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EXTENDED RADIOCARBON CALIBRATION IN THE ANGLO-SAXON PERIOD, AD 395–485 AND AD 735–805

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ABSTRACT. Radiocarbon dating has been used infrequently as a chronological tool for research in Anglo-Saxon archaeology. Primarily, this is because the uncertainty of calibrated dates provides little advantage over traditional archaeological dating in this period. Recent advances in Bayesian methodology in conjunction with high-precision ^{14}C dating have, however, created the possibility of both testing and refining the established Anglo-Saxon chronologies based on typology of artifacts. The calibration process within such a confined age range, however, relies heavily on the structural accuracy of the calibration curve. We have previously reported decadal measurements on a section of the Irish oak chronology for the period AD 495–725 (McCormac et al. 2004). In this paper, we present decadal measurements for the periods AD 395–485 and AD 735–805, which extends the original calibration set.

INTRODUCTION

Radiocarbon dating has seldom been used for archaeological dating in western Europe in relation to the migration period (about AD 400–700). This is because the calibrated dates produced in this period have usually been insufficiently precise to refine existing archaeological chronologies (principally those based on artifact types).

A major research program into the chronology of Anglo-Saxon graves in the period AD 570–720, however, is currently underway at Queen's University Belfast and Cardiff University. This project uses Bayesian chronological modeling (Bronk Ramsey 1995; Buck et al. 1996) to combine high-precision ^{14}C dates with sequences produced by correspondence analysis of the artifact types recovered from graves (Greenacre 1984, 1992; Høilund Nielsen 1995). The exact structure of the calibration curve in this period is critical to the project, as is the accuracy of the ^{14}C measurements produced. For this reason, replicate ^{14}C determinations were made on known-age wood samples from the period AD 495–725. These were measured quasi-simultaneously with the human skeletons from the artifact-containing graves. The calibration results for the period AD 495–725 have been reported previously (McCormac et al. 2004), and are incorporated within IntCal04 (Reimer et al. 2004).

The higher temporal resolution of the measurements given in this paper, compared to the bidecadal measurements of Pearson et al. (1986), shows structure in the calibration data, which was not previously apparent (Figure 1). The effect of this refined calibration is shown in Figure 2, which provides a comparison of the calibrated date for Grave 91 from the cemetery of Edix Hill, Cambridgeshire (UB-4512; 1345 ± 18 BP), using the revised calibration data (McCormac et al. 2004; this paper), the bidecadal data on the same oak chronology of Pearson et al. (1986), and the IntCal98 calibration curve (Stuiver et al. 1998a). IntCal98 was used, rather than the currently internationally agreed IntCal04 (Reimer et al. 2004), because it does not incorporate the data reported by McCormac et al. (2004). The differences in the probability distributions of the calibrated dates are relatively subtle (less than 20 calendar years). However, because the rate of change of ^{14}C at this time produces precise calibrated dates, these differences can be proportionally significant. Variations of this magnitude are of considerable value in the archaeological and historical interpretation of Anglo-Saxon chronological sequences.

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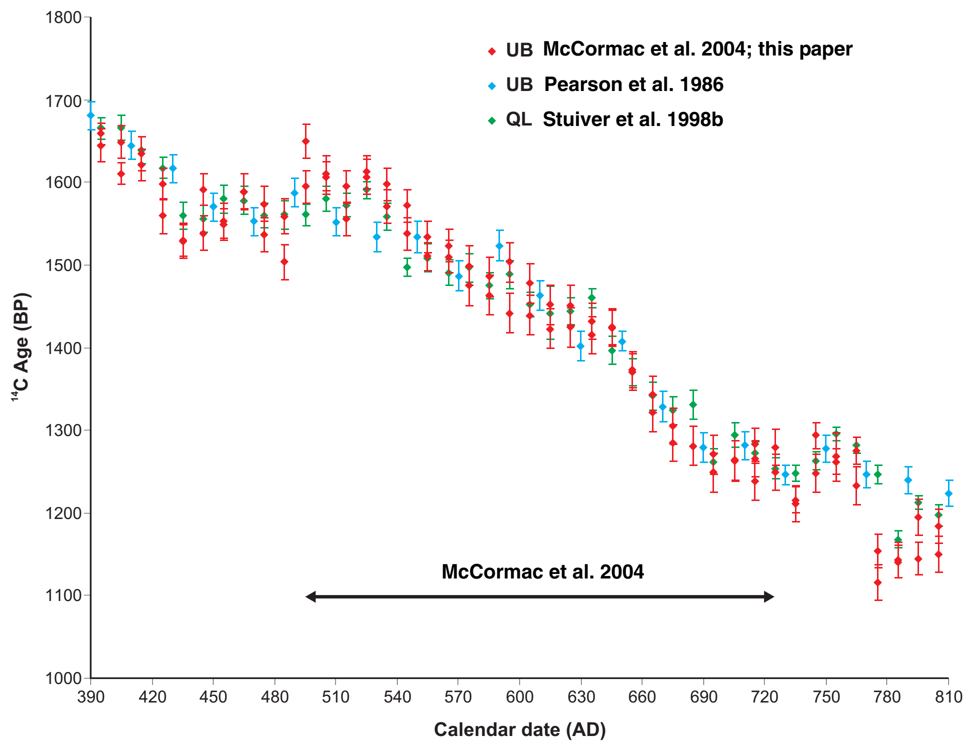

Figure 1 ^{14}C measurements from decadal samples of Irish oak (McCormac et al. 2004; Table 2), and bidecadal averages for ^{14}C measurements from wood dated by dendrochronology, AD 395–805 (QL = University of Washington at Seattle; UB = Queen's University Belfast). All errors are quoted at 1 σ.

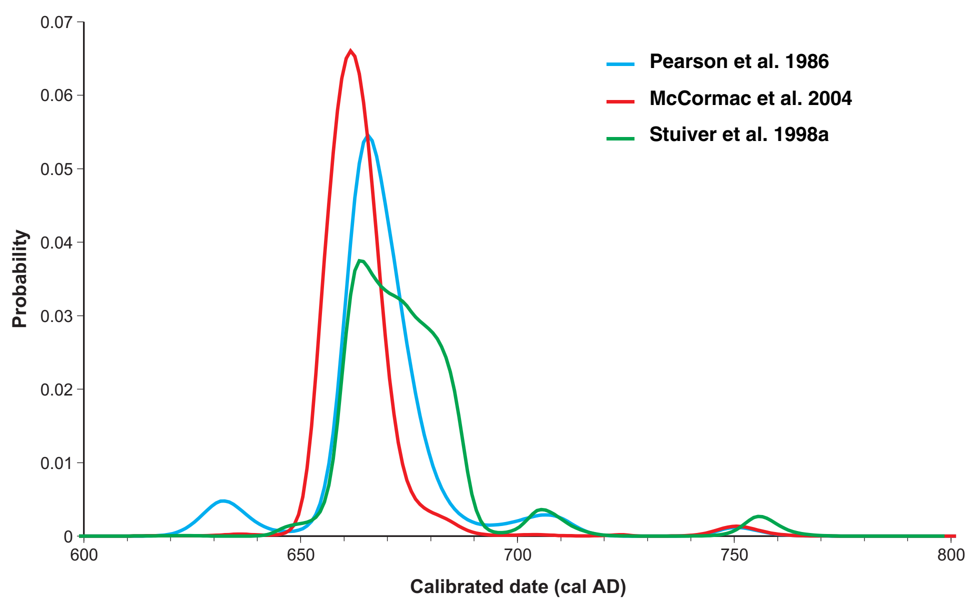

Figure 2 Probability distributions for dates calibrated by the probability method (Stuiver and Reimer 1993), using data from Pearson et al. (1986), McCormac et al. (2004), and IntCal98 (Stuiver et al. 1998a).

The extension of the calibration data reported in this paper was required to ensure that all the measurements from skeletons dated as part of the project to refine Anglo-Saxon chronologies in the period AD 570–725 could be accurately calibrated. The detailed structure revealed in the extended data allows the potential of the techniques pioneered in this project to refine the archaeological chronologies in the earlier Anglo-Saxon period to be assessed. Improvements in chronologies of the 5th and 6th centuries AD would have significant consequences for the integration of archaeological evidence into the historical understanding of the period.

METHODS AND RESULTS

Two ^{14}C measurements were made on each of a series of decadal samples of Irish oak (*Quercus* spp.) from Little Island, Co. Cork (AD 395–485), and Cappagh South, Co. Clare (AD 735–805). A single replicate measurement was also made on the decade centered on AD 715 (Brabstown, Q3693; McCormac et al. 2004: Table 1).

Table 1 Tree-ring cross-matches for the site sequence from Little Island, Co. Cork, and the 2-timber mean from Cappagh South against independent reference chronologies.

Site chronology	*t* value
Little Island, Co. Cork	
Ballydaly, Co. Offaly	5.70
Lemanaghan, Co. Offaly	6.03
Brabstown, Co. Kilkenny (Baillie 1982:188–90)	3.94
Nendrum, Co. Down (Brown 2007)	5.32
Teeshan, Co. Antrim (Baillie 1982:188–90)	4.69
Oxford Island, Co. Armagh (Baillie 1982:241)	3.95
Cappagh South, Co. Clare	
Clonlea, Co. Clare	5.28
Newtown, Co. Tipperary	4.82
Werburgh Street, Dublin	4.49
Farranmarren, Co. Cork (Baillie 1982:191)	4.14
Ballyroe, Co. Wexford	3.24

When the original Belfast long oak tree-ring chronology was being constructed, extensive use was made of timbers from destroyed horizontal mill sites throughout Ireland. It was found that these early Christian sites exploited massive and often long-lived oaks, the timbers being preserved due to the waterlogged locations used for mill construction. The timbers from Little Island, Co. Cork, are from a mill dating to AD 630 (Baillie 1982). The timbers from Cappagh South, Co. Clare, are from 2 naturally preserved riverside oaks. These series cross-match with each other with a *t* value of 7.23 (Munro 1984), and the last measured ring in the sequence dates to AD 895. Evidence for the dating of these sequences is provided in Table 1.

It was sample blocks from these long-lived archaeological timbers that were supplied for the original Belfast calibration program (Pearson et al. 1986). The long-lived nature of the trees was important because long runs of samples could be cut consecutively from individual timbers, a factor useful for eliminating any possibility of sampling error. When it was proposed to repeat the calibration at decadal resolution (the original calibration was at bidecadal resolution), further replicate samples were not available from the original trees (AD 390–510, unprovenanced Q2907; AD 730, Drumard Q2164; AD 740–810, Brabstown Q3691). Alternative samples were provided, however, whose ring patterns cross-date with a range of local independent site chronologies to a level of statistical and visual matching equivalent to that which had underpinned the construction of the original chronology. Thus, these new samples represent decadal replication of the original calibration and can be compared with the Pearson et al. (1986) calibration results by combining appropriate groups of measurements.

The samples were pretreated to holocellulose for ^{14}C dating as described by Hoper et al. (1998), combusted as outlined in McCormac et al. (1993), and synthesized to benzene using methods described in Long and Kalin (1992) and Witkin et al. (1993). All samples were measured by liquid scintillation spectrometry as described by McCormac et al. (1998, 2001) and Wilson et al. (1996).

The results are provided in Table 2. Quoted errors include both the Poisson counting error and an error multiplier to account for overall laboratory reproducibility.

Table 2 ^{14}C ages and $\delta^{13}C$ measurements for oak samples from Little Island, Co. Cork, and Cappagh South, Co. Clare. (Only 1 $\delta^{13}C$ measurement was made for each decadal pair in the range AD 394.5–484.5 because the sample pairs were split after combustion.)

Site	Tree number	Laboratory ID	Year (AD)	^{14}C age (BP)	Error	$\delta^{13}C$ (‰)
Little Island	Q3676	UB-4951	394.5	1645	20	–24.9
Little Island	Q3676	UB-4952	394.5	1659	13	
Little Island	Q3676	UB-4949	404.5	1649	20	–25.4
Little Island	Q3676	UB-4950	404.5	1611	13	
Little Island	Q3676	UB-4947	414.5	1621	19	–24.7
Little Island	Q3676	UB-4948	414.5	1635	21	
Little Island	Q3676	UB-4945	424.5	1598	19	–25.3
Little Island	Q3676	UB-4946	424.5	1560	21	
Little Island	Q3676	UB-4943	434.5	1530	19	–24.4
Little Island	Q3676	UB-4944	434.5	1529	21	
Little Island	Q3676	UB-4941	444.5	1591	19	–24.8
Little Island	Q3676	UB-4942	444.5	1539	21	
Little Island	Q3676	UB-4939	454.5	1549	19	–23.9
Little Island	Q3676	UB-4940	454.5	1554	21	
Little Island	Q3676	UB-4937	464.5	1589	21	–24.9
Little Island	Q3676	UB-4938	464.5	1589	22	
Little Island	Q3676	UB-4935	474.5	1574	21	–25.8
Little Island	Q3676	UB-4936	474.5	1537	21	
Little Island	Q3676	UB-4933	484.5	1559	21	–26.2
Little Island	Q3676	UB-4934	484.5	1504	21	
Brabstown	Q3693	UB-5232	714.5	1283	20	–25.2
Cappagh South	Q9308	UB-6107	734.5	1216	16	–25.2
Cappagh South	Q9308	UB-6108	734.5	1211	22	–24.9
Cappagh South	Q9308	UB-6109	744.5	1294	16	–25.0
Cappagh South	Q9308	UB-6110	744.5	1248	23	–25.8
Cappagh South	Q9308	UB-6111	754.5	1262	16	–26.3
Cappagh South	Q9308	UB-6112	754.5	1268	29	–25.9
Cappagh South	Q9308	UB-6113	764.5	1275	16	–26.9
Cappagh South	Q9308	UB-6114	764.5	1233	23	–25.9
Cappagh South	Q9309	UB-6115	774.5	1154	20	–25.0
Cappagh South	Q9308	UB-6116	774.5	1116	22	–25.0
Cappagh South	Q9308	UB-6117	784.5	1141	20	–26.2
Cappagh South	Q9308	UB-6118	784.5	1143	22	–26.3
Cappagh South	Q9308	UB-6119	794.5	1145	20	–25.8
Cappagh South	Q9308	UB-6120	794.5	1195	22	–25.8
Cappagh South	Q9308	UB-6121	804.5	1184	20	–25.7
Cappagh South	Q9308	UB-6122	804.5	1150	22	–25.7

DISCUSSION

Each set of measurements on each decadal wood sample (McCormac et al. 2004; Tables 1 and 2) is statistically consistent (Ward and Wilson 1978), and can be combined to provide a bespoke set of data for specific calibration within the period AD 395–805.

To investigate differences between the new data set and the existing bidecadal measurements on Irish oaks (Pearson et al. 1986), weighted means were calculated from the decadal measurements on each bidecade previously sampled. These 20 bidecadal means were compared with the original Belfast measurements. In 6 cases, the pairs are statistically significantly different, with 3 pairs being different at more than 99% confidence.

Comparison of the new data set with the 42 decadal averages on sequoia (*Sequoia dendron*) and Douglas fir (*Pseudotsuga menziesii*) from the western coast of North America measured by the University of Washington, Seattle (Stuiver and Becker 1986; corrected as described by Stuiver et al. 1998b) reveals 8 pairs that are statistically significantly different, with 4 pairs being different at more than 99% confidence.

The new measurements are only significantly different from both of the existing data sets in the period AD 765–795 (Figure 3). The new results show a rapid enrichment of ^{14}C between AD 765 and AD 775, which lies outside the 95% probability envelope for IntCal04 (Reimer et al. 2004). Some of the decadal measurements made at the University of Washington (Stuiver et al. 1998b) confirm atmospheric ^{14}C enrichment in this interval, although in a few instances these measurements lie closer to the original bidecadal Belfast measurements. The large spread in ^{14}C ages in this interval requires further study.

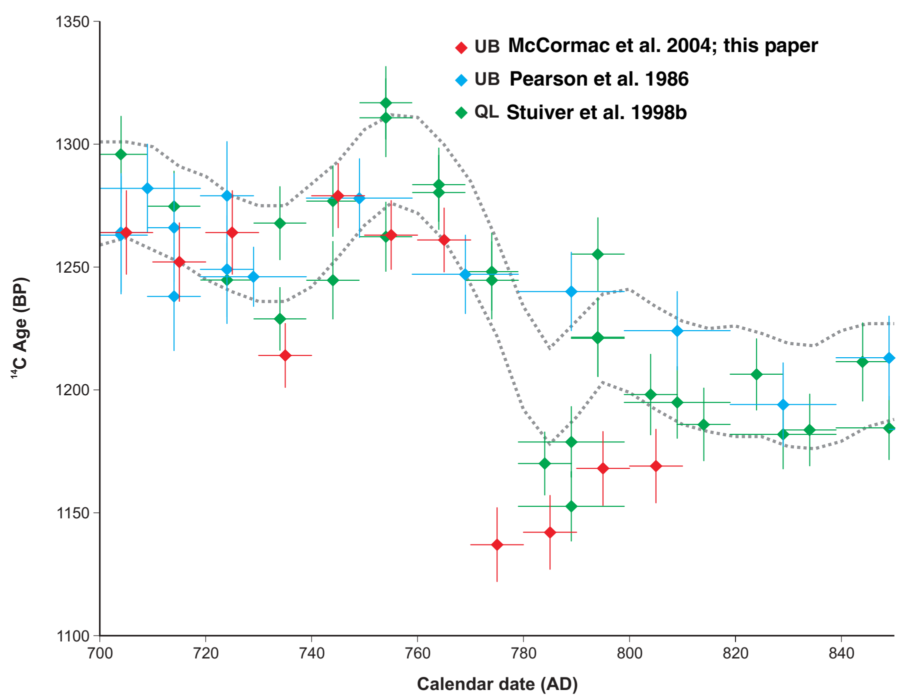

Figure 3 Mean ^{14}C measurements (with 1-σ errors) from wood dated by dendrochronology, AD 700–850 (QL = University of Washington at Seattle; UB = Queen's University Belfast); overlain by the 95% probability envelope of IntCal04 (Reimer et al. 2004).

CONCLUSIONS

The new decadal measurements for calibration between AD 395–805 have improved the resolution of the existing data set, and revealed structure in the shape of the calibration curve, which was previously masked by using measurements made on bidecadal wood samples and by interlaboratory variation. These refinements, although of relatively modest scale, may be of archaeological significance when producing precise chronologies by Bayesian modeling.

The possibility of a significant rapid enrichment of ^{14}C between AD 765 and AD 775 is highlighted by these data.

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