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RADIOCARBON DATING AND BAYESIAN MODELLING OF THE LATE IRON AGE CREMATION BURIAL CEMETERY AT WESTHAMPNETT (WEST SUSSEX / GB)

The later Iron Age in North-West Europe is characterised by major changes such as the appearance of fortified oppida and new burial rites. This study examines the absolute chronology of the adoption of cremation burial in southern England through radiocarbon dating of human bone from the Late Iron Age cremation cemetery at Westhampnett (West Sussex / GB). The earliest and second largest of its type in Britain, the cemetery occupied a low but prominent hill in the coastal plain, some 9 km from the modern coast and 4 km east of the modern city of Chichester (**fig. 1**).

Some 161 graves, four shrines and numerous pyre sites were found when the cemetery was excavated in 1992 before a new road was built[1]. In the Early Bronze Age, a ring ditch had been constructed on the hill and this monument may have provided the focus for the Iron Age cemetery. The use of space was strongly defined: the shrines and pyres lay in discrete areas, and the graves were arranged around a circular space with later burials added to the periphery. Within this distribution, a minority of well-furnished burials appeared to have been the foci for small clusters of graves. As the graves rarely intercut it is likely that they were marked in some way.

The burials were un-urned, but most of the graves contained pottery, including some early wheel-made vessels, which were placed as grave goods, and about a quarter contained brooches or other metal objects that had accompanied the deceased on the pyre (**fig. 2**). The number of burials suggested that the cemetery was used

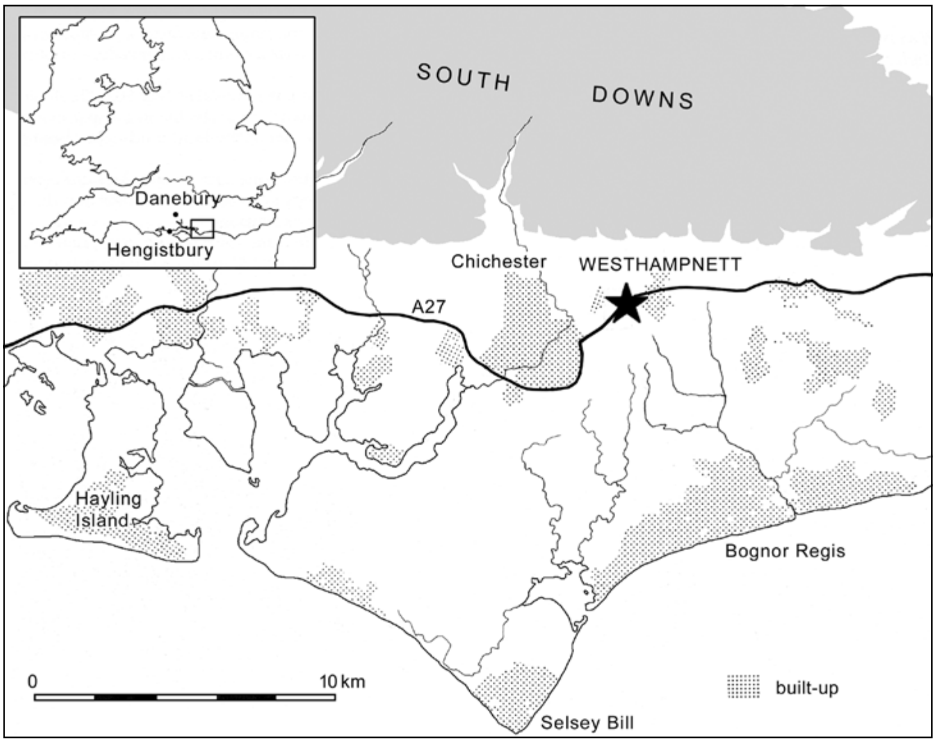


Fig. 1 The location of the Westhampnett cremation burial cemetery (West Sussex / GB). – (Map P. Lowther after Fitzpatrick 1997, fig. 1).

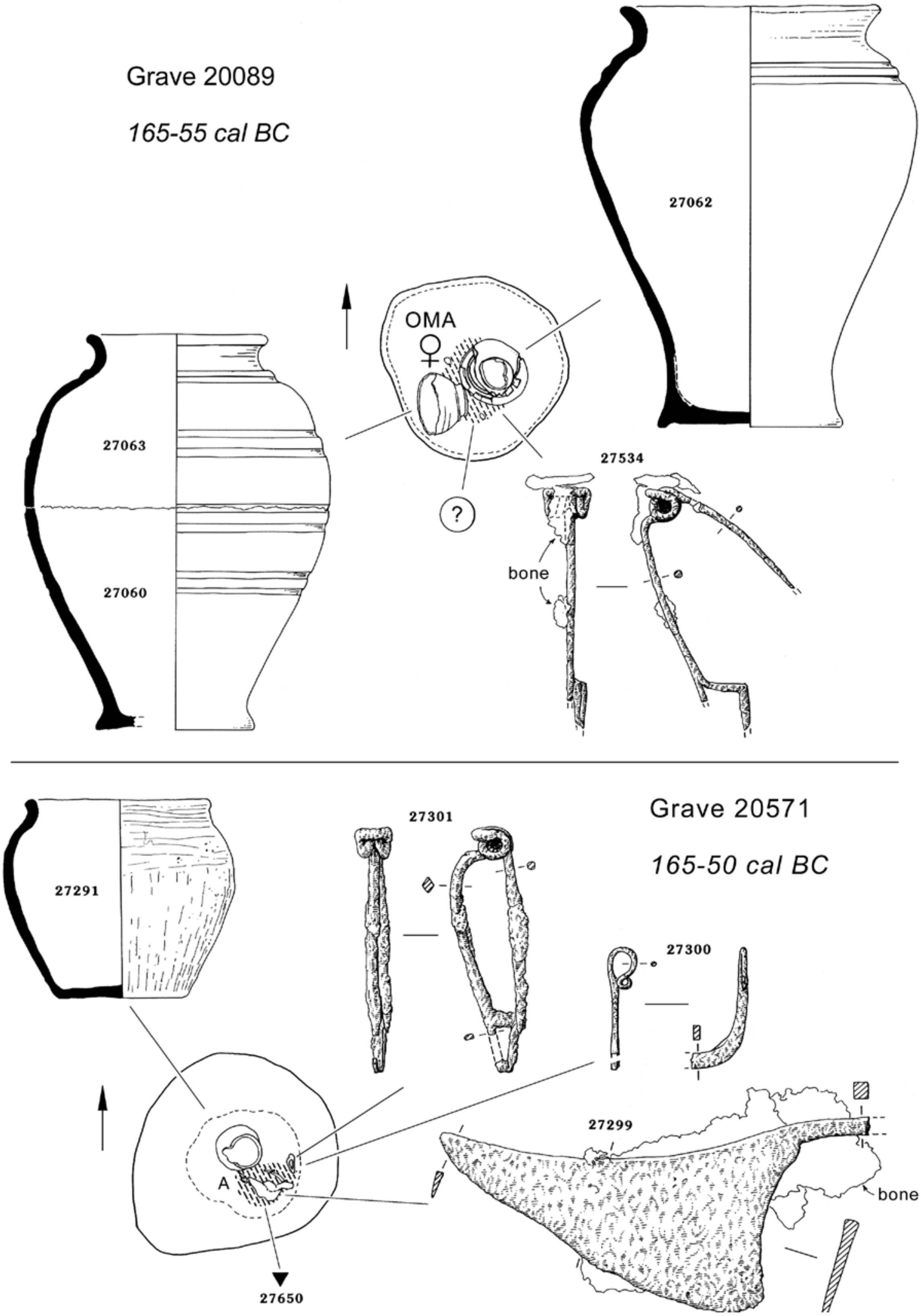


Fig. 2 Westhampnett (West Sussex/GB). Two representative graves from the cemetery selected for dating. The modelled radiocarbon probabilities are also shown. – (After Fitzpatrick 1997, figs 70. 98). – Scale: metalwork 1:2; pottery 1:4.

by a number of settlements. All the graves, pyres and pyre-related features (i.e. features that contained pyre-debris, but were not pyres) were whole-earth sampled in order to retrieve as much evidence as possible.
In addition to the Bronze Age ring ditch and the Iron Age cemetery, the low hill was also the site of a small Romano-British cremation cemetery (1st-2nd century) and a small Anglo-Saxon inhumation cemetery (5th-7th centuries). Both later cemeteries were also fully excavated but are not considered here[2]. The excavations around the hill yielded evidence for occupation for all the periods between the Late Upper Palaeolithic and the Anglo-Saxon, and some flints of Neolithic date were found on the hill itself[3].

CHANGING CHRONOLOGIES: THE 1997 REPORT AND SUBSEQUENT CHANGES TO LATE IRON AGE CHRONOLOGIES

The monograph on the Westhampnett cemeteries was published in 1997. At that time it was not possible to radiocarbon date cremated human bone and the modest budget available for dating was applied to the Late Upper Palaeolithic to Early Bronze Age evidence from the road scheme, as it was considered that the scientific dates would be more helpful for these periods.
The dating of the Iron Age cemetery relied on the pyre and grave goods, especially the brooches. This was not without its difficulties, whilst widely distributed in Continental Europe, where they are typical of the Lt D1 and D2 horizons, the brooches were relatively rare types in Britain. Three main categories are represented (**fig. 3**). One-piece filiform brooches with external chords and short 2- or 4-coil springs predominate (Feugère Type 2a-b)[4], but there were three brooches with internal chords belonging to the Nauheim family (Feugère Type 5a-b) and seven boss-on-bow brooches of the Almgren 65 family (Feugère Type 8b)[5]. No brooches definitely of Middle La Tène construction were present.
The cemetery dating consequently rested on the continental typo-chronologies for these brooches, which had very recently undergone a major revision, resulting in a significantly earlier start for Lt D1[6]. The fragmentation caused by the process of cremation, the transfer of the brittle objects to the grave, and subsequent post-depositional disturbance (mainly by ploughing) made it difficult to distinguish between earlier or later varieties of iron filiform brooches. However, the relatively curved bows of the more complete brooches were considered closer to examples attributed to Lt D2a by A. Miron[7]. While acknowledging the earlier appearance of Nauheim and filiform types on the continent, the Westhampnett brooches were attributed to a period straddling Lt D1b-D2a and a date range for the cemetery of 100-40 BC was suggested, with a preferred range within that of 90-50 BC[8].
Few other metal objects from the cemetery were from well-defined groups with relatively secure typologies and chronologies. These were a winged belt-hook, an iron razor, and a British gold coin. The pottery assemblage was considered to occupy a transitional date between the local Middle Iron Age Saucepan pottery tradition (the St Catherine's Hill/Worthy Down style) and the Late Iron Age pottery of the »Aylesford-Swarling« tradition best known from cremation burials in south-east England. However, the typological affinities of the assemblage were considered to be as much with Lower Normandy, and to a lesser extent Armorica, as within Britain. As the spatial organisation of the cemetery seemed to have been established early on, the site was regarded as only having a single phase. While cautious in relation to A. Miron's chronology for the Saar-Moselle region, the preferred date range of 90-50 BC for Westhampnett represented a significantly earlier dating for the adoption of cremation burial in England, which had previously been dated to after c. 50 BC.
With its fine-grained and seemingly well-dated evidence, Westhampnett has become a reference site for Late Iron Age mortuary rituals and chronology in southern Britain[9], but 20 years on, the time has come to revisit the dating.

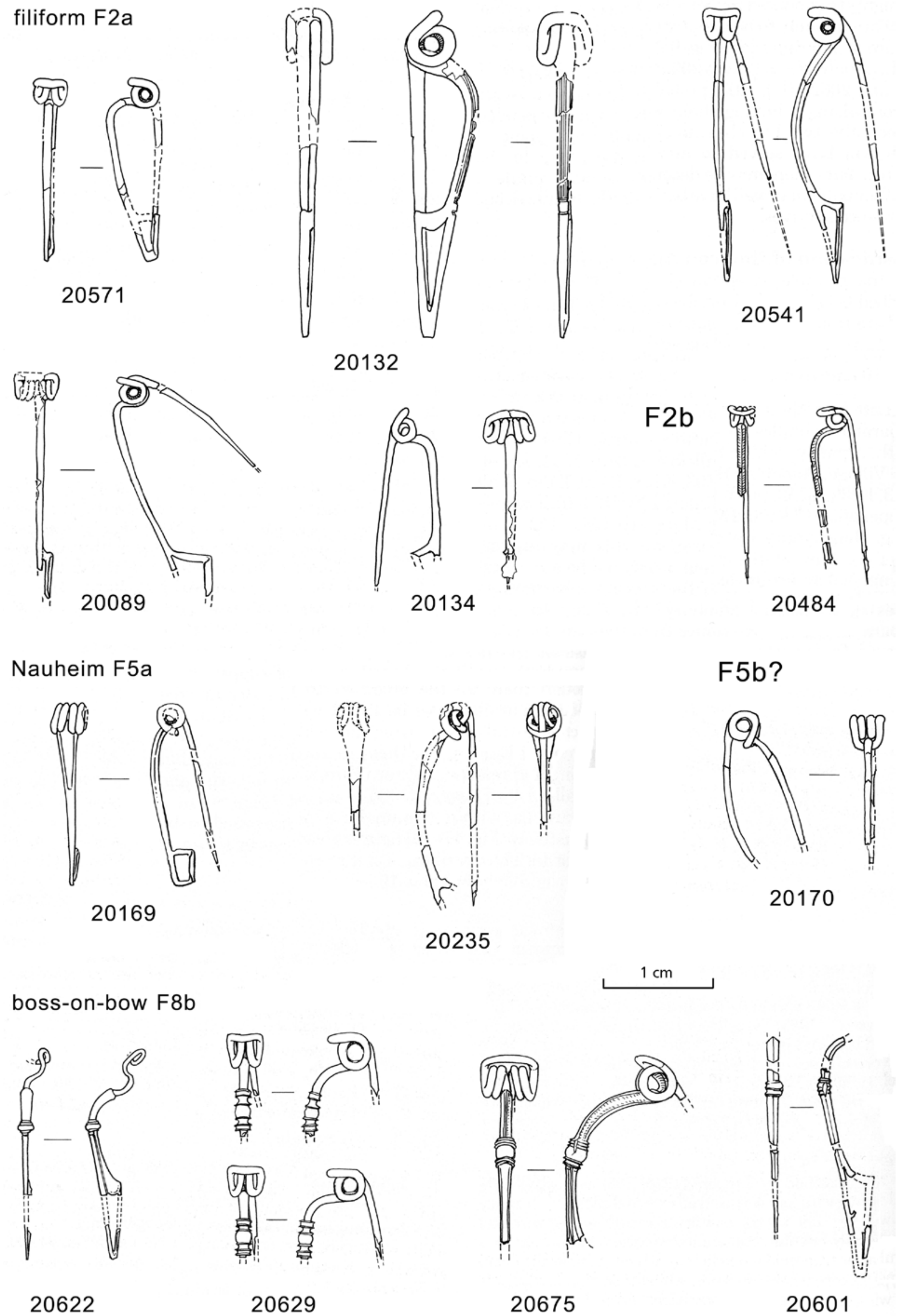


Fig. 3 Westhampnett (West Sussex / GB). Principal types of brooches from the cemetery. The brooches illustrated are all of iron apart from those from graves 20622 (silver) and 20484, 20609 and 20675 (all copper alloy). – (After Fitzpatrick 1997, fig. 47).

Firstly, a series of studies using Bayesian modelling to develop independent radiocarbon chronologies for later Iron Age artefact typologies have yielded earlier than expected dates for insular metalwork previously dated by reference to the continent[10]. Some of the dates obtained in these programmes are not without their difficulties and will be discussed elsewhere, but others raise questions about the accepted chronologies. To give one example, modelled dates for two Arras-culture inhumation burials in East Yorkshire in northern England imply that one-piece filiform brooches of Late Iron Age form appeared before the mid-2nd century BC[11]. Although the brooches in question have solid rather than framed catch-plates like the Westhampnett examples, and would generally be considered to be typologically later, they pose questions about the accepted dating of the series that need to be addressed.

Secondly, the chronology of the presumed continental brooch prototypes is also open to question. The start of Lt D1b west of the Rhine, for which Nauheim and one-piece filiform brooches are one of the principal markers, is usually set around 120 BC, but a date of 130 BC has been advocated in some areas[12]. Independent evidence that would resolve the matter is not only in short supply but also, particularly where it takes the form of dendrochronological dates from loosely associated pieces of wood, it is sometimes open to question.

Moreover, dating the start of Lt D1b establishes when these brooch types became widespread, not when they first appeared. In Lorraine, some contexts containing early varieties of Nauheim brooches are now thought to belong to an earlier phase of Lt D1[13]. One-piece iron filiform brooches with external chords and long springs also occur in Lt D1a graves in eastern France[14] and in the Bern region (CH) the type is suggested to have appeared between 160 and 125 BC[15]. These brooches have longer springs than the examples from Westhampnett but show that filiform brooches developed from Lt C2 types rather than from the Nauheim[16]. Lastly, boss-on-bow brooches related to the Almgren 65 – the latest form at Westhampnett – are recorded in Lt D1 contexts[17], which may also have implications for the end date of the cemetery.

Thirdly, radiocarbon dating of calcined bone is now widely applied to prehistoric burials of all periods across North-West Europe[18], including the Iron Age[19]. Allied to Bayesian modelling, which allows archaeologists to date events to margins of decades rather than centuries[20], it should be possible to develop robust chronologies for cremation burial cemeteries that provide a similar level of precision to artefact typo-chronologies. Westhampnett provides a good test case; quite apart from the merits of revisiting any chronology that is now 20 years old in the light of current understanding, the presence of brooches in many of the graves allows us directly to confront the two forms of dating. Any addition to the limited corpus of independent dates for the brooch types that form a mainstay of Late Iron Age chronologies on both sides of the Channel has to be of value. More widely, the study could open the way to the systematic dating of cremation burials across Central and Western Europe, which are widely seen as a diagnostic trait of the Late La Tène.

It was clear, therefore, that successful radiocarbon dating of the Westhampnett cemetery could have a significance reaching far beyond southern England. The radiocarbon dating programme reported on here was undertaken with the aid of a grant from the UK Natural Environment Research Council (NERC) Radiocarbon Facility for Archaeology.

RADIOCARBON DATING CREMATION BURIALS

The method of pretreating calcined bone to enable radiocarbon dating was first published by J. N. Lanting et al.[21] Before this, it was impossible to date calcined bone. An interlaboratory study by P. Naysmith et al. showed good reproducibility of radiocarbon dates on cremated bone by six laboratories, demonstrating the technical method to be reliable[22]. Unlike the radiocarbon age produced from extracted bone collagen (i.e. from an inhumation burial), which dates the death of the individual, the processes of cremation are

such that the radiocarbon measurement on this material directly dates the cremation. A potential problem for interpretation is the possibility for carbon exchange between the bioapatite, the datable fraction of the cremated bone, and the carbon (CO and CO_2) in the pyre »atmosphere« that is derived from the fuel source. This possibility for exchange has been demonstrated using both controlled laboratory cremation[23] and small real-world experiments on joints of animal meat[24]. While the processes are not fully understood, for an offset to occur requires the pyre fuel to contain »old« carbon (i.e. coal, old growth wood, or even peat).
Although the analysis of the charcoals found in the pyres at Westhampnett indicated a preponderance of roundwood from coppices that were managed to provide fuel[25], the occurrence of iron nails and structural fittings in almost every pyre site and pyre-related feature strongly suggests that some wooden objects and/or seasoned timbers were reused as fuel[26]. In practice, the need to sustain temperatures of over 700 °C for several hours in order to cremate the corpse[27] and for the pyre to maintain its shape in order to provide the heat to do this means that seasoned timbers, probably of oak, were almost certainly used[28]. The rarity of charcoals from heartwood amongst the excavated charcoals at Westhampnett may be due to these timbers being reduced to ash (presumably because they were left to burn overnight and it was only possible to approach the pyre the following morning). The smaller, coppiced, timbers may have been placed both within and around the pyre and it may be that only the smaller timbers that were placed around the pyre and fell away from it, survived as identifiable charcoals. Therefore as a precaution, replicate measurements on charred seeds or roundwood charcoal from ten graves were sought as a cross-check on the cremated bone results. This has been shown to demonstrate the reliability of the bone measurements for accurately dating cremation burials[29].
Simulation models were run to estimate the number of samples needed to establish the date and duration of the cemetery, and to investigate whether there was discernible spatial and chronological patterning between the graves. As well as dating all graves with identifiable brooches, a representative sample of graves without brooches was also dated because brooches may not have featured in the funerary rites throughout the lifetime of the cemetery. Graves containing other typical Late Iron Age objects such as locally-made copies of Armorican wheel-made pottery were also dated, as was the one grave with a funerary monument (grave 20566). To accommodate a longer timespan than the 40-60 years proposed in 1997, multiple simulations were created that allowed for the cemetery to have been used for up to 100-150 years. These models estimated that 50-55 dates were required, including replicate measurements on ten graves.

METHODOLOGY

A total of 54 samples from 44 of the 161 cremation graves (27 %) were submitted to the Oxford Radiocarbon Accelerator Unit (ORAU) for dating by accelerator mass spectrometry (AMS). All the samples were single entities[30]. They consisted of a single fragment of cremated bone from each of the 44 burials (**fig. 4**) and ten samples of non-human material from nine burials to test for offsets in the dates of the cremated bone. Six of the replicate samples consisted of carbonized cereal remains, along with a charred hazelnut shell, fragments of hazel and ash charcoal and a piece of cremated sheep long bone. All of these samples were found amongst the cremated bone. Only a small minority of graves contained material suitable for replicate samples.
The samples were pretreated following methods detailed in F. Brock et al.[31] and have been calibrated using the internationally agreed IntCal13 calibration curve of P. J. Reimer et al.[32] There was insufficient charred material for dating in one replicate sample (20601b), but three auto-replicate dates were generated as part of the ORAU internal Quality Assurance procedures, giving a total of 56 determinations (**tab. 1**).

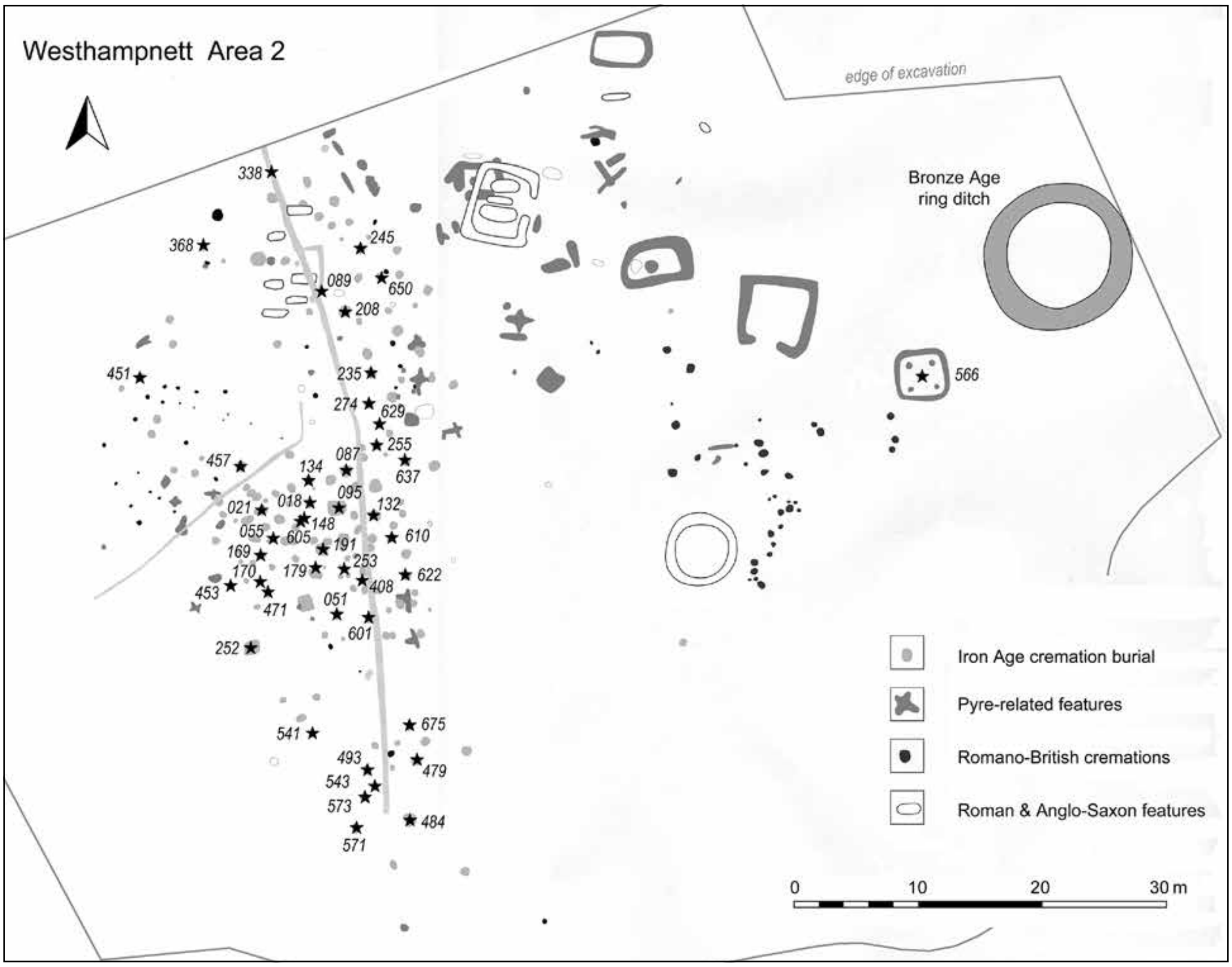


Fig. 4 Plan of the Westhampnett cemetery (West Sussex/GB) showing the location of the dated graves. The first two digits (20) are omitted from the burial numbers. – (Illustration P. Lowther after Fitzpatrick 1997, fig. 6).

Five of the eight pairs of samples have radiocarbon measurements that fail a chi-square test (**tab. 2**)[33]. As the paired samples were of short-lived material, there was no reason to expect any offset in age. For three pairs, the result from the replicate is clearly too early. The hazel charcoal from grave 20095 dates from the Neolithic, whilst the charred cereal from graves 20089 and 20245 is of earlier Iron Age date. The charred hazelnut shell from grave 20170 dates to the Late Iron Age, but fails the chi-square test and so appears to be residual in this grave. On the other hand, the Late Iron Age cereal in grave 20018 would seem to be intrusive, as it is younger than its pair.

These discrepancies are not particularly surprising in view of the abundant evidence for earlier activity nearby. This includes Neolithic flints from the hill itself and in general, there was a marked increase in settlement on the West Sussex Coastal Plain through the Late Bronze Age and Iron Age[34]. Mention should also be made of a grain of bread wheat, submitted as a second replicate from grave 20170, which proved to be modern (OxA-32645, not listed in **tab. 2**). Although rare in Britain during the Iron Age, bread wheat was widely cultivated in France[35], so its presence in a cemetery with strong continental links would have been of considerable interest if the seed proved to be of Iron Age date. Truncation by ploughing and the fact that the burials were un-urned made it comparatively easy for small materials like seeds to be intrusive amongst the cremated bone, as evidently happened in this case and with grave 20018 (above).

lab ID	context (sample)	associated finds (brooches unless otherwise specified)	material dated	δ13C (‰)	radio-carbon age (BP)	modelled date (95 % prob-ability)
OxA-32485	20018 (a)		cremated human bone	–21.73	2207 ± 26	225-85 cal BC
OxA-32444	20018 (b)		carbonized cereal	–22.58	2110 ± 28	185-65 cal BC
OxA-32486	20021 (a)	Feugère 2a? 4-coil, iron	cremated human bone	–18.94	2089 ± 25	170-60 cal BC
OxA-32949	20021 (b)		cremated sheep bone	–21.76	2123 ± 33	195-70 cal BC
OxA-32487	20051		cremated human bone	–19.93	2149 ± 26	200-80 cal BC
OxA-32488	20055	crescent-shaped iron knife	cremated human bone	–17.26	2099 ± 26	175-60 cal BC
OxA-32489	20087		cremated human bone	–19.41	2110 ± 27	185-65 cal BC
OxA-32522	20089 (a)	Feugère 2a 4-coil, iron	cremated human bone	–20.47	2068 ± 28	165-55 cal BC
OxA-32445	20089 (b)		carbonized cereal	–24.99	2513 ± 27	
OxA-32523	20095 (a)		cremated human bone	–20.29	2141 ± 27	200-80 cal BC
OxA-32402	20095 (b)		charcoal: *Corylus avellana*; roundwood	–27.99	4250 ± 31	
OxA-32617	20132	Feugère 2a 2-coil, iron	cremated human bone	–21.07	2077 ± 26	170-60 cal BC
OxA-32524	20134	Feugère 2a 4-coil, iron	cremated human bone	–22.12	2149 ± 27	200-80 cal BC
OxA-32525	20148		cremated human bone	–25.46	2133 ± 28	195-75 cal BC
OxA-32527	20169 (a)	Feugère 5a 4-coil, iron	cremated human bone	–22.59	2121 ± 27	
OxA-32557*	20169 (a)		cremated human bone	–21.87	2103 ± 28	
mean 20169 (a)		T′ = 0.2; ν = 1; T′ (5 %) = 3.8			2112 ± 20	185-70 cal BC
OxA-32618	20170 (a)	Feugère 5b 4-coil, iron	cremated human bone	–22.99	2034 ± 26	160-50 cal BC
OxA-32619	20170 (b)		carbonized hazelnut shell	–25.78	2109 ± 26	185-65 cal BC
OxA-32645	20170 (c)		carbonized grain: *Triticum aestivum*	–26.83	[fM 1.64176 ± 0.00423]	
OxA-32950	20179	Feugère 2a? 4-coil, iron	cremated human bone	–19.35	2097 ± 31	180-60 cal BC
OxA-32620	20191	Feugère 2a? 4-coil, iron	cremated human bone	–19.23	2102 ± 26	180-60 cal BC
OxA-32621	20208		cremated human bone	–19.68	2099 ± 26	175-60 cal BC
OxA-32622	20235	Feugère 5a 4-coil, iron	cremated human bone	–20.26	2145 ± 27	200-80 cal BC
OxA-32623	20245 (a)		cremated human bone	–20.87	2058 ± 26	165-55 cal BC
OxA-32951	20245 (b)		carbonized cereal	–22.77	2466 ± 32	
OxA-32624	20252 (a)	2 × Feugère 2a 2-coil, iron; iron winged belt hook	cremated human bone	–24.17	2147 ± 29	200-80 cal BC
OxA-32952	20252 (b)		charcoal: *Fraxinus* sp.	–25.50	2068 ± 32	
OxA-32953*	20252 (b)		charcoal: *Fraxinus* sp.	–25.99	2051 ± 31	
mean 20252 (b)		T′ = 0.1; ν = 1; T′ (5 %) = 3.8			2059 ± 23	165-55 cal BC
OxA-32625	20253 (a)	Feugère 2, 4 or 5b, iron	cremated human bone	–21.70	2061 ± 27	165-55 cal BC
OxA-32626	20253 (b)		carbonized cereal	–22.81	2089 ± 27	175-60 cal BC
OxA-32627	20255	iron razor	cremated human bone	–23.60	2091 ± 27	175-60 cal BC
OxA-32628	20274		cremated human bone	–17.72	2125 ± 26	195-75 cal BC
OxA-32954	20338	Feugère 2a? 4-coil, iron	cremated human bone	–20.69	2235 ± 34	225-85 cal BC
OxA-32955	20368	Feugère 2a? 4-coil, iron	cremated human bone	–21.77	2138 ± 33	200-75 cal BC
OxA-32858	20408	Feugère 2a? 4-coil, iron	cremated human bone	–19.00	2052 ± 28	165-55 cal BC
OxA-32629	20451		cremated human bone	–23.83	2107 ± 28	185-65 cal BC
OxA-32630	20453	Feugère 2, 4, or 5b, iron	cremated human bone	–21.27	2195 ± 27	
OxA-32631*	20453		cremated human bone	–20.85	2184 ± 26	
mean 20453		T′ = 0.5; ν = 1; T′ (5 %) = 3.8			2075 ± 20	220-85 cal BC
OxA-32632	20457		cremated human bone	–26.29	2196 ± 28	220-85 cal BC
OxA-32633	20471		cremated human bone	–20.91	2158 ± 37	205-75 cal BC
OxA-32634	20479		cremated human bone	–21.70	2132 ± 28	195-75 cal BC
OxA-32635	20484	Feugère 2b 2-coil, copper alloy	cremated human bone	–23.56	2116 ± 28	190-70 cal BC
OxA-32636	20493	British O gold quarter-stater	cremated human bone	–19.74	2105 ± 26	180-65 cal BC
OxA-32637	20541	Feugère 2a 2-coil, iron	cremated human bone	–16.71	2112 ± 26	185-65 cal BC
OxA-32956	20543	Feugère 2a? 2-coil, iron	cremated human bone	–22.64	2082 ± 32	175-60 cal BC
OxA-32638	20566		cremated human bone	–18.41	2422 ± 27	
OxA-32639	20571	Feugère 2a 2-coil; iron knife; iron latch lifter	cremated human bone	–18.83	2034 ± 32	165-50 cal BC
OxA-32640	20573	Feugère 2a? 4-coil, iron	cremated human bone	–20.06	2115 ± 26	190-70 cal BC
OxA-32641	20601 (a)	2 × Feugère 8b, iron	cremated human bone	–19.23	2083 ± 27	170-60 cal BC
OxA-32859	20605	Feugère 2, 4, or 5b, iron	cremated human bone	–19.54	2116 ± 28	190-70 cal BC
OxA-32642	20610	Feugère 2a? 2-coil, iron	cremated human bone	–24.96	2100 ± 28	180-60 cal BC
OxA-32643	20622	Feugère 8b, silver; wooden tub with iron binding	cremated human bone	–19.05	2108 ± 27	185-65 cal BC
OxA-32860	20629	2 × Feugère 8b 2-coil, copper alloy	cremated human bone	–19.38	2125 ± 27	195-75 cal BC
OxA-32957	20637		cremated human bone	–25.12	2058 ± 31	165-55 cal BC
OxA-32658	20650		cremated human bone	–21.10	2151 ± 32	205-75 cal BC
OxA-32644	20675	2 × Feugère 8b 4-coil, copper alloy	cremated human bone	–19.44	2080 ± 29	170-60 cal BC

grave	lab ID	material	radiocarbon date (BP)	chi-square result	
20018	OxA-32485	human bone	2207±26	T′=6.4; ν=1; T′ (5%)=3.8	fail
	OxA-32444	cereal	2110±28		
20021	OxA-32486	human bone	2089±25	T′=0.7; ν=1; T′ (5%)=3.8	pass
	OxA-32949	sheep bone	2123±33		
20089	OxA-32522	human bone	2068±28	T′=130.5; ν=1; T′ (5%)=3.8	fail
	OxA-32445	cereal	2513±27		
20095	OxA-32402	hazel charcoal	4250±31	T′=2651.8; ν=1; T′ (5%)=3.8	fail
	OxA-32523	human bone	2141±27		
20170	OxA-32618	human bone	2034±26	T′=4.2; ν=1; T′ (5%)=3.8	fail
	OxA-32619	hazelnut shell	2109±26		
20245	OxA-32623	human bone	2058±26	T′=98.8; ν=1; T′ (5%)=3.8	fail
	OxA-32951	cereal	2466±32		
20252	OxA-32624	human bone	2147±29	T′=5.9; ν=1; T′ (5%)=6.0	pass
	OxA-32952	ash charcoal	2068±32		
	OxA-32953*		2051±31		
20253	OxA-32625	human bone	2061±27	T′=0.5; ν=1; T′ (5%)=3.8	pass
	OxA-32626	cereal	2089±27		

Tab. 2 Chi-square test results for paired samples from eight of the 44 cremations. – A sample of bread wheat submitted as a second replicate from grave 20170 proved to be modern and is omitted; OxA-32645.

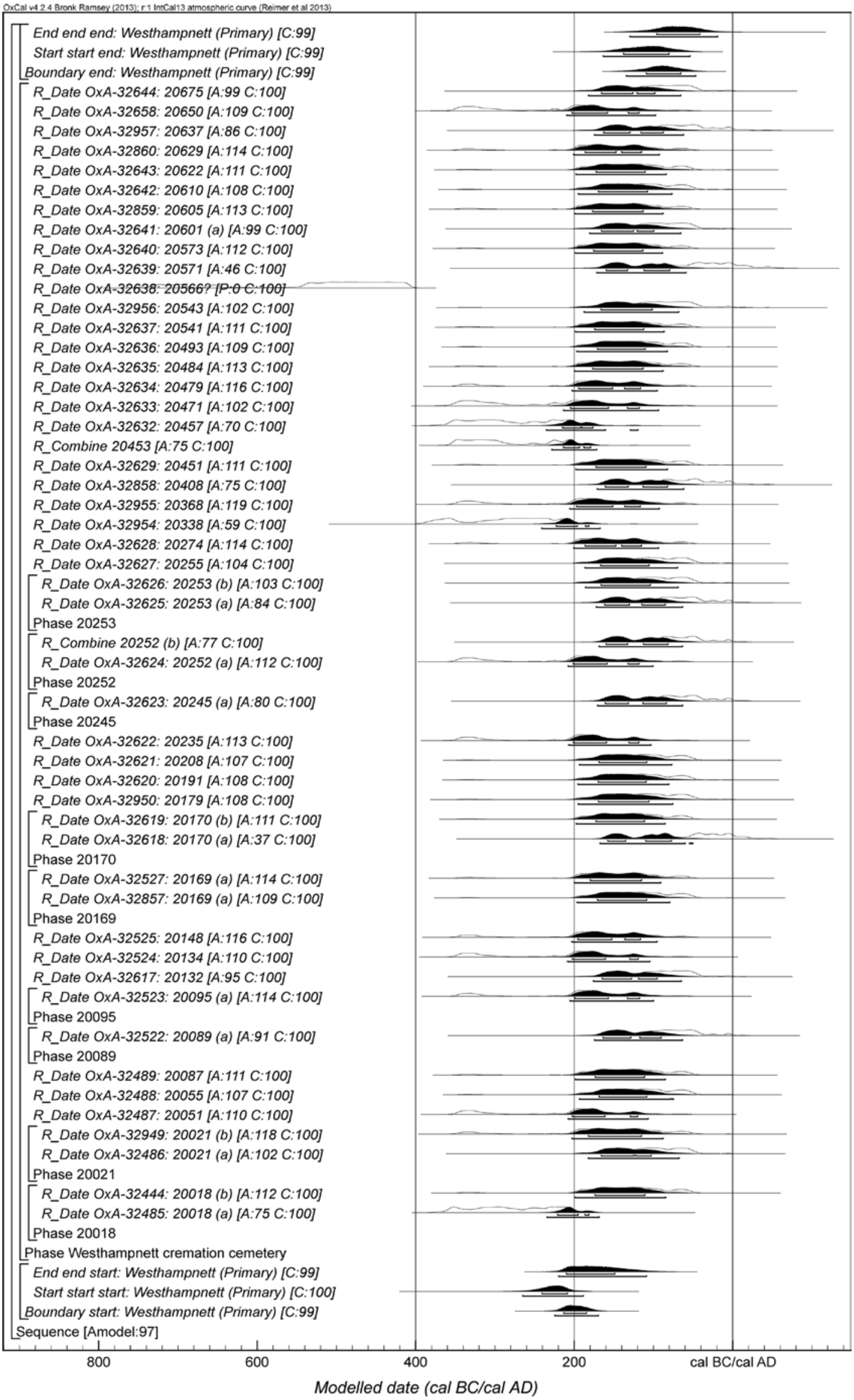
CHRONOLOGICAL MODELS

The three results among the paired dates that predate 500 cal BC have been excluded from further analysis (OxA-32402, -32445, -32951), but the two that fall broadly within the expected range were both retained, giving a total of 52 dates for modelling the use of the cemetery[36].

These dates are very consistent, apart from OxA-32638 for grave 20566, which is significantly earlier than the others. This grave was the only one to be marked by a monument – a four-post structure set within a small ditched enclosure – and it stood 40 m to the east of the cemetery. The burial was also unusual in being urned rather than being un-urned and the pot was the only one in the cemetery with a red slip. This type of funerary monument is well-known in northern France where it is dated to the 4th to 3rd centuries BC[37] and this, in conjunction with the type of burial and the pot, led A. P. Fitzpatrick to suggest that the dead individual (who was probably female) might be from France. However, the Westhampnett burial was suggested to date to the Late Iron Age[38].

OxA-32638 shows that the burial is in fact earlier. Although it calibrates across the »Hallstatt plateau« to 745-400 cal BC (95 % probability), the bulk of the probability density is at 540-410 cal BC (68 % probability), but this still seems early compared to the 4th to 3rd-century French monuments. Given the discrepancy in date, it seems prudent to treat grave 20566 as a separate phase and so we have excluded it from the modelling but retained the calibrated probability (in outline) for visual reference in **figure 5**. Rather than the larger Early Bronze Age ring ditch, it could even have been the focus for the development of the cemetery; it lies due east of the centre of the circular space around which the Late Iron Age cemetery seems to have been organised (see **fig. 4** above)[39].

Tab. 1 Radiocarbon results for the Westhampnett burials (West Sussex/GB). – Radiocarbon measurements denoted by an * are internal auto-replicates measured as part of the Oxford Radiocarbon Accelerator Unit internal Quality Assurance procedures.


OxCal v4.2.4 Bronk Ramsey (2013); r:1 IntCal13 atmospheric curve (Reimer et al 2013)
End end end: Westhampnett (Primary) [C:99]
Start start end: Westhampnett (Primary) [C:99]
Boundary end: Westhampnett (Primary) [C:99]
R_Date OxA-32644: 20675 [A:99 C:100]
R_Date OxA-32658: 20650 [A:109 C:100]
R_Date OxA-32957: 20637 [A:86 C:100]
R_Date OxA-32860: 20629 [A:114 C:100]
R_Date OxA-32643: 20622 [A:111 C:100]
R_Date OxA-32642: 20610 [A:108 C:100]
R_Date OxA-32859: 20605 [A:113 C:100]
R_Date OxA-32641: 20601 (a) [A:99 C:100]
R_Date OxA-32640: 20573 [A:112 C:100]
R_Date OxA-32639: 20571 [A:46 C:100]
R_Date OxA-32638: 20566? [P:0 C:100]
R_Date OxA-32956: 20543 [A:102 C:100]
R_Date OxA-32637: 20541 [A:111 C:100]
R_Date OxA-32636: 20493 [A:109 C:100]
R_Date OxA-32635: 20484 [A:113 C:100]
R_Date OxA-32634: 20479 [A:116 C:100]
R_Date OxA-32633: 20471 [A:102 C:100]
R_Date OxA-32632: 20457 [A:70 C:100]
R_Combine 20453 [A:75 C:100]
R_Date OxA-32629: 20451 [A:111 C:100]
R_Date OxA-32858: 20408 [A:75 C:100]
R_Date OxA-32955: 20368 [A:119 C:100]
R_Date OxA-32954: 20338 [A:59 C:100]
R_Date OxA-32628: 20274 [A:114 C:100]
R_Date OxA-32627: 20255 [A:104 C:100]
R_Date OxA-32626: 20253 (b) [A:103 C:100]
R_Date OxA-32625: 20253 (a) [A:84 C:100]
Phase 20253
R_Combine 20252 (b) [A:77 C:100]
R_Date OxA-32624: 20252 (a) [A:112 C:100]
Phase 20252
R_Date OxA-32623: 20245 (a) [A:80 C:100]
Phase 20245
R_Date OxA-32622: 20235 [A:113 C:100]
R_Date OxA-32621: 20208 [A:107 C:100]
R_Date OxA-32620: 20191 [A:108 C:100]
R_Date OxA-32950: 20179 [A:108 C:100]
R_Date OxA-32619: 20170 (b) [A:111 C:100]
R_Date OxA-32618: 20170 (a) [A:37 C:100]
Phase 20170
R_Date OxA-32527: 20169 (a) [A:114 C:100]
R_Date OxA-32857: 20169 (a) [A:109 C:100]
Phase 20169
R_Date OxA-32525: 20148 [A:116 C:100]
R_Date OxA-32524: 20134 [A:110 C:100]
R_Date OxA-32617: 20132 [A:95 C:100]
R_Date OxA-32523: 20095 (a) [A:114 C:100]
Phase 20095
R_Date OxA-32522: 20089 (a) [A:91 C:100]
Phase 20089
R_Date OxA-32489: 20087 [A:111 C:100]
R_Date OxA-32488: 20055 [A:107 C:100]
R_Date OxA-32487: 20051 [A:110 C:100]
R_Date OxA-32949: 20021 (b) [A:118 C:100]
R_Date OxA-32486: 20021 (a) [A:102 C:100]
Phase 20021
R_Date OxA-32444: 20018 (b) [A:112 C:100]
R_Date OxA-32485: 20018 (a) [A:75 C:100]
Phase 20018
Phase Westhampnett cremation cemetery
End end start: Westhampnett (Primary) [C:99]
Start start start: Westhampnett (Primary) [C:100]
Boundary start: Westhampnett (Primary) [C:99]
Sequence [Amodel:97]
800
600
400
200
cal BC/cal AD
Modelled date (cal BC/cal AD)

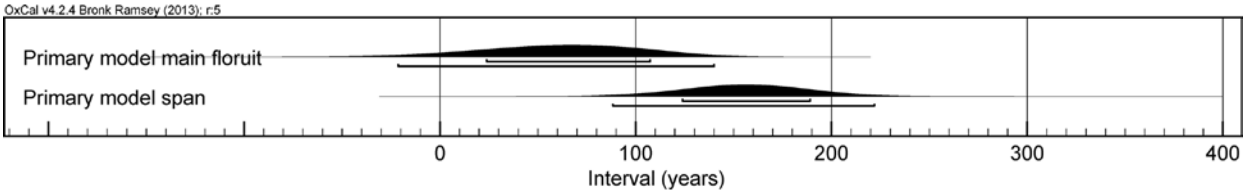


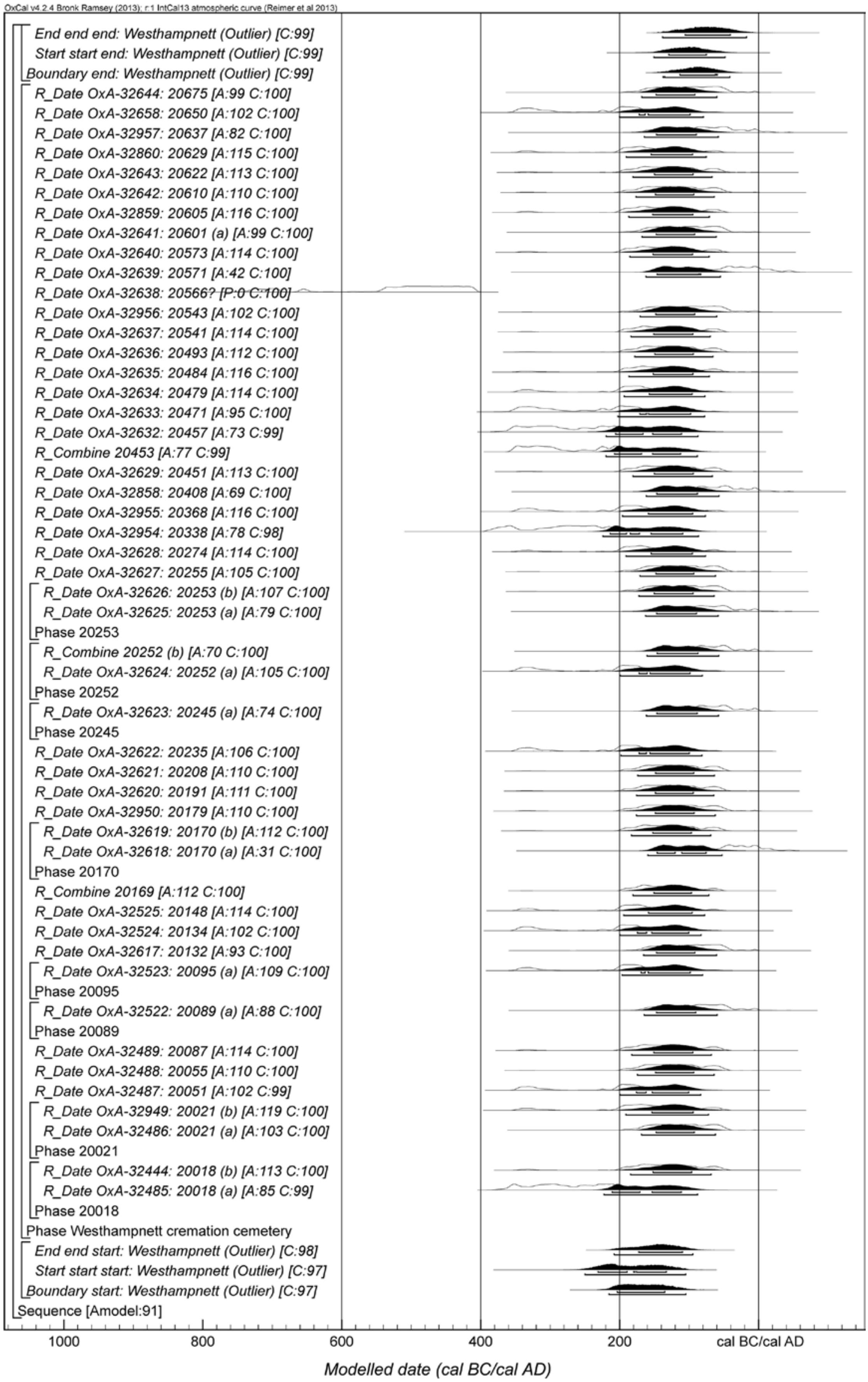
Fig. 6 Probability distributions for the overall span of activity associated with the cremation cemetery (*end end: Westhampnett* [*Primary*]-*start start: Westhampnett* [*Primary*]) and for the span of the main floruit of activity (*end start: Westhampnett* [*Primary*]-*start end: Westhampnett* [*Primary*]), as derived from the modelling shown in **fig. 5**. – (Illustration D. Hamilton).

In developing the dating models for the cemetery it is important to provide an explicit assumption regarding the distribution of the dates through time. Most models make use of the »Uniform Prior«, which effectively acts as a binary switch, where at one moment in time there is no activity and then there is, after which activity occurs relatively uniformly at a maximum level until it ceases, in the same binary manner as it began. C. Willis et al. have argued, however, that the Uniform Prior is not to be preferred where there is no archaeological information to suggest this abrupt increase in activity[40]. In modelling the chronology of the 4th millennium BC cremation burials in the Aubrey Holes at Stonehenge (Wiltshire/GB), C. Willis et al. chose a »Trapezium Prior« model[41], which assumes a gradual increase in activity during the Neolithic, leading to a period of full and constant use, and then a gradual decline. This form of model also allows the tempo of activity to be estimated between the first or last uses of the cemetery and the middle period in which activity was at its peak[42].

The initial or Primary chronological model (**fig. 5**) utilises all 51 dates for the principal phase of Late Iron Age cremation burial. No stratigraphic relationships are modelled between results. This model has good agreement between the radiocarbon dates and the assumption that the dated material is from a »trapezium« distribution, that is to say, that it all belongs to a single phase of relatively continuous activity (Amodel = 97). This Primary model estimates that cremation started at Westhampnett in *270-185 cal BC* (*95% probability*; **fig. 5**; *start start: Westhampnett* [*Primary*]), probably in *245-205 cal BC* (*68% probability*). Peak use began in *220-105 cal BC* (*95% probability*; **fig. 5**; *end start: Westhampnett* [*Primary*]), probably in *210-145 cal BC* (*68% probability*). Cremation began to decline in *165-50 cal BC* (*95% probability*; **fig. 5**; *start end: Westhampnett* [*Primary*]), probably in *140-80 cal BC* (*68% probability*). The activity ended in *130-20 cal BC* (*95% probability*; **fig. 5**; *end end: Westhampnett* [*Primary*]), probably in *100-40 cal BC* (*68% probability*). The total span of dated activity was *85-225 years* (*95% probability*; **fig. 6**; *Primary model span*), and probably *120-190 years* (*68% probability*). The main floruit of cremation activity took place over a period of *1-145 years* (*95% probability*; **fig. 6**; *Primary model main floruit*), and probably *20-110 years* (*68% probability*).

The start date suggested by this model is a century earlier than the date of 100/90 BC proposed in 1997. More importantly, it is several decades earlier that the current date of 130/120 BC for the inception of Lt D1b and the widespread appearance of Nauheim and one-piece filiform brooches west of the Rhine. A shift of several decades might seem relatively unimportant for earlier periods in prehistory, for example in

Fig. 5 Primary chronological model for Westhampnett using the trapezium prior (Lee/Bronk Ramsey 2012). 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 used. The other distributions correspond to aspects of the model. For example, »start start: Westhampnett (Primary)« is the estimated date that this phase of cremation burial activity began on the site, based on the radiocarbon dating results. The large square »brackets« along with the OxCal keywords define the overall model exactly. – (Illustration D. Hamilton).


OxCal v4.2.4 Bronk Ramsey (2013); r:1 IntCal13 atmospheric curve (Reimer et al 2013)
End end end: Westhampnett (Outlier) [C:99]
Start start end: Westhampnett (Outlier) [C:99]
Boundary end: Westhampnett (Outlier) [C:99]
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R_Date OxA-32658: 20650 [A:102 C:100]
R_Date OxA-32957: 20637 [A:82 C:100]
R_Date OxA-32860: 20629 [A:115 C:100]
R_Date OxA-32643: 20622 [A:113 C:100]
R_Date OxA-32642: 20610 [A:110 C:100]
R_Date OxA-32859: 20605 [A:116 C:100]
R_Date OxA-32641: 20601 (a) [A:99 C:100]
R_Date OxA-32640: 20573 [A:114 C:100]
R_Date OxA-32639: 20571 [A:42 C:100]
R_Date OxA-32638: 20566? [P:0 C:100]
R_Date OxA-32956: 20543 [A:102 C:100]
R_Date OxA-32637: 20541 [A:114 C:100]
R_Date OxA-32636: 20493 [A:112 C:100]
R_Date OxA-32635: 20484 [A:116 C:100]
R_Date OxA-32634: 20479 [A:114 C:100]
R_Date OxA-32633: 20471 [A:95 C:100]
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R_Date OxA-32858: 20408 [A:69 C:100]
R_Date OxA-32955: 20368 [A:116 C:100]
R_Date OxA-32954: 20338 [A:78 C:98]
R_Date OxA-32628: 20274 [A:114 C:100]
R_Date OxA-32627: 20255 [A:105 C:100]
R_Date OxA-32626: 20253 (b) [A:107 C:100]
R_Date OxA-32625: 20253 (a) [A:79 C:100]
Phase 20253
R_Combine 20252 (b) [A:70 C:100]
R_Date OxA-32624: 20252 (a) [A:105 C:100]
Phase 20252
R_Date OxA-32623: 20245 (a) [A:74 C:100]
Phase 20245
R_Date OxA-32622: 20235 [A:106 C:100]
R_Date OxA-32621: 20208 [A:110 C:100]
R_Date OxA-32620: 20191 [A:111 C:100]
R_Date OxA-32950: 20179 [A:110 C:100]
R_Date OxA-32619: 20170 (b) [A:112 C:100]
R_Date OxA-32618: 20170 (a) [A:31 C:100]
Phase 20170
R_Combine 20169 [A:112 C:100]
R_Date OxA-32525: 20148 [A:114 C:100]
R_Date OxA-32524: 20134 [A:102 C:100]
R_Date OxA-32617: 20132 [A:93 C:100]
R_Date OxA-32523: 20095 (a) [A:109 C:100]
Phase 20095
R_Date OxA-32522: 20089 (a) [A:88 C:100]
Phase 20089
R_Date OxA-32489: 20087 [A:114 C:100]
R_Date OxA-32488: 20055 [A:110 C:100]
R_Date OxA-32487: 20051 [A:102 C:99]
R_Date OxA-32949: 20021 (b) [A:119 C:100]
R_Date OxA-32486: 20021 (a) [A:103 C:100]
Phase 20021
R_Date OxA-32444: 20018 (b) [A:113 C:100]
R_Date OxA-32485: 20018 (a) [A:85 C:99]
Phase 20018
Phase Westhampnett cremation cemetery
End end start: Westhampnett (Outlier) [C:98]
Start start start: Westhampnett (Outlier) [C:97]
Boundary start: Westhampnett (Outlier) [C:97]
Sequence [Amodel:91]
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800
600
400
200
cal BC/cal AD
Modelled date (cal BC/cal AD)

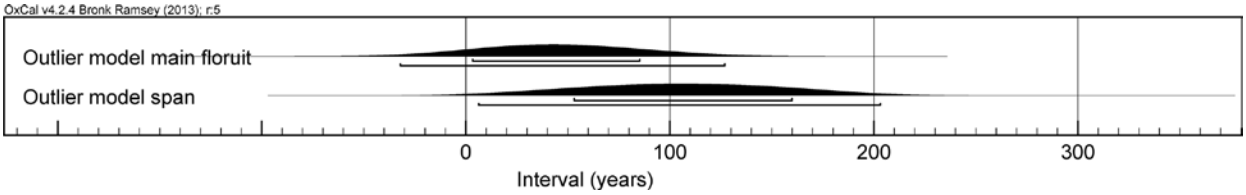

Fig. 8 Probability distributions for the overall span of activity associated with the cremation cemetery (*end end: Westhampnett* [*Outlier*]-*start start: Westhampnett* [*Outlier*]) and for the span of the main floruit of activity (*end start: Westhampnett* [*Outlier*]-*start end: Westhampnett* [*Outlier*]), as derived from the modelling shown in **fig. 7**. – (Illustration D. Hamilton).

the Early Bronze Age for which the dating of cremated bone has been used extensively in Britain and Ireland[43], but can alter the narrative quite dramatically when situated on the cusp of the Roman period.

As noted above, M. C. Hüls et al. and J. Snoeck et al. have shown that an age-offset in cremated bone can be induced during cremation[44]. Moreover, as we have also seen, there are good reasons for thinking that seasoned timbers were used in the Westhampnett pyres[45]. Accordingly, an Outlier model was constructed that assumed an old-wood offset of unknown age was transferred from pyre material to the cremated bone. This model utilises the dataset from the Primary model and applies a »Charcoal Outlier Model« to the dates on the carbonised charcoal and cremated bone to see what effect this has on the results[46]. The single year samples (e. g. charred seeds and hazel nutshell) remain in the model as accurately dating the year of their respective deaths. It is assumed that they were burnt on the pyre, for example as tinder to start the fire.

This Outlier model also has good agreement between the dates (Amodel = 91). It estimates that the start of cremation occurred in *250-100 cal BC* (*95% probability*; **fig. 7**; *start start: Westhampnett* [*Outlier*]), probably in *235-130 cal BC* (*68% probability*). Peak use began in *210-90 cal BC* (*95% probability*; **fig. 7**; *end start: Westhampnett* [*Outlier*]), probably in *175-105 cal BC* (*68% probability*). Cremation began to decline in *155-45 cal BC* (*95% probability*; **fig. 7**; *start end: Westhampnett* [*Outlier*]), probably in *130-75 cal BC* (*68% probability*). The activity ended in *140-15 cal BC* (*95% probability*; **fig. 7**; *end end: Westhampnett* [*Outlier*]), probably in *110-40 cal BC* (*68% probability*). The total span of dated activity was *1-205 years* (*95% probability*; **fig. 8**; *Outlier model span*), probably *50-160 years* (*68% probability*). The main floruit of cremation activity took place over a period of *1-130 years* (*95% probability*; **fig. 8**; *Outlier model main floruit*), and probably *1-90 years* (*68% probability*).

In both models, the probabilities for the end dates of the cemetery are near identical and a high degree of confidence can be placed in these values. Qualitatively, the results are similar, making it difficult to prefer one model over the other. The obvious discrepancy is between the start dates for the Primary and Outlier models, and especially the calculation of when cremation started (e. g. »start start«). The difference between *start start: Westhampnett* (*Primary*) and *start start: Westhampnett* (*Outlier*) is from *–35 to 135 years* (*95% probability*). The negative element stems from the overlap in probabilities, which could reflect the same actual date. On the other hand, these two modelled distributions may differ by as many as 135 years. Interrogating the posterior output for the charcoal outlier indicates there is an offset of *1-78 years* (*95% probability*; **fig. 9**), and probably *1-21 years* (*68% probability*). This suggests that there was indeed sufficient »old wood« in the funeral pyres to induce an offset in the radiocarbon ages of some samples.

Fig. 7 Alternative chronological model for Westhampnett (West Sussex/GB), incorporating a »Charcoal Outlier Model« to account for the uptake of »old carbon« in the cremated remains. The structure is as given in **fig. 5**. – (Illustration D. Hamilton).

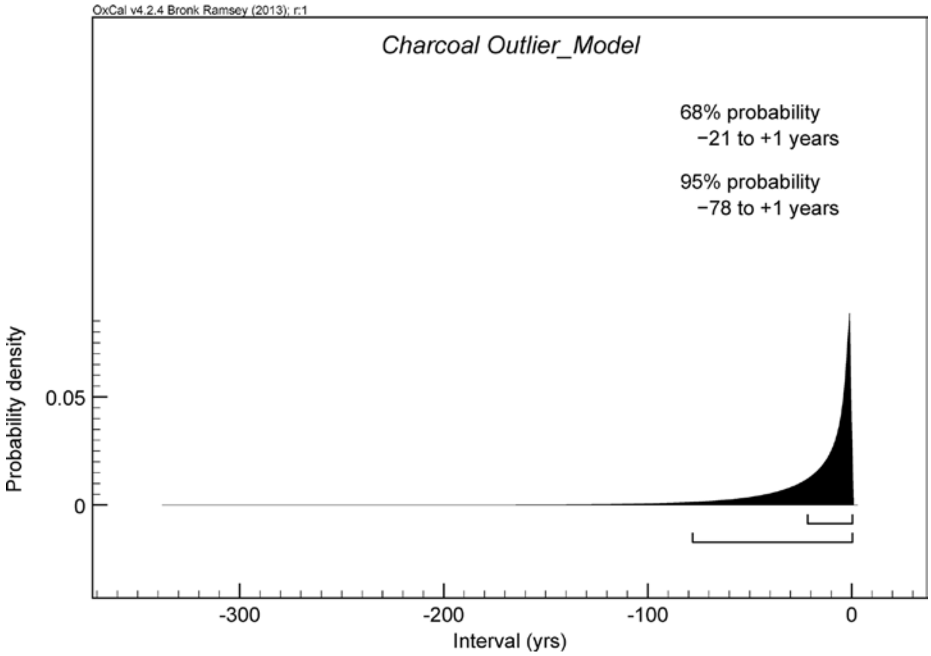

Fig. 9 Charcoal Outlier posterior showing the probability for the »old wood« offset across these samples. – (Illustration D. Hamilton).

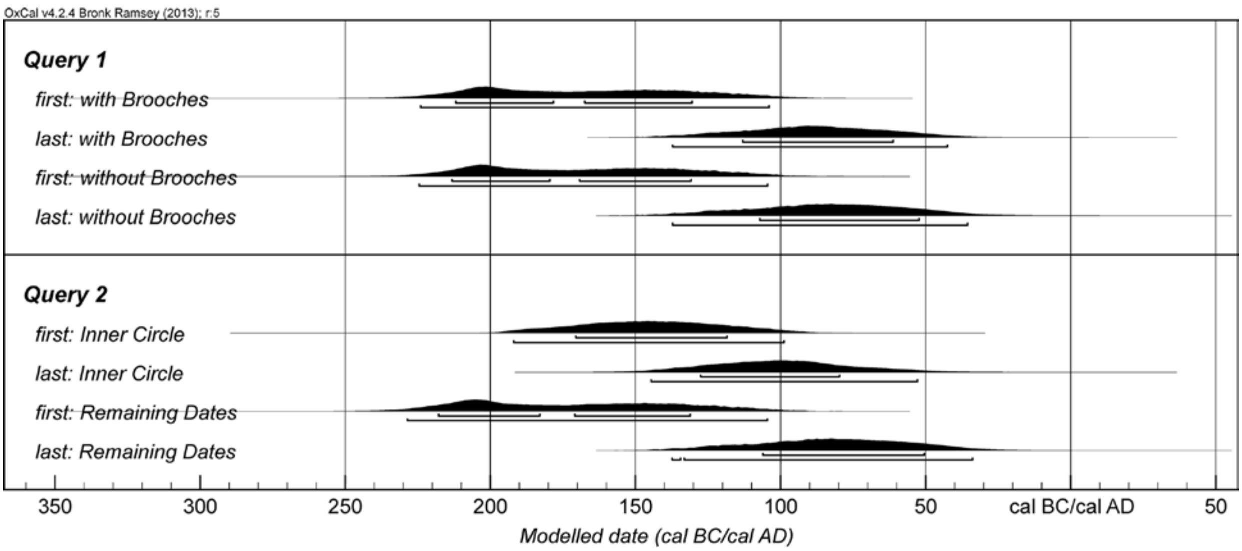

Fig. 10 Probability distributions for the start and end dates for the graves identified in Queries 1-2. – (Illustration D. Hamilton).

Returning to the discrepant start dates it becomes clear that the Outlier model, whilst maintaining much of the probability in the Primary model, has lessened the overall precision in the probability density estimate for *start start: Westhampnett* (*Outlier*). This reduces the precision of the dating, but more realistically represents the increased errors in the model associated with the possible uptake of »old carbon« during the cremation process, and so somewhat paradoxically, increases its overall accuracy. Along with the greater consistency with current typo-chronologies, this leads us to prefer the Outlier model and to employ it for exploring some possible chronological patterns within the cemetery.

INTERNAL CHRONOLOGICAL PATTERNS

A number of questions about the internal chronology of the cemetery were examined by running queries. Much of this exploration entails the extraction of posterior density estimates from the preferred Outlier model and importing them into groups (e.g. in Query 1 the group »graves without Brooches«). The earliest and latest probability for the groups are calculated using the First and Last functions in OxCal, in conjunction with the Order function to provide a probability that one »event« pre- or post-dates another. Brief commentaries on the results are given after each query.

Query 1: Are the graves with brooches earlier than those without?

This query was run to investigate whether brooches were placed in graves throughout the life of the cemetery or there were phases at the start and/or end when brooches did not feature in the funerary rite. A plot of the First and Last dates for graves »with Brooches« and »without Brooches« shows no clear chronological distinction (**fig. 10**, Query 1), but there is a *69% probability* that the graves »with Brooches« (*last: with Brooches*) ended before those »without Brooches« (*last: without Brooches*).
Commentary: It is possible therefore that brooches were not placed in the latest graves.

Query 2: Relationship of the »Inner Circle« to the remainder of the cemetery

A. P. Fitzpatrick suggested that the graves around the edge of the circular space (the so-called Inner Circle) might be the earliest[47]. His reasons were a) the spatial organisation of the cemetery appeared to have been determined from the start and b) the proportion of typologically early pots from »Inner Circle« graves (five of nine biconical bowls of Middle Iron Age tradition). Four »Inner Circle« burials were dated (20087, 20208, 20255, 20274). However, the calculated probabilities for the »Inner Circle« dates fall comfortably within those for the Remaining Dates and do not support the suggestion that these graves are the earliest in the cemetery (**fig. 10**, Query 2).
Commentary: The location of a grave in the »Inner Circle« may have been determined by other factors such as the age of the deceased. It is clear that older adults (i.e. individuals certainly or possibly over 45 years of age) were preferentially buried in the »Inner Circle«[48].

Query 3: Is there any chronological variation between the brooch groups?

The graves with brooches were divided according to the typological categories represented. Group 1 burials contained brooches of Nauheim form (Feugère Type 5a-b) (20169, 20170*, 20235). Group 2 burials contained one-piece filiform brooches with external chords (Feugère Type 2a-b) with either 4-coil (20021*, 20089, 20134, 20179*, 20191*, 20338*, 20368*, 20408*, 20573*) or 2-coil springs (20132, 20252, 20484, 20541, 20543*, 20571, 20610*). The brooches in another three graves are possibly of this type but were missing their springs (20253*, 20453*, 20605*). Lastly, Group 3 graves contained boss-on-bow brooches (Feugère Type 8b) either in pairs (20601, 20629, 20675) or a singleton (20622). Where graves are asterisked, the brooches are too incomplete to be absolutely certain of the type.

This query was run twice, the first time using the above groups, the second time excluding graves with brooches not certainly identified to type. The results show why a large number of dates are required for robust analysis. Running the query with all the data suggests not only that the deposition of Feugère Type 2 brooches at Westhampnett began before Types 5 and 8b, but also suggests chronological patterning within the Group 2 graves (**fig. 11**, Query 3a). There is an *84% probability* that burials with Feugère Type 2 brooches with 4-coil springs (Groups 2-4) began prior to Group 1 and an *83% probability* that they started before Group 3 graves. Moreover, there is a *73% probability* that some Group 2 graves with 4-coil spring brooches are earlier than those with 2-coil springs (Group 2-2). It should, however, be noted that much of the internal chronology is driven by the relatively early date for grave 20338. If this grave is excluded, the query suggests that Group 2 is still the earliest of the three groups, but further comparisons are inconclusive.

When the less certainly identified brooches are excluded, little internal chronology can be teased out, apart from a *74% probability* that Group 2 graves began before the first Group 1 graves, and a *73% probability* that Group 2 graves began prior to Group 3 (**fig. 11**, Query 3b). From this, it would also appear that the start of Groups 1 and 3 were approximately contemporary and both belong to the later stages of the cemetery.

Commentary: An earlier date for filiform brooches with 4-coils would be consistent with their derivation from Lt C types with 4-coils, such as those from the Bern region[49]. Boss-on-bow brooches are known from Lt D1 contexts[50], but most examples of the Almgren 65 form seem to date to Lt D2[51]. The typologically developed examples from Westhampnett seem unlikely to be as early as the Nauheim brooches, although the Bayesian modelling provides no reasons for separating them.

Query 4: Pottery of Middle Iron Age tradition

The pottery from the cemetery displays a range of typological influences. Some of these influences are from Continental Europe but as already noted, a small number of pots are typologically earlier, some appearing to derive from the local Middle Iron Age »Saucepan« pot tradition. Three graves were dated (20051, 20255, 20451), two of which contained biconical-shaped pots related to the Middle Iron Age tradition (20255, 20451). The results indicate that these graves lie early in the span of dated activity (**fig. 12**, Query 4), with a start date of *200-95 cal BC* (*95% probability; first: MIA pottery dates*), and probably *180-115 cal BC* (*68% probability*). The latest of these deposits was in *155-55 cal BC* (*95% probability; last: MIA pottery dates*), probably in *135-80 cal BC* (*68% probability*).

Commentary: Some burials accompanied by Middle Iron Age vessels evidently post-date others with Late Iron Age forms but there is a 94% probability that Middle Iron Age tradition vessels stopped being placed in graves before the cemetery went out of use. The modelling supports the view that they are one of the earlier types in the cemetery.

Query 5: Copies of Armorican pottery

Four graves contained locally-made copies of Armorican pots (20018, 20471, 20601, 20637). There is an *82% probability* that some of the other burials are earlier, but a *91% probability* that Armorican copies stopped being placed in graves before the cemetery went out of use (**fig. 12**, Query 5).

Commentary: Imported Armorican vessels have been found at the nearby Late Iron Age settlement of North Bersted (West Sussex/GB; M. Lyne pers. comm.). There can be little doubt that the locally-made pots from

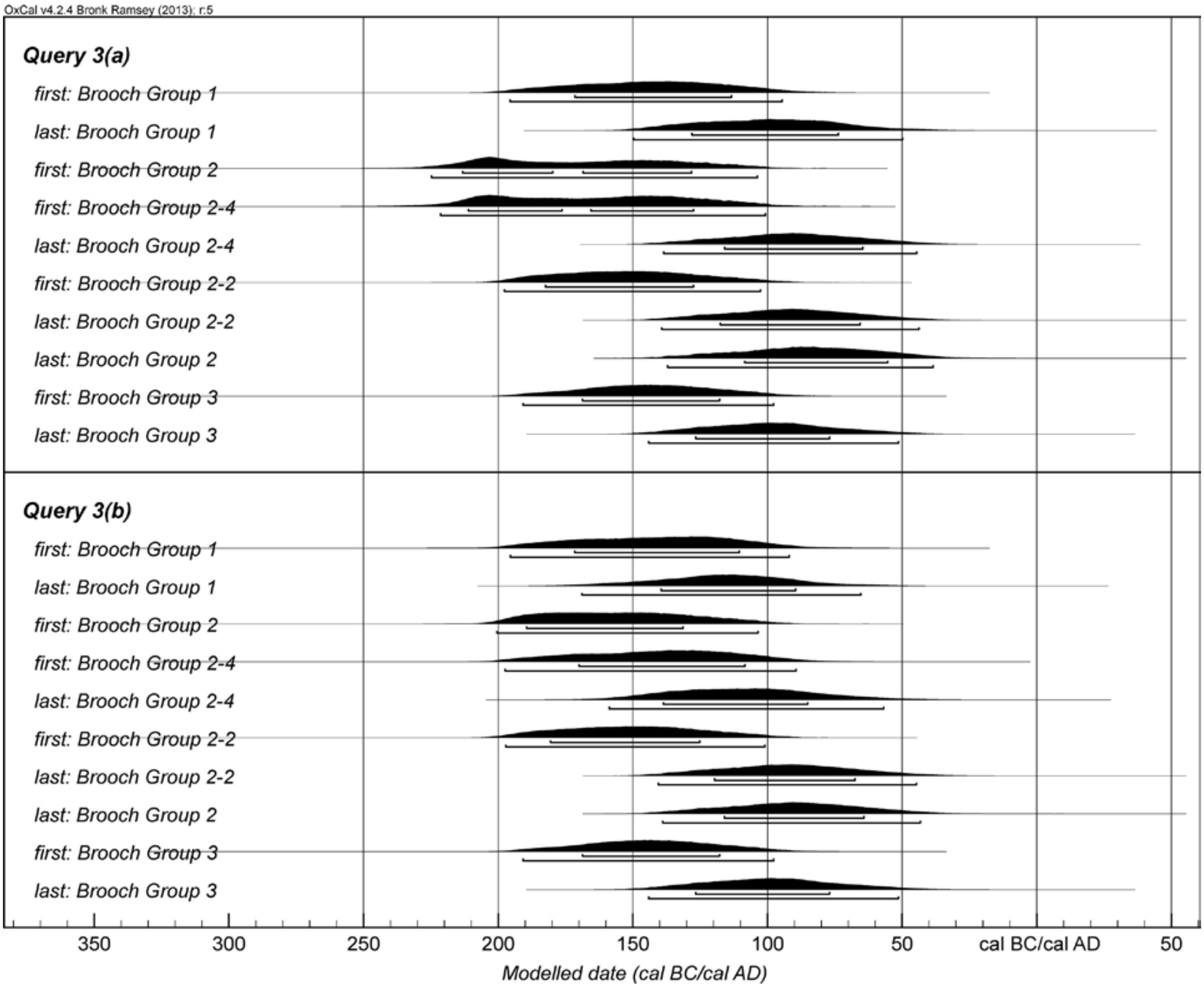

Fig. 11 Probability distributions for the start and end dates for the graves identified in Query 3. – (Illustration D. Hamilton).

the cemetery are direct copies of such imports. The largest assemblage of imported Armorican pottery in England was found at Hengistbury Head on the Dorset coast, c. 60 km to the west, where they were associated with Dressel 1A amphorae and attributed to the Late Iron Age 1 phase, which B. W. Cunliffe dated »roughly« to c. 100-50 BC [52]. The query is not inconsistent with this dating, but can also be taken as indicating that Armorican imports were arriving earlier in the Westhampnett area.

Query 6: Wheel-made pottery

Two graves contained wheel-made pottery (20457, 20650), for which the modelled distributions fall in the 2nd century cal BC, if not the very end of the 3rd century cal BC (**fig. 12**, Query 6).
Commentary: These graves containing wheel-made vessels were expected to date towards the end of the use of the cemetery, but the modelling does not support this. Wheel-made vessels are found in appreciable quantity at sites in northern France from the middle of the 2nd century BC [53], but the modelled date for Westhampnett would be exceptionally early for Britain.

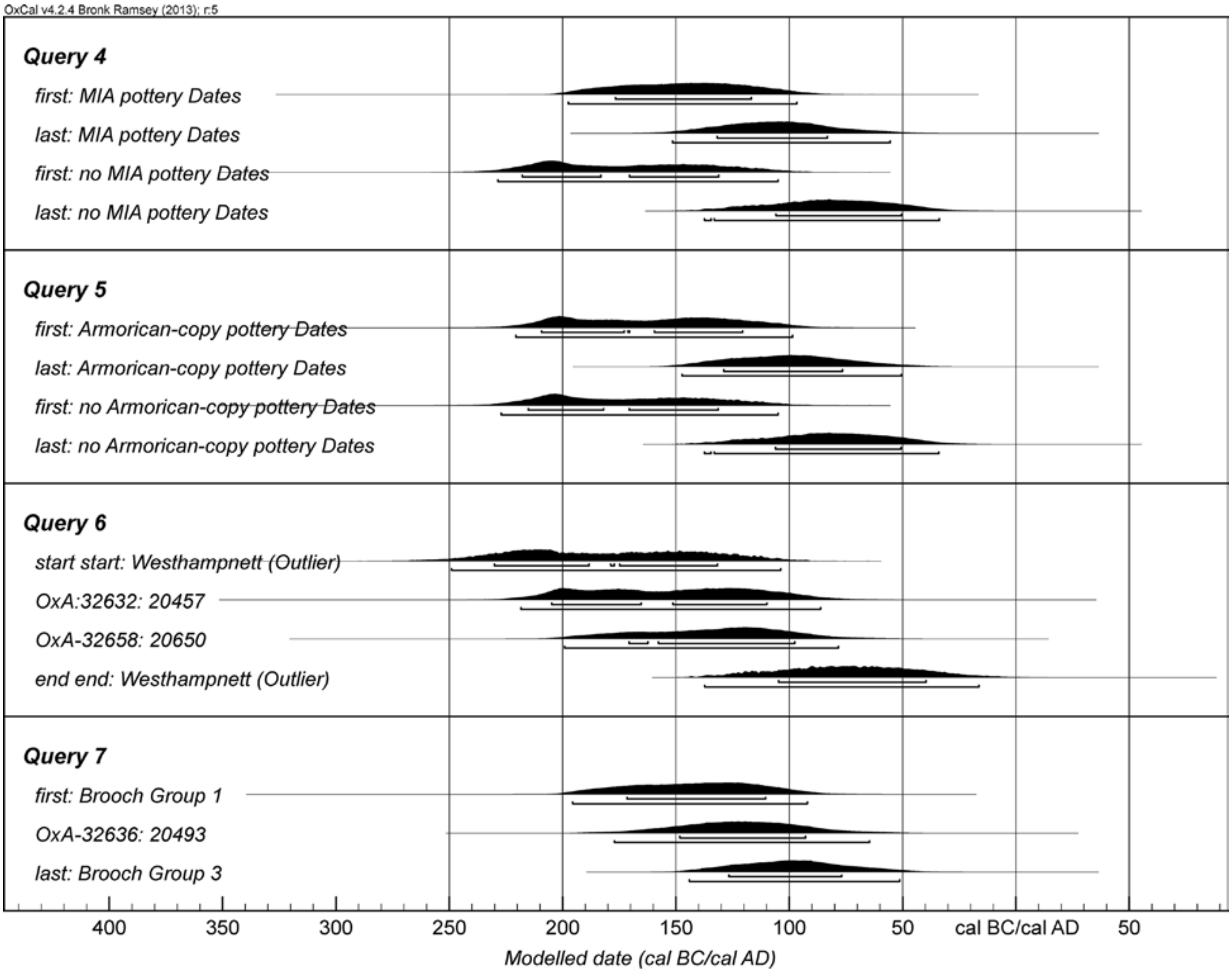

Fig. 12 Probability distributions for the start and end dates for the events and graves identified in Queries 4-7. The probabilities *first: Brooch Group 1* and *last: Brooch Group 3* are from the more conservative model that excludes those brooches that cannot be confidently placed into these two categories (see Query 3b). – (Illustration D. Hamilton).

Query 7: Coin dating

Burial 20493 contained an uninscribed British O quarter-stater, a rare example of an Iron Age gold coin from a secure archaeological context. The relationship of this grave to the Group 1 and 3 graves containing Nauheim and boss-on-bow brooches was queried (**fig. 12**, Query 7).

Commentary: British O quarter-staters are derived from the so-called *au bateau* series which circulated widely on both sides of the Channel[54]. On numismatic grounds, a date spanning the late 2nd century BC and the first half of the 1st century BC can be argued for the series, including the British derivatives[55], which copy an early biface variety of the *au bateau* type. The posterior density estimate for grave 20493 falls squarely within the period when Nauheim and Almgren 65 brooches were being deposited at Westhampnett. This supports the broad numismatic dating and additionally suggests that, like these brooches, the British O coin belongs to the later stages of the cemetery.

Lastly, attention may be drawn to the dating of grave 20252, which in addition to the pair of 2-coil filiform brooches, contained a winged belt hook. This is a relatively common object in France and was current in Lt D1 and into D2[56].

DISCUSSION

The radiocarbon dating programme for the Westhampnett cemetery is one of the first to date a European later prehistoric cremation burial cemetery. The results demonstrate that the method is valuable, but that further work is necessary.

At the site-specific level, the Bayesian modelling in general terms supports the published dating of the cemetery, which suggested that the cremation rite was adopted in southern England significantly earlier than previously thought. The results also support the view that the cemetery passed out of use around the mid-1st century BC. Although over 50 radiocarbon dates were obtained, the number available for specific types of objects is mostly small, limiting the confidence that may be attached to the results of the queries, which nevertheless support the conclusions reached in 1997. Perhaps the most significant outcome is from Query 3. This suggests that filiform brooches with external chords and 4-coil springs are earlier than the 2-coil varieties and the Nauheim brooches. This is consistent with their derivation from Lt C types.

The significance of the Westhampnett case study is, however, considerably wider and the following observations may be made. First and most importantly, the results show that radiocarbon dating of cremated bone provides a reliable independent dating method for the Iron Age. Cremation was practised across North-West Europe in the later Iron Age and existing chronologies are largely based on the brooches which are often found in the graves. In consequence, there is potential to develop a chronological framework that both links and transcends existing regional chronologies. Second, as Query 3 showed when there are no stratigraphic controls within the archaeological features from which a set of radiocarbon dates have been obtained, it may be necessary to obtain a large number of dates for Bayesian modelling to be effective. The samples dated, whether cremated human bone or another material, do not affect this observation.

Third, there is a significant difference between the start dates for the cemetery given by the Primary and Outlier models. Both models are internally consistent so this requires explanation. No definitive answer is possible on the basis of a single case study, but carbon exchange between the bioapatite, the datable fraction of the cremated bone, and carbon (CO and CO_2) derived from the fuel during cremation appears the most likely explanation. We have suggested above that this may have been caused by the use of old and/or seasoned timbers on the pyre. Old timbers could have been used for purely functional reasons, i.e. the need for a slow burning fuel to transform the body, but it is also possible that old timber, for example from buildings, was deliberately incorporated into the pyres.

The start date suggested by the Primary model is difficult to reconcile with current typo-chronologies. The date range indicated by the Outlier model which allows for the old wood effect is also somewhat earlier than expected, but we should not rush to dismiss the possibility that use of the Westhampnett cemetery began a generation or so earlier than proposed in 1997. A start date in the mid to late 2nd century BC would be consistent both with the mounting Continental evidence for the use of one-piece filiform brooches with external chords during Lt D1a (c. 150-120 BC) and our results suggesting that 4-coil brooches of this type were the earliest in the Westhampnett cemetery. Both models also suggest that the cemetery could well have been used for somewhat longer than the half century originally proposed.

In conclusion, radiocarbon dating of cremated bone provides a valuable dating technique for the later Iron Age in North-West Europe. Further case studies and more methodological research are needed, but the technique has the potential to help develop a systematic and independent chronological framework with which to assess the dramatic changes that characterised the later Iron Age.

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Notes

1) Fitzpatrick 1997.
2) Ibidem 242-295.
3) Fitzpatrick / Powell / Allen 2008.
4) Feugère 1985.
5) »Le Câtillon type« within Meller's Almgren 65, Group 2. Meller 2012, 190 fig. 39, 14-18 pl. Typol. 3 map 17.
6) Haselgrove 1997, 56-57.
7) Miron 1986, 151-159; 1991.
8) Fitzpatrick 1997, 203-204.
9) See e. g. Luke 2008; Allen et al. 2012; Stevenson 2013; Evans / Appleby / Lucy 2016.
10) Garrow et al. 2009. – Hamilton / Haselgrove / Gosden 2015.
11) Jay et al. 2012, 184.
12) e. g. Orléanais and Basse-Auvergne; Barral / Fichtl / Guichard 2012, 13.
13) e. g. Tomblaine: Le Pré Chenu (dép. Meurthe-et-Moselle / F); Deffressigne / Tikonoff 2012, 150-152.
14) See e. g. Lambot / Friboulet / Méniel 1994; Acy-Romance: La Croizette and Thugny-Trugny: Le Mayet (both dép. Ardennes / F).
15) Notably at the Bern-Reichenbachstrasse cemetery (Kt. Bern / CH); Jud / Ulrich-Bochsler 2014, 92-99.
16) Gebhard 1991, 87-90. – Curdy / Jud / Kaenel 2012, 53.
17) Haselgrove 1997. – Edgar 2012.
18) Bradley et al. 2015.
19) See e. g. De Mulder et al. 2007.
20) See e. g. Hamilton / Haselgrove / Gosden 2015.
21) Lanting / Aerts-Bijma / van der Plicht 2001.
22) Naysmith et al. 2007.
23) Hüls et al. 2010.
24) Snoeck / Brock / Schulting 2014.
25) Gale 1997.
26) Fitzpatrick 1997, 106-107.
27) McKinley 1994; 1997.
28) Gale 1997, 82.
29) De Mulder et al. 2007. – Olsen et al. 2008.
30) Ashmore 1999.
31) Brock et al. 2010.
32) Reimer et al. 2013.
33) Ward / Wilson 1978.
34) Fitzpatrick / Powell / Allen 2008, 140. 186.
35) Matterne 2001.
36) Modelled dates are shown in italics along with their probability e. g. 1-145 years (95 % probability).
37) See e. g. Bradley et al. 2015, 317-318 fig 7, 21; Buchez 2011, 292-296.
38) Fitzpatrick 1997, 236.
39) Ibidem 10-12. 234-237 fig. 37.
40) Willis et al. 2016.
41) Lee / Bronk Ramsey 2012.
42) Willis et al. 2016.
43) See e. g. Brindley 2007; Sheridan 2007; Sheridan / Bayliss 2008.
44) Hüls et al. 2010; Snoeck / Brock / Schulting 2014.
45) Fitzpatrick 1997, 106-107.
46) Bronk Ramsey 2009.
47) Fitzpatrick 1997, 203-204 fig. 113
48) Ibidem 234 fig. 123.
49) Gebhard 1991, 87-90. – Curdy / Jud / Kaenel 2012, 53. – Jud / Ulrich-Bochsler 2014.
50) Haselgrove 1997. – Edgar 2012.
51) See e. g. Demetz 1999; Poux et al. 2007.
52) Cunliffe 1987, 75.
53) See e. g. Gransar / Pommepuy 2005.
54) Scheers 1977, no. 13. – Delestrée 1996.
55) Haselgrove 1999, 140-141. – Sillon 2016.
56) See e. g. Bataille 2001, his Type 4E2.

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Zusammenfassung / Summary / Résumé

^{14}C-Datierung und bayessche Modellierung am späteisenzeitlichen Brandgräberfeld von Westhampnett (West Sussex / GB)

Die hier vorgestellte Studie ist eine der ersten systematischen ^{14}C-Untersuchungen an einem späteisenzeitlichen Brandgräberfeld. Das Gräberfeld von Westhampnett in Südengland wurde ausgegraben, bevor es möglich war, Leichenbrand zu datieren. Die Datierung in das 1. Jahrhundert v. Chr. (Lt D1b-D2a), die für den Fundplatz in der Publikation von 1997 vorgeschlagen wurde, basierte auf der Zeitstellung der Fibeln in den Gräbern und ihrer kontinentalen Parallelen. 44 der 161 Bestattungen (27 %) wurden nun mithilfe von ^{14}C datiert und die Ergebnisse der bayesschen Modellierung unterzogen. Zwei Modelle werden beschrieben, das »Primary Model« und das »Charcoal Outlier Model«. Letzteres zielt auf das potenzielle Problem des Kohlenstoffaustausches zwischen Bioapatiten (dem datierbaren Bruchteil des Knochenbrandes) und dem Kohlenstoff (CO and CO_2) vom Feuerholz des Scheiterhaufens ab, das älter sein könnte (»Altholzeffekt«). Beide Modelle sind in sich stimmig und kommen zum selben Enddatum für die Nutzung des Gräberfeldes. Allerdings ist der frühe Beginn, der durch das »Primary Model« nahegelegt wird, schwer mit der aktuellen Typochrono-

logie der Fibeln zu vereinbaren. Auch das »Charcoal Outlier Model« verlegt den Beginn des Gräberfeldes in eine frühere Zeit als erwartet, was jedoch zur kürzlich vorgenommenen Datierung kontinentaler einteiliger Drahtfibeln passt. Obwohl weitere Untersuchungen benötigt werden, ist schon jetzt deutlich, dass die ^{14}C-Datierung von Leichenbrand ein großes Potenzial birgt, eine exaktere und unabhängige Chronologie für die späte Eisenzeit in ganz Europa zu entwickeln. Übersetzung: M. Struck

Radiocarbon Dating and Bayesian Modelling of the Late Iron Age Cremation Burial Cemetery at Westhampnett (West Sussex/GB)
The work reported here is one of the first systematic radiocarbon dating studies of a Late Iron Age cremation burial cemetery. The Westhampnett cemetery in southern England was excavated before it was possible to date cremated bone. The 1st century BC date (Lt D1b-D2a) for the site proposed in the 1997 publication was based on brooches present in the graves and their continental parallels. 44 of the 161 cremation burials were radiocarbon dated (27 %) and the results modelled using Bayesian statistics. Two models are presented, the »Primary Model« and the »Charcoal Outlier Model«. The latter model addresses the potential problem of carbon exchange between the bioapatite (the datable fraction of the cremated bone) and the carbon (CO and CO_2) from the fuel for the pyre, which could be earlier in date (i. e. an »old wood effect«). Both models are internally consistent and suggest the same end date for the use of the cemetery. However, the early start date suggested by the »Primary Model« is difficult to reconcile with current typo-chronologies for the brooches. The start date indicated by the »Charcoal Outlier Model« is also earlier than expected but not incompatible with recent continental dating for one-piece filiform brooches. Whilst further studies are needed, it is clear that radiocarbon dating of cremated bone has great potential to help develop a more rigorous independent chronological framework for the Late Iron Age across Europe.

Datations radiocarbone et modélisations bayésiennes sur le cimetière à inhumation de la fin de l'âge du Fer de Westhampnett (West Sussex/GB)
Le travail présenté ici est l'une des premières études systématiques sur la datation radiocarbone d'une nécropole à inhumation de la fin de l'âge du Fer. Le cimetière de Westhampnett, dans le Sud de l'Angleterre, a fait l'objet de fouilles avant qu'il ne soit possible de dater des ossements crématisés. La datation du site au 1er siècle av. J.-C. (Lt D1b-D2a) a été proposée en 1997 sur la base des fibules présentes dans les tombes et leurs parallèles continentaux. 44 des 161 crémations (27 %) ont fait l'objet de datations ^{14}C et les résultats ont été pondérés en utilisant un modèle statistique bayésien. Deux modèles sont présentés, le »Primary Model« et le »Charcoal Outlier Model«. Ce dernier modèle concerne le problème potentiel de l'échange de carbone entre la bioapatite (la partie datable de l'os crématisé) et le carbone (CO et CO_2) du bûcher, qui peut être antérieur (c. à. d. un effet »vieux bois«). Les deux modèles présentent une cohérence interne et suggèrent la même date pour la fin de l'utilisation du cimetière. Cependant, la date du début de l'utilisation de la nécropole suggérée par le »Primary Model« est difficile à réconcilier avec celle des fibules. La date indiquée par le »Charcoal Outlier Model« est également ancienne, mais pas incompatible avec les datations récentes des fibules filiformes monoblocs. Bien que des études complémentaires soient nécessaires, il est clair que la datation radiocarbone des ossements crématisés a un fort potentiel pour développer un cadre chronologique indépendant et plus rigoureux pour la fin de l'âge du Fer européen. Traduction: L. Bernard

Schlüsselwörter / Keywords / Mots clés

England / Eisenzeit / Gräberfeld / Brandbestattung / Chronologie / ^{14}C
England / Iron Age / cemetery / cremation / chronology / ^{14}C
Angleterre / âge du Fer / cimetière / crémation / chronologie / ^{14}C

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