

# **ABSOLUTE CHRONOLOGY FOR EARLY CIVILIZATIONS IN AUSTRIA AND CENTRAL EUROPE USING $^{14}\text{C}$ DATING WITH ACCELERATOR MASS SPECTROMETRY WITH SPECIAL RESULTS FOR THE ABSOLUTE CHRONOLOGY OF THE BADEN CULTURE<sup>1</sup>**

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## **Summary**

This project is an interdisciplinary initiative of archaeologists and nuclear physicists to substantially improve the absolute chronology of archaeologically interesting cultures in Austria and Central Europe by using  $^{14}\text{C}$  dating with Accelerator Mass Spectrometry (AMS). An improved absolute chronology based on precise  $^{14}\text{C}$  dating would lead to a better understanding of the interactions between early cultures and would help to deepen our insight into the rich diversity of pre-historic life in Austria and adjacent countries. The  $^{14}\text{C}$  dating is performed at the Vienna Environmental Research Accelerator (VERA), a new centre for AMS at the *Institut für Isotopenforschung und Kernphysik*<sup>5</sup> of the University of Vienna, which came into operation in 1996.

In the first two years of the project, 1555 samples from Austria and adjacent countries, Slovakia, Czech Republic, Hungary, Romania, Slovenia were collected. Besides collecting samples from a variety of well-documented sites, emphasis will be put on a detailed analysis of the Early Bronze Age Cemetery from Franzhausen I in Lower Austria (2200 BC to 1500 BC)<sup>6</sup>, and on the Early and Middle Avar Period (568 AD to ~700 AD)<sup>7</sup>. Now we already have results for about 270 samples. Among these, a large amount of new dates of the Baden Culture was measured. The results of these dates will be discussed here.

For the Baden Culture two groups can be archaeologically differentiated, Baden-Boleráz and Baden-Classical, which were confirmed by radiocarbon dates. The new dates suggest that the Baden Culture (Boleráz) developed somewhere in Lower Austria, Moravia, Slovakia or Western Hungary and then spread to the East.

## **Sample collection**

In June 1999 we stopped the further reception of samples, because we had already obtained 1555 samples, 555 more than in our original project proposal. All the sample sheets received by the different sample suppliers were fed into a database. 74 fields of information were entered, concerning general information, laboratory data, sample parameters, scientific investigations by archaeobotany, zoology and human biology. Some of the parameters are used for possible correction of the calibrated radiocarbon age, such as dendrochronology for wiggle-matching or the age of a skeleton to estimate the offset given to the radiocarbon age<sup>8</sup>. Table 1 lists all these fields with some explanation where necessary.

## Development for the $^{14}\text{C}$ Measurements at VERA

The new Vienna Environmental Research Accelerator (VERA) is the facility of choice for all  $^{14}\text{C}$  measurements within the project. First  $^{14}\text{C}$  dating test experiments with this facility started in the middle of 1996 (Priller et al. 1997, 193-198). In 1997, a variety of dating experiments and also systematic measurements were performed, including fully automated  $^{14}\text{C}$  measurements (Puchegger et al. 2000). This led to the current precision of 0.5%, quite satisfactory for the project. Within the project, the following specific activities concerning VERA have been pursued:

The employed chemist, Susanne Draxler, built a semi-automatic collagen extraction system for bone samples. This allows to treat 24 bone samples simultaneously. She is also building an eight-fold graphitization system, and is responsible to prepare all archaeological samples for the AMS measurements.

The current status of the sample preparation is, that 441 samples have been treated with ABA<sup>9</sup>, out of which we have about 270 samples ready, 191 samples must now be converted to  $\text{CO}_2$  and graphitized, 1300 samples must be prepared, graphitized and measured.

## $^{14}\text{C}$ Data Base

The already existing data base has been enlarged by Angela Carneiro to about 30.000 radiocarbon dates, beginning in July 1997. Thereby, the data base is world-wide one of the biggest of its kind, the data base of the University of Lyon consisting now of "only" about 9000 archaeological  $^{14}\text{C}$  data<sup>10</sup>. In the near future it is intended to make the results of the group-calibration of more than 500 cultural groups available in the Internet. At the same time, a possibility for scientists to co-operate will be installed, e.g. completing missing data in the "*Microsoft-Access-data base*", which allows them to work with certain parts of the data base.

As an example see further below Table 7 presented with 77 dates of the Baden Culture, which are contained in our database of published dates.

## The samples

A total of 1555 samples were collected from about 120 sample suppliers. The samples for the Czech Republic and Slovakia were collected by Inna Mateiciucova, those for Hungary by Hajnalka Herold and those for Austria by Angela Carneiro, Tomas Bence Viola and Friederike Gerold.

As there are many samples, we decided to set up priorities. Table 2 presents these priorities.

Priorities were chosen corresponding to our project goals. High priority A have the samples which belong to the Avar period, priority B are the samples from the Early Bronze Age cemetery from Franzhausen. These together make about 20% of the whole number of samples and they were given such a high priority, because in our project proposal we wanted to clear up two archaeological questions:

- a) to improve the existing relative and absolute chronology for the Avar Period.
- b) to improve the relative chronology from Franzhausen I.

Priority 1 to 3 correspond to other questions, for example the chronology of the Baden Culture, the Avar settlement of Brunn/ Gebirge etc. Samples with priority 1 were dated earlier than those with priority A and B, which are mostly human bones. For these we had to build first our collagen extraction and had to collect experience with it. As the extraction is working

fine now, we want to continue immediately with priority A and B samples.

Most of the samples come from Austria and the neighbouring countries, CZ, SK and H, see Table 3.

The material of the samples is shown in Table 4. Most materials are human bones, followed by animal bones and charcoals.

Most interesting for archaeologists is the distribution of the samples to different archaeological cultures and cultural groups. Here most samples come from Linear Ceramics, Lengyel, Early Bronze-Age (Aunjetitz, Wieselburg) and Avar Period, the last two were explicitly announced in our project proposal. See all cultures in Table 5.

Table 6 presents how many of the measured samples fall within the time span of the culture, to which the sample was assigned by the archaeologist. Only about 16 percent lie outside this time range. This result is quite convincing, considering that only a small amount of all radiocarbon dates measured since 1950 fulfilled this condition (and only those were published).

### **Absolute Chronology of the Baden Culture and the relation of Boleráz and Classical Baden<sup>11</sup>**

32 samples archaeologically assigned to the Baden Culture were collected for our project. <sup>14</sup>C measurements of these samples proved them to be indeed from the Baden Culture. Since prior to our project 43 <sup>14</sup>C-dates existed, we increased the available data-set by more than a half. All data are presented together in our Table 7. These new data with lower sigma are expected to improve the knowledge of the chronology of the Baden Culture.

Figure 1 shows the group calibration of the Baden Culture in total. Table 8 shows the results for all different Baden cultural groups.

Figure 2 presents the group calibration for the dates of Boleráz, Figure 3 the group calibration for the Classical Baden Group.

As Table 8 suggests a separation of 5 different phases of the Baden Culture seems possible, with some restrictions. The Protoboleráz (Figure 4) can not be differentiated in time from Boleráz, these two phases last almost the same from about 3640 to 3370 BC. The oldest phase of the classical Baden, Červený-Hradok (see Figure 5), overlaps with Boleráz, but not in the predominant intervals. Ossarn I (see Figure 6) shows an overlap with Červený-Hradok, but only starting from its second interval. Ossarn II (see Figure 7) starts at about the same time as I, but lasts till 2870 instead of 2930 BC. The conclusion is that Boleráz starts 140 years earlier as compared to the assumption by Maran (Maran 1998, 497-525). Thus, all the ideas about influences from the East must be checked. If one takes into account the calibration curve (see Figure 8), the big wiggles from about 3550 to 3250 BC restrict the possibilities of radiocarbon dating and explain the overlaps between the different phases.

In Table 9 and Figures 9-11 the cultural groups, which are similar to Baden from Eastern Europe are presented. Cernavodă I is by means of typology older than Cernavodă III<sup>12</sup>. This sequence Cernavodă I - Cernavodă III must be handled with care, as long as the find material is not published. If this sequence is correct and after radiocarbon dates Cernavodă I goes parallel with Baden-Classical, it seems impossible that Cernavodă III is contemporary with Baden-Boleráz. Also the Sitagroi and Ezero groups are only possibly paralleled with Baden-Classical and late Baden-Classical culture and not with Baden-Boleráz. Thus the direction of the Baden-Culture development seems to be opposite to what was thought before, that means from the West to the East, which was already pointed out by Maran<sup>13</sup>. As there are no modern

dates for these Eastern groups, this hypothesis must be confirmed by new measurements.

Arbon Bleiche 3 (de Capitani and Leuzinger, 1998, 237-249. It will be discussed elsewhere in this book) is a late Neolithic settlement, situated near the Bodensee and thus conserved well by means of humidity. Although no new radiocarbon measurements were done in our project, this excavation seems to be a key site for understanding the development of Boleráz Group of the Baden Culture.

The settlement belongs to the transition between Pfyn and Horgen Culture, but most important for our investigation of the early Baden Culture (Boleráz) is that ceramics of Boleráz was found together with Pfyn and Horgen. Thus Arbon Bleiche is the most western settlement in the Boleráz distribution, which has its centre in the Vienna Basin and Burgenland, in Moravia, Slovakia and in Western Hungary. More than that, Arbon Bleiche is the best dated place with a dendrochronological time span from 3384 to 3370 BC, thus lasting for only 14 years. Then the settlement burnt down and the remains were preserved under layers of sea sediments. The absolute chronology by means of radiocarbon dates for Pfyn and Horgen Culture are presented in Figures 12 and 13.

There are also 6 radiocarbon dates<sup>14</sup> of wood absolutely dated by means of dendrochronology. Table 10 shows these results. Figure 14 presents the results of a wiggle matching with these data. The dendro age of the youngest sample of 3384 BC lies within the 1-sigma time span from 3390 to 3360 BC, which has the higher probability than the "wrong" interval from 3500 to 3480 BC. Thus the radiocarbon measurement confirms the dendro age. The comparison with two Baden Culture phases is presented in Table 12.

Against former ideas<sup>15</sup> Elisabeth Ruttkay now (Ruttkay 1999) believes that it could be possible that the ceramics found in Arbon Bleiche has some elements which can show that it belongs to the end phase of a developed Boleráz, as suggested by our new dates concerning the time span of Boleráz and the dates for Arbon Bleiche.

## Conclusion

So far, about 27% of the samples originally planned within this project (1000), 17% of the samples collected (1555) are analysed. As we demonstrated in this report, already interesting results evolved. It seems clear that the original goal of obtaining better absolute chronology is demonstrated by this subset of available data.

For the Baden Culture two groups can be differentiated, Baden-Boleráz and Baden-Classical, which can be confirmed very well by radiocarbon dates. Baden-Boleráz begins much earlier than expected, about 3640-3370 BC, Baden-Classical lasts from 3360 to 2930 BC. The site from Arbon Bleiche 3, which contains among material from late Pfyn and early Horgen such of late Boleráz, fits very well in between the two Baden phases. The ideas of an Eastern genesis of the Baden Culture must be cross-checked by dating new samples of the Eastern parallels, because the current dates would not allow such influences. On the contrary – at the moment – it seems possible that the Baden Culture (Boleráz) developed somewhere in Lower Austria, Burgenland, Moravia, Slovakia and Western Hungary and then spread to the East.

## NOTES

1. Status of the Austrian Science Fund Project P12253-PHY.

2. Prähistorische Abteilung, Naturhistorisches Museum, Vienna and Institut für Ur- und Frühgeschichte, University of Vienna.

3. Institut für Isotopenforschung und Kernphysik, University of Vienna.
4. Institut für Ur- und Frühgeschichte, University of Vienna.
5. The former Institut für Radiumforschung und Kernphysik.
6. 116 samples were collected.
7. Here 190 samples were collected.
8. Wild et al. 2000.
9. Acid Base Acid treatment.
10. <http://www.univ-lyon1.fr/~carbon14/banadora.html>.
11. I have to be very grateful to Elisabeth Ruttkay for organising the sample collection together with her Hungarian colleague Mária Bondár. More than that, she helped with the cultural assignment of the samples.
12. This is the opinion of Petre Roman, somewhere else in this book.
13. See above.
14. With the friendly permission of Urs Leuzinger and Trivun Sormaz we can present here new radiocarbon dates measured in Bern. These dates were measured in the Swiss National Fund Project (NF Projekt Nr. 1214-3358.92) "Jahrringchronologische Korrelation von Weichholz- und Weißtannenproben in Verbindung mit Analysen Prähistorischer Siedlungsstrukturen", in the years 1992-1995.
15. Cited in Annick de Capitani, see above.

## LITERATURE

- |                                |  |
|--------------------------------|--|
| de Capitani and Leuzinger 1998 | = de Capitani A. and Leuzinger U., <i>Arbon Bleiche 3, Siedlungsgeschichte, einheimische Traditionen und Fremdeinflüsse im Übergangsfeld zwischen Pfyner und Horgener Kultur</i> , JSGU 81, 237-249. |
| Maran 1998                     | = Maran J., <i>Die Badener Kultur und der ägaisch-anatolische Bereich</i> , Germania 76/2, 497-525.  |
| Priller et al. 1997            | = Priller A., Golser R., Hiller P., Kutschera W., Rom W., Steier P., Wallner A., Wild E.M., <i>First performance tests of VERA. Nuclear Instruments and Methods B 123</i> .                          |
| Puchegger et al. 2000          | = Puchegger St., Rom W., Steier P., <i>Automated evaluation of <sup>14</sup>C AMS-measurements</i> . To be published in: Nuclear Instruments and Methods B.  |
| Ruttkay 1999                   | = Ruttkay E., <i>Siedlungsfunde der Boleráz-Gruppe aus Wien und dem norddanubischen Niederösterreich</i> , FÖ 38 (in press).   |
| Wild et al. 2000               | = Wild E.M., <i><sup>14</sup>C dating with the bomb peak: an application to forensic medicine</i> . To be published in Nuclear Instruments and Methods B.  |

## ABBREVIATIONS

FÖ = Fundberichte aus Österreich.

JSGU = Jahrbuch der Schweizerischen Gesellschaft für Urgeschichte.

Table 1. Database structure for  $^{14}\text{C}$  samples.

Fields used in sample database	
<b>General information</b>	Scientist
Date, when sample was received by VERA	
Priority: A, B, 0, 1, 2, 3, highest priority A, B, 1, A for Avar subproject, B for Bronze Age subproject	
Sample number in project	Species:
Sample supplier	Number of Species
Culture	Species 2
<b>Laboratory data</b>	Number of Species 2
Lab	Species 3
Lab-Number	Number of Species 3
BP	Scientist
Sigma	Scientist's comment
Delta $^{13}\text{C}$	
Sigma Delta $^{13}\text{C}$	<b>Site parameters</b>
Cal. I Sigma	Name of site
Weight of sample used	Location
<b>Sample parameters</b>	District
Weight of sample	Region 1
Sample name	Region 2
Date, when sample was taken	Country
Find inventory	Co-ordinates
Name of sample taker	Type of Site: cemetery, settlement etc.
Material	Type of soil
Object	Possible contamination
<b>Science/Dendrochronology</b>	Context
Dendrochronological info1: number of year rings taken as sample	<b>Photo documentation</b>
Dendrochronological info1: number of year rings in total	Number of photo from site
Wood edge	Number of slide from site
Wood from inner/outer part	Number of photo with finds
Dendro date	Number of slide with finds
<b>Science/Human Biology/Zoology</b>	<b>Cultural assignment</b>
Bone	Cultural level
Side: left or right side of skeleton	Cultural level 1
End of bone: distal/proximal	Cultural level 2
Fragmented	Cultural level 3
Number of bones	Fine level 1
Patinated	Fine level 2
Anthropological gender	Diverse
Archaeological gender	Alphanumeric part of complex 1
Age: infans, juvenile, mature, senile	Complex
Age2: under border of age interval	Alphanumeric part of complex 2
Age3: upper border of age interval	Planum
	reasons for dating
	Literature
	Data of sample supplier

**Table 2. Priority of samples.**

Priority	Number of samples	Percent
A	199	12.8
B	112	7.2
0	36	2.3
1	160	10.3
2	228	14.7
3	47	3.0
Missing	773	49.7
Total	1555	100.0

**Table 3. Origin of samples.**

Country	Number of samples	Percent
A	938	60.3
BG	9	0.6
CZ	247	15.9
D	17	1.1
GR	1	0.1
H	163	10.5
KIRG	2	0.1
RO	4	0.3
RU	6	0.4
SK	153	9.8
SLO	10	0.6
SY	5	0.3
TOTAL	1555	100.0

**Table 4. Material of samples.**

Material	Number of samples	Percent
Cereals	42	2.7
Wood	115	7.4
Charcoal	374	24.1
Burnt human bone	8	0.5
Human bone	532	34.3
Seed	2	0.1
Snail	9	0.6
Animal Bone	469	30.2
Animal Bone/ Burnt bone	3	0.2
Total	1555	100.0

**Table 5. Cultural context of samples (Culture names in German, in alfabetical order).**

Culture	Number of samples	Precent
10.Jh.	1	0.1
11.Jh.	1	0.1
12.Jh.	4	0.3
13.Jh.	4	0.3
3/4.Jh.	1	0.1
4.Jh	4	0.3
5.Jh.	2	0.1
?	6	0.4
Aunjetitz	125	8
Aurignacien	12	0.8
Awaren	190	12.2
Baden	2	0.1
Baden-Boleráz	27	1.7
Baden-Klassisch	18	1.2
Baiern	9	0.6
Bajč-Retz	1	0.1
Barca	1	0.1
Bisamberg-Oberpullendorf	6	0.4
Chlopice-Veselé	1	0.1
Danilo	1	0.1
Epigravettien	1	0.1
Frühbronzezeit	15	1
Frühbronzezeit?	2	0.1
Frühmesolithikum	1	0.1
Frühmittelalter	1	0.1
Frühneolithikum	5	0.3
Furchenstich	1	0.1
GBK	12	0.8
Gemeinlebarn	2	0.1
Gepiden	1	0.1
Gärla Mare	1	0.1
Gravettien	9	0.6
Gravettien/Pavlovien	3	0.2
HGK	13	0.8
Hallstatt	7	0.5
Hamangia	7	0.5
Hochmittelalter	6	0.4
Jevišovice	15	1
Jordanov	1	0.1
Jungpleistozän	1	0.1
KAK	3	0.2



Table 5. Continued.

Kosihy-Čaka-Mako	20	1.3
LBK	245	15.8
Langobarden	53	3.4
Latěnc	42	2.7
Lausitz	11	0.7
Lengyel	246	15.8
Lengyel?	1	0.1
LgK	2	0.1
Ludanice	1	0.1
MMK	1	0.1
Madarovce	8	0.5
Magyaren	4	0.3
Maisbirbaum-Zohor	1	0.1
Mesolithikum	7	0.5
Mesolithikum/Frühneolithikum	1	0.1
Mistelbach-Regelsbrunn	1	0.1
Mittel-/Spätbronzezeit	5	0.3
Mittel-/Spätpaläolithisch	2	0.1
Mittelbronzezeit	1	0.1
Mittelnolithikum	4	0.3
Mondsec	1	0.1
Montcoru	3	0.2
Neolithikum	4	0.3
Nitra	11	0.7
Orava	1	0.1
Paläolithikum	1	0.1
Polgár	1	0.1
Protoaunjetitz	8	0.5
Púchov	8	0.5
RKZ	22	1.4
STBK	18	1.2
Schnurkeramik	16	1
Slawen	40	2.6
Spätbronzezeit	7	0.5
Spätcisenzeit	22	1.4
Späthelladisch	2	0.1
Spätlatěnczeit	1	0.1
Spätmesolithikum	5	0.3
Spätnolithikum	16	1
Spätpaläolithikum	9	0.6
TRBK	34	2.2
TRBK?	4	0.3
Tiszadob	3	0.2
UK	50	3.2
UK - HA	18	1.2
Unterwölbling	3	0.2
VKWZ	8	0.5

**Table 5. Continued.**

Veterov	8	0.5
Vlaska	1	0.1
Vorpúchov	12	0.8
ÄLBK	10	0.6
Missing	29	1.9
Total	1555	100

**Table 6. Date falls within range of expectation.**

Date falls within range of expectation	Number	Percentage
no	43	16.0
yes	225	84.0
Total	268	100.0

**Table 7, Currently available data for Baden culture (database in German), together with new dates measured in our project.**

Land	Fundort	Labor	Nr	Funddetails	Art d. Fundortes	Material	Radio- carbon AgeBP	$\sigma$	Kultur	Species	Ausgräber	Literatur
YU	Gomolova	GrN	13168			Hk	4380	70	Baden			Forenbaher 1993
H	Ószentiván	Bln	476	VIII		Hk	4515	80	Baden			Bojadziev 1992
SK	Podolie	Bln	556	Obj.3/63		Hk	4455	80	Baden			Forenbaher 1993
H	Sümeg	A	246				4520	60	Baden			Forenbaher 1993
H	Szigetescép	Bln	1637				4350	45	Baden			Forenbaher 1993
A	Niederhollabrunn	ETH	15241	Grab, Skelett I		Mk	4710	95	Baden?	Menschenknochen		Lauermann, unpubl.
BG	Ezero	Bln	421	Qu. D 8, T. 1.30 m	Tellsiedlung	S	4335	80	Baden-Analogie			Görsdorf 1996
BG	Ezero	Bln	422	Qu. A 7, T. 1.30 m	Tellsiedlung	Hk	4310	80	Baden-Analogie			Görsdorf 1996
BG	Ezero	Bln	427	Qu. D 10, T. 0.85 m	Tellsiedlung	Hk	4365	80	Baden-Analogie			Görsdorf 1996
BG	Ezero	Bln	428	Qu. D 10, T. 0.80 m	Tellsiedlung	S	4260	80	Baden-Analogie			Görsdorf 1996
BG	Ezero	Bln	429	Qu. C 10, T. 0.70 m	Tellsiedlung	S	4130	100	Baden-Analogie			Görsdorf 1996
BG	Ezero	Bln	1822	Qu. A 7, T. 1.30 m	Tellsiedlung	Hk	4275	65	Baden-Analogie			Görsdorf 1996
BG	Ezero	Bln	1824	Qu. C 10, T. 0.70 m	Tellsiedlung	G	4135	65	Baden-Analogie			Görsdorf 1996
GR	Sitagroi	Bln	773			G	4390	100	Baden-Analogie			Breunig 1987
GR	Sitagroi	Bln	782			Hk	4310	100	Baden-Analogie			Breunig 1987
GR	Sitagroi	Bln	878			Hk	4395	100	Baden-Analogie			Breunig 1987
GR	Sitagroi	Bln	879			Hk	4550	100	Baden-Analogie			Breunig 1987
GR	Sitagroi	Bln	880			G	4510	100	Baden-Analogie			Breunig 1987
GR	Sitagroi	BM	650a			Hk	4363	56	Baden-Analogie			Breunig 1987
GR	Sitagroi	BM	651			G	4332	79	Baden-Analogie			Breunig 1987
CH	Arbon Bleiche	B	6360				4710	30	Baden-Boleráz			Capitani 1998
CH	Arbon Bleiche	B	6361				4700	30	Baden-Boleráz			Capitani 1998
CH	Arbon Bleiche	B	6362				4640	30	Baden-Boleráz			Capitani 1998
CH	Arbon Bleiche	B	6363				4690	30	Baden-Boleráz			Capitani 1998
CH	Arbon Bleiche	B	6364				4620	40	Baden-Boleráz			Capitani 1998
CH	Arbon Bleiche	B	6365				4660	40	Baden-Boleráz			Capitani 1998
A	Baierdorf	VERA	838	Grube 2	Siedlung, Grube	Tk	4645	35	Baden-Boleráz	indet.		Stadler 1999
A	Grub an der March	VERA	876	Objekt 21/NW-Hälfte/Sig. 97	Siedlung/Grube	Tk	4770	55	Baden-Boleráz	Bos p. f. taurus		Stadler 1999
A	Grub an der March	VERA	877	Objekt 28/Sig. 53	Siedlung/Grube	Tk	4760	50	Baden-Boleráz	Bos p. f. taurus		Stadler 1999
A	Grub an der March	VERA	878	Objekt 50/NW-Hälfte/Sig. 94	Siedlung/Grube	Tk	4790	55	Baden-Boleráz	Bos p. f. taurus		Stadler 1999

Table 7. Continued.

CZ	Hlinsko	Bln	3232	Obj.246-6/1975			4780	70	Baden-Boleráz			Pavelčík 1992
CZ	Hlinsko	Bln	3233	Obj.319-20/1977-26/1978			4680	60	Baden-Boleráz			Pavelčík 1992
CZ	Hlinsko	GrN	13149	Objekt 443-21/1984			4750	60	Baden-Boleráz			Pavelčík 1992
CZ	Hlinsko	GrN	16728	Objekt 525B-1/1988			4650	40	Baden-Boleráz			Pavelčík 1992
CZ	Hlinsko	GrN	16729	Objekt 443-21/1984			4605	40	Baden-Boleráz			Pavelčík 1992
A	Schwechat	VERA	849	Grube 14	Siedlung, Grube	Tk	4935	45	Baden-Boleráz	indet.		Stadler 1999
H	Szihalom	VERA	852	Obj. 43, Südhälfte		Tk	4785	40	Baden-Boleráz	indet.	Szabó J.J 1997	Stadler 1999
H	Szihalom	VERA	853	Obj. 44		Tk	4740	40	Baden-Boleráz	indet.	Szabó J.J 1997	Stadler 1999
H	Szihalom	VERA	854	Obj. 72		Tk	4830	40	Baden-Boleráz	indet.	Szabó J.J 1996	Stadler 1999
H	Szihalom	VERA	855	Obj. 149		Tk	4850	60	Baden-Boleráz	indet.	Szabó J.J 1996	Stadler 1999
H	Szihalom	VERA	856	Obj. 161		Tk	4785	35	Baden-Boleráz	indet.	Szabó J.J 1996	Stadler 1999
H	Szihalom	VERA	857	Obj. 224, Südhälfte, auf Sohle		Tk	4755	35	Baden-Boleráz	indet.	Szabó J.J 1996	Stadler 1999
H	Szihalom	VERA	862	Obj. 161, Südwestteil		Hk	4735	35	Baden-Boleráz	Quercus sp.(Eiche)	Szabó J.J 1997	Stadler 1999
H	Szihalom	VERA	863	Obj. 161, Südwestteil		Hk	4745	35	Baden-Boleráz	Fraxinus(Esche)	Szabó J.J 1997	Stadler 1999
A	Zillingtal	VERA	860	Grube 1	Siedlung, Grube	Tk	4625	35	Baden-Boleráz	Ovis(Schaf)/Capra(Ziege)		Stadler 1999
A	Zillingtal	VERA	861	Grube 4	Siedlung, Grube	Tk	4700	45	Baden-Boleráz	Ovis(Schaf)/Capra(Ziege)		Stadler 1999
SK	Bajc-Vlkanovo	VERA	736	Objekt 22	Siedlung der Badener Kultur, Siedlungsgrube	Hk	4530	45	Baden-Klassisch-Červený Hradok	Laubholz indet.		Stadler 1999
SK	Červený Hradok	GrN	11994	Obj.7W/70			4390	70	Baden-Klassisch-Červený Hradok			Němejcová-Pavůková 1985
A	Ossam Stickelberger	GrN	6940				4520	40	Baden-Klassisch-Červený Hradok			Mayer 1995
A	Stillfried	VERA	850	Objekt 10		Hk	4605	35	Baden-Klassisch-Červený Hradok	indet.		Stadler 1999
A	Stillfried	VERA	851	Objekt 21		Hk	4645	35	Baden-Klassisch-Červený Hradok	Canis lupus familiaris(Hund)		Stadler 1999
CZ	Beladice	Bln	2171	Obj.3/70			4420	60	Baden-Ossam I			Forenbaher 1993
PL	Iwanowice	Bln	352				4200	100	Baden-Ossam I			Bogucki 1992
PL	Iwanowice	M	2166			Hk	4300	200	Baden-Ossam I			Breunig 1987
H	Nagykanizsa	VERA	840	Obj. 8		Tk	4455	50	Baden-Ossam I	indet.	Horváth L, Barna J. 1996	Stadler 1999
H	Nagykanizsa	VERA	841	Obj. 10		Tk	4425	40	Baden-Ossam I	Ovis(Schaf)/Capra(Ziege)	Horváth L, Barna J. 1996	Stadler 1999

Table 7. Continued.

H	Nagykanizsa	VERA	843	Obj. 15		Tk	4400	40	Baden-Ossarn I	Ovis(Schaf)/Capra (Ziege)	Horváth L, Barna J. 1996	Stadler 1999
H	Nagykanizsa	VERA	844	Obj. 20		Tk	4425	35	Baden-Ossarn I	indet.	Horváth L, Barna J. 1996	Stadler 1999
H	Nagykanizsa	VERA	846	Obj. 30		Tk	4080	40	Baden-Ossarn I	Sus scrofa f. domestica? (Hausschwein)	Horváth L, Barna J. 1996	Stadler 1999
A	Pottenbrunn	GrN	14016	Gru.212		Hk?	4560	40	Baden-Ossarn I			Mayer 1996
SK	Šarišské Michalany	VERA	769	Objekt 241/85	Siedlung Speichergrube	Hk	4385	35	Baden-Ossarn I	Fraxinus(Esche)		Stadler 1999
A	Straß im Straßertale	VERA	893	Objekt 17	Siedlung, Grube	Tk	4515	45	Baden-Ossarn I	Sus scrofa f. domestica (Hausschwein)		Stadler 1999
SK	Svodín	Bln	2173	Ob.498/78			4460	60	Baden-Ossarn I			Forenbaher 1993
H	Vámosgyörk	VERA	903	Grab 12		Mk	4475	45	Baden-Ossarn I	Homo	Farkas Cs. 1997	Stadler 1999
H	Vámosgyörk	VERA	904	Grab 13		Mk	4400	45	Baden-Ossarn I	Homo	Farkas Cs. 1997	Stadler 1999
YU	Vučedol	Z	1446			Hk	4540	86	Baden-Ossarn I			Forenbaher 1993
YU	Vučedol	Z	1466				4540	130	Baden-Ossarn I			Ehrich 1992
YU	Vučedol	Z	1617			Hk	4500	100	Baden-Ossarn I			Bojadžiev 1992
YU	Vučedol	Z	1618			Hk	4300	100	Baden-Ossarn I			Bojadžiev 1992
YU	Vučedol	Z	1619			Hk	4400	100	Baden-Ossarn I			Bojadžiev 1992
YU	Vučedol	Z	1864			Kn	4626	100	Baden-Ossarn I			Forenbaher 1993
A	Franzhausen	VERA	868	206	Gräberfeld	Mk	4510	40	Baden-Ossarn-I	Homo		Stadler 1999
A	Girm	VERA	869	Grube 9	Siedlung	Tk	4530	50	Baden-Ossarn-I	Bos(Rind)		Stadler 1999
A	Girm	VERA	875	Grube 12	Siedlung	Tk	4565	45	Baden-Ossarn-I	Bos(Rind)		Stadler 1999
A	Hadersdorf	VERA	880	Objekt 46	Siedlung, Grube	Tk	4510	45	Baden-Ossarn-I	indet.		Stadler 1999
A	Hadersdorf	VERA	881	Objekt 68	Siedlung, Grube	Tk	4485	40	Baden-Ossarn-I	Bos(Rind)?		Stadler 1999
A	Lichtenwörth	Bln	2069				4540	45	Baden-Ossarn-II			Mayer 1995
A	Lichtenwörth	Bln	2070				4530	70	Baden-Ossarn-II			Mayer 1995
A	Lichtenwörth	Bln	2071				4410	60	Baden-Ossarn-II			Mayer 1995
SK	Svodín	Bln	2169				4270	50	Baden-Ossarn-II			Bojadžiev 1992
SK	Svodín	Bln	2174			Hk	4390	60	Baden-Ossarn-II			Bojadžiev 1992
SK	Červený Hrádok	GrN	11992	Obj.7D/70			4820	70	Baden-Šturovo-Protoboleráz			Němčicová-Pavůková 1985
SK	Červený Hrádok	GrN	11993	Obj.7D/70			4710	100	Baden-Šturovo-Protoboleráz			Němčicová-Pavůková 1985
H	Gyöngyöshalász	Bln	2589	Gru.		Hk	4790	50	Baden-Šturovo-Protoboleráz			Szabó 1983
CZ	Hlinsko	Bln	1165	Obj.141-4/1972			4670	80	Baden-Šturovo-Protoboleráz			Pavelčík 1992

Table 7. Continued.

CZ	Hlinsko	Bln	1166	Obj.156-19/1972			4670	80	Baden-Šturovo- Protoboleráz			I Pavelčík 1992
CZ	Hlinsko	Bln	1396				4775	60	Baden-Šturovo- Protoboleráz			Forenbaher 1993
CZ	Hlinsko	GrN	6941	Obj.156-19/1972			4670	40	Baden-Šturovo- Protoboleráz			Pavelčík 1992
CZ	Hlinsko	GrN	6942	Objekt 141-4/1972			4670	45	Baden-Šturovo- Protoboleráz			I Pavelčík 1992

**Table 8. Absolute chronology of groups of Baden Culture.**

Groupname	Number of samples	Phase of Baden-Culture	Interval 1-Sigma	Probability %
Šturovo-Protoboleráz	8	Ia	3640-3550 3540-3490 3470-3370	24.3 13.8 30.2
Boleráz	26	Ib-Ic-IIa	3640-3370	68.2
Červený-Hradok	5	IIb	3510-3430 3380-3300 3240-3100	22.1 19.8 26.3
Ossarn I	25	III	3350-3010 2980-2960 2950-2930	64.4 1.6 2.2
Ossarn II	5	IV	3350-3310 3240-3170 3160-2870	6.9 11.6 49.6

**Table 9. Absolute chronology of eastern parallels of Baden Culture.**

Groupname	Number of samples	Interval 1-Sigma	Probability %
Cernavodă I	3	3340-3210 3190-3150 3130-2880	19.6 5.2 43.4
Sitagroi	7	3330-3230 3180-3150 3120-2880	12.5 1.8 53.9
Ezero	7	3090-3060 3030-2840 2820-2670	2.1 41.8 24.3

**Table 10.  $^{14}\text{C}$ -Dates for six samples of wood, which were dated also by means of dendrochronology, from Arbon Bleiche<sup>1</sup>. Gap is the distance in years between two consecutive samples (middle years).**

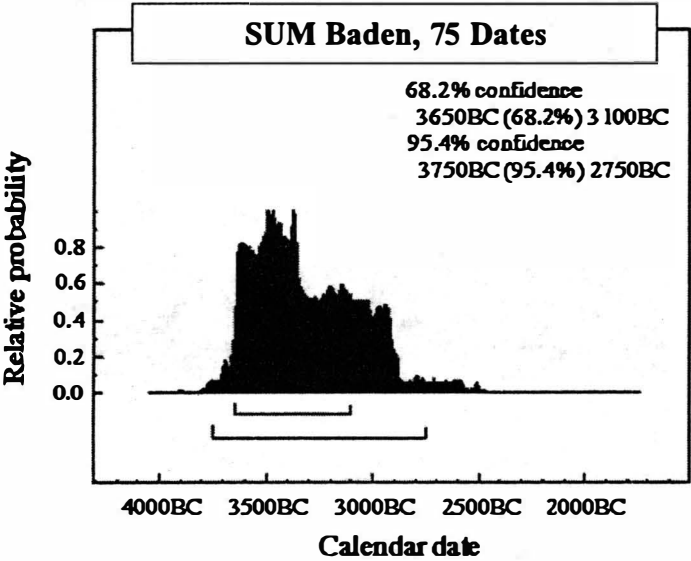
Lab #	Radio-carbon Age BP	$\sigma$	Dendro1 BC	Dendro2 BC	Middle year BC	GAP years
B-6364	4620	40	3439	3414	3426.5	7.0
B-6360	4710	30	3432	3407	3419.5	21.5
B-6363	4690	30	3403	3393	3398.0	0.5
B-6365	4660	40	3413	3382	3397.5	4.0
B-6361	4700	30	3406	3381	3393.5	9.5
B-6362	4640	30	3392	3376	3384.0	

1. Data used with friendly permission by Urs Leuzinger und Trivun Sormaz.

**Table 11. Absolute Chronology of Pfyn, Horgen and Arbon Bleiche 3, Boleráz and Classical Baden.**

Group-name	Number of samples	Phase of Baden-Culture	Intervall 1-sigma BC	Probability in %
Pfyn	36		4000-3500	68.2
Arbon Bleiche 3	Dendro	Late Pfyn, Early Horgen, Late Boleráz	3384-3370	100.0
Horgen	24		3500-2850	68.2
Boleráz	27	I-IIa	3640-3370	68.2
Classical Baden	35	IIb-IV	3360-3010	64.1
			2980-2960	1.7
			2950-2930	2.5

**Figure 1. Group calibration of Baden Culture.**



**Figure 2. Group Calibration of Protoboleráz-Šturovo Phase of Early Baden Culture.**

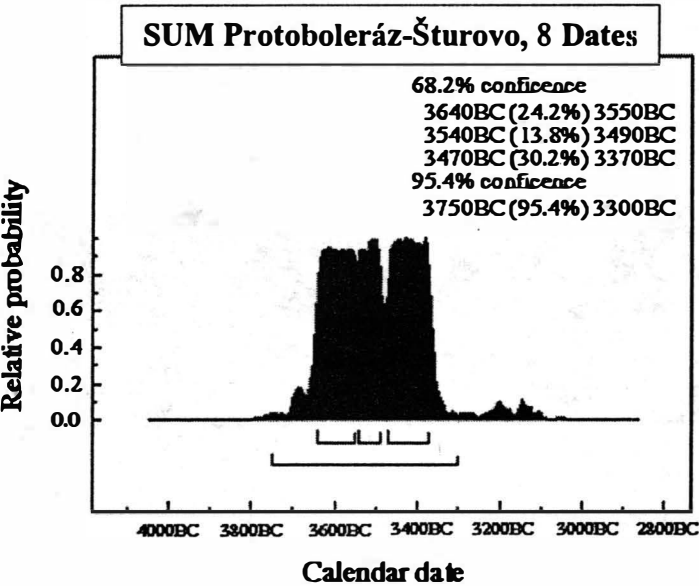




Figure 3. Group calibration of Boleráz phase of Baden Culture.

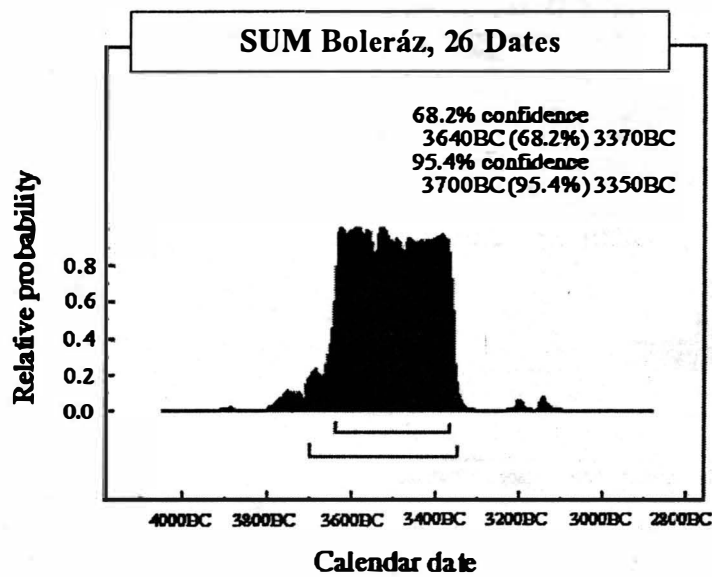


Figure 4. Group calibration of Classical phase of Baden Culture.

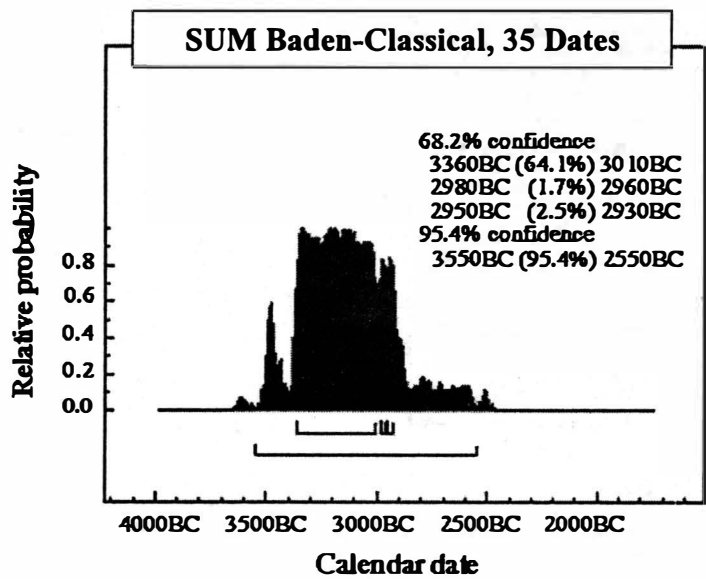


Figure 5. Group Calibration of Červený-Hradok Phase of Classical Baden Culture.

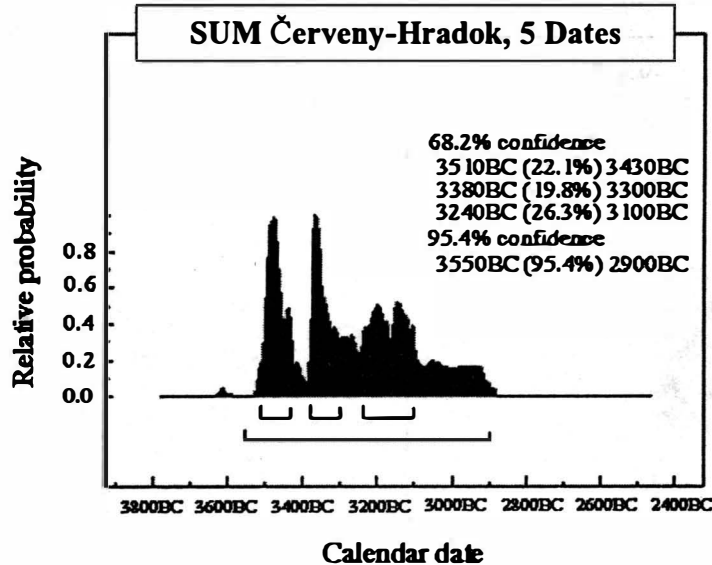


Figure 6. Group Calibration of Ossarn I Phase of Classical Baden Culture.

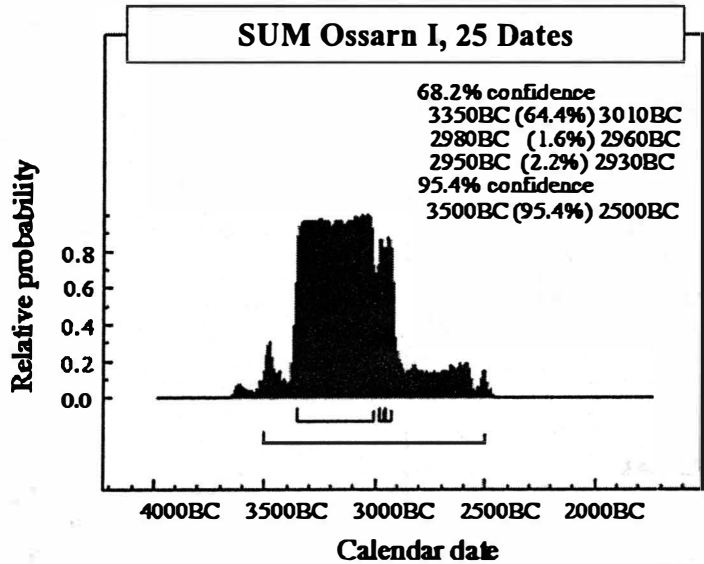


Figure 7. Ossarn II Phase of Classical Baden Culture.

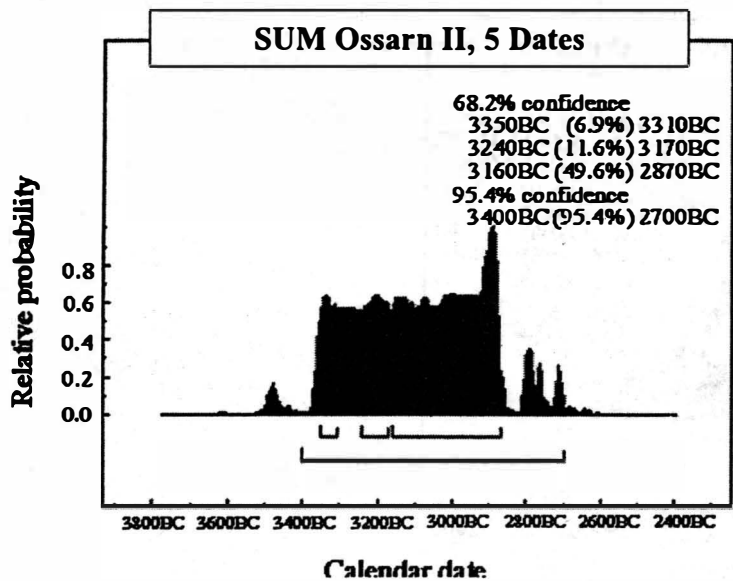


Figure 8. Calibration curve from 4200 to 3200 BC, Atmospheric data after Stuiver et al. 1998.

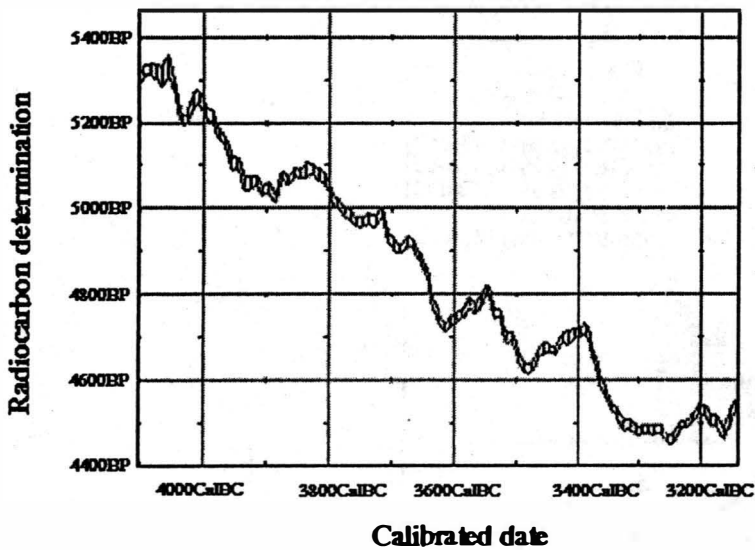


Figure 9. Group Calibration of Cernavodă I.

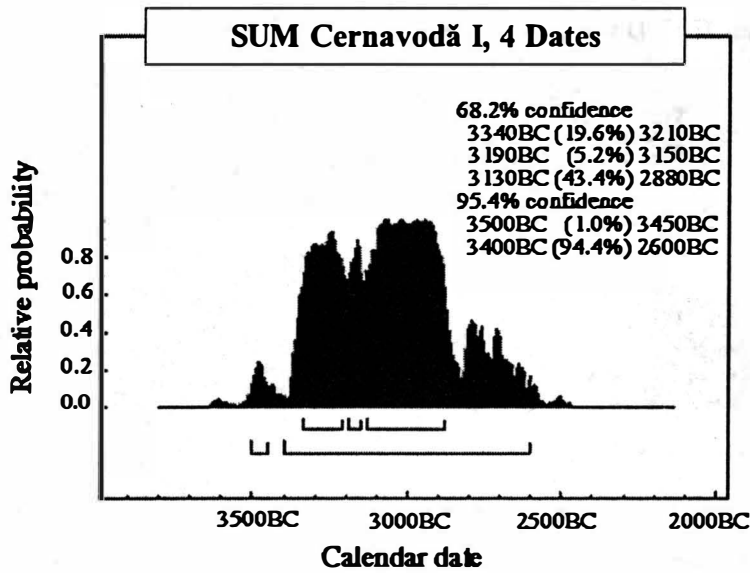


Figure 10. Group Calibration of Sitagroi Culture.

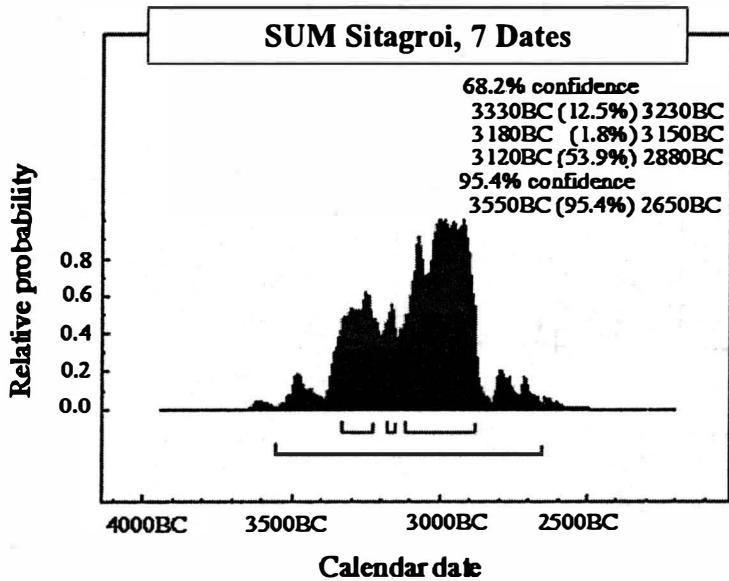


Figure 11. Group Calibration of Ezero, Level 1-6/1-4.

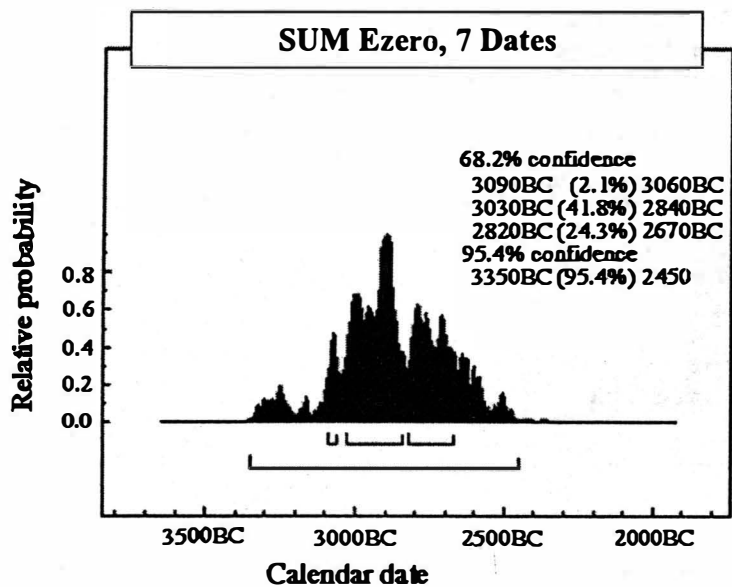


Figure 12. Group Calibration of Pfyn Culture.

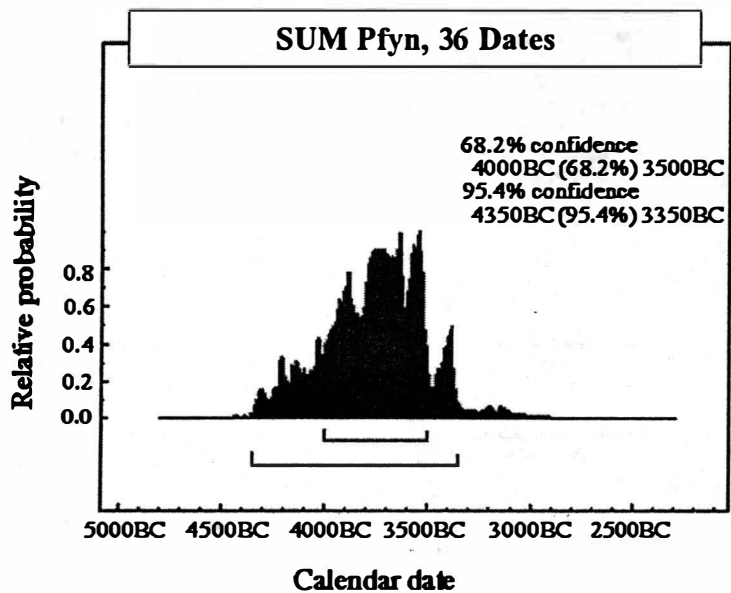


Figure 13. Group Calibration of Horgen Culture.

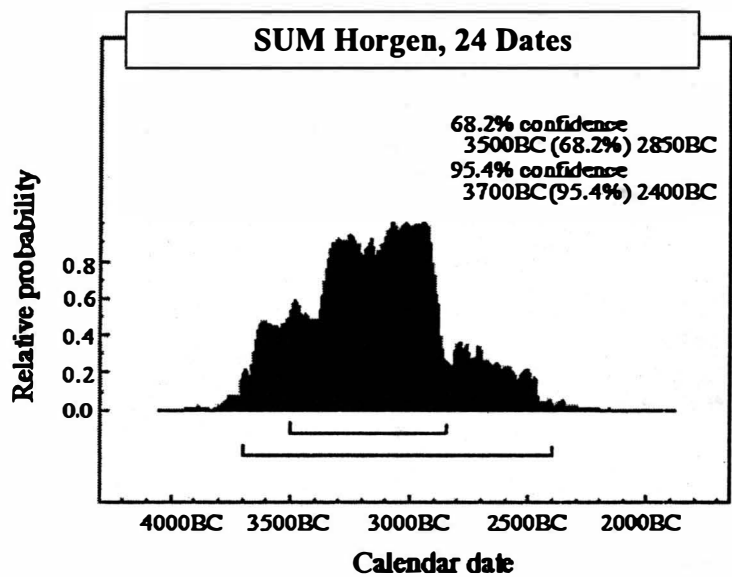


Figure 14. Wiggle matching calibration (dark shaded area) of youngest sample of dendro-dated wood from Arbon Bleiche 3. The unshaded area is the calibrated time range before wiggle matching.

