Oxford Dendrochronology Laboratory
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THE TREE-RING DATING OF CHURCH HOUSE, ARELEY KINGS, WORCESTERSHIRE (NGR SO 801 710)

Summary

Eight samples from the ten extracted from a range of structural elements of this building were dated. They appear to form a single batch of timbers, many having similar heartwood-sapwood transition dates, and were most likely felled at the same time. One timber retained complete sapwood, and was felled in the winter 1535/6. The most likely date of construction is therefore **1536**, or within a very few years following. An intermediate truss of uncertain date has been shown to be part of the primary construction of the building

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BACKGROUND TO DENDROCHRONOLOGY

The basis of dendrochronological dating is that trees of the same species, growing at the same time, in similar habitats, produce similar ring-width patterns. These patterns of varying ring-widths are unique to the period of growth. Each tree naturally has its own pattern superimposed on the basic 'signal', resulting from genetic variations in the response to external stimuli, the changing competitive regime between trees, damage, disease, management etc.

In much of Britain the major influence on the growth of a species like oak is, however, the weather conditions experienced from season to season. By taking several contemporaneous samples from a building or other timber structure, it should be possible to crossmatch the ring-width patterns, and by averaging the values for the sequences, maximise the common signal between trees. The resulting 'site chronology' may then be compared with existing 'master' or 'reference' chronologies.

This process can be done by a trained dendrochronologist using plots of the ring-widths and comparing them visually, which also serves as a check on measuring procedures. It is essentially a statistical process, and therefore requires sufficiently long sequences for one to be confident in the results. There is no defined minimum length of a tree-ring series that can be confidently crossmatched, but as a working hypothesis most dendrochronologists use series longer than at least fifty years.

The dendrochronologist also uses objective statistical comparison techniques, these having the same constraints. The statistical comparison is based on programs by Baillie & Pilcher (1973, 1984) and uses the Student's t test. The values of '*t*' which give an acceptable match have been the subject of some debate; originally values above 3.5 being regarded as acceptable (given at least 100 years of overlapping rings) but now 4.0 is often taken as the base value. It is possible for a random set of numbers to give an apparently acceptable statistical match against a single reference curve - although the visual analysis of plots of the two series usually shows the trained eye the reality of this match. When a series of ring-widths gives strong statistical matches in the same position against a number of independent chronologies the series becomes dated with an extremely high level of confidence.

One can develop long reference chronologies by crossmatching the innermost rings of modern timbers with the outermost rings of older timbers successively back in time, adding data from numerous sites. Data now exist covering many thousands of years and it is, in theory, possible to match a sequence of unknown date to this reference material.

It follows from what has been stated above that the chances of matching a single sequence are not as great as for matching a tree-ring series derived from many individuals, since the process of aggregating individual series will remove variation unique to an individual tree, and reinforce the common signal resulting from widespread influences such as the weather. However, a single sequence can often be successfully dated.

Growth characteristics vary over space and time, trees in south-eastern England generally growing comparatively quickly and with less year-to-year variation than in many other regions (Bridge, 1988).

This means that even comparatively large timbers in this region often exhibit few annual rings and are less useful for dating by this technique.

When interpreting the information derived from the dating exercise it is important to take into account such factors as the presence or absence of sapwood on the sample(s), which indicates the outer margins of the tree. Where no sapwood is present it may not be possible to determine how much wood has been removed, and one can therefore only give a date after which the original tree must have been felled. Where the bark is still present on the timber, the year, and even the time of year of felling can be determined. In the case of incomplete sapwood, one can estimate the number of rings likely to have been on the timber by relating it to populations of living and historical timbers to give a statistically valid range of years within which the tree was felled. For this region the estimate used is that 95% of oaks will have a sapwood ring number in the range 11 - 41 (Miles 1997).

CHURCH HOUSE, ARELEY KINGS

This three-bay Grade II* listed building is thought to have been built in the mid to late 16th century. It is timber framed with painted brick and plaster infill, and jettied on three sides. The ground floor consists of a single room, having a framed ceiling with chamfered beams and unchamfered joists, on jowled storey posts, the SW bay having two dragon beams. On the first floor the tie beam and queen strut roof is open, showing two tiers of purlins and straight windbraces. An intermediate truss forms a narrow bay at the NE end of the building: part of the tie and one strut having been removed. It has redundant holes showing that it used to have a partition. Dendrochronological investigation was requested by the Worcestershire Historic Environment and Archaeological Service, who were undertaking recording work at the time of this work.

SAMPLING

Assessment and sampling was carried out on 25th June 2003. All samples taken were given the prefix ARK , and their positions are described in Table 1, and illustrated, where appropriate, on Figs 1 - 3. The intermediate truss at the NE end of the building was cored to see whether or not it was part of the primary building, as this was unclear at the time of sampling. Elsewhere, a range of structural elements were sought, preferably with sufficient rings and sapwood.

Samples were labelled and removed for further preparation and analysis. They were mounted on wooden laths and polished with progressively finer grits down to 400 to allow the measurement of ring-widths to the nearest 0.01 mm. The samples were then measured under a binocular microscope on a purpose-built moving stage with a linear transducer, attached to a desktop computer. Measurements and subsequent analysis were carried out using DENDRO for WINDOWS, written by Ian Tyers (Tyers 1999a).

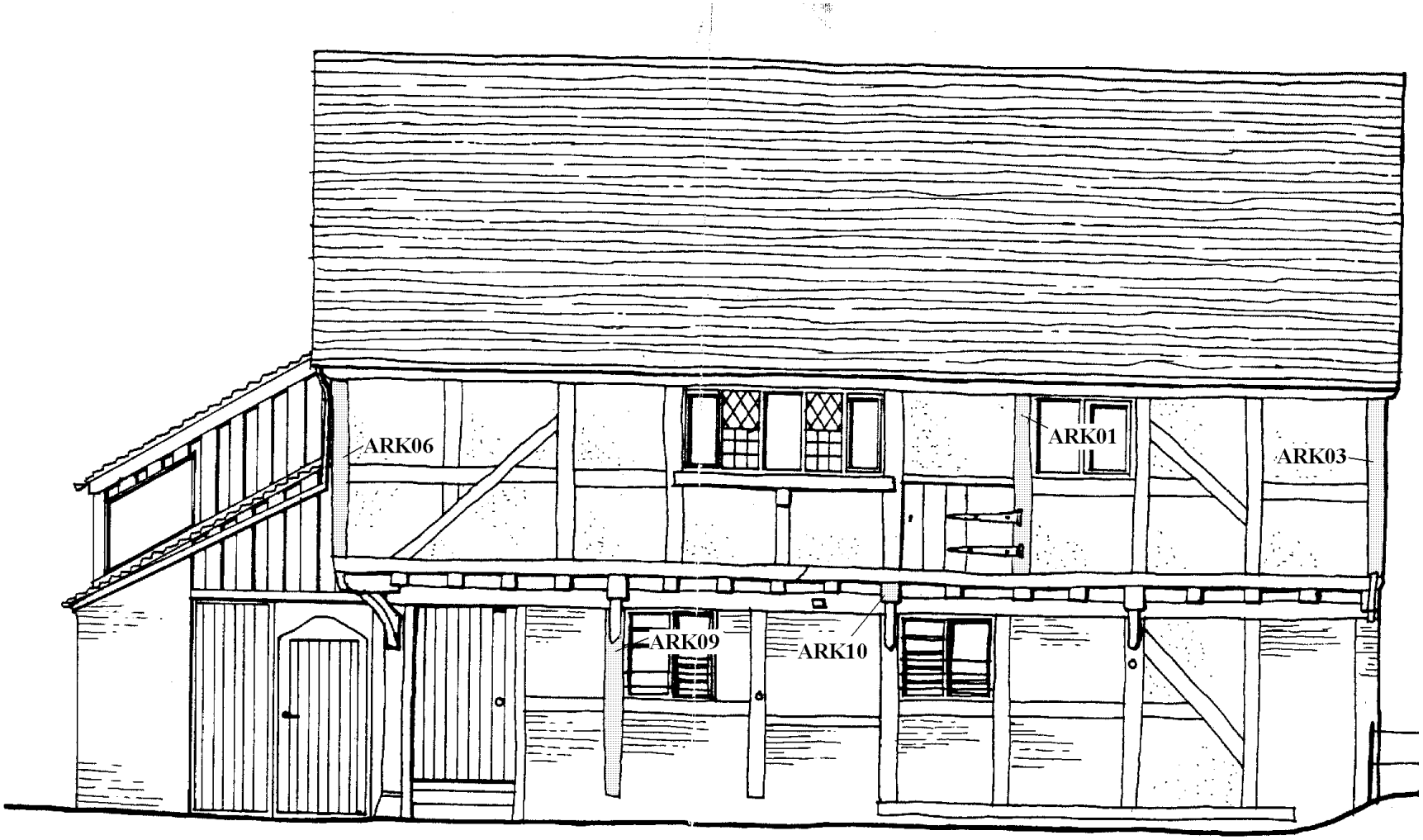

Figure 1: South elevation of Church House, showing the timbers sampled for dendrochronology. Adapted from drawings supplied by Anna Deeks

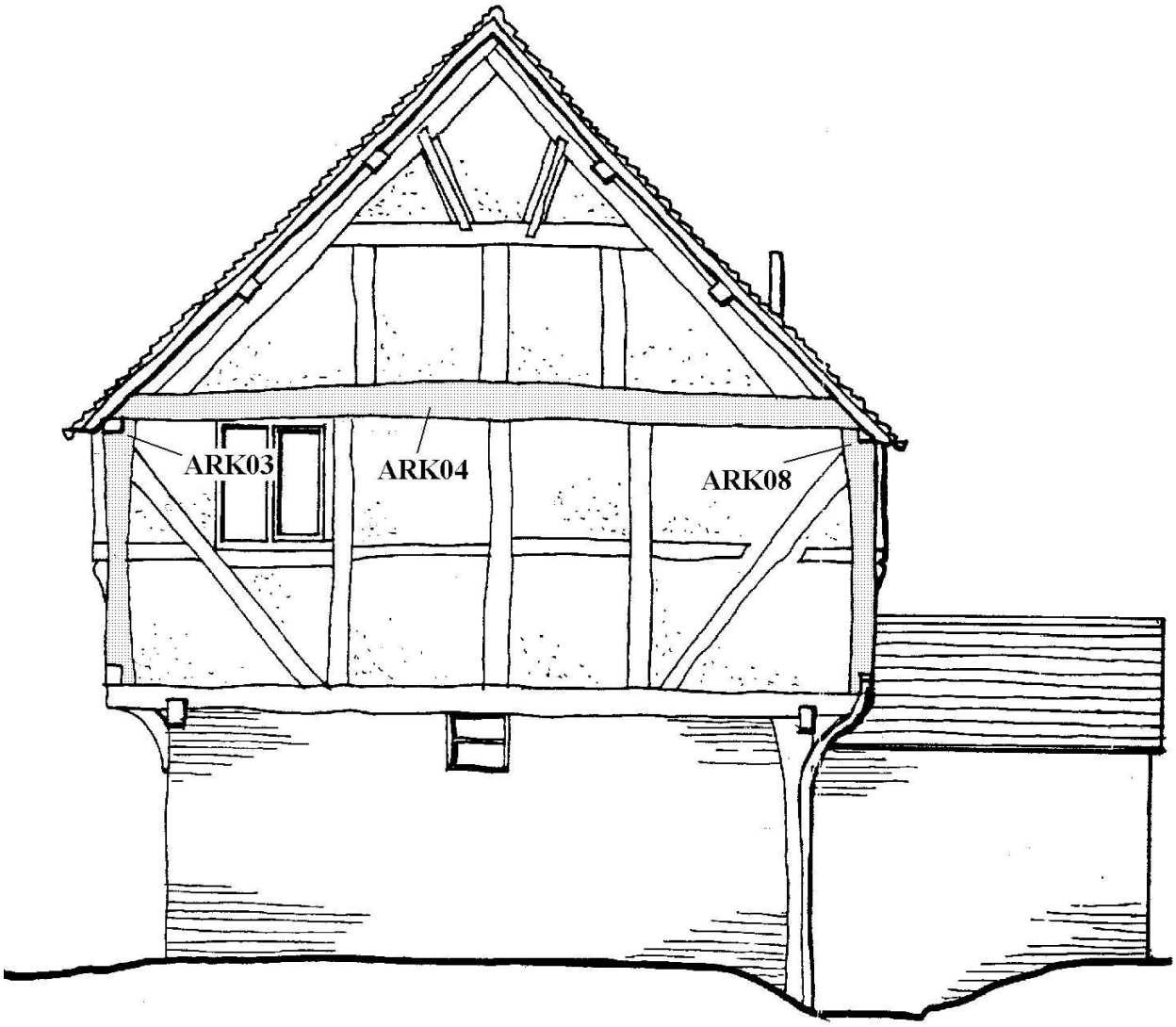

Figure 2: East elevation of Church House, showing timbers sampled for dendrochronology. Adapted from drawings supplied by Anna Deeks

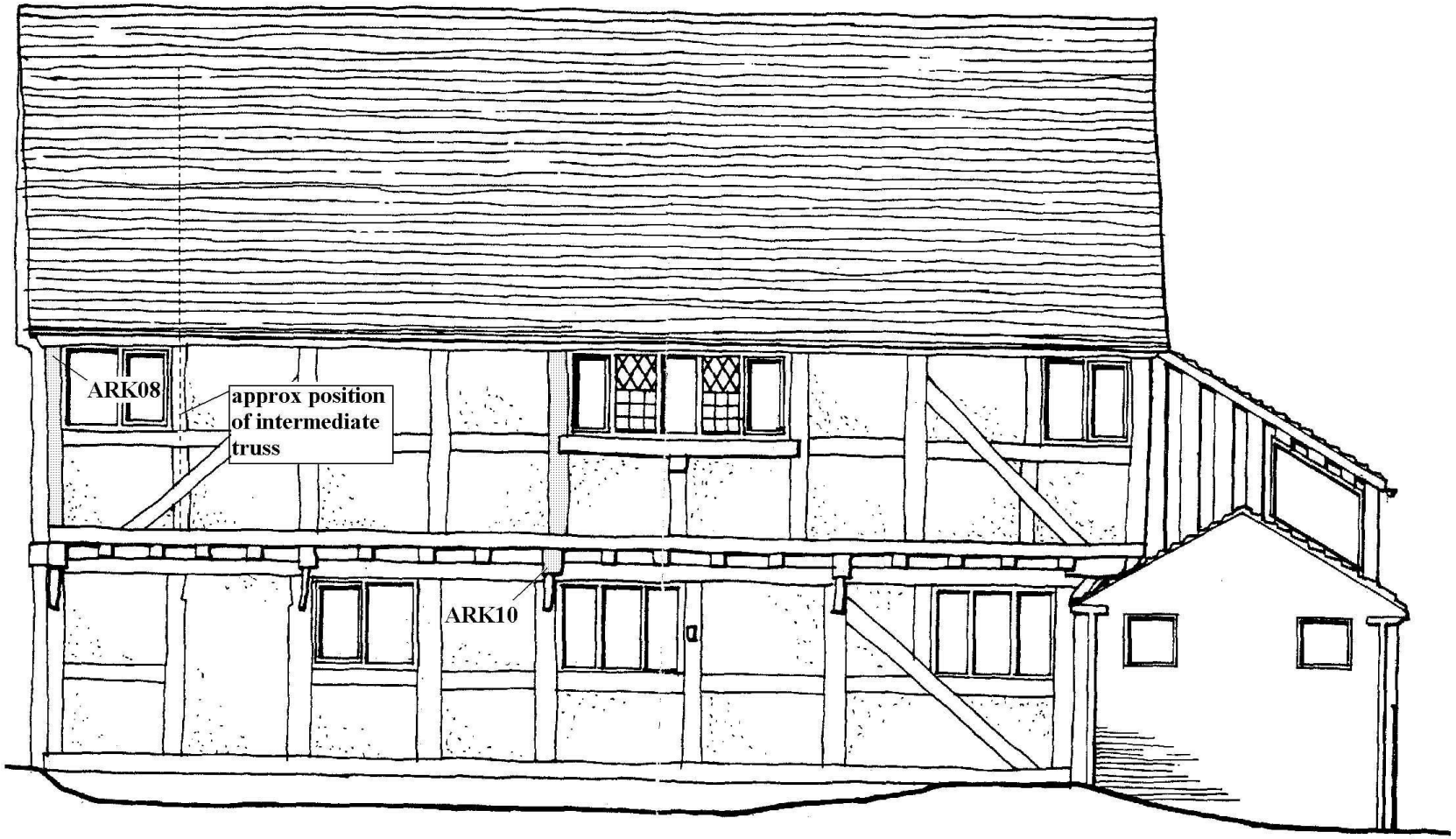

Figure 3: North elevation of Church House, showing timbers sampled for dendrochronology. Adapted from drawings supplied by Anna Deeks.

RESULTS

All the timbers sampled were of oak (*Quercus* spp.). Details of the location of the samples, along with other information about each sample, their date span and interpreted likely felling dates are given in Table 1.

Most of the timbers matched well against each other (Table 2). One timber, ARK06 had a very 'sensitive' ring-width series (i.e. had marked year-to-year variation in width, with some sudden growth rate changes, and this timber did not match the others, despite its length (103 years). It should be noted that the crossmatching of sample ARK08 with other dated samples was relatively weak. This sample was remeasured to make sure that no mistakes had been made. No errors were found. It was dated independently against the database, and its relative position of overlap was confirmed (Figure 4). Its weak crossmatching against the other series led to this sample being excluded from the site chronology ***ARELEY***, which therefore consisted of eight samples, covering a span of 171 years.

The site chronology, ***ARELEY,*** was dated by comparison with a large number of regional multi-site, and individual site chronologies. This established its date as 1365-1535 – the best results being shown in Table 3.

Table 1: Timbers sampled from Church House, Areley Kings, Worcs.
h/s = heartwood-sapwood boundary, C = complete sapwood, winter felling, * = sample included in site chronology

Sample number	Origin of core	Total no of years	Average growth rate (mm yr^{-1})	Sapwood details	Date of sequence AD	Felling date of timber AD
First Floor						
ARK01*	Post, truss 3 south	88	0.94	h/s	1417 - 1504	1515 - 1545
ARK02*	Post, truss 3 north	89	1.06	13	1433 - 1521	1521 - 1549
ARK03*	Post, truss 4 south	114	0.64	24	1400 - 1513	after 1531
ARK04*	Tie, truss 4	151	1.25	11	1365 - 1515	1515 - 1545
ARK05*	South prin. rafter, int. truss	105	1.26	26C	1431 - 1535	winter 1535/6
ARK06	Post, truss 1 south	103	0.75	-	undated	unknown
ARK07*	Tie, int. truss	136	1.25	16	1384 - 1519	1519 – 1544
ARK08	Post, truss 4 north	122	0.95	-	1360 - 1481	after 1492
Ground Floor						
ARK09*	Post, truss 1 south	126	1.21	h/s	1378 - 1503	1514 – 1544
ARK10*	Floor beam, truss 2	116	1.47	-	1379 - 1494	after 1505

Table 2: Crossmatching between the individual dated samples from Church House, Areley Kings

	t - values							
SAMPLE	ARK02	ARK03	ARK04	ARK05	ARK07	ARK08	ARK09	ARK10
ARK01	-	5.0	6.7	4.6	6.5	3.1	6.8	4.9
ARK02		-	3.5	3.3	4.6	-	3.2	5.3
ARK03			3.1	3.5	4.3	4.0	6.2	5.3
ARK04				-	6.7	3.4	5.8	7.9
ARK05					7.1	-	6.5	5.4
ARK07						-	7.0	6.1
ARK08							4.0	-
ARK09								6.9

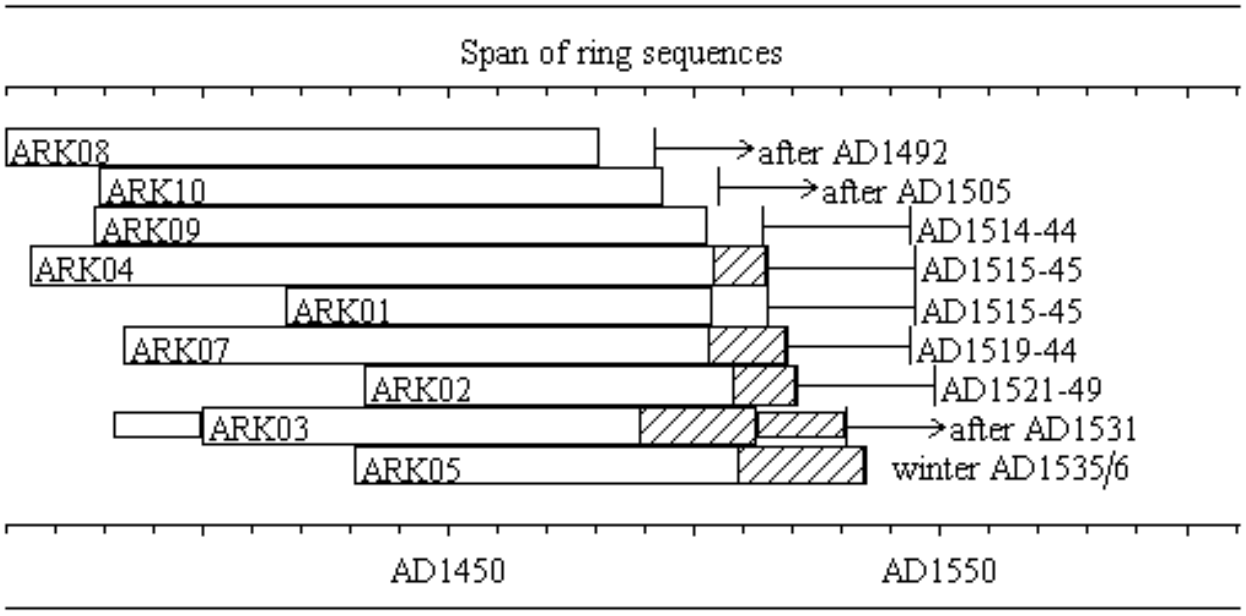

Figure 4: Bar diagram showing the relative positions of overlap of the dated samples, along with their interpreted likely felling date ranges. Hatched sections represent sapwood, narrow bars indicate additional unmeasured rings.

Table 3: Dating of the site chronology *ARELEY*. The upper section contains regional chronologies, the lower section contains individual site chronologies.

			ARELEY **AD 1365-1535**	
Dated reference or site master chronology	**Lab code**	**Spanning**	***t*-value**	**Overlap (yrs)**
Shropshire (Miles, Oxford Dendro Lab)	SALOP95	881-1745	13.0	171
Wales (Miles, Oxford Dendro Lab)	WALES97	404-1981	11.9	171
Hereford & Worcester (Siebenlist-Kerner 1978)	GIERTZ	1341-1636	10.7	171
London (Tyers per comm.)	LONDON	413-1728	10.1	171
British Isles (Pilcher and Baillie pers comm.)	BRITIM	401-1981	9.8	171
Oxfordshire (Miles, Oxford Dendro Lab)	OXON93	632-1987	9.3	171
Southern England (Bridge 1988)	SENG	1083-1589	8.2	171
Vowchurch, Herefordshire (Nayling 2000)	VOWCH	1364-1602	11.7	171
Bromyard, Herefordshire (Nayling 2001)	LBG-T10	1368-1543	11.2	168
Mercer's Hall, Gloucester (Howard *et al* 1996)	GLOUC_MH	1289-1541	11.2	171
Cathedral Barn, Hereford (Tyers 1996a)	HEREF_CB2	1359-1491	10.9	127
Booth Hall, Hereford (Boswijk and Tyers 1997)	HIGHTOWN	1302-1489	10.9	125
Westgate St., Gloucester (Tyers and Wilson 2000)	66GLMEAN	1209-1518	9.8	154
Farmers Club, Hereford (Tyers 1996a)	HEREF_FC	1313-1617	9.4	171
Brook Gate, Salop. (Miles and Haddon-Reece 1993)	BROOKGT	1362-1611	9.0	171
Wick, Worcs. (Bridge 1983)	WICK	1257-1496	8.7	132
Bowhill, Exeter (Hillam pers comm.)	EX_BOWHL	1292-1467	8.7	103
Bedstone, Salop. (Miles and Haddon-Reece 1995)	BEDSTONE	1341-1560	8.6	171
Mamble, Worcs. (Tyers 1996b)	MAMBLE_B	1348-1582	8.5	171
Fiddleford, Dorset (Bridge 2003)	FIDDLE2	1433-1553	8.4	103

INTERPRETATION AND DISCUSSION

The good level of crossmatching between these timbers, and the similarity in the heartwood-sapwood transition dates, strongly suggest that this is a single group of timbers, probably all felled in the same year, or over a very short period. Only one timber, a principal rafter from the intermediate truss, retained full sapwood to the bark edge, this being a timber felled in the winter of 1535/6. It seems most likely therefore that the building was constructed in **1536** – or within a very few years thereafter.

The intermediate truss has been shown to be made from timbers from the same batch as the remainder of the primary construction, indeed it is a timber from this truss that gives the precise felling date.

The high level of crossmatching with other sites is remarkable, and probably reflects the fact that these series are relatively long, several samples having over 100 years, and that the database now contains several sites within the neighbouring region. The results strongly suggest that the building was constructed from local timbers.

ACKNOWLEDGEMENTS

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