EXCAVATIONS AT KNOWTH 6

The Passage Tomb Archaeology of the Great Mound at Knowth

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CHAPTER IV

DATING THE NEOLITHIC HUMAN REMAINS AT KNOWTH

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4.1 Introduction

Knowth presents one of the most elaborate and extensive passage tomb cemeteries in western Europe (Eogan 1986). Not only is the great mound itself one of the largest and most complex passage tombs known, but also it is unique in being surrounded by at least twenty smaller tombs (see Fig. 2.1). These monuments vary in size, morphology and complexity of deposition. The history of development and use of the cemetery as a whole is therefore of great interest. Previous efforts at radiometric dating have been limited in part by the emphasis on cremation as a burial rite in Irish passage tombs because, until the methodological advances of the late 1990s, calcined bone did not yield reliable results (Lanting and Brindley 1998; Lanting *et al*. 2001). Although the monuments can be placed in the Middle Neolithic/early Late Neolithic (*c*. 3400–2800 BC), this provides little sense of the finer chronological detail and sequence of construction and use that should be possible, given the quantity of available material and the quality of its associated contextual information. However, a marked plateau in the radiocarbon calibration curve at 3350–3000 BC presents a particular challenge to this enterprise (see, for example, A.L. Brindley 1999a; 1999b).

In an attempt to refine the chronology of the passage tomb cemetery at Knowth, a dating programme was initiated, consisting of 66 new AMS ^{14}C determinations on cremated and non-burnt human bone from Tombs 1, 3, 6, 9 and 15–18. The remaining tombs either did not yield sufficient bone for dating or were so disturbed that no clear context could be identified (Eogan 1984). Some of the main questions to be addressed were: (1) the earliest and latest use of the cemetery for burial, leading to a consideration of the overall span of use both of individual tombs and of the whole site; (2) the chronology of the central Tomb 1 in relation to the smaller, surrounding tombs, in particular Tomb 16, which stratigraphically pre-dates and was partly encroached on by the construction of Tomb 1C; (3) the chronology of the alternative funerary rites of cremation and inhumation; (4) the chronology of the two different tomb types represented, cruciform and undifferentiated; and (5) the dating of a number of specific contexts, such as the putative Beaker burial in Tomb 15, and calcined bone in probable association with the maceheads in the eastern and western passages of Tomb 1. The non-burnt human bone also provides new stable carbon and nitrogen isotope data, contributing to our understanding of Neolithic diets in Ireland and, more generally, in Atlantic Europe.

4.2 Sampling strategy

A total of 104 'traditional' (beta-counting) and AMS ^{14}C determinations are now available for the earlier prehistoric phases of the Knowth complex (excluding 23 results relating to Late Iron Age/Early Christian activity, and six new results from cereals relating to medieval activity; Eogan 2012, 765; Appendix 4), of which 66 are from cremated and non-burnt human bone. The remaining dates include 21 previously published results from Tombs 1, 2, 9, 16 and 17 (Eogan 1984; Bergh 1995; Eogan and Roche 1997a). Many of these are from charcoal samples deriving from the old land surfaces underlying the mounds or from material incorporated into the mounds during construction, and they may be subject to an 'old wood effect' and/or be residual. These early determinations have been supplemented with seventeen new results from *Corylus* wood and charcoal, charred hazelnut shells, charred cereal grains and *Bos* bone, relating to Tomb 1C, or at least to the space occupied by it and its immediate vicinity (see Chapter II). However, as all of the samples from the central monument derive from contexts either pre-dating the final mound or associated with its construction (and probably also predating it), they cannot be related directly to the passage tomb burial deposits—as these lie within the earlier, structurally independent Tomb 1B—and so cannot usefully be employed to constrain the human bone determinations in a Bayesian model. A small number of samples relate to the Late Neolithic Grooved Ware phase, represented primarily by the timber circle outside the eastern passage of Tomb 1 (Eogan and Roche 1997a; Appendix 4). These results are discussed below, where appropriate.

The main focus of the present chapter, however, is on the human remains from the tombs' chambers and passages and thus the cemetery's use for funerary activity. Much of the human bone found at Knowth was cremated, with all of the attendant problems for osteological analysis, foremost being the difficulty of securely identifying distinct individuals (see Chapter III). The main strategy for dealing with this in the current dating programme has been to sample both cremated and non-burnt human bone from the same context, where these are available. The latter is generally limited to a small number of elements from any single context, certainly nothing approaching a complete skeleton. However, there is no indication of partial burning in this material: in other words, its presence among the cremated bone does not appear to relate to the incomplete cremation of a body. In a number of cases, mainly with the non-burnt bone, multiple individuals can be identified through the repetition of elements or, more usually, through the presence of both adult and infant/child remains. In a few cases in which the context is of particular interest (for example Deposit I in the left-hand recess of Tomb 1B East) and no other material is available, multiple samples of cremated bone have been taken, with the understanding that there is no guarantee that they represent separate individuals. In the great majority of cases, because of the sample size (*c*. 5g), the cremated bone samples taken could be securely identified as human. The presence of burnt animal bone in the passage tombs (Section 8.10; Appendix 8b), however, means that in a small number of cases the identification as human is not certain, but such material is assumed to relate to the contemporaneous use of the monument, given its context. All but four samples (one cremated and three non-burnt) are adult or probable adult (that is, adult-sized, which could include older adolescents).

As a quality-control exercise, five single-entity samples (four cremated bone and one non-burnt bone) were divided and sent to the ^{14}CHRONO Centre at Queen's University Belfast and to Oxford University's Research Laboratory for Archaeology and the History of Art. In addition, two samples—one of which was also sent to QUB—were measured in duplicate as part of Oxford's internal quality-control procedures, leaving 60 determinations on unique human samples and one on a non-burnt cattle mandible, together with 20 wood/charcoal/hazelnut samples from the same tombs (Table 4:1).

4.2.1 Bayesian modelling

With the presence of recorded stratigraphic relationships, a number of passage tombs at Knowth present the opportunity for Bayesian modelling (C.E. Buck *et al*. 1992; 1996; Bayliss *et al*. 2007; Bronk Ramsey 2009a). This takes advantage of the fact that, in the absence of disturbance and reworking of material, radiocarbon determinations relating to a lower stratigraphic unit must precede those relating to a higher unit. It uses this prior information to reduce the uncertainty associated with the spread of calibrated probability distributions from radiocarbon determinations. For multiple samples in each stratigraphic context, the models used here assume a uniform period of activity between unknown start and end dates, defined only by the distribution of measured results. The suitability of the models is assessed by the agreement of individual determinations, as well as by the model's overall index of agreement 'A_{model}'. A value of less than 60% indicates that the model is improbable (equivalent to a 5% significance test). This may be due to a small number of individual determinations that are out of sequence and/or to a wider lack of

Table 4:1—Number and material of radiocarbon-dated samples from Knowth passage tombs, excluding six duplicate [14]C dates on bone. Also excluded are non-bone dates from contexts unrelated to the monuments under discussion here, and hence the total differs from the total of 104 mentioned in the text.

Site	Bone			Other material		Total	Tomb form
	Cremated	Non-burnt	Total	Wood or charcoal	Hazelnut shell		
Tomb 1C mound	0	1	1	8	5	14	—
Tomb 1C West	3	0	3	0	0	3	Undifferentiated
Tomb 1B East	19	15	34	0	0	34	Cruciform
Tomb 1B West	1	0	1	0	0	1	Undifferentiated
Tomb 2	2	1	3	2	0	5	Cruciform
Tomb 3	1	0	1	0	0	1	Undifferentiated; passage-less
Tomb 6	2	1	3	0	0	3	Cruciform
Tomb 9	1	0	1	1	0	2	Cruciform
Tomb 15	4	1	5	0	0	5	Undifferentiated
Tomb 16	5	1	6	1	0	7	Undifferentiated
Tomb 17	2	0	2	2	0	4	Cruciform
Tomb 18	1	0	1	1	0	2	Cruciform
Total	**41**	**20**	**61**	**15**	**5**	**81**	

correspondence between the calibrated results and the recorded stratigraphy (where available). In the former case, the determinations showing poor agreement can be omitted and the model run again, although care needs to be taken when doing so (because one in twenty dates can be expected to fail a 5% significance test even if they legitimately belong; therefore a degree of flexibility is required, and individual determinations that fall just below 60% may be retained as long as the overall model is acceptable). Outlier analysis in OxCal 4.1.5 (Bronk Ramsey 2009b) is also used to identify potentially problematic dates. Additionally, a number of previous determinations on charcoal are available; these will invariably have an in-built age of unknown duration, which can be taken into account using a 'charcoal outlier model'. This treats all specified charcoal determinations as older than their contexts, by an unknown period determined by the series of results for that sequence or phase, with greater emphasis placed on results from short-lived materials (Bronk Ramsey 2009b).

When modelling the results from human bone, it is assumed that the bone was deposited soon after the death of the individual; in other words, long-term curation and/or retrieval are not considered to be confounding factors (cf. Bayliss and O'Sullivan 2013). Discrepancies between death and deposition in the order of a few years would not significantly affect the models: for example, cremation or initial burial at a distant settlement, followed by gathering and then keeping the bone for some months or a few years before bringing it to Knowth for placement in one of the passage tombs (see Chapter III).

Modelled start and end dates for phases of activity take into account the number of determinations assigned to that phase and their variability, which are used to estimate the probable date ranges of additional events (that is, bone deposition) from that phase that were not sampled. In some cases, particularly where only a few determinations are available for a phase, the modelled start and end ranges will be very wide, taking into account the increased uncertainty. Much of this range, however, will be itself of low probability and can often be discounted when additional information is considered (for example the results from the site complex as a whole). There is insufficient space here to include all of the model permutations that were run; in most cases only the preferred model is presented, taking into account the stratigraphic information where available and excluding clearly defined outliers as discussed in the relevant sections.

As the results of repeated model runs vary slightly in terms of their start and end date ranges, intervals and spans, they are reported here to the nearest half-decade. Because the modelled ranges are not solely based on the calibration curve but include archaeological information, they are reported as 'BC' rather than 'cal. BC'. The reference is still to calendar years in all cases. Modelled results are presented in italics, following common usage.

Use is made of summed probabilities in the final sections primarily for the purposes of graphical display. Although their analytical use is problematic in some respects (Bayliss *et al*. 2007; Bronk Ramsey 2013), in this case it is to provide convenient visual summaries of large datasets (that is, 'stacking' the probability distributions for a series of individual calibrated determinations). In all cases discussed here, reference is to *modelled* summed probabilities, such that the start and end points of the distribution reflect the earliest and latest modelled date ranges for the phase in question, and it is this aspect to which attention is drawn. The start and end date ranges in a Bayesian model give a clearer and less ambiguous indication of the modelled onset and end of each phase than the summed probability, but the latter encapsulates both aspects of the model. Furthermore, the intervening probability distribution gives some indication of the varying intensity of activity, even though it cannot be directly interpreted as such. The complication comes from the shape of the calibration curve, which partly determines the shape of the distribution; of course, this affects individual calibrated dates, as well as summed probabilities of multiple determinations. These models follow the format seen in a subset of the Knowth dataset in Fig. 4.1 (chosen for illustrative purposes only), with the resulting summed probability distribution presented in Fig. 4.2.

Fig. 4.1—*Example of summed probability model for an assumed single phase of activity.*

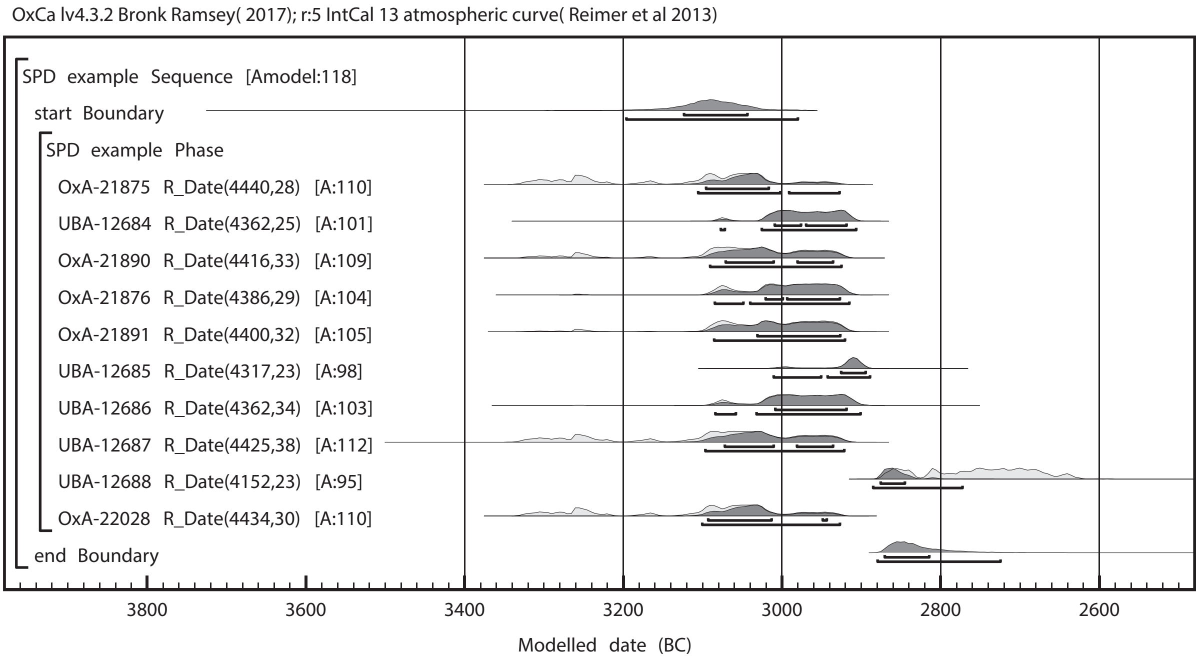
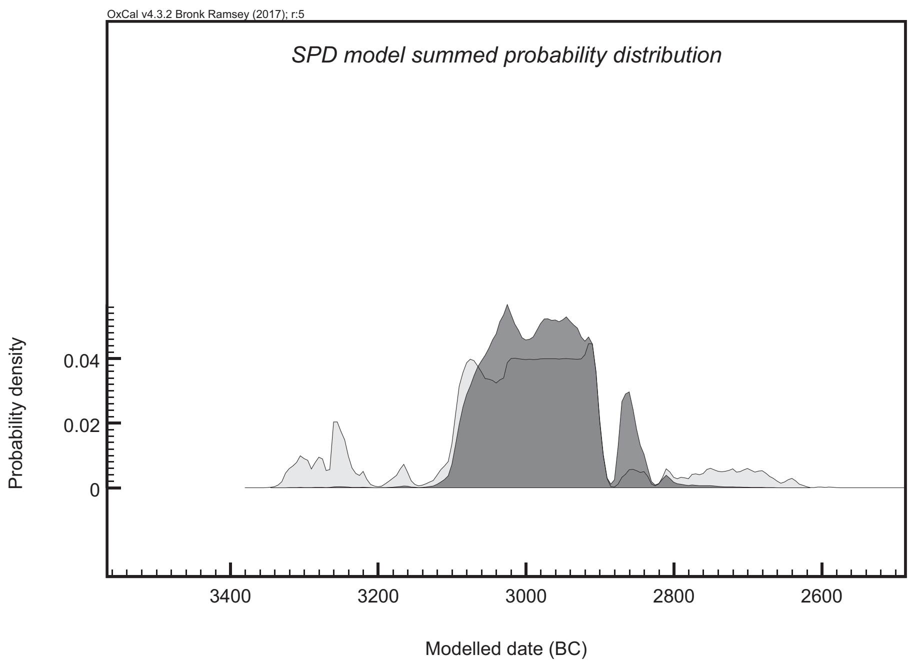


Fig. 4.2—*Summed probability distribution for example in Fig. 4.1. The lightly shaded area and its continuation as a dark line denote the unmodelled summed probability distribution, before the application of the Bayesian model (i.e., it is the area of the probability distribution for the various individual determinations rejected by the application of the model).*



4.3 Results

Results for the individual tombs are presented below, in numerical order, followed by a more general discussion. All dates are reported in years cal. BC at 95.4% probability unless otherwise noted (abbreviated to 95% in the text and tables; similarly, 68.2% probability is abbreviated to 68%). Only completely calcined bone was sampled for the cremated material, and with a single exception (from Tomb 18), the samples yielded acceptable results. For the non-burnt bone, carbon-to-nitrogen ratios (C:N) were all within the accepted range of 2.9–3.6 for well-preserved collagen (DeNiro 1985). All but one (OxA-21994, 1548±29 BP) of the new bone determinations can be attributed to the Middle/Late Neolithic use of the cemetery (Table 4:2). Tomb 1 is, of course, by far the most complex monument in the Knowth cemetery in the data it provides. This is because of

Table 4:2—^{14}C determinations on human bone from Knowth passage tombs. Calibrated in OxCal 4.1.5 and Calib 6.0 using IntCal 2009 (Reimer *et al.* 2009). Note that δ^{13}C values from cremated bone are not interpretable in palaeodietary terms.

Site/area	Context	Sample	Condition	Lab. code	^{14}C yrs BP	±	Cal. BC (95%)		δ^{13}C
Tomb 1B East									
Left-hand recess	Pit A	50133	Cremated	UBA-12995	4397	28	3094	2920	–23.9
Left-hand recess	Pit B	50134	Cremated	OxA-21923	4496	29	3345	3096	–19.8
Left-hand recess	Pit B	50134	Cremated	OxA-21924	4446	30	3333	2936	–20.1
Left-hand recess	Pit B	50134	Cremated	Combined	4472	21	3334	3029	–20.0
Left-hand recess	Compartment 2	168	Cremated	OxA-21983	4340	50	3094	2885	–21.4
Left-hand recess	Compartment 4	170a	Cremated	UBA-10341	4449	21	3328	3021	–20.9
Left-hand recess	Compartment 4	170	Non-burnt	OxA-21925	4401	30	3263	2917	–21.5
Left-hand recess	Compartment 6	173a	Cremated	OxA-21926	4331	30	3020	2894	–20.3
Left-hand recess	Compartment 6	173b	Non-burnt	OxA-21927	4388	29	3091	2918	–21.1
Left-hand recess	Compartment 6	173c	Non-burnt	OxA-21928	4423	29	3322	2922	–21.0
Left-hand recess	Compartment 6	173d	Non-burnt	OxA-21929	4383	31	3091	2915	–21.3
Left-hand recess	Compartment 8	175	Cremated	OxA-21884	4512	33	3356	3097	–25.6

table continued

Table 4:2—^{14}C determinations on human bone from Knowth passage tombs. Calibrated in OxCal 4.1.5 and Calib 6.0 using IntCal 2009 (Reimer *et al.* 2009). Note that $\delta^{13}C$ values from cremated bone are not interpretable in palaeodietary terms. *(contd)*

Site/area	Context	Sample	Condition	Lab. code	^{14}C yrs BP	±	Cal. BC (95%)		$\delta^{13}C$
Tomb 1B East									
Left-hand recess	Deposit I	161	Cremated	UBA-10340	4779	25	3639	3521	–21.4
Left-hand recess	Deposit I	161a	Cremated	OxA-21885	4461	32	3339	3021	–23.6
Left-hand recess	Deposit I	161b	Non-burnt	UBA-12674	4381	22	3087	2916	–22.9
Left-hand recess	Deposit I	161b	Non-burnt	OxA-21930	4424	30	3323	2923	–21.3
Left-hand recess	Deposit I	161b	Non-burnt	Combined	4396	18	3090	2923	–22.1
Left-hand recess	Deposit I	163a	Cremated	UBA-12673	4362	38	3090	2901	–20.6
Left-hand recess	Deposit I	163b	Non-burnt	OxA-21931	4428	29	3323	2926	–21.7
Left-hand recess	Deposit I	Sample 2	Non-burnt	UB-6351	4333	43	3087	2886	–24.0
End recess	On floorstone	186	Cremated	UBA-12675	4448	39	3337	2931	–26.9
Right-hand recess	Deposit B	50142	Cremated	UBA-12676	4476	39	3346	3026	–19.4
Right-hand recess	Deposit C	50143	Cremated	OxA-21941	4543	32	3366	3103	–18.2
Right-hand recess	Deposit 1	Sample 3	Non-burnt	UB-6352	4529	38	3363	3099	–23.9
Right-hand recess	Deposit 1	50146b	Cremated	UBA-12678	4379	25	3089	2913	–19.9
Right-hand recess	Deposit 1	50146b	Cremated	OxA-21887	4476	32	3340	3028	–18.1
Right-hand recess	Deposit 1	50146b	Cremated	Combined	4416	20	3263	2927	–19.0
Right-hand recess	Deposit 1	50146c	Non-burnt	OxA-21932	4472	30	3339	3027	–21.4
Right-hand recess	Cremation 4	50144d	Cremated	UBA-12677	4416	24	3263	2924	–23.0
Right-hand recess	Cremation 4	50144d	Cremated	OxA-21886	4469	32	3330	3025	–18.7
Right-hand recess	Cremation 4	50144d	Cremated	Combined	4435	20	3322	2936	–20.9
Right-hand recess	Deposit 2	422a	Cremated	OxA-21888	4498	33	3353	3091	–12.9

table continued

Table 4:2—^{14}C determinations on human bone from Knowth passage tombs. Calibrated in OxCal 4.1.5 and Calib 6.0 using IntCal 2009 (Reimer *et al.* 2009). Note that δ^{13}C values from cremated bone are not interpretable in palaeodietary terms. *(contd)*

Site/area	Context	Sample	Condition	Lab. code	^{14}C yrs BP	±	Cal. BC (95%)		δ^{13}C
Tomb 1B East									
Right-hand recess	Deposit 2	422b	Non-burnt	OxA-21933	4430	31	3327	2926	–21.6
Right-hand recess	Deposit 3	218a	Cremated	OxA-22024	4424	34	3326	2921	–19.4
Right-hand recess	Deposit 3	218b	Non-burnt	OxA-21934	4480	31	3341	3029	–21.2
Right-h and recess	Deposit 3	218c	Non-burnt	OxA-21935	4470	31	3339	3026	–21.1
Right-hand recess	Deposit 3	Sample 1	Non-burnt	UB-6350	4418	49	3331	2913	–28.0
Right-hand recess	Deposit 4	50148a	Cremated	UBA-12679	4459	25	3332	3023	–18.3
Right-hand recess	Deposit 4	50148a	Cremated	OxA-21989	4526	32	3359	3102	–11.4
Right-hand recess	Deposit 4	50148a	Cremated	OxA-21990	4462	32	3338	3022	–16.5
Right-hand recess	Deposit 4	50148a	Cremated	Combined	4478	17	3336	3091	–15.4
Right-hand recess	Deposit 4	50148b	Non-burnt	OxA-21936	4399	30	3261	2917	–21.5
Right-hand recess	Deposit 5	425	Cremated	OxA-21991	4426	34	3327	2922	–12.0
Right-hand recess	Deposit 6	424	Cremated	UBA-12680	4410	27	3263	2921	–21.3
Right-hand recess	Deposit 6	183	Non-burnt	OxA-21984	4450	45	3339	2931	–21.9
Tomb 1B West									
Against Sillstone 2		50163	Cremated	UBA-12994	4431	26	3324	2928	–23.8
Tomb 1C West									
K98 CR3	Orthostat 29	50158	Cremated	OxA-21993	4423	36	3327	2920	–27.7
K98 CR5	Orthostat 5	50159a	Cremated	OxA-21992	4261	31	2920	2762	–10.9
K98 CR5	Orthostat 5	50159b	Cremated	UBA-12681	4160	23	2877	2636	–19.0
Tomb 2									
Right-hand recess	Under basin	50166	Cremated	OxA-22025	4437	31	3329	2929	–20.8
Right-hand recess	Around basin	120	Cremated	UBA-10339	4507	25	3348	3100	–19.0
Passage	Inside Socket 7	'Burial 1'	Non-burnt	GrN-15368	4375	40	3261	2902	—

table continued

Table 4:2—^{14}C determinations on human bone from Knowth passage tombs. Calibrated in OxCal 4.1.5 and Calib 6.0 using IntCal 2009 (Reimer *et al.* 2009). Note that δ^{13}C values from cremated bone are not interpretable in palaeodietary terms. *(contd)*

Site/area	Context	Sample	Condition	Lab. code	^{14}C yrs BP	±	Cal. BC (95%)		δ^{13}C
Tomb 3									
Chamber	—	110	Cremated	UBA-10338	4687	24	3624	3372	–25.8
Tomb 6									
Right-hand recess	—	104a	Cremated	OxA-22026	4375	29	3089	2910	–21.0
Right-hand recess	—	104b	Cremated	UBA-12682	4385	23	3089	2917	–21.6
Right-hand recess		104c	Non-burnt	OxA-21937	4377	29	3089	2911	–22.5
Tomb 9									
Cremation in end recess		—	Charcoal	GrN-11714	4415	50	3332	2915	—
End recess	Deposit 1	50171	Cremated	OxA-22027	4357	30	3083	2903	–19.7
Tomb 15									
Chamber	Segment 4	595a	Cremated	OxA-21889	4394	35	3263	2910	–20.1
Chamber	Segment 4	595b	Non-burnt	OxA-21994	1548	29	AD 428–582		–21.4
Chamber	Segment 3, primary deposit	598	Cremated	OxA-21874	4453	29	3336	3014	–22.1
Chamber	Segment 3, secondary deposit	599	Cremated	OxA-21942	4430	31	3327	2926	–17.2
'Beaker'	Above floor	3771	Cremated	UBA-12683	4265	24	2912	2877	–22.8
Tomb 16									
Chamber	Primary deposit	637	Cremated	OxA-21875	4440	28	3283	2935	–20.7
Chamber	Secondary deposit	639a	Cremated	UBA-12684	4362	25	3081	2908	–23.6
Chamber	Secondary deposit	639a	Cremated	OxA-21890	4416	33	3322	2918	—
Chamber	Secondary deposit	639a	Cremated	Combined	4382	20	3086	2936	—
Chamber	Secondary deposit	639b	Non-burnt	OxA-21876	4386	29	3087	2937	–22.2
Chamber	Tertiary deposit	641	Cremated	OxA-21891	4400	32	3077	2914	–11.9
Passage	Primary deposit	644	Cremated	UBA-12685	4317	23	3011	2890	–24.0
Passage	Secondary deposit	645	Cremated	UBA-12686	4362	34	3089	2902	–24.4

table continued

Table 4:2—^{14}C determinations on human bone from Knowth passage tombs. Calibrated in OxCal 4.1.5 and Calib 6.0 using IntCal 2009 (Reimer *et al.* 2009). Note that δ^{13}C values from cremated bone are not interpretable in palaeodietary terms. *(contd)*

Site/area	Context	Sample	Condition	Lab. code	^{14}C yrs BP	±	Cal. BC (95%)		δ^{13}C
Tomb 17									
Chamber	Socket 11	728	Cremated	UBA-12687	4425	38	3328	2921	–22.8
Passage	In upper fill	726	Cremated	UBA-12688	4152	23	2874	2634	–20.7
Tomb 18									
Left-hand recess	Under floorstone	747	Cremated	OxA-22028	4434	30	3328	2928	–22.2
Right-hand recess	—	745	Cremated	—	Failed	—	—	—	—

Table 4:3—Results of inter-laboratory comparison of repeat measurements of single-entity samples. * = non-burnt bone.

Tomb	Sample	Lab. no.	^{14}C yrs BP	±	Cal. BC (95%)		χ^2 test	
1B East	161b*	UBA-12674	4381	22	3087	2916		
1B East	161b*	OxA-21930	4424	30	3323	2923		
1B East	161b*	Combined	4396	18	3090	2923	1.3	(5%, 3.8)
1B East	50144d	UBA-12677	4416	24	3263	2924		
1B East	50144d	OxA-21886	4469	32	3339	3025		
1B East	50144d	Combined	4435	20	3322	2936	1.8	(5%, 3.8)
1B East	50146b	UBA-12678	4379	25	3089	2913		
1B East	50146b	OxA-21887	4476	32	3340	3028		
1B East	50146b	Combined	4416	20	3263	2927	5.7	Fails
1B East	50148a	UBA-12679	4459	25	3332	3023		
1B East	50148a	OxA-21989	4526	32	3359	3102		
1B East	50148a	OxA-21990	4462	32	3338	3022		
1B East	50148a	Combined	4478	17	3336	3091	3.1	(5%, 6.0)
16	639a	UBA-12684	4362	25	3081	2908		
16	639a	OxA-21890	4416	33	3322	2918		
16	639a	Combined	4382	20	3086	2917	1.7	(5%, 3.8)

the relative abundance of cremated and non-burnt bone in the eastern tomb and the complexity of the recorded stratigraphic relationships, reflected in the fact that 38 of the 60 determinations on human bone (63%) derive from this monument, with all but four of these coming from the cruciform eastern passage tomb, Tomb 1B East (see Table 4:1).

For the most part there is good agreement between the split single-entity samples prepared and analysed independently at Oxford and Belfast (Table 4:3). The single exception is sample 50146b, which failed to combine at 95% confidence (but not by a large margin) (Ward and Wilson 1978). Although the sample size is small, there is also a slight offset between the two laboratories, Oxford's results being on average some decades earlier than Belfast's. This offset is being investigated, but inter-laboratory comparisons have identified comparable offsets from cremated bone between different radiocarbon-dating facilities (Naysmith *et al.* 2007).

4.3.1 Pre-mound Tomb 1C

The area under and around the central Tomb 1C presents evidence for an extremely complex sequence of activity. The earliest evidence derives from three samples—charred hazelnut shell (UBA-12888, 7386±29 BP), humic acids from a sod layer (UB-358, 6835±100 BP) and charcoal (GrN-18773, 5885±45 BP)—and appears to relate to intermittent Mesolithic activity, for which there is some lithic evidence, albeit from derived contexts (see Section 6.2.3).

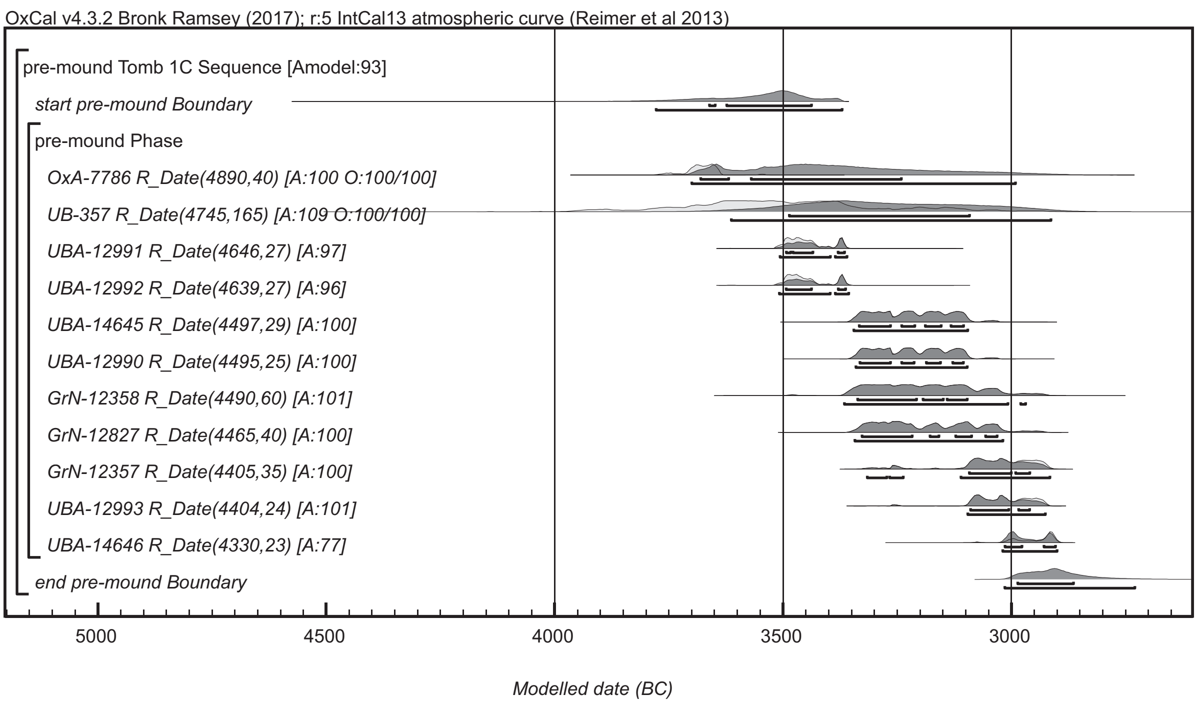
A number of determinations on wood, charcoal, charred hazelnut shells and cereal grains relate to at least two broad phases of Neolithic activity, apparently of a domestic character, both underlying and incorporated into the massive mound designated Tomb 1C (Eogan and Roche 1997a). An Early Neolithic (Phase I and II) occupation of rectangular houses, associated with Carinated Bowl pottery, is followed by a dark occupation layer with Middle Neolithic decorated pottery ('Carrowkeel Ware') and more lightly built round structures (Eogan 1984; 1991; Eogan and Roche 1997a; 1997b; 1998; Appendix 4). The temporal relationships between these two phases, the use of the eastern and western passage tombs, and the construction of the final mound are key points that remain unclear and are not addressed by this chapter's focus on the use phase of the monuments for burial. The first Early Neolithic phase of activity at Knowth, placed at *3725–3565 BC*, is discussed further in Section 1.4.1 and Appendix 4.1 (see also Eogan 1984; 1998; Eogan and Roche 1997a; 1997b; 1998).

Material underlying and in the Tomb 1C mound bears an uncertain relationship to the funerary use of the eastern and western passage tombs and so cannot be used to constrain the human bone determinations. From the results in Table 4:4, with OxA-7786 and UB-357 treated as outliers in a charcoal outlier model, the second phase of Neolithic pre-mound activity is modelled only very broadly as starting in the period *3780–3370 BC*; the early part of this range includes material that clearly pre-dates use of the passage tombs for burial and may be residual from the earlier Neolithic settlement (Fig. 4.3). In fact, most of these samples are in secondary contexts, incorporated into the sods used in the construction of the 1C mound, and many are likely to be residual, whereas others may represent later slippage from the mound (see Section 8.7.3) or incorporation during the setting or resetting of large stones. With readers bearing these caveats in mind, the modelled end range presents a *terminus post quem* for Tomb 1C's construction of *3015–2730 BC*. This range relies heavily on two determinations on short-lived materials

Table 4:4—^{14}C determinations relating to second phase of pre-mound activity incorporated into Tomb 1C.

Context	Material	Lab. code	^{14}C yrs BP	±	Cal. BC (95%)	
Tomb 1C, base of large mound	Charcoal (residual?)	OxA-7786	4890	40	3770	3635
Tomb 1C, basal sod layer	Combined charcoal	UB-357	4745	165	3940	3030
Tomb 1C West, basal sod layer in area of Capstones 19–23	Hazelnut shell	UBA-12991	4646	27	3516	3362
Tomb 1C East, socket of Orthostat 72	Hazelnut shell	UBA-12992	4639	27	3515	3359
Tomb 1C East, basal sod layer, opposite Orthostats 5–7	Wood, *Corylus avellana*	UBA-14645	4497	29	3345	3096
Tomb 1C East, basal sod layer on south side of passage	Wood, *Corylus avellana*	UBA-12990	4495	25	3341	3097
Tomb 1C East, underlying basal sod layer behind Orthostats 6–7	Charcoal, *Corylus avellana*	GrN-12358	4490	60	3365	2942
Tomb 1C East, basal sod layer behind Orthostat 75	Wood fragments	GrN-12827	4465	40	3350	3015
Tomb 1C East, basal sod layer behind Orthostats 19–20	Charcoal, *Corylus avellana*	GrN-12357	4405	35	3315	2910
Tomb 1C East, baulk opposite Orthostats 13–14	Hazelnut shell	UBA-12993	4404	24	3094	2925
Tomb 1C West, basal sod layer, packing around Kerbstone 36	Hazelnut shell	UBA-14646	4330	23	3023	2891

Fig. 4.3*—Modelled calibrated results for second phase of activity, pre-mound Tomb 1C.*

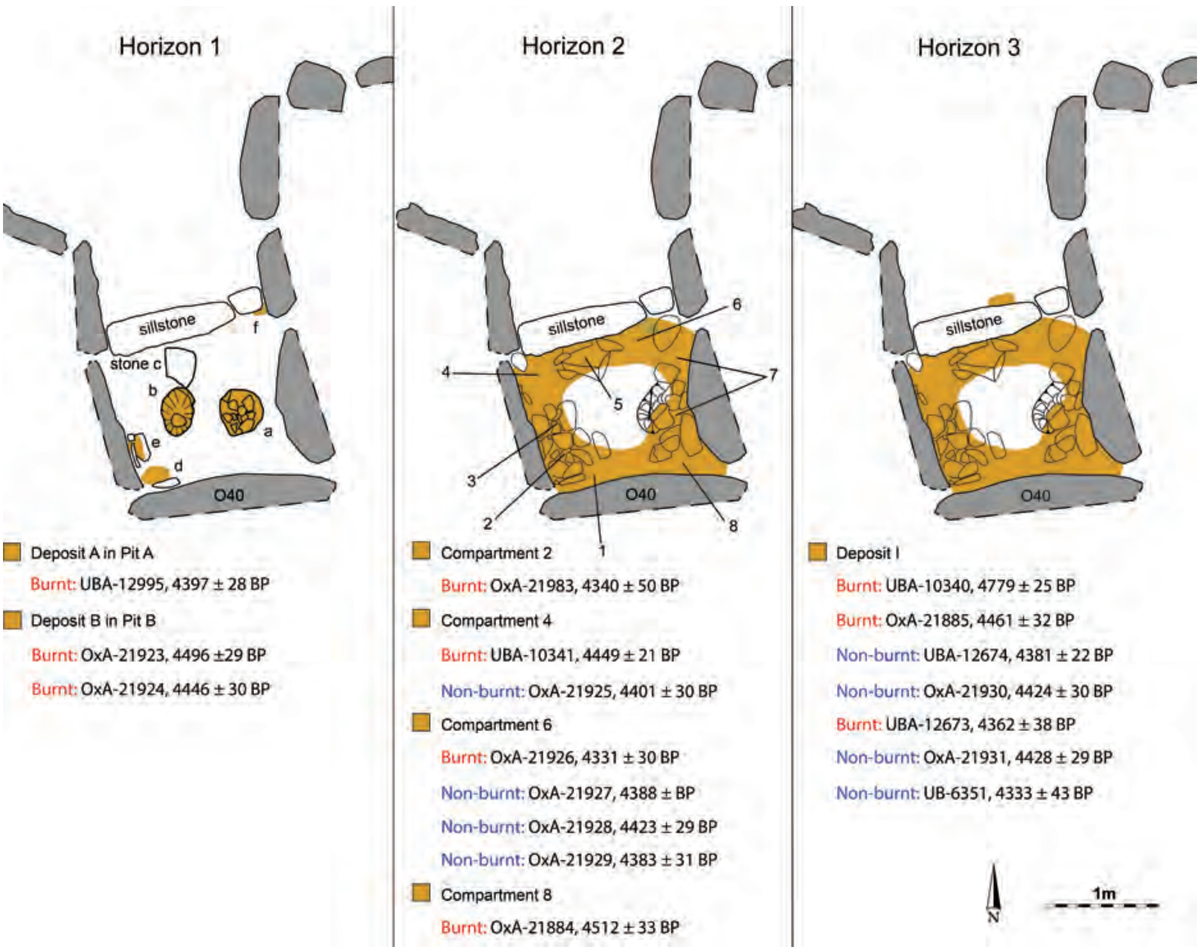


(UBA-12993, 4404±24 BP; UBA-14646, 4330±23 BP) from the basal sod opposite Orthostats 13–14 in the eastern passage and from the packing stones behind Kerbstone 36, respectively. With these determinations omitted, the modelled end range becomes much wider, *3310–2845 BC*.

4.3.2 Tomb 1B east

The cruciform chamber of Tomb 1B East contained by far the most abundant bone, both cremated and non-burnt, as well as the most complex stratigraphic relationships, in the Knowth complex. The material in the left-hand (southern) recess is restricted to two depositional events: Pits A and B, overlying which were a series of 'compartments', comprising shallow, irregularly shaped hollows, with a general bone spread partly overlying them designated Deposit I (Fig. 4.4; and see Section 2.3.2). One of two initial determinations on cremated bone in Deposit I returned a surprisingly early result of 4779±25 BP (UBA-10340, 3639–3521 cal. BC), providing the impetus for an additional five determinations from this

Fig. 4.4—*Burial deposits in left-hand recess of Tomb 1B East sampled for* ^{14}*C dating.*

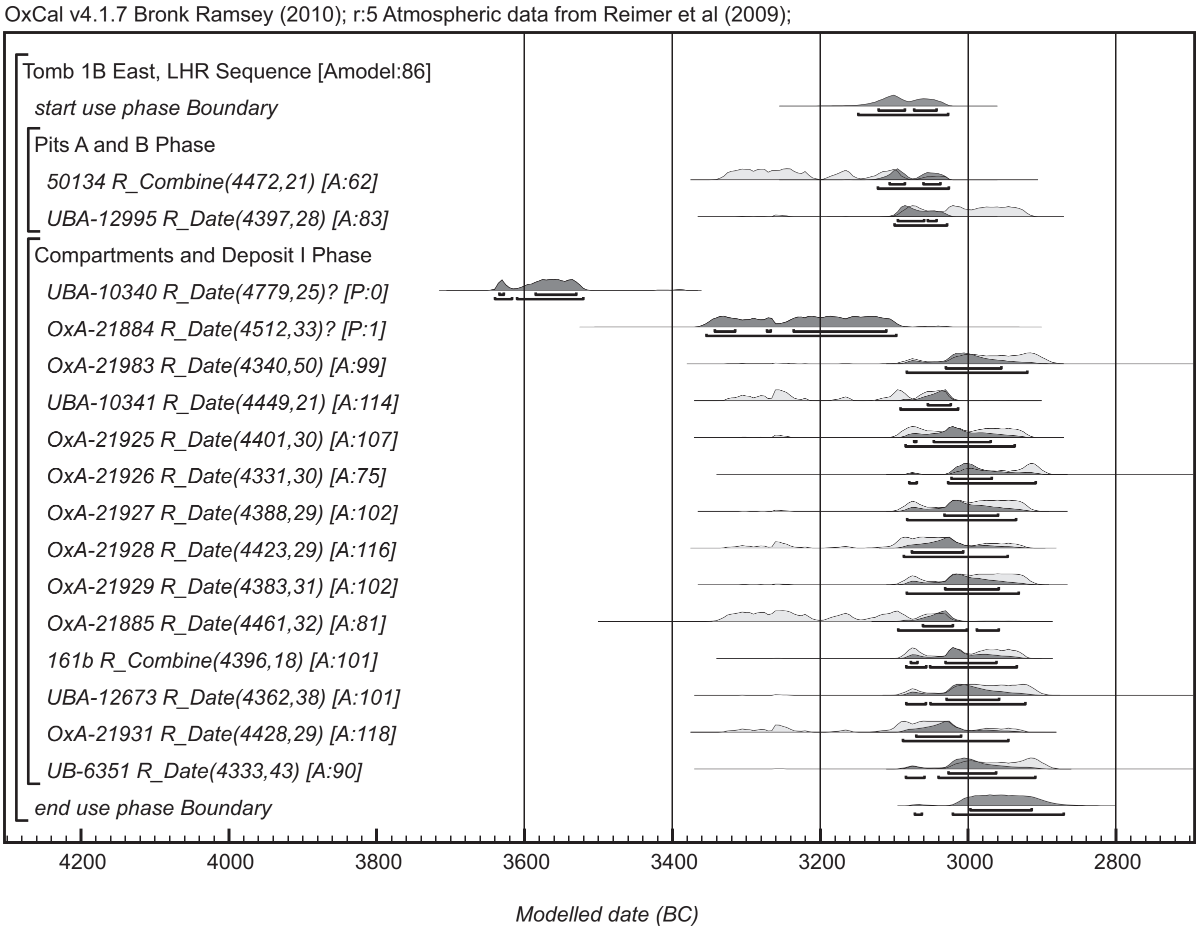


context (including one duplicate analysis: see Table 4:2). These results were all significantly later than UBA-10340 but were consistent with one another and, as shall be seen, with the wider corpus of determinations from the site. Unfortunately, no material is left from the sample that yielded the early date, and so this particular bone fragment cannot be re-analysed. The possibility therefore remains that the result represents earlier evidence for funerary activity, perhaps an earlier monument on the site, but this cannot be confirmed. (Note that this assumes that the bone was indeed human, which is not always easy to determine with calcined fragments.) Nevertheless, it is very plausible because there is good evidence for a pre-existing tomb (or tombs), designated 1A, on the site of the main mound (see Section 2.2).

Alternatively, the date itself may be slightly too old, reflecting the partial uptake of older carbon from the wood fuel used during the cremation. This has only recently been recognised as an issue, and the extent to which it is a problem is still under investigation (Hüls *et al*. 2010; Zazzo *et al.* 2012; Snoeck *et al*. 2014). In most cases the fuel used for cremation can be expected to be large branchwood lacking a significant in-built age, but on occasion older timbers (for example oak posts and planks from houses and other structures) may have been used. The strong degree of consistency between cremated and non-burnt bone from the same contexts in the present study supports the validity of the great majority of determinations on calcined bone, but there may be outliers such as UBA-10340 and a few others mentioned below to which this explanation applies. We therefore exclude UBA-10340 from the Bayesian models (from which it is strongly rejected as an outlier in any case).

The model considers two phases of activity: (1) Pits A and B and (2) the compartments and Deposit I. Although Deposit I partly overlay the compartments, there was insufficiently clear separation to warrant their being considered as distinct episodes of activity—a model assuming this stratigraphic order failed (A_{model} = 48.4%)—and therefore they are treated together. In addition to UBA-10340, one other determination is rejected from the model: OxA-21884 (4512±33 BP) from Compartment 8, with an index of agreement of only 17.2% (the cut-off for rejection, as noted above, being 60%), causing the overall model to fail (A_{model} = 44.7%). The remaining results are in satisfactory agreement with the proposed sequence (Fig. 4.5), placing the start of deposition of human bone in the range *3150–3030 BC* and the end in the range *3075–3150 BC*. This model assumes the above stratigraphic relationship, with no break in deposition between the two phases. Another way to approach this, as a heuristic exercise, is to assume that there may have been such a break. The results differ primarily in expanding the earlier part of the start date for Pits A and B to *3365–3025 BC* with an end range of *3260–3000 BC*, with the overlying deposits starting *3105–2965 BC* and ending *3080–2905 BC*. This model (not shown) permits an interval of *0–175 years* (*0–35 years* at 68%) between the use of Pits A and B and that of the compartments and Deposit I for the deposition of cremated and non-burnt bone. Archaeologically, however,

Fig. 4.5—*Modelled calibrated results for Tomb 1B East, left-hand recess. Outliers UBA-10340 and OxA-21884 are shown but are not included in the model.*



there is no good reason to assume the existence of a break in deposition, and so the first model presented is preferred.

The right-hand (northern) recess of Tomb 1B East has greater potential in its recorded stratigraphy, with six 'horizons' identified (Fig. 4.6; see Section 2.3.2). Deposits B and C either underlie or are contemporary with Deposit 1 in Pit 1, placed centrally in the outer portion of the recess, and considered together they constitute Horizon 1. Above this, Deposit 2 (Horizon 2) partly overlies Pit 1 (as an upper fill) and also extends beyond it. Deposit 3 (Horizon 3) is placed in Pit 2, immediately outside the recess, between the two jamb stones, and thus bears an uncertain relationship with Horizons 1 and 2. Deposit 4 (Horizon 4) partly extends over Pit 2. Deposit 5 (Horizon 5) is a dense spread of cremated bone overlying Deposit 4 but also spreading into the recess and so covering Horizons 1 and 2. Deposit 6 is difficult to separate

***Fig. 4.6**—Burial deposits in right-hand recess of Tomb 1B East sampled for ^{14}C dating.*

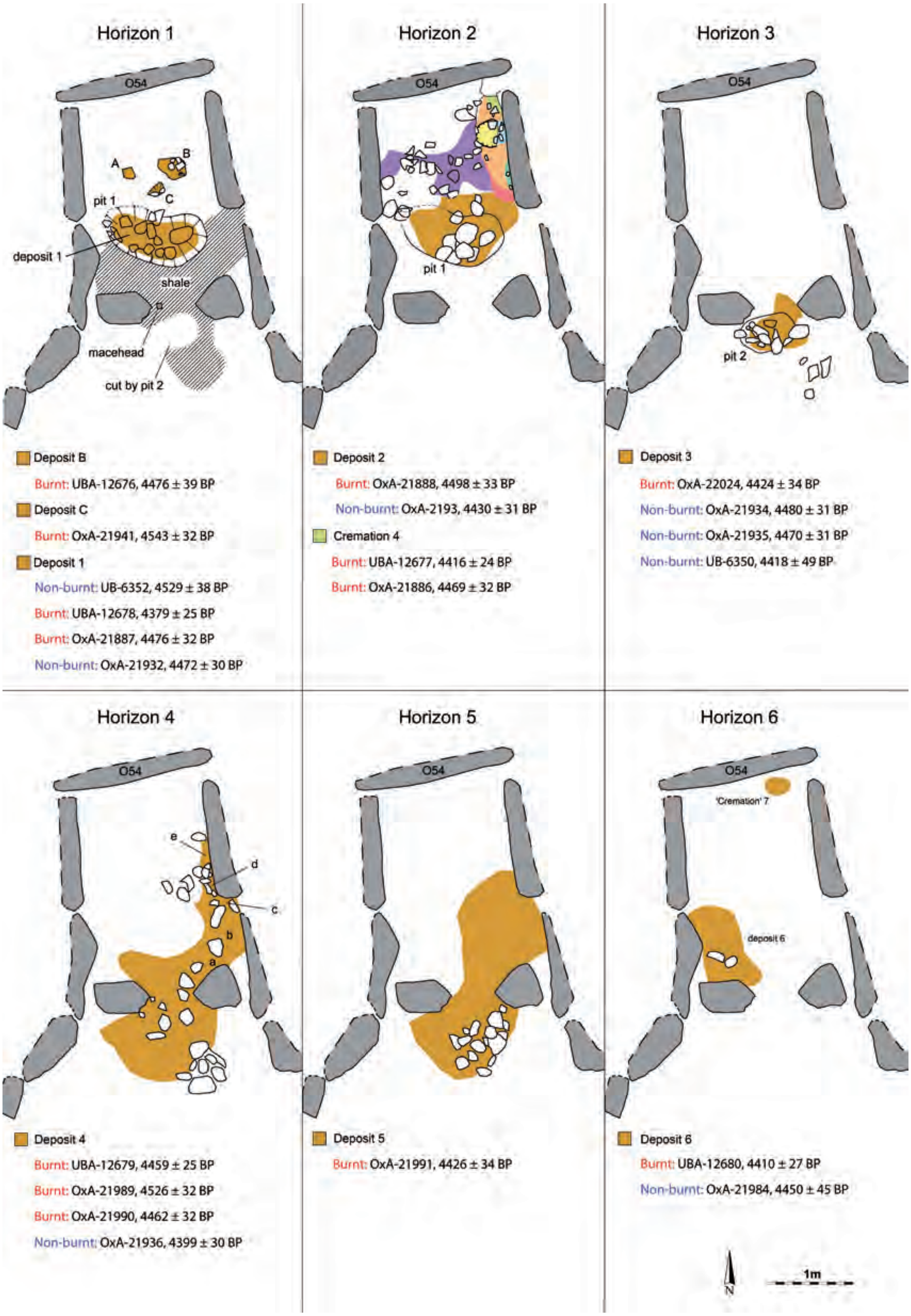
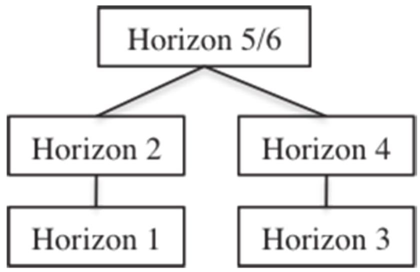


Fig. 4.7*—Harris matrix for deposits in right-hand recess of Tomb 1B East.*

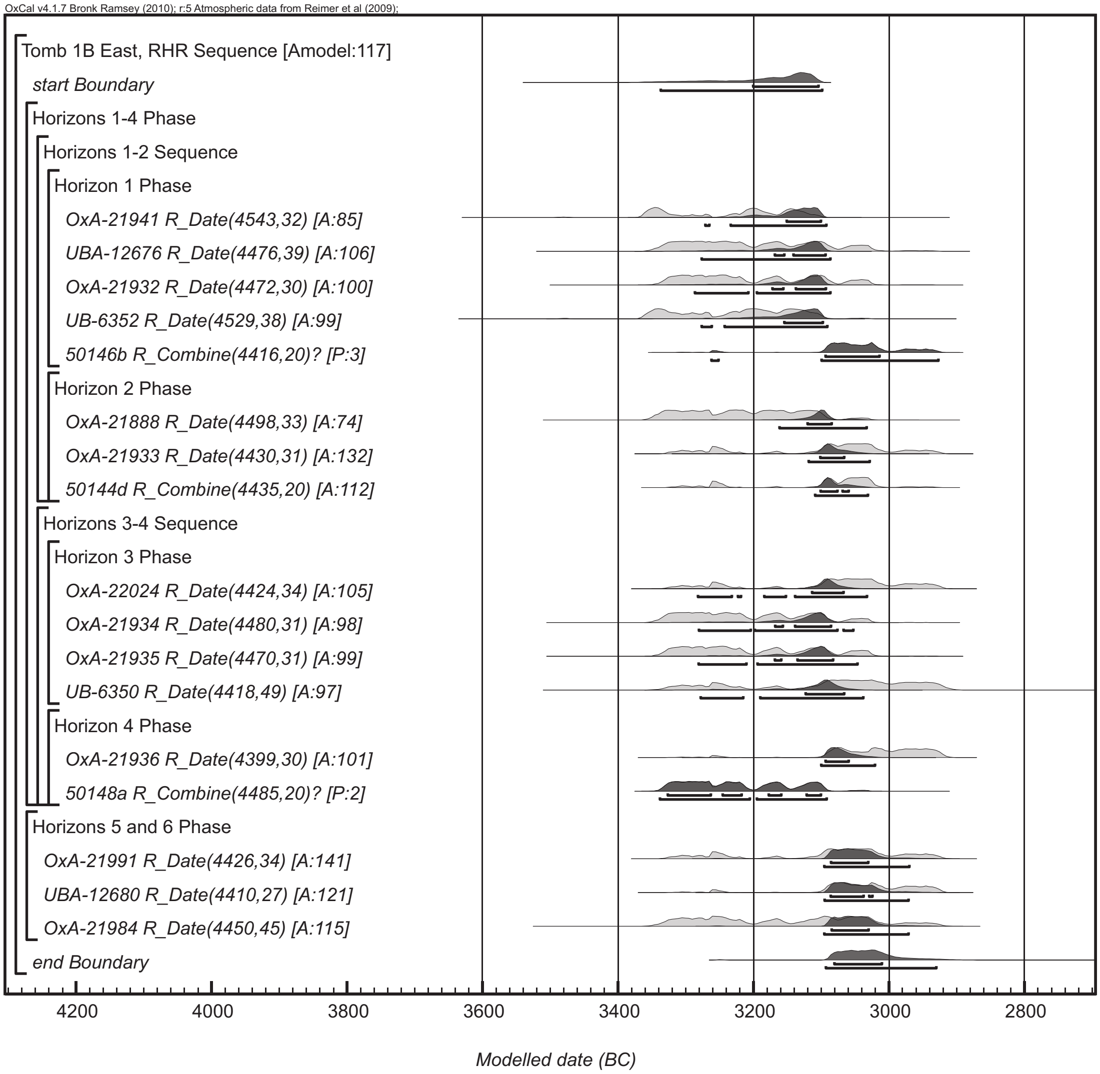


from Deposit 5, so these are combined as Horizons 5/6 in the model (Fig. 4.7). Given the nature of cremated bone and the generally small fragments of non-burnt bone, it is possible that fragments slipped between the rough stone pavings into lower levels. Movement in the other direction should be less likely. In many cases the bone fragments were mixed with clay, and calcined bone in Horizon 3 was found with redeposited sod together with charcoal and shale.

A first attempt to use all seventeen determinations on unique samples in five horizons highlighted two problematic samples with agreement indices well below 60% (50146b, A = 35.6%, and 50148a, A = 34.0%). These two aberrant results also caused the agreement for the overall model to fail to reach 60% (A_{model} = 31.7%). With these two samples removed from the model, the results can be satisfactorily reconciled with the stratigraphy (Fig. 4.8). Deposition is modelled as starting *3340–3100 BC*, with the final deposits of Horizons 5/6 modelled as ending *3095–2930 BC*. The overall use of the right-hand recess is modelled as spanning *10–370 years*, or *25–190 years* at 68%. However, the impression provided by these estimates may be overly long, given the results of models that consider the site as a whole, discussed below.

It is worth noting here that the decorated flint macehead (50479) was found on the floor of the outer part of the right-hand recess (see Fig. 2.25), probably contemporary with Pit 1 and stratigraphically below Horizons 2 to 5/6 (Eogan and Richardson 1982). This implies that it should predate *c*. 3100 cal. BC, in line with Sheridan's (2004, 28) suggestion (*contra* Simpson 1988; A.L. Brindley 1999b) that maceheads may precede the appearance of Grooved Ware in Ireland *c*. 3000/2900 BC (A.L. Brindley 1999a). Its date, within the 3300–3100 BC bracket, is not inconsistent with the suggestion (Eogan and Richardson 1982) of a link with northern Scotland at this time because the evidence from Orkney indicates that at least one Maeshowe-type passage tomb showing influences from the complex passage tombs of Brugh na Bóinne—namely, Quanterness—was being used within this date range (Schulting *et al.* 2010; see also MacSween *et al.* 2015 and C. Richards, Jones *et al.* 2016 on the emergence of Grooved Ware in Orkney during (or by) the 32nd century BC, and see Sheridan

Fig. 4.8—*Modelled calibrated results for Knowth Tomb 1B East, right-hand recess, with five phases of activity. Two results (50146b and 50148a) are shown but excluded from the model as their agreement indices fall well below 60%.*



2014 regarding the Scottish links of the miniature carved stone ball beads from Knowth's Tomb 1B East, Deposits 4 and 5).

A comparison of the modelled results for the left- and right-hand recesses of Tomb 1B East suggests that deposition was approximately contemporaneous, *c*. 3300–3100 BC (Table 4:5). Only a single determination of 3337–2931 cal. BC (UBA-12675, 4448±39 BP) is available on two cremated long-bone fragments from the end recess. With no stratigraphic constraints and only a single date, this result is subject to the full effects of the late-fourth-millennium BC calibration plateau, discussed further below.

Table 4:5—Modelled start and end date ranges for bone deposition in left- and right-hand recesses of Tomb 1B East.

Context	n	Start BC (68%)		End BC (68%)		Start BC (95%)		End BC (95%)		A_{model}
Tomb 1B East, left-hand recess	14	3120	3045	3000	2915	3150	3030	3075	2870	86%
Tomb 1B East, right-hand recess	15	3200	3105	3080	3010	3340	3100	3095	2930	117%

4.3.3 Tomb 1B west

The very limited excavations in the undifferentiated chamber and passage of Tomb 1B West (see Chapter II), resulted in the recovery of a much smaller quantity of bone than from Tomb 1B East. A single calcined bone sample from a slight depression against the outer face of Sillstone 2 returned a result of 3324–2928 cal. BC (UBA-12994, 4431±26 BP). The majority of its probability distribution (*c*. 76%) lies in the period 3120–2930 cal. BC, consistent with the main period of activity identified for Tomb 1B East, although it is not possible to compare the use of the two tombs adequately on this basis. The pestle-shaped macehead (50131) from the western passage tomb was found just next to Sillstone 2, on the edge of this slight depression, which may have held the stone basin found farther down the passage (Eogan and Richardson 1982, 125; see Section 2.3.1). The cremated bone fragments that provided the single determination from the chamber, therefore, could tentatively be associated with the macehead.

4.3.4 Tomb 1C

An important but difficult question relates to the date of the construction of the large mound, Tomb 1C, and the associated extension of the passages of the eastern and western tombs of Tomb 1B. As noted above (and see Table 4:4), a number of determinations are available on wood, charcoal and charred hazelnut shell from the mound, presumably stripped from the surrounding old land surface, but all of this material may be residual, and so it provides only a *terminus post quem*. The same applies to a single charcoal sample from the pre-mound surface (GrN-12358, 4490±60 BP: 3365–2942 cal. BC). A sample provided by a calcined cranial fragment found against Orthostat 29, near the start of the passage extension of Tomb 1C West (see Chapter II; Fig. 2.32), returned a result of 3327–2920 cal. BC (OxA-21993, 4423±36 BP). This falls within the main period of use seen in both the western and the eastern tomb, but its relationship to the construction of Tomb 1C is unclear (it may derive from pre-existing deposits in the western tomb, or it may have been deposited after the construction of the passage extension of 1C). Four samples derive from contexts interpreted as relating more directly to the construction of the large mound (Table 4:6). Two samples of multiple long-bone fragments (three in one case, and two in the other) were taken from a discrete deposit of cremated bone found halfway up the

Table 4:6—^{14}C determinations relating to Tomb 1C.

Context	Sample	Material	Lab. code	^{14}C yrs BP	±	Cal. BC (95%)	
Tomb 1C West, Orthostat 5	50159a	Cremated bone	OxA-21992	4261	31	2920	2762
Tomb 1C West, Orthostat 5	50159b	Cremated bone	UBA-12681	4160	23	2877	2636
Tomb 1C West, Orthostat 29	50158	Cremated bone	OxA-21993	4423	36	3327	2920
Tomb 1C East, 'wood and bone deposit'	S52-5	*Corylus* wood	UBA-12887	4503	27	3347	3098
Tomb 1C East, 'wood and bone deposit'	50057	*Bos* mandible	UBA-14647	4301	24	3008	2882

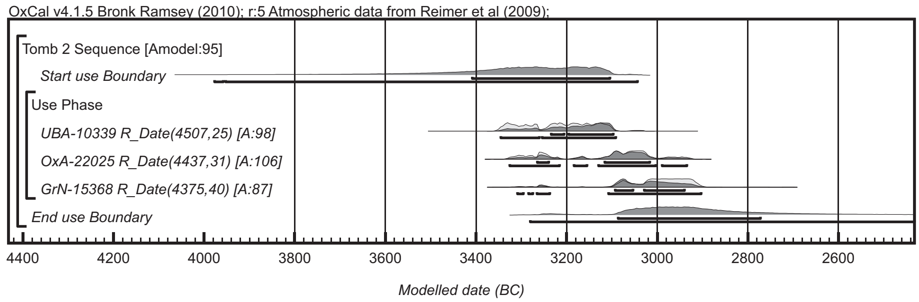
deposits lying against the rear of Orthostat 5, near the outer end of the western tomb's passage extension (see Section 2.4.8; Fig. 2.56). The two samples should relate to a single depositional event, but the dates cannot be combined (χ^2, T = 6.87 (5%, 3.8)). The results are among the four latest determinations for the entire site complex and would suggest, somewhat surprisingly, that the construction of Tomb 1C occurred in the period 2900–2700 BC.

There is a problem here, however, in that two determinations on what was thought to represent an *in situ* 'wood and bone deposit' in the mound, just to the south of the extension of the eastern tomb's passage (see Section 2.4.4; Fig. 2.41), are both earlier than the cremated bone behind Orthostat 5. Moreover, they are again inconsistent with one another, with a wood sample (*Corylus avellana*) being significantly earlier than a non-burnt cattle (*Bos taurus*) mandible. This alone calls into question the stratigraphic integrity of this deposit. One might take the position that the chronologically latest determinations, those from behind Orthostat 5 of the western passage extension, should provide the most reliable estimate for the construction of Tomb 1C. As shall be seen, although this is possible, it sits uncomfortably with the overall range of funerary activity at Knowth and would imply that the mound was built only after the site had already largely gone out of use for burial. Of course, this may have been the case, but an alternative interpretation for this burial deposit is that it was placed behind the orthostat after the construction of the mound. That a gap may have been present here receives tentative support from the apparent slippage of a roof corbel behind Orthostat 5 encountered during the excavations (see Fig. 2.56).

4.3.5 Tomb 2

Three new determinations are available from Tomb 2 (Table 4:2): two on cremated bone from the chamber's right-hand (south-western) recess, and one on non-burnt bone from the passage. From the chamber, one sample derives from under the stone basin (OxA-22025, 4437±31 BP: 3329–2929 cal. BC), and the other from a scatter of cremated bone around the basin (UBA-10339, 4507±25 BP: 3348–3100 cal. BC). The results are indistinguishable, falling within the late-fourth-millennium

Fig. 4.9—Modelled calibrated results for Tomb 2.



BC plateau. The single non-burnt sample from an adult male cranium and femur designated 'Burial 1' (originally Burial 15—Weekes in Eogan 1974a, 84) in the passage is somewhat later (GrN-15368, 4375±40 BP: 3261–2902 cal. BC) but is in agreement with a model assuming a single phase of continuous activity (Fig. 4.9). Of course, a model based on only three results, with no stratigraphic relationships, is of limited utility, and the non-burnt bone may equally reflect a distinct phase of secondary activity in the passage. It is clearly not late enough, however, to be associated with the Beaker sherd (3761), one of several sherds from what is probably a single pot found nearby in this tomb (Eogan 1984, 307). One of the two previously available determinations derives from a charcoal spread thought to be associated with the Beaker sherds, but it seems too late for this and also has such a large error term that it should be rejected in any case (BM-786, 3185±225 BP: 2025–901 cal. BC) (Eogan 1984, 305). The other charcoal determination post-dates the results from bone (BM-785, 4158±126 BP: 3090–2349 cal. BC) but is noted as deriving from the mound near the area of Beaker disturbance.

4.3.6 Tomb 3

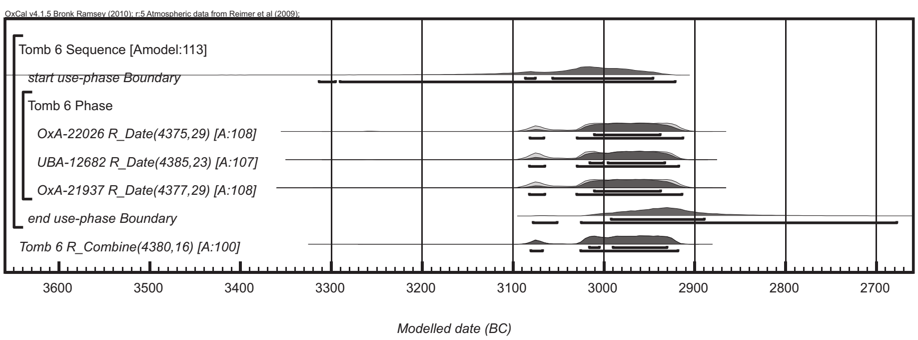
Tomb 3 is represented by a single determination on cremated bone, 3624–3372 cal. BC (UBA-10338, 4687±24 BP). Aside from the problematic determination from the left-hand recess of Tomb 1B East (UBA-10340), this is the earliest result from human bone in the present project (see Table 4:2). Unfortunately, having to rely on a single sample—the limited amount of cremated bone found appears to belong to a single individual—means that it is uncertain whether this is a statistical outlier (see below) or whether it indicates that this may indeed be one of the earliest passage tombs in the Knowth complex. Complicating interpretation further is the problem noted above — that old carbon from the pyre fuel may, depending on the age of the wood used, impact on the dating of cremated human bone. Interestingly, this tomb is unusual at Knowth in that it consists of a closed rectangular chamber, lacking a passage (Eogan 1984, 28). In addition, the finds included a burnt segmented bone pin with possible Iberian affinities that is thought to have been early (Eogan 1984, 30; 1986). Both features may support a cautious acceptance of the early date.

4.3.7 Tomb 6

Three determinations are available from the right-hand (northern) recess of Tomb 6 (Fig. 4.10). Two are on cremated bone, belonging to an adult and a sub-adult, with the third from non-burnt adult bone. Thus, it is likely that three individuals are represented. The results are identical, and as they fall on a steep part of the calibration curve just after the late-fourth-millennium BC plateau, when combined (4380±16 BP; (χ^2, T = 0.1 (5% 6.0)), they provide a tight range of *c*. 3080–2920 cal. BC. There is no stratigraphic relationship between the samples, and given the small number of determinations, a simple Bayesian model treating them as a single phase of activity can only provide wide-ranging estimates for the start and end of use. Nevertheless, the consistency of the three results suggests that this is potentially one of the later monuments at Knowth, but of course relating use to construction is problematic, and we may be seeing only its final phase of use.

It is not inconceivable that the cremated human remains are associated with the Grooved Ware pot (3773) found in the same recess, and indeed it may even have held the cremated remains (Eogan 1984, 312; Eogan and Roche 1999, 103–4), although there is no parallel for this practice to the authors' knowledge. Furthermore, the pot is in an early style. A.L. Brindley (1999a) places the appearance of this tradition in Ireland as early as *c*. 3000/2900 BC, specifically noting its connections with passage tombs and Carrowkeel Ware (see also Sheridan 2004). As noted above, whether the dating results reflect primary use of the monument is uncertain; if they do, they present the intriguing possibility that users of Grooved Ware constructed an Irish passage tomb. A recent dating programme at the Orcadian chamber tomb of Quanterness places that monument's initial use in the period *3510–3220 BC* (95% probability) with an entirely Grooved Ware assemblage (Schulting *et al.* 2010).

Fig. 4.10—*Modelled calibrated results for Tomb 6.*



However, this may be too early for the pottery, because the first results of a recent dating programme involving the temporal currency of Orcadian Grooved Ware make it seem unlikely that this distinctive ceramic tradition appeared before *c.* 3200 BC (MacSween *et al.* 2015). But this is still entirely consistent with the tradition's arrival in Ireland sometime around 3000 BC.

4.3.8 Tomb 9

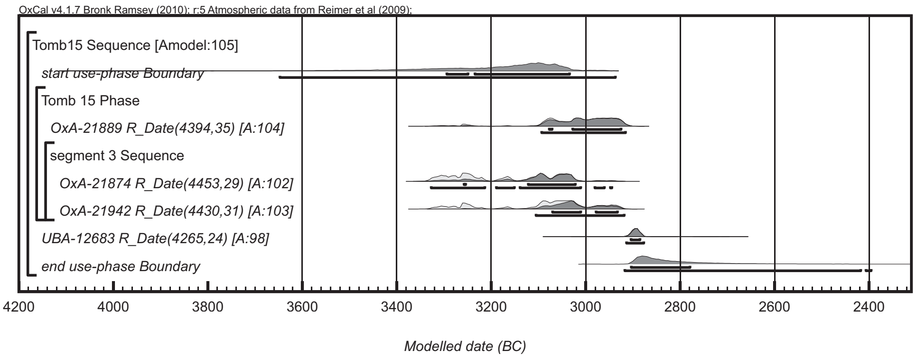
A new determination of 3083–2903 cal. BC (OxA-22027, 4357±30 BP) on cremated bone from Tomb 9 joins the previously available result from charcoal (a *terminus post quem*) from the chamber's end recess (GrN-11714, 4415±50 BP: 3332–2910 cal. BC). The two are in reasonable agreement, given the uncertainties inherent in the late-fourth-millennium BC plateau.

4.3.9 Tomb 15

Five determinations are available from Tomb 15, four on cremated bone and one on adult non-burnt bone. Two samples derive from Segment 4, and two from Segment 3, the latter divided into primary and secondary deposits (Eogan 1984, 96–9). A result of cal. AD 428–582 (OxA-21994, 1548±29 BP) from a non-burnt human cranial fragment from Segment 4 is the only sample in the present study that relates to post-Neolithic activity. The other result (OxA-21889, 4394±35 BP: 3263–2910 cal. BC) from this context is consistent with the overall site chronology. OxA-21994 is not discussed further here, other than to note that Late Iron Age and Early Christian activity is well attested at Knowth, including by a series of inhumation graves in the area around Tomb 1C (Eogan 1990a; 2012). Additionally, Tomb 15 itself was disturbed by both an Early Christian souterrain (Souterrain 7) built across part of its mound and the insertion of three burials (Burials 27–9) into Segment 3 of the chamber (Eogan 1984, 90; 2012, 54–6).

The incomplete, cremated remains of an adult and child were also found in the passage of Tomb 15, *c.* 30–40cm above the floor level and in apparent association with an undecorated Beaker vessel (3772; Eogan 1984, 90, 308–12). From our knowledge of Beaker chronology in Ireland and Britain, its date should fall within the second half of the third millennium BC (A.L. Brindley 2007). However, a long-bone fragment from the adult yielded a Late Neolithic date of 2912–2877 cal. BC (UBA-12683, 4265±24 BP), so that at least this individual cannot have been associated with the Beaker vessel. It is worth noting that, although the association with the Beaker pot had formerly been regarded as highly probable, most of the sherds were found outside the compartment containing the spread of cremated remains (Eogan 1984, 309, fig. 117). In the context of the other three Neolithic determinations from Tomb 15, as well as those from the complex overall, the result can be seen as rather late. It is unclear whether this determination is a statistical outlier or if it reflects late use of the monument (although clearly unrelated to the Beaker pot and still within only *c.* 100 years of the end of the main period of use of the entire complex). The stratigraphic

Fig. 4.11—*Modelled calibrated results for Tomb 15.*



position of the sample, well above the floor level, argues for the latter and suggests funerary activity at a time when early Grooved Ware may have been in use at Knowth (see Tomb 6).

With the Early Christian result excluded, the other determinations are consistent with a modelled single phase of activity, with no outliers identified in an outlier analysis. But the use of Tomb 15 falls firmly within the calibration plateau and so can only be said to lie somewhere between *c.* 3200 and 2900 cal. BC. The modelled start and end ranges are far wider than this, again owing to the small number of determinations and limited constraints (Fig. 4.11).

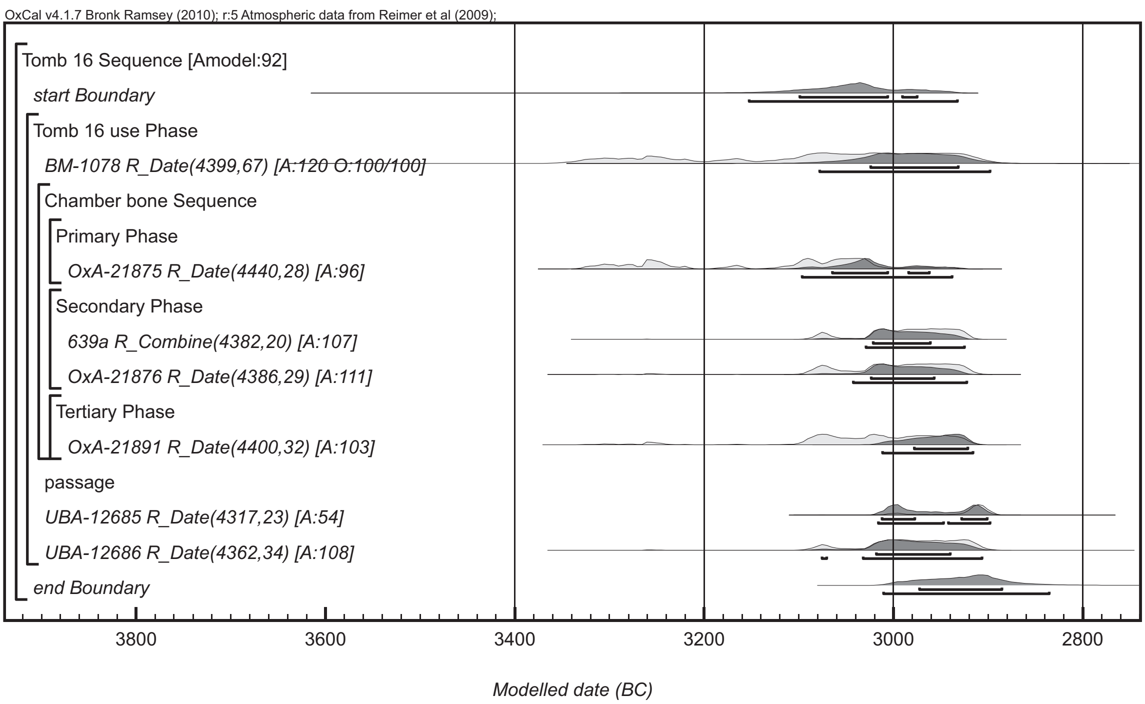
4.3.10 Tomb 16

Seven determinations (one of which is a duplicate) are available from Tomb 16, comprising six from adult cremated bone and one from a non-burnt infant tibia. This monument is of particular interest because of its relationship with Tomb 1C, the construction of which slighted Tomb 16's kerb and necessitated a realignment of its passage to maintain access to its chamber (see Section 2.4.6). The samples reflect the recorded stratigraphy, indicating the presence of primary, secondary and tertiary deposits in the chamber and primary and secondary deposits in the passage (Eogan 1984, 109–23). The non-burnt infant tibia came from the chamber's secondary fill, and its date of 3087–2937 cal. BC (OxA-21876, 4386±29 BP) is indistinguishable from those for the adult cremated bone from both this and the other levels. Although the results do not immediately suggest any chronological separation between the three identified depositional episodes (Table 4:7), it is possible to construct a Bayesian model for the chamber that produces good agreement with the stratigraphy (Fig. 4.12). The primary chamber deposit in particular is securely sealed beneath a very large floorstone (Eogan 1984, pl. 27a). The small number of determinations for each phase limits the model's precision, but it improves on the unmodelled date ranges. The overall use of the chamber is modelled as starting *3150–2930 BC*,

Table 4:7—¹⁴C determinations on bone from Tomb 16.

Context	Sample	Condition	Lab. code	^{14}C yrs BP	±	Cal. BC (95%)	
Chamber							
Primary deposit	637	Cremated	OxA-21875	4440	28	3283	2935
Secondary deposit	639a	Cremated	UBA-12684	4362	25	3081	2908
Secondary deposit	639a	Cremated	OxA-21890	4416	33	3322	2918
Secondary deposit	639a	Cremated	Combined	4382	20	3086	2936
Secondary deposit	639b	Non-burnt	OxA-21876	4386	29	3087	2937
Tertiary deposit	641	Cremated	OxA-21891	4400	32	3077	2914
Passage							
Primary deposit	644	Cremated	UBA-12685	4317	23	3011	2890
Secondary deposit	645	Cremated	UBA-12686	4362	34	3089	2902

Fig. 4.12—*Modelled calibrated results for chamber of Tomb 16. BM-1078 is specified as a charcoal outlier in the model.*



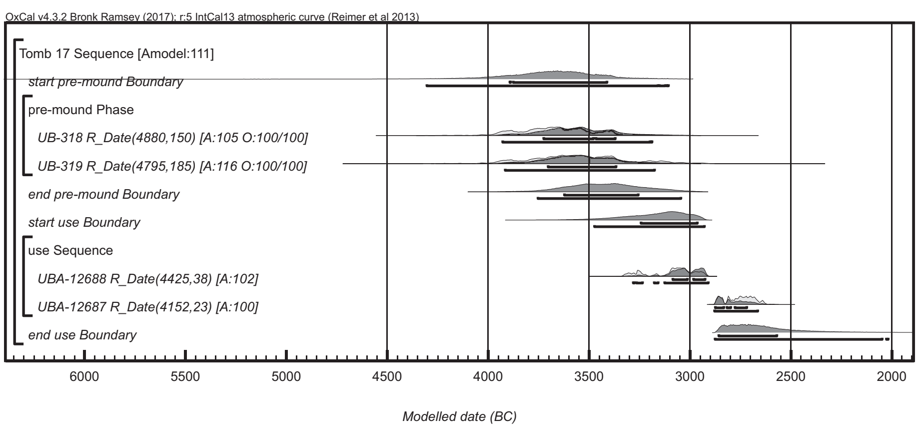
ending *3010–2840 BC*, with a use span of *0–280 years* (*0–150 years* at 68%). The human bone results are consistent with the previous determination of 3335–2900 cal. BC (BM-1078, 4399±67 BP) on charcoal from the mound (specified as a charcoal outlier in the model, Fig. 4.12).

By contrast, the two determinations from the passage cannot be reconciled with the recorded stratigraphy, placing one each in primary and secondary deposits (A_{model} = 48%, not shown). This suggests that either the filling of the passage took place relatively rapidly—and it is important to emphasise that this could still represent activity spanning several generations—or there was substantial disturbance of the deposits. Given the reworking of the passage on the construction of the mound of Tomb 1C, the latter would not be surprising. The relationship between Tombs 1C and 16 is explored further below.

4.3.11 Tomb 17

Four determinations are available from Tomb 17, of which two are early analyses from unidentified charcoal from the old land surface underlying the mound (Fig. 4.13). Taken together, these give a very wide-ranging *terminus post quem* (*3755–3050 BC*) for the deposition of cremated human bone in the chambers, which provided two samples. The first of these derived from Socket 11 in the chamber, yielding a result of 3328–2921 cal. BC (UBA-12687, 4425±38 BP). The second sample, from the upper fill of the passage, yielded a significantly later result of 2874–2634 cal. BC (UBA-12688, 4152±23 BP)—in fact, the latest Neolithic result from the site—suggesting the possibility of considerable longevity for this tomb, or at least an episode of later reuse (discussed below). Pre-monument activity probably preceded the construction and use of the tomb by some centuries (the modelled 95% interval between the two events being *0–575 years*) and so does little to constrain the calibrated date ranges from human bone from the chamber. In fact, the two charcoal determinations on a spread underlying Tomb 17 (UB-318–19; A.G.

Fig. 4.13*—Modelled calibrated results for Tomb 17. UB-318 and UB-319 are specified as charcoal outliers in the model.*



Smith *et al.* 1971) may relate to the Early Neolithic occupation underlying the adjacent Tomb 1C mound.

4.3.12 Tomb 18

Owing to the limited amount of human bone recovered from the heavily disturbed Tomb 18, only two samples were submitted, both from cremated adult bone. One (745), from the right-hand (eastern) recess, appears to have been incompletely calcined and failed to yield a result, leaving a single determination on a sample from under the floorstone in the left-hand (western) recess, 3328–2928 cal. BC (OxA-22028, 4434±30 BP). Even if the latter part of the estimate is emphasised (66.5% of the 95% probability distribution falls in the range 3122–2928 cal. BC), it is unlikely that this deposit of cremated bone can be associated with sherds of a Grooved Ware vessel (3774) found overlying the floorstone in the left-hand recess, particularly because these are in what A.L. Brindley (1999a) has termed the 'Dundrum-Longstone type', as seen in the postpits of the timber circle; this style has been placed in the mid-third millennium BC (Brindley 1999a, 31; Eogan and Roche's (1997a, 211) 'Knowth Style': see below and Appendix 4). Mixed charcoal from the left-hand recess and putatively associated with the Grooved Ware sherds gave an even later result of 2452–1954 cal. BC (GrN-9325, 3750±70 BP) but should be treated with caution given the nature of the sample.

Given the small number of relevant determinations from Tombs 17 and 18, three in total, a model of the proposed relationship between the two, that is that Tomb 18 was constructed first (Eogan 1984, 145; 1998, 170), is of limited utility. However, such a model is in good agreement (A_{model} = 108.3%, not shown) with this ordering of events. The relationship between Tomb 1C and Tombs 17 and 18 is explored further below.

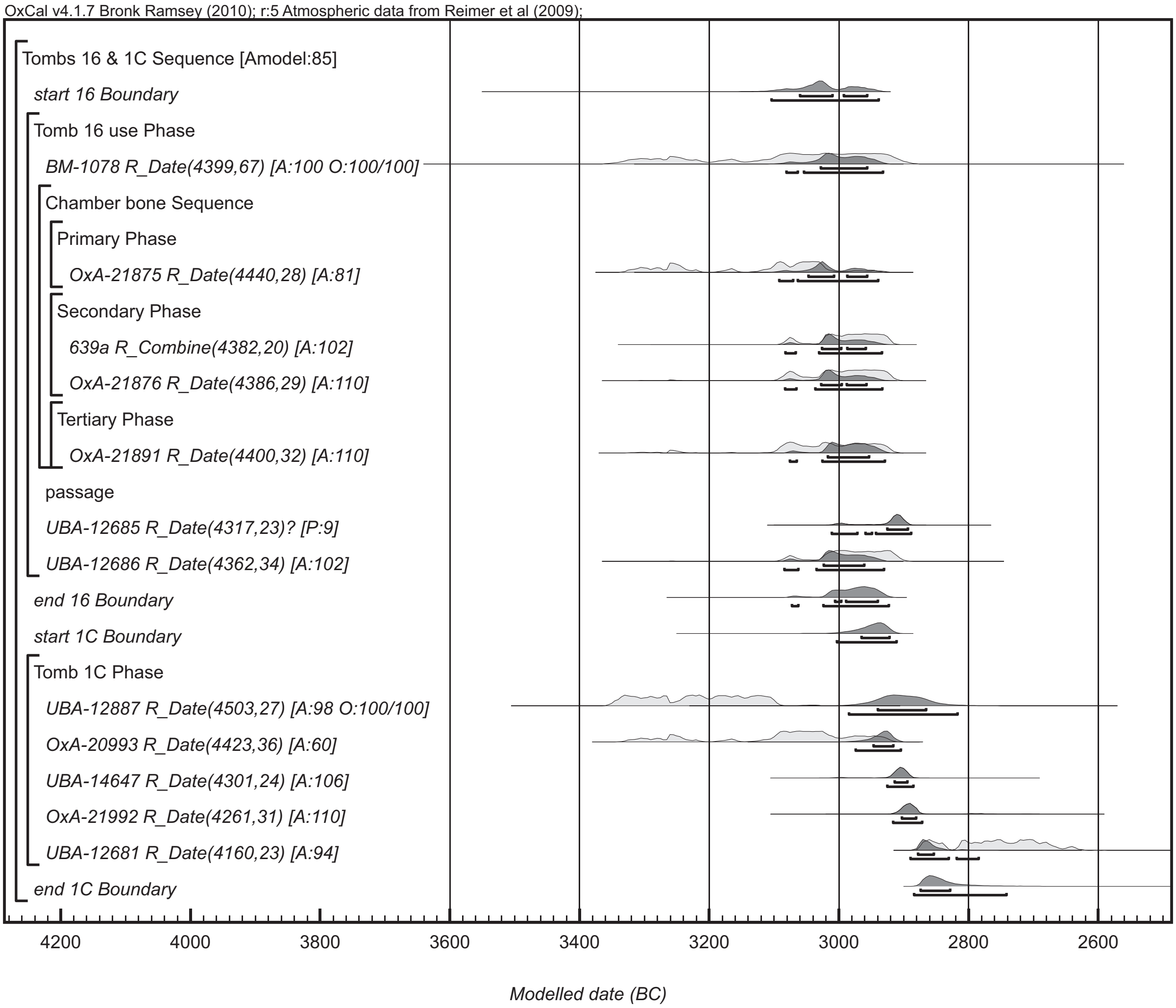
4.3.13 Relationship between tombs 1 and 16

In two cases, it is possible to investigate sequences of monument building proposed on stratigraphic grounds. (A third case, Tomb 13, was also affected by the construction of Tomb 1C (Eogan 1984, 79), but only a few small fragments of cremated bone were found in its chamber, insufficient for dating.) In the first of these, the construction of the great mound designated Tomb 1C impinged on the small mound of Tomb 16, resulting in the removal of a number of the latter's western kerbstones and the blocking of its original entrance (see Section 2.4.6; Fig. 2.61). However, continued access to Tomb 16 was clearly still felt to be necessary, as the passage was remodelled to facilitate this, by creating a sharp turn to the east (Eogan 1984, 109, fig. 50). Although there is good reason, then, to believe that Tomb 16 was the earlier monument, at least some of its contents may postdate the construction of the Tomb 1C mound. In principle, dating the construction of Tomb 16 should provide a means of refining the date of construction of the large mound of Tomb 1C. However, as discussed above, the dating of the latter event is itself problematic, and two scenarios emerge, neither of which can be said to be very secure: the first considers the two determinations on the 'wood and bone deposit' on the southern side of the eastern passage, and the second the two determinations on the discrete cremated bone deposit behind Orthostat 5 in the western passage of the Tomb 1C extension. The results from the former feature are themselves inconsistent, with the wood sample (*Corylus avellana*) being significantly earlier than the cattle mandible from the same context. Hazel should not be subject to the degree of in-built age that the difference in the results would imply, but if the date on the cattle mandible is assumed to be correct, it would post-date all of the evidence for funerary activity in Tomb 16, as would the results from behind Orthostat 5.

Given these uncertainties, a Bayesian model treats all of the determinations attributed to Tomb 1C (see Table 4:6) as a single phase, post-dating deposition in Tomb 16. In an initial run (not shown), two results are highlighted as outliers, causing the definite rejection of the model (A_{model} = 6.3%). The first, UBA-12887 (4503±27 BP), from *Corylus* (A = 0.4%) from the 'wood and bone deposit' in 1C, can be treated as an outlier, even though this should be a short-lived species (the alternative being to exclude it altogether). The second, UBA-12685 (4317±23 BP), from cremated bone from the passage of Tomb 16 (A = 18.1%), can be explained as evidence of later deposition in the realigned passage, necessitated by the construction of the mound of Tomb 1C as noted above. Removing this result leads to an acceptable model in good agreement (A_{model} = 84.7%) with the proposed ordering of events (Fig. 4.14). This places the end date for deposition in Tomb 16 (excluding UBA-12685) in the range *3075–2925 BC* and the start date for the mound of Tomb 1C in the range *3000–2910 BC*, with an interval between the two of *0–75 years* (95%) or *0–34 years* (68%). The end date for 1C is estimated here as *2885–2740 BC*; as noted previously, the date of the construction of the great mound remains problematic because of uncertainties about the interpretation of the stratigraphic relationships of the Tomb 1C samples. Nevertheless, it can be noted that this estimate is not inconsistent with the previously modelled end date for pre-mound Tomb 1C, *3015–2730 BC* (Section 4.3.1).

Although not related to the construction of Tomb 1C, an interesting comparison can be made between the use phases of Tomb 1B East and Tomb 16. A Bayesian model placing the determinations from Tomb 16 as a whole before the results from Tomb 1B is totally rejected (failing even to run). The earliest cremated bone deposits in Tomb 1B East (combining Pits A and B in the left-hand recess and Deposits B, C and 1 in the right-hand recess) are earlier than those from Tomb 16 as a whole, and the situation is not changed significantly by omitting these early results from the model. It is intriguing that the deposits in Tomb 1B East are as early as any of the other dated passage tombs at Knowth (although it must be recognised that most of the other monuments provided far fewer determinations), given the late position that most researchers have assigned to the central monument in the Knowth sequence (see, for example, Sheridan 1986; Cooney 2000). But, of course, this claim relates to Tomb 1C and returns us to the point that both eastern and western chambers and inner passages belong

***Fig. 4.14**—Modelled calibrated results for Tomb 16 and Tomb 1C. UBA-12685 is shown but not included in the model; BM-1078 and UBA-12887 are specified as charcoal outliers.*



to an earlier structure or structures (Tomb 1B), as well as there being the strong possibility of yet another passage tomb or tombs (1A) that had been dismantled and incorporated into both Tomb 1B and the extended passages of Tomb 1C. This makes good sense in terms of the orientation of the 'satellite' tombs, most of which are focused on the space that was to become occupied by Tomb 1C (Section 2.1; see also Cooney 2000, 153).

4.3.14 Relationship between Tombs 1C and 17

It was originally proposed that Tomb 17 was constructed over a spread of granite and quartz related to Tomb 1C (Eogan 1984, 145), and so its construction and use would therefore post-date the large mound. This relationship was seen as tentative, however, and would be problematic if the late construction date for Tomb 1C were accepted (that is, a model positing this sequence is rejected).

4.4 Stable isotope results

Collagen from the fifteen non-burnt human bone samples in the project was also analysed separately for stable carbon (δ^{13}C) and nitrogen (δ^{15}N) isotope values. These isotopes are widely used to assess past diets, and in prehistoric temperate Europe they inform primarily on the consumption or non-consumption of marine foods (Schulting and Richards 2002a; 2002b; Schulting 2011). In north-western Europe the endpoints for marine and terrestrial δ^{13}C values in human bone collagen are *c.* –12% and –21%, respectively. Stable nitrogen isotopes have the potential to inform on the consumption of marine and freshwater foods and also on the relative proportions of animal and plant protein sources in the diet. Their interpretation, however, is not straightforward, particularly in the absence of comparative faunal material from the same site (Hedges and Reynard 2007). Therefore, we primarily consider δ^{13}C values, and the question of whether individuals 'buried' (if the term can be used for the fragmentary non-burnt human bone present) at Knowth consumed any significant quantities of marine protein. By 'significant' is meant *c*. 5–10% or more of total protein intake, averaged over the last decade or more of life for adults (less for infants and children). The occasional consumption of marine foods (less than 5%) will be difficult to detect through the isotopic measurement of bulk collagen.

The average δ^{13}C value of the 11 adult (or adult-size) Neolithic samples is –21.5±0.4‰, and the average δ^{15}N value is 10.7±0.3‰ (Tables 4:8 and 4:9). The average δ^{13}C for three infants is identical to that of the adults, whereas the average δ^{15}N value is slightly higher, at 12.0±0.9‰. This order of difference between adults and infants or larger is often seen, and it reflects the fact that nursing infants are raised by a trophic level above their mothers (Schurr 1998).

The results therefore indicate very little or no consumption of marine protein. Although assuming a slightly lower terrestrial endpoint of –22‰ (feasible in the light of the observed values—see also Lanting and van der Plicht 1998, who suggest an average of *c*. –21.7‰ for Irish human bone) would permit a contribution of *c*. 5% marine protein, this might be expected to result in at least a slight positive correlation with the δ^{15}N values (M.P. Richards and Hedges 1999), which is not observed (r = –0.05). Of course, Knowth is not a coastal site, with the open coast lying *c.* 15km to the east, although the estuary of the River Boyne, and its tidal reach, is about one-half of this distance from Knowth. Perhaps more interestingly, the absence of a marine signal also argues strongly against any significant use of salmon from the river itself. Spending most of their lives in the sea before returning to spawn, salmon have predominantly marine δ^{13}C values, and their consumption would be readily apparent (see, for example, Lovell *et al*. 1986). This lack of evidence for the use of marine protein is consistent with other isotopic results seen across Ireland and Britain, including at coastal areas (Schulting and Richards 2002a; 2002b; M.P. Richards *et al*. 2003; Woodman 2004; Schulting *et al*. 2010).

Table 4:8—Stable isotope values on non-burnt human bone collagen. Sample 161b was measured at both Oxford and QUB; the average of the two values is used to calculate the figures for Table 4:9. Sample 595b post-dates the Neolithic (AD 428–572).

Tomb	Sample	Age	Lab. no.	δ^{13}C	δ^{15}N	C:N	Element
1B East	170	Adult	OxA-21925	–21.5	10.9	3.1	Rib
1B East	173b	Adult	OxA-21927	–21.1	10.7	3.1	Large mandible
1B East	173c	Adult	OxA-21928	–21.0	10.8	3.1	Small mandible
1B East	161b	Adult	UBA-12674	–21.6	10.4	3.2	Metatarsal fragment
1B East	161b	Adult	OxA-21930	–21.3	10.9	3.1	Duplicate of above
1B East	163b	Sub-adult?	OxA-21931	–21.7	10.8	3.1	Cranial fragment
1B East	50146c	Adult	OxA-21932	–21.4	10.1	3.1	Metatarsal I
1B East	422b	Adult	OxA-21933	–21.6	10.7	3.2	Vertebra
1B East	218b	Adult	OxA-21934	–21.2	11.1	3.2	Vertebra
1B East	50148b	Adult	OxA-21936	–21.5	10.2	3.1	Metacarpal
1B East	183	Adult	OxA-21984	–21.9	10.7	3.1	Cranial fragment
6	104c	Adult	OxA-21937	–22.5	10.9	3.1	Hand phalanx
15	595b	Adult	OxA-21994	–21.4	12.4	3.1	Cranial fragment
1B East	173d	Infant	OxA-21929	–21.3	12.8	3.1	Ilium, 39mm × 30mm
1B East	218c	Infant	OxA-21935	–21.1	11.1	3.1	Vertebral arch
16	639b	Infant	OxA-21876	–22.2	12.2	3.1	Tibia

Table 4:9—Average δ^{13}C and δ^{15}N values for adults and infants (excluding post-Neolithic sample 595b).

	Adult			Infant		
	$\overline{X}$ ‰	±	n	$\overline{X}$ ‰	±	n
δ^{13}C	–21.5	0.4	11	–21.5	0.6	3
δ^{15}N	10.7	0.3	11	12.0	0.9	3

A recent dating and stable isotope study on earlier Neolithic to Early Bronze Age human remains recovered from mortuary monuments in Northern Ireland found no significant differences in either δ^{13}C or δ^{15}N between individuals from coastal and inland sites (Schulting *et al*. 2012).

4.5 Discussion

From the above discussion of the determinations on individual tombs, the dating results are generally, but not always, compatible with the recorded stratigraphy, although this needs to be seen in the light of the considerable leeway in modelling imposed by the late-fourth-millennium BC calibration plateau. Discrepancies involving individual samples (for example from the passage of Tomb 16) might be the result of disturbance, including reworking of the deposits during the Neolithic as well as possible later activity, or might reflect the complex nature of the original deposition itself. Certainly, the cremated bone, and probably also much of the non-burnt bone, was introduced to the chambers and passages from elsewhere (Plates 4:1 and 4:2). The possible role of organic vessels or, indeed, Carrowkeel bowls in transporting bone to the site is suggested by the presence of such a vessel containing cremated bone in the earthen enclosure at Monknewtown (Sweetman 1976) and by a bowl containing both cremated and non-burnt human bone at the Mound of the Hostages, Tara (M. O'Sullivan 2005, 75–6). If this were the case, normal practice must have been to take the bowls away, because so few have been found (Herity 1974, 138–44). Unlike at Fourknocks II (Hartnett 1971), there is no evidence for sufficient *in situ* burning within or preceding the Knowth tombs to indicate that they held funeral pyres, nor were any traces of cremation pyres identified in the areas around the tombs in the programme of excavations at Knowth. The location of these pyres, then, remains an open question. Perhaps cremation took place near the settlements (poorly known for this period, but see Eogan 1963; Eogan and Roche 1997a; 1997b; Brady 2007a; 2007b; Smyth 2014), with the calcined bone fragments transported to the passage tombs of Brugh na Bóinne at certain times of the year—the winter solstice being the obvious candidate for Newgrange, given the alignment of its roofbox (M.J. O'Kelly 1982). In terms of Knowth, Kate Prendergast (2004) has made the intriguing suggestion that the orientations of the three major tombs of Brugh na Bóinne—Knowth, Newgrange and Dowth—follow the winter solar cycle, with the eastern and western tombs of Knowth 1B aligned on the rising and settings suns, respectively, near the spring and autumnal equinoxes. This is, however, contrary to the analysis undertaken at Knowth by Frank Prendergast and Tom Ray (see Appendix 2), who have conclusively demonstrated that neither of the tombs in the great mound was precisely aligned with the horizon position of the sun at the equinoxes, a finding consistent with wider passage tomb alignments, which show little evidence of any interest by prehistoric societies in the exact event of equinox (F. Prendergast 2011; Ruggles 1998; 1999).

The partial and highly fragmented nature of the non-burnt bone also suggests that much of it may have been introduced in an already disarticulated, defleshed state; this is particularly the case for the chamber recesses. The absence of animal gnawing and the lack of evidence for sub-aerial weathering suggest, however, that it had not been exposed for long periods, through a process of excarnation, for example. Conceivably bodies were buried elsewhere, in marked graves, with skeletal material subsequently retrieved. If so, the selection is odd, consisting of small elements such as metacarpals, metatarsals and ribs or fragments of larger elements such as mandibles and crania: there seems to be no pattern in the material represented (Plate 4:2; see Chapter III). Alternatively, the passage tombs themselves could have served this function, where, even though not buried, bone would not be subject to weathering. But if this were the case, further evidence of the practice might be expected, in the form of some surviving articulations from the last bodies deposited, as seen in the Cotswold–Severn

Plate 4:1—*Cremated human cranial fragments from Tomb 1B East (photo: Rick Schulting).*

Plate 4:2—*Non-burnt human bone fragments from Tomb 1B East (photo: Rick Schulting).*

chambered tomb at Hazleton North, for example (Saville 1990). This needs to be seen, however, in the context of the later disturbance affecting many of the Knowth tombs. As with the cremated bone, the source of the non-burnt bone remains an intriguing question. The partial nature of the non-burnt bone deposits was also identified as a puzzling feature at the Mound of the Hostages, Tara (M. O'Sullivan 2005, 238), although in contrast to Knowth, that site included a number of more or less complete crania.

4.5.1 Cremated and non-burnt bone

With the seven duplicate measurements discounted, 40 cremated bone samples and 18 non-burnt bone samples were analysed (excluding the anomalously early UBA-10340 and the Early Christian result, OxA-21994). At first glance there seems to be no difference in the chronology of these two groups, indicating that the two practices were contemporaneous over the duration of use of the site (Table 4:2). The question is, of course, why one option was chosen over the other in particular situations. It is worth noting, incidentally, that the consistency between the results for the cremated and the non-burnt bone from the same contexts provides further support for the reliability of AMS measurements on calcined bone, despite the potential problem of old fuel carbon that may affect a small number of determinations (Hüls *et al*. 2010; Zazzo *et al*. 2012; Snoeck *et al.* 2014).

Bayesian modelling, treating cremated and non-burnt bone from the site overall as two separate 'phases' of activity, offers another possible way of approaching the evidence. Deposition of the 40 calcined bone samples is modelled as beginning *3440–3370* BC and ending *2875–2790* BC (Fig. 4.15), whereas that of the 18 non-burnt bone samples is modelled as beginning *3170–3030* BC and ending

Fig. 4.15—*Modelled summed probability distribution of cremated human bone ^{14}C dates from Knowth (n = 40). The small spike at 3400 BC is due to a single probable outlier from Tomb 3.*

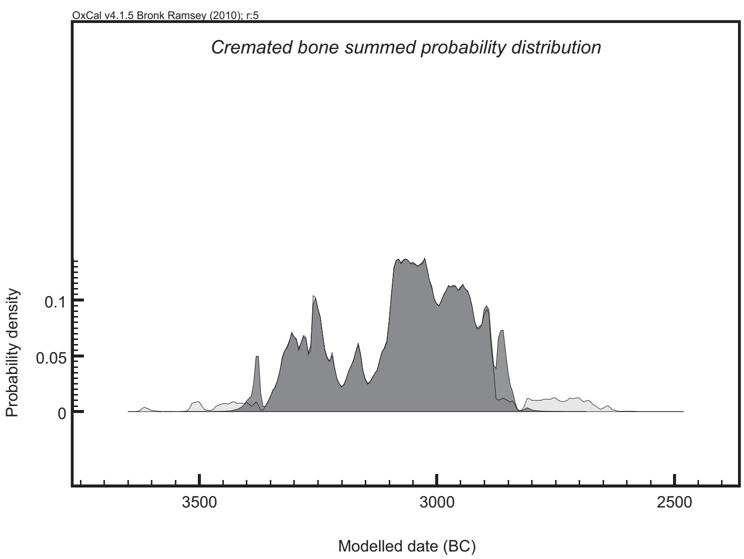


Fig. 4.16—*Modelled summed probability distribution of non-burnt human bone ^{14}C dates from Knowth (n = 18).*

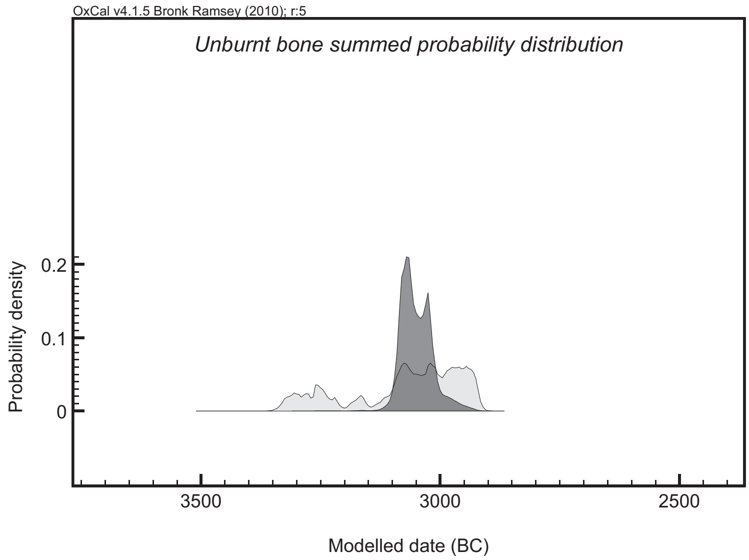
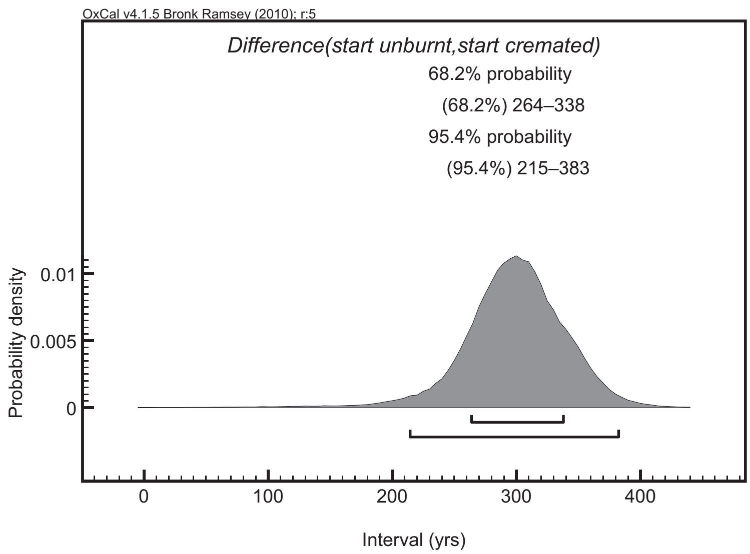


Fig. 4.17—*Difference between modelled start dates for 40 cremated and 18 non-burnt human bone ^{14}C dates from Knowth, modelled as single phases of activity.*



3080–2910 BC (Fig. 4.16). Thus, the deposition of non-burnt bone is modelled as having a much shorter duration, both starting later (Fig. 4.17) and ending earlier, than that of cremated bone (indeed, this is despite retaining one early and two late non-burnt samples with agreement indices of less than 60%, making this a conservative estimate). As all but two of the non-burnt bone samples derive from Tomb 1B East, a comparison of the calcined and non-burnt bone results from that monument alone may be more appropriate (Figs 4.18 and 4.19). Although the difference remains, the early start for the

Fig. 4.18—Comparison of modelled calibrated results for 18 cremated and 15 non-burnt human bone ¹⁴C dates from Knowth Tomb 1B East, modelled as single phases of activity.

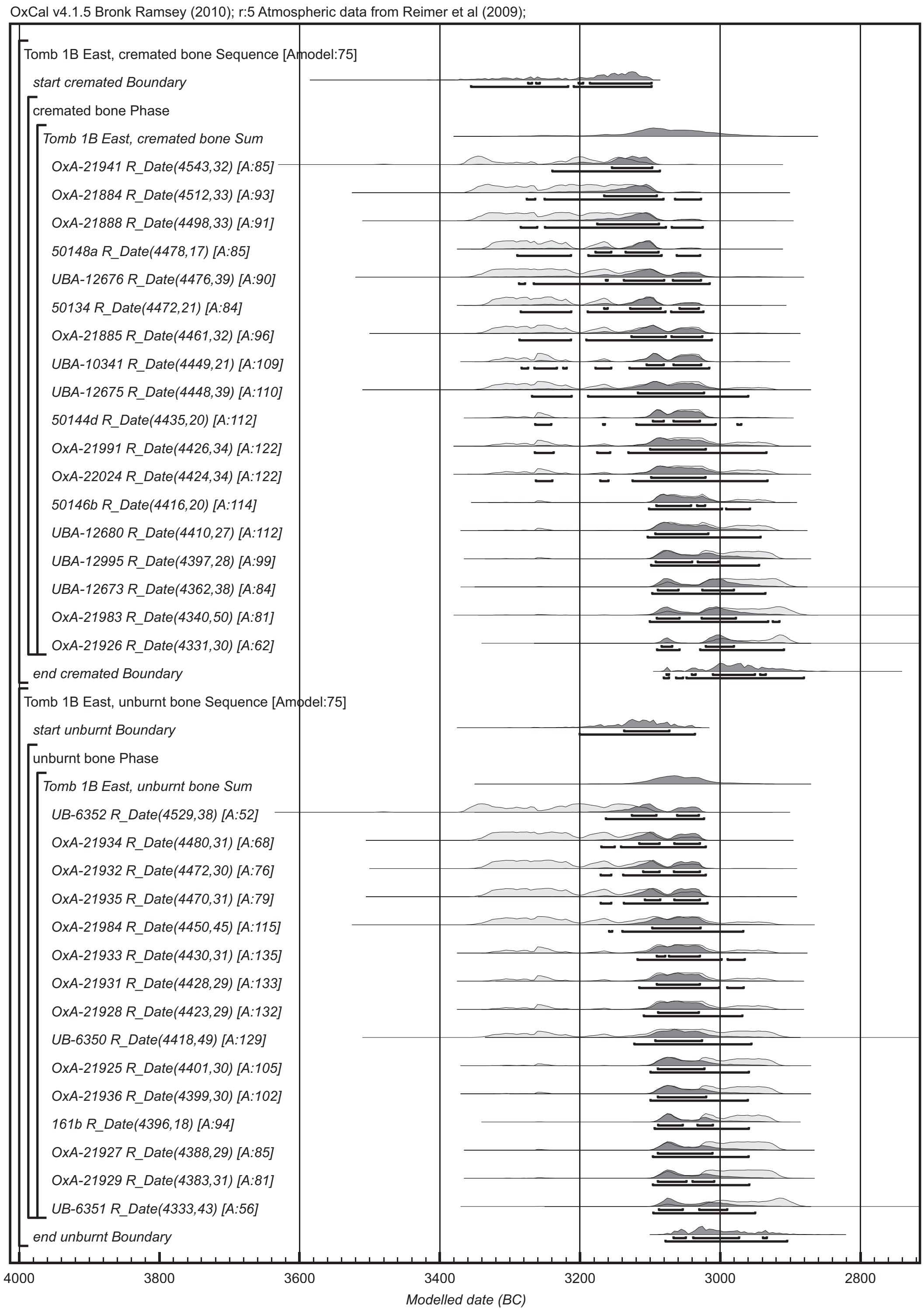
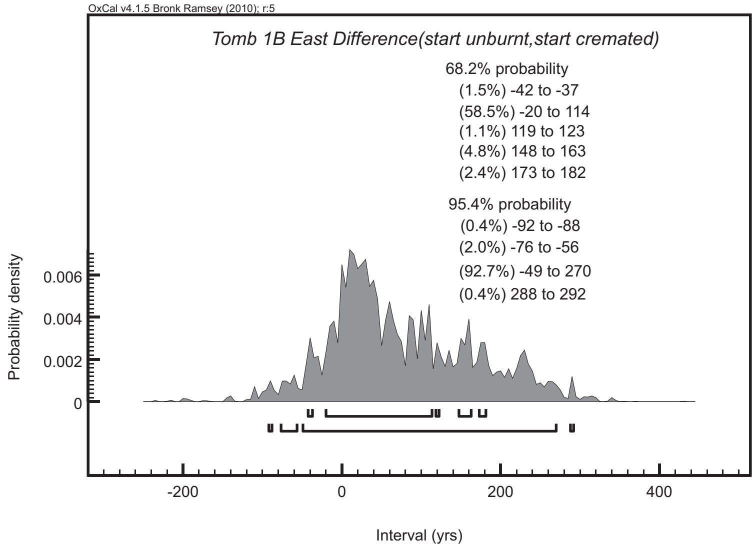


__Fig. 4.19__—Difference between modelled start dates for 18 cremated and 15 non-burnt human bone ^{14}C dates from Knowth Tomb 1B East, modelled as single phases of activity.



cremated bone can be seen to be due in large part to the tail-ends of the 95% probability distributions. Nevertheless, the trend can be said to be suggestive and worthy of further investigation, raising the possibility that the deposition of non-burnt bone was a practice of briefer duration constrained within the passage tomb tradition. A similar pattern may be evident at the Mound of the Hostages, Tara (M. O'Sullivan 2005, 225). However, a different perspective is offered on this below, calling into question any chronological difference in the two funerary practices at Knowth.

Four infant/young child samples were included in the project, partly, as noted above, as one means of ensuring that different individuals (adults and sub-adults) were sampled from the same contexts but also to address the question of whether the infant and child remains were contemporary with the adults or, as has sometimes been suggested, if they were later insertions (see, for example, Finlay 2000). The non-burnt bone is represented by two infants (less than 2 years of age) and one neonate. It is not possible to be precise about the age of the single sub-adult cremated bone sample, but the thinness of the cranial vault fragment suggests that it belongs to a child. In all cases the dating results for the non-adults are consistent with the adults from the same contexts: there is no evidence that the former are later additions. Although no non-burnt infant/child bones were dated from the Mound of the Hostages, these occurred in small numbers in many of the cremated bone deposits (M. O'Sullivan 2005, 237–8).

4.5.2 Use phases of cruciform and undifferentiated tombs

It is possible to compare the results from Knowth's cruciform chambers (Tombs 1B East, 2, 6, 9, 17, 18) with those from undifferentiated chambers (Tombs 1B West, 15, 16). A number of samples are excluded as deriving from demonstrably later contexts (see Section 4.5.4): UBA-12688 from cruciform Tomb 17; UBA-12683 from undifferentiated Tomb 15; and OxA-21992 and UBA-12681 from undifferentiated Tomb 1C West. With the remaining samples from each tomb type treated as a single phase of activity, the cruciform group (n = 41) is modelled as starting *3190–3100 BC* and ending *3030–2920 BC*, whereas the undifferentiated group (n = 11) is modelled as starting *3160–2975 BC* and ending *3020–2870 BC*. The use of the two tomb types thus appears to have been entirely contemporaneous, although the comparison is heavily biased by the large number of determinations from the cruciform Tomb 1B East, in contrast to the limited material available from the undifferentiated Tomb 1B West. It is unfortunate that the other undifferentiated passage tombs either did not yield any suitable bone or yielded bone only from disturbed contexts. Specifically, smaller undifferentiated tombs such as Tombs 8, 13 and 14, not represented in the present study, have been proposed to be among those falling early in the Knowth sequence (Eogan 1968; Sheridan 1986; Cooney 2000). Interestingly, as discussed above, Tomb 3—which can be seen as more similar to an undifferentiated tomb than to a cruciform tomb—presented one of the earliest determinations on human bone in the project, although little confidence can be placed in a single result, which was unfortunately all that was available for this monument.

4.5.3 Modelling funerary activity at the Knowth complex overall

In addition to the tombs being treated separately, the Knowth complex can be considered as a whole, although as with the above analyses of bone state and tomb type, this does not make use of the recorded stratigraphic relationships. Instead, a simple Bayesian model treats all of the bone samples as belonging to a single phase of activity, that is, the use of Knowth for funerary rites resulting in the deposition of both cremated and non-burnt human remains in the various tombs. As discussed above, one determination is rejected as too early (UBA-10340, 4779±25 BP)—its agreement index being only 5.1% when included in the model—and, of course, the Early Christian result (OxA-21994, 1548±29 BP) is also excluded. Models were run with and without UBA-10338 (4687±24 BP)—because there are indications (see Section 4.5.4) that this is also an outlier—which makes a significance difference in the modelled start date. The model including UBA-10338 indicates that the use of the complex for burial probably started *3430–3370 BC* and ended *2875–2820 BC* (Model 1 in Table 4:10; Fig. 4.20), spanning *500–580 years*. With UBA-10338 excluded, the modelled

Table 4:10—Modelled start and end date ranges for burial activity at Knowth, treating all samples as a single phase of activity. All models exclude UBA-10340 (4779±25 BP) and OxA-21994 (1548±29 BP) as extreme outliers.

Model	*n*	Start BC (95%)		End BC (95%)		Span (95%)		A_{model}	Notes
1	58	3420	3370	2875	2820	505	580	95.2%	All results (excludes UBA-10340, OxA-21994)
2	57	3275	3110	2875	2840	240	365	105.3%	Excludes UBA-10338 as an outlier
3	55	3190	3110	2915	2875	205	300	103.3%	Excludes UBA-10338, UBA-12681 and UBA-12688 as outliers
4	53	3160	3045	3020	2920	100	220	80.3%	Excludes UBA-10338 and four latest results as secondary activity (Table 4:11)

start date becomes *3275–3110 BC* and the end date *2875–2840 BC*, spanning *240–365 years* (all 95% probability) (Model 2 in Table 4:10). Although many determinations fall within the radiocarbon plateau between *c*. 3350 and 3000 BC, this model places the use of the cemetery as extending up to nearly two centuries beyond the turn of the third millennium BC, that is, into the Late Neolithic. This is consistent with the proposed end of primary passage tomb use recently modelled by Cooney *et al*. (2011, 657). It is also worth noting an apparent decline in funerary activity between *c*. 3200 and 3100 BC. Although the calibration curve certainly plays a role here, the observed distribution does not appear to be entirely an artefact of the curve (Fig. 4.21).

The dating programme for the passage tomb of the Mound of the Hostages, Tara (A.L. Brindley *et al*. 2005; M. O'Sullivan 2005), provides a useful comparison with the Knowth results, especially as the dates have recently been subjected to detailed Bayesian modelling. The preferred model in Bayliss and O'Sullivan (2013) presents an estimated start date for Neolithic burial activity of *3345–3095 BC*, with the main phase of activity in the slightly later range *3285–3075 BC*, and the primary use of the passage for the deposition of human remains ending *3090–2910 BC* (all 95% probability). Both start and end estimates are very similar to those for Knowth, although activity at the latter seems to continue somewhat longer. However, a different perspective on this is offered below.

An obvious difference between the two sites is that the Mound of the Hostages, after a gap of some centuries, became the focus for Early Bronze Age burial activity, from 2270–2030 BC to 1800–1570 BC (A.L. Brindley *et al*. 2005) or, as recently modelled, from *2140–1980 BC* to *1860–1730 BC* (Bayliss and O'Sullivan 2013). By contrast, none of the 60 determinations on human bone from the Knowth complex falls within this period, nor indeed does any of the charcoal and charred hazelnut shell dates. Yet there is abundant evidence for Beaker activity at Knowth, comprising more than 3,000 sherds from

Fig. 4.20—*Modelled distribution of 58 human bone* ^{14}*C dates from Knowth (excluding UBA-10340), treated as a single phase of activity. UBA-10338 has a strong influence on the start and span of activity. Asterisks indicate non-burnt bone.*

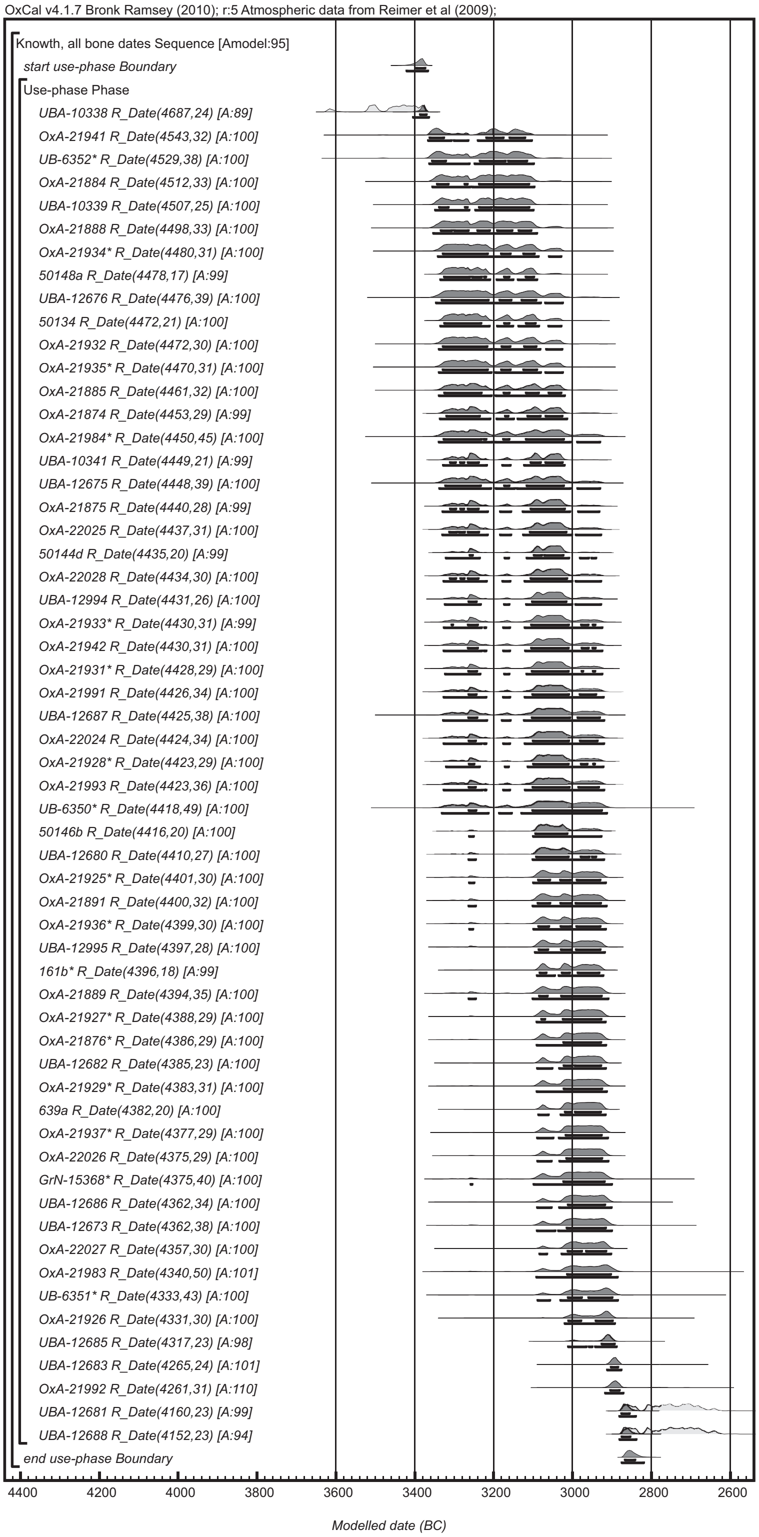
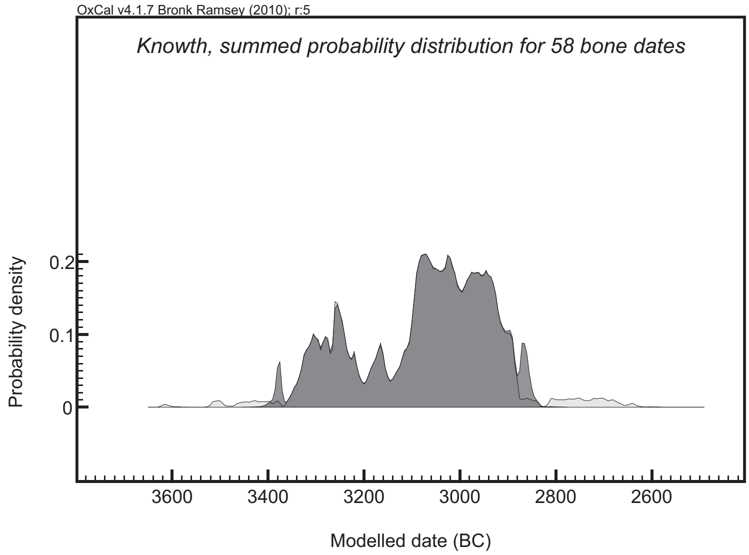


Fig. 4.21*—Modelled summed probability distribution for 58 human bone* ^{14}*C dates from Knowth. The spike just after 3400 BC is due entirely to UBA-10338.*



five distinct concentrations, although there are no associated radiocarbon dates for this phase (Eogan 1984; Eogan and Roche 1997a). This difference in the later histories of the two sites is striking. Indeed, the paucity of evidence for Bronze Age activity appears to extend across Brugh na Bóinne as a whole (Brady 2007a, 297; Eogan 2009; Smyth 2009, 37), although such activity is recorded nearby (Smyth 2009, 39; Eogan and Roche 2012).

4.5.4 Possible late onset of activity at Knowth

The modelled results in the preceding sections (see in particular Figs 4.8, 4.9, 4.11, 4.13) present the possibility that the main phase of funerary activity at Knowth may be even more tightly constrained than indicated above. This was explored using outlier analysis models in OxCal 4.1.5 (Bronk Ramsey 2009b). The first analysis, including the standard series of 58 measurements (that is, excluding UBA-10340 and OxA-21994), highlighted three determinations as outliers: UBA-10338 (with a 100% posterior probability of being an outlier), UBA-12681 (85%) and UBA-12688 (87%). Their removal from a subsequent analysis (Fig. 4.22) provides a modelled start date for activity of *3190–3110* BC. The modelled end range is *2915–2875* BC, with a use span of *205–300 years* (Model 3 in Table 4:10; Figs 4.23–4.25). However, the model can be constrained even further. As discussed below, there are four determinations from demonstrably secondary contexts. These include the two late results identified in the outlier analysis and an additional two results (UBA-12683 and OxA-21992). Excluding these from the main phase of funerary activity leaves 53 determinations, presenting a modelled start date of *3160–3045* BC and end date of *3020–2920* BC.

Fig. 4.22—*Modelled distribution of 55 human bone ^{14}C dates from Knowth treated as a single phase of activity. Three results (UBA-10338, UBA-12681 and UBA-12688) are shown but not included in the model. Asterisks indicate non-burnt bone.*

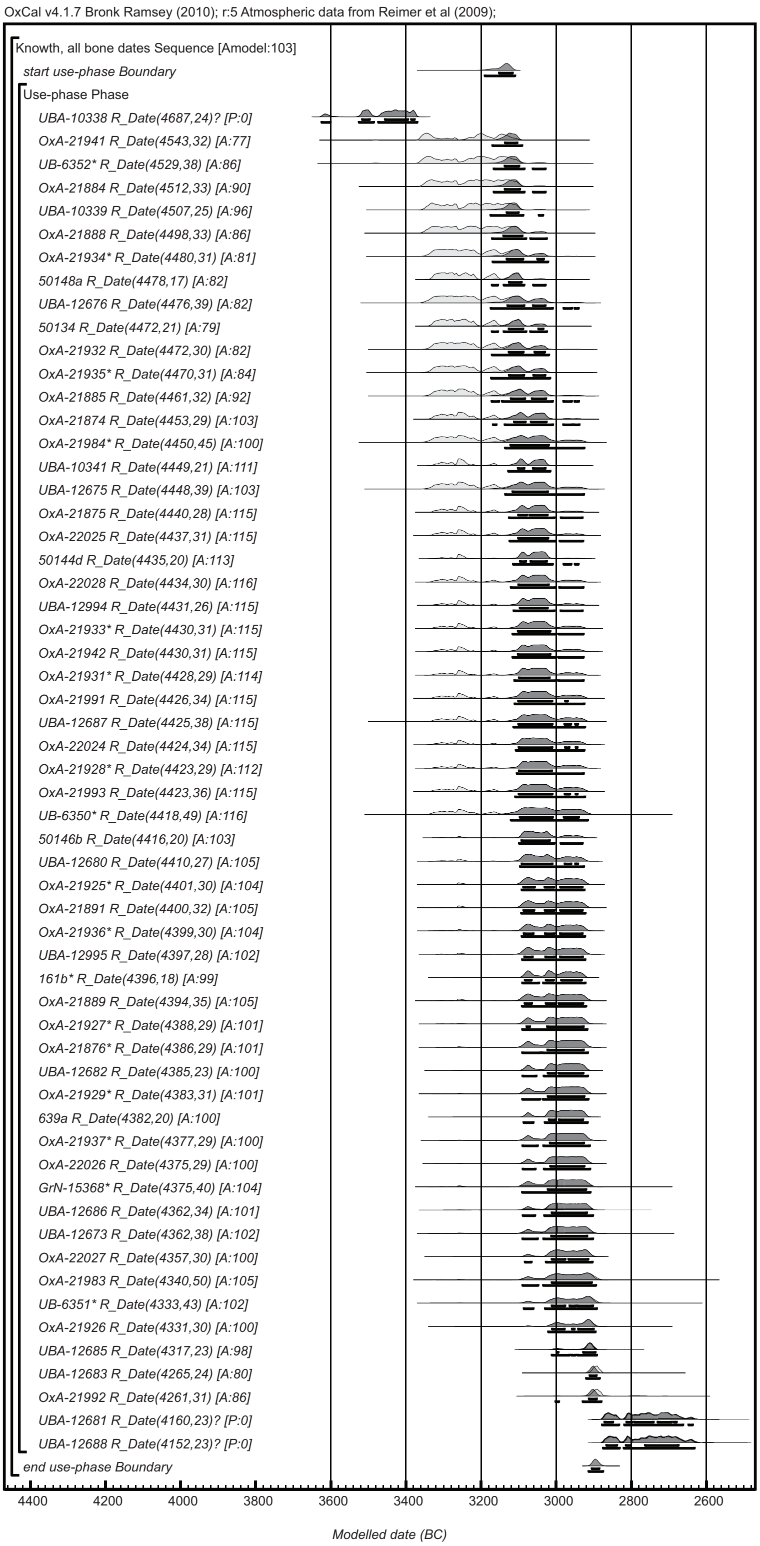


Fig. 4.23—*Modelled summed probability distribution for 55 human bone* ^{14}*C dates from Knowth, excluding three results (Model 3 in Table 4:10).*

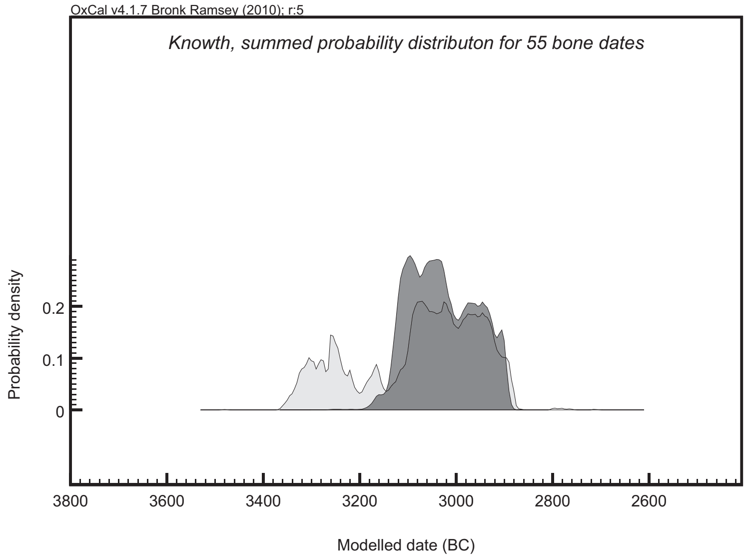
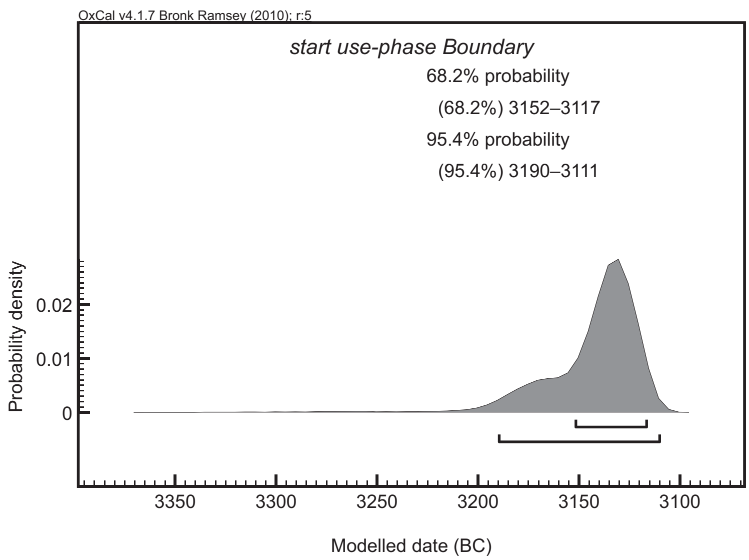


Fig. 4.24—*Modelled start date for 55 human bone* ^{14}*C dates from Knowth, excluding three results (Model 3 in Table 4:10).*



The overall span of use in this model is as little as *100–220 years* at 95% probability (*110–170 years* at 68%) (Model 4 in Table 4:10; Figs 4.26 and 4.27). The similarity to the modelled start and end ranges for the main phase of human bone deposition at the Mound of the Hostages (*3285–3075* BC and *3090–2910* BC) is striking and suggests that this passage tomb was contemporary with the Knowth complex.

Fig. 4.25—*Modelled use span based on an outlier analysis of 55 human bone ^{14}C dates from Knowth, excluding three results (Model 3 in Table 4:10).*

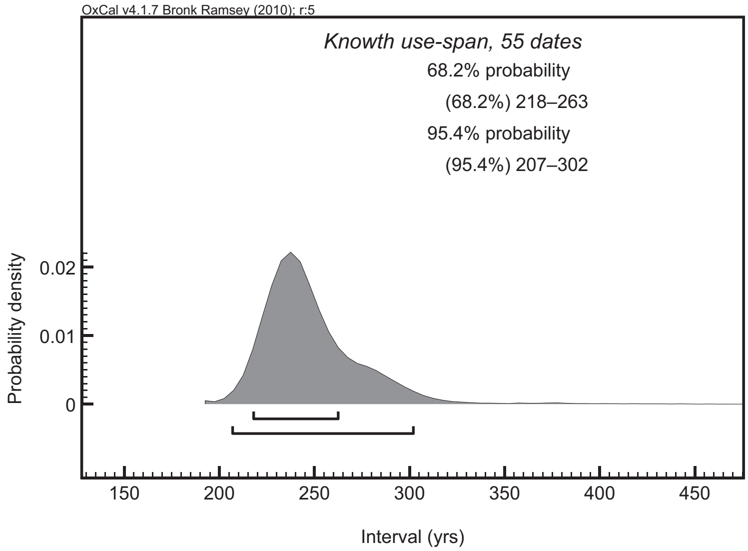
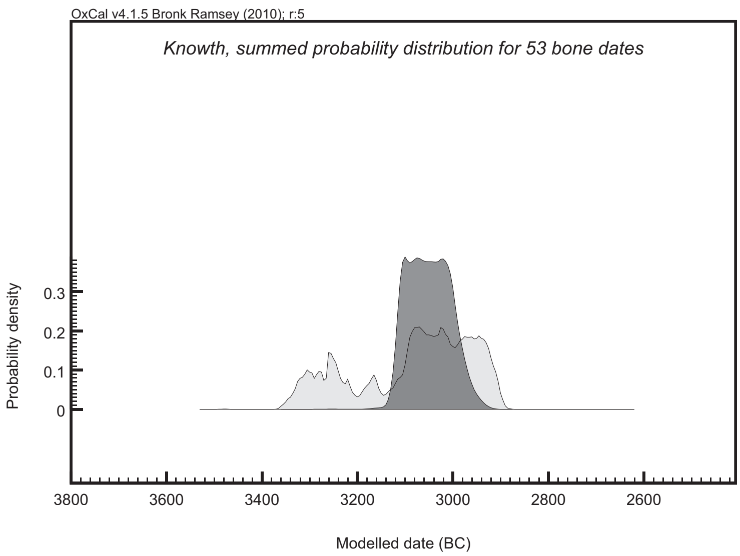
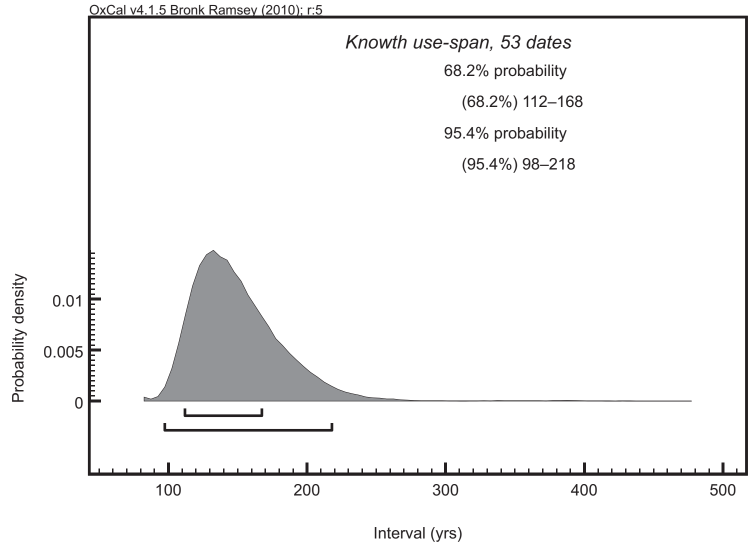


Fig. 4.26—*Modelled summed probability distribution for 53 human bone ^{14}C dates from Knowth, excluding five results (Model 4 in Table 4:10).*



Evidence for funerary activity at Knowth before 3200 BC is equivocal, consisting of (1) two outliers (UBA-10340 and UBA-10338—the former strongly rejected in all models, and the latter identified in the outlier analysis); (2) the tail-ends of some 95% probability distributions; and (3) the early part of the modelled start date of *3340–3100 BC* for the right-hand recess of Tomb 1B East. The two early (and the

Fig. 4.27—*Modelled use span based on 53 human bone ^{14}C dates from Knowth, excluding five results (Model 4 in Table 4:10).*



two late) outliers may, of course, refer to real activity: designating them as outliers means only that they do not sit well with the calibrated distributions of the other 55 determinations attributed to a single continuous phase of activity (see discussion in Bronk Ramsey 2009b). If it is indeed human, UBA-10340 could conceivably be residual from an earlier monument (as evidenced by the recycled stones termed 'Tomb 1A'), perhaps destroyed during construction of the dual Tomb 1B or in the extension of the passages of Tomb 1C and becoming incorporated into the spread of cremated bone in the left-hand recess of Tomb 1B East. The UBA-10340 sample was selected by Kerri Cleary for dating before the present study, but the burial deposit had been analysed by Laureen Buckley before this selection, and she had deemed it to be human. Multiple other determinations from the same deposit, however, did not yield any other early results. UBA-10338, the single sample analysed from Tomb 3, may place this unusual monument—a passage tomb lacking a passage—as among the earliest in the complex. If the two early dates are accepted as real, they suggest very low-level funerary activity compared with what was to come.

Thus, the chronology of the stratigraphic sequence in this and other chambers could be much more tightly constrained than implied in the models presented above for the individual tombs (for example Fig. 4.9). Those models are in no way inconsistent with the 'short chronology' proposed here because, being based on fewer determinations, the former incorporate a greater degree of uncertainty in their estimated start dates. If this late onset of use is accepted, it would negate the argument made above that the deposition of cremated bone may

Table 4:11—Four most recent Neolithic ^{14}C determinations on human bone from Knowth.

Tomb	Context	Sample	Lab. code	^{14}C yrs BP	±	Cal. BC (95%)	
15	'Beaker', in upper fill	3771	UBA-12683	4265	24	2912	2877
1C West	Orthostat 5, mid-fill	50159a	OxA-21992	4261	31	2920	2762
1C West	Orthostat 5, mid-fill	50159b	UBA-12681	4160	23	2877	2636
17	In upper fill	726	UBA-12688	4152	23	2874	2634

have started earlier than that of non-burnt bone, because this relied on the reality of the comparatively low-probability evidence for activity before *c*. 3200 BC.

Similarly, a fairly convincing case can be made for the main phase of funerary activity ceasing by *c*. 2900 BC. As with the early outliers, this does not deny the possibility of later funerary activity. The latest determination (in ^{14}C years BP) on human bone from the Neolithic cemetery derives from the upper fill of Tomb 17; the second and third are from halfway up the fill against the back face of Orthostat 5 in the western passage of Tomb 1C; and the fourth is from the upper fill of Tomb 15 (initially thought to have been associated with the Beaker pot) (Table 4:11). Thus the four most recent Neolithic results from human bone from Knowth are all demonstrably from stratigraphically late contexts, which argues strongly against their dismissal as statistical outliers and suggests that they reflect real activity at this time, albeit distinctly secondary to the main *floruit* discussed above. It is difficult to say much about this later phase of activity, which cannot be securely linked with any finds. However, the possibility that it relates to an early phase of Grooved Ware use at Knowth cannot be ruled out, as both A.L. Brindley (1999a; 1999b) and Sheridan (2004) have argued for a date *c.* 3000/2900 BC for the first appearance of this tradition in Ireland and because the pot from Tomb 6 is in an early style that has been dated elsewhere to around this time (see discussion in Schulting *et al*. 2010). This is distinct from a later phase of Grooved Ware activity at Knowth, attested by the presence of a timber circle in front of the entrance to Tomb 1C East; organic residues on pottery from this structure have produced dates of 2873–2581 cal. BC (GrA-445, 4130±35 BP) and 2611–2581 cal. BC (GrA-448, 3985±35 BP) (Eogan and Roche 1997a; 1999). A new determination of 2572–2466 cal. BC (UBA-14781, 3987±27 BP) on a charred hazelnut shell from a post-pit in the timber circle is compatible with the second of these two results, but three other new determinations proved to be unrelated to Grooved Ware activity (see Appendix 4). The Grooved Ware sherds from Tomb 18 are in a later style (for example compared to those in Tomb 6), but there is nothing to suggest that this vessel was associated with funerary activity: the date from cremated bone (OxA-22028, 4434±30 BP) from the chamber of

Tomb 18 is probably too early to be associated, whereas that from mixed charcoal (GrN-9235, 3750±70 BP) is too late, as well as being problematic in terms of the material dated.

4.6 Conclusions

The 60 AMS ^{14}C determinations on cremated and non-burnt human bone presented here have provided a robust chronological framework for the interpretation of the main use phase at Knowth. This large series was seen as necessary to overcome the problem presented by the late-fourth-millennium BC calibration plateau. To a large extent this strategy has been successful, but as is usually the case with modelling, there is not necessarily a single, clear-cut answer to questions of chronology, and much still depends on archaeological interpretation. Although the use of individual tombs is more variable, largely because of smaller sample sizes, overall modelling of funerary activity at Knowth consistently places the main phase of use as lasting between 100 and 300 years, maximum, in the period 3200–2900 BC (in a statement that now appears prescient, George Eogan (1991, 112) more than two decades ago suggested a date range of 3200–3000 cal. BC for the main phase of passage tomb construction and use at Knowth).

There is only very tentative evidence for burial activity before *c*. 3200 BC. Of course, it remains possible that earlier activity is missing owing to a clearing out of the smaller tombs as part of the reconfiguration of the site on the construction of Tombs 1B and 1C or, indeed because of the extensive later disturbance. But the nature of the bone deposits—small fragments of cremated and non-burnt bone—and the sheer number of contexts sampled, argue against this. The most likely location for pre-3200 BC funerary activity at Knowth may be the surface underlying the Tomb 1C mound, but its investigation would present obvious difficulties. There is firmer evidence for later burial activity, represented by four samples falling in the range *c*. 2900–2700 BC. If anything, the small number of early and late outliers serve to make clear the consistency of the remaining 55 (or 53) results.

Taken together, then, this suggests a relatively restricted *floruit* of tomb construction and funerary activity at Knowth, lasting between two and three centuries—or even as little as one to two centuries, depending on whether Model 3 or 4 is preferred (Table 4:10; Figs 4.21–4.23)—in the period 3200 to 2900 BC. With both archaeological information and the Bayesian modelling taken into account, the stronger case perhaps can be made for the 'short chronology' of Model 4. In this scenario, the main phase of funerary activity at Knowth began in *3160–3045 BC* and ended in *3020–2920 BC*, thus lasting only *100–220 years* (all at 95%). Of the 60 determinations, from nine of the ten passage tombs represented in the project, 53 fall comfortably in this range. This is a remarkably short duration for a complex site such as Knowth and suggests a strong pulse of activity.

This concentration of construction and use becomes even more impressive when seen in the context of the other passage tombs in Brugh na Bóinne, which may very well fall within the same period, although this remains to be investigated (and note here the evidence suggesting the possible existence of a passage tomb sealed underneath the main mound at Newgrange: A. Lynch *et al.* 2014). What is both interesting and puzzling, then, is the difficulty of finding settlement evidence dating to this period, particularly when compared with the preceding centuries of the Early Neolithic, with its boom in rectangular houses. This now well defined 'house horizon' ended by *c*. 3600 cal. BC (McSparron 2008; Cooney *et al*. 2011; Smyth 2014; Whitehouse *et al.* 2014), well before developed passage tombs began to be built. Although the monuments continued as foci of activity in the Late Neolithic and Beaker periods, this seems to have involved very limited deposition of human remains, restricted, so far, to the first half of the third millennium BC.

The passage tomb cemetery at Knowth cannot be seen in isolation. It is first and foremost part of the Brugh na Bóinne landscape, intimately linked with the large tombs at Newgrange and Dowth, as well as a series of smaller tombs. Farther afield, there are individual passage tombs such as the Mound of the Hostages, Tara, and other passage tomb cemeteries such as Loughcrew, Carrowmore and Carrowkeel. Is there a difference in the chronologies of individual tombs versus cemeteries in sites in the east compared with those in the west? A recent project dating calcined bone pins from Carrowmore, for example, has shown that the simple passage tombs there pre-date the Knowth complex by some centuries (Bergh and Hensey 2013). At present too little is known about the precise chronology of the passage tomb tradition in Ireland overall (Cooney *et al.* 2011, 657; Hensey 2015; Sheridan and Cooney 2014), let alone elsewhere in western Europe. The programme of radiocarbon dating at Knowth, as at the Mound of the Hostages, has made a start.

APPENDIX 4

ADDITIONAL RADIOCARBON DETERMINATIONS

Rick Schulting and Meriel McClatchie, with a contribution by Alison Sheridan

A number of new AMS ^{14}C determinations were obtained through the INSTAR-funded Cultivating Societies project (Whitehouse *et al*. 2010). The main focus of this project was on charred cereal grains from Irish Neolithic contexts, and it included eleven samples from Knowth. Three charred hazelnut shells were also sampled from the timber circle outside the east entrance of Tomb 1C, as this structure was of particular interest but yielded a limited number of charred cereals. This appendix presents these results.

A4.1 Pre-mound 1C, Early Neolithic (Phase I) occupation

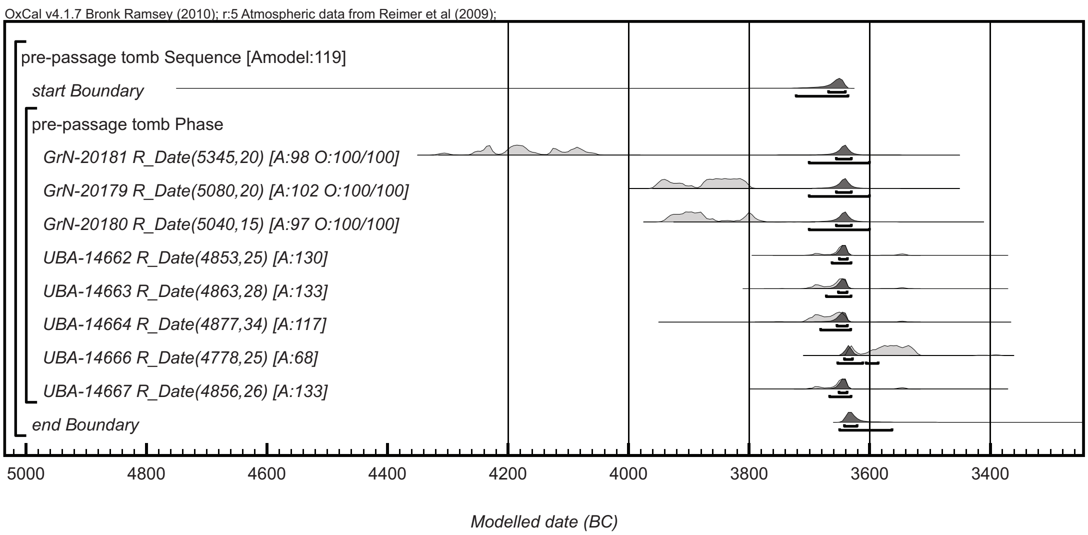
Eight determinations are available for the Early Neolithic occupation phase below Tomb 1C, associated with a Carinated Bowl pottery assemblage (Table A4:1). Of these, three from charcoal (species undetermined) were previously obtained by the Knowth project (Eogan and Roche 1997a, 9, 18) and the remaining five, from charred cereal grains, through the Cultivating Societies project. The contexts from which the cereals derive—post-holes and slot-trenches—relate to two rectangular structures (I in Zone A and II in Zone B) underlying Tomb 1C East (Eogan and Roche 1997a, figs 2–3). Two additional determinations thought to have been associated with the Early Neolithic occupation proved to refer to other periods. One, from a sample taken from a charcoal spread, provided a Mesolithic result (GrN-18773, 5885±45 BP: 4895–4617 cal. BC). An indeterminate cereal grain from a slot-trench (Foundation Trench 4) associated with the above structure (II) yielded a medieval date (UBA-14665, 946±22 BP: AD 1025–1151), no doubt intrusive from activity in and around the eastern passage tomb dating to this period (see Eogan 2012).

The three charcoal results are all earlier than the cereals; this can be attributed to a degree of in-built age and is taken into account by specifying a charcoal outlier model in OxCal 4.1 (Bronk Ramsey 2009b). The results (Fig. A4.1) provide an estimated start date of *3725–3635 BC* and end date of *3650–3565 BC*. This corresponds well with a previously

Table A4:1—Pre-passage tomb ^{14}C determinations from Early Neolithic (Phase I) activity.

Context	Material	Lab. code	^{14}C yrs BP	±	Cal. BC (95%)
Fill of post-hole to west of Foundation Trench 6, Structure II in Zone B	Charcoal	GrN-20181	5345	20	4315–4054
Fill of Foundation Trench 1, Structure I in Zone A	Charcoal	GrN-20179	5080	20	3957–3800
Fill of Foundation Trench 1, Structure I in Zone A	Charcoal	GrN-20180	5040	15	3943–3781
Fill of Foundation Trench 1 (K90 S179), Structure I in Zone A	Emmer wheat	UBA-14662	4853	25	3696–3540
Fill of Post-hole 3 (K90 S170), Structure I in Zone A	Emmer wheat	UBA-14663	4863	28	3703–3543
Fill of Post-hole 3 (K90 S170), Structure I in Zone A	Emmer wheat	UBA-14664	4877	34	3748–3540
Fill of Foundation Trench 7 (K91 S67), Structure II in Zone B	cf. wheat	UBA-14666	4778	25	3639–3521
Fill of Foundation Trench 7 (K91 S67), Structure II in Zone B	Emmer wheat	UBA-14667	4856	26	3698–3540

Fig. A4.1—*Modelled calibrated results for first phase of Early Neolithic activity, pre-mound Tomb 1C.*



available date for Early Neolithic (Phase II) activity: 3792–3381 cal. BC (BM-1076, 4852±71 BP) from charcoal from Pit 6 in House B, underlying Kerbstone 10 of Tomb 8. Moreover, this range is consistent with that recently proposed for the Irish 'house horizon', 3715–3625 BC (McSparron 2008), and is further supported by the results of the extensive Cultivating Societies dating programme (Whitehouse *et al*. 2014).

A4.2 Timber circle outside Tomb 1C East

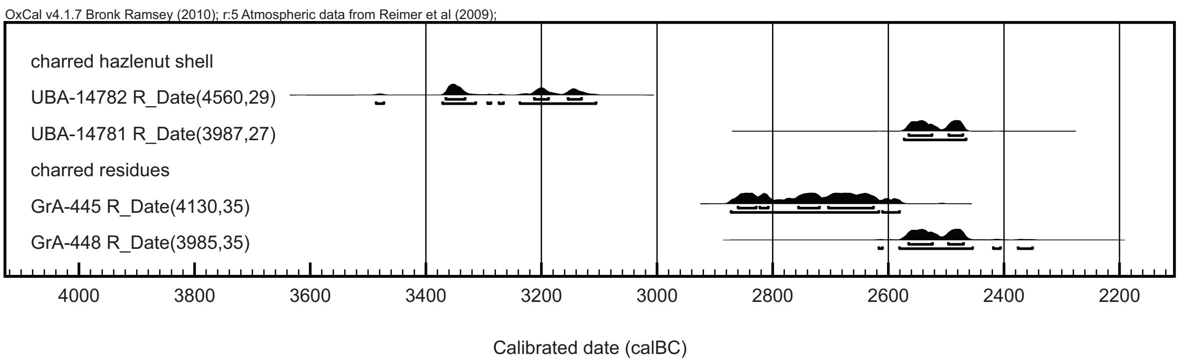
With a contribution by Alison Sheridan

Four new AMS ^{14}C determinations, two on charred wheat grains and two on charred hazelnut shells, are available from the post-pit fills of the timber circle outside the entrance to the eastern passage of the great mound (Tomb 1C East). These results join two previously available determinations on charred organic residues on Grooved Ware pot sherds from two post-pits of the timber circle at Knowth (Eogan and Roche 1997a, 130, 136; 1999) (Table A4:2). The results are very mixed, with the cereal grains (UBA-14668–9) clearly intrusive from the medieval period. Although the remaining determinations fall within the Neolithic, they do not form a coherent series (Fig. A4.2). The result for one of the two hazelnut samples (UBA-14782) dates to the main period of use of the Knowth complex for burial, in the late fourth millennium BC, and almost certainly pre-dates the introduction of Grooved Ware to Ireland, placed at *c*. 3000/2900 cal. BC (A.L. Brindley 1999a; 1999b; Sheridan 2004). Thus, it most likely represents residual activity.

Table A4:2—^{14}C determinations from timber circle outside Tomb 1C East (GrA results from Eogan and Roche 1997a, 130, 136). Sample numbers follow the system in B. Collins (1997).

Context	Material	Lab. code	^{14}C yrs BP	±	Cal. BC/AD (95%)
Post-pit 5 fill (K91:38:26)	Hazelnut shell	UBA-14782	4560	29	3486–3106 BC
Post-pit 8 fill (K91:31:24)	Hazelnut shell	UBA-14781	3987	27	2572–2466 BC
Sherds in Post-pit 16	Charred residue	GrA-445	4130	35	2873–2581 BC
Sherds in Post-pit 7	Charred residue	GrA-448	3985	35	2611–2581 BC
Post-pit 5 fill (K91:38:26)	Wheat grain	UBA-14668	932	22	AD 1029–1153
Post-pit 27 fill (K91:37:19)	Wheat grain	UBA-14669	344	21	AD 1469–1653

***Fig. A4.2**—Calibrated results from timber circle outside Tomb 1C East (GrA results from Eogan and Roche 1997a, 130, 136).*



Of the remaining three determinations, the two on charred organic residues adhering to Grooved Ware sherds still present the best estimate for the use of the timber circle and suggest that this may have spanned a century or more. The earlier of the two residue results (GrA-445) falls in the period 2873–2581 cal. BC, and the second charred hazelnut shell sample (UBA-14781) is nearly identical to the later of the two residue results (GrA-448), centring on *c*. 2500 cal. BC. Brindley identifies the Grooved Ware pottery from the timber circle as being of 'Dundrum-Longstone type' (Eogan and Roche's (1997a, 211) 'Knowth Style'), and two of the ^{14}C determinations fit well with the mid-third-millennium BC date currently proposed for that style (A.L. Brindley 1999a, 31; Sheridan 2004).

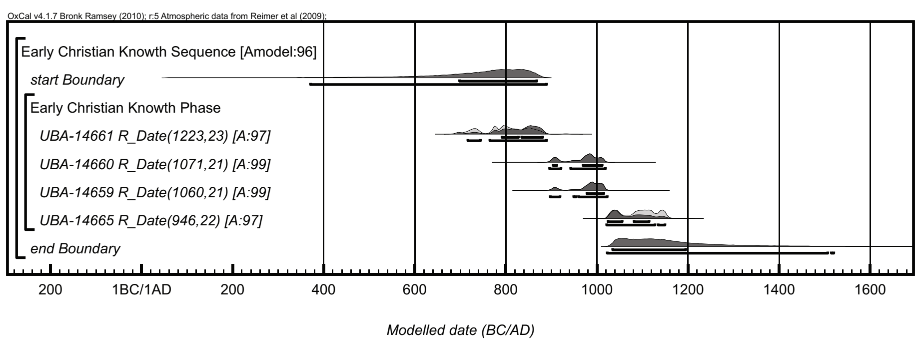
A4.3 Early Christian activity in Tomb 1B

Four AMS ^{14}C determinations on charred cereal grains from Knowth, obtained through the Cultivating Societies project, provide evidence for activity during the Early Christian period (Table A4:3; Fig. A4.3). The results appear to refer to more than a single episode of activity in the range *c*. AD 800–1200. This corresponds very well with the dating

Table A4:3—Early Christian ^{14}C determinations. [a] = context comparable with Sample 45 in Section 8.5 and Appendix 8a and Sample 13 in Section 8.7; [b] = context comparable with Sample A in Section 8.5 and Appendix 8a and Sample 9 in Section 8.7.

Context	Material	Lab. code	^{14}C yrs BP	±	Cal. AD (95%)
Tomb 1B East, chamber (S45; 383[a])	Wheat	UBA-14661	1223	23	695–1050
Tomb 1B West, chamber (K97 SL2[b])	Barley	UBA-14660	1071	21	896–1020
Tomb 1B West, chamber (K97 SL2[b])	Barley	UBA-14659	1060	21	898–1023
Fill of Foundation Trench 4 (K91 S62), Structure II in Zone B	Indeterminate cereal	UBA-14665	946	22	1025–1151

Fig. A4.3—Modelled calibrated results for Early Christian activity, Tomb 1B.



of disturbance and renewed activity identified archaeologically, including eighth-century graffiti on several structural stones (Section 2.1.1; Byrne 2008). Three samples derived from the two opposing passage tombs of Tomb 1B, and the fourth was from a slot-trench (Structure II in Zone B) relating to the earliest Neolithic occupation on the site and is clearly intrusive (see Section 1.4; Eogan and Roche 1997a, fig. 3; Eogan 2012). Eleventh- to twelfth-century agricultural activity is also seen in a charred wheat grain from the timber circle, noted above.