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Brunel Court, Preston, Lancashire Radiocarbon Dating and Chronological Modelling

Peter Marshall, Christopher Bronk Ramsey, Gordon Cook, and Ian Tyers

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BRUNEL COURT
PRESTON
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RADIOCARBON DATING AND CHRONOLOGICAL MODELLING

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SUMMARY
This report contains details of the radiocarbon determinations obtained on samples from Brunel Court. A chronological model incorporating radiocarbon and dendrochronoloical dates provides an outline chronological framework for the site.

CONTRIBUTORS
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INTRODUCTION

This document is a technical archive report on the radiocarbon dating and chronological modelling from excavations at Brunel Court, Preston, Lancashire (site code BCP07, NGR SD 5339 2954, Fig 1) undertaken in 2007. It is beyond the brief of this document to describe the archaeology of the site in detail – this can be found in Bradley and Rowland 2017. This report describes the results of the radiocarbon dating of samples from this site. Mathematical modelling of the scientific dates (radiocarbon and dendrochronological) has been combined with stratigraphic information to provide a chronological framework for the site

PERCENTAGE NITROGEN TESTING

Given the waterlogged conditions under which a number of the inhumations were preserved and the likelihood of post-depositional diagenetic loss of bone collagen a pre-screening programme was undertaken to determine whether samples suitable for radiocarbon dating survived.

Samples from 20 skeletons were submitted for percentage nitrogen (%N) measurements to the Oxford Radiocarbon Accelerator Unit (ORAU). The results (Table RC1) showed that only five of the samples had %N measurements >0.76% - the %N content of whole bone has been shown by Brock *et al* (2010a) to have a 84% likelihood of correctly predicting if a bone is suitable for dating if %N is greater than 0.76%. Given the small number of suitable samples it was decided to submit samples with %N values >0.5%N as further work (Brock *et al* 2012) suggests that such samples may yield sufficient collagen for dating, especially if samples sizes >1g are used.

RADIOCARBON LABORATORY METHODS

Eight samples were submitted to the Oxford Radiocarbon Accelerator Unit (ORAU); seven human bones and one waterlogged wood sample. The samples were pre-treated following methods outlined in Brock *et al* (2010b) and Bronk Ramsey *et al* (2004a). Two of the human bone samples both failed following pre-treatment as they produced no (Skel 203 (Grave 6)) and low collagen yields (Skel 124b (Grave 2) – sample A). Skeleton 203 (P31311) had a %N measurement of 1.79% and Skeleton 124b 0.53%N (Table 1). The remaining six samples were dated by Accelerator Mass Spectrometry (AMS) (Bronk Ramsey *et al* 2004b).

Five samples were submitted to the Scottish Universities Environmental Research Centre (SUERC); three human bone and two waterlogged wood samples. The human bone samples were pre-treated using a modified Longin method (Longin 1971) and the waterlogged wood as described by Stenhouse and Baxter (1983). Two of the human bone samples failed as they produced insufficient carbon following pre-treatment; a replicate sample from Skeleton 124b (Skel 124b (Grave 2) – sample B) and Skeleton 235 (Skel 235 (Grave 30) – sample B). The %N measurement for Skeleton 235 was 0.51%N and although the sample submitted to SUERC failed it did produce a date of ORAU (Table 2).

CO_2 obtained from the remaining three pre-treated samples was combusted in pre-cleaned sealed quartz tubes (Vandeputte *et al* 1996) and then converted to graphite (Slota *et al* 1987). The samples were dated by AMS as described by Freeman *et al* (2010).

Both laboratories maintain continual programmes of quality assurance procedures, in addition to participating in international inter-comparisons (Scott 2003; Scott *et al* 2010). These tests indicate no significant offsets and demonstrate the validity of the precision quoted.

RADIOCARBON RESULTS

The radiocarbon results are given in Table 2 and are quoted according to the international standard set at the Trondheim convention (Stuiver and Kra 1986). These are conventional radiocarbon ages (Stuiver and Polach 1977),

The radiocarbon result has been calibrated with data from Reimer et al (2009), using OxCal (v4.1) (Bronk Ramsey 1995; 1998; 2001; 2009). The date ranges given in Table RC2 have been calculated by the maximum intercept method (Stuiver and Reimer 1986), at two sigma confidence. The ranges are quoted in the form recommended by Mook (1986) and rounded outwards to 10 years or 5 years if the error is less than ±25. The probability distributions of the calibrated dates (Fig 2) were obtained by the probability method (Stuiver and Reimer 1993).

Stable isotope measurements

Carbon and nitrogen stable isotope analysis was undertaken on the human bone samples submitted to both laboratories as the potential for diet-induced radiocarbon offsets if the individual has taken up carbon from a reservoir not in equilibrium with the terrestrial biosphere (Lanting and van der Plicht 1998) might have implications for the determining the actual date of their death. If one of the reservoir sources has an inherent radiocarbon offset — for example, if the dated individual consumed marine fish or freshwater fish from a depleted source — then the bone will take on some proportion of radiocarbon that is not in equilibrium with the atmosphere. This makes the radiocarbon age older than they would be if the individual had consumed a diet consisting of purely terrestrial resources. Such ages, if erroneously calibrated using a purely terrestrial calibration curve will produce anomalously early radiocarbon dates (Bayliss *et al* 2004).

The human diet was mostly based on terrestrial foods produced in a C_3-ecosystem, as would be expected for England. However, the data do like those of many medieval sites in England indicate the incorporation of marine and freshwater foods into a predominantly terrestrial diet (Müldner and Richards 2007). The Brunel Court human isotopic data along with that from other religious establishment; Whithorn, Scotland (Müldner et al 2009), Fishergate, England (Müldner and Richards 2007), and Furness Abbey (Marshall and Beavan unpubl) suggests that these individuals consumed more marine and freshwater protein than the rest of the population (Fig 3).

Although the scale of the marine offset in the coastal waters around England is relatively well understood (Harkness 1983), we unfortunately have no information on freshwater radiocarbon offsets for fish in the north-west region. Thus although we could construct a calibration curve specific to each individual skeleton dated at Brunel Court which corrects for any marine dietary reservoirs in the dated collagen we are unable to model potential radiocarbon reservoir affects derived from the consumption of freshwater protein resources. Some freshwater aquatic sources do appear to be equilibrium with the atmosphere, but others have appreciable hard-water offsets (Keaveney and Reimer 2012). Given this we have simply calibrated the radiocarbon result with the terrestrial calibration curve (Reimer *et al* 2009); acknowledging that the calibrated age quoted provides a maximum age for the death of the individual and that the true age could be younger.

THE SAMPLES AND SEQUENCE

The two radiocarbon measurements (OxA-26233 and SUERC-39417) on samples from skeleton 198 (Grave 23) are statistically consistent (T'=0.9; v=1; T'(5%)=3.8; Ward and Wilson 1978) and a weighted mean (678±20 BP) was taken prior to calibration. Grave 23, which lay in the third row of graves, was cut by Grave 21 (OxA-26219) to the south and Grave 2 to the west. Samples from skeleton 124b (Grave 2) failed to date, but tree-ring dating provides a *terminus post quem* for the coffin of AD 1345 (Tyers 2011).

Skeleton 196 (OxA-26219) in Grave 21, which lay in the third row of graves from the west was cut by Grave 17 (Skeleton 193; OxA-26220) and Grave 2 (see above).

Skeleton 158 (OxA-26224) in Grave 8, which lay in the first row of graves from the west (ie the first row of graves just inside the western wall of the building) cut the head-end of Grave 18, in the second row of graves, to the east. Tree-ring dating provides a *terminus post quem* for the coffin in Grave 18 of AD 1312 (Tyers 2011)

Skeleton 235 in Grave 30, lay in the north-east angle of the buttress and the north wall. Replicate measurements (OxA-26221 and OxA-26222) are statistically consistent (T'=2.4; v=1; T'(5%)=3.8) and a weighted mean, 653±18 BP, provides the best estimate for the death of the individual. The missing left leg suggests that the inhumation was cut by Grave 28 to the immediate north, which was subsequently cut by ditch 106, from which three holly stakes; 132 (SUERC-39921), 153 (OxA-26233), and 154 (SUERC-39922) were dated.

The sample from stake 153 was dated twice as a test of reproducibility, the first attempt failed due to excessively low surviving carbon after pre-treatment. The second sub-sample weighed 68mg before pre-treatment but only 1mg remained afterwards. This suggests that the sample might be highly contaminated, but other analytical parameters measured were acceptable. The measurement (OxA-26233; 840±29 BP) is though significantly older than the other two determinations (565±30 BP; SUERC-39921 and 635±30 BP; SUERC-39922) on stakes 132 and 134. Given the extremely low yield for the sample from stake 153 (OxA-26233) and concerns about contamination it has been excluded from the modelling outlined below.

In addition the model includes a *terminus post quem* for the coffin in Grave 9; of AD 1242, derived from tree-ring dating (Tyers 2011).

INTERPRETATION

The model (Fig 4) shows good agreement (Amodel: 82) between the radiocarbon and tree-ring dates and the stratigraphy and estimates, albeit from a very limited number of samples, that burial activity started in *cal AD 1265–1305* (*95% probability*; *start_brunel_court*; Fig 3) and probably in the last quarter of the thirteenth century (*cal AD 1275–1295; 68% probability*). The first dated burial, skeleton 198 in Grave 23 (76% probability that it is the earliest), was buried in the third row of graves from the west in the late thirteenth or earlier fourteenth centuries cal AD.

Skeleton 235, buried in the outlying Grave 30 dates to the early part of the use of the site as a cemetery, with the interment of this individual estimated to have taken place in *cal AD 1280–1320* (*81% probability*; *grave_30*; Fig 4) and probably *cal AD 1285–1310* (*68% probability*).

The best estimate for the date of the stakes driven into ditch 106, is *cal AD 1320–1425* (*95% probability*; Fig 3) or *cal AD 1355–1420* (*68% probability*). The actual date of the stakes falls on a pronounced wiggle in the calibration curve and the lack of a constraint means the estimated is much less precise than for some other events.

The latest dated burial, Skeleton 158 in Grave 8 is estimated to have taken place in *cal AD 1440–1495* (*95% probability*; *OxA-26224*; Fig 4) and probably *cal AD 1445–1470* (*68% probability*).

DISCUSSION

The radiocarbon dating programme undertaken at Brunel Court has highlighted the advantage of undertaking a pre-screening of human bones thought to have poor collagen preservation (Brock *et al* 2010a) and thus reducing the loss of important archaeological samples. Although the number of human bone samples identified as likely to contain sufficient collagen for radiocarbon and stable isotope analysis was low (only 20% of those sampled had %N greater than the 0.76%N cut off identified by Brock *et al* 2010a) dating of these had together with dendrochronological dating provided an outline chronology for the burials.

The small number of dated burials means that it is not possible to test the hypothesis that burial activity within Building 1 commenced at the eastern end, with subsequent interments being made successively westward (Fig 5).

The holly stakes inserted into ditch 106 clearly pre-date the Dissolution, the best estimate for their insertion being *cal AD 1355–1420* (*68% probability*). Thus if they do represent a scaffold built to facilitate the demolition of Building 1 then another reason for the impetus behind this needs to be found.

The relationships between stable isotopes and diet are complex and as yet incompletely understood (Hedges and Reynard 2007). Although once the proportions of different dietary sources in an individual have been estimated, it should be possible to construct a calibration curve specific to that individual which corrects for any dietary reservoirs in the dated collagen. However, at present the lack of a complete understanding of the potential reservoir effects from non-terrestrial sources in north-west England means this cannot be undertaken for the people buried at Brunel Court.

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TABLES

Table 1: Brunel Court = %N and C:N ratio results from the pilot study of the human remains. Samples in bold have %N greater than the 0.76% cut-off (Brock et al *2010a) and those in bold italics have >%N greater 0.5% (Brock* et al *2012)*

Name	^{15}N (Sam) Delta Air	%N	C/N ratio molar	%N>0.76%
SK196	**11.57**	**1.80**	**4.80**	**Yes**
SK198	**12.35**	**0.68**	**7.79**	**Yes**
SK186A	9.29	0.25	19.35	No
SK145	8.59	0.14	26.84	No
SK124A	7.87	0.18	19.44	No
SK175	9.70	0.21	20.27	No
SK260	6.44	0.13	21.26	No
SK124B	**12.31**	**0.53**	**9.99**	**No**
SK178	8.68	0.26	14.83	No
SK235	**9.99**	**0.51**	**8.64**	**No**
SK213	9.36	0.28	14.66	No
SK252	6.48	0.17	20.46	No
SK223	6.90	0.20	15.83	No
SK193	**10.82**	**1.19**	**5.29**	**Yes**
SK129	8.38	0.16	24.11	No
SK149	9.35	0.26	15.48	No
SK158	**10.87**	**1.59**	**4.89**	**Yes**
SK186B	7.83	0.23	16.66	No
SK269	8.83	0.15	21.83	No
SK203	**12.52**	**1.79**	**4.48**	**Yes**

Table 2: Brunel Court – radiocarbon and stable isotope results

Laboratory number	Sample reference	Material & context	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	C/N ratio	Radiocarbon Age (BP)	Calibrated Date – cal AD (2σ)	*Posterior Density Estimate – cal AD (95% probability)*
OxA-26219	Skel 196 (Grave 21)	Human bone, left femur, from an articulated leg, skeleton 196, Grave 6, lay in the third row of graves from the west.	−19.4±0.2	12.4±0.3	3.2	536±24	1325–1435	*cal AD 1320–1350*
OxA-26233	Skel 198 (Grave 23) – sample A	Human bone, left femur, from articulated skeleton 198 in Grave 23 which lay in the third row of graves from the west.	−19.2±0.2	13.1±0.3	3.3	662±26	-	-
SUERC-39417	Skel 198 (Grave 23) – sample B	As OxA-26233	−19.4±0.2	13.0±0.3	3.3	700±30	-	-
-	Skel 198	T'=0.9; v=1; T'(5%)=3.8	-	-	-	678±20	1275–1385	1280–1315
OxA-26220	Skel 193 (Grave 17)	Human bone, right femur, from an articulated skeleton, 193, Grave 6, lay in the third row of graves from the west.	−19.8±0.2	11.7±0.3	3.2	459±25	1410–1460	*1415–1460*
OxA-26221	Skel 235(Grave 30) – sample A	Human bone, right femur, from articulated skeleton, 235, in Grave 30, which lay in the north-east angle of the buttress and the north wall.	−19.2±0.2	12.0±0.3	3.2	679±25	-	-
OxA-26222	As OxA-26221	Replicate of OxA-26221	−19.3±0.2	11.7±0.3	3.2	625±25	-	-

Laboratory number	Sample reference	Material & context	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	C/N ratio	Radiocarbon Age (BP)	Calibrated Date – cal AD (2σ)	*Posterior Density Estimate – cal AD (95% probability)*
		(T'=2.4; v=1; T'(5%)=3.8)	-	-	-	653±18	1280–1390	*1280–1320 (81%) or 1355–1385 (14%)*
GU26805	Skel 235 (Grave 30) – sample B	Replicate of OxA-26221	-	-	-	Failed – insufficient carbon		
OxA-26224	Skel 158 (Grave 8)	Human bone, right femur, from skeleton 158 in Grave 8, which lay in the first row of graves from the west (ie inside the first row of graves just inside the western wall of the building)	−19.6±0.2	11.7±0.3	3.2	385±25	1440–1630	*1440–1495*
OxA-26233	BCP07 [153]	Waterlogged wood, *Illex*, outer rings, from a stake 153 driven into ditch 106 which clipped the edge of grave 30.	−22.8±0.2	-	-	840±28	1150–1270	-
SUERC-39921	BCP07 [132]	Waterlogged wood, *Illex*, outer rings, from a stake 132 driven into ditch 106 which clipped the edge of grave 30.	−27.9±0.2	-	-	565±30	1300–1430	*1305–1365 or 1380–1430*
SUERC-39922	BCP07 [154]	Waterlogged wood, *Illex*, from a stake 154 driven into ditch 106 which clipped the edge of grave 30.	−24.2±0.2	-	-	635±30	1280–1410	*1295–1405*

Laboratory number	Sample reference	Material & context	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	C/N ratio	Radiocarbon Age (BP)	Calibrated Date – cal AD (2σ)	*Posterior Density Estimate – cal AD (95% probability)*
P31311	Skel 203 (Grave 6)	Human bone, right femur, from fully articulated skeleton 203, Grave 6, which lay in the first row of graves from the west	-	-	-	Failed due to low yield		-
P31308	Skel 124b (Grave 2) – sample A	Human bone, right femur, from skeleton 124b in Grave 2, which lies in the second row of graves from the west.	-	-	-	Failed due to no yield		-
GU26806	Skel 124b (Grave 2) – sample B	Replicate of P31308	-	-	-	Failed – insufficient carbon		-

FIGURES

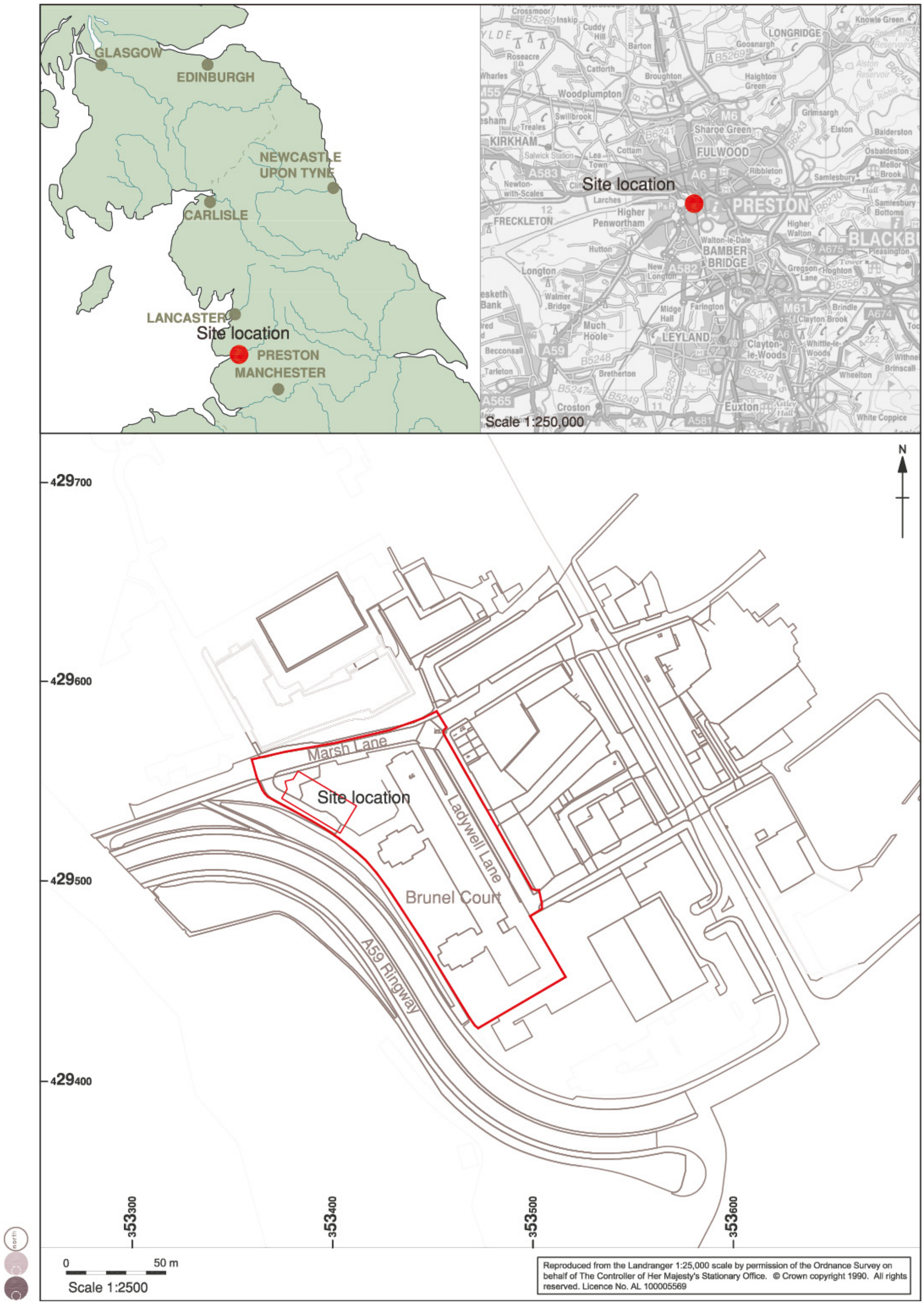

Figure 1: Brunel Court location plan

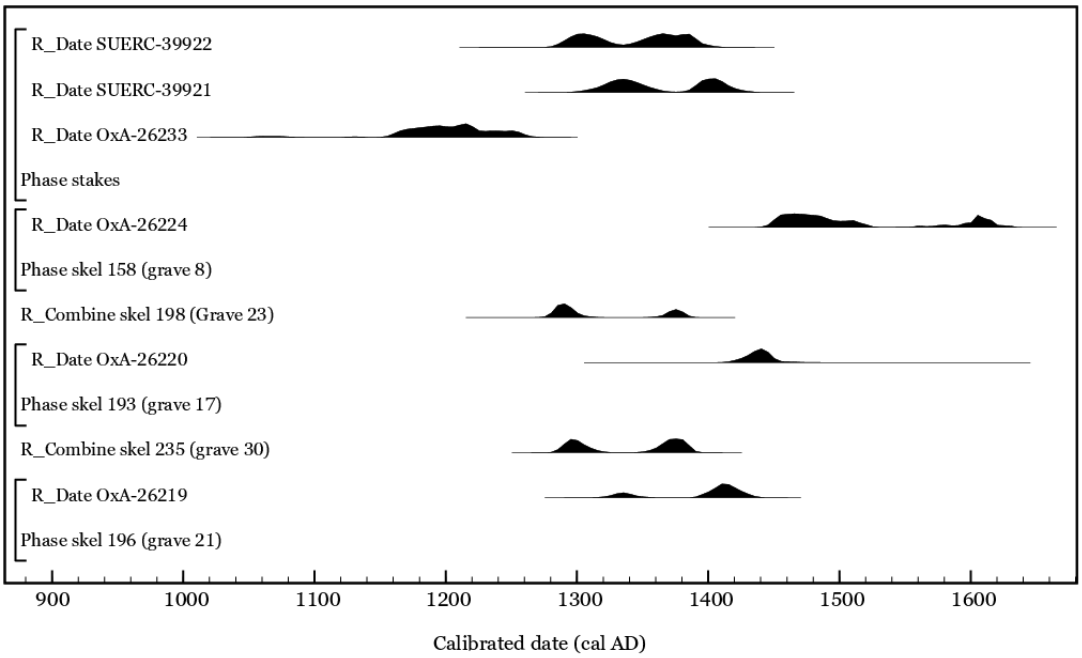

Figure 2: Probability distributions of dates from Brunel Court. The distributions are the result of simple radiocarbon calibration (Stuiver and Reimer 1993)

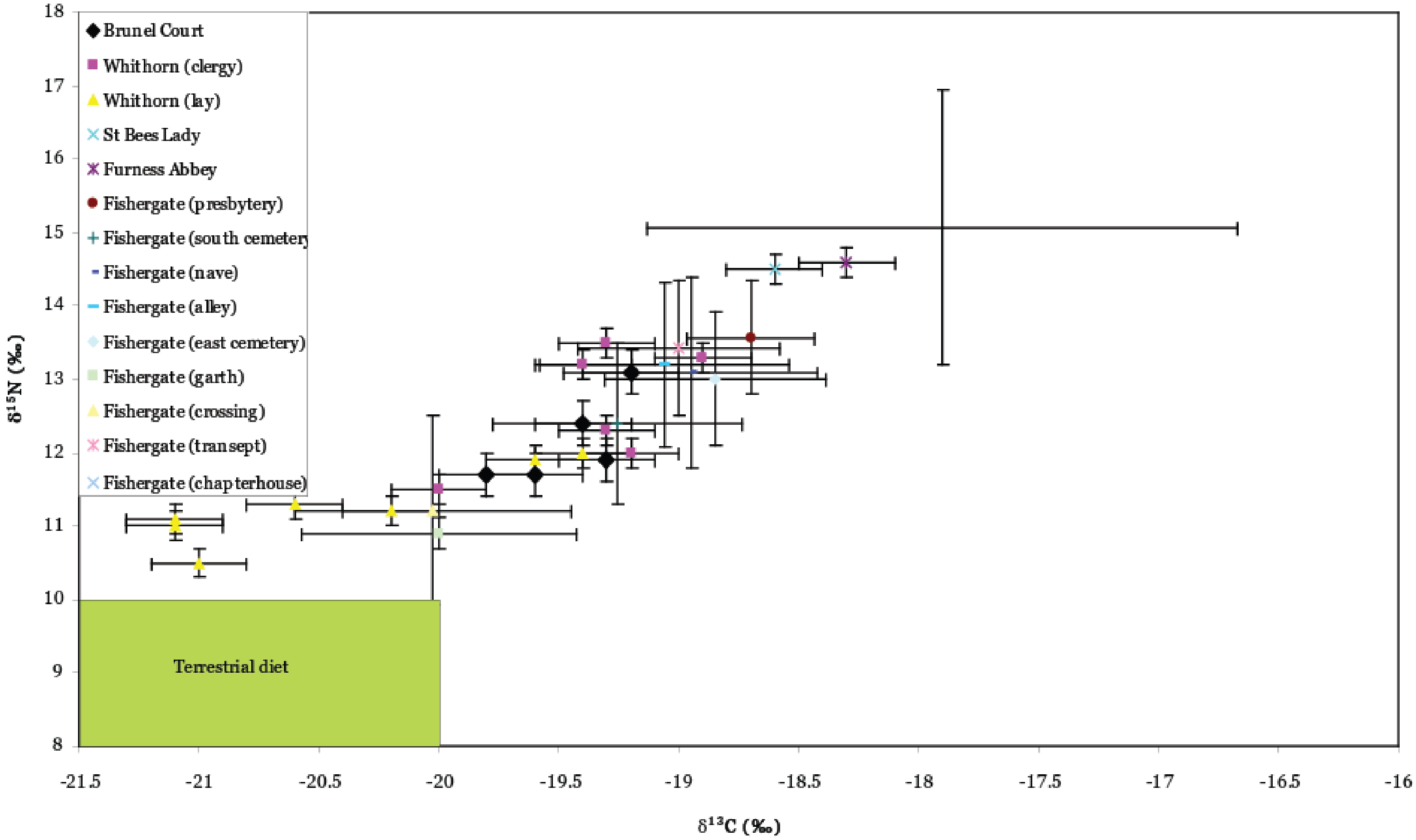

Figure 3: Carbon and nitrogen stable isotope data from Brunel Court in comparison with individuals from Furness Abbey (Marshall and Beavan 2012), St Bees Lady (Knüsel et al *2010), Whithorn (Müldner* et al *2009) and average values from Fishergate (Müldner and Richards 2007)*

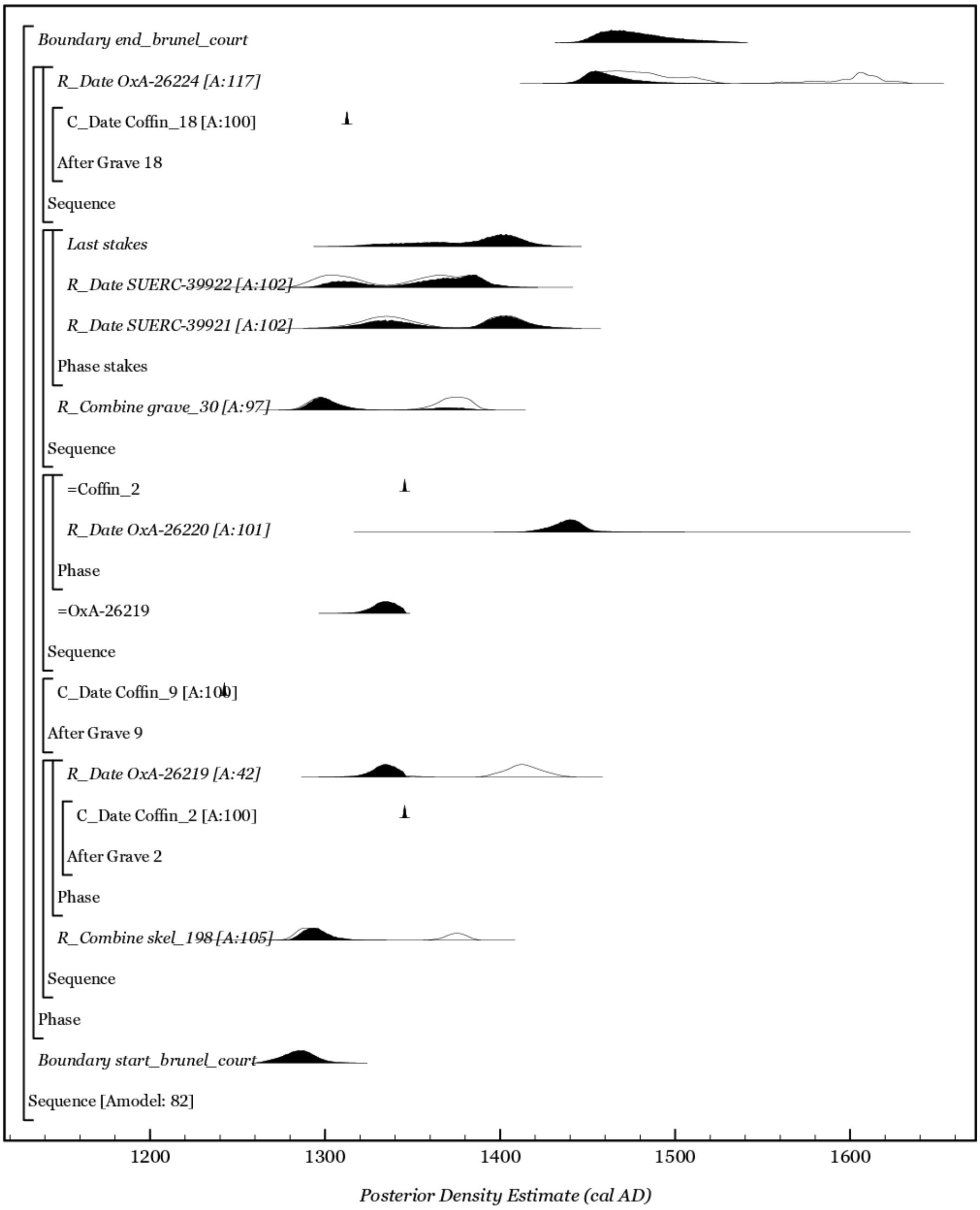

Figure 4: Probability distributions of dates from Brunel Court. Each distribution represents the relative probability that an event occurs at a particular time. For each radiocarbon date, two distributions have been plotted: one in outline which is the result of simple radiocarbon calibration, and a solid one based on the chronological model used. The other distributions correspond to aspects of the model. For example, the distribution 'start_brunel_court' *is the estimate for when the burial activity started. The large square brackets down the left-hand side of the diagram and the OxCal keywords define the overall model exactly.*

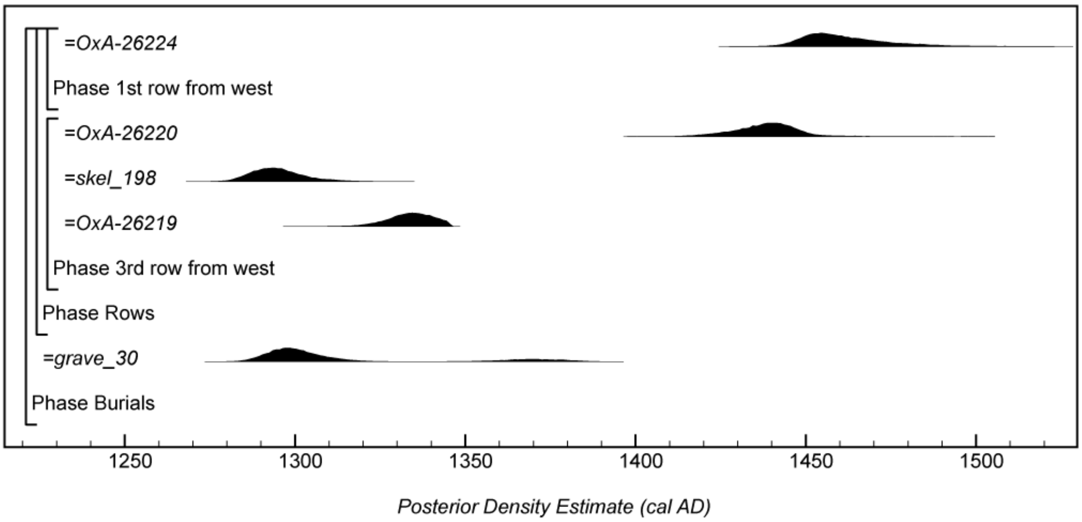

Figure 5: Posterior density estimates for the date of inhumations, ordered by rows, at Brunel Court derived from the model shown in Figure 4






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