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Scientific Dating

Wor Barrow, Cranborne Chase, Dorset Chronological Modelling

Michael J Allen, Martin Smith, Mandy Jay, Janet Montgomery, Christopher Bronk Ramsey, Gordon Cook, and Peter Marshall

Discovery, Innovation and Science in the Historic Environment

Research Report Series no. 9-2016

Research Report Series 9-2016

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CRANBORNE CHASE
DORSET

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NGR: SU 01239 17283

ISSN 2059-4453 (Online)

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SUMMARY
Wor Barrow is a well-known Neolithic 'long' barrow in Cranborne Chase, excavated in 1893–4 by General Pitt Rivers, and first radiocarbon-dated by Richard Bradley. Excavations were exceptionally well recorded and published by Pitt Rivers in 1898. Many of the key artefacts were kept and are still curated at the Salisbury and South Wiltshire Museum, and are available for study along with the surviving original field notebooks. The excavation itself was iconic, but the barrow's general plan and form have been discussed much more than the funerary element. As an oval barrow it is traditionally thought to fall late within the currency of long barrows. This report examines the chronology, human remains, mortuary processes and development of the barrow in the Neolithic period.

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ACKNOWLEDGEMENTS
This project was funded by Historic England (formerly English Heritage) through the National Heritage Protection Commissions Programme, and was part of a training project in Bayesian modelling overseen by Alex Bayliss and Peter Marshall. Jonathan Last monitored the project's progress giving much-needed support and advice.

The museum collections were accessed through the kind offices of Jane Ellis-Schon at Salisbury and South Wiltshire Museum, and advice and discussion on Wor Barrow and General Pitt Rivers was provided by Richard Bradley, David Field, Mark Bowden, Julian Thomas, and Julie Gardiner. Mandy Jay and Janet Montgomery provided the isotope information. Martin Smith undertook the bone analysis, and thanks are also due to Rosie Smith for assistance with sorting and re-association of human skeletal material. We are also grateful to Karina Gerdau Radonic (Bournemouth University) for reviewing our suggestions and sharing her opinions on the stratigraphy of the primary burials. Illustrations 1, 2, 5, and 6 by Rob Read.

Mandy Jay and Janet Montgomery: the isotope data have been interpreted in the context of a number of unpublished datasets, including that obtained for the Beaker People Project from Late Neolithic and Early Bronze Age burials from across Britain, including Dorset. That project is funded by the Arts and Humanities Research Council (PI Mike Parker Pearson, Institute of Archaeology, UCL ; co-PI for isotope research, Mike Richards, University of British Columbia and Max Planck Institute for Evolutionary Anthropology, Leipzig).

ARCHIVE LOCATION

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DATE OF RESEARCH

2007–2016

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INTRODUCTION

General Pitt Rivers' excavation of Wor Barrow, Cranborne Chase, Dorset (SU 01239 17283) in the late nineteenth century (1893–4) was hailed as the first scientific excavation of a Neolithic long barrow (Wheeler 1954; Thompson 1977; Bradley 1973; Bowden 1991; Barrett *et al* 1991) and was considered 'epochal' (Kinnes 1992, 54). As a result of the detailed record and publication (Pitt Rivers 1898) we can now re-interrogate both the archive and published record with twenty-first century questions about Neolithic society, monument building, and funerary events. These include the chronology of Neolithic long barrows, following on from the important new dating of four chambered tombs and one earthen long barrow in southern England (Bayliss and Whittle 2007). While Pitt Rivers concentrated on the stature and anthropology of the 'early British people' via craniology, discerning dolichocephalic and brachycephalic traits (Pitt Rivers 1898; Brodie 1994), we can now address the health, well-being, and origin of those interred within the great mound (cf Smith and Brickley 2009; Montgomery *et al* 2000).

Wor Barrow lies within Cranborne Chase, an area renowned for its prehistoric archaeology (Fig 1). The barrow itself is considered to be part of the distinctive Cranborne Chase type (Ashbee 1970, 15; Bradley *et al* 1984; Barrett *et al* 1991, 36); these comprise oval barrows in which the quarry ditch extends around one end of the mound (as in the case of Wor Barrow), or both (Fig 2). This monument tradition is thought to be later in date than the early Neolithic long barrows. Burial rites displayed within these barrows enabled Bradley, in 1984, to suggest that they were more allied with later long barrows (Bradley 1984a, 32–3) and have led to suggestions that in Cranborne Chase these monuments, including Wor Barrow, can be placed in the 'same chronological horizon' as the Dorset Cursus (Thomas 1984, 163; Bradley *et al* 1984, 92). It is generally considered that 'many of the shorter long barrows were among the last to be built' (Bradley 1984a, 32–3) and that the Dorset Cursus was being constructed whilst long barrows were still being used: 'most of the mounds closely associated with this monument are oval barrows' (Bradley 1984a, 33).

Wor Barrow

Wor Barrow is located within a complex of Neolithic monuments in Cranborne Chase, and forms part of the Cranborne Chase long barrow group (Fig 1) in a large expanse of Upper Chalk (Newhaven Chalk Formation) which supports brown rendzina soils of the Andover 1 Association (Jarvis *et al* 1984). The area comprises low undulating chalk with the ridges capped with Clay-with-Flints and Reading Beds, and incised by a series of broadly parallel north-west to south-east flowing streams and winterbournes (Fig 1). The barrow lies on Handley Down, on a slight spur ending at the Oakley Down round barrow cemetery and, while land rises gently from the barrow to the south-west, it is clearly sited to overlook the dry valley north of Oakley Down. The Cursus lies about 1km to the east, but cannot be seen from Wor Barrow. Adjacent to Wor Barrow are two Neolithic round barrows: Handley 26, with a penannular ditch with the 'entrance' clearly facing that of Wor Barrow (Fig 2) and from which a crouched burial with a shale belt slider was recovered, and Handley 27, which has a more irregular ditch with an entrance on the same alignment as that of Wor Barrow (Barrett *et al* 1991, 85–7). The latter had been excavated in part by Colt Hoare (1812, 242) and was re-excavated by Pitt Rivers in May 1894, when it contained the then disturbed remains of a crouched inhumation.

Wor Barrow was the first Neolithic long barrow to be completely excavated and recorded to 'modern' standards. It was excavated by Pitt Rivers during 1893 and 1894 (Figs 2–3), and published by him in 1898. The archive was extensively studied by Mark Bowden (1984; 1991) and is now housed in Salisbury and South Wiltshire Museum.

Previous dating

It is clear from Bradley's and Thomas's published speculations (Bradley *et al* 1984; Thomas 1984) that they experienced some difficulty in placing oval barrows, and Wor Barrow in particular, into the Neolithic sequence in Cranborne Chase. Although recognising both the presence of early Neolithic Plain Bowl pottery and the good ceramic chronological sequence from the monument (Bradley *et al* 1984, 98; Cleal 1991), which would suggest an earlier Neolithic date (ie 3900–3500 cal BC), they strove to place it within the Cursus horizon which belongs to the second half of the fourth millennium cal BC, ie *3640–2920 cal BC* (*95% probability*; Barclay and Bayliss 1999, 25; fig 2.7) and is associated with Peterborough Ware. This assertion was based on its form, burial rites including both articulated and disarticulated remains, and the spatial association of these oval barrows with the Dorset Cursus. Richard Bradley conjectured that their use, if not construction, was closely related to the Cursus.

Their chronological assignations were not helped by the three radiocarbon dates that were available at the time (Table 1 and see Allen 2000, appendix). Two radiocarbon determinations (BM-2283 and BM-284) for Wor Barrow were obtained from red deer antlers on the base of the ditch and within the primary fill (Table 1; Fig 4; Bradley 1984b; Barrett and Bradley 1991), and were reported by Bradley (1984b) as having a Grooved Ware association. Unfortunately, measurements produced by the British Museum Research Laboratory between 1980 and 1984 were subject to a technical problem and may be several centuries too recent (Tite *et al* 1988). These measurements were subsequently recalculated producing a much greater standard deviation

(Bowman 1991). The revised results (labelled R in Table 1) are about three centuries earlier than those originally reported (Bradley 1988; Bowman 1991). In the light of these Bradley reported that 'Although the monument is still among the later long barrows, it no longer stands out from comparable sites on the chalk' (Bradley 1988), and now fitted into the chronology of the distinctive 'Cranborne Chase type' at the end of the long barrow tradition (Bradley *et al* 1984, 94) with a typical Peterborough Ware association. Comparison with the radiocarbon result from the Thickthorn Down (Ambers *et al* 1987, 180) long barrow is not very informative as this was on red deer antler from the surface of the buried soil beneath the barrow, and only provides a *terminus post quem* date for construction.

In addition to Wor Barrow, a previous determination had been obtained from a Beaker skeleton in pit 10 on Handley Down (Table 1).

DATING WOR BARROW – NEW RESEARCH OBJECTIVES

There is a clear need to place Wor Barrow into an absolute chronology, especially following the ground-breaking results of the Bayesian modelling of new dates from five southern British long barrows (Bayliss and Whittle 2007) and causewayed enclosures (Whittle *et al* 2011). These have demonstrated the ability to date 'events' in the Neolithic to the centennial or generation scale via the application of Bayesian modelling (Bayliss *et al* 2007). Could the contemporaneous building and short period of use of those long barrows be true of Wor Barrow, or was this, as Bradley, Thomas, and others conjectured, a later monument with long use during the Neolithic? Not only has research in Cranborne Chase provided a narrative for the Neolithic (Barrett *et al* 1991), but it has been extensively built upon by excavations by Martin Green (2000), and by research led by Charly French (French *et al* 2005; 2007). Thus, if the chronology of Wor Barrow could be defined it could be placed securely within the early Neolithic context of Cranborne Chase and the recent research results and landscape modelling (French *et al* 2005; 2007; Allen 2002; Allen and Gardiner 2009). It is particularly prescient that Richard Bradley wrote in 1984 that 'It was ironic that this was the first barrow to be dug by modern method yet should be one of the last to be dated' (Bradley 1984) and only now, 30 years later, has this been redressed.

Not only has the barrow not been precisely dated, but the human remains have been poorly studied by modern criteria, despite the fact that the original studies of the human bone by Pitt Rivers assisted by Dr Garson, a physical anthropologist, were, at the time, seminal. Several recent studies have shown that re-examination of human burials can provide detailed evidence of the life and death of the incumbents; and cultural traditions associated with the burial (Smith and Brickley 2006; 2009; Benson and Whittle, 2006; Gibson and Bayliss 2009; Fowler 2010). Furthermore, isotopic analysis can help define if the buried individuals were all local or had travelled great distances, as seen from the Neolithic individuals at Monkton-up-Wimborne – including the 'Cranborne lady' (Montgomery *et al* 2000). All of these aspects are addressed in this new research programme based on the dating and examination of the human remains, and tools of construction, from Wor Barrow.

The fact this barrow belies conventional archaeological wisdom (Bradley 1984; 1988 and J Thomas pers comm) and dates to the earlier part of the fourth millennium (Table 2), also calls into question the chronological relationship of the Neolithic segmented round barrows Handley 26 and Handley 27 adjacent to Wor Barrow (Fig 2). Are these indeed Neolithic? Is the antler material from the secondary fills of the Wor Barrow ditch related to their construction? Indeed where in the Wor Barrow ditch infilling sequences do these barrows fit? Do they relate to the Beaker tradition, akin to the nearby Beaker pit (BM-2760)?

This project has unashamedly restricted itself to the Neolithic and Early Bronze Age activity and has not attempted to examine, or provide a chronology for, the numerous post-Neolithic secondary burials of Romano-British or Saxon date.

Event Dating Event Aims

The principal and initial aims were:

- to define the chronology of Wor Barrow within the Neolithic context of Cranborne Chase and the recent research results and landscape modelling (French *et al* 2005; 2007);
- to relate this chronology to the recent ground-breaking chronological research on the British Neolithic (Whittle *et al* 2011);
- to demonstrate the continuing potential of the Pitts Rivers archive for valuable research (cf Barrett *et al* 1991).

Following preliminary examination of the published record and archive, it was also clear that the monuments had considerable history and that the primary burial group (see below) was relatively complex, so a series of more specific aims were defined as:

- when and what was the time span of the primary burial activity (phase 1)?
- how does this relate chronologically to the construction of the final phase mound (Wor Barrow II)?
- what is the chronological relationship between the primary burials and the secondary Neolithic inhumation (skeleton 8) inserted into the ditch?

- what is the chronological relationship between the secondary inhumation (skeleton 8), the primary burials, and the adjacent segmented Neolithic round barrows of Handley 26 and 27 (Fig 2)?

It is clear that not all of the construction phases of the monuments (Figs 5a–c) can be dated, but this also glosses over the complexities of the primary burial group which contains two articulated flexed burials (skeletons 1 and 2), considered to be the first burials as they are overlain by flexed Burial 6 and partially or wholly disarticulated skeletons 3, 4, and 5).

The Wor Barrow monument

Pitt Rivers recognised that earthen long barrows contained 'a wooden version of the long chambers of stone found in barrows of the same kind in places where stone was more plentiful' (Pitt Rivers 1898, 20; Kinnes 1992, 58). Wor Barrow, as Bradley states (in Barrett *et al* 1991, 38), has been the subject of considerable discussion since its excavation (1893–4) and publication (1898), with the discovery of a site notebook providing additional information (Bradley 1973). Re-examination of the material, the written, and published archive allows the full event-history of the monument to be defined (Figs 5a–c and 8–10).

Wor Barrow comprises the following and is traditionally phased as follows:

Burial and funerary rites

Phase 1: burial (Fig 5a):

a) mortuary enclosure construction;

b) the burial of six Neolithic inhumations (primary Burials 1–6) within a wooden mortuary box or chamber set within a post-built mortuary enclosure/building represented by a rectilinear chalk-cut foundation trench. The sequence of burial given below for phase 1 is the model favoured by the present authors, although alternative interpretations remain possible (see Figs 8 and 9, and below).

Monument construction

Phase 2: sealing the burials (Fig 5b, top):

a) turf stripped (from the phase 1 ditch) and placed over the mortuary box sealing the burials, presumably within the mortuary enclosure;

b) the infilling of the mortuary enclosure with chalk quarried from primary ditches. The burials and turf mound are sealed by a low chalk mound (1.5m high; Pitt Rivers 1898; Piggott 1954, pl 2b; Bradley in Barrett *et al* 1991a, 43; Bradley 1973), presumably quarried from a shallow (probably segmented) ditch surrounding the mortuary enclosure.

Phase 3: the first mound (Fig 5b, bottom):

The first substantial ditches are cut and a chalk mound is thrown up embracing the entire mortuary structure, creating the barrow Wor Barrow I, and presumably accompanied by enlargement of the ditch.

Phase 4: the 'enlarged' mound (Fig 5c):

a) the excavation of a larger ditch (largely but not wholly removing the earlier one) and the construction of a more impressive chalk mound over the primary low mound, creating Wor Barrow II, as excavated by Pitt Rivers;

b) the primary fills of the ditch accumulate.

Phase 5: the second Neolithic interment phase (Figs 5c and 6):

The insertion of two further Neolithic crouched inhumations in the primary fills of the ditch (secondary Burials adult 8 and child 9. The secondary burials are numbered from the top of the ditch fill downwards 1–9 and are a different series to the primary burials 1–6) associated with a kite-shaped arrowhead.

Phase 6: Ditch filling

The secondary ditch infilling occurs, and other later Neolithic activity occurs in the vicinity, eg Handley 26 and Handley 27 Neolithic round barrows constructed (Fig 2).

Mortuary box

The primary burials were contained within an area described by Pitt Rivers as 'an oblong space 8 feet in length by 3½ feet in width' (Pitt Rivers 1989, 66); the tight proximity of all six inhumations and the straight-sided rectangular space they occupied suggests that they were in a large box or chamber, made of wood, within the mortuary enclosure. The area is too small and narrow to be a structure with any vertical height. We, therefore, conclude that this was a wooded container, a coffin or mortuary box with a lid. It would have been left largely exposed to the elements during a sequence of burial phases prior to the construction of the first chalk mound over it, resembling the reconstruction by

Blaise Vyner of the Street House, Cleveland long barrow (Vyner 1984). The first primary burials comprised two adjacent largely articulated burials with flexed legs (skeleton 1 and 2), one partially articulated slightly flexed Burial (6), and three disarticulated, but closely and individually bundled skeletons (3, 4, and 5). The rotting flesh in the unburied mortuary box would be expected to attract a range of scavenging carnivores (eg foxes, wolves, wild boar, and even brown bear: see Legge 1991), as well as rodents which would gnaw on the bones. We might expect, therefore, to see evidence of burrowing and disturbance of the buried soil from animals attempting to gain access to the cadaver-filled box, but no disturbance or burrowing was recorded in the buried soil by Pitt Rivers or is noticeable on the photographs. The implications of this for the state of the bodies are discussed below.

The last Neolithic burial event was that of a crouched adult and a child who were inserted into the top of the primary ditch fills some while after the construction of both the primary mound and enlarged secondary mound, and after the considerable primary silting of the ditch. Pitt Rivers reports that the burials were cut into the primary rubble prior to the commencement of the secondary fill (Pitt Rivers 1898, 61). By Pitt Rivers' own remarkable observations that 0.75m of chalk rubble had accumulated in 4–5 years since he had finished excavating the ditch (1898, 24–6), we may be able to calculate that primary fills would occur over a period of some 30–50 years. Ironically, a very similar figure was postulated for primary fill accumulation about a century later by modern scientific experimentation (Crabtree 1971; Bell *et al* 1996).

There seem to be at least three, and probably four, burial phases within the primary interment group (see below) and a later Neolithic burial phase within the ditch. The mound had two major phases of construction, and encompassed a pre-existing mortuary enclosure. The delineation of these phases of activity and construction raises a number of questions. In particular – over what length of time did these events occur? Could all of the buried individuals have known each other - were they interred over a period of decades, generations, or centuries?

The ditches were quarried out by red deer antlers, a collection of which survive in the archive - some shed and some hewn from the skull, many showing signs of wear and use (see for instance Serjeantson and Gardiner 1995). These were recorded by depth which was annotated on the antlers and often on the labels. Their locations within the ditch circuit were less well, and less often, recorded.

Although excavated in the nineteenth century, the archive includes site notebooks (Bradley 1973), much (but not all) of the excavated material, and the comprehensive publication that allows detailed re-interrogation. The human bones were collected by Pitt Rivers principally for anthropological measurement of long bones (stature) and skulls. Long bones are stored in boxes made especially for them by Pitt Rivers' carpenter and the boxes retain their original labels. The bones are individually marked, recognisably by the hand of St George Gray (J Gardiner pers comm), one of the General's foremen who did most of the surveying and recording on site. Not all of the remaining skeletal material was dealt with so meticulously and some pelves survive, but little other post-cranial material was retained. Similarly infants, whose measurements would not contribute to the corpus, were not retained. Some of the best antlers were retained, as was most of the animal bone, but unfortunately much, if not all, of the latter was subsequently discarded after Pitt Rivers' death (Bradley in Barrett *et al* 1991, 13–14); hence no ox scapula tools survive in Salisbury & South Wiltshire Museum's archive.

Analysis of the primary burial group

The primary burial group (Figs 7a– b and 10) has never been seriously examined in terms of either the deposition of the bodies, or the skeletal remains. Having now undertaken full osteoarchaeological analysis for the archived human bone, we can examine the burial record more fully. In order to do this we have provided a burial biography for each individual which records the position of the bones as far as we can identify, discusses any ambiguities, provides an argued interpretation for the history of burial emplacement and movement, and any minor subsequent disturbance during Pitt Rivers' excavation.

The primary burials comprised six individuals inhumed in differing states of articulation. Pitt Rivers did not publish a plan of the burial assemblage, although the primary burials are visible at a very small scale (c 12mm x 4mm) at the centre of his famous plan of the monument (Figs 3 and 7a–b). Two photographs in the 1894 monograph, together with a short written passage, comprise the extant record of the relative positions of skeletal material at excavation. Of these sources, the photographs, together with analysis of the bones, offer the greatest potential to extract information about the state of the burials. Although some of the detail is indistinct and a large proportion of the bones shown cannot be specifically recognised, key bones have been identified with confidence (Fig 7b). Re-analysis of the two images at an enlarged scale (by Mike Allen and osteoarchaeologist Martin Smith) permitted the identification of a range of skeletal elements and has allowed some progress to be made by the present study in identifying the relative positions of the six individuals present. This analysis has enabled us to discern the stratigraphic sequence of events and the re-arrangement in prehistory of the remains, leading to production of a schematic plan of the burials (Fig 7b). This analysis was significant as the choice of bones and burials to submit for radiocarbon dating and the construction of the Bayesian models is predicated on this. Conventionally the two articulated and least disturbed burials (skeletons 1 and 2) would be considered the last to be interred, the disarticulated remains being the earlier burials that had been moved aside to accommodate the later incumbents. This, however, as we will see, is not the case at Wor Barrow.

Burial biography

Burials 1 and 2 are described as lying ‘in sequence crouched on the right side with the heads to the southward’ (Pitt Rivers 1898, 66). This description is consistent with the photographs although these individuals can in fact be seen lying on their backs rather than their sides but with their legs tightly flexed and lying on the right side. Burial 6 is similarly described as being crouched in articulation with the head to the south and Pitt Rivers’ plan appears to also show this. The articulated spine and skull and the presumed lower limb bones of this burial are visible and appear consistent with this description. Burials 3, 4 and 5 are described as disarticulated with the long bones laid parallel to the skulls (Pitt Rivers 1898, 66). The skulls of these are all clearly visible on the images, as are some of the long bones (eg Fig 7a).

The details that have been discerned from the published images are summarised in Figures 8–10 and allow for multiple ‘readings’ as regards the sequence in which the inhumations were placed. Whilst acknowledging that alternative interpretations exist, the model we favour concurs with Pitt Rivers’ original interpretation. Given the fact that Burials 1 and 2 follow the orientation of the presumed timber structure so precisely, it seems reasonable to suggest that these were deposited first, having either been brought into the structure from an entrance at its north end, or lowered in from above. Pitt Rivers thought that Burial 6 had been placed next, followed by 3, 4, and 5. The photographs give an impression of parts of Burial 4 overlying the articulated Burial 6 – including a humerus visible in the right mid-ground. At the northern end the skull of skeleton 5 lies above parts of both 3 and 6 which would place skeleton 5 as being the final deposition of the group. This proposed sequence is summarised as a Harris matrix (Fig 8). A salient point regarding this interpretation is that it assumes that once deposited the burials were not subsequently disturbed. In this case, the disarticulated remains may have been placed as wrapped bundles or bags of bones. Alternatively, all of the burials could have been initially deposited as articulated corpses with earlier inhumations subsequently being moved aside to make way for later interments as has been suggested for some stone chambered monuments (Piggott 1962). Such a scenario would imply that the articulated burials are therefore the latest. However, the fact that 5 and 4 appear to overlie 6 would contradict such a model and is more consistent with the disarticulated material having been placed after the articulated burials.

DATING WOR BARROW

Approach to dating

A Bayesian approach has been adopted for the interpretation of the chronology of Wor Barrow (Buck *et al* 1996). Although the simple calibrated results (Fig 11a – shown in outline) are accurate estimates of the dates of the samples, this is usually not the archaeologist's primary aim. It is the dates of the events represented by those samples which are of archaeological interest. In the case of Wor Barrow it is the history of its use (ie start/end of various discrete events, gap between phases of events, and span of events and of use) that is under consideration. The dates of these activities (see above) can be estimated not only by using dating information from the calibrated radiocarbon dates of the samples, but also by using relative stratigraphic relationships between samples.

Fortunately, a methodology is now available which allows the combination of these different types of information explicitly, to produce realistic estimates of the dates of events of archaeological interest. It should, however, 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 (both radiocarbon dates and stratigraphic data or the interpretation of the stratigraphic data) become available, or as other researchers choose to model the existing data from different perspectives.

The chronological modelling described below has been undertaken using OxCal 4.2 (Bronk Ramsey, 1995; 1998; 2001; 2009), and the internationally agreed calibration curve for the northern hemisphere (IntCal13: Reimer *et al* 2013). The models are defined by the OxCal CQL2 keywords and by the brackets on the left-hand side of Figures 11a, 11b, 12a, 12b, and 18. In the diagrams, calibrated radiocarbon dates are shown in outline and the posterior density estimates produced by the chronological modelling are shown in solid black. The Highest Posterior Density intervals which describe the posterior distributions are given in italics.

Fifteen new radiocarbon determinations have been obtained: 14 from nine samples from Wor Barrow, in addition to the previous two results (Table 1), and one further determination from Handley 27 (Table 2). The strict selection of the suite of new samples was informed by simulation models to indicate the potential value and usefulness of submissions.

Sample selection

All samples selected were single entities (Ashmore 1999) and directly related to the event we were dating. These were either human remains from the burial mound itself or antlers used to dig the ditch.

Methods

Eight samples, four human bones and four antlers, were processed at the Scottish Universities Environmental Research Centre (SUERC). Following a modified version of the pre-treatment method outlined by Longin (1971), CO_2 was obtained from the samples by combustion in pre-cleaned sealed quartz tubes as described by Vandeputte *et al* (1996), the purified CO_2 was converted to graphite (Slota *et al* 1987), and dated by Accelerator Mass Spectrometry (AMS) (Xu *et al* 2004; Freeman *et al* 2010).

Six samples of human bone and one antler were submitted to the Oxford Radiocarbon Accelerator Unit (ORAU). The samples were processed according to the method outlined in Bronk Ramsey *et al* (2004a), and measured by AMS (Bronk Ramsey *et al* 2004b).

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

The two results originally obtained from antlers dated at the British Museum in 1984–5 (BM-2283 and BM-284) were affected by a technical problem in the laboratory between 1980 and 1984 that meant that results were systematically too young (Bowman *et al* 1990). These samples' radiocarbon ages were subsequently recalculated as denoted by the laboratory suffix 'R', eg BM-2284R (Bradley 1984b; 1988). The original radiocarbon determinations reported by the British Museum were produced as described by Barker *et al* (1969a; 1969b).

Results of the dating programme

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

Stable isotopes

The stable isotope results (Table 2) indicate that the humans consumed a diet predominantly based upon temperate terrestrial C_3 foods (Schoeninger and DeNiro 1984; Katzenberg and Krouse 1989). The radiocarbon results are therefore unlikely to be affected by any significant reservoir effects (Bayliss *et al* 2004) and the calibrated date ranges can be regarded as accurate estimates of the ages of their samples.

All the samples gave C:N values within the range normally used to indicate good collagen preservation (2.9–3.6; DeNiro 1985).

Chronological models

As a consequence of the multiple interpretations of the sequence of burials within the main burial group, it is possible to construct numerous different models for the chronology of the Wor Barrow. We have elected to present two of these in detail (Figs 11a–b and 12a–b) - a summary of the archaeological information that they include is shown in Figures 8–9. In the first reading, Event Model 1 (Fig 8), skeleton 5 is the latest inhumation of the primary burials, ie is later than skeletons 3 and 4. In the second, Event Model 2 (Fig 9), skeleton 5 is only interpreted as being later than skeleton 6, along with skeletons 3 and 4.

Mortuary enclosure

There is no suitable material in the archive from the timber construction trenches or the two pits associated with the mortuary enclosure. There is, therefore, no recorded material with which to date the mortuary structure. Although fragments of charcoal are recorded from the mortuary enclosure, none of this material survives in the archive, and if it did there is no evidence that it relates to the construction of that structure. Consequently the construction of the mortuary enclosure (event 1) is not dated.

Failing absolute dating of this phase we assume its construction is contemporary with the deposition of the first phase of burials. This assumes, however, that the mortuary house did not have a life or purpose prior to its use for the deposition of the dead that were recovered from it.

The mortuary enclosure beneath Wor Barrow is commonly compared with that at Normanton Down, Wiltshire (eg Field 2006; Barrett *et al* 1991) from which a radiocarbon determination from an antler in the bedding trench calibrates to 3650–2850 cal BC (4510±150 BP; BM-505).

The burial group

We can identify three distinct groups of burials with the six individuals of the primary burial group, representing at least two, if not three, separate depositional events (Fig 10). Samples from the right femur from at least one individual of each group were submitted. This included two from the disarticulated group (skeletons 3 and 5), the latter suffering a congenital syndrome (see Appendix); and one each from the articulated groups (skeletons 1 and 6). Replicate samples were submitted from skeletons 3 (SUERC-26117 and OxA-23275) and 1 (SUERC-26116 and OxA-21447). The determinations from skeleton 1are statistically consistent (T'=0.9; T'(5%)= 3.8; ν=1; Ward and Wilson), so a weighted mean (sk1; 4824±21 BP) has been calculated as the best estimate for the death of this individual (Table 2). The two measurements from skeleton 3 are not statistically consistent at 95% confidence (T'=5.9; T'(5%)= 3.8; ν =1), although they are at 99% (T'(1%)=6.0) and given they are from the same individual we have taken a weighted mean (sk3; 4896±23 BP) as providing the best estimate for this individual death.

Construction of Wor Barrow 2

The digging of the ditch and thus construction of the main (phase 4) mound, and the duration of the infilling of the chalk rubble primary fills, was dated using antlers specifically selected from the archive as being well provenanced (many have specific location/depth details), and as having been utilised (worn) or modified as tools. A few animal bones are present in the archive although none were clearly placed on the base of the ditch, and none were articulated elements. However, the antlers in the archive are recorded by depth, and often additionally as 'on the bottom' or in chalk rubble'. Antlers selected for dating were from the bottom of the ditch (at 12ft and 10ft) and one within the chalk rubble at 7.5ft. Two previous results on antlers were recorded as 'on bottom of ditch' and 'in primary fill' (Barrett and Bradley 1991, 9). Two samples were submitted from one antler at 12ft securely recorded as having been on the bottom of the ditch (SUERC-26118 and OxA21448). The results are statistically consistent (T'=0.0; T'(5%)= 3.8 ν=1) and a weighted mean was calculated (Table 2; 4763±23 BP).

The results from the antlers in the ditch (Table 2), despite selection at different depths to attempt to model the rate of and date of infill, are statistically consistent (T'(5%)= 1.1; T'=11.1; ν=5;) and could therefore all be of the same actual age. This suggests that despite the depth of the antler in the ditch they are all original tools for digging the ditch and have eroded into (or been deposited in) the ditch at different times. They thus might indicate either antlers scattered around the base of (or even formerly over) the chalk mound which had eroded into the ditch, or the deliberate act of discarding them into the ditch, perhaps having been curated as trophies for a period ranging from a couple of generations (ie the expected infill time of the primary fills) to many centuries (ie the expected duration of the secondary fill accumulation).

Antler

Infilling of the ditch (the primary and secondary fills)

The dating of the infilling of the ditch was not achieved. As explained above, although red deer antlers were carefully selected at different depths through the ditch (Table 2), the results indicate that they do not relate to their date of deposition, but their date of acquisition. They are all antlers used in the various phases of the construction of the ditch. In fact archaeologically there is no event that required the use of antlers subsequent to this, so there would be no source of other antler tools with which to date the ditch infilling.

Secondary inhumation in the ditch (skeletons 8 and 9)

The secondary Neolithic inhumation (skeleton 8; Table 2) cut into the primary fills and backfilled with primary rubble should post-date the digging of the ditch and the accumulation of the primary fills. The initial radiocarbon result (OxA-21448) was inconsistent with this interpretation and given the skeleton was found articulated it was difficult to provide an adequate explanation for this discrepancy. Two further samples from skeleton 8 were therefore submitted for dating (OxA-24079 and SUERC-33324). All three measurements are statistically consistent (T'=0.9, T'(5%)=6.0; ν=2) and a weighted mean (sk8; 4889±19 BP) has been calculated as providing the best estimate for the date of the death of this person.

Furthermore, the archaeological estimate of this burial, based on the kite-shaped (or lozenge) arrowhead (Pitt Rivers 1898, plate 260, fig. 5), is 2600–2400 cal BC. It was found below the last two ribs and Pitt Rivers assumed it had killed the individual. Although the ribs and sternum, from which we might see osteological damage, were not retained, the arrowhead is broken, possibly as a result of an impact fracture (J Thomas pers comm). However, recent examination of the object itself, shows this to be a recent break, probably caused during the excavation (J Gardiner pers comm).

Interpretation

The models shown in Figures 11a and 11b both have poor overall agreement (A_{model}=7 and A_{model}=11; Bronk Ramsey 1995) between the radiocarbon dates and prior information outlined in Figures 8–9. It is clear that the date of the secondary Neolithic inhumation (sk8) cut into the primary fills and backfilled with primary rubble is inconsistent with its stratigraphic position – that it post-dates the digging of the ditch and the accumulation of the primary fills. The individual index of agreement values for skeleton 8 (A=0; sk8) in both models, would indicate the sample's calendar age is different to that implied by its stratigraphic position.

Both models that exclude skeleton 8 (Figs 12a–b) have good overall agreement (A_{model}=64 and A_{model}=128). Both these models indicate the individual 8 had died some considerable time before finally being placed into the ditch fill: *20–185 years* (*95% probability*; Fig 13; event model 1) and probably *30–130 years* (*68% probability*) or *20–205 years* (*95% probability*; Fig 13; event model 2) and probably *65–165 years* (*68% probability*). These estimates are derived from calculating the difference between the date for the completion of the ditch (*ditch_finish*; Figs 12a–b) and the death of the individual represented by skeleton 8 (*sk8*; Figs 12a–b). But it should be remembered that this is only a minimum estimate given that Burial 8 was cut into the top of the primary fill and that it could have taken 50–70 years to accumulate after the ditch was dug.

Since Burial 8 was found articulated when excavated this individual must have been kept in such a way as to retain the articulations. The crouched position could be indicative of the body being tightly wrapped. Examples of 'trussed' bodies that were reminiscent of 'mummy bundles' are not completely unknown, eg Down Farm (Green 2003, 112–3), Tallington (Simpson 1976, 223), Dorchester (Smith *et al* 1997, 78) and Bradley Fen (Booth 2008). However, this is the first example where it can be independently demonstrated that a complete articulated body was of some age when it was 'buried'.

The post-death biography of the individuals that make-up the 'composite bodies' of the 'Cladh Hallan mummies' (Parker Pearson *et al* 2005; 2007; forthcoming; Hanna *et al* 2012) is complex and as such it has been argued on the basis of chronological modelling (Marshall *et al* forthcoming), that was not available when the initial claims were put forward, that they do not represent 'mummies'. Although processes of mummification undoubtedly played a part in the post-mortem history of parts of the composite bodies, there is no evidence for a single individual being preserved after death in such a way as Burial 8 from Wor Barrow.

Burial 8 is also considerably older than either the 'Cladh Hallan mummies' or other possible examples (Booth 2008; Booth *et al* 2015), which are all Bronze Age or later in date. It is unfortunate that the infant found with individual 8 does not survive in the archive so we could not determine its chronological relationship to the 'curated' body it was found next to in the ditch. This may have allowed us to date the moment of burial of individual 8 in addition to the moment of death (cf Parker Pearson *et al* 2005, 544).

The posterior density estimates for the main archaeological events at Wor Barrow from both models (Figs 12a and 12b) are shown in detail in Figures 14–16. Both models indicate that the construction of the mortuary enclosure probably took place in the last part of the 38th or the first half of the 37th century cal BC: *3720–3640 cal BC* (*95% probability*; *start_wor_barrow*; Fig 12a and Fig 14), probably *3685–3645 cal BC* (*68% probability*) or *3735–3645 cal BC* (*95% probability*; *start_wor_barrow*; Fig 12b and Fig 14), probably *3700–3655 cal BC* (*68% probability*).

It is clear that both models are consistent in suggesting that the closure of the mortuary phase when a turf mound was laid over the primary inhumations occurred in the second half of the 37th century cal BC: *3655–3605 cal BC* (*95% probability*; *turf_mound*; Fig 12a and Fig 15), probably *3650–3630 cal BC* (*68% probability*) or *3650–3600 cal BC* (*95% probability*; *turf_mound*; Fig 12b and Fig 15), probably *3645–3620 cal BC* (*68% probability*). The mortuary phase and deposition of the primary burial group therefore probably took place over at most about four generations (*95% probability*; Fig 17) and probably a little over a couple of generations (*68% probability*) – assuming a generation is 25 years.

Completion of the ditch occurred at some time in the late 37th to 35th centuries cal BC: *3635–3495 cal BC* (*95% probability*; *ditch_finish*; Fig 12a and Fig 16), probably *3630–3540 cal BC* (*68% probability*) or *3630–3475 cal BC* (*95% probability*; *ditch_finish*; Fig 12b and Fig 16), probably *3630–3610 cal BC* (*8% probability*) or *3585–3515 cal BC* (*57% probability*). Unfortunately, as skeleton 8 does not provide a constraint for the digging of the ditch this estimate is much less precise than we had hoped.

We believe that the first of the two models is the more plausible as this reading is in agreement with Pitt Rivers' original interpretation of the primary burial sequence. The fact that both models provide very similar age estimates suggests that the data are robust and that neither model is providing answers that are importantly wrong.

Handley Barrows and their relationship to Wor Barrow

It was thought that the later Neolithic Handley barrows might be of a similar age to the secondary inhumation in the ditch (skeleton 8). The dates from Handley 27 (3310–2910 cal BC; SUERC-33328) and the adjacent pit (2350–1980 cal BC; BM-2760) are clearly later, while the secondary burial now forms part of the early fourth millennium primary burial group, even thought it was finally buried sometime after the main group.

Discussion

Wor Barrow belongs to the distinctive 'Cranborne Chase type' (Ashbee 1984, 15, Barrett *et al* 1991, 36). Being a short or oval long barrow of the Cranborne type it has previously been considered to be later than the long and bank barrows (Bradley 1984). The results from the new dating programme dispel these chronological assumptions for Wor Barrow which clearly demonstrate its currency falls within the 37th century BC along with a number of other dated long barrows in southern England (Bayliss and Whittle 2007).

Radiocarbon dates from Cranborne Chase are shown in Figure 18 (Healy *et al* 2011, table 4.6) and estimates from the individual site-based models for early Neolithic activity along with key events from Wor Barrow (these are derived from our preferred model shown in Fig 12a) are shown in Figure 19. Wor Barrow does not belong to the earliest Neolithic on Cranborne Chase, especially if OxA-7981 is (as claimed) from a domestic pig (Maltby 2007, 297). Although the Dorset Cursus is poorly dated, with a pick (*BM-2348*; Fig 19) from the top of the primary silts (Barrett *et al* 1991, fig 2.13) providing the best current estimate for its construction, it is clear that Wor Barrow is considerably earlier – with the turf mound estimated to have covered the burial chamber *265–635 years* (*93% probability*; distribution not shown) or *655–690 years* (*2% probability),* probably *300–540 years* (*68% probability*) before the Cursus was built. Thus the Dorset Cursus was probably constructed long after the use of long barrows on Cranborne Chase had finished.

Cranborne Chase in the fourth millennium cal BC is characterised by a mosaic of habitats, with substantial open areas of grassland as well as mixed deciduous woodland including some pine (French and Lewis 2007, 220). But it is clear that only local clearance of vegetation (Allen 2000, 43–4) had taken place around Wor Barrow when the mortuary enclosure was in use and the mound built. This contrasts with the established grassland in which Gussage Cow Down and Thickthorn Down long barrows were built (French *et al* 2003, 229; Allen 2007, 158).

A full discussion of the meaning of the identification of a 'curated' body (individual 8) from Wor Barrow is beyond the remit of this technical report on the radiocarbon dating project, but it should serve to remind us that people in our prehistoric past must have had well-developed concepts of 'history' and ancestry, with people from the past being 'embodied' to some extent in the present of living people.

APPENDIX THE WOR BARROW PEOPLE

The remains of the seven skeletons were examined by Smith (below) with regard to evidence for lifeways, pathology, mortuary treatment, and the overall demographic profile of the burials. Stable isotopes were studied from all seven and examined for evidence of mobility and diet (Jay and Montgomery below).

Special lives and exceptional deaths? Re-analysis of the human skeletal material

Martin Smith

All skeletal material of Neolithic date in the surviving archive from Pitt Rivers' excavation of Wor Barrow was re-examined by the present author between 2009–10. The human skeletal remains that were present consisted of parts of a minimum of seven crania and six mandibles, plus a selection of postcranial material. The latter consisted mainly of long bones in Pitt Rivers' wooden boxes, each labelled as containing bones from an individual skeleton. The crania and long bones were individually marked in writing recognisable as that of St. George Gray (J Gardiner pers comm), Pitt Rivers' lieutenant. These were the six primary inhumations (Figs 7a and 7b) plus Burial 8 (Fig 6), the Neolithic crouched burial from one of the barrow ditches. Bones of a crouched Burial (9) accompanying Burial 8 and described as a "child" (Pitt Rivers 1898, 63) were not present in the archive. Fragments of an additional skull were present with the cranial material for Burial 1. These additional fragments may belong to Burial 2 whose skull was fragmentary and incomplete and which lacks the respective additional elements present with Burial 1. Pelvic bones consisting of sacra and innominates from 16 individuals are stored in the surviving archive in three modern boxes. The style and quality of labelling on the pelvic bones was variable and appeared to have been added at different times and by different hands. The pelvic material included bones from both Neolithic and secondary (Romano-British or later) burials. It was possible to identify pelvic bones from four of the primary Burials (1, 3, 4, and 5). One animal long bone fragment was also present in the box containing the skull of Burial 1.

Careful attention has been paid to the 1898 report with regard to the confidence with which the above material can be confirmed to belong to the individual burials recorded by Pitt Rivers. Comparison of the skeletal material in the present archive with textual descriptions and metric data given by Pitt Rivers revealed no inconsistencies regarding postcranial material. Comparison with photographs and drawings of the skulls was highly conclusive as these were accurate and the skulls from the Neolithic phases are highly distinctive. Consequently we are comfortable in attributing the material discussed here to the burial numbers given in the original publication.

Preservation

The skeletal material present for each of the Neolithic burials is shown in Figure 20 and Table 3. Each individual is substantially incomplete with only the larger skeletal elements represented. Photographic plates published in the 1898 report clearly show bones from throughout the skeleton to have been present at excavation, including ribs, vertebral columns and hand and foot bones. Consequently, the partial representation of material in the surviving archive must derive from selective recovery by the excavators rather than any features of Neolithic mortuary practice. The bones had been subject to a degree of breakage although in comparison to many other assemblages from earlier Neolithic monuments the Wor Barrow bones are relatively complete. Overall, the crania had suffered the greatest degree of fragmentation, but also received the greatest attention post excavation. The crania had been carefully reconstructed using combinations of adhesive (probably animal bone glue) and wire with some missing sections reconstructed in plaster of Paris. All the fractures displayed irregular margins consistent with post-mortem breakage. Where crania had been reconstructed, the margins of fractures were no longer visible. With regard to postcranial bones, the majority (75/113 - 66.37%) had been subject to some degree of breakage with fracture margins that were patinated identically to the rest of the respective bone indicating breakage in the burial environment. Twenty postcranial bone specimens (17.69%) exhibited clean fracture margins consistent with damage occurring post-excavation.

In general, cortical surfaces were well-preserved with no peeling or flaking. No signs of weathering were apparent although bones from three burials exhibited damage by water erosion. The distribution of this damage is likely to have been influenced by the position in which these remains were deposited. Individuals 2, 3, and 6 all exhibited considerable water erosion on long bones from the left side. Burials 2 and 6 were articulated and crouched on the right side, whilst 3 was disarticulated. Given that the erosion therefore predominates on the uppermost limbs, at least of 2 and 6, presumably this was caused by water percolating through the overburden above rather than accumulating at the original ground surface. The lack of evidence for weathering suggests the bones have not been subject to any prolonged outdoor (sub-aerial) exposure. No signs of animal scavenging were present and no toolmarks were observed on any of the bones.

Demography

Demographic profiles were produced for each set of remains utilising the guidelines published by (Buikstra and Ubelaker 1994; Brickley and McKinley 2004). Sex was assessed using morphological features of the skull and pelvis wherever possible. Metric dimensions of postcranial bones were also taken into account. Age at death was assessed from a combination of indicators depending upon the skeletal elements present, with techniques acknowledged to be more reliable such as pubic symphiseal or auricular surface change given preference over less precise indicators such as dental wear or sutural fusion, wherever possible. It should be borne in mind that the techniques used to assess age, sex, and stature are based upon data derived from studies of modern/recent populations. It is not possible to say with certainty how far prehistoric populations may have deviated from the standards defined by such studies, although the respective techniques are assumed to be broadly correct. Conversely, where observations of dental wear contributed to age assessment, the standard used (Brothwell 1981) is based upon data derived from a range of British populations from Neolithic to Medieval date. Three decades on there is now arguably a case for re-evaluating Brothwell's method as it ultimately lacks precision, although it remains in common use for the time being.

As shown in Table 4, five of the individuals were clearly male, with one assessed as a probable male, and one for which sex could not be determined. The lack of certainty regarding these latter two relates to insufficient cranial and pelvic material being present to make a reliable assessment, rather than to these individuals having skeletons where the expression of sexually dimorphic features was genuinely ambiguous. Five individuals were young adults with ages ranging from 17–30, the remaining two were assessed as aged between 30–40 and 35–45 years respectively. Pitt Rivers similarly determined all the primary burials to be adult males, although it is not clear how this was assessed and a generalised bias towards sexing skeletons as male was ubiquitous among nineteenth century analyses (Smith and Brickley 2009, 19–33).

Stature and activity markers

Stature estimations were calculated from femoral length measurements using the equations given by Trotter and Gleser (1952; 1958). Median stature estimates by individual ranged from 156.85–171.77cm. These figures sit comfortably within the general range of stature estimates for earlier Neolithic Britain (Smith and Brickley 2009, 96–7). The median estimates obtained during the current study are compared with Pitt Rivers' (1898) stature calculations (Figure 21). As shown for two individuals, the two studies are in good agreement (<1cm difference), whilst for the remainder the 1898 report underestimates stature by varying amounts (2.32–9.09cm) and one (skeleton 8) is overestimated by 1.8cm. The differing magnitude of these disagreements plus the reverse direction of the error for skeleton 8 raise questions over how Pitt Rivers calculated stature (which is not stated in his report), as these differences seem random rather than systematic disagreements. Such issues are common to nineteenth century studies in general which commonly produced stature estimates for Neolithic people that would now be regarded as incorrect despite obtaining accurate bone measurements (Smith and Brickley 2009, 96). Such inaccuracies were most commonly underestimates leading to the continuing popular misconception that the builders of long barrows were particularly short.

Assessment of the extent of lateralization amongst the sample was hindered by incompleteness of humeri and clavicles. Tables 5 and 6 show the measurements which were taken and consequent asymmetry values, although it was not possible to take a complete set for any of the seven individuals. However, from the measurements available four individuals (Burials 1, 2, and 3, with 8 also probable) were clearly strongly lateralized in comparison to more recent populations (Battles 2009; Blackburn and Knüsel 2006). Four individuals were right-handed (2, 4, 5, and 8), with two left-handed (1and 3), and one indeterminate (6). Two individuals were less lateralized indicating that during earlier life they were more habituated to physical tasks that place more equal demands on the left and right sides of the body, whilst the remaining individual (6) lacked sufficient measurable features for this to be determined.

All individuals with one or both clavicles present (2–8) displayed lesions at the medial end, indicative of pronounced stress at the costoclavicular ligament insertion, which attaches the clavicle to the first rib. Similar lesions have been noted in other British Neolithic samples including West Kennet (Wysocki and Whittle 2000) and also in Neolithic groups from regions as diverse as Portugal (Silva 2009) Italy (Marchi *et al* 2006), Sweden (Molnar 2006) and Siberia (Lieverse *et al* 2009). Such stress markers indicate a repeated bilateral pulling or alternating flexion and extension of the arm in a rotary motion. Suggested activities involving such a movement include very general actions such as lifting heavy objects above the head, as well as more specific ones such as hide scraping, wood-working, bimanual use of axes, archery, and paddling watercraft (Hawkey and Merbs 1995; Blakey and Rankin-Hill 2004, 440; Lieverse *et al* 2009; Marchi *et al* 2006; Molnar, 2006). In fact, any or all of these might have influenced the development of such stress markers in the men buried at Wor Barrow with a combination of activities being perhaps more likely than any single repetitive task.

Pathology

In general, the individuals from Wor barrow exhibited few signs of skeletal pathology. Given the young overall age of this sample this is unsurprising as diseases which produce skeletal changes are generally longstanding chronic conditions which take effect progressively as individual's age. However, Burial 3 exhibited a range of skeletal anomalies most consistent with a congenital or developmental syndrome, whilst three individuals displayed healed traumatic injuries. Burial 3 displayed an abnormal level of craniofacial asymmetry with the left side of the face dropped in relation to the right. This asymmetry was also manifested throughout other parts of the skull with the temporal bones and foramen magnum displaced in relation to the midline (Fig 22a, b, and d). The anomalous positioning of the foramen magnum would be consistent with some abnormal curvature of the spine although this was not possible to assess directly as no vertebrae had been retained. The postcranial bones that were present exhibited further anomalies, in particular both distal humeri were externally rotated, by 40° and 44° respectively (Fig 22e and f) producing an increased carrying angle (cubitus valgus). The humeral shafts also displayed lateral bowing (Fig 22f). The pelvic bones and proximal femora appeared normal but the knee joints were markedly asymmetrical in size with the right knee joint showing a degree of flaring in both the distal femur and proximal tibia. The patellae were markedly unequal in size (Fig 23). The right fibula was laterally bowed for the proximal third of its shaft. This distortion related to the flaring of the knee joint with no bowing present in the other lower limb. The left fibula was absent and so could not be compared. Musculoskeletal stress markers were present on the left humerus at the attachment site of the pectoralis muscles, with no sign of similar stress in the opposing humerus. This difference is again suggestive of generalised body asymmetry arising from the axial skeleton and may relate to the use of a crutch.

Although it is possible that Burial 3 suffered from multiple conditions, taken together these anomalies are suggestive of a congenital syndrome rather than isolated pathologies. Several congenital syndromes are known which might fit the range of abnormalities present. The feature of greatest interest in this regard was the presence of bilateral cubitus valgus which is very unusual. Congenital disorders in which this defect is seen include Turner's syndrome, Noonan's syndrome, Cohen's syndrome and Cardiofaciocutaneous syndrome. The first of these can be discounted as it only affects females. Western (2007) suggested Cohen's syndrome to be present in a medieval individual with cubitus valgus, although this skeleton was much more complete than Wor Barrow 3 allowing for a more precise diagnosis. Noonan's, Cohen's and Cardiofaciocutaneous syndrome are all very similar and in this instance it may not be possible to differentiate between them. All three commonly involve a range of abnormalities including facial defects, learning difficulties, and curvature of the spine. As with many congenital conditions the overall list of potential defects relating to each syndrome is long, and any one affected individual need not exhibit all of them, for example in Noonan's syndrome only 25% of affected individuals experience learning difficulties (Jones 1997).

Trauma

Three individuals displayed healed injuries to their lower limbs. Burial 1 had a spur of calcified soft tissue near the proximal end of his right tibia consistent with a soft-tissue injury at the attachment site of tibialis posterior. Burial 4 displayed a similar instance of calcified soft tissue at the distal end of his left fibula consistent with an inversion injury to the ankle damaging the calcaneofibular ligament. Burial 5 had a healed fracture to his left fibula shaft (Fig 24). The fracture was situated approximately a third of the way down (94mm) from the proximal tip of the bone (total bone length = 305mm). The fracture is angulated obliquely at approximately 55° to the longitudinal axis of the shaft. The site of the injury had healed well with solid lamellar bone having formed and no woven bone present. The bone ends had healed in good apposition with no angulation or discernible rotation to either end. Pointed spurs of bone indicated some ossification of soft tissue structures, respectively the interrosseous ligament and the origin of flexor hallucis longus. The ipsilateral tibia displayed no signs of injury which would explain the well-healed nature of the fibular fracture, the uninjured tibia having acted as a splint.

The soft tissue injuries noted are arguably unremarkable as knee and ankle injuries of this kind sustained during falls are likely to be frequent in individuals given to walking or running over uneven ground. However, it is also possible that these injuries could be the result of direct trauma to the affected region. This is most likely in the case of the fibular fracture noted on Burial 5. Isolated fibular fractures resulting from falls commonly affect the distal portion of the bone with fractures to the proximal third occurring much less frequently. When such injuries do occur they are generally the result of a direct blow with contact sports being a principal cause in modern populations (King *et al* 1990; Slauterbeck *et al* 1995; Boden *et al* 1999) second only to road traffic collisions. An earlier study by Bizarro (1922) found only 2.38% of fibular fractures were located at the proximal end and also noted that fractures at this point are generally the result of direct force. Possible sources of such direct force during the Neolithic include being kicked by an animal or interpersonal violence. It is possible that an unusual or awkward fall onto a projecting object might have produced this injury, although this is a less likely cause.

The crouched burial from the ditch (Burial 8) is of further interest in that a leaf arrowhead was recovered from "between the lower ribs" (Pitt Rivers 1898, 72). Whilst this could have been placed at the time of burial, it may alternatively be the case, as Pitt Rivers concluded, that an arrow wound to the thorax may have caused, or at least contributed to this man's death (Fig 25). Recent re-evaluations of earlier Neolithic assemblages from throughout Britain have revealed repeated instances of injuries consistent with violence, including a number of arrow wounds (Smith *et al* 2007; Smith and Brickley 2009; Knüsel, 2006; Schulting and Wysocki 2005; Wysocki and Whittle 2000). As with the other burials from Wor Barrow, the ribs of Burial 8 were not retained at excavation so cannot now be assessed for signs of trauma. It should be borne in mind, however, that most traumatic injuries leave no sign in bone (Banasr *et al* 2003) and so even having all the ribs available would not necessarily be conclusive in this respect. In the absence of surviving skeletal material, little can be said about the child burial laid next to Burial 8, whose death may just have been coincidental around the time of the young man's demise.

Skeletal isotope analyses

Mandy Jay and Janet Montgomery

Introduction

All seven burials (primary Burials 1– 6 and secondary ditch Burial 8) have had bone collagen analysed for carbon, nitrogen, and sulphur stable isotopes ($\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$), whilst six of them (excluding skeleton 2) have had the same analyses applied to dentine collagen. Those six have also had $\delta^{18}O$phosphate and $^{87}Sr/^{86}Sr$ analyses applied to tooth enamel samples. This overall data set is intended to provide information about mobility, diet, and environmental background by tracing the signals inherent in dietary resources from the plants at the base of the food chain through to the skeletal fraction being analysed (see Lee-Thorp 2008 for a good synthesis of the theory for various isotope systems). Differences between bone and dentine data may reflect timing differences during life, because the dentine forms during childhood and the bone reflects an averaged lifetime dietary signal, probably weighted towards adolescence. The enamel samples also reflect childhood formation periods.

Laboratories and methods

Collagen extractions and $\delta^{13}C$ and $\delta^{15}N$ analyses were undertaken at the University of Bradford, with $\delta^{34}S$ analysis undertaken at Iso-Analytical Ltd (Crewe). $^{87}Sr/^{86}Sr$ and $\delta^{18}O$phosphate data were obtained from the NERC Isotope Geosciences Laboratory (NIGL) in Nottingham, with the enamel sampling undertaken at the University of Bradford. Details of methods can be found in Montgomery *et al* 2007 (enamel sampling and $^{87}Sr/^{86}Sr$ analyses), Jay *et al* 2008 (collagen extraction and $\delta^{13}C$ and $\delta^{15}N$ analyses [$\delta^{34}S$]) and Chenery *et al* 2010 ($\delta^{18}O$ phosphate analyses [$\delta^{34}S$]).

The full dataset will be published, with detailed technical and interpretation information, elsewhere, but a short summary of the findings is presented here, although at present the $\delta^{34}S$ data were unavailable. There are no significant or systematic differences between the bone and dentine carbon and nitrogen isotope ratios, such that the averages for the two skeletal fractions are similar ($\delta^{13}C$ bone (n = 7): −21.2 ± 0.1‰; dentine (n = 6): −21.2 ± 0.2‰; $\delta^{15}N$ bone: 9.9 ± 0.4‰; dentine: 9.8 ± 0.4‰). The data are also relatively closely clustered for the group of individuals as a whole. The tooth enamel $^{87}Sr/^{86}Sr$ data range from 0.707904 to 0.709282 and are consistent with the local chalk bedrock, whilst the $\delta^{18}O$ phosphate values range from 17.5 to 18.4‰, again being in a range which is probably consistent with other material from this general region (Pellegrini and Richards forthcoming).

Overall, the data are consistent with the geology and environmental background for the region and are relatively closely clustered, such that there is no reason to suspect long-distance mobility for any of these individuals and they would appear to be a cohesive group in dietary terms, unlike the '*Cranborne lady*' from Monkton-up-Wimborne, for whom the isotopic evidence suggested a possible origin in the Mendips (Montgomery *et al* 2000), albeit later in the Neolithic 3500–3100 cal BC (OxA-8035; 4585±50 BP). They appear to be a cohesive group in dietary terms and the carbon and nitrogen isotope ratios are indicative of a terrestrial diet, relatively high in animal protein, which is the norm for people from mainland Britain at this point in the Neolithic.

Whilst these basic conclusions appear, on an initial inspection, to be relatively pedestrian, there are indications that they are of particular interest in considering issues of movement within the local landscape as part of these people's subsistence strategy. There are relationships between the oxygen, strontium, and nitrogen isotope ratios which may be indicative of a strategy of movement or dietary resource acquisition between different, possibly seasonal, environments. There is also some indication, when all of the data are taken together, that skeleton 8, the secondary ditch burial, is unusual in the context of the closely grouped data patterns for the primary barrow burials, possibly in relation to early childhood being spent at a different point in the seasonal round. Detailed analyses of these points will be presented elsewhere.

The $\delta^{13}C$ data are also interesting because they are relatively closely clustered, but also at the more positive extreme of what is usual for this time period and location. Currently unpublished comparative data for sites in the area (Jay and Richards forthcoming) suggest that both animals and humans have a tendency towards more positive $\delta^{13}C$ values from sites such as Down Farm, Canada Farm, Cranborne, Long Crichel, and Chalbury. This may be related to the local environment in terms of factors such as having a more open landscape with less woodland cover or perhaps having a warmer and/or drier climate and this may well be consistent with environmental studies of the area (French *et al* 2007; Allen and Gardiner 2009).

FIGURES

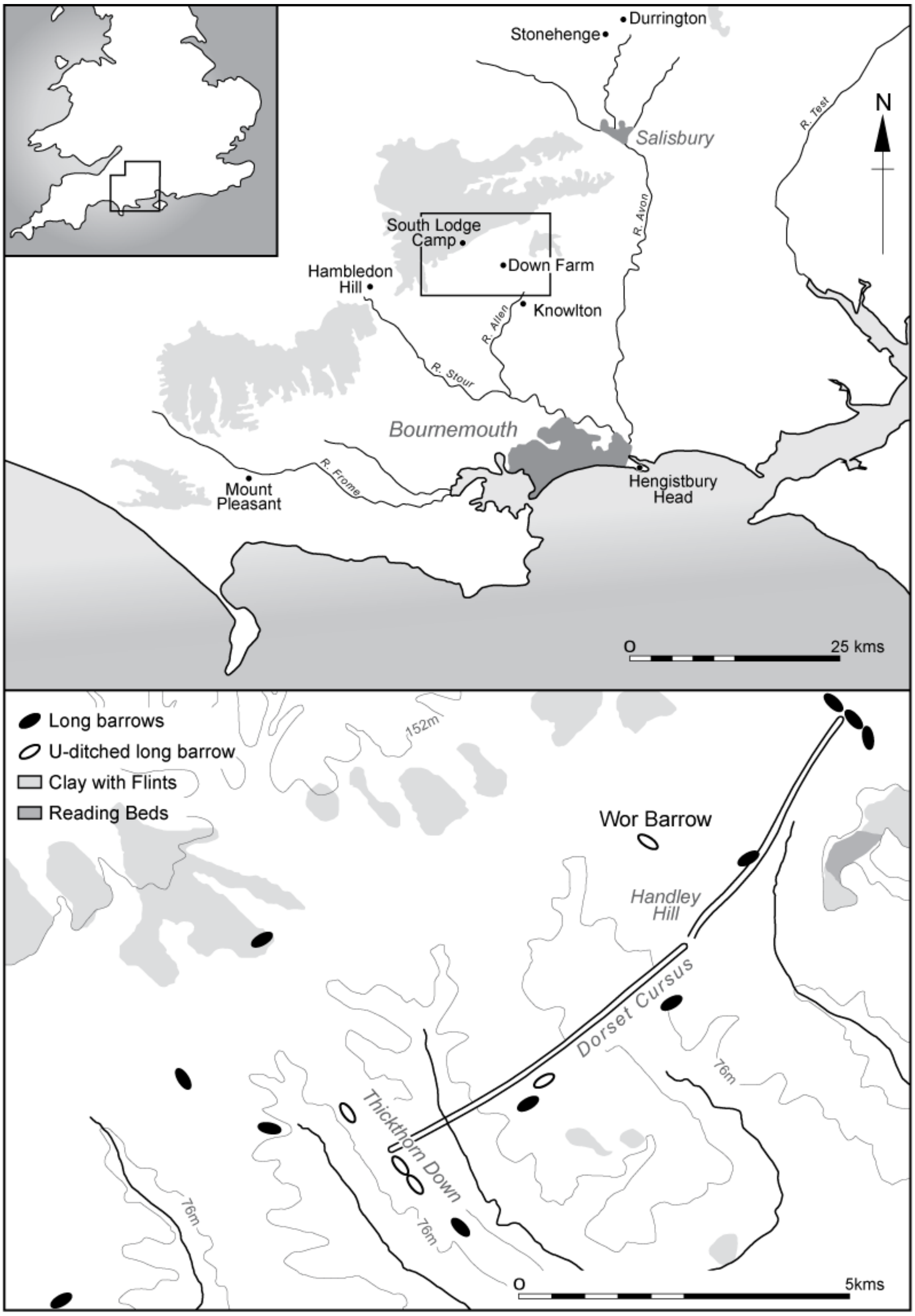

Figure 1: Location of Wor Barrow in southern England, and the Cranborne Chase barrows around the Dorset Cursus

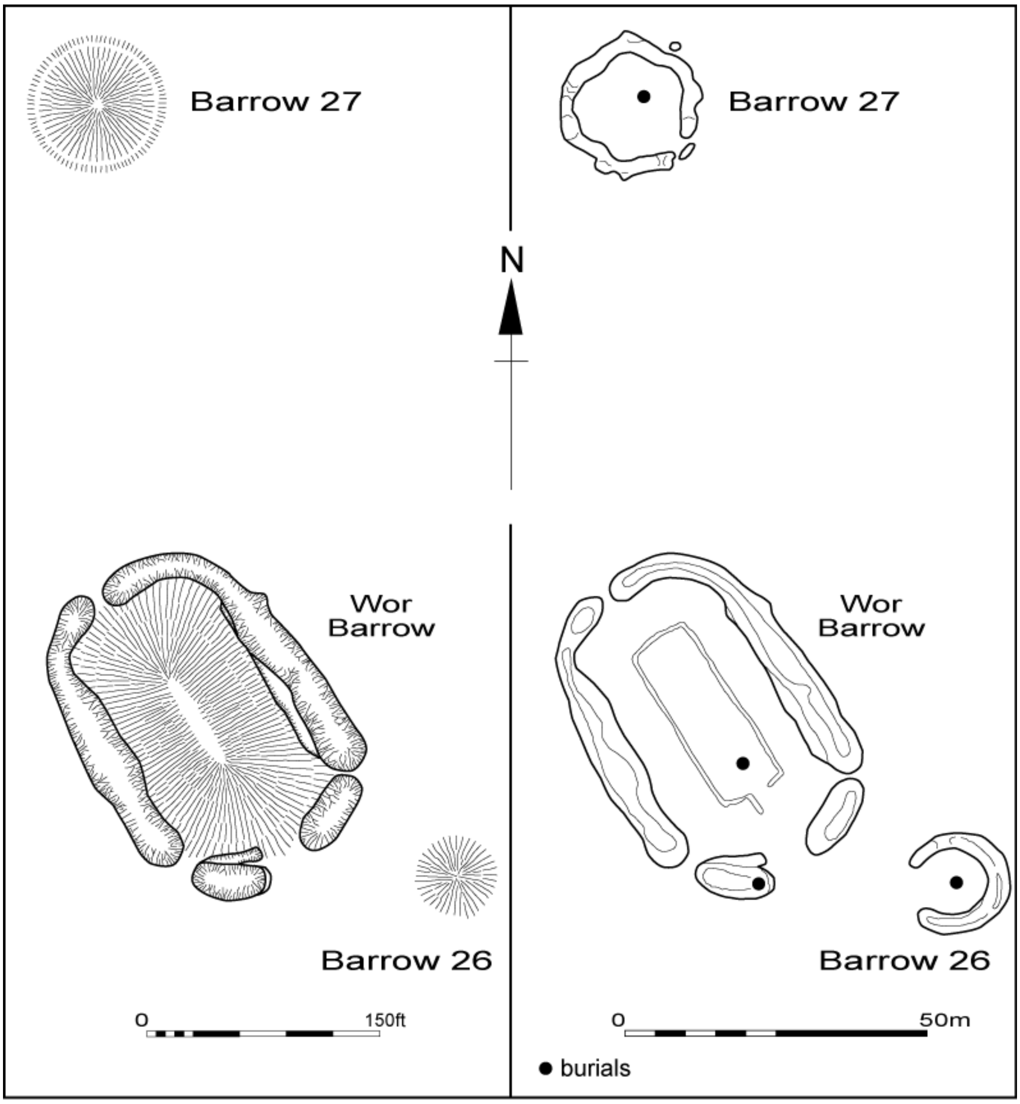

Figure 2: Plan of Wor Barrow and Handley 26 and 27; pre and post-excavation (after Pitt Rivers 1898 and Barrett et al *1991)*

Figure 3: The excavation of Wor Barrow in 1894 (photograph published by Pitt Rivers)

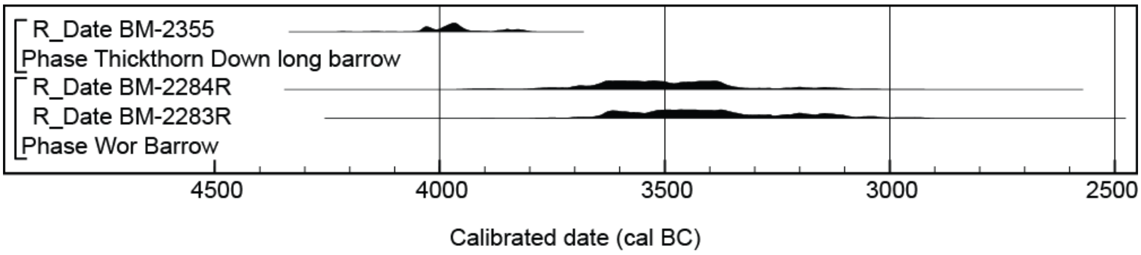

Figure 4: Probability distributions of dates from long barrows on Cranborne Chase prior to commencement of this project. The distributions are the result of simple radiocarbon calibration (Stuiver and Reimer 1993)

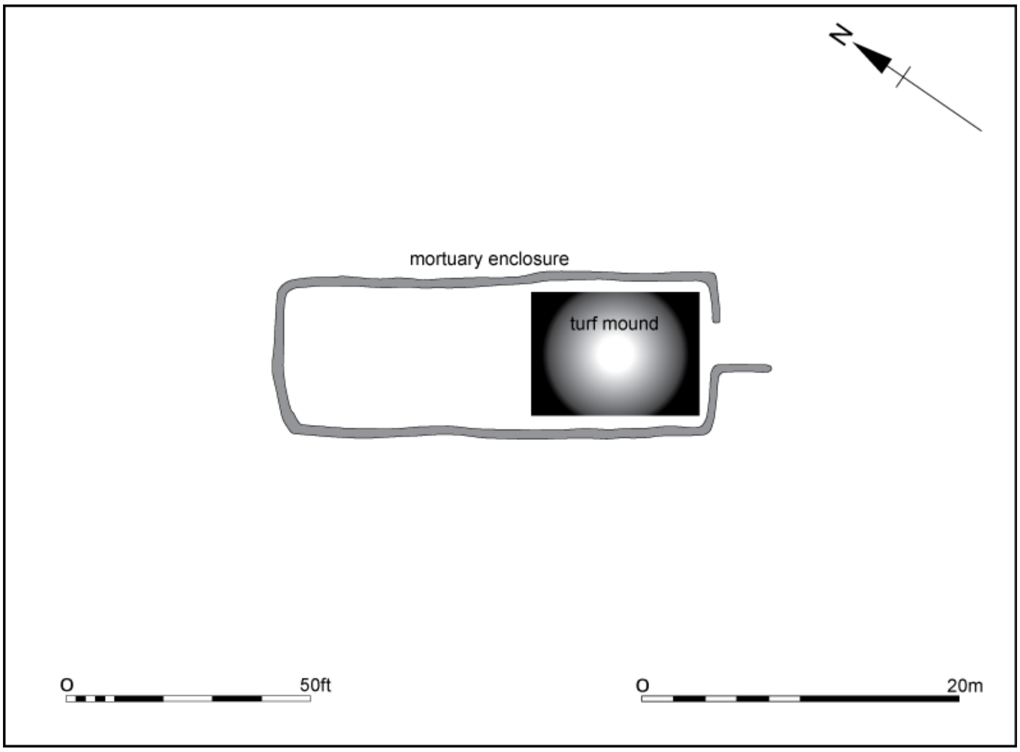

Figure 5a: Phase 1: the mortuary enclosure and burials

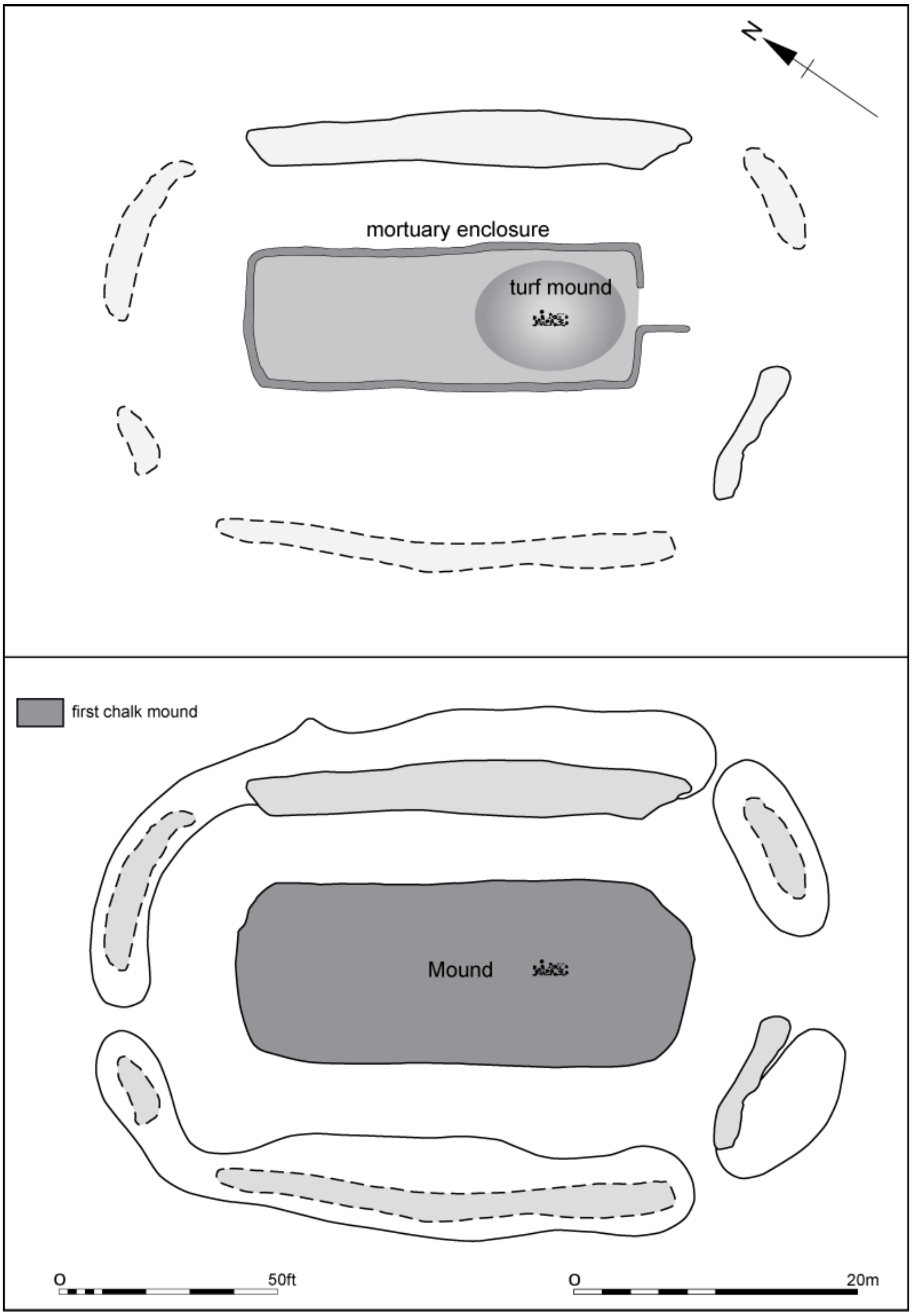

Figure 5b: (top) Phase 2a; the infilling of the mortuary enclosures with chalk from first ditch digging phase, and (bottom), Phase 2b; the initial primary Wor Barrow mound

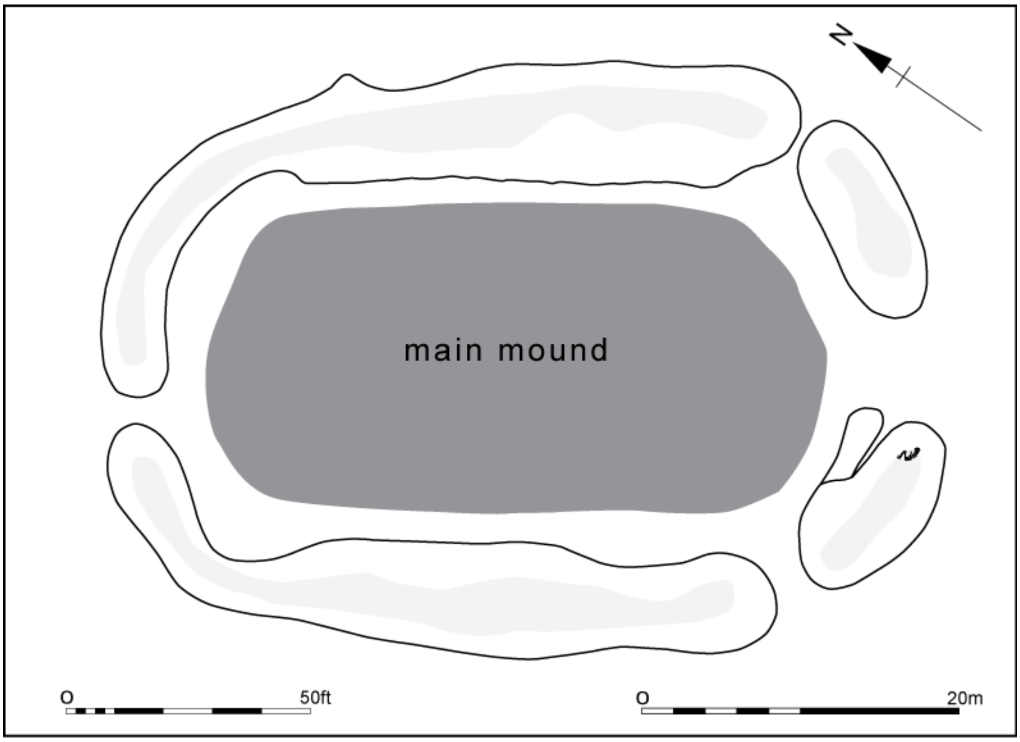

Figure 5c: Phase 3; Enlargement of the ditch and the major final barrow mound

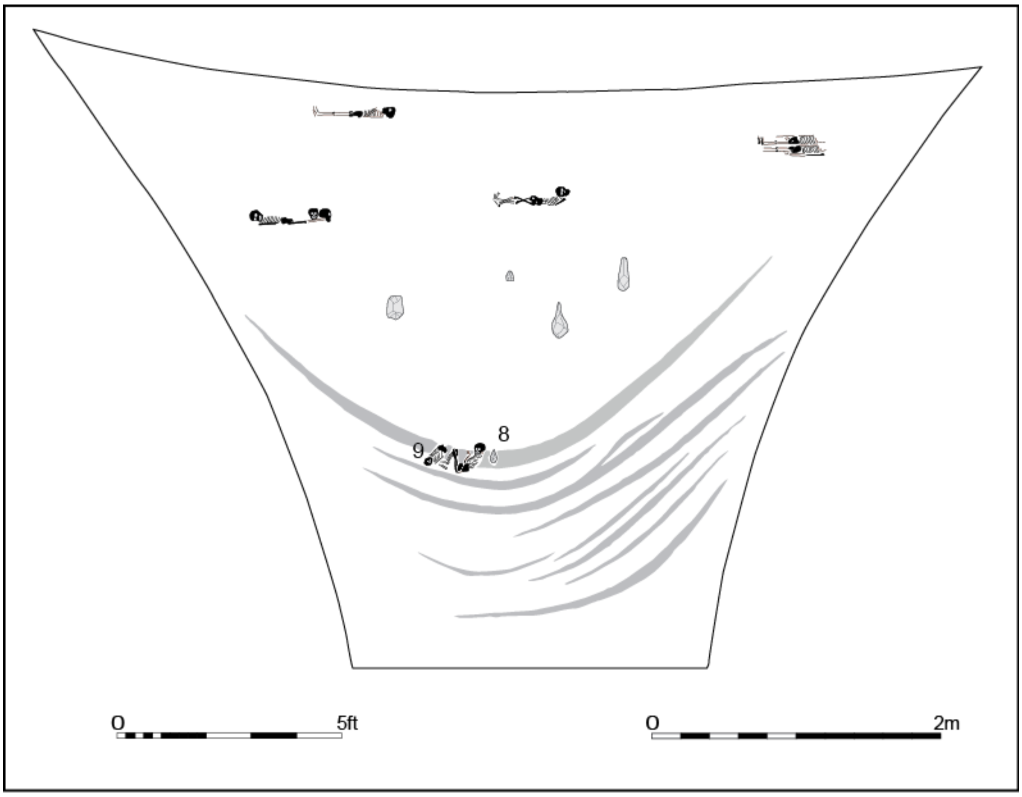

Figure 6: The schematic ditch section showing skeleton 8 lying in the upper primary fills (after Pitt Rivers)

Figure 7a: Photograph of the primary burials (Pitt Rivers 1898)

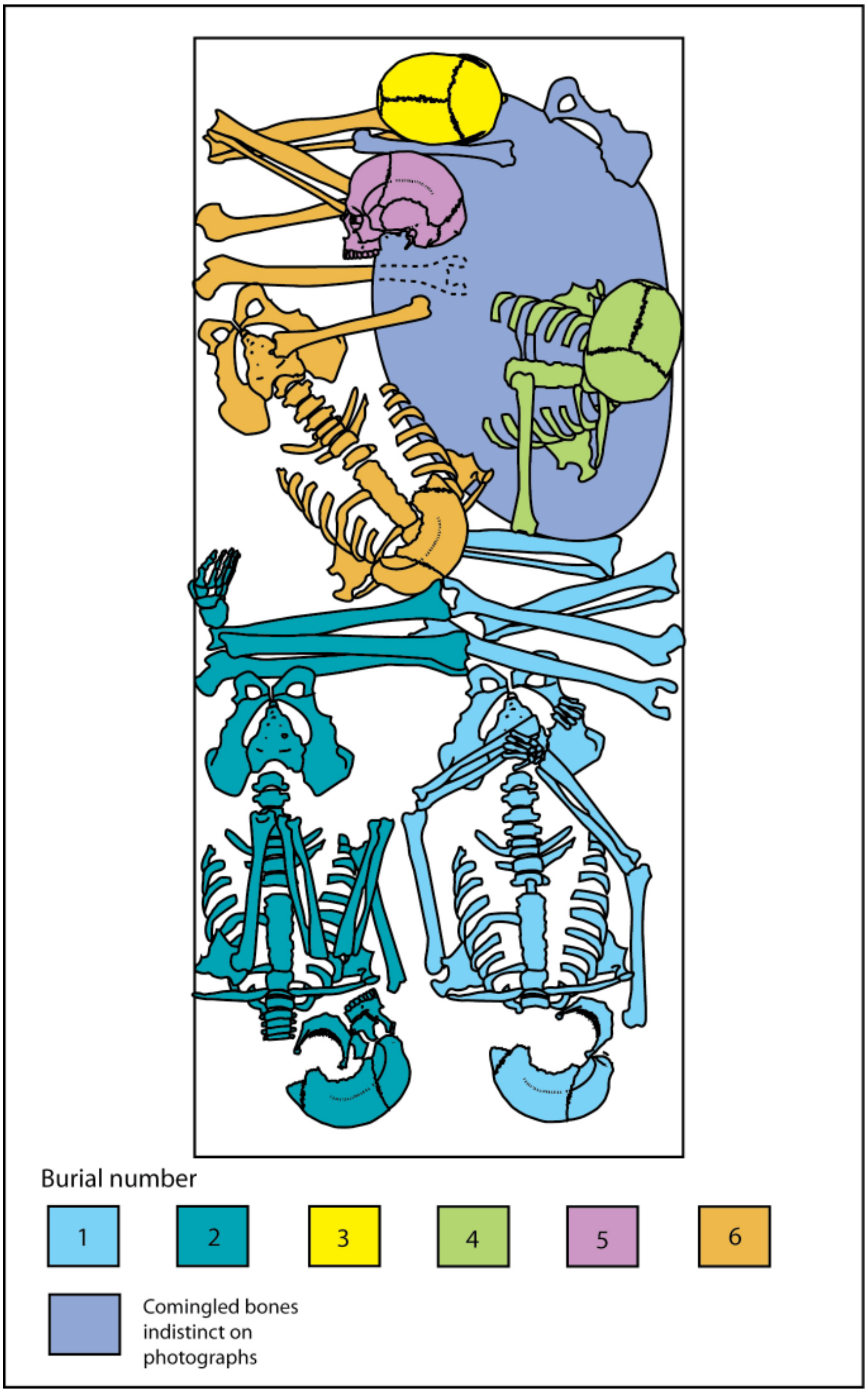

Figure 7b: Rectified drawing of the primary burials

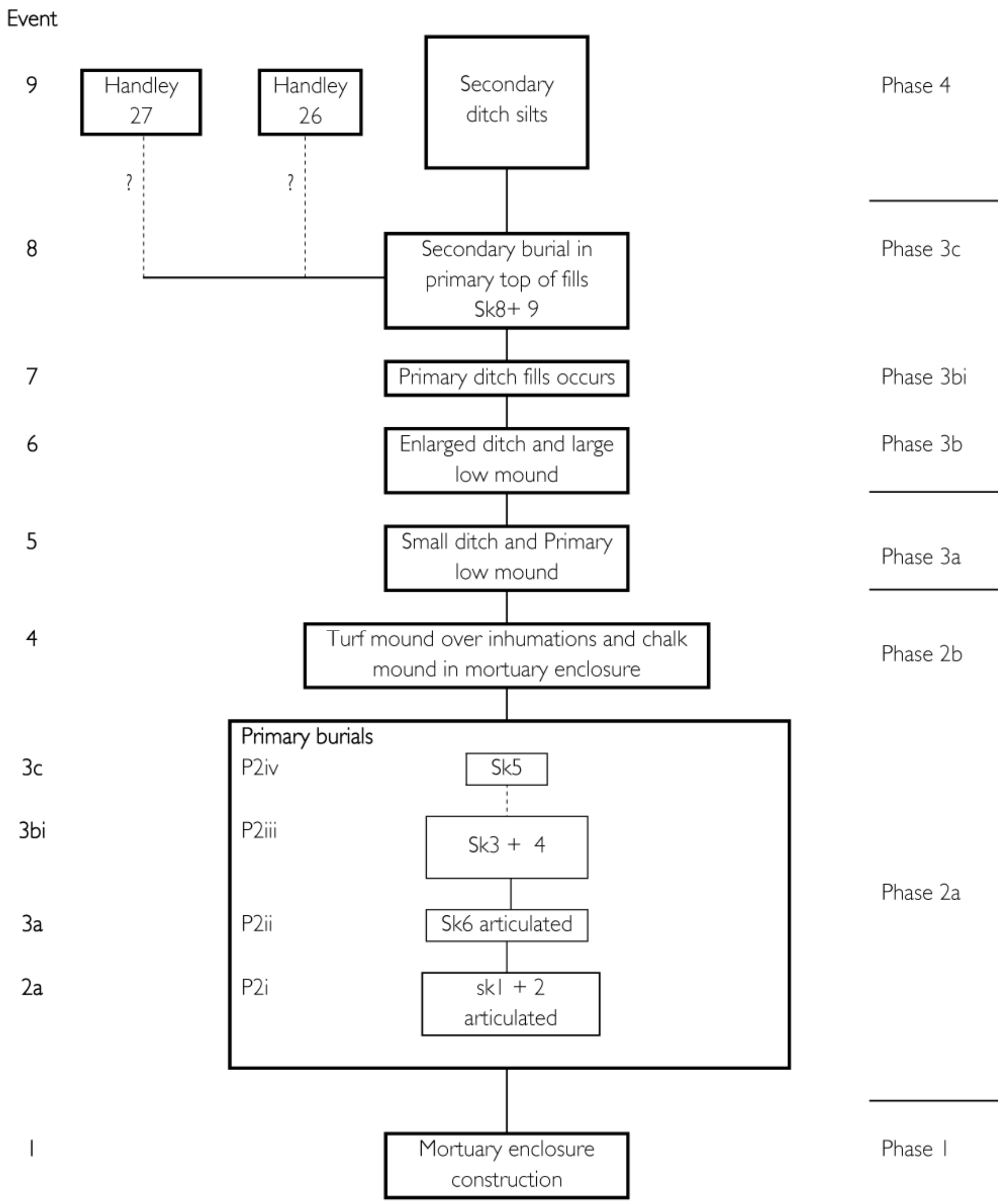

Figure 8: Event model 1 for Wor Barrow

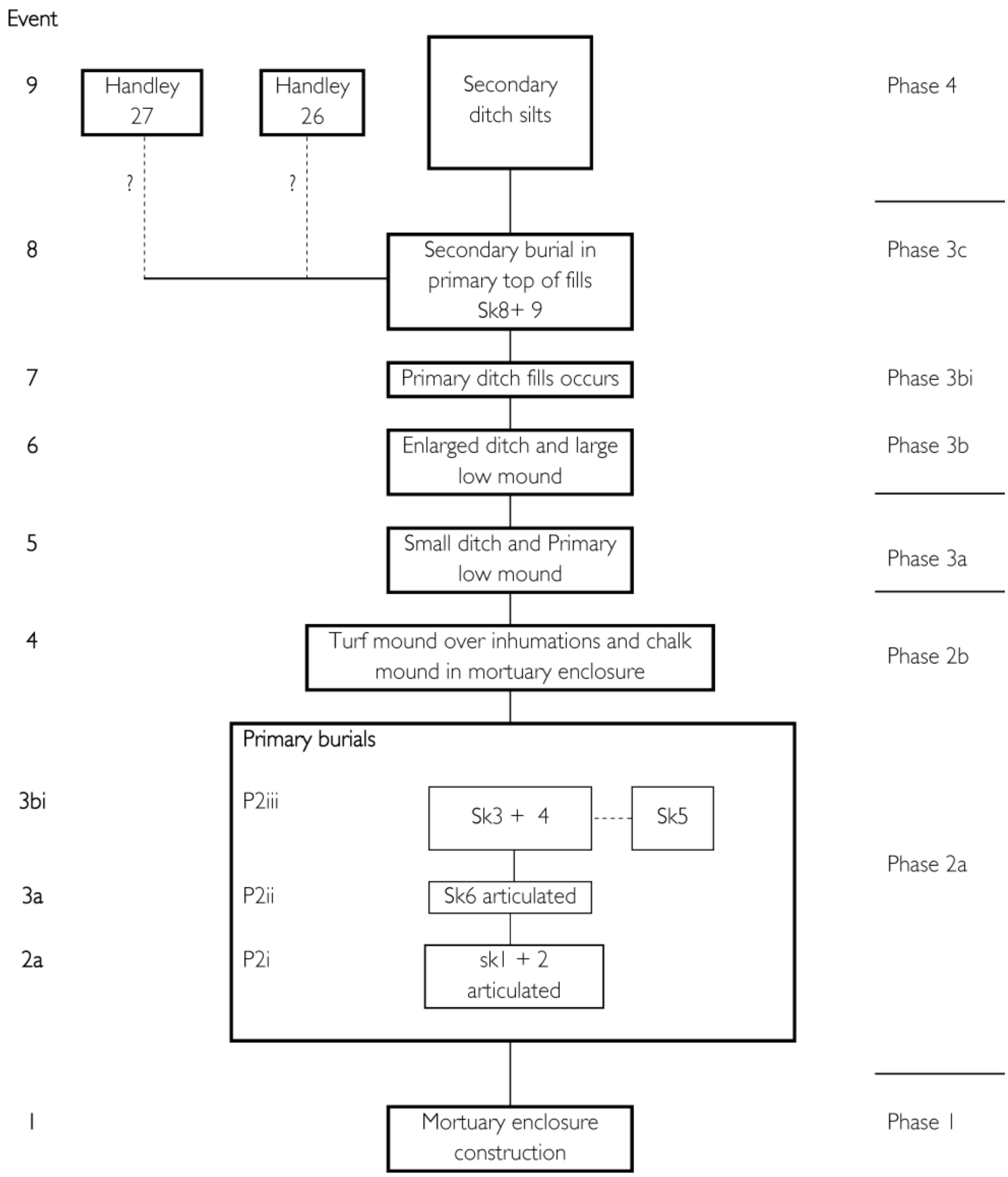

Figure 9: Event model 2 for Wor Barrow

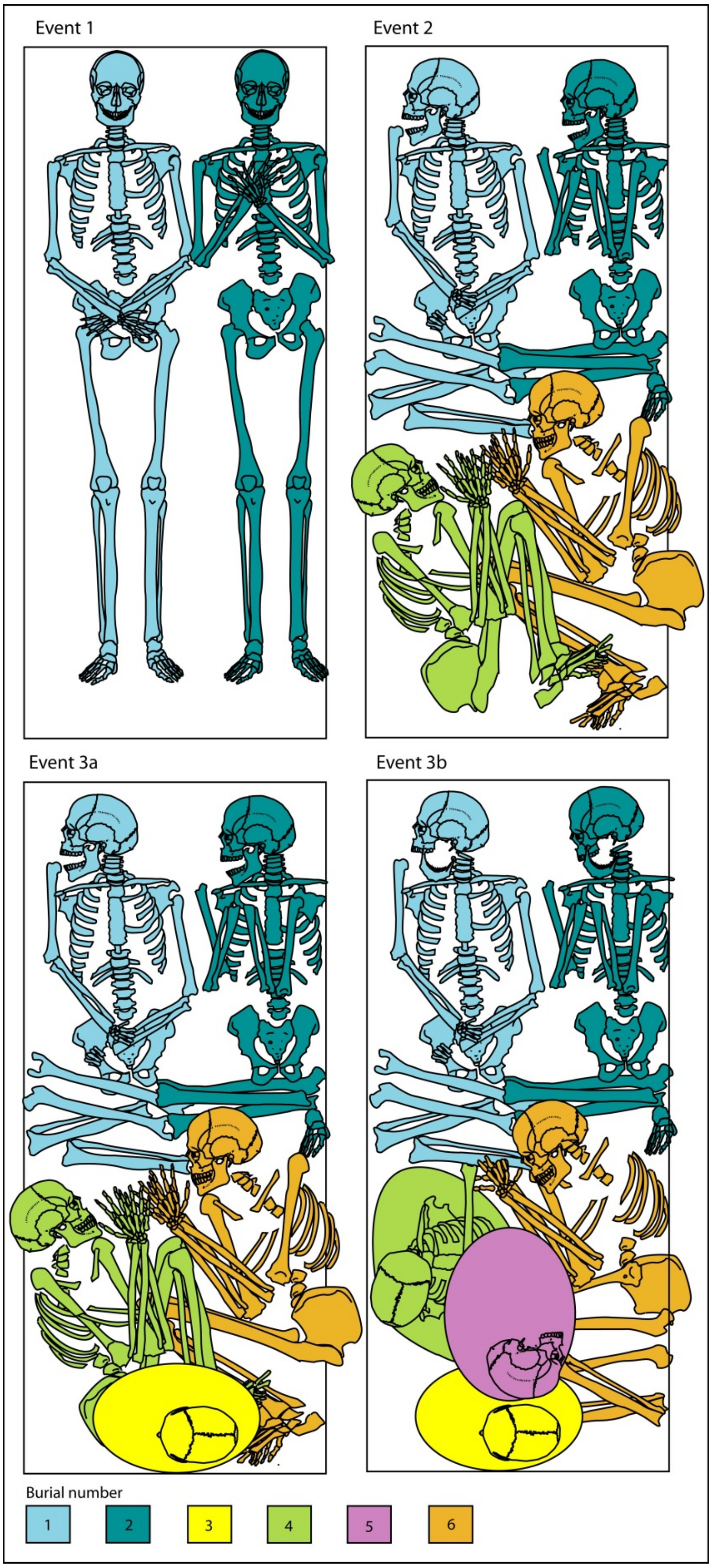

Figure 10: Burial Event sequence

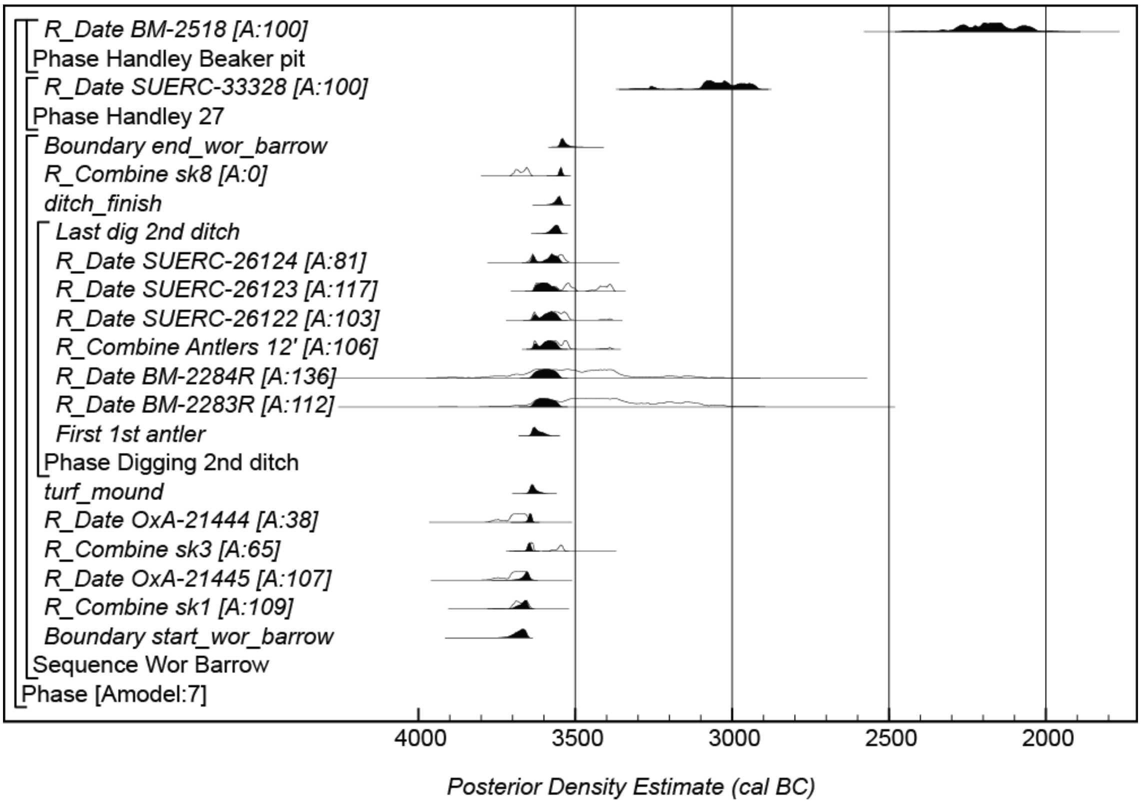

Figure 11a: Probability distributions of dates from Wor Barrow (event model 1). Each distribution represents the relative probability that an event occurs at a particular time. For each radiocarbon date, two distributions have been plotted: one in outline which is the result of simple radiocarbon calibration, and a solid one based on the chronological model used. The other distributions correspond to aspects of the model. For example, the distribution 'ditch_finish' *is the estimate for when digging of the ditch finished. The large square brackets down the left-hand side of the diagram and the OxCal keywords define the overall model exactly.*

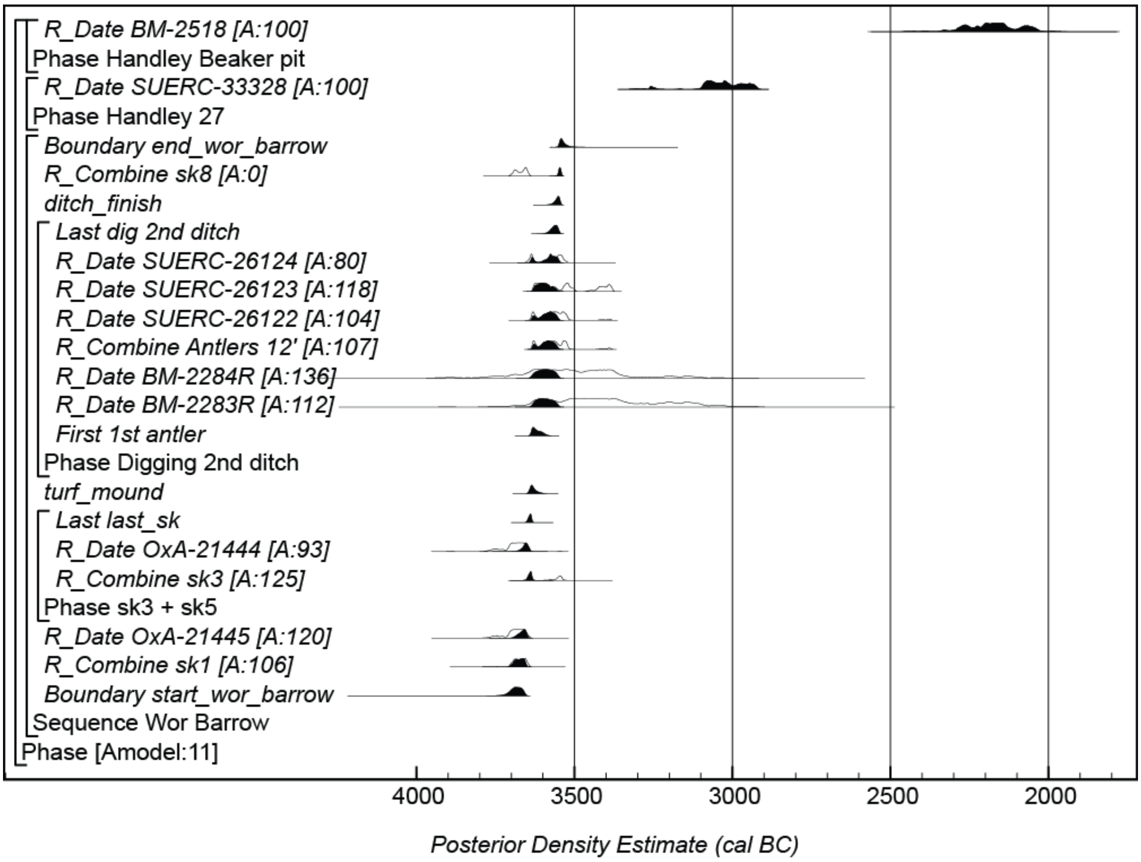

Figure 11b: Probability distributions of dates from Wor Barrow (event model 2). The format is identical to Figure 11a.

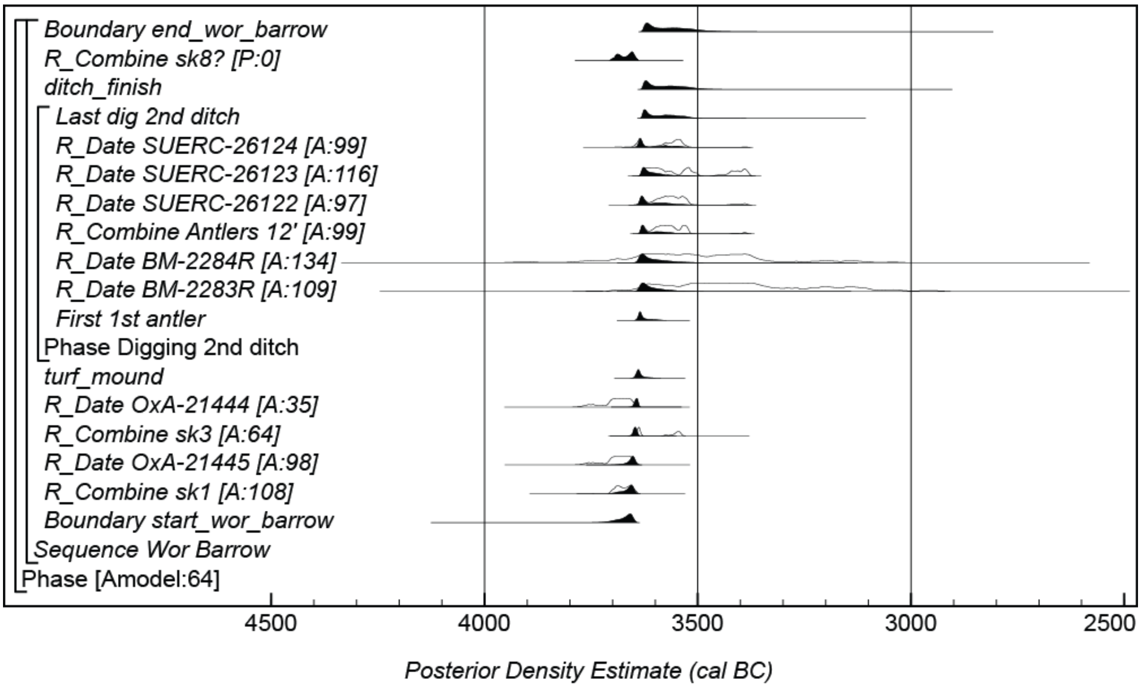

Figure 12a: Probability distributions of dates from Wor Barrow (event model 1). The format is identical to Figure 11a, apart from the '?' that denotes a date has been excluded from the model.

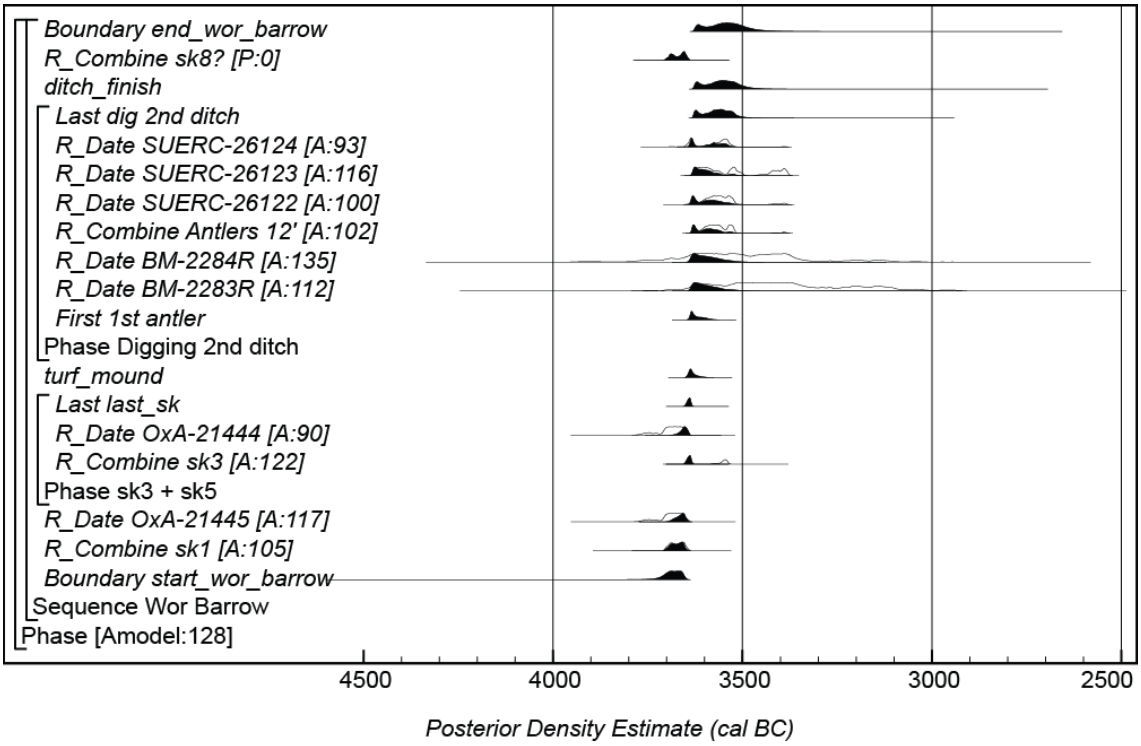

Figure 12b: Probability distributions of dates from Wor Barrow (event model 2). The format is identical to Figure 12a.

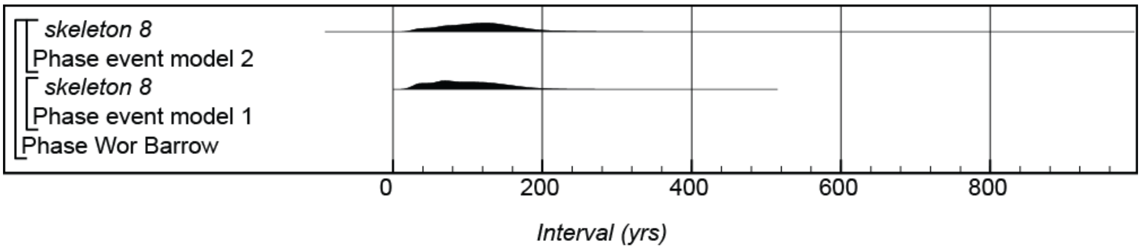

*Figure 13: Estimated difference between the death of individual 8 (*sk8*) and the digging of the ditch (*ditch_finish*). The distributions provide a minimum amount of time that the body was kept articulated before final burial in the top of the primary fill of the ditch. The distributions are derived from the models shown in Figures 12a–12b.*

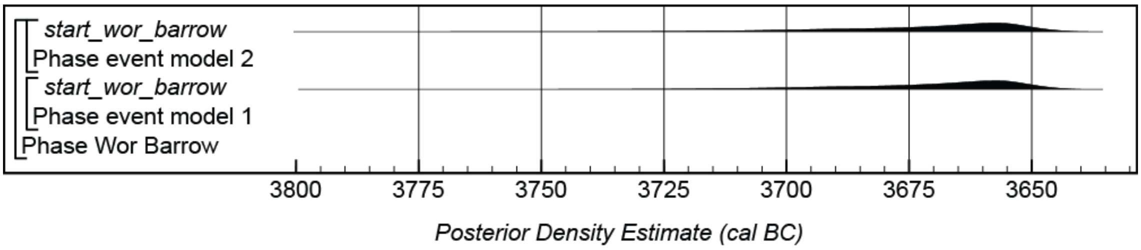

Figure 14: Probability distributions of dates for the start of activity at Wor Barrow. The estimates are derived from the models shown in Figures 12a–12b.

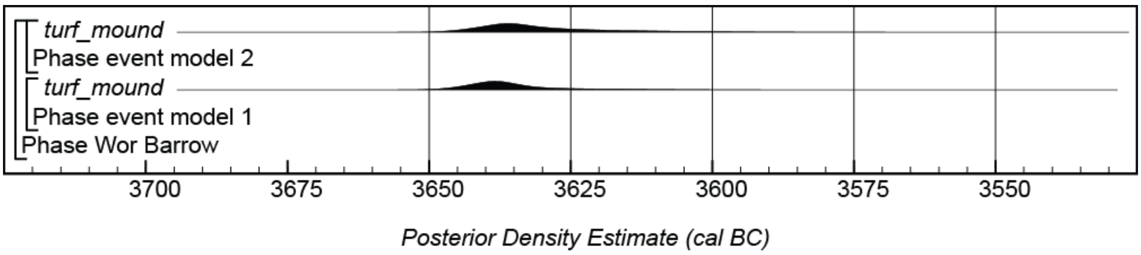

Figure 15: Probability distributions of dates for the closing of the mortuary chamber at Wor Barrow (construction of the turf mound). The estimates are derived from the models shown in Figures 12a–12b.

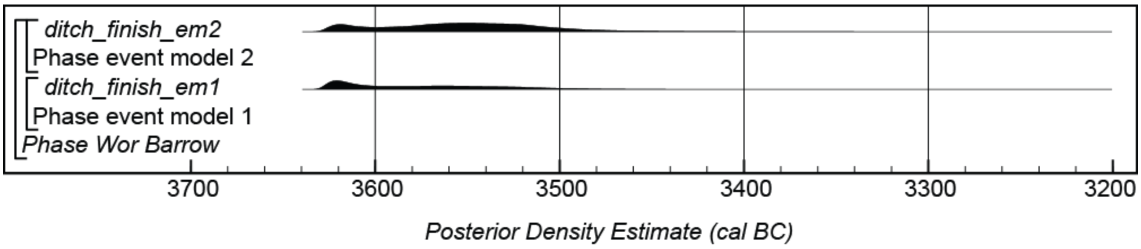

Figure 16: Probability distributions of dates for the completion of the ditch at Wor Barrow. The estimates are derived from the models shown in Figures 12a–12b.

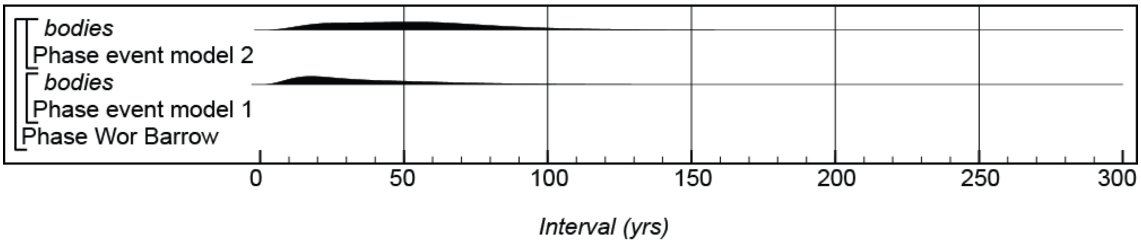

*Figure 17: Probability of number of years the mortuary enclosure was in use (calculated by taking the difference between the closing of the mortuary chamber (*turf_mound*) and the start of its use (*start_wor_barrow*). The estimates are derived from the models shown in Figures 12a–12b.*

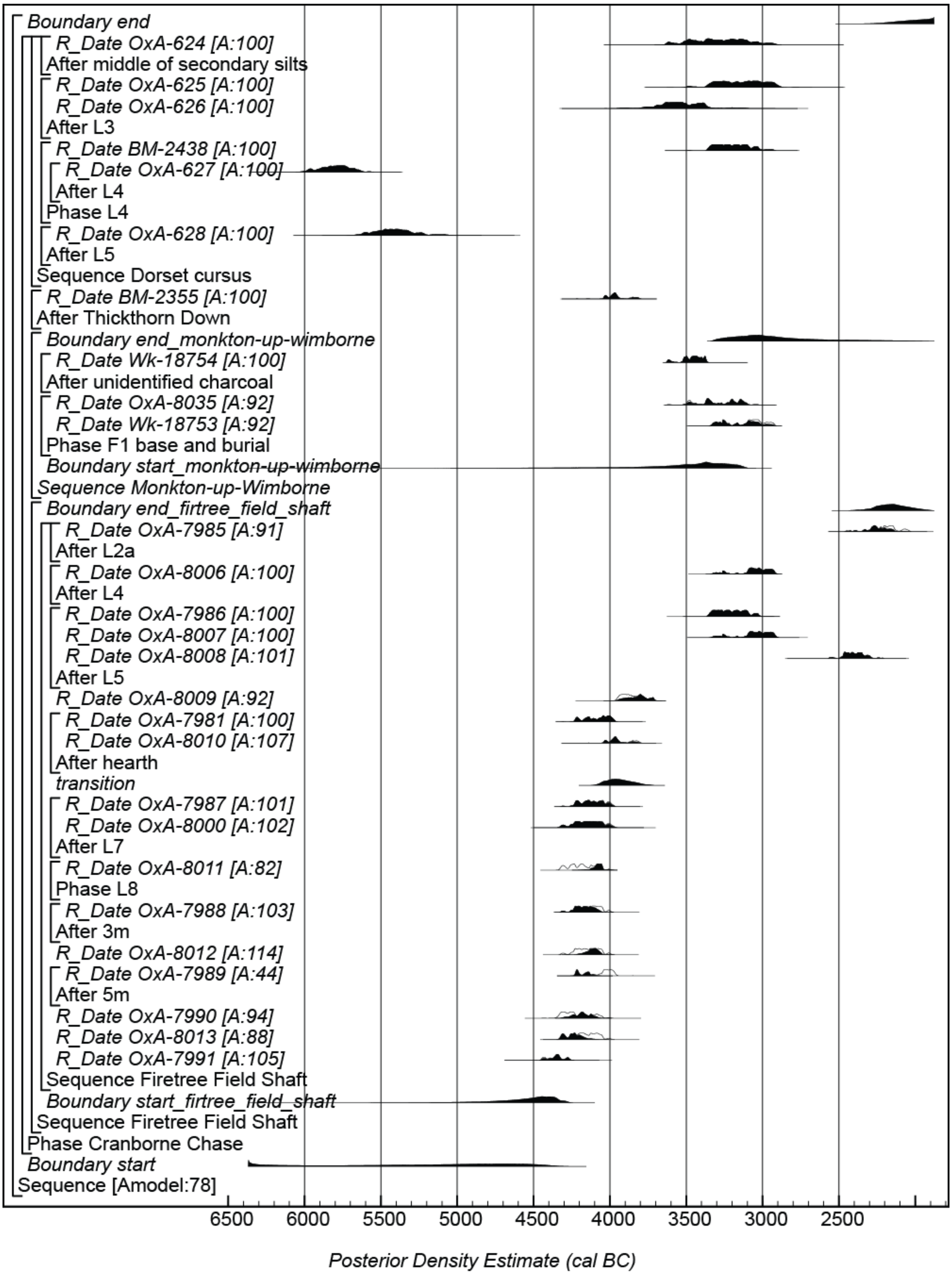

Figure 18: Probability distributions of dates from Cranborne Chase. The format is identical to Figure 12a.

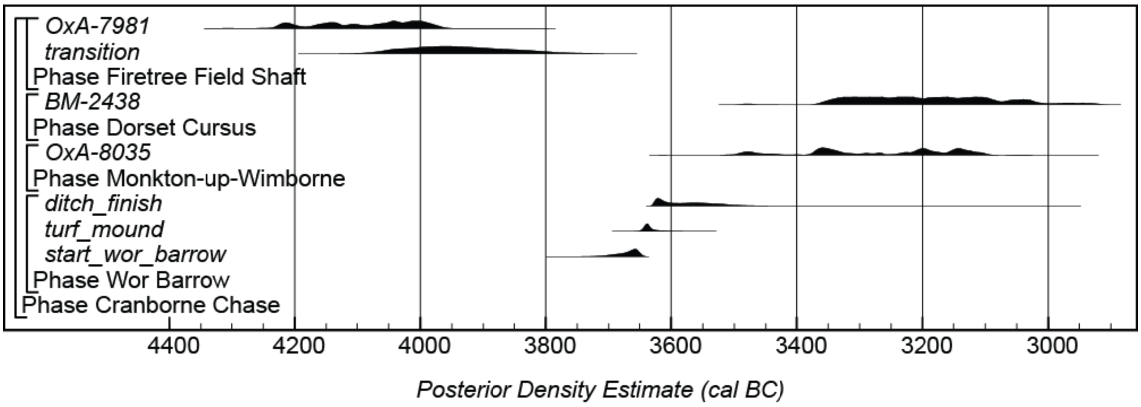

Figure 19: Probability distributions of dates for Neolithic activity from Cranborne Chase taken from the models shown in Figures 12a and 18.

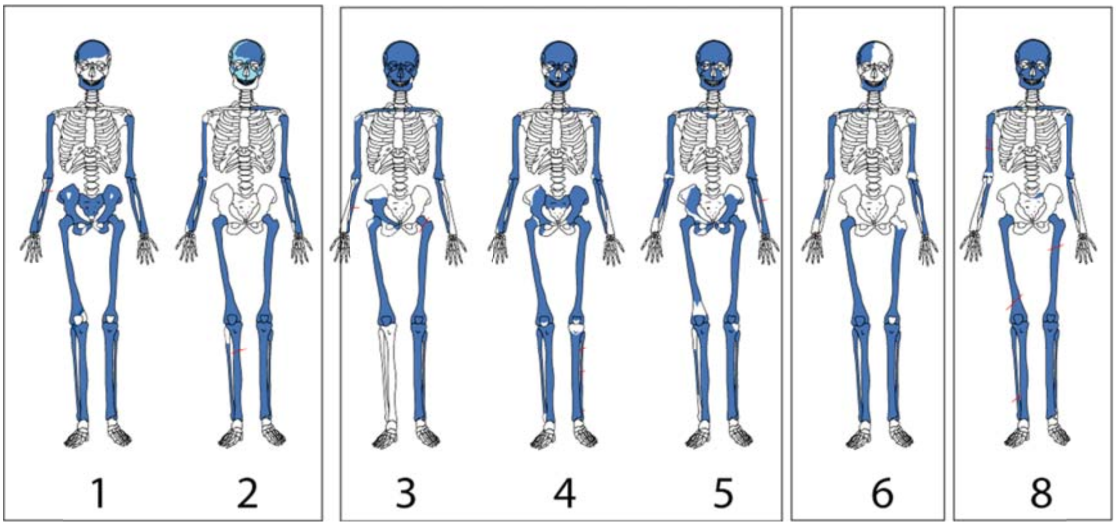

Figure 20: Skeletal material present in the surviving archive from Wor Barrow

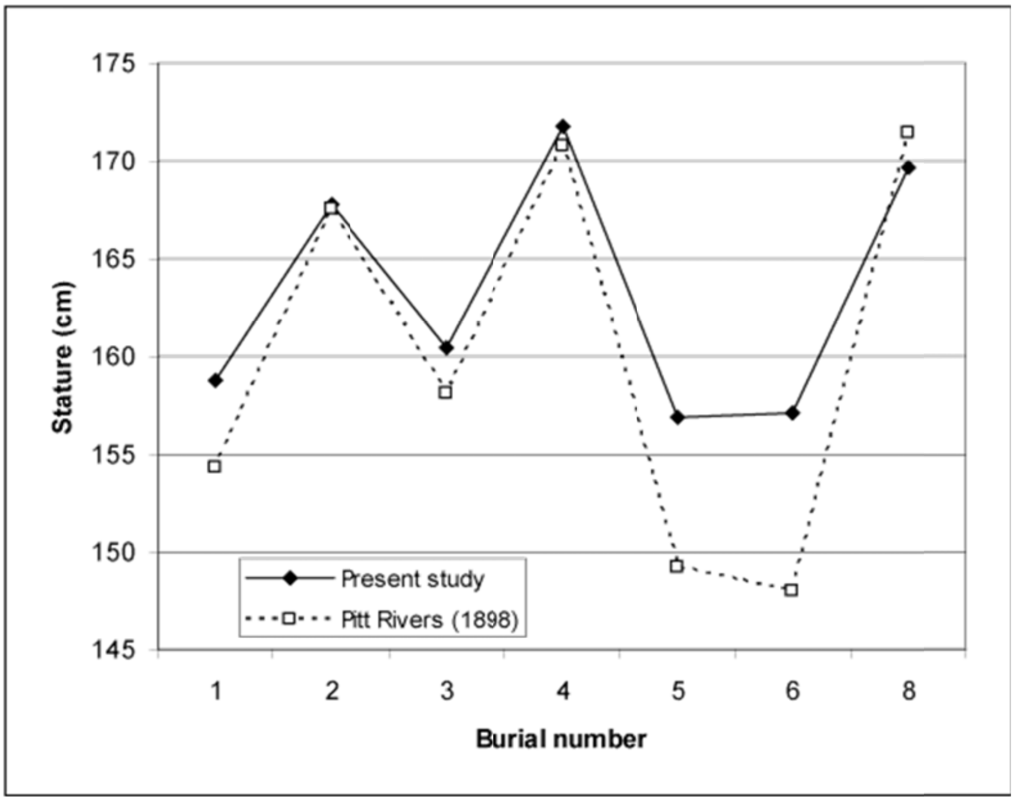

Figure 21: Median stature values for the Wor Barrow assemblage. Pitt River's stature estimates are also included

Figure 22: The skull and humeri of Burial 3. a. frontal view of skull, b. AP radiograph of cranium, c. view of Mandible showing bifurcation of mental region, d. inferior view of cranium showing lateral asymmetry, e. and f. humeri with bowing of shafts and lateral rotation of distal ends.

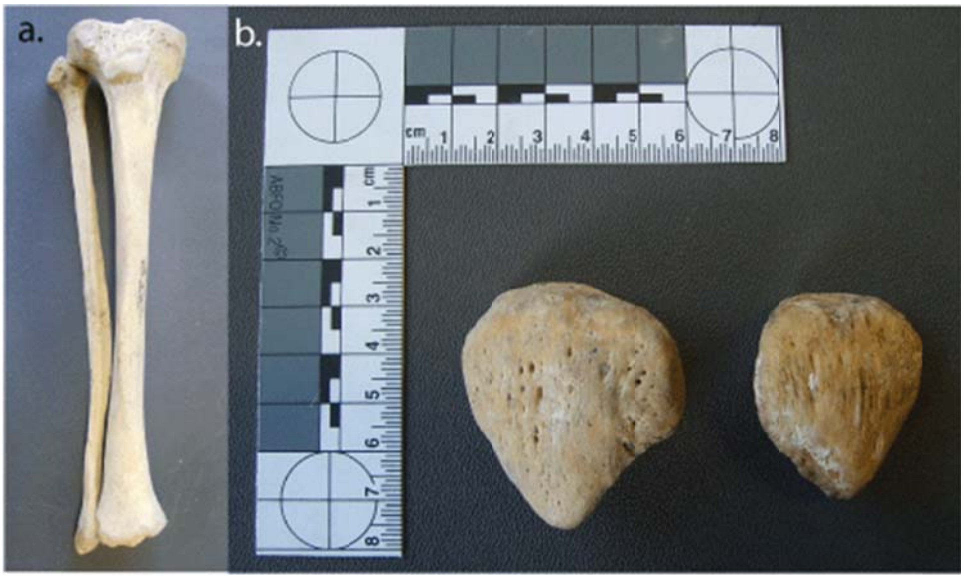

Figure 23: a. Tibia and fibula of Burial 3 showing lateral flaring of the proximal tibia and consequent bending of the fibula, b. Patellae of Burial 3 showing pronounced asymmetry

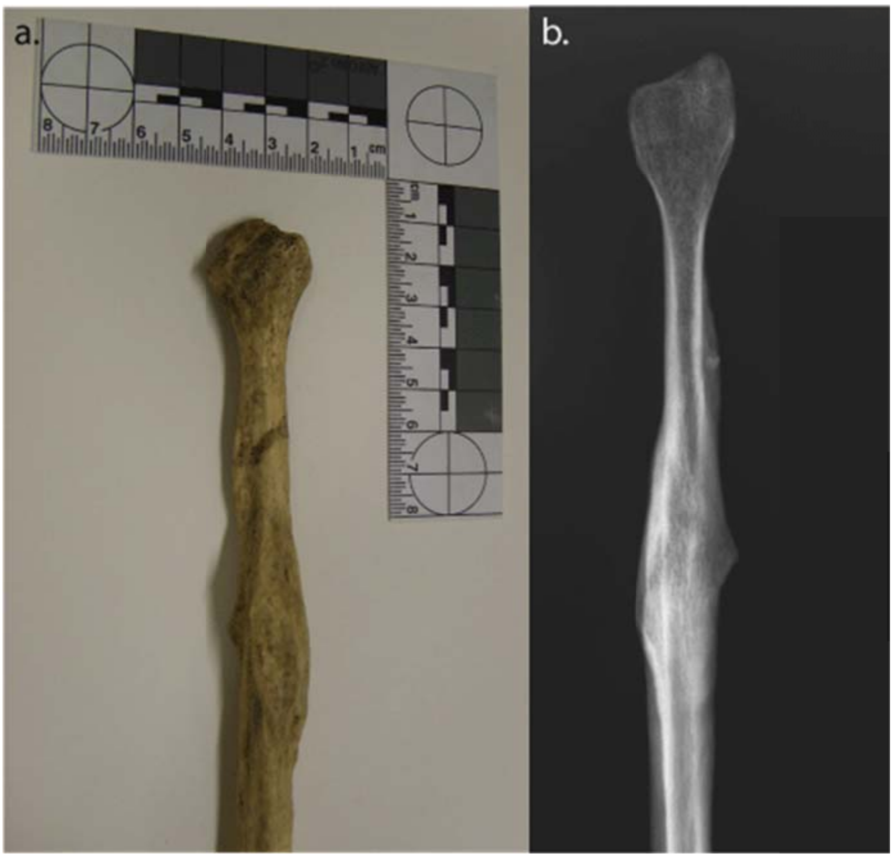

Figure 24: a. and b. Healed fracture to the left proximal fibula of Burial 5

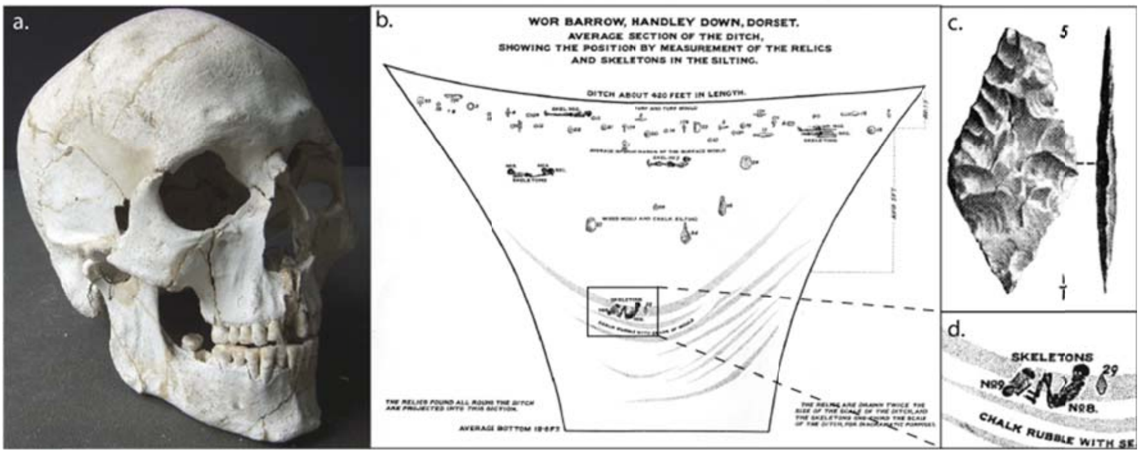

Figure 25: Burial 8, the crouched burial in the barrow ditch, a. Skull with reconstruction visible using glue and plaster, b. Pitt Rivers' (1898) section drawing showing location of the burial, c. Pitt Rivers' (1898) drawing of the arrowhead found "between the lower ribs", d. Detail of the burial from the section drawing

TABLES

Table 1: Previous radiocarbon results from Wor Barrow and Thickthorn Down long barrows

Material	Laboratory number	Radiocarbon Age (BP)	^{13}C (‰)	Ceramic association
Handley Down barrow 26				
Human femur, crouched burial, from adult male burial (Skel 10)	BM-2518	3750±50	−19.0	Beaker
Wor Barrow (revised results; Bradley 1988; Bowman 1991)				
Red deer antler fork, on bottom of ditch	BM-2284R	4740±130	−21.0	Peterborough Ware (and decorated bowl)
Red deer antler base, probably pick, in primary fill	BM-2283R	4660±130	−21.9	
Thickthorn Down long barrow				
Red deer antler from buried soil*	BM-2355	5160±45	−21.0 (estimated)	Plain bowl and earlier

* Sample was treated with PVA and was cleaned with acetone but there is a slight possibility of contamination surviving pre-treatment (Ambers *et al* 1987, 180) and the result may be too old (Barrett and Bradley 1991, 10)

Table 2: Wor Barrow radiocarbon and stable isotope results (derived from Event Model 1; Fig 12a)

Laboratory Number	Material	Context	Radiocarbon Age (BP)	^{13}C (‰)	^{15}N (‰)	C:N	Weighted mean	*Posterior density estimate (95% probability) - cal BC*
Primary burials								
SUERC-26117	Human, right femur	Skeleton 3: disarticulated with skeleton 4 & skeleton 5	4770±30	−20.7±0.2	8.9±0.3	3.3	4824±21 BP (ν=1; T'=5.9 (5% =3.8)	*3660–3635*
OxA-23275			4870±28	−20.7±0.2	9.1±0.3	3.2		
OxA-21444	Human, right femur	Skeleton 5: disarticulated with skeleton 3 & skeleton 4	4914±33	−20.5±0.2	10.2±0.3	3.2		*3655–3635*
OxA-21445	Human, right femur	Skeleton 6: ?articulated but with disarticulated group skeleton 3, skeleton 4 & skeleton 5	4911±33	−20.4±0.2	9.2±0.3	3.2	-	*3680–3640*
SUERC-26116	Human, right femur	Skeleton 1; articulated with skeleton 2	4915±30	−20.5±0.2	10.1±0.3	3.3	4896±23 BP (ν=1; T'=9 (5%=3.8)	*3695–3640*
OxA-21447			4873±33	−20.5±0.2	10.5±0.3	3.2		
Ditch digging								
OxA-21448	Red deer antler	Ditch 12ft, bottom of ditch in mouth of south-east angle (below skeleton 8), worn, worked and cut tine	4767±33	−20.5±0.2	-	-	4763±23 BP ν=1; T'=0.0 (5% =3.8)	*3640–3550 (94%) or 3540–3530 (1%)*
SUERC-26118			4760±30	−20.3±0.2	-	-		
SUERC-26122	Red deer antler	Ditch 10ft bottom of ditch, worn and worked tine	4775±30	−20.4±0.2	-	-	-	*3645–3535*
BM-2284R	Red deer antler	Bottom of ditch, depth 10.5ft, probably in lower silts, rather than on ditch bottom (Bradley *et al* 1991, 43)	4740±130		-	-	-	*3650–3535*
BM-2283R	Red deer antler	Primary fill, bottom of ditch, depth 11ft.	4660±130		-	-	-	*3645–3530*
SUERC-26123	Red deer tine and beam shed	Ditch 7.5ft chalk rubble (primary) shed beam typical pick	4735±30	−21.8±0.2	-	-	-	*3640–3555 (93%) or 3535–3520 (2%)*

Laboratory Number	Material	Context	Radiocarbon Age (BP)	^{13}C (‰)	^{15}N (‰)	C:N	Weighted mean	*Posterior density estimate (95% probability) - cal BC*
Neolithic Secondary inhumation								
OxA-21446	Human, right femur	Skeleton 8; crouched buried in primary fills of ditch, (with child 9)	4881±32	−20.7±0.2	9.9±0.3	3.2	4889±19 BP ν=2; T'=0.9 (5% =6.0)	*3700–3640*
OxA-24079			4914±32	−20.9±0.2	9.4±0.3	3.2		
SUERC-33324			4875±30	−21.3±0.2	9.6±0.3	3.2		
Ditch infill (secondary fills)								
SUERC-26124	Red deer worn tine	Ditch 4ft (probably silt and chalk – secondary); worn and worked tine	4810±30	−20.8±0.2	-	-	-	*3645–3615 (55%) or 3605–3535 (40%)*
Handley 27 and Handley pit								
SUERC-33328	Human left femur	Crouched inhumation skeleton 1 in Handley 27 irregular ditched barrow	4410±30	−21.8±0.2	10.3±0.3	3.3	-	*3310–3295 (1%) or 3285–3235 (4%) or 3105–2915 (90%)*
BM-2518	Human femur	Human femur (Skeleton 10) from adult male burial in flat grave, associated with FN Beaker.	3750±50	-	-	-		

Table 3: Material present by element for the seven primary burials. In general the bones present were relatively complete and the figures here refer to actual numbers rather than minimum numbers of each element

Element	Number left	Number right
Cranium	8	
Mandible	6	
Clavicle	5	4
Manubrium/ Sternum	1	
Humerus	7	7
Radius	5	5
Ulna	6	7
Sacrum	3	
Innominate	2	4
Femur	7	7
Patella	5	5
Tibia	7	6
Fibula	7	6

Table 4: Basic demographic information for Neolithic burials at Wor Barrow

Burial No	Phase	Sex	Age	Stature range	
				cm	inches
1	1a	M	25–33	155.48–162.02	61.2–63.8
2	1a	Ind.	18–22	164.17–171.30	64.6–67.4
3	1c	M	17–21	157.15–163.69*	61.9–64.4*
4	1c	M	35–45	168.18–175.35	66.5–69.0
5	1b	M	30–40	153.58–160.12	60.5–63.0
6	1c	?M	25–30	153.82–160.36	60.6–63.1
8	2	M	25–35	166.43–172.97	65.5–68.1

M= Male, ?M = Probable male, Ind.=Sex indeterminate.
*The stature estimate for individual no.3 will be less accurate due to various pathological anomalies present (see below)

Table 5: Assessment of bilateral humeral and clavicular asymmetry and handedness

Measurement	L	R	% asymmetry	Handedness	Strongly lateralized?
Burial 1					
AW	42.3	39.1	−7.86241	L	Y
EW	58.5	56.7	−3.125		
HD	44.3	42.3	−4.61894		
ML	292	293	0.34188		
Burial 2					
AW	41	42.4	3.357314	R	Y
EW	u	u			
HD	u	u			
ML	u	u			
Burial 3					
AW	46.6	44.8	−3.93873	L	Y
EW	64.2	62.6	−2.52366		
HD	u	u			
ML	30.5	31	1.626016		
CL	133	126	−5.40541		
Burial 4					
AW	42.9	43.1	0.465116	L	N
EW	u	u			
HD	44.3	44.8	1.122334		
ML	u	u			
Burial 5					
AW	u	u		R	N
EW	u	u			
HD	42.3	43	1.641266		
ML	u	u			
Burial 6					
AW	u	u		U	U
EW	u	u			
HD	u	u			
ML	u	u			
Burial 8					
AW	u	u		R	Y
EW	u	u			
HD	47.7	48.9	2.484472		
ML	u	u			

Measurements in mm; AW: Articular width; EW: Epicondylar width; HD: Head diameter; ML: Maximum humeral length; CL: Clavicular length; R: Right; L: Left; U: Unobservable; Asymmetry values calculated using the formula given by Mays *et al* (1999).

Table 6: Mean % humeral asymmetry by measurements given in Table 3

Humeral measurement	Number observable	Mean % asymmetry total sample	Mean % asymmetry – strongly lateralized individuals (burials 1,2,3,8)
AW	4	3.905893	5.052818
EW	2	2.82433	3.125
HD	4	2.466753	3.551706
ML	2	0.983948	0.983948

AW: Articular width; EW: Epicondylar width; HD: Head diameter; ML: Maximum humeral length

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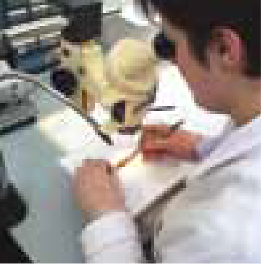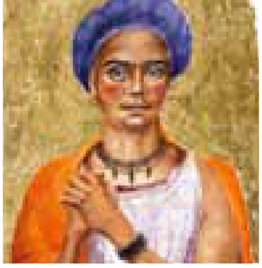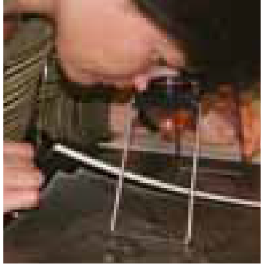

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ISSN 2059-4453 (Online)