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Exeter, The Old Deanery, Great Chamber, Devon

Dendrochronology and Radiocarbon Wiggle-matching of Oak Timbers

Cathy Tyers, Robert Howard, Alex Bayliss, Bisserka Gaydarska, Michael Dee, and Sanne Palstra

Scientific Dating

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Summary

Re-analysis of timbers sampled in the 1990s means that three of the site master chronologies (EXTBSQ01, EXTBSQ02, and EXTBSQ04), representing 16-timbers, along with an individual timber (EXT-B20), from the Great Chamber in the Old Deanery are now securely dated by dendrochronology.

The nine timbers previously dated (Howard et al. 2000a) all appear to derive from English oak trees and represent both floor and roof timbers. Applying an updated sapwood estimate for trees that grew in South-West England, along with consideration of the variation in the dates of their heartwood/sapwood boundaries, suggests that all these timbers were probability felled at a similar time in the AD 1410s or AD 1420s. These dated timbers are thought to be associated with the initial construction of the Great Chamber/Parlour block that stands today.

The growth rings in eight floor joists from the Great Chamber, forming site master chronology EXTBSQ02, have been dated as spanning AD 999–1118. Cross-matching clearly indicates that they were imported from Northern France, and as such they are the first structural timbers identified as being imported from this source into Medieval England. The variation in their heartwood/sapwood boundary dates demonstrates that all eight are clearly coeval, and these timbers are therefore likely to have been felled as part of a single felling event between the early AD 1120s and the mid-AD 1130s.

Contributors

Cathy Tyers, Robert Howard, Alex Bayliss, Bisserka Gaydarska, Michael Dee, and Sanne Palstra

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Front cover image

The Great Chamber block looking North-West (photograph Keystone Historic Buildings Consultants)

Archive location

Historic England, The Engine House, Fire Fly Avenue, Swindon, SN2 2EH

Historic Environment Record

Devon Historic Environment Record (including Torbay), Historic Environment Team, County Hall, Exeter, Devon, EX2 4QD

Date of investigation

2021–24

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Introduction

The Old Deanery is a multi-phase building in The Close of Exeter Cathedral (Fig 1), which is listed under the name 'The Deanery' at Grade II* (LEN 1104026 https://historicengland.org.uk/listing/the-list/list-entry/1104026). It should not be confused with present Deanery located at 10 Cathedral Close. The property was certainly occupied by the dean from the end of the thirteenth century, and it was very probably the site of his house from the creation of the office by Bishop Brewer in AD 1225, although it is possible that at that time the dean moved into a house formerly belonging to the archdeacon of Totnes (Allan and Higham 2023, 30–1).

The long and complex history of the building is now visible in the form of four blocks aligned in a north-east/south-west direction, with a fifth projecting block to the north-west (Keystone Historic Building Consultants 2005, 13–32; Howard et al. 2000a, fig 3). The now divided Great Hall, which perhaps has its origins in the thirteenth- or early fourteenth-century, lies to the site east and the Porch Block, which seems to have been divided from The Great Hall in the sixteenth century to provide smaller and more private rooms, lies immediately west.

The early fifteenth-century Great Chamber, above a parlour, lies further to the west. This has a high-status surviving medieval roof consisting of five bays with seven A-frame trusses, moulded arch-braces springing from stone corbels, cusped intermediate trusses, and coved rafters above. The floor of the Great Chamber is carried on four main beams forming five bays (Fig. 2). There are two layers of joists, the lower of which supports the parlour ceiling and is therefore missing in bay 5, the westernmost bay. Most of these lower joists are reused and thought to have been derived from an earlier roof, which was thirteenth- or fourteenth-century in character. The upper joist layer consists of two types, of which those in bays 2–4 are less substantial than those in bay 5 and are secured to the beams using open mortises and projecting spurs. Again, there is evidence for reuse in the upper layer of joists. In bay 5 the larger scantling joists bear on the stone wall and are not jointed to beam 4. A blocked lancet window in the enormously thick north wall of this range suggests that this may be of thirteenth- or early fourteenth-century date.

Beyond the Great Chamber to the west lies the medieval solar block, which has an early fifteenth-century three-bay arch-braced roof. The block which projects to the north-west of the Great Hall block consists of a late fifteenth- or early sixteenth-century Chapel with a wagon roof set on corbels with carved angels that have gilded wings.

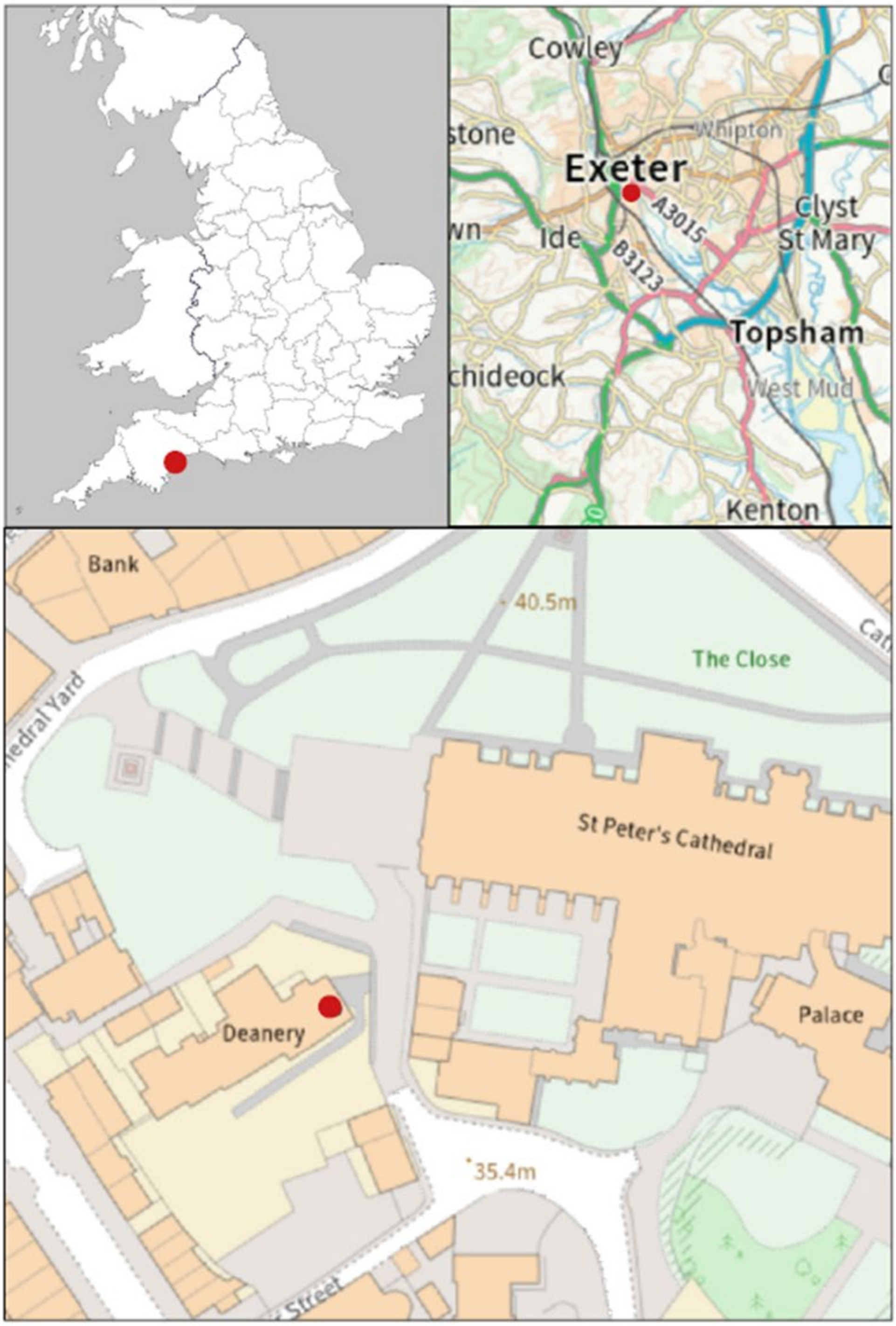

Figure 1: Maps to show the location of The Old Deanery, Exeter, in red. Scale: top right 1:200,000; bottom 1:1,600.

Figure 2: The Great Chamber floor from east (photograph courtesy of Exeter Archaeology)

Tree-ring analysis

Samples from thirty oak (*Quercus* spp.) timbers from the floor and the roof of the Great Chamber were analysed by ring-width dendrochronology in late 1998 and 1999 when works were being undertaken to strengthen the floor (Howard et al. 2000a). The purpose of the analysis was to determine whether this two-storey block was added to the west of the Great Hall in the early sixteenth century, as was believed at the time of sampling, and to provide independent dating for its roof for comparative purposes, as this is of similar form to others in the locality (Blaylock 2004; Howard et al. 1999a–b, 2000b; Arnold and Howard 2011). The analysis also formed part of a programme of research undertaken with the aim of enhancing the network of reference chronologies for what was an under-represented and challenging region from a dendrochronological perspective (Groves 2005; Tyers et al. forthcoming).

Thirteen core samples came from timbers in the roof (EXT-B01–EXT-B13), 16 core samples came from timbers in the floor (EXT-B14–EXT-B29), and one sample (EXT-B30) was a cross-sectional slice, labelled ‘Great Chamber Hall floor joist sample 1 of 2’, removed from a timber at some point previously and made available for analysis by Exeter Royal Albert Memorial Museum. This sample was subsequently returned to the museum storage facility. The growth-ring widths of each sample were measured and compared with each other by the Litton/Zainodin grouping procedure (Laxton et al. 1988; Litton and Zainodin 1991). Four groups of samples formed at a minimum value of t=4.5, (Howard et al. 2000a).

Site master chronology EXTBSQ01, consisting of 6 timbers, has 171 rings (Howard et al. 2000a, fig 7) and spans the period AD1233–1403 (Howard et al. 2000a, table 2). Site master chronologies EXTBSQ02, consisting of 8 samples and 120 rings (Howard et al. 2000a, fig 8), and EXTBSQ03, consisting of three samples and 121 rings (Howard et al. 2000a, fig 9), both failed to date securely by ring-width dendrochronology. EXTBSQ04, consisting of two samples and forming a sequence of 85 rings (Howard et al. 2000a, fig 10), spans the period AD 1322–1406 (Howard et al. 2000a, table 3). Comparison of the remaining 11 ungrouped samples with a full range of reference chronologies identified cross-matching for sample EXT-B20 when the first ring dates to AD 1314 and last measured ring to AD 1399 (Howard et al. 2000a, table 4).

As indicated at the time of the original analysis, it is unusual for a reasonably long and well replicated site chronology, such as EXTBSQ02, to remain undated by ring-width dendrochronology. This was surprising as the ring series were generally neither complacent, nor showed repeated abrupt changes in growth rates, such as those derived from pollarding or other woodland management, that might prevent cross-matching and dating. This site chronology was re-run against the reference chronologies now available as part of the *Exeter: A Place in Time* project (Tyers 2021) and was found to cross-match consistently, but relatively weakly, with chronologies predominantly from sites in London and Kent when it spans AD 999–1118 (Table 1). These site chronologies are almost all long and well-replicated, with the timbers all thought to be derived from trees growing relatively locally to the sites from which they were recovered. This tenuous dating was unexpectedly early and implied the possibility of the timbers having been derived from trees sourced outside the south-west region. It was therefore decided at this stage to undertake radiocarbon dating and wiggle-matching to validate the tentative dating suggested by the new tree-ring analysis (see below).

Following the radiocarbon wiggle-matching (see below), site chronology EXTBSQ02 and its individual component ring-width series were reassessed using methodology outlined in English Heritage (1998). The eight component, individual ring-width series cross-match strongly (Table 2). The strength of the cross-matching is such that samples EXT-B14, EXT-B16, EXT-B17, and EXT-B18 may be derived from the same tree, or from trees growing in close proximity to each other. Notably, however, the first 10 rings of the site chronology, represented by only a single sample, show the presence of a growth anomaly in the form of a band of very narrow rings (Fig 3). Such anomalies, arising from local environmental affects, can adversely affect the climatic signal needed for secure dating purposes. Thus, these innermost (oldest) 10 ring-widths were removed leaving a truncated, 110-ring, version of the site chronology.

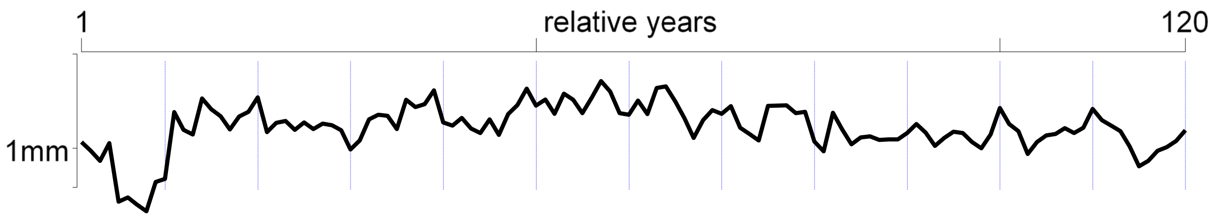

Figure 3: Plot of the site master chronology EXTBSQ02. The y-axis is ring width (mm) on a logarithmic scale.

This truncated version was then initially compared to reference chronologies from sites in the British Isles. It cross-matched consistently when it spans AD 1009–1118, this being compatible with the previously identified tenuous dating suggested by ring-width dendrochronology and the radiocarbon wiggle-matching, with some additional chronologies from London producing significant *t*-values (Table 3; see below). However, the truncated version also notably cross-matched well with three chronologies formed from barrel staves found in London, Scotland, and Denmark (Table 4) which are thought to be derived from trees that grew in north-eastern France, roughly Burgundy and the Paris Basin (Crone 2005; Daly 2007). The ring-width data for site chronology EXTBSQ02 was therefore sent to a number of other European dendrochronology facilities that confirmed the secure dating of this site master chronology through ring-width dendrochronology (Table 4).

Table 1: Results of the cross-matching of site chronology EXTBSQ02 and relevant reference chronologies from sites in England when the first ring date is AD 999 and the last ring date is AD 1118.

Reference chronology	Date span	*t*-values	Reference
London: Custom House boat	AD 922–1156	5.5	Tyers 1996
Kent: Tonbridge, Bank Street	AD 998–1116	5.3	Tyers 2005
Kent: Canterbury, Marlowe Theatre	AD 799–1141	5.2	Tyers 2010
London: Garlick Hill	AD 784–1124	5.0	Tyers 2017
Wiltshire: Salisbury Cathedral	AD 1035–1254	5.0	Miles 2002
London: Fleet Valley	AD 745–1316	4.0	Tyers 1993
London: Millennium Bridge	AD 999–1389	4.0	Tyers 1999a
Bristol: Merchants Quarter, Cabot Circus	AD 1020–1168	4.0	Tyers 2007
London: Westminster Abbey, Pyx	AD 827–1148	3.9	Miles and Bridge 2008
London: Vintry	AD 743–1241	3.9	Hibberd 1992

Table 2: Cross-matching between the eight individual ring-width series from site chronology EXTBSQ02 (the relative positions of the first and last ring in each sequence is indicated).

	Relative years		*t*-values							
			EXT-B14	EXT-B16	EXT-B17	EXT-B18	EXT-B21	EXT-B25	EXT-B26	EXT-B27
	start date		14	46	34	51	1	27	11	45
		end date	108	117	109	120	110	111	105	104
EXT-B14	14	108	*	8.2	12.7	9.4	5.1	6.3	7.0	7.4
EXT-B16	46	117		*	9.10	14.6	4.2	5.7	5.0	7.0
EXT-B17	34	109			*	11.2	5.7	7.6	6.7	8.3
EXT-B18	51	120				*	4.4	6.8	6.2	7.6
EXT-B21	1	110					*	5.6	3.9	5.9
EXT-B25	27	111						*	5.0	6.7
EXT-B26	11	105							*	8.0
EXT-B27	45	104								*

Table 3: Results of the cross-matching of the truncated site chronology EXTBSQ02 and relevant reference chronologies from England when the first ring date is AD 1009 and the last ring date is AD 1118.

Reference chronology	Date span	*t*-values	Reference
London: Garlick Hill	AD 784–1124	6.4	Tyers 2017
Kent: Canterbury, Marlowe Theatre	AD 799–1141	6.2	Tyers 2010
Kent: Tonbridge, Bank Street	AD 998–1116	6.0	Tyers 2005
London: Custom House boat	AD 922–1156	5.7	Tyers 1996
London: Westminster Abbey, long chest	AD 850–1161	5.6	Miles and Bridge 2008
London: Swan Lane	AD 938–1192	5.5	Groves and Hillam 1987
London: Fleet Valley	AD 745–1316	5.4	Tyers 1993
London: Vintry	AD 743–1241	5.1	Hibberd 1992
London: Bull Wharf	AD 620–1181	5.1	Tyers and Boswijk 1997
Wiltshire: Salisbury Cathedral	AD 1035–1254	5.0	Miles 2002
Bristol: Merchants Quarter, Cabot Circus	AD 1020–1168	4.0	Tyers 2007
London: Westminster Abbey, Pyx	AD 827–1148	3.9	Miles and Bridge 2008
London: Millennium Bridge	AD 999–1389	3.7	Tyers 1999a

Table 4: Results of the cross-matching of the truncated site chronology EXTBSQ02 and relevant European reference chronologies when the first ring date is AD 1009 and the last ring date is AD 1118.

Reference chronology	Date span	*t*-values	Reference / Laboratory
London: Guildhall, barrel staves (imported)	AD 998–1128	7.3	Tyers 2001
Scotland: Perth, High Street, barrel staves (imported)	AD 964–1121	5.4	Crone 2005
Denmark: Ribe, Praestegade 13, barrel staves (imported)	AD 963–1147	5.1	Eriksen 1995a–b; Daly 2007
France: Maine-et-Loire, Angers, Cathédrale Saint-Maurice	AD 914–1134	7.9	DENDROTECH
France: Paris, Seine, Cathédrale Notre-Dame	AD 996–1226	7.7	LCE
France: Loir-et-Cher, Meusnes, église Saint-Pierre	AD 1046–1156	7.6	CEDRE
France: Loir-et-Cher, Villeherviers, église	AD 1046–1229	7.0	CEDRE
France: Ille-et-Vilaine, Livré-sur-Changeon, ZAC de l'Abbaye	AD 950–1094	6.5	DENDROTECH
France: Indre-et-Loire, Rochecorbon, Chapelle Saint-Georges	AD 1052–1127	6.3	CEDRE
France: Indre-et-Loire, Huismes, Église Saint-Maurice	AD 1042–1156	6.3	DENDROTECH

Reference chronology	Date span	*t*-values	Reference / Laboratory
France: Cher, Bruères-Allichamps, abbaye de Noirlac	AD 1016–1232	6.2	CEDRE
France: Maine-et-Loire, Angers, Greniers Saint-Jean	AD 897–1180	6.2	DENDROTECH
France: Maine-et-Loire, Fontevraud, église Saint-Lazare	AD 1003–1166	6.1	CEDRE
France: Cher, Saint-Amand-Montrond, église	AD 1016–1180	6.1	CEDRE
France: Maine-et-Loire, Angers, collégiale Saint-Martin	AD 1043–1184	5.9	CEDRE
France: Vendée, Château-d'Olonne, Aménagement portuaire de la baie de Cayola	AD 922–1165	5.9	DENDROTECH
France: Ille-et-Vilaine, Rennes, Place Saint-Germain	AD 907–1213	5.9	DENDROTECH
France: Aube/Marne Departments	AD 880–2009	6.9	DENDRONET
France: Paris Basin	AD 279–1994	5.8	RENNES

Key to laboratories:

CEDRE: Centre d'Etudes en Dendrochronologie et de Recherches sur l'Environnement, 12 avenue de Chardonnet, 25000 Besançon, France

DENDRONET: Laboratory for Dendrology, 78224 Bohlingen, Germany

DENDROTECH: Expertise Dendro-Archéologique, 6 rue de la Forge, 35830 Betton, France

LCE: Laboratoire de Chrono-Environnement - UMR 6249 - CNRS, Université de Franche-Comté, Campus de la Bouloie, 16 route de Gray, 25030 - Cedex Besançon, France

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Radiocarbon dating

To confirm the tentative calendar dating for EXTBSQ02 initially suggested by the cross-matching of the full-length chronology (Table 1), two timbers from this site sequence were selected for radiocarbon dating and wiggle-matching. Between them, samples EXT-B18 and EXT-B21 comprise relative years 1–120 of EXTBSQ02 that potentially spans AD 999–1118.

Radiocarbon dating is based on the radioactive decay of ^{14}C, which trees absorb from the atmosphere during photosynthesis and store in their growth-rings. The radiocarbon from each year is stored in a separate annual ring. Once a ring has formed, no more ^{14}C is added to it, and so the proportion of ^{14}C versus other carbon isotopes reduces in the ring through time as the radiocarbon decays. Radiocarbon ages, like those in Table 5, measure the proportion of ^{14}C in a sample and are expressed in radiocarbon years BP (before present, 'present' being a constant, conventional date of AD 1950).

Radiocarbon measurements have been obtained from five single annual tree-rings, two samples from timber EXT-B21 and three from timber EXT-B18 (Table 5). Dissection was undertaken by Robert Howard at the Nottingham Tree-Ring Dating Laboratory. Prior to sub-sampling, the cores were checked against the tree-ring width data. Then each annual growth ring was split from the rest of the core using a chisel and/or scalpel blade. Each radiocarbon sample consisted of a complete annual growth ring, including both earlywood and latewood. Each annual ring was then weighed and placed in a labelled bag. Rings not selected for radiocarbon dating as part of this study have been archived by Historic England.

Table 5: Radiocarbon measurements and associated $\delta^{13}C$ values from oak samples EXT-B21 and EXT-B18

Laboratory Number	Sample	Radiocarbon Age (BP)	$\delta^{13}C_{IRMS}$ (‰)
GrM-26302	EXT-B21, ring 10 (*Quercus* spp., heartwood)	1095±18	−24.05±0.15
GrM-26295	EXT-B21, ring 32 (*Quercus* spp., heartwood)	982±10	−24.13±0.15
GrM-26296	EXT-B18, ring 30 (*Quercus* spp., heartwood)	920±18	−23.28±0.15
GrM-26297	EXT-B18, ring 45 (*Quercus* spp., heartwood)	967±18	−23.84±0.15
GrM-26298	EXT-B18, ring 64 (*Quercus* spp., heartwood)	962±18	−23.55±0.15

Radiocarbon dating was undertaken by the Centre for Isotope Research, University of Groningen, the Netherlands in 2021. Each ring was converted to α-cellulose using an intensified aqueous pretreatment (Dee et al. 2020) and combusted in an elemental analyser (IsotopeCube NCS), coupled to an Isotope Ratio Mass Spectrometer (Isoprime 100). The resultant CO_2 was graphitised by hydrogen reduction in the presence of an iron catalyst (Wijma et al. 1996; Aerts-Bijma et al. 1997). The graphite was then pressed into aluminium cathodes and dated by Accelerator Mass Spectrometry (Synal et al. 2007; Salehpour et al. 2016). Data reduction was undertaken as described by Wacker et al. (2010).

The Centre for Isotope Research maintains a continual programme of quality assurance procedures (Aerts-Bijma et al. 2021), in addition to participation in international inter-comparison exercises (Scott et al. 2017; Wacker et al. 2020). These tests demonstrate the reproducibility and accuracy of these measurements.

The results are conventional radiocarbon ages, corrected for fractionation using $\delta^{13}C$ values measured by Accelerator Mass Spectrometry (Stuiver and Polach 1977; Table 5). The quoted $\delta^{13}C$ values were measured by Isotope Ratio Mass Spectrometry, and more accurately reflect the natural isotopic composition of the sampled wood.

Wiggle-matching

Radiocarbon ages are not the same as calendar dates because the concentration of ^{14}C in the atmosphere has fluctuated over time. A radiocarbon measurement has thus to be calibrated against an independent scale to arrive at the corresponding calendar date. That independent scale is the IntCal20 calibration curve (Reimer et al. 2020). For the period covered by this study, this is constructed from radiocarbon measurements on tree-ring samples dated absolutely by dendrochronology. The probability distributions of the calibrated radiocarbon dates from EXTBSQ02, derived from the probability method (Stuiver and Reimer 1993), are shown in outline in Figures 4 and 6.

Wiggle-matching is the process of matching a series of calibrated radiocarbon dates which are separated by a known number of years to the shape of the radiocarbon calibration curve. At its simplest, this can be done visually, although statistical methods are usually employed. Floating tree-ring sequences are particularly suited to this approach as the calendar age separation of tree-rings submitted for dating is known precisely by counting the rings in the timber. A review of the method is presented by Galimberti et al. (2004).

The approach to wiggle-matching adopted here employs Bayesian chronological modelling to combine the relative dating information provided by the tree-ring analysis with the calibrated radiocarbon dates (Christen and Litton 1995). It has been implemented using the program OxCal v4.4 (http://c14.arch.ox.ac.uk/oxcal.html; Bronk Ramsey et al. 2001; Bronk Ramsey 2009). The modelled dates are shown in black in Figures 4 and 6 and quoted in italics in the text. The Acomb statistic shows how closely the assemblage of calibrated radiocarbon dates as a whole agree with the relative dating provided by the tree-ring analysis that has been incorporated in the model; an acceptable threshold is reached when it is equal to or greater than An (a value based on the number of dates in the model). The A statistic shows how closely an individual calibrated radiocarbon date agrees its position in the sequence (most values in a model should be equal to or greater than 60).

Figure 4 illustrates the chronological model for EXTBSQ02. This model incorporates the gaps between each dated annual ring known from tree-ring counting (e.g. that the carbon in ring 10 of the measured tree-ring series (GrM-26302) was laid down 22 years before the carbon in ring 32 of the series (GrM-26295); Fig 5), with the radiocarbon measurements (Table 5) calibrated using the internationally agreed radiocarbon calibration data for the northern hemisphere, IntCal20 (Reimer et al. 2020).

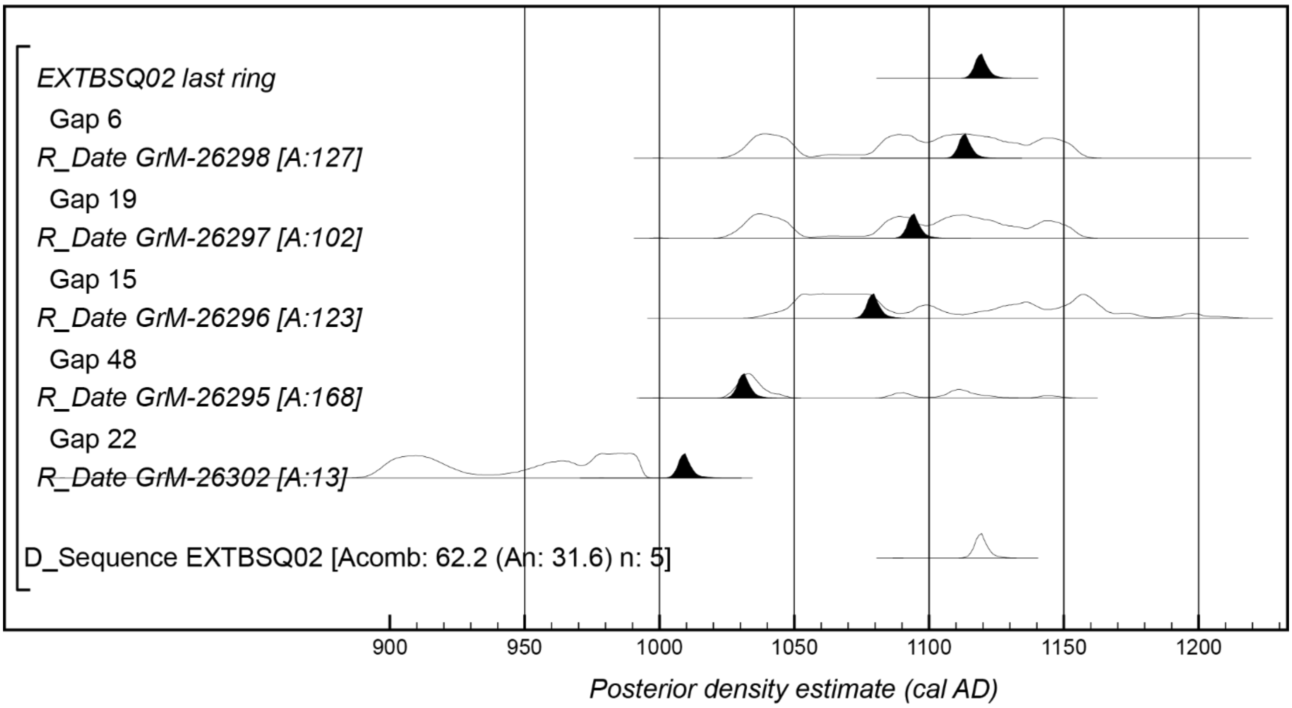

Figure 4. Probability distributions of dates from the undated site sequence EXTBSQ02. Each distribution represents the relative probability that an event occurs at a particular time. For each of the dates two distributions have been plotted: one in outline, which is the simple radiocarbon calibration, and a solid one, based on the wiggle-match sequence. The large square brackets down the left-hand side along with the OxCal keywords define the overall model exactly

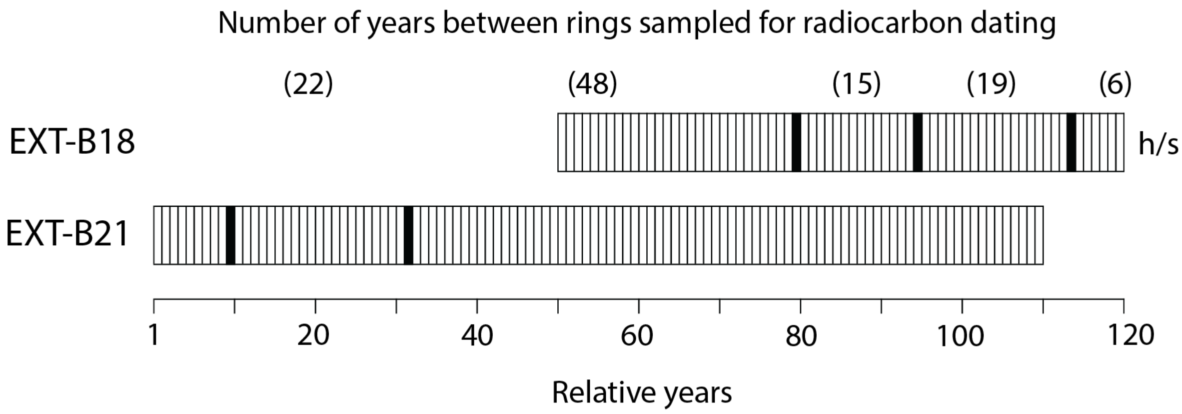

Figure 5. Schematic illustration of samples EXT-B21 and EXT-B18 to locate the single-ring sub-samples submitted for radiocarbon dating (h/s = heartwood/sapwood boundary)

The model has good overall agreement (Acomb: 62.2, An: 31.6, n: 5; Fig 4), with all radiocarbon dates having good individual agreement (A > 60), apart from *GrM-26302* (A:13). It suggests that the final ring of EXT-B18, and thus the final ring of the site master sequence, EXTBSQ02, formed in *cal AD 1114–1125 (95% probability; EXTBSQ02 last ring*; Fig 4), or in *cal AD 1117–1122 (68% probability)*.

When the last surviving ring of this timber is constrained to have formed in AD 1118, as suggested tentatively by the ring-width dendrochronology for the full length 120-year site chronology, the model again has good overall agreement (Acomb: 75.8, An: 28.9, n: 6; Fig 6), with all the radiocarbon dates again having good individual agreement (A > 60) apart from *GrM-26302* (A:14), which is slightly earlier than suggested by its position in the model.

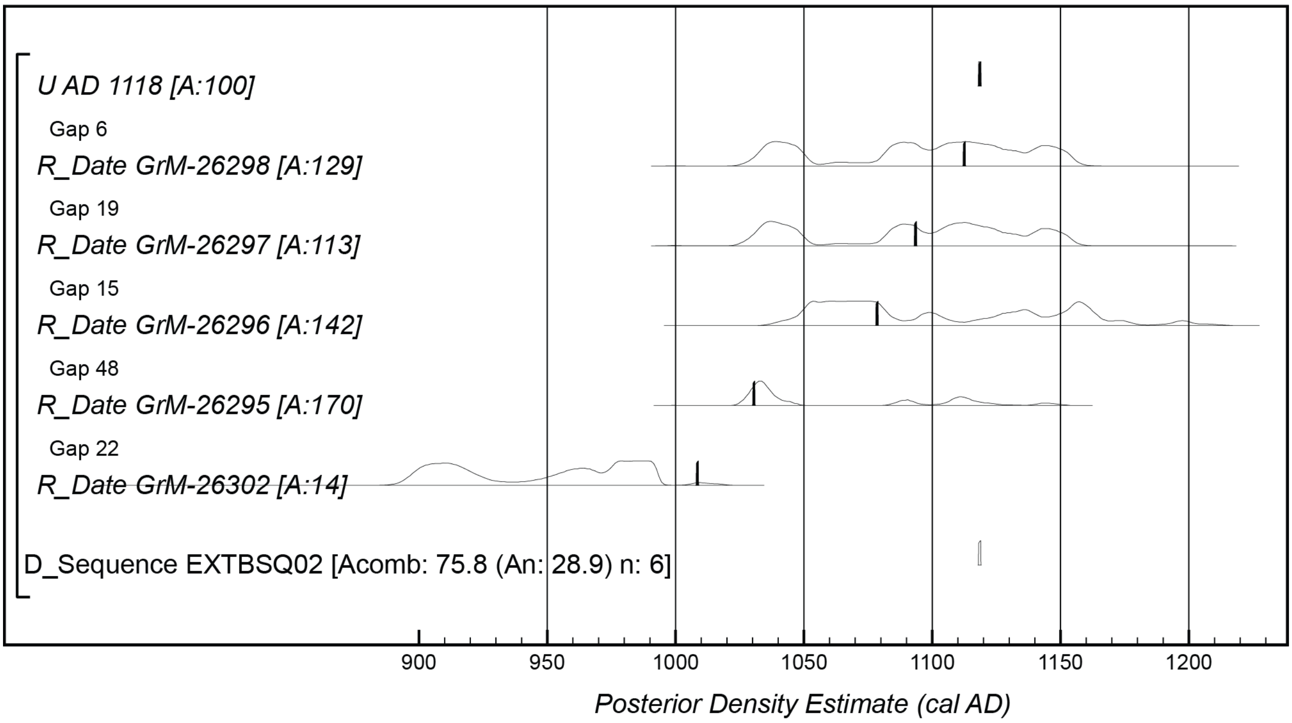

Figure 6. Probability distributions of dates from EXTBSQ02, including the tentative date produced by ring-width dendrochronology for the formation of its last surviving ring in AD 1118. The format is identical to Figure 4. The large square brackets down the left-hand side along with the OxCal keywords define the overall model exactly.

Interpretation and Discussion

The new scientific dating presented for EXTBSQ02 means that three of the site master chronologies (EXTBSQ01, EXTBSQ02, and EXTBSQ04), representing 16-timbers, along with an individual timber (EXT-B20), from the Great Chamber in the Old Deanery are now securely dated by dendrochronology (Fig 7).

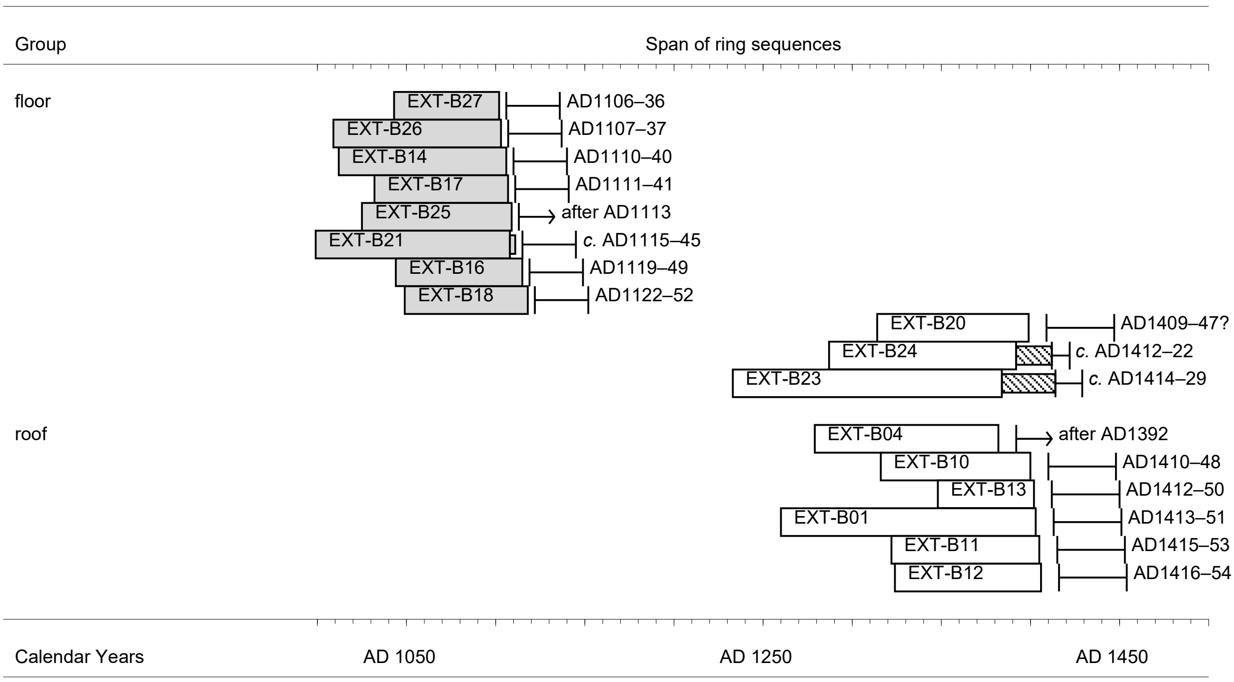

Figure 7: Bar diagram showing the relative positions of the dated ring series and their individual estimated felling dates / date ranges arranged by area and interpretation. White bars – heartwood rings, English oak; grey bars = heartwood rings, French oak; hatched bars – sapwood rings.

Details of all samples, including updated estimated felling date ranges for each timber, are presented in Table 6. These details have also been updated using the original notes made in 1998 during sampling, sample preparation, and initial analysis of the timbers from the floor of the Great Chamber by Cathy Tyers (née Groves). The original sampling notes indicate that small amounts of wood were lost during the coring process from some of the floor joists. A record was made of the length of section lost and so, on the basis of the average ring width of the outermost 10-rings on the intact core, it is possible to estimate how many rings were lost. Importantly, in two cases it was noted that these timbers retained complete sapwood to bark edge, allowing more precise estimates of the felling dates of these timbers to be produced (Table 6; Fig 7).

Table 6: Details of the samples from the roof and floor of the Great Chamber, The Deanery, Exeter

Sample	Sample origin	Number of rings	Sapwood rings	ARW	Date of measured sequence (AD)	Felling date / date range (AD)
Great Chamber roof						
EXT-B01	South principal rafter, truss 2	144	hs	1.49	1260–1403[01]	1413–51
EXT-B02	South arch-brace, truss 2	100	-	1.50	-	-
EXT-B03	South cove rafter, frame 5, bay 1	54	-	2.57	-	-
EXT-B04	South midrib, frame 3, bay 1	104	-	1.39	1279–1382[01]	after 1392
EXT-B05	South common rafter, bay 1	75	-	1.41	-	-
EXT-B06	North common rafter, bay 1	75	-	1.11	-	-
EXT-B07	North midrib, frame 3, bay 1	57	-	0.98	-	-
EXT-B08	North common rafter, frame 3, bay 1	62	-	1.44	-	-
EXT-B09	Collar, frame 2	71	-	1.36	-	-
EXT-B10	North arch-brace, truss 2	85	hs	1.62	1316–1400[01]	1410–48
EXT-B11	South principal rafter, truss 6	84	hs	2.05	1322–1405[04]	1415–53
EXT-B12	South principal rafter, truss 4	83	hs	2.05	1324–1406[04]	1416–54
EXT-B13	North post, truss 2	55	hs	1.59	1348–1402[01]	1412–50
Great Chamber floor						
EXT-B14	Upper joist 5, bay 5	95	hs	1.81	1012–1106[02]	1110–40
EXT-B15	Upper joist 6, bay 5	77	hs	2.95	-	-
EXT-B16	Upper joist 4, bay 5	72	hs	1.65	1044–1115[02]	1119–49
EXT-B17	Upper joist 3, bay 5	76	hs	1.88	1032–1107[02]	1111–41
EXT-B18	Upper joist 2, bay 5	70	hs	2.07	1049–1118[02]	1122–52
EXT-B19	Upper joist 1, bay 5	65	hs?	2.66	-	-
EXT-B20	Cross beam 4	86	hs?	1.41	1314–1399	1409–47?

Sample	Sample origin	Number of rings	Sapwood rings	ARW	Date of measured sequence (AD)	Felling date / date range (AD)
EXT-B21	Upper joist 4, bay 4	110	- +*c.* 3nm hs	1.12	999–1108[02]	c 1115–45
EXT-B22	Upper joist 2, bay 4	97	-	2.28	-	-
EXT-B23	Upper joist 1, bay 4	152	hs +*c.* 30-45nm be	1.00	1233–1384[01]	c 1414–29
EXT-B24	Upper joist 1, bay 3	106	hs +*c.* 20-30nm be	1.05	1287–1392[01]	c 1412–22
EXT-B25	Upper joist 2, bay 3	85	-	1.51	-	after 1113
EXT-B26	Upper joist 9, bay 3	95	hs	1.50	1009–1103[02]	1107–37
EXT-B27	Upper joist 12, bay 3	60	hs	1.73	1043–1102[02]	1106–36
EXT-B28	Cross beam 3	74	3 +*c.* 4nm	2.07	-	-
EXT-B29	Upper joist 1, bay 2	nm	-			
EXT-B30	"Great Chamber Hall floor joist sample 1 of 2"	76	hs	2.94	-	-

Key: Number of rings – total number of rings measured; nm – not measured; +*nn* – number of unmeasured rings; hs – heartwood/sapwood boundary present; hs? – possible heartwood/sapwood boundary present; be – bark edge present; ARW – average ring width in millimetres; [01] component of EXTBSQ01; [02] component of EXTBSQ02; [04] component of EXTBSQ04.

The nine timbers previously dated (Howard et al. 2000a) all appear to derive from English oak trees and represent both floor and roof timbers. Evidence for the cross-matching of EXTBSQ01, EXTBSQ04, and EXT-B20 against the updated suite of reference chronologies for English oak that are now available is given in Tables 7–9. These timbers all appear to be broadly coeval although, taking into account the low levels of cross-matching between site master chronologies EXTBSQ01 and EXTBSQ04 and EXT-B20 (*t*-values of: EXTBSQ01/EXTBSQ04 = 3.8, EXTBSQ01/EXT-B20 = 3.4, and EXTBSQ04/EXT-B20 = 3.4), they may be derived from different woodland sources and hence have slightly different felling dates. The timbers forming EXTBSQ01 are likely to be derived from relatively local woodland sources in the Devon (Table 7), but it is possible, although not proven, that EXT-B20 and the pair of timbers (EXT-B11 and EXT-B12) forming site master chronology EXTBSQ04 could be derived from woodland sources slightly further away (Tables 8 and 9).

Table 7: Results of the cross-matching of site chronology EXTBSQ01 and relevant reference chronologies when the first ring date is AD 1233 and the last ring date is AD 1403.

Reference chronology	Date span	*t*-values	Reference
Devon: Awliscombe, Wadhayes	AD 1179–1331	7.7	Tyers et al. forthcoming
Gloucestershire: Kingswood, New Inn House	AD 1191–1519	7.6	Arnold et al. 2004
Devon: Braunton, Church of St Brannock	AD 1215–1378	7.2	Tyers 2004
Devon: Hockworthy, Hole Farm	AD 1306–1468	7.1	Miles et al. 2004
Dorset: Sturminster Newton, Fiddleford Manor	AD 1167–1315	7.1	Bridge 2003
Devon: Exeter, Cathedral	AD 1137–1332	7.1	Mills 1988
Devon: Hemyock, Culm Davy	AD 1265–1402	7.1	Tyers et al. forthcoming
Devon: Alwington, Church of St Andrew	AD 1253–1391	6.7	Arnold and Howard 2009a
Dorset: Holwell, Church of St Laurence	AD 1195–1427	6.4	Bridge 2004
Somerset: Meare Manor Farmhouse	AD 1156–1315	6.4	Bridge 2002a

Table 8: Results of the cross-matching of site chronology EXTBSQ04 and relevant reference chronologies when the first ring date is AD 1322 and the last ring date is AD 1406.

Reference chronology	Date span	*t*-values	Reference
Devon: Holcombe Rogus, Holcombe Court	AD 1349–1536	6.5	Bridge pers comm
Worcestershire: Worcester, The Commandery	AD 1284–1473	6.2	Arnold et al. 2006
Herefordshire: Hereford, Booth Hall and 16-18 High Town	AD 1215–1378	6.0	Boswijk and Tyers 1997
Devon: Exeter, Archdeacons House	AD 1186–1404	5.8	Howard et al. 1999a
Herefordshire: Pembridge, Kings House	AD 1315–1450	5.8	Tyers 2002
Wales: Merioneth, Llangar, Plas-Uchaf, Cathedral	AD 1315–1434	5.7	Miles et al. 1996
Herefordshire: Pembridge, West End Farm	AD 1322–1424	5.5	Tyers 2002
Shropshire: Neen Savage, Church of St Mary	AD 1227–1532	5.5	Arnold and Howard 2014
Herefordshire: Hereford, Widemarsh Street, Farmers Club	AD 1313–1617	5.5	Tyers 1999b
Worcestershire: Wick, Church of St Cuthberts	AD 1255–1496	5.4	Bridge 1981; Tyers 2013

Table 9: Results of the cross-matching of the individual series EXT-B20 and relevant reference chronologies when the first ring date is AD 1314 and the last ring date is AD 1399.

Reference chronology	Date span	*t*-values	Reference
Devon: Exeter, 5/7 West Street and 15/16 Stepcote Hill	AD 1282–1439	7.7	Arnold et al. 2020
Herefordshire: Whitbourne, Church of St John the Baptist	AD 1301–1399	7.2	Arnold and Howard 2009b
Essex: Harlow, Netteswellbury Barn	AD 1245–1439	7.2	Tyers 1997a
Wiltshire: West Lavington, Old Manor	AD 1264–1497	7.1	Tyers and Hurford 2014
Bedfordshire: Toddington, Church of St George	AD 1226–1392	6.6	Bridge 2001
London: Upminster, Tithe Barn	AD 1276–1414	6.6	Tyers 1997b
Essex: Hatfield Broad Oak, Forest Cottage	AD 1308–1359	6.5	Tyers et al. 2003
Oxfordshire: Harwell, Bayllols Manor	AD 1170–1370	6.4	Haddon-Reece 1992
Somerset: Muchelney, Muchelney Abbey	AD 1148–1498	6.2	Bridge 2002b
London: Sugar Quay	AD 1000–1410	6.2	Tyers 2018

The sapwood estimates used to obtain estimated felling date ranges for native English timbers have been revised since the original report (Howard et al. 2000a). Updated ranges for these timbers are presented in Table 6 and Figure 7. They have been calculated by adding a regional sapwood estimate of 10–48 rings (95% probability) for timbers sourced from the south-west of England (Ian Tyers pers comm; Fig. 8), allowing for any surviving sapwood. This estimate was produced as part of compiling the probability distribution of the number of sapwood rings present to bark edge shown in Arnold et al. (2019, fig 9). Whilst it is possible that EXT-B20 and the pair of timbers (EXT-B11 and EXT-B12) forming site master chronology EXTBSQ04 are derived from woodland sources slightly further away from Exeter, in both cases the strongest similarity is with another site chronology from Devon, and thus it is considered reasonable to apply the same regional sapwood estimate.

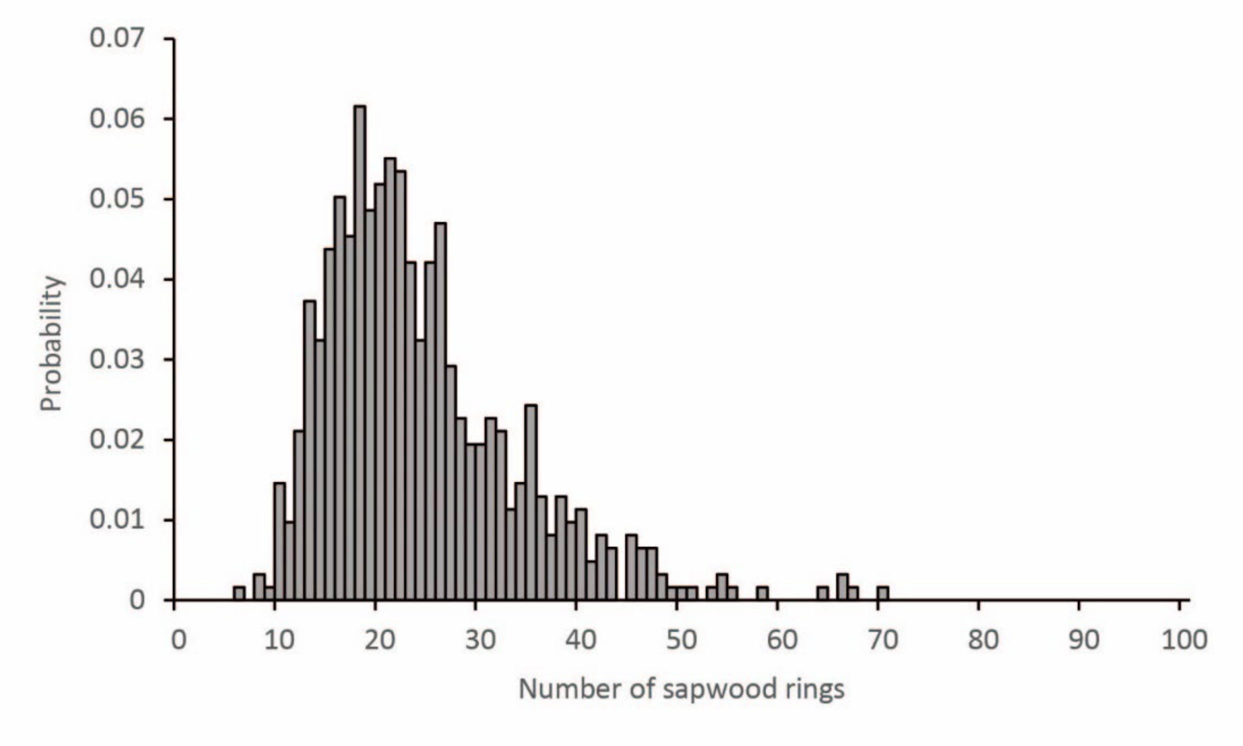

Figure 8: Distribution of the number of sapwood rings present on historic oak timbers complete to bark edge from South-West England (n=617)

The two floor joists, both of larger scantling from the upper layer of joists in the floor at the southern end of bays 3 and 4, from which samples EXT-B24 and EXT-B23 were obtained and both had bark edge present. As indicated above it was therefore possible to produce more precise felling date estimates which suggest that these two timbers are likely to be coeval and hence both felled at the same, or similar, time in the AD 1410s or AD 1420s. Sample EXT-B20, representing main beam 4 in the floor, which is slightly smaller than the other main beams and is also scarf jointed in the middle, has a possible felling date of AD 1409–47 and hence clearly broadly coeval but could have been felled at the same time as the two large joists.

The six dated timbers from the roof are clearly coeval and appear likely to have been felled at, or around, the same time as part of a single period of felling that, bearing in mind the potential for stockpiling of timber in relation to major building campaigns associated with the cathedral, may have spanned a number of years, as opposed to a single discrete felling event. With heartwood/sapwood boundary dates ranging from AD 1400 (EXT-B10) to AD 1406 (EXT-B12), felling is likely to have occurred at some point between the mid-AD 1410s and the AD 1440s, as indicated by the period of common overlap of the individual felling date ranges (Table 6; Fig 7).

Whilst it is possible that this group of nine English timbers could represent slightly different felling dates in the first half of the fifteenth century, the overall variation in heartwood/sapwood boundary date ranging from AD 1384 (EXT-B23) to AD 1406 (EXT-B12) suggests that they were all probably felled at a similar time in the AD 1410s or AD 1420s.

These dated timbers are thought to be associated with the initial construction of the Great Chamber/Parlour block that stands today, and potentially places the construction of this block towards the earlier part of the range identified in the original analysis (Howard et al 2000a), during the time when either Stephen Payne (AD 1415–19) or John Cobthorne (AD 1419–57) was dean of Exeter.

A sapwood estimate of 4–34 rings (95% probability), currently suggested for timbers from northern France (Lambert 2006; Durost and Lambert 2007), has been used to calculate estimated felling dates for the newly dated timbers forming EXTBSQ02 (Table 6). The eight dated French timbers are all floor joists and are found in three of the bays sampled (bays 3–5). They thus represent both the larger joists in bay 5 and the less substantial upper layer of joists in bays 3 and 4. All eight are clearly coeval with heartwood/sapwood boundary dates varying from AD 1102 (EXT-B27) to AD 1118 (EXT-B18) and high levels of similarity between their ring-width series (Table 2). These timbers are therefore likely to have been felled as part of a single felling event at some point between the early AD 1120s and the mid-AD 1130s, as indicated by the period of common overlap of the individual felling date ranges (Table 6; Fig 7). Whilst this group of French timbers were originally felled and used in the early twelfth century, they appear likely to be reused in their current location in the floor of the Great Chamber.

The French timbers appear likely to have derived from a single woodland source, that source being located in the northern half of France. The geographical distribution of the reference chronologies and their relative scarcity for the relevant period, however, makes more precise provenance difficult. Exeter is known to have had strong trading links to Normandy at this time, particularly around Rouen, notably in relation to North French pottery and Caen building stone, as well as links to Brittany and the Low Countries with many Breton carpenters and carvers working in Devon and Cornwall, albeit somewhat later than when these timbers were felled (see for example, Allan 2014; Allan 2021).Thus it seems perfectly possible that timber could also have been part of this trading connection, though rather earlier than previously identified imported structural baulks, although Irish timber in the form of planking has been identified in Exeter dating from the late-twelfth and thirteenth centuries (Tyers 2021).

There is certainly evidence that the Great Chamber/Parlour block constructed in the early fifteenth-century incorporated elements of an earlier building. A blocked lancet window in the enormously thick north wall of this range suggests that this may be of thirteenth- or early fourteenth-century date (Keystone Historic Buildings Consultants 2005, fig 30), and so could potentially be the remnants of a new house built to house the dean on the creation of the office by Bishop Brewer in AD 1225. This is around a century later than the felling of the French timbers now identified in the Great Chamber floor. It is of interest that these French timbers are contemporary with works to construct the Romanesque Cathedral, which started in AD 1114, and also with the evolving demand for accommodation for senior clergy in the Close, which developed as the community of canons led by an Archdeacon, living in common under a monastic order, established in AD 1050, gradually evolved into one of secular canons, living in separate houses (Allan and Higham 2023, 29). It is possible that these timbers derive from an earlier building within the cathedral complex or indeed an earlier clerical house on this site, potentially one housing the archdeacon of Totnes, as he moved to a house in Palace Gate in the AD 1230s and the deanery was endowed with properties formally belonging to him (Allan and Higham 2023, 30). However, even in realms of building campaigns associated with a cathedral it seems highly unlikely that these timbers were stockpiled for a century.

Conclusions

This study has identified important new evidence about the development of the Old Deanery, and hence the wider Cathedral Close, at Exeter. It clearly demonstrates the potential for the reassessment of data from previous studies in the light of scientific advances to provide new results and highlights the need for detailed reporting of the initial sampling and the secure archiving of both the scientific data and the samples.

Use of structural timbers sourced from France has not previously been securely identified through dendrochronology in England. These timbers are also notably very early examples of the importation of structural baulks, as opposed to boards, securely identified through dendrochronology. Miles (2002) reports on the earliest previously identified imported structural baulks, dating to the AD 1220s, being Irish and used extensively in the earliest roofs in Salisbury Cathedral.

The sampling of the Great Chamber floor undertaken in 1998 was opportunistic, with access to the upper joists hampered by the on-going works and access to the lower joists prevented by the presence of the upper joists, as access was only possible from above at the time. The importance of this assemblage, however, is such that, should the opportunity arise at some point in the future, both layers of joists and the associated main beams should be considered for more extensive sampling, which may assist in dendroprovenancing investigations.

In addition, it is hoped that this study, and the recording undertaken during the works by Exeter Archaeology, may now form the stimulus for a further line of research on links between the South-West Peninsula and France in the Middle Ages.

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