IntCal98 Calibration for Radiocarbon Ages of Samples from Amarna

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On March 14th and 15th 1982 Martha Bell, site supervisor for the EES excavations in the Main Quarry at Tell el-Amarna, south of the Workmen's Village, collected, after discussion with B. J. Kemp, a number of organic samples destined to radiocarbon measurements and subsequent age determination. The samples were taken at about 1.8 meters of depth from the adopted zero level of the stratigraphic section of the Quarry[1]. Five of these samples were at the end effectively used for date calculations. The treatment and analysis of the samples were supervised at the Godwin Laboratory (Cambridge University, UK) by V. R. Switsur. Full details of the results of these investigations were published in 1984[2]. The main goal of the analysis apparently was the inverse check of a recent (for those times) calibration curve based on Irish oak tree-rings[3]. The conclusion was[4]:

> "*It may be concluded from this series of dates, limited though it is, that the new calibration curve based on Irish oak is effective, at least in the portion of the time-scale studied, in that the calibrated conventional radiocarbon dates are consistent with the established historical chronology for the Amarna Period*"

Of course there was a certain interest on the dates of the specimens themselves too. The following table shows data about the five samples.

Table I

Sample	Type	Conventional Radiocarbon Age (Years Before Present)	Uncertainty in Conventional Radiocarbon Age (Years)	Irish Oak Calibrated Age b.C.	Uncertainty Range in Calibrated Age[5] (Years b. C.)
A	Wood	3030	35	1360 or 1285	1390 to 1260
B	Charcoal	3055	35	1365 or 1305	1400 to 1260
C	Animal Skin	3050	35	1365 or 1305	1400 to 1285
D	Horn	3025	35	1360 or 1285	1385 to 1260
E	Bone	3088	35	1400 or 1330	1410 to 1300

[1] C. Hulin, Report on the 1983 Excavations – The Main Quarry, in B. J. Kemp (ed.), Amarna Reports 1, London 1984, 81-88, especially pg. 85 and 87.
[2] V. R. Switsur, Radiocarbon Date Calibration using historically dated Specimens from Egypt and New Radiocarbon Determinations for el-Amarna, in B. J. Kemp (ed.), Amarna Reports 1, London 1984, 178-88.
[3] G. W. Pearson, J. R. Pilcher and M. G. L. Baillie, High Precision C-14 measurement of Irish oaks to show natural Radiocarbon variations from 200 bC to 4000 bC, Radiocarbon 25 (1983), 179-86. I. M. E. Shaw, Egyptian Chronology and the Irish Oak Calibration, JNES 44 (1985), 295-317.
[4] Switsur, op. cit., pg. 187.
[5] 1 standard deviation (68.2%).

The Conventional Radiocarbon Age is correlated to the measured C-14 content of each sample and is reported in "years before present", where "present" is conventionally assumed to be 1950 A.D.
The Calibrated Age is the Conventional Radiocarbon Age transformed into years of the b.C. era making use of well-established calibration curves. These take into account the atmospheric variations of C-14 with time and other time-dependent phenomena; calibration curves are constructed usually by comparison between real C-14 content in tree-rings and dendrochronological dates obtained from the same tree samples.
The most critical phases of radiocarbon dating are the C-14 measurements in the sample (which give the Conventional Radiocarbon Age and its associated uncertainty in terms of an estimated standard deviation) and the conversions into calibrated ages (which are based upon the reliability of the calibration curves). It is to be expected that with time both these phases are improved with new instruments, techniques and calibration data. However while it is possible to improve a calibrated age by applying more precise calibration curves, it is impossible to get a better conventional radiocarbon age from a given sample which underwent measurement in the past: samples must be burnt in the process.
To the best of the present writer's knowledge the conventional radiocarbon ages of the five samples taken at the Main Quarry at Amarna have never been retransformed into calibrated dates using more recent (and perhaps more precise) calibration curves than that based on Irish oaks available in 1983.
The aim of this paper is to report newly calculated calibrated dates obtained using the 1998 IntCal98 calibration curve[6]. The calculations are carried out, and the graphs below created, with the OxCal software version 3.8. The IntCal98 dataset is recommended for most non-marine samples. It is based on a decadal average of tree-ring C-14 measurements[7] and a smoothing spline of marine coral and varve data obtained between 1993 and 1998. A 500 year reservoir correction was used for the marine data older than 10,000 cal BP. Details of dataset construction are as follows: single year tree-ring dataset (AD 1954-1951) + decadal tree-ring dataset (AD 1950 - 9905 BC, 0 - 11,850 cal yr BP) + inferred atmospheric spline from marine coral and varve data (9915 BC - 20,051 BC, 11,864 - 24,000 cal yr BP) + 1000 yr linear extension for estimation of calibrated age ranges only.
The part of the calibration curve needed between 1400 and 1200 b.C. is given in Figure 1. The next five pictures are graphs of calibration results for the Amarna samples. On the ordinates are plotted

[6] M. Stuiver, J. P. Reimer, E. Bard, J. W. Beck, G. S. Burr, K. A. Hughen, B. Kromer, F. G. McCormac, J. v. d. Plicht, and M. Spurk, INTCAL98 Radiocarbon age calibration 24,000 - 0 cal BP., Radiocarbon 40 (1998), 1041-1083.
[7] G. W. Pearson, B. Becker and F. Qua, High-precision 14C measurement of German and Irish oaks to show the natural 14C variations from 7890 to 5000 BC, Radiocarbon 35 (1993), 93-104. G. W. Pearson, and M. Stuiver, High-precision bidecadal calibration of the radiocarbon time scale 500-2500 BC, Radiocarbon 35 (1993), 25-33. M. Stuiver, P. J. Reimer and T. F. Braziunas, High-precision radiocarbon age calibration for terrestrial and marine samples, Radiocarbon 40 (1998), 1127-1151. J. C. Vogel, A. Fuls and E. Visser, Pretoria calibration for short- lived samples, 1930-3350 BC, Radiocarbon 35 (1993), 73-85.

in red the conventional radiocarbon ages, reproduced into gaussian error curves. On the abscissae the possible intersections of the red gaussians with the calibration curve itself are projected within one standard deviation (68.2%). The last two pictures are a multiplot graph, for comparison purposes, of the five results and a multiplot graph where the five results are given in terms of areas upon the calibration curve.

The results of the calculations are summarized in the following table.

Table II

Sample	First Chance Calibrated Age b.C.	Second Chance Calibrated Age b.C.	Third Chance Calibrated Age b.C.	Overall Period b.C. (1 standard deviation)
A	1320 to 1250 (39.2%)	1380 to 1330 (19.8%)	1240 to 1210 (9.2%)	1380 to 1210
B	1390 to 1260 (68.2%)	-	-	1390 to 1260
C	1390 to 1260 (68.2%)	-	-	1390 to 1260
D	1320 to 1250 (39.1%)	1380 to 1330 (16.7%)	1240 to 1210 (12.3%)	1380 to 1210
E	1360 to 1310 (34.4%)	1410 to 1365 (33.8%)	-	1410 to 1310

Comparison of Table I and Table II gives a clear idea on how the calibration has changed between 1983 and 1998.

Of course nothing extraordinary has changed between the present calculations and those carried out in 1983, this being evidence that Irish oak is still a good calibration reference. It is however felt important that these measured data are kept updated as far as possible as regards the application of calibrations, until new samples are measured with better instruments or techniques giving newer and possibly improved[8] conventional radiocarbon ages for the period.

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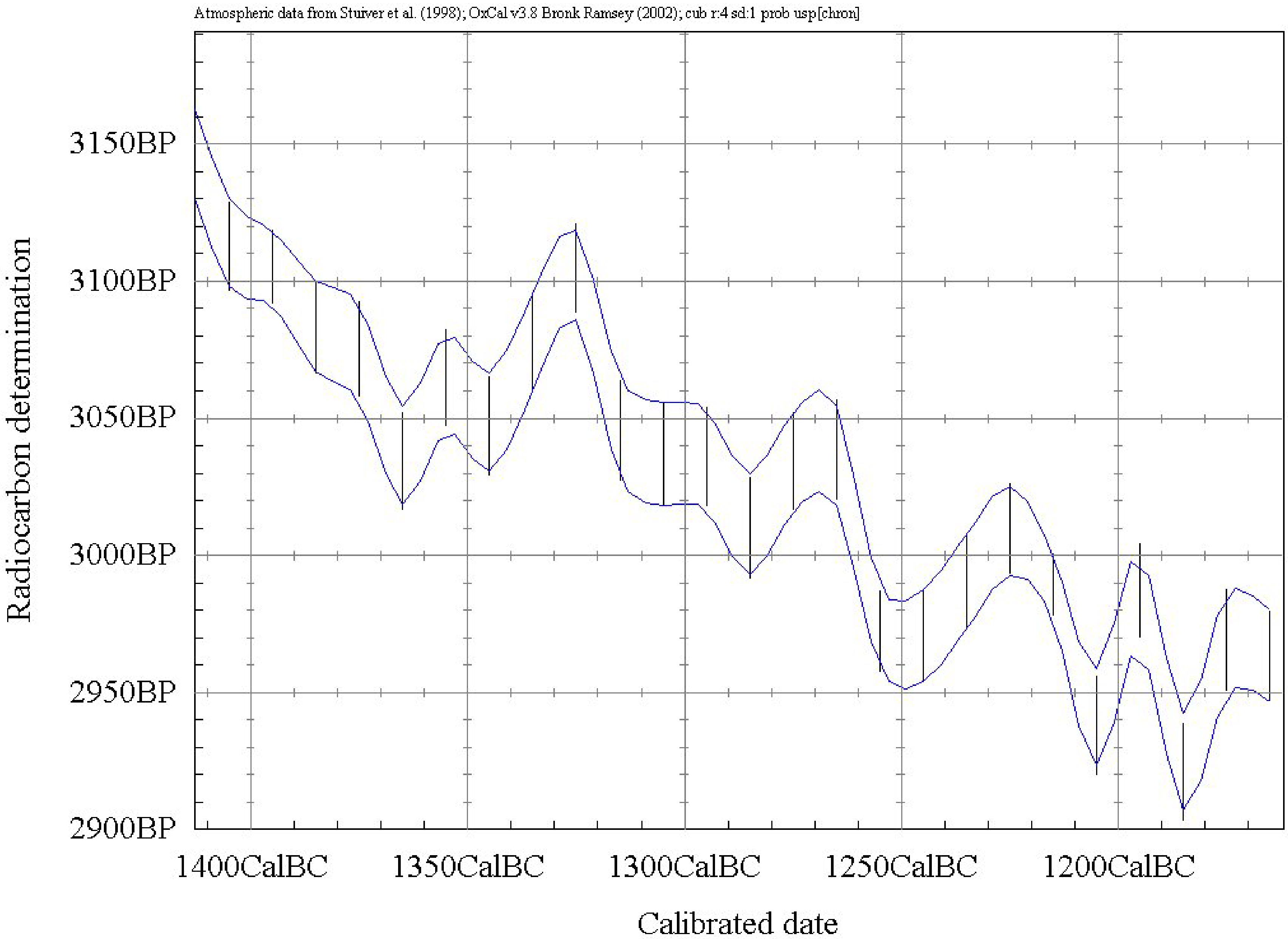
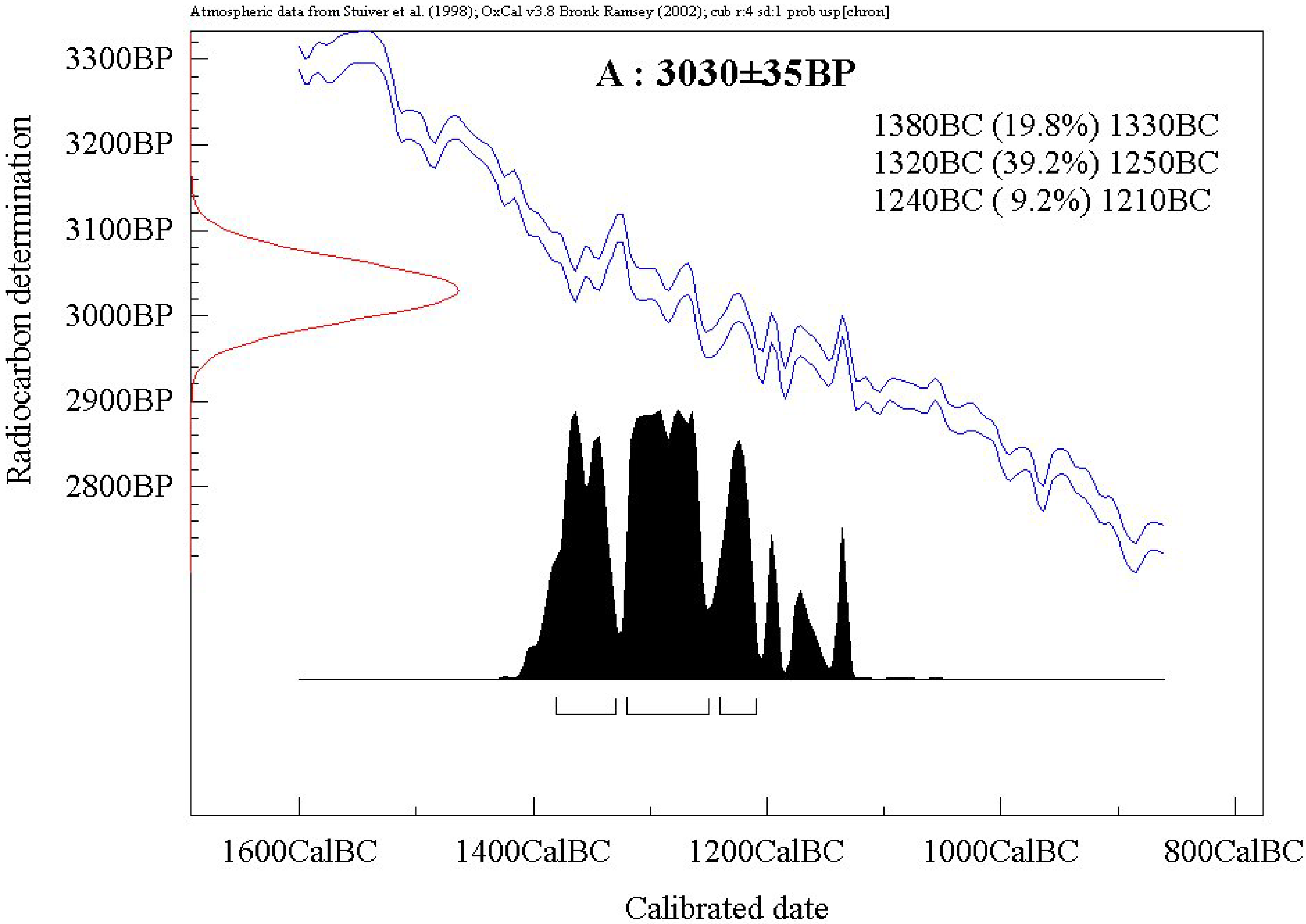
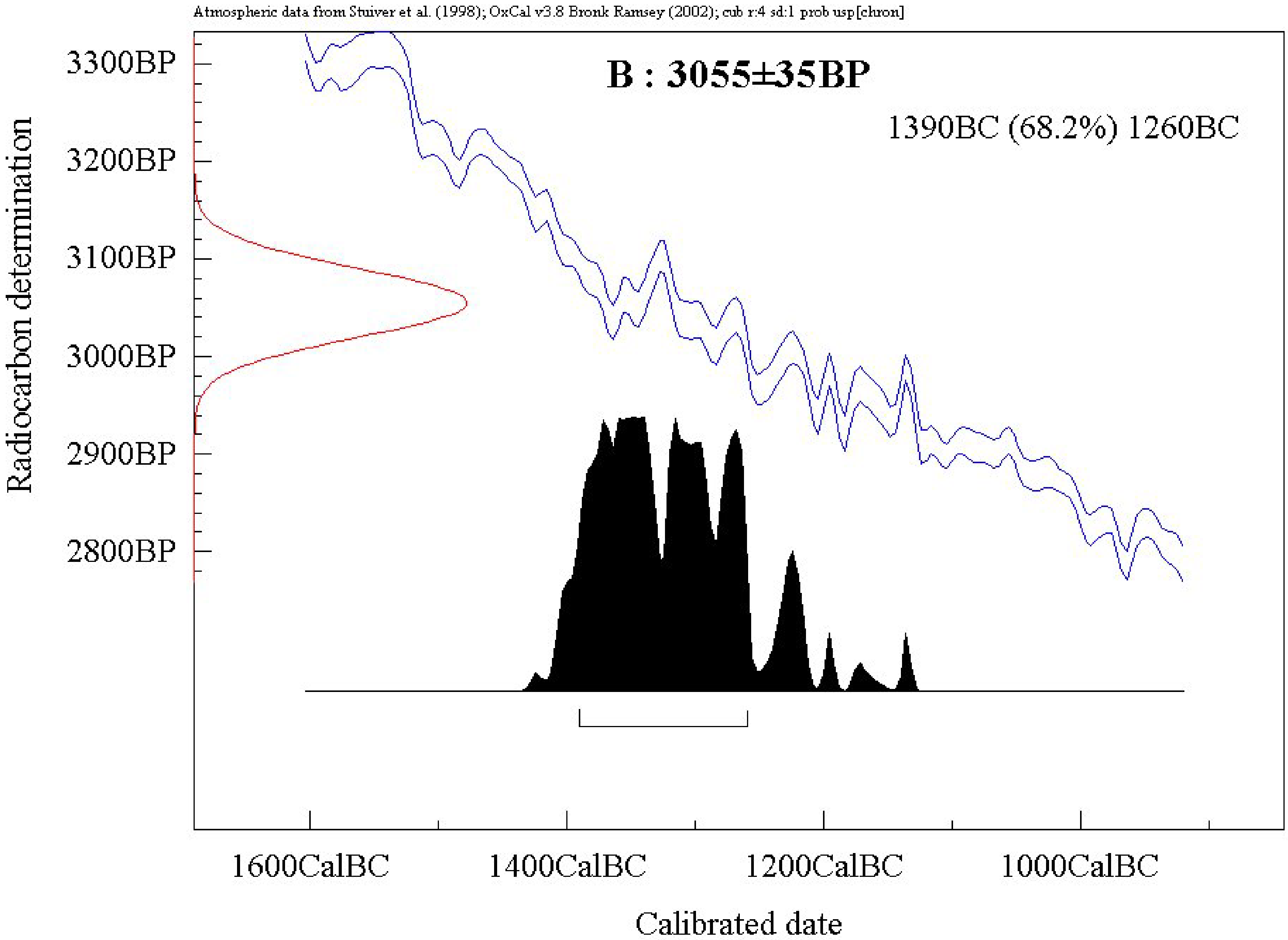
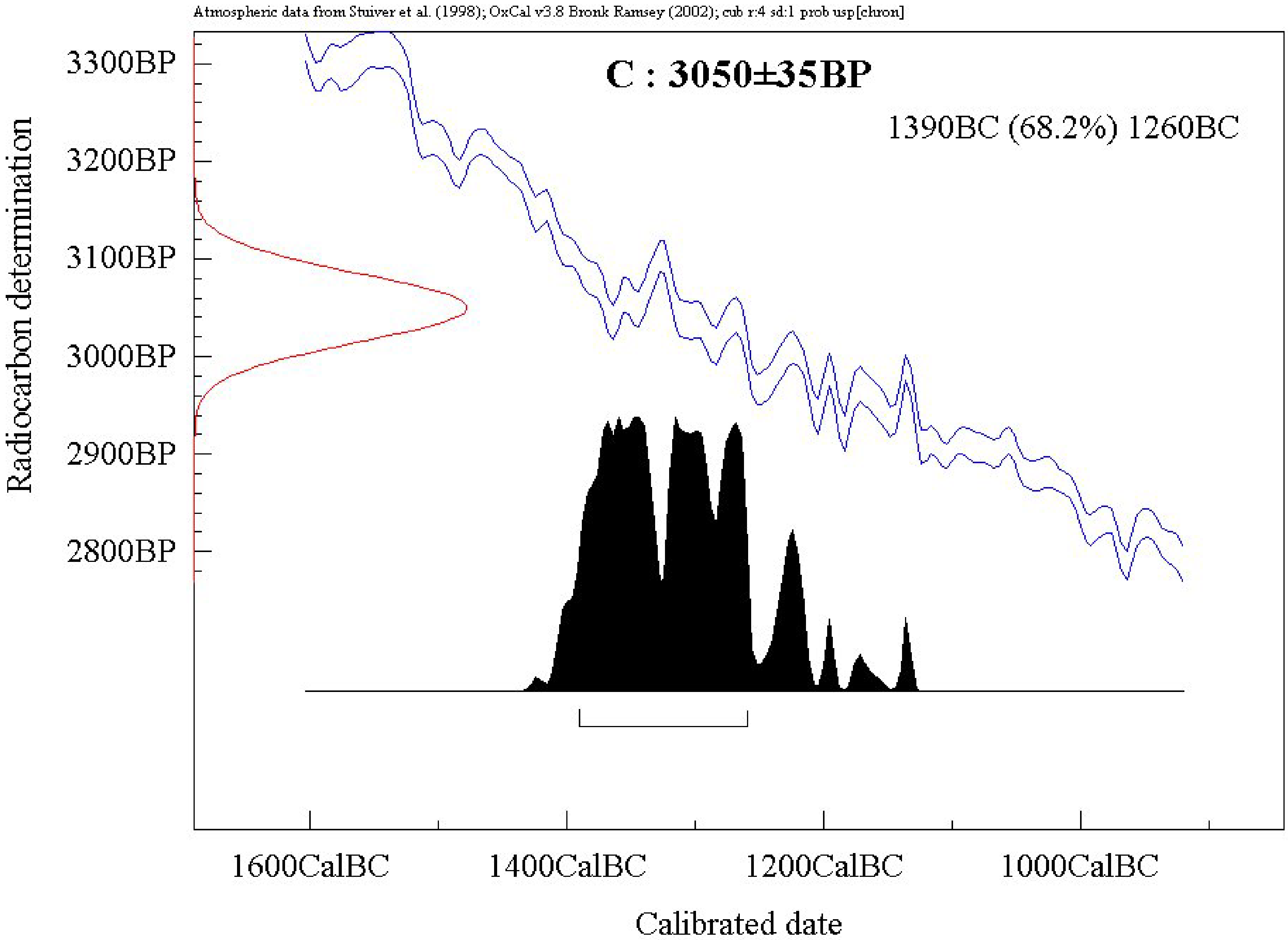
[8] F. i. lower uncertainties in conventional radiocarbon age.

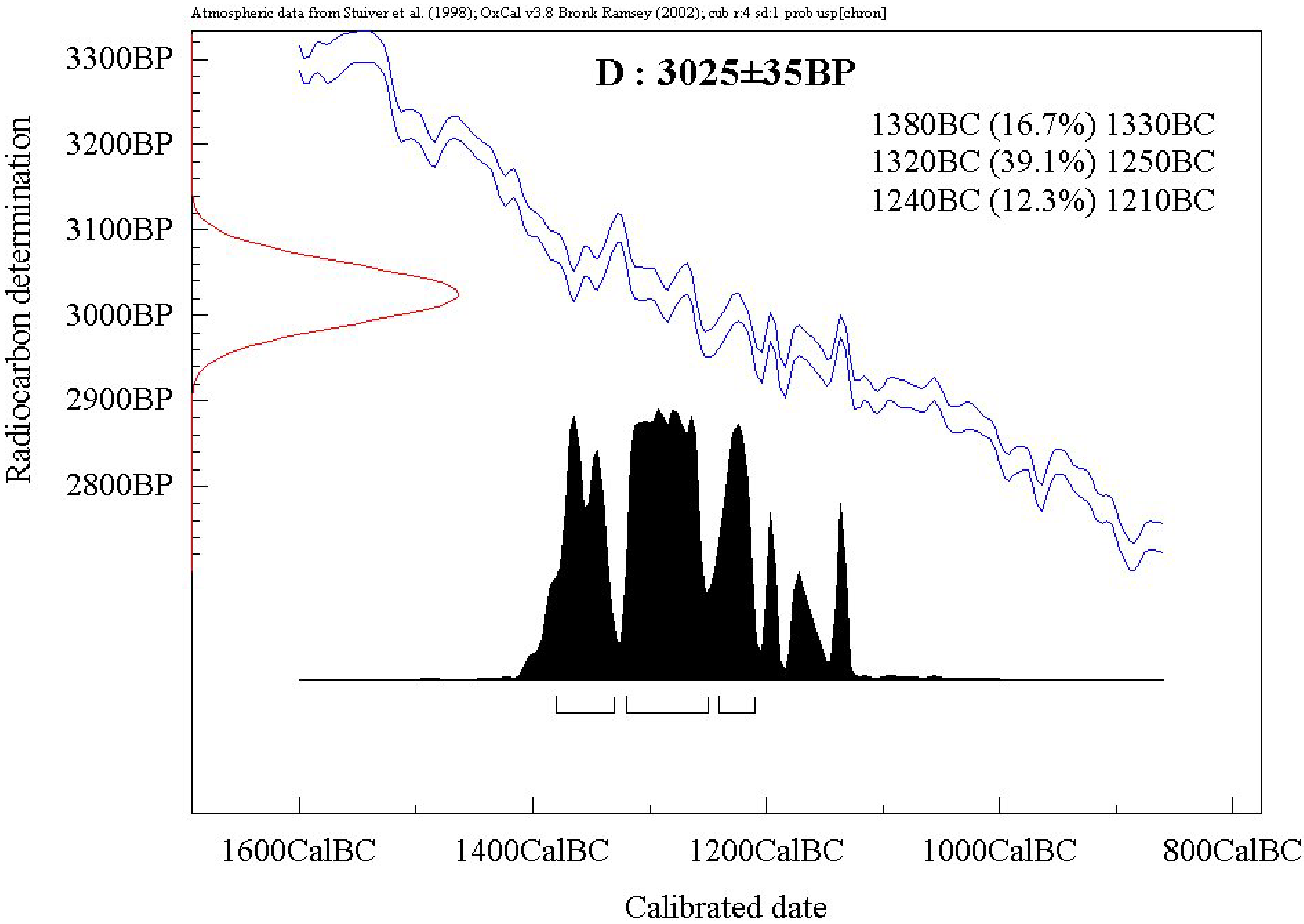


Atmospheric data from Stuiver et al. (1998); OxCal v3.8 Bronk Ramsey (2002); cub r:4 sd:1 prob usp[chron]
Radiocarbon determination
3150BP
3100BP
3050BP
3000BP
2950BP
2900BP
1400CalBC
1350CalBC
1300CalBC
1250CalBC
1200CalBC
Calibrated date

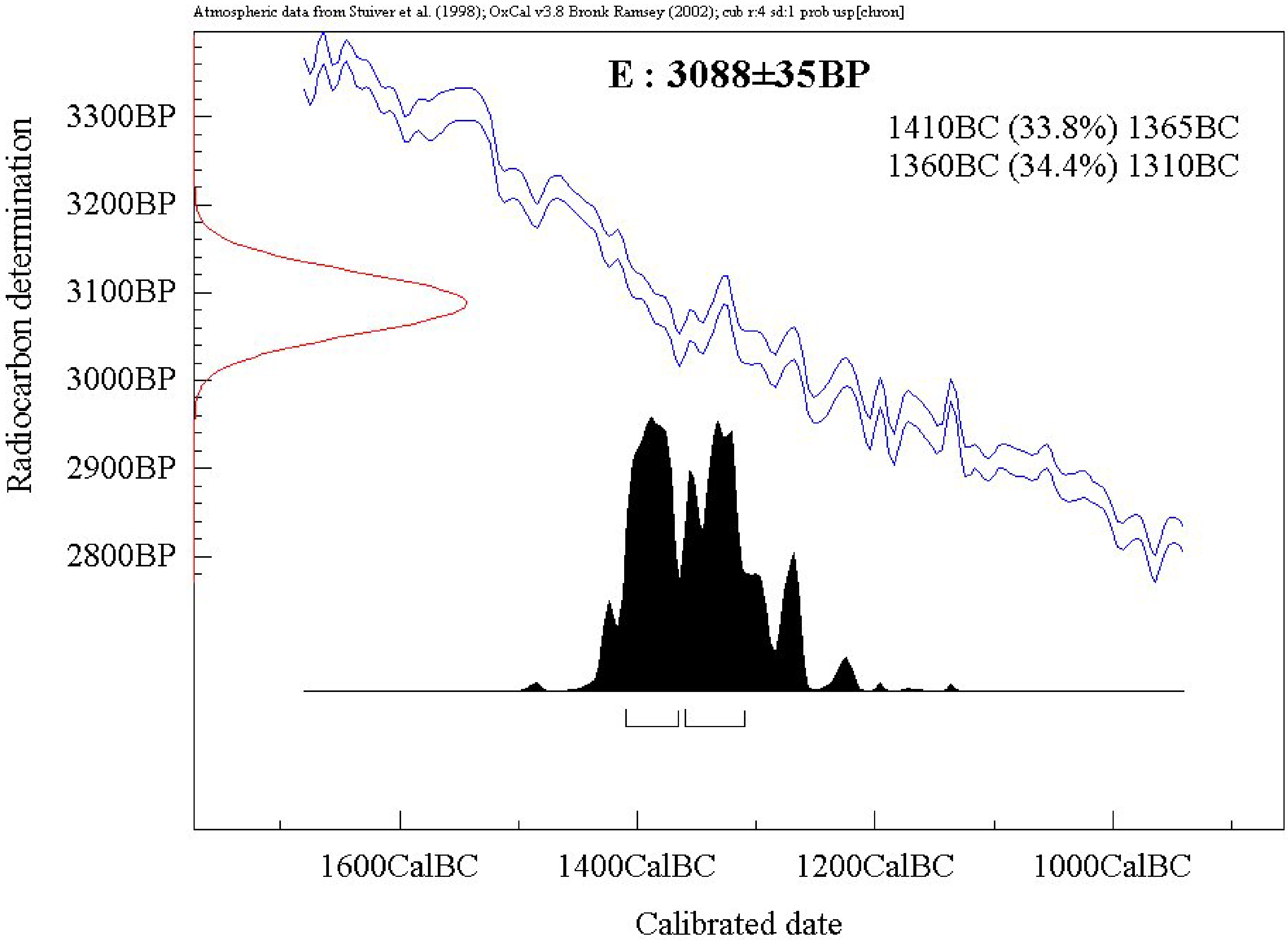

Atmospheric data from Stuiver et al. (1998); OxCal v3.8 Bronk Ramsey (2002); cub r:4 sd:1 prob usp[chron]
A : 3030±35BP
1380BC (19.8%) 1330BC
1320BC (39.2%) 1250BC
1240BC (9.2%) 1210BC
3300BP
3200BP
3100BP
3000BP
2900BP
2800BP
Radiocarbon determination
1600CalBC
1400CalBC
1200CalBC
1000CalBC
800CalBC
Calibrated date

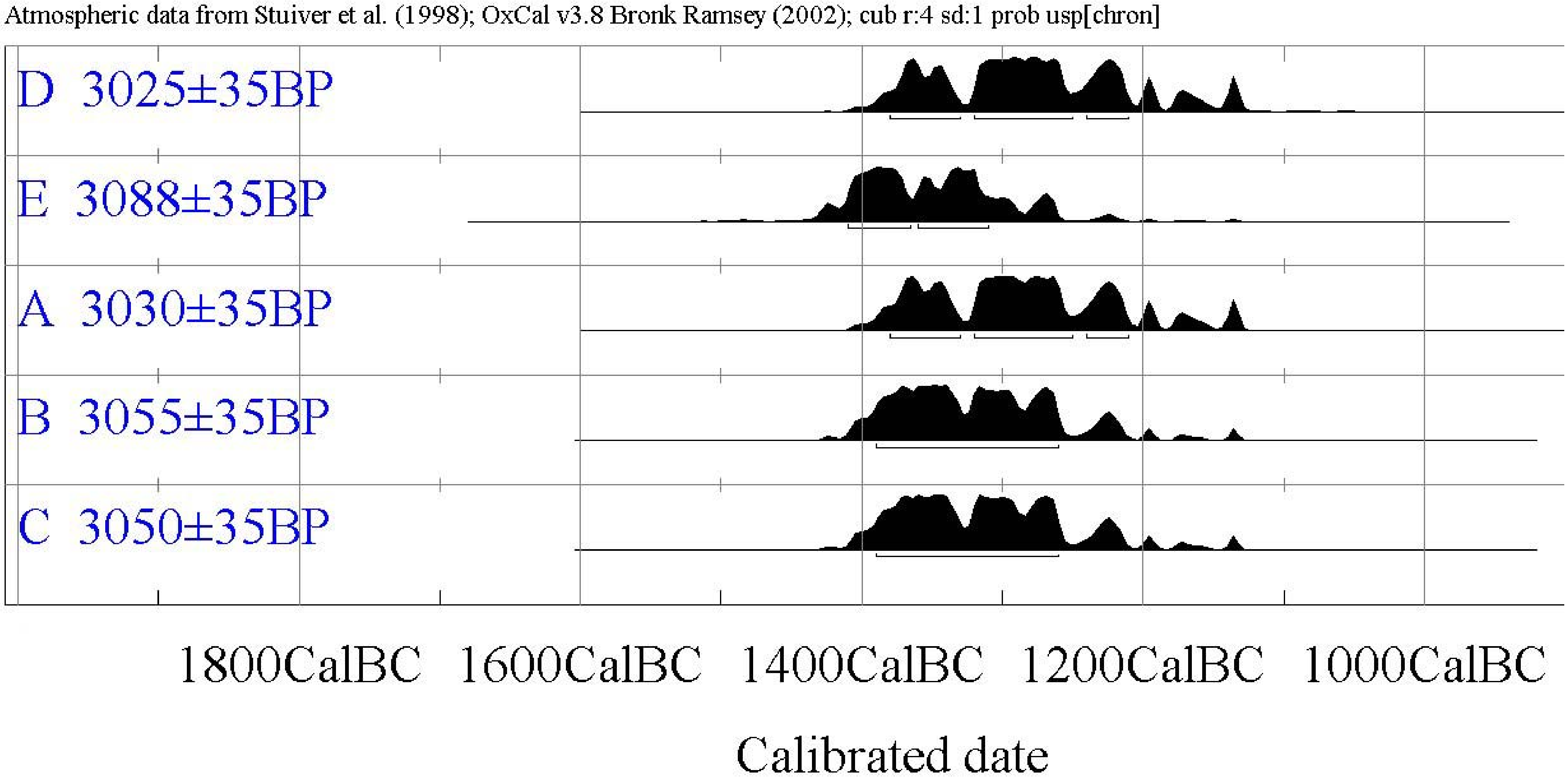

Atmospheric data from Stuiver et al. (1998); OxCal v3.8 Bronk Ramsey (2002); cub r:4 sd:1 prob usp[chron]
B : 3055±35BP
1390BC (68.2%) 1260BC
3300BP
3200BP
3100BP
3000BP
2900BP
2800BP
Radiocarbon determination
1600CalBC
1400CalBC
1200CalBC
1000CalBC
Calibrated date


Atmospheric data from Stuiver et al. (1998); OxCal v3.8 Bronk Ramsey (2002); cub r:4 sd:1 prob usp[chron]
C : 3050±35BP
1390BC (68.2%) 1260BC
3300BP
3200BP
3100BP
3000BP
2900BP
2800BP
Radiocarbon determination
1600CalBC
1400CalBC
1200CalBC
1000CalBC
Calibrated date

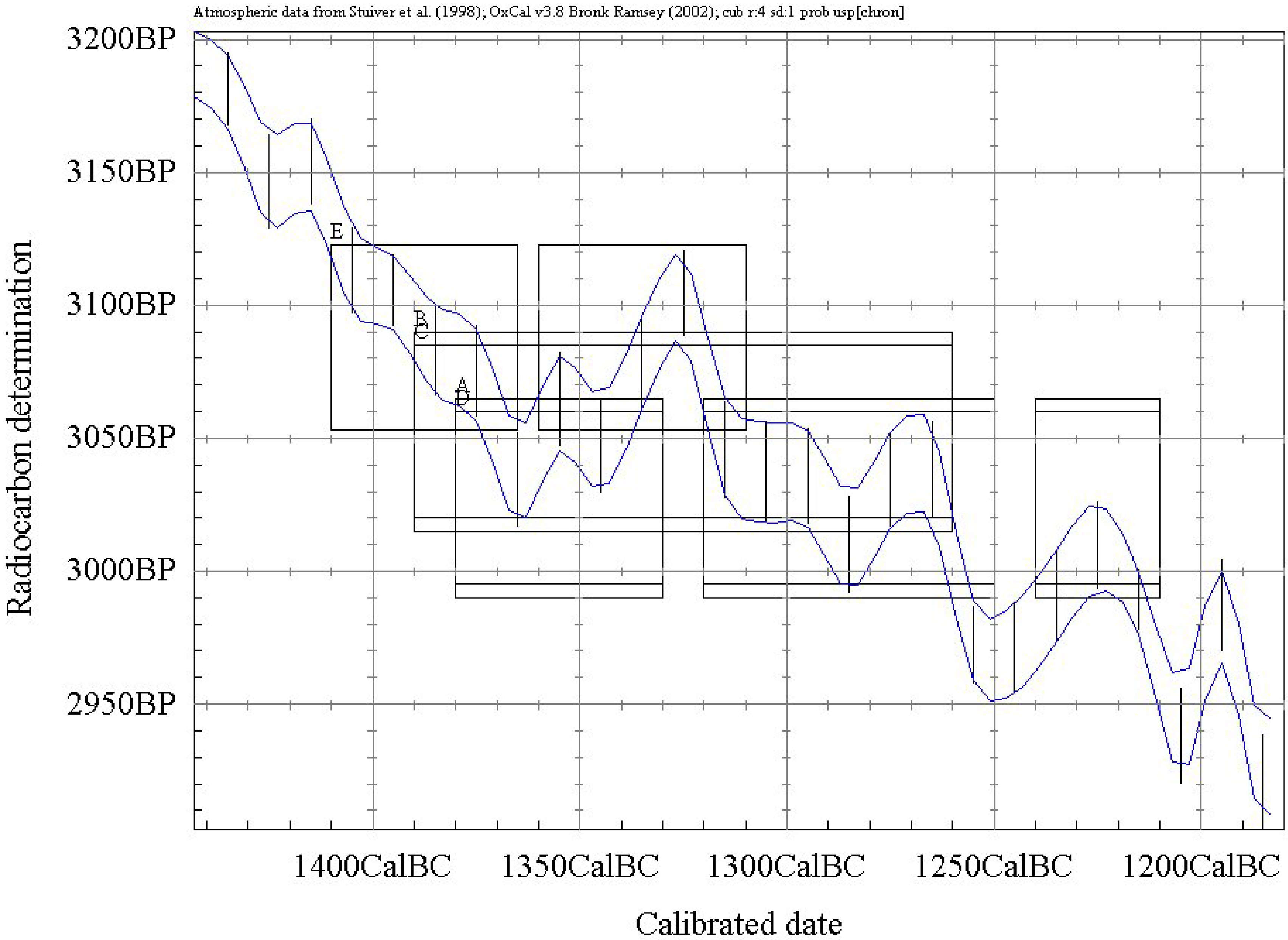


Atmospheric data from Stuiver et al. (1998); OxCal v3.8 Bronk Ramsey (2002); cub r:4 sd:1 prob usp[chron]
D : 3025±35BP
1380BC (16.7%) 1330BC
1320BC (39.1%) 1250BC
1240BC (12.3%) 1210BC
3300BP
3200BP
3100BP
3000BP
2900BP
2800BP
Radiocarbon determination
1600CalBC
1400CalBC
1200CalBC
1000CalBC
800CalBC
Calibrated date


Atmospheric data from Stuiver et al. (1998); OxCal v3.8 Bronk Ramsey (2002); cub r:4 sd:1 prob usp[chron]
E : 3088±35BP
1410BC (33.8%) 1365BC
1360BC (34.4%) 1310BC
3300BP
3200BP
3100BP
3000BP
2900BP
2800BP
Radiocarbon determination
1600CalBC
1400CalBC
1200CalBC
1000CalBC
Calibrated date



Atmospheric data from Stuiver et al. (1998); OxCal v3.8 Bronk Ramsey (2002); cub r:4 sd:1 prob usp[chron]
D 3025±35BP
E 3088±35BP
A 3030±35BP
B 3055±35BP
C 3050±35BP
1800CalBC 1600CalBC 1400CalBC 1200CalBC 1000CalBC
Calibrated date


Atmospheric data from Stuiver et al. (1998); OxCal v3.8 Bronk Ramsey (2002); cub r:4 sd:1 prob usp[chron]
3200BP
3150BP
3100BP
3050BP
3000BP
2950BP
Radiocarbon determination
E
B
C
A
D
1400CalBC
1350CalBC
1300CalBC
1250CalBC
1200CalBC
Calibrated date