Research Report Series 90/2024

Church of St Nicholas, Bromham, Wiltshire: Radiocarbon Wiggle-matching of Timbers from the Roof of the Beauchamp or 'Bayntun' Chapel

Anne Crone, Alison Arnold, Robert Howard, Silvia Bollhalder, Lukas Wacker, Michael Dee, Sanne Palstra, Alex Bayliss, Bisserka Gaydarska, Cathy Tyers and Peter Marshall

Scientific Dating

Church of St Nicholas, Bromham, Wiltshire: Radiocarbon Wiggle-matching of Timbers from the Roof of the Beauchamp or ‘Bayntun’ Chapel

Anne Crone, Alison Arnold, Robert Howard, Silvia Bollhalder, Lukas Wacker, Michael Dee, Sanne Palstra, Alex Bayliss, Bisserka Gaydarska, Cathy Tyers and Peter Marshall

National Grid Reference: ST 96309 65188

Print: ISSN 2398-3841
Online: ISSN 2059-4453

The Research Report Series incorporates reports by Historic England’s expert teams, their predecessors and other researchers. Many Research Reports are interim, to make available the results of specialist investigations in advance of full publication. Although subject to internal quality assurance, they are not usually refereed externally and their conclusions may sometimes have to be modified in the light of information not available at the time of the investigation. Where no final project report is available, readers should consult the author before citing these reports.

For more information email Res.reports@HistoricEngland.org.uk or write to:

Historic England
Fort Cumberland
Fort Cumberland Road
Eastney
Portsmouth PO4 9LD

Summary

Reanalysis of timbers sampled in 2006, as part of a wider dendrochronology project aiming to identify imported American oak timbers in historic buildings, wrecks and other artefacts in the British Isles, means that site master chronology SNCBx7, which includes seven timbers, is now securely dated by ring-width dendrochronology as spanning AD 1622–1866. Radiocarbon dating was undertaken on ten single-ring samples from BRM-B24, from site sequence SNCBx7. Wiggle-matching of these results confirms the date of this sequence suggested by dendrochronology.

Overall, 13 of the 34 measured ring-width series from St Nicholas' Church, Bromham have now been dated by dendrochronology. Six English oak timbers from the lower roof were probably felled in AD 1486–1511, and seven oak timbers from the eastern seaboard of North America were used as narrow boards in the upper roof in the late 19th or early 20th century. The three site master chronologies from the wide boards in the upper roof currently remain undated, as do a number of ungrouped samples.

Contributors

Anne Crone, Alison Arnold, Robert Howard, Silvia Bollhalder, Lukas Wacker, Michael Dee, Sanne Palstra, Alex Bayliss, Bisserka Gaydarska, Cathy Tyers and Peter Marshall

Acknowledgements

Emma Brownlee kindly produced Figure 2.

Front cover image

Church of St Nicholas, Bromham from the north-east, © Mr Charles Hart, source Historic England Archive

Archive location

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

Historic Environment Record

Wiltshire and Swindon Historic Environment Record, Wiltshire Archaeology Service, The Wiltshire and Swindon History Centre, Cocklebury Road, Chippenham, SN15 3QN

Date of survey/research/investigation

2019–2024

Contact details

Historic England, Cannon Bridge House, 25 Dowgate Hill, London, EC4R 2YA. 020 7973 3700. customers@HistoricEngland.org.uk

Anne Crone, AOC Archaeology Group, Edgefield Road Industrial Estate, Loanhead, Midlothian, EH20 9SY. anne.crone@aocarchaeology.com

Alison Arnold and Robert Howard, Nottingham Tree-ring Dating Laboratory, Mayfield Cottage, Tattle Hill, Dale Abbey, Derbyshire, DE7 4RR. alisonarnold@tree-ringdating.co.uk; roberthoward@tree-ringdating.co.uk

Michael Dee and Sanne Palstra, Centre for Isotope Research, University of Groningen, Nijenborgh 6, 9747 AG Groningen, The Netherlands. m.w.dee@rug.nl

Alex Bayliss, Peter Marshall and Cathy Tyers, Historic England, Cannon Bridge House, 25 Dowgate Hill, London, EC4R 2YA. alex.bayliss@historicengland.org.uk; pete.chonologies@googlemail.com; cathy.tyers@historicengland.org.uk

Bisserka Gaydarska, Historic England, Bessie Surtees House, 41–44 Sandhill, Newcastle-upon-Tyne, NE1 3JF bisserka.gaydarska@historicengland.org.uk

Silvia Bollhalder and Lukas Wacker, Laboratory of Ion Beam Physics, ETH Zürich, Otto-Stern-Weg 5, CH-8093 Zürich, Switzerland, bollhalder@phys.ethz.ch; wacker@phys.ethz.ch

Contents

Illustrations

Tables

Introduction

The North American oak project

Tree-ring dating of buildings and objects constructed of oak that are thought, on other grounds, to date to the 18th or early 19th centuries has, surprisingly frequently, proven problematic in the British Isles. This is a period when documentary evidence indicates widespread importation and use of oak timber from North America (Lower 1973; Knight 1986; Truxes 1988).

Dendrochronology is an established component in the informed conservation of the wooden built environment across the British Isles. The data obtained over the last 40 years, however, is predominantly from native oak trees, although timber imported from elsewhere in Northern Europe has been identified by tree-ring analysis from the 13th to the 18th centuries (e.g. Tyers 2010). In contrast, the identification of North American oak in British contexts by dendrochronology has been distinctly lacking.

The North American oak project aims to rectify this deficiency by pooling undated tree ring-width data from British sites that are thought on other evidence to date to the 18th or early/mid-19th century. This material seems generally to include long-lived and slow-grown ring-width series, with in excess of 100 rings and average ring widths of less than 1.3mm. These tree-ring data have been reanalysed in order to establish links between different site chronologies and produce well-replicated master chronologies that may represent different regional woodland sources. This structured dataset has then been compared with reference chronologies from likely source areas, as indicated in documentary sources, in collaboration with North American colleagues.

The project has succeeded in dating sequences and chronologies from 25 British assemblages against a series of regional master chronologies from North America (Crone et al. forthcoming). The data were ‘passed’ through a series of four analytical stages—Passes 1–4—and independent validation of the tree-ring dating identified has been obtained by radiocarbon wiggle-matching for six site chronologies. These are BWKASQ01&02 from Dewar’s Lane Granary, SNCBx7 from St Nicholas’ church, Bromham, Wiltshire, discussed in this report, CHEDDARx6 from St Andrew’s Church, Cheddar, Somerset, COBHSQ06 from Cobham Hall, Kent, MICKLETON from the bellframe in the church of St Lawrence, Mickleton, Gloucestershire, and NWCCSQ01 from St Nicholas’ Church, Newcastle upon Tyne, Tyne and Wear (Bayliss et al. forthcoming). At least one of these comes from each pass that produced calendar dating.

Church of St Nicholas

The Church of St Nicholas (Fig. 1) is designated grade I (List Entry Number 1033887) and principally of 13th-century date, with some Norman stonework in the nave. An aisle and porch were added on the south side in the 14th century, and in AD 1485 a licence to build a chantry on the south side of the chancel was granted to Sir Roger Tocotes and Sir Richard Beauchamp. This is now known as the Bayntun Chapel as so many members of that family are buried there.

There are in fact two roofs covering the chapel. The lower panelled roof is believed to be the original, dating to the AD 1490s, although it shows evidence of some repair and replacement. This roof is framed within a series of slightly cambered, moulded and painted, lateral bridging beams, and a longitudinal ridge beam, also moulded and painted. These main structural elements divide the ceiling of the chapel into 32 panels, each usually made of three boards and measuring *c*. 0.8m square. The panels themselves are further fixed to lateral battens between these main structural elements. To the north side of the chapel roof there are a series of short vertical posts. The function of these posts is uncertain.

The later upper roof consists of widely spaced lateral bridging, or tie, beams (although there are no trusses). These bridging beams are supported at each end by newer wall plates set above the original medieval ones. Common rafters are then set longitudinally, running between each pair of bridging beams. The common rafters support oak boards, which are in turn covered with lead sheeting. It is not clear how much later this upper roof is than the original lower roof. It is known from documentary sources that work to the chapel roofs was undertaken in the early 20th century, but some of the upper roof timbers appear older than this, though not medieval.

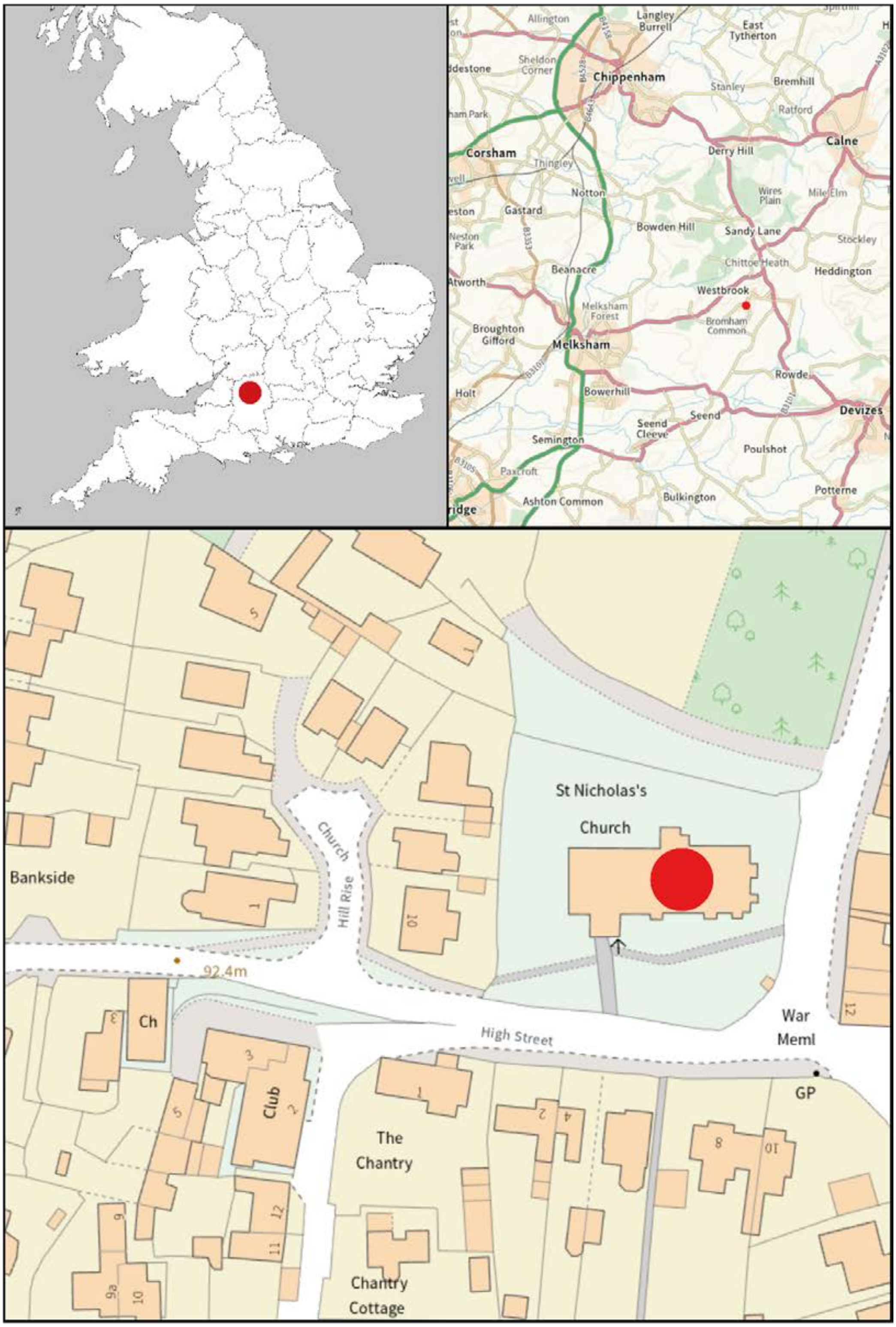

Figure 1: Maps to show the location of the Church of St Nicholas, Bromham (red dot). Scale: top right 1:105,827; bottom 1:827. [© Crown Copyright and database right 2024. All rights reserved. Ordnance Survey Licence number 100024900].

Dendrochronology

Original tree-ring analysis

In association with repair works undertaken in 2006, a programme of ring-width dendrochronology was undertaken on the roofs of the Bayntun Chapel (Arnold and Howard 2008). In total, 36 timbers were sampled by coring from the lower panelled roof and from the upper roof structure, including both structural timbers and wide and narrow boards (Arnold and Howard 2008, table 1).

Two samples had insufficient rings for analysis, but the other 34 samples were prepared by sanding and polishing, and their growth ring-widths were measured. The ring-width series were then compared with each other using the Litton/Zainodin grouping procedure (Laxton et al. 1988; Litton and Zainodin 1991).

At minimum *t*-values of *t*=4.9 (BRMBSQ01), *t*=8.3 (BRMBSQSQ02), *t*=17.5 (BRMBSQ03), *t*=10.0 (BRMBSQ04) and *t*=4.8 (BRMBSQ05), 19 of the 34 measured samples formed five groups, of which only one, BRMBSQ01, could be dated as spanning AD 1359–1483 (Table 1; Arnold and Howard 2008, table 2). This site chronology comprises six samples, all from timbers of the lower, earlier roof, and has an overall length of 125 rings.

Table 1: Details of the dated timbers from the lower roof at the Church of St Nicholas, Bromham.

Sample number	Sample location	Total rings	Sapwood rings	Date of first measured ring (AD)	Date of last heartwood ring (AD)	Date of last measured ring (AD)
BRM-B25	North lateral batten 1	86	14	AD 1398	AD 1469	AD 1483
BRM-B26	North lateral batten 2	50	no h/s	AD 1387	------	AD 1436
BRM-B28	North lateral batten 8	50	h/s	AD 1423	AD 1472	AD 1472
BRM-B29	South lateral batten 4	52	no h/s	AD 1408	------	AD 1459
BRM-B31	North vertical post 8	89	no h/s	AD 1369	------	AD 1457
BRM-B32	Lateral bridging beam1	92	no h/s	AD 1359	------	AD 1450

Three further site chronologies were formed of samples from the wide boards of the upper roof: BRMBSQ02 comprising four samples and 112 rings, BRMBSQ03 comprising two samples and 96 rings, and BRMBSQ04 comprising two samples and 65 rings. A fifth site chronology, comprising five samples and with an overall length of 245 rings, was formed from samples from the narrow boards of the upper roof. Attempts to date the four site sequences from the upper roof by comparing them with the database of reference chronologies for oak from the UK and from other north European countries failed. They were also tested against the North American oak reference data then available, but to no avail. The ring-width data for all of the measured samples from the church of St Nicholas, Bromham are listed by Arnold and Howard (2008, 20–5). It should be noted that there is a typographical error in the data provided for sample BRM-B14, which actually has 184 rings. The correct data are provided in the Appendix.

Revised tree-ring analysis

All undated oak data from Bromham church were revisited as part of a recent research programme into the dendrochronological identification of oak timbers imported from the eastern seaboard of America found in historic buildings and objects in the UK (Crone et al. forthcoming).

Cross-matching was attempted by a process of qualified statistical comparison by computer, supported by visual checks using software written by Tyers (2004). The ring-width series were compared for statistical cross-matching, using a variant of the Belfast CROS program (Baillie and Pilcher 1973). The *t*-values between six measured ring-width series from narrow boards in the upper roof are shown in Table 2. The sequences were combined at the relevant offset positions to form a combined six-timber mean, BRMBSQ05&20, of 245-rings.

Table 2: Cross-matching and overlaps between ring-width series included in the six-timber mean chronology, BRMBSQ05&20. *t*-values in excess of 3.5 are significant, - = *t*-value less than 3.00, \ = overlap less than 30 years.

	start position	end position	BRM-B14	BRM-B17	BRM-B19	BRM-B24	BRM-B20
BRM-B13	29	215	4.38	5.77	3.50	13.92	3.51
BRM-B14	55	238		-	9.24	3.67	3.27
BRM-B17	29	118			\	4.46	\
BRM-B19	130	245				-	3.64
BRM-B24	1	175					5.76
BRM-B20	120	165					

Analysis undertaken as part of the North American oak project identified that the timbers represented by this site chronology were imported American oak. The chronology thus dated spans AD 1622–1866, and one of the ungrouped series, BRM-B18, has also been dated independently against the American chronologies when it spans AD 1685–1770 (Crone et al. forthcoming; Table 3).

Consequently, sample BRM-B18 has been combined with site chronology BRMBSQ05&20 to form a new dated seven-timber site master chronology, SNCBx7, which also contains 245 rings and spans AD 1622–1866.

Table 3: Details of the samples derived from imported North American oak at the Church of St Nicholas, Bromham.

Sample number	Sample location	Total rings	Sapwood rings	Date of first measured ring (AD)	Date of last heartwood ring (AD)	Date of last measured ring (AD)
BRM-B13	Board – exact position unknown	187	no h/s	1650	1836	1836
BRM-B14	Board – exact position unknown	184	no h/s	1676	1859	1859
BRM-B17	Board – exact position unknown	90	no h/s	1650	1739	1739
BRM-B18	Board – exact position unknown	86	no h/s	1685	1770	1770
BRM-B19	Board – exact position unknown	116	no h/s	1751	1866	1866
BRM-B20	Board – exact position unknown	46	no h/s	1741	1786	1786
BRM-B24	Board – exact position unknown	175	no h/s	1622	1796	1796

Radiocarbon dating

As this project was breaking new ground in terms of the dating of imports from a previously unidentified source in the dendrochronological assemblage in the British Isles, it was considered sensible to obtain independent validation of the calendar dating identified through ring-width dendrochronology. Samples from several of the newly dendrochronologically dated site chronologies were therefore selected for radiocarbon dating and wiggle-matching. Sample BRM-B24, with 175 annual growth-rings, was the sample selected from site master chronology SNCBx7. This was dated as part of Pass 1 of the revised tree-ring analysis (Crone et al. forthcoming).

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 4, 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 10 single annual tree-rings from timber BRM-B24 (Table 4; Fig. 2). Dissection was undertaken by Alison Arnold and Robert Howard at the Nottingham Tree-Ring Dating Laboratory. Before sub-sampling, the core was checked against the tree-ring width data. Then each annual growth ring was split from the rest of the tree-ring sample using a chisel 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.

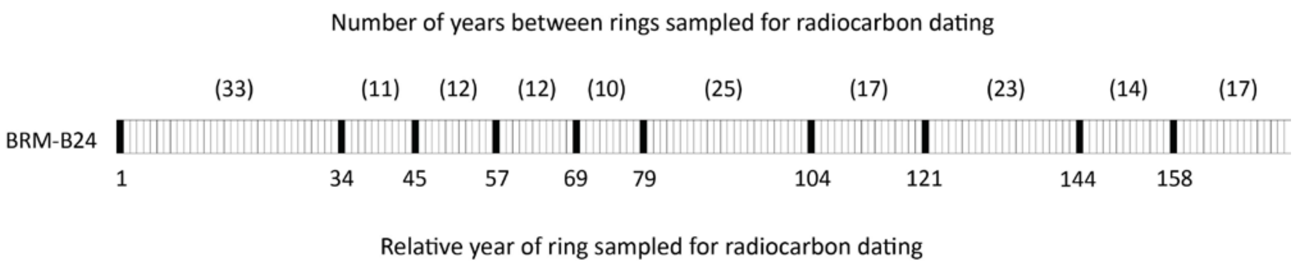

Figure 2: Schematic illustration of sample BRM-B24 to locate the single-ring sub-samples submitted for radiocarbon dating (white = heartwood; black = ring sampled for radiocarbon dating).

Radiocarbon dating was undertaken by the Laboratory of Ion Beam Physics, ETH Zürich, Switzerland and the Centre for Isotope Research, University of Groningen, the

Netherlands in 2021. At ETH Zürich cellulose was extracted from each ring using the base-acid-base-acid-bleaching (BABAB) method described by Němec et al. (2010), combusted and graphitised as outlined in Wacker et al. (2010a), and dated by Accelerator Mass Spectrometry (Synal et al. 2007; Wacker et al. 2010b). Data reduction was undertaken as described by Wacker et al. (2010c).

At the University of Groningen 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 AMS (Synal et al. 2007; Salehpour et al. 2016). Data reduction was undertaken as described by Wacker et al. (2010c).

Both facilities maintain a continual programme of quality assurance procedures (Sookdeo et al. 2020; 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 4). Both pairs of measurements on single tree-rings measured in two laboratories are statistically consistent at the 5% significance level and so weighted means have been taken before further analysis (Ward and Wilson 1978). The $\delta^{13}C$ values measured by Isotope Ratio Mass Spectrometry more accurately reflect the natural isotopic composition of the sampled wood.

Table 4: Radiocarbon measurements and associated $\delta^{13}C$ values from oak sample BRM-B24 (an unprovenanced 'narrow board') part of site sequence SNCBx7 (replicate measurements have been tested for statistical consistency and combined by taking a weighted mean as described by Ward and Wilson (1978)).

Laboratory Number	Sample	Radiocarbon Age (BP)	$\delta^{13}C_{AMS}$ (‰)	$\delta^{13}C_{IRMS}$ (‰)
ETH-112357	BRM-B24, ring 1 (*Quercus* sp., heartwood)	321±16	−25.5	
ETH-112358	BRM-B24, ring 34 (*Quercus* sp., heartwood)	226±16	−24.7	
ETH-112359	BRM-B24, ring 45 (*Quercus* sp., heartwood)	205±24	−25.6	
ETH-112360	BRM-B24, ring 57 (*Quercus* sp., heartwood)	165±23	−26.1	
ETH-112361	BRM-B24, ring 69 (*Quercus* sp., heartwood)	156±23	−25.4	
ETH-112362	BRM-B24, ring 79 (*Quercus* sp., heartwood)	120±25	−24.6	
GrM-25388	BRM-B24, ring 104 (*Quercus* sp., heartwood)	122±18		−23.3±0.1
ETH-112363	Replicate of GrM-25388	146±25	−25.1	
Mean	130±15 BP; T′=0.6, T′(5%)=3.8, v=1			
ETH-112364	BRM-B24, ring 121 (*Quercus* sp., heartwood)	232±25	−26.3	
GrM-25389	BRM-B24, ring 144 (*Quercus* sp., heartwood)	156±18		−23.8±0.1
ETH-112365	Replicate of GrM-25389	202±25	−26.5	
Mean	172±15 BP; T′=2.2, T′(5%)=3.8, v=1			
ETH-112366	BRM-B24, ring 158 (*Quercus* sp., heartwood)	195±16	−24.5	

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 BRM-B24, derived from the probability method (Stuiver and Reimer 1993), are shown in outline in Figures 3 and 4.

Wiggle-matching is the process of matching a series of calibrated radiocarbon dates that 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 used. 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 uses 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 3 and 4 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 with its position in the sequence (most values in a model should be equal to or greater than 60).

Figure 3 illustrates the chronological model for master chronology SNCBx7. This model incorporates the gaps between each dated annual ring known from tree-ring counting (e.g. that the carbon in ring 1 of the measured tree-ring series (ETH-112357) was laid down 33 years before the carbon in ring 34 of the series (ETH-112358); Fig. 2), with the radiocarbon measurements (Table 4) calibrated using the internationally agreed radiocarbon calibration data for the northern hemisphere, IntCal20 (Reimer et al. 2020).

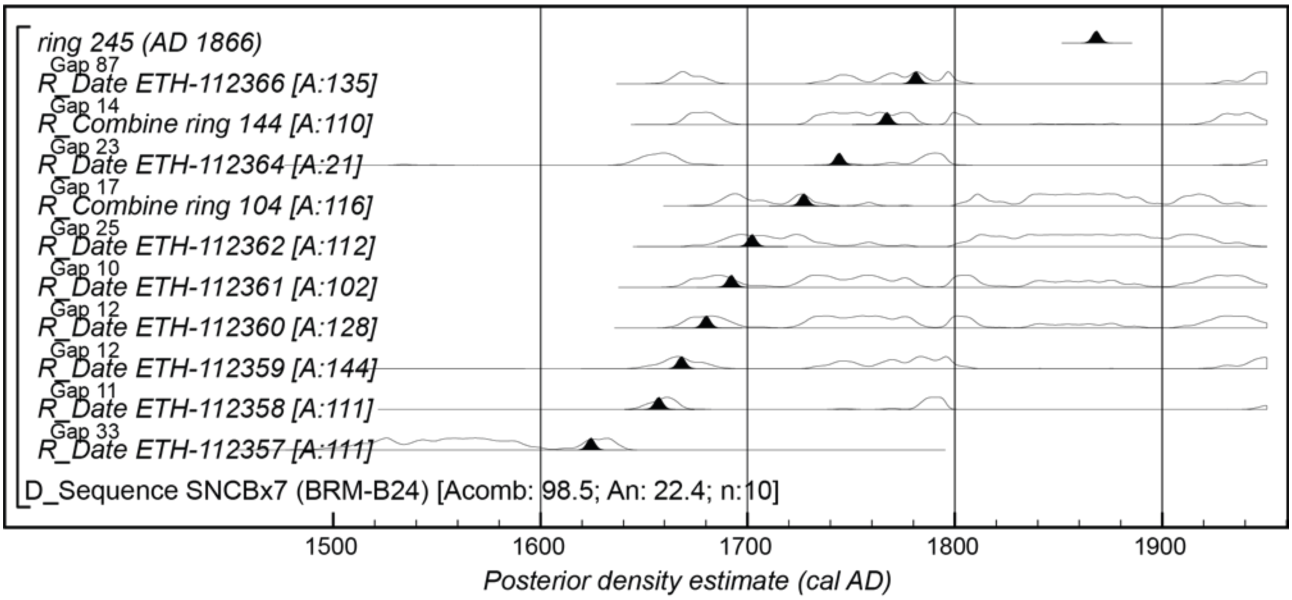

Figure 3: Probability distributions of dates from timber board BRM-B24, part of site sequence SNCBx7. Each distribution represents the relative probability that an event occurs at a particular time. For each of the dates two distributions have been plotted: one in outline, which is the simple radiocarbon calibration, and a solid one, based on the wiggle-match sequence. Distributions other than those relating to particular samples correspond to aspects of the model. For example, the distribution '*ring 245 (AD 1866)*' is the estimated date when the last ring of SNCBx7 formed. The large square brackets down the left-hand side along with the OxCal keywords and the description of the sapwood estimates in the text defines the overall model exactly.

The model has good overall agreement (Acomb: 98.5, An: 22.4, n: 10; Fig. 3), with only a single radiocarbon date having poor individual agreement (A < 60): ETH-112364 (A:12). It suggests that the final ring of SNCBx7 formed in *cal AD 1863–1873* (*95% probability*; *ring 245 (AD 1866)*; Fig. 3), probably in *cal AD 1866–1871 (68% probability)*, compatible with the last measured ring being formed in AD 1866 (Table 3). When the last ring of the wiggle-match is constrained to be AD 1866, the model also has good overall agreement (Acomb: 32.3, An: 26.7, n: 7; Fig. 4), with only one of the radiocarbon dates having poor individual agreement (A < 60): *ETH-112364* (A:18).

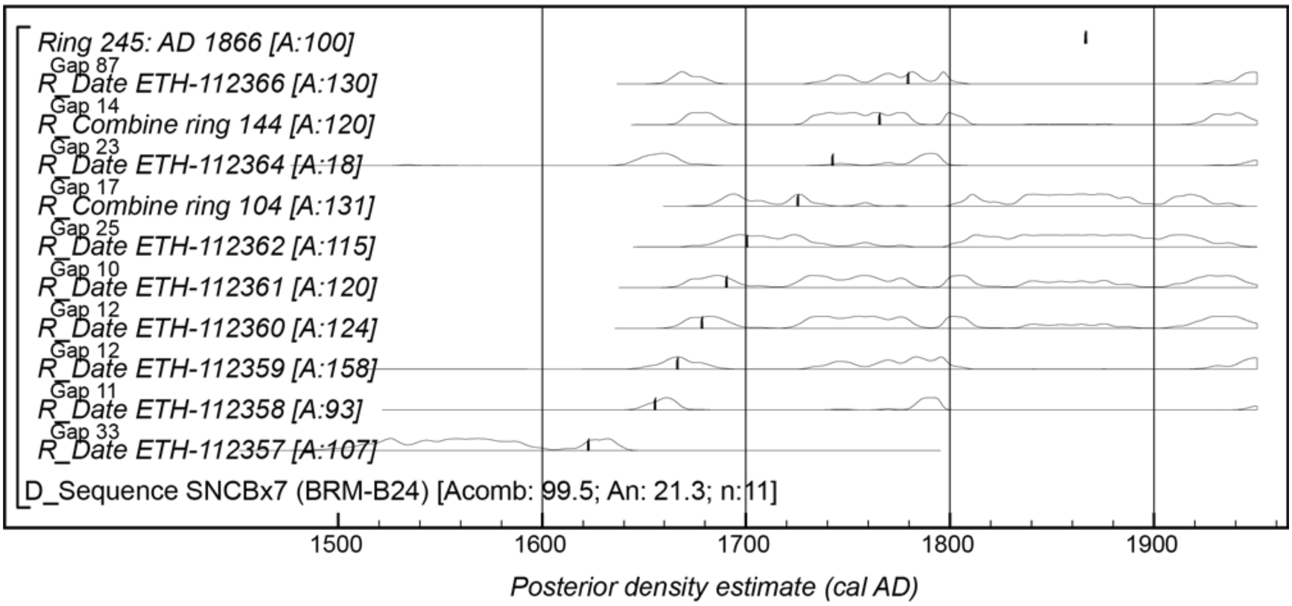

Figure 4: Probability distributions of dates from timber board BRM-B24, part of site sequence SNCBx7 when the last ring of site sequence SNCBx7 is constrained to have formed in AD 1866. The format is identical to that of Figure 3.

Discussion

The radiocarbon wiggle-matching confirms the calendar date identified through ring-width dendrochronology for site master chronology SNCBx7, thus providing independent validation of that date. This, along with the dating of site master chronology BRMBSQ01 during the original analysis, means that 13 timbers from the church of St Nicholas, Bromham, have now been dated by dendrochronology (Fig. 5).

None of the samples in site chronology BRMBSQ01 retains complete sapwood, and thus a precise felling date cannot be given for any of the timbers represented. Two samples, BRM-B25 and BRM-B28, do, however, retain the heartwood/sapwood boundary. The average date of this boundary is AD 1471. Using a sapwood estimate of 15–40 rings at (95% confidence) that is appropriate for English oak would give the timbers represented an estimated felling date in the range AD 1486–1511. There is no evidence that the other four timbers in this group were not felled at the same time.

In site chronology SNCBx7, none of the samples retained their heartwood/sapwood boundaries (Table 3). It is possible, however, that they formed part of a single felling episode and that the dates for the final surviving ring, which range from AD 1739 (on BRM-B17) to AD 1866 (on BRM-B19), reflect differences in trimming and the conversion of the parent trees into boards. Clearly, this group was felled after AD 1866, probably slightly later when account is taken of the missing sapwood. Providing a more robust *terminus post quem* for these timbers is, however, problematic.

Site chronology SNCBx7 correlates well with regional chronologies from US States of Pennsylvania and Virginia (Crone et al. forthcoming), and so the timbers are probably American white oak (*Quercus alba*) for which there are currently no sapwood estimates. Counts of between 1 and 42 sapwood rings have been recorded (*see* Crone et al. forthcoming for discussion), so the trees could potentially have been felled any time between the late AD 1860s and the first decade of the 20th century. It is known from documentary sources that work to the chapel roofs was undertaken in the early 20th century, so it is possible that the narrow boards in the upper roof are survivals of this episode.

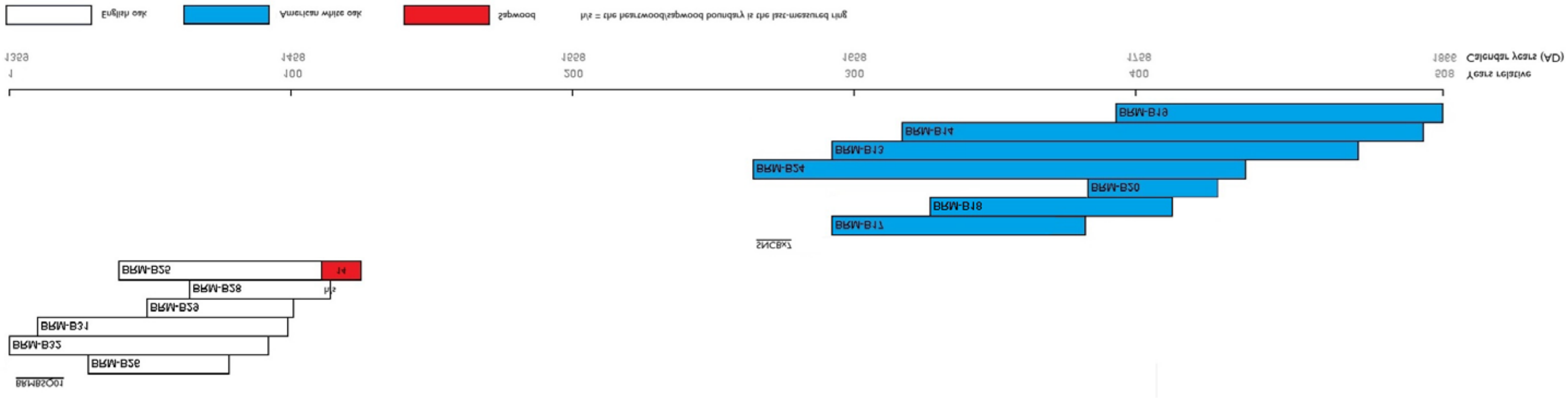

Figure 5: Bar diagram of samples from site chronologies BRMBSQ01 and SNCBx7 dated by ring-width dendrochronology.

Conclusions

Overall, 13 of the 34 measured ring-width series from St Nicholas' church, Bromham have now been dated by dendrochronology. Six English oak timbers from the lower roof were probably felled in AD 1486–1511. Seven oak timbers from the eastern seaboard of North America were used as narrow boards in the upper roof in the late 19th or early 20th century. The three site master chronologies from the wide boards in the upper roof currently remain undated, as do a number of ungrouped timbers (Table 5).

Table 5: Summary of ring-width dendrochronology from the Church of St Nicholas, Bromham.

Site chronology	Number of samples	Number of rings	Timbers from	Date span (where dated)
BRMBSQ01	6	125	lower roof	AD 1359–1483
BRMBSQ02	4	112	upper roof: wide boards	undated
BRMBSQ03	2	96	upper roof: wide boards	undated
BRMBSQ04	2	65	upper roof: wide boards	undated
SNCBx7	7	245	upper roof: narrow boards	AD 1622–1866
---.---	13	---		undated
---.---	2	---		unmeasured

References

Aerts-Bijma, A. T., Meijer, H., and van der Plicht, J. 1997 'AMS sample handling in Groningen', *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms*, 123, 221–5: https://doi.org/10.1016/S0168-583X(96)00672-6

Aerts-Bijma, A. T., Paul, D., Dee, M. W., Palstra, S. W. L., and Meijer, H. A. J. 2021 'An independent assessment of uncertainty for radiocarbon analysis with the new generation high-yield Accelerator Mass Spectrometers', *Radiocarbon*, 63, 1–22: https://doi:10.1017/RDC.2020.101

Arnold, A. J., and Howard, R. E. 2008 'Church of St Nicholas, Bromham, Wiltshire: tree-ring analysis of timbers from the roof of the Beauchamp or 'Bayntun' chapel', Historic England Research Report Series, 37/2008: https://historicengland.org.uk/research/results/reports/37-2008 (acc. 21 November 2024)

Baillie, M. G. L., and Pilcher, J. R. 1973 'A simple cross-dating program for tree-ring research', *Tree-Ring Bulletin*, 33, 7–14.

Bayliss, A., Crone, A., Dee, M. W., Gaydarska, B., Tyers, C., and Wacker, L. forthcoming 'Paired ^{14}C measurements on European and North American oak from Historic buildings in England', *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms*

Bronk Ramsey, C. 2009 Bayesian analysis of radiocarbon dates, *Radiocarbon*, 51, 37–60: https://doi.org/10.1017/S0033822200033865

Bronk Ramsey, C., van der Plicht, J., and Weninger, B. 2001 ''Wiggle matching' radiocarbon dates', *Radiocarbon*, 43, 381–9: https://doi.org/10.1017/S0033822200038248 (acc.19 July 2024)

Christen, J. A., and Litton, C. D. 1995 'A Bayesian approach to wiggle-matching', *Journal of Archaeological Science*, 22, 719–25: https://doi.org/10.1016/0305-4403(95)90002-0

Crone, A., Arnold, A., Bale, R, Bridge., M, Brown, D., Cook, E., Griggs, C., Howard, R., Miles, D., Mills, C., Nayling, N., Tyers, C., and Tyers, I. forthcoming 'American oak imports to the British Isles in the 18th and early 19th centuries; the dendrochronological evidence'

Dee, M. W., Palstra, S. W. L., Aerts-Bijma, A. T., Bleeker, M. O., de Bruin, S., Ghebru, F., Jansen, H. G., Kuitems, M., Paul, D., Richie, R. R., Spriensma, J. J., Scifo, A., von

Zonneveld, D., Verstappen-Dumoulin, B. M. A. A., Wietzes-Land, P., and Meijer, H. A. J. 2020 ‘Radiocarbon dating at Groningen: new and updated chemical pretreatment procedures’, *Radiocarbon*, 62, 63–74: https://doi.org/10.1017/RDC.2019.101

Galimberti, M., Bronk Ramsey, C., and Manning, S. 2004 ‘Wiggle-match dating of tree-ring sequences’, *Radiocarbon*, 46, 917–24: https://doi.org/10.1017/S0033822200035967

Knight, R. J. B. 1986 ‘New England forests and British seapower: Albion revised’, *The American Neptune*, 46, 221–9.

Laxton, R. R., Litton, C. D., and Zainodin, H. J. 1988 ‘An objective method for forming a master ring-width sequence’, *PACT*, 22, 25–35.

Litton, C. D., and Zainodin, H. J. 1991 ‘Statistical models of dendrochronology’, *Journal of Archaeological Science*, 18, 29–40: https://doi.org/10.1016/0305-4403(91)90036-O

Lower, A. R. M. 1973 *Great Britain’s woodyard: British America and the timber trade*, 1763–1867 (Montreal).

Němec, M., Wacker, L., Hajdas, I., and Gäggeler, H. 2010 'Alternative methods for cellulose preparation for AMS measurement', *Radiocarbon,* 52, 1358–70: https://doi.org/10.1017/S0033822200046440

Reimer, P. J., Austin, W. E. N., Bard, E., Bayliss, A., Blackwell, P., Bronk Ramsey, C., Butzin, M., Cheng, H., Edwards, R. L., Friedrich, M., Grootes, P. M., Guilderson, T. P., Hajdas, I., Heaton, T. J., Hogg, A. G., Hughen, K. A., Kromer, B., Manning, S. W., Muscheler, R., Palmer, J. G., Pearson, C., van der Plicht, J., Reimer, R. W., Richards, D. A., Scott, E. M., Southon, J. R., Turney, C. S. M., Wacker, L., Adolphi, F., Büntgen, U., Capano, M., Fahrni, S., Fogtmann-Schultz, A., Friedrich, R., Kudsk, S., Miyake, F., Olsen, J., Reinig, F., Sakamoto, M., Sookdeo, A., and Talamo, S. 2020 ‘The IntCal20 Northern Hemispheric radiocarbon calibration curve (0–55 kcal BP)’, *Radiocarbon*, 62, 725–57: https://doi:10.1017/RDC.2020.41

Salehpour, M., Håkansson, K., Possnert, G., Wacker, L., and Synal, H-A. 2016 ‘Performance report for the low energy compact accelerator mass spectrometer at Uppsala University’, *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms*, 371, 360−4: https://doi.org/10.1016/j.nimb.2015.10.034

Scott, E. M., Naysmith, P., and Cook, G. T. 2017 ‘Should archaeologists care about 14C intercomparisons? Why? A summary report on SIRI’, *Radiocarbon*, 59, 1589–96: https://doi.org/10.1017/RDC.2017.12

Sookdeo, A., Kromer, B., Büntgen, U., Friedrich, M., Friedrich, R., Helle, G., Pauly, M., Nievergelt, D., Reinig, F., Treydte, K., Synal, H.-A., and Wacker, L. 2020 'Quality Dating: A well-defined protocol implemented at ETH for high-precision ^{14}C dates tested on Late Glacial wood', *Radiocarbon,* 62(4), 891–9: https://doi.org/10.1017/RDC.2019.132

Stuiver, M., and Polach, H. A. 1977 'Reporting of ^{14}C data', *Radiocarbon*, 19, 355–63: https://doi.org/10.1017/S0033822200003672

Stuiver, M., and Reimer, P. J. 1993 'Extended ^{14}C data base and revised CALIB 3.0 ^{14}C calibration program', *Radiocarbon,* 35(1), 215–30: https://doi.org/10.1017/S0033822200013904

Synal, H. A., Stocker, M., and Suter, M. 2007 'MICADAS: a new compact radiocarbon AMS system', *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms*, 259, 7–13: https://doi.org/10.1016/j.nimb.2007.01.138

Truxes, T. M. 1988 *Irish–American trade 1660–1783* (Cambridge).

Tyers, I. 2004 'Dendro for Windows Program Guide 3rd edn', ARCUS Report, 500b.

Tyers, I. 2010 'Aspects of the European trade in oak boards to England 1200–1700' in Kirby, J., Nash, S., and Cannon, J. eds*. Trade in Artists materials: markets and commerce in Europe to 1700* (London), 42–9.

Wacker, L., Bonani, G., Friedrich, M., Hajdas, I., Kromer, B., Němec, M., Ruff, M., Suter, M., Synal, H. A., and Vockenhuber, C. 2010a 'MICADAS: Routine and high-precision radiocarbon dating', *Radiocarbon*, 52(2), 252–62: https://doi.org/10.1017/S0033822200045288

Wacker, L., Němec, M., and Bourquin, J. 2010b 'A revolutionary graphitisation system: Fully automated, compact and simple', *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms*, 268(7–8), 931–4: https://doi.org/10.1016/j.nimb.2009.10.067

Wacker, L., Christl, M., and Synal, H. A. 2010c 'Bats: A new tool for AMS data reduction', *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms*, 268, 976–9: https://doi.org/10.1016/j.nimb.2009.10.078

Wacker, L., Scott, E. M., Bayliss, A., Brown, D., Bard, E., Bollhalder, S., Friedrich, M., Capano, M., Cherkinsky, A., Chivall, D., Culleton, B. J., Dee, M. W., Friedrich, R., Hodgins, G. W. L., Hogg, A., Kennett, D. J., Knowles, T. D. J., Kuitems, M., Lange, T. E., Miyake, F., Nadeau, M-J., Nakamura, T., Naysmith, J .P., Olsen, J., Omori, T., Petchey, F., Philippsen, B., Ramsey, C. B., Prasad, G. V. R., Seiler, M., Southon, J., Staff, R., Tuna, T. 2020 ‘Findings from an in-depth annual tree ring radiocarbon intercomparison’, *Radiocarbon*, 62, 873–82: https://doi:10.1017/RDC.2020.49

Ward, G. K., and Wilson, S. R. 1978 'Procedures for comparing and combining radiocarbon age determinations: a critique', *Archaeometry,* 20(1), 19–32: https://doi.org/10.1111/j.1475-4754.1978.tb00208.x

Wijma, S., Aerts, A. T., van der Plicht, J., and Zondervan, A. 1996 ‘The Groningen AMS facility’, *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms*, 113, 465–9: https://doi.org/10.1016/0168-583X(95)01420-9

Appendix

Measurements in 0.01mm units

BRM-B14

64	50	58	71	42	34	30	27	40	23
27	22	30	24	42	40	34	27	36	33
29	30	33	31	30	17	34	28	35	46
45	42	29	33	55	90	107	105	88	99
101	118	89	71	69	47	71	36	39	66
66	85	83	80	70	80	71	80	76	85
108	28	42	71	53	43	83	73	57	90
41	78	44	83	86	65	58	60	52	42
93	86	105	75	99	67	72	74	45	28
75	49	84	65	83	54	65	50	87	81
70	44	32	42	46	74	52	49	44	44
52	69	56	51	44	44	39	51	63	43
51	58	57	52	74	74	74	48	62	76
94	129	108	109	127	121	106	120	126	35
45	99	86	78	91	85	81	110	122	135
132	201	197	144	138	142	113	135	137	141
143	102	73	101	134	129	124	150	153	135
125	117	137	130	140	121	118	90	115	157
127	120	105	148						

Historic England

Historic England's Research Reports

We are the public body that helps people care for, enjoy and celebrate England's historic environment.

We carry out and fund applied research to support the protection and management of the historic environment. Our research programme is wide-ranging and both national and local in scope, with projects that highlight new discoveries and provide greater understanding, appreciation and enjoyment of our historic places.

More information on our research strategy and agenda is available at HistoricEngland.org.uk/research/agenda.

The Research Report Series replaces the former Centre for Archaeology Reports Series, the Archaeological Investigation Report Series, the Architectural Investigation Report Series, and the Research Department Report Series.

All reports are available at HistoricEngland.org.uk/research/results/reports. There are over 7,000 reports going back over 50 years. You can find out more about the scope of the Series here: HistoricEngland.org.uk/research/results/about-the-research-reports-database.

Keep in touch with our research through our digital magazine *Historic England Research* HistoricEngland.org.uk/whats-new/research.

ISSN 2398-3841 (Print)
ISSN 2059-4453 (Online)