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Digest 3 RADIOCARBON DATES

3.1 Radiocarbon dating and Bayesian modelling

DEREK HAMILTON (Scottish Universities Environmental Research Centre)

Between 1992 and 2011, seventy-two radiocarbon measurements were produced from seventy-one samples representing seventy individual archaeological contexts from the Tarbat Discovery Programme. In total, the pool of samples comprised thirty-six on human bone, eight on charcoal, eight on charred grain, seven on wood, five on animal bone, four on humic acids from bulk organic sediment, three on waterlogged seeds and one on cremated animal bone.

Of the seventy-one samples, six samples (three human bone and three bulk organic sediment) were submitted to the Scottish Universities Research and Reactor Centre, East Kilbride, and measured by liquid scintillation counting. The human bone was pretreated with a modified Longin (1971) method while the sediment was pretreated as described in Stenhouse and Baxter (1983), with the humic acid fraction reserved for dating. The samples were further processed and measured as described by Noakes et al (1965). These results are identified by their GU- number.

Forty-eight samples were submitted to the Scottish Universities Environmental Research Centre, East Kilbride, for Accelerator Mass Spectrometry dating (AMS). The twenty-five samples of human bone and five animal bone samples were pretreated using a modified Longin (1971) method. The twenty-one samples of charcoal and plant macrofossils were pretreated as described in Stenhouse and Baxter (1983). The sample of cremated animal bone was pretreated using the methods of Lanting et al (2001). All the samples were combusted as described in Vandeputte et al (1996), graphitised as described in Slota et al (1987), and measured by AMS as described in Xu et al (2004). These samples are identified by their SUERC- number.

The remaining samples were submitted to the Oxford Radiocarbon Accelerator Unit for AMS dating. The one sample of human bone was pretreated following the original 'ultrafiltration' method detailed in Bronk Ramsey et al (2000), while the remaining twelve samples were pretreated using the improved 'ultrafiltration' method described in Bronk Ramsey et al (2004a). The five samples of charcoal and wood were pretreated following methods described in Hedges et al (1989). The samples were further processed and measured as described in Bronk Ramsey et al (2004b). These are identified by their OxA- number.

Both laboratories maintain rigorous internal quality assurance procedures and participation in international inter-comparisons (Scott 2003) indicate no laboratory offsets; thus validating the measurement precision quoted for the radiocarbon ages.

The radiocarbon results are given in Table D3.2, and are quoted in accordance with the international standard known as the Trondheim convention (Stuiver & Kra 1986). They are conventional radiocarbon ages (Stuiver & Polach 1977).

The calibrations of the results, relating the radiocarbon measurements directly to calendar dates, are also given in Table D3.2. All have been calculated using the internationally agreed calibration curve of Reimer et al (2009) and the computer program OxCal v4.1 (Bronk Ramsey 1995; 1998; 2001; 2009). The calibrated date ranges cited in the text are those for 95% confidence. They are quoted in the form recommended by Mook (1986), with the end points rounded outwards to ten years if the error term is greater than or equal to twenty-five radiocarbon years or to five years if it is less. The ranges quoted in italics are posterior density estimates derived from mathematical modelling. The ranges in roman type in Table D3.2 have been calculated according to the maximum intercept method (Stuiver & Reimer 1986). All other ranges are derived from the probability method (Stuiver & Reimer 1993).

Methodological approach

A Bayesian approach has been adopted for the interpretation of the chronology (Buck et al 1996). Although the simple calibrated dates are accurate estimates of the dates of the samples, this is usually not what archaeologists really wish to know. It is the dates of the archaeological events represented by those samples that are of interest. In the case of the Tarbat Discovery Programme, it is the chronology of the church and graveyard and that of the sequence of settlements beyond them that are under consideration. The dates of the overall chronological activity in each Sector can be estimated, not only using the absolute dating information from the radiocarbon measurements on the samples, but also by using the stratigraphic relationships between samples.

Fortunately, methodology is now available which allows the combination of these different types of information explicitly, to produce realistic estimates of the dates of archaeological interest. It should be emphasised that the *posterior density estimates* produced by this modelling are not absolute. They are interpretative *estimates*, which can and will change as further data become available and as other researchers choose to model the existing data from different perspectives.

The technique used is a form of Markov Chain Monte Carlo sampling, and has been applied using the program OxCal v4.2. Details of the algorithms employed by this program are available from the on-line manual or in Bronk Ramsey (1995; 1998; 2001; 2009). The algorithm used in the model described below can be derived directly from the model structure shown in Illus D3.1.2–5.

Stable isotopes and marine correction

The C:N ratios for these samples suggest that bone preservation was sufficiently good to have confidence in the accuracy of the radiocarbon determinations (Table D3.2; Masters 1987; Tuross et al 1988).

The $\delta^{13}C$ and $\delta^{15}N$ values from the majority of the earlier burials from this site (Illus D3.1) 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 same cannot be said for the later burials, nearly all of which have a moderate to significant marine signature.

When humans and non-human animals consume marine resources, the radiocarbon age of their bones will be older than expected. The reason for this is that while the production and distribution of radiocarbon in the atmosphere is virtually instantaneous, so that terrestrial plants and animals that feed on those plants will have their ratio of radiocarbon in equilibrium, when ^{14}C enters the oceans it does not become distributed instantaneously and 'hangs around' for a while at some depth. The result is that the marine carbon cycle is not in sync with the terrestrial, and marine ages are too old when calibrated with the terrestrial radiocarbon calibration curve.

It is possible to 'correct' radiocarbon ages for material whose protein has come from

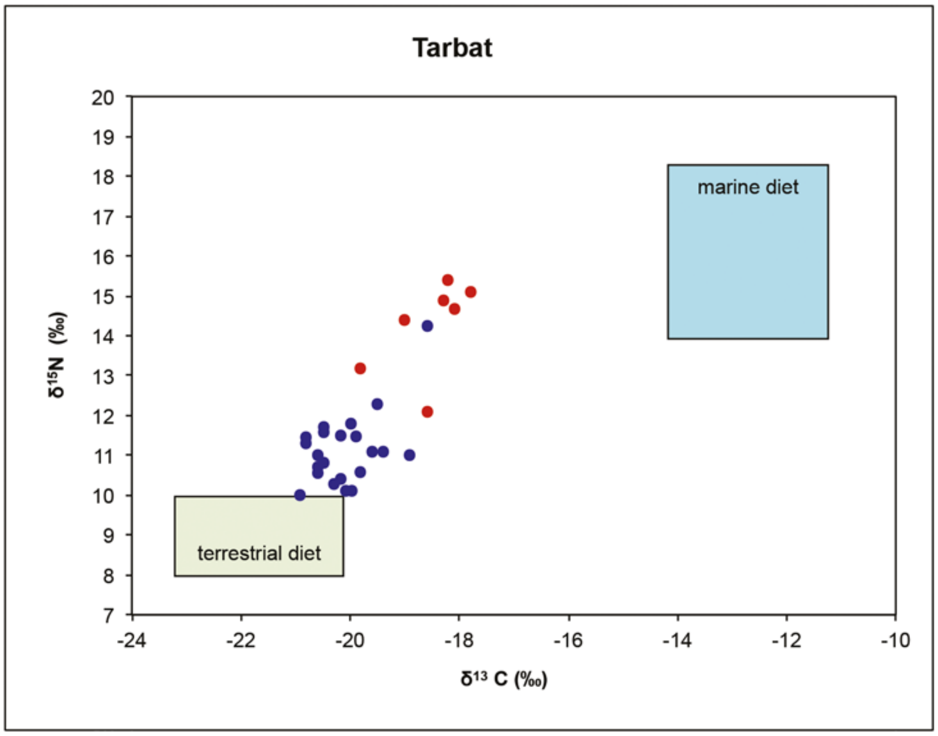

Illustration D3.1.1
Plot of the stable isotope results for those human bone samples where there is both a δ^{13}C and δ^{15}N measurement available. The points plotted in blue are from earlier burials, while those in red are from the later burials. The boxes for the expected values of fully terrestrial versus fully marine values are based on the data of Mays (1998, fig 9)

both terrestrial and marine sources (Bayliss et al 2004). It should be stressed that this marine correction is, in essence, a modelled radiocarbon calibration that uses a mixture of the internationally agreed calibration curves IntCal09 and Marine09 of Reimer et al (2009). It is a modelled calibration because there is more than one way to determine the percentage of diet that derived from terrestrial/marine resources. As such, the results will vary slightly, depending on the method used.

The method employed here was to calculate the percentage of the diet that was terrestrial by using −12.5‰ and −20.0‰ as the end members for the δ^{13}C, where −20.0‰ was the equivalent of 100% terrestrial and −12.5‰ was equal to 100% marine. The local marine reservoir correction (ΔR) of −29 ± 51 was used (Russell 2011). Radiocarbon results with a marine component that was determined to be 1% or greater were corrected using OxCal and ‘mixing’ the two calibration curves at the calculated percentage. The corrected radiocarbon dates are given in Table D3.2, and these same corrected dates were used throughout the modelling of the results from Tarbat.

The Tarbat discovery samples

Except for samples submitted from a palaeo-environmental sequence (discussed below), all the samples were single-entities and from short-lived species (Ashmore 1999). The overall model employed combines the observed stratigraphy in the three excavated and dated sectors (Sectors 1, 2 and 4) with the samples discussed within their place in the overall site periodisation. While the samples are discussed below by period and then by sector, the model maintains independence between the dating of the individual sectors and uses the multiple estimations for period transitions across the sectors as a point for later discussion. Furthermore, the model only stipulates that the Periods are sequential, and that they are not necessarily temporally contiguous, which is attested to in some cases by the archaeology (eg wind-blown sand deposits at the transition from Period 1 and 2 in Sectors 2 and 4, and the burning event that marked the end of Period 2).

Period 1

Seven features were dated from Sector 2 and placed into Period 1. There was no stratigraphy between these features. There is a result (SUERC-14989) from a bulk sample (C2310/4874) of waterlogged weed seeds from the marsh. SUERC-13277 is a result from a waterlogged willow stake in a pool (F436/C2224). SUERC-33420 is from a charred hazelnut shell recovered from a hearth (F535/C3406). SUERC-33421 is from a fragment of hazel woven to form the lining of a well (F527/C3570). SUERC-13263 is on a carbonised barley grain from the fill of a pre-church ditch (F129/C1345). There are two results (SUERC-13256 and -33416) on two burials (Burial 186/F515/C2987 and Burial 187/F516/C3346) that were excavated outside the church, but which form part of the cist burial cemetery that was excavated within the church. Finally, SUERC-14994 is on a fragment of waterlogged birch from a context (C2296/4873) that represents the end of the Period 1 peat deposits that were superseded by the pool in Period 2.

Six features, forming two sequences, in Sector 4 provided eight results. The first sequence of burials begins with Burial 170, a simple inhumation, with one result (SUERC-33413) on a rib, which is followed by another simple inhumation (Burial 169) from which there is a result (SUERC-33412) on a rib.

The second sequence begins with two results (SUERC-13255 and OxA-13483) from cist Burial 162. These two results are statistically consistent (T’ = 0.4; n = 1; T’(5%) = 3.8 (Ward & Wilson 1978) and have been combined prior to calibration to form mean 162 (1546 ± 21 BP). Burial 162 is stratigraphically coeval with Burial 172, from which there are two results (SUERC-37079 and OxA-9699) that are not statistically consistent at 2-sigma (T’ = 5.3; n = 1; T’(5%) = 3.8: Ward & Wilson 1978), though they are at less than 3-sigma (T’(1%) = 6.6). Given the two samples are from the same body, it is more likely that the measurements from the two labs are only slightly more variable than would usually be expected. The results have been combined prior to calibration to form mean 172 (1441 ± 23 BP). Burial 172 is followed stratigraphically by cist Burial 146, which produced a single result (SUERC-37078) on a metatarsal. Burial 146 is of similar stratigraphic age to Burial 163 (they are not actually in contact), which produced a result (OxA-13484) on a leg bone from the probable shrouded inhumation.

Period 2

In Sector 1, there is one result (OxA-10159) from a wooden stake recovered in situ in the outer enclosure ditch. Three samples of bulked organic sediment taken from the early fill of the outer enclosure ditch in 1991 (Int 1) gave dates in the later Iron Age (GU-3265, -3266, and -3267). There is a result (SUERC-2621) on a fragment of cremated cattle bone recovered

Illustration D3.1.2
Simplified structure of the model for all three dated sectors at Tarbat

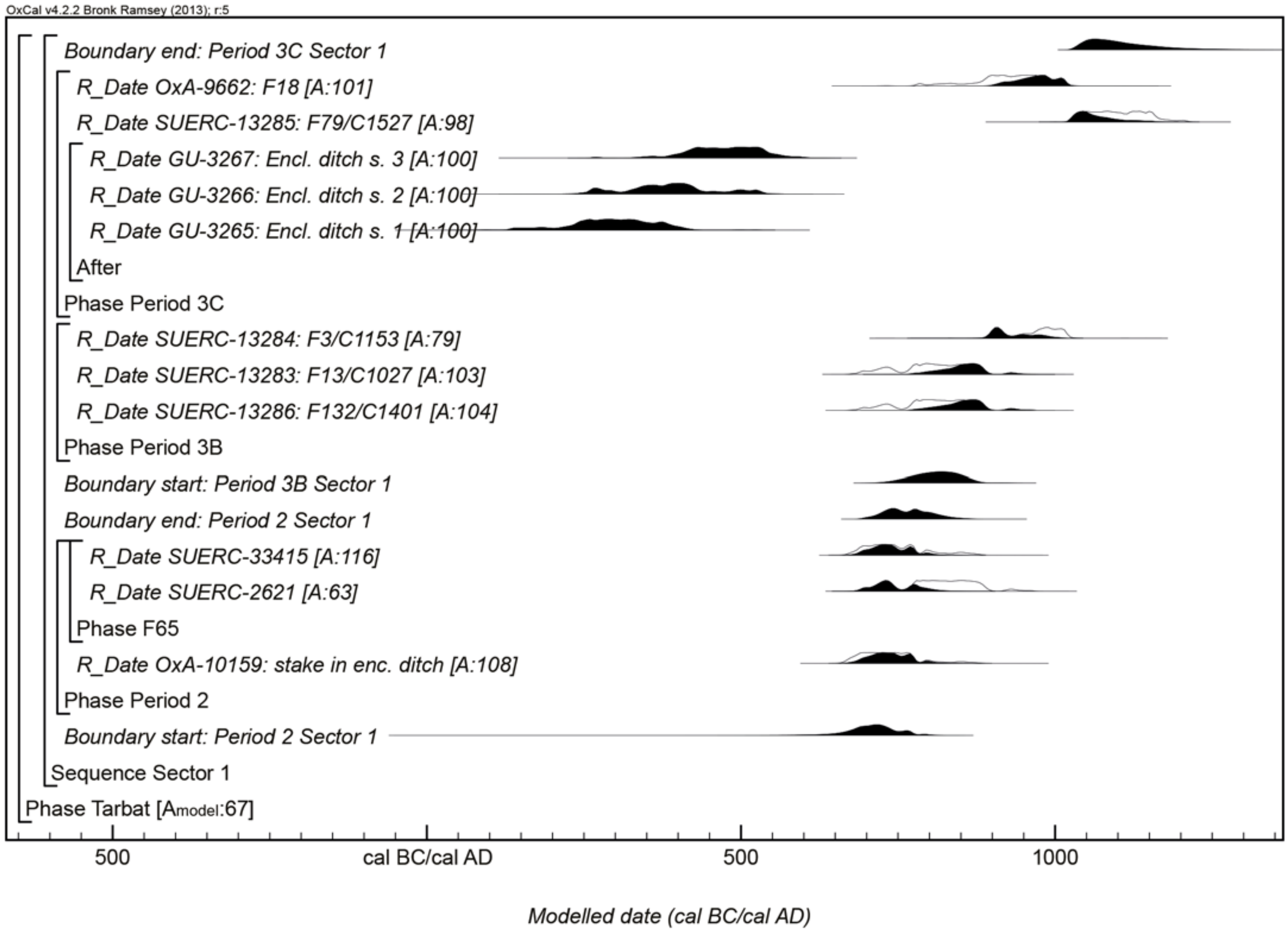

Illustration D3.1.3

Chronological model for the radiocarbon dates from Sector 1 at Tarbat. 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 of the model. For example, *'start: Period 2 Sector 1'* is the estimated date that activity began at that site, based on the radiocarbon dating results. The large square 'brackets' along with the OxCal keywords define the overall model exactly

from the hearth (F65/C1141) in the Smith's Hall (S1), with a replicate measurement (SUERC-33415) made on a charred hazelnut shell from the same context. The two results are statistically consistent (T' = 1.2; v = 1; T'(5%) = 3.8: Ward & Wilson 1978) and could be the same actual age.

There are twelve radiocarbon-dated contexts from Period 2 in Sector 2. A single date (SUERC-13581) is available from charred barley recovered the hearth (F495/C2786) in S9. Four dates are available from features in the S9 yard. SUERC-13272 is a result from a charred barley grain recovered from a hearth in the yard (F445/C2468). SUERC-13266 is from a cattle metatarsal recovered as part of a 'bone raft' beneath S9 yard wall (F480/C3122). SUERC-13267 is from one of an alignment of worked cattle metapodials in the S9 yard (F393/C1957), and this result is the earlier in a sequence with SUERC-13271, a result on a cattle metatarsal that was one in a cache of metapodials in the workshop yard (C2000). SUERC-13265 is on a cattle metatarsal from a horizon of butchered bone on the eastern roadside surface (C2335), and SUERC-13276 of a sample from a waterlogged willow stake that was recovered in situ in the nearby stream (F404/C2295).

The Period 2 sequence in Sector 2 ended with a widespread fire, providing a strong stratigraphic horizon in this sector. A burnt hazel stake from the terrace wall (F490/C2697) produced SUERC-13273, and OxA-9664 came from a sample of burnt structural timber from primary burning horizon [C1030]. These final two results were potentially in use for an extended period of time prior to the destruction level that they form a part of, and so the results are included here as providing a *terminus post quem* for that destruction. A Frisian sceat, originating in the Rhineland in AD 715–35 was redeposited in a pit of Period 3 (F185) and also provides a *tpq* for the fire. There is one result that relates directly to the date of the fire (SUERC-13274 and -13275) on burnt hazel wattles from the terrace wall that formed part of a primary burning horizon (F483/C2584 and C2704, respectively), while a bulk sample of waterlogged elder seeds in the latest pool deposit (C2310) produced SUERC-14995, which also marked the end of Period 2 in Sector 2.

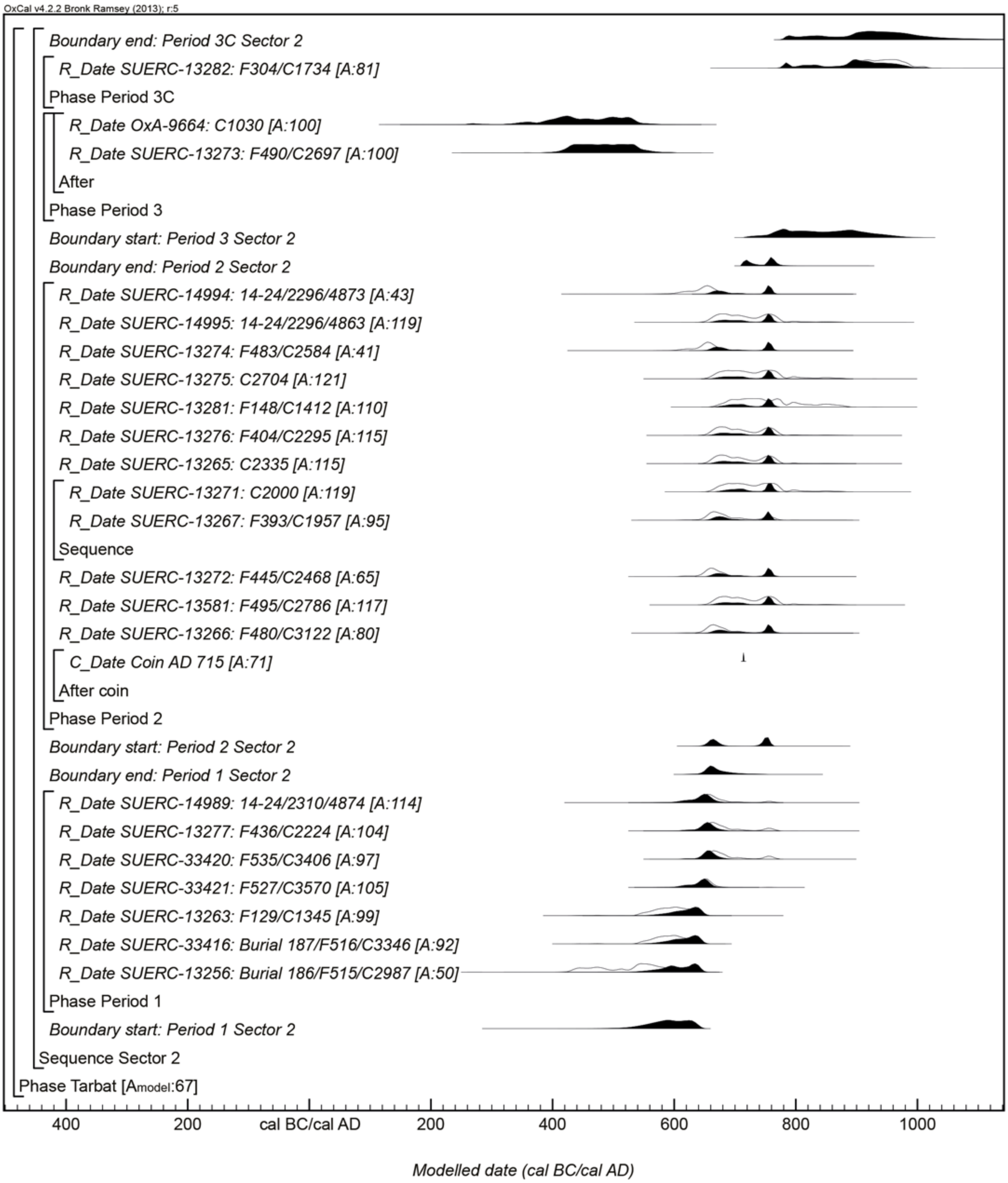

Illustration D3.1.4
Chronological model for Sector 2 at Tarbat. The model structure is as described in Illus D3.1.3

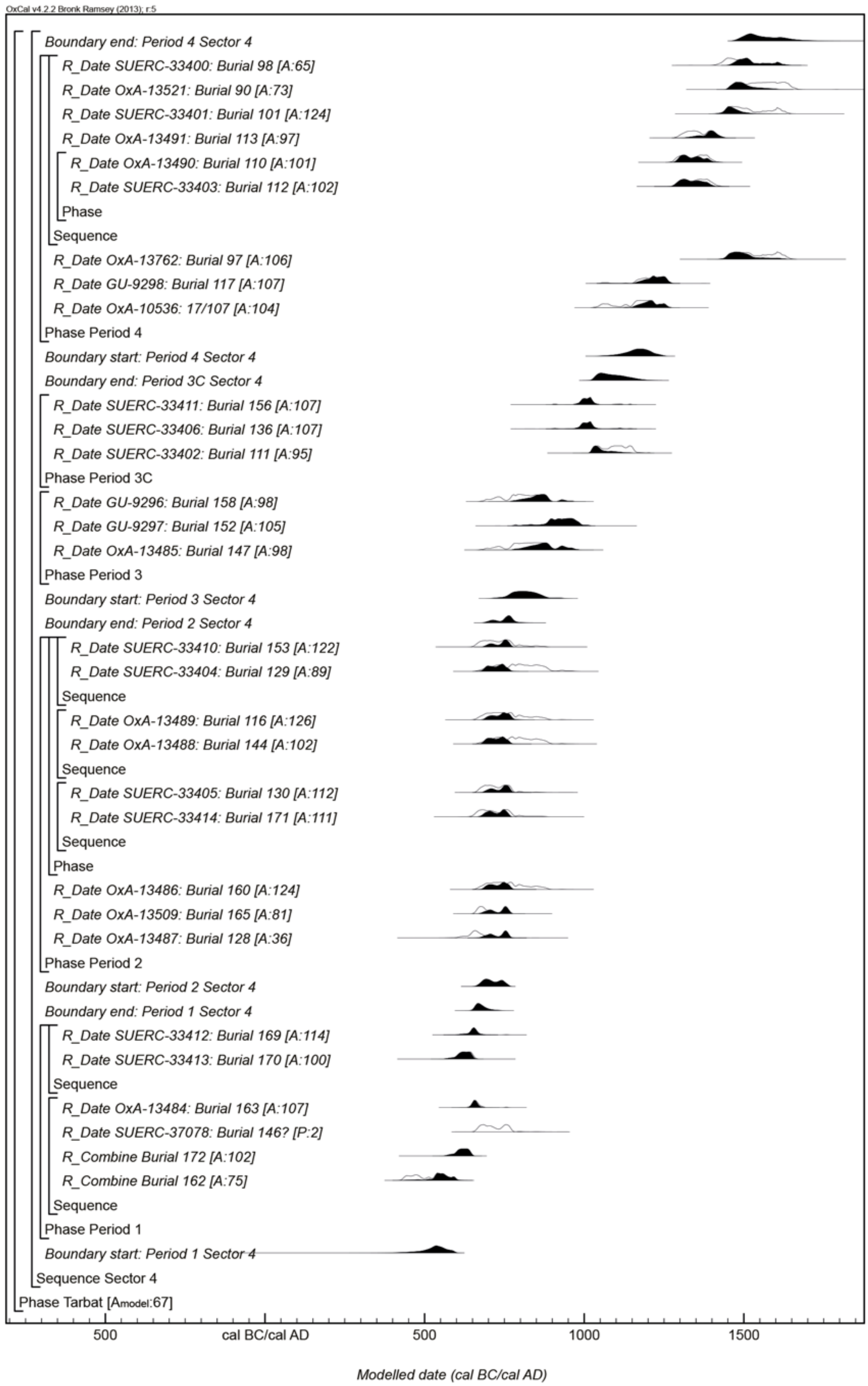

Illustration D3.1.5
Chronological model for Sector 4 at Tarbat. The model structure is as described in Illus D3.1.3

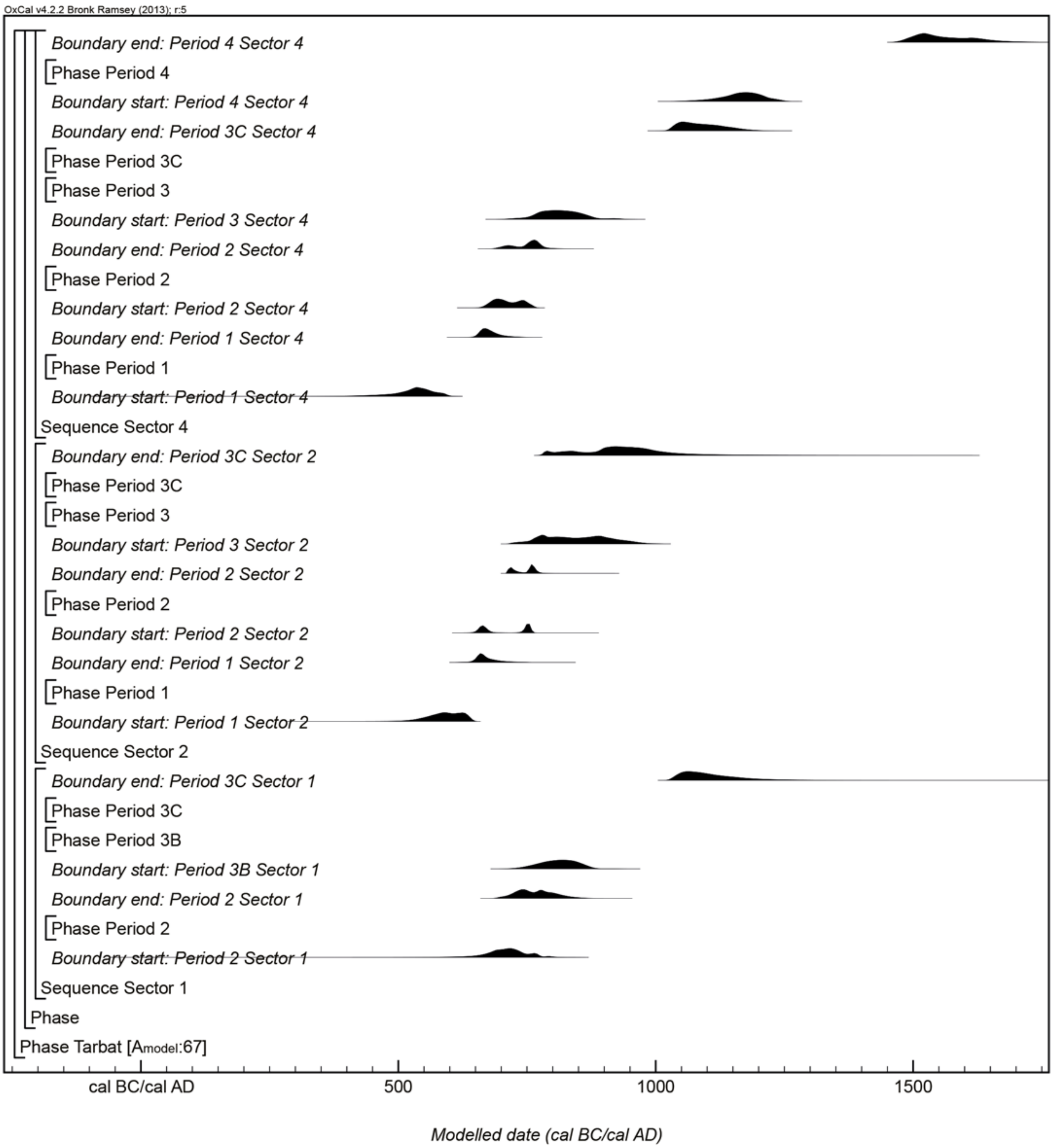

Illustration D3.1.6
Summary of the transitions of all three sectors dated and modelled from Tarbat

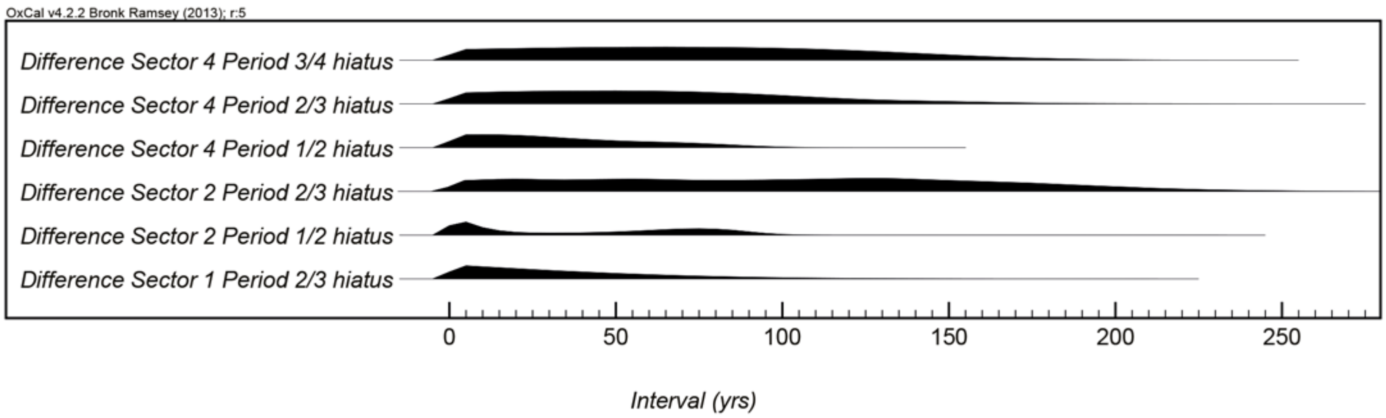

Illustration D3.1.7
Ranges for hiatuses, and potential hiatuses, noted in the archaeology from Tarbat, calculated from the probability estimates shown in the models for Sectors 1, 2 and 4

There are nine burials that belong to Period 2 in Sector 4. The head-support Burial 128 has a result (OxA-13487) on a humerus. Burial 165 provided a result (OxA-13509) from the tibia of this probable simple inhumation. The probable shrouded inhumation (Burial 160) provided a result (OxA-13486) on a leg bone. In addition to the previous three burials, there are three sequences of burials. There is a result (OxA-13488) on a humerus from a simple inhumation, Burial 144, which is followed by head-support Burial 116, from which there is a result (OxA-13489) on a humerus. The second sequence begins with a result (SUERC-33414) from the rib of a simple inhumation (Burial 171), that is followed by Burial 130, from which there is a result (SUERC-33405) on a rib from a probable shrouded inhumation. The third sequence of burials begins with a result (SUERC-33404) on a rib bone from a shrouded inhumation (Burial 129), which is followed by a result (SUERC-33410) on a rib from shrouded inhumation Burial 153.

Period 3

In Sector 1 and 2, Period 3A represents the revival of activity and Period 3B a period of abandon.

Period 3A

In Sector 1 there are two results on single charred barley grains from oval S5 features: SUERC-13283 is from the central pit (F13/C1027), and SUERC-13284 is from the ditch of the same structure (F3/C1153). These two dates relate to grain from the same structure and so should be contemporary, which would suggest the structure likely dates to the ninth or tenth century.

In Sector 2, SUERC-13281 is on a fragment of hazel charcoal from a metal-working hearth (F148/C1412) and represents the first stratigraphic event following the fire in Sector 2.

Period 3B

In Sector 1, SUERC-13285 is on a single charred barley grain recovered from the flue

Table D3.2.2
Calibrated dates for radiocarbon results on samples of human bone that have been identified with a marine component

Lab ID [Burial ID]	Radiocarbon age (BP)	Modelled % marine	Marine-corrected calibrated date (95% confidence)
OxA-13521 [Burial 90]	439 ± 30	29.0	cal AD 1460–1660
OxA-13762 [Burial 97]	475 ± 27	25.3	cal AD 1440–1640
SUERC-33400 [Burial 98]	520 ± 30	24.0	cal AD 1420–1620
OxA-13490 [Burial 110]	644 ± 27	2.7	cal AD 1290–1410
SUERC-33401 [Burial 101]	450 ± 30	13.3	cal AD 1440–1630
SUERC-33403 [Burial 112]	710 ± 30	22.7	cal AD 1280–1420
OxA-13491 [Burial 113]	659 ± 27	18.7	cal AD 1290–1430
OxA-13489 [Burial 116]	1268 ± 28	3.0	cal AD 680–880
OxA-13487 [Burial 128]	1364 ± 28	1.0	cal AD 640–770
OxA-13488 [Burial 144]	1304 ± 28	19.0	cal AD 680–890
OxA-13485 [Burial 147]	1213 ± 31	5.0	cal AD 720–960
OxA-13486 [Burial 160]	1283 ± 27	8.0	cal AD 680–880
SUERC-33414 [Burial 171]	1325 ± 30	6.7	cal AD 660–850

of the converted S1 (F79/C1527) and should represent its last use. OxA-9662 is on a piece of unidentified charcoal that is part of the ultimate fill of the tributary ditch. SUERC-13286 is from a fragment of waterlogged willow that was in a deposit related to the early disuse of the enclosure ditch (F132/C1401). These events should be broadly contemporary.

In Sector 2, a pit that contained an articulated cow burial (F304/C1734) produced a result (SUERC-13282) from a metatarsal. This represents the final disuse of the road (S13).

There are three results from Period 3 burials in Sector 4. There is one result (OxA-13485) on the humerus from a possible wicker-lined burial (147). A second result (GU-9297) is available from the humerus of head-support Burial 152, while the right humerus of shrouded inhumation Burial 158 provides the third result (GU-9296). From head-support inhumation Burial 111, there is a result (SUERC-33402) on a rib. There are results from two bodies in a possible double burial. From the first body (Burial 156) there is a result (SUERC-33411) on a rib, and from the second (Burial 136) there is a result (SUERC-33406) on a rib.

Period 4

The earliest dated events in Sector 4 (assigned to Period 4A) were a bell-casting pit (F107/C1220), which gave a result (OxA-10536) on a fragment of unidentified charcoal, and a single Burial 117, which gave a result (GU-9298) on a humerus. These are contemporary with the early church (Church 2/3).

There were three burials broadly contemporary with the early years of Church 4 (Period 4B): Burial 110, from which there is a result (OxA-13490) on a juvenile tibia, Burial 112, from which there is a result (SUERC-33403) on a rib. There is a result (OxA-13941) from the tibia of a coffined, shrouded Burial 113.

Four other burials belong to a later period, associated with the refurbishment of Church 4 following a fire (Period 4C). The first is a coffined, shrouded Burial 101 dated by a result (SUERC-33401) from a rib. Coffined Burial 90 produced result OxA-13521 on a humerus, while the shrouded Burial 98 produced a result (SUERC-33400) on a rib. These three burials were stratigraphically sequential to those of Period 4B. Another shrouded inhumation (Burial 97) had a humerus dated (OxA-13762).

Bayesian modelling results

The model that follows the relationships given in the section above (Illus D3.1.2) has good agreement between the archaeology and the radiocarbon dates ($A_{model} = 67$). The results for the start and end date of the major periods are given in Table D3.2.3 and Illus D3.1.3–6.

The chronological model for Sector 1 (Illus D3.1.3) begins with Period 2 and ends with a general Period 3. The model estimates that the potential hiatus between the two periods in this sector was *0–115 years* (*95% probability*; Illus 7; *Sector 1 Period 2/3 hiatus*), but maybe only up to *60 years* (*68% probability*).

The chronological model for Sector 2 (Illus D3.1.4) has a greater time-depth, beginning with Period 1 and continuing until Period 3B. Here the hiatus between Periods 1 and 2, as evidenced by the wind-blown sand deposit, was *0–95 years* (*95% probability*; Illus D3.1.7; *Sector 2 Period 1/2 hiatus*), and probably either *0–20 years* (*49% probability*) or *60–85 years* (*19% probability*). There was a break in activity between Periods 2 and 3, evidenced in Sector 2 by the site-wide fire that included the breaking up of sculpture. The Periods 2 and 3 are easily distinguishable and there is the possibility that there was another hiatus in activity at this time

Table D3.2.3
Probability ranges for the start and end dates of the different Periods, by Sector, derived from the modelling shown in Illus D3.3–5

	Sector 1 (Illus D3.3)	Sector 2 (Illus D3.4)	Sector 4 (Illus D3.5)
start: Period 1		cal AD 525–650 (95%) cal AD 570–635 (68%)	cal AD 420–600 (95%) cal AD 500–80 (68%)
end: Period 1		cal AD 635–730 (95%) cal AD 645–85 (68%)	cal AD 645–725 (95%) cal AD 655–90 (68%)
start: Period 2	cal AD 610–780 (95%) cal AD 670–745 (67%) or cal AD 760–770 (1%)	cal AD 645–85 (50%) or cal AD 735–65 (45%) cal AD 655–75 (35%) or cal AD 745–60 (33%)	cal AD 670–760 (95%) cal AD 675–715 (46%) or cal AD 730–50 (22%)
end: Period 2	cal AD 700–840 (95%) cal AD 725–800 (68%)	cal AD 710–80 (95%) cal AD 710–25 (27%) or cal AD 750–70 (41%)	cal AD 690–790 (95%) cal AD 705–25 (11%) or cal AD 745–80 (58%)
start: Period 3		cal AD 735–965 (95%) cal AD 765–840 (38%) or cal AD 850–910 (30%)	cal AD 720–895 (95%) cal AD 770–855 (68%)
end: Period 3			
start: Period 3A	cal AD 740–880 (95%) cal AD 775–855 (68%)		
end: Period 3B	cal AD 1025–1250 (95%) cal AD 1035–1135 (68%)	cal AD 775–1130 (95%) cal AD 785–95 (2%) or cal AD 815–850 (7%) or cal AD 885–1015 (59%)	cal AD 1025–1175 (95%) cal AD 1035–1120 (68%)
start: Period 4			cal AD 1085–1245 (95%) cal AD 1135–1215 (68%)
end: Period 4			cal AD 1470–1690 (95%) cal AD 1490–1590 (61%) or cal AD 1605–25 (7%)

that lasted *0–210 years* (*95% probability*; Illus D3.7; *Sector 2 Period 2/3 hiatus*), and probably *5–150 years* (*68% probability*).

Sector 4 (Illus D3.1.5) has the greatest time-depth, and runs from Period 1 through Period 4. Here the hiatus between Periods 1 and 2 lasted *0–85 years* (*95% probability*; Illus D3.1.7; *Sector 4 Period 1/2 hiatus*), and probably for up to *55 years* (*68% probability*). The hiatus between Periods 2 and 3 lasted for *0–150 years* (*95% probability*; Illus D3.1.7; *Sector 4 Period 2/3 hiatus*), and probably for *1–90 years* (*68% probability*). The break between Periods 3 and 4 lasted for *0–160 years* (*95% probability*; Illus D3.1.7; *Sector 4 Period 3/4 hiatus*), and probably for *5–110 years* (*68% probability*).

It should be noted that, based on the radiocarbon data alone, there is no clear evidence for a hiatus between any of the periods. The calculation of the difference between the end probability for one period and the start of the next always begins in the negative, which indicates the possibility for no hiatus. Given the archaeological evidence for hiatuses between periods in some sectors, it is worthwhile summarising the data based on that evidence. The hiatus between Periods 1 and 2 was dated in Sectors 2 and 4, and suggested a break in activity of perhaps *one century* (*95% probability*), but perhaps only *a half-century* (*68% probability*). The estimated period for the break in activity following the widespread burning (Period 2 to 3) is more varied across the site and ranges from one to two centuries, but the consensus at *68% probability* is *between one-half and three-quarters of a century*. Any break in activity between Periods 3 and 4 would have probably lasted for *up to a century* (*68% probability*), though it might have lasted closer to a *century and a half* (*95% probability*).

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D3.2
Table of Radiocarbon determinations

Lab ID	Context	Material type	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	C:N	Radio-carbon Age (BP)	Calibrated date (95% confidence)
OxA-13521	Burial 90: shrouded inhumation	human bone: male; right humerus	−17.8	15.1	3.3	439 ± 30	cal AD 1420–1480*
OxA-13762	Burial 97: shrouded inhumation	human bone: ?female; right humerus	−18.1	14.7	3.3	475 ± 27	cal AD 1410–1450*
SUERC-33400	Burial 98: coffined inhumation	human bone: male; rib	−17.9	15.4	3.2	520 ± 30	cal AD 1320–1450*
SUERC-33401	Burial 101: coffined, shrouded inhumation	human bone: female; rib	−18.9	14.4	3.2	450 ± 30	cal AD 1410–1470*
OxA-13490	Burial 110: simple inhumation	human bone: juvenile; right tibia	−19.8	13.2	3.3	644 ± 27	cal AD 1280–1400*
SUERC-33402	Burial 111: head-support inhumation	human bone: male; rib	−20.2	11.5	3.3	945 ± 30	cal AD 1020–1170
SUERC-33403	Burial 112: coffined inhumation	human bone: male; rib	−17.9	14.9	3.3	710 ± 30	cal AD 1260–1380*
OxA-13491	Burial 113: coffined, shrouded inhumation	human bone: male; right tibia	−18.6	12.1	3.2	659 ± 27	cal AD 1270–1400*
OxA-13489	Burial 116: head-support burial	human bone: male; left humerus	−19.8	10.6	3.3	1268 ± 28	cal AD 660–810*
GU-9298	Burial 117: simple inhumation	human bone: male; right humerus	−20.5	–	–	830 ± 35	cal AD 1150–1270
OxA-13487	Burial 128: head-support burial	human bone: ?male; right humerus	−19.9	11.5	3.5	1364 ± 28	cal AD 640–690*
SUERC-33404	Burial 129: shrouded inhumation	human bone: male; rib	−20.5	10.8	3.3	1255 ± 30	cal AD 670–880
SUERC-33405	Burial 130: probable shrouded inhumation	human bone: male; rib	−20.5	11.6	3.3	1280 ± 30	cal AD 660–780
SUERC-33406	Burial 136: possible double burial with Burial 156	human bone: male; rib	−20.8	11.5	3.3	1020 ± 30	cal AD 970–1040
OxA-13488	Burial 144: simple inhumation	human bone: male; right humerus	−18.6	14.2	3.4	1304 ± 28	cal AD 650–780*
SUERC-37078	Burial 146: possible cist burial	human bone: female; left 4th metatarsal	−20.8	10.6	3.3	1295 ± 30	cal AD 660–780
OxA-13485	Burial 147: possible wicker-lined burial	human bone: male; right humerus	−19.4	11.1	3.2	1213 ± 31	cal AD 690–900*
GU-9297	Burial 152: head-support burial	human bone: male; right humerus	−20.1	–	–	1120 ± 35	cal AD 780–1000
SUERC-33410	Burial 153: shrouded inhumation	human bone: male; rib	−20.0	11.8	3.3	1315 ± 30	cal AD 650–780
SUERC-33411	Burial 156: possible double burial with Burial 136; head-support burial	human bone: male; rib	−20.8	11.3	3.3	1020 ± 30	cal AD 970–1040
GU-9296	Burial 158: shrouded burial	human bone: male; right humerus	−20.2	–	–	1215 ± 35	cal AD 680–900
OxA-13486	Burial 160: probable shrouded inhumation	human bone: male; left femur or tibia	−19.6	11.1	3.3	1283 ± 27	cal AD 660–780*
SUERC-13255	Burial 162: cist burial	human bone: male; right tibia	−20.9	–	–	1565 ± 35	
OxA-13483	Burial 162: cist burial	human bone: male; left tibia	−21.0	10.4	3.3	1536 ± 26	
mean 162	T′ = 0.4; v = 1; T′(5%) = 3.8					1546 ± 21	cal AD 430–575
OxA-13484	Burial 163: probable shrouded inhumation	human bone: male; left femur or tibia?	−20.6	11.0	3.3	1359 ± 26	cal AD 640–690
OxA-13509	Burial 165: probable simple inhumation	human bone: undetermined; right tibia	−20.6	10.6	3.2	1309 ± 26	cal AD 650–780
SUERC-33412	Burial 169: simple inhumation	human bone: male; rib	−20.2	10.4	3.2	1375 ± 30	cal AD 610–680
SUERC-33413	Burial 170: simple inhumation	human bone: male; rib	−20.5	11.7	3.3	1420 ± 30	cal AD 580–660
SUERC-33414	Burial 171: simple inhumation	human bone: male; rib	−19.1	12.3	3.3	1325 ± 30	cal AD 650–770*
OxA-9699	Burial 172: cist burial	human bone: female; right femur	−20.0	–	–	1498 ± 34	
SUERC-37079	Burial 172: cist burial	human bone: female; left second metatarsal	−20.7	10.7	3.3	1441 ± 23	
mean 172	T′ = 5.3; v = 1; T′(5%) = 3.8					1441 ± 23	cal AD 570–650
SUERC-13256	Burial 186: cist burial in group of three burials	human bone: ?male; left rib	−20.3	10.3	3.4	1525 ± 35	cal AD 420–610
SUERC-33416	Burial 187: cist burial in group of three burials	human bone: male; rib	−20.6	10.7	3.4	1470 ± 30	cal AD 540–650
Balnabruach Burials							
SUERC-13257	Burial A at Balnabruach [Bal A]	human bone: ?male; right ulna	−18.9	11.0	3.3	2290 ± 35	410–230 cal BC
SUERC-13261	Burial B at Balnabruach [Bal B]	human bone: female; left humerus	−20.0	10.1	3.4	1705 ± 30	cal AD 240–420

Lab ID	Context	Material type	δ^{13}C (‰)	δ^{15}N (‰)	C:N	Radio-carbon Age (BP)	Calibrated date (95% confidence)
SUERC-13262	Burial C at Balnabruach [Bal C]	human bone: male; left ulna	−20.1	10.1	3.6	1655 ± 35	cal AD 260–530
OxA-10536	Bell casting pit [17/F107/C1220]	charcoal: unidentified	−27.8	–	–	865 ± 39	cal AD 1040–1260
SUERC-13263	Ditch under church [20/F129/C1345]	carbonised grain: *Hordeum* sp	−23.6	–	–	1465 ± 35	cal AD 540–660
SUERC-33422	Pit with deliberate charcoal deposit [14-24/F573/C3536]	charcoal: birch	−26.3	–	–	1765 ± 30	cal AD 170–380
OxA-9664	Burnt structural timber from primary burning horizon [26/C1030]	charcoal: unidentified	−23.6	–	–	1615 ± 45	cal AD 330–550
SUERC-13271	Cache of metapodials in workshop yard [14-24/C2000]	animal bone: cattle; right metatarsal	−22.7	5.5	3.2	1280 ± 35	cal AD 660–810
SUERC-13265	Butchered bone horizon on eastern roadside surface [14-24/C2335]	animal bone: cattle; left metatarsal (distal)	−21.1	5.4	3.3	1305 ± 35	cal AD 650–780
SUERC-13275	Burnt wattle from structure destroyed in primary burning horizon [14-24/C2704]	charcoal: hazel	−27.2	–	–	1285 ± 40	cal AD 650–810
SUERC-13282	Cow burial [14-24/F304/C1734]	animal bone: cattle; left metatarsal	−22.8	4.4	3.4	1115 ± 35	cal AD 830–1020
SUERC-13276	Stake in situ in stream [14-24/F404/C2295]	waterlogged wood: willow	−28.3	–	–	1305 ± 35	cal AD 650–780
SUERC-13277	Stake in pool [14-24/F436/C2224]	waterlogged wood: willow	−27.3	–	–	1345 ± 35	cal AD 640–770
SUERC-13272	Hearth in S9 yard [14-24/F445/C2468]	carbonised grain: *Hordeum* sp	−23.5	–	–	1350 ± 35	cal AD 640–770
SUERC-13266	Bone raft beneath S9 yard wall [14-24/F480/C3122]	animal bone: cattle; right metatarsal (proximal)	−22.0	5.1	3.3	1340 ± 35	cal AD 640–770
SUERC-13274	Burnt wattle from terrace wall destroyed in primary burning horizon [14-24/F483/C2584]	charcoal: hazel	−26.9	–	–	1370 ± 35	cal AD 610–690
SUERC-13273	Burnt stake from terrace wall [14-24/F490/C2697]	charcoal: hazel	−26.4	–	–	1575 ± 35	cal AD 400–570
SUERC-13581	Hearth in S9 [14-24/F495/C2786]	carbonised grain: *Hordeum* sp	−24.3	–	–	1295 ± 35	cal AD 650–780
SUERC-33421	Well [14-24/F527/C3570]	waterlogged wood: willow; woven well lining	−27.5	–	–	1385 ± 30	cal AD 610–680
SUERC-33420	Hearth [14-24/F535/C3406]	charred hazel nutshell	−24.7	–	–	1335 ± 30	cal AD 640–770
SUERC-13281	Metal-working hearth [14-24/F148/C1412]	charcoal: hazel	−27.7	–	–	1255 ± 35	cal AD 660–880
SUERC-13267	Alignment of worked cattle metapodials in S9 yard [14-24/F393/C1957]	animal bone: cattle; right metatarsal (distal)	−21.6	5.0	3.3	1335 ± 35	cal AD 640–770
SUERC-13283	Central pit of oval S5 [25/F13/C1027]	carbonised grain: *Hordeum* sp	−22.9	–	–	1215 ± 35	cal AD 680–900
SUERC-13284	Ditch of S5 [25/F3/C1153]	carbonised grain: *Hordeum* sp	−22.0	–	–	1065 ± 35	cal AD 890–1030
SUERC-13285	Flue of S1 [11/F79/C1527]	carbonised grain: *Hordeum* sp	−24.3	–	–	925 ± 30	cal AD 1020–1210
SUERC-13286	Deposit relating to the clogging or earliest disuse of the enclosure ditch [25/F132/C1401]	waterlogged wood: willow	−26.0	–	–	1210 ± 35	cal AD 680–940
SUERC-13264	14-24/C2310	bulk sediment: humic acid	−30.0	–	–	2445 ± 35	770–400 cal BC
SUERC-14989	Latest deposit in marsh, between (14-24/2310/4910) and (2296/4863) [14-24/2310/4874]	bulk waterlogged weed seeds	−27.4	–	–	1370 ± 40	cal AD 600–760
SUERC-14990	Earliest deposit in marsh, beneath (14-24/2310/4874) [14-24/2310/4910]	bulk waterlogged seeds	−26.5	–	–	2365 ± 40	720–380 cal BC
SUERC-14994	Earliest deposit in pool, between (14-24/2310/4874) and (2296/4863) [14-24/2296/4873]	waterlogged birch twig	−27.4	–	–	1375 ± 40	cal AD 590–760
SUERC-14995	Latest deposit in pool, above (14-24/2296/4873) [14-24/2296/4863]	bulk waterlogged elder seeds	−26.9	–	–	1300 ± 40	cal AD 650–840
GU-3265	Peat from enclosure ditch S16, Int 1 (Harden 1995)	bulk organic material	−28.8	–	–	1740 ± 50	cal AD 140–410
GU-3266	Peat from enclosure ditch S16, Int 1 (Harden 1995)	bulk organic material	−28.8	–	–	1660 ± 50	cal AD 250–530
GU-3267	Peat from enclosure ditch S16, Int 1 (Harden 1995)	bulk organic material	−29.6	–	–	1590 ± 50	cal AD 350–580
OxA-9663	Wooden stake in situ in outer enclosure ditch	waterlogged wood: unidentified	−24.9	–	–	1410 ± 45	cal AD 550–680

Lab ID	Context	Material type	δ13C (‰)	δ15N (‰)	C:N	Radio-carbon Age (BP)	Calibrated date (95% confidence)
OxA-10159	Supersedes OxA-9663	waterlogged wood: unidentified	–24.0	–	–	1270 ± 33	cal AD 670–890
OxA-9662	Ultimate backfilling of tributary ditch (F18)	charcoal: unidentified	–27.3	–	–	1110 ± 45	cal AD 790–1020
SUERC-2621	Hearth in the Smith's Hall (S1) [Sample #1 F65 C1141]	cremated cow bone	–24.7	–	–	1205 ± 35	cal AD 700–940
SUERC-33415	Hearth in the Smith's Hall (S1) [Sample #2 F65 C1141]	charred hazelnut shell	–25.3	–	–	1255 ± 30	cal AD 670–870

* The calibrated result given here in Table D3.1 is based on the assumption that the individual had a 100% terrestrial diet. The stable isotopes for these samples, however, suggest a marine component to the diet. These results have been adjusted for the marine component and recalibrated in Table D3.2 using a mixture of the terrestrial and marine radiocarbon calibration curves