

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 $\pm 2\%$) 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 \rightarrow 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 $\hat{\sigma} = \text{SS}/2n$ where $\text{SS} = \text{Sum of the (difference between duplicates)}^2$, $n = \text{No. of duplicated measurements}$, 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 $\bar{\sigma} = [\sum_{i=1}^n (\sigma_i)^2/n]^{1/2}$, 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 $< \pm 20$ 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 archaeological 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 'wiggles 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 archaeological chronology, providing, of course, the samples submitted have the same credentials in terms of precise association and integrity, allowing for correct interpretation.

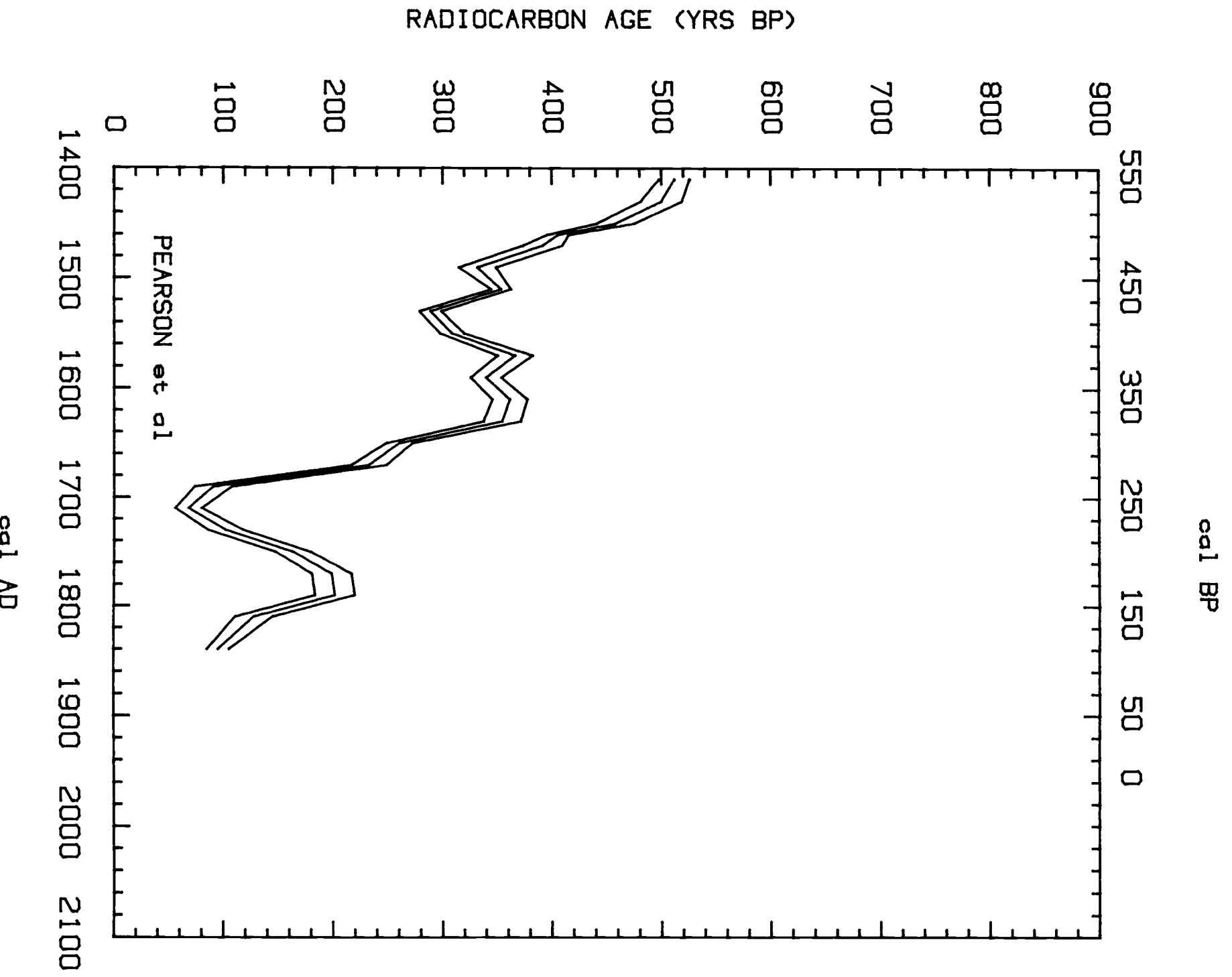
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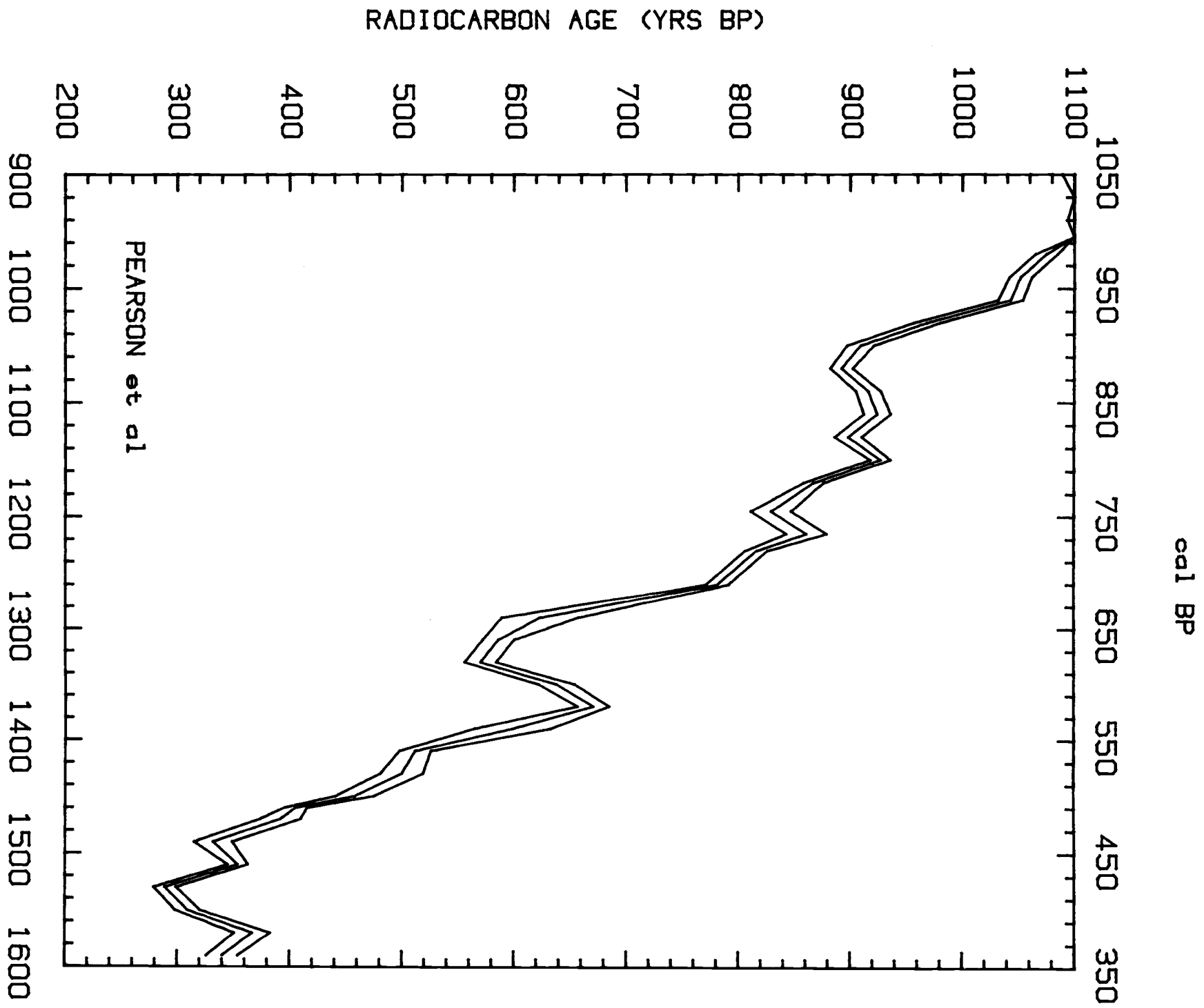
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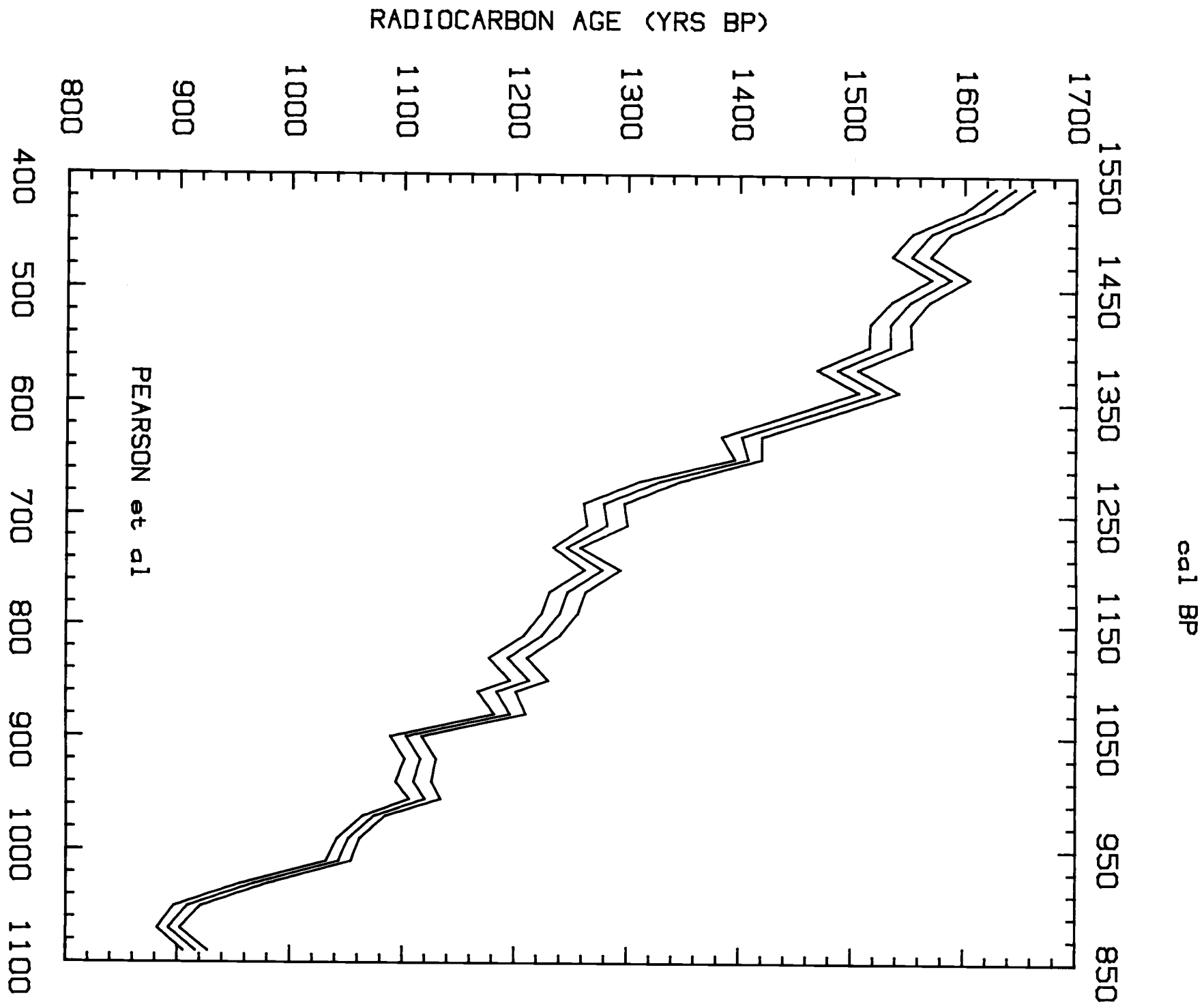


Figs 1A-1O. Radiocarbon time-scale calibration from AD 1840 to 5210 BC

Fig 1A

AD





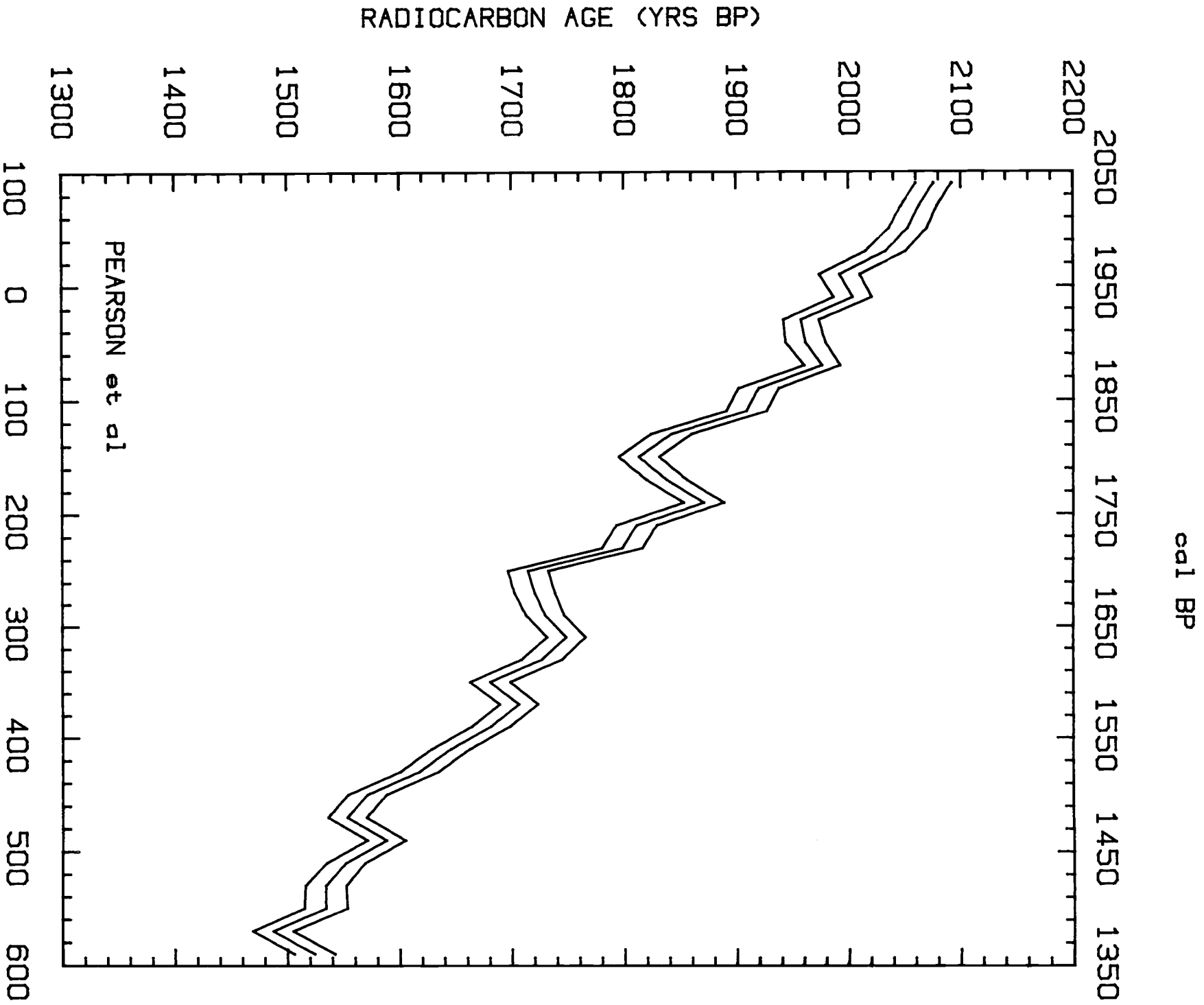
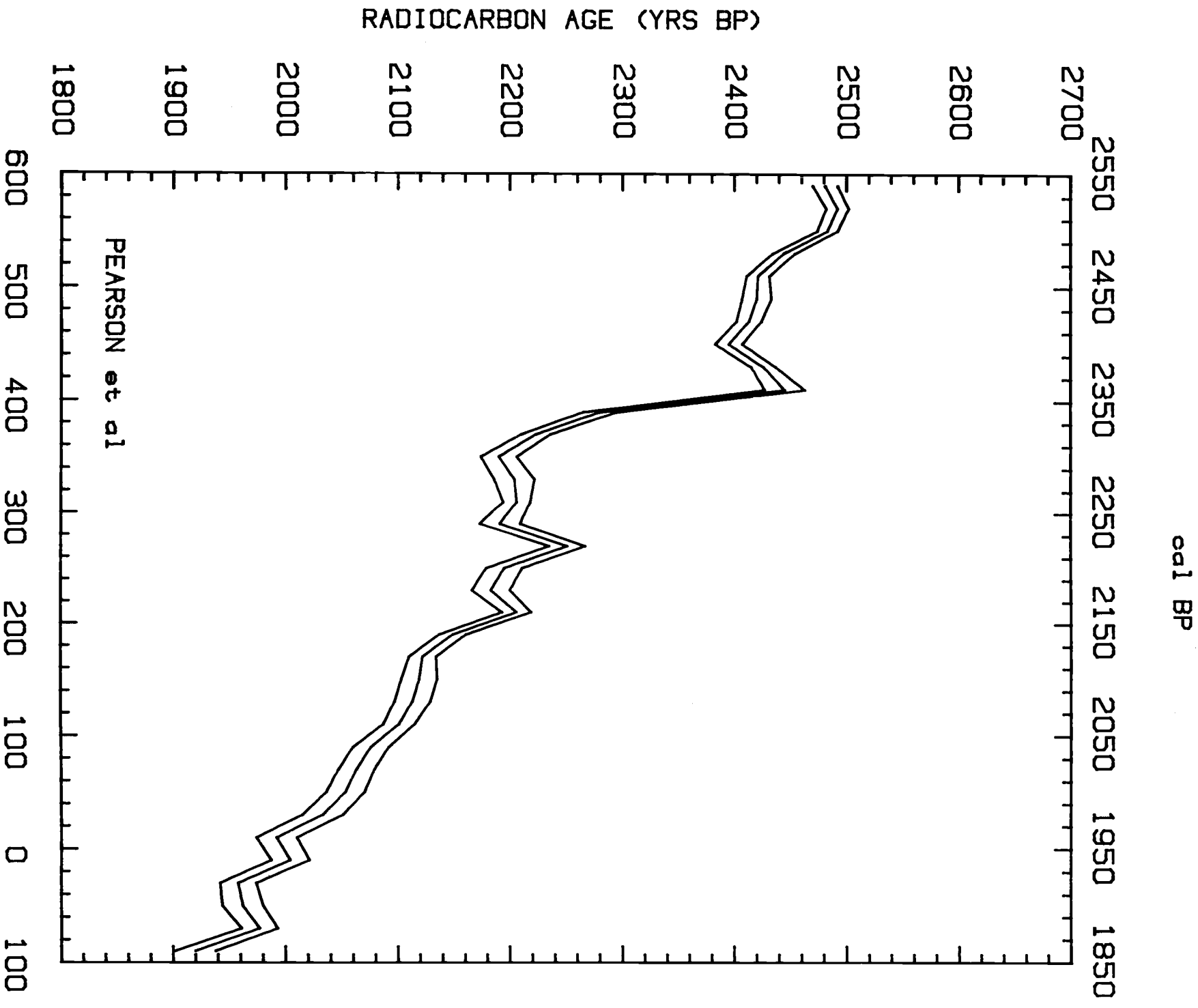
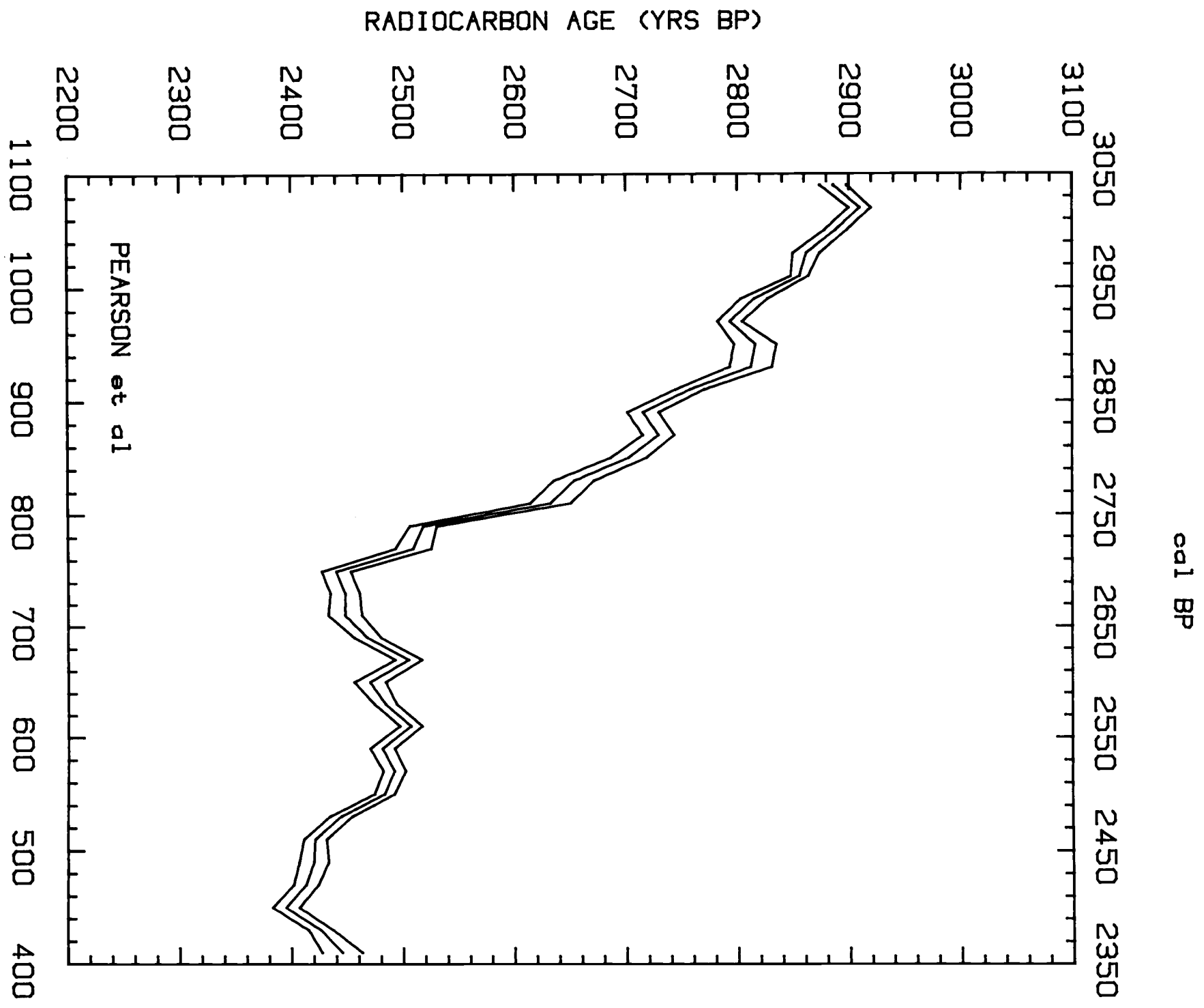


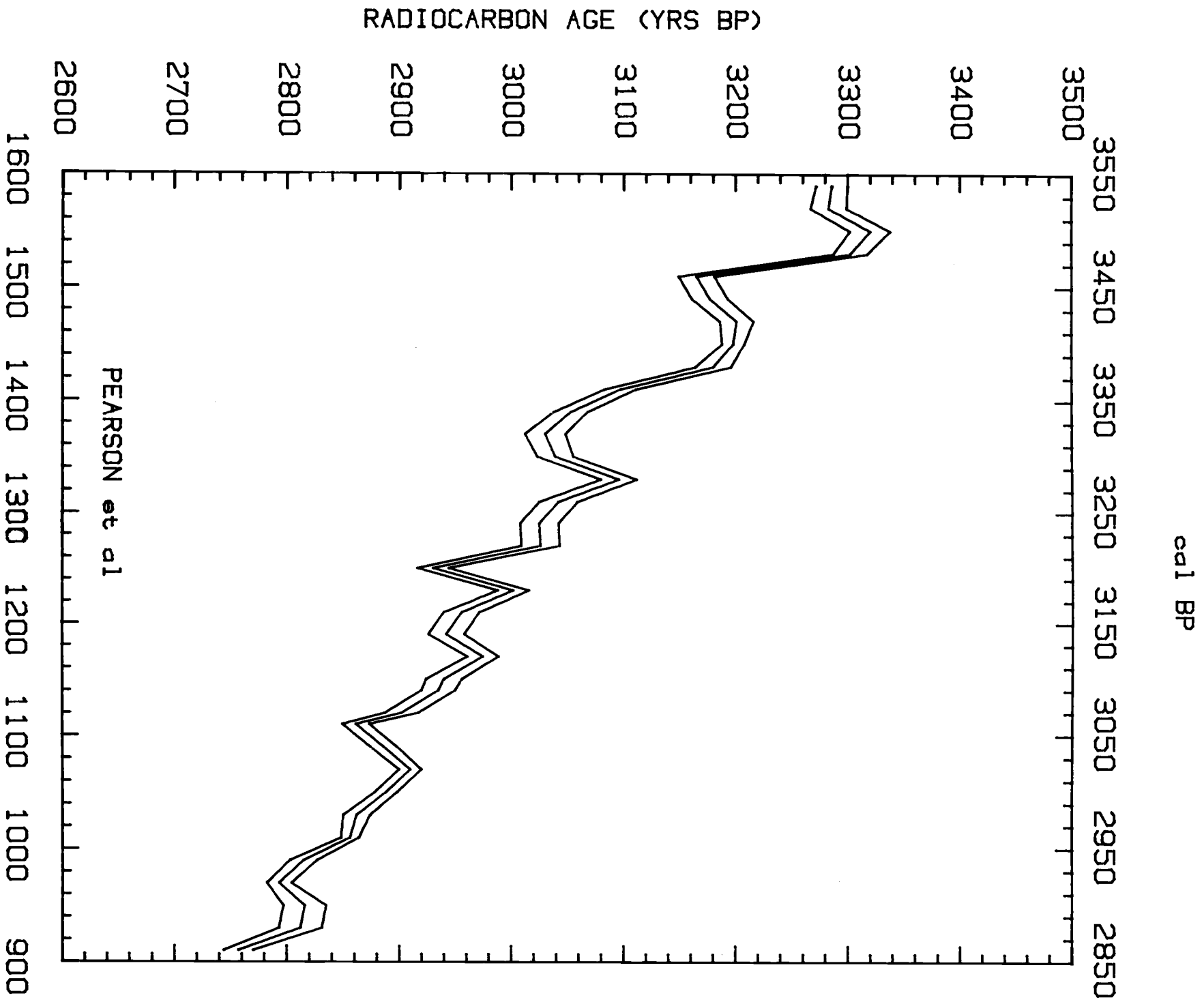
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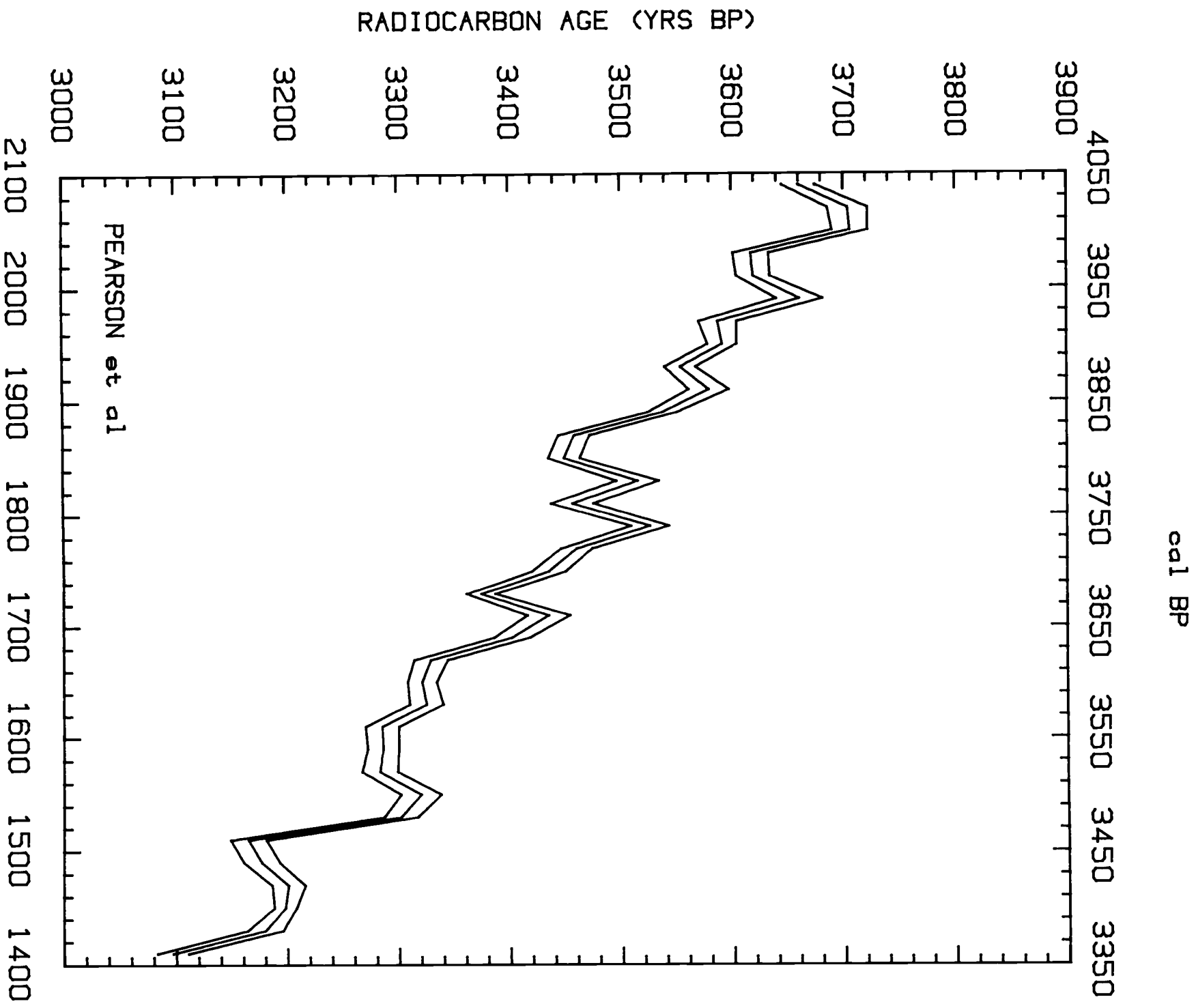
od1 BC AD
Fig 1E



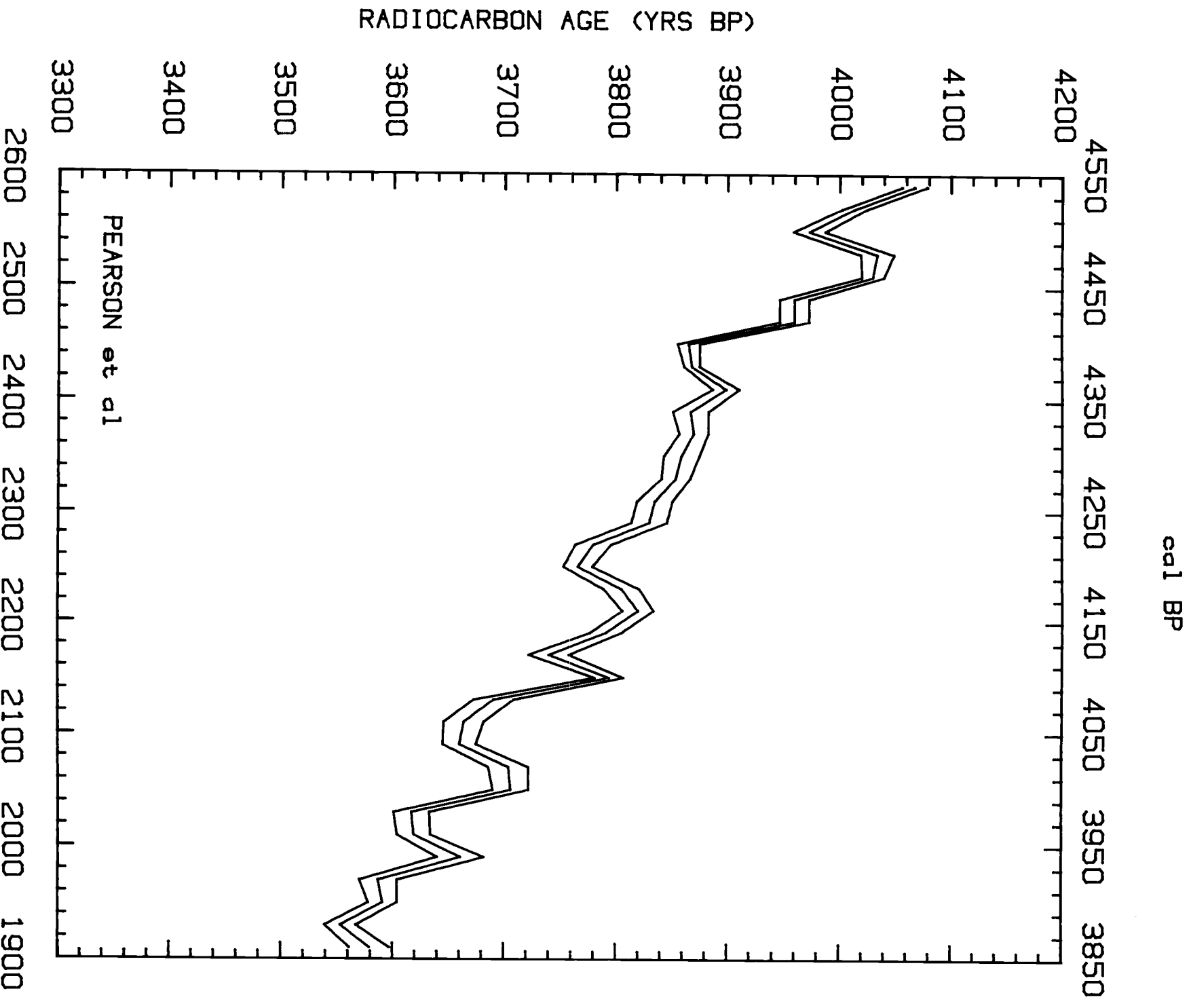
cal BC
Fig 1F



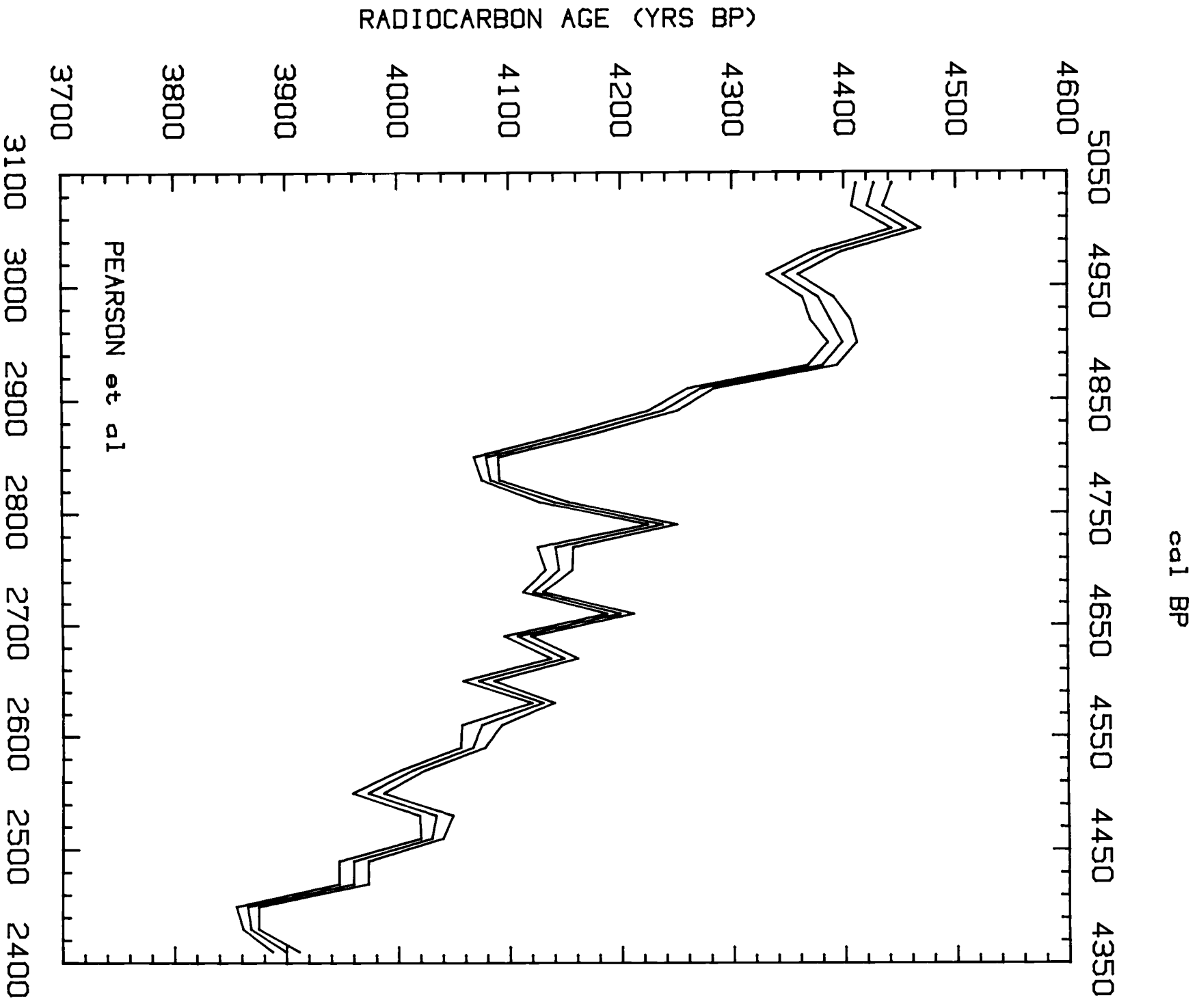
cal BC
Fig 1G



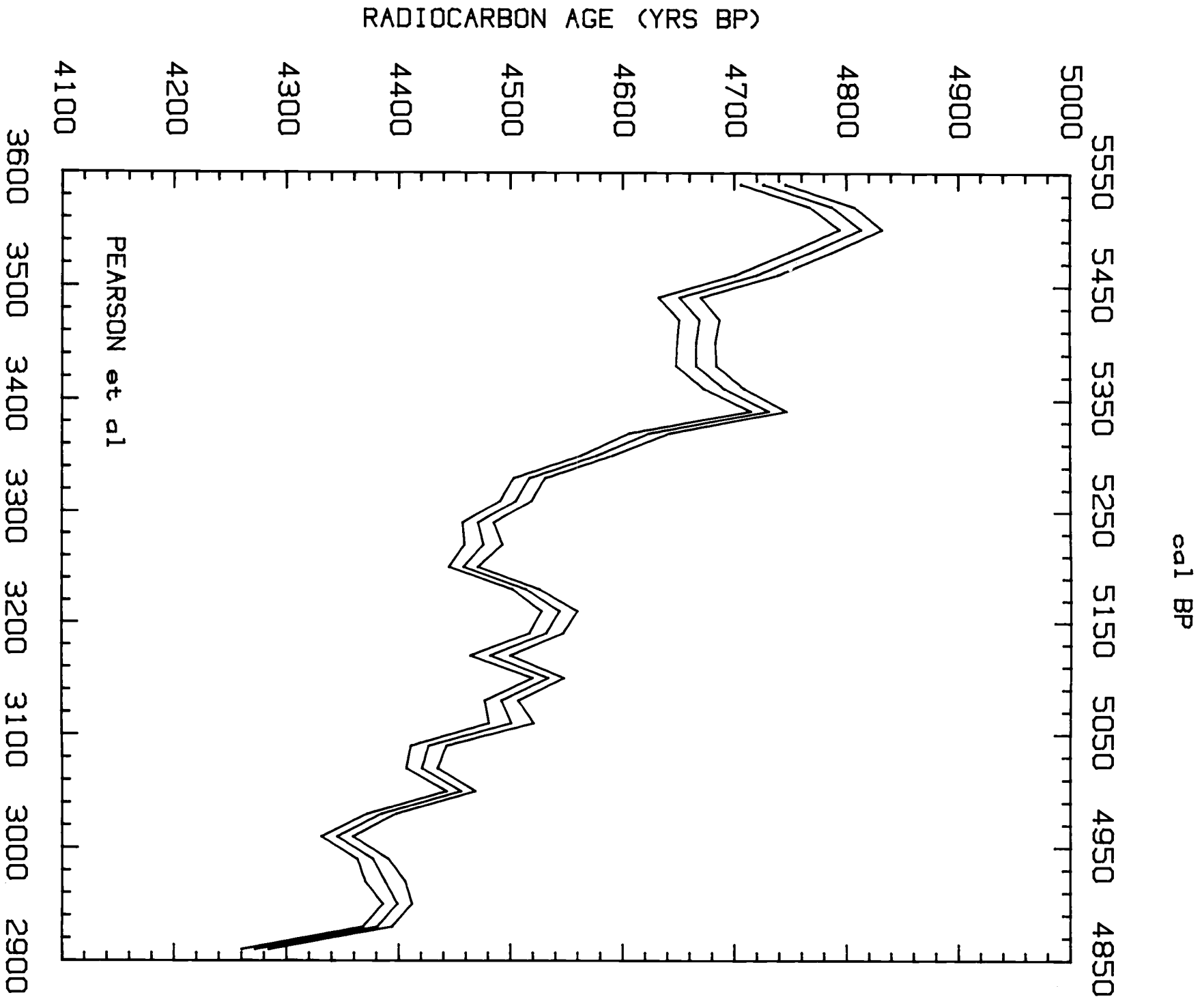
ca 1 BC
PEARSON et al
Fig 1H

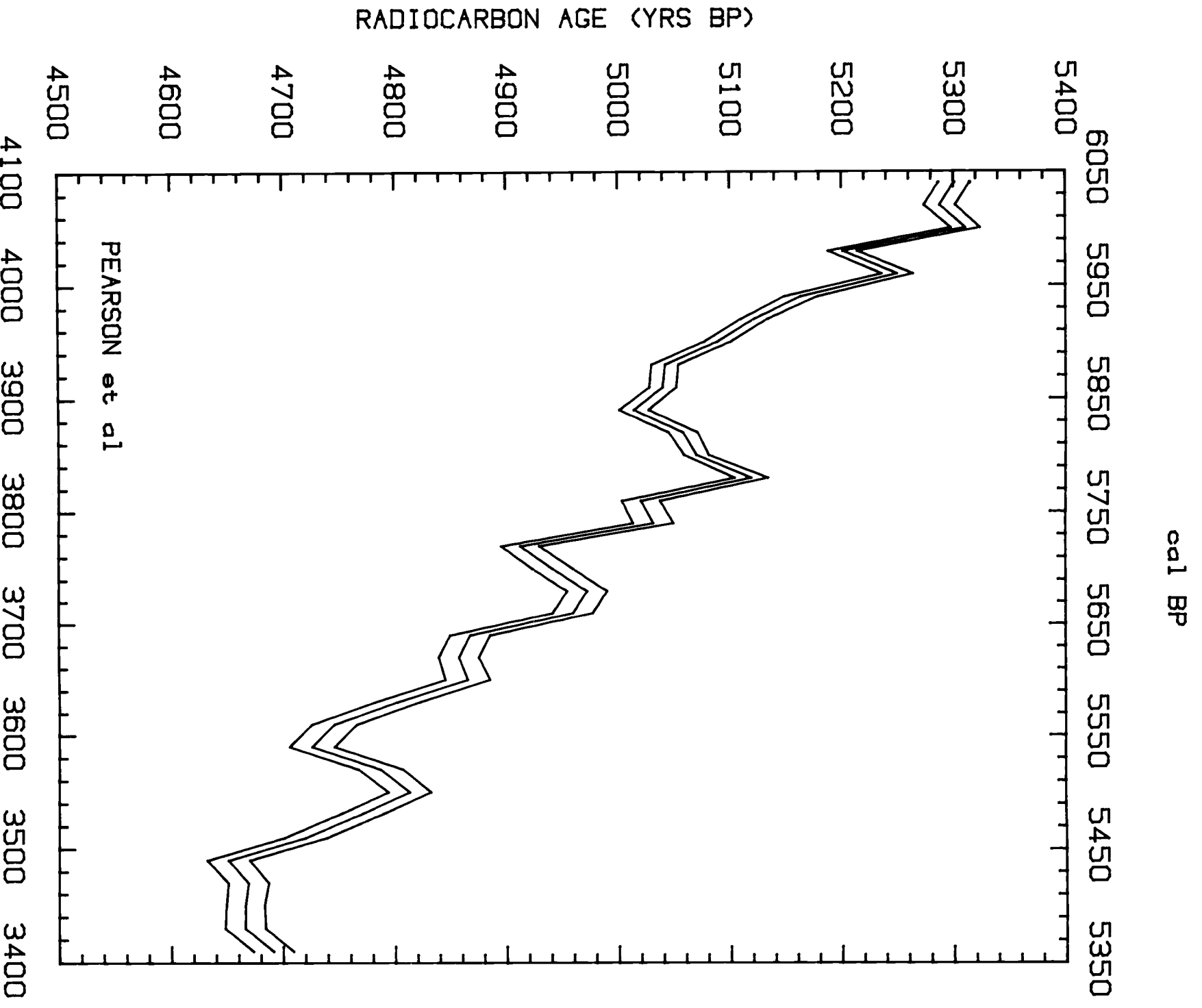


ca 1 BC
Fig 11

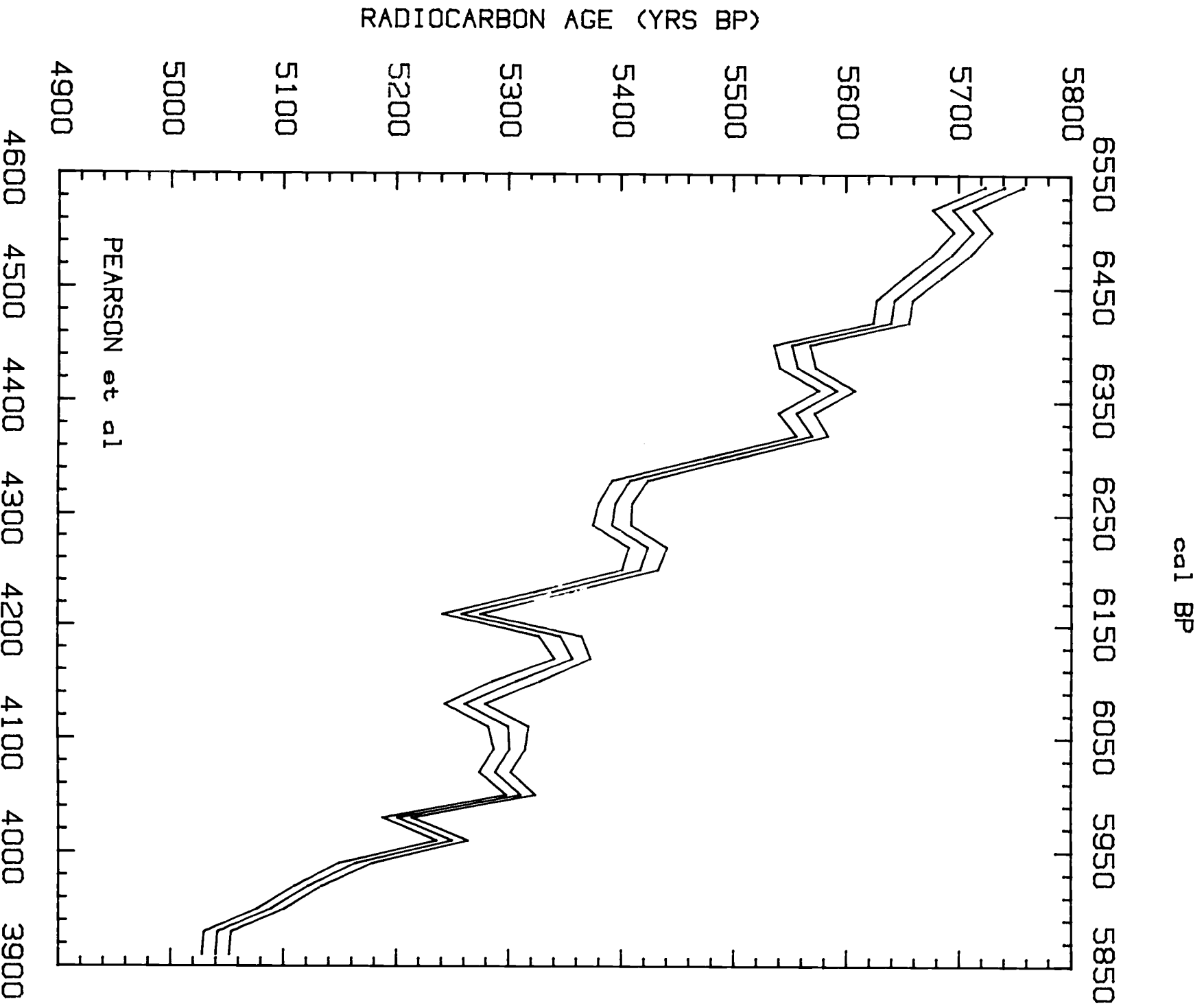


cal BC
Fig 1J



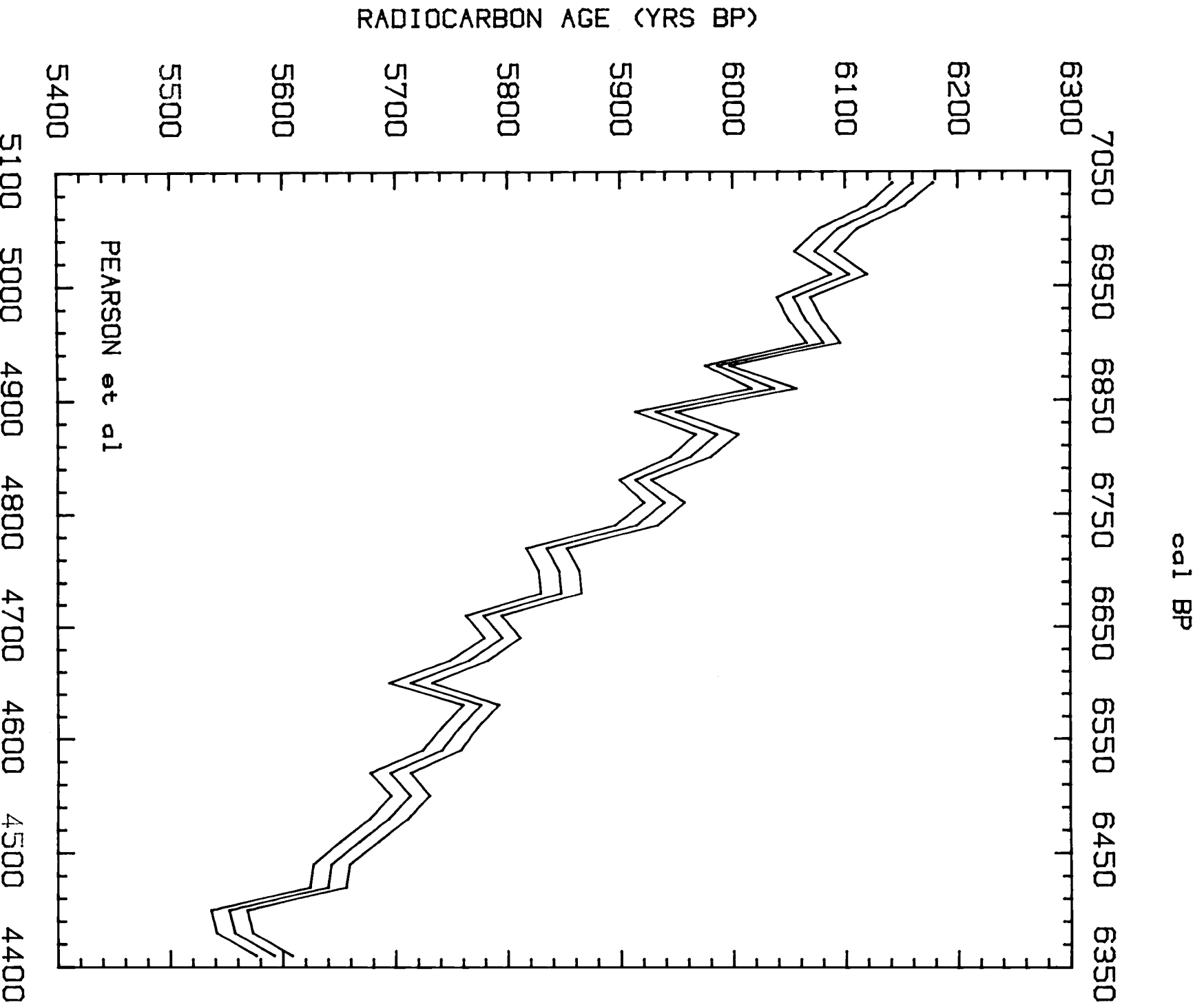


od1 BC
Fig 1L



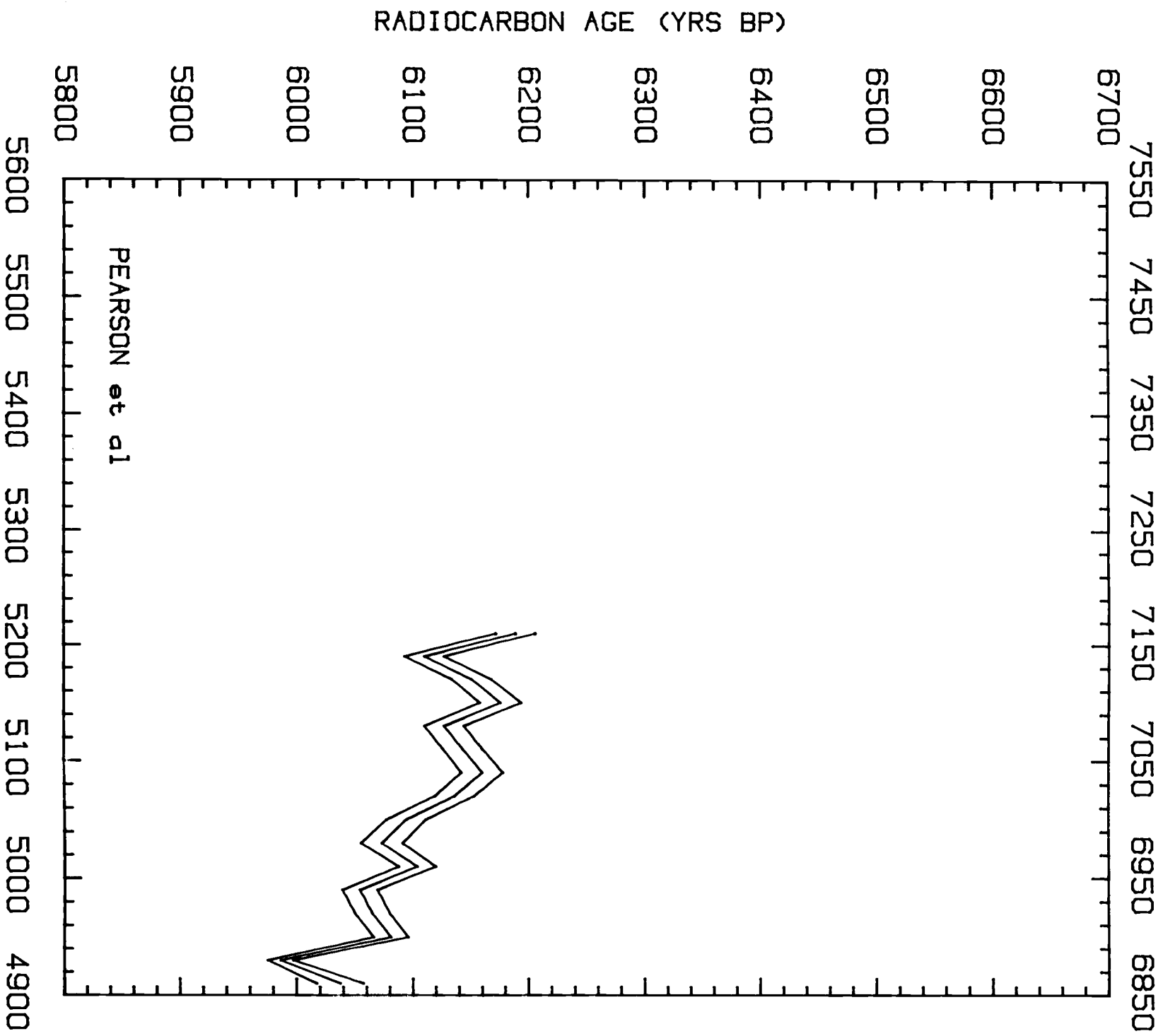
cal BC

Fig 1M



cal BC
Fig 1N

cal BP



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 OF SAMPLE = 1 ¹ NET SAMPLE = 60 CPM	ESTIMATED ERROR IN YEARS IF UNCORRECTED OF SAMPLE = 1 ¹ NET SAMPLE = 60 CPM
Background variation with 'purity'	Channel ratio of external 133Ba 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% of T _{1/2} ie ± 2.5 years	Channels ratio variation = ± 0.05 ie ± 0.1 cpm ie ± 13 years
Background variation with weight loss from vial	Vial weightings; 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 C6H6	Weighing error ± 1 mg ie ± 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 weightings; average weight loss calculated	Linear regression of efficiency on weight loss over a 1 g fall Slope = 0.00162/mg fall in weight	Filling weight = 14.2666 g = 13.1325 g	Error in weighing = ± 1 mg ie ± 0.00096 cpm ie ± 0.13 years	Loss of 1 mg/day ie ± 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 ie ± 0.006 cpm ie ± 0.6 years	Loss of 1 mg/day ie ± 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 as 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 ie ± 0.002 cpm ie ± 0.25 years. SRT ± 4 units ie ± 0.0007 cpm ie ± 0.25 years Neutron flux ± 0.1 units ie ± 0.25 years	Range errors ± 100 mb PLH ± 500 m ie ± 13 years SRT ± 40 units ie ± 0.28 cpm ie ± 4 yrs Neutron flux ± 4/Au ie ± 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 133Ba contribution	Known contribution A = A' (-0.0077e) ^{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 133Ba 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 + (x ² /g)) (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 ie ± 0.019% ie ± 0.011 cpm ie ± 1.5 years	Channels ratio ± 0.05 ie ± 0.46% ie ± 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 ie ± 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	$\Delta^{14}\text{C}$	Radiocarbon age BP	cal AD/BC cal BP	$\Delta^{14}\text{C}$	Radiocarbon age BP
AD 1840 ¹	1.5 ± 1.3	95 ± 10	AD 1290	2.3 ± 4.2	623 ± 34
BP 110			BP 660		
AD 1810	1.0 ± 2.1	128 ± 17	AD 1260 ⁴	-13.7 ± 1.2	781 ± 10
BP 140			BP 690		
AD 1790	-5.8 ± 2.2	202 ± 18	AD 1230 ³	-14.4 ± 1.2	816 ± 10
BP 160			BP 720		
AD 1770	-3.0 ± 2.2	199 ± 18	AD 1215 ⁷	-18.1 ± 2.2	861 ± 18
BP 180			BP 735		
AD 1750	3.8 ± 2.0	164 ± 16	AD 1195 ⁷	-11.8 ± 2.2	829 ± 18
BP 200			BP 755		
AD 1730	14.0 ± 2.0	102 ± 16	AD 1170 ³	-13.5 ± 1.1	867 ± 9
BP 220			BP 780		
AD 1710	20.8 ± 1.5	68 ± 12	AD 1150 ³	-18.5 ± 1.1	927 ± 9
BP 240			BP 800		
AD 1690	20.3 ± 2.2	91 ± 17	AD 1130 ³	-12.5 ± 1.5	898 ± 12
BP 260			BP 820		
AD 1670	4.9 ± 2.0	233 ± 16	AD 1110 ³	-13.3 ± 1.5	924 ± 12
BP 280			BP 840		
AD 1650	3.8 ± 1.5	261 ± 12	AD 1090 ³	-10.0 ± 1.4	916 ± 11
BP 300			BP 860		
AD 1630	-5.5 ± 2.1	355 ± 17	AD 1070 ³	-4.6 ± 1.2	892 ± 10
BP 320			BP 880		
AD 1610	-3.9 ± 2.0	362 ± 16	AD 1050 ³	-4.3 ± 1.5	909 ± 12
BP 340			BP 900		
AD 1590	1.2 ± 1.7	340 ± 14	AD 1030 ³	-9.2 ± 1.5	968 ± 12
BP 360			BP 920		
AD 1570	0.3 ± 2.0	367 ± 16	AD 1010 ³	-16.0 ± 1.4	1043 ± 11
BP 380			BP 940		
AD 1550 ¹	10.0 ± 1.4	309 ± 11	AD 990 ³	-17.1 ± 1.2	1052 ± 10
BP 400			BP 960		
AD 1530 ⁴	14.9 ± 1.3	289 ± 10	AD 970 ³	-15.2 ± 1.2	1075 ± 10
BP 420			BP 980		
AD 1510 ⁴	9.2 ± 1.1	354 ± 9	AD 955 ⁷	-18.9 ± 1.7	1120 ± 14
BP 440			BP 995		
AD 1490	14.4 ± 2.2	332 ± 17	AD 940	-15.9 ± 2.0	1110 ± 16
BP 460			BP 1010		
AD 1470	9.3 ± 2.3	392 ± 18	AD 920	-14.2 ± 1.7	1116 ± 14
BP 480			BP 1030		
AD 1460 ⁶	8.8 ± 1.3	406 ± 10	AD 900	-10.2 ± 1.7	1103 ± 14
BP 490			BP 1050		
AD 1450	3.5 ± 2.1	458 ± 17	AD 880	-19.3 ± 1.7	1196 ± 14
BP 500			BP 1070		
AD 1430	0.7 ± 2.4	500 ± 19	AD 860	-15.4 ± 2.1	1184 ± 17
BP 520			BP 1090		
AD 1410	1.6 ± 1.8	512 ± 14	AD 850	-17.8 ± 2.1	1213 ± 17
BP 540			BP 1100		
AD 1390	-6.8 ± 4.2	599 ± 34	AD 830	-13.1 ± 2.1	1194 ± 17
BP 560			BP 1120		
AD 1370	-13.3 ± 1.7	671 ± 14	AD 810	-14.4 ± 2.0	1224 ± 16
BP 580			BP 1140		
AD 1350	-6.8 ± 2.0	638 ± 16	AD 790	-14.0 ± 2.0	1240 ± 16
BP 600			BP 1160		
AD 1330	4.1 ± 1.8	570 ± 14	AD 770	-12.4 ± 2.0	1247 ± 16
BP 620			BP 1180		
AD 1310	4.5 ± 1.8	586 ± 14	AD 750	-13.8 ± 2.0	1278 ± 16
BP 640			BP 1200		

TABLE 2B

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

TABLE 2C

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

TABLE 2D

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

TABLE 2E

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

TABLE 2F

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

TABLE 2G

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

Legend

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

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 meant to give a bi-decade value which is then meant 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

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

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

TABLE 3B

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

Legend

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

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

calculated using the ^{14}C age $\pm 1\sigma$
(Stuiver & Polach, 1977)

Radiocarbon
age BP : Age of single decade sample $\pm 1\sigma$