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GROUNDWELL RIDGE, SWINDON, WILTSHIRE
RADIOCARBON DATING AND CHRONOLOGICAL MODELLING

SCIENTIFIC DATING REPORT

John Meadows, Alex Bayliss, Christopher Bronk Ramsey, Gordon Cook, Derek Hamilton, Peter Marshall, Geoff Morley, and Pete Wilson

INTERVENTION
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SUMMARY

A programme of radiocarbon dating and chronological modelling was undertaken in 2008–10 on material recovered from excavations centred around Building 2 at Groundwell Ridge. The results of the dating and modelling indicate that Building 2 was occupied throughout most, if not all, of the Roman period, with part used as a bath suite through much of this time.

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INTRODUCTION

The site of Groundwell Ridge focuses on a Roman villa that lies approximately 5km north of the town centre of Swindon, Wiltshire (NGR SU 1408 8935), and was probably located within the territory of the Cornovii, a sub-tribe of the Dobunni whose tribal centre was Cirencester (*Corinium Dubunnorum*). The villa was first discovered in 1996 when a metal detectorist, Mr Lloyd, discovered Roman metalwork, pottery, and tile in the material coming out of house builders' test pits. Swindon's archaeological advisor, Roy Canham, was alerted and when visiting the site while roads were being stripped saw Roman buildings being destroyed. He then managed to persuade the builders to stop despite them having planning permission for the work.

Following initial recording in 1996 the site underwent archaeological evaluation in 1997 by two local archaeologists, Bryn Walters and Bernard Phillips. They dug five small trenches and determined that there was well-preserved archaeology existing beyond the roads. Amongst this there was at least two major buildings of second- to forth-century date, along with a stone-built cistern (Phillips 1997; Phillips and Walters 1998).

In 1999, the site was purchased by English Heritage and Swindon Borough Council, and is currently owned by the Council. The main field and buildings are a Scheduled Ancient Monument (29664.), further protecting the site by law from development or damage. The site has been subjected, over the years, to an array of geophysical investigation, using resistivity, magnetometry, and ground-penetrating radar, that have provided significant information on the plans of the buried buildings. In 2003, Time Team based their national community archaeology project, The 'Big Dig', in the field east of the main site, known as The Combe, with an aim to determine how far the settlement extended from the main locus of buildings (Brett 2003).

As part of a joint English Heritage/Swindon Borough Council project small-scale excavations were undertaken on the site in 2003, in advance of proposed works to install footpaths and cycleways across the site. In 2004, a larger programme of limited excavation was begun, with a key aim of involving local people and schools in thinking how to use Groundwell Ridge while also adding to our knowledge of the villa. This work was undertaken in the area of Building 2, which had been damaged in 1996. In order to minimise damage to the site, no walls were dismantled, which did limit the ability to get back to the very earliest levels of the site, but the excavation has remained extremely important for furthering our understanding of 'Villa life' in Roman Wiltshire.

Although two radiocarbon dates were acquired in 2006 on material from a buried soil in Trench 3 (Hamilton 2006), the Groundwell Ridge radiocarbon dating programme was undertaken in earnest between 2008 and 2010, and focused on the Roman bath suite sequence (Phase 2) in Trench 1 and the succeeding post-built structure (Phase 3). The chronology of the Phase 2 bath suite could not be closely defined by excavation and artefactual evidence alone, as the Scheduled Monument Consent, which allowed the excavation did not permit the removal of floors or walls. Most of the material culture recovered was thus found in collapse and demolition deposits and was of limited value in dating the different phases of use of the structure.

Scientific dating methods were therefore employed to try to refine the bath suite chronology. Archaeomagnetic dating samples were taken from the two furnaces in the bathhouse to date the final use of each feature. The first (1GW, context 10062) appeared to have been well-fired during the Roman period but analysis of a strong viscous remanence component suggested it had subsequently been disturbed. Enough undisturbed material was identified to date the last firing of the feature to between AD 170 and AD 305 (calibrated using the 1988 UK calibration curve of Clark *et al* 1988). This date range is, however, of poorer precision than might be expected for a Roman feature that had not been subject to disturbance. The second feature (2GW, context 10060) proved not to have been exposed to sufficient heat for a stable thermoremanent magnetisation to form and could not be dated using archaeomagnetism. It was only possible to produce an age estimate for the last firing of the southern furnace (1GW) from these samples, as the other material was unsuitable for dating (Linford 2010).

A waterlogged oak timber, apparently sitting on the natural clay [5186] and representing a joist of the original wooden floor from the cellar in Building 2 was submitted to the Sheffield Dendrochronology Laboratory for tree-ring dating, but given it only had 48 rings was not suitable for analysis (C Tyers pers comm). Furthermore, the heartwood/sapwood boundary did not survive on the timber and so it was not suitable for radiocarbon dating and wiggle-matching.

The Phase 3 post-built structure was essentially undated by material culture, but its stratigraphic position cutting into the demolition/collapse deposits which post-date the final use of the southern furnace provided a clear sequence. It was hoped that carbonised grain and charcoal from the posthole fills would date to the period in which this building was occupied, and that by dating these samples it would be possible to elucidate a significant element in the post-Roman history of the site. The radiocarbon programme aimed to date the construction of the bath suite, the last use of the earlier eastern furnace, the construction of the southern furnace, the last use of the southern furnace, and the final abandonment of the bath suite.

Radiocarbon Sample Selection

Following a careful assessment of the stratigraphy, artefactual dating evidence, and of the availability of material suitable for radiocarbon dating, 27 radiocarbon measurements were obtained from 25 samples, consisting of 20 fragments of carbonised plant remains (one of which was dated twice) and five articulated animal bones (one of which was also dated twice).

The first criterion for sample section was that a sample should derive from a single entity (Ashmore 1999). Such samples consist of a fragment or fragments derived from a single, short-lived organism. This means that the radiocarbon age of the sample corresponds to a single calendar date (e.g. cereal grain) that is equivalent to the date when the organism died, or to the mean of the final few years that an organism was alive (e.g. bone or multiple tree-rings in charcoal). The material available meeting this criterion included animal bones (identified by Fay Worley), individual carbonised cereal grains (identified by David Earle Robinson), and some single fragments of wood charcoal (identified by Zoë Hazell).

Taphonomy was the second criterion for sample selection. When integrating the stratigraphic sequence of the contexts with the radiocarbon dates in a Bayesian chronological model, it is essential that the samples dated died close to the time when the context was deposited so that the relative order of contexts is the same as the relative order of the samples. It can reasonably be assumed that bones found in articulation have not been redeposited more than a few months after the death of the animal concerned, since after this time the decomposition of the flesh and ligaments would mean that the bones would disperse if moved (Mant 1987). Samples of articulated bone must therefore date the deposition of the context from which they were recovered. Unfortunately, only a handful of contexts contained articulated bones. In other contexts, there was a clear relationship between the potential radiocarbon samples and the function of the context itself, for example, where a context consisted of charcoal raked out of one of the furnaces. In these instances, it is highly likely that the date of context formation is close to the date of short-lived charcoal from the rake out. Where no clear functional relationship between potential samples and their context could be observed, it must be assumed that the potential samples could be residual (significantly earlier than the date of context formation), and thus provide only *terminus post quem* dating for their context.

Radiocarbon Results

All samples were dated by Accelerator Mass Spectrometry (AMS), at the Scottish Universities Environmental Research Centre in East Kilbride (SUERC), and the Oxford Radiocarbon Accelerator Unit at Oxford University (ORAU). At SUERC, bone samples are pretreated using a modified version of the technique described by Longin (1971), and plant remains following Stenhouse and Baxter (1983). The samples are then combusted following Vandeputte *et al* (1996); graphite targets are prepared according to the methods of Slota *et al* (1987); and AMS measurement as described by Xu *et al* (2004). Laboratory methods used at ORAU are given by Brock *et al* (2010) and Bronk Ramsey *et al* (2004a; 2004b). Both laboratories maintain rigorous internal quality assurance procedures, and international inter-comparisons (Scott 2003) indicate no laboratory offsets, and validate the measurement precision quoted for the radiocarbon ages.

The radiocarbon results are given in Table 1. These are conventional radiocarbon ages (Stuiver and Polach 1977), quoted according to the international standard set at the

Trondheim convention (Stuiver and Kra 1986). The radiocarbon ages have 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 1 have been calculated by the maximum intercept method (Stuiver and Reimer 1986). They are quoted in the form recommended by Mook (1986), rounded outwards to 5 years if the error term is less than 25 radiocarbon years, or to 10 years otherwise. The probability distributions of the calibrated dates (Fig 2) were obtained by the probability method (Stuiver and Reimer 1993). Where more than one radiocarbon result is available for the same sample, a weighted mean has been calculated (Ward and Wilson 1978), and it is the calibration of that value which provides the most accurate estimate of the sample's calendar date (Table 1; Fig 2).

Ward and Wilson (1978) also provided a test for statistical consistency between radiocarbon measurements. Two independent samples were dated from each context if there was any uncertainty about the samples' taphonomy (that is, for all carbonised plant remains, including charcoal). If a context formed rapidly, the normal expectation is that these two samples will give statistically consistent radiocarbon measurements, if both are short-lived and neither is residual or intrusive. Where the results are not statistically consistent, it requires re-evaluation of the taphonomic understanding of the formation of the particular context to determine which sample may be residual or intrusive.

Only one feature, 5027, produced an inconsistent pair of results: samples 5040A (weighted mean of OxA-18635 and OxA-18636) and 5040B (SUERC-18021) (T'=11.1; v=1; T'(5%)=3.8), and it is likely that sample 5040B is residual in this context. The result for SUERC-18021 has been excluded from the chronological modelling shown below.

INTERPRETATION

The Bayesian approach (Buck *et al* 1996) is based on the premise that whereas scientific dating techniques accurately estimate the dates of individual samples, this is usually not what we want to know as archaeologists. Instead, we generally are more concerned with the dates of events associated with these samples. In this case, for example, we wanted to know: when the bath suite was first constructed; how long it was used in its original configuration; when the second furnace was built; when the building ceased to be used for bathing; whether the site was then abandoned for a significant period of time; and when the post-built structure was built, used, and abandoned.

The tools available in OxCal and other Bayesian chronological modelling software packages allow radiocarbon dates and other scientific dating evidence to be combined with the relative dating of samples surmised from the site stratigraphy, to produce realistic estimates of the dates of the samples themselves and other events of interest. Such *posterior density estimates* are necessarily interpretative, and are always reported in italics, to emphasise the fact that (unlike the calibrated date ranges given in Table 1) they would change according to which results are included in or omitted from the model, and according to the relative dating constraints built into the model structure.

Model description

One result of the constraints placed on the excavators in the Scheduled Monument Consent that did not allow for the removal of any structural material, thus limiting the visibility of pre-villa deposits, is that the model begins with the earliest dateable contexts at Groundwell Ridge, Phase 2. Two dated contexts, which are stratigraphically unrelated, are early in the sequence, predating the construction of the east furnace.

Three measurements (OxA-18635/6 and SUERC-18021) are available from two samples (Pomoideae charcoal and a charred wheat grain) recovered from fill 5040 of the curvilinear foundation ditch 5027 that predates the earliest structural elements of Building 2. The two Oxford measurements are auto-replicates that are used for internal quality assurance procedures. These two measurements are on the same material and after combining using a weighted mean results in a combined measurement of 1893 ±19 BP (T'=0.0; v=1; T'(5%)=3.8). As mentioned earlier, however, the combined measurement on 5040A is not statistically consistent with the measurement from 5040B (T'=11.1; v=1; T'(5%)=3.8) and given the sealed nature of this context, it seem likely that the charred grain sample 5040B (SUERC-18021) is residual. Therefore, SUERC-18021 has been excluded from the model.

Two results (OxA-18639 and SUERC-18011) are available from two single-entity samples of charred wheat from fill 5160 of oven 5159, which was cut by the main north-south wall of building 2. These two measurements are statistically consistent (T'=0.2; v=1; T'(5%)=3.8) and could be the same actual age.

At some point after these two contexts were formed, the east furnace was constructed. To provide an estimated date for the construction, the query *build. eastern furnace* is inserted into the model at this point.

There are two measurements (OxA-18639 and SUERC-18019) on single charred wheat grains from rake-out 10098 from the eastern furnace 10142/10060. The two measurements are statistically consistent (T'=0.9; v=1; T'(5%)=3.8) and could be the same actual age. A second deposit that post-dates the construction of the east furnace, but which has no direct stratigraphic relationship to the furnace rake-out was dated. The two measurements (OxA-18638 and SUERC-18020) are from the same cattle bone that was found in articulation with other bones in deliberate backfilling episode 5021 of Room1 (cellar). The measurements are statistically consistent (T'=1.0; v=1; T'(5%)=3.8) and since the two measurements are from the same sample can be combined to form the weighted mean 1857 ±21 BP. Samian pottery was also recovered from this context and the stamp indicates it was produced in *c* AD 160. Therefore, AD 160 has been used to provide a *tpq* for this context. The radiocarbon date should post-date the samian and so it has been placed in a sequence with AD 160 providing a lower constraint.

Both 5021 and 10098 predate the construction of the south furnace. An estimate of its construction is produced by the insertion of the query *build: southern furnace* at this point.

A result (OxA-18640) is available on a sheep/goat bone that was recovered with other articulating bones from beneath many layers of carbonised material and lying on the clay floor of the southern furnace 10062. Above the floor there are measurements from a series of rake out episodes. There are two measurements (OxA-18640 and SUERC-18018), both on individual fragments of hazel charcoal, from rake-out 10061 of the southern furnace. The two measurements are statistically consistent (T'=0.4; v=1; T'(5%)=3.8) and could be the same actual age. Another two measurements (OxA-18642 and SUERC-18014), made on single fragments of hazel and poplar/willow charcoal, from rake out 10054 are statistically consistent (T'=3.5; v=1; T'(5%)=3.8) and could be the same actual age. A final two measurements (OxA-18641 and SUERC-18013) on single fragments of Pomoideae and poplar/willow charcoal from the final rake-out 10037 of the southern furnace are also statistically consistent (T'=0.9; v=1; T'(5%)=3.8). These results probably represent the near-final use of the hypocaust. The archaeomagnetic date (1GW) is later than this episode of rake-out and provides the best estimate for the last use of the furnace (*last firing: southern furnace*).

Three stratigraphically unrelated deposits from Phase 2.5, immediately post-dating the abandonment of the southern furnace, were dated. A measurement (SUERC-18221) was made on an articulating cattle phalanx from demolition layer 5082 in room 4. Also within this deposit was a House of Constantine coin that provides a *tpq* of AD 330. The second deposit, demolition layer 10019 in room 2b, provides a measurement (SUERC-18012) from an articulating neonatal dog bone. This deposit also contains a Tetricus II coin that provides a *tpq* of AD 270. The third deposit, demolition layer 10028 from room 2a, contained an articulated sheep metatarsal that was measured (OxA-18644). These deposits also mark the end of the phase 2 occupation at the site (*end: bath suite*). As with the samian sherd above, the House of Constantine and Tetricus II coins should predate any material in their respective contexts and so have been used in a sequence to provide a lower constraint for each radiocarbon date.

Phase 3 at the site is characterised by a post-built structure constructed over the location of Building 2. Given there is no archaeological evidence that there was a hiatus in use between the end of the bath suite use and this post-built structure, the two have been modelled as temporally contiguous. Two samples were submitted from each of four stratigraphically unrelated contexts associated with this structure. The two measurements (OxA-18645 and SUERC-18028) from single fragments of *Prunus* sp. and hazel charcoal in fill 5033 of feature 5034 above room 2 of building 2 are statistically consistent (T'=0.9; v=1; T'(5%)=3.8). The two measurements (OxA-18646 and SUERC-18024) from a single fragment of Pomoideae charcoal and a charred wheat grain in fill 5043 of feature 5036, also above room 2 of building 2, are statistically consistent (T'=1.4; v=1; T'(5%)=3.8). The measurements (OxA-18647 and SUERC-18023) on a single charred wheat grain and a fragment of Pomoideae charcoal from post-pit fill 5106 of post-hole 5107 above the southeastern room of building 2 are statistically consistent (T'=0.0; v=1; T'(5%)=3.8). Finally, the two measurements (OxA-18648 and SUERC-18022) on a single fragment of Pomoideae charcoal and a charred wheat grain from fill 5113 of post-hole 5110 above room 6 of building 2 are statistically consistent (T'=3.0; v=1; T'(5%)=3.8). When all the results are subjected to a chi-square test they are not statistically consistent (T'=27.4; v=7; T'(5%)=14.1). When the earliest result, OxA-18648, is removed as being a residual sample the remaining measurements are consistent (T'=8.7; v=6; T'(5%)=12.6). OxA-18648 has been excluded from the modelling and since that result is consistent with its replicate, SUERC-18022, it too has been excluded as it is likely to be residual as well. The final model (Fig 3) gives a 0% and 2% probability that OxA-18648 and SUERC-18022, respectively, accurately date their context.

The chronological model (Fig 3) shows good agreement between the radiocarbon and archaeomagnetic dates and the archaeological information (Amodel=72).

The model estimates that Phase 2 of the occupation at Groundwell Ridge began in *cal AD 20–120* (*95% probability*; Fig 3; *start: Roman*) and probably in *cal AD 55–110* (*68% probability*). The eastern furnace was constructed in *cal AD 95–190* (*95% probability*; Fig 3; *build: eastern furnace*) and probably in *cal AD 115–160* (*68% probability*).

The southern furnace was built in *cal AD 190–275* (*95% probability*; Fig 3; *build: southern furnace*) and probably in *cal AD 215–265* (*68% probability*). The last firing of this furnace took place in *cal AD 295–355* (*95% probability*; Fig 3; *last firing: southern furnace*) and probably in *cal AD 310–345* (*68% probability*). The bath suite went out of use in *cal AD 335–380* (*95% probability*; Fig 3; *end: bath suite*) and probably in *cal AD 350–380* (*68% probability*).

The post-built structure was built after the bath suite went out of use, and as long as all the dated material from the four features are not residual it went out of use in *cal AD 335–410* (*95% probability*; Fig 3; *abandon: post-built structure*) and probably in *cal AD 365–395* (*68% probability*).

It is possible to subtract the probabilities for any two 'events' to calculate a new probability that relates to the span of time between the two 'events'. This is accomplished in OxCal using the Difference function. The modelled 'events' are given in Figure 4, and they are directly derived from the modelling shown in Figure 3.

There is a span of *10–130 years* (*95% probability*; Fig 5; *start: Roman – build: eastern furnace*), and probably *25–85 years* (*68% probability*) between start: Roman, which is equivalent to the beginning of Phase 2 at Groundwell Ridge, and *build. eastern furnace*.

The eastern furnace was in use for *35–155 years* (*95% probability*, Fig 5; *build: eastern furnace – build: southern furnace*) and probably for *65–130 years* (*68% probability*) before the southern furnace was constructed.

The southern furnace was in use for *40–145 years* (*95% probability*, Fig 5; *build: southern furnace – last firing: southern furnace*) and probably for *60–115 years* (*68% probability*).

Another *5–65 years* (*95% probability*, Fig 5; *last firing: southern furnace – end: bath suite*) and probably *15–50 years* (*68% probability*), passed before the bath suite went out of use.

After the bath suite went out of use, the post-built structure was constructed. The modelling suggests that it was in use for only *1–50 years* (*95% probability*, Fig 5; *end: bath suite – abandon: post-built structure*) and probably for only *1–20 years* (*68% probability*).

Phase 2 probably began in the mid-late first century cal AD and ended in the mid-late fourth century (Fig 4). It is not exactly clear when Building 2 was built, as radiocarbon samples were not available from contexts directly associated with its construction (sub-phase 2.2.), and the context 10098 (sub-phase 2.3) samples are likely to represent the final rake-out of the eastern furnace, but the bath suite was probably in use by the middle of the second century cal AD. The southern furnace (sub-phase 2.4) was probably built in the early-mid third century cal AD, and abandoned in the early-mid fourth century. Each furnace was therefore probably in use for around a century, although these estimates are rather imprecise (Fig 5).

The radiocarbon results from several articulated animal limbs in demolition contexts, and the sequence of rake-outs from the southern furnace, allows a reasonably precise estimate of the date of abandonment of the bath suite to be calculated (Fig 4). There is only a small probability that the furnace remained in use after the middle of the fourth century. The latest closely-dated coins from Groundwell Ridge, found in Phase 3 or later contexts, are of Constantius II (AD 353–8), and these may well be derived from the bath suite's final decade of use.

CONCLUSION

On the whole, the radiocarbon chronology validates the phasing derived from artefactual and stratigraphic evidence, which suggests that this chronology can be extended to areas of the site, which have been phased but did not produce taphonomically secure radiocarbon samples. It indicates that Building 2 was occupied throughout most, if not all of the Roman period, and part was used as a bath suite over much of this time. The earlier eastern furnace was used in the second century cal AD, but was then replaced by the southern furnace, most probably in cal AD 210–260 (68% probability; Table 2). The second furnace was also used for about a century, but the building probably ceased to function as a bath suite by the middle of the fourth century cal AD.

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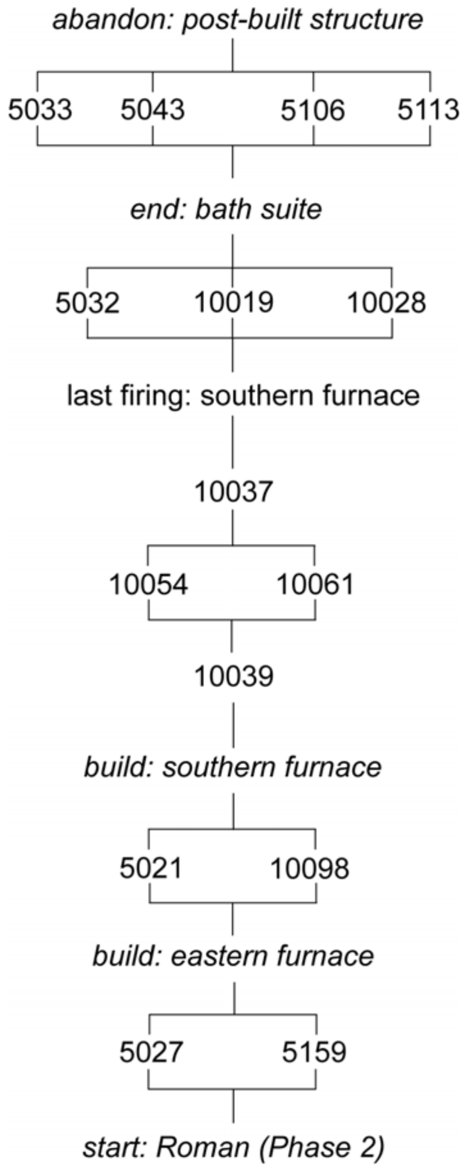


Figure 1: Harris matrix of the contexts from which radiocarbon samples were selected; the event 'last firing: southern furnace' is the calibrated date probability for the archaeomagnetic samples from context 10062

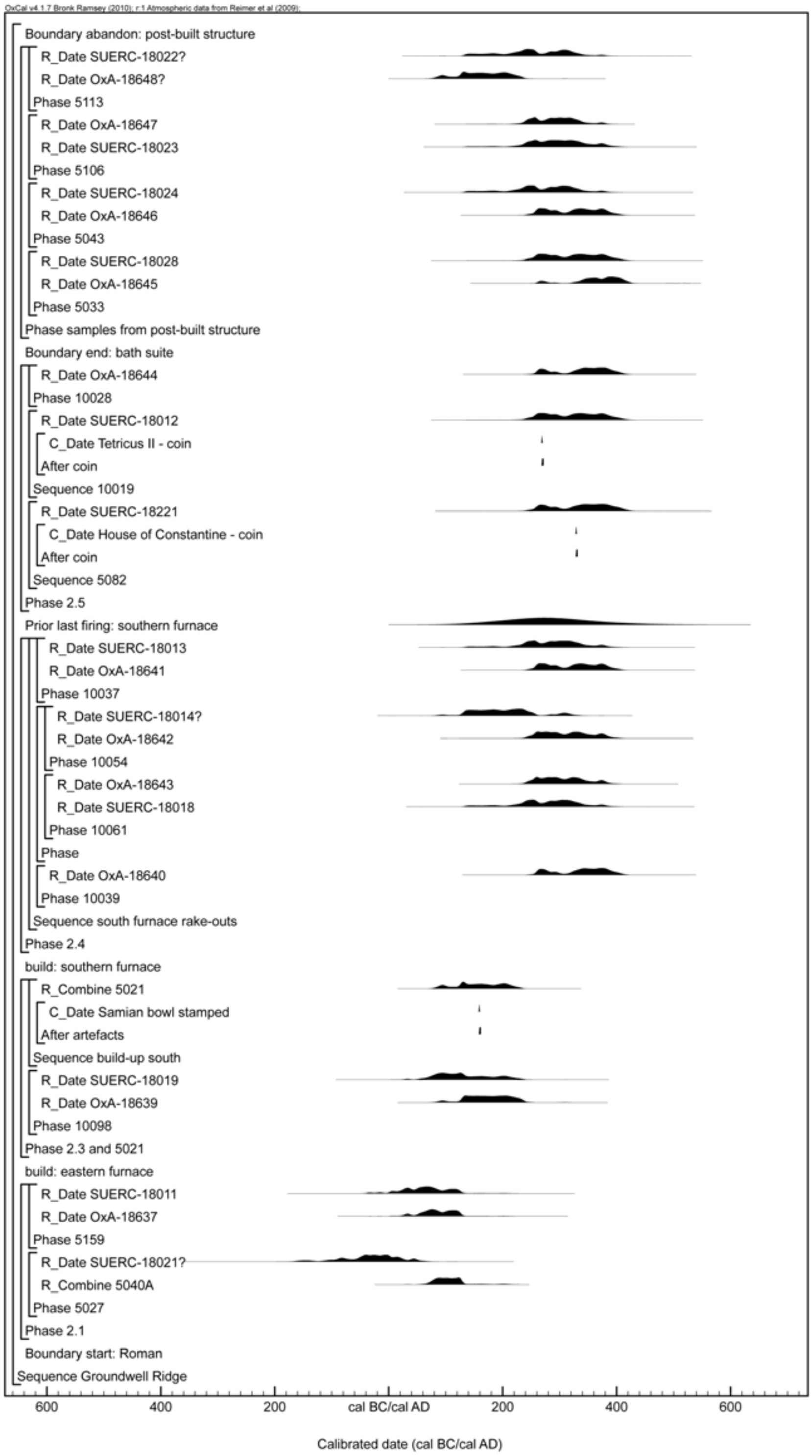


Figure 2: Probability distributions of calibrated radiocarbon dates, an archaeomagnetic date, and the earliest minting date of the identifiable stratified coins from Groundwell Ridge. The OxCal structure, defined by the keywords and 'brackets' along the left side of the image, is derived from the Harris Matrix shown in Figure 1

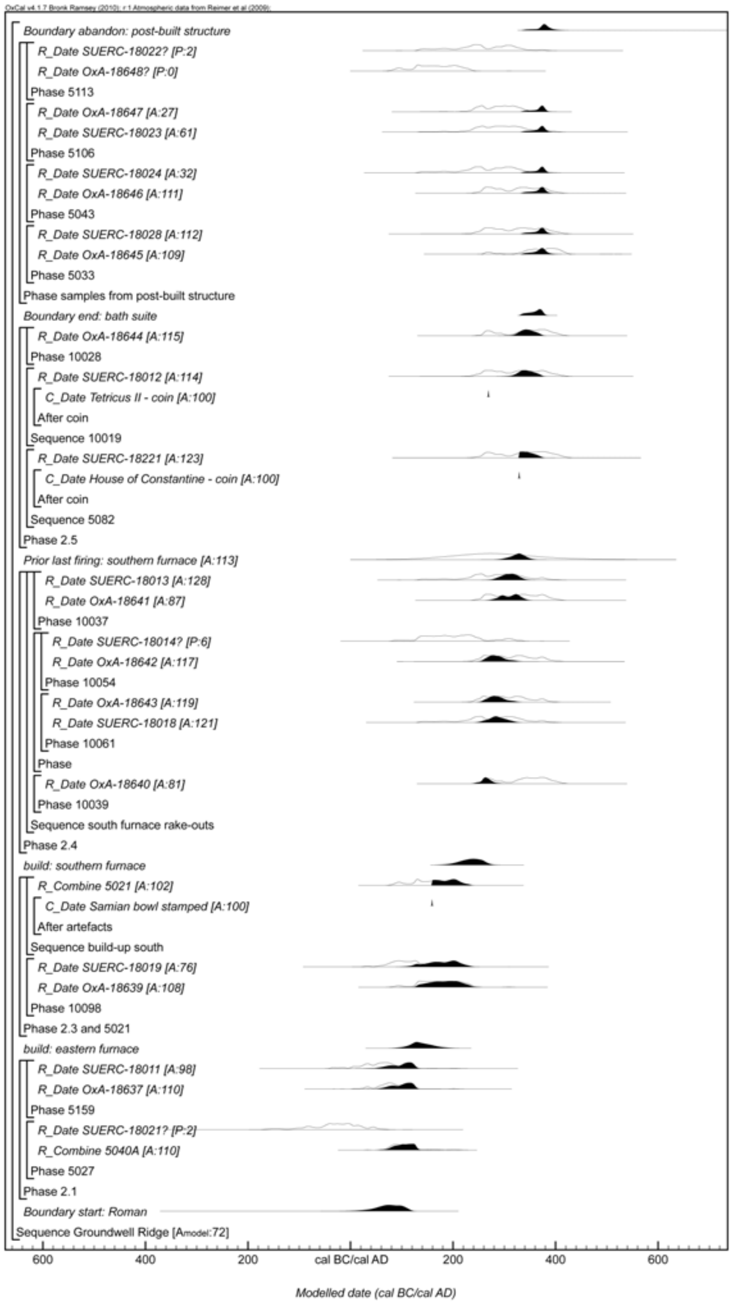


Figure 3: Chronological model for Groundwell Ridge. Each distribution represents the relative probability that an event occurred at some particular time. For each of the radiocarbon measurements two distributions have been plotted, one in outline, which is the result of simple radiocarbon calibration, and a solid one, which is based on the chronological model use. The other distributions correspond to aspects if the model. For example, 'start: Roman' is the estimated date that the Phase 2 activity on site began, based on the dating results. The large square 'brackets' along with the OxCal keywords define the overall model exactly

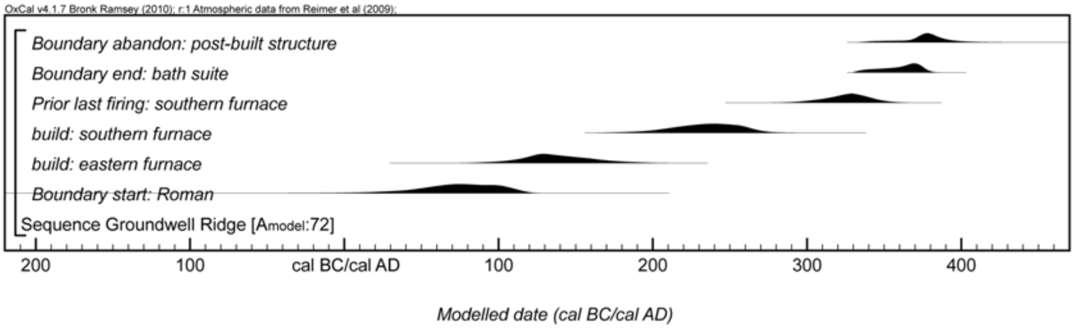


Figure 4: Modelled dates for specific 'events' shown is the model shown in Figure 3

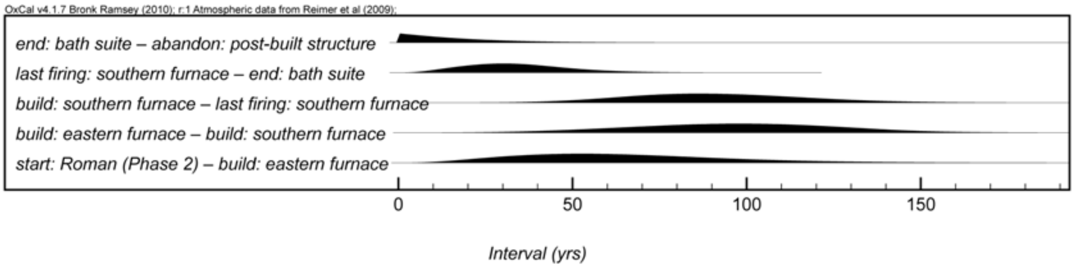


Figure 5: Spans for intervals of interest, derived from the 'events' in the model shown in Figure 3. The spans are calculated using the Difference function in OxCal with the probability label indicating the two 'event' probabilities used for the calculation

Table 1: radiocarbon results, Groundwell Ridge. Each sample consisted of either a single grain, a single charcoal fragment, or one or more bones from a single, articulated animal. Posterior density estimates are given for the dates of samples included in the Bayesian model shown in Figure 3

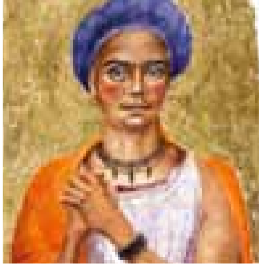
Sample	Context	Material dated	Laboratory number	$\delta^{13}C$ (‰)	Radiocarbon age (BP)	Calibrated date range (95% confidence)	*Posterior density estimate (95% probability)*
Phase 2.1							
5040 A	fill of 5027, curvilinear foundation trench predating Building 2	charcoal, Pomoidae	OxA-18635	-25.8	1894 ±26		-
5040 A			OxA-18636	-25.3	1891 ±26		-
5040 A			mean (T'=0.0, T'(5%)=3.8, v=1)	1893 ±19	cal AD 60–140	cal AD 70–135	
5040 B		charred wheat grain, *Triticum* sp.	SUERC-18021	-21.1	2025 ±35	160 cal BC–cal AD 60	-
5160 A	fill of oven 5159, cut by main north-south wall of Building 2	charred wheat grain, *Triticum* sp.	OxA-18637	-23.5	1917 ±26	cal AD 20–140	*cal AD 60–135*
5160 B		charred wheat grain, *Triticum* sp.	SUERC-18011	-22.2	1935 ±35	20 cal BC–cal AD 140	*cal AD 50–135*
Phase 2.3							
10098 A	10098, rake-out from eastern furnace 10142	charred wheat grain, *Triticum* sp.	OxA-18639	-23.7	1839 ±25	cal AD 80–250	*cal AD 130–235*
10098 B		charred wheat grain, *Triticum* sp.	SUERC-18019	-22.8	1880 ±35	cal AD 50–240	*cal AD 120–235*
Phase 2.4							
5021 A	5021, backfill of room 1 before	articulating cattle distal fibula (lateral	OxA-18638	-21.8	1843 ±25		-

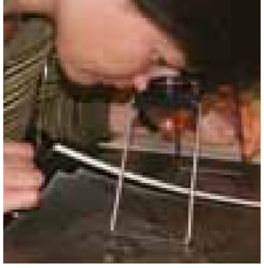
	construction of southern furnace	malleolus)					
5021 B			SUERC-18020	-21.3	1885 ±35		-
5021			mean (T'=1.0, T'(5%)=3.8, v=1)	1857 ±21	cal AD 80–240	cal AD 155–225	
10039	10039, clay floor of southern furnace 10062	articulating sheep/goat distal radius and carpal	OxA-18640	-21.0	1702 ±25	cal AD 250–420	*cal AD 240–290*
10061 A	10061, rake-out from southern furnace 10062	charcoal, *Corylus avellana*	OxA-18643	-25.2	1734 ±25	cal AD 230–390	*cal AD 255–325*
10061 B		charcoal, *Corylus avellana*	SUERC-18018	-24.9	1760 ±35	cal AD 130–390	*cal AD 255–325*
10054 A	10054, rake-out from southern furnace 10062	charcoal, *Corylus avellana*	OxA-18642	-26.8	1727 ±27	cal AD 230–400	*cal AD 255–325*
10054 B		charcoal, *Populus/Salix* sp.	SUERC-18014	-25.3	1810 ±35	cal AD 120–330	-
10037 A	10037, final rake-out from southern furnace 10062	charcoal, Pomoideae	OxA-18641	-27.9	1714 ±26	cal AD 240–410	*cal AD 275–345*
10037 B		charcoal, *Populus/Salix* sp.	SUERC-18013	-23.5	1755 ±35	cal AD 170–390	*cal AD 280–340*
Phase 2.5							
5082	5082, demolition layer in room 4	articulating cattle proximal first phalanx	SUERC-18221	-21.7	1700 ±35	cal AD 240–430	*cal AD 325–370*
10019	10019, demolition layer in room 2b	neonatal dog, articulating right humerus and femur	SUERC-18012	-20.1	1715 ±35	cal AD 230–420	*cal AD 315–375*
10028	10028, demolition layer in room 2a	articulating sheep metatarsal	OxA-18644	-21.1	1699 ±25	cal AD 250–420	*cal AD 320–375*

Phase 3	post-built structure						
5033 A	5033, fill of 5034, above room 2 of Building 2	charcoal, *Prunus* sp.	OxA-18645	-25.1	1674 ±26	cal AD 260–430	*cal AD 335–395*
5033 B		charcoal, *Corylus avellana*	SUERC-18028	-24.0	1715 ±35	cal AD 230–420	*cal AD 335–390*
5043 A	5043, fill of 5036, above room 2 of Building 2	charcoal, Pomoideae	OxA-18646	-27.5	1714 ±26	cal AD 240–410	*cal AD 335–390*
5043 B		charred wheat grain, *Triticum* sp.	SUERC-18024	-23.1	1765 ±35	cal AD 130–390	*cal AD 335–390*
5106 A	5106, fill of 5107, above south-eastern room of Building 2	charred wheat grain, *Triticum* sp.	OxA-18647	-21.7	1750 ±25	cal AD 230–390	*cal AD 335–390*
5106 B		charcoal, Pomoidae	SUERC-18023	-24.9	1745 ±35	cal AD 210–400	*cal AD 335–390*
5113 A	5113, fill of 5110, above room 6 of Building 2	charcoal, Pomoidae	OxA-18648	-26.3	1851 ±26	cal AD 80–240	-
5113 B		charred wheat grain, *Triticum* sp.	SUERC-18022	-22.8	1775 ±35	cal AD 130–380	-

Table 2: Posterior density estimates ranges for the dates of events shown in the model in Figure 3

event	68% probability	95% probability
start: Roman	*cal AD 55–110*	*cal AD 20–120*
build: eastern furnace	*cal AD 115–160*	*cal AD 95–190*
build: southern furnace	*cal AD 215–265*	*cal AD 190–275*
last firing: southern furnace	*cal AD 310–345*	*cal AD 295–355*
end: bath suite	*cal AD 350–380*	*cal AD 335–380*
abandon: post-built structure	*cal AD 365–395*	*cal AD 335–410*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