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Woodhenge, Durrington, Wiltshire

Radiocarbon Dating and Chronological Modelling

Peter Marshall, Amanda Chadburn, Irka Hajdas, Michael Dee and Joshua Pollard

Scientific Dating

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Summary

Radiocarbon dating and chronological modelling of samples from Woodhenge was undertaken in support of research undertaken by Dr Amanda Chadburn for a Historic England book, *Stonehenge: Sighting the Sun* (Ruggles and Chadburn 2024*).* The results suggest that the timber monument was constructed in *2635–2575 cal BC* (*95% probability*), probably in *2635–2610 cal BC* (*54% probability)* or *2595–2580 cal BC* (*14% probability)* and enclosed by the ditch and bank in *2555–2505 cal BC* (*2% probability*) or *2495–2180 cal BC* (*93% probability*), probably in *2465–2345* cal BC (*68% probability)*.

Contributors

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Acknowledgements

We would like to thank David Dawson and Lisa Brown (Wiltshire Museum) for access to the Woodhenge archive and permission from them and the museum trustees to undertake destructive analysis on the antler and charcoal samples. They both also provided helpful advice and encouragement throughout the gestation of this project. Mike Pitts answered queries relating to his attempts to locate material from Maud Cunnington's excavations.

Archive Location

Wiltshire Museum, 41 Long Street, Devizes, SN10 1NS

Historic Environment Record

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

Front Cover

Reconstruction illustration showing Woodhenge to the north-east of Stonehenge, as it may have appeared in about 2600 cal BC, looking south-west towards the 'entrance', the upright timbers may have been quite simple, or elaborately carved and decorated (by Peter Lorimer ©Historic England Archive).

Date of Research

2019–2024

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Introduction

This document is a technical archive report on the radiocarbon dating and chronological modelling of samples from Woodhenge, Durrington, Wiltshire (Fig. 1). The work was undertaken in support of research undertaken by Dr Amanda Chadburn for a Historic England book, *Stonehenge: Sighting the Sun* (Ruggles and Chadburn 2024), that provides both an introduction to Stonehenge and its landscape and an overview to archaeoastronomy–the study of how ancient peoples understood phenomena in the sky, and what role the sky played in their cultures. Elements of this report may be combined with additional research at some point in the future to form a comprehensive publication on the chronology of Woodhenge and its timescape within the Stonehenge landscape.

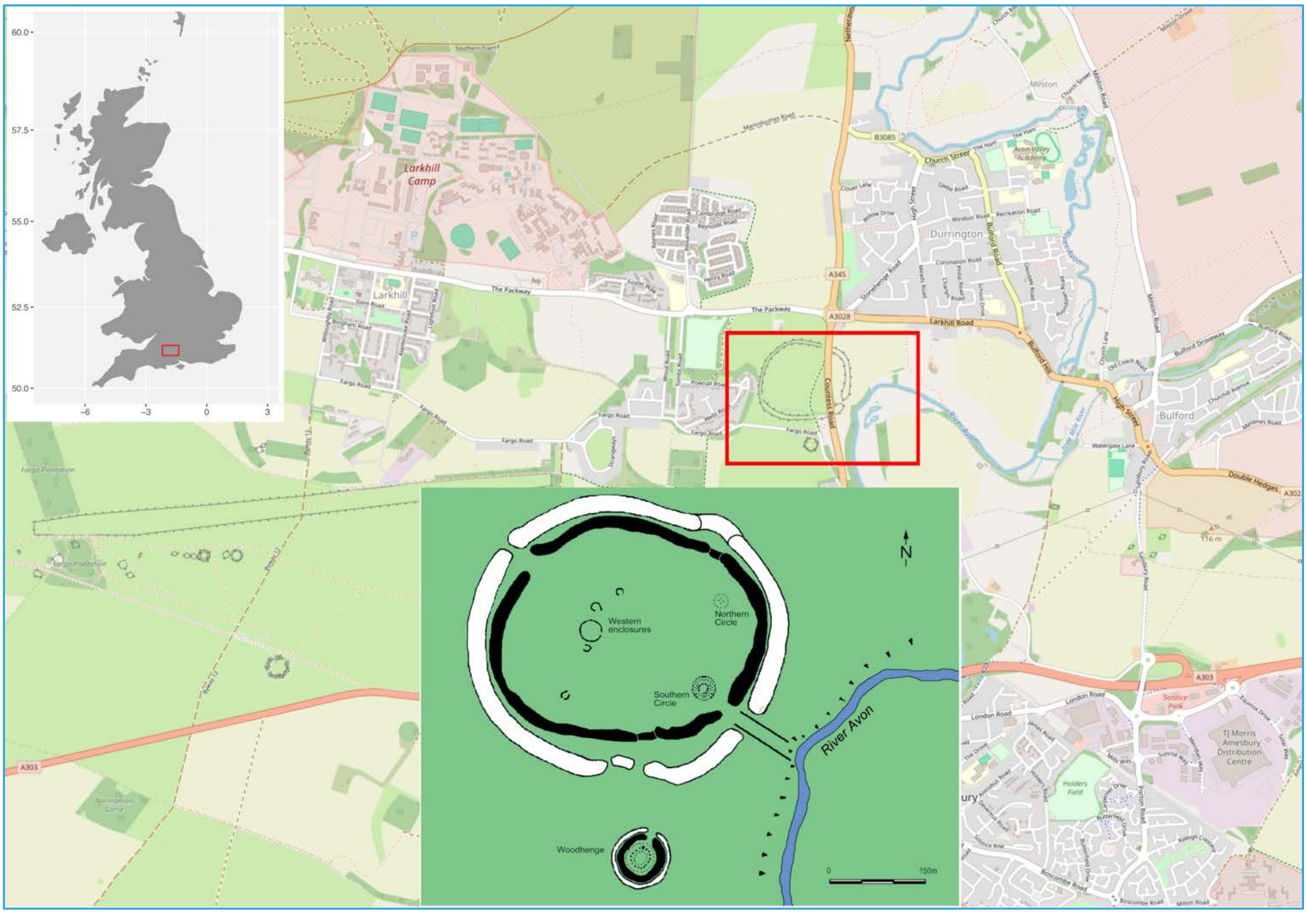

Figure 1: Location of Woodhenge and Durrington Walls. The ditches of the monuments on the bottom inset are shaded black and the banks white (© Irene de Luis)

Woodhenge

Woodhenge holds a significant place in the history of archaeological research, as it was one of the first monuments to be identified from the air, specifically its timber component, during a flight by Squadron-Leader Insall in December 1925 (Cunnington 1927, 92). It later became the first multi-timber circle from the late Neolithic period to be excavated, with Maud Cunnington leading the excavation over two seasons in 1926 and 1927 (Cunnington 1929). These excavations were groundbreaking in their exploration of prehistoric timber architecture, involving trenching across the entire interior to uncover the plan of the timber rings, as well as cutting sections through the bank and ditch on all four sides (north, east, south, and west). The resulting plan revealed six concentric oval rings of post-holes (labelled A–F from outer to inner; Fig. 2), enclosed by an oval earthwork about 85m in diameter, with a break for a north-eastern entrance. A total of 168 postholes were identified during the excavations, with the majority ranging from 0.6–1.2m (2–4 feet) in diameter and up to 1.5m (5 feet) in depth (Cunnington 1929). In the southern part of the monument, two potential stone-holes were identified between posts B8 and B9, and C5 and C6. Cunnington *(ibid)* noticed that the axis of symmetry of the oval rings was the same as that of Stonehenge – in other words, Woodhenge also appeared aligned on the summer solstice sunrise and winter solstice sunset axis.

In 1970, additional small-scale excavations were carried out John Evans and Geoff Wainwright. The work involved cutting a 27m long trench through the ditch and bank on the southeastern side (Evans and Wainwright 1979). The excavation provided a detailed environmental sequence based on molluscs found in the ditch fills and the buried soil beneath the bank. Radiocarbon dating of antler and animal bone from the base and primary fills of the ditch placed the construction of the earthwork between the third and fourth quarters of the 3rd millennium cal BC, with dates of 2470–2040 cal BC (BM-677) and 2390–2000 cal BC (BM-678). Woodhenge was thereafter described as dating to “around 2300 BC” (Richards 2007, 41), therefore a little later than the stone settings of Stonehenge.

Woodhenge plays a key role in unravelling the mysteries of the Stonehenge landscape. Its comparable layout and alignment to Stonehenge imply that these monuments were components of a broader, interconnected sacred landscape, deeply meaningful to the Neolithic people of the area. It was thought that they dated to the same approximate period, although Woodhenge did not have a modern scientific dating programme, and it was therefore difficult to compare the chronologies of the two monuments reliably.

Subsequent re-assessments of the monument (Pollard 1995, Pitts 2000, Gibson 2005) highlighted several other important questions that needed to be addressed and verified:

1. Based on Grooved Ware ceramics found underneath the bank and comparisons with revised sequences at other henge-enclosed timber circles, Gibson (2005, 46 and 66) postulated that the earthwork was constructed later than the timber circles.

2. The stepped profiles of several post-holes indicate that individual posts within rings A, B, D, E, and F may have been replaced on one or more occasions, as demonstrated at the Sanctuary near Avebury (Pitts 2001). This process of post replacement could have been associated with rituals of renewal, remembrance, and commemoration, symbolised by the cycle of erecting, decaying, and replacing the posts.

3. Around the middle of the third millennium cal BC, monuments with precise astronomical alignments were constructed in and around the Stonehenge World Heritage Site, and then this type of construction appears to have stopped. Chadburn (2010) and Chadburn and Ruggles (2017), suggested (based on Cunnington's plan which showed the henge entrance was on a different axis to the timber monument) that Woodhenge may not be wholly "astronomical" but only the timber monument, or indeed perhaps only parts of that (for example timber rings C, D, E and F) followed the astronomical alignment. Was the "astronomical monument" a different date to the henge earthworks? Were the timber rings themselves of different dates? (Cunnington had noticed that rings A and B appeared to have an entrance which was similar to the henge entrance).

To address these specific questions relating to the chronology of the various components of the monument and wider temporal issues relating to its contemporary timescape (Leivers and Powell 2016) a programme of radiocarbon dating and chronological modelling was instigated in 2019 following an assessment of the Woodhenge archive held at Devizes Museum.

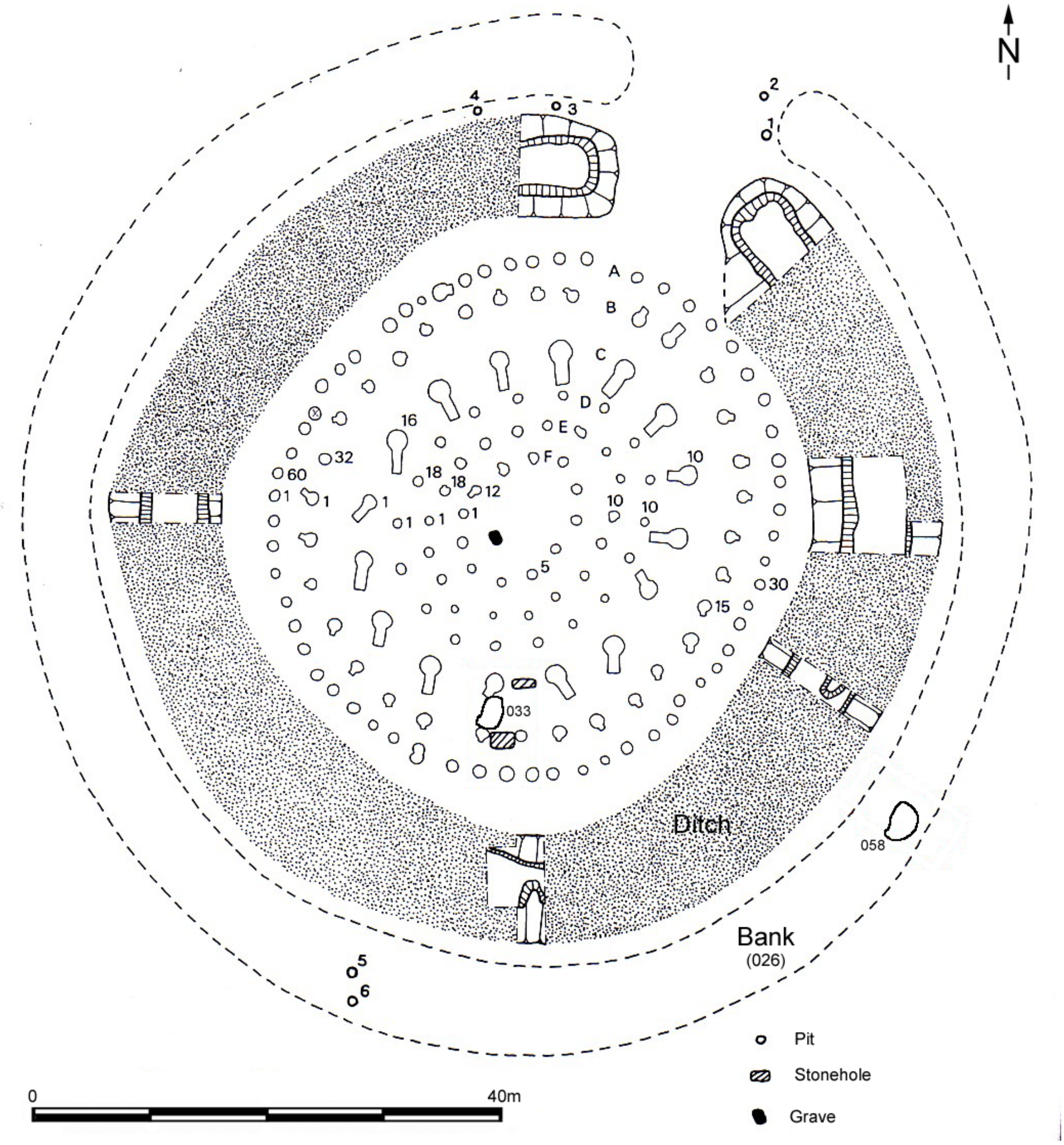

Figure 2: Plan of Woodhenge (© Josh Pollard)

Radiocarbon Dating and Chronological Modelling

The new radiocarbon dating programme for Woodhenge was conceived within the framework of Bayesian chronological modelling (Buck et al. 1996). This allows the combination of calibrated radiocarbon dates with archaeological prior information using a formal statistical methodology. The objective of the programme was to provide a robust chronology for the construction of the timber circle, henge ditch, and bank. Two radiocarbon determinations had been obtained from the British Museum radiocarbon laboratory in 1971 on antler and bone recovered from primary ditch during the small-scale excavations undertaken in 1970 (Burleigh et al. 1972; Evans and Wainwright 1979). A measurement on animal bone, undertaken by the Scottish Universities Environmental Research Centre (SUERC) in 2010 (Parker Pearson et al. 2020, 141), and one on calcined human bone, obtained from the Oxford Radiocarbon Accelerator Unit (ORAU) in 2008, were made on samples excavated as part of the 2006 Stonehenge Riverside Project (SRP)(Pollard and Robinson 2007, 160).

Sample selection was undertaken using the iterative process for implementing Bayesian chronological modelling on archaeological sites as outlined in Bayliss and Marshall (2022). At Woodhenge, we targeted for dating antler tools discarded at or near the base of negative features thought to be functionally related to the digging of them. This inference is more secure when use-wear such as battering on the posterior side of the beam/burr/coronet is identifiable (Bayliss and Marshall 2022, §3.2.2). Short-lived charcoal identified by Dana Challinor was dated, with selected material chosen based on the context description (i.e. oak sapwood in postholes was interpreted as deriving from the outside of burnt structural posts, given the evidence for fragments of charcoal adhering to the packing surrounding the postpipe, which suggested that the timber butts were in some cases charred to facilitate preservation or shaping (Cunnington 1929, 23)).

Radiocarbon Dating

A total of twenty-two radiocarbon measurements are now available relating to activity at Woodhenge, from samples of antler (n=8), animal bone (n=2), calcined human bone (n=1), and charcoal (n=11). Details of the dated samples, radiocarbon ages, and associated stable isotopic measurements are provided in Table 1. The radiocarbon results are conventional radiocarbon ages, corrected for fractionation (Stuiver and Polach 1977).

Age calculations have been undertaken using $\delta^{13}C$ values measured by Accelerator Mass Spectrometry (AMS), except at SUERC where the values obtained by Isotope Ratio Mass

Spectrometry (IRMS) were used. The δ^{13}C values measured by IRMS more accurately reflect the natural isotopic composition of the sampled material.

The two samples dated at the British Museum radiocarbon dating laboratory were measured by liquid scintillation counting of benzene as described in Barker et al. (1969a; 1969b). At SUERC in 2010 the gelatin fraction of a single bone sample was extracted using a modified version of the method introduced by Longin (1971) as described by Cook et al. (2012). It was then converted to carbon dioxide in pre-cleaned sealed quartz tubes (Vandeputte et al. 1996), graphitised as described by Slota et al. (1987), and measured by AMS using the SUERC SSAMS (Freeman et al. 2010). At ORAU in 2008 the calcined bone was pretreated as described by Lanting et al. (2001) and converted to carbon dioxide the by devolving the carbonate under vacuum using phosphoric acid (Brock et al. 2010, 108). This was then graphitised (Dee and Bronk Ramsey 2000). Dating was undertaken using the HVEE AMS (Bronk Ramsey et al. 2004).

Eight samples were dated at the Laboratory of Ion Beam Physics, ETH Zürich, Switzerland in 2020. The five antler samples were gelatinised and ultrafiltered as described by Hajdas et al. (2007; 2009) and the three charcoal samples were pretreated using the acid-base-acid protocol described by Hajdas (2008). They were then combusted in an elemental analyser and graphitised using the fully automated system described by Wacker et al. (2010a). Graphite targets were dated using a 200kV, MICADAS Accelerator Mass Spectrometer as described by Wacker et al. (2010b). Stable isotopic ratios were obtained on sub-samples of the pretreated material using a ThermoFischer Flash-EA 1112 elemental analyzer coupled through a Conflo IV interface to a ThermoFisher Delta V Isotope Ratio Mass Spectrometer.

Four antler samples and five fragments of charcoal were dated at the Centre for Isotope Research, University of Groningen in 2020. The samples were pretreated as described by Dee et al. (2020). They were then combusted in an elemental analyser (IsotopeCube NCS), coupled to an Isotope Ratio Mass Spectrometer (Isoprime 100) for measurement of %C, %N, C/N, δ^{13}C and δ^{15}N. The resultant CO_2 was graphitised by hydrogen reduction in the presence of an iron catalyst. The graphite was then pressed into aluminium cathodes and dated by AMS (Synal et al. 2007; Salehpour et al. 2016). Data reduction at ETH Zürich and the University of Groningen was undertaken as described by Wacker et al. (2010c).

Both facilities maintain continual programmes of quality assurance procedures, in addition to participation in international inter-comparison exercises (Scott et al. 2017). Details of

Table 1: Woodhenge radiocarbon and stable isotope results. Replicate measurements have been tested for statistical consistency and combined by taking a weighted mean before calibration as described by Ward and Wilson (1978; T'(5%)=3.8, v=1).

Laboratory Number	**Sample number, material and context**	**Radiocarbon Age (BP)**	**$\delta^{13}C_{IRMS}$ (‰)**	**$\delta^{13}C_{AMS}$ (‰)**	**$\delta^{15}N_{IRMS}$ (‰)**	**C:N**
Ditch						
BM-677	Antler, collagen separated from red deer antler from ditch floor (layer 8), one of a pile of ten antler picks resting on the rock cut floor of the ditch (Burleigh et al. 1976, 25–6; Evans and Wainwright 1979, 73; pl. XXXVb)	3817±74	-	-	-	-
BM-678	Animal bone collagen separated from domestic animal bone, (a small collection of animal bone from primary rubble silting of ditch, (Burleigh et al. 1976, 25–6; Evans and Wainwright 1979, 73)	3755±54	-	-	-	-
GrM-21325	1975.99.2.A. Antler, red deer, from ditch floor (layer 8), one of a pile of ten antler picks resting on the rock cut floor of the ditch (Evans and Wainwright 1979, 73; pl. XXXVb)	4048±28	−22.4±0.15	-	6.1±0.3	3.2
ETH-103635	1975.99.1.A. Antler, red deer, from ditch floor (layer 8), one of a pile of ten antler picks resting on the rock cut floor of the ditch (Evans and Wainwright 1979, 73; pl. XXXVb)	3932±23	−23.3±0.1	-	6.2±0.1	3.8
GrM-21326	1975.99.1.B. Antler, red deer, from ditch floor (layer 8), one of a pile of ten antler picks resting on the rock cut floor of the ditch (Evans and Wainwright 1979, 73; pl. XXXVb)	4092±30	−23.6±0.15	-	4.0±0.3	3.2
ETH-103636	1975.99.1.C. Antler, red deer, from ditch floor (layer 8), one of a pile of ten antler picks resting on the rock cut floor of the ditch (Evans and Wainwright 1979, 73; pl. XXXVb)	3961±23	−22.9±0.1	-	7.2±0.1	3.6
GrM-21327	1975.99.1.D. Antler, red deer, from ditch floor (layer 8), one of a pile of ten antler picks resting on the rock cut floor of the ditch (Evans and Wainwright 1979, 73; pl. XXXVb)	4040±29	−22.8±0.15	-	3.9±0.3	3.2

Laboratory Number	Sample number, material and context	Radiocarbon Age (BP)	$\delta^{13}C_{IRMS}$ (‰)	$\delta^{13}C_{AMS}$ (‰)	$\delta^{15}N_{IRMS}$ (‰)	C:N
Below bank						
SUERC-32161	053 1037. Animal bone, *Bos* from the upper fill [053] of a large oval tree-throw pit [058] under eastern tail of henge bank in Trench 16	3980±30	−23.1±0.2	-	5.3±0.3	3.3
Ring C						
ETH-104544	C6.1. Charcoal, *Quercus* cf. sapwood (D Challinor) from posthole C6 (Cunnington 1929, 36; plate 10.2)	4123±24	-	−25.3	-	-
GrM-21412	C6.2. Charcoal, *Quercus* cf. sapwood (D Challinor) from posthole C6 (Cunnington 1929, 36; plate 10.2)	4105±26	−26.8±0.15	-	-	-
ETH-104545	C10.1. Charcoal, *Quercus* cf. sapwood (D Challinor) from posthole C10	4101±24	-	−24.8	-	-
GrM-21413	C10.2. Charcoal, *Quercus* cf. sapwood (D Challinor) from posthole C10	4074±26	−24.4±0.15	-	-	-
OxA-19047	WOE C14. Human bone, calcined, mature adult femoral shaft (C Willis) from posthole C14; 1.52m deep, 1.3m diameter (Cunnington 1929, 36; plate 10.1)	3997±30	−19.0±0.2	-	-	-
ETH-104546	C15.1. Charcoal, *Quercus* cf. sapwood (D Challinor) from posthole C15	4128±24	-	−24.2	-	-
GrM-21414	C15.2. Charcoal, *Quercus* cf. sapwood (D Challinor) from posthole C15; 1.83m deep, 1.52m diameter	4116±27	−24.4±0.15	-	-	-
Ring B						
ETH-104542	B10. Charcoal, *Quercus* cf. sapwood (D Challinor) from posthole B10	4118±25	-	−27.9	-	-
ETH-104543	B11.1. Charcoal, *Quercus* cf. sapwood (D Challinor) from posthole B11; 1.37m deep, 1.07m diameter	4157±24	-	−24.8	-	-

Laboratory Number	Sample number, material and context	Radiocarbon Age (BP)	$\delta^{13}C_{IRMS}$ (‰)	$\delta^{13}C_{AMS}$ (‰)	$\delta^{15}N_{IRMS}$ (‰)	C:N
GrM-21411	B11.2. Replicate of ETH-104543	4095±30	−24.9±0.15	-	-	-
Weighted mean B11: ^{14}C: 4133±19 BP, T'=2.6						
Ring A						
ETH-104541	A10.1. Charcoal, *Quercus* cf. sapwood (D Challinor) from posthole A10	4084±24	-	−27.3	-	-
GrM-21409	A10.2. Charcoal, *Quercus* cf. sapwood (D Challinor) from posthole A10	4074±26	−24.7±0.15	-	--	
GrM-21315	2004.256.361.1. Antler, red deer from posthole A60	3973±27	−23.1±0.15	-	4.81±0.3	3.2
ETH-103634	2004.256.361.2. Replicate of GrM-21315	3850±23	−23.4±0.1	-	5.0±0.1	3.6
Weighted mean 2004.256.361: ^{14}C: not calculated, **T'=12.1**; δ^{13}C: 23.3±0.08‰, T'=2.8; δ^{15}N: 4.98±0.09‰, T'=0.4						

quality assurance data and error calculation at Groningen are provided by Aerts-Bijma et al. (2021), and similar details for ETH are provided in Sookdeo et al. (2020).

In the 1970s, the British laboratories then in operation (including the British Museum) participated in a formal inter-comparison study in which samples of benzene of known activities were distributed and dated (Otlet et al. 1980). This demonstrated excellent reproducibility in the counting and combustion stages of the dating process. The analysis of results on samples of waterlogged timbers that had been subsequently dated by dendrochronology, however, suggested that quoted error estimates were in many cases too low to account for the total error on the measurements, and that there was clear evidence of systematic laboratory bias in some facilities (Baillie 1990).

As well as participating in international inter-comparison exercises in the mid–late 2000s (Scott et al. 2007; 2010a; 2010b) ORAU and SUERC both maintained continual programmes of quality assurance procedures during the time when the reported measurements were made (see Bayliss et al. 2023, xvi).

Replicate radiocarbon measurements are available on two samples, of which one pair (ETH-104543/GrM-21411 on charcoal) are statistically consistent at the 5% significance level, but the other pair (GrM-21315/ETH-103634 on antler) are statistically significantly different at the 1% significance level. This reproducibility is not within statistical expectation, and so the accuracy of these measurements has been assessed during the modelling process by their compatibility with related radiocarbon dates. The pairs of $\delta^{13}C$ values and $\delta^{15}N$ values measured by Isotope Ratio Mass Spectrometry (IRMS) on this sample, however, are statistically consistent at the 5% significance level (Ward and Wilson 1978; Table 1).

Chronological Modelling

The chronological modelling presented here has been undertaken using OxCal 4.4 (Bronk Ramsey 2009), and the internationally agreed calibration curve for the northern hemisphere (IntCal20; Reimer et al. 2020). The model is defined by the OxCal CQL2 keywords and by the brackets on the left-hand side of Figure 3. In the figures, calibrated radiocarbon dates are shown in outline, and the posterior density estimates produced by the chronological modelling are shown in solid black. The other distributions correspond to aspects of the model. For example, the distribution *BuildHenge* (Fig. 3) is the posterior density estimate for the date when the henge ditch and bank where constructed. In the text and tables highest posterior density intervals, which describe the posterior distributions, are given in italics.

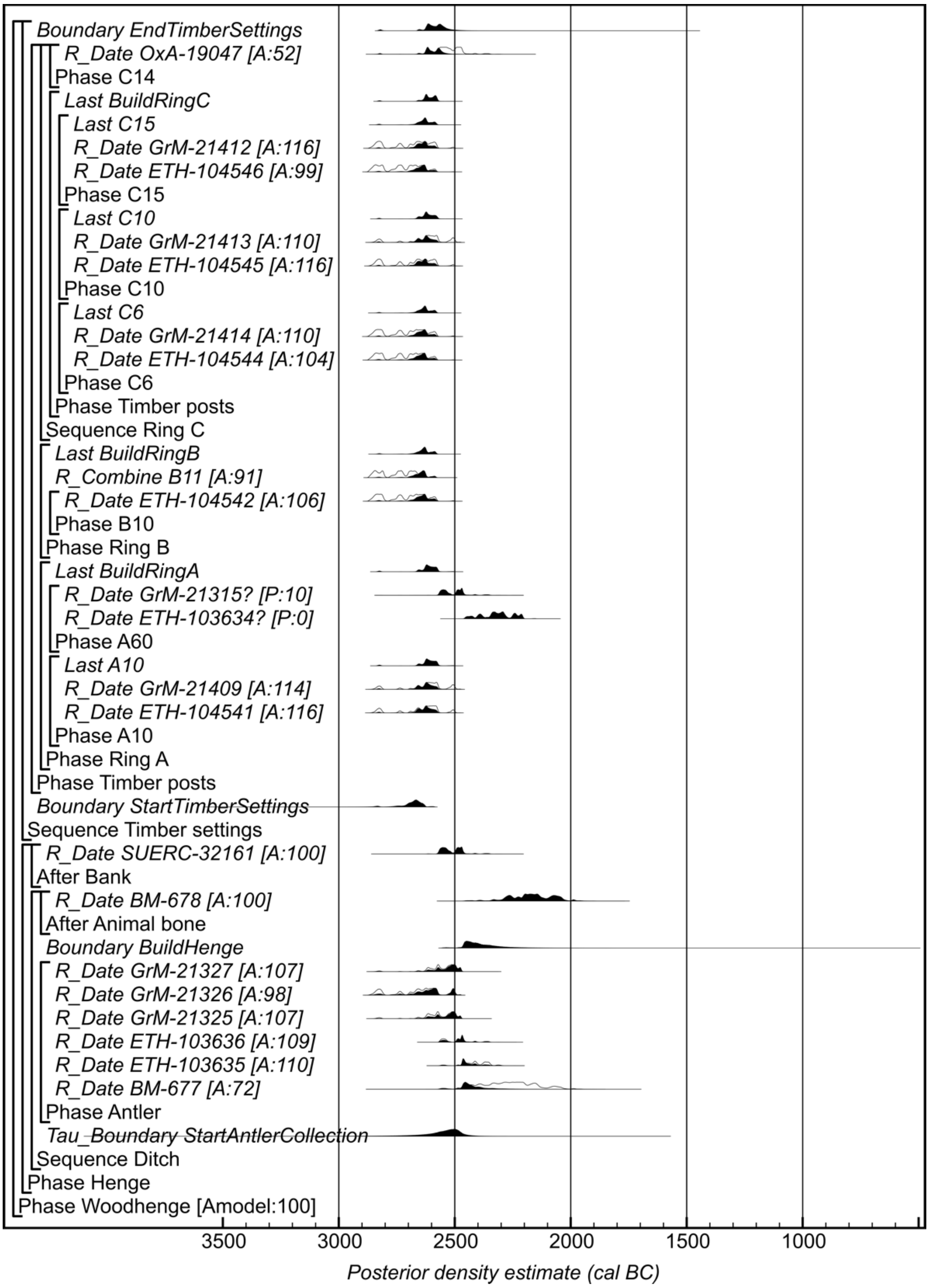

Figure 3: Probability distributions of dates from Woodhenge.
Each distribution represents the relative probability that an event occurs at a particular time. For each of the dates two distributions have been plotted: one in outline, which is the result of simple radiocarbon calibration, and a solid one, based on the chronological model used. Distributions other than those relating to particular samples correspond to aspects of the model. For example, the distribution '*BuildRingC*' is the estimated date when ring C of the timber settings was built. The large square brackets down the left-hand side along with the OxCal keywords define the overall model exactly.

The model for the chronology of Woodhenge is shown in Figure 3. It has good overall agreement (Amodel: 100). We consider the elements of this model working from the interior outwards. Samples from four of the 16 postholes of ring C were dated (C6, C10, C14, and C15; Table 1). The postholes of ring C are both the largest and regular in terms of size and spacing with ramps or sloping tracks cut to about half their depth for the erection of upright timbers (Cunnington 1929, 9). Duplicate samples of carbonised oak sapwood, interpreted as deriving from the outside of burnt structural posts, from postholes C6, C10, and C15 were dated. The duplicate measurements from all three postholes are statistically consistent at the 5% level (Table 2) and could be of the same actual age. Calculating the last dated event from each of these postholes (Fig. 3) allows us to estimate the felling date of the timber upright each of them contained, with the latest of these (*BuildRingC*; Fig. 3) providing the best estimate for the construction of the ring.

Table 2: Woodhenge: statistical consistency of radiocarbon ages (as described by Ward and Wilson (1978; T'(5%)=3.8, v=1) on samples of carbonised oak sapwood from the same posthole

Posthole	**Laboratory Code**	**Radiocarbon Age (BP)**	**Statistical consistency (Ward and Wilson 1978)**
A10	ETH-104541	4084±24	T'=0.1
	GrM-21409	4074±26	
C6	ETH-104544	4123±24	T'=0.0
	GrM-21412	4105±26	
C10	ETH-104545	4101±24	T'=0.6
	GrM-21413	4074±26	
C15	ETH-104546	4128±24	T'=0.4
	GrM-21414	4116±27	

Posthole C14 contained the only cremation from the site, 523g of calcined bone from a mature adult, that appears to have been placed at the foot of the upright timber while it was standing (Cunnington 1929, 88; plate 10.1). A single measurement on calcined bone from this cremation therefore provides a *terminus ante quem* for the construction of ring C.

The postholes of ring B are smaller than those of ring C but larger than those in ring A, they also have evidence for ramps although these are in some cases little more than lips (Cunnington 1929, 9; plate 11). Single fragments of carbonised oak sapwood were dated from postholes B10 and B11. Replicate measurements on the single fragment of charcoal from posthole B11 are statistically consistent at the 5% level (T'=2.6; T'(5%)=3.8, v=1; Ward and Wilson 1978) and a weighted mean (4133±19 BP; B11) has been calculated as providing the best estimate for its age before calibration and inclusion in the model. The radiocarbon determinations from both postholes of ring B are statistically consistent at the 5% level (T’=0.2; T’(5%)=3.8, v=1) and could be of the age, suggesting that its timbers could have all been felled at the same time.

The postholes of the outer ring A superficially appear the most irregular in size and alignment but the irregularity in size is probably due to cultivation erosion (Cunnington 1929, 9–10; plate 12). Radiocarbon measurements on two fragments of carbonised oak sapwood from posthole A10 are statistically consistent at the 5% level (T’=0.1; T’(5%)=3.8, v=1) and could be of the same age. But the two measurements on an antler fragment from A60 are statistically significantly different at the 1% significance level (T’=12.1; T’(1%)=6.6; v=1). Since these measurements are replicates on a single object, they cannot both be accurate. In the absence of independent information determining, which is correct, we have chosen to exclude both from the final model.

In June 1970 a single trench 2m x 27m was excavated across the external bank and ditch enclosing the timber structure. The ditch was between 4.4–5.1m wide with a buttress of unexcavated chalk 1.0m high that almost extend across the trench. In the outer bay formed by this buttress a pile of ten antler picks were found on the ditches rock floor (Evans and Wainwright 1979, 71; fig 42, plate XXXVIa–b). The tips of the tines of the antlers were smoothed from use, with one also having evidence of battering behind the burr suggesting that they had been used to excavate the ditch and discarded in a heap once it had been completed (Wainwright 1989, 175).

The six radiocarbon measurements on these antler tools (Table 1) are not statistically consistent at the 5% level (T’=31.8; T’(5%)=11.1, v=5) although given that antler collection and excavation of the ditch may have taken place of a period of time this is not unexpected. The model shown in Figure 3 includes all the dated antler as deriving from an exponential distribution rising to the greatest numbers being found from the end of the constructional activity (Bronk Ramsey 2009, fig 4). This is based on the suggestion that it is most likely that the antlers found in the base of the ditch come from the last stages of their digging, with a few older antlers being mixed in (Bronk Ramsey 2009, fig 5). BM-678 was produced from a small collection of animal bone from the primary fill of the ditch and given the unknown taphonomy of the material together with the fact that it could contain material of different ages it has been included in the chronological model as providing a *terminus post quem* for the secondary infilling.

Trench 16 excavated by the Stonehenge Riverside Project in 2006 inadvertently intersected, at a slightly oblique angle, the southern edge of the 1970 trench that had, in turn, cut into the edge of a 1926 trench along the same axis meaning only an area of buried soil 5.4m x 3.2m was left for investigation (Pollard and Robinson 2007, 164). The buried soil ran into the top of a large oval tree-throw, 3.5m x 2.5m and 0.5m deep, under the eastern tail of the bank (Pollard and Robinson 2007, fig 14.7) that contained large quantities of animal bone in its upper fill. A radiocarbon determination (SUERC-32161; Parker Pearson et al. 2020, 141) on a single, potential residual, cattle bone fragment from this context provides a *terminus post quem* for the raising of the bank.

The amount of sapwood in prehistoric oaks in England varies between 10–55 rings (Hillam et al. 1987) and thus the best estimate for the construction of rings C, B, and A is provided by the latest date on the sapwood from them. The model suggests ring C was constructed in *2665–2565 cal BC* (*95% probability*; *BuildRingC*; Fig. 3), probably in *2635–2575 cal BC* (*68% probability);* ring B in *2830–2820 cal BC* (*1% probability*; *BuildRingB*; Fig. 3) or *2690–2575 cal BC* (*94% probability*), probably in *2660–2615 cal BC* (*59% probability)* or *2600–2580 cal BC* (*9% probability),* and ring A in *2830–2820 cal BC* (*1% probability*; *BuildRingA*; Fig. 3) or *2665–2565 cal BC* (*94% probability*), probably in *2630–2575 cal BC* (*68% probability).*

The differences between the date estimates for the construction date of each ring are shown in Figure 4. Obviously, within the uncertainties on our date estimates, the intervals between their construction were negligible and therefore we must consider whether they could have been built in a single episode. Such a model also accords with Cunnington's analysis, although she considered that for practical reasons, ring C was constructed first (Cunnington 1929, 17).

By combining the posterior distributions for their dates, we can estimate that this unitary episode of construction would have occurred in *2635–2575 cal BC* (*95% probability*; *BuildWoodhenge*; Fig. 5), probably in *2635–2610 cal BC* (*54% probability)* or *2595–2580 cal BC* (*14% probability)*. The date estimates are in good agreement with this interpretation (Acomb= 127.3; An= 40.8, n: 3).

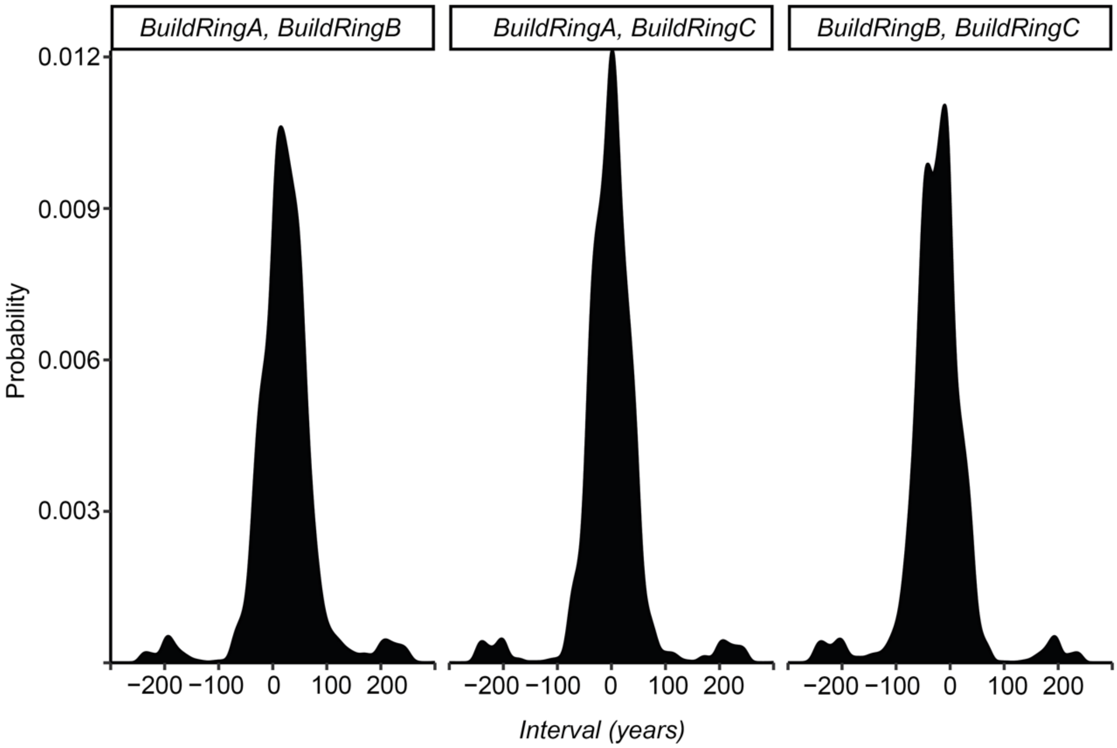

Figure 4: Probability distributions for the number of years between the construction of the timber rings A, B, and C at Woodhenge (derived from the model shown in Figure 3)

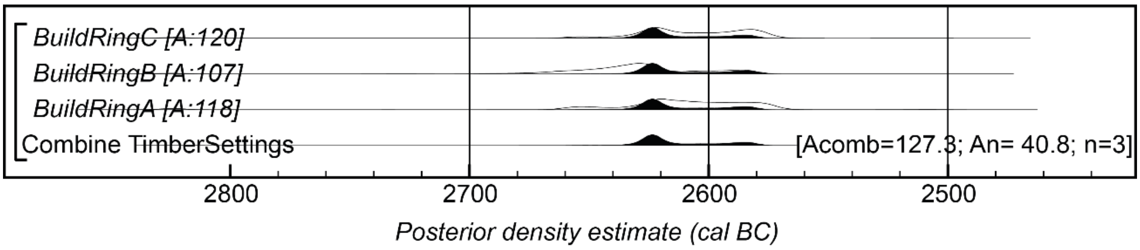

Figure 5: Probability distribution for the construction of the Woodhenge timber settings (rings A, B, and C), following the interpretation of a unitary construction

The model provides an estimate for the construction of the ditch and bank of the henge in *2555–2505 cal BC* (*2% probability*; *BuildHenge*; Fig. 3) or *2495–2180 cal BC* (*93% probability*), and probably in *2465–2345* (*68% probability).*

The timber setting was thus enclosed with a ditch and bank after a period of *75–440 years* (*95% probability;* Fig. 6i), and probably after a period of *145–280* years (*68% probability).* This is a much longer interlude than the ‘short interval’ previously postulated, leading to us rejecting the assertion that Woodhenge resulted from a ‘single phase of development’ (Pollard 1995, 142).

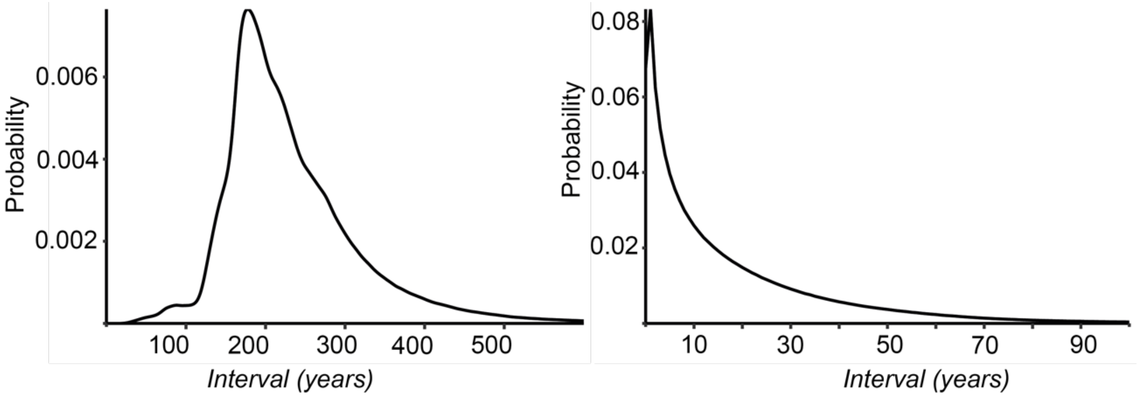

Figure 6: i) Probability distribution for the number of years between the construction of the Woodhenge timber settings and henge (bank and ditch) (derived from the models shown in Figs 3 and 5); (ii) probability distribution for the number of years between the construction of the Woodhenge timber settings and the cremation placed at the base of the timber in C14 (derived from the model shown in Fig, 3)

The recognition by Cunnington (1929, 22) that most of the postholes contained post-pipes implies that that the 'timbers were allowed to rot *in situ*' (Pollard 1995, 142). Based on calculations that oak rots at a rate of 15 years for every 50mm of post diameter (Wainwright 1989, 155), the posts of ring C (diameter 0.91m, Cunnington (1929, 13) estimated they were 3ft in diameter) could have stood for *c*. 270 years and those of rings A and B (diameter 0.3m, Cunnington (1929, 13) estimated they were 1ft in diameter) for *c*. 90 years. Along with the results of the chronological modelling, this means that when Woodhenge timber settings were enclosed by the ditch and bank only the timbers of ring C may have been visible with those of rings A and B probably long since disintegrated.

The remains of an adult cremation were place at the base of the timber in posthole C14 *1–65 years* (*95% probability*; Fig. 6ii) and probably *1–25 years* (*68% probability*) after ring C had been completed.

Discussion

Woodhenge is a key part of the late Neolithic complex at Durrington Walls and the Avon riverside. Although located outside the Durrington henge's boundary, the two sites may have been connected by a southern entrance through the Durrington earthwork. The size and architectural complexity of Woodhenge's timber circles (Fig. 2) closely resemble those of the Southern Circle inside Durrington Walls henge, and both share similarities with the phase 3 stone settings at Stonehenge (Darvill et al. 2012). This architectural continuity across different materials supports the idea that these monuments were components of a unified, contemporary ritual complex (Parker Pearson and Ramilisonina 1998, Parker Pearson et al. 2006).

We can now demonstrate the possible contemporaneity of the Stonehenge phase 3 stone settings and Woodhenge timber settings (Fig. 7), although the imprecise chronology for Stonehenge (Marshall et al. 2012) obviously limits our ability to determine this within any certainty.

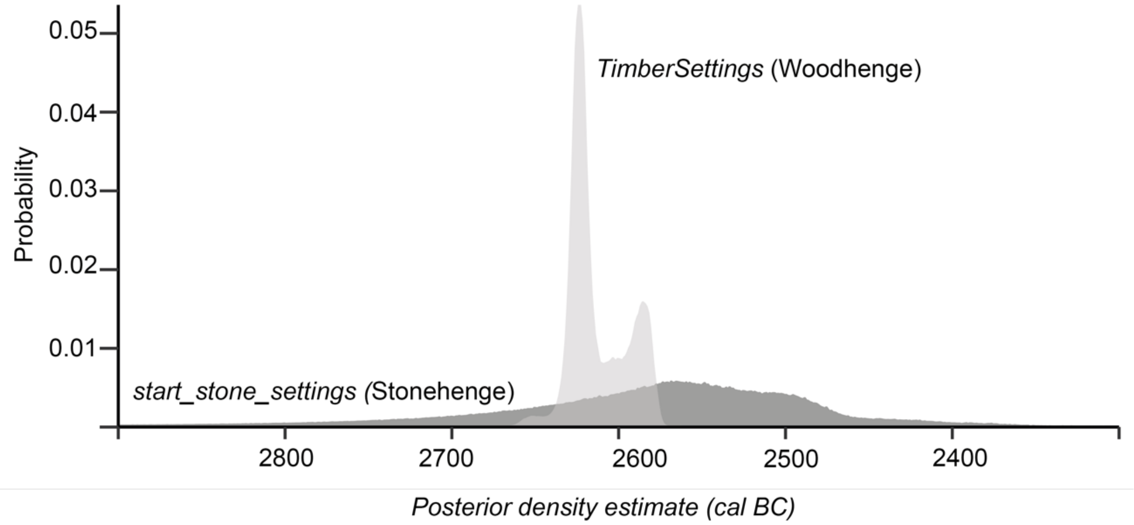

Figure 7: Probability distributions for the construction of the stone settings at Stonehenge (Marshall et al. 2012, fig 22; recalculated using IntCal20 (Reimer et al. 2020)) and the timber settings at Woodhenge (derived from the model shown Fig. 3)

The timber monument was 'wrapped' (Richards 2013) when the enclosing bank and ditch were constructed after a interval of *75–440 years* (*95% probability*) and probably *145–280* years (*68% probability)* following its building during which the posts of rings A and B had probably long since disintegrated, although the much thicker timbers of ring C may have still been visible.

In terms of the initial research questions, Gibson's suggestion (based on pottery typologies and comparisons with other sites) that the earthwork was constructed later than the timber circles is likely to be correct (Gibson 2005, 46; 66).

However, despite having similar plans, Woodhenge now appears to be rather different from the Sanctuary near Avebury, where timber posts were replaced on one or more occasions (Pitts 2001). There, the process of post replacement was suggested as being associated with rituals of renewal, remembrance, and commemoration, symbolised by the cycle of erecting, decaying, and replacing the posts. At Woodhenge, the timber rings appear to have been erected once only and to be solstitially aligned, suggesting a different function altogether.

Woodhenge now appears to be a multi-phase monument with at least two main phases – an "astronomical" monument comprising concentric oval timber rings, later enclosed by a bank and ditch. The functioning astronomical monument (Cunnington 1929, 9, note) appeared to be of relatively short duration, and presumably was no longer used when the timber rings decayed and the bank and ditch was erected (the latter might have prevented solstitial viewing too). This fits with the pattern where around the middle of the third millennium cal BC, monuments with precise astronomical alignments were constructed in and around the Stonehenge WHS, and then this type of construction appears to have stopped (Chadburn 2010; Chadburn and Ruggles 2017; Ruggles and Chadburn 2024).

The centuries around the middle of the third millennium cal BC represent the *floruit* of activity that produced the unique character of the Stonehenge and Avebury landscapes of the World Heritage Site (Lievers and Powell 2016). It was during these couple of hundred years that some of the greatest prehistoric monumental constructions in Europe took place—principally Avebury, Stonehenge, and Silbury Hill. The precise and detailed sequence for Woodhenge will, when woven with other site chronologies from across the World Heritage Sits, enable us to create a narrative rich in 'connections, agency and plot' (Whittle 2018, 13) to illuminate the remote past.

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