Wasperton cemetery: radiocarbon dating

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A total of 15 samples were processed and measured by Accelerator Mass Spectrometry at the Scottish Universities Environmental Research Centre (SUERC) in East Kilbride, the Centre for Isotope Research, the University of Groningen, the Netherlands (GrA), and the Oxford Radiocarbon Accelerator Unit (ORAU) at Oxford University.

Two samples of human bone were processed at SUERC following a modified version of the pre-treatment method outlined by Longin (1971), graphitisation as described in Slota *et al* (1987), and measurement as described by Xu *et al* (2004).

Three samples of human bone and four sampled of cremated human bone were submitted to Groningen. The bone was processed following the method outlined in Longin (1971), and the cremated bone was processed following the methodology outlined by Lanting *et al* (2001). All samples were measured as described by Aerts-Bijma *et al* (1997; 2001) and van der Plicht *et al* (2000).

One sample of human bone and five samples of cremated human bone were submitted to ORAU. The bone sample was processed according to the method outlined in Bronk Ramsey *et al* (2004a), and the cremated bone was processed following Lanting *et al* (2001). All samples were measured according to the procedures described in Bronk Ramsey *et al* (2004b).

All three laboratories maintain continual programmes of quality assurance procedures, in addition to participation in international inter-comparisons (Scott 2003). These tests indicate no laboratory offsets and demonstrate the validity of the measurements quoted.

Furthermore, subsamples of Inhumations 27, 34, 46, 169, and 174 were submitted to the Rafter Radiocarbon Laboratory, New Zealand for dietary carbon and nitrogen stable isotope measurements following procedures described by Beavan Athfield *et al* (2001).

Results

The results, given in Table 1, are conventional radiocarbon ages (Stuiver and Polach 1977), and are quoted in accordance with the international standard known as the Trondheim convention (Stuiver and Kra 1986).

The calibrations of these results, relating the radiocarbon measurements directly to calendar dates, have been calculated using the calibration curve of Reimer *et al* (2004) and the computer program OxCal (v3.10) (Bronk Ramsey 1995; 1998; 2001). The calibrated date ranges for these samples are given in Table 1 and have been calculated using the maximum intercept method (Stuiver and Reimer 1986). They are quoted in the form recommended by Mook (1986), with the end points rounded outwards to 10 years if the error term is greater than or equal to 25 radiocarbon years. The graphical distributions of the calibrated dates, shown in Figure 1, are derived from the probability method (Stuiver and Reimer 1993).

Stable Isotopes

The $\delta^{13}C$ and $\delta^{15}N$ values from the inhumations at this site (Fig 4) suggest a very small marine component in the diet, which is not likely to affect the radiocarbon dating significantly

(Chisholm *et al* 1982; Schoeninger *et al* 1983). The C:N ratios suggests that bone preservation was sufficiently good to have confidence in the radiocarbon determinations (Table 1; Masters 1987; Tuross *et al* 1988).

General Approach

The Bayesian approach to the interpretation of archaeological chronologies has been described by Buck *et al* (1996). It is based on the principle that although the calibrated age ranges of radiocarbon measurements accurately estimate the calendar ages of the samples themselves, it is the dates of archaeological events associated with those samples that are important. Bayesian techniques can provide realistic estimates of the dates of such events by combining absolute dating evidence, such as radiocarbon results, with relative dating evidence, such as stratigraphic relationships between radiocarbon samples. These 'posterior density estimates', (which, by convention, are always expressed *in italics*) are not absolute. They are interpretative estimates, which will change as additional data become available or as the existing data are modelled from different perspectives.

The technique used is a form of Markov Chain Monte Carlo sampling, and has been applied using the program OxCal (v3.10) (http://units.ox.ac.uk/departments/rlaha/), which uses a mixture of the Metropolis-Hastings algorithm and the more specific Gibbs sampler (Gilks *et al* 1996; Gelfand and Smith 1990). Details of the algorithms employed by this program are available from the on-line manual or in Bronk Ramsey (1995; 1998; 2001). The algorithms used in the models described below can be derived from the structure shown in Figure 1.

Objectives and Sampling

The primary objective of the dating programme was to provide a chronological framework for the Wasperton cemetery through the dating of both inhumed and cremated human remains. More specific objectives were:

1) to provide a model for understanding the transition from late Roman to Anglo-Saxon burial,

2) to provide a chronological framework for understanding the longevity and date of cremation burial,

3) to provide a chronological model to test the initial archaeological phasing of burials and the spatial groupings,

4) to provide a comparative mathematical means to examine the chronology of the inhumations and cremations.

The first stage in sample selection was to identify suitable material from both the inhumations and cremations, which was demonstrably not residual in the context from which it was recovered. The taphonomic relationship between a sample and its context is the most hazardous link in this process, since the mechanisms by which a sample came to be in its context are a matter of interpretative decision rather than certain knowledge.

Very little bone remained in the inhumations so from the beginning high-precision radiometric dating had to be abandoned as a possibility for this project. Furthermore, a small pilot-dating programme was undertaken with two samples having been submitted to ORAU. One sample failed to provide enough collagen to date, a problem that has come to our attention with bone recovered from gravel sites. As a result all of the inhumations with approximately 5 or more grams of material had stable isotope measurements made on ^{13}C and ^{15}N, the ratio of which has been shown to provide a good indication of bone protein preservation. Only those samples with C:N ratios within the optimum range 2.9–3.6 (DeNiro 1985) were submitted for radiocarbon dating at SUERC and GrA. Of the 13 burials with enough material available for both stable isotope and radiocarbon dating, only six had C:N ratios that were optimal, and of those one failed due to insufficiently preserved collagen.

There were 21 cremations with material suitable for radiocarbon dating. Based upon computer simulations using OxCal (v3.10), a total of nine cremations had material submitted with the results being used to either confirm the postulated chronology or identify early/late cremation activity.

Analysis and Interpretation

The Wasperton cemetery presented at least two ways to model the site. The first is based on the identified burial 'groups' (Table 1). These groups were determined by spatial proximity, burial position and rite, chronologically-sensitive artefacts, and orientation.

However, amongst the groups of inhumations, Groups 4 and 5 have only one dated burial and Groups 3 and 2 have 2 and 3 dated burials each, respectively. The low number of samples in these groups, as compared to the eight dated cremations in Group 7, renders this model choice less than desirable as there is not enough information to reliably quantitatively compare the inhumation groups to one another.

All of the dated burials lie within the enclosure. The second model choice is one that favours the assumption that all of the 'enclosed' burials belong to a period of continuous activity and then separating them by burial rite (ie, cremation *vs* inhumation). This model allows us to not only provide estimates for the beginning, end, and span of all of the burial activity within the enclosure, but also to analyse and compare the beginning and end dates for the two specific burial rites.

The model shows good overall agreement ($A_{overall}$=83.6%), and estimates that burial activity began within the enclosure in *cal AD 125–330* (*95% probability*; Fig 1; *start*), or more likely *cal AD 200–310* (*68% probability*). Burial activity within the enclosure ends in *cal AD 490–700* (*98% probability*; Fig 1; *end*), or more likely *cal AD 540–640* (*68% probability*). Activity within the enclosure persisted for *180–420 years* (*98% probability*; Fig 2), or perhaps *240–360 years* (*68% probability*).

Inhumations within the enclosure began in *cal AD 180–340* (*95% probability*; Fig 1; *start inhumations*). Inhumations likely ceased in *cal AD 450–640* (*95% probability*; Fig 1; *end inhumations*), or more likely *cal AD 540–610* (*68% probability*).

Cr12 (GrA-32241; 2370 ±30 BP) is anomalously old, being Iron Age in date. Since the cremation was found within a clearly identified Anglo-Saxon vessel, this anomalous date is more likely the result of recognised, but insufficiently understood, problems that can arise when radiocarbon dating cremated bone. The date has been removed from the model, as denoted by the '?'.

Cremations within the enclosure began in *cal AD 230–400* (*95% probability*; Fig 1; *start cremations*), or likely *cal AD 260–370* (*68% probability*). They ceased in *cal AD 470–590* (*95% probability*; Fig 1; *end cremations*), or likely in *cal AD 510–560* (*68% probability*).

The model would suggest that both inhumation and cremation activity began at approximately the same time and were concurrent at the Wasperton cemetery (Fig 3). While it is possible that inhumation activity slightly pre- and post-dates cremation activity, the lower number of samples (33% fewer inhumations than cremations dated) results in reduced precision for both the start and end dates.

Table 1: Radiocarbon results from Wasperton cemetery

Lab ID	Sample ID	Material	Period	Spatial Group	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	C/N ratio	Radiocarbon Age (BP)	Calibrated Date (95% confidence)	*Posterior density estimate (95% probability)*
GrA-32672	Inhumation 46	human bone, ?tibia/long bone shaft frag.	4th	2	-19.8	12.0	3.6	1740 ±30	cal AD 230–390	*cal AD 240–390*
SUERC-11973	Inhumation 27 F309/C1259	human bone, skull frags.	4th	2	-19.7	11.4	3.3	1700 ±35	cal AD 240–430	*cal AD 250–420*
OxA-14459	Inhumation 26 F325/C1294	human bone, distal femur	4th	2	-19.8	11.9	3.3	1806 ±31	cal AD 120–330	*cal AD 170–350*
GrA-32671	Inhumation 34 F346/C1265	human bone, rt. Femur shaft	?5th	2	-20.0	8.6	3.4	1670 ±30	cal AD 250–430	*cal AD 260–300 (at 7%)* or *cal AD 310–440 (at 88%)*
SUERC-11974	Inhumation 174 F3122/C3683	human bone, skull frags.	7th [?5th]	13	-19.9	10.2	3.3	1460 ±35	cal AD 540–660	*cal AD 430–490 (at 12%)* or *cal AD 530–640 (at 83%)*
GrA-32674	Inhumation 169 F3110/C3614	human bone, femur shaft	6th	3	-19.9	9.7	3.4	1580 ±25	cal AD 410–550	*cal AD 420–550*
OxA-15964	Cremation 20 F3006/3307	cremated bone, mixed long bone shaft frags.	late 5th	7	-24.1	—	—	1735 ±55	cal AD 130–430	*cal AD 220–430*
OxA-15985	Cremation 26 F1589/3279	cremated bone, mixed long bone shaft frags.	late 5th	1	-20.2	—	—	1687 ±28	cal AD 250–430	*cal AD 260–300 (at 11%)* or *cal AD 310–420 (at 84%)*
GrA-32136	Cremation 6 F371/1311	cremated bone, mixed unident. frags.	6th	5		—	—	1595 ±35	cal AD 390–550	*cal AD 390–550*
GrA-32135	Cremation 1a F51/1000/2	cremated human bone, mixed long bone shaft frags.	6th	1		—	—	1570 ±35	cal AD 410–580	*cal AD 410–560*
GrA-32241	Cremation 12 F1504/3008	cremated bone, mixed unident. frags.	6th	7		—	—	2370 ±30	520–390 cal BC	---
OxA-15963	Cremation 10 F1502/3004	cremated bone, mixed unident. frags.	6th	7	-22.4	—	—	1565 ±29	cal AD 410–570	*cal AD 420–560*
OxA-15965	Cremation 22 F3021/3307	cremated bone, mixed long bone shaft frags.	6th	2	-24.1	—	—	1566 ±30	cal AD 410–570	*cal AD 420–560*
OxA-15962	Cremation 3 F76=F1511/3209	cremated bone, mixed long bone shaft frags.	6th	6	-19.7	—	—	1609 ±32	cal AD 380–550	*cal AD 380–540*
GrA-32242	Cremation 14 F1506/3013	cremated bone, mixed long bone shaft frags.	6th	6		—	—	1550 ±30	cal AD 420–590	*cal AD 420–570*

Figure 1: Chronological model of Romano-British and Anglo-Saxon activity at Wasperton cemetery. Figures in outline are the probability distributions of the simple calibrated dates, following Stuiver and Reimer (1993), while those in solid black are the posterior density estimates derived from the Bayesian modelling. The brackets down the left side and the OxCal keywords define the model exactly.

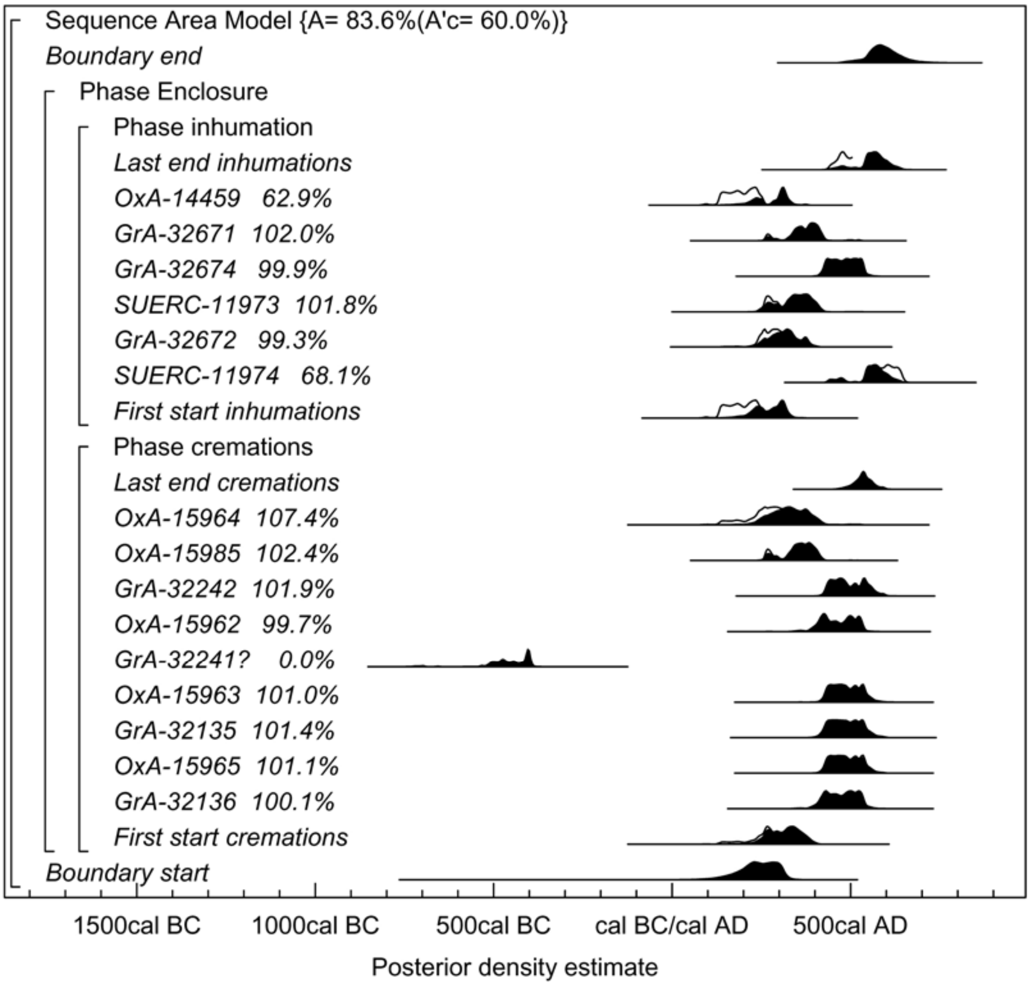


Figure 2: Estimate for the duration of all burial activity within the enclosure from Wasperton, as derived from the chronological model in Figure 1.

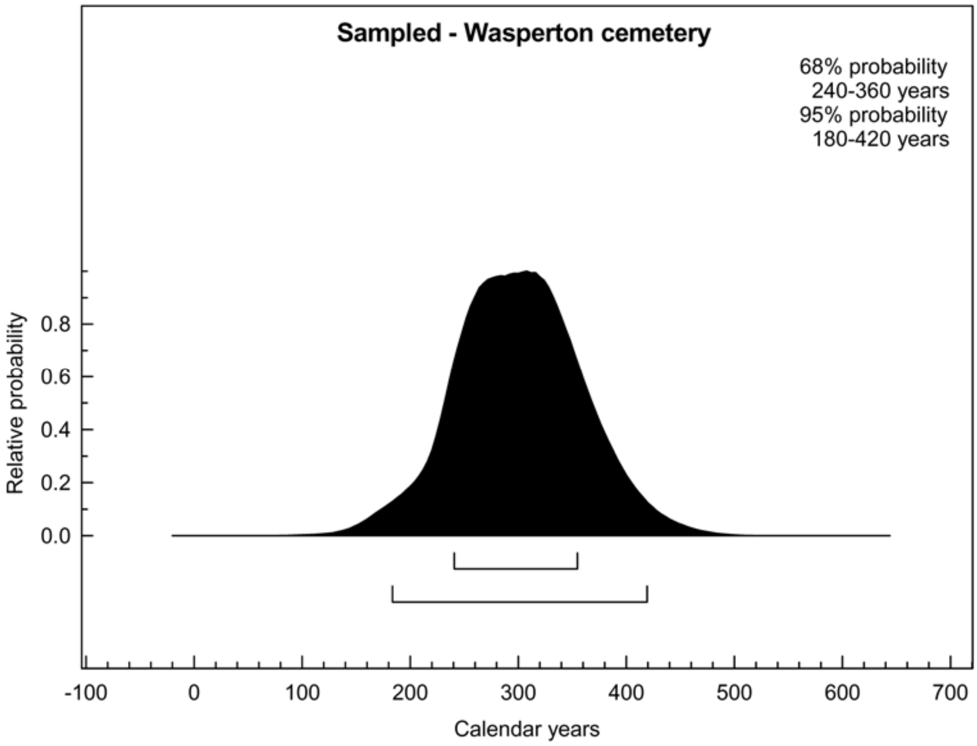


Figure 3: Estimates for the start of burial activity within the enclosure by burial rite.

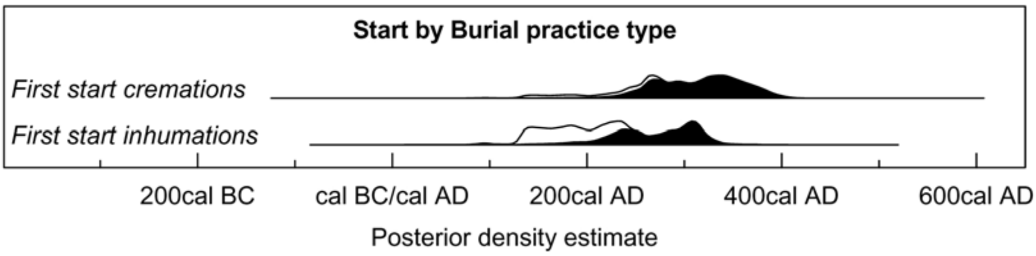
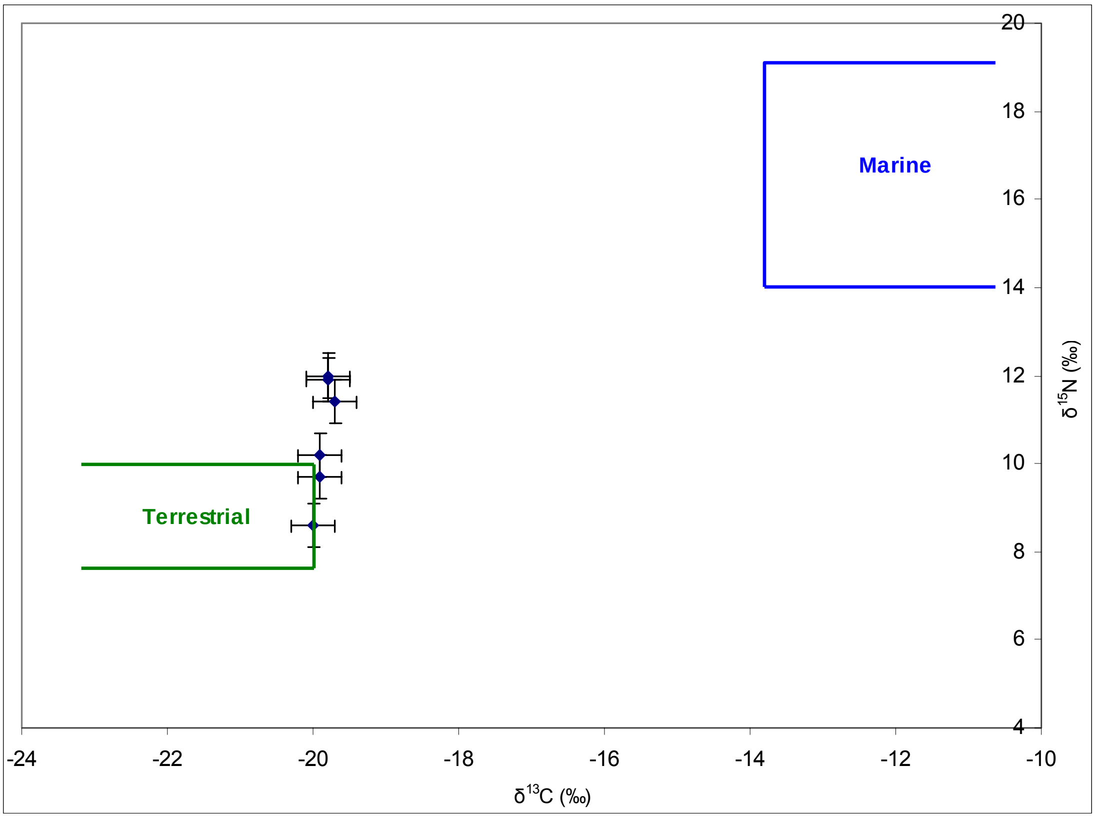


Figure 4: Estimated protein foods contribution to stable isotope values in bone. Stable isotope values in these human bone samples suggest that diet contained predominantly terrestrial sources of protein. Boxes are based on known ranges for protein sources (Mays 1998, fig 9). Stable isotope results are from the Rafter Radiocarbon Laboratory, New Zealand.



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