ring to give a *terminus post quem* (*tpq*) or *felled after* date.

An alternative method of estimating felling date ranges has recently been developed (Miles 2005) which runs as a function under OxCal (Bronk Ramsey 1995; Miles and Bronk Ramsey *in prep*). Instead of using a simple empirical estimate for a particular geographical location, one model was found to be suitable for the whole of England and Wales. With the methodology set out by Millard (2002), Bayesian statistical models are used to produce individual sapwood estimates for samples using the variables of number of heartwood rings present, the mean ring width of those heartwood rings, the heartwood/sapwood boundary date, and the number of any surviving sapwood rings or a count of those lost in sampling. Using the suite of calculation and graphical plotting functions in OxCalInput and OxCalPlot (Bronk Ramsey *in prep*), the area of highest probability density for each sample can be graphically displayed to any of three confidence levels. The addition of surviving sapwood to the equation narrows the felling date range for each sample, although the outer end of the range shifts slightly later, more noticeably on those samples with higher sapwood counts. An empirically-derived stock-piling factor added to the ranges produced also helps to make the estimated felling date ranges more representative for the actual latest common felling date, from which a construction date can then be extrapolated.

This new method of predicting sapwood ranges has resulted in over 94% of the samples tested producing felling date ranges narrower than the 36-year empirical estimates currently used by some other laboratories. About a quarter of the samples tested showed an improvement with a range of 24 years or less. Conversely, some 4.5% of the samples tested produced a range larger than the empirical range, but again these ranges are more representative of the actual sapwood found.

However, it has been found that some unusual samples do not fit the model well. These include samples which have exceptional or sudden variation in mean ring width, such as might be found in pollarded or managed timber. Sometimes a tree will exhibit a sudden drop in mean ring width toward the end of its life, resulting in more sapwood rings being present then might be suggested in the faster-grown heartwood. Additionally, samples which have come from small timbers converted from larger, slow-grown trees would have a much larger number of heartwood rings then were actually present in the sample. Some examples of heartwood ring counts of 25 years or less with a narrow mean ring width are good indicators of this situation, as were observations made during sampling. Samples with these characteristics should be excluded from such analysis.

A particularly useful feature of OxCalPlot is the ability of producing combined felling date ranges for a group of samples comprising a single phase of building. Here, two samples combined can reduce the individual felling date ranges from about 30 to about 20 years. By including more samples within the combined phase, this 20-year range can be reduced to half or even less, depending on the number of samples in the phase. Thus felling date ranges for combined building phases have the potential to being reduced by as much as a two-thirds or even three-quarters of the individual empirically-derived felling date ranges (Miles 2005).

Some caution must be used in interpreting solitary precise felling dates. Many instances have been noted where timbers used in the same structural phase have been felled one, two, or more years apart. Whenever possible, a *group* of precise felling dates should be used as a more reliable indication of the *construction period*. It must be emphasised that dendrochronology can only date when a tree has been felled, not when the timber was used to construct the structure under study. However, it is common practice to build timber-framed structures with green or unseasoned timber and that construction usually took place within twelve to eighteen months of felling (Miles 2006).

Details of Dendrochronological Analysis

The results of the dendrochronological analysis for the artefact under study are presented in a number of detailed tables. The most useful of these is the summary **Table 1**. This gives most of the salient results of the dendrochronological process, and includes details for each sample, its location, and its felling date or date range, if successfully tree-ring dated. This last column is of particular interest to the end user, as it gives the actual year and season when the tree was felled, if the final ring is present, or an estimated felling date range if the sapwood is incomplete. Occasionally it will be noted that the felling date ranges may not coincide with the precise felling dates. This is nothing to be overly concerned about so long as these are not too far apart. It must be remembered that the estimated felling date ranges are calculated at a 95% confidence level, which means that statistically one sample in 20 will have felling dates which actually fall *outside* the predicted range.

It will also be noticed that often the precise felling dates will vary within several years of each other. Unless there is supporting archaeological evidence suggesting different phases, all this would indicate is either stockpiling of timber, or of trees which have been felled or died at varying times but not cut up until the commencement of the particular building operations in question. When presented with varying precise felling dates, one should always take the *latest* date for the structure under study, and it is likely that construction will have been completed for ordinary vernacular buildings within twelve or eighteen months from this latest felling date (Miles 1997).

Table 2 gives an indication of the statistical reliability of the match between one sequence and another. This shows the *t*-value over the number of years overlap for each combination of samples in a matrix table. It should be borne in mind that *t*-values with less than 80 rings overlap may not truly reflect the same degree of match and that spurious matches may produce similar values.

First, multiple radii have been cross-matched with each other and combined to form same-timber means. These are then compared with other samples from the site and any which are found to have originated from the same parent tree are again similarly combined. Finally, all samples, including all same timber and same tree means are combined to form one or more site masters. Again, the cross-matching is shown as a matrix table of *t*-values over the number of years of overlap. Reference should always be made to **Table 1** to clearly identify which components have been combined.

Table 3 shows the degree of cross-matching between the site master(s) with a selection of reference chronologies. This shows the county or region from which the reference chronology originated, the common chronology name together with who compiled the chronology, a publication reference and the years covered by the reference chronology. The number of years overlap of the reference chronology and the site master being compared are also shown together with the resulting *t*-value. It should be appreciated that well-replicated regional reference chronologies, which are shown in **bold**, will often produce better matches than with individual site masters or indeed individual sample sequences.

Figures include a bar diagram which shows the chronological relationship between two or more dated samples from a phase of building. The site sample record sheets are also appended, together with any plans showing sample locations, if available.

Publication of dated sites are published in *Vernacular Architecture* annually, and the entry, if available, is shown on the summary page of the report. This does not give as much technical data for the samples dated, but does give the *t*-value matches against the relevant chronologies, provide a short descriptive paragraph for each building or phase dated, and gives a useful short summary of samples dated. These summaries are also listed on the web-site maintained by the Laboratory, which can be accessed at `www.Oxford-dendroLab.com`. The Oxford Dendrochronology Laboratory retains copyright of this report, but the commissioner of the report has the right to use the report for his/her own use so long as the authorship is quoted. Primary data and the resulting site master(s) used in the analysis are available from the Laboratory on request by the commissioner and *bona fide* researchers. The samples form part of the Laboratory archives.

BACKGROUND

The Church of St Peter at Church Laneham in Nottinghamshire has Norman origins, with a fine chancel arch and a south door case with two orders of nook shafts with waterleaf capitals, whilst the arch has orders of roll mouldings, chevrons, and billet (Geddes 1999, 336)(Figs 6 & 7). The roof has been replaced at some point in the past, and the south door itself was replaced earlier last century with a facsimile door with details loosely based on the original, which still survives mounted on the west wall adjacent, face out.

The programme of dendrochronology proposed by Gavin Simpson and Chris Pickvance was to date both the door and the chest, with supplementary recording of both. The door was removed from the wall and set up on trestles face down, and the chest was moved out from the wall and set up on blocks to allow access to the back.

SUMMARY OF FINDINGS

Dendroprovenancing in Britain is a topic of interest, but at this stage it is still difficult to be very accurate about the origins of growth of oak timbers (Bridge 2011; 2012). Nevertheless, trends in the stronger matches found for a given site or artefact do give useful clues as to the possible areas in which the parent trees grew, and these are often best illustrated using maps with the locations used plotted as circles of varying size, relating to the strength of the statistical matches found (usually *t*-values). Values of *t* over 3.5 are usually shown, this being the level at which matches are deemed significant (Baillie and Pilcher 1973).

Individual sites may themselves contain timber that was not of local origin, so it is important to look at the geographical trend, rather than a single site match. When considering the results below, it is useful to know that the chronologies from the door and the chest did not match each other, suggesting that the timber used came from different origins. The scales used for the dots in each map vary so as to give the best visual impression of the results. All significantly matching sites with at least 50 years overlap are shown

<u>THE DOOR (see Figs 1 to 8)</u>

Recording during this investigation has revealed that the door has square edged boards with loose tongues which are stopped top and bottom (that is to say that the tongues sit in a groove in either board, as in the detail at the bottom of Fig 1, but the groove is stopped, i.e. it does not run to the ends of the boards and is therefore not visible from the top or bottom of the board). These may have been glued originally, as there is no movement between the 1¼” thick boards with the joints still very tight. Only the top ledge remains, but the gap for the missing middle one is clearly evident, along with the original scribing lines, and the position of the lower ledge is also clearly evident. These are spaced 3 feet apart and have two sets of saltire braces between. The ledges are chamfered, but the braces are only lightly chamfered, and this is not consistent. Geddes felt that the boards were V-edged, but the back was not accessible where mounted on the wall, and so she could not have noted that the boards were square edged with stopped loose tongues. The ironwork is of two strap hinge bands with thin tendrils with Cs ending in split curls (Geddes 1999). She has proposed a date of *circa* 1200 for the door, and *circa* 1200-1250 for the chest.

Cores were taken with the micro-borer given the thinness of the material, and particular attention was given to any material which might have some sapwood remaining. Gavin Simpson felt that the top ledge and some of the braces might have had some sapwood, so these were sampled in addition to the door boards.

Three of the four boards were sampled through a single hole just below the top of the ledge, the core continuing from one board into the next. The first two boards from the fore edge of the door retained a small amount of sapwood at the top (**Inm1a** and **Inm2a**), and these were sampled again at the top where the heartwood/sapwood boundary remained clearly identifiable (**Inm1b** and **Inm2b**). The third board (**Inm3**) from the fore edge of the door was also sampled because it had a good number of rings – even though it did not have any heartwood/sapwood boundary, it was felt that it might help the sequences match with additional replication. The top ledge was sampled twice, as the small core fragmented (**lnm4a** and **lnm4b**), and two braces were also sampled (**lnm5** and **lnm6**). Apart from the first two boards, no other obvious sapwood or heartwood sapwood boundaries were noted on any of the timbers. It should be noted that the door was exceptionally weathered on its lower half.

First, the multiple radii from samples the door were compared with each other and combined to form the same-timber means **lnm1**, **lnm2**, and **lnm4** (Table 1). The first two boards **lnm1** and **lnm2** matched together with a respectable *t*-value of 6.71 (Table 2). These were dated independently to span the years 1012-1147 and 998-1140 respectively. The ledge **lnm4** also dated to 969-1030 independently. All three samples were then compared with each other and whilst the last sample **lnm4** did not match terribly well with the other two timbers, partly on account of the short overlap with the others (Table 2), they were nevertheless all combined to form the 179-ring site master **LANEHAM1**. The inclusion of **lnm4** increased the overall matching of the master (Table 3a). The third board (**lnm3**) with 122 rings, and the braces **lnm5** and **lnm6** with 55 and 51 rings respectively, all failed to date, either individually or with each other.

These results allowed empirical felling date ranges of 1159-92 for **lnm1** and 1152-85 for **lnm2**, based on a sapwood estimate of 12-45 rings (Miles 1997). By taking the average heartwood/sapwood boundary date of 1144, a combined empirical range of 1156-89 can be given.

However, these can be further reduced by Bayesian modelling using the dendro function in OxCal, with **lnm1** being reduced to 1157-87 and **lnm2** being reduced to 1152-83, using Miles's Model C (England and Wales). However, by using the 'combined' function of OxCal, the two can be combined to form a single felling date range of ***1157-78***, a range of 21 years compared to the 33-year empirical range. This gives an agreement of 118%, any value over 50% for two samples being significant (see Miles 2005). These ranges are all substantially earlier than the *circa* 1200 date proposed by Geddes. The last measured ring date of the ledge (**lnm4**) of 1030 does not suggest an earlier phase, but is just that the tree had been cut into planks and this represents the innermost of a series of members cut out of a single plank. Given this, there is no reason to think that it is anything other than of the ***1157-78*** date range.

The timber was most likely locally sourced, as suggested by the *t*-value matches in Table 3a and Fig 11.

THE CHEST

Inside the church are two chests, the larger one sits to the north of the west tower door, and is a stile chest with three trefoil lancet openings cut into the foot of each stile, and three circular chip-carved stars carved on the top of the stiles and front board. The original hinges were designed as pivots on the rear stiles, but this arrangement has been altered to iron strap hinges on a partially fixed pine top (Geddes 1999). A notable feature of this chest is the 'secret' till, a narrow till, probably for documents, under the pivoted floor of the main till.

The chest was of notably faster-grown timber, with some concern as to whether there would be enough rings to allow dendrochronology to be used satisfactorily. The bottom boards did appear to be original, and to have good ring sequences, but were inaccessible and the chest was in such poor condition that it was not possible to upend it. None of the components of the chest had any certain signs of heartwood/sapwood boundaries. All of the samples are detailed in Table 1 (see Figs 4 & 5).

The upper part of the front board was sampled (**lnm7**) due to the fact that it was in good condition with almost 100 rings. The front left stile appeared to be very fast grown and was not sampled, not was the rear right stile as it was partially rotted away and in a very poor condition. The front right stile (**lnm8**) and rear left stile (**lnm9a**, **lnm9b1**, and **lnm9b2**) were sampled. The latter was sampled twice as it was heavily beetle-ridden and the cores fragmented. The samples from the rear left stile were combined to form the mean **lnm9** (Table 2).

All samples were compared with each other and the two stiles **lnm8** and **lnm9** matched with a *t*-value of 5.42. Although it was not possible to determine that they had originated from the same parent tree on dendrochronological grounds, it is quite likely that they were. These two series were combined to form the second site master **LANEHAM2** with 122 rings.

This was compared with the reference chronologies and it too dated, spanning the years 1107-1228 (Table 3b). The three individual timbers were also compared with the reference chronologies and whilst the relevant dates for the stile samples **lnm8** and **lnm9** were confirmed, there was no matching for the front board **lnm7**.

Stiles **lnm8** and **lnm9** had last measured ring dates of 1228 and 1210 respectively, giving *terminus post quem* dates of 1237 for **lnm8** and 1218 for **lnm9**, using a 9-41 range appropriate for the south (Miles 1997). Therefore all one can say is that is unlikely to have been constructed before 1237, but is not likely to be much later than 1275, and assuming that only the minimum of heartwood rings had been removed with the sapwood during conversion, then a construction date of the third quarter of the 13th-century seems most likely.

The matching shown in Table 3b and Fig 12 suggest the tree(s) used grew in the Hampshire / Wiltshire / Somerset region.

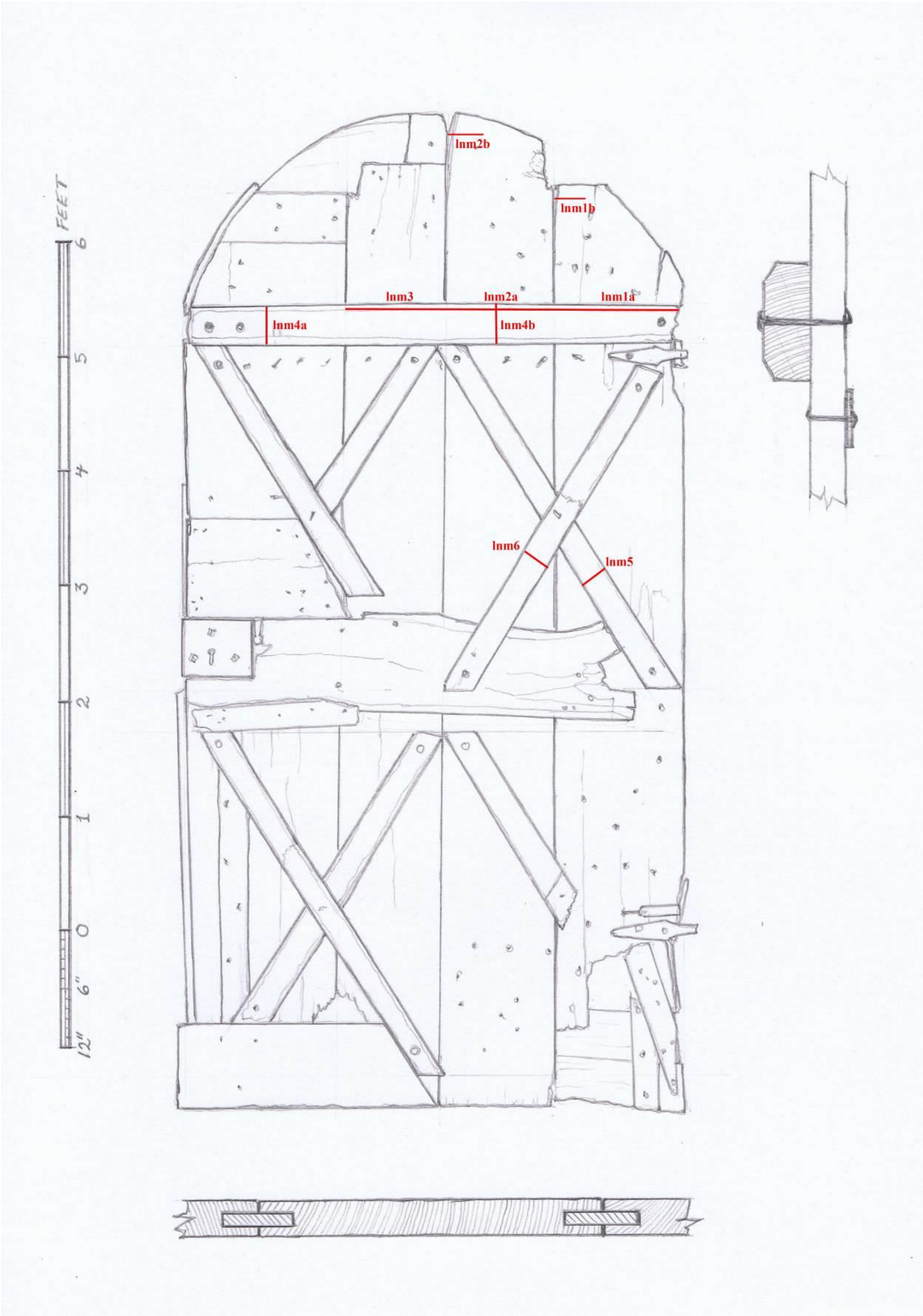


Figure 1: Measured drawing of rear face of door showing sample locations, with details at x3 scale (DM)

Acknowledgements

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Figure 2: Door being drilled with micro-borer (photo Amy Boyce)

Figure 3: Tip of drill in guide where entering edge of board (photo Amy Boyce)

Figure 4: Edge of the bottom of board 3 showing the stopped loose tongue groove at bottom of board from the hinge side (DM)

Figure 5: Stopped loose tongue groove at the top of board 2 with loose tongue (DM)

Figure 6: External view of south door with replacement door shut (DM)

Figure 7: Detail of stonework shafts and capitals with arch (DM)

Figure 8: Remains of niche inside of doorway (DM)

Figure 9: Right front stile of chest (**lnm8**) being drilled (photo Amy Boyce)

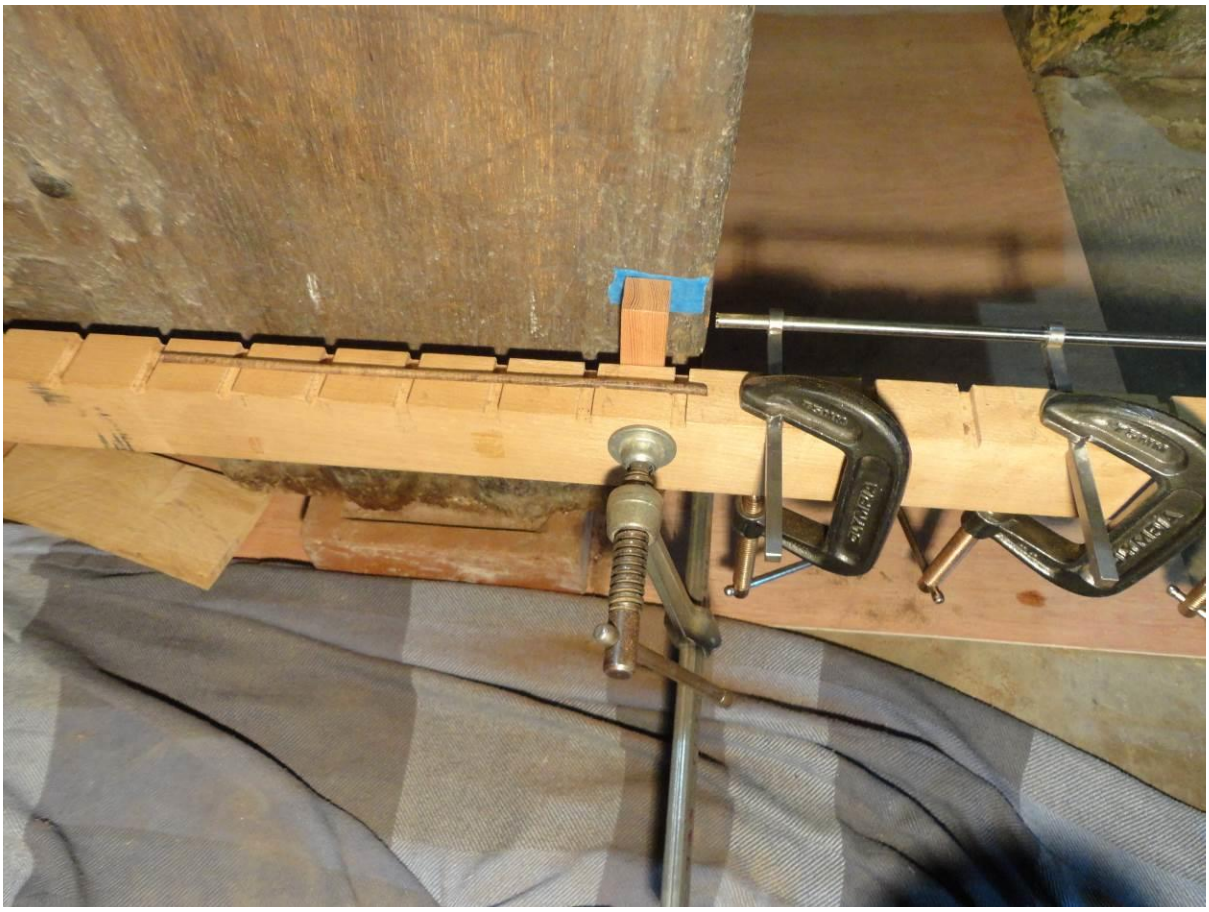

Figure 10: Sample **lmt8** after drilling (DM)

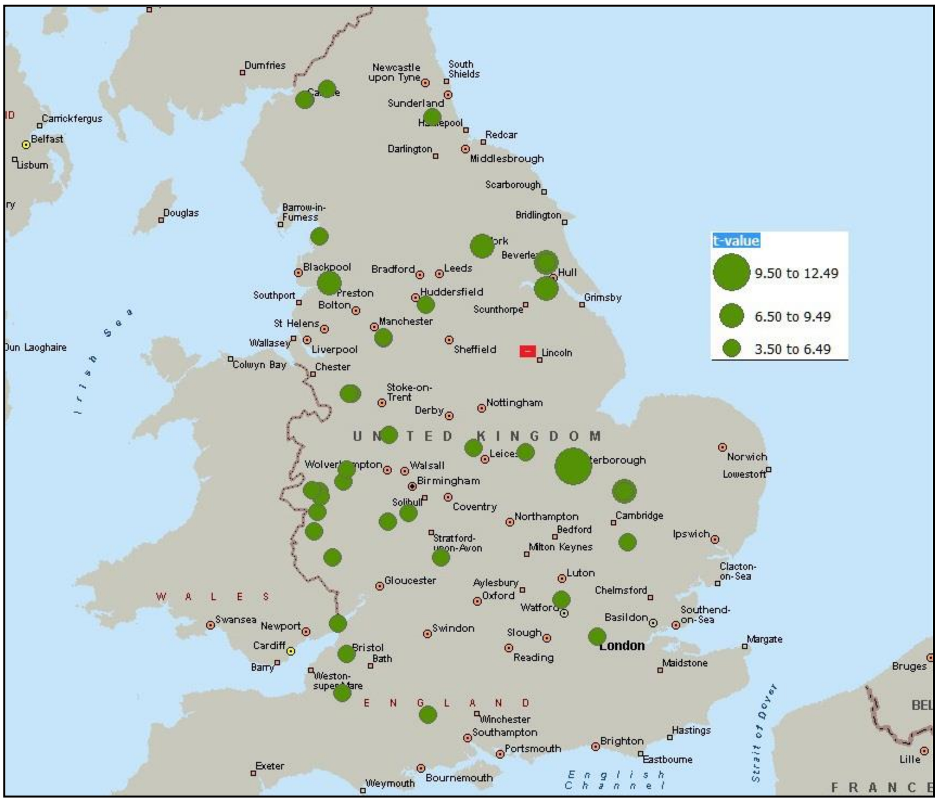

Figure 11: Map showing the matches for the Laneham door with other site chronologies. Whilst not conclusive, it suggests the wood used for the door may have been of local origin (MCB).

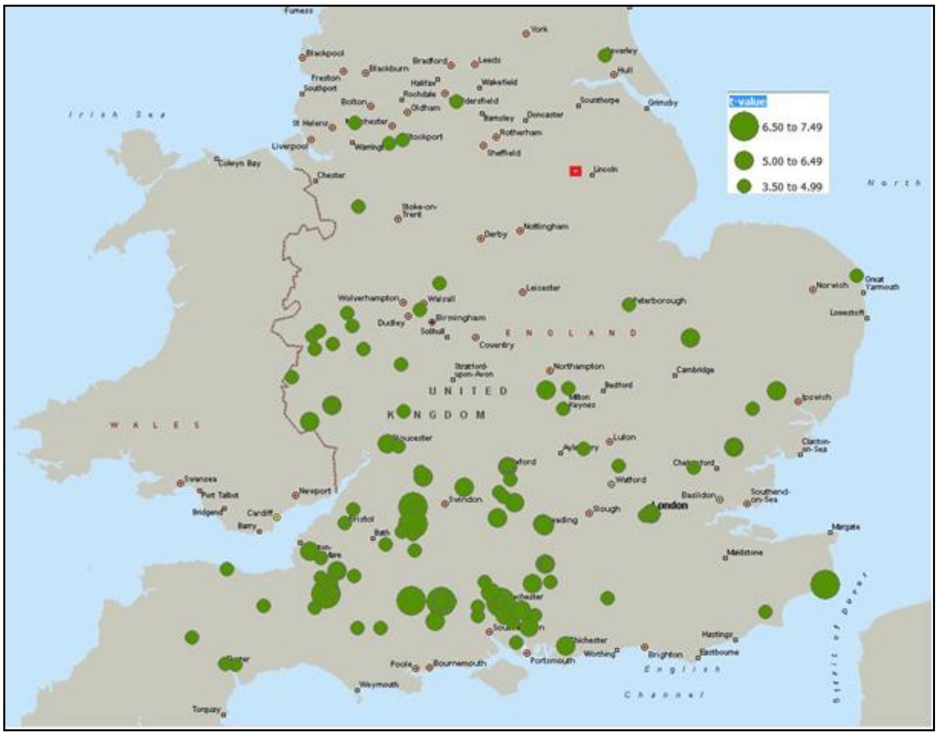

Figure 12: Map showing the matches for the Laneham chest. Although there is a lack of sites of similar age in the area surrounding Laneham, the strong matches in central and south-west England suggest that the wood used in its construction may have grown in this region, rather than closer to Laneham (MCB).

Table 1: Summary of Tree-Ring Dating

ST PETER'S CHURCH, LANEHAM, NOTTINGHAMSHIRE

Sample number & type		Timber and position	Dates AD spanning	H/S bdry	Sapwood complement	No of rings	Mean width mm	Std devn mm	Mean sens mm	Felling seasons and dates/date ranges (AD)
South Door (*ex situ*)										
lnm1a	mc	Board 4 opposite hinge	1012-1142			131	1.76	0.65	0.175	
lnm1b	mc	ditto	1094-1147	1147	H/S	54	1.26	0.29	0.138	
* **lnm1**		Mean of **lnm1a** + **lnm1b**	1012-1147	1147	H/S	136	1.74	0.65	0.169	1159-92 (OxCal 1157-87)
lnm2a	mc	Board 3 opposite hinge	998-1126			129	1.55	0.29	0.149	
lnm2b	mc	ditto	1092-1140	1140	H/S	49	1.21	0.19	0.132	
* **lnm2**		Mean of **lnm2a** + **lnm2b**	998-1140	1140	H/S	143	1.50	0.31	0.148	1152-85 (OxCal 1152-83)
lnm3	mc	Board 2 opposite hinge	-			127	1.73	0.81	0.224	
lnm4a	mc	top ledge	969-1030			62	1.59	0.42	0.202	
lnm4b	mc	ditto	970-1002			33	1.77	0.41	0.200	
* **lnm4**		Mean of **lnm4a** + **lnm4b**	969-1030			62	1.61	0.42	0.197	After 1042
lnm5	mc	Upper brace centre down to right	-			55	1.25	0.36	0.247	
lnm6	mc	Upper brace centre up to right	-			51	1.31	0.38	0.292	
*** = LANEHAM1 Site Master**			**969-1147**	**1144**	**Avg H/S bdy**	**179**	**1.60**	**0.38**	**0.146**	**1156-1189 (OxCal *1157-78*)**
Large Chest, West Wall										
lnm7	mc	Front upper board (carved)	-			95	3.11	0.70	0.180	
§ **lnm8**	mc	Front RH stile	1107-1228			122	2.49	1.19	0.266	After 1237
lnm9a	mc	Rear LH stile	1108-1209			102	2.26	0.87	0.265	After 1218
lnm9b1	mc	ditto	1131-1181			51	2.22	0.59	0.259	
lnm9b2	mc	ditto	1185-1210			26	1.68	0.55	0.247	
§ **lnm9**		Mean of **lnm9a** + **lnm9b1** + **lnm9b2**	1108-1210			103	2.25	0.87	0.271	
§ = LANEHAM2 Site Master			**1107-1228**			**122**	**2.31**	**0.94**	**0.242**	**Third quarter C13th**

Key: *, § = sample included in site-master; mc = micro-core; H/S bdry = heartwood/sapwood boundary - last heartwood ring date; std devn = standard deviation; mean sens = mean sensitivity

Explanation of terms used in Table 1

The summary table gives most of the salient results of the dendrochronological process. For ease in quickly referring to various types of information, these have all been presented in Table 1. The information includes the following categories:

Sample number: Generally, each site is given a two or three letter identifying prefix code, after which each timber is given an individual number. If a timber is sampled twice, or if two timbers were noted at time of sampling as having clearly originated from the same tree, then they are given suffixes '**a**', '**b**', etc. Where a core sample has broken, with no clear overlap between segments, these are differentiated by a further suffix '**1**', '**2**', etc.

Type shows whether the sample was from a core 'c', or a section or slice from a timber's'. Sometimes photographs are used 'p', or timbers measured *in situ* with a graticule 'g'.

Timber and position column details each timber sampled along with a location reference. This will usually refer to a bay or truss number, or relate to compass points or to a reference drawing.

Dates AD spanning gives the first and last measured ring dates of the sequence (if dated),

H/S bdry is the date of the heartwood/sapwood transition or boundary (if present). This date is critical in determining an estimated felling date range if the sapwood is not complete to the bark edge.

Sapwood complement gives the number of sapwood rings. The tree starts growing in the spring during which time the earlywood is produced, also known also as spring growth. This consists of between one and three decreasing spring vessels and is noted as *Spring* felling and is indicated by a ¼ C after the number of sapwood ring count. Sometimes this can be more accurately pin-pointed to very early spring when just a few spring vessels are visible. After the spring growing season, the latewood or summer growth commences, and is differentiated from the proceeding spring growth by the dense band of tissue. This summer growth continues until just before the leaves drop, in about October. Trees felled during this period are noted as *summer* felled (½ C), but it is difficult to be too precise, as the width of the latewood can be variable, and it can be difficult to distinguish whether a tree stopped growing in autumn or *winter*. When the summer growth band is clearly complete, then the tree would have been felled during the dormant winter period, as shown by a single C. Sometimes a sample will clearly have complete sapwood, but due either to slight abrasion at the point of coring, or extremely narrow growth rings, it is impossible to determine the season of felling.

Number of rings: The total number of measured rings present on the samples analysed.

Mean ring width: This, simply put, is the sum total of all the individual ring widths, divided by the number of rings, giving an average ring width for the series.

Mean sensitivity: A statistic measuring the mean percentage, or relative, change from each measured yearly ring value to the next; that is, the average relative difference from one ring width to the next, calculated by dividing the absolute value of the differences between each pair of measurements by the average of the paired measurements, then averaging the quotients for all pairs in the tree-ring series (Fritts 1976). Sensitivity is a dendrochronological term referring to the presence of ring-width variability in the radial direction within a tree which indicates the growth response of a particular tree is "sensitive" to variations in climate, as opposed to complacency.

Standard deviation: The mean scatter of a population of numbers from the population mean. The square root of the variance, which is itself the square of the mean scatter of a statistical population of numbers from the population mean. (Fritts 1976).

Felling seasons and dates/date ranges is probably the most important column of the summary table. Here the actual felling dates and seasons are given for each dated sample (if complete sapwood is present). Sometimes it will be noticed that often the precise felling dates will vary within several years of each other. Unless there is supporting archaeological evidence suggesting different phases, all this would indicate is either stockpiling of timber, or of trees which have been felled or died at varying times but not cut up until the commencement of the particular building operations in question. When presented with varying precise felling dates, one should always take the *latest* date for the structure under study, and it is likely that construction will have been completed for ordinary vernacular buildings within twelve or eighteen months from this latest felling date (Miles 2006).

Felling date ranges are produced using an empirical estimates using the appropriate estimate (Miles 1997). However, these can sometimes be reduced using a new sapwood estimation methodology which uses the mean ring width, number of heartwood rings, known H/S boundary date, and the number of surviving sapwood rings, if present (Miles 2006). These are used after the empirical range and are shown in brackets (OxCal followed by date range). Combined felling date ranges for a phase of building is shown at the end of the phase to which it relates.

Table 2: Matrix of *t*-values and overlaps for same-timber means and site masters

Components of timber **lnm1**

Sample:	**lnm1b**
Last ring date AD:	1136
lnm1a	<u>13.30</u> 49

Components of timber **lnm2**

Sample:	**lnm2b**
Last ring date AD:	1140
lnm2a	<u>9.25</u> 35

Components of timber **lnm9**

Sample:	**lnm9b1**	**lnm9b2**
Last ring date AD:	1181	1210
lnm9a	<u>23.37</u> 51	<u>10.20</u> 25

Components of site master **LANEHAM1**

Sample:	**lnm2**	**lnm4**
Last ring date AD:	1140	1030
lnm1	<u>6.71</u> 129	<u>1.18</u> 19
	lnm2	<u>3.72</u> 33

Components of site master **LANEHAM2**

Sample:	**lnm9**
Last ring date AD:	1210
lnm8	<u>5.42</u> 103

Table 3a: Dating of site master **LANEHAM1** (969-1147) against reference chronologies at 1147

County or region:	*Chronology name:*	*Short publication reference:*	*File name:*	*Spanning:*	*Overlap:*	t-*value:*
N Lincolnshire	Barton-on-Humber coffins	(Tyers 2001)	BOHSP_CO	785-1134	166	8.00
Yorkshire	York Medieval Chronology	(Groves *pers comm*)	YORKMEDX	695-1567	179	8.67
Yorkshire	Beverley buildings	(Groves *pers comm*)	BEVRLY94	858-1324	179	9.06
Great Britain	British Isles Master Chronology	(Haddon-Reece and Miles 1993)	**MASTERAL**	404-1987	179	9.09
East Midlands	East Midlands Master	(Laxton and Litton 1988)	**EASTMID**	882-1981	179	9.09
North	Northern England Master	(Hillam and Groves 1994)	**NORTH**	440-1742	179	10.06
Cambridgeshire	Peterborough Cathedral	(Tyers 1999)	PETERC	887-1225	179	12.02

Table 3b: Dating of site master **LANEHAM2** (1107-1228) against reference chronologies at 1228

County or region:	*Chronology name:*	*Short publication reference:*	*File name:*	*Spanning:*	*Overlap:*	t-*value:*
Somerset	Somerset Master Chronology	(Miles 2004)	**SOMRST04**	770-1979	122	7.05
Wiltshire	Salisbury Cathedral	(Miles 2002)	SARUM3x	1054-1254	122	7.22
England	Southern Central England	(Wilson *et al* 2012)	**SCENG**	663-2009	122	7.28
Great Britain	British Isles Master Chronology	(Haddon-Reece and Miles 1993)	**MASTERAL**	404-1987	122	7.40
Wiltshire	Salisbury Cathedral	(Miles *et al* 2004)	SARUM14	1053-1241	122	7.59
Hampshire	Hampshire Master Chronology	(Miles 2003)	**HANTS02**	443-1972	122	8.22
Hampshire	Stables at Bishops Waltham Palace	(Miles *et al* 2009)	BISHWTHM	1133-1291	96	8.57

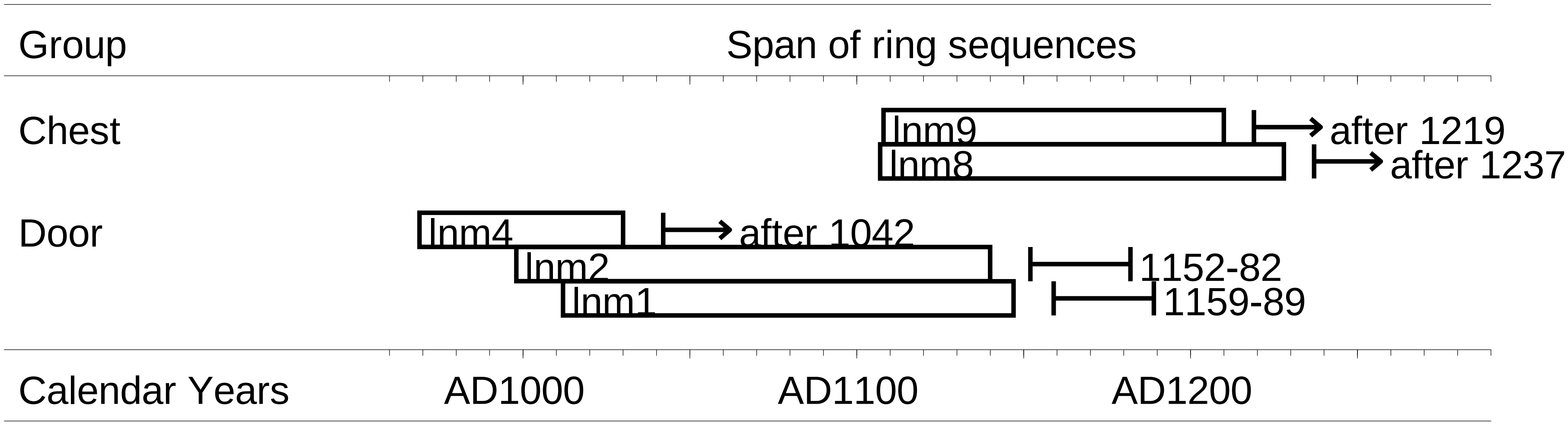

Figure 13: Bar diagram showing dated timbers in chronological position (MCB)