Chapter 9: Radiocarbon dating

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INTRODUCTION

OA commissioned 11 accelerator mass spectrometry (AMS) radiocarbon dates on material derived from contexts examined in the mitigation phase of the M1 widening project. Ten results were produced initially, with an 11th to examine the stratigraphic integrity of one result. The radiocarbon results were produced on charred plant macrofossils from pits containing Mesolithic lithic assemblages (at Junction 9) and on cremated human skeletal remains, and a charred cereal grain of intrinsic archaeobotanical interest. These dates and the sample details are listed in Table 9.1 and the results summarised in Fig. 9.1. The objectives of the dating programme were:

- to establish the period of activity associated with the Mesolithic lithic assemblages/pit use;
- to establish the period of the cremation burial traditions at Junction 8S;
- to estimate the age of the spelt wheat <2017> in pit 2064 at Junction 9.

SAMPLING

Material from the pits excavated during the project was selected for dating by OA, to investigate the chronology of the features and microlith technology. Mesolithic-period negative features are rare (Allen and Gardiner 2002), particularly those with demonstrable Mesolithic material culture (eg Allen and Green 1998), and traditions of Neolithic pit digging and infilling have been suggested to have had their origins in Mesolithic deposition in tree-throw holes (Lamdin-Whymark 2008). Furthermore, material from Neolithic features has been suggested to indicate storage in 'pre-pit' deposits (cf Garrow 2006), such as middens (eg Allen *et al*. 2004). While no examples of Mesolithic pre-pit contexts have been mooted for the M1, the material from the pits could be older than the archaeological phase of pit digging; there is no functional relationship between the dated material and the features from which they were recovered (cf Waterbolk 1971). Strictly speaking the results from these features form *termini post quos* for the infilling of the pits and deposition of the material.

After the production of the initial ten radiocarbon results, a series of simulated radiocarbon results (using the R_Simulate parameter in OxCal v4.1) was produced for the Mesolithic-period activity. These models (e.g. Fig. 9.2) employed errors based on the materials analysed and measurement technique (eg single/multiple run AMS). The modelling illustrated the location of the existing and simulated radiocarbon assemblage on a plateau in the 52nd century cal BC. Given the available informative archaeological model, further

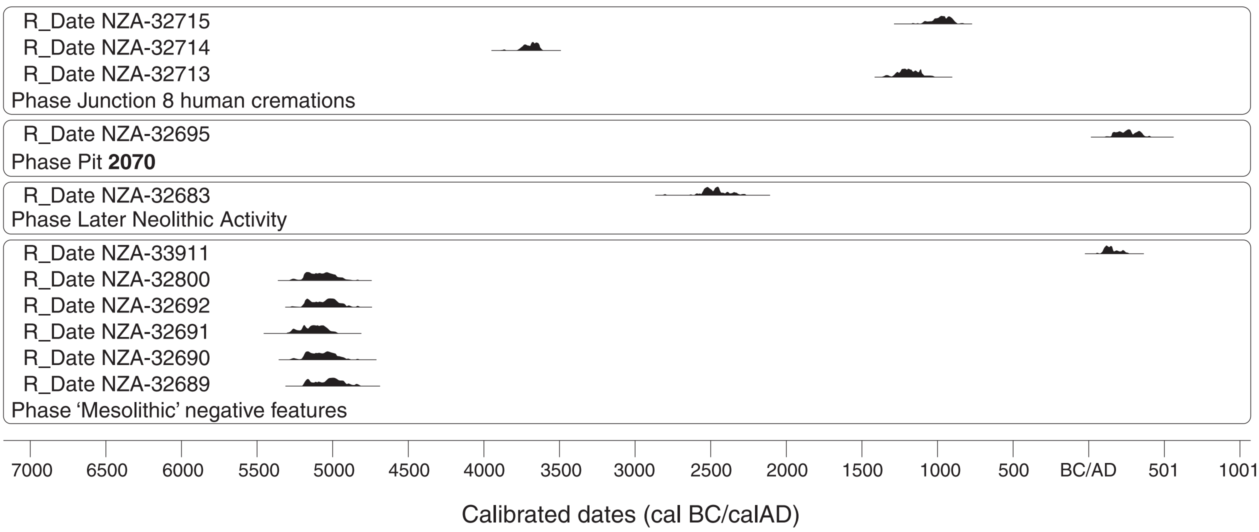

Fig. 9.1 Probability distributions from the M1

Table 9.1: Radiocarbon data

Laboratory code	*Context and sample*	*Material*	*Description*	*δ13C*	*Radiocarbon age BP*	*Calibrated date range*	*Preferred posterior density estimate (cal BC; 95.4% probable).*
NZA-32683	MOW05 <2004> (2051)	Charred *Corylus avellana* nutshell	Fill of pit 2052. No functional association with deposit – *terminus post quem* for infilling of pit, and deposition of broad flint flakes, and burnt flint	-22.1 ‰	3976 ± 50	2620-2340 cal BC (95.4% confidence; 2570-2460 cal BC, 68.2% confidence)	
NZA-32689	MOW05 <2008> (2195)	Charred *Corylus avellana* nutshell	Fill of gully 2196. No functional association with deposit – *terminus post quem* for infilling of pit, and deposition of small charcoal and small scalene triangle assemblage	-27 ‰	6108 ± 55	5220-4850 cal BC (95.4% confidence; 5210-4940 cal BC, 68.2% confidence)	5220-4960 cal BC
NZA-32690	MOW05 <2011> (2093)	Charred *Corylus avellana* nutshell	Fill of pit 2094. No functional association with deposit – *terminus post quem* for infilling of pit, deposition of a scalene microlith, hazel nutshell and indeterminate cereal grains	-26.7 ‰	6142 ± 55	5230-4980 cal BC (95.4% confidence; 5210-4990 cal BC, 68.2% confidence)	5220-4990 cal BC
NZA-32691	MOW05 <2012> (2095)	Charred *Corylus avellana* nutshell	Fill of pit 2096. No functional association with deposit – *terminus post quem* for infilling of pit, deposition of hazel nutshell, indeterminate cereal grains and 56 worked flints	-26.4 ‰	6201 ± 50	5310-5000 cal BC (95.4% confidence; 5230-5060 cal BC, 68.2% confidence)	5230-5000 cal BC
NZA-32800	MOW05 <2017> (2063)	Charred *Triticum spelta* grain	Fill of pit 2064. No functional association with deposit – *terminus post quem* for infilling of pit. This measurement was supposedly produced on a charred cereal grain. It is probable that material for NZA-32800 was mixed up with charred hazel nutshell at some point in the sample selection (see NZA-33911). 6th millennium BC spelt is not proved at the site	-18.6 ‰	6147 ± 55	5290-4940 cal BC (95.4% confidence; 5220-5000 cal BC, 68.2% confidence)	5230-4930 cal BC (94.5% probable; 5290-5270 cal BC, 0.9% probable)
NZA-33911	MOW 05 <2017> (2063)	Charred *Triticum* sp. glume base	Fill of pit 2064. No functional association with deposit – *terminus post quem* for infilling of pit. To investigate NZA-32800, NZA-33911 was commissioned. On the basis of NZA-33911 it is suggested charred hazel nutshell associated with Mesolithic activity was accidentally dated, rather than the cereal grain recorded on the sample submission form	-24.2 ‰	1883 ± 30	Cal AD 50-230 (95.4% confidence; cal AD 70-140 68.2% confidence)	
NZA-32695	MOW05 <2014> (2069)	Charred seeds	Fill of pit 2070. No functional association with deposit – *terminus post quem* for infilling of pit	-22.5 ‰	1789 ± 45	Cal AD 120-380 (95.4% confidence; cal AD 130-330, 68.2% confidence)	
NZA-32692	MOW05 <2041> (2317)	Charred *Corylus avellana* nutshell	Fill of pit 2316. No functional association with deposit – *terminus post quem* for infilling of pit, deposition of charred hazel nutshell, possible	-25.1 ‰	6125 ± 50	5210-4930 cal BC (95.4% confidence; 5200-4990 cal BC, 68.2% confidence)	5220-4980 cal BC

Table 9.1: Radiocarbon data – continued

Laboratory code	*Context and sample*	*Material*	*Description*	*δ13C*	*Radiocarbon age BP*	*Calibrated date range*	*Preferred posterior density estimate (cal BC; 95.4% probable).*
			grains of spelt wheat, indeterminate wheat seeds, and a scalene microtriangle				
NZA-32713	MOW05 <2052> (5067)	Cremated human bone	Dates death of individual	-22.1 ‰	2979 ± 35	1370-1090 cal BC (95.4% confidence; 1260-1130 cal BC, 68.2% confidence)	
NZA-32714	MOW05 <2053> (5082)	Cremated animal bone	Dates death of individual	-27.6 ‰	4931 ± 40	3800-3640 cal BC (95.4% confidence; 3760-3650 cal BC, 68.2% confidence)	
NZA-32715	MOW05 <2073> (5245)	Cremated human bone	Dates death of individual	-21.1 ‰	2836 ± 40	1130-900 cal BC (95.4% confidence; 1050-920 cal BC, 68.2% confidence)	

results would provide no significant improvement in precision.

RESULTS

The samples were pre-treated with acid-base-acid (cf http://www.rafterradiocarbon.co.nz/samprep.htm.). The calibrated ranges are shown in Fig. 9.1 and are cited in accordance with the international standard known as the Trondheim convention (Stuiver and Kra 1986). They are conventional radiocarbon ages (Stuiver and Polach 1977).

Calibrations

The calibrated results were produced using the Reimer *et al.* (2004) curve and the computer program OxCal (v4.1 build 44; Bronk Ramsey 1995; 1998; 2001). Ranges are quoted in accordance with the Mook (1986) protocol, with end points rounded out to ten years if the error term is greater than or equal to 25 radiocarbon years, or to five years if the error term is less than 25 years. Ranges in italics are *posterior density estimates* produced from the Bayesian statistical model (see below). Ranges in plain text are maximum intercepts (cf Stuiver and Reimer 1986).

The calibrated probabilities are presented graphically. The graphs have been generated using the error terms estimated by the laboratory for the uncertainty associated with all aspects of age calculation, and the shape of the calibration curve. In themselves, these probability estimates are the radiocarbon results; there is no a priori reason why any part of the date ranges of these graphs should be more or less probable. It is possible to refine the data with reference to explicit archaeological prior beliefs, as part of a Bayesian statistical model. The resultant posterior density estimates are refinements of the probability distributions expressing archaeological interpretation and not absolute dates.

Bayesian modelling

Chronometric data are not absolute, not least because all results are accompanied by an error term derived from the uncertainties in measurement. Within the result range, there is a point in time when the event, which is measured chronometrically, occurred. For example, all other things being equal, the result measured on a bone is the date when the animal died. The date measured on a cereal grain is the point in time the grain was removed from the plant. There can be a time lag between the measurement and the archaeological event in question; therefore a result produced on residual material within a context, will not date the context. Bayesian modelling of chronometric data relies on the archaeological interpretation of the association between dated event and archaeological event. This interpretation derives from the

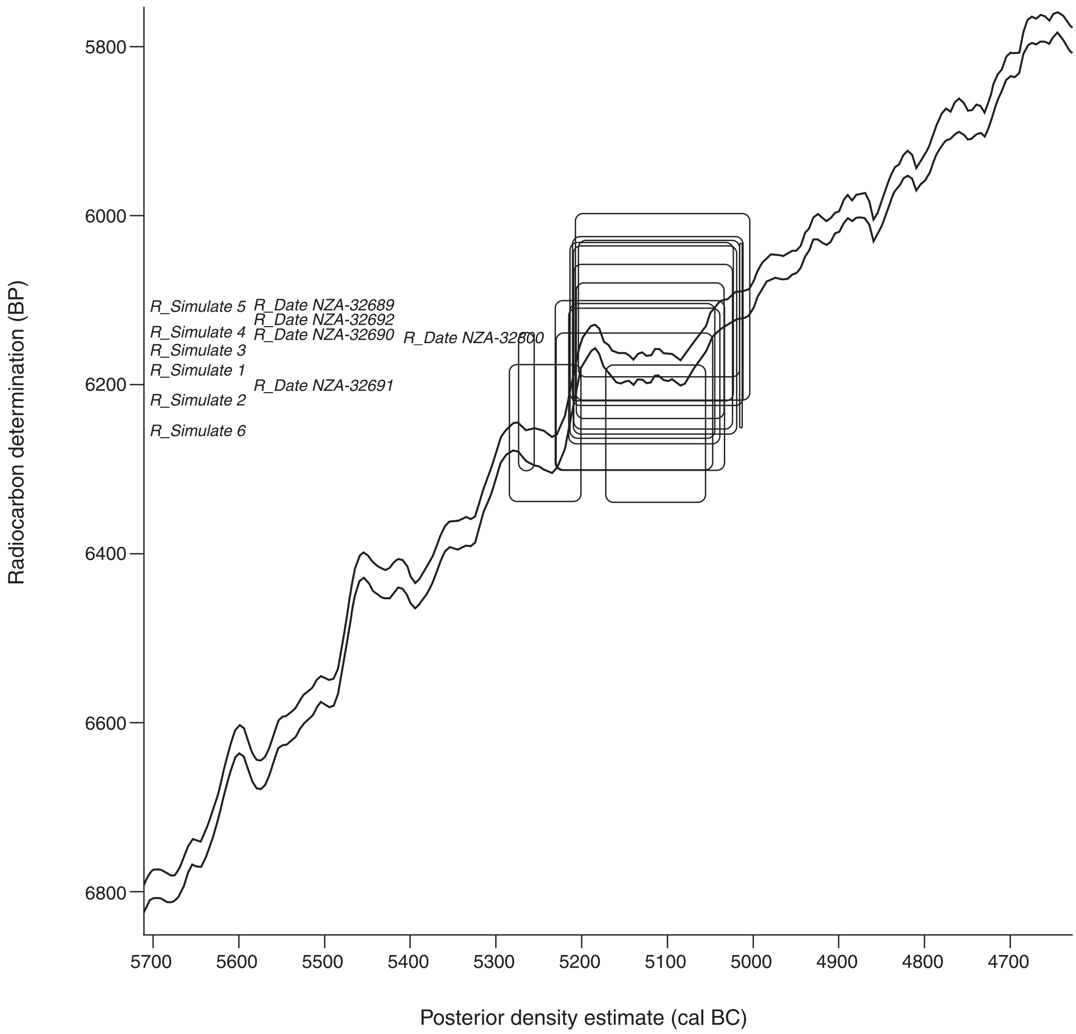

Fig. 9.2 Probability distributions from the M1 and predictive modelling of six simulated 'Mesolithic' radiocarbon results

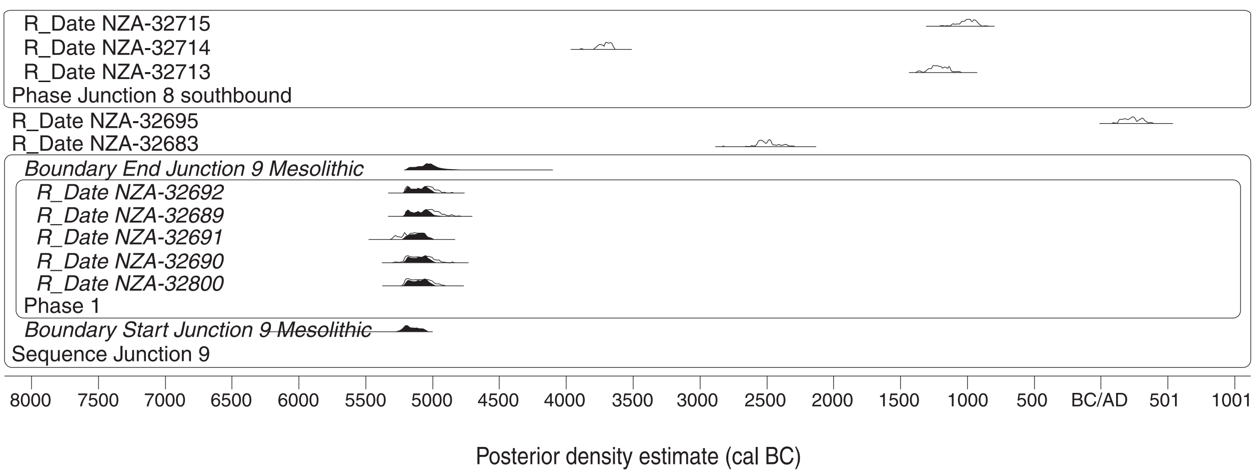

Fig. 9.3 Probability distributions of dates from the site model A

nature of dated material, taphonomy and deposit formation, and stratigraphic relationships, including the inferred relationships which constitute an archaeological phase. The seemingly neutral assumption of an archaeological phase can have important implications for the precision of chronometric data (if data are related as part of an archaeological event or phase, they are not independent estimates of this phase or event) and their probability estimates are related. Importantly, the statistical scatter generated from an assemblage of chronometric data (all the independent error term data) will be an artefact of the radiocarbon measurement process rather than the archaeological activity. Without accounting for statistical scatter, false imprecision will make archaeological events appear to start earlier, end later, and go on for longer than was really the case (Bayliss *et al.* 2007). OxCal v4.1, and other Bayesian programs, provide explicit, quantifiable, probabilistic methods of relating data, refining precision and estimating other chronometric aspects of archaeological interest.

The Bayesian modelling presented uses Markov Chain Monte Carlo sampling, applied in OxCal v4.1, details of which can be found on the online manual (http://c14.arch.ox.ac.uk/; Bronk Ramsey 1995; 1998; 2001). The consistency of the results has been tested, as outlined by Ward and Wilson (1978). The structure of the model described below is shown in Fig. 9.3.

The samples and their stratigraphic relationships

Mesolithic negative features

Six radiocarbon results were produced on material recovered from pits excavated at Junction 9. At this site were a cluster of pits, and four gullies. From many of the pits were recovered lithics and limited amounts of pottery and charred plant remains. Only 13 of the features contained diagnostic lithics; ten pits contained Mesolithic assemblages and three contained Neolithic assemblages.

A few of these features were interpreted as post-pits, because of the recognition of post-pipes (in features 2070, 2080 and 2182 and possibly in 2078, 2337, 2110 and 2148). Most of the pits were interpreted as deliberately backfilled in a single event. Despite the evidence for some post-pipes, no coherent structures were identified, though the activity at the site was considered as relating to occupation in the loosest sense.

The seven pits (2064, 2090, 2094, 2096, 2100, 2110 and 2316) from which Mesolithic material culture was recovered were located within the main concentration of pits (see Fig. 5.4). Some of the features contained fragmentary pottery and cereal grains. It is thought that these are intrusive, rather than that all the material had been redeposited. Possible mechanisms for this intrusion could include root action (see below).

Pit 2094

A single result (NZA-32690; 5230-4930 cal BC, 95.4% confidence; or 5210-4990 cal BC, 68.2% confidence) was produced on charred hazel nutshell from 2094. The feature contained hazel nutshell, modern root fragments, and a few indeterminate cereal grains. A scalene microlith, of Jacobi's (1978) type 7a2, was recovered from context 2093.

Pit 2316

A single result (NZA-32692; 5220-4930 cal BC, 95.4% confidence; or 5210-4990 cal BC, 68.2% confidence) was produced on charred hazel nutshell from pit 2316. The pit contained a few possible grains of spelt wheat, and indeterminate wheat seeds, as well as a type 7a2 (ibid.) scalene microtriangle.

Pit 2096

A single result (NZA-32691; 5310-5000 cal BC, 95.4% confidence; or 5230-5060 cal BC, 68.2% confidence) was generated on charred hazel nutshell from pit 2096. The feature contained hazel nutshell and indeterminate cereal grains. Worked flints (56 in total) including blades and narrow flakes were recovered from the feature.

Gully 2196

From gully 2196 a single result (NZA-32689; 5220-4850 cal BC, 95.4% confidence; or 5210-4940 cal BC, 68.2% confidence) was produced on hazel nutshell. The gully contained a small charcoal assemblage and a small type 7a2 (ibid.) scalene triangle.

Pit 2064

Two results were produced from pit 2064 (NZA-32800 and NZA-33911). These results are both recorded to have been produced on spelt wheat macrofossil fragments. The first result (NZA-32800), supposedly produced on a charred wheat seed, dated to 5290-4940 cal BC (95.4% confidence; or 5220-5000 cal BC, 68.2% confidence). A 6th millennium BC radiocarbon result on domesticated cereals would be nationally important, broadly contemporaneous with *Linearbandkeramik* activity on the Continent. Further, this feature contained a lightly burnt type 5c (ibid.) scalene triangle. Other charred plant remains included indeterminate wheat glume bases, and hazel nutshells. To investigate this, another result was commissioned on an indeterminate wheat glume base from the same sample as the original spelt grain (NZA-33911). This produced the range cal AD 50-230 (95.4% confidence; or cal AD 70-140, 68.2% confidence).

On this basis it is suggested that a charred hazel nutshell associated with Mesolithic activity on the site was accidentally dated, rather than the cereal grain recorded on the sample submission form. The presence of 6th millennium spelt on the site is discounted. Result NZA-32800 is poorly understood.

Later Neolithic and later activity

Within the main concentration of pits, pit 2052 contained broad flint flakes and burnt flint. It was assessed as late Neolithic on the basis of this material, and a radiocarbon result (NZA-32683) produced on hazel nutshell provides a *terminus post quem* for its infilling of 2630-2320 cal BC (95.4% confidence; or 2560-2410 cal BC, 68.2% confidence).

Pit 2070

A single result (NZA-32695) on charred seeds produced a *terminus post quem* for the infilling of pit 2070 of cal AD 110-370 (95.4% confidence; or cal AD 160-310, 68.2% confidence). This result indicates later activity in the vicinity of the Mesolithic-period pits. NZA-32695 and NZA-33911 are statistically consistent (T′=3.0; T′5%=3.8; n=1; Ward and Wilson 1978), and could measure material derived from the same archaeological event. If this were so, it would be more appropriate to take a weighted mean prior to calibration. An estimate for such an event would be cal AD 80-240 (95.4% confidence; or cal AD 120-220, 68.2% confidence). The consistency of these Roman-period data suggests a background scatter of later activity in the area that was earlier a focus for Mesolithic people (rather than errors in measurement, or contamination resulting in NZA-32695 and NZA-33911).

Deposit formation and interpretation

It is assumed, as with the dated cereal example from pit 2064, that all other cereal grains from the Mesolithic pits are intrusive. Models resulting in the presence of intrusive material could include on-site sampling contamination, or unconsolidated matrixes (into which material from overlying activity might move). Mixing could have been augmented by disturbance from overlying occupation, as evidenced by activity in the vicinity and the dated material from posthole 2070.

Junction 8S

Human and animal cremations

Dates were obtained on three deposits of cremated bone; one of animal bone and two of human bone.

Cremated animal bone <2053> (5082) was dated to 3780-3640 cal BC (95.4% confidence; or 3760-3650 cal BC, 68.2% confidence; NZA-32714).

Cremated human bone <2052> (5067) was dated to 1380-1090 cal BC (95.4% confidence; or 1270-1130 cal BC, 68.2% confidence; NZA-32713).

Cremated human bone <2073> (5245) was dated to 1130-900 cal BC (95.4% confidence; or 1050-920 cal BC, 68.2% confidence; NZA-32715).

All the radiocarbon results on the cremated skeletal material from Junction 8S are statistically significantly different (T′=1913.7%; T′5%=6.0; n=2; NZA-32713, -NZA32714 and NZA-32715; Ward and Wilson 1978). Even the two later results (NZA-32713 and NZA-32715) are statistically significantly different (T′=7.2; T′5%=3.8; n=1; ibid.). The results indicate that cremation burials were deposited at Junction 8S over a very considerable period of time from the earlier Neolithic until the Bronze Age. It seems most probable that these data represent highly episodic, unrelated practices, which are structured within a landscape, at a location that was perhaps physically marked, maybe preserved in some form of memory work over many generations (cf Pollard 2008). It is possible that the two later results present a single phase of activity – a tradition of burial practice – with principles structuring post-mortem rites more closely related, but the density of radiocarbon dates is not sufficient to support such an interpretation.

DISCUSSION AND INTERPRETATION

Mesolithic activity

The five radiocarbon results associated with Mesolithic activity at Junction 9 (including NZA-32800, produced on uncertain material) are statistically consistent (T′=1,9; T′5%=9.5; n=4; Ward and Wilson 1978). Because the results were all on short-lived material they might measure the same point in time – that is to say, it is possible that they represent a very short-lived archaeological event of a duration less than the ten-year optimum precision of this part of the calibration curve. There is, however, limited archaeological evidence for such a single episode of activity and there is no evidence to relate activity associated with these features other than as a spatially defined broad archaeological phase.

The archaeological interpretation is further complicated by the presence of later Neolithic activity, and indeed much later Roman activity in the vicinity. It seems that some of the Romano-British material, including domesticated cereal grains, was later incorporated into earlier features. The presence of significant Mesolithic lithic assemblages, in numerous features, including cores, and waste material (see Chapter 7) suggests *in situ* Mesolithic activity including flint working. The similar, homogeneous pit fills provide further evidence of Mesolithic tools, hazel nutshells and fills generically *in situ.*

The material sampled by NZA-32800 is uncertain, though it is suggested to be hazel nutshell. If all the material thought to represent *in situ* Mesolithic activity (ie all the results thought to have been produced on hazel) represented the same archaeological event, it would be more appropriate to take a weighted mean prior to calibration. An estimate for this event would be *5210-5010 cal BC* (95.4% probable; or *5210-5100 cal BC*, 39.8% probable; or *5080-5030 cal BC*, 28.3% probable; T′=1.9; T′5%=9.5; n=4).

Another interpretation is that these data represent *in situ* Mesolithic activity of a longer, unknown, duration. An estimate for the start of this activity is

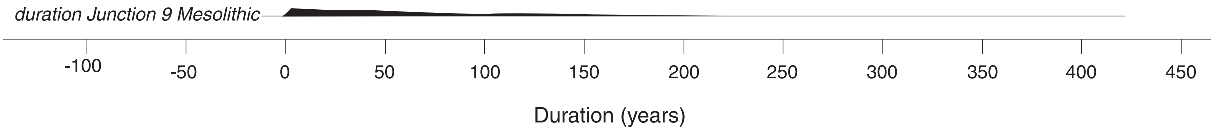

Fig. 9.4 Probability distribution for the duration of Mesolithic activity at the site

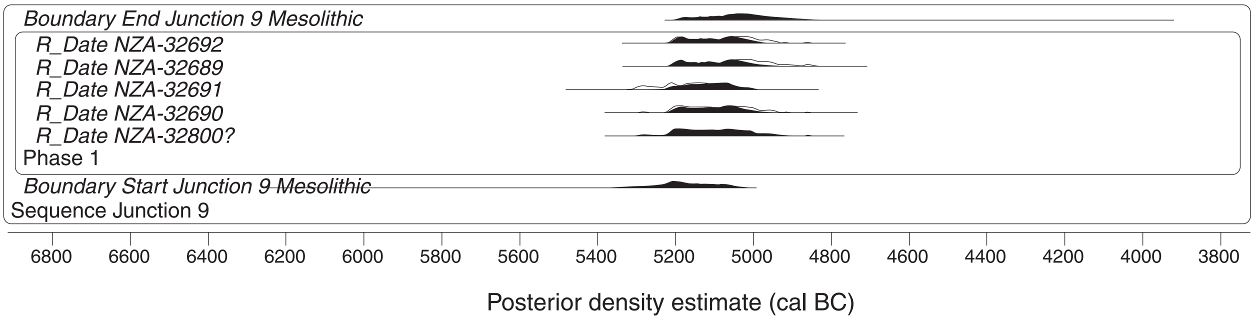

Fig. 9.5 The site model B, excluding NZA-32800

5330-5020 cal BC (95.4% probable; or *5230-5070 cal BC*, 68.2% probable; Start Junction 9 Mesolithic A; Fig. 9.3). An estimate for the end of this activity is *5210-4870 cal BC* (95.4% probable; or *5170-5160 cal BC*, 1.4% probable; or *5130-4960 cal BC*, 66.8% probable; End Junction 9 Mesolithic A; Fig. 9.3). The activity sampled went on for under 210 years (95.4% probable) or most probably under 100 years (68.2% probable; duration Junction 9 Mesolithic A; Fig. 9.4). If datum NZA-32800 is removed from the model, slightly different posteriors are produced, as activity begins *5410-5010 cal BC* (95.4% probable; or *5240-5070 cal BC*, 68.2% probable; Start Junction 9 Mesolithic B; Fig. 9.5). The end of this phase is estimated as *5210-4790 cal BC* (95.4% probable; or *5140-4950 cal BC*, 68.2% probable; End Junction 9 Mesolithic B; Fig. 9.5). The duration of this activity was under 220 years (95.4% probable), most probably under 110 years (68.2% probable; duration Junction 9 Mesolithic B; Fig. 9.6). NZA-32800 is not significant in model A's function; the parameters from model B are less precise because the model contains fewer likelihoods.

The earlier prehistoric activity indicated by the dated charred plant remains was of a relatively short duration. It could be truly contemporaneous (ie the material was harvested on the same day). It is possible that the activity took place at the optimal precision of this part of the calibration curve (ie over a period of under 10 years). Certainly this phase occurred over a period of less than 200 years (Figs 9.4 and 9.6). It is most probable that this activity occurred over a period of some 100 years (Figs 9.4 and 9.6).

The significance of the association of the radiocarbon results with the diagnostic Mesolithic

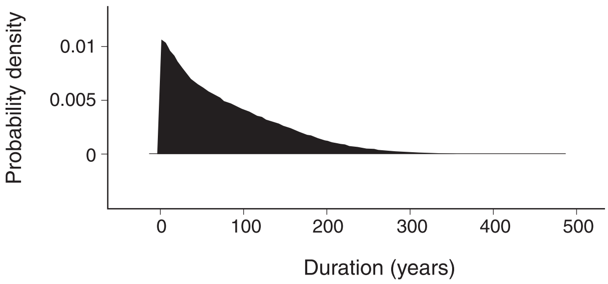

Fig. 9.6 Probability distribution for the duration of Mesolithic activity at the site

material culture recovered from these pits is more difficult to ascertain. The burnt hazel nutshells and wood demonstrate that people were active in the area (excluding the possibility of lightning strikes) but how this activity relates to the lithic industries is unknown. The presence of later charred plant remains from at least one of these features is demonstrated by NZA-33911, from pit 2064, from which were also recovered small sherds of intrusive pottery. It is therefore difficult to argue that these features represent sealed contexts, with excellent association between the lithic material and the radiocarbon results. These results are *termini post quos* for the infilling of the features and the deposition of associated lithic assemblages.

NZA-32690, NZA-32689 and NZA-32682 are *termini post quos* for the deposition of assemblages that include Jacobi's type 7a2 (1978) scalene triangle microliths. The infilling of these features and deposition of scalene microtriangles most probably occurred after the 52nd-51st centuries cal BC.