

[Supplementary material]

Warrior ideologies in first-millennium AD Europe: new light on monumental warrior stelae from Scotland

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Loch na Beirgh: radiocarbon dating and Bayesian modelling

There are 12 radiocarbon dates available from features associated with Phases 8–10 at the site of Loch na Beirgh, Lewis, from charred plant remains (grain and wood charcoal) and carbonised food residues from pottery. The samples had been submitted over a number of years to two different laboratories. There are two radiocarbon dates from samples submitted to the Glasgow University Radiocarbon facility (GU-) in 1997, which later became the Radiocarbon Laboratory at the Scottish Universities Environmental Research Centre (SUERC-). These samples of wood charcoal underwent radiometric dating by liquid scintillation counting with the pre-treatment as described in Stenhouse and Baxter (1983) and further processing and measurement as described by Noakes *et al.* (1965). A further eight samples were submitted to SUERC in 2003 for dating by accelerator mass spectrometry (AMS). These samples of single barley grains were also pre-treated as described by Stenhouse and Baxter (1983) and graphitised following the method of Slota *et al.* (1987), with the targets measured by AMS as described by Xu *et al.* (2004). The carbonised food residues adhering to pottery sherds were submitted to the Nagoya University Tandem Accelerator (NUTA-) for dating by AMS. While the methods undertaken on these particular samples are not entirely clear, the Nagoya University likely followed a very similar process as detailed in Nakamura *et al.* (2001).

Conventional radiocarbon ages (Stuiver & Polach 1977) are presented in Table S1, where they are quoted in accordance with the Trondheim convention (Stuiver & Kra 1986). The probabilities shown in Figure S1 were calculated using the probability method of Stuiver and Reimer (1993), the internationally agreed calibration curve of Reimer *et al.* (2013), and OxCal v4.3 (Bronk Ramsey 1995, 1998, 2001, 2009). A Bayesian approach has been taken to

the development of a chronological model for the period of interest at Loch na Beirgh (Buck *et al.* 1996; Hamilton & Krus 2018). The model groups the dates by their archaeological phasing and places these phases into their observed sequence with Phase 10 earlier than Phase 9, which is earlier than Phase 8. When initially looking at the radiocarbon results in their order it is clear that three of the NUTA radiocarbon results are considerably earlier than the date from the underlying archaeology and that they are almost certainly do not accurately date when these pots were used or indicate that these pot sherds are residual. With the former there are multiple reasons why radiocarbon dates on food residues might be inaccurate: 1) the food being cooked received its carbon from a non-terrestrial source that was depleted in ^{14}C (e.g. marine foods); 2) a sampling error introduced geological age carbon (e.g. absence of ^{14}C) into the sample from the ceramic matrix that was not removed adequately through pre-treatment; and 3) the food residue absorbed contained contaminant carbon in the form of humic acids, fluvic acids and lipids from the surrounding sedimentary matrix. While the third example is expected to result in a radiocarbon age that is younger than expected, the first two result in older than expected ages. Without more data it is impossible to know if these sherds were residual or whether other reasons account for these particular radiocarbon ages. These dates have been excluded from the modelling.

Table S1. Radiocarbon dates from Loch na Beirgh, Lewis.

Lab ID	Context and Sample IDs [Phase]	Material	$\delta^{13}\text{C}$ (‰)	Radiocarbon age (BP)
GU-4923	Context 153 [10]	Charcoal: <i>Corylus avellana</i>	-26.6	1760±50
GU-4927	Context 454, sample 190 [9]	Charcoal: <i>Pinus sylvestris</i>	-25.0	1700±50
NUTA2-1182	[9]	Carbonised food residue	*	1713±26
NUTA2-1188	[9]	Carbonised food residue	*	2121±36
NUTA2-1254	[9]	Carbonised food residue	*	2002±29
NUTA2-1255	[9]	Carbonised food residue	*	2145±33

SUERC-1049	Context 503, sample 1A [8]	Charred grain: <i>Hordeum</i> sp.	-24.2	1595 ±40
SUERC-1050	Context 503, sample 1B [8]	Charred grain: <i>Hordeum</i> sp.	-25.3	1725±40
SUERC-1051	Context 503, sample 1C [8]	Charred grain: <i>Hordeum</i> sp.	-23.4	1735±40
SUERC-1052	Context 503, sample 1D [8]	Charred grain: <i>Hordeum</i> sp.	-26.0	1650±35
SUERC-3176	Context 503, sample 1A [8]	Charred grain: <i>Hordeum</i> sp.	-25.1	1630±35
SUERC-3177	Context 503, sample 1B [8]	Charred grain: <i>Hordeum</i> sp.	-24.8	1650±35

* Unknown

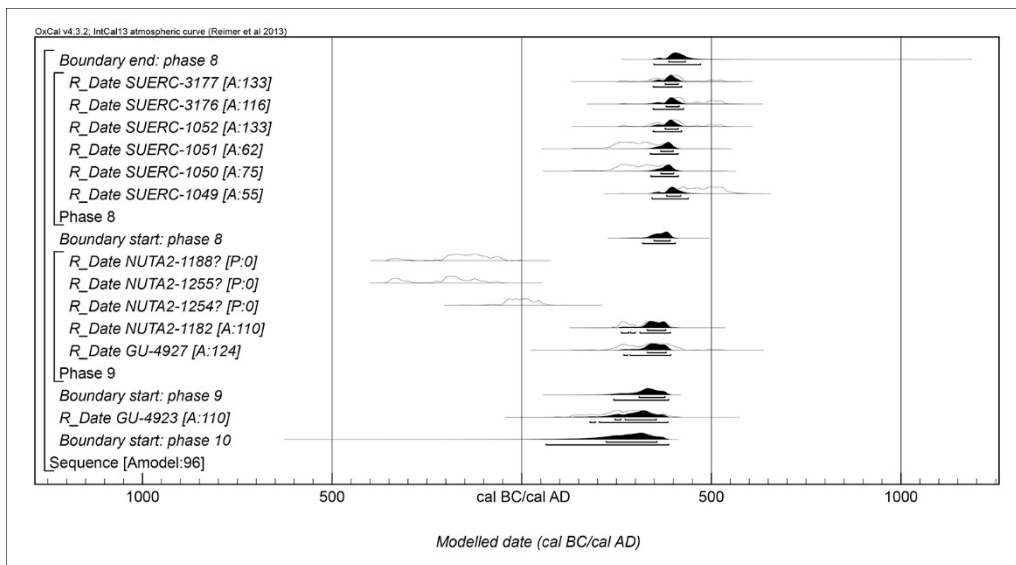


Figure S1. Chronological model for Loch na Beirgh. Each distribution represents the relative probability that an event occurred at some particular time. For each of the radiocarbon measurements, two distributions have been plotted: one in outline, which is the result of simple radiocarbon calibration; and a solid one, which is based on the chronological model used. The other distributions correspond to particular aspects of the model. For example, ‘start: phase 9’ is the estimated date that Phase 9 activity began on the site, based on the radiocarbon dating results. The large square ‘brackets’ along with the OxCal keywords define the overall model.

The resultant model developed has good agreement between the radiocarbon results and the archaeological phasing (Amodel=96). The model estimates that the transition between phases 10 and 9 at Loch na Beirgh occurred in cal AD 240–390 (95 per cent probability; Figure S1; start: phase 9), and probably in cal AD 310–380 (68 per cent probability). Phase 9 ended in cal AD 320–405 (95 per cent probability; Figure S1; start: phase 8), and probably in cal AD 350–395 (68 per cent probability). The overall span of Phase 9 activity encompassed 1–120 years (95 per cent probability; Figure S2; span: Phase 9), and probably for 1–50 years (68 per cent probability).

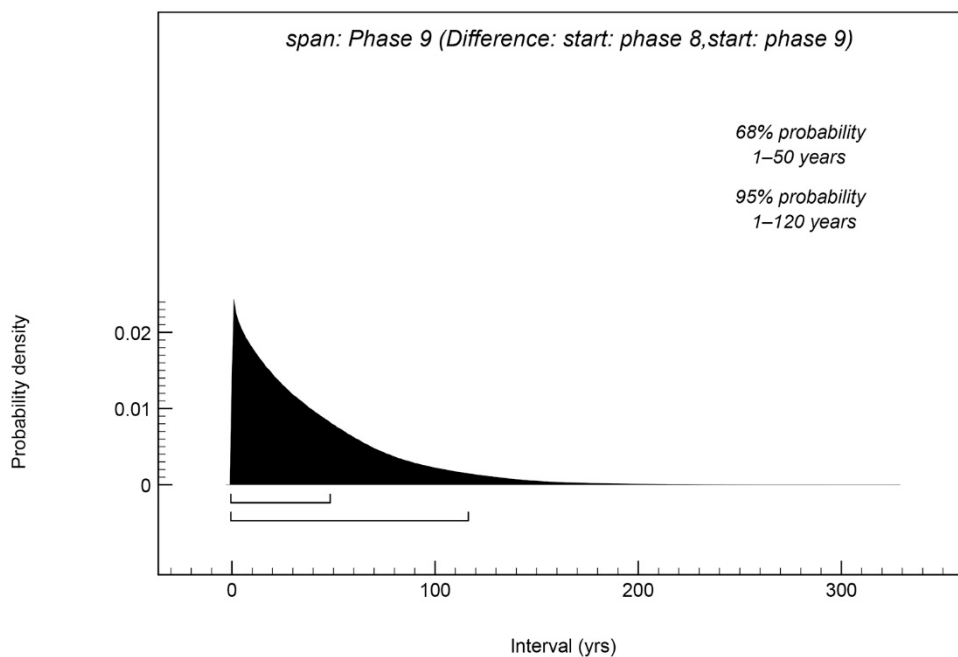


Figure S2. Probability distribution for the span of Phase 9. The probability is derived from the modelling shown in Figure S1.

Radiocarbon model code used in Oxcal

Plot()

```
{
Sequence()
{
Boundary("start: phase 10");
R_Date("GU-4923", 1760, 50);
Boundary("start: phase 9");
Phase("9")
}
```

```

{
  R_Date("GU-4927", 1700, 50);
  R_Date("NUTA2-1182", 1713, 26);
  R_Date("NUTA2-1254", 2002, 29)
  {
    Outlier();
  };
  R_Date("NUTA2-1255", 2145, 33)
  {
    Outlier();
  };
  R_Date("NUTA2-1188", 2121, 36)
  {
    Outlier();
  };
};
Boundary("start: phase 8");
Phase("8")
{
  R_Date("SUERC-1049", 1595, 40);
  R_Date("SUERC-1050", 1725, 40);
  R_Date("SUERC-1051", 1735, 40);
  R_Date("SUERC-1052", 1650, 35);
  R_Date("SUERC-3176", 1630, 35);
  R_Date("SUERC-3177", 1650, 35);
};
Boundary("end: phase 8");
};
Difference("span: Phase 9", "start: phase 8", "start: phase 9");
};

```

Geophysical survey at Collessie

Both gradiometry and electrical resistance surveys conducted by the University of Aberdeen have clarified evidence for burial monuments located in the immediate vicinity of the Newton

of Collessie warrior carving and clarified and added to existing aerial photographic images of cropmark features in the field adjacent to the Collessie standing stone. The survey was conducted over three days in February 2018 using a Bartington 601-2 gradiometer and a Geoscan resistivity meter. The survey confirmed aerial photographic evidence from 1977, 1984 and 2010. In particular, it showed that to the north of the stone there are the remains of a massive square barrow, measuring around 23m across. While this barrow had been recorded by aerial photography, the survey has defined the cropmark and identified a centrally placed pit, probably a central burial. The survey also identified a smaller square barrow to the immediate north-west measuring 13m across, as well as a partial arc of a circular ring-ditch to the east approximately 9m in diameter. About 50m to the south-east, a second cluster of features with a similar layout was identified. Two smaller circular ring-ditches, each about 8m in diameter and one with a centrally placed pit, surrounds a larger anomaly comprising the arc of a 23m diameter ring ditch with a central, elongated anomaly which may represent a burial. The morphology of the large barrow and associated monuments are characteristic of early medieval Pictish monumental cemeteries (Ashmore 1980; Winlow 2011: 341; Mitchell & Noble 2017: 12, 27). The results of the geophysical survey along with the existing aerial photographic evidence archived in Historic Environment Scotland (NMRS No. 30166) was used to create Figure 9 in the main text. The raw geophysical data is illustrated in Figure S3 below:

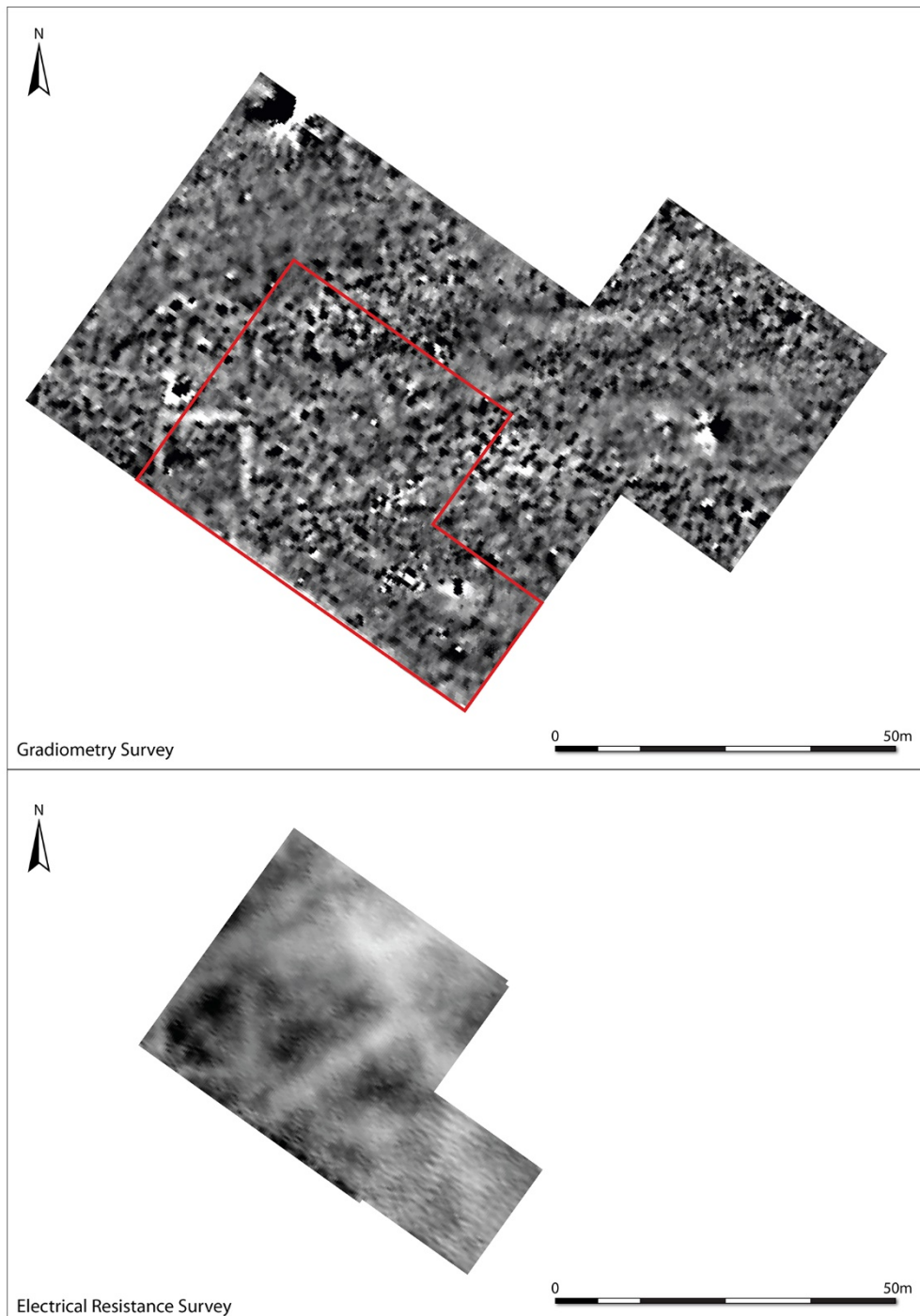


Figure S3. Geophysical survey results from Collessie.

Wider parallels

Two further marital images are considered in the text: Westerton, Angus, and Kilmorack (Balblair No.1), Inverness-shire. Photogrammetry was also undertaken at these monuments, with the result summarised in Figure S4.

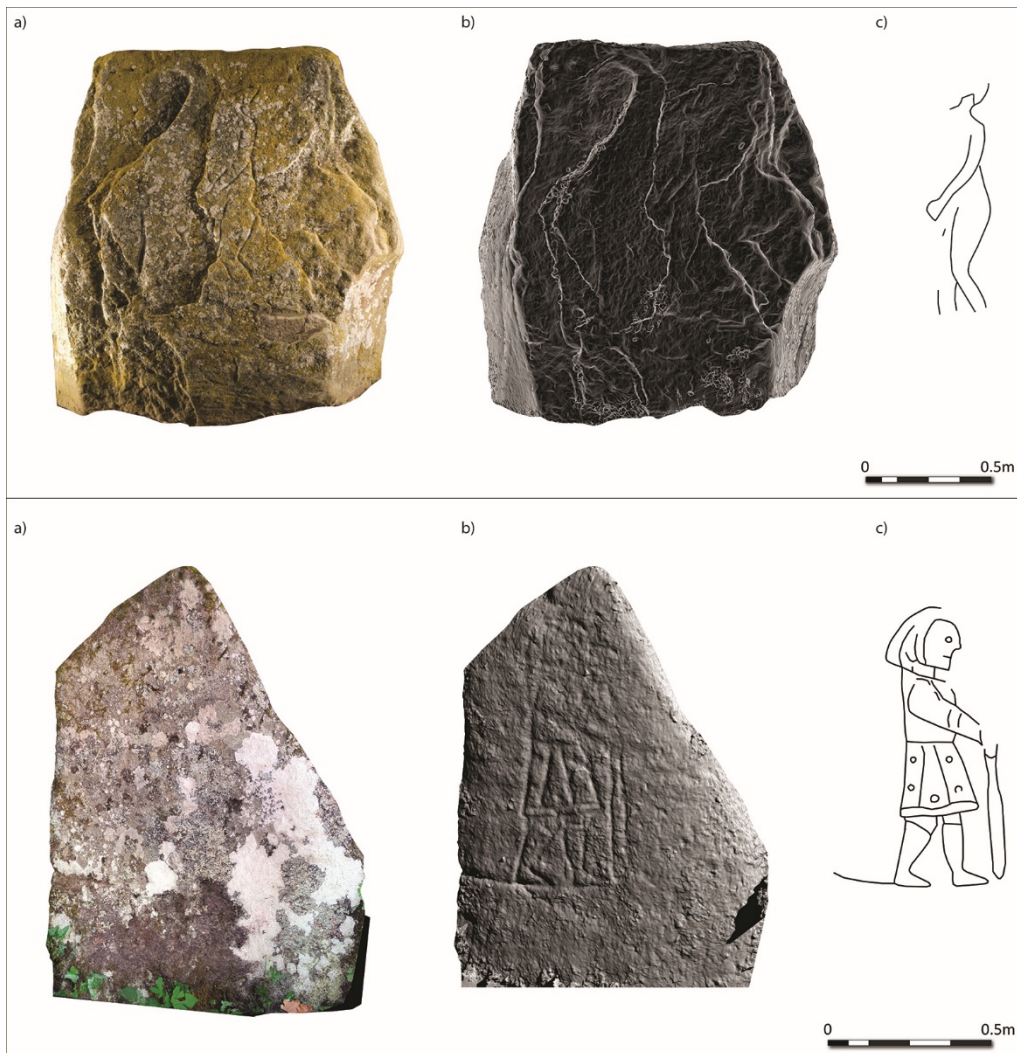


Figure S4. Images of the Westerton stone (above) and Balblair 1 stone (below). a) photogrammetry images b) 3D models c) interpretations.

3D models

Full 3D models of the Tulloch, Collessie and Rhynie No.3 stones are available on the Antiquity and University of Aberdeen sketchfab accounts:

<https://sketchfab.com/tags/antiquity>

https://sketchfab.com/aberdeen_archaeology

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