Grey Friars, Leicester 2012: Radiocarbon dating of human bone from Skeleton 1, the, since confirmed, remains of Richard III

D. Hamilton and C. Bronk Ramsey (compiled and edited by N.J. Cooper)

Introduction

This report is divided into three sections: the first and second are the respective independent reports done by the research laboratories at the Universities of Glasgow (SUERC) and Oxford and the third is a modelling of the four dates combined undertaken by Derek Hamilton at the University of Glasgow (SUERC). Two samples of rib bone from Skeleton 1 were submitted to each laboratory for analysis.

Report on the radiocarbon dating of human bone from Skeleton 1, undertaken at Scottish Universities Environmental Research Centre (SUERC)

(Report received 14/11/12; updated 18/06/13)

Derek Hamilton

Two samples of human rib bone were submitted for radiocarbon dating to the Scottish Universities Environmental Research Centre (SUERC) in 2012 from a skeleton recovered by archaeologists from the University of Leicester Archaeological Services from the site of Greyfriars Friary in Leicester. The samples were pretreated following a modified Longin (1971) method. They were then combusted to carbon dioxide (Vandeputte *et al* 1996), graphitised (Slota *et al* 1987), and measured by accelerator mass spectrometry (AMS) (Xu *et al* 2004).

The radiocarbon results in Table 1 are quoted in accordance with the international standard known as the Trondheim Convention (Stuiver and Kra 1986). These are conventional radiocarbon ages (Stuiver and Polach 1977). The two measurements are statistically consistent (T’=0.1; v=1; T’(5%)=3.8; Ward and Wilson 1978) and have been combined to form weighted **mean Greyfriars 2012** (437 ±13 BP).

The calibrated date range in Table 1 has been calculated using the maximum intercept method (Stuiver and Reimer 1986), the calibration curve of Reimer *et al* (2009) and the computer program OxCal v4.2 (Bronk Ramsey 1995; 1998; 2001; 2009). It is quoted with endpoints rounded outwards to 5 years, following Mook (1986). The graphical distribution of the calibrated result (Fig 1) is derived from the probability method (Stuiver and Reimer 1993).

Table 1: Radiocarbon results from Greyfriars Friary, Leicester

Lab ID	**Sample ID**	**Material**	**δ^{13}C (‰)**	**δ^{15}N (‰)**	**C:N**	**Radiocarbon age (BP)**	**Calibrated date (95% confidence)**
SUERC-42896	Greyfriars 2012 – Burial 1 Sample 1	human bone: rib	-18.7	14.6	3.2	434 ±18	
SUERC-42897	Greyfriars 2012 – Burial 1 Sample 2	human bone: rib	-18.6	15.0	3.2	440 ±17	
mean Greyfriars 2012						437 ±13	cal AD 1430–1460

The stable isotope measurements for the two samples indicate that this individual had a highly varied, protein-rich diet that included non-terrestrial resources probably seafood (Fig 2) (Chisholm *et al* 1982; Schoeninger *et al* 1983). Furthermore, the C:N ratios suggests that bone preservation was sufficiently good to have confidence in the radiocarbon determinations (Table 1; DeNiro 1985; Masters 1987; Tuross *et al* 1988).

It is known that both oysters and seafish were available and consumed by people across social classes in the medieval period, and it is likely that marine resources are the cause for these stable isotope values. While the ratios of ^{14}C:^{13}C:^{12}C are in equilibrium between the atmosphere and biosphere, they are not also in equilibrium with the oceans, and can cause organisms that derive their carbon from the sea to appear up to several hundred years too old when radiocarbon dated. When humans and other terrestrial animals derive a portion of their protein from marine resources, it becomes necessary to ‘correct’ the radiocarbon age for this marine reservoir effect.

For the samples from Greyfriars, the correction follows the methodology of Arneborg *et al* (1999), where linear interpolation is used between the δ^{13}C end members -12.5‰ (purely marine) and -21‰ (purely terrestrial) to calculate the ‘percent marine diet’. In the case of this individual, using the mean of the two δ^{13}C measurements, the percent marine value is 27.6%. This percent marine value has been given a standard error of ±10%, and is used for the modelled calibration that mixes the international terrestrial and marine radiocarbon calibration curves of Reimer *et al* (2009). Since the offset between these two curves is both spatially and temporally dependent, a further ΔR correction of -29 ±51 years, derived from research into the marine reservoir of samples along the North Sea coast of Scotland in the medieval period, has been included into the calculation (Russell 2011).

An unfortunate side-effect of marine reservoir correction is that the modelled date will decrease in precision. In the case of the result from Greyfriars, the precision of the unmodelled date was the result of the calibration falling onto a steep section of the calibration curve (Fig 1), however as we apply the marine reservoir correction the ^{14}C age decreases and the resulting date falls along a flattened area of the calibration curve, which serves to expand the calibrated probability significantly.

The application of Bayesian statistical modelling can help to reduce the area of the probability (Buck *et al* 1996). By AD 1541, the monasteries had been dissolved by Henry VIII, with Greyfriars in Leicester having been dissolved near the end of the 1530s. It is possible to provide a more realistic estimate for the death of the individual by using Bayesian statistics to re-calculate the probability with the additional information that the individual dies pre-Dissolution. In this model the year AD 1538 was used. The result (Fig 4) indicates that the individual probably died at some time in *cal AD 1460–1540* (*95% probability*).

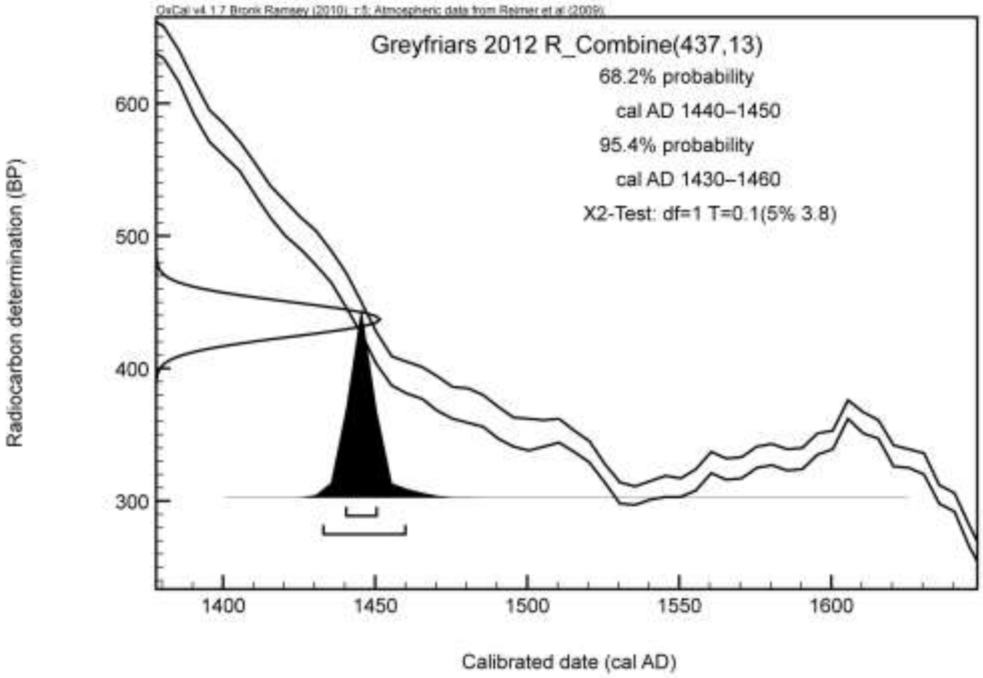

Figure 1: Calibration of mean Greyfriars 2012 shown against the IntCal09 terrestrial calibration curve

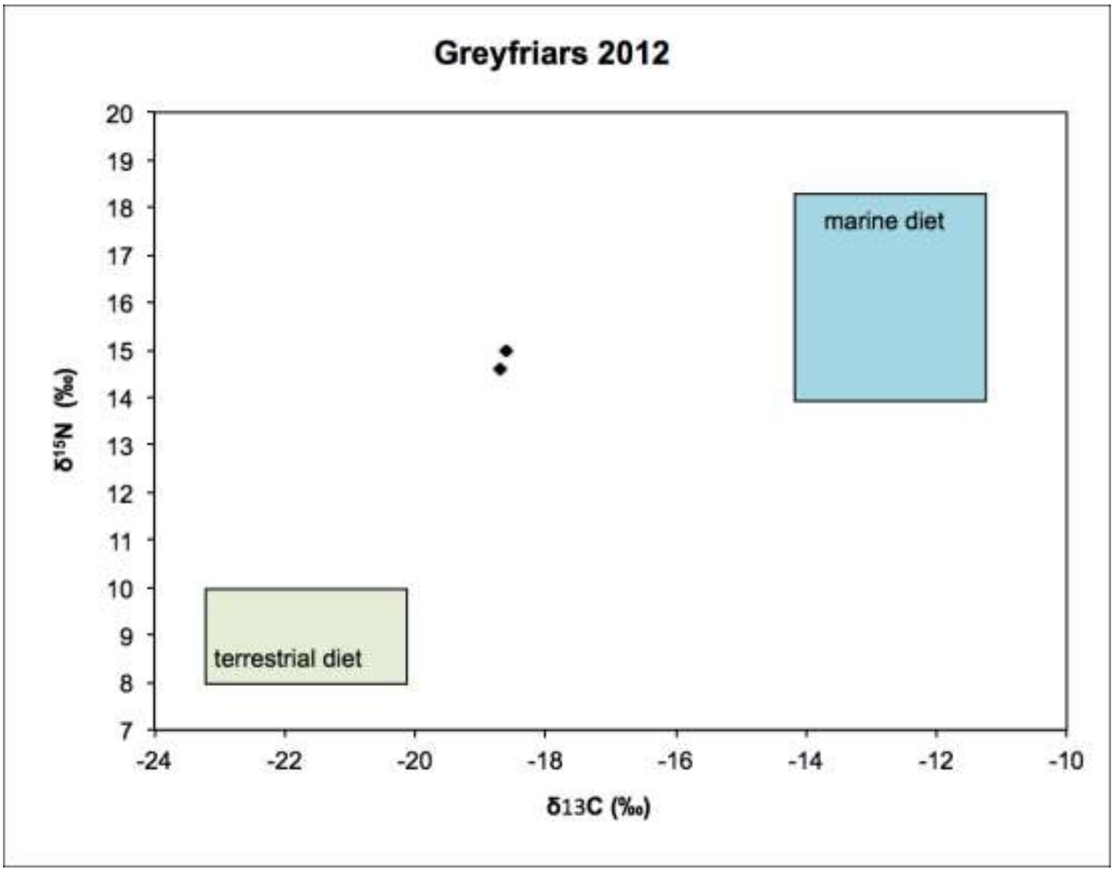

Figure 2: Estimated protein foods contribution to stable isotope values in bone. Stable isotope values in these human bone samples suggest that diet contained varied sources of protein, including a significant marine component. Boxes are based on known ranges for protein sources (Mays 1998, fig 9)

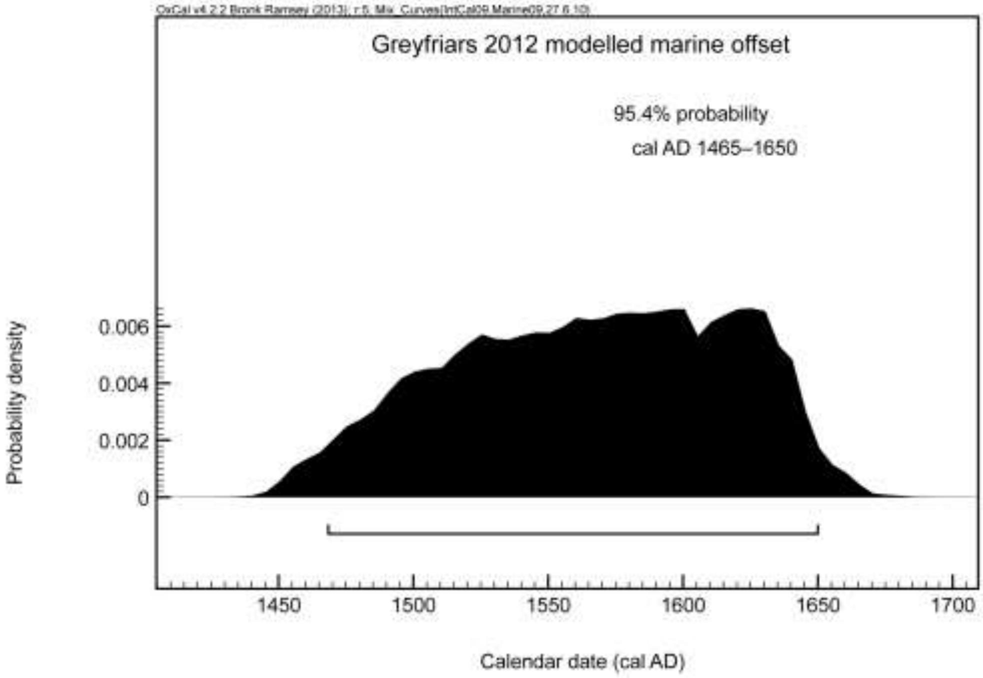

Figure 3: Modelled date of mean Greyfriars 2012, after applying the marine reservoir correction and calibration in OxCal by mixing the IntCal09 and Marine09 calibration curves

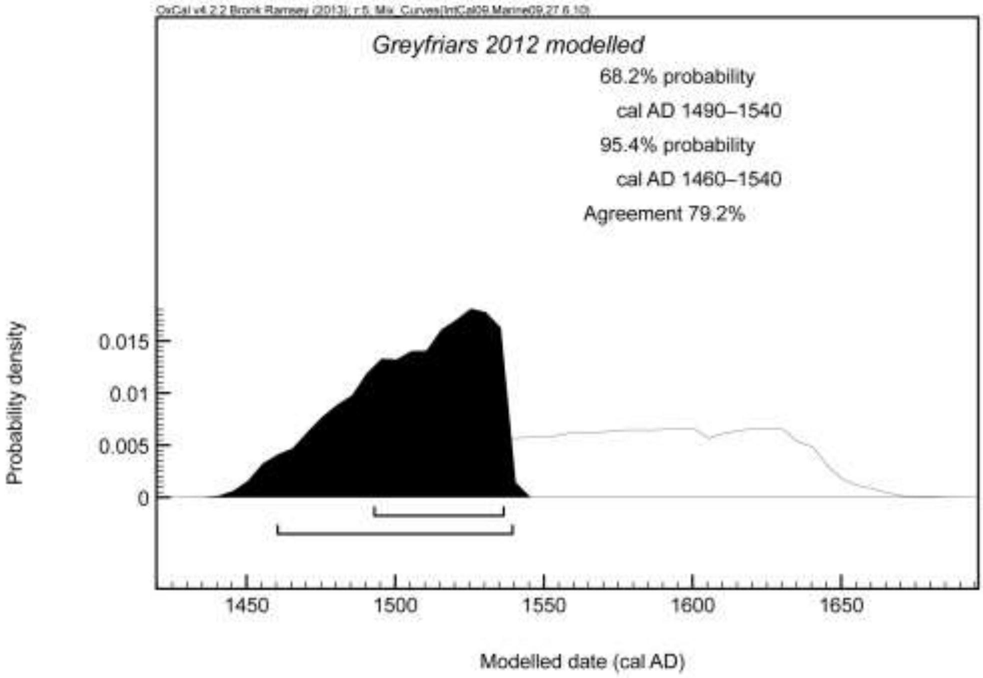

Figure 4: Further refined modelled date of mean Greyfriars 2012, after the application of Bayesian statistics to constrain the date of the burial to pre-Dissolution, before AD 1538 in this instance

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Report on the Radiocarbon dating of human bone from Skeleton 1 undertaken at the University of Oxford

(Report received 20/12/12 and updated May 2013)

Christopher Bronk Ramsey

Two samples of rib bone were received for analysis at the University of Oxford Radiocarbon Accelerator Unit in the Research Laboratory for Archaeology and the History of Art. The results of the analysis are tabulated below (Table 1).

Table 1 Results of analysis at the University of Oxford Radiocarbon Accelerator Unit

OxA	**Sample**	**Material**	**δ^{13}C**	**δ^{15}N**	**Date**
OxA-27182	Greyfriars SK1 Sample 1	bone	-18.37	15.0	478+/-25
OxA-27183	Greyfriars SK1 Sample 2	bone	-18.38	15.3	480+/-25

The dates are uncalibrated in radiocarbon years BP (Before Present - AD 1950) using the half-life of 5568 years. Isotopic fractionation has been corrected for using the measured δ^{13}C values measured on the AMS. The quoted δ^{13}C values are measured independently on a stable isotope mass spectrometer (to ±0.3 per mil relative to VPDB). For details of the chemical pretreatment, target preparation and AMS measurement see *Radiocarbon* **46** (1) 17-24, **46** (1): 155-63, and *Archaeometry* **44** (3 Supplement 1): 1-149. The attached calibration plots (fig 1), showing the calendar age ranges, have been generated using the OxCal computer program (v4.1) of C. Bronk Ramsey, using the 'INTCAL09' dataset (*Radiocarbon* **51** (4), 2009).

The two radiocarbon dates are in very good agreement with each other and the calibrations for the combined results are also shown (fig.1).

The stable isotope values for these samples clearly suggest a marine component to the diet (the δ^{15}N values were 15.0 and 15.3 respectively) and the δ^{13}C values above are also higher than for a purely terrestrial diet. Estimating absolute levels of dietary contribution is very difficult without local information about dietary end-members. However, we can use estimated date of death to inform us about the diet - in this case, assuming a date of death of 1485, and a local marine reservoir relevant for England (taken as the 10 nearest points to London from the CHRONO marine reservoir database; these give a mean value of 4 and an error on the mean of 17) suggests that the marine component of the diet is 27±4%. This must be treated with caution as it takes no account of bone turnover or exact source of the marine diet but it does suggest (as do the stable isotope values), that about a quarter of the dietary protein is from marine sources. For reference, I have also attached calibrations based on the assumption of a 25±5% marine component of the diet (fig.2).

The nitrogen isotope levels further suggest a high-trophic level - perhaps also a very carnivorous diet for the terrestrial component.

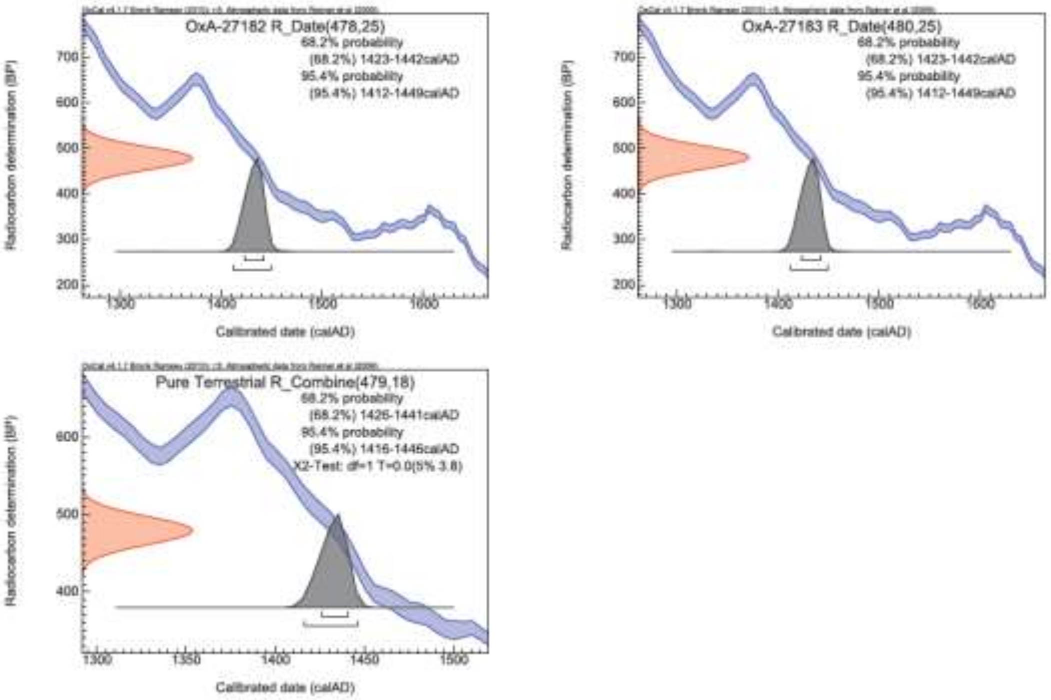

Figure 1 Calibrated individual and combined results

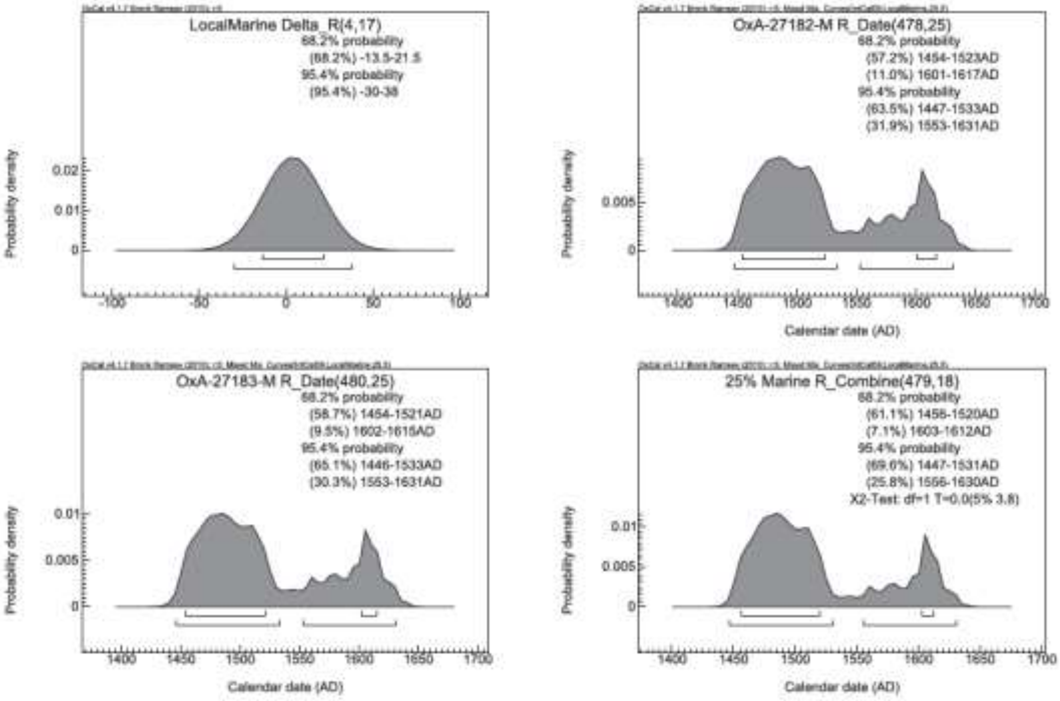

Figure 2 Calibrated individual and combined dates taking into account high marine component in the diet.

The Modelling of the Four Dates

Derek Hamilton (SUERC, University of Glasgow, East Kilbride)
Result received February 1st 2013 (updated 18/06/13)

The two pairs of radiocarbon results from the laboratories in Oxford and East Kilbride were combined using a weighted mean. Stable isotope values for the samples indicated that approximately 29% of the dietary protein was from marine sources; they were calibrated using a mixed modelling approach to account for this percentage of marine protein. The result was then placed into a Bayesian statistical model, using the OxCal program, to determine the most probable date of the sample given the burial would have occurred prior to the Dissolution (*c*1538 in the region) (Fig.1).

The ^{14}C evidence provides a modelled date of death of *cal AD 1455–1540* (*95% probability*), consistent with an individual who died in 1485. This date is *contra* Buckley *et al*. 2013, where, due to a late editing error, the modelled date of death was given as *cal AD 1456–1530* (*95% probability*).

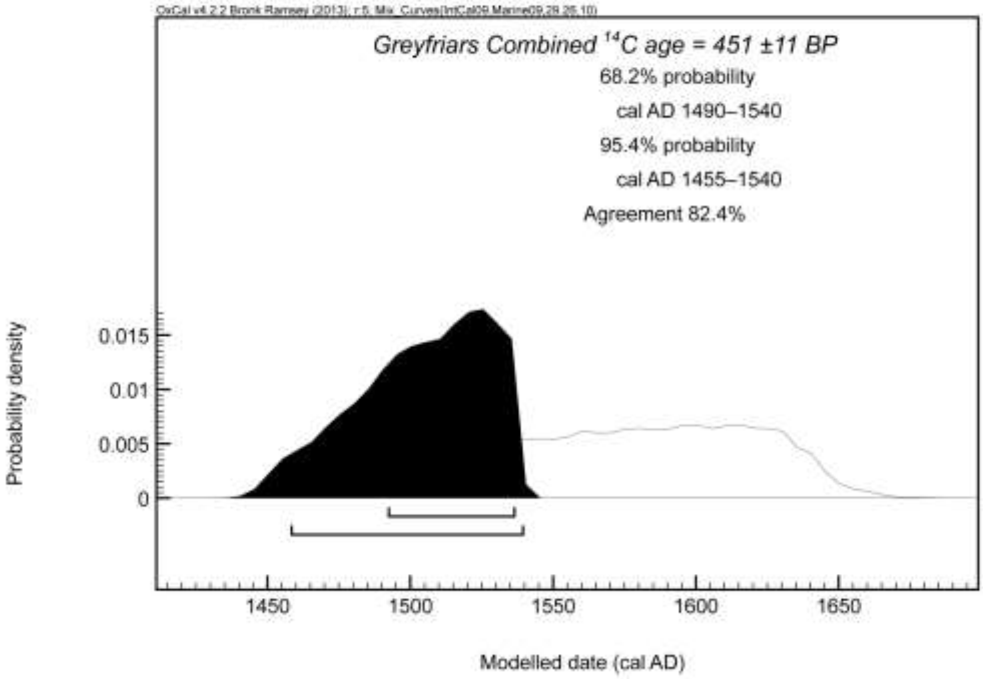

Figure 1 Combined and modelled date using the combined results from Glasgow and Oxford

Reference

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