To Cut a Long Story Short: Formal Chronological Modelling for the Late Neolithic Site of Ness of Brodgar, Orkney

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To Cut a Long Story Short: Formal Chronological Modelling for the Late Neolithic Site of Ness of Brodgar, Orkney

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In the context of unanswered questions about the nature and development of the Late Neolithic in Orkney, we present a summary of research up to 2015 on the major site at the Ness of Brodgar, Mainland Orkney, concentrating on the impressive buildings. Finding sufficient samples for radiocarbon dating was a considerable challenge. There are indications from both features and finds of activity predating the main set of buildings exposed so far by excavation. Forty-six dates on 39 samples are presented and are interpreted in a formal chronological framework. Two models are presented, reflecting different possible readings of the sequence. Both indicate that piered architecture was in use by the thirtieth century cal BC *and that the massive Structure 10, not the first building in the sequence, was also in existence by the thirtieth century cal* BC*. Activity associated with piered architecture came to an end (in Model 2) around 2800 cal* BC*. Midden and rubble infill followed. After an appreciable interval, the hearth at the centre of Structure 10 was last used around 2500 cal* BC*, perhaps the only activity in an otherwise abandoned site. The remains of some 400 or more cattle were deposited over the ruins of Structure 10: in Model 2, in the mid-twenty-fifth century cal* BC*, but in Model 1 in the late twenty-fourth or twenty-third century cal* BC*. The chronologies invite comparison with the near-neighbour of Barnhouse, in use from the later thirty-second to the earlier twenty-ninth century cal* BC*, and the Stones of Stenness, probably erected by the thirtieth century cal* BC*. The Ness, including Structure 10, appears to have outlasted Barnhouse, but probably did not endure as long in its primary form as previously envisaged. The decay and decommissioning of the Ness may have coincided with the further development of the sacred landscape around it; but precise chronologies for other sites in the surrounding landscape are urgently required. The spectacular feasting remains of several hundred cattle deposited above Structure 10 may belong to a radically changing world, coinciding (in Model 2) with the appearance of Beakers nationally, but it was arguably the by now mythic status of that building which drew people back to it.*

Keywords: Orkney, Late Neolithic, Grooved Ware, Ness of Brodgar, radiocarbon dating, chronological modelling

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Questions for Late Neolithic Orkney

A series of striking changes in practice from the late fourth to the mid-third millennium cal BC characterise what can be defined as the Late Neolithic in Orkney. Although continuing survey and excavation are revealing more settlements from earlier stages of the Neolithic and thereby documenting a long-established insular tradition of constructing houses in timber and later in stone (Richards & Jones, 2016), it appears that Late Neolithic settlements became more numerous, and, in some instances, much larger than their predecessors. Their greater archaeological visibility was the outcome of a shift in the regularity with which substantial, well-made, stone-walled houses were built, often in concentrated or nucleated layouts. There were some monumental structures, such as the Maeshowe passage tomb, and much skill in building with stone was displayed. This has been claimed as a time when the house, as social fact and pervasive metaphor, dominated the social strategy (Richards, 2013; Richards & Jones, 2016). The idea of chambered cairns persisted into the Late Neolithic, but now, in contrast to earlier styles of simple-chambered and stalled cairns, these probably principally took the form of the passage grave, of 'Maeshowe' type (Henshall, 1972), seen in the construction of monuments such as Quanterness, Quoyness, and Maeshowe itself (Renfrew, 1979; Davidson & Henshall, 1989; Schulting et al., 2010; Griffiths & Richards, 2013; MacSween et al., 2015; Griffiths, 2016). Their elaborate architecture, with marked separation of the interior from the exterior, controlled access via passages, and gradation among internal chambers, may have derived from or been part of active connections with the zenith of the passage tomb tradition in eastern Ireland (Sheridan, 2004; Schulting et al., 2010; Hensey, 2015).

The stone circle was another innovation, as manifest in the Stones of Stenness, probably constructed by the thirtieth century cal BC (Ritchie, 1976; Griffiths & Richards, 2013), and even more spectacularly by the Ring of Brodgar, possibly (but far from certainly) erected in the middle part of the third millennium cal BC (Downes et al., 2013). Whether this was an invention of people living in Orkney (Sheridan, 2004; 2012) or the outcome of wider social connections (Griffiths & Richards, 2013: 286) remains open to debate. That such links to further afield existed and probably intensified in the Late Neolithic is seen in the range of other places from which materials or practices present in Orkney originated, including pitchstone from Arran, flint from mainland Scotland and possibly beyond, tuff from the central Fells of Cumbria (Mark Edmonds, *pers. comm.*), and decorative motifs present in passage ~~graves~~ in eastern Ireland (Sheridan, 2004; Card & Thomas, 2012). Stone maceheads and balls add to the picture of material elaboration (Simpson & Ransom, 1992; Sheridan, 2014).

Finally, the novel style of Grooved Ware, replacing an earlier ceramic tradition featuring the use of Unstan bowls and associated decorated and plain round-based pottery, appeared in Orkney, from at least the later thirty-second century cal BC at Barnhouse (Richards et al., 2016). Flat-based, bucket-like forms in a wide range of sizes, with varying incised and applied decoration, characterise the new ceramic assemblages. Some of those in Orkney have close similarities to others much further away in other parts of Britain (Wainwright & Longworth, 1971; MacSween et al., 2015; Richards et al., 2016). Whether the new style originated exclusively in Orkney, where the largest assemblages have been found so far, or in more widely dispersed social networks has again been the subject of debate (Sheridan, 2004; Thomas, 2010; Richards, 2013; Sheridan et al., in prep.). There is no doubt, however, that Late Neolithic Orkney was a place where the combination of changes was extensive, and the pace of change probably intense, even though we cannot claim that all the innovations listed here occurred at the same time. That uncertainty defines the first of a whole series of unanswered questions. How quickly did change happen, and what was the timing and tempo of subsequent development? What kind of communities and worldviews are we dealing with? What role did the outside world play in the initiation and maintenance of Late Neolithic Orkney society and material practice? What were the circumstances in which the Late Neolithic ended in Orkney, and when?

Ness of Brodgar: The Story So Far, 2003–2015

The Ness of Brodgar (Figure 1) sits on the south-eastern tip of the Brodgar isthmus that separates the Loch of Harray to the east from the Loch of Stenness to the west, at the centre of the large natural bowl of hills of the West Mainland of Orkney. From it the Ring of Brodgar (0.75 km to the north-west), the Stones of Stenness (0.5 km to the south-east), and Maeshowe (1.5 km to the east) are clearly visible. On the south side of the Bridge of Brodgar, barely 300 m distant, lies the Neolithic settlement of Barnhouse (Richards, 2005).

The site is located in the middle of the 'Heart of Neolithic Orkney' World Heritage Site (Historic Scotland, 1998). That designation was awarded in 1999, before the discovery of the Ness. In 2002 the area was geophysically surveyed as the pilot study for the Heart of Neolithic Orkney Geophysics Programme (GSB 2002; Card et al., forthcoming), the results unexpectedly revealing a mass of anomalies covering the peninsula. Their nature and character started to be realised the following year when investigations of a large notched slab discovered during ploughing revealed architecture similar in form to House 2 at nearby Barnhouse (Ballin Smith, 2003). Between 2004 and 2008 trial trenching to investigate the nature of a massive mound (*c.* 250 × 100 m, lying NW–SE, and over 4 m high) and the threat to it from agricultural practices gave indications that this mound, which had previously been thought to be a natural feature of the landscape, was mainly artificial and consisted of a sequence of Neolithic buildings, middens and midden-enhanced soils.[1] Since 2008, area excavation (though still less than 10 per cent of the site) has been carried out (Figure 2). This has revealed a complex sequence of monumental buildings contained within a massive walled enclosure. In its latter phases the site is dominated by several large buildings which, judging by their scale and architectural refinement including piered buildings (internally divided by pairs of opposed stone piers), would appear to be outside the norm for the domestic sphere. This is also reflected in the artefactual assemblage, including 700 examples of decorated stone (Card & Thomas, 2012).

Due to the depth and complexity of the stratigraphy, and the exceptional preservation of the architecture, only the later phases of the site have been investigated in detail to date. Although in several cases construction levels have yet to be reached

1 We use midden as a general term, aware of the complexities of its diverse character and formation (Shepherd, 2016).

Fig. 1 - B/W online, B/W in print

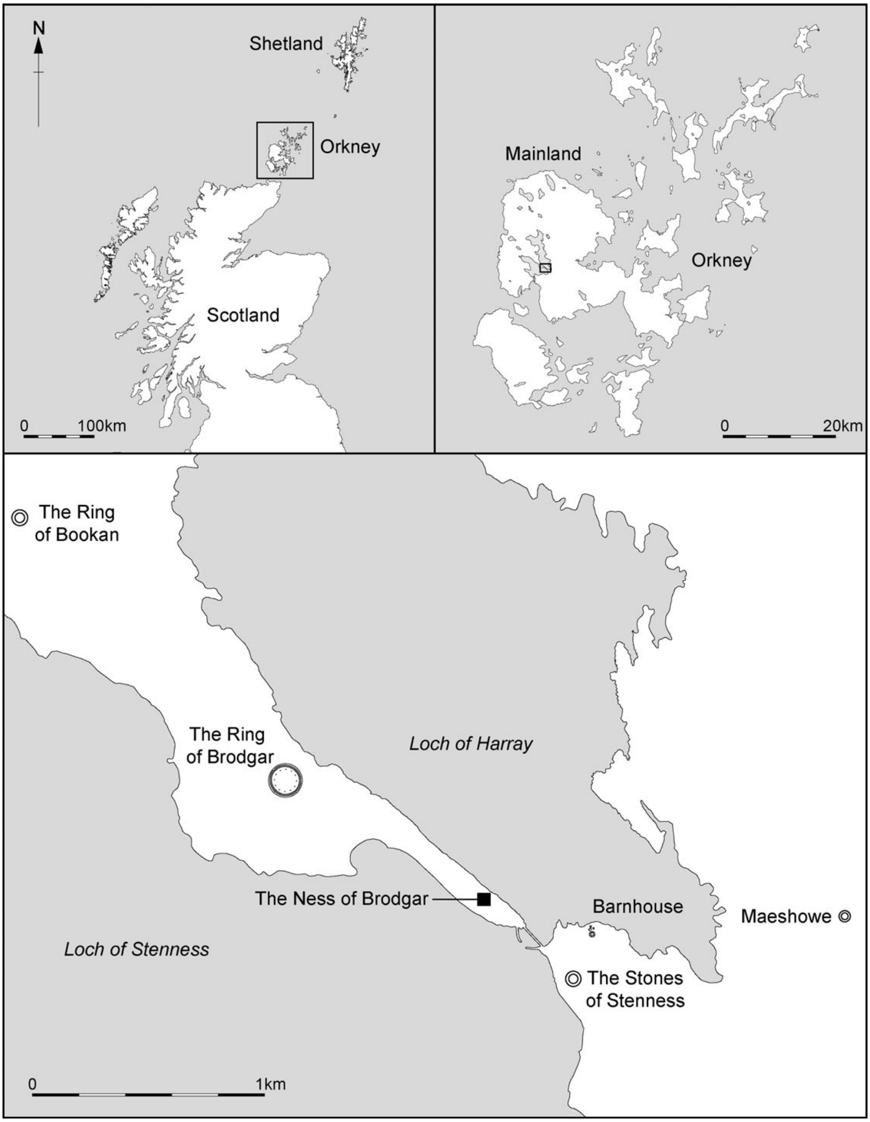

Figure 1. *Location map of the Ness of Brodgar.*

and cross-site stratigraphic relationships fully determined, a preliminary phasing is possible. Selective sondages between buildings have revealed definitive relationships between several buildings, while other more obvious relationships are discernible where a clear sequence of construction is visible (Figure 3).

The earliest physical evidence of activity is a few sherds of Modified Carinated Bowl, discovered in 2014 in a sondage on the natural boulder clay under a robbed-out wall of Structure 14. Structural remains associated with this pot have yet to be found.

Other activity pre-dating the construction of the large piered buildings is represented by several lengths of walling revealed between, under, and in some cases incorporated into, the buildings

Fig. 2 - B/W online, B/W in print

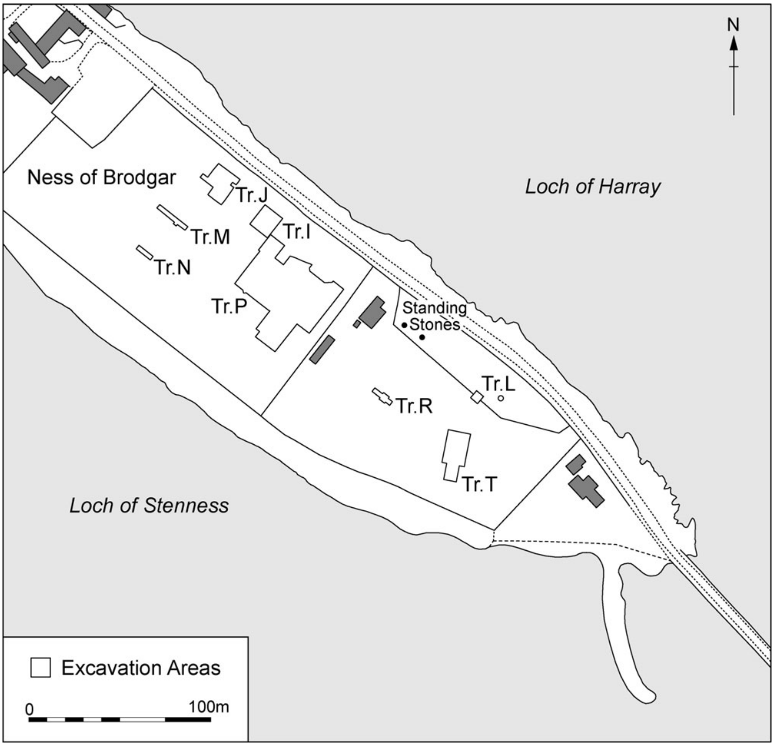

Figure 2. *Overall plan showing location of trenches at the Ness of Brodgar.*

currently under investigation. Other earlier buildings are also implied by the subsidence, collapse, and undulating nature of wall lines of later buildings. These earlier buildings, where revealed, utilise orthostats partly built into wall lines to define internal space similar to stalled tombs and Early Neolithic houses. It is presumed that the surrounding walled enclosure was first constructed during these earlier phases.

In the later phases, orthostats are replaced by opposed stone-built piers to create recesses along internal wall faces as in Structures 1, 8, 12, 14, and 21, each of which saw several phases of reuse and remodelling. These buildings (which are the present focus of excavation) can be considered exaggerated or elongated versions of Neolithic houses of the kind seen, for instance, in the early phase of Skara Brae (Clarke, 1976). A paved area with a standing stone is central to the whole of the walled enclosure at this stage.

The last major construction so far identified, Structure 10 (Figure 4), differs in style and scale from earlier building styles. It partly overlies the collapsed remains of the piered Structure 8. Its internal square chamber with rounded corners bears close comparison with Structure 8 at Barnhouse (Richards, 2005), as does its scale (some 20 × 19 m externally), which mirrors a general trend towards monumentality in the Late Neolithic of Orkney. Like the piered structures at the Ness which mirror other house plans but on an exaggerated scale, Structure 10 reflects later house styles, such as House 1 at Skara Brae (Clarke, 1976). Although the foundations of Structure 10 show the overall monumentality of its build, it suffered from

Fig. 3 - B/W online, B/W in print

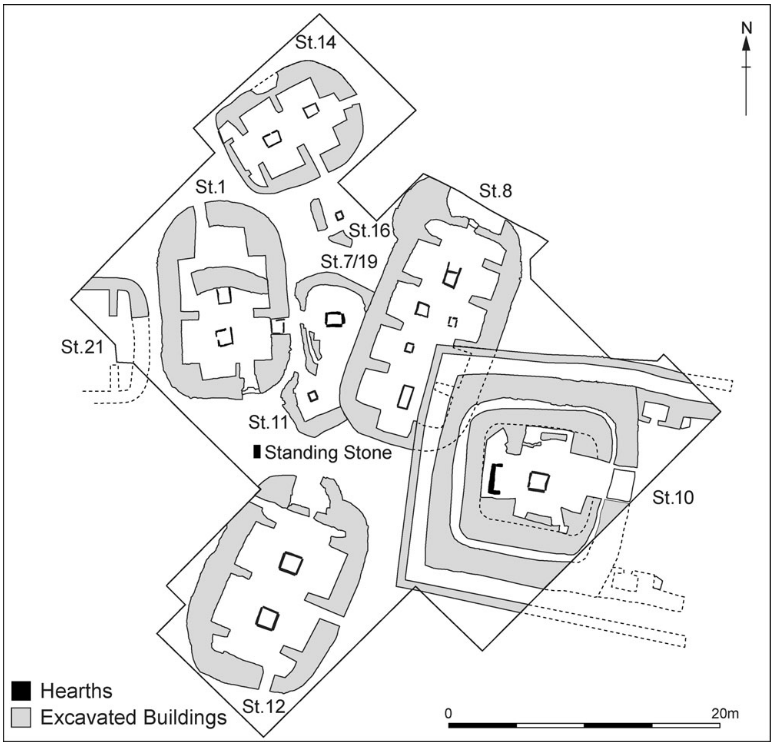

Figure 3. *Plan showing Trench P structures.*

subsidence like most other late structures at the Ness. That may have been the cause of the collapse of its south-western corner. It was rebuilt with extensive remodelling of the interior into a cruciform plan with the addition of new wall faces and corner buttressing.

At the end of these monumental phases, the buildings at the Ness were partly demolished and infilled with layers of midden and rubble. The placing of a structured bone deposit, mainly comprising ~~of over 400+,~~ cattle, (based on MNI of 87 so far recovered from c. 20 per cent of the excavated deposit) around Structure 10 has been interpreted as forming part of this decommissioning process (Mainland et al., 2014). It has been suggested that it was 'a single depositional event' or 'at the least a series of events occurring over a fairly short period of time' (Mainland et al., 2014: 875). This vast amount of meat is suggestive of a communal event involving feasting, and the gathering together of large numbers of people as has also been suggested for Durrington Walls and other Grooved Ware sites in the UK (Parker Pearson, 2003). Later, some of the walls of the structures were systematically robbed of stone. Ephemeral activity continued, but on a greatly reduced scale.

Outside the walled enclosure, at the very tip of the peninsula, a large partially quarried mound previously considered to be a broch has been shown to be an integral part of the development of the Ness. The preliminary geophysical survey of this mound revealed concentric anomalies encircling the mound interpreted as revetments, as present at various Maeshowe-type tombs. Initial investigations in 2013 showed that these were indeed revetments, but related to a remodelling of the mound, probably in the Iron Age, as a revetted,

Fig. 4 - Colour online, B/W in print

Figure 4. *Aerial view of Structure 10 (photograph: Hugo Anderson-Whymark).*

rubble-filled ditch around its summit produced pottery of that date. The mound consists mostly of a monumental Neolithic midden heap over 70 m in diameter and over 4 m high. In 2015, near the bottom edge of the mound, and predating the deposition of the midden, structural remains that may represent a robbed-out chambered cairn were encountered. The structural elements revealed so far have parallels with the tomb of Bookan, 2 km to the north-west (Card, 2006). Apart from Grooved Ware found in both the main trenches there is no direct stratigraphic relationship between the two areas. It is presumed, however, that the midden used in the creation of this monumental mound was a result of activity associated with the structures revealed elsewhere at the Ness.

A large assemblage of Grooved Ware in Trench P, dominated by sherds from overlying midden deposits, was characterised by applied cordons, both plain and incised (Towers & Card, 2015). By contrast, Grooved Ware pottery from Trench J is mainly shell-tempered and comes from fairly large and thin-walled vessels with flat bases and flat, simple rounded and interior bevelled rims, principally with incised decoration (MacSween, 2008). The assemblage as a whole will be assessed in a subsequent synthesis (Sheridan et al., in prep.) within the project *The Times of Their Lives* (ToTL hereafter; see Acknowledgments), from which the current article derives.

The exceptional architecture, the diversity of structures (Figure 5), and the evident size and spatial complexity of the Ness of Brodgar all emphasise its special character. Even the newly-discovered external midden mound may refer to themes of conspicuous consumption,

Fig. 5 - Colour online, B/W in print

Figure 5. *The structures in Trench P as seen in the 2015 season (photograph: Hugo Anderson-Whymark). For orientation, see Figure 3.*

status, and affluence. The discovery and current investigation of the site add to the list of research questions noted at the start of this article. Could the Ness of Brodgar have acted as a focus for communities not only locally but across the Orkney archipelago and possibly beyond? If so, who pulled the strings and made decisions? How was the site articulated into its local setting, in relation to other known sites such as Barnhouse, or monuments such as Maeshowe, the Stones of Stenness, and the Ring of Brodgar? How quickly did the site come into being, how long did it last, and did it retain the same character over the course of its life? That puts basic questions of chronology centre-stage.

Aims of the Ness of Brodgar Dating Project

The dating presented here forms part of the Orkney component of the ToTL project, which seeks to refine our understanding of the development of Late Neolithic settlement and Grooved Ware pottery, by formal chronological modelling of scientific dates. For Orkney, the project has investigated Pool (MacSween et al., 2015), Barnhouse (Richards et al., 2016), and the Links of Noltland (Sheridan, 1999; Clarke et al., submitted.). It is also contributing to a new formal chronology for Skara Brae.

A number of specific objectives relating to the site sequence at the Ness of Brodgar were identified:

- to provide formal estimates of the date and duration of activity
- to provide a precise date for the deposition of the cattle bones as part of the late history of Structure 10
- to help in the construction of an archaeomagnetic calibration curve for the Late Neolithic period.

Radiocarbon Dating and Chronological Modelling

The radiocarbon dating programme for the Ness of Brodgar was conceived within the framework of Bayesian chronological modelling (Buck et al., 1996). This makes it possible to combine calibrated radiocarbon dates, or other scientific dates, with archaeological prior information using a formal statistical methodology. At the Ness of Brodgar a number of stratigraphic relationships between stone-walled structures and the surrounding midden layers were available to constrain the radiocarbon dates (Figure 6).

A limited number of radiocarbon dates had been obtained as part of doctoral studies into aspects of the geoarchaeology of the site (Cluett, 2008) and dietary reconstruction of the Neolithic-Bronze Age transition in Orkney (Chelsea Budd, *pers. comm.*). The dating of three charcoal samples from below the southern boundary wall was funded by the BBC for an episode of *A History of Ancient Britain*.

Material suitable for radiocarbon dating was scarce. Unburnt bone did not survive particularly well, the exception being the mass of cattle bones associated with the near-final act at Structure 10 (Mainland et al., 2014) and charred plant remains were scarce. Sherds were scanned for the presence of charred residues which might represent carbonised organic material, although in many cases what appeared to be 'residue' was covered by a thin layer of 'midden' material that precluded sampling. Fragments of calcined bone were available from hand-collection and bulk environmental samples.

Fig. 6 - B/W online, B/W in print

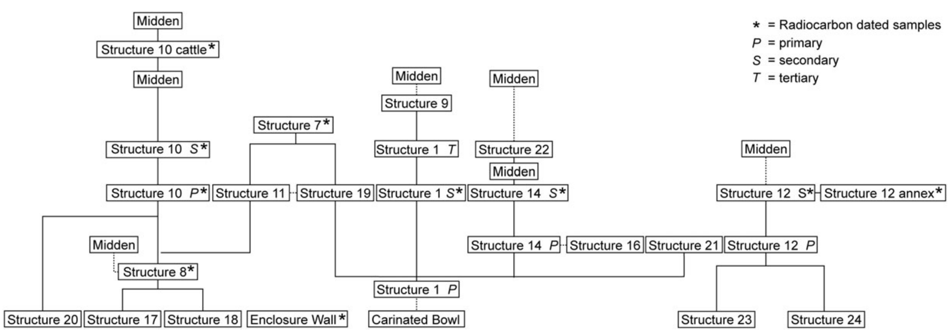

Figure 6. *Schematic representation of stratigraphic relationships between structures, middens, and other features that define prior information incorporated into the chronological models for the Ness of Brodgar.*

The amount of burnt bone recovered suggests a scale of burning beyond what might be expected from the routine burning of domestic waste (Richards, 2005; Card, 2010), and there is evidence for spatial variation in both the intensity of burning and the species and elements represented.

Rarely was there a choice of material for sampling, and, with the exception of carbonised residues from refitting sherds, only one of the samples was 'articulated'. Thus a high proportion of the samples have the potential to be residual in the context from which they were recovered. Some samples have a plausible functional relationship with their parent contexts (such as calcined bone in hearth deposits) and in some cases the state of preservation of large and unabraded sherds may suggest that they are not reworked; in other cases the taphonomy of the dated material (such as most of the single sherds from midden deposits) is much more uncertain.

In addition to some of the issues outlined above, the nature of the buildings, with stone-built foundations and walls, means that samples suitable for radiocarbon dating and functionally related to the archaeological 'event' — stone wall construction — are extremely rare. This contrasts with much Late Neolithic monumental construction, particularly from southern Britain, which is based on the digging out of ditches, stoneholes, and postholes, and the raising of banks and mounds, where tools used in their construction such as antler picks and scapula shovels are regularly found. An architecture based on stone foundations does not in itself produce samples for dating, unlike the timber-built structures associated with the digging of postholes.

The Ness of Brodgar therefore offers both a challenge and an opportunity to determine how we build chronologies for such settlement and monument complexes built of stone. The paucity of contexts with potential samples for scientific dating related to key 'archaeological events' — the building and abandonment of structures — contrasts with the potentially huge pool of samples from the 'residues' of activity taking place in the structures which ended up on the midden heap and midden deposits on the site, which are yet to be fully explored.

Radiocarbon Results

A total of 65 radiocarbon measurements are now available from the Ness of Brodgar (Tables 1–2). All are conventional radiocarbon ages (Stuiver & Polach, 1977).

Samples of animal bone, carbonised residue, charred plant remains, and calcined bone were measured by Accelerator Mass Spectrometry (AMS) at the Oxford Radiocarbon Accelerator Unit (ORAU). The samples were pretreated and combusted as described in Brock et al. (2010), graphitised (Dee & Bronk Ramsey, 2000), and dated (Bronk Ramsey et al., 2004).

The Scottish Universities Environmental Research Centre (SUERC) processed samples of bulk soil, charcoal, charred plant material, charred residues, calcined and non-calcined bone, which were dated by AMS using the methods described in Dunbar et al. (2016).

The ^{14}CHRONO Centre, The Queen's University, Belfast, processed 16 samples using methods described by Reimer et al. (2015). Charred residues were pretreated using an acid wash; charred plant remains were prepared using an acid-base-acid protocol; and samples of calcined bone were pretreated as described by Lanting et al. (2001). All samples were graphitised using zinc reduction (Slota et al., 1987), except for UBA-26534, -29335, -6, -29752, and -29754, which were subject to hydrogen reduction (Vogel et al., 1984).

Table 1. *Ness of brodgar: radiocarbon and stable isotope results*

Laboratory code	**Sample ref.**	**Material & context**	**δ¹³C (‰) - diet**	**δ¹³C (‰) - AMS**	**δ¹⁵N (‰)**	**C:N**	**Radiocarbon age (BP)**	***Posterior Density Estimate, cal BC (95% probability) Model 1***	***Posterior Density Estimate, cal BC (95% probability) Model 2***
				Structure 1					
SUERC-55466	SF 7423, context [2114]	Carbonised residue (61 mg) adhering to the interior of a thick (14 mm), rock-tempered Grooved Ware body sherd. From within Structure 1: context [2114], a firm dark reddish brown silt clay up to 0.2 m thick, that had been used to level the area in the western inner part of [1176]	−25.0 ± 0.2				4305 ± 30	*3015–2880*	*3015–2880*
SUERC-55462	SF bone 1907, context [3603] – sample A	Calcined animal bone, large ungulate rib from within Structure 1. The hearth slabs contain a thin soft mid grey brown layer of silt [3247] that seals a soft bright orange ashy silt clay deposit [3248]. This derives from the last phases of use. [**3603**] is a hearth fill stratigraphically below [3248]	−25.1 ± 0.2				4158 ± 30	*2885–2700*	*2890–2770*
UBA-26531	SF bone 1907, context [3603] – sample B	Calcined animal bone, large ungulate as SUERC-55462		−15.5			4225 ± 37	*2910–2835* (*56%*) or *2815–2745* (*36%*) or *2725–2700* (*3%*)	*2915–2845* (*90%*) or *2810–2775* (*5%*)

Table 1. (*Cont.*)

Laboratory code	Sample ref.	Material & context	$\delta^{13}C$ (‰) - diet	$\delta^{13}C$ (‰) - AMS	$\delta^{15}N$ (‰)	C:N	Radiocarbon age (BP)	*Posterior Density Estimate, cal* BC *(95% probability) Model 1*	*Posterior Density Estimate, cal* BC *(95% probability) Model 2*
SUERC-55465	SF bone 14290, context [3247] – sample A	Calcined animal bone, large ungulate long bone from within Structure 1. The hearth slabs contain a thin soft mid grey brown layer of silt [**3247**] that seals a soft bright orange ashy silt clay deposit [3248]. This derives from the last phases of use. Layer [3248] contains frequent fragments of burnt bone. The presence of a silt layer above the final use fill of the hearth suggests that the clay layers used to seal the hearth were not deposited immediately	−21.4 ± 0.2				4115 ± 30	*2850–2805* (*5%*) or *2765–2570* (*90%*)	*2870–2715*
UBA-26536	SF bone 14290, context [3247] – sample B	Calcined animal bone, unidentified mammal as SUERC-55465		−23.4			4175 ± 30	*2815–2625*	*2880–2700*
				Structure 7					
SUERC-55463	SF bone 2017, context [2680] – sample A	Calcined animal bone, large ungulate long bone from within the central hearth in Structure 7. The lowest use fill of the hearth [2679] (80 mm thick) was completely sealed by layer [2670] and consisted of ash-rich light orange/pinkish brown clay silt with occasional charcoal and burnt bone fragments. This appears to represent the primary episode of burning and sealed a lower levelling layer [**2680]** up to 0.15 m thick in the base of the hearth setting	−26.1 ± 0.2				4294 ± 30	2940–2875	2925–2880

UBA-26532	SF bone 2017, context [2680] – sample B	Calcined animal bone, cow tibia, as SUERC-55463		−19.6	4379 ± 50	2990–2890	2965–2885
Structure 8							
SUERC-60417	[2213] SF 5299	Carbonised residue [163 mg] adhering to the interior of a large, thick (16 mm) heavily rock-tempered Grooved Ware body sherd. From **[2213]**, a dark yellowish grey clayey silt, which was overlain by [**2212]**, a mid orangey brown silty clay, which was in turn overlain by [**2208]**, a mid greyish brown silty clay. ~~The~~ midden in the central part of Structure 8	−28.7 ± 0.2		4350 ± 35	*3015–2920*	*2990–2910*
UBA-26535	SF bone 12851, context [3806]	Calcined animal bone, large ungulate rib from within Structure 8: [**3806**] is the lowest hearth deposit and seals [3807]		−21.5	4380 ± 34	*3030–2930*	*3005–2915*
Structure 10							
SUERC-55457	SF bone 1524, context [3482] – sample A	Calcined animal bone, red deer antler from the central hearth area within Structure 10: 3463 = 3468 = **3482** = 3489 an orangey brown friable peat-ashy silt with occasional burnt bone and charcoal flecks (which may be a midden-enhanced soil rather than a 'true' hearth deposit)	−18.0 ± 0.2		4019 ± 30	*2625–2490*	*2620–2610* (*1%*) or *2600–2475* (*94%*)
UBA-26530	SF bone 1524, context [3482] – sample B	Calcined animal bone, large ungulate long bone, as SUERC-55457		−23.6	4278 ± 39		
SUERC-60627	SF bone 1524, context [3482] – sample C	Calcined animal bone, large ungulate long bone, replicate of UBA-26530	−25.2 ± 0.2		4200 ± 31		

Table 1. (*Cont.*)

Laboratory code	Sample ref.	Material & context	$\delta^{13}C$ (‰) - diet	$\delta^{13}C$ (‰) - AMS	$\delta^{15}N$ (‰)	C:N	Radiocarbon age (BP)	*Posterior Density Estimate, cal* BC *(95% probability) Model 1*	*Posterior Density Estimate, cal* BC *(95% probability) Model 2*
	SF bone 1524, context [3482], large ungulate	Weighted mean (T' = 2.5; ν = 1; T'(5%) = 3.8)					4230 ± 25	*2900–2860 (60%) or 2810–2755 (32%) or 2720–2705 (3%)*	*2905–2860 (64%) or 2810–2755 (29%) or 2720–2705 (3%)*
SUERC-55458	SF bone 1560, context [3490]	Calcined animal bone, cow humerus (right), from the central hearth area within Structure 10: 3466 = 3469 = 3483 = **3490**, was a mottled grey brown to black ashy silt, the product of *in situ* burning that underlay 3463 = 3468 = 3482 = 3489 (which may be a midden-enhanced soil rather than a 'true' hearth deposit)	−26.3 ± 0.2				4350 ± 30	*2910–2880*	*2935–2885*
SUERC-55464	SF bone 10823, context [3488] – sample A	Calcined animal bone, cow femur, left from the central hearth area within Structure 10: [3461], [3481] and [**3488**]. The uppermost fill, a 30–140 mm-deep light orangey brown silt 3461 = 3467 = 3188 = 3481 = **3488** contained occasional charcoal and bone, and appears to be an interface layer between [2526] and the underlying hearth fills. The NE quadrant of this layer, i.e. [**3488**], contained a significant amount of animal bone in comparison to the other quadrants The sample is stratigraphically later that the two samples from hearth fill = [3463], [3468] and [3489]	−19.6 ± 0.2				4020 ± 30	2570–2470	2560–2465

UBA-26534	SF bone 10823, context [3488] – sample B	Calcined animal bone, large ungulate long bone, as SUERC-55464		−21.5			3915 ± 32		
OxA-32032	SF bone 10823, context [3488] – sample C	Calcined animal bone, large ungulate long bone, as SUERC-55464, (replicate of UBA-26534)	−20.7 ± 0.2				4012 ± 33		
OxA-32447	SF bone 10823, context [3488] – sample C	Calcined animal bone, large ungulate long bone, as SUERC-55464, (replicate of OxA-32032 and UBA-26534)	−20.8 ± 0.2				4009 ± 38		
SF bone 10823		Weighted mean (T' = 5.6; ν = 2; T'(5%) = 6.0)					3975 ± 20	*2565–2515* (*34%*) or *2500–2460* (*61%*)	*2565–2515* (*21%*) or *2500–2460* (*74%*)
SUERC-55468	SF bone 38E, context [1403]	Animal bone, red deer, metacarpal proximal + shaft, left-hand side. Structure 10 was decommissioned and infilled with a sequence of middens and rubble deposits. This included infilling the outer paved area with deposits, [**1403**], including a large bone assemblage consisting almost entirely of cattle tibia representing hundreds of cattle. The articulated red deer skeleton overlay the main Structure 10 bone spread and provides a constraint for the deposition of the bone assemblage	−21.6 ± 0.2		8.0 ± 0.3	3.4	3720 ± 32	*2295–2125*	*2205–2025*
SUERC-55472	SF bone 32, context [1403]	Animal bone, cattle tibia distal + shaft, left-hand side. Structure 10 was decommissioned and infilled with a sequence of middens and rubble deposits. This included infilling the outer paved area with deposits, [**1403**], including a large bone assemblage consisting almost entirely of cattle tibia representing hundreds of cattle	−21.4 ± 0.2		5.0 ± 0.3	3.3	3946 ± 33	*2570–2515* (*16%*) or *2500–2335* (*79%*)	*2465–2360*

Table 1. (*Cont.*)

Laboratory code	Sample ref.	Material & context	$\delta^{13}C$ (‰) - diet	$\delta^{13}C$ (‰) - AMS	$\delta^{15}N$ (‰)	C:N	Radiocarbon age (BP)	*Posterior Density Estimate, cal BC (95% probability) Model 1*	*Posterior Density Estimate, cal BC (95% probability) Model 2*
SUERC-55473	SF bone 72, context [1403]	Animal bone, cow tibia, left-hand-side, distal + shaft. As SUERC-55472	−21.6 ± 0.2		5.4 ± 0.3	3.4	3832 ± 33	*2460–2200*	*2465–2360*
SUERC-55474	SF bone 98, context [1403]	Animal bone, cow tibia, left proximal + shaft. As SUERC-55472	−21.9 ± 0.2		5.4 ± 0.3	3.5	3900 ± 30	*2470–2295*	*2465–2360*
OxA-30798	SF bone 139, context [1403]	Animal bone, cow tibia, left-hand-side, distal. As SUERC-55472	−21 ± 0.2		4.5 ± 0.3	3.2	3901 ± 33	*2470–2290*	*2465–2360*
OxA-30799	SF bone 147, context [1403]	Animal bone, cow mandible, right-hand-side. As SUERC-55472	−21.1 ± 0.2		5.2 ± 0.3	3.1	3912 ± 34	*2480–2290*	*2465–2360*
OxA-30800	SF bone 213, context [1403]	Animal bone, cow tibia, left-hand-side, distal + shaft. As SUERC-55472	−21.2 ± 0.2		5.5 ± 0.3	3.1	3915 ± 33	*2480–2290*	*2465–2360*
GU35059	SF 7161, context [2510]	Carbonised residue (59 mg) adhering to the interior of a Grooved Ware sherd. From within Structure 10: context [2510] from the loose fill of pot SF 7161 within [2441] (cut containing 2442 [E-W orthostat on 2441] and 2443 [N-S orthostat in 2441]					Failed due to insufficient carbon		
UBA-26529	SF 18080, context [4381]	Carbonised residue (60 mg) adhering to the interior of a Grooved Ware sherd. From within Structure 10: context [4381] is a levelling surface beneath context [4374]. This sherd is from a find spot [4382] close to SF 16858; however, the sherd is from a separate vessel to SF 16858 and is the "upper pot"	−26.4 ± 0.2				4271 ± 42	*2935–2885*	*2930–2855* (*91%*) or *2810–2775* (*4%*)

OxA-30950	SF 16858, context [4381]	Carbonised residue (60 mg) adhering to the interior of a Grooved Ware body sherd, from large sections of a pot. The base is flat with almost vertical walls while the walls are 9 mm thick and the vessel height is *c.* 150 mm. From within Structure 10: context [4381] is a levelling surface beneath context [4374]. This sherd is associated with an incised stone	−24.0 ± 0.2		4231 ± 37	*2920–2885*	*2915–2840* (*77%*) or *2815–2755* (*18%*)
OxA-25032	CBNB 1	Animal bone, *Bos* (M. Lillie), from the bone deposit forming the upper fill of the paved pathway around Structure 10 that marked its decommissioning	−20.9 ± 0.2		3878 ± 26	*2465–2290*	*2465–2360*
OxA-25033	CBNB 2	Animal bone, *Bos* (M. Lillie), from the bone deposit forming the upper fill of the paved pathway around Structure 10 that marked its decommissioning	−21.2 ± 0.2		3829 ± 27	*2455–2375* (*13%*) or *2350–2200* (*83%*)	*2465–2360*
		Structure 12 and annex					
UBA-26533	SF bone 2340, context [4509]	Calcined animal bone, large ungulate long bone from within Structure 12: [**4509**] is a black charcoal 'hearth' layer with animal bones, ?*in situ* burning, sealed by [4053]		−25.3	4447 ± 31	*3335–3210* (*39%*) or *3195–3150* (*7%*) or *3140–3005* (*46%*) or *2985–2935* (*3%*)	*3335–3210* (*39%*) or *3195–3150* (*7%*) or *3140–3005* (*46%*) or *2995–2935* (*3%*)
SUERC-60419	[4509] <2360> sample A	Carbonised grain, *Hordeum vulgare* (S. Timpany), from black charcoal 'hearth' layer [**4509**] with animal bones, *in situ* burning sealed by [**4053**] in Structure 12	−25.2 ± 0.2		4100 ± 28	*2860–2805* (*22%*) or *2760–2715* (*9%*) or *2705–2570* (*63%*) or *2515–2500* (*1%*)	*2875–2800* (*90%*) or *2760–2720* (*5%*)

Table 1. (*Cont.*)

Laboratory code	**Sample ref.**	**Material & context**	**$\delta^{13}C$ (‰) - diet**	**$\delta^{13}C$ (‰) - AMS**	**$\delta^{15}N$ (‰)**	**C:N**	**Radiocarbon age (BP)**	***Posterior Density Estimate, cal BC (95% probability) Model 1***	***Posterior Density Estimate, cal BC (95% probability) Model 2***
UBA-29335	[4509] <2360> sample B	Carbonised grain, *Hordeum vulgare* (S. Timpany), from black charcoal 'hearth' layer [**4509**] with animal bones, *in situ* burning sealed by [**4053**] in Structure 12	−22.0 ± 0.22				4149 ± 30	*2880–2625*	*2885–2725*
OxA-32069	[4509] <2360> sample C	Carbonised grain, *Hordeum vulgare* (S. Timpany), from black charcoal 'hearth' layer [**4509**] with animal bones, *in situ* burning sealed by [**4053**] in Structure 12	−27.4 ± 0.2				4114 ± 30	*2865–2800* (*25%*) or *2775–2575* (*70%*)	*2880–2720*
SUERC-55467	SF 10100, context [2306] sample A	Carbonised residue (119 mg) adhering to the interior of Grooved Ware sherd. From within Structure 12 (annex): finds deposit [**2306**] was located in the junction between wall [2832] and orthostat [2848]. It consisted of a large spread of Grooved Ware pottery, which measured 1.15 m WNW to ESE by 0.3 m wide. Context [**2306**] was recorded in four horizons; during excavation each successive pottery horizon was lifted, revealing more pottery below	−26.2 ± 0.2				4197 ± 30		

UBA-26528	SF 10100, context [2306] sample B	Carbonised residue (114 mg) adhering to the interior of Grooved Ware sherd. From within Structure 12 (annex): finds deposit [**2306**] was located in the junction between wall [283]2 and orthostat [2848]. It consisted of a large spread of Grooved Ware pottery, which measured 1.15 m WNW to ESE by 0.3 m wide. Context [**2306**] was recorded in four horizons; during excavation each successive pottery horizon was lifted, revealing more pottery below	−26.4 ± 0.2	4246 ± 39		
	SF 10100, context [2306]	Weighted mean (T' = 1.0; ν = 1; T'(5%) = 3.8)		4215 ± 24	*2900–2855* (*42%*) or *2810–2750* (*45%*) or *2725–2695* (*8%*)	*2900–2855* (*72%*) or *2810–2755* (*23%*)
GU37544	[5337] SF 21623 sample A	Carbonised residue [210 mg] adhering to the interior of a Grooved Ware sherd from Structure 12, context [**5337**] SF 21623		Failed due to insufficient carbon		
UBA-29338	[5337] SF 21623 sample B	Carbonised residue [194 mg] adhering to the interior of a Grooved Ware sherd from Structure 12, context [**5337**] SF 21623	−27.2 ± 0.22	4148 ± 35	*2880–2620*	*2885–2730*
SUERC-60626	[5337] SF 20850, sample A	Carbonised residue [390 mg] adhering to the interior of a Grooved Ware sherd from Structure 12, context [**5337**] SF 20850	−27.4 ± 0.2	4155 ± 31		
UBA-29337	[5337] SF 20850, sample B	Carbonised residue [283 mg] adhering to the interior of a Grooved Ware sherd from Structure 12, context [**5337**] SF 20850	−26.8 ± 0.22	4145 ± 37		

Table 1. (*Cont.*)

Laboratory code	Sample ref.	Material & context	$\delta^{13}C$ (‰) - diet	$\delta^{13}C$ (‰) - AMS	$\delta^{15}N$ (‰)	C:N	Radiocarbon age (BP)	*Posterior Density Estimate, cal BC (95% probability) Model 1*	*Posterior Density Estimate, cal BC (95% probability) Model 2*
OxA-32310	[5337] SF 20850, sample C	Carbonised residue [210 mg] adhering to the interior of a Grooved Ware sherd from Structure 12, context [**5337**] SF 20850	−27.1 ± 0.2				4187 ± 29		
	SF 20850	Weighted mean (T' = 1.0; ν = 2; T'(5%) = 6.0)					4165 ± 19	*2880–2835* (*18%*) or *2815–2670* (*77%*)	*2880–2830* (*63%*) or *2820–2740* (*31%*) or *2725–2710* (*1%*)
		Structure 14							
SUERC-60418	[4662] <2499>	Carbonised grain, *Hordeum vulgare* (S. Timpany), from **[4662]**, western hearth, red silt clay, burning sealed by [**4665**] in Structure 14	−23.8 ± 0.2				4369 ± 25	*3015–2910*	*2985–2905*
GU37541	[4613] <2424> sample A	Carbonised grain, *Hordeum vulgare* (S. Timpany), from eastern hearth, ashy deposit of rake out [**4613**] sealed by [**4612**] in Structure 14					Failed due to insufficient carbon		
GU37925	[4613] <2424> sample A - replacement	As GU37541					Failed due to insufficient carbon		
UBA-29336	[4613] <2424> sample B	Carbonised grain, *Hordeum vulgare* (S. Timpany), from eastern hearth, ashy deposit of rake out [**4613**] sealed by [**4612**] in Structure 14	−23.5 ± 0.22				4386 ± 41	*3025–2905*	*2985–2900*
GU37543	[5074] SF 19116	Carbonised residue [163 mg] adhering to the interior of pot under Structure 14, context [**5074**] SF 19116					Failed due to insufficient carbon		

Trench J – Structure 5

OxA-X-2633-41	[410] <240>	Calcined animal bone, unidentified (I. Mainland), from **[410]**, a fine peat ash deposit, stratigraphically earlier than [**448**]	–27.5 ± 0.2		5432 ± 38
P38996	[460] <247>	Calcined animal bone, unidentified (I. Mainland), from [**460**], a silty ash deposit, interpreted as a fire-spot; it is stratigraphically earlier than [**456**] and later than **[461]**	Failed due to insufficient carbon		±
SUERC-61344	[458] <251>	Charcoal, *Betula* sp. (S. Timpany), from [458] a charcoal-rich ashy silt interpreted as a fire-spot; it is stratigraphically earlier than [**457**]	–25.0 (assumed)		4608 ± 30
GU-37924	[461] <248>	Carbonised single grain *Hordeum vulgare* var. nudum (S. Timpany), from **[461]** a raked ash deposit probably from fire-spot [**460**], stratigraphically earlier than [**460**] and later than [**462**]	Failed due to insufficient carbon		
SUERC-61637	[461] <248>	As GU-37924	–23.5 ± 0.2		4337 ± 29
UBA-29752	[441] <257>	Carbonised single grain *Hordeum vulgare* var. nudum (S Timpany), from the primary fill of the hearth cut below the cist, stratigraphically earlier than [**440**] and later than [**443**]	–25.5 ± 0.22		4384 ± 30
UBA-29753	[456] <243>	Calcined animal bone, unidentified (I. Mainland), from [**456]** a ?hearth deposit stratigraphically earlier than [**458**] and later than [**460**]		–28.0	6042 ± 36
UBA-29754	[462] <249>	Calcined animal bone, unidentified (I. Mainland), from **[462]**, a ?hearth deposit in Trench J [Structure 5], stratigraphically earlier than [**461**] and later than [**457**]		–20.5	5212 ± 35

Table 1. (*Cont.*)

Laboratory code	Sample ref.	Material & context	δ13C (‰) - diet	δ13C (‰) - AMS	δ15N (‰)	C:N	Radiocarbon age (BP)	*Posterior Density Estimate, cal BC (95% probability) Model 1*	*Posterior Density Estimate, cal BC (95% probability) Model 2*
				Trench R					
SUERC-35999	7741	Charcoal, *Pinus sylvestris*, from [3029] a greyish brown midden	−25.6 ± 0.2				4450 ± 30	*3335–3210* (*44%*) or *3190–3150* (*7%*) or *3135–3015* (*44%*)	*3335–3210* (*19%*) or *3195–3150* (*2%*) or *3140–3010* (*74%*)
SUERC-36000	1263	Charcoal, *Pinus sylvestris*, from [3029] a greyish brown midden	−25.1 ± 0.2				4420 ± 30	*3330–3215* (*19%*) or *3175–3155* (*2%*) or *3120–2990* (*75%*)	*3325–3230* (*14%*) or *3120–2940* (*81%*)
SUERC-36004	1263	Charcoal, *Betula*, from [3029] a greyish brown midden	−25.6 ± 0.2				4430 ± 30	*3330–3215* (*28%*) or *3180–3155* (*3%*) or *3125–3005* (*64%*)	*3330–3215* (*23%*) or *3175–3155* (*2%*) or *3125–2945* (*70%*)
				Trench T					
SUERC-61360	[5816] SF 22469	Calcined animal bone, cattle phalange II (I Mainland), from **[5816]**, a midden layer above the clay capping sealing the earliest phase of midden deposition	−22.6 ± 0.2				4219 ± 27	*2905–2855* (*44%*) or *2810–2745* (*43%*) or *2725–2695* (*8%*)	*2905–2855* (*74%*) or *2810–2755* (*21%*)
SUERC-61343	[5822] SF 22497	Animal bone, cattle (?*Aurochs*) skull (I Mainland), from **[5822]**, a midden layer above the clay capping sealing the earliest phase of midden deposition	−22.5 ± 0.2		5.0 ± 0.3	3.2	4146 ± 31	*2875–2620*	*2885–2725*

Quality Assurance

All three laboratories maintain continuous programmes of internal quality control in addition to participation in international inter-comparisons (Scott et al., 2007; 2010). These tests indicate no laboratory offset and demonstrate the validity of the precision quoted.

Two pairs of replicate and two sets of triplicate measurements are available on samples that were divided and submitted for dating to different laboratories. In all cases the measurements are statistically consistent at 95 per cent confidence (Table 1; Ward & Wilson, 1978). These measurements on the same samples have therefore been combined by taking a weighted mean before calibration and inclusion in the chronological models.

Bayesian Modelling

The chronological modelling described in this section has been undertaken using OxCal 4.2 (Bronk Ramsey, 1995; 2009), and the internationally agreed calibration curve for the northern hemisphere (IntCal13: Reimer et al., 2013). The models are defined by the OxCal CQL2 keywords and by the brackets on the left-hand side of Figures 7 and 9. In the diagrams, calibrated radiocarbon dates are shown in outline and the posterior density estimates produced by the chronological modelling are shown in solid black. The Highest Posterior Density intervals which describe the posterior distributions are given in italics.

The Chronological Model

The radiocarbon samples dated as part of a PhD dissertation on soils and sediments in the World Heritage Site buffer zones (Cluett, 2008) were selected to provide a chronology for soils and sediment-based cultural records. The excavated trenches were deliberately located away from the main structural features and cannot be directly related to the excavated archaeological evidence. Although sample selection was based on sound principles — single entity, short-lived fragments of charcoal, and single fragments of calcined bone — the utility of the results in contributing anything beyond the fact that Late Neolithic material exists in the soils surrounding the site is such that we have not included them in the chronological modelling.

A series of earlier structures is indicated by walling encountered under Structure 8 (Structures 17 and 18), Structure 10 (Structure 20), Structure 12 (Structures 23 and 24), and Structure 5, which was excavated in Trench J adjacent to the northern boundary wall. It is perhaps during this stage of development that the massive stone enclosure was built to contain all these buildings. The three samples from under the southern boundary wall provide *termini post quos* for its construction (Figure 7). Whether the *Pinus sylvestris* charcoal represent trees growing on the island at the time (Farrell, 2015) or driftwood (Dickson, 1992) is open to debate. However, the three measurements are statistically consistent (T' = 0.5; T'5% = 6.0; ν = 2) and could be of the same actual age (~~Figure 7).~~

Trench P

The construction and primary use of Structures 1, 8, 12, 14, 16, and 21 (plus several others revealed by the geophysical surveys) probably took place over a relatively restricted period. Similarities in architecture of the main buildings (the use of pairs of opposed stone piers to define internal space) and their spatial respect for

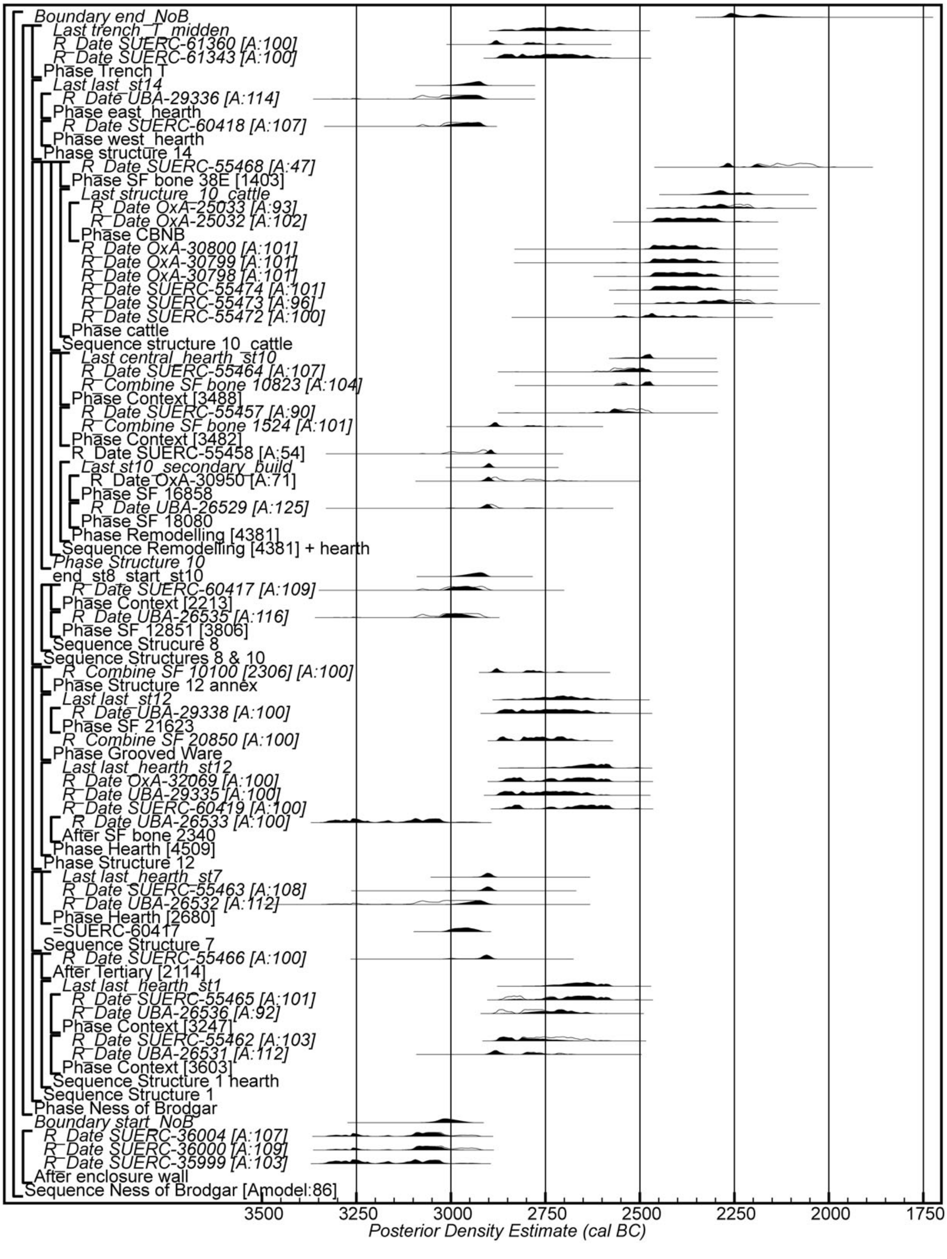

Fig. 7 - B/W online, B/W in print

Figure 7. Ness of Brodgar. Probability distributions of dates (Model 1). Each distribution represents the relative probability that an event occurs at a particular time. For each radiocarbon date, two distributions have been plotted: one in outline which is the result of simple radiocarbon calibration, and a solid one based on the chronological model used. The other distributions correspond to aspects of the model. For example, the distribution 'last_hearth_st1' *is the estimate for when the hearth in Structure 1 was last used.*

each other are taken, for the present, to imply their contemporaneity. This would appear to be borne out by the proven stratigraphic relationships between Structures 1 and 14, and 1 and 21.

Five samples have been dated from the secondary phase of Structure 1 (Figure 7). The latest use of the sub-square hearth [3603] from its 'secondary' phase is dated by calcined bone fragments (SUERC-55462 and UBA-26531) from the hearth fill [3603] that is stratigraphically below [3247] a silt layer, dated by calcined bone fragments (SUERC-55465 and UBA-26536). For both contexts, the pairs of measurements on single fragments of calcined bone are statistically consistent ($T' = 2.0$; $T'5\% = 3.8$; $\nu = 1$) and could be of the same actual age. Carbonised residue (SUERC-55466) from SF 7423, a single sherd of a Grooved Ware vessel from a levelling deposit [2114] that may have been part of the initial backfilling of the structure at the end of its tertiary phase, is stratigraphically later than the hearth, but appears to be a residual sample and is thus incorporated into the model as a *terminus post quem*.

Two calcined animal bone fragments (SUERC-55463 and UBA-26532) from the lowest use fill of a hearth [2679] are statistically consistent ($T' = 2.1$; $T'5\% = 3.8$; $\nu = 1$) and represent the primary episode of burning in the feature in the centre of Structure 7 (Figure 7). Structure 7 is stratigraphically later than Structure 8 and its use is therefore likely to have been contemporary with the use of Structure 10.

Two samples have been dated from Structure 8 (Figure 7). A single calcined bone (UBA-26335) from the lowest hearth deposit [3806] provides a date for its initial use, and a carbonised residue (SUERC-60417) from a large, thick Grooved Ware body sherd provides a date for its infilling with midden deposits prior to the construction of Structure 10.

Seven samples have been dated from the secondary use of Structure 12 and its annex (Figure 7). Four measurements (calcined bone UBA-26533, and three single barley grains, OxA-32069, SUERC-60419, and UBA-29335) from the black charcoal 'hearth' layer [4509] are not statistically consistent with each other ($T' = 89.1$; $T'5\% = 7.8$; $\nu = 3$), but the measurements on the three grains are ($T' = 1.5$; $T'5\% = 6.0$; $\nu = 2$). The calcined bone fragment (UBA-26533) is considerably older than the grains and has been included in the model as a *terminus post quem*; it could either be residual or have a fuel-derived offset (see below). Measurements on sherds from two Grooved Ware vessels (SF 20850 and SF 21623) from finds deposit [5337] are statistically consistent ($T' = 0.2$; $T'5\% = 3.8$; $\nu = 1$). Part of a late occupation layer [4508], ~~located~~ between the northerly hearth and the interior entrance to the annex of Structure 12, the large spread of fragmented ceramics [5337], may have formed as the result of the roof of Structure 12 collapsing on to pots standing upright on the floor just to the east of the hearth. Carbonised residue adhering to the interior of Grooved Ware sherds from a very large pottery deposit [2306], and sealed by the lowest midden infill deposits ([2278] and [2287]), provides a date for the end of use of the annex of Structure 12.

Two samples, single grains of carbonised barley from its western [4662] and eastern hearths [4613], were dated from Structure 14 (Figure 7). The two determinations are statistically consistent ($T' = 0.1$; $T'5\% = 3.8$; $\nu = 1$).

Following subsidence and the roof collapse of Structure 8, Structure 11 was built against its southern end, while similarly Structure 19 was built against the west wall of Structure 8 (Figure 3). It was at this time that midden dumping within Structure 8 and the central midden area began, although no samples deriving from this activity could be identified for dating.

The primary phase of Structure 10 necessitated the removal or clearing of the south-eastern section of the collapsed Structure 8. Structure 10 was built with a square central chamber with rounded corners and extensive use of dressed stone. The monumental foundation slabs of Structure 10 may in part be an (ultimately unsuccessful) attempt to counteract the subsidence evident elsewhere on the site (e.g. in Structure 8). The construction of the Structure 10 annex area (slightly later than the original build) at its eastern end incorporates at least one standing stone. After possibly the partial collapse of its primary build, a thick, very mixed clayey levelling or floor deposit was laid, particularly over the northern side where subsidence is most evident, and new internal walls and corner buttresses were built to create a cruciform central chamber. Dressers and orthostatic arrangements were also inserted, but, compared to the original build, this secondary phase is rather shoddily constructed.

Measurements on carbonised residues adhering to sherds of different vessels (UBA-26529 and OxA-30950) from a foundation deposit [4381] associated with the remodelling of Structure 10 are statistically consistent (T' = 0.9; T'5% = 3.8; ν = 1) and provide *termini post quos* for its rebuilding (Figure 7). A sequence of samples from the central hearth in Structure 10 were dated. At the base of this sequence, SUERC-55458 was measured on a fragment of calcined cow humerus from an *in situ* burning deposit [3490] that underlies a (?)midden-enhanced soil [3482] rather than a true hearth deposit. Measurements on two fragments of cremated animal bone from the latter [3482] are statistically different (T' = 29.0; T'5% = 3.8; ν = 1), although those from the overlying context [3488], the uppermost fill of the hearth, are statistically consistent (T' = 2.4; T'5% = 3.8; ν = 1).

The end of the formal use of Structure 10 as a building is marked by its demolition and infilling with a sequence of middens and rubble deposits; this is also the case of Structures 8, 12, 14, and 16 but with apparent intervals between various episodes of deposition and ephemeral reuse of the structures. Further deposition of large amounts of midden in the Central Midden Area perhaps originates from tertiary phases of activity.

The late history of Structure 10 sees its reuse with an elaborately pecked stone placed next to an upturned cattle skull in the central hearth and the surrounding pathway backfilled; the uppermost fill [1403] of this backfill contained an enormous amount of mainly cattle bone (Mainland et al., 2014). Radiocarbon determinations on eight samples from the cattle deposit [1403] are statistically consistent (T' = 12.3; T'5% = 12.3; ν = 7). The bones dated from the cattle bone deposit as part of the ToTL project were chosen to maximise the likelihood that separate individuals were being sampled. Five tibiae were sampled (SF 72, SF139, SF213, SF98, SF32), all of which are from different animals on the basis of body ~~side~~ and fragmentation. The remaining sample from this deposit, a cattle mandible (SF147), could however derive from one of these five individuals, as could the two unidentified skeletal elements (CBNB1 and 2; OxA-25032 and OxA-25033).

Finally, the remains of articulated red deer skeletons were deposited over part of the Structure 10 bone layer and one of these (SUERC-55468) provides a *terminus ante quem* for the deposition of the cattle remains.

Trench T

Two samples from Trench T (Figures 2 and 7), on the 70 m-diameter mound located on the south-eastern portion of the low ridge occupying the Brodgar peninsula, were dated to provide an indication of when a very large animal, perhaps an aurochs, died and whether the midden surrounding the animal could be contemporary with this. The two measurements (SUERC-61360 and SUERC-61343) are statistically consistent ($T' = 3.1$; $T'5\% = 3.8$; $\nu = 1$) and could therefore be of the same actual age.

Trench J

A series of stratigraphically related samples from a number of hearth deposits overlying Structure 5 in Trench J were submitted to provide an idea of the length of activity in this part of the site. There the Grooved Ware was markedly thinner-walled than the Grooved Ware recovered elsewhere at the Ness and was also dominated by a shell filler (Ann MacSween, *pers. comm.*), and therefore probably of a date that was different from most of the activity in Trench P. The radiocarbon dates, although on samples with a plausible functional relationship to their contexts (charcoal and calcined bone from hearths) do not, however, form a coherent chronological sequence (Figure 8) and must represent the incorporation of residual material from activity that significantly predates the main phase of activity at the site. They have been excluded from the chronological modelling, but nevertheless provide a tantalising glimpse of the time-depth of the Ness of Brodgar as a place of human activity.

Assessment

Of the 65 radiocarbon determinations from the Ness of Brodgar, 13 have been excluded from the analysis, seven because they were not from trenches excavated as part of the main archaeological investigations (Table 2) and six from Trench J because deposits there seem to contain material deriving from earlier activity. The model thus includes 46 determinations on 39 samples. Five samples that are potentially residual are included as only providing *termini post quos* for overlying deposits (UBA-26533, SUERC-35999, SUERC-36000, SUERC-36004, and SUERC-55466), and therefore 34 samples are believed to provide accurate ages for the deposits from which they were recovered.

In assessing the reliability of the model for the Ness of Brodgar we need to reflect on the number of dated samples available from different parts of the site. Structure 1 has five dated samples, Structure 7 two, Structure 8 two, Structure 10 sixteen, Structure 12 and its annex seven, Structure 14 two, Trench R three, and Trench T two. We clearly have fewer dated samples than would be ideal from some structures and it is disappointing that no samples could be found for a number of structures (9, 11, 16, 19, 21, and 22). Our model therefore quite clearly

Fig. 8 - B/W online, B/W in print

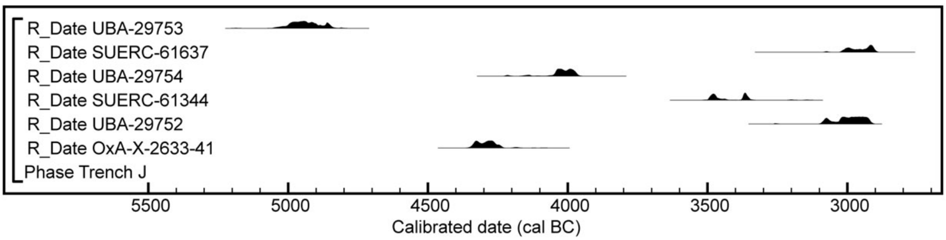

Figure 8. *Ness of Brodgar. Calibrated dates from radiocarbon determinations obtained from Trench J (Stuiver & Reimer, 1993).*

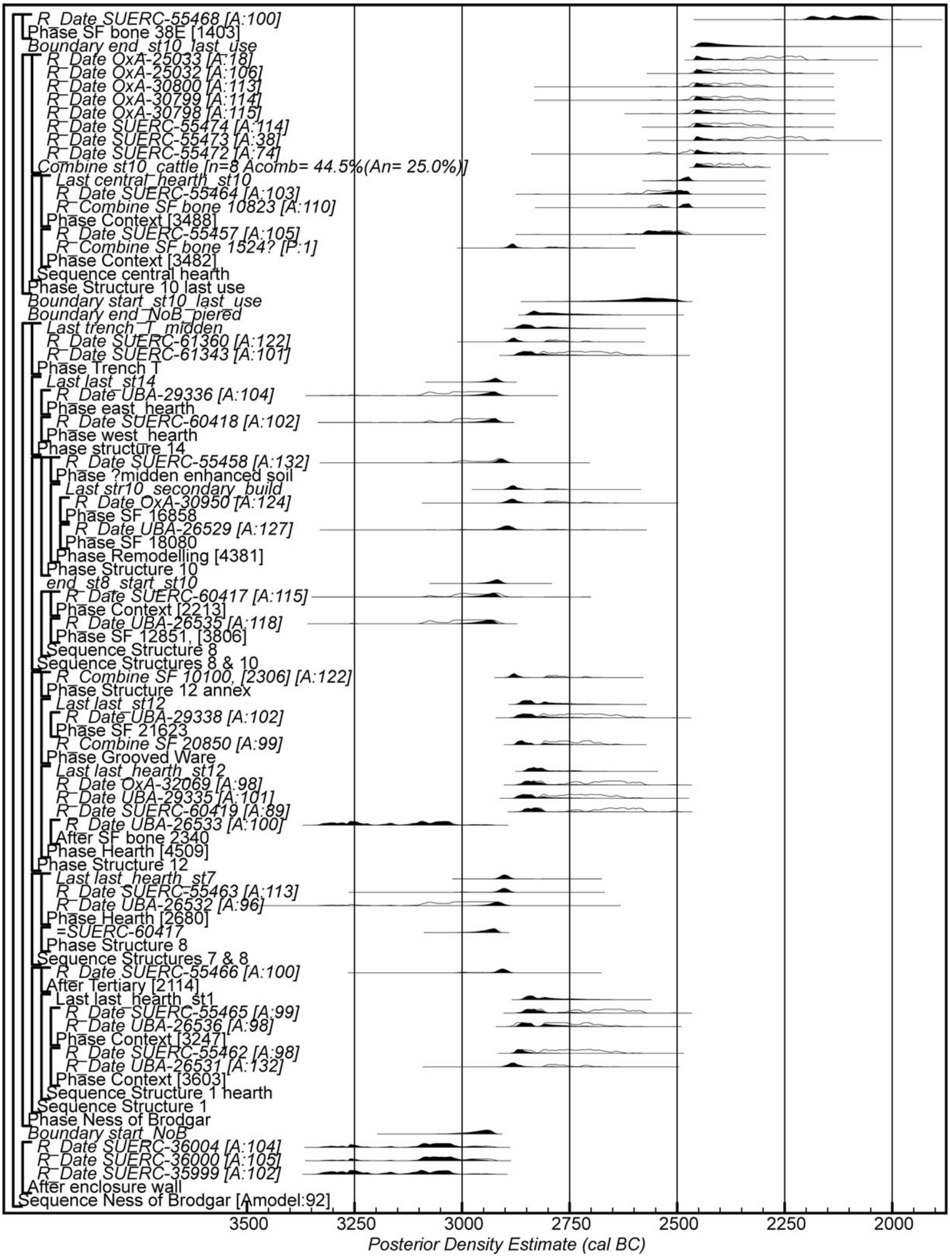

Fig. 9 - B/W online, B/W in print

Figure 9. *Ness of Brodgar. Probability distributions of dates (Model 2). The date followed by a question mark has been calibrated (Stuiver & Reimer, 1993) but not included in the chronological model for the reason outlined in the text. The overall structure of the diagram is identical to that of Figure 7.*

under-samples activity at the site and hence can only provide an imprecise picture of the chronology.

The confidence we have placed on samples of calcined bone (13 out of 39) is a further consideration when assessing the reliability of the model. Fuel used in the cremation process, this being represented by the large hearths at the Ness of Brodgar, has been shown in experimental

Table 2. *Ness of brodgar: radiocarbon results obtained as part of a phd dissertation on soils and sediments in the world heritage site buffer zones (cluett, 2008)*

Laboratory code	Material & context	$\delta^{13}C$ (‰)	Radiocarbon age (BP)	Calibrated date (95% confidence) cal BC
SUERC-6191	Charcoal, Ericales (S. Ramsay, GUARD), from NOB E 047	−25.0 ± 0.2	4280 ± 35	2930–1870
SUERC-6684	Bulk soil, humic acid from NOB E 047	−27.2 ± 0.2	3160 ± 40	1510–1300
SUERC-6762	Animal bone, cremated (C. Smith, SUAT), from NOB E 047	−22.4 ± 0.2	4225 ± 40	2910–2690
SUERC-6764	Charcoal, *Betula* sp. (S. Ramsay, GUARD), from NOB C 075	−26.0 ± 0.2	4320 ± 40	3030–2880
SUERC-6685	Bulk soil, humic acid from NOB C 075	−27.4 ± 0.2	4085 ± 40	2870–2490
SUERC-6761	Animal bone, calcined (C. Smith, SUAT), from NOB C 86	−27.0 ± 0.2	4185 ± 45	2900–2620
SUERC-9542	Animal bone, calcined (C. Smith, SUAT), from NOB E 003	−20.4 ± 0.2	4285 ± 35	2930–2870

work (Snoeck et al., 2014) to contribute to the carbon in calcined bone apatite along with components from the atmosphere and the dated individual. This could be an issue at the Ness of Brodgar, as for the one hearth ([4509] in Structure 12) where it was possible to find samples of calcined bone and charred material (barley grains), the calcined bone (UBA-26533) is considerably older in age (327 ± 36 yrs BP older than a weighted mean of the three charred barley grains: SUERC-60419, UBA-29335, and OxA-32069).

The possibility of fuel offsets should be taken into account but these may not be substantial. The ~~absence~~ of cramp (vitreous slag-like material; Photos-Jones et al., 2007) indicates that seaweed was not used as a fuel and therefore we have no reason to believe that any of the calcined bone dated from the site has a marine offset. Ongoing analysis of the fuels used at the Ness of Brodgar indicates a significant use of turf for burning, with heather and seeds indicative of such practices identified from hearth features. Wood fuel has also been identified but to a lesser extent than turf and, so far, shows a varied assemblage of some ten different arboreal taxa. The tree types attested by charcoal indicate a landscape dominated by scrub woodland largely made up of birch, with some hazel. Areas of wetland woodland are also shown by the presence of alder and willow, while there is some evidence of stands of deciduous and evergreen woodland from the presence of smaller amounts of oak, Pomoideae, and pine, together with other coniferous charcoal. The occurrence of larch/spruce is likely to represent the use of driftwood and this has also been suggested for the pine, although pollen evidence (Farrell, 2015) has indicated that pine was probably present in the woodlands of Orkney. For the most part, the short-lived species indicated support the conclusion that any inbuilt age offset in the cremated bones is likely to be minimal.

Finally, radiocarbon offsets can occur if samples (such as samples from animals or carbonised residues) have taken up carbon from a reservoir not in equilibrium with the terrestrial biosphere (Lanting & van der Plicht, 1998). Dietary stable isotope measurements from animals (Table 1; see Jones & Mulville, 2015), together with lipid analysis of cooking vessels (Cramp et al., 2014), confirm that offsets from freshwater or marine reservoirs are not found at this site.

Interpretations

Two models for the chronology of activity at the Ness of Brodgar are presented in detail. The first (Model 1) assumes that the dated material from Trenches P and T derives from a single continuous phase of activity (Buck et al., 1992). The second (Model 2) incorporates an alternative reading of the archaeological evidence relating to the later use of Structure 10, and in particular to the relationship of the large hearth in the remodelled structure to the main phase of activity associated with the distinctive piered architecture. In this alternative reading, outlined in detail below, the hearth in the remodelled Structure 10 and the deposition of the cattle remains are interpreted as a separate phase of activity from that associated with the stratigraphically earlier piered architecture. The activity is thus modelled in terms of distinct, but successive, periods of continuous activity with an interval of unknown duration between them.

Model 1

Model 1, shown in Figure 7, interpreting the activity in Trench P and Trench T as a single continuous phase, has good overall agreement (Amodel: 86) between the radiocarbon dates and this reading of the archaeological evidence. The model estimates that the main dated phase of activity at the Ness of Brodgar began in *3060–2950 cal BC* (*95% probability; start NoB*; Figure 7). There is, however, yet to be fully excavated earlier activity at the site, such as the structures discovered under the southern boundary wall of the site, and the primary phases of Structures 1, 12, and 10. The sherds of round-based Modified Carinated Bowl discovered embedded into the natural substrate under Structure 14 further support the view of earlier, pre-Grooved Ware Neolithic activity at the Ness. Thus, although the dating programme has provided an estimate for the primary use of Structure 8, and secondary use of Structures 1, 12, and 14, this is only a *terminus ante quem* for the beginning of the monumental building activity.

The earliest dated material from Structures 1, 8, 12, and 14 suggests that they were in use during the thirty-first to the thirtieth centuries cal BC, although for Structures 1, 12, and 14 samples from hearth deposits do not derive from their primary use.

Providing formal estimates for the end of use of the structures is extremely challenging, due to the difficulty in finding samples associated with such events. However, for Structure 12, the roof collapse that resulted in the smashing of pots near the hearth occurred in *2855–2835 cal BC* (*2% probability; last_st_12*; Figure 7) or *2820–2585 cal BC* (*93% probability*). The replacement of Structure 8 by Structure 10 is estimated to have occurred in *2990–2895 cal BC* (*95% probability; end_st8_start_st10*; Figure 7). Thus, compared to other structures on the site, Structure 8 would therefore have been standing for a relatively short period, although providing a robust estimate for this is problematic given that only a single dated sample relates directly to its use.

Structures 7 and 10 were both built later than Structure 8. Although no samples were dated from the first phase of use of Structure 10, it is estimated to have been constructed in *2990–2895 cal BC* (*95% probability; end_st8_start_st10*; Figure 7), with its remodelling estimated to have taken place shortly after *2915–2885 cal BC* (*95% probability; st10_secondary_build*; Figure 7), when a significant quantity of pottery was deliberately deposited before rebuilding took place.

The midden above the clay capping sealing the earliest phase of midden deposition in Trench T started to accumulate in the twenty-ninth to twenty-seventh centuries cal BC (Figure 7).

The construction of the large hearth in the remodelled Structure 10 must have begun just before the deposition of one of its first fills around the very end of the twenty-ninth century cal BC. Although the hearth contains no obvious evidence for a hiatus, it was last used in *2550–2460 cal BC* (*95% probability; central_hearth_st10*; Figure 7). This suggests that either the hearth was partially cleaned on a regular basis over its apparently centuries-long lifespan, or that a break in its use is not visible. During the lifespan of the remodelled Structure 10, many of the other structures were backfilled with 'midden' material.

The final use of what at that time may have simply been the foundations of Structure 10 began with the placement of vast amounts of predominantly cattle remains that took place an estimated *135–320 years* (*95% probability*; distribution not shown) after the last use of the hearth, in *2340–2200 cal BC* (*95% probability; structure_10_cattle*; Figure 7). The final act in the history of Structure 10 occurred with the deposition of a red deer skeleton in *2290–2125 cal BC* (*95% probability; SUERC-55468*; Figure 7).

Model 2

Model 2 (Figure 9) presents an alternative reading of the archaeological evidence for activity at the Ness of Brodgar. The model interprets the activity associated with the construction and use of the piered structures (dated by samples from Structures 1, 7, 8, 10, 12, 14, and the Trench T midden) as a single continuous phase (Buck et al., 1992) that is followed by a hiatus (after the deposition of layers of midden and rubble) before the final phase of activity in what by that time may have only been the remains of Structure 10.

The key components that differentiate Model 2 from Model 1 are, first, that two phases of coherent activity (piered architecture and the last use of Structure 10) are separated by a hiatus. Second, the dated calcined bone (SF bone 1524) from the basal hearth deposit [3482] is interpreted as residual, being significantly earlier than another dated single fragment of calcined bone (SUERC-55457) from the same context, and earlier than samples from the last use of the hearth. The visible, horizontally bedded, layers within the hearth suggest only a continuous, short period of use, with no evidence for cleaning out, recutting or hiatus (Figure 10). Third, the cattle deposited in Structure 10 are thought to belong to animals that probably all died at the same time, since 'the faunal assemblage together with a comparable stratigraphic record in each excavated area is indicative of a single depositional event' (Mainland et al., 2014: 875). Hence the probability distributions of the calibrated dates obtained from the cattle bones can be combined (using the OxCal function Combine), as they are not from the same organism, to produce an estimate for the date of this event. Finally, the deer placed on top of the cattle spread is not interpreted as part of that phase of activity, but as a later isolated act.

The chronological model shown in Figure 9 has good overall agreement (Amodel: 92), suggesting that the radiocarbon dates do not contradict the reading of the archaeological sequence outlined in Model 2. This model suggests that the first dated activity associated with the use of structures characterised by piered architecture took place in *3020–2920 cal BC* (*95% probability; start_NoB*; Figure 9). The end of activity in the dated piered structures is estimated to have occurred in *2855–2665 cal BC* (*95% probability; end*

Fig. 10 - B/W online, B/W in print

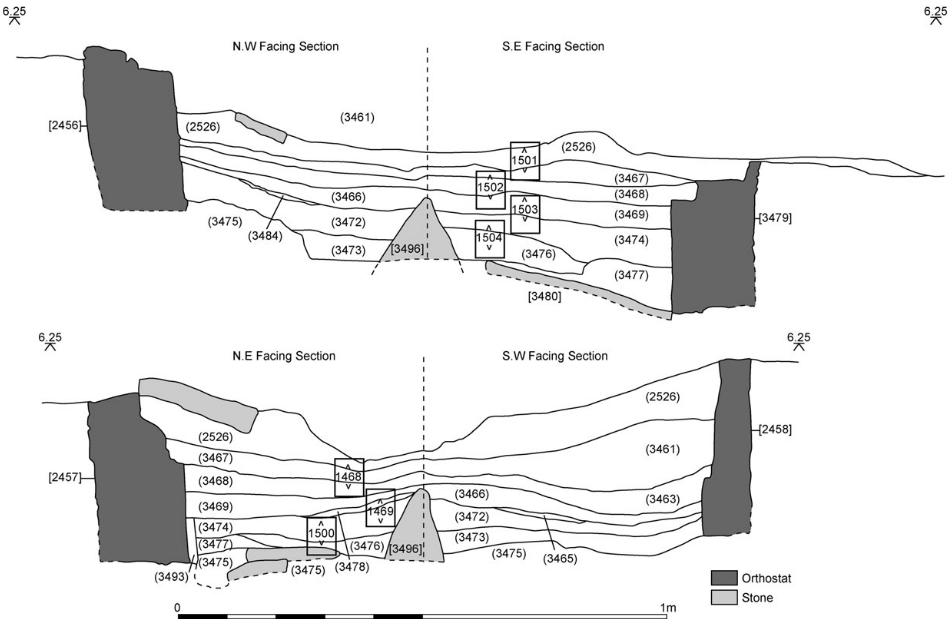

Figure 10. *Sections through the central hearth of Structure 10.*

NoB; Figure 9). On this reading, the monumental structures were therefore in use for between *70 and 305 years* (*95% probability; piered_architecture*; Figure 11).

Following the end of activity associated with the piered structures, a period of disuse ensued, lasting for *30–335 years* (*95% probability; gap_1*; Figure 11). Following this potentially considerable gap, activity in what were by then probably only the remains of Structure 10 is estimated to have resumed in *2720–2480 cal* BC (*95% probability; start_st10_last_use*; Figure 9). The final use of the hearth in Structure 10 took place in *2545–2460 cal* BC (*95% probability; central_hearth_st10*; Figure 9). The eight dates obtained for cattle bones from the enormous deposit of animal bone that filled the pathway running around the building are consistent (A_{comb} = 44.5%; A_n = 25.0; n = 8) with the interpretation suggested by the faunal analysis (i.e. that they represent a 'single-event' deposit; Mainland et al., 2014: 875) and the model estimates that the cattle died in *2565–2360 cal* BC (*95% probability; st10_cattle*; Figure 9), with deposition taking place very quickly after this. The deposition of the animal bone took place very shortly after the last use of the hearth,

Fig. 11 - B/W online, B/W in print

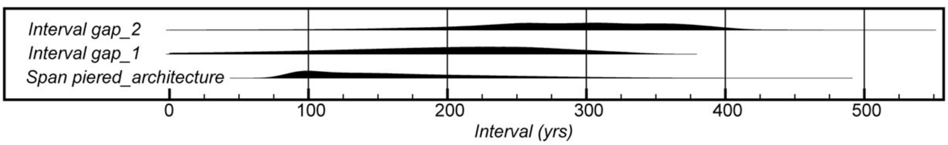

Figure 11. *Ness of Brodgar. Durations of the dated phase of activity associated with structures of piered architecture, for the interval between the end of activity associated with these structures and the later use of Structure 10 (gap_1), and from the last use of structure 10 and the deposition of the articulated deer skeleton (gap_2), derived from the model defined in Figure 11.*

an interval estimated to have been between *1–135 years* (*95% probability*; distribution not shown).

Following a considerable gap lasting *115–420 years* (*95% probability; gap_2*; Figure 11), an articulated deer skeleton (SUERC-55468) was placed on top of the animal bone deposit in the last quarter of the third millennium cal BC.

Archaeomagnetic Dating

Precise and reliable magnetic directions have been obtained from a number of sampled hearth features (Batt & Outram, 2014). Although no archaeomagnetic calibration curve currently exists for the Late Neolithic in Britain, estimates from this scientific dating programme will provide some initial calibration data points, as the magnetic directions obtained (Figure 12) reflect temporal differences in the use of structures. The magnetic directions for the primary use of the Structure 8 hearth differ markedly from those measured from secondary hearths in Structures 1, 12, 14, and 16.

The two magnetic directions from the secondary hearth in Structure 1 do not overlap, suggesting that some time elapsed between the different phases of use (Batt & Outram, 2014: 18), a picture confirmed by radiocarbon dating.

Discussion

Robust dating of a site of the character of the Ness of Brodgar throws up considerable challenges, and the models presented above are both unavoidably provisional, because excavation continues, and incomplete, since neither includes any estimate for the start of Grooved Ware activity at the site. A precise chronology for the Ness of Brodgar simply derived from scientific dates is unlikely to materialise given some of the challenges outlined above, but integrating architectural sequence and

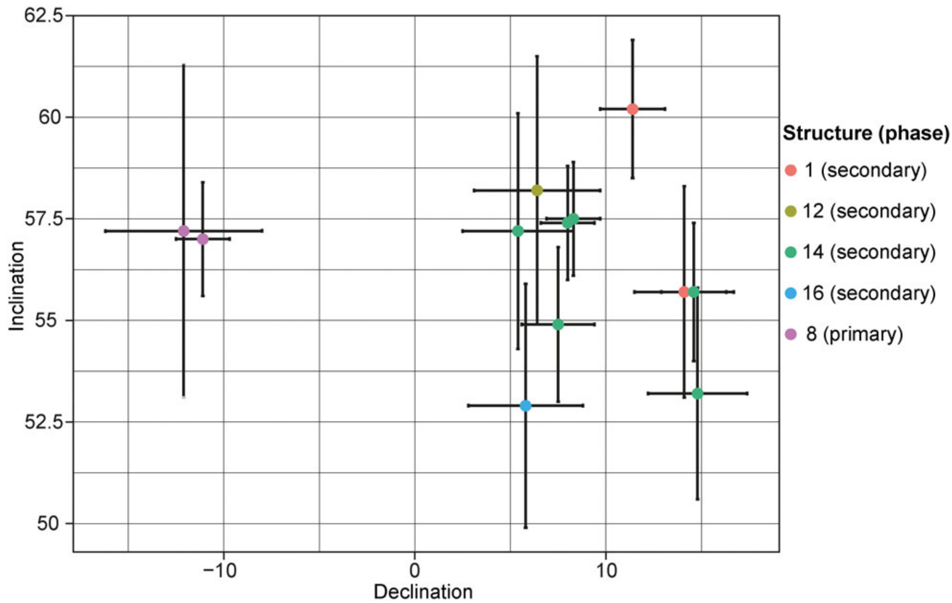

Fig. 12 - Colour online, B/W in print

Figure 12. *Ness of Brodgar. Mean magnetic directions, after removal of outliers (Batt & Outram, 2014) with errors at 95 per cent confidence.*

chronological modelling has given us the opportunity to construct provisional narratives for the chronology of activity which are different from what has previously been suggested. This has many implications. The discussion here focuses on the Ness and its immediate setting, in relation to the chronological questions set out at the start of this article. Wider considerations will be followed in subsequent syntheses that draw together all the strands of the ToTL project in Orkney.

It had previously been tempting to think of a very long span of more or less continuous use of the Ness, on the basis of preliminary radiocarbon dates and on the assumption that a large site of this kind was likely to have been in use over a long period (Card, 2012). Now, although neither of the proposed models provides a start date for Late Neolithic activity on the site, both indicate a broadly similar *terminus ante quem* of *3065–2950 cal* BC (*95% probability; start_NoB*; Figure 7; Model 1; Table 3), and *3020–2920 cal* BC (*95% probability; start_NoB*; Figure 9; Model 2; Table 3). It is impossible to say how much earlier the first Late Neolithic activity may have taken place, though the presence of the underlying structures noted above and the different character of the Grooved Ware in Trench J allow the possibility of some time-depth.

Models 1 and 2 both provide comparable estimates for the primary (Structures 7, 8, 10, and 14) and secondary (Structures 1 and 12) use of the distinctive piered buildings (Figure 13). Model 1 suggests a concentration of activity in the first quarter of the third millennium cal BC (Figure 13), with the primary use of Structures 7, 8, 10, and 14 (Figure 7) clearly occurring during the thirtieth century cal BC. Model 2, however, provides a formal estimate which places this activity between *3020–2920 cal* BC (*95% probability; start_NoB*; Figure 9) and *2855–2665 cal* BC (*95% probability; end_NoB_piered*; Figure 9; Table 3). The phase of piered architecture at the Ness of Brodgar therefore lasted, on this reading, *70–305 years* (*95% probability; piered_architecture*; Figure 11).

How long this set of buildings, including Structure 10, continued in active and continuous use is hard to define from Model 1. We can say with some confidence that there were no further new constructions in Trench P. A series of modifications to various buildings were made (Structure 8 having gone out of use with the construction of Structure 10). Structure 1 had its interior area much reduced by the insertion of a large curving wall and the creation of a new side entrance; Structure 12 was dismantled (due to subsidence) and then rebuilt with the addition of a new entrance with an annex, and two of its earlier entrances blocked; and Structure 14 had many of its orthostatic divisions removed and its entrances remodelled. Model 1 suggests that the last use of hearths in Structure 12 (*2755–2565 cal* BC (*94% probability; last_hearth_st12*; Figure 13; Table 3) or *2515–2500 cal* BC (*1% probability*) and Structure 1 (*2770–2570 cal* BC (*95% probability; last_hearth_st1*; Figure 13; Table 3) was relatively late. It is not possible to follow this part of the Ness story in detail in Model 1. Model 2, however, does suggest that this activity came to an end *around* 2800 cal BC, after a minimum duration of a couple of centuries.

As had been the case of Structure 8 at neighbouring Barnhouse (Richards et al., 2016), the most monumental of all the buildings at the Ness, Structure 10, was not the first to be set up. It does, however, seem to have appeared early on in the sequence of piered architecture, with both models agreeing that it was probably built during the thirtieth century cal BC. Model 1 estimates a date of *2990–2895 cal* BC (*95% probability; end_st8_start_st10*;

Table 3. *Highest posterior density intervals from key parameters from ness of brodgar, derived from the models defined in figure 7 (model 1) and Figure 9 (model 2)*

Parameter name		**Model 1 (see Figure 7 for definition of the model)**		**Model 2 (see Figure 9 for definition of the model)**	
		Posterior Density Estimate (95% probability unless otherwise stated)	***Posterior Density Estimate (68% probability unless otherwise stated)***	***Posterior Density Estimate (95% probability unless otherwise stated)***	***Posterior Density Estimate (68% probability unless otherwise stated)***
start_NoB	Boundary parameter estimating the start of the dated Late Neolithic activity and providing a *terminus ante quem* for the start of activity	*3065–2950 cal* BC	*3035–2980 cal* BC	*3020–2920 cal* BC	*2975–2925 cal* BC
last_hearth_st1	Last parameter estimating the last dated event in the Structure 1 hearth	*2770–2570 cal* BC	*2705–2585 cal* BC	*2865–2695 cal* BC	*2860–2875 cal* BC
last_hearth_st7	Last parameter estimating the last dated event in the Structure 7 hearth	*2930–2875 cal* BC	*2915–2890 cal* BC	*2925–2880 cal* BC	*2915–2890 cal* BC
last_hearth_st12	Last parameter estimating the last dated event in the Structure 12 hearth	*2755–2565* (*94%*) or *2515–2500* (*1%*) *cal* BC	*2670–2575 cal* BC	*2860–2715* (*94%*) or *2705–22685* (*1%*) *cal* BC	*2855–2800 cal* BC
last_st12	Last parameter estimating the dated event in Structure 12 when the roof collapse resulted in the smashing of pots near the hearth	*2855–2835* (*2%*) or *2820–2585* (*93%*) *cal* BC	*2775–2660* (*65%*) or *2645–2634* (*3%*) *cal* BC	*2875–2710 cal* BC	*2870–2830* (*46%*) or *2820–2780* (*22%*) *cal* BC
last_st14	Last parameter estimating the last dated event in the Structure 14	*2995–2905 cal* BC	*2960–2915 cal* BC	*2970–2900 cal* BC	*2940–2910 cal* BC
end_st8_start_st10	Date parameter estimating the end of activity associated with Structure 8 and the start of activity associated with the construction of Structure 10	*2990–2895 cal* BC	*2955–2905 cal* BC	*2965–2895 cal* BC	*2935–2905 cal* BC
st10_secondary_build	Last parameter estimating the last dated event associated with the primary use of Structure 10 prior to its remodelling	*2920–2885 cal* BC	*2910–2890 cal* BC	*2910–2840* (*73%*) or *2815–2755* (*22%*) *cal* BC	*2900–2860* (*66%*) or *2800–2795* (*2%*) *cal* BC
end_NoB_piered	Boundary parameter estimating the end of the dated activity associated with piered architecture	–	–	*2855–2665 cal* BC	*2850–2755 cal* BC
start_st10_last_use	Boundary parameter estimating the start of the dated activity associated with last use of Structure 10	–	–	*2720–2480 cal* BC	*2620–2500 cal* BC

Table 3. (*Cont.*)

Parameter name		**Model 1 (see Figure 7 for definition of the model)** *Posterior Density Estimate (95% probability unless otherwise stated)*	*Posterior Density Estimate (68% probability unless otherwise stated)*	**Model 2 (see Figure 9 for definition of the model)** *Posterior Density Estimate (95% probability unless otherwise stated)*	*Posterior Density Estimate (68% probability unless otherwise stated)*
central_hearth_st10	Last parameter estimating the last dated event in the Structure 10 hearth	*2550–2460 cal BC*	*2500–2465 cal BC*	*2545–2460 cal BC*	*2495–2465 cal BC*
structure_10_cattle	Last parameter estimating the last dated event in the Structure 10 animal deposit	*2340–2200 cal BC*	*2315–2265 (50%) or 2250–2205 (18%) cal BC*	*2465–2360 cal BC*	*2460–2420 cal BC*
end_st10_last_use	Boundary parameter estimating the end of the dated activity associated with Structure 10	-	-	*2460–2270 cal BC*	*2455–2380 cal BC*
end_NoB	Boundary parameter estimating the end of the dated activity	*2285–2100 cal BC*	*2275–2230 (36%) or 2200–2150 (32%) cal BC*	-	-

Figure 13; Model 1; Table 3), and Model 2 estimates a date of *2965–2895 cal BC* (*95% probability; end_st8_start_st10*; Figure 13; Model 2; Table 3).

How are pre-eminent structures of this kind to be characterised? In some of the preliminary and popularising accounts, labels such as 'temple' and 'cathedral' have been used (Card, 2010), but even more modest terms such as 'shrine' or 'meeting house' can carry significant charge (Waterson, 1990; Gell, 1998). Structure 10 ~~should~~ be seen in terms of what have been called ceremonial or 'big houses' (Bradley, 2005; Pollard, 2010; Darvill, 2016). Whatever the role of Structure 10 was, the models raise the question of the circumstances in which such a remarkable construction came into being. Did it need predecessors, and a previous history which it could trump? Or did it come out of conditions of competition among the users of the other buildings, be they purely local householders or, say, kin groupings, or representatives of wider communities from further afield across Orkney (see Card, 2012; Downes et al., 2013: 116)?

The models now available (Figure 14) indicate that the Ness of Brodgar and Barnhouse were in use at the same time. In Model 1, this was for a minimum of *75–195 years; 95% probability*; distribution not shown), and in Model 2 for a minimum of *45–155 years (95% probability*; distribution not shown). Barnhouse was abandoned in the earlier twenty-ninth century cal BC. It is not possible to envisage which of the two sites may prove to be the older. Barnhouse appears to have been a fresh foundation, but indications are that there had been earlier activity on the Ness of Brodgar.

These overlapping histories raise further questions about relationships. Were these rival sites, on either side of the narrows that separate them, one claiming seniority and precedence and the other challenging

Fig. 13 - Colour online, B/W in print

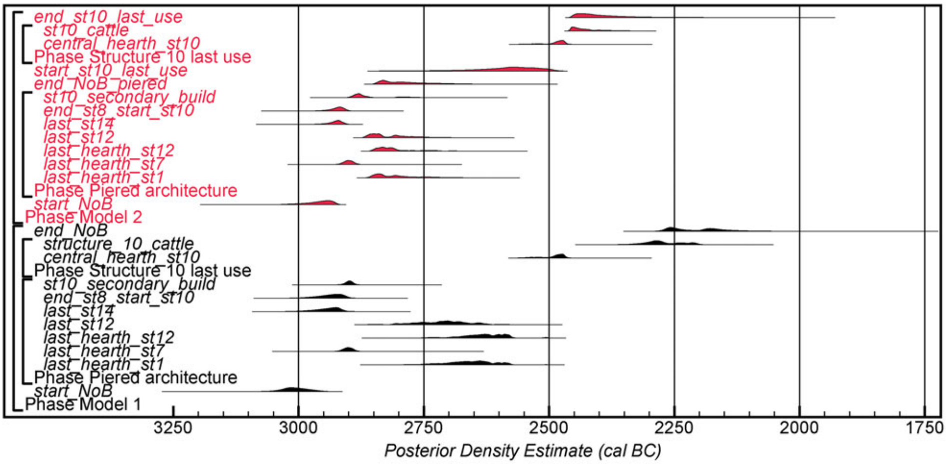

Figure 13. *Ness of Brodgar. Probability distributions of key archaeological events derived from the models shown in Figures 9 and 11.*

for equal or better position? We can say that the construction of Structure 8 at Barnhouse (Richards et al., 2016: fig. 7) was earlier (*94.8% probable*; Model 1; *98.9% probable*; Model 2) than that of Structure 10 at the Ness (Figure 14), and it would be plausible to envisage the builders of the latter setting out to emulate and surpass the scale of the former. But we should also be aware that the term 'site', so often used, may not be appropriate. Do these 'sites' represent separate communities? Did they start as such but became part of a wider complex in which, on grounds of scale, Barnhouse could be some kind of satellite to the Ness? From

Fig. 14 - Colour online, B/W in print

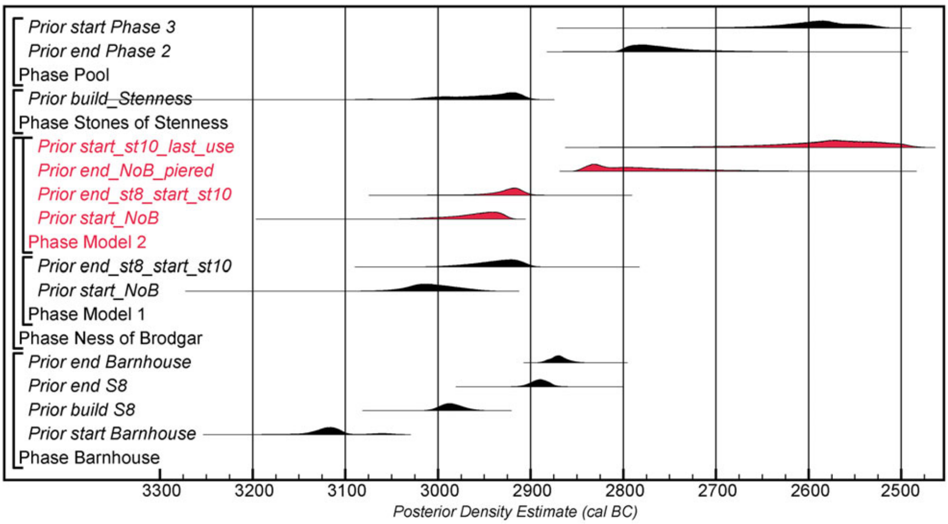

Figure 14. *Probability distributions for key parameters from Barnhouse (Richards et al., 2016), Ness of Brodgar (Figures 7 and 9), Pool (MacSween et al., 2015), and the Stones of Stenness (Bayliss et al., in press).*

this perspective, it is interesting to remember the estimate placing the construction of the Stones of Stenness probably in the thirtieth century cal BC (Schulting et al., 2010; Griffiths & Richards, 2013: 284–85), and thus squarely within the period of overlap between these two 'neighbours'. Although the samples dated from the Stones of Stenness are not in direct relationship with its construction and thus only give an indication of the chronology of activity taking place at the stone circle, the available models would indicate that this monument was erected at about the same time as Structure 10 at the Ness (Figure 14). This challenges our interpretive powers, since generally in most other settings in Britain and Ireland monuments are not directly accompanied by such a wealth of settlement remains (and it is a moot point in any case whether we label the Ness of Brodgar as simply a settlement). These models certainly set difficult questions about ownership and the constituency of the users of monuments. Finally, given the earlier twenty-ninth century cal BC as the date of abandonment of Barnhouse, this was probably (on the reading built into Model 2) the time when the character of the Ness of Brodgar began to change too. Activity at the Ness associated with piered architecture probably continued for *10–210 years* (*95% probability*; Model 2; distribution not shown), or *20–120 years* (*68% probability*) after Barnhouse ended.

Model 1 does not provide a precise estimate for the duration of the use of piered architecture at the Ness; Model 2 suggests this was not less than a century or two (Figure 11). Barnhouse was in use for *165–205 years* (*9% probability; use Barnhouse*; Richards et al., *2016*: fig. 13) or *210–295 years* (*89% probability*). It is entirely possible that the primary Late Neolithic phase at the Ness lasted longer — but not for several centuries, and that should give us pause for thought. It may also provide a valuable clue as to the nature of social relations, at the site as well as in the networks beyond in which it participated and perhaps even had a controlling interest. There must have been both risks and costs in first constructing and then maintaining a site of the size and potential complexity of the Ness. Labour had to be mobilised, and people fed, even if some of the users of the site may only have been there some of the time. As well as a place of renown and even awe, the site could have encouraged rivalries and engendered jealousies. Early Mesa Verde villages in the south-western United States have been called 'social tinderboxes', which rarely lasted beyond 30–70 years or one to three generations, as precise dendrochronological dates indicate (Wilshusen & Potter, 2010: 178). A possible scenario for the Ness of Brodgar is that the effort to keep it all going was not maintained for more than a few generations (our estimates being unavoidably imprecise). Buildings began to be modified, and in some instances were reduced in size; if there was a degree of social differentiation behind the emergence and initial development of the Ness, it did not become institutionalised enough to keep the complex going in an unaltered state forever. Conversely, one could use the analogy to turn the perspective right round; perhaps some settlements and complexes in Late Neolithic Orkney *were* able to maintain social cohesion for considerable periods of time, and the Ness could be the pre-eminent candidate for this kind of role. Whatever the interpretation, defining duration with greater precision becomes of key importance.

At various points in the sequences of individual buildings, and over the site as a whole, extensive middening began probably by at least around 2600 cal BC (Figure 7; Model 1) or by *c.* 2800 cal BC (Figure 9; Model 2). In Colin Richards' terms, we might think of this as 'wrapping' the site; whether for concealment, protection, containment, or other purposes (Richards, 2013: 17), it certainly marks a further shift in the character of the site.

Following this, after an appreciable interval (even in the less precise Model 1), there were the final modifications to the hearth in the centre of the once great Structure 10, around 2500 cal BC (Model 2) or a little later, *2550–2460 cal BC* (*95% probability; central_hearth_st10*; Figure 13; Model 1; Table 3). Again, it seems no accident that by this date this is the one visible (and so far dated) locus of activity on the site; the massive and special building was still able to attract attention presumably by the enduring power of social memory.

At this point in the sequence, our two models strongly diverge. Model 1 suggests another significant interval following the last use of the hearth in Structure 10 before the last major event associated with it (*135–320 years* (*95% probability*); distribution not shown): the enormous cattle deposit dated in the model to *2340–2200* cal BC (*95% probability; structure_10_cattle*; Figure 13; Table 3). There has been previous discussion of this as a 'decommissioning' of Structure 10 (Mainland et al., 2014: 869), but following Model 1 it would be more plausible to apply that concept to the final deposition in the central hearth around or slightly later than 2500 cal BC.

Model 2 indicates that there was a significant gap before the reuse of Structure 10 following the end of the primary phase of Late Neolithic activity (*30–335 years* (*95% probability; gap_1*: Figure 11)). In contrast to Model 1, the use of the hearth and the placing of the animal bone deposit were part of a short-lived phase of activity, which was over by *2465–2360 cal BC* (*95% probability; st10_cattle*; Figure 13; Table 3). In this reading, the animal bone deposit does indeed constitute a major decommissioning of Structure 10 (Mainland et al., 2014: 869).

The stupendous scale of this depositional event marks it out as something completely different from other acts of deposition on the site: as much a new beginning as an ending. Once again, it was Structure 10 which was chosen for the extraordinary deposition of cattle and other remains, plausibly a final testament to its now arguably mythic status. Presumably we should look to circumstances in a wider world, which now included Beaker-related practices and which can be dated nationally from *2475–2360 cal BC* (*95% probability*; Parker Pearson et al., 2016, fig. 2), even though we know rather little about the Beaker presence in Orkney (see Sheridan, 2013), and there is only one incised sherd in the deposit which could be compared with Beaker or Beaker-related pottery elsewhere. It is striking that the Model 2 estimate for the animal bone deposit so closely overlaps that for the appearance of Beakers nationally. The lack of Beaker material may suggest some kind of insular resistance to the spread of Beaker-related practices, as has been argued in the case of Silbury Hill, finished in the late twenty-fourth or early twenty-third century cal BC (Marshall et al., 2013: 111) — at a slightly later date following Model 1, but at the point of initial Beaker spread following Model 2. The Beaker funerals marked by extravagant deposition of cattle remains at Irthlingborough and Gayhurst in southern Britain also spring to mind (Davis & Payne, 1993; Chapman, 2007), but these are significantly later in the Beaker sequence.

After the deposition of the cattle bone spread, the interior of Structure 10 was infilled in a very structured manner with alternating layers of midden and rubble (Mainland et al., 2014: 869).

Looking beyond the Ness of Brodgar, there may be significant hints elsewhere in Orkney of similar chronological patterning. Barnhouse went out of use in the earlier twenty-ninth century cal BC. There was a pronounced hiatus in the occupation of Pool, Sanday, between the twenty-eighth and twenty-sixth centuries cal BC (MacSween et al., 2015; Figure 14), at roughly the same time as at the Ness (in Model 2). We should therefore not assume that Grooved Ware settlements went on forever, right across the archipelago. What, if anything, could have occurred locally at the Ness of Brodgar in the phase of reduced or absent activity before the final events connected to Structure 10? Is it coincidence that one estimate, claimed as 'reasonable', for the date of the digging of the Ring of Brodgar ditch is 2600–2400 BC, based on very imprecise OSL dating (to which we will return critically in a subsequent synthesis) (Downes et al., 2013: 113)? Was the Ness now mainly a place of memories, closed off (as it were) by a great new sacred ring close by? Or does the construction of the Ring of Brodgar — and perhaps also of Maeshowe — better belong to the floruit of the Ness of Brodgar, Barnhouse, and the Stones of Stenness, when we know that substantial numbers of people must have been concentrated, at least at intervals, in the local landscape?

Finally, the provisional formal chronologies for the Ness of Brodgar presented here already define the goals of future research. Deeper levels need to be uncovered, and across the sequence the search is on for more short-life samples of known taphonomy. The emergent chronologies for the Ness also demand more certain dating for both the Ring of Brodgar and Maeshowe (Griffiths & Richards, 2013), in line with the declared research strategy for the World Heritage Site (Downes & Gibson, 2013: 25, objectives 266 and 270). Robust formal modelling can help change fundamentally our understanding of the major research questions, and such a remarkable landscape requires a committed and continuing response.

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Une longue histoire en bref : une modélisation chronologique du site Néolithique récent du Ness of Brodgar dans les Orcades

Dans le cadre des questions ~~non~~ encore résolues sur la nature et l'évolution du Néolithique récent dans les Orcades nous présentons un sommaire des recherches menées jusqu'en 2015 sur le site du Ness of Brodgar sur l'île principale (Mainland) et en particulier ses imposantes structures bâties. L'identification d'échantillons pour datation radiocarbone suffisamment fiables a constitué un défi majeur. Certains indices parmi les objets et les éléments structurels découverts démontrent que le site a été occupé avant le principal ensemble de bâtiments fouillés à ce jour. Ici nous présentons quarante-six dates obtenues sur trente-neuf échantillons et proposons une modélisation chronologique. Deux modèles représentent deux lectures distinctes de la séquence chrono-stratigraphique. Les deux démontrent que l'architecture sur piliers existait au trentième siècle av. J.-C. (cal BC*) et que la Structure 10, immense et non pas le premier bâtiment érigé sur le site, était en place au trentième siècle cal* BC*. L'occupation associée à cette architecture sur piliers prit fin (selon le Modèle 2) autour de 2800 cal* BC*. Des dépôts de déchets et de déblais vinrent ensuite s'amonceler sur le site. Au bout d'un intervalle assez considérable un foyer situé au centre de la Structure 10 constitue peut-être le seul indice d'occupation sur un site autrement abandonné, et celle-ci prit fin autour de 2500 cal* BC*. Les restes d'environs 400 bovins ont été déposés sur les vestiges de la Structure 10, au milieu du vingt-cinquième siècle cal* BC *(selon le Modèle 2) ou vers la fin du vingt-quatrième ou vingt-troisième siècle cal* BC *(selon le Modèle 1). Ces chronologies donnent lieu à des comparaisons avec le site voisin de Barnhouse, occupé entre la fin du trente-deuxième et le début du vingt-neuvième siècle cal* BC *et avec le site des Stones of Stenness vraisemblablement construit au trentième siècle cal* BC*. Le Ness of Brodgar, y compris la Structure 10, semble avoir survécu à Barnhouse, mais il n'a probablement pas continué longtemps sous sa forme originale comme on l'avait envisagé autrefois. Le déclin et le démantèlement du Ness of Brodgar a peut-être coïncidé avec une évolution ultérieure du paysage sacré qui l'entourait mais il nous manque encore des chronologies précises pour les sites avoisinants. Les vestiges spectaculaires de festins qui ont recouvert la Structure 10 font peut-être partie d'un monde qui a changé de façon radicale et qui correspond (selon le Modèle 2) à l'arrivée des vases campaniformes dans les Iles Britanniques. Cependant c'est sans doute la position dorénavant mythique que ce bâtiment occupait dans l'esprit des gens qui a continué à les attirer.* Translation by Madeleine Hummler

Mots-clés: Orcades, Néolithique récent, céramique cannelée (Grooved Ware), Ness of Brodgar, datation radiocarbone, modélisation chronologique

Eine lange Geschichte kurz geschildert: eine chronologische Modellierung der spätneolithischen Siedlung vom Ness of Brodgar auf Orkney

Im Rahmen von offengebliebenen Fragen über den Charakter und die Entwicklung des Spätneolithikums auf Orkney legen wir eine Zusammenfassung der bis 2015 unternommenen Untersuchungen im Ness of Brodgar auf der Hauptinsel (Mainland) vor. Die eindrucksvollen Bauten, *die dort gefunden worden sind, bilden den Schwerpunkt. Es erwies sich als besonders schwierig, ausreichende Proben für Radiokarbon Datierungen zu finden. Die Funde und Befunde zeigen, dass eine frühere Phase, die vor den Hauptbauten, die bislang ausgegraben worden sind, auf dem Ness of Brodgar vorhanden ist. Sechsundvierzig Datierungen (auf neununddreißig Proben) werden hier vorgelegt und in einem neuen chronologischen Schema ausgewertet. Wir schlagen zwei Modelle vor, die zwei unterschiedliche Varianten der zeitlichen Abfolge widerspiegeln. Beide zeigen, dass Steinpfeiler in der Architektur des 30. Jahrhunderts v.Chr. (cal BC) verwendet wurden und dass die massive Struktur 10, die nicht das erste Gebäude in der Abfolge war, auch zum 30. Jahrhundert cal BC gehört. Die Tätigkeit, die mit der Steinpfeilerarchitektur in Zusammenhang stand, endete (laut Modell 2) rund um 2800 cal BC. Abfallhaufen und Schuttablagerungen folgten danach. Nach einem beträchtlichen Zeitabstand wurde eine Feuerstelle in der Mitte der Struktur 10, vielleicht der einzige Beleg für eine sonst verlassene Siedlung, errichtet und letztmals um 2500 cal BC genutzt. Die Reste von über 400 Rindern wurden auf den Ruinen der Struktur 10 niedergelegt; im zweiten Modell geschah das in der Mitte des 25. Jahrhunderts cal BC, aber im ersten Modell fand das im späten 24. oder im 23. Jahrhundert cal BC statt. Diese chronologischen Modelle laden zu einem Vergleich mit der nachbarlichen Siedlung von Barnhouse ein; die letztere ist vom späteren 32. Jahrhundert bis zum früheren 29. Jahrhundert cal BC belegt, und die Stones of Stenness Stätte wurde wahrscheinlich im 30. Jahrhundert cal BC errichtet. Die Siedlung vom Ness of Brodgar, samt Struktur 10, scheint Barnhouse überdauert zu haben, aber wahrscheinlich nicht so lange in ihrer ursprünglichen Form wie man es früher gedacht hatte. Der Zerfall und die Außerbetriebnahme des Ness of Brodgars könnte mit der weiteren Entwicklung der Sakrallandschaft in der Umgebung zeitlich übereinstimmen, aber es fehlen noch exakte chronologische Angaben für die anderen Fundstätten in der umgebenden Landschaft. Die beeindruckenden Überreste von Feiern, welche die Struktur 10 überdeckten, könnten zu einer radikal veränderten Welt gehören, die (in unserem zweiten Modell) man mit dem Auftreten der Glockenbecher auf den Britischen Inseln in Zusammenhang bringen könnte. Wahrscheinlich war es aber der inzwischen mythisch gewordene Status der Struktur 10, der die Menschen wieder heranlockte.* Translation by Madeleine Hummler

Stichworte: Orkney, Spätneolithikum, Grooved Ware (gekerbte Ware), Ness of Brodgar, Radiokarbon Datierung, chronologische Modellierung