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The *Maison Dieu* Museum, 17 Ospringe Street, Faversham, Kent
Radiocarbon wiggle-matching of oak timbers

Robert Howard, Cathy Tyers, Michael Dee, Sanne Palstra, and Peter Marshall

Discovery, Innovation and Science in the Historic Environment

Research Report Series no. 41-2022

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NGR: TR 00362 60855

ISSN 2059-4453 (Online)

SUMMARY
Radiocarbon wiggle-matching of timbers in the previously undated ring-width site chronology OSPASQ01 suggests they were all felled in a single felling phase in *cal AD 1457–1468* (*95% probability*), probably in *cal AD 1460–1465* (*68% probability*). Previous ring-width dendrochronological dating of site chronology OSPASQ02 also indicated a small group of timbers were felled in a single felling phase in *AD 1458–1473* (*95% probability*), probably *AD 1461–1468* (*68% probability*). The fact that all these timbers are late fifteenth-century in date is at odds with the expected sixteenth-century dating suggested on stylistic and documentary grounds.

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ACKNOWLEDGEMENTS
The Laboratory would like to take this opportunity to thank all those who assisted with the sampling of the timbers AD 1998. In particular thanks are due to Mr and Mrs Friar, custodians of the site, who were most helpful and hospitable during sampling. We would also like to thank Paul Roberts of English Heritage who recorded this building and who assisted with the interpretation of the site prior to sampling.

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DATE OF INVESTIGATION
2021–22

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INTRODUCTION

The *Maison Dieu* Museum

The *Maison Dieu* Museum at Ospringe (Fig 1) is a Grade II* listed (List Entry Number 1069431) timber-framed house incorporating parts of a building formerly belonging to the Hospital of the Blessed Mary of Ospringe (commonly known as the *Maison Dieu*). The house is jettied on the north and east sides, and the upper hall has a king-post roof, the coupled rafters being joined by short collars toward the top and the collars of each couple being linked by a collar purlin.

Tree-ring analysis

A programme of ring-width dendrochronology in AD 1998–9 sampled 20 oak timbers, 14 believed to relate to the original construction, and six believed to be later (possibly inserted in the sixteenth century) (Howard *et al* 1999). The tree-ring analysis produced two site master chronologies: OSPASQ01, of 89 rings, contained the ring-width series from eight timbers and OSPASQ02, of 65 rings, contained the ring-width series from four timbers. Both chronologies contain timbers believed to be original and timbers thought to have been inserted, and the variation in the relative positions of the heartwood/sapwood boundary rings (5 years and 6 years respectively) suggest that each contained timbers produced in a single felling episode (although these might be different). OSPASQ02 was dated by ring-width dendrochronology as spanning AD 1388–1452. None of the samples included in OSPASQ02 has complete sapwood (Howard *et al* 1999, fig 6; table 1), but one retains the heartwood/sapwood boundary and three a small number (<5) of sapwood rings. The estimated felling dates of these timbers can be determined by the addition of the probability distribution for the expected number of sapwood rings in ancient oak timbers from England (Arnold *et al*, fig 9) to the dates of the last rings of the respective timbers. For the samples that retain some sapwood the probability distribution has been shortened to allow for their surviving sapwood rings (Bayliss and Tyers 2004, 960–1). These distributions are shown in outline in Figure 2.

The relative positions of the heartwood/sapwood boundaries on the samples in OSPASQ02 lie within narrow limits, having a six-year difference (Howard *et al* 1999, fig 6; table 1), suggesting they are from a single felling phase. The date of this felling phase can be estimated by combining the probability distributions for the felling of each timber that has a heartwood/sapwood boundary. The model shown in Figure 2 that combines the felling dates for the four timbers in OSPASQ02 that have heartwood/sapwood boundaries has good overall agreement (Acomb: 128.6, An: 35.4, n: 4; Fig 2), with each prior distribution having good individual agreement (A:>60). This analysis suggests the timbers in OSPASQ02 were felled in *AD 1458–1473* (*95% probability;* OSPASQ02; Fig 2), probably *AD 1461–1468* (*68% probability*).

The felling date estimates given above for site chronology OSPASQ01 are slightly different to those in Howard *et al* (1999) as they are derived from a different methodology (see Laxton *et al* 2001, 11–13 for full details of the methodology that originally employed a 95% confidence limit for the amount of sapwood on mature oaks from Kent of 15–35 rings).

RADIOCARBON DATING

Given the relatively high proportion of undated timbers from what were believed the primary phase of construction and the need to better understand the chronology of the building undated site chronology OSPASQ01, containing eight samples and spanning 85 rings was selected for radiocarbon dating and wiggle-matching (Howard *et al* 1999, fig 5). The radiocarbon samples all come from OSP-A03, the lintel of the first-floor fireplace, that is one of the longest ring-series in OSPASQ01 spanning relative years 1–85 of the master sequence and ends in the heartwood/sapwood boundary of the parent tree.

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 1, 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 six single annual tree-rings from timber OSP-A03, part of undated site chronology OSPASQ01 (Table 1). Dissection was undertaken by Alison Arnold and Robert Howard at the Nottingham Tree-Ring Dating Laboratory. Prior to 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.

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 AMS (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 1). 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 OSPASQ01 derived from the probability method (Stuiver and Reimer 1993), are shown in outline in Figure 3.

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 Figure 3 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 3 illustrates the chronological model for OSPASQ01. This model incorporates the gaps between each dated annual ring known from tree-ring counting (eg that the carbon in ring 5 of the measured tree-ring series (GrM-26048) was laid down 15 years before the carbon in ring 20 of the series (GrM-26049), with the radiocarbon measurements (Table 1) calibrated using the internationally agreed radiocarbon calibration data for the northern hemisphere, IntCal20 (Reimer *et al* 2020).

The model has good overall agreement (Acomb: 119.5, An: 28.9, n: 6; Fig 3), with all the radiocarbon dates having good individual agreement (A: > 60). It suggests that the final ring of OSPASQ01 formed in *cal AD 1438–1452* (*95% probability*; *last_OSP-A08/A15 (ring 89)*; Fig 3), probably in *cal AD 1444–1450* (*68% probability*).

INTERPRETATION

The relative positions of the heartwood/sapwood boundaries of the eight samples in OSPASQ01 appears to be consistent, varying by only five years, with an average date of relative ring 87.

None of the samples in OSPASQ01 has complete sapwood (Howard *et al* 1999, fig 65; table 1), but they all retain the heartwood/sapwood boundary. Using the same methodology outlined above (§ Tree-ring analysis) distributions for the estimated felling dates of these timbers are shown in outline in Figure 4.

A model that combines the felling dates for these eight timbers, shown in Figure 4, has good overall agreement (Acomb: 249.2, An: 25.0, n: 8; Fig 4) with each prior distribution having good individual agreement (A:>60). The analysis suggests that timbers in OSPASQ01 were felled in *cal AD 1457–1468 (95% probability; OSPASQ01*; Fig 4*),* probably in *cal AD 1460–1465 (68% probability)*.

DISCUSSION

Ring-width dendrochronological dating and radiocarbon wiggle-matching of timbers has dated two site chronologies, OSPASQ01 and OSPASQ02, with it plausible that they contain timbers that could derive from a single felling phases in the late fifteenth-century (Fig 5). Although the two site chronologies do not cross-match each other, this does not mean that the timbers are of different dates but may indicate that the trees from which they were derived were sourced from different woodlands, and although it is not possible to say conclusively they are contemporary the results indicate this could be the case.

The samples in OSPASQ02 are from jetty joists from the north side of the building, a door post and fireplace lintel, while those in OSPASQ01 derive from jetty joists from the north and east sides and two of the fireplace lintels. The fact that all these timbers are late-fifteenth century in date is at odds with the expected sixteenth century date suggested on stylistic and documentary grounds (Rigold and Dunning 1958) and suggests a revised narrative for the building's structural history is required.

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TABLES

Table 1: Radiocarbon measurements and associated $\delta^{13}C$ values from oak sample OSP-A03 part of undated site chronology OSPASQ01

Laboratory Number	Sample	Radiocarbon Age (BP)	$\delta^{13}C_{IRMS}$ (‰)
GrM-26048	OSP-A03, ring 5, *Quercus* sp., heartwood, relative ring 5 of site chronology OSPASQ02	618±18	−24.9±0.15
GrM-26049	OSP-A03, ring 20, *Quercus* sp., heartwood, relative ring 20 of site chronology OSPASQ02	644±14	−24.0±0.15
GrM-26050	OSP-A03, ring 35, *Quercus* sp., heartwood, relative ring 35 of site chronology OSPASQ02	592±20	−24.7±0.15
GrM-26051	OSP-A03, ring 50, *Quercus* sp., heartwood, relative ring 50 of site chronology OSPASQ02	542±18	−25.3±0.15
GrM-26052	OSP-A03, ring 65, *Quercus* sp., heartwood, relative ring 65 of site chronology OSPASQ02	523±18	−24.9±0.15
GrM-26053	OSP-A03, ring 81, *Quercus* sp., heartwood, relative ring 81 of site chronology OSPASQ02	489±20	−23.8±0.15

FIGURES

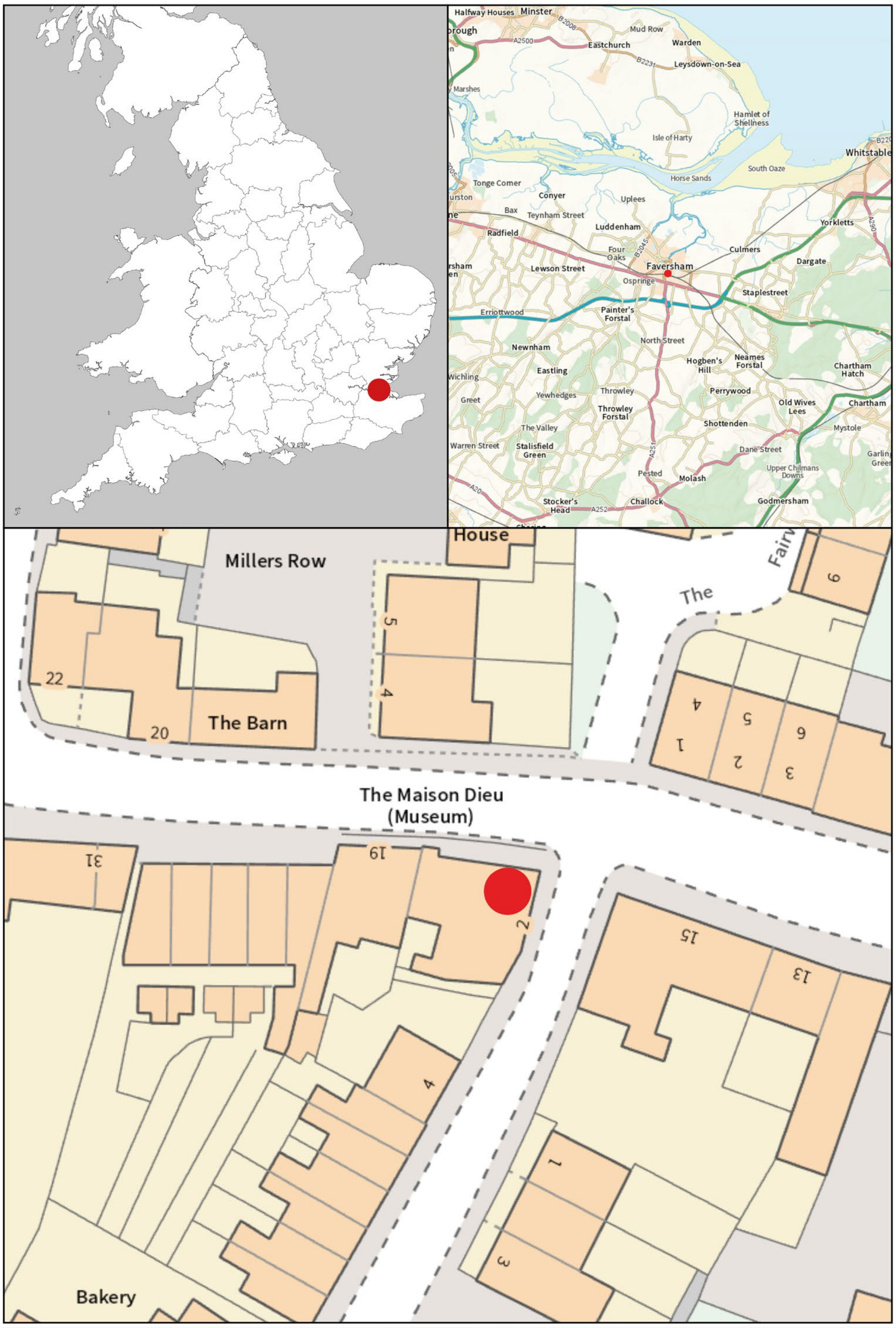


Figure 1: Maps to show the location of Faversham and the Maison Dieu *Museum. Scale: top right 1:105827; bottom 1:412. © Crown Copyright and database right 2022. All rights reserved. Ordnance Survey Licence number 100024900*

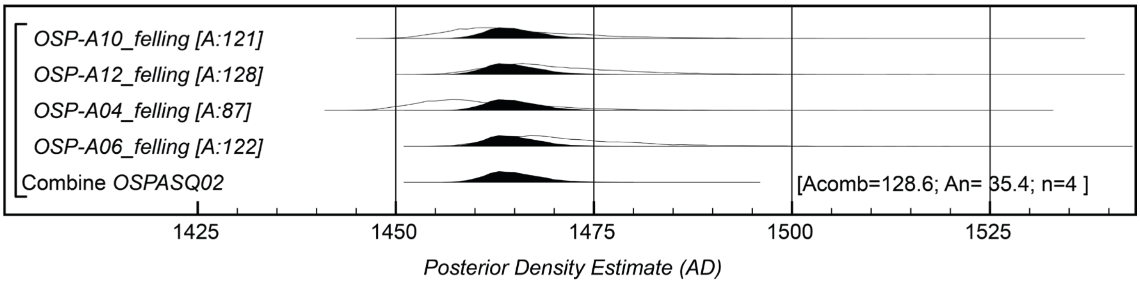


Figure 2: Combined probability distribution estimating the felling date of timbers in site sequence OSPASQ02, if it is interpreted as representing a single felling event

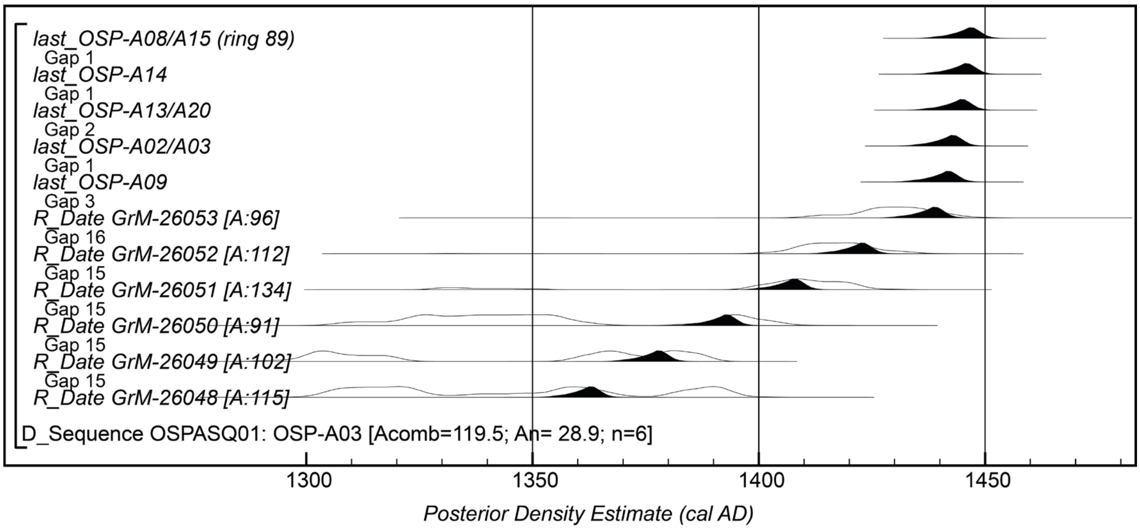


Figure 3: Probability distributions of dates from the undated site sequence OSPASQ01. Each distribution represents the relative probability that an event occurs at a particular time. For each of the dates two distributions have been plotted: one in outline, which is the simple radiocarbon calibration, 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 'last_OSP-A14' *is the estimated date for the last ring on sample* OSP-A14.*The large square brackets down the left-hand side along with the OxCal keywords define the overall model exactly*

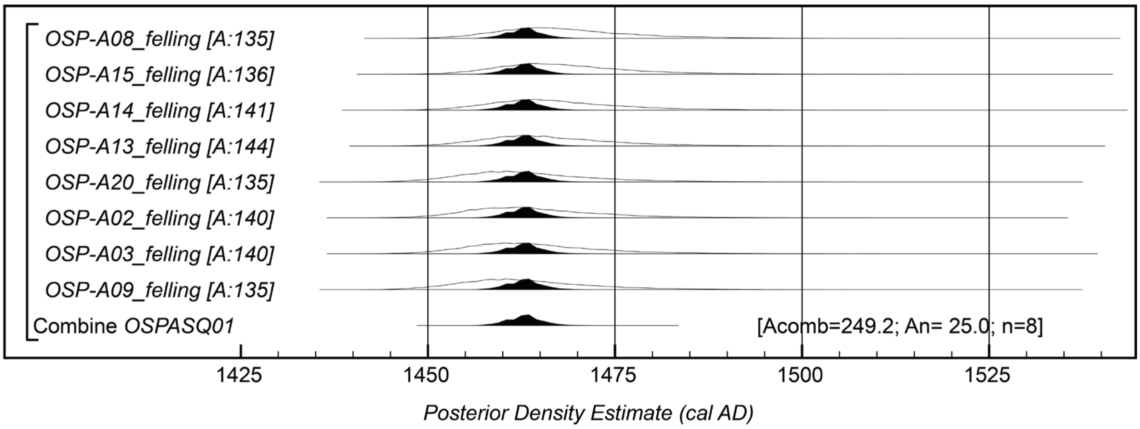


Figure 4: Combined probability distribution estimating the felling date of timbers in site sequence OSPASQ01, if it is interpreted as representing a single felling event

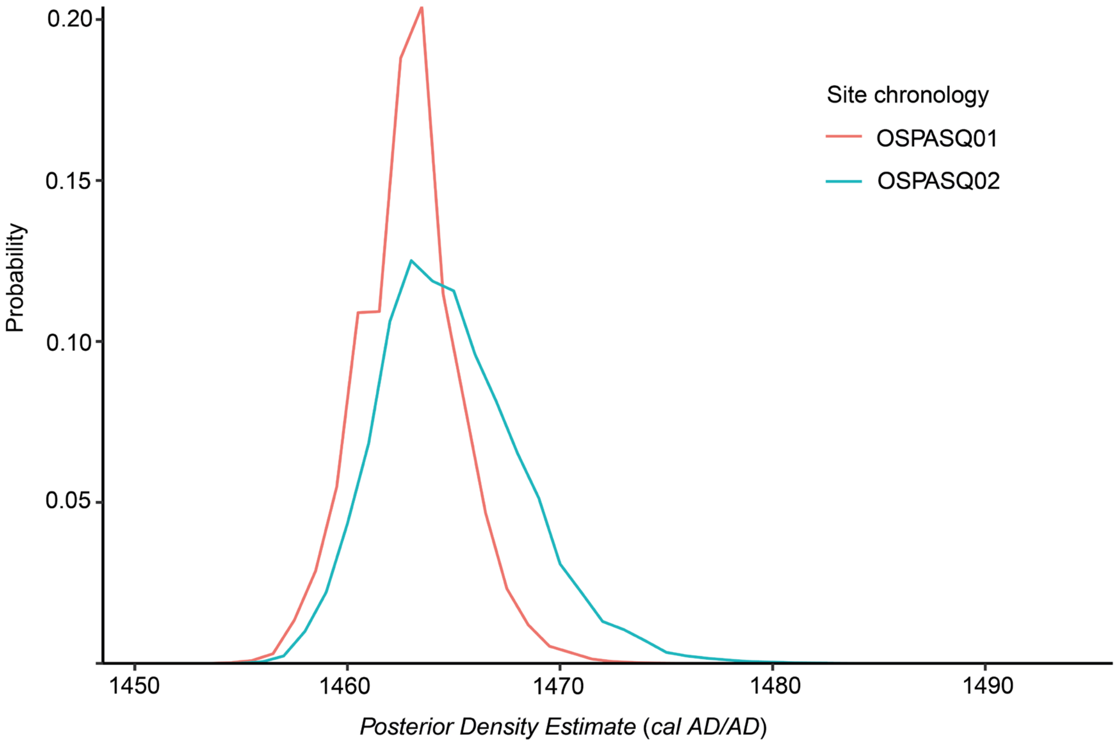
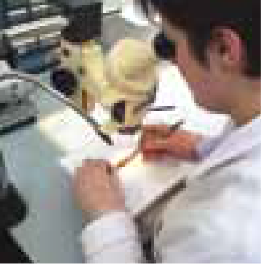
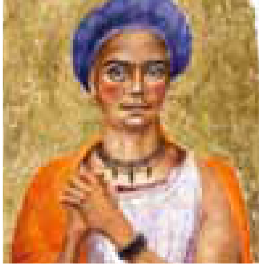
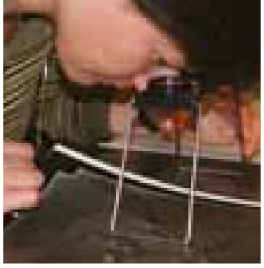


Figure 5: Probability distributions for the estimated felling dates of site chronologies OSPASQ01 (radiocarbon wiggle-matching) and OSPASQ02 (ring-width dendrochronology). The distributions are derived from the models described in Figures 2 and 4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ISSN 2059-4453 (Online)