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TREE-RING ANALYSIS OF TIMBERS FROM
WYTHEFORD HOUSE,
GREAT WYTHEFORD,
SHAWBURY,
SHROPSHIRE,

A J ARNOLD
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WITH DOCUMENTARY INFORMATION PROVIDED BY MR RODERICK DAVIES

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SUMMARY

Analysis by dendrochronology of a number of timbers from Wytheford House has produced a single dated site chronology comprising 13 of the 14 samples obtained. This site chronology has an overall length of 211 rings, these rings dated as spanning the years 1516–1726.

Interpretation of the sapwood on the dated samples indicates that there are two phases of felling represented by the sampled timbers.

The earliest phase is represented by four reused timbers originally cut as part of a single episode of felling some time between 1646–71. It is likely that they have been salvaged from another building and reused in their present positions, but it is just possible that they represent an existing, earlier, building that has been incorporated or amalgamated with the present house. These earlier timbers may well be remnants of a Mr. Francis Hill's house which is believed to have stood on or near the spot of the present house, and which is first referred to in a rent roll of 1664. These four timbers are all from the roof of the southwest wing which is believed, on the basis of documentary evidence, to have been built in 1737.

The construction of the main body of the present house appears to be represented by seven timbers from the roof of the main range and two timbers in its cellar. These timbers again appear to have been cut as part of a single phase of felling, this taking place in 1726. As such it is likely that the house was built by a Mr Thomas Dorsett who is known to have taken out a lease on the site in 1725.

A single sample, from an oak table in the dining room, remains undated.

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Introduction

The main body of Wytheford House, at Great Wytheford, presents what appears to be a rectangular, brick-built, structure of two storeys with attics beneath a plain slate roof (Fig 1a). Closer inspection to the rear and west shows, however, that the northwest quarter of the house was never built, so that the building is formed of a rectangular main range with what is in effect a short southwest wing (Fig 1b). In the roof space there is the remains of a brick partition wall between the two portions. The Listing Description suggests that the main house is a complete, singe-phase, structure of mid-eighteenth century date, although more recent documentary research has shown this to be possibly not quite the case.

There is, for example, an extension to the northwest (see Fig 2), dated on the basis of a Michaelmas rent roll, to 1737. This lists the bill of one Andrew Penny, Bricklayer, for the building of 'Thomas Dorsett's Vault' at a cost of £23.1.0 (Fig 3). Photographs taken in 1963, when a further extension was added to its north end, show that this northwest range was much altered internally when the vaulted ceiling was removed and the vault itself was partially filled in. Despite this 1963 work, the outer shell of the vault is as it originally was apart from a filled-in window and door, and a missing set of steps. There are also other extensions added to the east gable of the main range.

Amongst other documents, the southwest range is referred to in the Rent Roll of Michaelmas 1737: *"Paid ye Charges of Building Thomas Dorsett's Parlour and Rooms over it as of particulars in the other book, £124.18.11"*. This refers to details in another book (presumably the Lady Day book of 1737) which is not in the archive collection. There are also two leases that survive between the said Thomas Dorsett and the Charlton's of Apley Castle, these dated 1725 and 1733, though it is known from an account book of 1701 that Thomas Dorsett had taken an interest in a Mr. Hill's Tenement at that time. This last may refer to Mr Francis Hill whose house is believed to have stood on or near the present house, and which was described in 1672 as having two hearths. The first mention of Francis Hill is in a rent roll of 1664.

The roof of the main range is triple ridged, forming a northern, middle, and southern roof, (the ridges hidden behind a brick parapet), while the roof to the southwest wing is a one-and-a-half ridge roof (Fig 4a/b). Within, the main range roof (Fig 5a) comprises coupled common rafter frames, with single principal rafters to the north pitch of the north roof and to the south pitch of the south roof only (truss 1 in Fig 6). These common and principal rafters support single purlins, again to the north pitch of the north roof and to the south pitch of the south roof only. The roof of the southwest wing also comprises coupled common rafter frames, there being a single principal rafter with tiebeam truss (truss 2 in Fig 6). These also carry a single purlin to the south pitch only (Fig 5b).

Sampling

Sampling and analysis by tree-ring dating of the timbers within Wytheford House were commissioned by the owner, Mr Roderick Davies, as part of a long-standing personal interest in the building and its history, and as part of a general programme of research into its origins and development. It was hoped that tree-ring dating would establish the date of the original

building. With this aim in mind core samples were obtained from a number of different suitable timbers, each sample being given the code WYT-A (for Wytheford site 'A').

An attempt was made to distribute the samples throughout the building to ensure that any differences in date might be detected, and to ensure that any possible variations in construction might be identified. In respect of this, it should be noted that a number of floor joists, which were exposed for the purposes of sampling, although large, were derived from fast-grown trees. As such they were deemed to have too few rings, ie, less than 50, for reliable tree-ring dating and they were not sampled, this resulting in samples being obtained from the roof of the main range, the southwest wing, and the cellars only.

In addition to the structural timbers a single core sample was obtained for a large table made from a single section of oak. It was hoped that analysis might give some indication of the date of the table.

Where possible, the sampled timbers are located on a simple plans or sections, these being given here as Figures 4a/b and 6. Details of the samples are given in Table 1, including the timber sampled and its location, the total number of rings each sample has, and how many of these, if any, are sapwood rings. The individual date span of each dated sample is also given. In this Table, and on the drawings, the trusses, bays, and individual timbers, have been located on a site north–south/east–west basis as appropriate.

The Nottingham Tree-ring Dating Laboratory would like to take this opportunity to thank the owner of Wytheford House, not only for his enthusiasm and interest in the building, and the application of tree-ring dating to its interpretation, but also for commissioning and funding this programme of tree-ring 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 timber most commonly found preserved in archaeological excavations) grow by adding one, and only one, growth-ring to their circumference each, and every, year. Each new annual growth-ring is added to the outside of the previous year's growth just below the bark. The width of this annual growth-ring is largely, though not exclusively, determined by the weather conditions during the growth period (roughly March–September). In general, good conditions produce wider rings and poor conditions produce narrower rings. Thus, over the lifetime of a tree, the annual growth-rings display a climatically influenced pattern. Furthermore, and importantly, all trees growing in the same area at the same time will be influenced by the same growing conditions and the annual growth-rings of all of them will respond in a similar, though not identical, way (Fig 7).

Secondly, because the weather over any number of consecutive years is unique, so too is the growth-ring pattern of the tree. The pattern of a short period of growth, 20, 30**,** or even 40 consecutive years, might conceivably be repeated two or even three times in the last one thousand years. A short pattern might also be repeated at different time periods in different parts of the country because of differences in regional micro-climates. It is less likely,

however, that such problems would occur with the pattern of a longer period of growth, that is, anything in excess of 54 years or so. In essence, a short period of growth, anything less than 54 rings, is not reliable, and the longer the period of time under comparison the better.

Tree-ring dating relies on obtaining the growth pattern of trees from sample timbers of unknown date by measuring the width of the annual growth-rings. This is done to a tolerance of 1/100 of a millimeter. The growth patterns of these samples of unknown date are then compared with a series of reference patterns or chronologies, the date of each ring of which is known. When the growth-ring sequence of a sample "cross-matches" repeatedly at the same date span against a series of different relevant reference chronologies the sample can be said to be dated. The degree of cross-matching, that is the measure of similarity between sample and reference, is denoted by a "*t*-value"; the higher the value the greater the similarity. The greater the similarity the greater is the probability that the patterns of samples and references have been produced by growing under the same conditions at the same time. The statistically accepted fully reliable minimum *t*-value is 3.5.

However, rather than attempt to date each sample individually it is usual to first compare all the samples from a single building, or phase of a building, with one another, and attempt to cross-match each one with all the others from the same phase or building. When samples from the same phase do cross-match with each other they are combined at their matching positions to form what is known as a "site chronology". As with any set of data, this has the effect of reducing the anomalies of any one individual (brought about in the case of tree-rings by some non-climatic influence) and enhances the overall climatic signal. As stated above, it is the climate that gives the growth pattern its distinctive pattern. The greater the number of samples in a site chronology the greater is the climatic signal of the group and the weaker is the non-climatic input of any one individual.

Furthermore, combining samples in this way to make a site chronology usually has the effect of increasing the time-span that is under comparison. As also mentioned above, the longer the period of growth under consideration, the greater the certainty of the cross-match. Any site chronology with less than about 55 rings is generally too short for reliable dating.

Having obtained a date for the site chronology as a whole, the date spans of the constituent individual samples can then be found, and from this the felling date of the trees represented may be calculated. Where a sample retains complete sapwood, that is, it has the last or outermost ring produced by the tree before it was cut, the last measured ring date is the felling date of the tree.

Where the sapwood is not complete it is necessary to estimate the likely felling date of the tree. Such an estimate can be made with a high degree of reliability because oak trees generally have between 15 to 40 sapwood rings. For example, if a sample with, say, 12 sapwood rings has a last sapwood ring date of 1400 (and therefore a heartwood/sapwood boundary ring date of 1388), it is 95% certain that the tree represented was felled sometime between 1403 (1400+3 sapwood rings (12+3=15)) and 1428 (1400+28 sapwood rings (12+28=40)).

Analysis

All 14 samples obtained from both roof areas, the cellar below the main range, and from the table were prepared by sanding and polishing, and the widths of their annual growth rings were measured. The data of these measurements were then compared with each other as described in the notes above. By this process 13 samples could be formed into a single cross-matching group, an attempt to illustrate the length, relative position, and overlap of these 13 samples being given in the bar diagram Figure 8. The 13 samples were combined at these off-set positions to form WYTASQ01, a site chronology with an overall length of 211 rings. This site chronology was then satisfactorily dated by repeated and consistent comparison with a large number of relevant reference chronologies for oak as spanning the years 1516 to 1726. The evidence for this dating is given in the *t*-values of Table 2.

The single remaining, ungrouped sample, WYT-A14, from the oak table, was compared individually with the full corpus of reference data, but there was no satisfactory cross-matching. This sample must, therefore, remain undated for the moment, though periodic attempts will be made in the future to cross-match it with additional site chronologies as they are accumulated.

Interpretation

Analysis of 14 samples from a range of locations at Wytheford House has produced a single dated site chronology, WYTASQ01, comprising 13 samples, all of them from the structural timbers of the house, this site chronology having a last measured ring date of 1726. Interpretation of the sapwood, and the position of the heartwood/sapwood boundary on the dated samples, would suggest that two periods of felling are represented amongst the sampled timbers.

Phase 1 timbers

The earliest material is represented by samples WYT-A07, A08, A09, and A10, all of them from the timbers of the southwest wing, with all such timbers showing possible evidence for reuse. None of these four samples retain complete sapwood, that is, none of them have the last growth ring produced by the tree they each represent before it was felled, and it is thus not possible to reliably indicate an exact felling date for the trees. Three of these four samples do, however, retain the heartwood/sapwood boundary, that is, only the sapwood rings have been lost (indicated by h/s in Table 1 and the bar diagram). In such circumstances it is usual to calculate the average date of the heartwood/sapwood boundary and, given that 95% of oak trees have between 15–40 sapwood rings, add these rings to the average date to give a time span during which it is highly likely that the trees were felled.

In this case the average heartwood/sapwood date on the three samples that retain it is 1631. Adding 15–40 to this date would suggest that the trees were felled some time in the period 1646–71. Given the cross-matching between the samples, and that they form a single integral structure (a main truss) within the roof, it is very likely that all the timbers were felled at the same time as each other in a single episode of felling.

These timbers have a series of empty mortices which would normally suggest that they have been reused in their present position. It is therefore possible that they are from an earlier building, or perhaps part of a building, on this site, and have simply been incorporated into the present structure, or are possibly timbers salvaged and reused from a now demolished building in the immediate vicinity.

The cross-matching between these four samples and the other nine from the main range suggests that all the trees used, in both parts of the building, were originally growing in woodlands reasonably close to each other, and it is unlikely that they have travelled very far. Either way, the four early timbers represent some hitherto unknown structure dating to the mid- to later-seventeenth century. It is quite possible that these timbers may be the reused remnants of a Mr Francis Hill's house which is believed to have stood on or near the present house. The first mention of Francis Hill is in a rent roll of 1664, a date which would coincide very nicely with the felling date range for the timbers, 1646–71, deduced from tree-ring analysis.

Phase 2 timbers

If we were to do the same calculations for the nine other dated samples in site chronology WYTASQ01, we would find that the average date of the heartwood sapwood boundary was very much later, at 1704, suggesting that these timbers were felled at a completely different time. Using the same sapwood estimate as above, 15–40 rings, would give these timbers an estimated felling date in the range 1719–1744.

However, as can be seen from Table 1 and the bar diagram, Figure 8, three of these later samples, WYT-A01, A03, and A11, retain complete sapwood (represented by upper case 'C' in Table 1 and the bar diagram), meaning they each have the last ring produced by the tree they represent before it was cut down. In each case the last complete sapwood ring, and thus the felling of the tree, is the same, this being dated to 1726.

It can also be seen from Table 1 and the bar diagram that two further samples, WYT-A02 and A06, are from timbers which, while they do have complete sapwood on them, have lost portions of the sapwood from the cores in sampling (this being due to the soft and fragile nature of this part of the wood and being indicated by lower case 'c' in Table 1 and the bar diagram). Under such circumstances, having noted at the time of sampling the amount of sapwood lost from each core (approximately 15 and 5 mm, respectively), it is possible to estimate the likely number of sapwood rings the lost sections might have contained. By adding the lost rings to the date of the last existing ring of the respective sample, a very close approximation of the true felling date can be calculated. In this instance it is estimated that the timbers represented by these two other samples were also felled in 1726.

Given the high level of cross-matching between these samples, whose felling date is known, and the remaining four samples, WYT-A04, A05, A12, and A13, from these later timbers, it is likely that all the main range roof timbers, as well as the timbers from the cellar, were felled together in 1726.

None of these timbers show any evidence for reuse, and given that they form a jointed and integral structure to the roof, and are found in the cellar, they all probably represent the construction date of the present house. It is almost certain, therefore, that the present house was built by Mr Thomas Dorsett who is known to have taken out a lease on the site in 1725. As such, this early-eighteenth century date is perhaps very slightly earlier than the mid-eighteenth century date ascribed to Wytheford House in the Listing Description.

Undated timber

A single sample, WYT-A14, from an oak table, remains ungrouped and undated, despite having nearly 200 growth rings. This sample, however, does show bands of compressed, narrow, and distorted rings, particularly in the earlier years of its growth, and it is possible that these represent some non-climatic influence which is affecting its ability to cross-match and date. Unfortunately, removing these bands and using only the outer 100 or so apparently undisturbed growth rings has no effect, and the sample must remain undated for the moment.

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Table 1: Details of tree-ring samples from Wytheford House, Great Wytheford, Shawbury, Shropshire

Sample number	Sample location	Total rings	Sapwood rings*	First measured ring date (AD)	Heart/sap boundary (AD)	Last measured ring date (AD)
	Main range roof timbers					
WYT-A01	South purlin, east gable–truss 1, south roof	156	20C	1571	1706	1726
WYT-A02	North purlin, east gable–truss 1, north roof	120	7c	1590	1702	1709
WYT-A03	South purlin, truss 1–brick wall, south roof	130	22C	1596	1704	1726
WYT-A04	South common rafter 12, bay 2, south roof	61	no h/s	1619	------	1679
WYT-A05	South common rafter 19, bay 2, south roof	69	no h/s	1610	------	1678
WYT-A06	North common rafter 20, bay 2, south roof	99	22c	1622	1698	1720
	Southwest wing roof timbers					
WYT-A07	North principal rafter, truss 2	73	no h/s	1516	------	1588
WYT-A08	South principal rafter, truss 2	106	h/s	1523	1628	1628
WYT-A09	Tiebeam, truss 2	88	h/s	1540	1627	1627
WYT-A10	South purlin, brick wall–truss 2	111	h/s	1527	1637	1637
WYT-A11	South common rafter *II*, bay 3	68	21C	1659	1705	1726
	Cellar timbers					
WYT-A12	South beam to ceiling (next south wall)	117	h/s	1592	1708	1708
WYT-A13	Beam to partition wall and doorway	124	7	1591	1707	1714
	Other timbers					
WYT-A14	Table	192	26C	------	------	------

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

C = Complete sapwood is retained on the sample, the last measured ring date is the felling date of the timbers

c = complete sapwood is found on the timber, but all or part has been lost from the sample in coring

Table 2: Results of the cross-matching of site chronology WYTASQ01 and relevant reference chronologies when the first ring date is 1516 and the last ring date is 1726

Reference chronology	***t*-value**	
Bolsover Castle (Riding House,) Derbys	8.3	(Howard *et al* 2005)
Lodge Farm, Staunton Harold, Leics	7.7	(Arnold *et al* 2008a)
Hilltop Farm, Staunton Harold, Leics	7.0	(Arnold *et al* 2008a)
Sinai Farm, Burton on Trent, Staffs	6.9	(Arnold *et al* 2008b)
Hulme Hall, Allostock, Cheshire	6.9	(Arnold *et al* 2003)
Bolsover Castle (Little Castle), Derbys	6.9	(Arnold *et al* 2003)
Stoneleigh Abbey, Stoneleigh, Warwicks	6.7	(Howard *et al* 2000)
Combermere Abbey, Combermere, Cheshire	6.6	(Howard *et al* 2003)

Site chronology WYTASQ01 is a composite of the data of all 13 cross-matching samples, this producing an 'average' tree-ring pattern, where the overall climatic signal of the ring growth is enhanced, and the possible erratic variations of any one individual sample is reduced. This 'average' site chronology is then compared with several hundred reference patterns covering every part of Britain for all time periods. As can be seen here, WYTASQ01 matches only when its 211 rings span the years 1516–1726, the table above giving only a small selection of the very best matches as represented by '*t*-values' (ie, degrees of similarity).

Figure 1a/b: Views of Wytheford House from the southwest (top) and northwest (bottom) showing how the northwest corner of the house has not been built

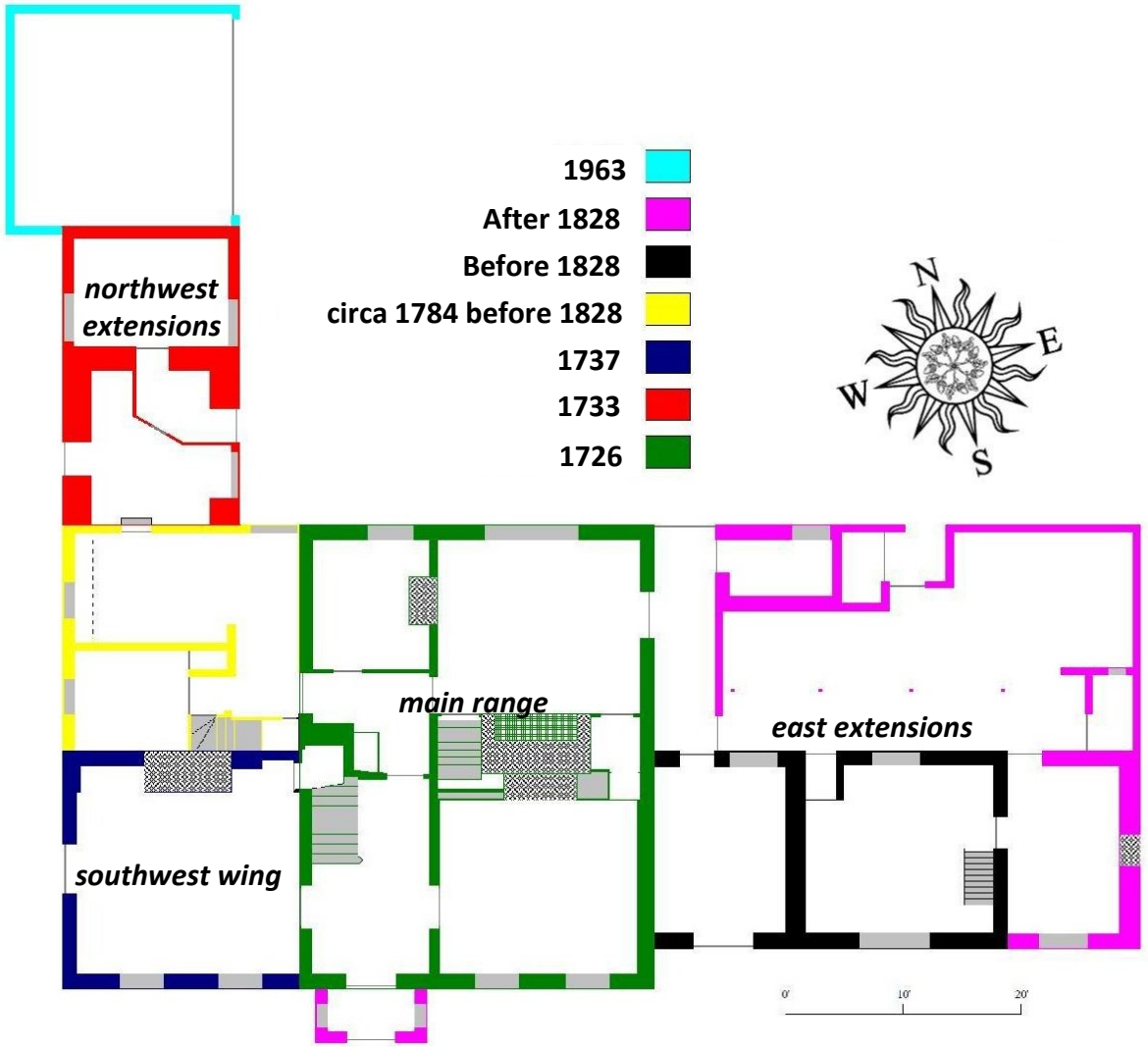


Figure 2: Plan of Wytheford House to show layout of the various ranges; phases based on interpretation of stylistic and documentary evidence (after Roderick Davies)

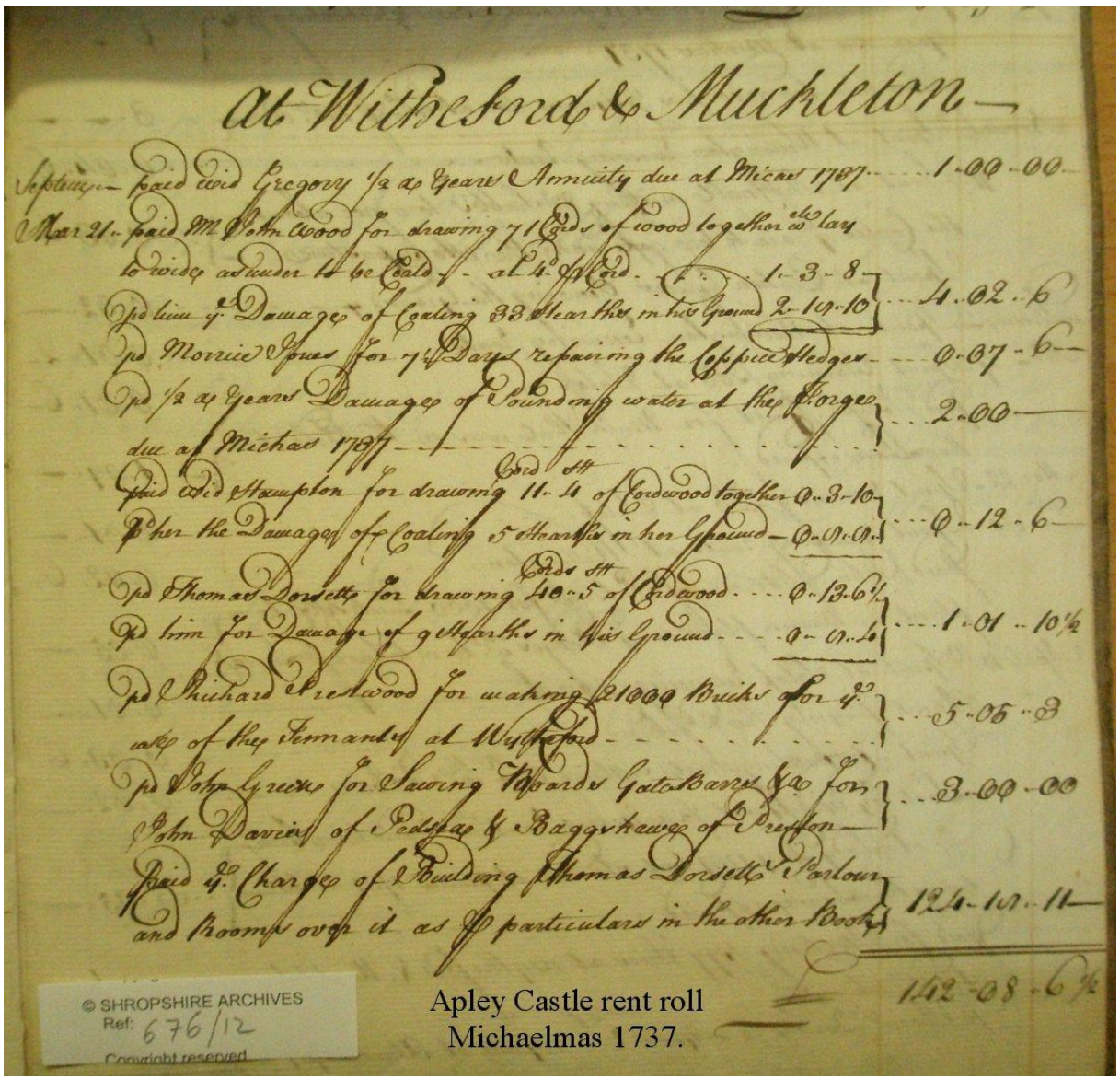
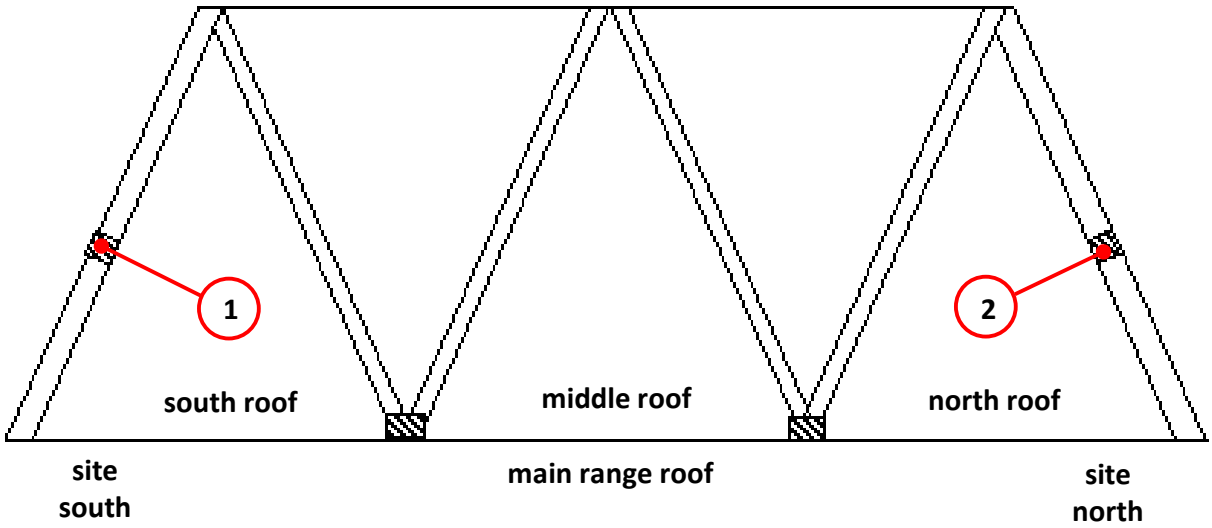


Figure 3: The rent roll of Michaelmas 1737 with the entry *"Paid y.e Charges of Building Thomas Dorsett's Parlour and Rooms over it as of particulars in the other book 124.18.11", probably referring to the construction of the southwest wing.* (Courtesy of Roderick Davies from the Shropshire Archives of the Apley Castle Estate papers).



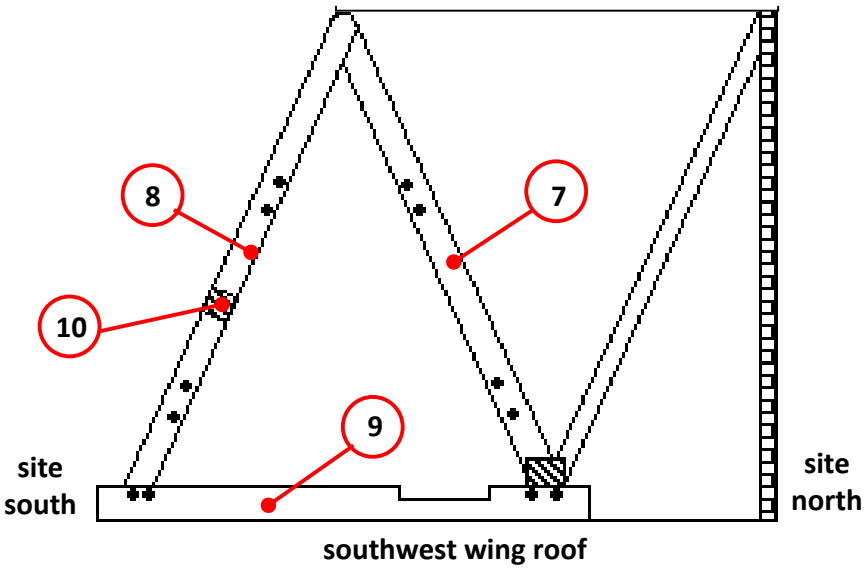


Figure 4a/b: Simple schematic sections at 'truss' positions through the main range (top) and southwest wing (bottom) to show arrangement of the roofs. Position of some sampled timbers also shown (see Table 1).

Figure 5a/b: Views of the coupled common rafter roof of the main range (top), and the southwest wing roof (bottom), with its potentially reused principal rafter truss.

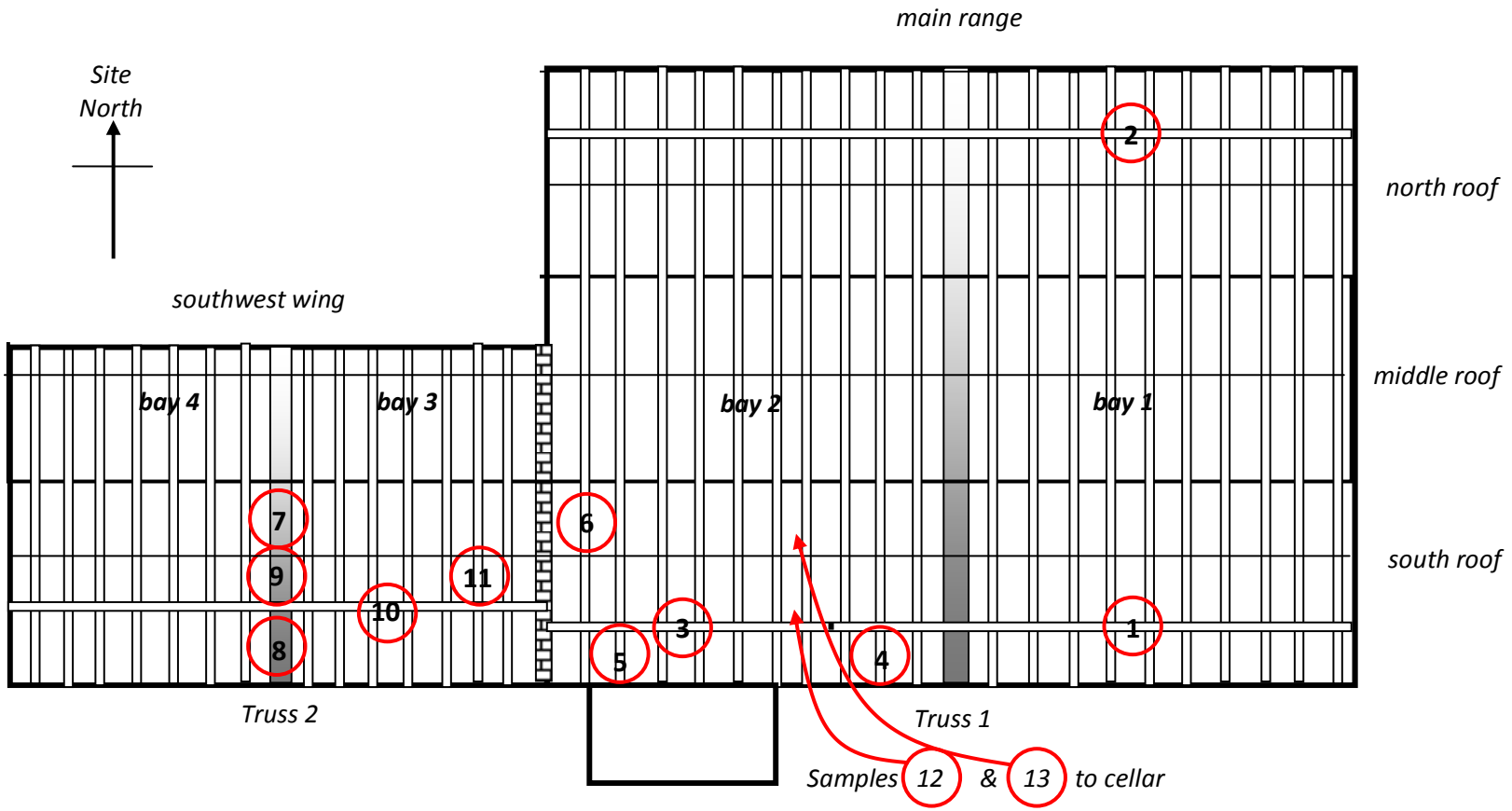


Figure 6: Simple schematic plan to show positions of sampled timbers

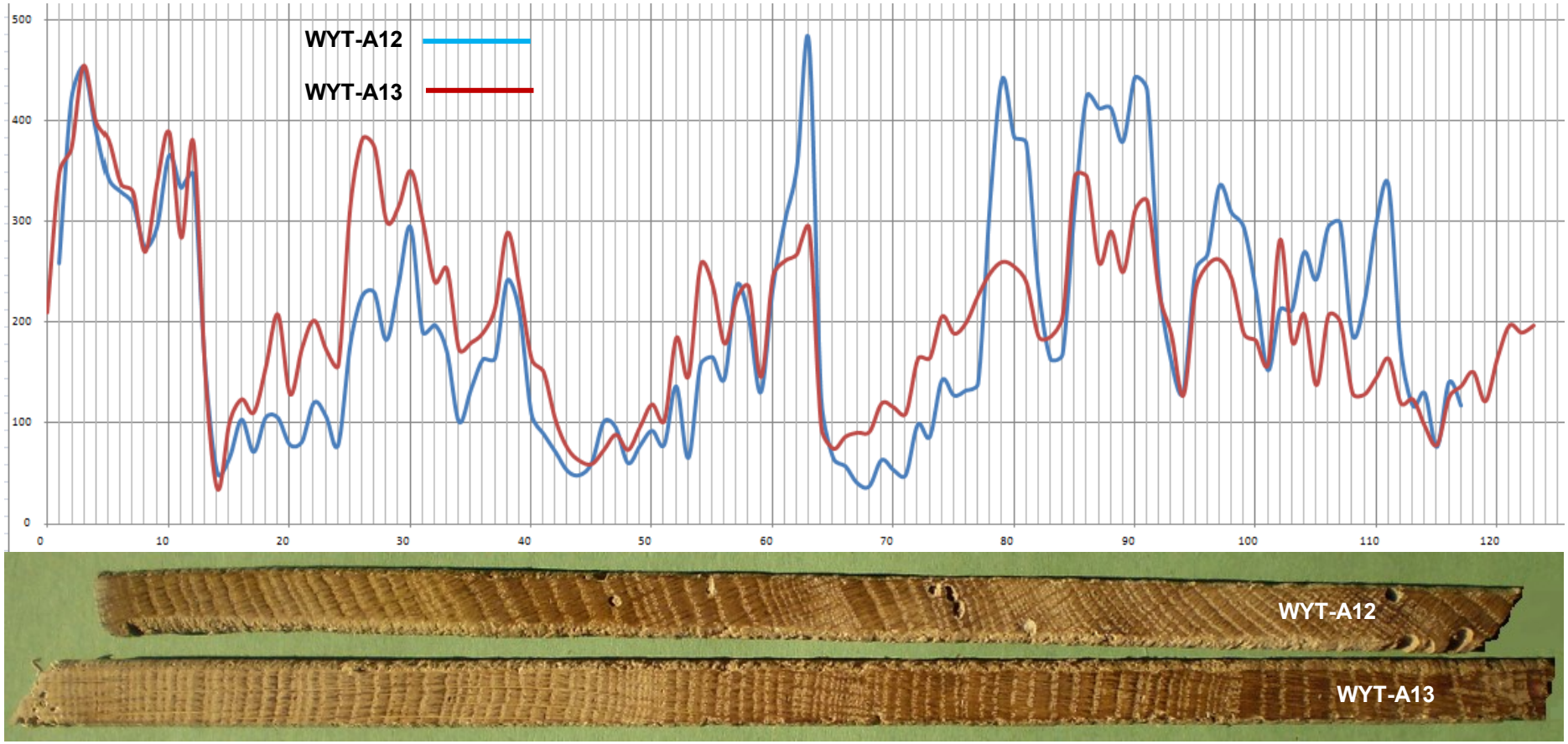
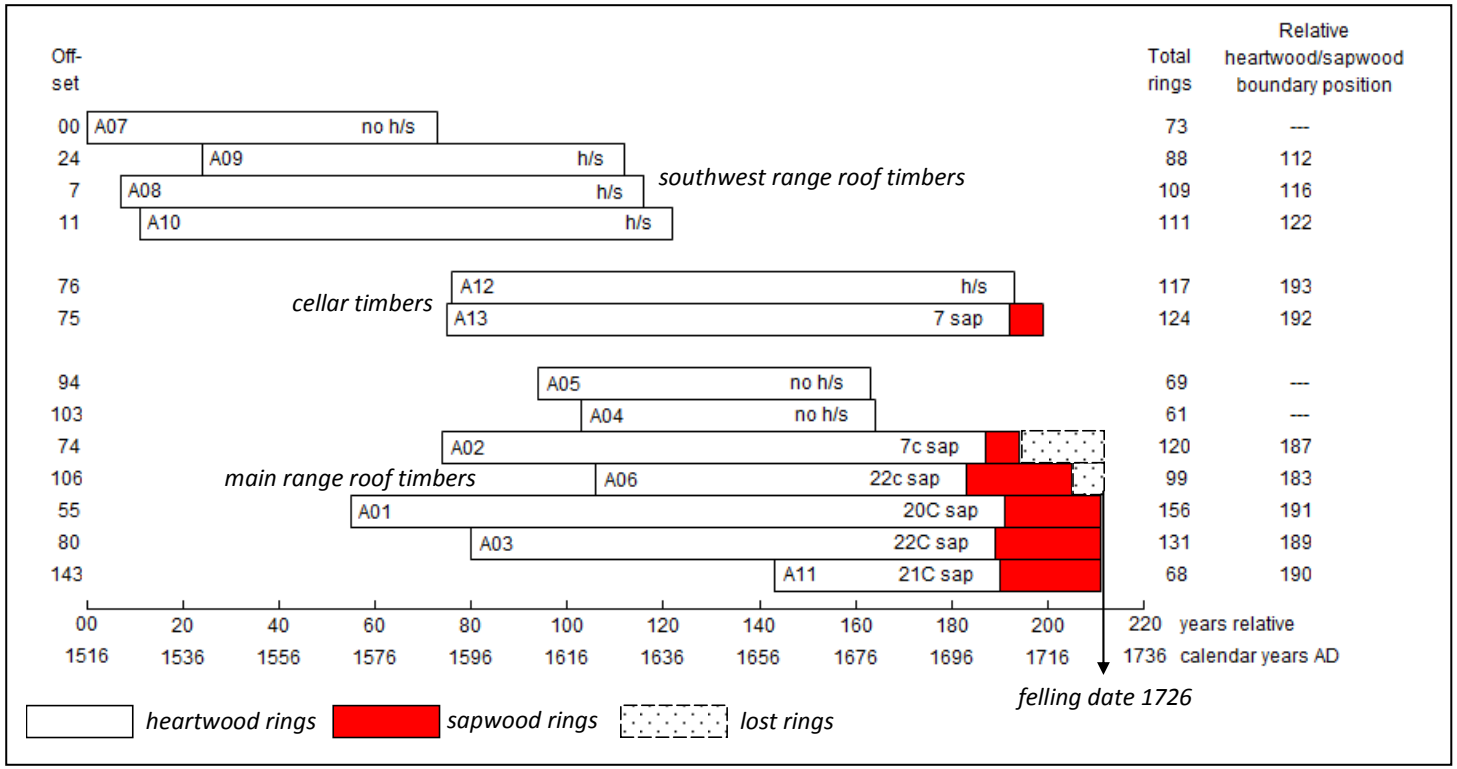


Figure 7: Graphic representation of the cross-matching of two samples, WYT-A12 (blue) and A13 (red). It can be seen that when cross-matched at the correct off-set positions, as here, the variations in width of the annual growth rings of these two samples correspond with a high degree of similarity. As the annual rings widths of one sample increase (represented by peaks in the graph), or decrease (represented by troughs), so too do the annual ring widths of the second sample. This similarity in growth pattern is a result of the two trees represented having grown in the same area *at the same time.* The growth ring pattern of two samples from trees grown at different times should never cross-match at any position.



c = complete sapwood is found on the timber but a portion of this has been lost from the sample in coring
C = complete sapwood is retained on the sample, the last measured ring date is the felling date of the timbers

Figure 8: Bar diagram of the samples in site chronology WYTASQ01. The samples are shown in the form of 'bars' at the positions where the variations in the rings cross-match with each other – this similarity being produced by the trees from which the sampled beams were derived all growing in the same place, *at the same time.* The samples are combined to form a 'site chronology', and it is this 'averaged' data which is compared and dated by comparison with the 'reference' chronologies.

It will be noticed that samples A07, A08,A09, and A10, have last ring dates much earlier than all the other samples; even allowing for the likely maximum number of sapwood rings these timbers might only have been felled as late as 1671.

It will also be seen that sample A01, A03, and A11 retain complete sapwood ie, they have the very last growth ring produced by the trees represented before they were cut down. The last ring on these samples, and thus the felling of the trees, is dated to 1726. Samples WYT-A02 and A06 are from trees that were almost certainly felled in 1726 as well, as indeed are all the other samples in this later group, including those in the cellar.