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CALIBRATED ^{14}C DATES IN CENTRAL EUROPE - SAME AS ELSEWHERE?

J C FREUNDLICH and BURGHART SCHMIDT

^{14}C -Laboratorium and Labor fuer Dendrochronologie, Univ Koeln
Weyertal 125, D-5000 Koeln 41, Germany (Fed Rep)

ABSTRACT. ^{14}C dating results derived from an absolutely-dated 471-year tree-ring sequence from central European oak show a trend towards somewhat older dates than those for bristlecone-pine tree rings of the same age, but similar to those for Egyptian historical samples. Differences visible between these trend lines are not relevant considering the standard errors proposed by Clark (1975).

INTRODUCTION

From the beginning, the ^{14}C dating method has been extensively checked (Arnold and Libby, 1949) by testing samples of known age. Subsequently, many more known-age samples were cross-dated by ^{14}C, (1) mostly tree-rings from California long-lived trees (more than 1000 dates; Clark, 1975; Klein et al, 1982) and (2) Egyptian historically dated materials (about 50 dates; Olsson, 1970; Clark and Renfrew, 1973). From these measurements it was concluded that ^{14}C dates generally deviate from known ages by determinable amounts of time and that recalibration is needed before comparing ^{14}C dates with historical dates.

CALIBRATION FUNCTIONS

For this "calibration," 16 tables or graphs were prepared by a variety of interpolation methods: (1) free-hand line drawing, (2) Fourier analysis, (3) polynomial regression, (4) averaging methods, and (5) spline functions. McKerrell (1975) compiled ^{14}C analyses on Egyptian historically dated samples for comparison with the results gained on bristlecone-pine tree rings. Figure 1 shows that there is no contradiction between calibration functions as long as realistic allowance is made (Clark, 1975) for measurement scatter.

EUROPEAN OAK CHRONOLOGIES

A third path towards known-age material was opened by Huber (1941) inaugurating dendrochronology of the European oak. Seven laboratories in Germany reported on progress of dendrochronology in central Europe (Frenzel, 1977), other laboratories are active in Northern Ireland, Belgium, and Switzerland. Close cooperation recently resulted in an absolute oak chronology

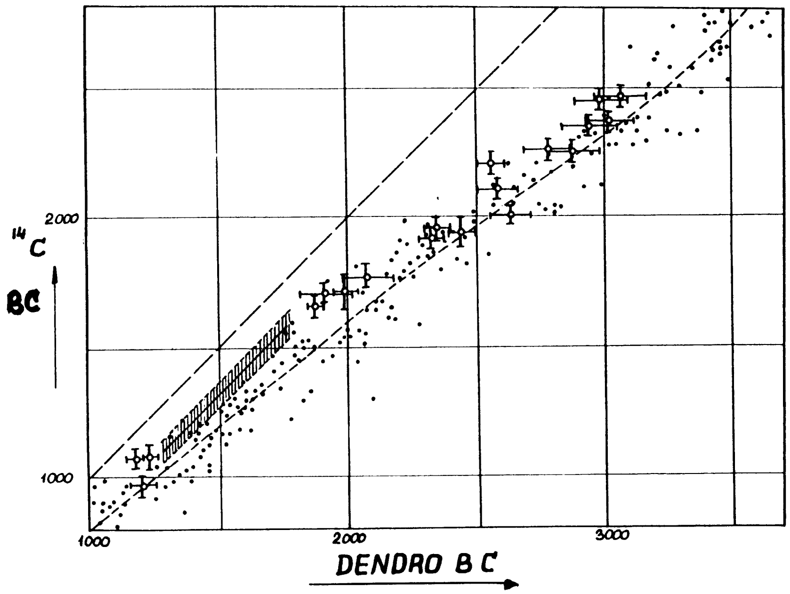

Fig 1. Comparison of ^{14}C measurements on samples of precisely known age from Egyptian history and from bristlecone-pine tree rings.

• = bristlecone-pine tree rings (after McKerrell, 1975, fig 5, p 73)

= Egyptian samples (with error range after McKerrell, 1975, fig 11, p 77)

----- = 6th order regression polynomial

covering the last four millennia (Schmidt and Schwabedissen, 1982) and offered promise for a connection with the 4000-yr chronology of the Irish oak (Pearson, Pilcher, and Baillie, 1983; Becker, 1983).

RESULTS

A tree-ring sequence of nearly 500 years close to the oldest part of our chronology was analyzed in our laboratory (table 1). Figure 2A shows the results as well as those of contemporaneous bristlecone-pine tree rings (Suess, 1978). Measurements were made in our CO_2-filled proportional counters containing ca 1g of carbon accumulating ca 150,000 to 300,000 counts. Tree-ring samples were pretreated by the acid/alkali/acid (AAA) method described earlier (Freundlich, 1973); results were measured to a counting statistic precision of 2.4‰ (±19 yr) to 3.5‰ (±28 yr). Estimating a set of additional error sources equivalent to Pearson et al (1977) increases these standard errors by a factor of nearly 1.3.

TABLE 1. Koeln ^{14}C measurements on absolutely-dated tree rings from European oak

^{14}C sample	Tree-ring sample	No. annual rings	Dendro-date* BC	Dendro-date* BP	^{14}C Date: ^{13}C corrected	^{14}C Date: BP	^{14}C Date: 1σ error	$\delta^{13}C$ ‰
KN-2800	Ram 5/ 36	16	1732	3681	1507	3456	21	-25.8
-2799	Ram 5/ 69	11	1699	3648	1597	3546	19	-25.8
-2798	Ram 5/ 95	8	1673	3622	1492	3441	22	-24.2
-2797	Ram 5/125	8	1643	3592	1436	3385	28	-24.3
-2796	Ram 5/155	5	1613	3562	1394	3343	23	-24.4
-2795	Ram 5/185	7	1583	3532	1450	3399	25	-24.5
-2429	IpM370/ 18	4	1559	3508	1403	3352	27	-25.0
-2794	Ram 5/215	8	1553	3502	1293	3242	22	-25.4
-2430	IpM370/ 38	4	1539	3488	1343	3292	28	-24.6
-2793	Ram 5/247	12	1521	3470	1320	3269	26	-24.9
-2431	IpM370/ 58	4	1519	3468	1336	3285	27	-24.8
-2432	IpM370/ 78	4	1499	3448	1384	3333	28	-24.6
-2792	Ram 5/275	8	1493	3442	1334	3283	28	-24.8
-2433	IpM370/ 98	4	1479	3428	1366	3315	27	-24.2
-2791	Ram 5/305	12	1463	3412	1288	3237	25	-25.0
-2434	IpM370/118	4	1459	3408	1236	3185	28	-24.5
-2435	IpM370/138	4	1439	3388	1256	3205	27	-25.0
-2790	Ram 5/335	7	1433	3382	1212	3161	26	-24.5
-2436	IpM370/158	4	1419	3368	1191	3140	25	-25.1
-2437	IpM370/178	4	1399	3348	1249	3198	27	-25.4
-2438	IpM370/198	4	1379	3328	1231	3180	28	-24.4
-2439	IpM370/218	4	1359	3308	1163	3112	28	-25.1
-2440	IpM370/238	4	1339	3288	1158	3107	27	-24.5
-2441	IpM370/258	4	1319	3268	1104	3053	28	-24.5
-2442	IpM370/278	4	1299	3248	1134	3083	27	-24.6

* From middle tree ring

Statistical approximation by a weighted least squares regression line yields a slope ($\Delta^{14}C/\Delta$dendro) = 1.0138 and least squares standard deviation of ±43.3 years (fig 2B). The calibration curve of Clark (1975) is included for reference (including Clark's standard error of ± 112 years). Figures 2A and 2B show a trend similar to that found by comparing Egyptian historical samples with bristlecone-pine tree rings. Our ^{14}C dates for central European tree rings lie fairly close to bristlecone-pine tree rings of the same dendrochronologic age, almost within the 1σ statistical range. (The same is evident by entering our regression line in figure 1 - shaded band).

WIGGLES. Our results show "wiggles" although not very conspicuously. It seems that we are in a relatively quiet period similar to that of Pearson et al (1977). Perhaps the wiggles structure will become more evident upon subsequent reduction of standard errors. The average standard deviation, ± 43.3 years as derived from our least squares approximation is comparable to the adjusted average precision figure, ± 33 years, especially when visualizing the observable wiggles structure.

FHS DATE. Besides the absolute dendrochronologic date of our analyzed tree rings, a "wiggle-matching" date has also been tentatively determined by a method similar to the one proposed by FHS (Ferguson, Huber, and Suess, 1966) (table 2; fig 3).

TABLE 2. Comparison of dendrochronologic and FHS dates for the first tree ring of our 471-year sequence.

FHS date (fig 3)	1830 ± 40	BC
Dedrochronologic date	1737	BC

The resulting difference, 63 ± 40 years, closely resembles the "off-set" figures quoted for bristlecone pine by Stuiver (1982, table 2, p 18). Possible reasons for this off-set may be attributed to 1) in situ ^{14}C production (Suess and Strahm, 1970, p 94,95; Radnell, Aitken, and Otlet, 1979), 2) younger ^{14}C transported by mobile organic constituents (Suess, 1978, p 4, legend, App 1; Long et al, 1979).

CONCLUSION

There has been considerable unrest about calibrated ^{14}C dates from the Old World Bronze age, presumably because inherent precision questions had not been adequately assessed. Even McKerrell's (1975) alternate list of "Egyptian historical" calibration figures lying almost halfway between bristlecone-pine calibration figures and zero calibration, does not lie off further than permissible by statistics (!). Our results fit this quite well (fig 1). They are somewhat different from formerly accepted bristlecone-pine based calibration figures; they do not give completely new figures, but rather form a narrower band of somewhat revised calibration figures for the time period mentioned (table 3).

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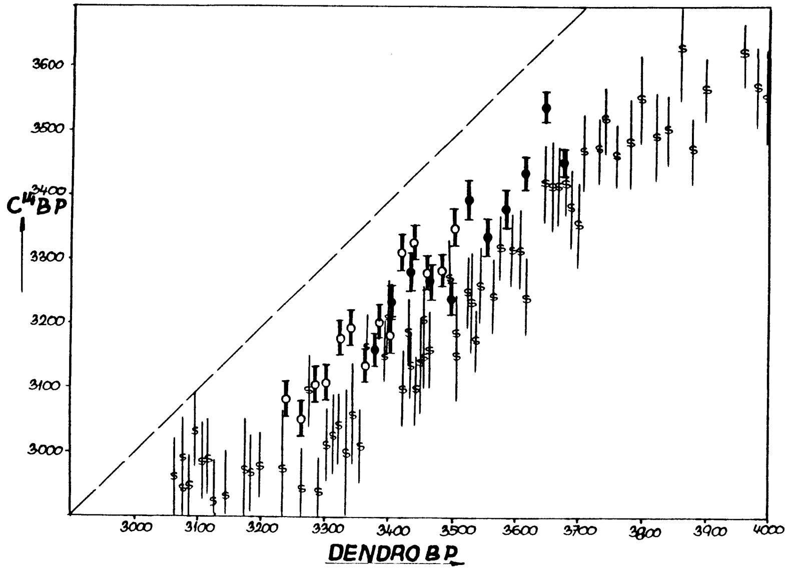

Fig 2A. ^{14}C measurement on absolutely dated tree rings from European oak. Chart of individual dates with 1σ counting error.

= this paper (IpM370; Ram5 tree-ring series)

= bristlecone-pine dates (after Suess, 1978)

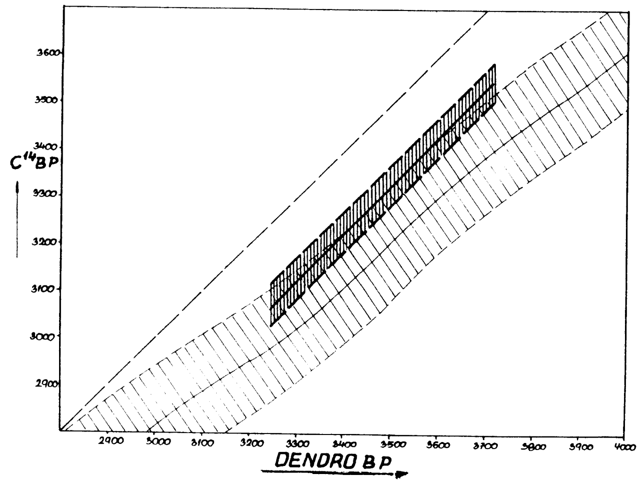

Fig 2B. Trend lines (with band giving average 1σ statistical error)

= this paper; least squares regression line

= bristlecone pine: spline functions (after Clark, 1975)

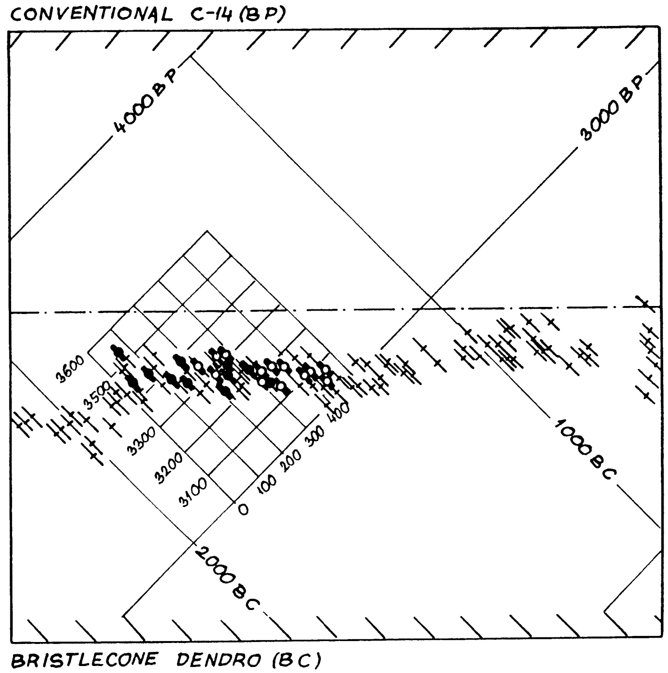

Fig 3. Tentative bristlecone-pine calibration with method proposed by Ferguson, Huber, and Suess (1966)

= this paper (only relative year rings used)

= bristlecone-pine date (after Suess, 1970)

TABLE 3. Comparison between calibration figures from various sources (calendrical minus ^{14}C dates in years)

Calibration figure (years) as quoted from / Conventional ^{14}C date (5568)	1050 3000	1250 3200	1450 3400	1650 BC 3600 BP
Damon, Long, and Wallick (1972)	275±125	325±103	380±103	440± 63
Switsur (1973)	280±125	310±103	375±103	445± 63
Ralph, Michael, and Han (1973)	250	270/340	270/420	460
Clark (1975 (1 σ standard error)	270±112	300±112	320±112	385±112
McKerrell (1975) ("Egyptian historical")	80/170	90/180	120/230	200/320
("50-year average")	210/320	270/310	250/430	430/460
Suess (1979)	260/340	270/330	290	310/450
Freundlich and Schmidt (1983) (least squares fit)	(184± 43)	181± 43	179± 43	(176± 43)

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