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DYDDIO HEN DAI CYMREIG — DATING OLD WELSH HOUSES

PROSIECT DENDROCRONOLEG GOGLEDD ORLLEWIN CYMRU — NORTH WEST WALES DENDROCHRONOLOGY PROJECT

Oxford Dendrochronology Laboratory

THE TREE-RING DATING OF

Trefadog, Llanfaethlu, Isle of Anglesey

Report
2011/TREFADOG

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March 2011

A report commissioned by The North West Wales Dendrochronology Project in partnership with The Royal Commission on the Ancient and Historical Monuments in Wales (RCAHMW).

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Trefadog, Llanfaethlu, Isle of Anglesey

This isolated house was visited in March 2011. It is the only known example of full cruck construction on the island, with rare decorative wind-bracing to the roof. There are two bays to the left of the front door, and one to the right. The crucks are made from very large timbers, but unfortunately these had very few rings, being of very fast-grown oak.

It was decided that there were too few rings for dendrochronological dating, but two samples were taken in case it might be possible to carry out radiocarbon dating at a later stage. Sample 01 was taken from the west cruck of the central truss (Fig 1), next to the stairs, and had complete sapwood. Sample 02 was taken from a timber above the door on the east side of the truss (Fig 2).

Figure 1: West cruck of central truss

Figure 2: Timber above door, central truss

The position of the truss sampled is shown in Fig 3. Sample 01 had 57 rings, including 28 sapwood rings, plus the spring vessels of the next year (28¼C), and the series was compared with the dated reference material, but as expected, this short series failed to date.

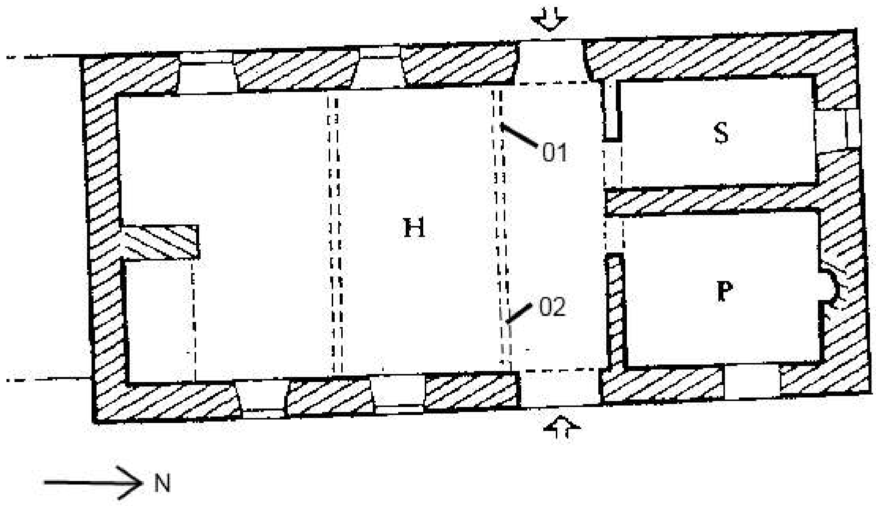

Figure 3: Plan of the house, showing the approximate positions of samples 01 and 02 taken for possible future radiocarbon analysis (adapted from Houses of the Welsh Countryside, Peter Smith RCAHMW).

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UNIVERSITY OF OXFORD
RADIOCARBON
ACCELERATOR UNIT

Dr Dan Miles
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Mapledurham
Oxon
RG4 7TX

19th Dec, 2011

Our ref: **C14/3777**

Dear Dan

The following radiocarbon measurements have been made on samples from this project.

OxA	**Sample**	**Material (species)**	**δ^{13}C**	**Date**
Trefadog, Anglesey, UK				
OxA-25581	trf 01a	wood (oak)	-24.85	559 ± 25
OxA-25582	trf 01b	wood (oak)	-25.12	348 ± 24

The dates are uncalibrated in radiocarbon years BP (Before Present - AD 1950) using the half life of 5568 years. Isotopic fractionation has been corrected for using the measured δ^{13}C values measured on the AMS. The quoted δ^{13}C values are measured independently on a stable isotope mass spectrometer (to ±0.3 per mil relative to VPDB). For details of the chemical pretreatment, target preparation and AMS measurement see *Radiocarbon* **46** (1) 17-24, **46** (1): 155-63, and *Archaeometry* **44** (3 Supplement 1): 1-149. The attached calibration plots, showing the calendar age ranges, have been generated using the Oxcal computer program (v4.1) of C. Bronk Ramsey, using the 'INTCAL09' dataset (*Radiocarbon* **51** (4), 2009).

As you may know we publish all dates measured at Oxford in a datelist which appears in the journal *Archaeometry*. When you have had the chance to consider the implications of the results I wonder if you would be kind enough to send your brief comments to me.

Yours sincerely

Hayley Sula

Interpretation of C14 Dates OxA-25581 and OxA-25582 from Trefadog, Anglesey

Dr Peter Marshall, Assistant Scientific Dating Co-ordinator, English Heritage
December 2011

Radiocarbon wiggle-matching
Wiggle-matching is the process of matching a series of radiocarbon determinations 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 different blocks of wood submitted for dating is known precisely by counting the rings in the timber.

Recent advances in the accuracy and precision of radiocarbon measurements produced by Accelerator Mass Spectrometry (eg Bronk Ramsey *et al* 2004; Dellinger *et al* 2004) now make this approach feasible for small wood samples, such as those available from cores taken for tree-ring dating. An excellent summary of the history and variety of approaches employed for wiggle-matching is provided by Galimberti *et al* (2004) and recent applications can be found in Hamilton *et al* (2008) and Tyers *et al* (2009).

A variety of the wiggle-matching approach has also been applied to validate, or choose between, different matching positions of a floating tree-ring sequence against the absolutely dated master chronologies (Bayliss *et al* 1999). This is useful in situations where possible cross-matching positions have been identified by the tree-ring analysis, but where these are not strong enough statistically to be accepted without independent, confirmatory, evidence.

A Bayesian approach to wiggle-matching
The first method of wiggle-matching which has been applied to these data, is using a Bayesian approach to combine the radiocarbon dates with the relative dating provided by the tree-ring analysis. This is a probabilistic approach, which determines which parts of the calibrated radiocarbon date are most likely given the tree-ring evidence. This results in a reduced date range, known as a *posterior density estimate*, which is shown in black in Figure 1, and given in italics in the text.

The technique used is a form of numerical integration, and has been applied using the program OxCal v4.1 (http://www.rlaha.ox.ac.uk/orau/) and the calibration data of Reimer *et al* (2009). Details of the algorithms employed for this application are available from the on-line manual or in Bronk Ramsey (1995; 1998; 2001; 2009). The algorithms used in the models described below can be derived from the structure shown in Figures 1and 2.

A general introduction to the Bayesian approach to interpreting archaeological data is provided by Buck *et al* (1996) and for dating buildings (Bayliss 2007). The approach to wiggle-matching adopted here is described by Christen and Litton (1995) and Bronk Ramsey *et al* (2001).

The chronological model for the dating of samples from trf01 is shown in Figure 1. This includes the radiocarbon measurements on each of the five year blocks of wood from the cores, the information that the centre ring of block A is 75 years earlier than the centre ring of block B, and the information that after the centre point of block B there were two and half years to the bark edge.

This analysis suggests that sample trfo1, was felled in *cal AD 1465-1505 (95% probability; bark edge*; Fig 1), or *cal AD 1475–1495 (68% probability)*. This model has good overall agreement (A_{comb} = 97.9%, A_n= 50%, n-2; Bronk Ramsey 1995). This means that the radiocarbon measurements are compatible with the tree-ring sequence of the timber samples.

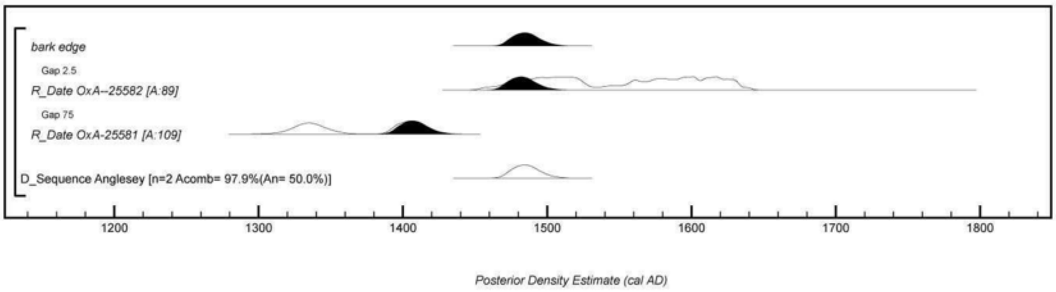

Figure 1: Probability distributions of dates from core trf01. Each distribution represents the relative probability that an event occurs at a particular time. For each of the dates two distributions have been plotted: one in outline, which is the result of simple radiocarbon calibration, and a solid 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 '*bark edge*' is the estimated date when the timber was felled. The large square brackets down the left-hand side along with the OxCal keywords define the overall model exactly.

A Bayesian approach to validating tentative tree-ring matches

Despite exhaustive cross-checking for potential matches with an extensive set of reference data from Great Britain, conclusive dating of the tree-ring series from Trefadog by dendrochronology has not been possible. A potential tree-ring match was suggested by the dendrochronology for the site sequences - AD 1468 - although the match is not sufficiently strong for acceptance in absence of confirmatory evidence.

Figure 2 shows the chronological model for the dating of samples where the last ring of the sequence is constrained to be AD 1468, as tentatively suggested by the tree-ring analysis. This model includes the radiocarbon results on each of the five year blocks of wood from the core, the information that the centre of one block is 75 years earlier than the centre of the next block in the sequence, and the information that the centre point of block B is two and a half years earlier than the bark edge date of AD 1468. This model has poor overall agreement (A_{comb} =35.0%; A_n=40.8%, n=3; Bronk Ramsey 1995). This suggests that the dating of this sequence, cautiously suggested by tree-ring analysis, may be in-correct.

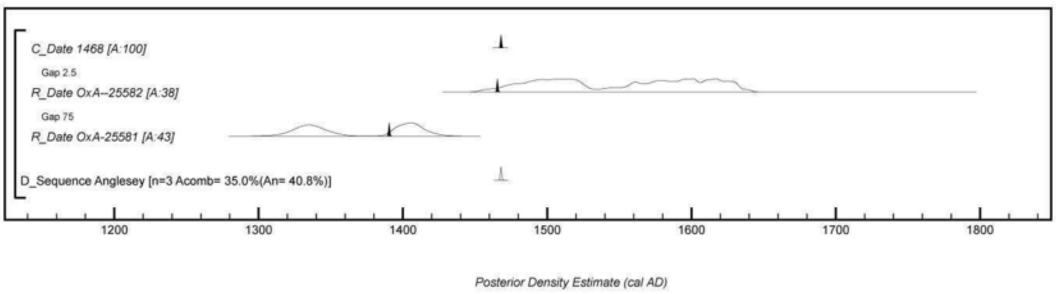

Figure 2: Probability distributions of dates from core trf01. The format is identical to that of Figure 1. *C_Date AD 1468* has been included to test whether the radiocarbon dates agree with the weak match provided by tree-ring analysis at this date. The large square brackets down the left-hand side along with the OxCal keywords define the overall model exactly

Discussion

The radiocarbon calibration curve for the late fifteenth century and early sixteenth century is complex (see Fig 3) and accounts for the wide and bi-modal distribution for sample B (shown in outline in Figs 1 and 2).

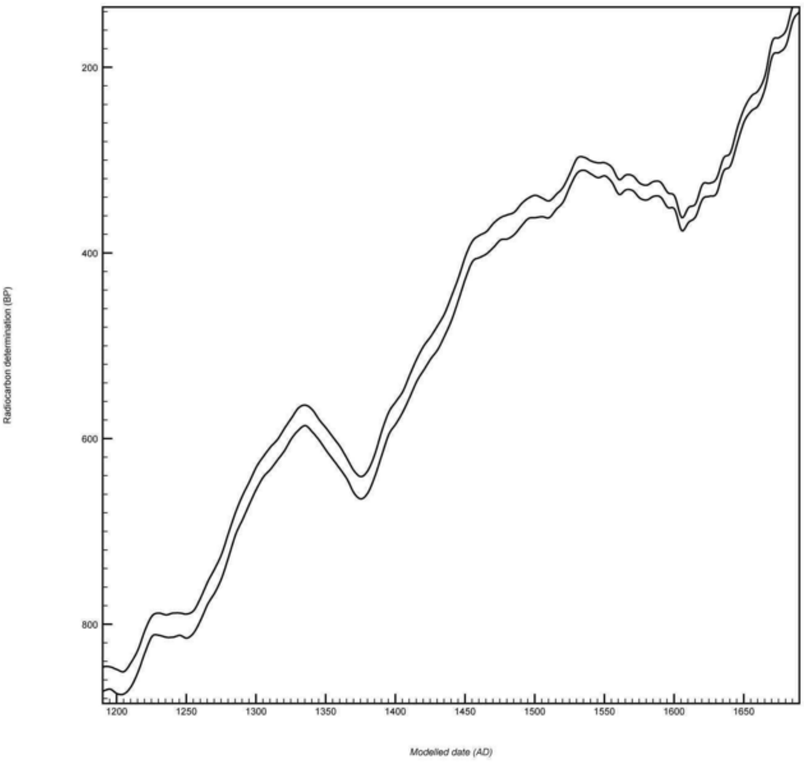

Figure 3: Radiocarbon calibration curve c AD 1200-1700 (Reimer *et al* 2009)

In order to refine the estimated date for the last ring in the core we have run a simulation (Fig 4) that exploit the steep piece of the calibration curve in the mid-fifteenth century (Fig 3). This simulation model includes an additional radiocarbon sample (R_Simulate). This simulation suggests that sample trfo1, was felled in *cal AD 1465-1490 (95% probability; bark edge*; Fig 1), or *cal AD 1470–1485 (68% probability)*. This model has good overall agreement (A_{comb} = 82.1%, A_n= 40.8%, n-3; Bronk Ramsey 1995). This means that the radiocarbon measurements are compatible with the tree-ring sequence of the timber samples.

Thus the submission of an additional sample will improve the precision of the estimated felling date, however, it will never confirm the tentative tree-ring date because of where sample B falls on the calibration curve.

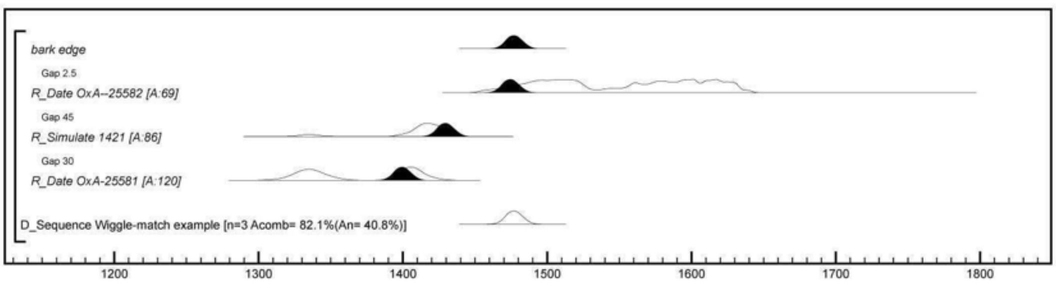

Figure 4: Probability distributions of dates from core trf01. The format is identical to that of Figure 1. *R_Simulate 1421* has been included to determine whether an additional radiocarbon dates increases the precision of the estimated felling date (*bark edge*). The large square brackets down the left-hand side along with the OxCal keywords define the overall model exactly

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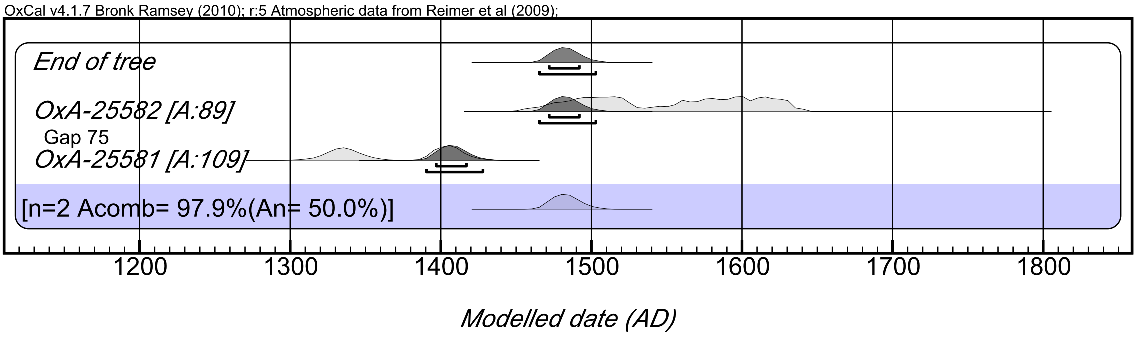
Trefadog Miles_wigglematch[1]



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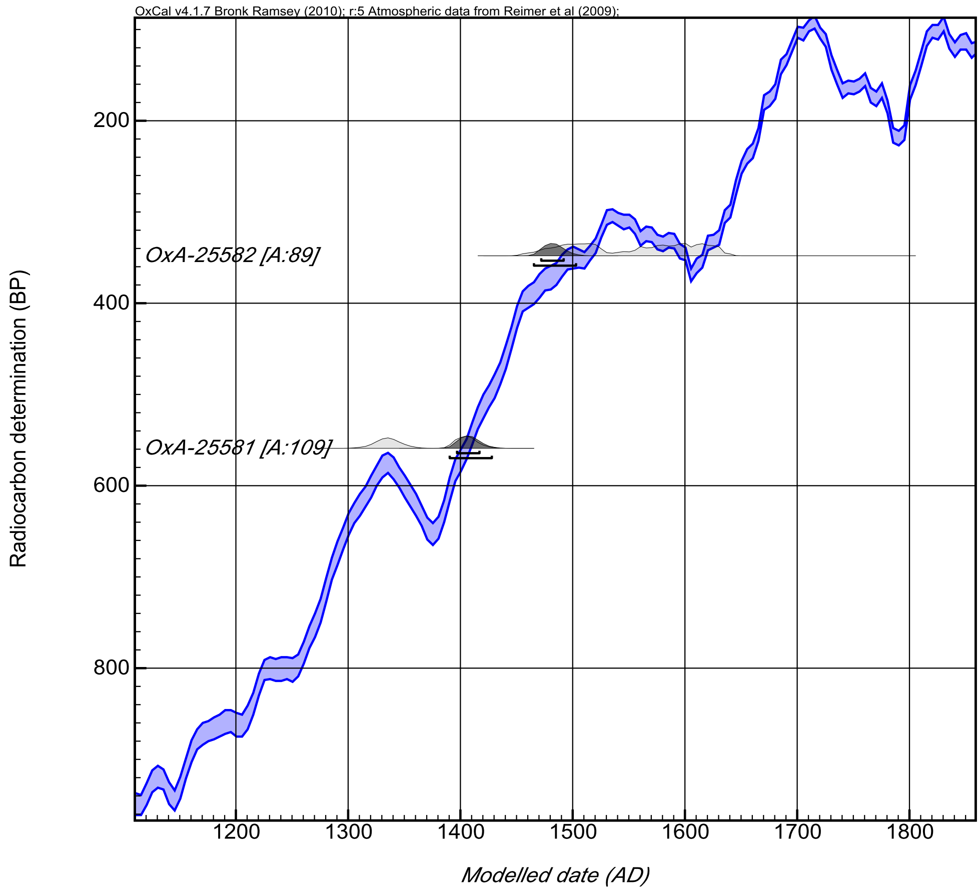

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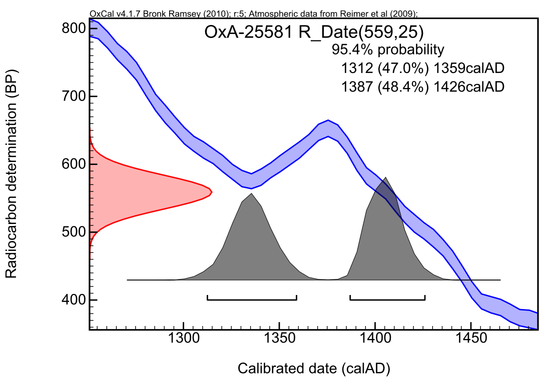

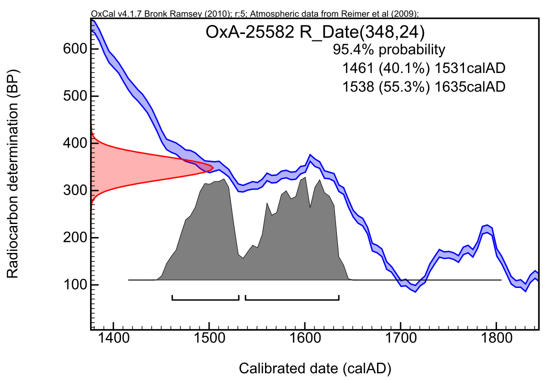

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UNIVERSITY OF OXFORD
RADIOCARBON
ACCELERATOR UNIT

Dr Dan Miles
Mill Farm
Mapledurham
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RG4 7TX

10^{th} Nov, 2014

Our ref: **C14/4336**

Dear Dan

The following radiocarbon measurements have been made on samples from this project.

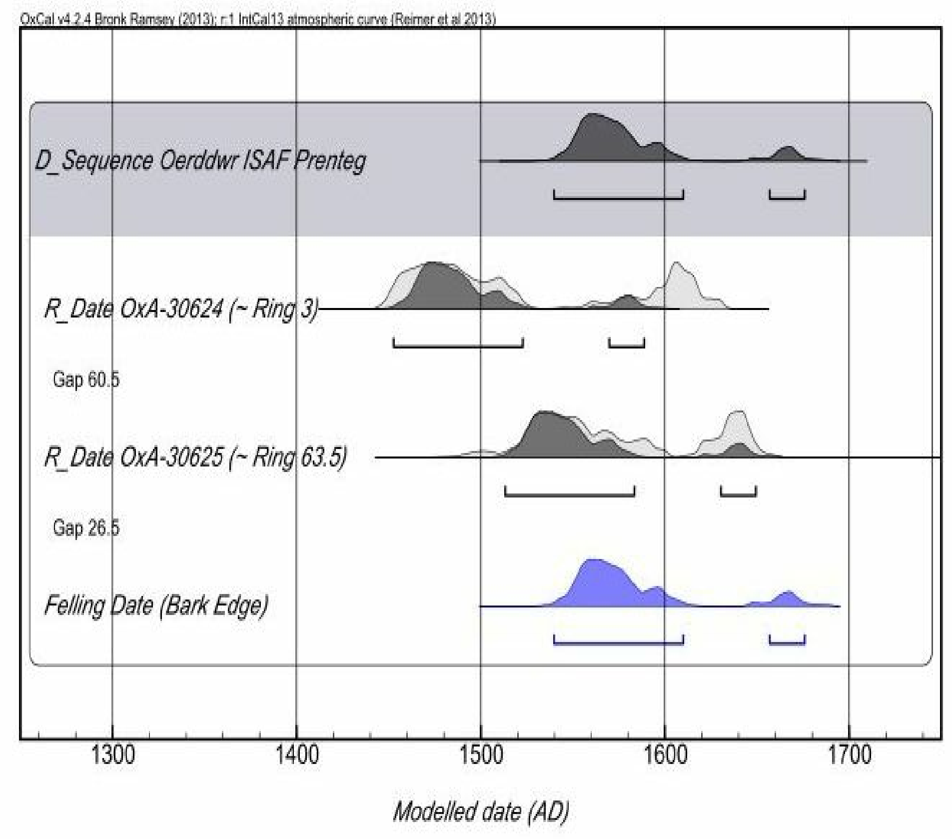
OxA	Sample	Material (species)	δ^{13}C	Date
Oerddwr ISAF Prenteg, Portmado, UK				
OxA-30624	BDGV 7c1	wood (oak)	-24.47	377 ± 25
OxA-30625	BDGV 7c2	wood (oak)	-23.59	296 ± 25
Tudor Rose, Beaumaris, Anglese, UK				
OxA-30626	ANGD 1a	wood (oak)	0.00	673 ± 25
OxA-30627	ABGD 1b	wood (oak)	-24.35	424 ± 25
OxA-30628	ABGD 1b	wood (oak)	-23.73	400 ± 25
Ty Mawr, Wybrnant, Gwynedd, UK				
OxA-30622	WYB 2a	wood (oak)	-23.81	372 ± 26
OxA-30623	WYB 2b	wood (oak)	-24.78	437 ± 24

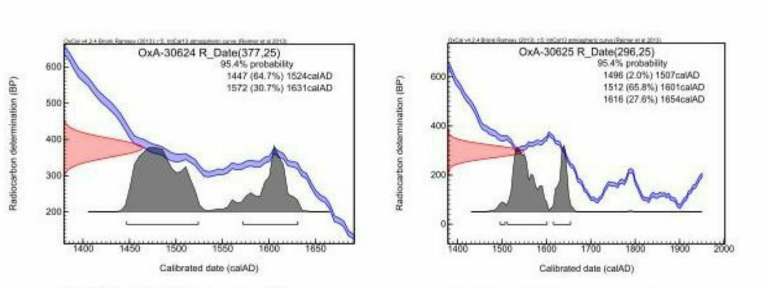
The dates are uncalibrated in radiocarbon years BP (Before Present - AD 1950) using the half life of 5568 years. Isotopic fractionation has been corrected for using the measured δ^{13}C values measured on the AMS. The quoted δ^{13}C values are measured independently on a stable isotope mass spectrometer (to ±0.3 per mil relative to VPDB). For details of the chemical pretreatment, target preparation and AMS measurement see *Radiocarbon* **46** (1) 17-24, **46** (1): 155-63, and *Archaeometry* **44** (3 Supplement 1): 1-149. The attached calibration plots, showing the calendar age ranges, have been generated using the Oxcal computer program (v4.2) of C. Bronk Ramsey, using the 'IntCal13' dataset (*Radiocarbon* **55** (4), 2013).

As you may know we publish all dates measured at Oxford in a datelist which appears in the journal *Archaeometry*. When you have had the chance to consider the implications of the results I wonder if you would be kind enough to send your brief comments to me.

Yours sincerely

Hayley Sula





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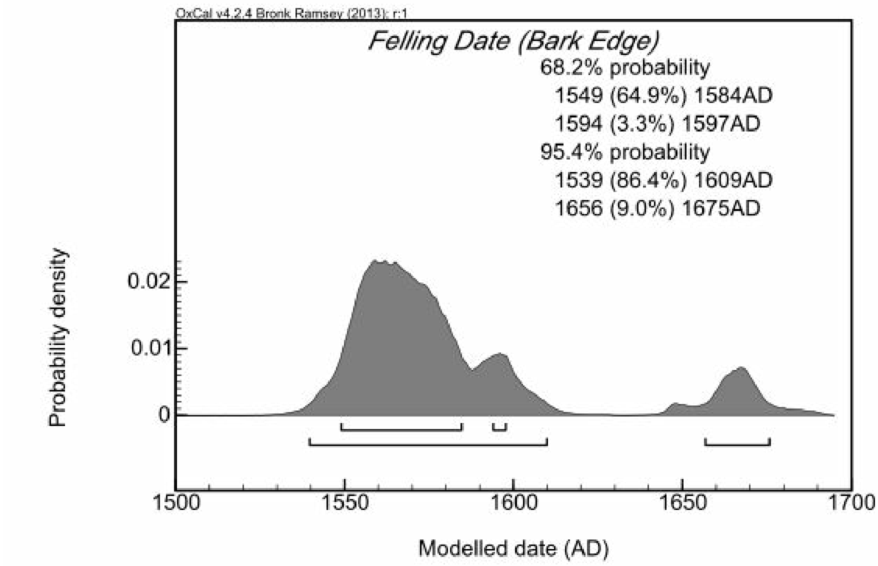
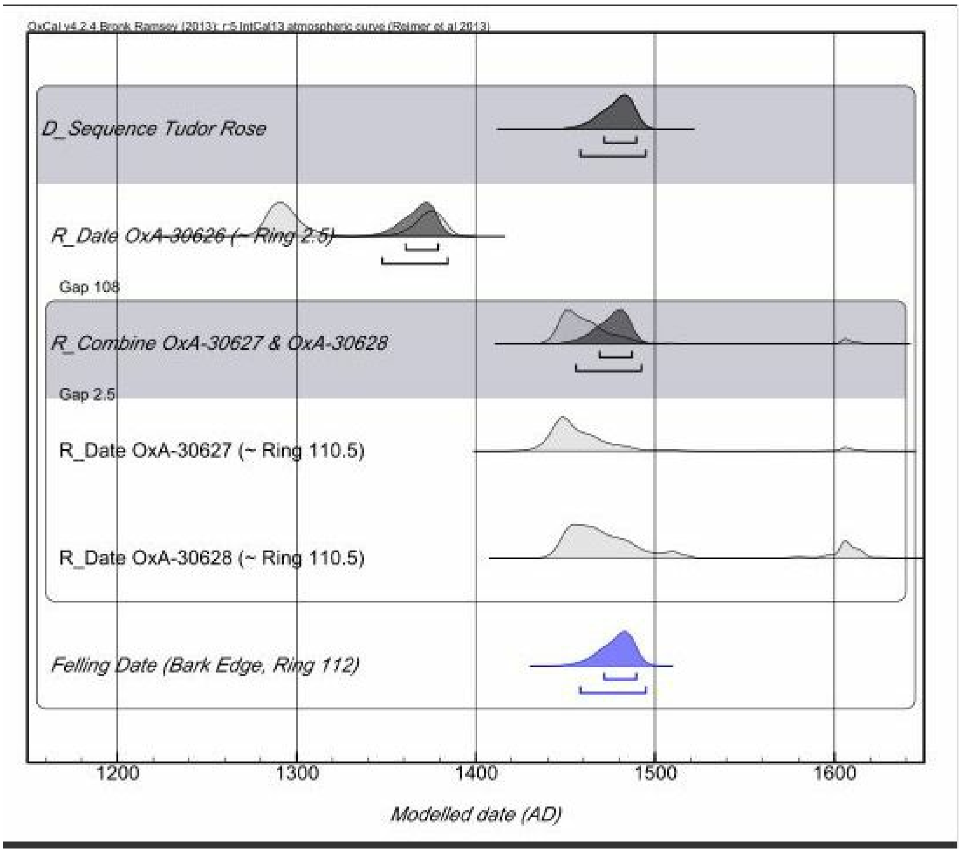
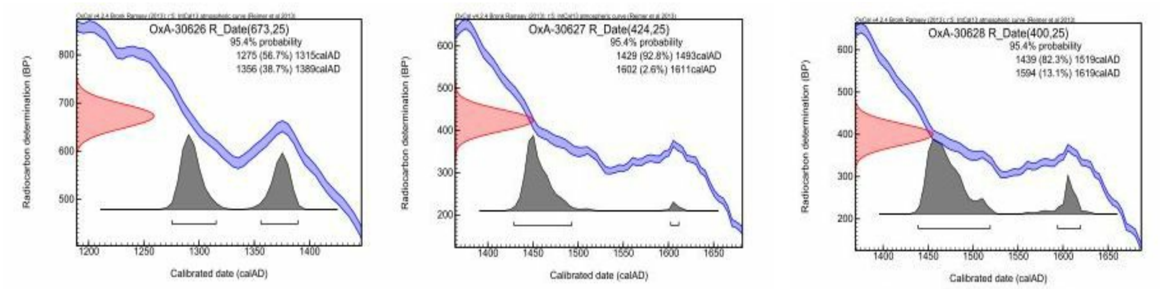
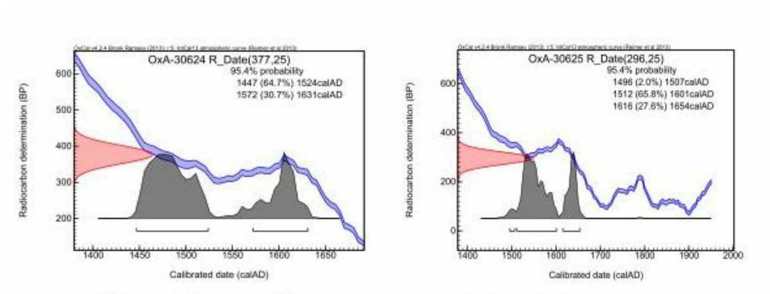






Tudor rose



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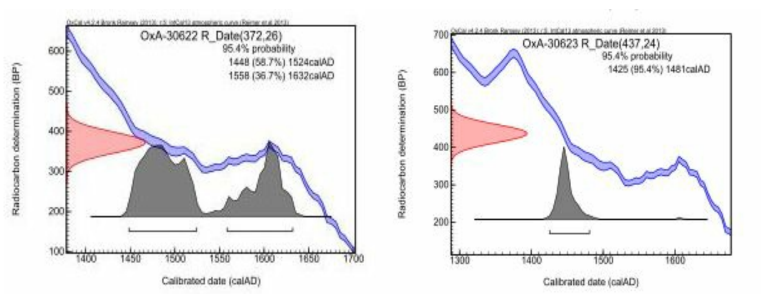

Ty Mawr ,Wybrant

BACKGROUND TO DENDROCHRONOLOGY

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

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

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

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

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

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

Growth characteristics vary over space and time, trees in south-eastern England generally growing comparatively quickly and with less year-to-year variation than in many other regions (Bridge, 1988). This means that even comparatively large timbers in this region often exhibit few annual rings and are less useful for dating by this technique.

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

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