Dating Briar Hill: interpreting controversial radiocarbon results from the Neolithic causewayed enclosure at Briar Hill, Northamptonshire

John Meadows
Institute of Archaeology
University College London
31–34 Gordon Square
London WC1H 0PY

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The Neolithic causewayed enclosure at Briar Hill, Northamptonshire, excavated in the mid-1970s, became the subject of controversy when radiocarbon dating appeared to show that it had been constructed in the fifth millennium cal BC, and maintained for about a thousand years (Bamford 1985). If true, this interpretation made Briar Hill the earliest-known causewayed enclosure in Europe, and Britain's earliest agricultural site (Kinnes and Thorpe 1986). Doubts were raised about the contextual reliability of the radiocarbon samples, given the artefactual evidence, which only indicated occupation from the later fourth millennium cal BC onwards (ibid).

This report assesses the usefulness of each radiocarbon result, and the plausibility of the various interpretations of these results, against criteria that were accepted at the time of the controversy. The results and interpretations are then reassessed, using new techniques of radiocarbon date calibration and chronological modelling. The report finds that only the final phase of maintenance of the enclosure can be confidently dated, to the later fourth millennium cal BC, and that the original interpretation depends entirely on the contextual reliability of two samples. It cannot be proved that these samples were residual, but there are reasons to suspect that they were, in addition to the artefactual evidence. This conclusion can be tested by dating the surviving remains of some samples.

Introduction

Briar Hill was excavated between October 1974 and October 1978 by the Archaeological Unit of the Northampton Development Corporation, under the direction of Helen Bamford. In addition to a Neolithic causewayed enclosure, the excavation found later Neolithic features, an Early Bronze Age cremation cemetery, Iron Age rectilinear enclosures and pits, Roman pits, Saxon sunken-featured buildings (*Grubenhäuser*), and medieval and post-medieval furrows (Bamford 1985, 1–7).

Altogether, 23 samples, most from prehistoric features and all consisting of wood charcoal, were dated at the AERE Harwell Isotope Measurements Laboratory between 1978 and 1982 (Table 1). Bamford's (1985) interpretation of the radiocarbon dates from the causewayed enclosure was heavily criticised (Kinnes and Thorpe 1986). The controversy centred on Bamford's claim that dates from of the outer ditch circuit placed the construction of the enclosure at *c* 5600BP, 'or around 4480BC in calendar years'[1] (Bamford 1985, 40). Kinnes and Thorpe argued that these dates were much too early, given ceramic parallels between Briar Hill and other dated sites, and appeared to show that Briar Hill had the earliest causewayed enclosure in Europe, and the earliest agriculture and decorated pottery in Britain (Kinnes and Thorpe 1986, 221).

The present report, written as part of a training programme in chronological modelling at University College London, is a reassessment of the Briar Hill radiocarbon evidence. In addition to published reports, cited in the bibliography, this exercise relied on unpublished material held on file at the Scientific Dating Section of the Centre for Archaeology. These documents reflect the involvement of its predecessor, the Ancient Monuments Laboratory (AML), which funded the Briar Hill dating programme, and includes the majority of the archive relating to radiocarbon dating from AERE Harwell. Other relevant archives (from the excavation and Harwell) were not examined.

The report begins with a review of the sampling and processing methods used at Briar Hill and Harwell, and an evaluation of each of the results. The next section discusses earlier interpretations of these results, firstly in terms of what was known at the time and then in light of more recent developments in radiocarbon calibration and chronological modelling. Finally, a reinterpretation of the Briar Hill chronology is proposed.

[1] Except in quotation, this report follows the agreed international standard known as the Trondheim convention: uncalibrated radiocarbon ages are denoted 'BP' (before AD1950) and calendar (calibrated) ages are denoted 'cal BC' or 'cal AD' (Mook 1986).

Interpretation of radiocarbon results

Waterbolk (1971; 1983) and van Strydonck *et al* (1998) have described guidelines for the archaeological interpretation of radiocarbon results. According to Waterbolk's (1983) format, these can be summarised as follows:

Contextual relevance: it is necessary to establish how closely associated each sample is with the deposit or artefact it is used to date. In the case of charcoal samples, the age of the charcoal itself is not of intrinsic interest; rather, it is the age of the deposit in which the charcoal was found that the archaeologist wishes to discover (van Strydonck *et al*'s 'archaeological or human event of interest'). Ideally, the charcoal should have been burnt *in situ* (eg in a hearth), or at least have been found in a primary context (such as a dump of hearth contents), so that the archaeological event to be dated (the deposition of the charcoal where it was found) was very close in age to the burning event. This principle was well-understood by Bamford at the time of the excavation (*see below*).

Age offset: inevitably, the material sampled will be older than the archaeological event in question (its incorporation into an archaeological deposit)[2]. Sometimes the age difference is negligible, as in the case of grain, nutshells, twigs, or bones (short-lived samples); with wood charcoal, it can be a matter of a few decades or of several centuries (*see below*). This problem received little attention in earlier interpretations of the Briar Hill results.

Contamination: samples may be contaminated with younger or older carbon, which can produce misleading results, if not removed by pretreatment. Charcoal presents fewer challenges with regard to contamination than do some other dating materials (such as shells and mineral fractions of bone samples, which readily absorb carbonates from groundwater). The age of the Briar Hill samples also means that slight contamination would have had little effect on the results[3].

Mixing: if a sample contains carbon from 'chemically identical material' with a mixture of ages, the radiocarbon result will be an average of these ages, which could be misleading (Waterbolk 1983, 60). The only real safeguard against this is the use of 'single entity' samples (Ashmore 1999). This was not possible at Briar Hill, due to the poor preservation of bone and the use of decay-counting to date charcoal, which inevitably meant that fragments with potentially different ages were bulked together to obtain larger samples. The risk that residual or intrusive charcoal fragments were included in these samples was reduced by the sampling policy (*see below*), but not eliminated.

Intra-site comparison: the 'reliability' of a radiocarbon result can be assessed by comparison with other results, from a different chemical fraction of the same sample (in the case of bone, for example), from samples of other types of material in the same

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[2] Unless, of course, the sample includes intrusive material, such as modern plant roots. The age offset of a sample corresponds to the difference between van Strydonck *et al*'s '^{14}C event' (the isolation of ^{14}C in the material sampled) and the 'archaeological event'.

[3] Waterbolk (1983, table 1) notes that a sample with a 'true' radiocarbon age of 6000BP would appear to be 90 radiocarbon years younger if contaminated with 1% modern carbon. By contrast, a 24,000BP sample would appear to be 1400 radiocarbon years younger if contaminated with 1% modern carbon.

context, or from samples of similar material in stratigraphically earlier or later deposits (Waterbolk 1983, 61). Only the last of these options was available to Bamford, who rejected or reassigned several samples whose results did not fit the stratigraphic sequence as excavated (*see below*)[4].

Understanding of laboratory procedures: radiocarbon results may be misleading if the archaeologist fails to take into account factors such as the pretreatment measures taken, whether the results were corrected for isotopic fractionation, and how error terms were calculated, especially when results obtained in different laboratories are compared. All the Briar Hill samples were processed at Harwell, one of the more meticulous laboratories in terms of comparability of results (Otlet 1979; Otlet *et al* 1980). Results were corrected for isotopic fractionation, and the quoted error terms were 'true estimates of the full replicate sample reproducibility' (Walker and Otlet 1985, 127).

Graphical presentation: results should be presented in a form that shows both individual measurements (and associated error terms) and patterns of results (Waterbolk 1983, 67). Bamford's presentation (1985, fig 21) was incomplete and potentially misleading (Kinnes and Thorpe 1986, 221–2).

Calibration: the results should be calibrated against the dendrochronologically-derived calendar scale for the purpose of interpretation (Waterbolk 1983, 68). Calibration curves for the relevant periods were available when the Briar Hill samples were processed, but there was not an agreed international standard. Walker and Otlet (1985) therefore used both Damon *et al*'s (1972) curve and the MASCA curve (Ralph *et al* 1973). Bamford (1985, 42) cited the MASCA-calibrated dates, which appeared to be more precise. An internationally agreed calibration curve, INTCAL98 (Stuiver *et al* 1998) is now available, representing a considerable advance on the situation in 1985.

Wiggle-matching: in some cases there is a known age difference between two samples, and this can be used, in conjunction with the calibration curve, to obtain very precise dates. This was not, and is not, possible with any of the Briar Hill radiocarbon results.

Apart from wiggle-matching, each of these guidelines informs this reassessment of the Briar Hill radiocarbon results. Particular attention is paid to the contextual relevance of each sample, and to the effect of applying age offsets.

[4] Two other options were available, and used at Briar Hill to some degree: replication (obtaining a second measurement from a sample by the same method used to obtain the first measurement), and using a second technique of radiocarbon dating.

Excavation and Sampling Methods at Briar Hill

The 3ha Neolithic causewayed enclosure, detected in 1972 from cropmarks in aerial photographs, consisted of three roughly circular ditch circuits: the outer ditch (615m in circumference), main inner ditch (480m), and inner 'spiral' extension (a 170m-long arc within the main inner ditch, contiguous with its eastern side). Each circuit was made up of many short segments, typically 1-2m deep and up to 5m long. More than a third of the inner ditch and 'spiral' extension (38%) was excavated, together with a smaller proportion (13%) of the outer ditch, over four seasons (1974–78). Each excavated segment contained a series of fills and had been recut up to four times, suggesting a lengthy period of use and maintenance (Bamford 1985, 1–6).

At the time, all radiocarbon dating was done by decay-counting. This required relatively large quantities of carbon per sample, and at Briar Hill wood charcoal was the only suitable material. Even charcoal was not as abundant as the excavator might have wished, however (Walker and Otlet 1985, 126). All charcoal samples from the ditch fills appear to have been considered for dating. With one exception (HAR-4092), the samples selected were from primary contexts, or 'well defined, clearly stratified deposits; usually the distinctive 'ashy' or burnt deposits in the ditch fills' (Bamford 1985, 40).

The shortage of datable material from the earlier fill deposits of the enclosure ditches was to be problematic. Some samples were too small to be dated by the established method of liquid scintillation spectrometry, and either failed to produce a result or were dated in a new facility, the miniature gas counter, when it was introduced in 1981–82 (*see below*). Part of the problem, it appears, was the difficulty of identifying recuts, and thereby attributing deposits to the correct episode of ditch maintenance. Sometimes this was not done until after the excavation (Bamford 1985, 7; 31), which may have led the excavator to reject some potential samples.

The question of residuality was raised in correspondence in the Briar Hill file as early as October 1979, before the second batch of samples was processed. Bamford remarked that 'The possibility that material in the ditch could be residual from earlier deposits was borne in mind. Charcoal scattered diffusely in general tip layers has not been used. In particular, no sample has been used in a secondary or later phase of any ditch segment which seemed possibly derived from the fill of an earlier phase.' If Bamford succeeded in sampling only *in situ* or primary contexts, the risk that a sample contained charcoal fragments with very different ages at the time of deposition (ie representing a wide range of '^{14}C events') was greatly reduced. Such mixing is difficult to detect, however, when the proportion of older wood in samples of bulk charcoal is relatively low, or the age difference between charcoal fragments is relatively small (Ashmore 1999).

Harwell Laboratory Procedures

Liquid scintillation counting (LSC)

Liquid scintillation counting had been standard procedure at Harwell since the mid 1960s (Otlet and Polach 1990). The method entails converting the carbon content of the sample to benzene (C_6H_6), and mixing the benzene in a solution (the scintillant) containing dissolved fluorescent chemicals (solutes). As each ^{14}C nucleus decays, a β-particle is emitted and energy is released. When that energy is absorbed by the fluorescent solutes, causing a burst of photons to be released, the decay-event can be detected using photo-multiplier tubes. The samples and the detectors were heavily shielded to minimise the effect of background radiation, but samples of at least 1g of carbon (increasing with the age of the sample) were required to provide reliable estimates of the rate of radiocarbon decay above the level of background 'noise'.

The Briar Hill samples were pretreated by the normal acid-alkali-acid (AAA) method to remove contaminants such as carbonates and humic acids[5]. The remaining charcoal was combusted to obtain carbon dioxide (CO_2), which was converted to acetylene (C_2H_2) and then to benzene. The sample mass recorded on the dating certificates (Table 2) appears to have been that of benzene, which is mainly carbon by weight. The laboratory's only concern was the small size of some samples: 'few produced the optimum size sample (5g carbon) for the standard liquid scintillation system and a number were closer to the minimum amount (1g carbon)' (ibid, 126).

Harwell made concerted efforts to maintain quality control, in particular by explicitly describing how it calculated the error term associated with each measurement, with the aim of 'full reproducibility' (Otlet and Warchal 1978; Otlet 1979). 'Full reproducibility' meant that all Harwell measurements of the same sample were statistically consistent. The error term was therefore calculated to include the counting error of the radioactivity of the sample, the background, and the modern standard, as well as the uncertainties in counting efficiency, sample weight, and in the sample stable isotope ratio. At the time, not all laboratories measured and corrected for stable isotope ratios, and systematic inter-laboratory comparisons of known-age samples had not been attempted. Harwell did subsequently take part in the first of these exercises (International Study Group 1982). It is assumed, for the purpose of this report, that the results of liquid scintillation counting can be accepted as accurate measurements of the radiocarbon age of the samples processed by this method.

[5] After manual cleaning to remove dirt and modern roots, the samples would first have been soaked overnight in dilute hydrochloric acid (HCl), then soaked overnight in dilute sodium hydroxide (NaOH), and then soaked in hydrochloric acid again for a few hours, to remove soil carbonates and humic acids. This process would also have destroyed about a third of the carbon in each sample (Mook and Streurman 1983, 48–9). Many of the submission forms noted some mould growth on the samples, but this does not appear to have influenced the results, presumably because the AAA process successfully removed this potential source of modern carbon.

Miniature gas counter

The Harwell 'small counter', or miniature gas counter, was introduced in late 1981. It allowed samples containing as little as 10mg of carbon to be dated by decay-counting. Larger samples, however, gave more precise results in less time. All the Briar Hill samples were large enough (*c* 65mg) to process in miniature (30cc) counters, rather than in micro (5cc) counters. According to an unpublished report in the AML file, the 30cc counters needed only 0.2–0.4g of cleaned charcoal per sample, against the 15–30g required to produce enough benzene for a precise measurement by liquid scintillation.

The technique was a version of proportional gas counting, in which the sample was pretreated by the AAA method and converted to carbon dioxide (CO_2) by combustion, 'followed by rigorous purification of the gas' (Walker and Otlet 1985, 127). The small counters were filled with carbon dioxide at high pressure (4 atm) and shielded within a large sodium iodide crystal. This reduced background radiation to a minimum, allowing the low level of radioactivity produced by the decaying ^{14}C nuclei to be measured[6].

Published reports (Otlet and Evans 1983; Otlet *et al* 1983; Otlet *et al* 1986) do not mention technical problems with the 'small counter', other than 'sporadic EHT breakdown', which affected the electronic equipment used to measure and record the results: 'the ability to identify it and to cure it quickly on the occasions when it has arisen has been invaluable' (Otlet *et al* 1983, 573). The reports also stress the laboratory's efforts to purify the carbon dioxide used, to maintain stable sample pressure in the counters, and to identify any changes in these conditions (idem; Otlet *et al* 1986, 606–7).

Nevertheless, the unpublished report in the AML file, dated no later than March 1983, refers to a delay caused by the presence of radioactive radon gas in the 'small counter' samples: 'this led to an extension of counting times since the short-lived isotope had to be allowed to decay'[7]. The presence of radon would have increased the radioactivity of a sample, at least initially (Nydal 1983), resulting in a younger age measurement, although a low level of radon contamination would have had little discernible effect (Hedberg and Theodórsson 1995).

[6] Strictly speaking, the challenge was to maximise the signal: background radioactivity ratio. In early (pre-1978) experiments with small gas counters (30-40cc), the background level of radioactivity was more than half the measured radioactivity of modern standard carbon samples. As ancient carbon is less radioactive than the modern standard, these counters could not measure the radioactivity of archaeological samples to a satisfactory level of precision. The sodium iodide shield, however, reduced the level of background radiation, by fluorescing in response to cosmic radiation. The fluorescence could be measured and electronically filtered out of the measured radioactivity. Pressurisation increased the proportion of measured radioactivity coming from the sample itself, rather than from the equipment. These changes allowed miniature gas counters to approach the sensitivity of liquid scintillation dating (ie a modern: background ratio of *c* 8:1) (Otlet and Evans 1983).

[7] The radon problem was reported to the AML to explain why fewer samples than expected had been processed during the first year of the miniature gas counter's operation, not to cast doubt on the accuracy of the results. The 1982-83 'small counter' results were regarded as less precise than those obtained by liquid scintillation, because a 'very stringent programme' of quality control had not yet been completed.

Of the four Briar Hill samples processed in the ‘small counter’, only HAR-5271 produced a result consistent with the excavator’s expectation. The other three samples (HAR-4110, HAR-5125, and HAR-5216) gave measurements that appeared to be far too young. It is not clear from the unpublished report when the radon problem was detected, how serious it was, or which samples were affected by it, but the Briar Hill samples are listed among the first batch of ‘small counter’ results obtained on behalf of the Ancient Monument Laboratory. There is reason to suspect, therefore, that the Briar Hill results were among those affected by the presence of undetected radon, although such contamination alone need not have accounted for the difference between the measurements and the expected results[8].

There are no final dating certificates on file for the four ‘small counter’ results. The details of individual sample processing are therefore unknown. Two results (HAR-5216 and HAR-5271) were published without $\delta^{13}C$ measurements. If the stable isotope ratio in either sample was not measured, the radiocarbon age would not have been corrected for isotope fractionation (ie a $\delta^{13}C$ value of -25‰ would have been assumed, so that the measured sample activity did not have to be corrected). As almost all the measured values of $\delta^{13}C$ at Briar Hill were below the reference value (-25‰), failure to correct for isotope fractionation in these two cases probably meant that their radiocarbon ages were slightly exaggerated – in other words, that had a correction been applied, the radiocarbon ages of these two samples would have been slightly younger. The difference is marginal, however: each 1‰ difference in $\delta^{13}C$ means a 16 year correction of radiocarbon age (Mook and Streurman 1983, 45), and most of the Briar Hill $\delta^{13}C$ measurements were between -25‰ and -28‰. Whether or not HAR-5216 and HAR-5271 were corrected for isotope fractionation, these results were closer to their expected ages than were HAR-4110 and HAR-5125, which were corrected.

[8] The fact that a second measurement of HAR-5216 in late 1983 or early 1984 was consistent with the first (Walker and Otlet 1985, 127) indicates that this sample was not seriously contaminated with radon, as the effect of radon contamination would only have lasted a few weeks (Nydal 1983).

Wood-age offsets

All the Briar Hill radiocarbon samples consisted of wood charcoal from mature timber. Even if the deposit in which the charcoal was found was an *in situ* or primary context, the radiocarbon result would in every case have dated an earlier '^{14}C event' (the growth of the wood fragment) than the archaeological event of interest (Waterbolk 1983; Warner 1990; van Strydonck *et al* 1998). Species identification provides some idea of size of this age offset, since different species have different natural lifespans. It is assumed here that there was not an additional age offset due to the recycling of old timber, although this possibility cannot be excluded (cf Ashmore 1999). It is assumed, therefore, that the timber was cut shortly before it was burnt, and that the maximum age offset for each fragment is the upper limit of the natural lifespan of that species (referred to as 'age-lapse' by Warner (1990).

Clearly, however, not every tree would have reached its potential lifespan, and only a fraction of the timber in any tree (the first year's growth) is as old as the tree itself. The age of a fragment of wood therefore has to be expressed as a probability distribution, since it may fall anywhere between the maximum age of that species and the age of new growth. Warner (1990) favoured a 'rectangular' (ie uniform) probability distribution as the 'least objectionable' means of relating the age of each fragment of wood to the maximum age of the tree from which it came. In other words, each fragment was as likely to belong to any year of the tree's growth as any other, which implies that the tree added the same volume of new wood every year of its life. The Briar Hill samples, however, were not individual fragments of charcoal, but a mixture of fragments, often not belonging to the same species. The appropriate age offset is a weighted average of the estimated ages of each fragment. With these reservations in mind, the Briar Hill samples can be divided into three groups:

- samples in which the only taxa identified were from the Rosaceae family (*Prunus* sp. and/or Sect. Pomoideae) (ie blackthorn, hawthorn etc); very minor wood-age offsets, of the order of a few decades at most, could be applied.
- samples in which the only taxon identified was oak; as oak can live to 500 years or more (Mitchell and Wilkinson 1989, 16), the appropriate wood-age offset may be substantial. The average age of mature timber from an old oak tree was probably more than 100 years but less than 300 years.
- samples in which a mixture of wood taxa was identified, to which intermediate wood-age offsets should be applied; one sample consisting only of alder and/or hazel probably also falls in this category. The appropriate offset is almost certainly less than 200 years and probably less than half this age.

In the models developed below, the offsets used are 40±20 years for samples in the first category, 200±100 years for samples of oak only, and 100±50 years for mixed samples. These are normal (Gaussian) probability distributions. It is assumed that each sample contains fragments of various ages, and that the 'average age' of the sample is governed by the unknown proportion of charcoal fragments in each age group. Extreme values of the weighted average age are therefore unlikely, as every fragment would need to be from the same end of the possible age range. If the probability distribution of the age of individual fragments is approximately uniform (Warner 1990), the probability distribution for the average age of a mixture of fragments would be close to normal.

The Briar Hill samples

The Briar Hill file includes 25 ^{14}C measurements, all obtained at the Harwell Isotope Measurements Laboratory between 1978 and 1982 (Table 1)[9]. An original batch of samples, submitted in 1977, gave four measurements (HAR-2282, HAR-2283, HAR-2284, and HAR-2389). Two more samples (HAR-2607 and HAR-2625) were submitted and processed in 1978, and one in 1979 (HAR-3208). In 1980, a large batch of 17 samples was submitted. Six of these were processed by mid-November 1980 (HAR-4057, HAR-4065, HAR-4071, HAR-4072, HAR-4074, and HAR-4075). Another six were processed by May 1981 (HAR-4058, HAR-4066, HAR-4067, HAR-4073, HAR-4089, and HAR-4092). Five more samples were processed in late 1982 (HAR-4110, HAR-5125, HAR-5216, HAR-5217, and HAR-5271). Apart from HAR-5217, the final batch of samples was dated in Harwell's new miniature gas counter system. All other samples were dated by liquid scintillation counting.

1977–79

HAR-2282: 5440±110BP (4450–3990 cal BC[10])

HAR-2282 came from 77A (2), the secondary fill of the primary cut of a segment of the outer ditch circuit (Bamford 1985). The sample was from 'a tip of dark sand mixed with charcoal and containing pottery sherds and worked flints which overlay the primary accumulation at the east end of 77A' (ibid, 35). Neither the sherds nor the flints seem to have been diagnostic. The sample consisted mainly of mature oak charcoal. Of the four bags examined by the wood specialist, only one included some hawthorn in addition to oak charcoal; the rest contained only oak (Keepax 1977)[11]. A significant wood-age offset should therefore be taken into account, dating the primary cut of this segment to the late fifth millennium cal BC or the early fourth millennium, provided that the charcoal was not residual. If the charcoal was residual, HAR-2282 can be regarded as a *terminus post quem* for the construction of this segment of the outer ditch circuit.

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[9] One sample of burnt soil was given a laboratory number, HAR-2317, but was not apparently processed. Another sample, HAR-4091, was processed, but it did not yield enough benzene to give a reliable measurement. Replicate measurements were obtained from a third sample, HAR-5216, and it is (usually) the weighted mean of these that is reported. It is unclear why these measurements were not given individual laboratory numbers, when replicate measurements from another sample (HAR-2284 and HAR-2389) were. Perhaps HAR-5216 consisted of two measurements using the same vial of CO_2, while HAR-2284 and HAR-2389 were separate sub-samples (as the different weights of benzene suggest).

[10] The calibrated date ranges quoted are 95% confidence intervals obtained by the maximum intercept method (Stuiver and Reimer 1986), using the INTCAL98 data set (Stuiver *et al* 1998) and the program OxCal v.3.5 (Bronk Ramsey 1995; 1998; 2001).

[11] For the sake of clarity, English tree names are used throughout this report. The taxa Keepax identified at Briar Hill were: *Fraxinus excelsior* (ash), *Corylus/Alnus* sp. (alder/hazel), *Quercus* sp. (oak), *Salix/Populus* sp. (willow/poplar), *Acer* sp. (maple), Pomoideae (eg hawthorn), and *Prunus* sp. (eg blackthorn).

HAR-2283: 1700±60BP (220–530 cal AD)

HAR-2283 was one of the larger samples processed (5.37g of benzene). It consisted of charcoal from a wide range of species: ash, hazel, oak, willow/poplar, hawthorn, and probably maple and blackthorn (Keepax 1977)[12]. Given the range of species represented, in unknown proportions, an intermediate wood-age offset is appropriate. The sample was from the fill of feature 29, a Saxon *Grubenhaus*, or sunken-featured building. Uncalibrated, the result was apparently too early for the building, and was not mentioned the 1979 interim report or commented on in the monograph. The latter (Bamford 1985, 55) noted the presence of 'pottery of the first to fourth century AD… presumably derived from earlier deposits' in the same deposit, which was described as 'uniform dark brown loamy sand, flecked with charcoal'. It is possible, therefore, that the charcoal itself was 'derived from earlier deposits'. After calibration, however, it is not necessary to draw this conclusion (nor possible to exclude it). Given the mixture of species, and the sample's uncertain context, the date provides at best a *terminus post quem* for the abandonment of the building.

HAR-2284: 3460±120BP (2140–1490 cal BC)
HAR-2389: 3540±90BP (2140–1680 cal BC)
pooled mean: 3511±72BP[13] (2030–1640 cal BC)

These were replicate measurements of a single sample, P76E7041, taken from a pit cutting the uppermost fill layer of segment 41 of the main inner ditch circuit. Again, a variety of species was identified: oak, alder/hazel, hawthorn, and probably blackthorn, all mature timbers (Keepax 1977). Initially this sample produced a low yield of benzene (HAR-2284, 1.46g), and Harwell were sufficiently concerned to carry out a replicate measurement (HAR-2389, 1.87g), which, however, was consistent with the initial result ($\nu = 1$; $T' = 0.3$; T' (5%) = 3.8) (Ward and Wilson 1978).

On the sample submission form, the provenance was said to be 'feature 41, layers 41, 42 (68)… fill of pit or third recut'. No context 42 (68) is visible in plan or section, while the pit cutting the final ditch fill is feature 337 (Bamford 1985, fig 10.2). According to the monograph (Bamford 1985, table 27), the sample came from layer 337B, described as 'very dark brown to black sand with much charcoal and burnt ironstone fragments' (ibid, microfiche). It appears that the feature was renumbered after the sample was submitted. The sample produced a late Neolithic or early Bronze Age date, as estimated by Bamford at the time of submission, and appeared to provide a *terminus ante quem* for the abandonment of the ditch system (Bamford 1979, 5). A modest wood-age offset has to be taken into account.

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[12] Gale (1999 unpubl) identified ash, maple, oak, willow/poplar, hawthorn and blackthorn among the remains of this sample (after processing).

[13] The pooled mean is supposed to be a better estimate of the 'true' radiocarbon age of the sample than either of the individual results. The pooled mean is calculated by Ward and Wilson's (1978) method, which assumes that the two results are both measurements of the same radiocarbon age. This is permitted by the two results, which are statistically consistent, but it is only an approximation, as each sample consisted of a mixture of charcoal fragments.

HAR-2607: 4010±90BP (2880–2230 cal BC)

Not part of the original batch of samples, HAR-2607 was nevertheless processed before any of the initial results was available. The sample came from feature 145, described as 'timber slots forming base of rectangular structure – probably late Neolithic' (sample submission form, before 23 March 1978). It consisted of charcoal from mature timber of a mixture of species: oak, alder/hazel, willow/poplar, and blackthorn (Keepax, undated annotation of submission form). Grooved Ware sherds from the same feature suggested the late Neolithic date, which the radiocarbon result appears to confirm. The sample was rather small (2.1g of benzene).

Stratigraphically, the feature cannot be related to any other (Bamford 1985, 44). Both the charcoal and the Grooved Ware sherds were from the fills of the 'slots', but this description could include the fills of postholes within the slots (deposited following the abandonment of the structure) as well as the packing around the posts (deposited before the use of the structure). Given the wood-age offset, even a date from the fill of the postholes would not be regarded as a *terminus ante quem* for the abandonment of the structure, but HAR-2607 does provide a *terminus post quem* for the construction of feature 145, which was therefore probably built no earlier than the second half of the third millennium cal BC.

HAR-2625: 4290±80BP (3100–2630 cal BC)

Processed at the same time as HAR-2607, HAR-2625 also came from an interior feature, 156, described as a large post pit, 'possibly Neolithic' (submission form). The predicted date probably reflected the similarity of this feature to feature 218, which contained 'several small sherds of undecorated Neolithic pottery' (Bamford 1979, 5), and which was subsequently dated (HAR-4057). Charcoal in 156 was said to have been abundant (Bamford 1985, 44), but may not have come from the primary fill of the feature (ibid, fig 23). Only mature oak was identified in the single bag examined by the wood specialist (Keepax, undated annotation of submission form). The sample size was more than adequate (4.6g of benzene).

As with HAR-2284/HAR-2389, the archaeological event in question (the construction of the feature) was probably earlier than the deposit from which the sample was taken (a secondary fill), but the '^{14}C event' represented by the charcoal was also earlier than the deposit in which it was found, as the sample consisted of mature oak charcoal. The radiocarbon result provides only a *terminus post quem* for the secondary fill. If the charcoal came from the original post, HAR-2625 also provides a *terminus post quem* for the construction of the feature. The feature could not be related to any other dated feature stratigraphically. Its supposed relationship with feature 218, however, appears to be justified by the radiocarbon results (*see below,* HAR-4057).

HAR-3208: 4600±90BP (3640–3020 cal BC)

The result, but not the laboratory number, of this sample was quoted in the 1979 interim report (Bamford 1979, 6), perhaps indicating that only the preliminary measurement was available when the article was written. HAR-3208 appears to have remained at the Ancient Monuments Laboratory between 1977 and 1979, and received two AML numbers. The ^{14}C certificate is dated 26 July 1979, barely two months after Harwell received the sample.

Consisting of blackthorn and other unidentified charcoal (Gale 1999 unpubl), HAR-3208 was from feature 52, a 'flat-bottomed scoop with cremation deposit cut into fill of recut inner causewayed ditch segment', and was thought to be '?Early Bronze Age' (submission form). The section drawings (Bamford 1985, fig 9.2) in fact show a black lens (layer 52 (1)) that is clearly overlain by another layer of ditch fill (38E (2–3)). The detailed context descriptions on microfiche (Bamford 1985) confirm that context 52 cut 38E (1) and was overlain by 38E (2–3), although the latter fill layers were said to have been deposited 'deliberately' to cover the cremation. On that basis, its attribution in the monograph to Phase VII, the final phase of maintenance of the enclosure (Bamford 1985, table 27), is correct. It is unclear why the sample was originally attributed to the Early Bronze Age.

As the provenance of HAR-3208 appears to be secure, and the wood-age offset is minor, the radiocarbon result probably does date the archaeological event in question (the insertion of the cremation burial in the fill of the final recut of ditch segment 38) reasonably well. This conclusion is supported by the results of two more 'final recut' samples, HAR-4071 and HAR-4075 (*see below*).

1980

HAR-4057: 4250±70BP (3020–2620 cal BC)

HAR-4057 came from the fill of a large post pit, 218, within the inner enclosure, which was thought to be Neolithic in date (submission form). The sample consisted of mature oak charcoal (Keepax 1980 unpubl). Although the final dating certificate is on file, the computer printout of the details of this result is missing, so that the sample mass is unknown.

The sample may have come from a blackened layer in feature 218, which appears in section to be a secondary fill, not part of the post packing (Bamford 1985, fig 23). Consequently, the archaeological event represented by the sample was probably the abandonment of the post pit, not its construction. The radiocarbon result dates the ^{14}C event (the growth of the wood in the sample), and only provides a *terminus post quem* for the archaeological event. If the charcoal was from the post in feature 218 itself, the radiocarbon date must also be earlier than the construction of the feature.

HAR-4057 was statistically consistent with the result previously obtained from feature 156, HAR-2625 ($\nu = 1$; $T' = 0.1$; $T' (5\%) = 3.8$) (Ward and Wilson 1978). The two features, though 36m apart, were similar in construction and were thought to be contemporaneous. The same considerations of wood-age and contextual relevance apply to both samples. It is possible that the two features were constructed simultaneously in the early-mid third millennium cal BC. They may also be several centuries apart in age.

HAR-4065: 3180±70BP (1620–1260 cal BC)

HAR-4065 was one of the larger samples (4.98g of benzene). The sample, of comminuted oak heartwood charcoal (Gale 1999 unpubl) from a cremation, feature 275, produced the expected early Bronze Age date. Feature 275 cut at least two other cremation burials (279, 291, and perhaps 285) and was cut by three others (267, 276, and 277; Bamford 1985, fig 25). None of these was dated, but the cluster of burials was clearly associated with another dated cremation, feature 240 (*see below*, HAR-4058). It seems unlikely, given the size of the burial pits, that any of the cremations took place *in situ*, and in the case of feature 275 the cremated bone was in a secondary context (within an urn). The charcoal sample was taken from the surrounding fill, not from the urn itself (sample submission form). The result is therefore regarded as at best a *terminus post quem* for the cremation, considering the old-wood offset. The cremation thus probably belongs to the late second millennium cal BC, if not later[14].

HAR-4071: 4610±90BP (3640–3030 cal BC)

HAR-4071 was from the fill of the final recut of the inner ditch segment 199 (sample submission form). A section drawing in the monograph (Bamford 1985, microfiche frame 129) shows a burnt layer in 199D, matching the excavator's description. One of the larger samples (4.59g of benzene), it consisted of mature blackthorn (Keepax 1980 unpubl). The wood-age offset should therefore be relatively minor. The similarity of this result to HAR-3208 (*above*) and HAR-4075 (*below*) appears to support the dating of the 'final recut' of the main inner ditch to the late fourth millennium cal BC.

HAR-4072: 5680±70BP (4710–4350 cal BC)

One of the largest samples (5.63g of benzene), HAR-4072 consisted of mature oak charcoal (Keepax 1980 unpubl). It came from a pit, feature 219, which had been cut by the 'weathered outer edge' of the outer ditch circuit, but which was thought to have been part of the entrance way to the enclosure and therefore Neolithic in date (sample submission form). At the time the sample was submitted, pit 219 was thought to predate the ditch circuit, although the section drawings (Bamford 1985, fig 7.2) are not conclusive[15].

HAR-4072 provides a *terminus post quem* for the construction of the outer ditch, or at least for its second recut (197C). Bamford went further, arguing that feature 219 'looks, on circumstantial evidence, to have had some structural, functional or symbolic relationship to the outer ditch … it was cut by the upper edge of 197C so that, on stratigraphic grounds, it could have been contemporary with 197A or 197B or have predated both of them and the enclosure. If the latter it would have been a

[14] Given the fact that the charcoal was comminuted, and that the result of HAR-4065 appears to date this cremation rather later than feature 240 (*see below*, HAR-4058), it is worth considering whether there may not have been some modern (or relatively recent) charcoal mixed into the sample.

[15] Several other pits (196, 327, 324) cut the latest fill of 197. In the detailed description on microfiche, Bamford states that 219 was cut by 197C and '?197B'.

feature in isolation, and as such makes little sense' (Bamford 1985, 35). Hence, she continued, it 'could just post-date the initial phase of construction, although it is not possible to prove this' (ibid, 40). If HAR-4072 was not residual, and 219 was cut by 197A (the original cut of the ditch), then the construction of the outer circuit dates to any time after 4710–4350 cal BC. If feature 219 postdated the initial construction, as Bamford suggested, then either the outer ditch circuit was constructed before 4710–4350 cal BC, or the sample was residual.

This argument does not take the wood-age offset into account; in either case, the age of the wood at deposition must be subtracted from the age of the event being dated. For example, if the archaeological event (the infilling of pit 219) took place after the construction of the outer ditch circuit, and if the outer ditch was cut in 3800 cal BC, then the wood-age offset for HAR-4072 is at least 550 years, if the sample is not residual. Such a high wood-age offset is very unlikely, even in the case of oak.

Three explanations are possible: (i) if the wood-age offset was lower, the outer ditch circuit may have been significantly earlier than 3800 cal BC, as Bamford believed; (ii) if pit 219 predated the construction of the ditch segment, HAR-4072 provides only a *terminus post quem* for that event; or (iii) some or all of the charcoal in HAR-4072 was residual, and does not date the infilling of the pit.

HAR-4074: 4370±80BP (3340–2870 cal BC)

This sample, of charcoal from a mixture of mature timbers, including oak, hazel/alder, and blackthorn (Keepax 1980 unpubl), came from 137, a pit in the inner enclosure that contained 49 worked flints and a few sherds of Neolithic pottery[16] (Bamford 1985, 44), and was described as 'probably Neolithic' (sample submission form). The pit was shallow, and stratigraphically it could not be related to any other feature. At 3.11g of benzene, the sample size was satisfactory.

The radiocarbon result fitted comfortably with HAR-2607 and HAR-2625, which had already been obtained from other internal features. Again, the inclusion of mature timber, particularly oak, is likely to have exaggerated the age of the feature, which can probably be assigned to the early third millennium cal BC.

HAR-4075: 4660±70BP (3640–3120 cal BC)

HAR-4075 was a sample of mature blackthorn charcoal (Keepax 1980 unpubl) from 124E (3), the fill of the final cut of inner ditch segment 124. It was the largest sample processed (6.38g of benzene). A Neolithic date was expected (sample submission form) and the result was similar to HAR-4071 (processed simultaneously) and HAR-3208 (done in 1979), both samples from upper ditch fills. The section drawings (Bamford 1985, fig 16.2) support the attribution of 124E to the 'final recut' phase. As with HAR-3208 and HAR-4071, the calibrated date range is a reasonable estimate of the date of the final recut of the main inner ditch circuit, as any wood-age offset is relatively minor.

[16] None of these was illustrated in the monograph, and it must be assumed that none was very diagnostic; only two retouched tools were identified (Bamford 1985, table 5).

1981

HAR-4058: 3700±150BP (2560–1680 cal BC)

The unidentified charcoal in HAR-4058 came from feature 240, a cremation burial containing a burnt flint arrowhead of early Bronze Age type. The sample was rather small (1.22g), which probably accounts for the large error term in the measurement.

Feature 240 appears to have cut another cremation burial, feature 246 (Bamford 1985, fig 25), but the latter was not dated. While the concentration of cremations in this area of the site ('at least twenty seven small pits, tightly grouped and overlapping, within a roughly triangular area of about 17m^2') was consistent with a single, prolonged phase of activity (Bamford 1985, 47–9), there was no stratigraphic relationship between feature 240 and feature 275 (*see above*, HAR-4065), or any other dated context.

A date consistent with HAR-4065 was expected, and the uncalibrated result for HAR-4058 was uncomfortably early[17]. After calibration, an early Bronze Age date is possible, particularly if the charcoal was already a century or two old at the time of the cremation. There is no reason, therefore, to suspect that the entire sample was residual, although a degree of mixing with residual charcoal cannot be ruled out.

HAR-4066: 4080±70BP (2880–2460 cal BC)

HAR-4066 consisted of charcoal from a variety of taxa, including hawthorn, blackthorn, oak, and hazel (Keepax 1980 unpubl). It was relatively large (4.6g of benzene). The sample came from 248B (3), the middle fill of the second cut of an inner ditch segment, and was expected to give a Neolithic date (sample submission form). Nothing in the section drawings (Bamford 1985, fig 11.2) suggests otherwise.

The result, however, was unexpectedly late – later, in fact, than the three results (HAR-3208, HAR-4071, and HAR-4075) from the fills of the final recuts that Bamford had at the time. Another result, HAR-5217 (4420±90BP), was subsequently obtained from the fill of the third cut of this ditch segment; it appeared to be earlier than HAR-4066. Bamford (1985, 36) concluded that:

'This layer (ie 248B (3)) was thought at first to have been cut by 248C, the latest segment in the sequence. Further consideration of the stratigraphy and internal dating evidence including radiocarbon determinations led, however, to the conclusion that 248B (3) accumulated or was dumped in the hollow of the earlier cut (ie 248B) alongside 248C, some time after the latter had been dug but before it had filled again completely, and had then been truncated by the erosion of the southern edge of 248C'.

In the detailed context descriptions (Bamford 1985, microfiche), 248B (3) was 'above 248B (2), postdating cutting of 248C…sealed by 248C (6)'. Bamford attributed 248A to Phase IV, 248B (1–2) to Phase V, 248C (1–5) to Phase VII, and 248B (3) and 248C (6–8) to VIII–IX. However, 'the finds from it (ie 248B (3)) suggest that in fact it is to be equated with 248C (4) or (5)' (Bamford 1985, 36).

[17] A second measurement of the sample was evidently considered: a laboratory note reads 'HAR-4058 No obvious cause for concern in lab books but no sample left'.

Clearly, it was the radiocarbon result itself which led to the attribution of HAR-4066 to a later phase than the final recut of ditch segments (Phase VII). Nevertheless, the simplest explanation is that the sample was from a later pit that was not observed during the excavation, which is essentially what Bamford suggested[18]. The alternative is that this segment of the enclosure was maintained well into the third millennium cal BC.

HAR-4067: 3730±70BP (2400–1920 cal BC)

HAR-4067 consisted of mature oak charcoal (Keepax 1980 unpubl). At 4.99g of benzene, it was one of the largest samples processed. The certificate is dated 28 November 1980, but the result had apparently not been sent by 25 March 1981.

The sample was said to have been from the primary fill of feature 228A, a pit ('part of structure?') cut into the upper fill of a main inner ditch segment, 192 (sample submission form). According to the section drawing, however, 228A is clearly within the adjoining segment, 251; it, and at least two other pits (228B and 228C) cut the fill of the second recut of the segment (251C) and were sealed by the uppermost fill layer (251D); a later feature (194) cut both 251D and 228A (Bamford 1985, fig 8.2). The question is not whether 228A belonged in segment 192 or 251, which were essentially the same, but the interpretation of 251D. If the latter was (as its designation implies) the final recut of the ditch segment, and if it sealed 228A, as both the section drawing and sequence diagram (ibid, fig 5) imply, then 228A predated the abandonment of the ditch segment. None of the other ditch segments, however, has pits within its fill sequence, and it seems more likely that 251D was not a true recut of the ditch segment. Although it was almost as long and as broad as the earlier recuts, it was not as steep-sided.

In that case, HAR-4067 may be grouped with HAR-2284/HAR-2389 and HAR-4089, the other samples from pits cutting the final fills of the enclosure ditches. An old-wood offset for HAR-4067 has to be considered, however. As the radiocarbon date may be significantly earlier than the cutting of feature 228A, it need not provide a *terminus ante quem* for the abandonment of the enclosure. In practice, however, the 'final recut' dates were much earlier than HAR-4067.

HAR-4073: 3790±100BP (2490–1920 cal BC)

HAR-4073 consisted of mature oak charcoal (Keepax 1980 unpubl) and was about half the optimal size (2.46g of benzene). At the time of submission, the sample provenance was described as '192C – segment of inner ditch, outer enclosure, middle fill of third phase cut (of 4). Neolithic'. A result earlier than the 'final recut' dates was evidently expected. When the result was published, however, its context was feature 303, a pit cutting the final fill of the inner ditch (Bamford 1985, table 27; Walker *et al* 1991, 84). According to correspondence on file, the unexpectedly late date led the excavators to re-examine their records and to conclude that a late Neolithic pit (303)

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[18] The section drawing also shows two hollows or burrows at that connect 248B (3) with a later fill layer, 248C (7), suggesting the possibility that intrusive charcoal was dated in 248B (3). If the burrows were recognised during the excavation, however, the sample would probably not have been taken in a contaminated area of the context, and 248C (7) appears to have been a broad, shallow layer covering most of the segment, rather than the fill of a later pit.

was deeper than originally thought. Feature 303 did not actually cut 192C, however (the two contexts were in different quadrants) (Bamford 1985, fig 8.2). It did cut 192E, the final layer of ditch fill, and a layer of burnt sand (probably 303 (2)) is shown in the middle of 303, close to where it met 192E (section SC3/23). Section SC3/51, however, shows a downward extension of pit 303 into 251C, taking in a dark lens (within 303 (1)). Context 251C was the third of four cuts of segment 251, which was contiguous with segment 192.

Clearly the sample was not from 192C. The description on the submission form (third phase of four) and the section drawing suggest that the original provenance was 251C. The detailed context descriptions on microfiche (Bamford 1985) do not list any stratigraphic relationships for 303, which was 'not fully defined in excavation', but do state that 192E and 251C were cut by 303, as shown in the section drawing. Were the original provenance to be used, and a significant wood-age offset taken into account, HAR-4073 implies that part of the main inner ditch was maintained until the late third millennium cal BC or later, whereas the 'final recut' dates (HAR-3208, HAR-4071, and HAR-4075) imply that it was abandoned in the late fourth millennium cal BC. The anomaly is resolved if it can be argued that HAR-4073 was from the fill of a later pit. No other solution is more convincing[19].

HAR-4089: 3620±90BP (2280–1740 cal BC)

With HAR-4067, this is one of two samples with certificates dated 28 November 1980. The sample, of mature oak charcoal (Keepax 1980 unpubl), came from feature 258, a pit cutting the upper fill of inner ditch segment 192, possibly related to pit 228 and possibly Neolithic (sample submission form). HAR-4067 came from pit 228. There is a minor discrepancy between the HAR-4089 submission form and the monograph, which shows feature 258 as a pit cutting the adjoining ditch segment, 251. Feature 258 is not shown in the section drawings, as it was entirely excavated, but it does appear in plan, where it also appears to have cut feature 265[20] (Bamford 1985, fig 8.2). Features 228 and 265 were both stratigraphically earlier than layer 251D (1) and later than 251B (8), but the relationship between feature 258 and feature 228 is unclear.

Assuming that 251D was a later feature, not the final recut of the ditch segment (*see above*, HAR-4067), it remains arguable that HAR-4089 provides a *terminus ante quem* for the abandonment of this segment of the enclosure ditch, after taking into

[19] Bamford's final comment on HAR-4073 was: 'this result is consistent with the ceramic evidence' (Jordan *et al* 1994, 122). According to the monograph, however (Bamford 1985, microfiche appendix 7.2), there were no sherds in pit 303. One non-diagnostic sherd in 251C (2) was of a fabric type associated with early Neolithic levels. There were four non-diagnostic sherds in 251D (4), which, like 303, was ultimately placed in Phase IX; three were of early Neolithic fabric types, but the fourth was of type H, which only occurred in late Neolithic levels. The stratigraphic relationship between 303 and 251D is uncertain (both were cut by pit 194), but one could argue that the ceramic evidence at least did not contradict the conclusion that 303 was a later Neolithic pit.

[20] In plan, feature 265 is labelled '256', which is clearly a mistake; not only is this feature in identical position to 265 in the section drawing SC3/23, but the lift-out site plan shows feature 256 as an Iron Age pit about 10m to the east of segment 192. In the text of the monograph (Bamford 1985, 54 and microfiche appendix 2) feature 256 is described as an Iron Age pit. In the sequence diagram, however, it is placed in Phase IX, the Later Neolithic, where feature 265 ought to be (between 251B (8) and 258) (ibid, fig 5).

account the wood-age offset, which places the archaeological event represented by HAR-4089 (the filling of pit 258) in the early-mid second millennium cal BC. The provenance and stratigraphic position of the sample are not entirely clear, and the wood-age offset could be significant.

HAR-4092: 5540±140BP (4710–4000 cal BC)

The last of the second batch of samples to be processed (certificate dated 4 May 1981), HAR-4092 was from 128E (4), the middle fill of the final recut of segment 128 of the inner ditch 'spiral' extension (sample submission form). The sample consisted of charcoal from a mixture of mature timbers (oak, ash, blackthorn, and hawthorn; Keepax 1980 unpubl). The sample was rather small for liquid scintillation (1.63g of benzene), hence the large error term.

After taking into account the difference in wood-age offsets, the result should have been consistent with the other 'final recut' samples (HAR-3208, HAR-4071, and HAR-4075, which consisted mainly of blackthorn), if the 'spiral' extension was contemporary with the main inner ditch circuit. The gap of 500–1000 calendar years between HAR-4092 and those dates, which fall in the later fourth millennium cal BC, immediately suggested that the sample was residual. Bamford (1985, 40) noted that the fill layer from which the sample was collected had been 'clean rubble which may have derived from an adjacent bank' or the primary phase fill below it. Unlike the other samples, therefore, HAR-4092 appeared to be from a secondary context[21]. The sample therefore provides only a *terminus post quem* for the deposit in which it was found.

1982

HAR-4110: 3410±100BP (1960–1450 cal BC)

Although it was submitted in September 1980, HAR-4110 was too small to process by liquid scintillation spectrometry. With HAR-5125, it was the first of the Briar Hill samples to be processed in the 'small counter', in late 1982. HAR-4110 was from 192B, a 'well defined layer of discoloured 'ashy' sand' in the secondary fill of the second of four cuts of a segment of the main inner ditch, or 'possibly primary cut (of 3)' (sample submission form; cf Bamford 1985, fig 8.2)[22]. Mature oak charcoal was identified (Keepax 1980 unpubl). The result could therefore have been significantly earlier than the date of the context.

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[21] The section drawing (Bamford 1985, fig 14.2), however, does not support Bamford's claim (ibid, 40) that 'the recut was directly above a primary phase'. The latest recut, 128E, is separated from the fills of the primary phase, 128A, by the fills of 128B. Nearly a metre separates the fill layer in question, 128E (4), from the uppermost fill of 128A.

[22] As with HAR-4067, HAR-4073, and HAR-4089 (above), it can be assumed that segment 192 on the submission form includes the adjoining segment, 251. In the monograph (Bamford 1985, 40 and table 27) the provenance of the sample was listed as 251B (6). The section drawing (ibid, fig 8.2) shows no stratigraphic relationship between the fills of the primary cut 251A and fills 251B (1) and (2), although all are sealed by 251B(3). This appears to fit with the sample submission form; if 251A (1) and (2) are equivalent to 251B (1) and (2), which is possible, then segment 251 has only three phases, and 251B is the earliest of these. If 251A was earlier than 251B (1), which is also possible, then the sample would have been from the second phase.

A result between the very early dates (HAR-2282, HAR-4072, and HAR-4092) and the 'final recut' dates (HAR-3208, HAR-4071, and HAR-4075) was expected; that is, 1000–2000 radiocarbon years earlier than the actual measurement. HAR-4110 should at least have been older than HAR-4073 (3790±100BP), which was at first supposed to be from the next phase of the same segment (251C), and then assigned to a later pit (303).

If HAR-4110, with an appropriate wood-age offset, correctly dates the fill of 251B, the other three samples from segment 192/251 (HAR-4067, HAR-4073, and HAR-4089) must all have been residual, and the segment must have been maintained into the mid second millennium cal BC. If HAR-4110 correctly dates the sample, but not the context, then the sample itself was intrusive. If the sample was not intrusive, the only other explanation is that the result was inaccurate. This, essentially, was Bamford's conclusion: 'it could, conceivably, be attributed to contamination from one of these features,' (the later Neolithic pits) 'although the burnt soil layer from which the charcoal was taken was very well defined' (Bamford 1985, 42). There are three problems with HAR-4110: its uncertain contextual reliability, the need for a large wood-age offset, and the possibility of radon contamination (*see above*). It should therefore be treated with scepticism.

HAR-5125: 3900±90BP (2620–2060 cal BC)

HAR-5125, processed with HAR-4110 in the 'small counter', consisted of charcoal that either was from hawthorn or was too fragmented to identify (Gale 1999 unpubl). The sample came from the primary fill of the second of four cuts of segment 165 of the inner 'spiral' ditch (sample submission form)[23]. A minor wood-age offset could be applied.

The result, which was expected to be earlier than the 'final recut' dates from the main inner ditch circuit, appeared to date its context to the later third millennium cal BC. It might be argued that segment 165, or indeed the entire inner 'spiral' ditch, was significantly later than the main inner ditch circuit. Bamford considered this argument, but concluded that 'such an hypothesis seems fundamentally absurd and is in no way consistent with the considerable body of pottery and worked flints … (which) includes nothing at all of specifically later neolithic type' (Bamford 1985, 40).

As with HAR-4110, the alternatives are that the material dated was intrusive or that the result was inaccurate. As HAR-5125 was processed with HAR-4110, by the same method, and as both results were much later than expected, the possibility that radon contamination (*see above*) contributed to the discrepancies cannot be overlooked. Whatever the explanation, the result cannot be regarded as a reliable date for its context.

[23] The monograph is more specific, attributing the sample to context 165B (1) (Bamford 1985, table 27). In correspondence on file, the context was identified as a possible hearth. The second cut (165B) is not visible in the section drawings (ibid, fig 13.1), but the fills of the third and fourth cuts clearly contain lenses of blackened material.

HAR-5216: 4365±85BP (3350–2880 cal BC)

HAR-5216 came from 'a deposit of discoloured sand & charcoal in lower infill of the primary cut (of at least 3 & probably 4)' of a segment of the inner 'spiral' ditch, 176A (1) (sample submission form; cf Bamford 1985, table 27). This context was the earliest fill of a short segment with only two phases, which was, however, cut by the second phase of the adjoining segment, 181B. The latter had four phases, which explains the attribution of HAR-5216 to the primary phase of the inner 'spiral' ditch (ibid, fig 15.1). Charcoal remaining after HAR-5216 was processed was either too fragmented to identify or was identified as oak (Gale 1999 unpubl).

Two 'small counter' measurements from the same sample (4130±150BP and 4470±100BP) were statistically indistinguishable (ν = 1; T' = 3.5; T' (5%) = 3.8), and were combined using the Ward and Wilson (1978) method (Walker and Otlet 1985, 127)[24]. The result was more than 1000 radiocarbon years later than might have been expected, given that the three liquid scintillation counting results attributed to the primary phase have a weighted mean of 5600±55BP (idem; 4550–4330 cal BC). Taking the wood-age offset into account, it is probably also too young relative to the 'final recut' dates, which date the final in-filling of the ditches to the late fourth millennium cal BC. Again, this outcome can be explained in three ways. Either the inner 'spiral' enclosure was more recent than the main inner and outer ditch circuits, an explanation Bamford rejected (*see above*, HAR-5125); or the material dated was intrusive; or the results were inaccurate.

HAR-5216 was processed after HAR-4110 and HAR-5125, and perhaps after the radon issue had been resolved. Moreover, a replicate measurement was carried out in late 1983 or early 1984 to check the first measurement. Given that the very early results (HAR-2282, HAR-4072, and HAR-4092) may have been obtained with residual material, the expectation that HAR-5216 would have produced a fifth millennium cal BC date was probably misplaced. Nevertheless, an early third millennium cal BC date for 176A (1) (HAR-5216, taking into account a wood-age offset) seems untenable, given the consistency of the 'final recut' dates from the main inner ditch circuit, unless the 'spiral' extension was a later construction. HAR-5216 cannot be earlier than more than one or two of the 'final recut' dates[25]. The most likely explanation, therefore, is that the material dated was intrusive, and thus does not date the construction of the inner 'spiral' ditch.

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[24] In the Harwell report on file (and in the 1985 monograph), the data table (ie Bamford 1985, table 27) shows only the first measurement for HAR-5216 (4130±150BP), but the text gives both measurements and the weighted mean. Walker *et al* (1991) quote only the weighted mean result for HAR-5216.

[25] This can be demonstrated using the ORDER command in OxCal v.3.5 (Bronk Ramsey 1995; 1998; 2001). Of the possible sequences of HAR-3208, HAR-4071, HAR-4075, and HAR-5216, no order with at least 0.1% probability begins with HAR-5216. In fact, there is only a 16.3% probability that HAR-5216 is not the latest of these dates. Adding wood-age offsets of 200±100 to HAR-5216 (oak) and 100±50 to the others reduces still further (to 10%) the probability that HAR-5216 is not the latest of these dates.

HAR-5217: 4420±90BP (3370–2880 cal BC)

The last Briar Hill sample to be measured by liquid scintillation counting, in November 1982, HAR-5217 consisted of unidentified charcoal. The sample size was adequate (2.79g of benzene). The context was described as a 'layer of discoloured sand and heavily burnt stone … above primary infill of third phase cut (of 4)' of feature 248, a segment of the main inner ditch (sample submission form). The sample came from 248C (1) or (2), just above the primary fill of the third cut of segment 248 (Bamford 1985, 36; table 27; fig 11.2). According to correspondence on file, this sample was selected after 'an unexpectedly late date' was obtained from HAR-4066 (248B (3)), which ought to have predated 248C (*see above*, HAR-4066).

The HAR-5217 result fits fairly well with the other 'final recut' dates (HAR-3208, HAR-4071, and HAR-4075). According to the submission form, however, it was not from the 'final recut' of segment 248, although a fourth phase cut is not shown in the section drawing or in the sequence diagram (Bamford 1985, figs 5 and 11.2). Evidently, the presence of a fourth cut was deduced from the result obtained for HAR-4066 (whose sample submission form mentions only three phases). If it is assumed that the latter sample was intrusive, or from an undetected later pit, HAR-5217 can be argued to date the 'final recut' of this segment to the late fourth millennium cal BC. Nevertheless, some doubt remains about the contextual relevance of HAR-5217, and an appropriate wood-age offset cannot be determined. The result must therefore be used with caution.

HAR-5271: 4780±120BP (3800–3340 cal BC)

Probably the last of the 'small counter' samples to be processed, HAR-5271 consisted of comminuted charcoal, mainly of alder and/or hazel (Gale 1999 unpubl). According to the submission form, the sample came from either the 'lower infill of the recut' of inner ditch segment 28 or the 'secondary infill of the primary cut which was exposed in the edge of the recut'. In the text, Bamford (1985, 40) attributed it to 28C (2), but 28B (2) (a 'lens of dark brown sand with charcoal and burnt ironstone') better fits the description on the submission form and the section drawing (Bamford 1985, microfiche frame 112).

HAR-5271 was the only sample from segment 28, and the result was apparently earlier than the 'final recut' dates from other segments of the main inner ditch (HAR-3208, HAR-4071, and HAR-4075). Of the 'small counter' results, this was the only one to meet the excavator's expectations (Bamford 1985, 40). There is nothing to suggest that the result is inaccurate or that the sample was intrusive or residual. Because HAR-5271 is not bracketed by other dates from the same segment, however, the result cannot be corroborated. Given the problems with the other 'small counter' results, HAR-5271 should be treated with caution. There is also some uncertainty about its provenance and a moderate wood-age offset to consider.

Summary of Briar Hill radiocarbon results

All three of the earliest samples (HAR-2282, HAR-4072, and HAR-4092) include mature oak charcoal, and thus may incorporate a significant wood-age offset. One of these samples, HAR-4092, was clearly residual, while the other two appear to date their contexts to the later fifth millennium cal BC. It is possible that wood-age accounts for part of the difference between these dates and the current consensus view that the causewayed enclosure is a phenomenon of the mid fourth millennium cal BC (Oswald *et al* 2001, 3). It is also possible that all three samples were residual, although it cannot be ruled out that the outer ditch circuit at Briar Hill is indeed one of the earliest causewayed enclosures in Britain. The fact that HAR-2282 and HAR-4072 were not from deeply-stratified segments of the main inner ditch argues for caution.

Four samples (HAR-3208, HAR-4071, HAR-4075, and HAR-5217) appear to provide much better evidence of a 'final recut' phase. These samples, from the upper fills of four different segments of the main inner ditch circuit, yielded dates that overlap substantially in the later fourth millennium cal BC. Except for HAR-5217, in which the wood was not identified, each sample consisted of blackthorn-type charcoal, which means that the appropriate wood-age offset is relatively insignificant. Only in the case of HAR-5217 was sample size or provenance of concern.

Of the possible 'intermediate' samples, only HAR-5271 produced a date that could be earlier than the 'final recut' phase. The two samples dated by liquid scintillation counting (HAR-4066 and HAR-4073) gave dates in the third or early second millennium cal BC, and were reassigned to later pits cutting the 'final recut' fills. Of the four samples measured in the 'small counter', a combination of inaccurate measurement and/or poor sample selection has to be invoked to account for the discrepancy between three of the dates (HAR-4110, HAR-5125, and HAR-5216) and their attribution to strata earlier than the 'final recut' phase, unless the inner 'spiral' ditch circuit was a significantly later construction than the main inner and outer ditch circuits. HAR-5271, however, produced a mid fourth millennium cal BC date, earlier than the 'final recut' dates and in line with the consensus chronology of causewayed enclosures. There is no obvious reason to reject this result, but the problems with the other 'small counter' samples suggest caution.

The remaining samples came from a variety of contexts, of which only three could be related stratigraphically to the ditch sequence. These were the 'later Neolithic pits', represented by samples HAR-2284 (and its replicate, HAR-2389), HAR-4067, and HAR-4089. Each of the four measurements concerned gave a date that was later than the 'final recut' phase, as the stratigraphic position of the pits implied. Each of these fell in the late third and early second millennium cal BC, consistent with the diagnostic pottery from other pits cutting the ditch fills (Bamford 1985, 47). These dates provide *termini ante quem* for the abandonment of the main inner ditch circuit, after the wood-age offset for oak is taken into account. The other samples (HAR-2283, HAR-2607, HAR-2625, HAR-4057, HAR-4058, HAR-4065, and HAR-4074) were from unrelated contexts. In each case, the calibrated radiocarbon date met the excavator's expectation for the age of that feature. Some of these samples provoke minor concerns about wood-age, mixing, or residuality, but these concerns do not affect the chronology of the causewayed enclosure.

Previous stratigraphic and chronological interpretations

Bamford (1985)

Bamford defined an occupational sequence at Briar Hill of fourteen phases (I–XIV). The first nine of these, representing the stratigraphic sequence in the causewayed enclosure, were illustrated in a sequence diagram (Bamford 1985, fig 5)[26]. Based on the geometry of the plan of the enclosure, it was thought that the inner and outer ditches and the inner 'spiral' ditch were contemporaneous. The sequences of recuts of the separate ditch segments were thus interpreted as 'a series of major reinstatements of the earthwork as a whole rather than … piecemeal modification or repair'. It was therefore also assumed that the several (up to five) phases within each ditch segment could be correlated across the site, without direct stratigraphic relationships or artefactual evidence (ibid, 39–40).

These assumptions allowed each radiocarbon sample to be attributed to a phase, as shown in Table 3. Bamford's phasing was not, however, independent of the radiocarbon results. For example, HAR-2282 was attributed to Phase II (the original construction), when on stratigraphic grounds alone it could have dated a later phase: 'a radiocarbon date (HAR-2282) for 77A provides a rather stronger reason for placing the segments early' (Bamford 1985, 40), but 77A could have been as late as Phase V or VI[27].

The three earliest results (HAR-2282, HAR-4072, and HAR-4092) provided 'a possible date for the construction of the earthwork, or at least a *terminus post quem* for this event', but Bamford did not believe that they dated a much earlier episode of woodland clearance (ibid, 40 and 42). HAR-4092, admittedly, was from a Phase VII context, and had to be regarded as residual, but HAR-4072 and HAR-2282, from opposite ends of the outer ditch circuit, were from contexts that could have been as early as Phase II. Bamford therefore proposed that the enclosure ditches were all originally cut around or shortly after '3650±55bc', the pooled mean of the three earliest dates (idem) (5600±55BP; 4550–4330 cal BC).

The samples HAR-3208, HAR-4071, HAR-4075, and HAR-5217 were 'from deposits well stratified in Phase VII', the fills of the final phase of recutting. Their pooled mean, '2635±40bc, or around 3380BC in calendar years' (Bamford 1985, 40) (4585±40BP; 3500–3110 cal BC[28]) was assumed to date the final recutting of the

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[26] The Harris matrix (Harris 1979) would not have been in use at the time of the excavation.

[27] Typically, the latest fill of each segment was attributed to Phase VII, and any earlier recuts to preceding phases (Bamford 1985, 40 and figure 5). According to the full context list on microfiche (in the 1985 monograph), 77A was cut by 77C, the final recut of that segment, but its relationship to 77B was uncertain. The fill sequence in 77A and 77B appears fairly similar, and in the section drawing on microfiche (frame 117) the two layers are at opposite ends of segment 77, separated by 77C. In that case, segment 77 may have only had two phases, 77A/B and 77C, in which case 77A/B could have been attributed to Phase VI. As there were no earlier deposits in segment 77, however, 77A could also be placed in Phase II. Despite the later controversy, Bamford continued to maintain that 'this sample (HAR-2282) is probably, but not certainly, contemporary with the original construction of the outer ditch circuit' (Jordan *et al* 1994, 120).

[28] This is the 95% confidence interval of the calibrated date, calculated by the maximum intercept method (Stuiver and Reimer 1986). If the pooled mean is calibrated by the probability method (Stuiver and Reimer 1993), there are four distinct probability peaks within this range, of which the highest (41%) spans 3380–3320 cal BC.

enclosure ditches. This implied that the causewayed enclosure was maintained 'according to the calibrated dates within limits of one sigma, (for) between 885 and 1395 years', which meant 'an interval of not less than 220 years between the identifiable major phases of recutting' (ibid, 42)[29].

The intermediate phases could not be dated to Bamford's satisfaction. Liquid scintillation spectrometry dating of HAR-4066 and HAR-4073, which should have belonged to phase III or IV, proved that these samples were not intermediate in date, and they were reassigned to phases VIII and IX respectively. When the Harwell miniature gas counter was introduced in 1982, four very small samples (HAR-4110, HAR-5125, HAR-5216, and HAR-5271) were processed. The first three of these 'small counter' results were found to be 'at variance with all the archaeological evidence' (Bamford 1985, 40) and were disregarded (ibid, fig 21). Only HAR-5271, from phase III or IV, produced an intermediate date consistent with Bamford's chronology, 'but only within limits of two sigma' (ibid, 42). The enclosure chronology therefore depended heavily on the use of the three earliest results (HAR-2282, HAR-4072, and HAR-4092).

Four features within the enclosure of the inner 'spiral' extension (145, 156, 218, and 137) were dated, and each produced the Neolithic result expected at the time of submission. These dates (HAR-2607, HAR-2625, HAR-4057, and HAR-4074) became Phase VIII, which appeared to be later than the final recut of the causewayed enclosure. Three pits (features 337, 228, and 258) cutting the latest fills of inner ditch segments gave results (HAR-2284/2389, HAR-4067, and HAR-4089) that were slightly later than Phase VIII, so it was possible to distinguish these as Phase IX. Two early Bronze Age cremation burials (features 240 and 275) in the south-western part of the main enclosure yielded dates (HAR-4058 and HAR-4065) that could be argued to represent a separate Phase X. No radiocarbon samples from the Iron Age (Phase XI) or Roman (Phase XII) features were dated, and a single date (HAR-2283) from an Anglo-Saxon *Grubenhaus* (feature 29) was placed in Phase XIII. There were no radiocarbon results from medieval and post-medieval features (Phase XIV).

Bamford's interpretation owed something to the order in which the radiocarbon results were obtained. The first batch, used in the second interim report (Bamford 1979), consisted of three results (HAR-2282, HAR-2283, and HAR-2389) from the four original samples, submitted in 1977[30], two results from samples submitted in 1978 (HAR-2607 and HAR-2625), and HAR-3208, which was processed by July 1979. The five prehistoric results first suggested the long Neolithic sequence and 1000-year use of the enclosure (Bamford 1979, 7).

This hypothesis seemed to be confirmed by the results of the first half of the second batch of samples, submitted in September 1980[31]. These were HAR-4057, HAR-4065,

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[29] In the 1985 monograph, calibrated dates were calculated by Walker and Otlet (1985, 128) using 'two of the original calibration curves', published by MASCA (Ralph *et al* 1973) and Damon *et al* (1972). Bamford cited the MASCA results, which appeared to be more precise. Those estimates fall within the ranges calculated using the INTCAL98 (Stuiver *et al* 1998) calibration curve.

[30] Bamford did not have the result HAR-2284, and 'sample 2', or HAR-2317, was not processed.

[31] The second batch of samples is HAR-4057 to HAR-4092 (Table 2). HAR-4110 was among five samples in the second batch that were too small to date by liquid scintillation. The samples were apparently collected in May and June 1978, shortly before the results of the first batch were available.

HAR-4071, HAR-4072, HAR-4074, and HAR-4075, which have certificates dated 14 November 1980. The two results on samples from pits within the enclosure, HAR-4057 and HAR-4074, were very similar to HAR-2607 and HAR-2625. The two dates from upper fills of the inner ditch, HAR-4071 and HAR-4075, were almost identical to HAR-3208. The very early result from a pit cut by the outer ditch, HAR-4072, was very similar to that on a sample from a primary fill of the outer ditch, HAR-2282. The sixth result, HAR-4065, confirmed Bamford's belief (Bamford 1979, 6) that the cremation burials in the south-western part of the enclosure were early Bronze Age in date. Not only did the very early date of the initial construction and the 1000-year maintenance of the enclosure ditches now seem more plausible; it appeared that every sample correctly dated its context.

The long chronology would have been undermined by the results of the second half of this batch, which were probably sent to Bamford in July 1981. HAR-4058, which was expected to be similar in age to HAR-4065, appeared to be 500 years older[32]. HAR-4066 and HAR-4073, supposedly from intermediate fills, were more recent than the 'final recut' dates, and had to be assigned to later phases. HAR-4092 was as early as the samples from the outer ditch – but it undeniably came from a 'final recut' context, and had to be regarded as residual. Only HAR-4067 and HAR-4089, from later Neolithic pits cutting the final fills of the enclosure, gave the expected results.

Bamford then prepared a list of nine more samples for the new Harwell 'small counter'. The Ancient Monuments Laboratory supported the application, noting that Bamford would surely be 'considering the relevance of the samples to their contexts as rigorously as possible'. In a detailed report to the Science Panel of the Ancient Monuments Board, Bamford countered criticism that some of the charcoal submitted for radiocarbon dating could have been residual. Samples were only taken from what appeared to be 'deliberate tips or dumps of rubbish or hearth material', and not from 'charcoal scattered diffusely in otherwise 'clean' layers.' Moreover, Bamford wrote, of the seventeen results to date[33], only HAR-4073 was out of stratigraphic sequence, and that anomaly was explained by re-checking the excavation records. None of the very early results was in doubt.

Four of the nine samples were ultimately measured in the 'small counter', while HAR-5217 was dated by liquid scintillation counting. Preliminary results from the 'small counter' samples seem to have been available in December 1982, and these appeared to contradict the earlier liquid scintillation spectrometry results[34]. HAR-5217, the only liquid scintillation spectrometry result in the final batch, appeared to fit Bamford's sequence, however. Further correspondence ensued, the excavators apparently hoping that Harwell would resolve the anomalies by revising the 'small counter' results. The final results, which Harwell produced in 1984, did not eliminate the discrepancies. The revised result for HAR-5216, in fact, was further from the

[32] Ironically, HAR-4058 was the sample from the pit with the better claim to an early Bronze date – it seems to have been the tanged arrowhead in that pit, 240, which suggested that the whole cemetery dated to early Bronze Age. The pit from which HAR-4065 was taken, 275, was apparently attributed to the early Bronze Age by association with pit 240, before the radiocarbon result was obtained.

[33] The seventeen results were the twelve results obtained in 1980–81 and the five published prehistoric dates (Bamford 1979).

[34] From the file, it appears that the preliminary results were HAR-4110: 2850±100BP; HAR-5125: 3320±100BP; HAR-5216: 4470±150BP; HAR-5271: 4460±110BP.

expected result than was the original measurement. Only the final result for HAR-5271 was consistent with Bamford's interpretation.

Kinnes and Thorpe (1986)

A brief note in *Antiquity* by Kinnes and Thorpe (1986) challenged Bamford's use of the Briar Hill radiocarbon results, arguing that 'the replacement of stratigraphy by phasing disguises the observable cultural affinities of the site and the very real problems posed by an almost random radiocarbon sequence' (ibid, 223). In particular, acceptance of the earliest dates implied that Briar Hill had 'the earliest causewayed enclosure in Europe, the earliest agricultural manifestation in Britain, the earliest decorated pottery' (ibid, 221), and these dates 'seem to have incurred misattribution of the pottery to Grimston sty(l)e: none of the illustrated sherds belongs here, although many are clearly Mildenhall in character' (ibid, 223).

Kinnes and Thorpe (1986, fig 3) placed each Neolithic date within one of five groups: lower, middle, upper, and final ditch fills, and internal features (Table 4). Only the 'final ditch fills' group, consisting of HAR-2284, HAR-2389, HAR-4067, and HAR-4089 (Bamford's Phase IX), could be regarded as a coherent phase. Every other group included samples from more than one of Bamford's phases, and these gave an 'almost random' scatter of dates within each group.

It is not clear how Kinnes and Thorp assigned each sample to a group. The 'lower ditch fills' included samples from Bamford's Phase II (HAR-2282 and HAR-5216), but also HAR-5125, which Bamford had assigned to Phase III or IV. The 'middle ditch fills' included HAR-4110 and HAR-5271, which Bamford placed in Phase III or IV, but also three of the samples assigned to Phase VII (the 'final recut' phase): HAR-4071, HAR-4075, and HAR-5217. The 'upper ditch fills' included the other two Phase VII samples, HAR-3208 and HAR-4092, and the two samples that Bamford had moved from intermediate phases to Phases VIII and IX, HAR-4066 and HAR-4073. The very early HAR-4072, which came from a pit cut by the outer ditch circuit, was placed in the otherwise coherent group of dates from interior features (Bamford's Phase VIII).

There are legitimate questions about how Bamford assigned samples to phases. This is particularly true in the case of HAR-2282 and HAR-4072, which were placed in Phase II rather than in later phases on the basis of the radiocarbon results, and HAR-4066 and HAR-4073, which were moved from before Phase VII to after it for the same reason. Nevertheless, Kinnes' and Thorpe's scheme appears to be just as arbitrary. If they did not accept Bamford's reallocation of HAR-4066 to Phase VIII, for example, they did not explain why, in their scheme, it was still placed in a later phase than HAR-5217[35]. In particular, HAR-4071 and HAR-4075 are out of place in the 'middle ditch fills' group, and HAR-4072 belongs in the ditch sequence, even if not in its primary phase.

[35] As discussed above, HAR-4066 came from a fill of 248B, supposedly the first recut of that segment, while HAR-5217 came from 248C, the second and final recut. The date obtained from HAR-4066 was so late, however, that Bamford had to construe a later pit that was not detected during the excavation. If that explanation was rejected, HAR-4066 belonged to an earlier phase than HAR-5217.

Kinnes and Thorpe did not attempt to explain the very early dates 'in the absence of plausible associations, although late mesolithic flintwork occurred at the site', noting also that some of the samples were very small and included mature timber, and that 'there are very late determinations from good ditch contexts' (ibid, 223). Their discussion pointed out 'a general clustering from (the) main enclosure span(ning) *c.* 2800–2200BC' (*c* 4750–4150BP; *c* 3600–2900 cal BC[36]), in line with accepted dates for Mildenhall pottery.

Walker *et al* (1991)

Harwell subsequently published the Briar Hill date list (Walker *et al* 1991) without Bamford's fourteen-phase system. The 1991 report was heavily based on Walker and Otlet's contribution to the Briar Hill monograph (Walker and Otlet 1985). Unlike the 1985 report, however, the 1991 article did not specify which of the results had been obtained by liquid scintillation counting and which in the miniature gas counter.

The results were grouped into a sequence of three phases plus sundry other samples (Table 5). The 'primary phase' included the three earliest results (HAR-2282, HAR-4072, and HAR-4092), and HAR-5216. Noting that the last could not 'belong to the same distribution' as the other three results, the authors did not explain why they nevertheless included it in the primary phase. The second, or 'final recut', phase was equivalent to Bamford's Phase VII, without the very early HAR-4092. The four remaining samples (HAR-3208, HAR-4071, HAR-4075, and HAR-5217) provided measurements ranging between 4660±70BP and 4420±90BP. Walker *et al* (1991, 84) noted that these samples came from 'in or just above' the primary fills of the final recuts, and regarded the results as providing 'an approximate date for final recutting of the ditch system'. The third phase consisted of five measurements (HAR-2284, HAR-2389, HAR-4067, HAR-4073, and HAR-4089), ranging from 3790±100BP to 3460±120BP, on samples from later Neolithic pits that cut the upper fills of the ditch segments. This phase was exactly equivalent to Bamford's Phase IX. Walker *et al* (1991, 84) noted the consistency of these results and their agreement with dates from other sites that had similar pottery.

The three 'small counter' results that Bamford had placed in Phase III or IV of the ditch sequence were put in a separate group of 'intermediate dates' (Walker *et al* 1991, 84). The accompanying comments are perplexing. Only HAR-5271 'fits with archaeologic (sic) expectation', but without Bamford's phasing it is unclear what that expectation was. No explanation was offered as to why the other two dates did not fit. Then Walker *et al* inferred that 'the site was maintained' for no more than 'ca. 500 years'. This may be the difference between HAR-5271 (4780±120BP) and the latest of the final recut results (HAR-5217: 4420±90BP), if one assumes that HAR-5271 gives a *terminus ante quem* for the construction of the enclosure[37]. Walker *et al* then repeated Bamford's (1985, 42) suggestion of an interval of 220 years between major

[36] Minimum range to the nearest calendar century of the span 4750–4150BP, obtained visually using the INTCAL98 calibration curve (Stuiver *et al* 1998).

[37] The maximum difference between the calibrated estimates for HAR-5271 ('3595±140BC') and the pooled mean of the final recut results ('3335±100BC'), using the Damon *et al* (1972) calibration curve (Bamford 1985, table 28), was exactly 500 years (3735–3235'BC'). Walker *et al* (1991) did not, however, quote calibrated dates.

phases of recutting, despite the fact that this was based on the enclosure being maintained for between 885 and 1395 years.

Five more samples from Neolithic features 'in the interior of the site' were placed in a group that corresponds exactly to Bamford's Phase VIII (Walker *et al* 1991, 85). Whether the samples were grouped together on the basis of archaeological evidence or of the radiocarbon results is not made clear. The inclusion of HAR-4066 suggests the latter, as it came from a fill of the inner ditch circuit, not from an interior feature.

The scheme did not attempt to reconcile the radiocarbon results with the archaeology, and did not explain anomalies. Walker *et al* (1991, 83) regarded the three earliest results as providing 'a possible date for construction… or, at least, a *terminus post quem* for this event'[38]. The point of the 1986 controversy was that Bamford appeared to have claimed that the enclosure was constructed in the fifth millennium cal BC, and maintained for about a thousand years afterwards. Walker *et al* appear to have accepted a shorter duration ('a time span of ca 500 years'), in line with Kinnes' and Thorpe's critique. By 1991, Kinnes' and Thorpe's view had prevailed: Mercer (1990, 63) described the three earliest samples from Briar Hill as residual.

Summary of earlier interpretations

Bamford clearly relied on the radiocarbon results to interpret the Briar Hill stratigraphy. Even if her phasing was correct, however, not all the radiocarbon results fitted the sequence. Bamford implicitly attributed the anomalies to laboratory error, by omitting three of the 'small counter' results (Bamford 1985, fig 21). The 'small counter' was new at the time and its results appeared to contradict those previously obtained by liquid scintillation spectrometry. Kinnes and Thorpe (1986) argued that Bamford had used the results selectively, in support of an argument that could not be sustained on ceramic grounds and which disguised serious stratigraphic discrepancies, but they did not offer a clear alternative. Walker *et al* (1991) accepted all the radiocarbon results and did not attempt to explain the stratigraphic anomalies. The chronology of the causewayed enclosure at Briar Hill therefore remains unresolved.

[38] In 1985, Walker and Otlet said only that the primary phase represented 'the earliest activity on the site'.

Bayesian modelling of radiocarbon results

Improvements in analytical techniques and in the dendrochronologically-derived calibration curve now permit more realistic interpretation of radiocarbon results than was possible in 1985. Figure 1 shows the uncalibrated 1σ and 2σ calibrated date ranges of each of the Briar Hill radiocarbon results (cf Bamford 1985, fig 21). Radiocarbon results are often calibrated by the maximum intercept method (Stuiver and Reimer 1986) to obtain 95% confidence intervals of the calendar date of the sample (Table 1; Fig 2). The 95% confidence interval, equivalent to the 2σ range, refers to the date range within which one can be 95% confident that the ^{14}C event in question took place.

The development of Bayesian techniques of chronological modelling has provided another means to interpret radiocarbon results (Buck *et al* 1994; 1996). The program OxCal (Bronk Ramsey 1995; 1998) uses Bayesian statistical techniques to allow chronostratigraphic interpretations to be explored. The program calibrates radiocarbon results by the probability method (Stuiver and Reimer 1993), giving probability distributions for each date (Fig 3), which can be offset to incorporate wood-age (Fig 4).

If the results are included in a model that specifies stratigraphic relationships between the samples, OxCal calculates 'posterior density estimates' for each date, which reflect the effect on each probability distribution of the other distributions in the model. It is also possible to obtain a estimated probability distribution for the date of an event, such as the end of a phase of activity, which was not dated directly by radiocarbon, and to determine a date range that includes 95% of a modelled probability distribution. Such ranges are always reported in italics, to reflect the fact that estimated probability distributions depend on the structure of the model as well as on the radiocarbon results.

The dated ^{14}C events cannot always be reconciled with the sequence of archaeological events specified by the stratigraphy. OxCal calculates a model's overall 'index of agreement', which, if it falls below 60% (a threshold statistically equivalent to the 0.05 significance level in a χ^2 test), indicates that the radiocarbon results are inconsistent with the stratigraphic relationships specified. The Briar Hill Neolithic radiocarbon results were placed in several, alternative, OxCal models, wood-age offsets applied, and replicate measurements combined, with the following results:

- It is indeed impossible to reconcile all the Neolithic radiocarbon results with Bamford's phasing (Fig 5). No index of agreement can be calculated.
- Bamford's solution (accepting HAR-5271, rejecting the other 'small counter' results, and treating HAR-4092 as residual) is mathematically possible (Fig 6). Because this model relies on the phasing of some samples according to their radiocarbon results, however, this outcome is practically a foregone conclusion.
- The Neolithic results cannot be reconciled with the stratigraphic sequence proposed by Kinnes and Thorpe (1986, fig 3), as they pointed out (Fig 7). This scheme, however, does not accurately reflect the stratigraphic record (*see above*).

Reassessment and potential

The long chronology Bamford proposed for the Briar Hill causewayed enclosure has not been accepted, but the alternative schemes proposed by Kinnes and Thorpe (1986) and Walker *et al* (1991) are also unsatisfactory. The consensus today is that causewayed enclosures in Britain flourished between about 3700 and 3300 cal BC (Oswald *et al* 2001, 3). The three very early results at Briar Hill (HAR-2282, HAR-4072, and HAR-4092), spanning the middle and late fifth millennium cal BC, clearly precede this period[39]. Most of the other dates from the ditch fills are consistent with it, however. The exceptions are two of the three 'small counter' results rejected by Bamford (HAR-4110 and HAR-5125), and HAR-4066 and HAR-4073, which Bamford decided were from later pits[40].

The only samples from the outer ditch circuit (HAR-2282 and HAR-4072) produced two of the very early dates. It is stratigraphically possible that these provide *termini ante quem* for the construction of the enclosure, after wood-age offsets are applied, but that construction would have to have taken place in the fifth millennium cal BC. If Briar Hill was not much older than comparable sites, therefore, these samples were probably residual. While it might be argued, on stylistic grounds, that the inner 'spiral' extension was a later addition (Oswald *et al* 2001, 77), the main inner and outer ditch circuits have always been regarded as contemporaneous (Bamford 1985, 39). There are no fifth millennium cal BC dates from the main inner ditch circuit, but this could be due to the shortage of dateable material in the earliest levels of the excavated segments.

Five segments of the main inner ditch produced one sample each: 'final recut' samples from segments 38 (HAR-3208), 199 (HAR-4071), and 124 (HAR-4075), the replicated measurements (HAR-2284/2389) on a sample from a pit cutting the final fill of segment 41, and the 'intermediate' 'small counter' sample (HAR-5271) from segment 28. Each of these samples appears to date its context correctly, after a wood-age offset is applied.

There are two results, HAR-4066 and HAR-5217, from segment 248 of the main inner ditch. The latter was close to the 'final recut' dates from segments 38, 199, and 124, but HAR-4066 was much later, despite coming from an earlier layer than HAR-5217. Either HAR-4066 was from a later pit, not detected during the excavation, or segment 248 was maintained long after the other segments were abandoned, and HAR-5217

[39] This can be shown using the ORDER function of OxCal. If all three of the earliest radiocarbon results have wood-age offsets of 200±100 years, the calculated probability that all three date events after 4000 cal BC is 0.2%. Under the same assumptions, the probability that all three date events later than 4100 cal BC is 3.0%. Only a hypothetical calendar date shortly before 4300 cal BC has more than a 50% probability of preceding all three of the earliest radiocarbon results, if the 200±100 year offset is applied.

[40] An OxCal simulation of nine ^{14}C results, each with an error margin of ±90, corresponding to calendar dates between 3700 and 3300 cal BC, was run five times to see whether comparable results could have been obtained by chance. Nearly every radiocarbon age generated by the simulation fell between 4900 and 4400BP; the earliest was 5140BP and the latest 4290BP. Neither the very early results from Briar Hill nor HAR-4066 or HAR-4073 could have been obtained on *in situ* samples, had the ditches only been maintained between 3700 and 3300 cal BC. Unless the Briar Hill enclosure was much earlier than similar structures in Britain, the very early samples are therefore likely to be residual. Unless it was maintained for longer than comparable sites, HAR-4066 and HAR-4073 almost certainly do not relate to the main use of the enclosure.

was residual. Not unreasonably, Bamford favoured the former explanation, which does not, however, prove the stratigraphic integrity of HAR-5217.

There were four samples from segment 192/251 of the main inner ditch, two of which are suspect: HAR-4110, which gave a Bronze Age date, and HAR-4073, which Bamford admitted must have come from a later pit, not the ditch fill it was supposed to date. Both of the others, HAR-4067 and HAR-4089, were also ‘later pit’ samples, and their results are consistent with HAR-2284/2389. There was no stratigraphic relationship between HAR-4067 and HAR-4089. It is likely that HAR-4073 was stratigraphically earlier than both these samples, but it also appears to date later pitting activity, rather than the maintenance of the ditch segment.

No sample from the inner ‘spiral’ extension produced the expected results. Two were ‘small counter’ results (HAR-5125 and HAR-5216), which were much later than their contexts implied, if the samples were not intrusive and the ‘spiral’ extension was not later than the main inner ditch circuit. The LSC result HAR-4092, on the other hand, was far too early for its ‘final recut’ context, and the sample was thought to be residual.

None of the dates from interior features is suspect, although most were on samples of oak charcoal, and may require significant wood-age offsets. These features are therefore more recent than the dates suggest, and are probably all later than the use of the enclosure ditches. No more than one sample was dated from each interior feature, and the dated features did not overlap each other or the ditches.

In summary, there is no reason to question the ‘final recut’ dates from segments 199, 124, and 38 of the main inner ditch, or the ‘later pit’ dates from features 337, 228, and 258, which were cut into the final fills of segments 41 and 192/251. The very early samples from the outer ditch appear to be residual, based on the chronology of other sites. There are no other dates from intermediate or primary phases that are not later than the ‘final recut’ dates (apart from one ‘small counter’ sample, HAR-5271). The radiocarbon results contradict the stratigraphic sequence, as excavated, in the only ditch segments with multiple dated samples. Results from the inner ‘spiral’ extension are not consistent the results from the main inner ditch.

All the samples from ditch fills must therefore be placed in a single phase, reflecting the fact that no stratigraphic relationship between any of them is assured (Fig 8). The only stratigraphic relationship that can be assumed is that the ‘later pit’ phase did not begin until after the end of the ditch fill phase. In this case, HAR-4066, HAR-4073, HAR-4110, and HAR-5125 must be inaccurate or intrusive, or both. These dates, according to the model, cannot belong to the ditch fill phase if that phase is earlier than the ‘later pit’ phase. Two other samples, HAR-5216 and HAR-5217, may also be excluded. Both could be intrusive: HAR-5217 appeared to be stratigraphically later than the intrusive HAR-4066, while two measurements of HAR-5216 dated it later than the ‘final recut’ dates, when it was supposed to date a primary-phase fill.

In this simple model, the probability distribution of the estimated date of abandonment of the enclosure spans *3430–2340 cal BC* (95% probability), but it is concentrated in the second half of the fourth millennium cal BC. There is a significant probability that HAR-5217 belongs in the ditch fills phase (47.5%) and a somewhat lower probability (30.1%) that HAR-5216 does also. The estimated date of construction, after allowance for wood-age offsets and assuming that none of the very early samples is residual, is *5120–4070 cal BC* (95% probability). The span of the ditch-filling phase, estimated by Bamford at between 885 and 1395 calendar years (Bamford 1985, 42), is *680–1380 years* (95% probability). Including HAR-5216 and HAR-5217 in the ditch-filling phase naturally results in a later estimate of abandonment (*3140–2190 cal BC*) and longer span (*1050–1770 years*) (95% probability).

If all the suspect samples[41] are excluded from the analysis, the overall index of agreement is high, but the estimated dates of construction and abandonment overlap (Fig 9). The maximum estimated span of the ditch-filling phase is *420 years* (95% probability), but, as none of the samples used in this model was from the primary cut of a ditch segment, the estimate may be misleading. Similar results are obtained when the two results from primary cuts of the outer ditch circuit (HAR-2282 and HAR-4072) are used as *termini post quem* for the construction of the enclosure (Fig 10).

The problem, clearly, is that there are no reliable dates from the earlier fills of the ditch segments. The 'primary' and 'intermediate' samples processed gave either suspiciously early results (HAR-2282 and HAR-4072), or improbably recent results (HAR-4066, HAR-4073, HAR-4110, HAR-5125, and HAR-5216). If the very early results postdate the construction, the enclosure dates to the fifth millennium cal BC. If they are residual, it was probably constructed between 4000 cal BC and 3500 cal BC, and abandoned sometime after 3400 cal BC[42]. Without more samples from the fills of earlier ditch cuts, we cannot be more exact.

Table 6 lists the seven samples Bamford submitted that were not given Harwell numbers. Of these, P76B6014 and P76A7195 are listed on an undated Harwell printout as probably having been processed, with 'no details of result'. Neither of these is likely to help to date the construction, given their provenance. P76D7095 appears to have been submitted to the Ancient Monuments Laboratory at the same time, in 1979, but was apparently not sent to Harwell. It came from the fill of the first recut of segment 165 – not a primary phase, but stratigraphically earlier than any of the 'final recut' dates. The last four samples were sent to Harwell with the 'small counter' samples, in 1981, but were not processed. None of these seems likely to date the earlier ditch fills. P76D7125 (AML 812931) at least was from the fill of a primary cut, but of a segment with only two phases.

Carbonised plant remains were scarce, particularly in the ditch fills. The monograph (Bamford 1985 microfiche) listed no identifiable remains at all before Phase V, and

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[41] The suspect samples excluded are the three earliest (HAR-2282, HAR-4072, and HAR-4092), which appear to have been residual, and the six latest samples from ditch fills (HAR-4066, HAR-4073, HAR-4110, HAR-5125, HAR-5216, and HAR-5217), which appear to have been intrusive, misdated, or to represent a later phase of activity.

[42] According to the model shown in Figure 8, there is a 2.2% probability that construction preceded 4000 cal BC, a 55.5% probability that it took place between 4000 cal BC and 3500 cal BC, a 32.7% probability that it occurred between 3500 cal BC and 3400 cal BC, and a 9.6% probability that it took place after 3400 cal BC. Abandonment probably did not take place before 3300 cal BC (5.0%), but probably occurred before 3000 cal BC (52.5%). These estimated probabilities are based on the application of assumed wood-age offsets and the exclusion, on stratigraphic grounds, of the 'suspect' samples (*see above*).

then only two items (a barley grain and one *Prunus spinosa* (fruit-stone?) in 162D (1)). Seven contexts from Phase VII (the 'final recut' phase) were listed as having some identifiable plant remains, as well as two fragments of hazelnut shell from 248B (3), the ditch fill deposit that was redefined as a 'later pit' because of the unexpectedly late result of HAR-4066. Dating these plant remains would not help to date the enclosure sequence. Animal bone preservation was poor as well. Calcined fragments of bone were recovered in three contexts attributed to Phase II, including 77A (2), from which the very early date HAR-2282 was also obtained. None of the animal bone appears to have been articulated. The microfiche appendices do not list charcoal samples that were collected but not submitted for dating, but it appears that all samples from reliable contexts were submitted.

There are some charcoal fragments left over from the processing of samples HAR-2283, HAR-3208, HAR-4065, HAR-5125, HAR-5216, and HAR-5271 (Gale 1999 unpubl). The last three of these were from the fills of primary or intermediate cuts and were processed in the miniature gas counter. Two (HAR-5125 and HAR-5216) produced dates that were far too recent for their positions in the sequence. It may be worthwhile to date these remains by Accelerator Mass Spectrometry (AMS). Doing so would check the results of the 'small counter' method and perhaps provide more useful dates from the earlier fills. If the samples were intrusive, AMS dating would at least vindicate the 'small counter' method. HAR-5271, the only 'intermediate' date, would also be confirmed. If AMS produces earlier dates, providing evidence of use of the enclosure between the *termini post quem* provided by the very early dates and the *termini ante quem* provided by the 'final recut' dates, Bamford's scepticism of the 'small counter' results would be justified.

Conclusion

The dating programme at Briar Hill was neither as successful as the excavator believed, nor as misleading as the critics claimed. After adjustment for wood age, all 10 samples from pits and other features later than the causewayed enclosure appear to date their contexts correctly, although there may be minor, undetectable problems due to mixing and residuality. The 13 samples from the enclosure ditches, however, did not date the sequence of cuts and fills as expected. Several factors were involved:

- Some residual fifth-millennium cal BC charcoal may have been present when the enclosure was originally constructed. Three samples (HAR-2282, HAR-4072, and HAR-4092) therefore gave dates that apparently are too early for the structure, even when wood age is taken into account.

- The excavators were not as successful at recognising the various cuts and recuts of the ditch segments as they believed, leading to some misattribution of intrusive samples to earlier phases (HAR-4066, HAR-4073, and perhaps HAR-5217).

- At least two of the four 'small counter' samples from intermediate fills (HAR-4110 and HAR-5125) may have been dated inaccurately, probably due to the presence of radon gas, whose rapid decay would have led to artificially recent results. It cannot be ruled out, however, that these samples were (also) intrusive. The replicate measurement of HAR-5216 appears to exclude inaccuracy, and it must therefore be assumed that this sample was intrusive.

The result for the 'small counter' sample HAR-5271 appears to be accurate and consistent with its stratigraphic position, dating the primary fill of the first recut of ditch segment 28 to the middle of the fourth millennium cal BC. Three or four liquid scintillation samples (HAR-3208, HAR-4071, HAR-4075, and perhaps HAR-5217), from the fills of 'final recuts' of segments of the main inner ditch circuit, dated the final phase of the enclosure's use to the late fourth or early third millennium cal BC.

The main obstacle to a more exact chronology was a shortage of suitable dating material, particularly from fills of the earlier recuts. Imprecision due to wood age was unavoidable: all the charcoal identified was of mature timber, not of twigs or branches, and other short-lived material (bone, antler, nutshell, or grain) was scarce. A high standard of stratigraphic integrity was required of each sample. As none of the segments excavated contained a good sequence of charcoal in primary contexts, samples were taken from many different ditch segments. Had AMS dating been available at the time, it would still not have been possible to date a true stratigraphic sequence of short-lived material. Given the lack of reliable dates from the earlier fills, however, AMS dating of short-lived material from the remains of three of the 'small counter' samples (HAR-5125, HAR-5216, and HAR-5271) probably would be worthwhile.

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Table 1: Radiocarbon dates from Briar Hill**.** HAR-5216 is the pooled mean of two measurements on the same sample. HAR-2284 and HAR-2389 are also replicates, but were given individual numbers. The range cited is the 95% confidence interval of the calibrated date, obtained by the maximum intercept method (Stuiver and Reimer 1986). # Not reported (a $\delta^{13}C$ value of -25.0‰ will have been assumed)

Laboratory Code	Radiocarbon Age (BP)	$\delta^{13}C$ (‰)	Calibrated Range (95% confidence)	Charcoal Identifications	Feature/Deposit
HAR-2282	5440±110	-24.4	4450-3990 cal BC	mainly oak, some hawthorn	fill 77A (2), outer ditch circuit
HAR-2283	1700±60	-24.5	220-530 cal AD	hazel, oak, ash, willow/poplar, hawthorn, maple, blackthorn	feature 29, Saxon *Grubenhaus*
HAR-2284	3460±120	-25.2	2140-1490 cal BC	oak, alder, hazel, hawthorn	feature 337, pit cutting main inner ditch segment 41
HAR-2389	3540±90	-25.6	2140-1680 cal BC	as HAR-2284	as HAR-2284
HAR-2607	4010±90	-25.2	2880-2230 cal BC	oak, hazel/alder, willow/poplar, blackthorn	feature 145, interior; timber structure with Grooved Ware
HAR-2625	4290±80	-30.4	3100-2630 cal BC	oak	feature 156, interior; large post pit, related to feature 218
HAR-3208	4600±90	-24.5	3640-3020 cal BC	blackthorn and unidentified	feature 52, cremation in upper fill of inner ditch segment 38
HAR-4057	4250±70	-27.7	3020-2620 cal BC	oak	feature 218, interior; large post pit, related to feature 156
HAR-4058	3700±150	-26.0	2560-1680 cal BC	not identified	feature 240, cremation burial within outer enclosure
HAR-4065	3180±70	-27.1	1620-1260 cal BC	probably all oak heartwood	feature 275, fill around cremation urn, outer enclosure
HAR-4066	4080±70	-26.9	2880-2460 cal BC	oak, hazel, blackthorn, hawthorn	fill 248B (3), main inner ditch
HAR-4067	3730±70	-27.0	2400-1920 cal BC	oak	feature 228A, pit cutting inner ditch segment 192/251
HAR-4071	4610±90	-26.1	3640-3030 cal BC	blackthorn	fill 199D (2), final phase, main inner ditch circuit
HAR-4072	5680±70	-26.5	4710-4350 cal BC	oak	feature 219, pit cut by outer ditch segment 197
HAR-4073	3790±100	-27.8	2490-1920 cal BC	oak	feature 303, pit cutting inner ditch segment 192/251 (?)
HAR-4074	4370±80	-25.2	3340-2870 cal BC	oak, hazel, alder, blackthorn	feature 137, interior pit
HAR-4075	4660±70	-25.2	3640-3120 cal BC	mature *Prunus* charcoal	fill 124E (3), final phase, main inner ditch circuit
HAR-4089	3620±90	-25.7	2280-1740 cal BC	mature oak	feature 258, pit cutting inner ditch segment 192/251
HAR-4092	5540±140	-24.2	4710-4000 cal BC	oak, ash, blackthorn, hawthorn	fill 128E (4), final phase, main inner ditch circuit
HAR-4110	3410±100	-27.3	1960-1450 cal BC	oak	fill 192B, second cut of main inner ditch segment 192/251
HAR-5125	3900±90	-27.1	2620-2060 cal BC	hawthorn and unidentified	fill of 2nd cut of ≥4 in inner 'spiral' ditch segment 165
HAR-5216	4365±85	#	3350-2870 cal BC	oak and unidentified	fill 176A (1), primary cut of inner 'spiral' ditch extension
HAR-5217	4420±90	-26.3	3370-2880 cal BC	not identified	fill 248C (2), 3rd cut (of 4?) cuts, main inner ditch circuit
HAR-5271	4780±120	#	3800-3340 cal BC	alder/hazel	fill 28B (2) or 28C (2), main inner ditch circuit

Table 2: Details of sample processing, based on archival information from the Ancient Monuments Laboratory and Harwell held by the Scientific Dating Section, Centre for Archaeology, English Heritage

Site code	AML code	Harwell code	Submitted	Benzene (g)	Certificate	Result sent
P76 E8 077	777409	HAR-2282	received 01.06.77	2.35	11.01.78	by 16.06.78
P76 C9 025	777411	HAR-2283		5.34		
P76 E7 041	777412	HAR-2284		1.46		not sent?
P76 E7 041	777412	HAR-2389		1.88	16.03.78	by 17.07.78
P76 B6 060	780607	HAR-2607	received 23.03.78	2.07	25.08.78	by 18.01.79
P76 B7 390	780606	HAR-2625		4.60		
P76 D7 083	781604/777413	HAR-3208	received 14.05.79	3.92	26.07.79	by 21.09.79
P76 B5 116	794871	HAR-4057	received 29.09.80	?	14.11.80	by 16.07.81, probably before 25.03.81
P76 B3 168	794874	HAR-4065		4.98		
P76 C3 116	794867	HAR-4071		4.59		
P76 C2 011	794870	HAR-4072		5.63		
P76 B6 047	794872	HAR-4074		3.12		
P76 A7 185	794865	HAR-4075		6.38		
P76 C3 251	794868	HAR-4067		4.99	28.11.80	by 03.08.81, probably after 25.03.81
P76 C3 335	794869	HAR-4089		3.80		
P76 B3 001	794875	HAR-4058		1.22	24.12.80	
P76 A3 020	794866	HAR-4066		4.63		
P76 C3 503	794863	HAR-4073		2.46		
P76 A6 051	794861	HAR-4092		1.63	04.05.81	
P76 C3 275	794862	HAR-4110		'small counter'	no certificates	initial results sent by 27.01.83, final results in mid-1984
P76 D6 095	794860	HAR-5125	01.02.82			
P76 C5 241	812930	HAR-5216	1981 or 06.10.82			
P76 C8 330	812929	HAR-5271	07.07.81			
P76 A3 021	812928	HAR-5217	07.10.82	2.79	20.11.82	by 27.01.83?

Table 3: Phasing of Briar Hill radiocarbon dates (Bamford 1985, table 27)
* 'determinations inconsistent with stratigraphic position of sample'
# sample regarded as residual by the excavator

Phase	Description	Radiocarbon results
XIV	medieval and post-medieval farming	none
XIII	early Saxon *Grubenhaus*	HAR-2283: 1700±60BP
XII	Roman period	none
XI	Iron Age	none
X	Bronze Age cremation cemetery	HAR-4058: 3700±150BP HAR-4065: 3180±70BP
IX	later Neolithic/early Bronze Age pits, cutting upper fills of enclosure ditches	HAR-2284: 3460±120BP HAR-2389: 3540±90BP HAR-4067: 3730±70BP HAR-4073: 3790±100BP HAR-4089: 3620±90BP
VIII	use of inner enclosure following final re-cut of ditches	HAR-2607: 4010±90BP HAR-2625: 4290±80BP HAR-4057: 4250±70BP HAR-4066: 4080±70BP HAR-4074: 4370±80BP
VII	final re-cut of enclosure ditches	HAR-3208: 4600±90BP HAR-4071: 4610±90BP HAR-4075: 4660±70BP HAR-4092: 5540±140BP# HAR-5217: 4420±90BP
VI	not defined	none
V	third major re-cut	none
III/IV	first and second major re-cuts of enclosure ditches (each sample could belong to either phase)	HAR-4110: 3410±100BP* HAR-5125: 3900±90BP* HAR-5271: 4780±120BP
II	primary construction of causewayed enclosure	HAR-2282: 5440±110BP HAR-4072: 5680±70BP HAR-5216: 4365±85BP*
I	marking out of circuits	none

Table 4: 'Stratigraphic' grouping of Briar Hill Neolithic radiocarbon results, according to Kinnes and Thorpe (1986, fig 3)

Group	Radiocarbon results	Phase (Bamford 1985)
internal features	HAR-2607: 4010±90BP	VIII
	HAR-2625: 4290±80BP	VIII
	HAR-4057: 4250±70BP	VIII
	HAR-4074: 4370±80BP	VIII
	HAR-4072: 5680±70BP	II
final ditch fills	HAR-2284: 3460±120BP	IX
	HAR-2389: 3540±90BP	IX
	HAR-4067: 3730±70BP	IX
	HAR-4089: 3620±90BP	IX
upper ditch fills	HAR-3208: 4600±90BP	VII
	HAR-4066: 4080±70BP	VIII
	HAR-4073: 3790±100BP	IX
	HAR-4092: 5540±140BP	VII (residual from II)
middle ditch fills	HAR-4071: 4610±90BP	VII
	HAR-4075: 4660±70BP	VII
	HAR-4110: 3410±100BP	III/IV
	HAR-5217: 4420±90BP	VII
	HAR-5271: 4780±120BP	III/IV
lower ditch fills	HAR-2282: 5440±110BP	II
	HAR-5125: 3900±90BP	III/IV
	HAR-5216a: 4130±150BP	II
	HAR-5216b: 4470±100BP	II

Table 5: Grouping of Briar Hill radiocarbon results by Walker *et al* (1991)

Group	Radiocarbon results	Bamford (1985) phasing
Saxon sunken-featured buildings	HAR-2283: 1700±60BP	equivalent to Phase XIII
cremation cemetery	HAR-4058: 3700±150BP HAR-4065: 3180±70BP	equivalent to Phase X
interior of site	HAR-2607: 4010±90BP HAR-2625: 4290±80BP HAR-4057: 4250±70BP HAR-4066: 4080±70BP HAR-4074: 4370±80BP	equivalent to Phase VIII
intermediate dates	HAR-4110: 3410±100BP HAR-5125: 3900±90BP HAR-5271: 4780±120BP	equivalent to Phase III/IV; authors note that only HAR-5271 meets expectations
3. later Neolithic pits	HAR-2284: 3460±120BP HAR-2389: 3540±90BP HAR-4067: 3730±70BP HAR-4073: 3790±100BP HAR-4089: 3620±90BP	equivalent to Phase IX
2. ‘final recut’ of enclosure	HAR-3208: 4600±90BP HAR-4071: 4610±90BP HAR-4075: 4660±70BP HAR-5217: 4420±90BP	equivalent to Phase VII, without HAR-4092
1. primary phase	HAR-2282: 5440±110BP HAR-4072: 5680±70BP HAR-4092: 5540±140BP HAR-5216: 4365±85BP	equivalent to Phase II, with the addition of HAR-4092; authors note that HAR-5216 does not belong here

Table 6: Briar Hill radiocarbon samples submitted but apparently not processed

Sample	Submitted	Provenance	Comments
P76 B6 014 (AML 794873)	to AML Oct 79; to Harwell 29.09.80	feature 135, interior pit, possibly Neolithic	samples evidently too small to process by liquid scintillation 'Shelved – awaiting further instructions' on 16.07.81; 'Samples believed to have been dated, no details of result' (nd)
P76 A7 195 (AML 794864)	to AML Oct 79; to Harwell 29.09.80	middle fill, third phase of four, segment 124, main inner ditch	
P76 D7 095 no AML code	to AML Oct 79	primary fill, second phase of four, segment 165, inner 'spiral' ditch	probably never sent to Harwell
P76 D5 064 (AML 812932)	to Harwell Aug 81?	upper fill of central slot of a post pit (?) in a gap (entrance?), inner 'spiral' ditch extension; well-defined layer with burnt stone and charcoal	exact provenance not specified; described as 'very small' samples, but said to include large pieces of charcoal
P76 D7 125 (AML 812931)	to Harwell Aug 81?	fill of primary cut (of 2) in a pit at north end of 'spiral' ditch; from well-defined layer of discoloured sand with fragments of burnt stone	
P76 C2 092 (AML 812927)	to Harwell Aug 81?	primary fill of penultimate cut of ≥ 4, a segment of outer ditch; from well-defined sandy layer with patches of discoloured 'ashy' sand	
P76 C2 061 (AML 812926)	to Harwell Aug 81?	secondary fill of final recut of same segment as P76 C2 092; charcoal from 2 spots 1m apart in rubble, not from distinct ashy deposit; above P76 C2 092	

Figure 1: Briar Hill radiocarbon results, uncalibrated, showing 2σ range (outline) and 1σ range (solid) . Replicate results have been combined (Ward and Wilson 1978). Wood-age offsets have not been applied

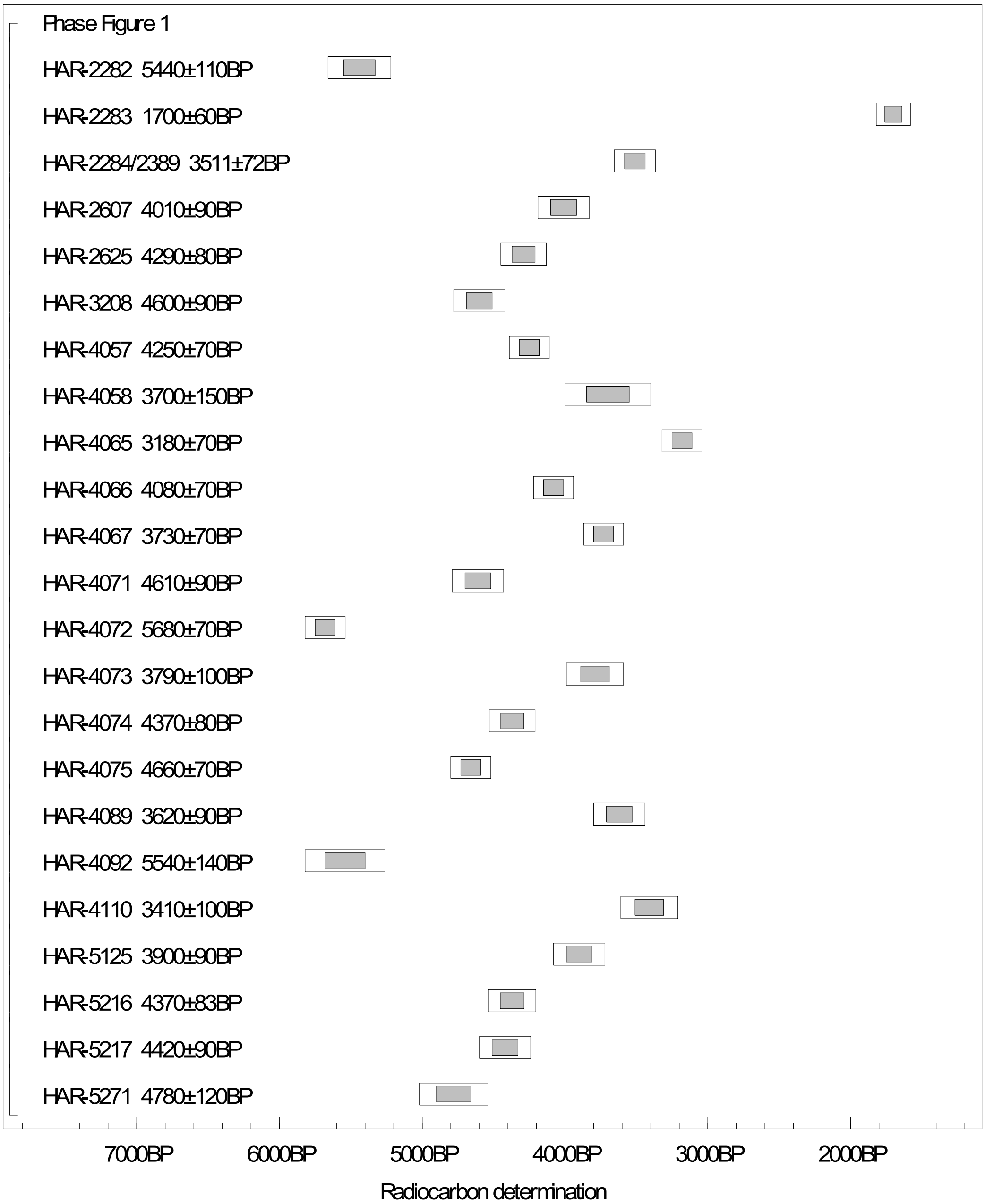

Figure 2: Calibration of all Briar Hill radiocarbon results by maximum intercept method (Stuiver and Reimer 1986). Outline: 95.4% confidence interval. Solid: 68.2% confidence interval. Replicate results have combined (Ward and Wilson 1978). Wood-age offsets have not been applied

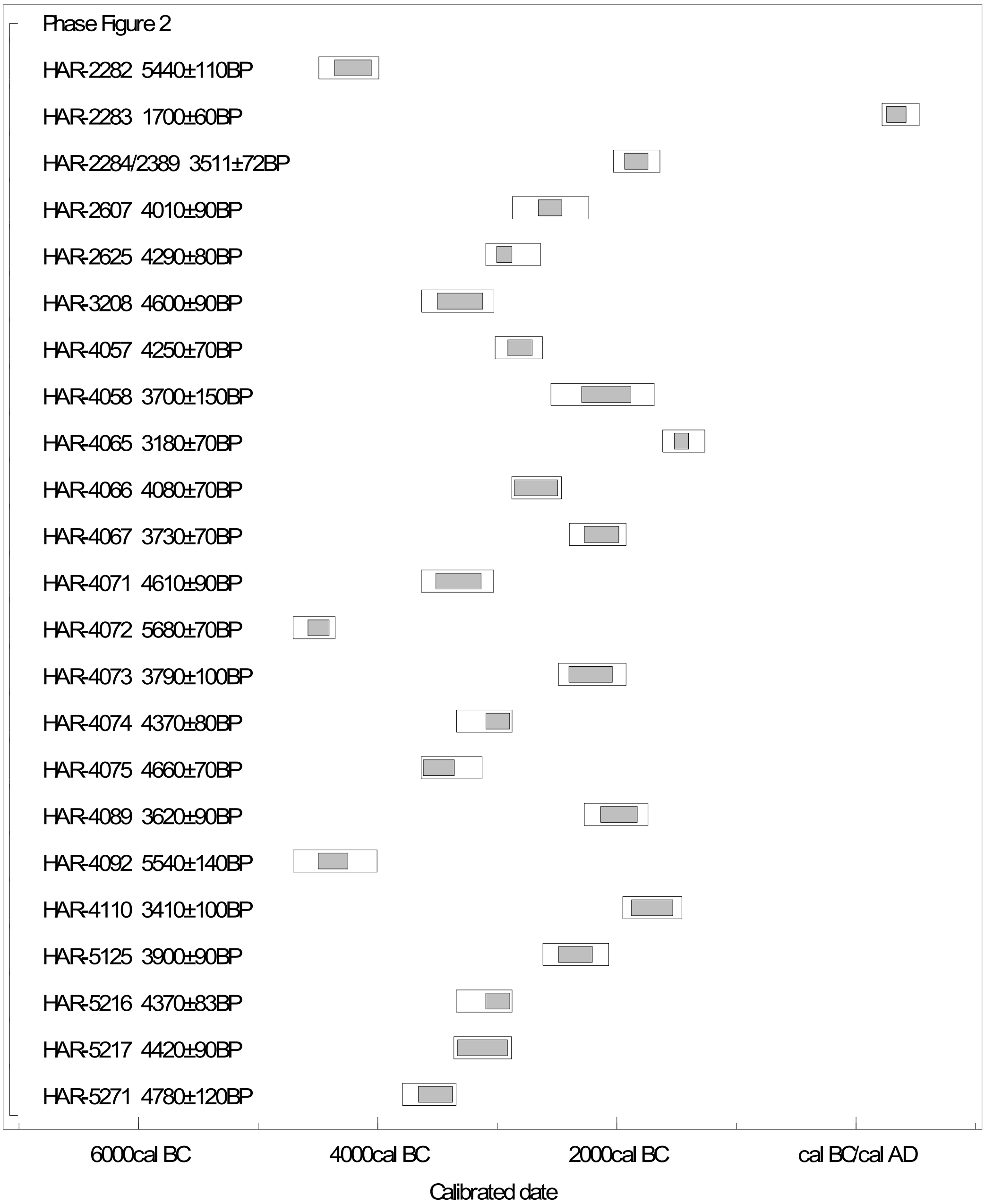

Figure 3: Calibration of all Briar Hill radiocarbon dates, by the probability method (Stuiver and Reimer 1993). No wood-age offsets applied

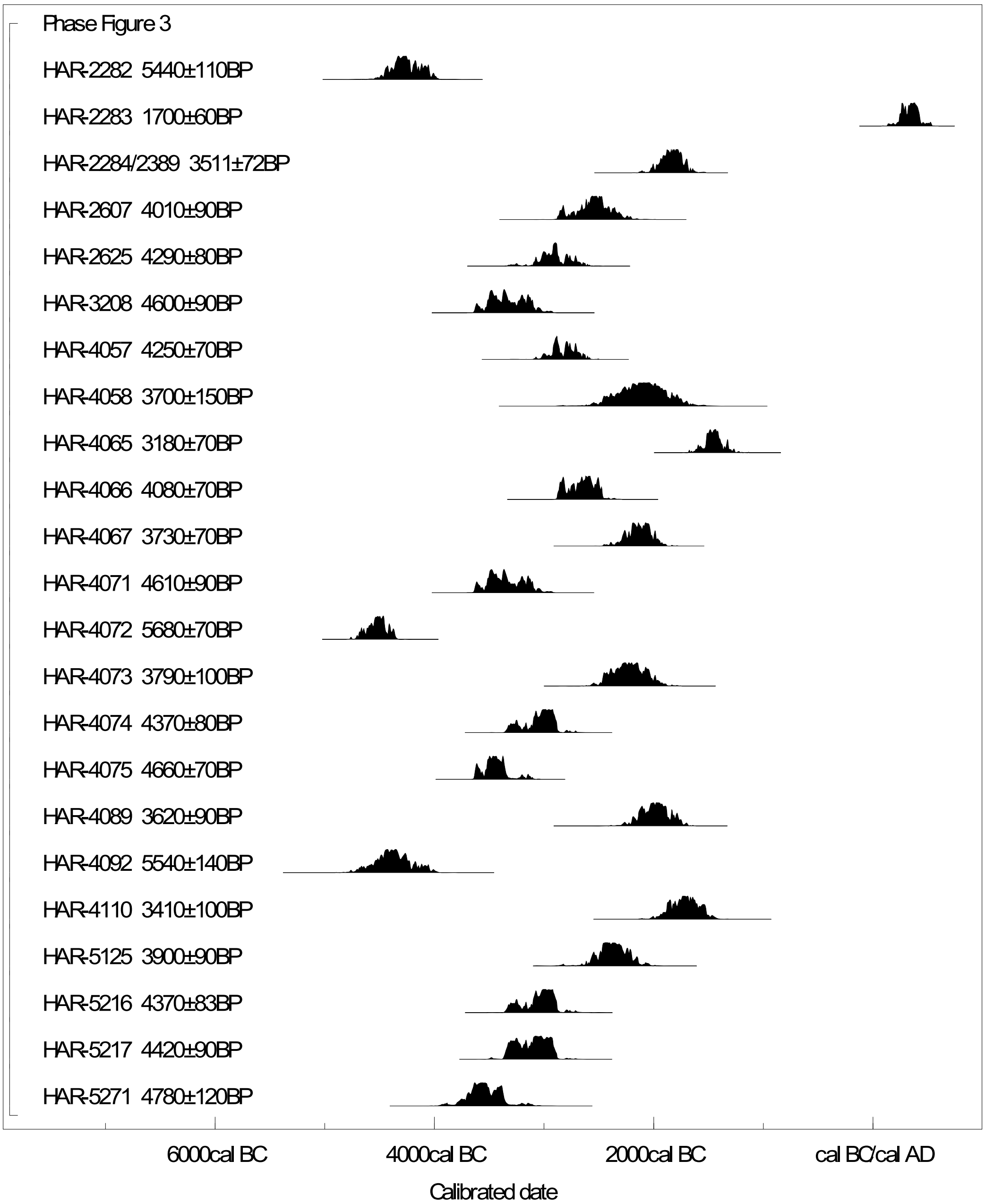

Figure 4: Calibration of all Briar Hill radiocarbon results by the probability method (Stuiver and Reimer 1993), with wood-age offsets applied (Rosaceae only: 40±20 years; oak only: 200±100 years; mixed, alder/hazel: 100±50 years)

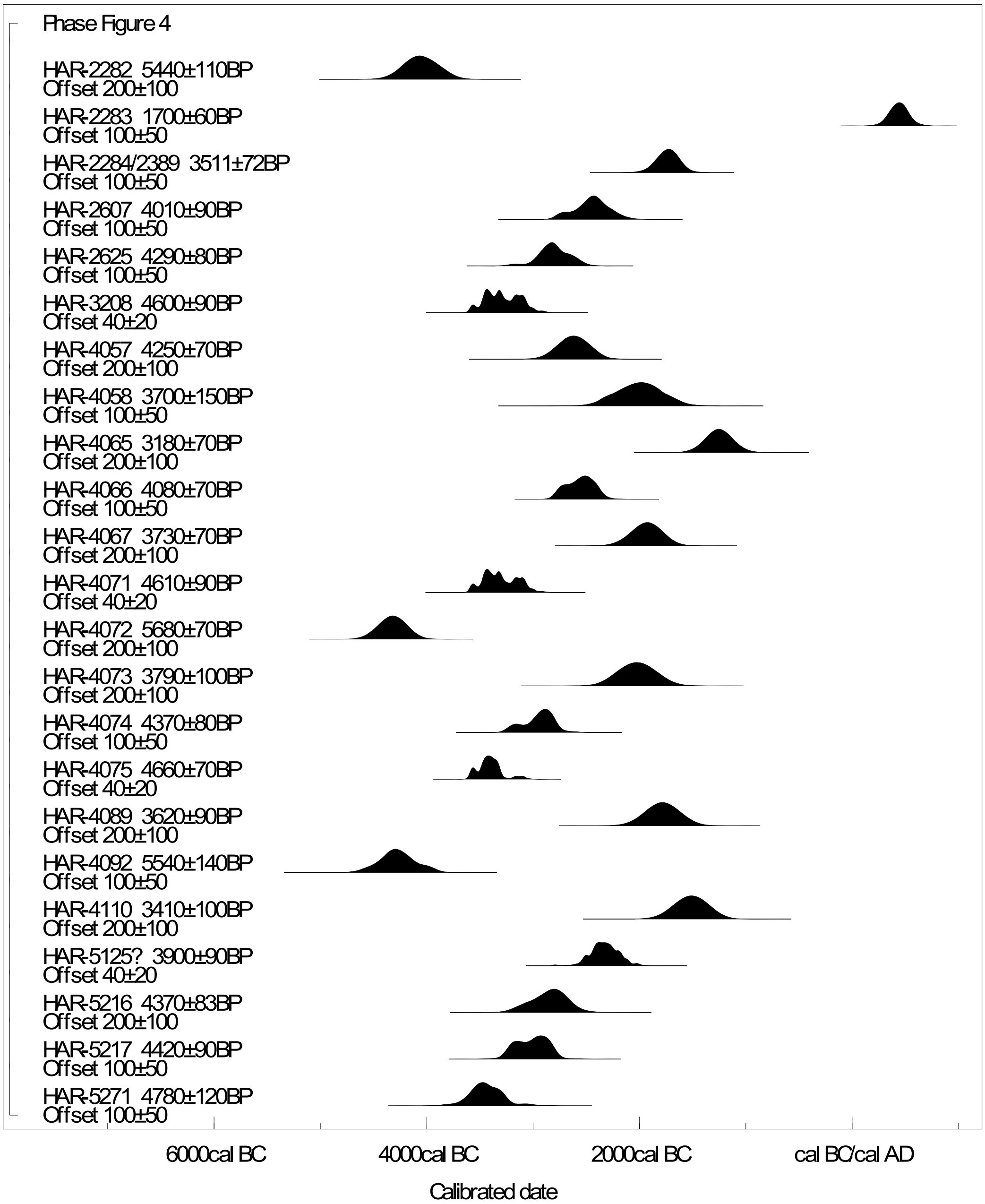

Figure 5: Calibration of radiocarbon results from Neolithic contexts at Briar Hill, arranged according to Bamford's (1985, fig 5) phasing. Wood-age offsets applied and replicate results combined. This model, defined by the OxCal keywords and square brackets, is not mathematically possible, and no index of agreement can be calculated

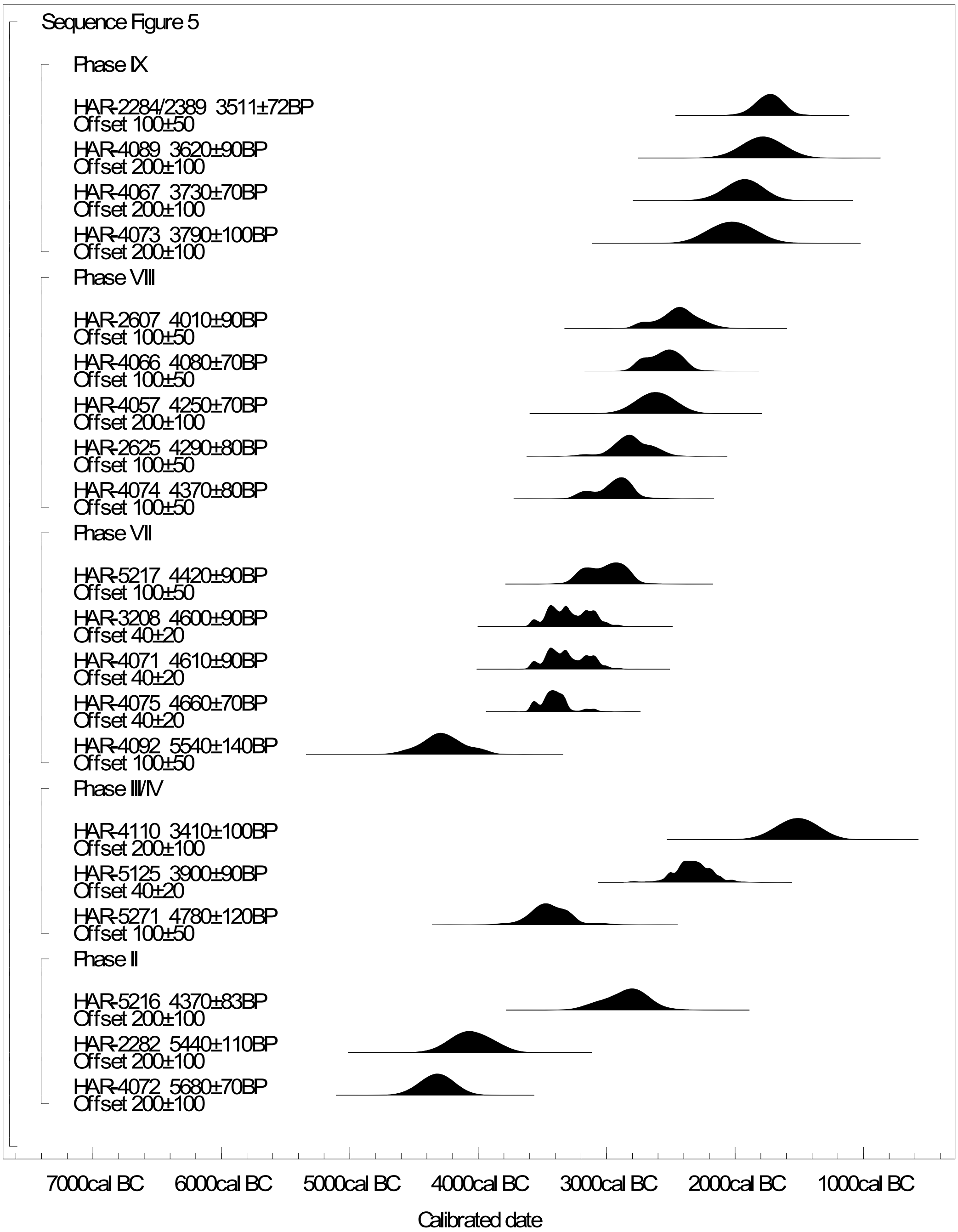

Figure 6: Briar Hill Neolithic chronology, according to Bamford (1985, figs 5 and 21), with appropriate wood-age offsets (Fig 4). The model structure is defined by the square brackets and OxCal keywords. Two distributions are plotted for each radiocarbon date: the prior probability distribution, obtained by simple calibration, in outline, and the 'posterior density estimate' calculated by the model (solid). Results denoted by '?' were rejected by the excavator and are excluded from the analysis. The overall index of agreement (A) is high, reflecting the fact that Bamford's phases were based in part on the radiocarbon results

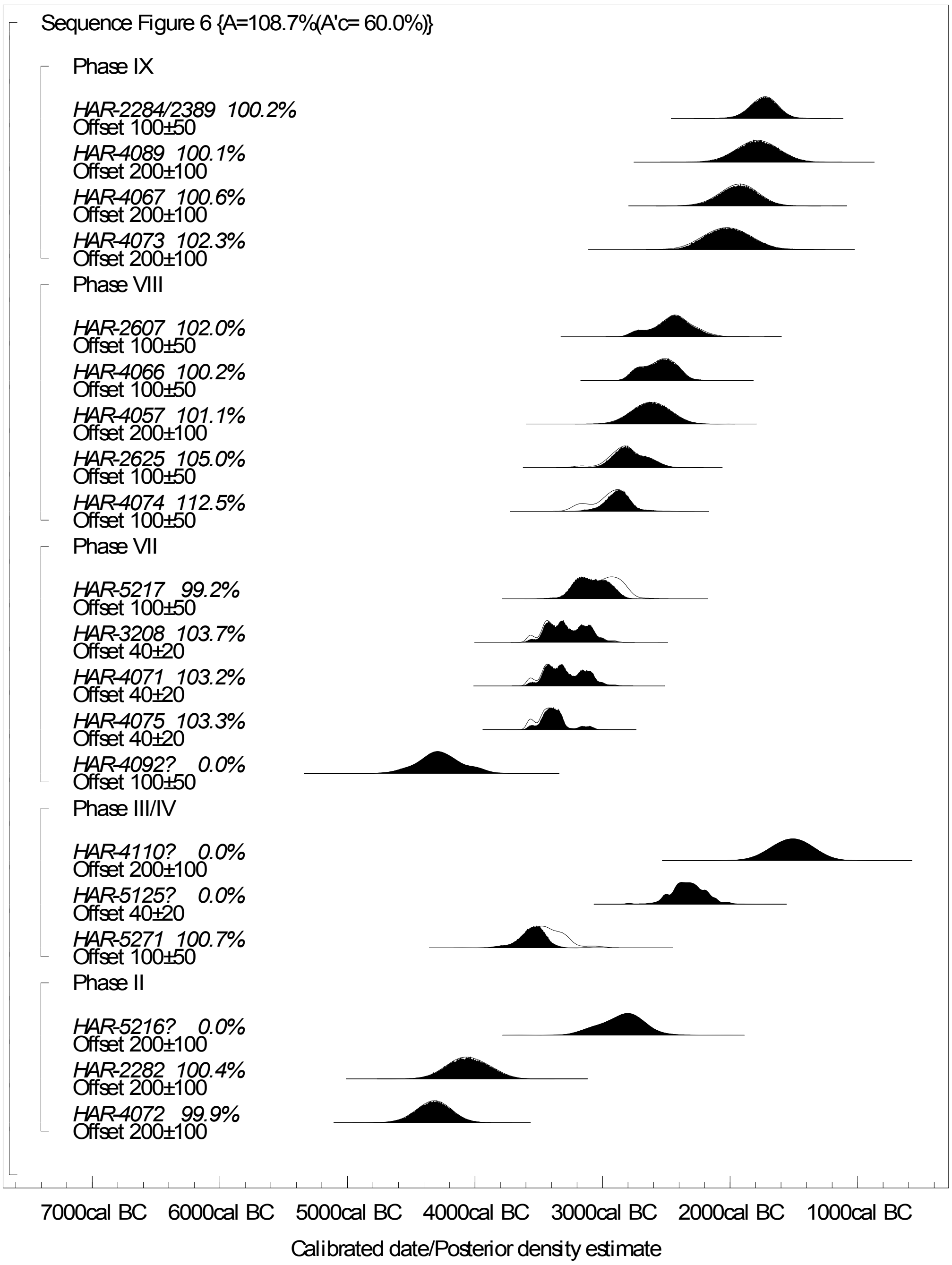

Figure 7: Calibrated Neolithic results, with wood-age offsets, arranged according to Kinnes' and Thorpe's (1986, fig 3) scheme, with replicate results combined and wood-age offsets applied. The OxCal keywords and square brackets define the structure of the notional model. As anticipated by Kinnes and Thorpe, this sequence is mathematically impossible, and no index of agreement can be calculated

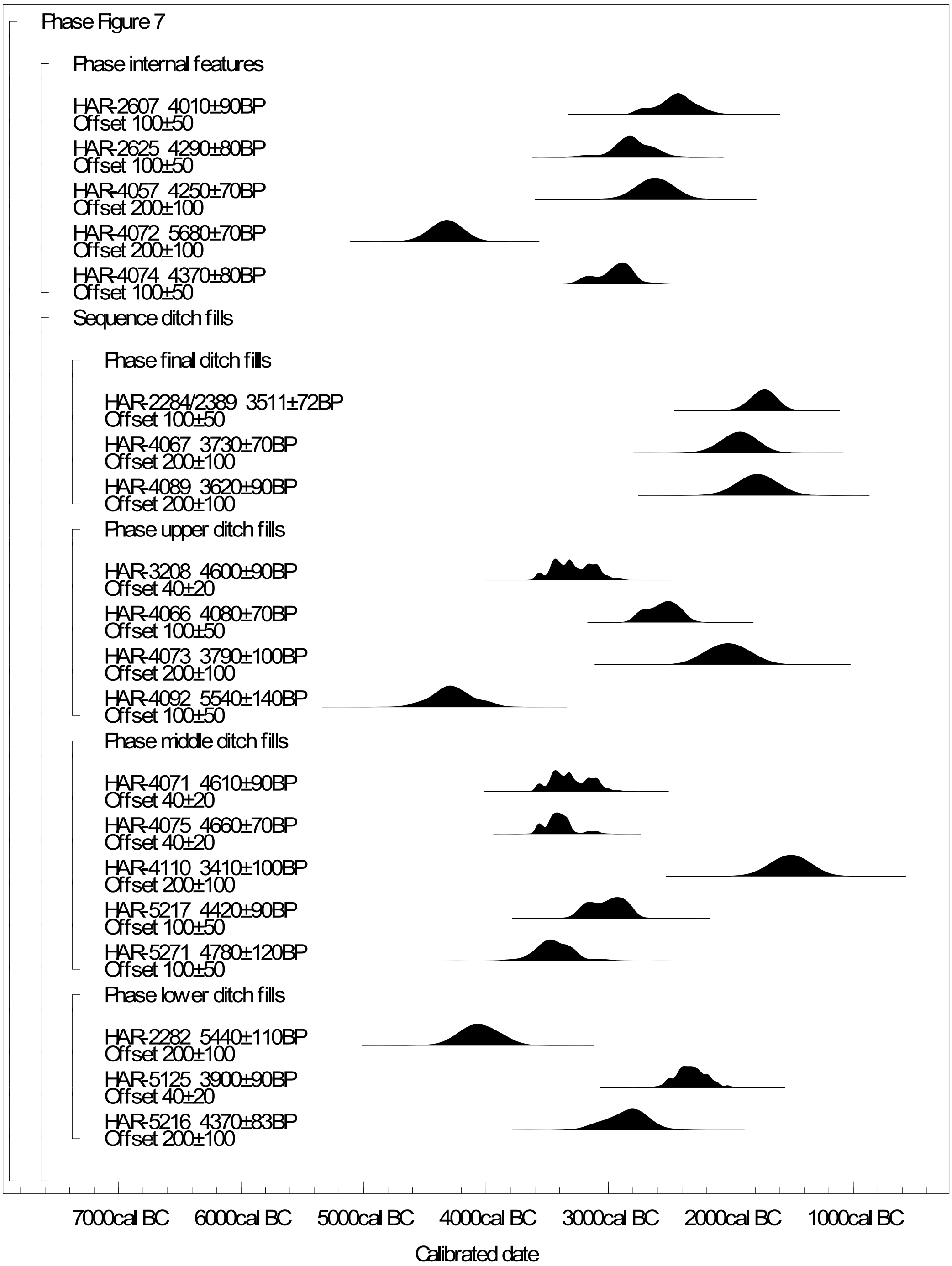

Figure 8: Preferred model of Briar Hill Neolithic chronology, if the very early samples from the outer ditch circuit are not residual. Appropriate wood-age offsets are applied. The model structure is defined by the square brackets and OxCal keywords. Two distributions are plotted for each radiocarbon date: the prior probability distribution, obtained by simple calibration, in outline, and the 'posterior density estimate' calculated by the model (solid). Dates denoted by '?' are excluded from the analysis. The distributions 'construction' and 'abandonment' are calculated by OxCal, based on the model's structure and the radiocarbon results used in the analysis

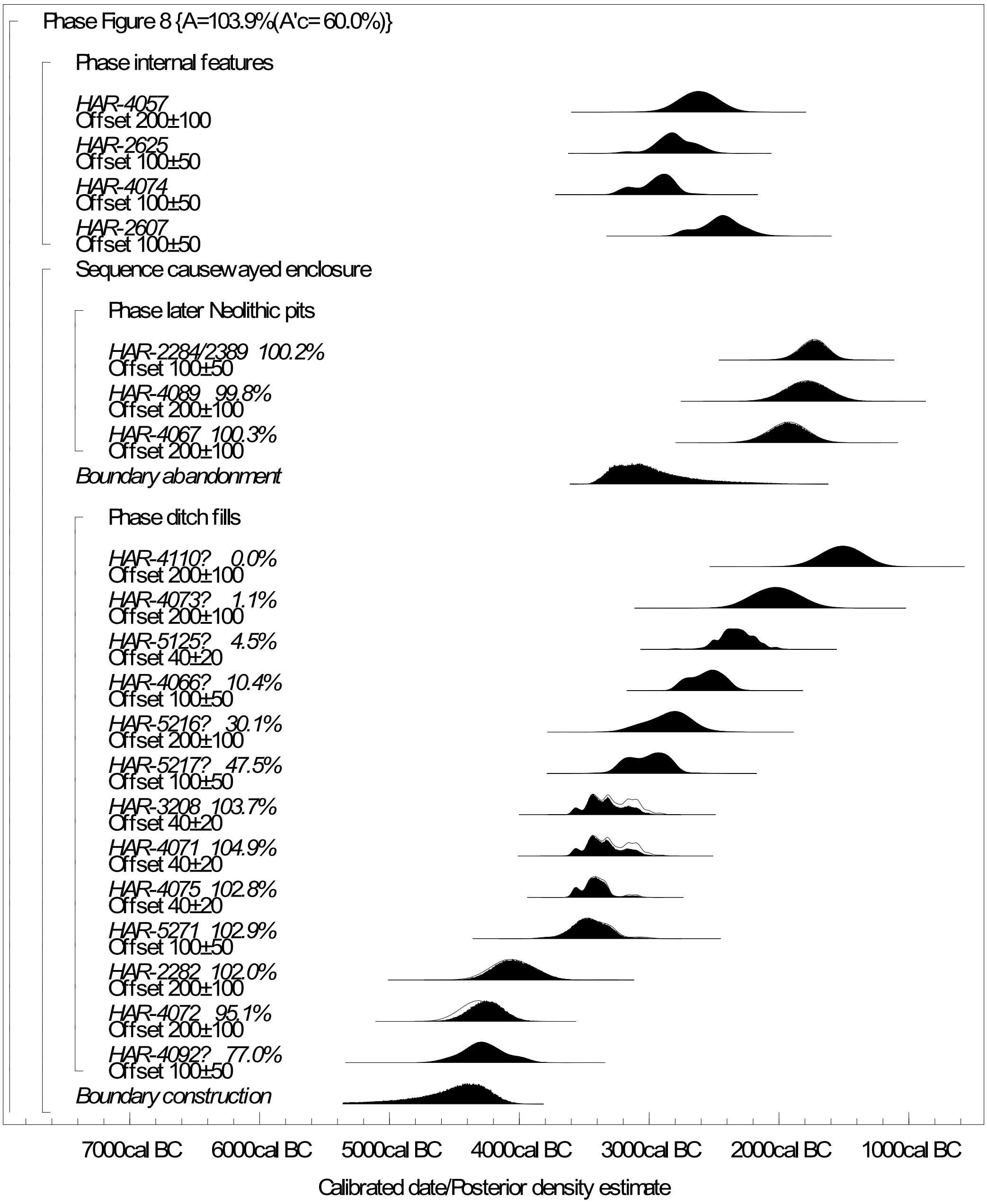

Figure 9: Preferred model of Briar Hill Neolithic chronology (Fig 8), in which the very early dates from the outer ditch circuit are excluded from the analysis

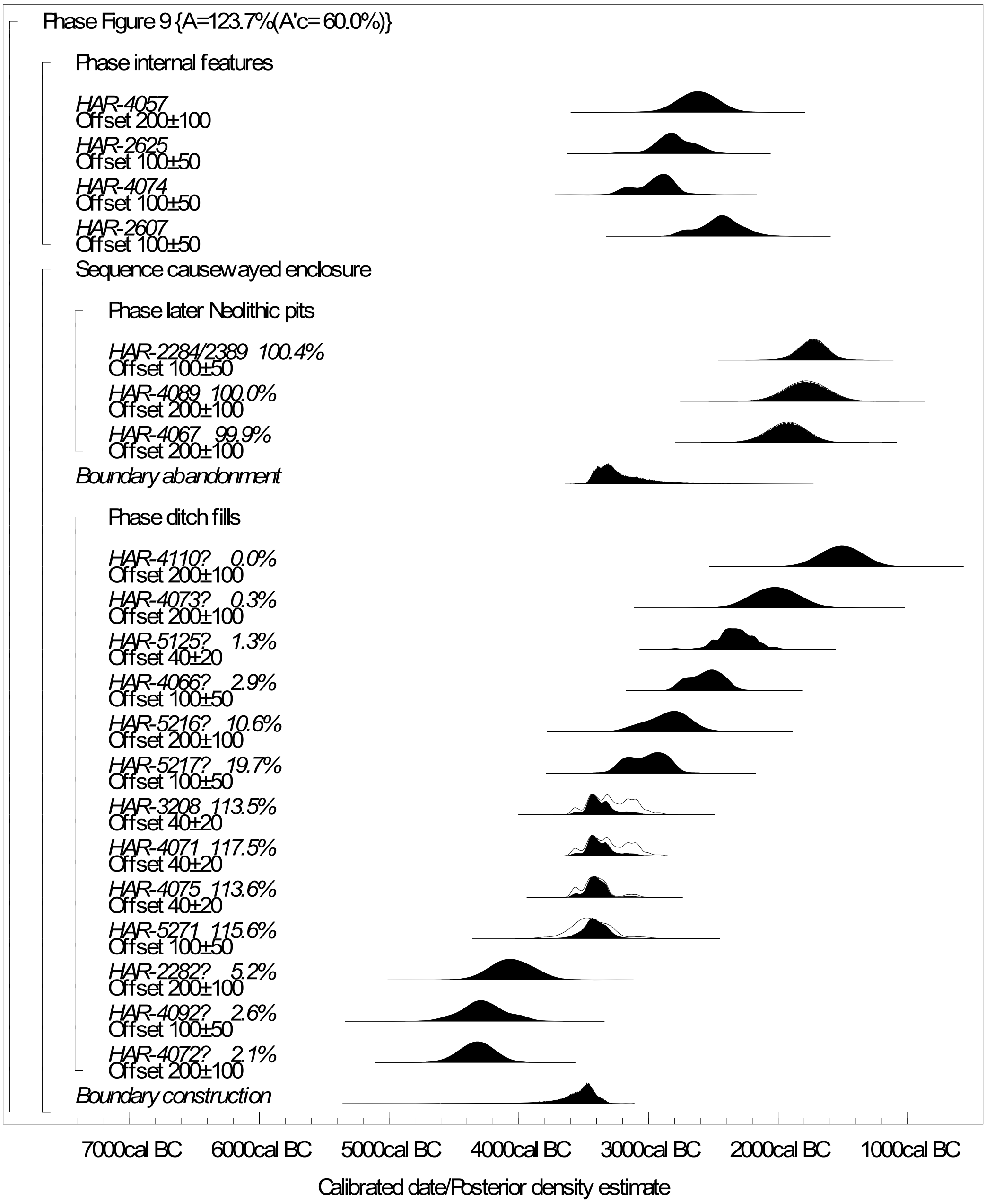

Figure 10: Preferred model of Briar Hill Neolithic chronology (Fig 8), in which the very early results from the outer ditch circuit are regarded as *termini post quem* for the construction of the enclosure