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A re-investigation of the scientific dating evidence from the hillfort at Rainsborough

by

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SUMMARY

A chronological framework is an integral part of any archaeological interpretation but it is often restricted by the lack of precision in the dates available to the archaeologist. This is a particular problem in the Iron Age, due to the limitations of radiocarbon dating in this period; specifically the period between 700-400BC where the radiocarbon calibration curve provides large errors. Archaeomagnetic dating is predominately a method of dating materials that have been heated in antiquity. Therefore archaeomagnetic studies offer an underexploited opportunity to provide dates for the Iron Age through the study of past geomagnetic field, as recorded by archaeological materials. As with radiocarbon, archaeomagnetic dating requires a calibration curve to provide calendar dates. However, in order to produce a calibration curve it is necessary to assign a calendar date to every magnetic direction used to construct it. One of the main problems with the current method of calibrating magnetic directions is the imprecision of the calendar dates attributed to the magnetic direction determinations used in it. This ongoing research is attempting to improve on the independent dating associated with each data point in the current calibration curve. Unlike radiocarbon dating, there is evidence that the direction of the geomagnetic field was undergoing rapid changes between 700-100BC, so archaeomagnetism should be capable of high resolution dating during this period. This paper describes how evidence from the Iron Age hillfort at Rainsborough is being used to improve the current archaeomagnetic calibration curve for the UK.

INTRODUCTION

The British Iron Age marks the end of prehistory, yet the archaeological record is unclear whether this was a time of upheaval and migration or prosperity and trade. Archaeologists want to answer these questions and comment on the rate and causes of changes but these discussions are limited by poor chronological resolution (Haselgrove *et al* 2001). Perhaps most prominent of these is the 'plateau' in the radiocarbon calibration curve (Fig 1). Any radiocarbon determinations that fall on the section of the calibration curve between 700-400BC provides calibrated radiocarbon dates with poor precision (Reimer *et al* 2004). This 'plateau' exists because during this 300 year span the production of radiocarbon in the upper atmosphere was changed. The cause of this interference is still unclear but possibilities include sunspot activity or fluctuations in the geomagnetic field (Damon & Linick 1986; Van der Plict 2004). The geomagnetic field protects the Earth from the effect of solar activity and it changes in intensity and direction from year to year. This secular variation in the geomagnetic field has been directly monitored since the 17th century (Tarling 1983, 3) and its application to archaeological investigations as a method of dating has been realised since the beginning of the 20th century (Belshé 1957). This is called archaeomagnetic dating and it exploits two naturally occurring physical phenomena: that the geomagnetic field changes over time and that under certain conditions iron oxides present in archaeological materials can record the ambient geomagnetic field (Tarling 1975; Linford 2006). Of most relevance to archaeology is the action of heat on clay, when features made of clay cool down from over 600°C, the direction of the local geomagnetic field is captured and will be archived as long as the feature remains *in situ*. Archaeomagnetism is an under-exploited dating technique with particular relevance to Iron Age archaeology due to the increase in pyrotechnological applications during this period, for example: metalworking, ceramic production, salt manufacture, corn drying and enamelling. This method provides a date of last use for any feature that has been subjected to intensive heating so can provide a *terminus post quem* for settlement sites or industrial activity.

Like radiocarbon dating, archaeomagnetic dating requires a calibration curve in order to produce a date in calendar years. However, due to the nature of the geomagnetic field it is necessary to have different calibration curves for different regions (Aitken 1990, 228). These calibration curves are records of the secular variation in the geomagnetic field so are called secular variation curves (SVC). The current SVC for the UK is the accumulation of 60 years of research by geophysists (Aitken & Weaver 1962; Aitken & Hawley 1967; Clark *et al* 1988; Batt 1997; Zananiri *et al* 2007) and currently the section of the curve that relates to the first millennium BC is described by just under 100 magnetic directions of known date. Research is currently being undertaken

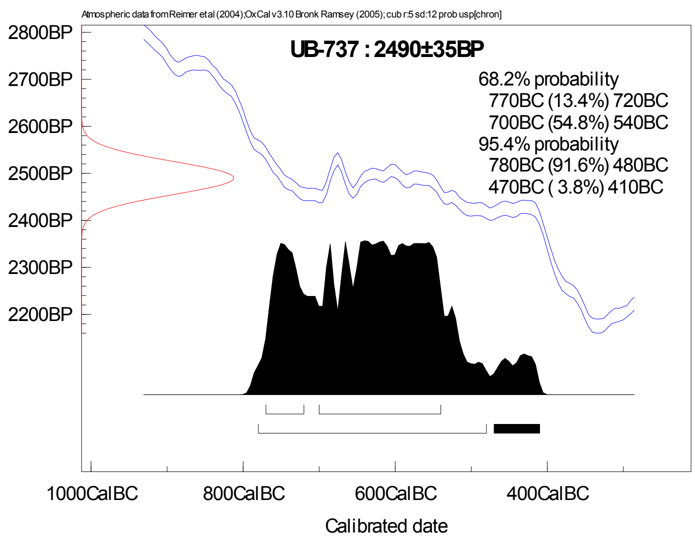


Fig 1 Calibrated radiocarbon date (using OxCal 3.10), showing the plateau in the curve (blue line) 700-400 BC

to improve the UK reference curve, so consequently our ability to date the archaeological record in the first millennium BC in Britain using archaeomagnetic dating. This is being achieved by focusing on improving the precision of the data used to construct the British archaeomagnetic reference curve and increasing the number of suitable data points. As part of this work the dating evidence from the site of Rainsborough, Northampton was re-examined.

Rainsborough is an Iron Age fort located in South Northamptonshire (SP 526 348, Fig 2), and is arguably one of the earliest forts to display a stone-faced rampart (Cunliffe 2005, 359). This site was originally excavated between 1961 and 1965 (Avery *et al* 1967) and was one of the first hillfort sites to be sampled by archaeomagnetic dating (Aitken & Hawley 1966). The sampling at Rainsborough was carried out on an *in situ* hearth within the northern guard chamber of the excavated entrance. The magnetic data collected from Rainsborough is part of the current British SVC, so is one of the 96 sites that are being reviewed in order to improve the precision of this curve. As the excavations were carried out in the 1960s, the sampling regimes employed for radiocarbon were not as rigorous or intensive as those of a modern excavation. Therefore in order to make the most of the dating evidence available it is necessary to consider the phasing of the entire site in order to provide a date range that is independent of any tautological statements involving reference to other similar archaeological sites. It is important to obtain an independent assessment of the date of last use of this hearth if it is to remain in the UK SVC.

SUMMARY OF THE HISTORY OF RAINSBOROUGH'S RAMPART

Two phases of rampart construction were identified at Rainsborough, the first rampart was later replaced by a double rampart and ditch complex (Avery *et al* 1967, 210f). This re-working of the outer perimeter into a double rampart has been classed as phase 2a. During this phase, two stone-lined C-shaped rooms were set into the return of the inner entrance and as one was placed on either side they have been interpreted as 'guard houses'. The occupation of these guard houses is phase 2b, and during this phase the 'guardroom' floors were remade. Phase 3a marks the end of use of the guardrooms when the fort was deliberately burnt and the roof of these rooms collapsed inwards. The excavation record suggests that subsequent occupation at this site ignored the guardroom entrance (Avery *et al* 1967). A total of five radiocarbon dates have been obtained for this site (Pearson & Pilcher 1975, 228) (Table 1), two of them relate to the guardrooms at the entrance of the hill fort: one from the northern guardroom (UB-737) and from the southern guardroom (UB-853). Both these dates were obtained from wood charcoal, so it is likely that the radiocarbon dates are distinctly earlier than the use of the guardrooms in which they were eventually incorporated. In addition, one set of archaeomagnetic samples were extracted from

Table 1: Radiocarbon dates from Rainsborough Camp

Sample number	**Context**	**Conventional date BP**	**Calibrated date Cal BC** **68% confidence** ***95% confidence***
UB-737	Oak charcoal from north guard room	2490+/-35	770-540 *780-410*
UB-736	Charcoal from pit K	2460+/-70	760-410 *770-400*
UB-855	Carbonised grain	2450+/-75	750-410 *780-400*
UB-853	Ash charcoal from south guard room	2430+/-75	750-400 *770-390*
UB-854	Charcoal from hollow	2305+/-115	550-150 *800-100*

Calibration: OxCal 3.10

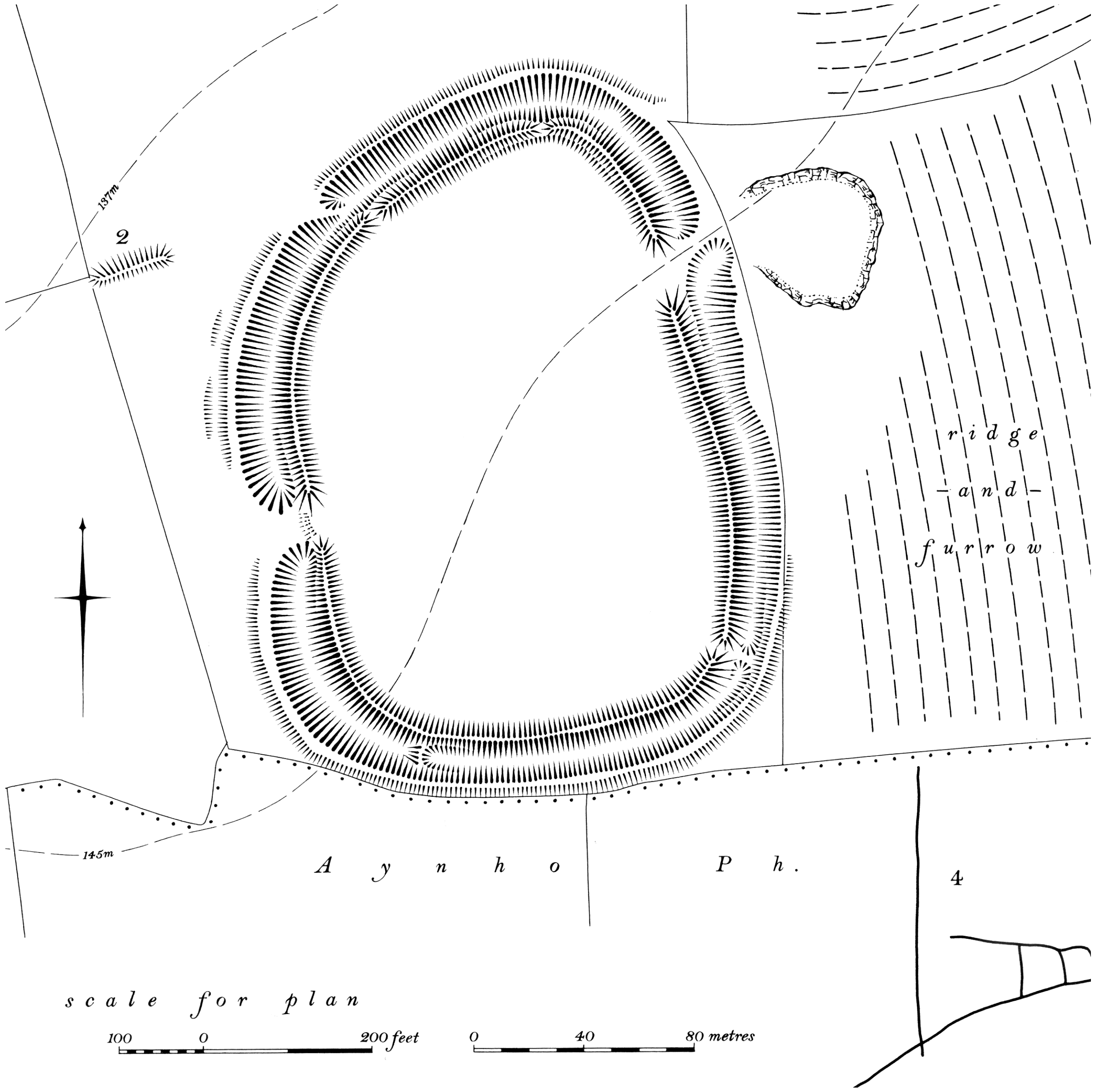


Fig 2 Survey of Rainsborough Camp (from RCHME 1982, fig 87)

the hearth in the north guard house (Aitken & Hawley 1966). The archaeomagnetic event being dated is the last use of the hearth; this can be assumed to be concurrent with the burning down of the fort.

It has been argued that the construction of the double rampart and ditch dates to the 5th century BC (Cunliffe 2005, 357), but this is based on using individual radiocarbon dates which cannot be directly related to the construction of the rampart or use of the guard houses. The other associated dating evidence can be interpreted in several ways so definitive dating of the double rampart and ditch complex remains unproven. The original phasing of the site (Avery *et al* 1967) places phase 3a, the deliberate burning of the entrance as occurring during 450-300BC. This dating is based on the discovery of a broken bronze ring in the ash near the hearth in the north guardroom. Although at the time there were no direct parallels for this ring in Britain, a 4th century BC date was reached by considering the technique of manufacture of this object, leading to the conclusion that it was at least Halstatt period. By considering aspects of the design it was suggested that it is La Tène Ia, mainly due to the spiral motif (Avery *et al* 1967, 288).

RESEARCH METHODOLOGY IN GENERAL

Archaeomagnetic dating is a derivative dating method, matching regionally specific patterns of secular changes in geomagnetism, therefore needs a calibration curve, the SVC. The pattern of change for each magnetic phenomenon has to be established by other chronometric methods, typically: historical records, radiocarbon or dendrochronology, as the secular variation pattern of geomagnetism is not predictable (Batt 1997). It is therefore necessary to assign a date to every magnetic direction used to construct the SVC. The main problems with the current British SVC relates to the chronological placement afforded to the majority of magnetic direction determinations that comprise it. At the moment these date ranges are based on the date range estimated whilst the excavation was ongoing, so many points had just been described as Iron Age and were ascribed the date range 700BC-43AD. The problem is that at present it does not include any of evidence that came to light post-excavation; consequently, the temporal assignments of many points are ill defined with little confidence in their reliability (Clark *et al* 1988). In order to address this issue it was decided to review the archaeological evidence associated with each archaeomagnetic direction in the reference curve as it should be possible to improve on the current situation and may enable the age range associated with each data point to be reduced from 750 years. Having identified this problem with the current reference curve the question remains, how to provide an independent date for each of the magnetic directions when they are recovered from a pre-Roman site and produce a realistic measure of the errors associated with that date? This is a complex issue, particularly as it is essential to provide a rigorous and transparent methodology that avoids any tautological arguments.

The common element of the stratigraphic record was used to combine all the available chronological indicators to answer a single question: when were each of the hearths last used. The focus on this aspect is because it is the event that is dated by archaeomagnetic dating. The British SVC has undergone a series of developments and is currently in its third incarnation, the first only covered the last two millennia, the 'Aitken curve' (Aitken & Hawley 1967); the second and third SVC, the 'Clark' (Clark *et al* 1988) and 'Zananiri' curves (Zananiri *et al* 2007) respectively, cover the last three millennia, including the first millennium BC. In order to avoid circular arguments by referring back to the dates provided by earlier calibration curves it was deemed necessary to attempt to provide a completely independent, yet reliable date for each of the magnetic directions selected for reanalysis. It is envisaged that an independent measure of when the hearth was last used will be obtained one of two ways:

1 The most straightforward case would be if the hearth was directly dated by another method. An independent date available from the same context sampled to provide the magnetic direction could be used to directly date the last burning event. This will be applied with caution as predominantly the independent dating method involved will be radiocarbon, so the material sampled needs to be a short lived single entity, for example a charred cereal grain, and other criteria for assessing the reliability of radiocarbon determinations will be observed (Ashmore 1999).

2 If the hearth cannot be directly dated then the location of the last use of the hearth will be identified within the stratigraphic record and transferred to the sequence of dates for that structure. Then Bayesian analysis will be used to provide posterior density estimates for each of the dated events in the sequence by taking into account the restrictions imposed by the stratigraphic sequence (Buck *et al* 1996) and finally the age range that should be assigned to the magnetic direction from each hearth will be calculated to within 95% probability.

This methodology was applied to the site of Rainsborough and attempted to incorporate the radiocarbon dating evidence (Pearson & Pilcher 1975) and the stratigraphic details available (Avery *et al* 1967) to model the events that created the archaeological record. The hypothesis is that by applying Bayesian logic it should be possible to calculate the most likely date range that the hearth in the north guardroom was last used given all the other stratigraphic relationships, a posterior density estimate (Bronk Ramsey 2008). This analysis was done using OxCal v3.10 (Bronk Ramsey 1995 & 2001) as it allows the user to enter archaeological information, which will constrain the radiocarbon dates.

RESULTS

The results of applying this method to the data from Rainsborough are provided in Figure 3. Overall this sequence shows excellent agreement, A=92.0%, with the agreement indexes for the individual radiocarbon determinations well above the critical value of 60.0%. This demonstrates that the radiocarbon determinations match their stratigraphic positions so the modelled dates are valid. The posterior density estimate for the hearth suggests that the hearth in the north guardroom was in use between 640 and 370BC at 95% probability, see Figure 4. This shows some overlap with the date range for the end of use of the guard house proposed by Avery of 450-300BC but has been obtained using the radiocarbon dates so is independent of any typological assumptions. It is not possible to improve the precision any further for two reasons: firstly the nature of the material sampled for radiocarbon dating and secondly the lack of a direct relationship between the hearth and samples UB-854 and UB-855. The stratigraphically earliest of the samples submitted for dating were wood timbers from the construction of the guard houses. It was possible to apply a correction to UB-853, as this sample was of 25 year old ash wood but this was not possible for the oak timber sampled for UB-737 as there was no estimate of the age of the tree. It is difficult to relate the cutting down of a tree to the use of a building but these dates were more likely to represent the construction of the guard houses. The model suggests that this happened between 1020-500BC. Only one sample UB-736 could be directly related to the destruction of the entrance as it was sampled from debris from the burning. Finally the last two samples UB-854 and UB-855 had no direct stratigraphic relationship to the hearth in the north guardroom. As all of these radiocarbon determinations are conventional radiocarbon dates, coupled with the

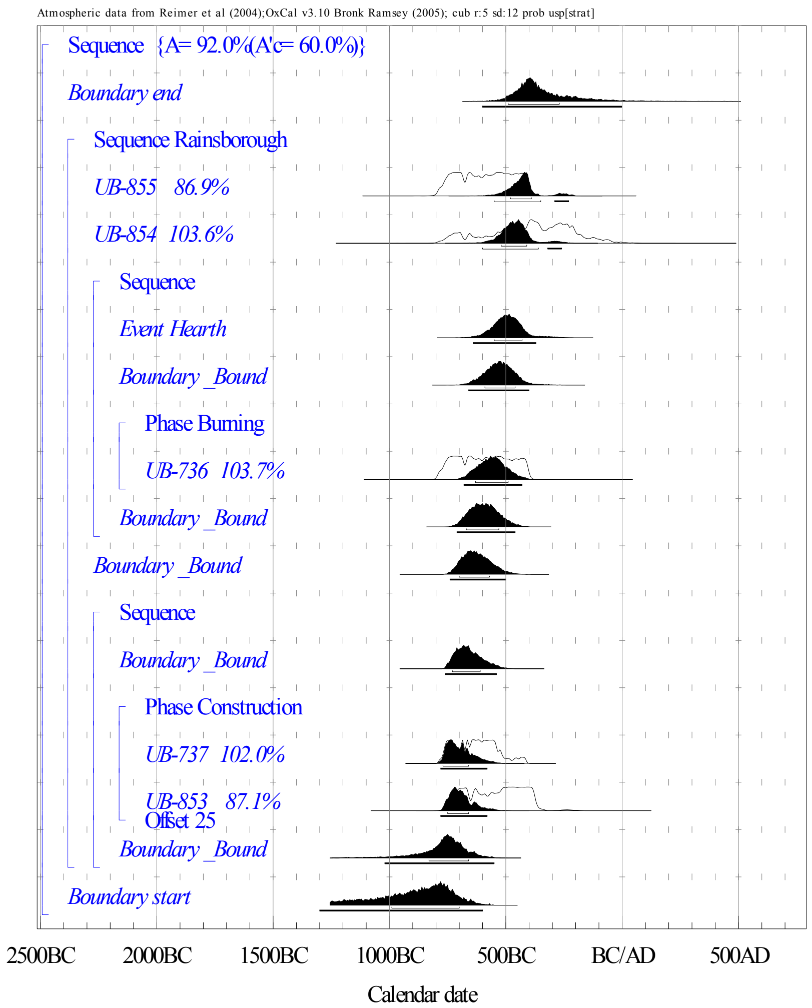
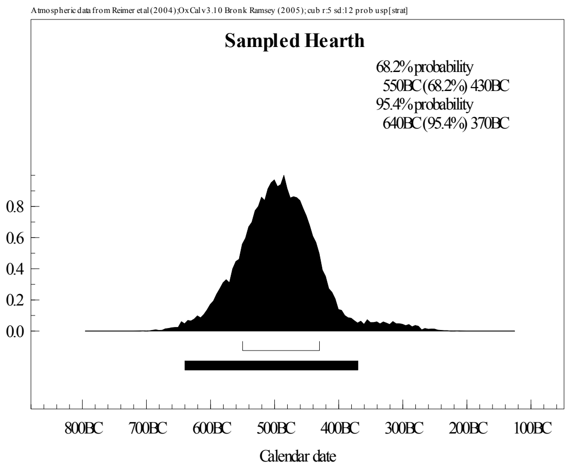


Fig 3 Probability distributions for the radiocarbon determinations from Rainsborough



lack of relationship between the contexts sampled for radiocarbon dating has meant that in this case the date ranges obtained are still quite broad. The details of this analysis will be incorporated into the new SVC and Table 2 shows the magnetic and chronological data recovered from this site as they will be incorporated into the British SVC.

Fig 4 Posterior density estimate for the burning event as calculated within the sequence of events recorded at Rainsborough

Table 2: Table summarising the magnetic and chronological information from Rainsborough that will be included in the archaeomagnetic master curve

Sample	Dec	Inc	Alpha-95	Date range in Zananiri database	'Event' date range	Data in revised database
RAB	357.6	67.5	2.8	375BC±75	640-370BC	505BC±135

CONCLUDING REMARKS

Traditionally, assemblages of material culture have been used as chronological indicators but it can be difficult to identify contemporaneous cultures when the wider landscape is considered. This becomes even more challenging when Britain as an entity is considered, due to the degree of regionality that can be identified within the archaeological record for this period (eg Hill 1995a; Harding 2004, 3-5). Furthermore the dating evidence from Rainsborough has previously been considered problematic as it could be interpreted in different ways. Archaeomagnetic dating is predominately a method of dating objects that have been heated in antiquity and is currently an underexploited method to provide dates for the Iron Age. The results from the re-evaluation of Rainsborough have lent some support to the original dates proposed by Avery but in this case have not been able to offer more precision. The evidence from the radiocarbon dates does suggest that the burning event may have happened earlier than originally proposed but there are insufficient data to make any claims in this direction. This is due to the choice of material sampled for radiocarbon, the small number of radiocarbon determinations, and the lack of clear and direct stratigraphic relationships between the contexts sampled for radiocarbon dating.

This is part of a larger research project where the primary aim is to use studies of the geomagnetic field, as recorded by archaeological and geological materials, to identify and characterise short (decadal) timescale changes in the Earth's magnetic field. Once completed these data should be able to improve our ability to define the chronology of the British Iron Age. This research is still incomplete but some interim statements can be made on the progress so far. It has been possible to propose an approach to improving the dating of the magnetic directions in the current SVC and demonstrate its validity. Originally there were 78 magnetic directions from 40 different sites in the British SVC, and Rainsborough was one of them. So far this has been increased by the collection of more samples during fieldwork (15 directions from 7 new sites) and from identifying new sites in literature searches (71 new directions from 30 new sites). This provides at total of 200 magnetic directions from 96 sites. Of these, 100 magnetic directions have had their associated date re-evaluated and the new date ranges are substantially smaller than the original dates, generally ±100 years, unfortunately Rainsborough is one of the exceptions. This success in general demonstrates that the proposed methodology works, so will be applied the remaining magnetic directions and the additional magnetic data collected.

Once the British SVC is reconstructed with the new data it will be possible to investigate the impact of this work on our understanding of the geomagnetic field. Changes in the geomagnetic field have far reaching consequences, as it protects the Earth from the effects of solar radiation (Evans & Heller 2003, 245). Increased understanding of the geomagnetic field will impact on the ability to calibrate radiocarbon determinations; as fluctuations in the amount of cosmic radiation that enter the Earth's upper atmosphere directly affects the concentrations of 14C present in the atmosphere (Evans & Heller 2003, 111; Van der Plict 2004). This has major implications for the use of radiocarbon dating in the period in question. As it is apparent that the direction of the geomagnetic field undergoes a rapid change whilst the production of radiocarbon in the upper atmosphere is affected over a prolonged period; this suggests that there may be some connection between these two systems. It will also be possible to investigate the factors that underpin chronological models of the British Iron Age, via architectural features and structural sequences where there is fired material *in situ*. These dates have a direct relationship to the archaeology under investigation, as they provide a date of abandonment for domestic structures or date of last use for kilns and furnaces. It is hoped that improvements to the resolution of the British SVC may provide some insights to these and other questions relating the archaeology of the British Iron Age.

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