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RADIOCARBON RESULTS FOR THE BRITISH BEAKERS

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ABSTRACT. The beginning of the Bronze Age in the British Isles has traditionally been marked by the appearance, in the archaeological record, of Beaker assemblages, mainly characterized by the Beaker pottery form itself. Ceramic typologies based on this style, which is undoubtedly continental in origin, have been used both for relative dating and as evidence of the social and economic developments of the period. Systematic radiocarbon dating has been attempted for the continental European Beaker material (Lanting, Mook & van der Waals 1973), but no such program has been carried out on British material. An examination of the existing radiocarbon results for the British Beakers showed many to be flawed in some way, particularly in the use of materials, such as mature wood, where there is no *a priori* reason for assuming a direct relationship between sample death and context. An attempt has been made at the British Museum to test the validity of archaeologically derived chronologies for the Beaker pottery of the British Isles. This involved analysis of a group of carefully selected human bone samples from Beaker burials, where there is a known direct association between ceramic usage and the cessation of carbon exchange. Twenty such samples have been identified and measured. The results presented here, combined with other previously produced determinations, show no obvious relationship between pottery style and calendar date of deposition.

INTRODUCTION

In the 40 years since Libby's first ^{14}C measurements, the use of radiocarbon has radically altered archaeological chronologies and our perceptions of the past. It provided the first absolute means of dating those sites and cultures which are truly prehistoric, and now, post the production of reliable calibration curves, it gives a means of relating archaeological phenomena to the calendrical scale.

Despite this, ^{14}C dating has not solved all our chronological problems. This is due partly to unavoidable difficulties; there will always be gaps in material availability, and measurement precision will always be limited by physical laws and technical possibilities. In addition, the variation in ^{14}C production, reflected in the calibration curve, places immutable limitations on the applications of radiocarbon dating to archaeology. There are, however, other avoidable reasons for difficulties within radiocarbon-derived archaeological chronologies. Most of these can be put into two categories: first, a lack of scientific rigor in the selection of samples for dating; and second, a widespread over-optimism among laboratories about the precision and accuracy of their analyses. This study reflects an attempt to overcome both these pitfalls and to solve a specific archaeological problem by careful and controlled use of radiocarbon as a dating tool.

BRITISH BEAKERS: THE ARCHAEOLOGICAL FRAMEWORK

This work relates to the period at the beginning of the first half of the fourth millennium BP, marked by the introduction to Britain of new pottery styles, notably the Beaker form itself, and of metal working. Most of the evidence for this period has come from graves, normally single inhumations, each accompanied by a Beaker; finds of occupation material do exist but are seldom linked with any structural evidence. The Beaker pottery form is distinctive, defined by an S-shaped profile with frequent, and often very attractive, use of various forms of geometric decoration. It is not wheel thrown, but is of fine materials with a generally high standard of manufacture, and each vessel required a large input of effort; it has been estimated that some of the Dutch Beakers took 4–6 h, excluding clay preparation and drying and firing the finished product (Clarke 1970).

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The style is widespread throughout continental Europe, where the origins of the British material seem to lie, but the mechanism for the introduction and the way in which it might be possible to subdivide the corpus of material into typologies, and by inference, into chronological groups has been a cause of debate. The most influential such study is the massive work of Clarke (1970), in which he collated and illustrated a large body of data, including all the Beaker material known at that time. Based on an analysis of the non-functional aspects of the pottery form,including size, exact shape and decoration, he suggested the immigration into the British Isles of seven different Beaker making groups in two main phases. Each group would be distinguishable by a particular pottery style, followed by the development of two distinctive native pottery traditions, each again divisible into typological and chronological groups. Since Clarke's seminal publication, several attempts have been made to rework the same data, notably by Lanting and van der Waals (1972) who, as Dutch archaeologists, had the advantage of coming to the material when already familiar with the continental forms. They presented a scheme involving only one continental influx into the British Isles, followed by the development of regional styles, in seven developmental stages.

As is apparent from this, Beaker pottery styles have long been associated with chronological periods, and they have been used widely within British archaeology to date and sequence those sites on which they appear. What has been lacking until now is any concerted attempt to validate this assumption, although Lanting, Mook and van der Waals (1973) attempted a similar process for the European lowlands. In this paper, we attempt to fill this gap.

SAMPLE SELECTION

It is a truism that all a radiocarbon result can ever date is the time at which the carbon of the material analyzed ceased to exchange with its environment. Despite widespread lip service to this fact, with a few admirable exceptions, sample selection for archaeological dating has seldom been rigorous, and the excellent guidelines set out by Waterbolk as long ago as 1971 have seldom been fully applied. To an extent, this has been due to a tendency by laboratories, even those specifically concerned with archaeology, to regard themselves as principally measurement services, and to assign the responsibilities for sample integrity and selection to the archaeologist. In this study, the opportunity arose for radiocarbon scientists and archaeologists to work together to produce a reliable group of sample materials which could be used to answer specific problems.

Two questions may be asked of any possible radiocarbon sample at the earliest stage: 1) does it come from a known, firm archaeological context? and 2) can its ^{14}C content be directly related to an archaeological event? In attempting to date the British Beaker series, it is possible to provide samples that fulfill both of these criteria. An intact burial of articulated bone is about as firm and controlled a context as it is possible to find in archaeology, with any post-depositional disturbance likely to be reflected by some disturbance of the skeleton itself.

The analysis of materials that cannot directly reflect the age of the context in which they are found has been the cause of much confusion in the use of radiocarbon for archaeological dating. In particular, frequent use of wood samples of unknown and unquantifiable initial age has undermined many efforts to give firm dating frameworks. Here again, dating an inhumation has many advantages. Providing it is possible to isolate a chemically unaltered fraction from the bone, a radiocarbon result on human bone from a burial must relate directly to the time of death of that individual. If the inhumation is articulated, then appreciable delay in archaeological terms between death and burial is unlikely. Radiocarbon analysis of bone from an articulated human burial can therefore be reliably assumed to date the time of that burial and the deposition of any accompanying grave goods. To relate this figure to the period of normal currency of such pottery is, of course, speculative. There are many possible reasons why it may not reflect non-funerary trends including the use of heirlooms or the deliberate production of archaic styles solely for burial purposes, or simply the opportunistic disposal of unwanted objects, but the result certainly provides a calendar date for ultimate usage.

The requirement, in this study, for a large number of long bones from articulated burials securely associated with known Beaker types meant that most of the samples would have to come from previously excavated collections, which were both adequately recorded and provenanced, and available for destructive analysis. In practice, this severely limited the number of samples available. Some material that fulfilled these criteria was then rejected on technical grounds by the laboratory because of poor protein survival, or because of previous conservation treatment. Whereas bone is, in many ways, an ideal sample material, it has some well-documented technical drawbacks, resulting from post-depositional chemical changes. With the development of small counter techniques and the processing of increasing numbers of collagen dates, it has become apparent that not even all results on proteinaceous extracts are reliable (see *e.g.*, Long *et al.* 1989; Gillespie 1989). There is, however, general agreement that contamination problems large enough to be important within the precision of conventional ^{14}C analysis only occur when the collagen survival is poor. Bearing all this in mind, we decided to include, in this study, only material from single human long bones, from articulated well-provenanced burials, clearly associated with Beaker pottery, where the extracted protein was well-preserved, giving a clear pseudomorph of the original material. This stringency in sample selection meant that, of the projected 40–50 samples originally envisaged, only 20 were ultimately measured.

Laboratory Reliability, Accuracy and Precision

In light of successive Glasgow University intercomparison studies (International Study Group 1982; Scott *et al.* 1990), it has become uncomfortably apparent that laboratory reliability and precision have been widely overestimated in the past. This lesson has been particularly learned at the BM Laboratory, where analysis of the results of the first Glasgow study was, at least partially, responsible for the identification of an error, and the withdrawal, recalculation and, where possible, re-issue of some 470 results produced between 1980 and 1984 (Tite *et al.* 1988). The reasons for this error, and the way in which the revised figures were generated, is published fully (Bowman, Ambers & Leese 1990) and will not be repeated here, but its salutary effect can easily be imagined. Efforts at the British Museum have, therefore, been concentrated on improving the counting system and installing checks to ensure that such a situation does not recur. These measures have been reported in other papers (Bowman & Ambers, in press), and are briefly summarized in Table 1, which lists the results for the first counting run of a series of samples of dendrochronologically dated wood, kindly supplied by Drs. Baillie and Pilcher, of Queen's University, Belfast. Each result is for independent, synthesized and counted raw material. The Belfast high-precision measurements for wood of the same date (Pearson *et al.* 1986) are also given. At least one such known-age sample is included in each counting run, with regular replacement to ensure no distortion by sample evaporation. This procedure effectively fulfills the quality assurance proposals included in Long (1990), but its institution precedes that publication. The close agreement between BM and Belfast analyses is clear, and serves to support a claim by the British Museum Laboratory that the results produced are accurate and the precision quoted is justifiable.

Measurement Procedures and Results

All of the samples in this series were selected to be of reasonably well-preserved bone, and were treated with dilute acid to extract "collagen" (here defined as the acid-insoluble fraction of bone

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TABLE 1. Comparison of British Museum and Belfast ^{14}C analyses for dendrochronologically dated oak samples*

British Museum results BP** (unrounded)		Weighted mean ± std. error BP	Belfast result BP (Pearson *et al.* 1986)
BM-2494	2879 ± 39		
BM-2493	2835 ± 37	2876 ± 21	2886 ± 12
BM-2562	2920 ± 53		
BM-2747	2869 ± 47		
BM-2746	1059 ± 52		
BM-2563	1017 ± 44		
BM-2564	1060 ± 45	1020 ± 13	1020 ± 17
BM-2432	1029 ± 47		
BM-2432L†	999 ± 37		
BM-2745	981 ± 44		
BM-2560	4364 ± 47		
BM-2561	4362 ± 45		
BM-2580	4337 ± 43	4357 ± 23	4345 ± 14
BM-2616	4368 ± 48		

*These figures are for the first 2000 min count time of each independently generated sample.

**Samples were counted quasi-simultaneously, in 1 of 3 counters, in trains including at least 2 modern and 2 background samples, with standards being replaced regularly but at staggered intervals. Samples are made up of 5.5 ml C_6H_6 with 15 gl^{-1} butyl PBD.

†All samples are separately synthesized from raw wood except BM-2432 and BM-2432L, separate aliquots of the same benzene, counted in different counters.

rather than the true biochemical definition). Only this collagen fraction was dated. After pretreatment, the cleaned samples were converted to benzene and analyzed by conventional liquid scintillation counting, using the cocktail and configuration described in Ambers, Matthews and Bowman (1989).

The results of the British Museum program are quoted in Table 2, together with calibrations based on 68% and 95% confidence, using the curves of Pearson & Stuiver (1986) and Pearson *et al.* (1986) and Method B of CALIBM, an adaptation of revision 2.0 of the University of Washington Quaternary Laboratory Radiocarbon Calibration Program (Stuiver & Reimer 1987) for the in-house computer of the British Museum Department of Scientific Research. This program uses the probability method of calibration. Errors quoted are the counting error for the sample combined with an estimate of the errors contributed by the modern and background samples. This estimate includes both counting and non-counting errors, the latter being computed from differences in the overall count rates observed among the individual backgrounds and moderns. All results are quoted in the form recommended by Stuiver & Polach (1977) in uncalibrated years BP (before 1950), and corrected for measured isotopic fractionation.

Calibrated dates are quoted in the form recommended in Mook (1986). The end points of the calibrated date ranges have been rounded outwards to five years. An effect of this rounding process is to slightly overestimate the possible calendar ranges given. Calibrations are depicted graphically in two ways; as simple line plots showing the 68% and 95% confidence limits and, where space allows, as probability distributions.

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TABLE 2. British Museum Beaker Dating Program Results

BM-no.	Site	Result BP	Calibrated age ranges (Pearson & Stuiver 1986) Cal BC by probability method		Beaker type		Assocs.	Date list*
			68% confidence	95% confidence	Clarke	Lanting & Van der Waals		
2512	Chealamy NC 724502	3630 ± 50	2120–2080 or 2045–1935	2140–1885	N/NR	4		BM XXII
2513	Boysack Mill NO 628491	3460 ± 50	1880–1735	1915–1675	N3	4		BM XXII
2514	Fodderty NH 510592	3770 ± 50	2295–2135	2455–2425 or 2395–2370 or 2365–2110 or 2090–2035	N4	5		BM XXII
2515	Bractullo NO 524473	3780 ± 60	2330–2135	2455–2415 or 2410–2110 or 2090–2035	N/NR	4	Worked stone	BM XXII
2516	Shrewton 24 SU 095443	3750 ± 50	2280–2130 or 2075–2045	2395–2385 or 2350–2030 or 1995–1985	S4	6		BM XXII
2517	Shrewton 5a SU 089449	3560 ± 50	2020–2000 or 1985–1875 or 1835–1820 or 1795–1785	2100–2085 or 2040–1755	N3	4		BM XXII
2518	Handley Down SU 012173	3760 ± 50	2285–2135 or 2060–2045	2455–2440 or 2395–2380 or 2355–2035	FN	–		BM XXII
2519	Rotherley ST 950195	3390 ± 50	1755–1620	1880–1835 or 1825–1795 or 1785–1590 or 1570–1525	WMR	3		BM XXII
2520	Radley SU 513982	3630 ± 60	2130–2075 or 2045–1930	2195–2155 or 2150–1875 or 1835–1820 or 1795–1785	AOC	2		BM XXII

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2521	Smeeton Westerby SP 671912	3440 ± 50	1875–1835 or 1820–1800 or 1785–1690	1890–1640	WMR	3		BM XXII
2522	Risby TL 794685	3660 ± 50	2135–2055 or 2050–1975	2195–2155 or 2150–1905	S4	7		BM XXII
2523	Cookston Farm NO 336492	3800 ± 50	2340–2185 or 2165–2140	2460–2415 or 2410–2135 or 2060–2045	N3L	6	Bone button	BM XXII
2524	Middle Brighty Farm NO 630510	3730 ± 50	2275–2245 or 2205–2115 or 2085–2040	2315–2015 or 2005–1980	N3L	6		BM XXII
2525	Shrewton 5k SU 089449	3590 ± 50	2030–1890	2135–2070 or 2050–1870 or 1845–1810 or 1805–1775	S4	6		BM XXII
2590	Achavanich ND 178433	3700 ± 50	2195–2160 or 2145–2030	2280–1955	N4	6	Flint	BM XXII
2642	Manston TR 351652	3630 ± 50	2120–2080 or 2045–1935	2140–1885	S2		Jet button, flint	BM XXIII
2643	Lambourne SU 325830	3360 ± 50	1740–1610 or 1555–1545	1860–1845 or 1770–1520	S3	6		BM XXIII
2644	The Wig SU 187377	3500 ± 50	1890–1755	1965–1730 or 1725–1690	S4	7	Flint, bronze	BM XXIII
2700	Radley SU 514982	3360 ± 50	1740–1610 or 1555–1545	1860–1845 or 1770–1520	S4	7		BM XXIII
2725	Cottington Hill TR 337639	3630 ± 60	2130–2075 or 2045–1930	2195–2155 or 2150–1875 or 1835–1820 or 1795–1785	East Anglian	3		BM XXIII

*BM XV–Burleigh, R., Ambers, J. and Matthews, K. 1982 British Museum natural radiocarbon measurements XV. *Radiocarbon* 24(3): 262-290.
BM XXII–Ambers, J., Matthews, K. and Bowman, S. 1991 British Museum natural radiocarbon measurements XXII. *Radiocarbon* 33(1): 51-68.
BM XXIII-Ambers, J., Matthews, K. and Bowman, S. British Museum natural radiocarbon measurements XXIII. Ms. in preparation.
OxA 7–Hedges, R. E. M., Housely, R. A., Law, I. A. and Perry, C. 1988 Radiocarbon dates from the Oxford AMS system: Archaeometry datelist 7. *Archaeometry* 30: 155-164.
OxA 11–Hedges, R. E. M., Housely, R. A., Bronk, C. R. and van Klinken, G. J. 1990 Radiocarbon dates from the Oxford AMS system: Archaeometry datelist 11. *Archaeometry* 32: 211-237.

TABLE 3. Other Radiocarbon Results for Human Bone from Beaker Burials

Lab no.	Site	Result BP	Calibrated age ranges (Pearson & Stuiver 1986) Cal BC by probability method: 68% confidence	95% confidence	Beaker type: Clarke	Lanting & Van der Waals	Assocs.	Date list*
GU-1117	Boatbridge Quarry NS 981376	3730 ± 60	2280–2240 or 2210–2105 or 2090–2035	2345–1955	N1	4		Clarke *et al.* 1984
OxA-1072	Chilbolton SU 397396	3740 ± 80	2290–2035	2455–2420 or 2405–1950	WMR	3	Beads, gold, flint, dagger, antler	OxA 7: 161
OxA-1073	Chilbolton	3780 ± 80	2450–2445 or 2395–2385 or 2350–2130 or 2075–2045	2465–2025 or 2000–1985	FN	–		OxA 7: 161
GU-2100	Fetterangus NJ 981504	3650 ± 50	2135–2070 or 2050–1965	2190–2160 or 2145–1900	–	3/4		
GU-1122	Keabog NO 798819	3730 ± 60	2280–2240 or 2210–2105 or 2090–2035	2345–1955	N3	–		
GU-1123	Keabog	3700 ± 100	2280–2230 or 2210–1960	2460–1880 or 1835–1825	N3	4		
N-1240	Knockenny	3390 ± 90	1875–1840 or 1815–1800 or 1780–1600 or 1560–1535	1935–1505 or 1475–1465	–	–		
HAR-340	Little Pond Ground SP 801405	3670 ± 80	2195–2160 or 2145–1945	2325–1875 or 1840–1820 or 1795–1785	E	1		
GU-1121	Mains of Ballnagowan NH 811546	3510 ± 90	1970–1740	2135–2070 or 2045–1625	N/NR	4		

HAR-4792	Mount Farm SU 563968	3710 ± 110	2290–1960	2460–1880 or 1835–1820 or 1795–1785	FN	6?	Flint, tusk	
OxA-1874	Radley SU 513982	3930 ± 80	2575–2530 or 2510–2310	2860–2820 or 2660–2635 or 2625–2190 or 2160–2145	WMR B wire	2	Metal and bone discs	OxA 11: 218
OxA-1875	Radley SU 513982	3990 ± 80**	2855–2820 or 2660–2640 or 2620–2450 or 2425–2395	2870–2805 or 2775–2720 or 2700–2295	WMR	–	Metal and bone discs	
GU-1356	Ruchlaw Mains NT 616742	3720 ± 80	2280–2030	2455–2425 or 2395–2375 or 2365–1915	N2	4		
SRR-453	Skateraw NT 729754	4420 ± 130**	3325–3230 or 3185–3155 or 3140–2920	3505–3405 or 3380–2870 or 2810–2770 or 2755–2750 or 2725–2695 or 2675–2665	N2	4		
BM-1413	Sorisdale NM 272638	3890 ± 45	2465–2335	2560–2545 or 2495–2275 or 2240–2205	AOC	2		BM XV: 270
GU-2169	Tavelty NJ 790160	3710 ± 70	2275–2245 or 2205–2025 or 1995–1985	2340–1910	NZ	4	Dagger, arrow-head, flints	
HAR-4426	Wetwang Slack SE 946802	3900 ± 100	2570–2535 or 2500–2280 or 2240–2205	2860–2815 or 2695–2685 or 2665–2635 or 2620–2130 or 2080–2040	S2	–		
HAR-6631	West Heslerton SE 918767	3510 ± 80	1950–1740	2125–2080 or 2045–1670 or 1660–1645	N/NR	–		HAR VIII, 171

*See notes after Table 2
**Calibrated from Pearson *et al.* (1986)

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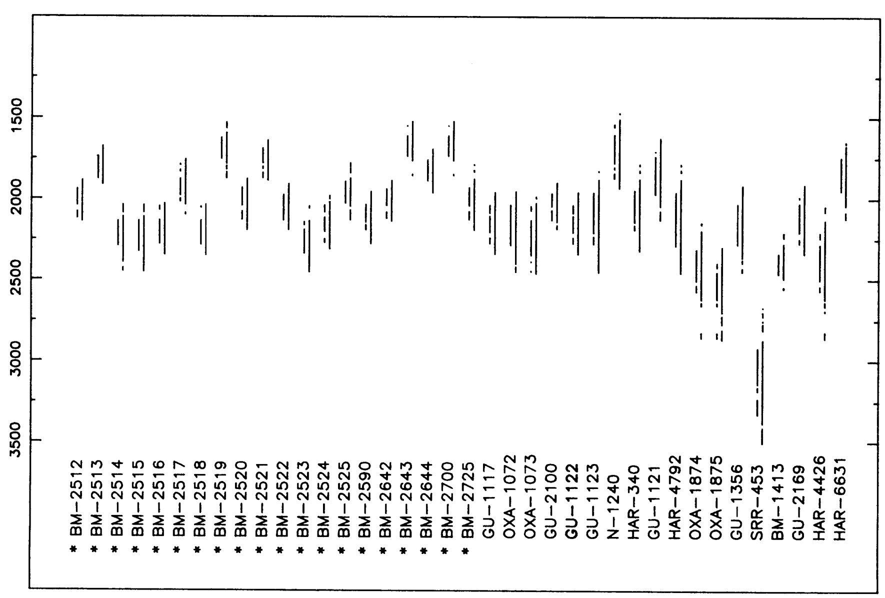

Fig. 1. Calibrated age ranges (by probability method) for all published results for human bone from British Beaker burials expressed as simple line plots for 68% and 95% confidence limits. Results in new series marked *.

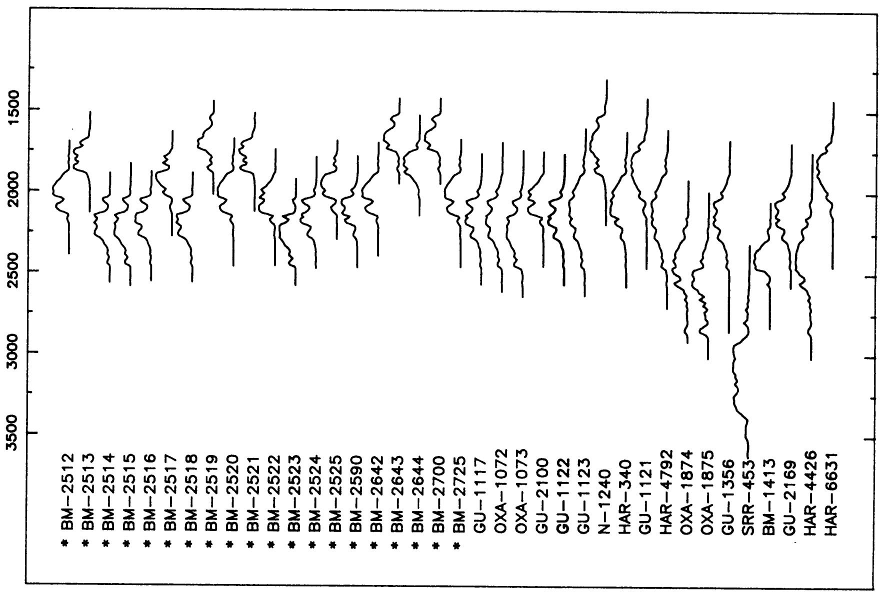

Fig. 2. Calibrated age ranges (by probability method) for all published results for human bone from British Beaker burials shown as probability distributions. Vertical scale is arbitrary. Results in new series marked *.

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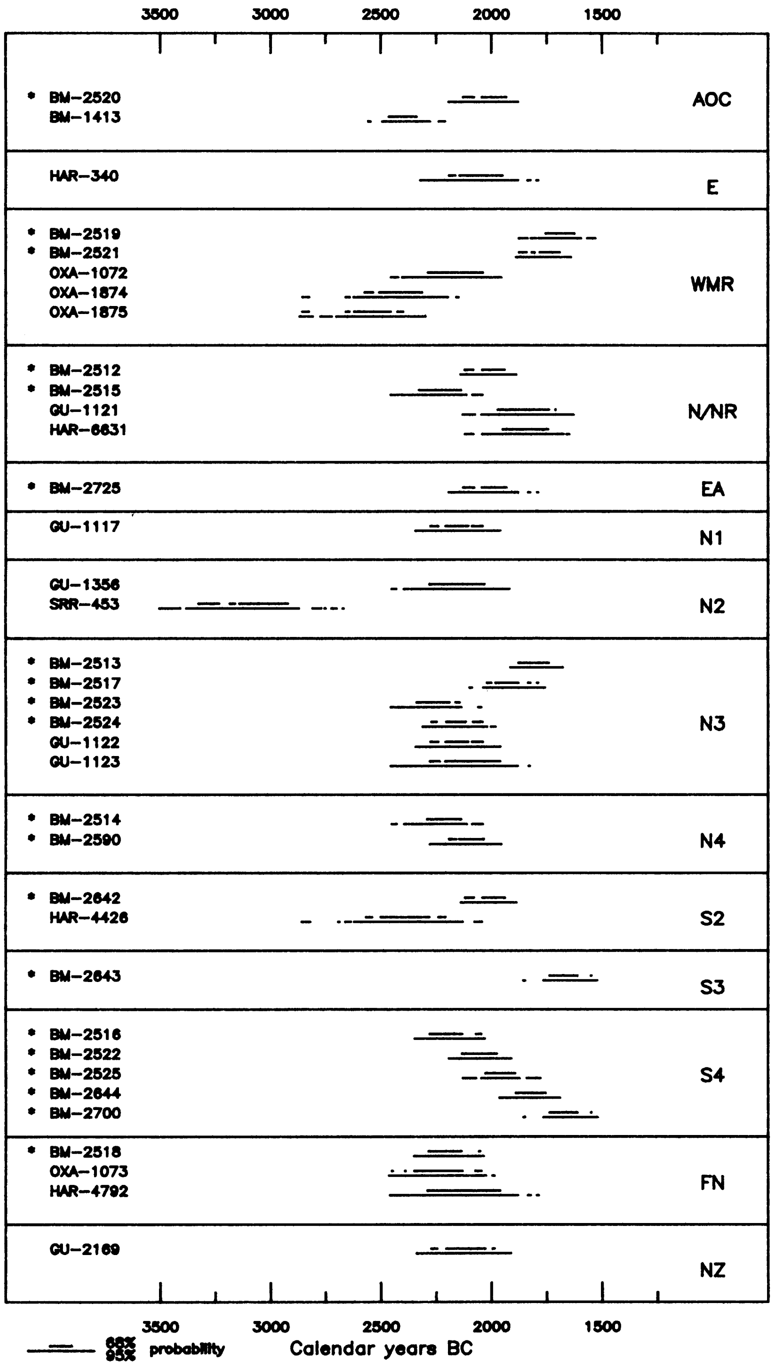

Fig. 3. Calibrated age ranges (by probability method) for all published results for human bone from British Beaker burials expressed as simple line plots for 68% and 95% confidence limits, subdivided by Clarke's Beaker types. Results in new series marked *.

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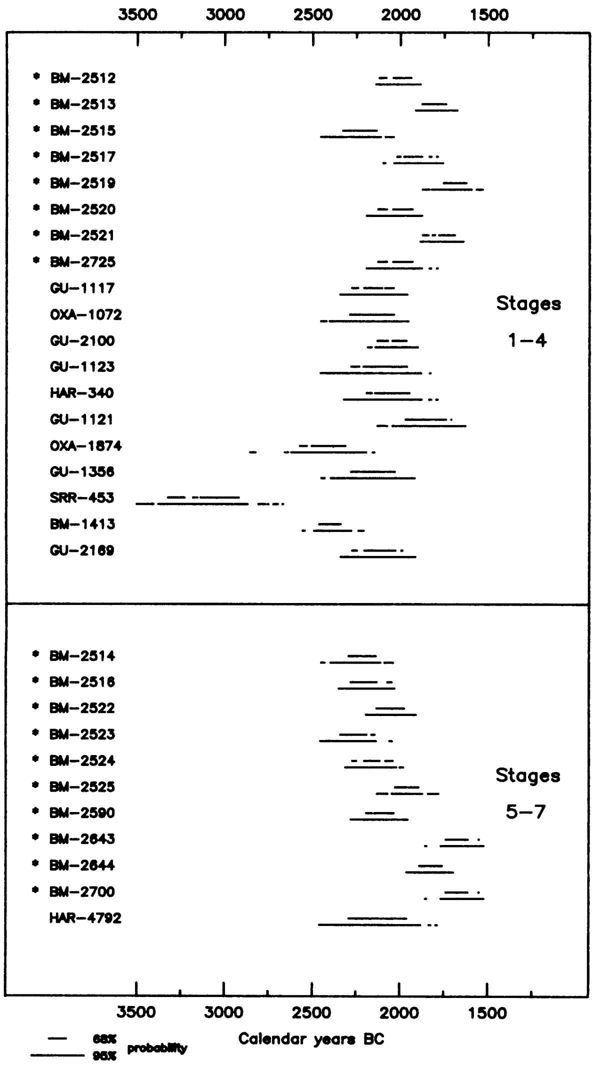

Fig. 4. Calibrated age ranges for all published results for human bone from British Beaker burials expressed as simple line plots for 68% and 95% confidence limits, subdivided by Lanting and van der Waals developmental steps. Results in new series marked *.

Results for human bone from British Beaker burials produced by other laboratories or by the British Museum, but not as part of this study, are also listed in Table 3, together with calibrations. Given the results of the intercomparison studies, it could be argued that many of these figures were not necessarily generated under conditions that would pass the Long *et al.* (1989) criteria, and so cannot be justifiably combined with those of the new BM series. We include them here for completeness, but for clarity in the diagrams, we have distinguished all the new BM analyses with *.

Discussion

The full archaeological implications of these data will be discussed elsewhere (Kinnes *et al.* 1991), but some points can be made here. All the published ^{14}C analyses listed in Tables 2 and 3 are shown plotted as simple line and as probability distributions in Figures 1 and 2. The same data are shown in Figures 3 and 4 but divided into Clarke Beaker types, and Lanting and van der Waals stages. No connection between typology and absolute chronology is obvious in either of these two

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arrangements, although the width of the calibrated ranges may conceal some trends. On this evidence, the use of such classifications as chronological indicators would be misleading.

This work emphasizes the requirement for strict and careful control of sample selection and measurement procedures if ^{14}C results are to be used in archaeological reconstruction. A full literature search for ^{14}C analyses for the British Beakers yielded a total of 124 results with the great majority of these being on charcoal, frequently unidentified, or on other material with the possibilities of age offset. Use of such results without due regard to their limitations serves only to cloud the archaeological picture.

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