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HIGH-PRECISION ^{14}C MEASUREMENT OF IRISH OAKS TO SHOW THE NATURAL ^{14}C VARIATIONS FROM AD 1840 TO 5210 BC

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ABSTRACT. High-precision measurement of dendrochronologically dated Irish oak at bi-decade/decade intervals has continued in the Belfast laboratory, extending the ^{14}C data base from ca AD 1840 to 5210 BC. The dendrochronology is now considered absolute (see Belfast dendrochronology this conference) (Brown *et al*, 1986) and a continuous detailed curve is presented, showing the natural variations in the atmospheric concentration of ^{14}C over >7000 years. Each data point has a precision of <2.5‰, and some 4500 years have now been compared with Seattle, giving excellent agreement. Discussion of this data base and the justification of the claimed accuracy is given together with a comparison of other chronologies. Some of the advantages and limitations of the above are discussed.

INTRODUCTION

High-precision (ca ± 2‰) measurements of dendrochronologically dated wood have shown in detail the short-term variation of ^{14}C in atmospheric carbon. Some 6000 years of bi-decade measurements were presented by Pearson and Baillie (1983) and Pearson, Pilcher and Baillie (1983) but were not considered absolute dendrochronologically from ca 500 BC → ca 4000 BC. The natural variations illustrated here are shown against an absolute dendro-axis and the ^{14}C measurements are demonstrated to be accurate internally, giving consistent replication over the whole time period presented and externally by comparison with ca 4500 years of Seattle measurements (Stuiver & Pearson, 1986; Pearson & Stuiver, 1986).

The achievement of high precision in liquid scintillation counting was detailed in Pearson (1979, 1980), but an updating of the corrections used, together with their effect on accuracy when omitted are discussed below. Greater detail of the variables giving rise to the above corrections and the parameters monitored to ascertain the variation, are given in Pearson (1983).

HIGH-PRECISION ^{14}C MEASUREMENT (BY LIQUID SCINTILLATION COUNTING OF BENZENE)

This method of analysis has been discussed in previous publications (Pearson, 1979, 1980, 1983; Pearson & Baillie, 1983). The fundamental requirements for high-precision analysis are 1) to have a pure uncontaminated sample, and 2) to measure this under stable standardized conditions. Rigorous pretreatment of samples (wood) (Dresser, 1970) and careful conversion to benzene can provide pure samples with relatively high conversion yields. To achieve stable standardized conditions of counting, many factors that influence both the efficiency of detection and the 'background' contribution to sample counts, determine the need for corrective measures. In high-precision counting, all variables that have a significance of >0.025% (Pearson, 1979, 1980) have to be resolved by correction or eliminated as variables. A list of those resolved by correction and the parameters monitored to derive the corrections is given in Table 1, together with the residual and estimated errors, if such a correction was ignored.

Potential variables such as 1) vial differences that may give inconsistent efficiencies and/or background, 2) plastic caps that do not allow accurate weighing because of their differential moisture absorption, dependent upon ambient conditions, 3) ^{222}Rn contamination from laboratory water supply, and 4) memory effects in the lithium reactor are eliminated. This is achieved for 1) by the selection of identical vials, 2) by the change of vial caps to a low radioactive lead alloy, 3) by specially selecting a water containing minimal amounts of ^{222}Rn, then completely degassing by boiling and standing the sample benzene for at least a month before measurement, and finally, 4) the memory effects are reduced to an insignificant level by using 'clean-out' samples (samples of similar age to the one under analysis) which condition the reactor.

The above list shows that the variables and potential variables are many and it is expected that with very few exceptions these would apply to most liquid scintillation counting systems, although with differing emphasis. Some of the variables may be avoided by the quasi-simultaneous counting of identically prepared standards and background, although it is statistically advantageous to be able to take mean values of these over longer periods than normal sample measurements.

Only one value of standard count rate was used for the calculations presented here. The standard and samples were measured over a 10-year period, allowing a precise value for the standard to be obtained. The actual standard deviation based on 55 duplicate analyses was calculated using the relationship $\hat{\sigma} = SS/2n$ where SS = Sum of the (difference between duplicates)^2, n = No. of duplicated measurements, and $\hat{\sigma}$ is the derived average standard deviation which can then be compared to the mean standard deviation ($\bar{\sigma}$) quoted on the 110 individual measurements. The actual calculated standard deviation value was $\hat{\sigma} = \pm 19.0$ yr. The mean quoted error on the individual measurements was evaluated from $\bar{\sigma} = [\Sigma_{i=1}^{n} (\sigma_1)^2/n]^{1/2}$, and gave a value of $\bar{\sigma} = \pm 15.4$ yr, thus suggesting that the quoted error is underestimated by ca 23%, or an error multiplier of 1.23 is required.

RADIOCARBON TIME-SCALE CALIBRATION

During the past decade high-precision techniques have been used to measure dendrochronologically dated wood samples to provide a record of the natural ^{14}C variations; this information has been used primarily for time-scale calibration with a quoted mean measurement error of <±20 yr. The longest previously published high-precision BC calibration (Pearson, Pilcher & Baillie, 1983) was based on a provisional fixing of a Belfast floating dendrochronologic sequence; consequently, for this period, it was probably more prudent to use the lower precision measurements of absolutely dated samples such as the calibration presented by Klein *et al* (1982).

The ^{14}C measurements presented here are derived from decade/bi-decade contiguous samples of mainly Irish oak. The decade sample measurements were combined, and are presented with bi-decade measurements in Table 2 and also separately in Table 3. Since the announcement of the continuous European dendrochronologic sequence in 1984 (Pilcher *et al*, 1984), the entire sequence in the BC era has been re-worked and dendrochronologically checked and is totally internally consistent. The links with the German chronologies have further been confirmed by cross-dating, between established chronologies from North Germany, England, and Northern Ireland (Pilcher *et al*, 1984). There are >700 trees in the section of chronology from 116 BC to 5289 BC and over most of this time span the replication is very good. The justification for the chronology at the few remaining places where replication is weakest, is given (Baillie, Pilcher & Pearson, 1983; Brown *et al*, 1986).

Some 7000 years of Irish oak have now been measured as decade or bi-decade contiguous samples, providing the longest single high-precision calibration of the ^{14}C time scale and the results are illustrated in Figure 1. Although much of it has been published before, (Pearson & Baillie, 1983; Pearson, Pilcher & Baillie, 1983) all measurements have been recalculated using updated corrections to give improved accuracy. Duplicate analyses on many samples have allowed reduction in their quoted precision, although this was shown above to be possibly underestimated by ca 23%. Tables 2 and 3 give the laboratory number of the bi-decade/decade sample respectively, together with the center dendro-year and its ^{14}C age in years BP, based on the Libby half-life of 5568 years. Also included are the equivalent Δ values and one standard deviation error limits on both the ^{14}C age and Δ values; this is the estimated error and includes all correction errors together with the counting statistics; it does not include the error multiplier discussed above.

The international validity of any calibration can only be proved by the independent analysis of other absolutely dated wood samples from other parts of the world. If the agreement between two such data sets is within statistical expectation, then it seems reasonable that such a calibration would be more internationally acceptable. Such a comparison is possible over 4500 years of calibration between Belfast and Seattle. Some 214 measurements were compared and the resulting differences closely fit a Gaussian distribution with a standard deviation of 25.6 years (Stuiver & Pearson, 1986) and a mean difference of 0.6 years. This agreement shows that no significant bias exists. The replicate analyses as discussed above suggest an error multiplier of ca 1.23 for the Belfast data. A similar approach yields an overall error 1.6 times the standard deviation in combining statistics for the Seattle data (Stuiver & Pearson, 1986). Application of these error multipliers result in an average standard deviation of the 214 points of 22.9 years. Thus, the Seattle and Belfast overall laboratory precision accounts for nearly the entire variability found between both data sets.

CONCLUSION

The fine detail of the natural ^{14}C variation curve will be of considerable interest to many workers in astrophysics, solar physics, geophysics, etc, but perhaps the most immediate use will be as a high-precision ^{14}C time-scale calibration.

It has been shown above that it is now possible by combining Seattle and Belfast data to provide an internationally acceptable calibration curve within a 1σ envelope of ca ±14 years, covering a time period of some 4500 years. The remaining Belfast curve from 2500–5210 BC would be valid using an error multiplier of 1.23 to give an average calibration band-width of $<\pm 20$ years.

The high-precision curve is essential for converting high-precision analysis and it has already proved useful in sorting out some archaeologic dating problems from the late Bronze age/early Iron age where the calibration curve is almost horizontal from 400–800 BC. Samples dated ca 2350 BP, eg, with precisions of ca ±100 years could not be converted to a calendar age band with any greater resolution than 480 years (750–270 BC). Using high-precision measurement ca ±20 years, this band width for the above sample can be reduced to almost 10 years. Single high-precision analysis of samples can give calendric band widths which are similar to the ^{14}C quoted error range over considerable portions of the calibration.

The use of 'wiggle matching' (Pearson, 1986) can give narrow calendric band widths for certain samples with a known deposition rate or growth period where wiggles would normally cause the reporting of large calendric band widths.

Thus, it can be concluded that high-precision analysis can provide fine calendric resolution to the archaeologic chronology, providing, of course, the samples submitted have the same credentials in terms of precise association and integrity, allowing for correct interpretation.

ACKNOWLEDGMENTS

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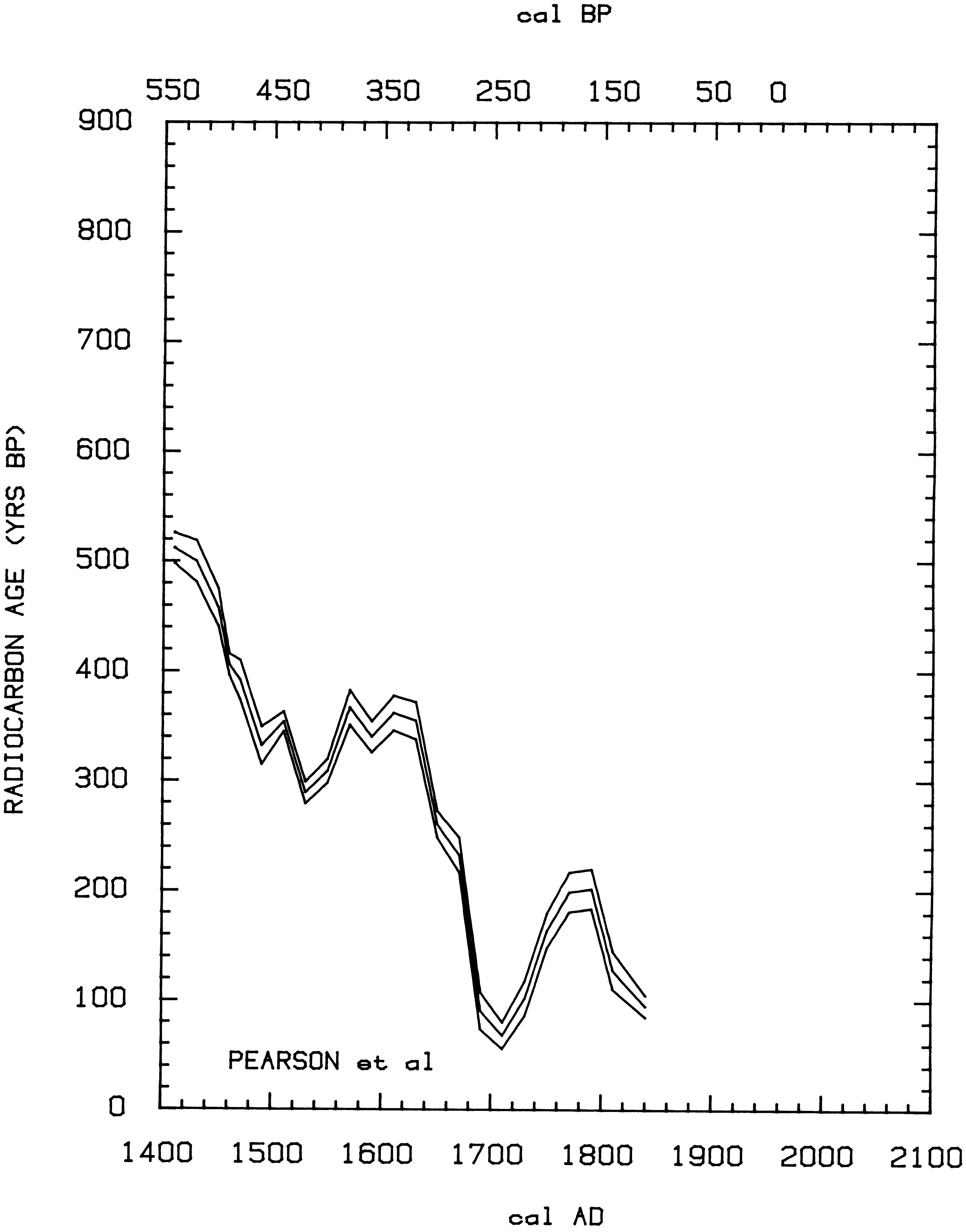
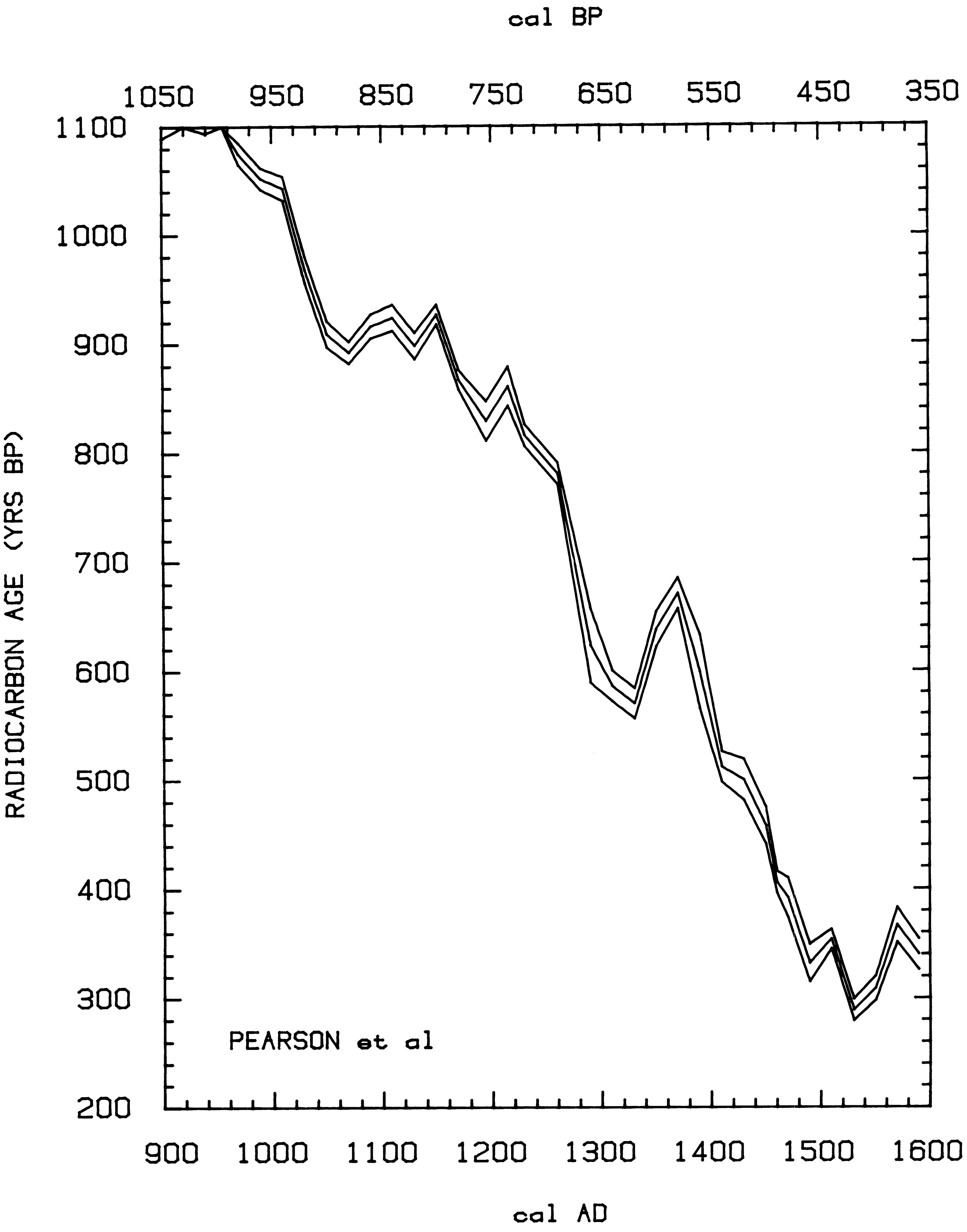


Fig 1A

Figs 1A–1O. Radiocarbon time-scale calibration from AD 1840 to 5210 BC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550
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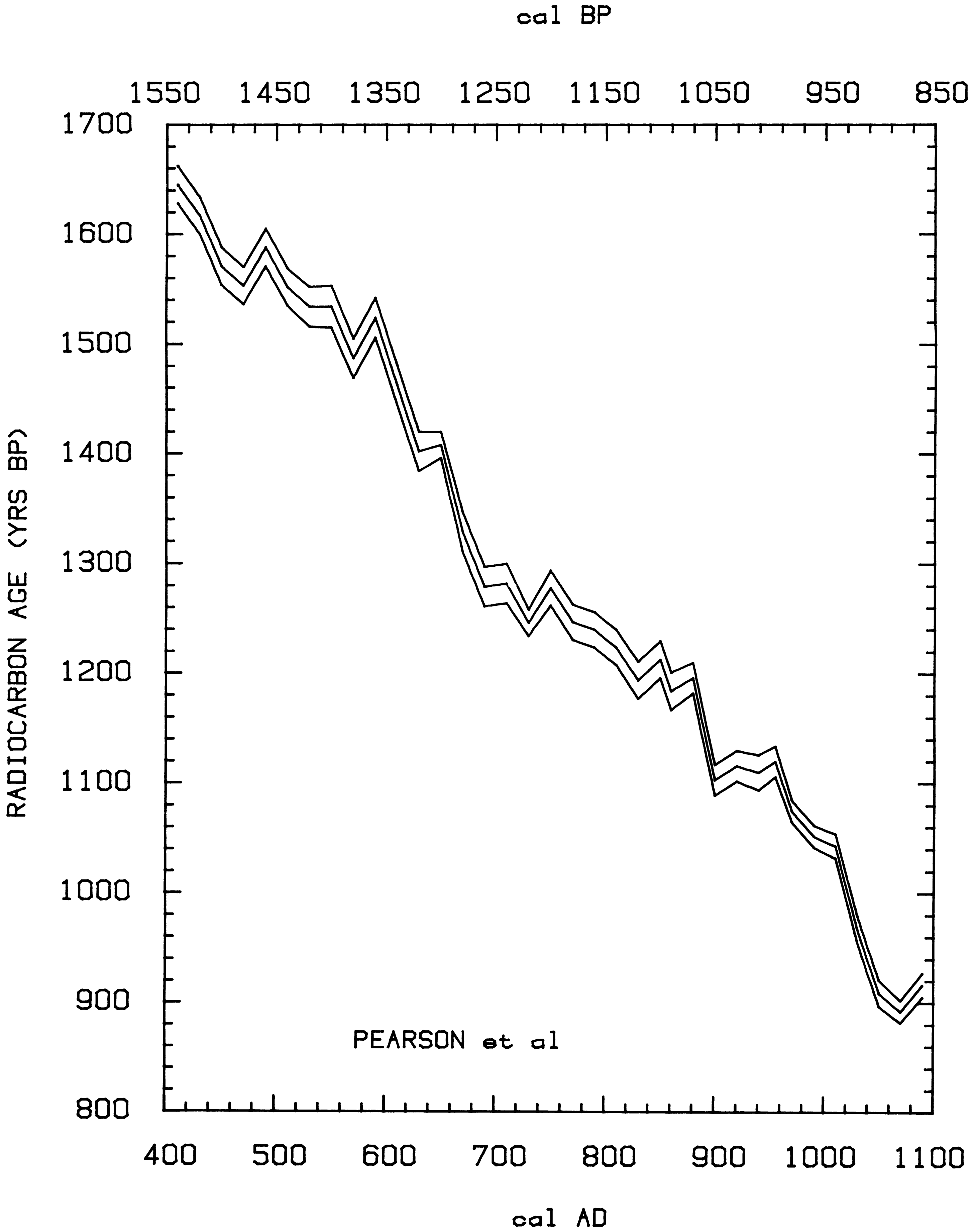
350
1100
1000
900
800
700
600
500
400
300
200
RADIOCARBON AGE (YRS BP)
PEARSON et al
900
1000
1100
1200
1300
1400
1500
1600
cal AD

Fig 1B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1600
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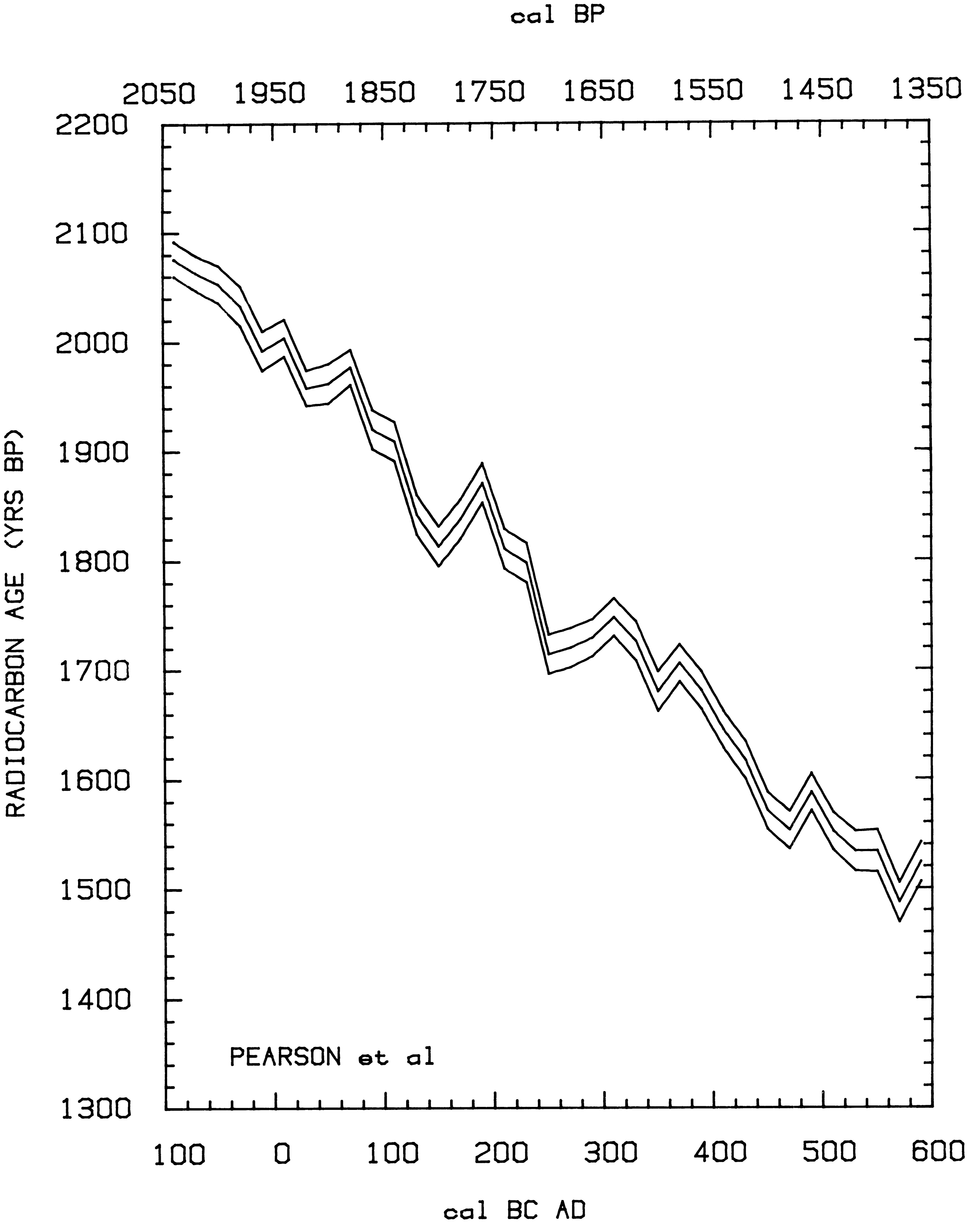
1400
1300
1200
1100
1000
900
800
RADIOCARBON AGE (YRS BP)
PEARSON et al
400
500
600
700
800
900
1000
1100
cal AD

Fig 1C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1450
1350
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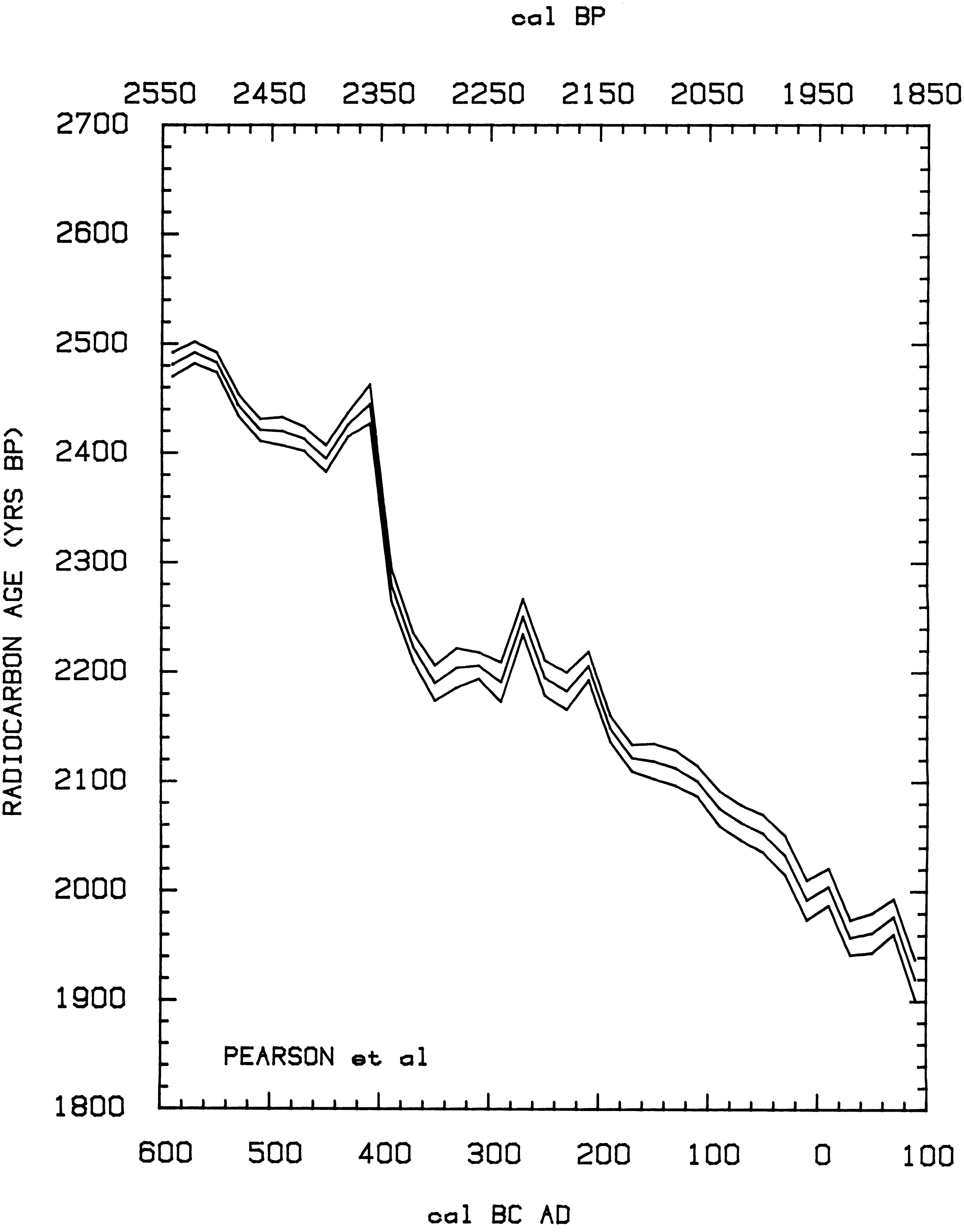
2100
2000
1900
1800
1700
1600
1500
1400
1300
PEARSON et al
100
0
100
200
300
400
500
600
cal BC AD

Fig 1D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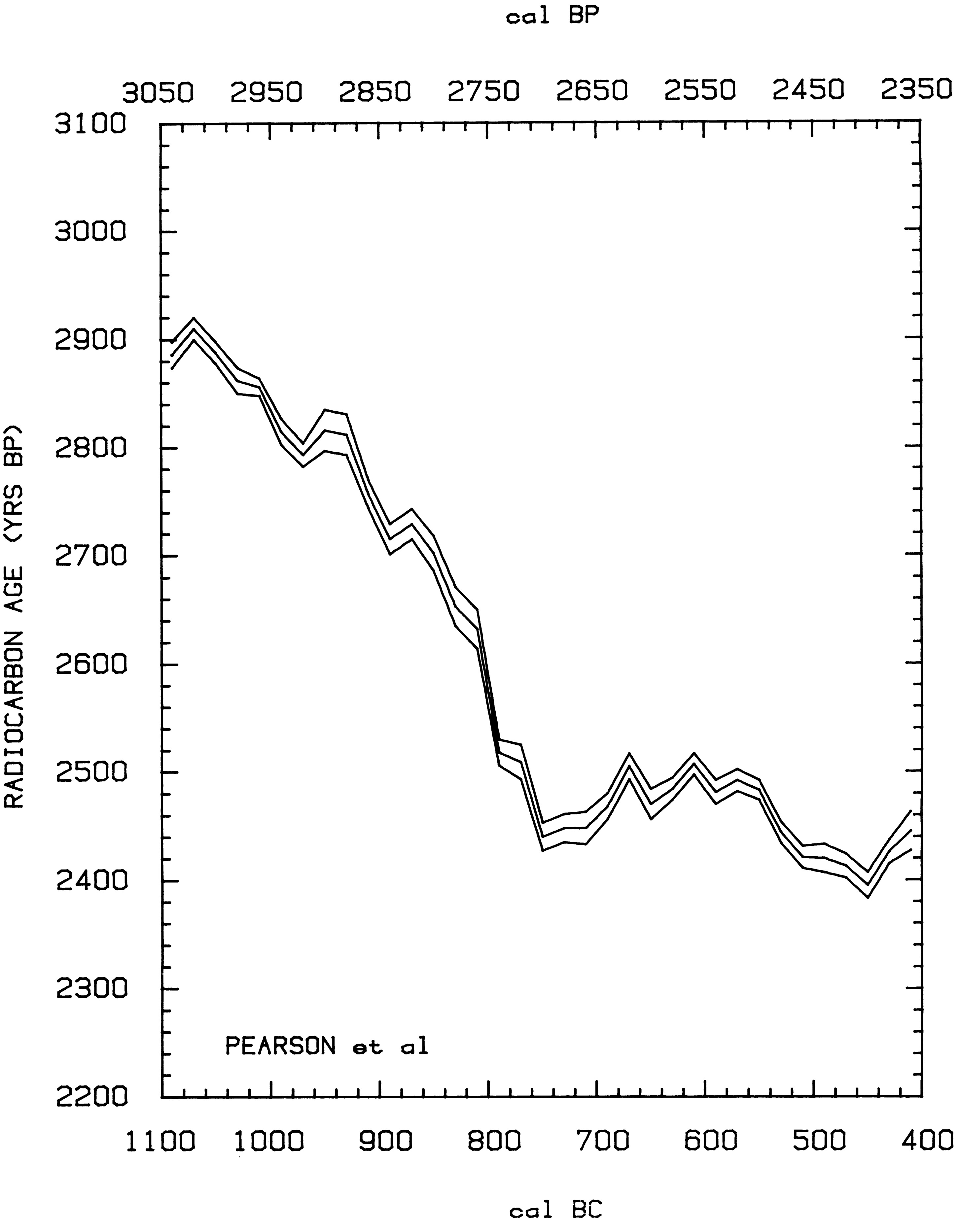
2100
2000
1900
1800
RADIOCARBON AGE (YRS BP)
PEARSON et al
600
500
400
300
200
100
0
100
cal BC AD

Fig 1E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2650
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2450
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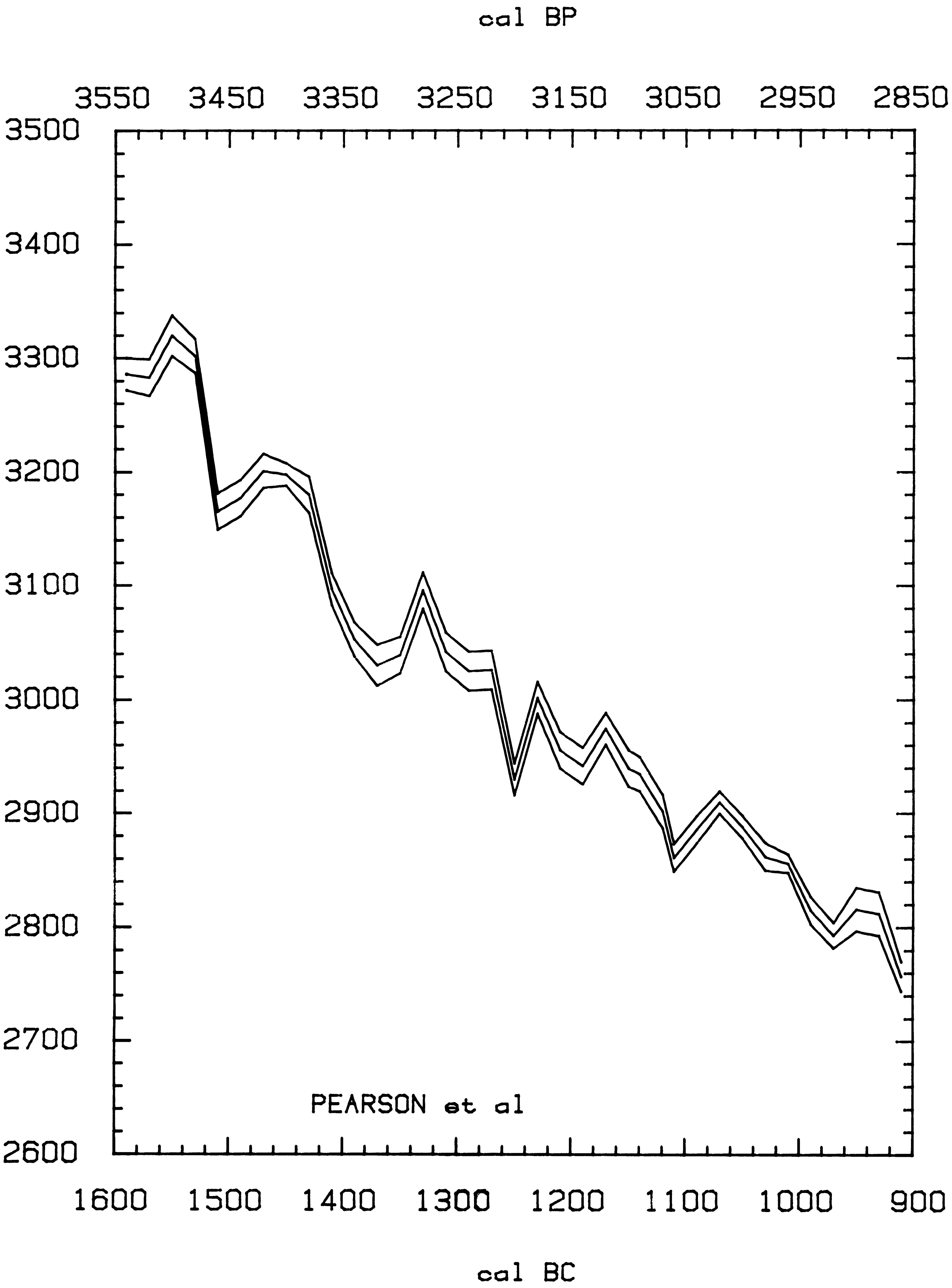
2500
2400
2300
2200
RADIOCARBON AGE (YRS BP)
PEARSON et al
1100
1000
900
800
700
600
500
400
cal BC

Fig 1F



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3350
3250
3150
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2950
2850
3500
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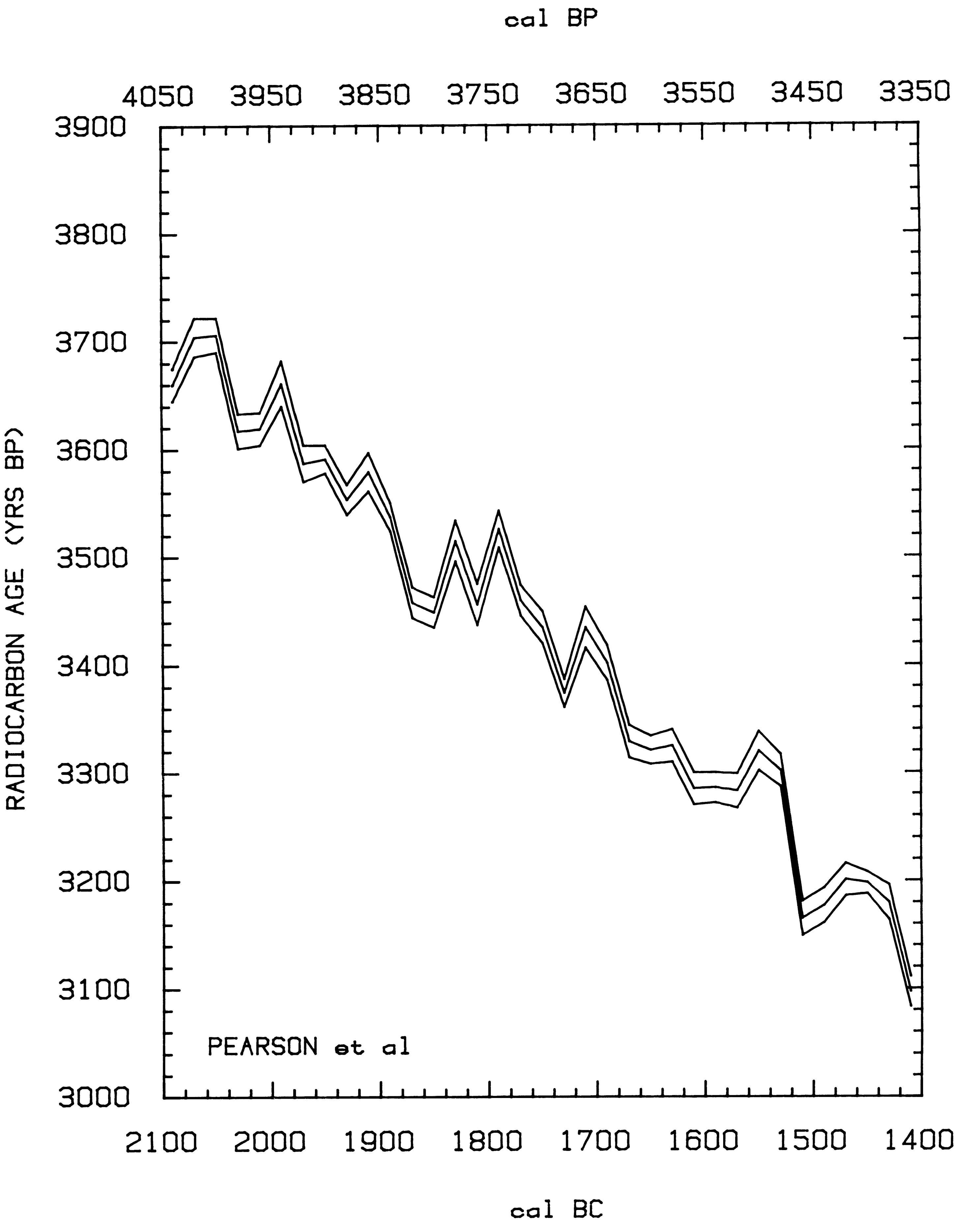
2900
2800
2700
2600
RADIOCARBON AGE (YRS BP)
PEARSON et al
1600
1500
1400
1300
1200
1100
1000
900
cal BC

Fig 1G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3200
3100
3000
RADIOCARBON AGE (YRS BP)
PEARSON et al
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1800
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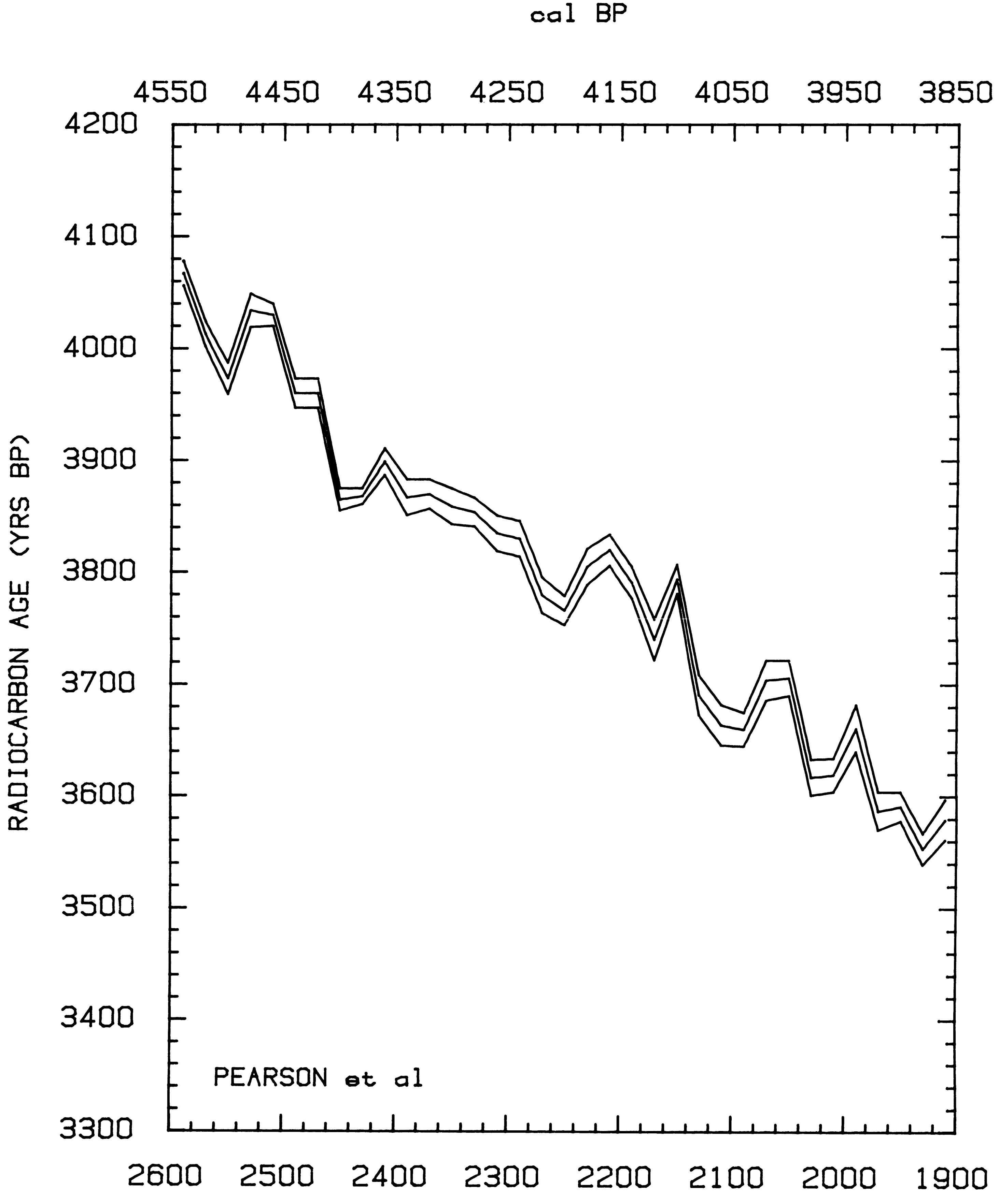
1600
1500
1400
cal BC

Fig 1H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3600
3500
3400
3300
RADIOCARBON AGE (YRS BP)
PEARSON et al
2600
2500
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2300
2200
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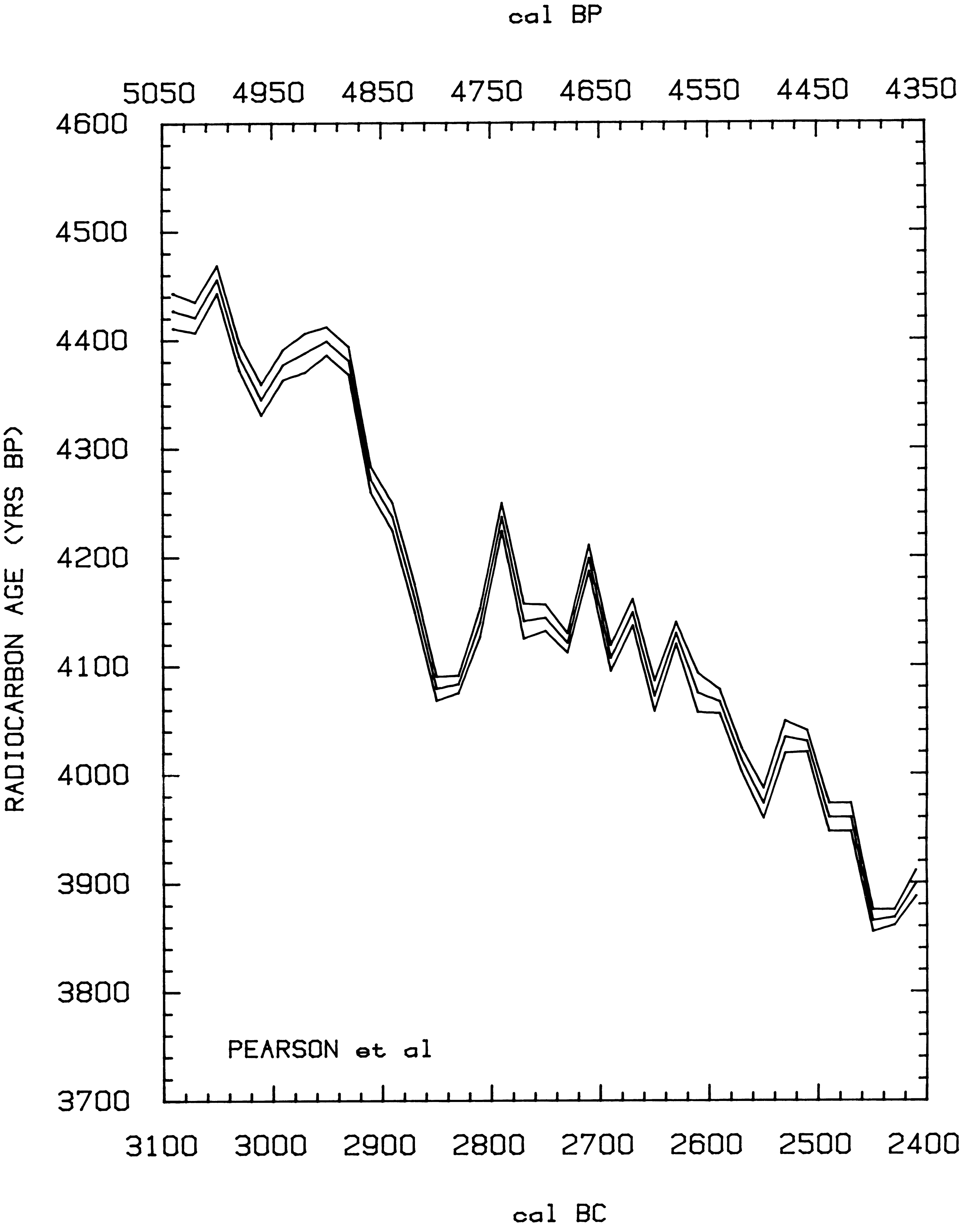
2000
1900
cal BC

Fig 1I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RADIOCARBON AGE (YRS BP)
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4400
4300
4200
4100
4000
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3800
3700
PEARSON et al
3100
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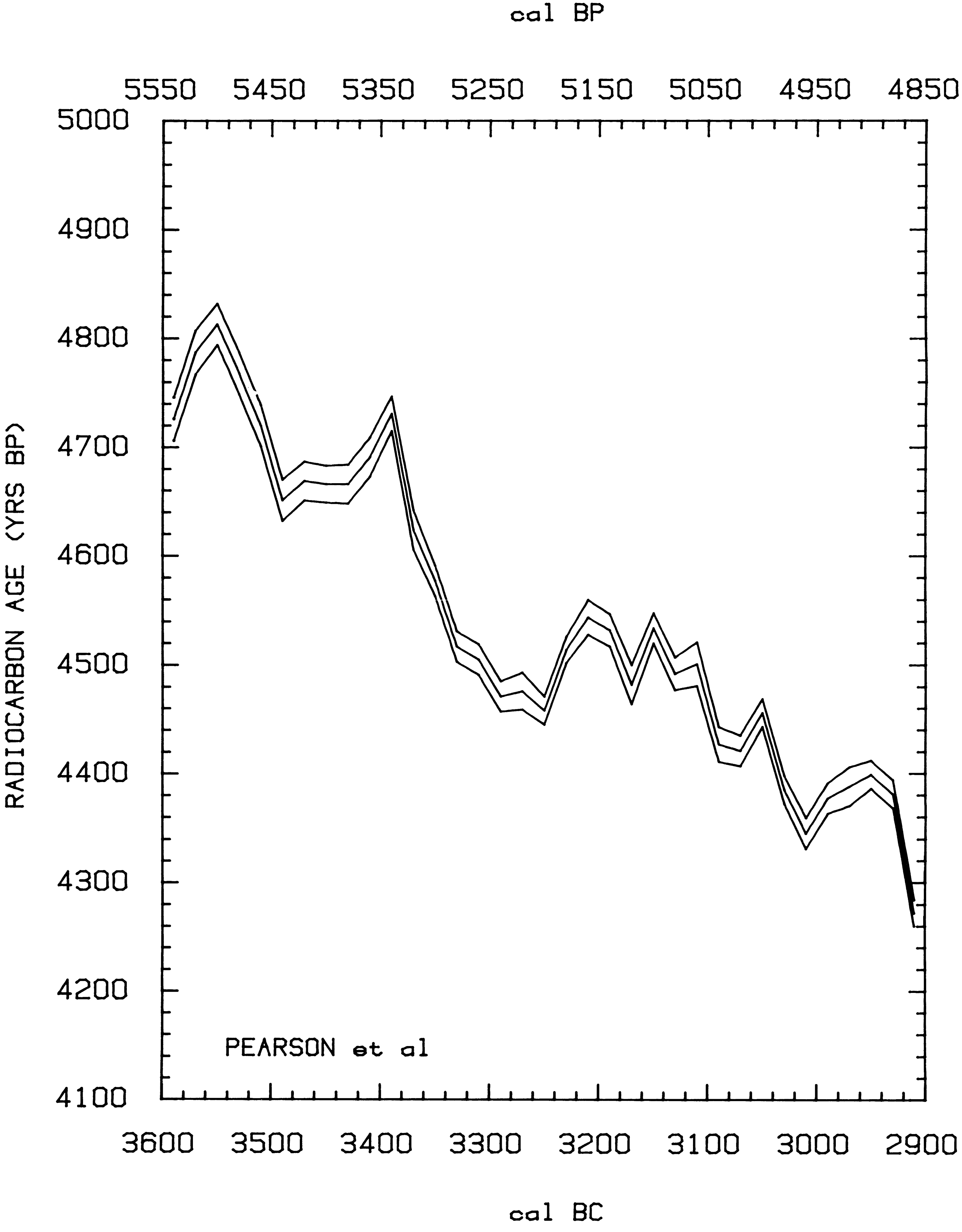
2500
2400
cal BC

Fig 1J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4300
4200
4100
RADIOCARBON AGE (YRS BP)
PEARSON et al
3600
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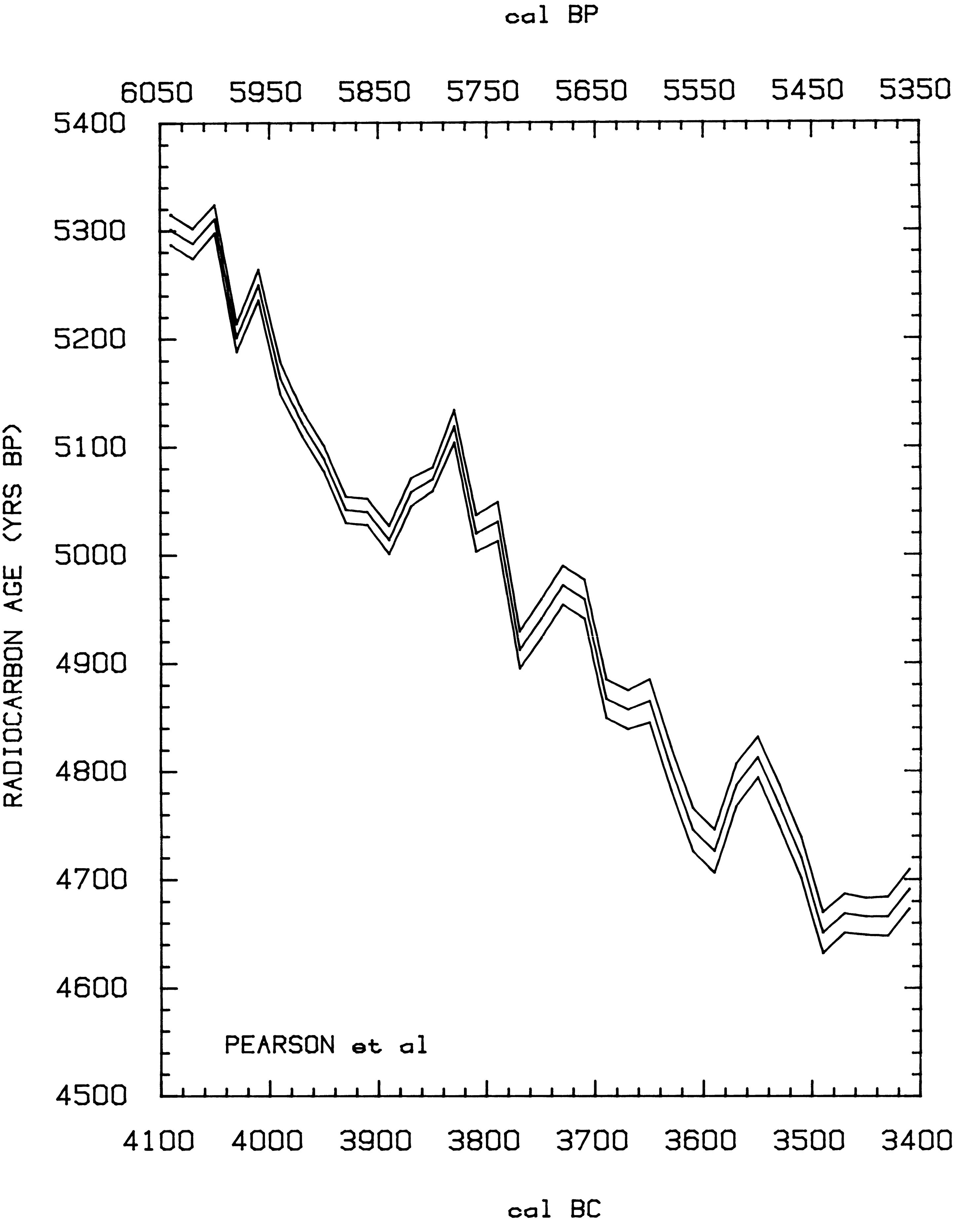
cal BC

Fig 1K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4700
4600
4500
RADIOCARBON AGE (YRS BP)
PEARSON et al
4100
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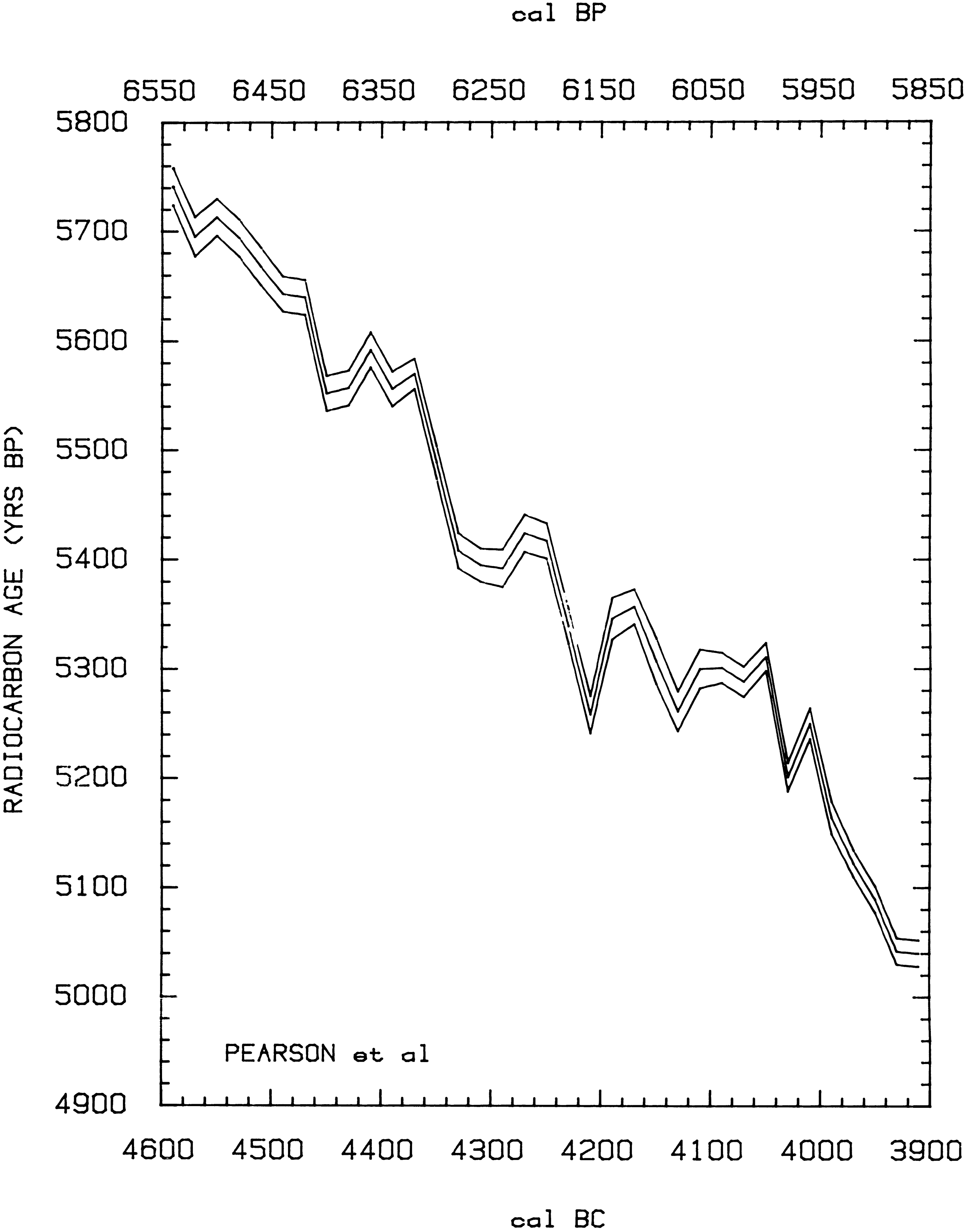
cal BC

Fig 1L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5600
5500
5400
5300
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PEARSON et al
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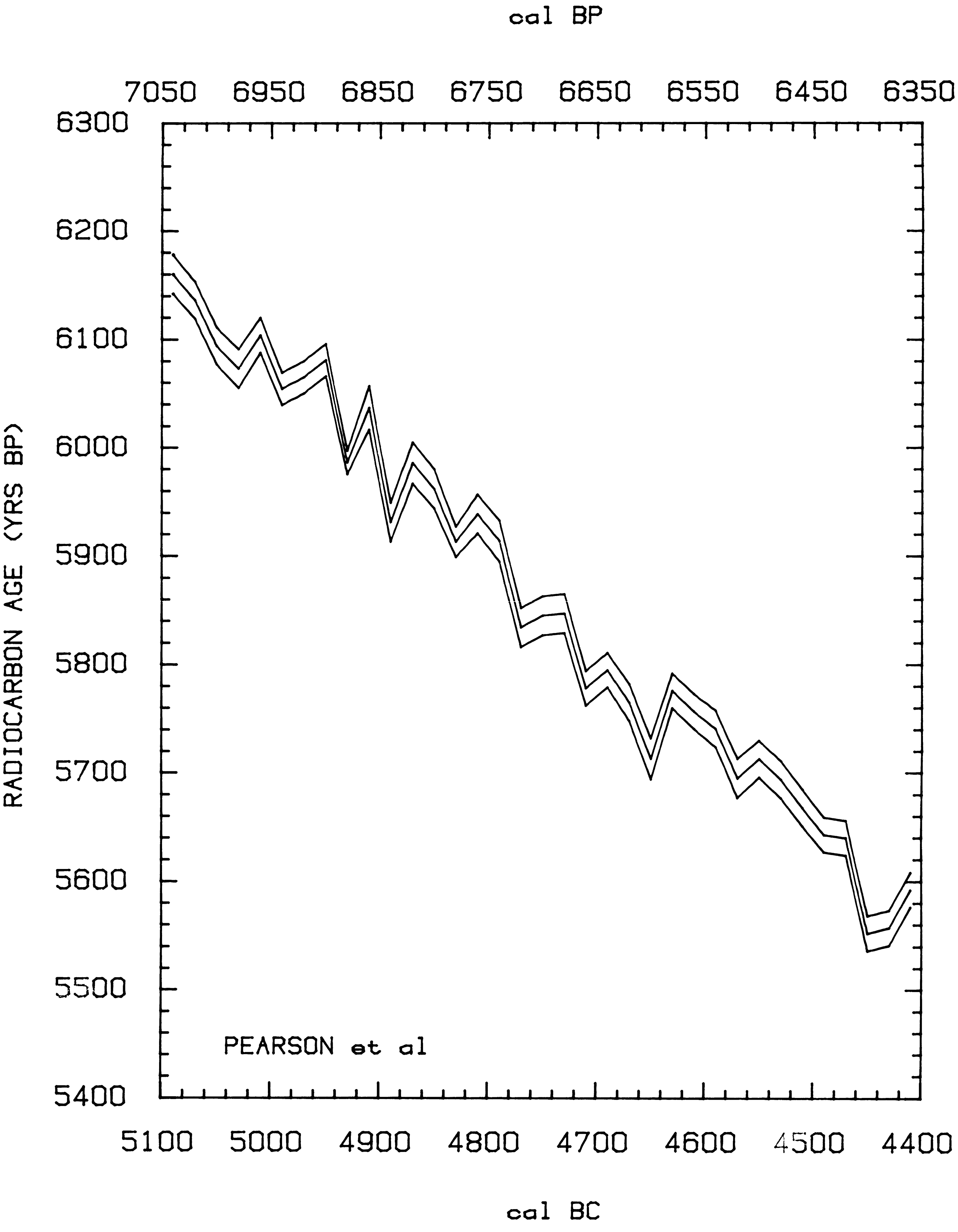
cal BC

Fig 1M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6100
6000
5900
5800
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PEARSON et al
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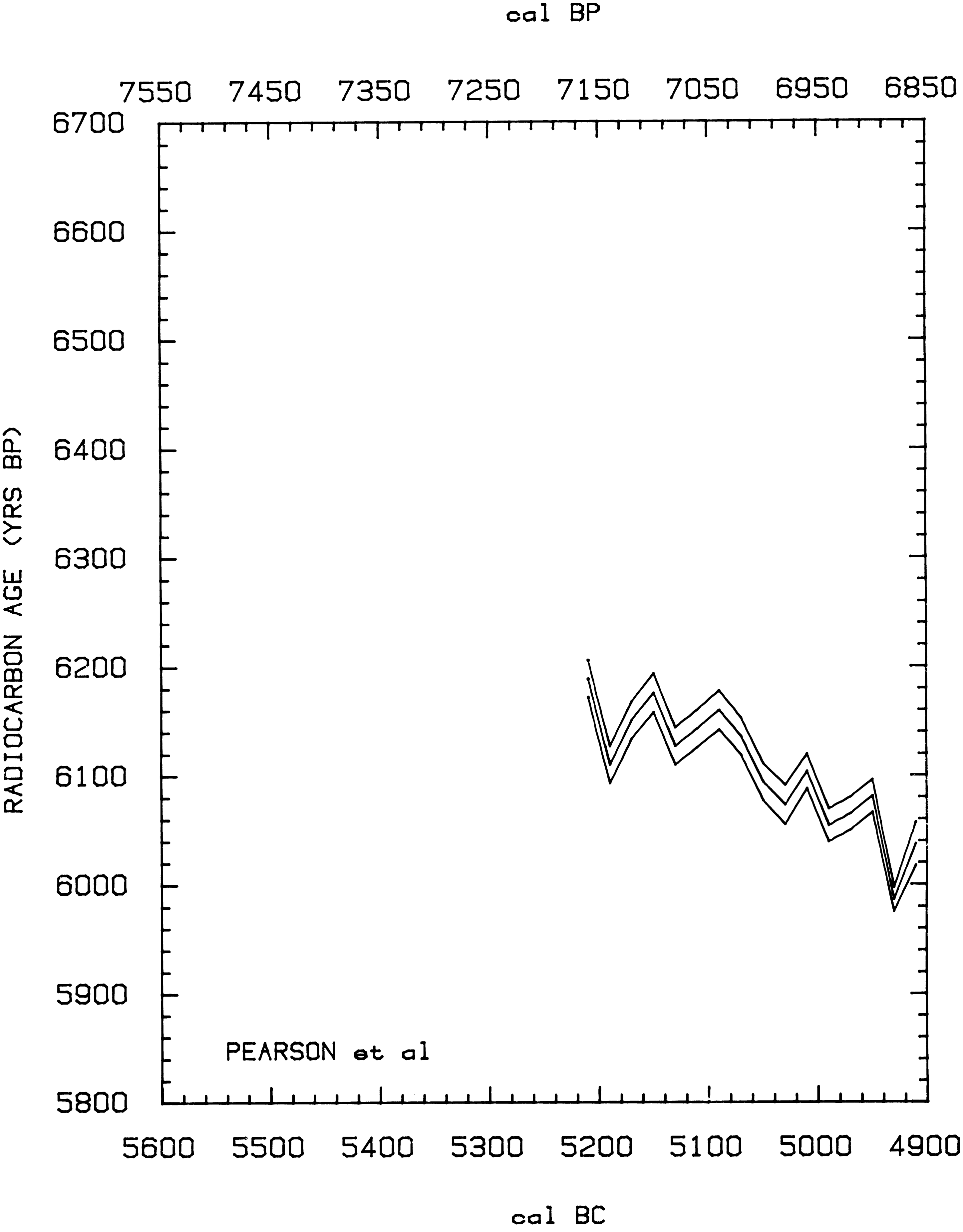
cal BC

Fig 1N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6100
6000
5900
5800
RADIOCARBON AGE (YRS BP)
PEARSON et al
5600
5500
5400
5300
5200
5100
5000
4900
cal BC

Fig 10

TABLE 1
Corrections applied to scintillation counting results

				ERROR ESTIMATED ON SAMPLE COUNTS ONLY	
ERROR SOURCE	PARAMETER MONITORED	DERIVATION OF CORRECTION	NORMALISED VALUE	ESTIMATED RESIDUAL ERROR IN YEARS cf SAMPLE = T^2 NET SAMPLE = 60 CPM	ESTIMATED ERROR IN YEARS IF UNCORRECTED cf SAMPLE = T^2 NET SAMPLE = 60 CPM
Background variation with 'purity'	Channel ratio of external ^{133}Ba source	Correction is in two parts:- Constant component = 0.013 cpm Variable component = 0.008 cpm for each 0.01 rise in channels ratio	Channels ratio = 1.95	Estimated at 0.03% cf T^2 ie ± 2.5 years	Channels ratio variation = ± 0.05 ≡ ± 0.1 cpm ie ± 13 years
Background variation with weight loss from vial	Vial weighing; average weight loss calculated	Background count rate variation with volume curve Slope = 0.289 cpm/g loss	Weight of standard contents=14.2666 g. 13.1325 g of C_6H_6	Weighing error ± 1 mg ≡ ± 0.000289 cpm ie 0.04 years	Normal losses are about 1 mg per day. On a 14 day count this would give an error of ± 0.6 years.
Efficiency variation with weight loss from vial	Vial weighing; average weight loss calculated	Linear regression of efficiency on weight loss over a 1 g fall Slope = 0.0016%/mg fall in weight	Filling weight = 14.2666 g	Error in weighing = ± 1 mg ≡ ± 0.00096 cpm ie ± 0.13 years	Loss of 1 mg/day ≡ 0.013 cpm ie ≃ 2 years
Differential loss of benzene and toluene from counting mixture	as above	Experimentally derived 97.65% loss is benzene	Filling weight of benzene = 13.1325 g	Error in weighing = ± 1 mg Weight loss of sample = ± 0.98 mg ≡ ± 0.004 cpm ie ± 0.6 years	Loss of 1 mg/day ≡ 0.06 cpm ie ≃ 8 years This loss can be up to 10 mg/day
Background variation with atmospheric depth, solar radiation and neutron flux	Height of atmosphere at 100 mb pressure level. Solar radio transmission at 9500 MHz. Neutron flux is monitored by Leeds University	Triple linear regression using the three parameters with BG corrected for BP Slopes: -0.0002 cpm/metre - 0.0007 cpm/unit flux 0.0233 cpm/unit flux	100 mb pressure level height = 16019 metres. Solar radio transmission = 303.688 units Neutron flux = 92.778/Au	These estimates are based on the ability to read parameters at levels indicated 100 mb PLH ± 10 metres ≡ ± 0.002 cpm ie ± 0.25 years. SRT ± 4 units ≡ ± 0.0007 cpm ie ± 0.25 years Neutron flux ± 0.1 units ie ± 0.25 years	Range errors 100 mb PLH ± 500 m ≡ ±0.1 cpm ie ± 13 years SRT ± 40 units ≡ 0.028 cpm ie ± 4 yrs Neutron flux ± 4/Au ≡ ± 0.093 ie ± 13 years
Background variation with barometric pressure	Barometric pressure	Linear regression of BG count rate (sealed vial) on BP. Slope = -0.0127 cpm/mb increase in pressure	1010 millibars	Barograph reading ± 0.05 mb ie ± 0.8 years	Pressure range ± 25 mb Error ≃ ± 0.32 cpm ie ± 42 years
Background variation with ^{133}Ba contribution	Known contribution $A = A' - \left(e^{-0.0077t}\right)0.35$ where A = corrected BG cpm A' =observed BG	The contribution was determined by source removal. There is a variation applied to this correction for 'purity' change (see correction below)	To zero contribution	Estimated at ± 0.02 cpm ie ≡ ± 2.5 years	Variable contribution 0.18 cpm ie ≡ 24 years although most of this would have been included in BG/Purity
Efficiency variation with gain 'purity'	Channels ratio of ^{133}Ba external source	The loss of counts is proportional to the increasing area of a triangle: the height varies as a function of the purity. The equation is:- $A=A_1(1+(\frac{x^2}{8})0.0015)$ where A = corrected cpm A_1=observed cpm (previously corr) x = change in channels ratio x 100	Channels ratio = 1.95	Channels ratio ± 0.01 ≡ ± 0.019% ≡ ± 0.011 cpm ie ± 1.5 years	Channels ratio ±0.05 ≡ ± 0.46% ≡ ± 0.28 cpm ie ± 38 years
Efficiency variation with counting time	Continuous quality control	Exponential regression of corrected standard cpm with time	Mid point of counting time	None	Loss of standard counts ≃ 0.005 cpm per day ≡ 0.67 years per day difference between sample & standard counting time

TABLE 2 A–G
Calibration table data (See legend, Table 2G)

TABLE 2A

cal AD/BC cal BP	Δ^{14}C	Radiocarbon age BP
AD 1840[1] BP 110	1.5 ± 1.3	95 ± 10
AD 1810 BP 140	1.0 ± 2.1	128 ± 17
AD 1790 BP 160	-5.8 ± 2.2	202 ± 18
AD 1770 BP 180	-3.0 ± 2.2	199 ± 18
AD 1750 BP 200	3.8 ± 2.0	164 ± 16
AD 1730 BP 220	14.0 ± 2.0	102 ± 16
AD 1710 BP 240	20.8 ± 1.5	68 ± 12
AD 1690 BP 260	20.3 ± 2.2	91 ± 17
AD 1670 BP 280	4.9 ± 2.0	233 ± 16
AD 1650 BP 300	3.8 ± 1.5	261 ± 12
AD 1630 BP 320	-5.5 ± 2.1	355 ± 17
AD 1610 BP 340	-3.9 ± 2.0	362 ± 16
AD 1590 BP 360	1.2 ± 1.7	340 ± 14
AD 1570 BP 380	0.3 ± 2.0	367 ± 16
AD 1550[1] BP 400	10.0 ± 1.4	309 ± 11
AD 1530[4] BP 420	14.9 ± 1.3	289 ± 10
AD 1510[4] BP 440	9.2 ± 1.1	354 ± 9
AD 1490 BP 460	14.4 ± 2.2	332 ± 17
AD 1470 BP 480	9.3 ± 2.3	392 ± 18
AD 1460[6] BP 490	8.8 ± 1.3	406 ± 10
AD 1450 BP 500	3.5 ± 2.1	458 ± 17
AD 1430 BP 520	0.7 ± 2.4	500 ± 19
AD 1410 BP 540	1.6 ± 1.8	512 ± 14
AD 1390 BP 560	-6.8 ± 4.2	599 ± 34
AD 1370 BP 580	-13.3 ± 1.7	671 ± 14
AD 1350 BP 600	-6.8 ± 2.0	638 ± 16
AD 1330 BP 620	4.1 ± 1.8	570 ± 14
AD 1310 BP 640	4.5 ± 1.8	586 ± 14
AD 1290 BP 660	2.3 ± 4.2	623 ± 34
AD 1260[4] BP 690	-13.7 ± 1.2	781 ± 10
AD 1230[3] BP 720	-14.4 ± 1.2	816 ± 10
AD 1215[7] BP 735	-18.1 ± 2.2	861 ± 18
AD 1195[7] BP 755	-11.8 ± 2.2	829 ± 18
AD 1170[3] BP 780	-13.5 ± 1.1	867 ± 9
AD 1150[3] BP 800	-18.5 ± 1.1	927 ± 9
AD 1130[3] BP 820	-12.5 ± 1.5	898 ± 12
AD 1110[3] BP 840	-13.3 ± 1.5	924 ± 12
AD 1090[3] BP 860	-10.0 ± 1.4	916 ± 11
AD 1070[3] BP 880	-4.6 ± 1.2	892 ± 10
AD 1050[3] BP 900	-4.3 ± 1.5	909 ± 12
AD 1030[3] BP 920	-9.2 ± 1.5	968 ± 12
AD 1010[3] BP 940	-16.0 ± 1.4	1043 ± 11
AD 990[3] BP 960	-17.1 ± 1.2	1052 ± 10
AD 970[3] BP 980	-15.2 ± 1.2	1075 ± 10
AD 955[7] BP 995	-18.9 ± 1.7	1120 ± 14
AD 940 BP 1010	-15.9 ± 2.0	1110 ± 16
AD 920 BP 1030	-14.2 ± 1.7	1116 ± 14
AD 900 BP 1050	-10.2 ± 1.7	1103 ± 14
AD 880 BP 1070	-19.3 ± 1.7	1196 ± 14
AD 860 BP 1090	-15.4 ± 2.1	1184 ± 17
AD 850 BP 1100	-17.8 ± 2.1	1213 ± 17
AD 830 BP 1120	-13.1 ± 2.1	1194 ± 17
AD 810 BP 1140	-14.4 ± 2.0	1224 ± 16
AD 790 BP 1160	-14.0 ± 2.0	1240 ± 16
AD 770 BP 1180	-12.4 ± 2.0	1247 ± 16
AD 750 BP 1200	-13.8 ± 2.0	1278 ± 16

TABLE 2B

cal AD/BC cal BP	Δ^{14}C	Radiocarbon age BP
AD 730[1] BP 1220	-7.5 ± 1.5	1246 ± 12
AD 710 BP 1240	-9.6 ± 2.2	1282 ±
AD 690 BP 1260	-6.8 ± 2.2	1279 ± 18
AD 670 BP 1280	-10.6 ± 2.2	1329 ± 18
AD 650[1] BP 1300	-17.9 ± 1.5	1408 ± 12
AD 630 BP 1320	-14.8 ± 2.2	1402 ± 18
AD 610 BP 1340	-19.8 ± 2.2	1463 ± 18
AD 590 BP 1360	-24.9 ± 2.2	1524 ± 18
AD 570 BP 1380	-18.0 ± 2.2	1487 ± 18
AD 550 BP 1400	-21.4 ± 2.3	1534 ± 19
AD 530 BP 1420	-19.0 ± 2.2	1534 ± 18
AD 510 BP 1440	-18.8 ± 2.1	1552 ± 17
AD 490 BP 1460	-20.9 ± 2.1	1588 ± 17
AD 470 BP 1480	-14.2 ± 2.1	1553 ± 17
AD 450 BP 1500	-14.0 ± 2.1	1571 ± 17
AD 430 BP 1520	-17.3 ± 2.1	1617 ± 17
AD 410 BP 1540	-18.3 ± 2.1	1645 ± 17
AD 390 BP 1560	-20.4 ± 2.1	1681 ± 17
AD 370 BP 1580	-21.0 ± 2.1	1706 ± 17
AD 350 BP 1600	-15.5 ± 2.2	1680 ± 18
AD 330 BP 1620	-18.7 ± 2.2	1726 ± 18
AD 310 BP 1640	-19.0 ± 2.1	1748 ± 17
AD 290 BP 1660	-14.3 ± 2.1	1729 ± 17
AD 270 BP 1680	-10.8 ± 2.2	1720 ± 18
AD 250 BP 1700	-7.7 ± 2.2	1714 ± 18
AD 230 BP 1720	-15.7 ± 2.2	1798 ± 18
AD 210 BP 1740	-14.9 ± 2.2	1811 ± 18
AD 190 BP 1760	-19.8 ± 2.2	1871 ± 18
AD 170 BP 1780	-13.4 ± 2.2	1838 ± 18
AD 150 BP 1800	-7.9 ± 2.2	1813 ± 18
AD 130 BP 1820	-9.1 ± 2.2	1842 ± 18
AD 110 BP 1840	-15.0 ± 2.2	1909 ± 18
AD 90 BP 1860	-13.9 ± 2.2	1920 ± 18
AD 70 BP 1880	-18.5 ± 2.0	1977 ± 16
AD 50 BP 1900	-14.3 ± 2.2	1962 ± 18
AD 30 BP 1920	-11.4 ± 2.0	1958 ± 16
AD 10 BP 1940	-14.7 ± 2.1	2004 ± 17
BC 10 BP 1960	-10.8 ± 2.2	1992 ± 18
BC 30 BP 1980	-13.5 ± 2.2	2033 ± 18
BC 50 BP 2000	-13.6 ± 2.1	2053 ± 17
BC 70 BP 2020	-12.4 ± 2.0	2063 ± 16
BC 90 BP 2040	-11.6 ± 2.0	2076 ± 16
BC 110 BP 2060	-12.3 ± 1.7	2101 ± 14
BC 130 BP 2080	-11.4 ± 2.0	2113 ± 16
BC 150 BP 2100	-9.7 ± 2.0	2119 ± 16
BC 170[3] BP 2120	-7.7 ± 1.5	2122 ± 12
BC 190[3] BP 2140	-8.6 ± 1.5	2149 ± 12
BC 210[3] BP 2160	-13.3 ± 1.6	2206 ± 13
BC 230 BP 2180	-8.0 ± 2.1	2183 ± 17
BC 250 BP 2200	-7.1 ± 2.0	2195 ± 16
BC 270 BP 2220	-11.6 ± 2.0	2251 ± 16
BC 290 BP 2240	-1.8 ± 2.2	2191 ± 18
BC 310[1] BP 2260	-1.2 ± 1.6	2206 ± 13
BC 330 BP 2280	1.4 ± 2.2	2204 ± 18
BC 350 BP 2300	5.6 ± 2.0	2190 ± 16
BC 370 BP 2320	3.9 ± 1.6	2223 ± 13

TABLE 2C

cal AD/BC cal BP	Δ^{14}C	Radiocarbon age BP
BC 390 BP 2340	-0.8 ± 1.9	2280 ± 15
BC 410 BP 2360	-18.7 ± 2.2	2445 ± 18
BC 430[4] BP 2380	-14.0 ± 1.4	2426 ± 11
BC 450[4] BP 2400	-7.8 ± 1.5	2395 ± 12
BC 470[4] BP 2420	-7.6 ± 1.4	2413 ± 11
BC 490[4] BP 2440	-6.1 ± 1.6	2420 ± 13
BC 510[4] BP 2460	-3.8 ± 1.2	2421 ± 10
BC 530[4] BP 2480	-4.3 ± 1.2	2444 ± 10
BC 550[4] BP 2500	-6.7 ± 1.1	2483 ± 9
BC 570[4] BP 2520	-5.4 ± 1.2	2492 ± 10
BC 590[4] BP 2540	-1.6 ± 1.4	2481 ± 11
BC 610[4] BP 2560	-2.4 ± 1.2	2507 ± 10
BC 630[4] BP 2580	2.9 ± 1.3	2484 ± 10
BC 650 BP 2600	7.1 ± 1.8	2470 ± 14
BC 670[1] BP 2620	5.1 ± 1.5	2505 ± 12
BC 690[1] BP 2640	12.2 ± 1.5	2468 ± 12
BC 710 BP 2660	17.2 ± 1.9	2448 ± 15
BC 730 BP 2680	19.6 ± 1.7	2448 ± 13
BC 750 BP 2700	23.1 ± 1.7	2440 ± 13
BC 770 BP 2720	16.8 ± 2.0	2509 ± 16
BC 790[1] BP 2740	18.1 ± 1.5	2518 ± 12
BC 810 BP 2760	6.2 ± 2.3	2632 ± 18
BC 830 BP 2780	6.0 ± 2.3	2653 ± 18
BC 850 BP 2800	2.3 ± 2.0	2702 ± 16
BC 870[1] BP 2820	1.4 ± 1.8	2729 ± 14
BC 890[1] BP 2840	5.6 ± 1.8	2715 ± 14
BC 910 BP 2860	2.8 ± 1.6	2757 ± 13
BC 930 BP 2880	-1.7 ± 2.4	2812 ± 19
BC 950 BP 2900	0.2 ± 2.4	2816 ± 19
BC 970[1] BP 2920	5.5 ± 1.4	2793 ± 11
BC 990[1] BP 2940	5.2 ± 1.5	2815 ± 12
BC 1010[2] BP 2960	2.5 ± 1.0	2856 ± 8
BC 1030[1] BP 2980	4.2 ± 1.5	2862 ± 12
BC 1050[1] BP 3000	3.4 ± 1.3	2888 ± 10
BC 1070[2] BP 3020	3.1 ± 1.3	2910 ± 10
BC 1090[1] BP 3040	8.5 ± 1.5	2886 ± 12
BC 1110[1] BP 3060	14.1 ± 1.5	2861 ± 12
BC 1120[3] BP 3070	10.2 ± 1.9	2902 ± 15
BC 1140[3] BP 3090	8.4 ± 1.9	2935 ± 15
BC 1150 BP 3100	9.0 ± 2.0	2940 ± 16
BC 1170 BP 3120	7.1 ± 1.8	2975 ± 14
BC 1190 BP 3140	13.7 ± 2.0	2942 ± 16
BC 1210 BP 3160	14.4 ± 2.0	2956 ± 16
BC 1230 BP 3180	11.0 ± 1.8	3002 ± 14
BC 1250 BP 3200	22.6 ± 1.8	2930 ± 14
BC 1270 BP 3220	12.9 ± 2.1	3026 ± 17
BC 1290 BP 3240	15.5 ± 2.2	3025 ± 17
BC 1310 BP 3260	15.8 ± 2.2	3042 ± 17
BC 1330 BP 3280	11.4 ± 2.0	3096 ± 16
BC 1350 BP 3300	21.1 ± 2.0	3039 ± 16
BC 1370 BP 3320	24.7 ± 2.3	3030 ± 18
BC 1390 BP 3240	24.3 ± 1.9	3053 ± 15
BC 1410 BP 3360	21.1 ± 1.8	3097 ± 14
BC 1430 BP 3380	13.1 ± 2.0	3180 ± 16
BC 1450[1] BP 3400	13.3 ± 1.3	3198 ± 10
BC 1470 BP 3420	15.3 ± 1.9	3201 ± 15

TABLE 2D

cal AD/BC cal BP	Δ^{14}C	Radiocarbon age BP
BC 1490 BP 3440	20.8 ± 2.0	3177 ± 16
BC 1510 BP 3460	24.8 ± 2.0	3165 ± 16
BC 1530 BP 3480	10.0 ± 1.9	3302 ± 15
BC 1550 BP 3500	10.1 ± 2.3	3320 ± 18
BC 1570 BP 3520	17.3 ± 2.0	3283 ± 16
BC 1590 BP 3540	19.3 ± 1.8	3286 ± 14
BC 1610 BP 3560	21.9 ± 1.9	3285 ± 15
BC 1630 BP 3580	19.3 ± 1.9	3325 ± 15
BC 1650 BP 3600	22.3 ± 1.7	3321 ± 13
BC 1670 BP 3620	23.8 ± 1.9	3329 ± 15
BC 1690 BP 3640	16.9 ± 2.0	3402 ± 16
BC 1710 BP 3660	15.2 ± 2.4	3435 ± 19
BC 1730 BP 3680	25.4 ± 1.7	3374 ± 13
BC 1750 BP 3700	20.2 ± 1.9	3435 ± 15
BC 1770 BP 3720	19.5 ± 1.8	3460 ± 14
BC 1790 BP 3740	13.6 ± 2.2	3526 ± 17
BC 1810 BP 3760	24.9 ± 2.4	3456 ± 19
BC 1830 BP 3780	19.9 ± 2.4	3515 ± 19
BC 1850 BP 3800	30.8 ± 1.8	3449 ± 14
BC 1870 BP 3820	32.1 ± 1.8	3458 ± 14
BC 1890 BP 3840	24.5 ± 1.7	3537 ± 13
BC 1910 BP 3860	21.6 ± 2.3	3579 ± 18
BC 1930 BP 3880	27.4 ± 1.8	3553 ± 14
BC 1950 BP 3900	25.0 ± 1.7	3591 ± 13
BC 1970 BP 3920	28.0 ± 2.2	3587 ± 17
BC 1990 BP 3940	21.1 ± 2.7	3661 ± 21
BC 2010 BP 3960	28.9 ± 1.9	3619 ± 15
BC 2030 BP 3980	31.7 ± 2.1	3617 ± 16
BC 2050 BP 4000	22.8 ± 2.0	3706 ± 16
BC 2070 BP 4020	25.5 ± 2.3	3704 ± 18
BC 2090 BP 4040	33.6 ± 1.9	3660 ± 15
BC 2110 BP 4060	35.6 ± 2.3	3664 ± 18
BC 2130 BP 4080	34.6 ± 2.3	3691 ± 18
BC 2150[1] BP 4100	23.9 ± 1.7	3794 ± 13
BC 2170 BP 4120	33.3 ± 2.3	3740 ± 18
BC 2190 BP 4140	29.3 ± 1.8	3791 ± 14
BC 2210 BP 4160	28.1 ± 1.8	3820 ± 14
BC 2230 BP 4180	32.5 ± 2.1	3805 ± 16
BC 2250 BP 4200	40.0 ± 1.7	3766 ± 13
BC 2270 BP 4220	40.7 ± 2.1	3780 ± 16
BC 2290 BP 4240	36.8 ± 2.1	3830 ± 16
BC 2310 BP 4260	38.6 ± 2.1	3835 ± 16
BC 2330 BP 4280	38.7 ± 1.7	3854 ± 13
BC 2350 BP 4300	40.6 ± 2.1	3859 ± 16
BC 2370 BP 4320	41.6 ± 1.7	3870 ± 13
BC 2390 BP 4340	44.6 ± 2.1	3867 ± 16
BC 2410 BP 4360	42.9 ± 1.6	3899 ± 12
BC 2430[1&4] BP 4380	49.5 ± 0.9	3868 ± 7
BC 2450 BP 4400	52.4 ± 1.3	3865 ± 10
BC 2470 BP 4420	42.6 ± 1.7	3960 ± 13
BC 2490 BP 4440	45.1 ± 1.7	3960 ± 13
BC 2510 BP 4460	38.5 ± 1.3	4030 ± 10
BC 2530 BP 4480	40.5 ± 1.9	4034 ± 15
BC 2550 BP 4500	51.0 ± 1.8	3973 ± 14

TABLE 2E

cal AD/BC cal BP	$\Delta^{14}C$	Radiocarbon age BP
BC 2570 BP 4520	48.3 ± 1.4	4013 ± 11
BC 2590[1] BP 4540	43.8 ± 1.4	4067 ± 11
BC 2610 BP 4560	45.3 ± 2.3	4075 ± 18
BC 2630 BP 4580	40.7 ± 1.3	4130 ± 10
BC 2650 BP 4600	50.8 ± 1.8	4072 ± 14
BC 2670 BP 4620	43.3 ± 1.6	4149 ± 12
BC 2690 BP 4640	51.3 ± 1.6	4107 ± 12
BC 2710 BP 4660	41.8 ± 1.6	4199 ± 12
BC 2730[1] BP 4680	54.4 ± 1.2	4121 ± 9
BC 2750 BP 4700	54.7 ± 1.6	4144 ± 12
BC 2770 BP 4720	57.0 ± 2.1	4141 ± 16
BC 2790 BP 4740	47.0 ± 1.7	4237 ± 13
BC 2810 BP 4760	62.3 ± 1.7	4140 ± 13
BC 2830[1&4] BP 4780	72.4 ± 1.1	4083 ± 8
BC 2850[4] BP 4800	75.6 ± 1.5	4079 ± 11
BC 2870[3] BP 4820	67.1 ± 1.7	4162 ± 13
BC 2890 BP 4840	59.7 ± 1.7	4237 ± 13
BC 2910 BP 4860	57.7 ± 1.6	4272 ± 12
BC 2930 BP 4880	46.0 ± 1.7	4381 ± 13
BC 2950 BP 4900	46.1 ± 1.7	4399 ± 13
BC 2970 BP 4920	50.1 ± 2.4	4388 ± 18
BC 2990 BP 4940	54.1 ± 1.8	4377 ± 14
BC 3010 BP 4960	60.9 ± 1.9	4345 ± 14
BC 3030 BP 4980	58.2 ± 1.7	4385 ± 13
BC 3050 BP 5000	51.4 ± 1.7	4456 ± 13
BC 3070 BP 5020	58.5 ± 1.8	4421 ± 14
BC 3090 BP 5040	60.3 ± 2.1	4427 ± 16
BC 3110 BP 5060	53.1 ± 2.6	4501 ± 20
BC 3130 BP 5080	56.9 ± 2.0	4492 ± 15
BC 3150 BP 5100	53.9 ± 1.8	4534 ± 14
BC 3170 BP 5120	63.3 ± 2.4	4482 ± 18
BC 3190[1] BP 5140	59.3 ± 2.0	4532 ± 15
BC 3210 BP 5160	60.3 ± 2.1	4544 ± 16
BC 3230[1] BP 5180	66.8 ± 1.6	4514 ± 12
BC 3250[1] BP 5200	76.9 ± 1.7	4458 ± 13
BC 3270 BP 5220	77.1 ± 2.3	4476 ± 17
BC 3290 BP 5240	80.3 ± 1.9	4471 ± 14
BC 3310 BP 5260	78.4 ± 1.9	4505 ± 14
BC 3330 BP 5280	79.4 ± 1.9	4517 ± 14
BC 3350 BP 5300	73.9 ± 1.9	4577 ± 14
BC 3370 BP 5320	70.3 ± 2.4	4624 ± 18
BC 3390 BP 5340	58.7 ± 2.1	4731 ± 16
BC 3410 BP 5360	66.5 ± 2.4	4691 ± 18
BC 3430 BP 5380	72.4 ± 2.4	4666 ± 18
BC 3450 BP 5400	75.0 ± 2.3	4666 ± 17
BC 3470 BP 5420	77.2 ± 2.4	4669 ± 18
BC 3490 BP 5440	82.3 ± 2.6	4651 ± 19
BC 3510 BP 5460	75.6 ± 2.5	4720 ± 19
BC 3530 BP 5480	71.8 ± 2.5	4768 ± 19
BC 3550 BP 5500	68.4 ± 2.5	4813 ± 19
BC 3570 BP 5520	74.4 ± 2.7	4787 ± 20
BC 3590 BP 5540	85.3 ± 2.7	4726 ± 20
BC 3610 BP 5560	85.2 ± 2.7	4746 ± 20
BC 3630 BP 5580	80.3 ± 2.7	4802 ± 20

TABLE 2F

cal AD/BC cal BP	$\Delta^{14}C$	Radiocarbon age BP
BC 3650 BP 5600	74.4 ± 2.7	4865 ± 20
BC 3670 BP 5620	78.1 ± 2.4	4857 ± 18
BC 3690 BP 5640	79.4 ± 2.4	4867 ± 18
BC 3710 BP 5660	69.6 ± 2.4	4959 ± 18
BC 3730 BP 5680	70.5 ± 2.4	4972 ± 18
BC 3750 BP 5700	77.2 ± 2.4	4941 ± 18
BC 3770 BP 5720	83.8 ± 2.3	4912 ± 17
BC 3790 BP 5740	70.4 ± 2.4	5031 ± 18
BC 3810 BP 5760	74.5 ± 2.3	5020 ± 17
BC 3830 BP 5780	63.9 ± 2.0	5119 ± 15
BC 3850[5] BP 5800	73.0 ± 1.5	5070 ± 11
BC 3870[5] BP 5820	77.2 ± 1.7	5058 ± 13
BC 3890[5] BP 5840	85.7 ± 1.8	5014 ± 13
BC 3910[5] BP 5860	84.9 ± 1.6	5040 ± 12
BC 3930[5] BP 5880	87.2 ± 1.6	5042 ± 12
BC 3950[5] BP 5900	83.5 ± 1.6	5089 ± 12
BC 3970[5] BP 5920	81.6 ± 1.6	5122 ± 12
BC 3990 BP 5940	78.6 ± 2.0	5164 ± 15
BC 4010 BP 5960	69.7 ± 1.9	5250 ± 14
BC 4030 BP 5980	78.9 ± 1.8	5201 ± 13
BC 4050 BP 6000	66.8 ± 1.7	5311 ± 13
BC 4070 BP 6020	72.4 ± 1.9	5288 ± 14
BC 4090 BP 6040	73.3 ± 1.9	5301 ± 14
BC 4110 BP 6060	76.0 ± 2.4	5300 ± 18
BC 4130 BP 6080	83.9 ± 2.4	5261 ± 18
BC 4150 BP 6100	80.3 ± 2.8	5307 ± 21
BC 4170 BP 6120	76.2 ± 2.1	5357 ± 16
BC 4190 BP 6140	80.3 ± 2.6	5346 ± 19
BC 4210 BP 6160	94.8 ± 2.3	5258 ± 17
BC 4230 BP 6180	86.5 ± 2.2	5339 ± 16
BC 4250 BP 6200	78.6 ± 2.2	5417 ± 16
BC 4270 BP 6220	80.2 ± 2.3	5424 ± 17
BC 4290 BP 6240	87.2 ± 2.3	5392 ± 17
BC 4310 BP 6260	89.4 ± 2.0	5395 ± 15
BC 4330 BP 6280	90.3 ± 2.2	5408 ± 16
BC 4350 BP 6300	81.9 ± 2.0	5489 ± 15
BC 4370 BP 6320	73.7 ± 1.9	5570 ± 14
BC 4390 BP 6340	78.2 ± 2.2	5556 ± 16
BC 4410 BP 6360	75.9 ± 2.1	5592 ± 16
BC 4430 BP 6380	83.3 ± 2.2	5557 ± 16
BC 4450 BP 6400	86.6 ± 2.2	5552 ± 16
BC 4470 BP 6420	77.3 ± 2.2	5640 ± 16
BC 4490 BP 6440	79.5 ± 2.2	5643 ± 16
BC 4510 BP 6460	78.8 ± 2.3	5668 ± 17
BC 4530 BP 6480	77.9 ± 2.3	5694 ± 17
BC 4550 BP 6500	78.0 ± 2.3	5713 ± 17
BC 4570 BP 6520	83.0 ± 2.4	5695 ± 18
BC 4590 BP 6540	79.4 ± 2.3	5741 ± 17
BC 4610 BP 6560	79.9 ± 2.2	5757 ± 16
BC 4630 BP 6580	79.9 ± 2.2	5776 ± 16
BC 4650 BP 6600	91.1 ± 2.6	5713 ± 19
BC 4670 BP 6620	86.7 ± 2.3	5765 ± 17
BC 4690 BP 6640	85.2 ± 2.2	5795 ± 16
BC 4710 BP 6660	90.2 ± 2.2	5778 ± 16

TABLE 2G

cal AD/BC cal BP	Δ^{14}C	Radiocarbon age BP
BC 4730 BP 6680	83.5 ± 2.4	5847 ± 18
BC 4750 BP 6700	86.4 ± 2.4	5845 ± 18
BC 4770 BP 6720	90.5 ± 2.4	5834 ± 18
BC 4790 BP 6740	82.2 ± 2.6	5914 ± 19
BC 4810 BP 6760	81.6 ± 2.4	5939 ± 18
BC 4830 BP 6780	87.7 ± 1.9	5913 ± 14
BC 4850 BP 6800	83.7 ± 2.4	5962 ± 18
BC 4870 BP 6820	83.1 ± 2.6	5986 ± 19
BC4890 BP 6840	93.1 ± 2.6	5931 ± 18
BC 4910 BP 6860	81.4 ± 2.7	6037 ± 20
BC 4930[1] BP 6880	91.0 ± 1.5	5986 ± 11
BC 4950 BP 6900	80.7 ± 2.0	6081 ± 15
BC 4970 BP 6920	85.5 ± 2.0	6065 ± 15
BC 4990 BP 6940	89.6 ± 2.0	6054 ± 15
BC 5010 BP 6960	85.5 ± 2.2	6104 ± 16
BC 5030 BP 6980	92.3 ± 2.5	6073 ± 18
BC 5050 BP 7000	92.1 ± 2.3	6094 ± 17
BC 5070 BP 7020	89.1 ± 2.3	6136 ± 17
BC 5090 BP 7040	88.4 ± 2.4	6160 ± 18
BC 5110 BP 7060	93.4 ± 2.3	6143 ± 17
BC 5130 BP 7080	98.2 ± 2.3	6127 ± 17
BC 5150 BP 7100	94.2 ± 2.5	6176 ± 18
BC 5170 BP 7120	100.3 ± 2.3	6151 ± 17
BC 5190 BP 7140	108.6 ± 2.4	6110 ± 17
BC 5210 BP 7160	100.4 ± 2.3	6189 ± 17

Legend

cal AD/BC / cal BP : Mid-point of bi-decade sample unless otherwise stated

Superscript:

[1] A weighted mean of the bi-decade results of a complete duplicate analysis
[2] A weighted mean of the bi-decade results of a complete triplicate analysis
[3] A weighted mean of two decades to give a bi-decade value
[4] Two decades meaned to give a bi-decade value which is then meaned with a bi-decade measurement, appropriately weighted
[5] Overlapping bi-decade results combined to give a weighted mean bi-decade value
[6] A weighted mean of the bi-decade results of a complete duplicate analysis combined with overlapping bi-decade values, appropriately weighted
[7] Decade result only

$$\Delta^{14}\mathrm{C} : \Delta = \left[\frac{A_{SN}e^{\lambda(y-x)}}{A_{ABS}} - 1\right] 1000‰$$

calculated using the mean ^{14}C age (where applicable) ± 1σ (Stuiver & Polach, 1977)

Radiocarbon age BP : Age of bi-decade sample unless otherwise stated (see superscript) ± 1σ

TABLE 3 A–B

Decade samples only (either extracted from or additional to Table 2)
(See legend, Table 3B)

TABLE 3A

cal AD/BC cal BP	Δ^{14}C	Radiocarbon age BP
AD 1535 BP 415	11.2 ± 2.0	314 ± 16
AD 1525 BP 425	17.6 ± 1.8	273 ± 14
AD 1515 BP 435	9.7 ± 1.8	345 ± 14
AD 1505 BP 445	6.8 ± 1.8	378 ± 14
AD 1265 BP 685	-12.5 ± 2.0	767 ± 16
AD 1255 BP 695	-15.3 ± 1.7	799 ± 14
AD 1235 BP 715	-11.2 ± 2.1	785 ± 17
AD 1225 BP 725	-15.6 ± 1.5	831 ± 12
AD 1215 BP 735	-18.1 ± 2.2	861 ± 18
AD 1195 BP 755	-11.8 ± 2.2	829 ± 18
AD 1175 BP 775	-12.1 ± 1.5	851 ± 12
AD 1165 BP 785	-14.9 ± 1.5	883 ± 12
AD 1155 BP 795	-16.7 ± 1.5	908 ± 12
AD 1145 BP 805	-20.1 ± 1.5	945 ± 12
AD 1135 BP 815	-11.4 ± 2.0	884 ± 16
AD 1125 BP 825	-13.6 ± 2.0	912 ± 16
AD 1115 BP 835	-16.0 ± 2.0	941 ± 16
AD 1105 BP 845	-10.6 ± 2.0	907 ± 16
AD 1095 BP 855	-11.3 ± 2.0	922 ± 16
AD 1085 BP 865	-8.7 ± 1.7	911 ± 14
AD 1075 BP 875	-9.1 ± 1.7	924 ± 14
AD 1065 BP 885	0.1 ± 1.7	859 ± 14
AD 1055 BP 895	-2.0 ± 2.0	886 ± 16
AD 1045 BP 905	-6.4 ± 2.0	931 ± 16
AD 1035 BP 915	-8.5 ± 2.0	958 ± 16
AD 1025 BP 925	-10.1 ± 2.1	980 ± 17
AD 1015 BP 935	-13.8 ± 2.1	1020 ± 17
AD 1005 BP 945	-17.3 ± 1.7	1058 ± 14
AD 995 BP 955	-13.1 ± 1.7	1034 ± 14
AD 985 BP 965	-16.2 ± 1.7	1069 ± 14
AD 975 BP 975	-12.2 ± 1.7	1046 ± 14
AD 965 BP 985	-18.1 ± 1.7	1104 ± 14
AD 955 BP 995	-18.9 ± 1.7	1120 ± 14
BC 165 BP 2115	-8.4 ± 2.0	2123 ± 16
BC 175 BP 2125	-7.0 ± 2.1	2121 ± 17
BC 185 BP 2135	-7.3 ± 2.0	2133 ± 16
BC 195 BP 2145	-10.5 ± 2.2	2169 ± 18
BC 205 BP 2155	-12.9 ± 2.1	2198 ± 17
BC 215 BP 2165	-13.5 ± 2.1	2213 ± 17
BC 295 BP 2245	-2.1 ± 2.0	2198 ± 16
BC 425 BP 2375	-16.6 ± 2.0	2442 ± 16
BC 435 BP 2385	-11.7 ± 2.3	2412 ± 19
BC 445 BP 2395	-7.8 ± 2.2	2390 ± 18
BC 455 BP 2405	-4.6 ± 2.4	2374 ± 19
BC 465 BP 2415	-5.5 ± 2.2	2391 ± 18
BC 475 BP 2425	-5.4 ± 2.2	2400 ± 18
BC 485 BP 2435	-6.9 ± 2.4	2422 ± 19
BC 495 BP 2445	-5.4 ± 2.2	2419 ± 18
BC 505 BP 2455	-2.8 ± 2.2	2408 ± 18
BC 515 BP 2465	-5.6 ± 1.9	2440 ± 15
BC 525 BP 2475	-3.2 ± 2.0	2431 ± 16
BC 535 BP 2485	-3.3 ± 2.0	2441 ± 16

Table 3B

cal AD/BC cal BP	$\Delta^{14}C$	Radiocarbon age BP
BC 545 BP 2495	-4.7 ± 2.0	2462 ± 16
BC 555 BP 2505	-7.3 ± 2.0	2493 ± 16
BC 565 BP 2515	-6.6 ± 2.0	2497 ± 16
BC 575 BP 2525	-8.0 ± 2.0	2518 ± 16
BC 585 BP 2535	-3.5 ± 2.2	2491 ± 18
BC 595 BP 2545	-1.3 ± 2.2	2483 ± 18
BC 605 BP 2555	-4.8 ± 2.2	2521 ± 18
BC 615 BP 2565	0.2 ± 2.0	2491 ± 16
BC 625 BP 2575	1.4 ± 2.0	2491 ± 16
BC 635 BP 2585	0.6 ± 2.0	2507 ± 16
BC 645 BP 2595	6.1 ± 1.8	2473 ± 14
BC 1115 BP 3065	10.9 ± 2.5	2891 ± 20
BC 1125 BP 3075	9.5 ± 2.5	2912 ± 20
BC 1135 BP 3085	6.6 ± 2.6	2945 ± 21
BC 1145 BP 3095	10.3 ± 2.5	2925 ± 20
BC 2375 BP 4325	32.1 ± 2.7	3949 ± 21
BC 2395 BP 4345	39.7 ± 2.7	3909 ± 21
BC 2415 BP 4365	39.9 ± 2.7	3927 ± 21
BC 2425 BP 4375	49.8 ± 1.8	3861 ± 14
BC 2435 BP 4385	42.8 ± 2.7	3924 ± 21
BC 2825 BP 4775	70.2 ± 2.4	4095 ± 18
BC 2835 BP 4785	76.4 ± 2.4	4058 ± 18
BC 2845 BP 4795	76.7 ± 2.4	4066 ± 18
BC 2855 BP 4805	67.5 ± 2.4	4144 ± 18
BC 2865 BP 4815	66.3 ± 2.4	4163 ± 18
BC 2875 BP 4825	68.0 ± 2.4	4160 ± 18
BC 2885 BP 4835	64.1 ± 2.4	4199 ± 18

Legend

cal AD/BC
cal BP : Mid-point of single decade sample

$$\Delta^{14}C : \Delta = \left[\frac{A_{SN}e^{\lambda(y-x)}}{A_{ABS}} - 1\right] 1000‰$$

calculated using the ^{14}C age ± 1σ
(Stuiver & Polach, 1977)

Radiocarbon
age BP : Age of single decade sample ± 1σ