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LA JOLLA MEASUREMENTS OF RADIOCARBON IN TREE-RING DATED WOOD

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In 1969, at the Nobel Symposium on "Radiocarbon Variations and Absolute Chronology" in Uppsala, a curve was presented that illustrated the functional dependence of measured conventional radiocarbon dates on true historical ages of wood samples (Suess, 1971). The curve was derived from the results of La Jolla measurements of radiocarbon in bristlecone pine wood dendrochronologically dated by and obtained from Professor C W Ferguson of the University of Arizona (Ferguson, 1968). The curve was intended to be adequate for deriving calibrated radiocarbon dates and also for allowing fairly reliable estimates of the accuracy of the absolute dates obtained in this manner. The basis for the validity of this calibration is the well known fact that, for all practical purposes, wood samples that had grown at the same time show the same radiocarbon content. However, the reverse is not always true: Wood samples showing the same radiocarbon content do not necessarily have the same age because of the windings and steps of the curve (Stuiver and Suess, 1966).

An accurate knowledge of the secular variations of radiocarbon is desirable not only for calibration purposes but also for understanding the geophysical and geochemical factors that cause these variations. The curve published in 1971 illustrated appropriately the character of the variations but was not sufficiently complete to show quantitatively the fine structure features and details that were undoubtedly present. Measurements by other laboratories confirmed the general trend of the curve but have not contributed to our knowledge of the more rapid fluctuations on a time scale of some 100 ys, the so-called "wiggles" of the calibration curve.

Since 1969 our measurements on tree-ring dated wood have been carried out primarily for the purpose of obtaining more detailed information on secular radiocarbon variations. For many years the number of measurements that could be carried out was limited by the number of samples that Profesor Ferguson made available. Unfortunately, these samples often did not come from a time range that appeared particularly interesting. Since 1972, however, long "floating" tree-ring sequences from logs of oak trees in riverbeds of central Europe have been compiled by Becker (1978). Results of measurements from these sequences and their comparisons with bristlecone pine results were presented at the Conference on Dendrochronology at Mainz in 1974 (Suess and Becker, 1977). It was shown that the "δ ^{14}C wiggles" were synchronous in the wood of European oak and of California bristlecone pine and that they had the same amplitudes within limits of errors of the measurements. About 200 numerical values of δ ^{14}C were published at that time. Samples from these oak trees, obtained from Becker, have also made it possible to carry out a sufficient number of measurements for the 4th millenium BC, so that a consistent picture of the variations during this time interval could be established. A graphic presentation of these results was published at the Ninth International Radiocarbon Conference in 1976 (Suess, 1978); their numerical values are included in the tables below. Some values deviate slightly from those given previously because of minor adjustments in counter calibrations.

It was intended to postpone publication of the individual numerical values of these and of the additional results until a statistical analysis of the data, as well as "computer-matching" of floating data with dendrochronologically derived absolute data, and also Fourier analyses could be carried out. Unfortunately, National Science Foundation funding for this purpose was denied, and it now appears that it will take another year or two before the reduction and interpretation of the experimentally obtained raw data will be completed. Therefore, following the requests of many colleagues, the conventional "Libby" ages obtained for wood samples, dendrochronologically dated or belonging to "floating" tree-ring series, are now listed here, in sequence of their ages. The results of the analyses of the data, and their discussion, in particular with respect to their geophysical significance, will be published later.

The results listed in the following tables are published here primarily to help to derive calibrated radiocarbon dates and to estimate their accuracy. At the time the Uppsala curve was published, it was not known that the two Öeschger-Houtermans counters (denoted here B and M respectively) used (Linick, 1976) showed a memory, even after three or four hours of pumping. The errors caused by this memory, in general, did not exceed expected statistical counting errors of the individual measurements but could be recognized by combining a number of results. Many standard and background measurements appeared affected by the ^{14}C-content of the preceding samples, so that all the results on which the curve was based had to be recalculated with revised values. Also, results that were obtained in the run immediately following the counting of a gas with considerably different radiocarbon content, such as a background or standard gas, were routinely omitted. These revised values deviate significantly only for limited time periods from those from which the Uppsala curve was derived. For optimally accurate conversion of conventional radiocarbon dates it is best simply to compare the numerical value of the conventional radiocarbon date of a given sample with those listed in appendix 1.

Column 1 of appendixes 1 and 2: Measurements were carried out approximately in sequence of their LJ-number. Before 1965 they were

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assigned LJ-numbers smaller than LJ-1150. These results were numerically published before (Suess, 1965) and are not included here.

Except for the results that were excluded for the reasons given above, all data obtained in La Jolla before Sept 1977 for radiocarbon in tree-rings are listed in the two appendices. No further attempts were made to screen the results, although, as can easily be seen, some of them are undoubtedly in error. For example, for several measurements the results from the two sets of counting equipment (B and M) differ by considerably more than the expected statistical variation, indicating that one of the two sets was out of order. It will certainly be possible to find and exclude questionable results on the basis of well defined criteria after an analysis of the raw data is made. For further remarks on errors see below.

Until 1969 the La Jolla Radiocarbon Laboratory was located in the basement of Ritter Hall, Scripps Institute of Oceanography. Measurements carried out there have LJ-numbers smaller than LJ 1930. In 1970 the laboratory moved to a new building on Mt Soledad, interrupting operations for about 6 months. During the following 2 years determinations were primarily carried out of radiocarbon in wood less than 100 ys old (Cain and Suess, 1976). These results were not included. In 1972, B Becker of the University of Stuttgart-Hohenheim made available the first samples from his floating European oak chronology. The LJ-numbers of the measurements listed in the two tables correspond approximately to the following years of operations:

1965 to 1969:	LJ 1150 - LP 1930
1970 to 1973:	LJ 2150 - LP 2890
1974:	LJ 2900 - LJ-3175
1975:	LJ 3180 - LJ 3465
1976:	LJ 3465 - LJ 3800
to 8-31-1977:	> LJ 3800

Column 2 of appendix 1: TRL numbers denote bristlecone pine samples and identify the respective tree from which the sample came (Ferguson, 1968). For dendrochronologically dated European samples (available back to 800 BC, the time for which an absolute tree ring chronology was established in Europe) the name of the submitter is listed (for provenience of these samples see Becker (1978) and Holstein [to be published]).

In appendix 2 the name of the floating tree-ring series and the name of the submitter (unless submitted by Becker) is listed in this column.

Column 3: Appendix 1 gives the midpoints of the years of growth of the sequence of rings used for the measurements. Negative numbers denote BC dates, except that, as Ferguson is anxious to point out, these numbers differ from the historical BC dates by 1 year because historians do not use a year zero in their time scale, whereas dendrochronologists and geophysicists do. In appendix 2 this column gives the midpoints of the respective ring numbers of the rings used for the measurements.

Column 4: The number of rings used for each measurement is listed here. With a few exceptions Ferguson makes available samples of ten rings

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of bristlecone pine wood. From European oak trees, samples consisting of one single ring can frequently be obtained.

Column 5 gives the measured $\delta\ {}^{13}C$ as conventionally defined. These values however are not necessarily those for the $\delta\ {}^{13}C$ in the original wood sample but rather for the gas used for counting. Until approximately 1967, this counting gas, acetylene, was prepared via strontium carbide. It can be seen from the $\delta\ {}^{13}C$ values that this method leads to a much greater isotope fractionation than the method using lithium carbide which is now employed. Values in parentheses are estimates used for the calculations of the ages. Until 1970 the $\delta\ {}^{13}C$ measurements were made in the laboratories of Harmon Craig and Samuel Epstein. Since then the old Chicago mass spectrometer of the laboratory of H C Urey, now in the hands of K Marti, is being used.

Column 6 lists the results expressed in conventional (Libby) radiocarbon years. With a few exceptions they were obtained by counting in succession for about 40 hrs in each of two Öeschger Houtermans counters. The characteristics of the two counters were published previously (Linick, 1977). Approximately 20 grams of wood was available for each measurement. The wood was treated with acetone, azide, and base as described previously (Cain and Suess, 1976; Linick, 1977).

Column 7 lists the statistical one sigma standard counting errors of the results. These errors include the statistical uncertainty of backgrounds and standards but not the uncertainties in the ${}^{14}C$-contents of the used standards. Until about 1973 late 19th century wood specimens were used as standards. Comparison measurements with the NBS oxalic acid standard were made only occasionally. It appears now, that the ${}^{14}C$ content in these wood samples may have varied by some 30 per mil, but no accurate figure can be given as such variations are well within the accuracy of the comparison measurements with the NBS oxalic acid, and additional wood to repeat these measurements is no longer available. During the more recent years both wood as well as NBS oxalic acid were used as standards. The conventional radiocarbon ages of these samples were obtained relative to a radiocarbon content of 0.944 ± 0.002 times that of the NBS oxalic acid. No attempts were made to correct for the differences in the used standards, although minor corrections by "computer matching" of data sequences obtained earlier with those obtained with optimally defined standards may be possible and will be attempted.

For several reasons a decrease in the listed statistical errors by increasing counting times and/or counter volumns is of no advantage and uneconomical. With the exception of some rare cases of malfunctioning of electronics, the main additional errors appear to be due to carbon impurities in the samples. In order to avoid these completely, the cellulose would have to be separated and purified, but neither sufficient wood quantities nor necessary manpower is available to carry out such laborious additional work.

Column 8 lists the difference in years of the results obtained for each sample from the two sets of counting equipment M and B. For some samples only one valid measurement was obtained, and in these cases the symbol for the set in which the result was obtained is shown instead of the difference.

As can be seen from the tables, the number of measurements for a given time interval varies greatly over the total period for which measurements have been carried out which is from 1300 AD to around 6000 BC. This is in part a consequence of the limited availability of samples and in part due to the fact that some periods of time appeared particularly interesting. Nevertheless, from the samples so far measured it can be seen already that the carbon-14 in the atmosphere did not fluctuate randomly but followed certain patterns so that one might be tempted to believe in the existence of cycles or at least in the significance of certain "magic numbers" of years. It can be expected that further measurements, which will be carried out during the next year or two, will complete the picture for the whole period of time for which tree-ring dated wood is available and will then make it possible to decide whether or not the observed patterns have a true physical meaning. It will then be time to look for correlations with other geophysical and geochemical parameters and to speculate about the explanations and interpretations of the findings.

ACKNOWLEDGMENTS

The results reported here represent only a fraction of the total number of measurements that are being carried out by the laboratory. Thanks to the unusual enthusiasm, efficiency, and dedication of the staff, in particular of Ms Carol Hutto and Dr Timothy Linick, the laboratory has for more than 6 years operated practically uninterruptedly on a 24 hour a day, 7 day a week basis. Besides taking care of all the technical operations for the radiocarbon determinations, Dr Linick is carrying out computerized data reductions and, together with Ms Hutto, mass spectrometric carbon-13 determinations. In this connection thanks are due also to Drs K Marti and G Lugmair for assistance and advice in the mass spectrometer operations.

As always it should be emphasized that this work is based entirely on the tree-ring sequence established for the past 8000 yrs by C W Ferguson. The dendrochronologically dated wood samples came from Dr. Ferguson with the exception of some samples from the European chronology that extends back to 800 BC. Almost all the samples from the floating chronologies were obtained from B Becker of the University of Stuttgart-Hohenheim. Dr E Hollstein, Landesmuseum Trier, supplied samples from the fifth and sixth century BC.

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APPENDIX 1

Conventional radiocarbon ages of dendrochronologically-dated wood (TRL samples supplied by C W Ferguson; Holstein samples by E Holstein, Trier, W Germany, to be pub; all others by B Becker, 1978.)

1.	2.	3.	4.	5.	6.	7.	8.
LJ-3314	TRL 70-46	−6045	10	−21.3	7095	51	73
LJ-3306	TRL 70-46	−6025	10	−20.4	7116	51	−220
LJ-3312	TRL 70-46	−6015	10	−20.1	7149	51	78
LJ-2874	TRL 70-46	−6015	10	−20.9	7027	57	154
LJ-2875	TRL 70-46	−5995	10	−21.5	7119	57	87
LJ-3311	TRL 70-46	−5995	10	−21.1	7187	52	79
LJ-3310	TRL 70-46	−5985	10	−20.7	7117	51	125
LJ-3313	TRL 70-46	−5975	10	−20.0	7046	50	−25
LJ-2877	TRL 70-46	−5975	10	−21.3	7087	57	69
LJ-3308	TRL 70-46	−5965	10	−21.1	6949	51	−247
LJ-2196	TRL 70-20	−5402	10	−21.1	6352	60	−17
LJ-2206	TRL 70-20	−5362	10	−21.6	6248	58	−6
LJ-1921	TRL 67-35	−5290	14	−21.9	6111	87	−68
LJ-2207	TRL 70-20	−5282	10	−21.4	6117	59	9
LJ-2198	TRL 70-20	−5263	10	−21.5	6311	59	−67
LJ-2204	TRL 70-20	−5243	10	−21.2	6143	60	−39
LJ-2194	TRL 70-20	−5223	10	−21.2	6224	62	28
LJ-2197	TRL 70-20	−5203	10	−21.2	6126	60	38
LJ-2435	TRL 70-20	−5182	10	−21.8	6163	55	132
LJ-2439	TRL 70-20	−5162	10	−22.2	6188	55	−56
LJ-2395	TRL 70-20	−5143	10	−20.4	6049	61	60
LJ-1538	TRL 63-92E	−5083	54	(−22.0)	6082	68	20
LJ-1492	TRL 63-92E	−5075	10	−21.8	6139	63	29
LJ-1713	TRL 63-92E	−5055	10	−21.9	6031	75	B
LJ-1712	TRL 63-92E	−5035	10	−21.4	6151	96	M
LJ-1734	TRL 63-92E	−4965	10	(−22.0)	6009	59	−85
LJ-1732	TRL 63-92E	−4945	10	(−22.0)	5958	58	−73
LJ-1739	TRL 63-92E	−4895	10	−22.5	5921	58	14
LJ-1740	TRL 63-92E	−4875	10	−22.0	5916	58	12
LJ-1539	TRL 63-92E	−4795	10	−21.4	5969	66	5
LJ-2164	TRL 63-92E	−4753	16	−22.2	5784	57	−5
LJ-2179	TRL 63-92E	−4735	10	−22.0	5738	73	B
LJ-2167	TRL 63-92E	−4695	10	−21.2	5625	57	−14
LJ-2177	TRL 63-92E	−4675	10	−22.8	5782	58	143
LJ-2160	TRL 63-92E	−4655	10	−22.3	5703	95	M
LJ-2170	TRL 63-92E	−4635	10	(−21.0)	5795	58	107
LJ-2165	TRL 63-92E	−4615	10	−21.6	5684	56	18
LJ-2173	TRL 63-92E	−4575	10	−21.9	5802	59	31
LJ-1543	TRL 63-92	−4373	34	−22.8	5433	84	B
LJ-1503	TRL 63-92	−4325	10	−22.3	5334	59	9
LJ-1506	TRL 63-92	−4305	10	−21.8	5387	60	−13
LJ-1505	TRL 63-92	−4265	10	−21.8	5404	104	M
LJ-3548	TRL 71-52	−4235	10	−19.4	5390	48	−9
LJ-1504	TRL 63-92	−4225	10	−21.8	5241	103	M
LJ-3547	TRL 71-52	−4215	10	−20.3	5334	47	−46
LJ-1553	TRL 63-92	−4205	10	−22.8	5174	64	102
LJ-3546	TRL 71-52	−4205	10	−21.0	5305	47	−93
LJ-3554	TRL 71-52	−4185	10	−21.4	5327	52	80
LJ-1542	TRL 63-92	−4179	22	−23.1	5269	61	67
LJ-3553	TRL 71-52	−4175	10	−20.4	5327	47	−22
LJ-3552	TRL 71-52	−4155	10	−20.6	5286	53	26
LJ-3555	TRL 71-52	−4135	10	−21.0	5308	47	71
LJ-2632	TRL 71-52	−4125	10	−20.6	5150	54	−147
LJ-3556	TRL 71-52	−4115	10	−20.6	5370	47	−39
LJ-2633	TRL 71-52	−4105	10	−20.9	5167	53	−37
LJ-1302	TRL 65-F131	−4077	52	−28.7	5209	59	−100

APPENDIX 1 (continued)

1.	2.	3.	4.	5.	6.	7.	8.
LJ-2757	TRL 71-52	—4065	10	—21.3	5272	51	—177
LJ-1307	TRL 65-F131	—4035	35	—27.3	5186	81	M
LJ-2818	TRL 71-52	—4025	10	—21.1	5203	50	73
LJ-2820	TRL 71-52	—4005	10	—21.5	5300	51	49
LJ-1305	TRL 65-F131	—4005	26	—25.6	5204	59	8
LJ-2817	TRL 71-52	—3985	10	—20.4	5264	50	—147
LJ-2821	TRL 71-52	—3965	10	—21.0	5171	50	54
LJ-2819	TRL 71-52	—3945	10	—20.4	5210	50	—60
LJ-1306	TRL 65-F131	—3938	26	—24.6	5203	82	M
LJ-2825	TRL 71-52	—3905	10	—21.3	5101	49	25
LJ-2826	TRL 71-52	—3885	10	—20.9	4979	49	57
LJ-2828	TRL 71-52	—3865	10	—21.2	5024	49	—71
LJ-2830	TRL 71-52	—3845	10	—20.8	5117	49	—140
LJ-1304	TRL 65-F131	—3822	17	—23.7	5057	59	—19
LJ-2832	TRL 71-52	—3805	10	—20.3	5031	49	31
LJ-1299	TRL 63-34	—3790	20	—26.3	4945	58	—23
LJ-3504	TRL 71-52	—3785	10	—20.7	4865	46	—40
LJ-1301	TRL 63-34	—3772	24	—30.1	5027	56	—113
LJ-3505	TRL 71-52	—3765	10	—19.4	5001	46	—239
LJ-3526	TRL 71-52	—3745	10	—20.8	4842	46	49
LJ-3529	TRL 71-52	—3725	10	—20.0	4951	46	3
LJ-3512	TRL 71-52	—3705	10	—20.2	4983	45	—129
LJ-1300	TRL 63-34	—3700	20	—25.5	4927	58	8
LJ-3520	TRL 71-52	—3685	10	—20.3	4874	46	—17
LJ-3521	TRL 71-52	—3665	10	—20.0	4893	45	67
LJ-3513	TRL 71-52	—3645	10	—20.1	4893	46	1
LJ-1298	TRL 63-34	—3635	10	—22.9	4840	56	124
LJ-1340	TRL 63-34	—3625	10	—35.1	4717	55	—75
LJ-3510	TRL 71-52	—3625	10	—20.3	4767	45	41
LJ-1341	TRL 63-34	—3605	10	—26.3	4759	57	62
LJ-3511	TRL 71-52	—3605	10	—20.3	4758	45	—97
LJ-3522	TRL 71-52	—3585	10	—20.6	4779	45	—142
LJ-3523	TRL 71-52	—3565	10	—20.6	4748	45	—10
LJ-3525	TRL 71-52	—3545	10	—20.6	4918	46	26
LJ-3528	TRL 71-52	—3525	10	—21.1	4732	45	—53
LJ-3524	TRL 71-52	—3505	10	—20.6	4752	45	—92
LJ-1286	TRL 63-89	—3495	10	—23.9	4710	58	33
LJ-3527	TRL 71-52	—3485	10	—20.8	4673	46	—93
LJ-1705	TRL 63-89	—3485	10	—22.1	4632	53	23
LJ-1288	TRL 63-89	—3465	10	—26.8	4628	57	22
LJ-1294	TRL 63-89	—3455	10	—24.9	4626	55	1
LJ-1342	TRL 63-89	—3445	10	—22.9	4660	56	45
LJ-1290	TRL 63-89	—3435	10	—23.4	4636	55	—12
LJ-1322	TRL 63-89	—3415	10	—24.0	4715	55	3
LJ-1289	TRL 63-89	—3405	10	—23.8	4637	55	—102
LJ-3929	TRL 71-52	—3355	10	—21.2	4560	46	52
LJ-3934	TRL 71-52	—3335	10	—21.0	4469	46	—92
LJ-1585	TRL 63-34	—3325	10	—21.9	4448	65	99
LJ-3937	TRL 71-52	—3315	10	—20.6	4434	45	—13
LJ-3932	TRL 71-52	—3301	10	—21.2	4485	46	115
LJ-1287	TRL 63-89	—3290	20	—30.4	4440	56	—53
LJ-1529	TRL 63-34	—3275	10	—22.6	4392	59	—6
LJ-1526	TRL 63-34	—3255	10	—21.8	4332	60	—9
LJ-1276	TRL 63-89	—3220	20	—23.8	4444	57	—12
LJ-1524	TRL 63-34	—3175	10	—22.2	4434	56	60
LJ-1489	TRL 63-34	—3125	10	—23.3	4365	56	0
LJ-1487	TRL 63-34	—3115	30	—21.6	4399	58	34
LJ-1275	TRL 63-89	—3105	10	—30.7	4371	77	M
LJ-1497	TRL 63-89	—3065	10	—23.2	4375	56	84
LJ-1512	TRL 63-89	—3045	10	—22.5	4436	56	—59

Appendix 1 (continued)

1.	2.	3.	4.	5.	6.	7.	8.
LJ-1494	TRL 63-89	−3025	10	−23.7	4419	56	153
LJ-1704	TRL 63-34	−3005	10	−20.9	4363	47	20
LJ-1268	TRL 63-89	−2995	10	−22.7	4337	57	−32
LJ-1496	TRL 63-89	−2985	10	−22.7	4315	55	−21
LJ-1662	TRL 63-89	−2965	10	−22.2	4330	50	3
LJ-1498	TRL 63-89	−2945	10	−22.7	4323	55	115
LJ-1663	TRL 63-89	−2925	10	−22.0	4220	50	95
LJ-1495	TRL 63-89	−2905	10	−23.1	4217	55	−75
LJ-1267	TRL 63-89	−2875	10	−23.2	4184	78	M
LJ-1511	TRL 63-89	−2825	10	−22.0	3977	54	−18
LJ-1510	TRL 63-89	−2805	10	−21.6	4125	54	−30
LJ-1692	TRL 63-89	−2785	10	−23.2	4113	51	43
LJ-1270	TRL 63-89	−2780	20	−26.0	4093	56	19
LJ-1584	TRL 63-89	−2745	10	−22.5	4088	63	−30
LJ-1519	TRL 63-89	−2718	25	−22.1	4057	73	B
LJ-1269	TRL 63-89	−2680	20	−22.3	4087	59	12
LJ-1313	TRL 63-89	−2645	10	−23.4	4021	53	−53
LJ-1319	TRL 63-89	−2613	35	−32.6	4137	76	M
LJ-1316	TRL 63-89	−2585	10	−23.6	4103	54	−109
LJ-1320	TRL 63-89	−2565	10	−27.5	4050	53	−58
LJ-1321	TRL 63-89	−2545	10	−25.8	3978	53	67
LJ-1327	TRL 63-89	−2485	10	−22.7	4019	76	M
LJ-1326	TRL 63-89	−2465	10	−27.6	3949	75	M
LJ-1333	TRL 63-89	−2445	10	−36.2	3851	52	−76
LJ-1325	TRL 63-89	−2425	10	−23.1	4007	76	M
LJ-1328	TRL 63-89	−2405	10	−24.0	3926	55	−33
LJ-1185	TRL 63-53	−2362	7	−22.0	3856	96	B
LJ-1187	TRL 63-53	−2345	7	−21.8	3734	58	97
LJ-3852	TRL 63-53	−2324	4	(−24.9)	3666	84	M
LJ-3831	TRL 63-53	−2315	6	−19.4	3745	46	33
LJ-1198	TRL 63-53	−2308	5	−23.3	3770	55	−25
LJ-3836	TRL 63-53	−2308	4	−20.0	3819	45	62
LJ-1197	TRL 63-43	−2302	28	−25.4	3837	75	M
LJ-3834	TRL 63-53	−2300	4	−19.9	3751	54	159
LJ-1193	TRL 63-53	−2298	5	−22.2	3727	54	44
LJ-3835	TRL 63-53	−2284	4	−20.0	3756	45	62
LJ-1194	TRL 63-43	−2282	23	−23.7	3769	54	18
LJ-1186	TRL 63-53	−2282	5	−22.0	3749	59	−161
LJ-2951	TRL 63-53	−2279	3	−20.6	3710	41	−119
LJ-3240	TRL 63-53	−2275	4	−20.1	3755	42	3
LJ-2415	TRL 63-53	−2272	16	−19.7	3683	47	−8
LJ-3238	TRL 63-53	−2268	5	−20.5	3754	33	17
LJ-3832	TRL 63-53	−2268	4	−19.7	3759	46	−90
LJ-3236	TRL 63-53	−2252	5	−20.0	3679	42	56
LJ-3242	TRL 63-53	−2248	5	−20.3	3779	42	−114
LJ-1204	TRL 63-53	−2246	8	−22.4	3823	75	M
LJ-3023	TRL 63-53	−2245	10	−20.3	3774	42	31
LJ-3830	TRL 63-53	−2244	4	−20.0	3666	47	−10
LJ-3235	TRL 63-53	−2238	5	−19.4	3803	42	203
LJ-3827	TRL 63-53	−2236	4	−20.2	3795	45	28
LJ-3237	TRL 63-53	−2222	5	−20.4	3708	42	−70
LJ-3851	TRL 63-53	−2220	4	−19.8	3703	59	B
LJ-2950	TRL 63-53	−2214	3	−21.5	3719	41	75
LJ-3829	TRL 63-53	−2213	6	−19.9	3751	46	57
LJ-2924	TRL 63-53	−2210	4	−21.2	3726	42	−129
LJ-2952	TRL 63-53	−2207	3	−21.2	3665	41	119
LJ-2923	TRL 63-53	−2204	3	−20.7	3729	41	−25
LJ-3239	TRL 63-53	−2202	5	−20.4	3736	41	119
LJ-2947	TRL 63-53	−2201	3	−21.8	3691	40	−46
LJ-3833	TRL 63-53	−2197	4	−20.2	3713	45	−88

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APPENDIX 1 (continued)

1.	2.	3.	4.	5.	6.	7.	8.
LJ-3241	TRL 63-53	−2190	5	−20.5	3650	42	14
LJ-3828	TRL 63-53	−2188	4	−19.1	3660	42	0
LJ-1180	TRL 63-53	−2186	20	−23.2	3892	83	B
LJ-3022	TRL 63-53	−2178	10	−20.2	3663	43	−61
LJ-3021	TRL 63-53	−2117	5	−20.5	3717	43	−30
LJ-1199	TRL 63-53	−2105	10	−24.0	3629	54	−34
LJ-1181	TRL 63-53	−2074	8	−21.9	3670	59	24
LJ-1188	TRL 63-53	−2044	18	−23.9	3566	75	M
LJ-1183	TRL 63-53	−2025	10	−23.1	3583	59	−122
LJ-1483	TRL 63-89	−2005	10	−22.0	3635	55	−34
LJ-1694	TRL 63-89	−1945	10	−20.9	3574	49	6
LJ-1475	TRL 63-89	−1925	10	−22.3	3482	53	−15
LJ-1589	TRL 63-89	−1905	10	(−22.0)	3643	78	M
LJ-1476	TRL 63-89	−1885	10	−22.6	3515	53	−3
LJ-1592	TRL 63-89	−1865	10	−21.5	3501	77	M
LJ-1472	TRL 63-89	−1845	10	−22.1	3558	67	B
LJ-1596	TRL 63-89	−1825	10	−21.4	3490	77	M
LJ-1473	TRL 63-89	−1805	10	−22.3	3469	53	−6
LJ-1467	TRL 63-89	−1785	10	−22.4	3524	57	3
LJ-1853	TRL 63-89	−1775	10	−21.3	3483	63	−30
LJ-1850	TRL 63-89	−1755	10	−21.5	3475	63	17
LJ-1468	TRL 63-89	−1745	10	−22.1	3366	74	B
LJ-1852	TRL 63-89	−1735	10	−21.4	3387	62	−165
LJ-1474	TRL 63-89	−1725	10	−22.1	3427	53	10
LJ-1851	TRL 63-89	−1715	10	−21.4	3421	62	−10
LJ-1469	TRL 63-89	−1705	10	−21.7	3420	75	B
LJ-1857	TRL 63-89	−1695	10	−21.0	3429	62	27
LJ-1583	TRL 63-89	−1665	10	−21.1	3246	59	−21
LJ-1839	TRL 63-89	−1655	10	−21.8	3320	62	101
LJ-1465	TRL 63-89	−1645	10	−21.5	3321	57	26
LJ-1537	TRL 63-89	−1625	10	−21.8	3325	55	−29
LJ-1845	TRL 63-89	−1615	10	−22.6	3246	61	58
LJ-1847	TRL 63-89	−1595	10	−21.2	3266	62	−88
LJ-1693	TRL 63-89	−1585	10	−21.0	3179	48	−71
LJ-1258	TRL 63-43	−1580	20	−27.3	3236	78	B
LJ-1840	TRL 63-89	−1575	10	−21.7	3252	61	12
LJ-1531	TRL 63-89	−1555	30	−22.4	3152	69	B
LJ-1846	TRL 63-89	−1555	10	−21.6	3189	61	33
LJ-1466	TRL 63-89	−1545	10	−21.1	3275	57	35
LJ-1838	TRL 63-89	−1515	10	−21.7	3160	61	88
LJ-1828	TRL 63-89	−1505	10	−22.0	3212	61	−23
LJ-1525	TRL 63-89	−1505	10	−21.5	3149	55	76
LJ-1253	TRL 63-430	−1500	20	(−23.0)	3147	78	B
LJ-1833	TRL 63-89	−1495	10	−21.5	3100	61	5
LJ-1482	TRL 63-89	−1485	10	−21.9	3142	52	−4
LJ-1530	TRL 63-89	−1479	17	−22.6	3190	52	−42
LJ-1837	TRL 63-89	−1475	10	−21.2	3102	61	122
LJ-1834	TRL 63-89	−1455	10	−21.5	3211	61	−63
LJ-1481	TRL 63-89	−1445	10	−22.0	3154	52	150
LJ-1259	TRL 63-43	−1412	15	−22.8	3167	53	−27
LJ-1703	TRL 63-89	−1405	10	−20.8	3011	62	B
LJ-1903	TRL 63-43	−1395	10	−21.8	3061	79	M
LJ-1885	TRL 63-43	−1385	10	−22.6	3003	91	B
LJ-1882	TRL 63-43	−1375	10	−22.1	3044	59	−61
LJ-1894	TRL 63-43	−1365	10	−22.6	2927	59	80
LJ-1884	TRL 63-43	−1355	10	−22.3	3012	59	−61
LJ-2399	TRL 63-43	−1345	10	−22.0	2937	46	−125
LJ-1893	TRL 63-43	−1325	10	−22.2	3095	60	−77
LJ-1881	TRL 63-43	−1315	10	−22.7	2943	59	95
LJ-1870	TRL 63-43	−1285	10	−21.7	2976	91	B

APPENDIX 1 (continued)

1.	2.	3.	4.	5.	6.	7.	8.
LJ-1345	TRL 63-43	—1250	40	—26.5	2980	51	80
LJ-1872	TRL 63-43	—1235	10	—22.9	2970	60	27
LJ-1871	TRL 63-43	—1225	10	—22.0	2973	60	17
LJ-1254	TRL 63-43	—1215	30	(—23.0)	2874	77	B
LJ-1865	TRL 63-43	—1205	10	—21.1	2862	60	11
LJ-1876	TRL 63-43	—1195	10	—22.4	2933	60	—9
LJ-1548	TRL 63-43	—1185	10	—22.7	2860	52	6
LJ-1861	TRL 63-43	—1175	10	(—21.0)	2924	60	—80
LJ-1878	TRL 63-43	—1165	10	—21.3	2989	59	—41
LJ-1858	TRL 63-43	—1155	10	—22.1	2985	60	41
LJ-1873	TRL 63-43	—1145	10	—21.8	3032	61	—88
LJ-1877	TRL 63-43	—1135	10	—22.2	2945	59	74
LJ-1249	TRL 63-43C	—1125	30	—26.1	2943	52	—70
LJ-1859	TRL 63-43	—1125	10	—21.8	2983	60	41
LJ-1860	TRL 63-43	—1115	10	—21.6	2957	61	102
LJ-1205	TRL 63-43	—1085	30	—23.5	2831	56	—45
LJ-1550	TRL 63-43	—1065	10	—21.6	2787	51	—55
LJ-1556	TRL 63-43	—1025	10	—22.2	2790	53	30
LJ-1549	TRL 63-43	—1005	10	—22.0	2819	51	—6
LJ-1209	TRL 63-43	—988	25	—24.4	2768	51	—42
LJ-1554	TRL 63-43	—985	10	—22.3	2752	54	—66
LJ-1695	TRL 63-43	—975	10	—22.2	2681	46	—123
LJ-1250	TRL 63-43	—962	25	—27.0	2726	51	76
LJ-1208	TRL 63-43	—938	25	—22.9	2850	52	22
LJ-1564	TRL 63-43	—905	10	—21.4	2798	54	27
LJ-1557	TRL 63-43	—895	10	—22.7	2708	56	—127
LJ-1210	TRL 63-43	—888	25	—23.2	2677	52	144
LJ-1566	TRL 63-43	—885	10	—21.4	2684	53	7
LJ-1559	TRL 63-43	—879	18	—22.8	2774	75	B
LJ-1696	TRL 63-43	—865	10	—21.5	2639	47	12
LJ-1248	TRL 63-43	—862	25	—23.0	2663	51	—21
LJ-1558	TRL 63-43	—855	10	—23.5	2775	57	7
LJ-1590	TRL 63-43	—845	10	—21.8	2740	74	M
LJ-1207	TRL 63-43	—834	31	—25.4	2702	75	B
LJ-1591	TRL 63-43	—825	10	—22.2	2718	73	M
LJ-1565	TRL 63-43	—815	10	—22.1	2597	53	41
LJ-1567	TRL 63-43	—805	10	—21.7	2579	53	—23
LJ-1570	TRL 63-43	—785	10	—22.2	2584	56	—18
LJ-3913	TRL 63-43	—785	10	(—21.8)	2454	64	M
LJ-3915	TRL 63-43	—775	10	—21.8	2486	41	27
LJ-3911	TRL 63-43	—765	10	—21.7	2465	41	38
LJ-3912	TRL 63-43	—755	10	—21.6	2398	41	—83
LJ-3907	TRL 63-43	—745	10	—21.8	2414	41	35
LJ-3914	TRL 63-43	—735	10	—21.4	2496	41	—4
LJ-1572	TRL 63-43	—725	10	—22.2	2423	55	25
LJ-1213	TRL 62-68	—712	25	—23.2	2416	50	—40
LJ-1595	TRL 63-43	—705	10	—22.1	2444	73	M
LJ-3910	TRL 63-43	—705	10	—22.4	2382	41	—14
LJ-3908	TRL 63-43	—695	10	—22.0	3435	41	—9
LJ-1283	TRL 62-68	—685	20	—22.7	2518	51	—98
LJ-1573	TRL 63-43	—685	10	—22.1	2439	55	124
LJ-3906	TRL 63-43	—685	10	—22.0	2487	42	23
LJ-1697	TRL 63-43	—665	10	—21.7	2418	46	—31
LJ-1571	TRL 63-43	—645	10	(—22.0)	2508	55	9
LJ-3909	TRL 63-43	—645	10	—22.4	2395	42	86
LJ-1574	TRL 63-43	—625	10	—22.0	2517	55	51
LJ-1284	TRL 62-68	—610	20	—22.4	2514	69	M
LJ-1577	TRL 63-43	—605	10	—22.2	2358	83	M
LJ-3903	TRL 63-43	—595	10	—21.7	2441	42	—82
LJ-1575	TRL 63-43	—585	10	—22.1	2294	55	—87

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APPENDIX 1 (continued)

1.	2.	3.	4.	5.	6.	7.	8.
LJ-3891	TRL 63-43	−585	10	−22.3	2162	45	−43
LJ-3892	TRL 63-43	−575	10	−21.9	2397	41	75
LJ-1578	TRL 63-43	−545	10	−22.4	2432	56	29
LJ-3889	TRL 63-43	−545	10	−22.1	2288	42	45
LJ-3900	TRL 63-43	−535	10	−21.8	2374	42	−4
LJ-1576	TRL 63-43	−525	10	−22.0	2399	56	−88
LJ-3902	TRL 63-43	−525	10	−21.8	2348	41	−127
LJ-3901	TRL 63-43	−515	10	−21.1	2407	41	−66
LJ-1671	TRL 63-43	−495	10	−22.1	2230	45	−10
LJ-3890	TRL 63-43	−495	10	−22.3	2333	46	102
LJ-3864	Holstein	−488	10	−25.2	2331	42	−3
LJ-3860	Holstein	−478	10	−25.4	2313	42	−16
LJ-1669	TRL 63-43	−475	10	−21.2	2420	45	63
LJ-3865	Holstein	−470	5	−24.8	2274	46	−74
LJ-3866	Holstein	−465	5	−25.1	2404	41	76
LJ-3859	Holstein	−458	10	−25.6	2336	42	−118
LJ-1672	TRL 63-43	−455	10	−21.1	2136	45	−88
LJ-3863	Holstein	−448	10	−25.7	2334	42	19
LJ-3861	Holstein	−438	10	−25.7	2294	42	−155
LJ-1670	TRL 63-43	−415	10	−22.7	2339	45	−50
LJ-3876	TRL 63-43	−405	10	−22.4	2247	45	65
LJ-1678	TRL 63-43	−395	10	−21.6	2243	45	−70
LJ-3874	TRL 63-43	−395	10	−21.4	2243	41	26
LJ-3878	TRL 63-43	−385	10	−21.5	2196	41	−105
LJ-1682	TRL 63-43	−375	10	−21.1	2145	45	9
LJ-3872	TRL 63-43	−375	10	−22.0	2147	41	−138
LJ-3877	TRL 63-43	−365	10	−22.1	2152	42	66
LJ-3862	Holstein	−358	10	−25.1	2157	42	28
LJ-1679	TRL 63-43	−355	10	−21.5	2171	45	−2
LJ-3875	TRL 63-43	−355	10	−21.3	2131	41	−63
LJ-3341	D4 Becker	−338	1	−26.3	2141	39	−40
LJ-3423	D4 Becker	−336	1	−25.4	2240	39	170
LJ-3342	TRL 63-43	−335	10	−21.9	2141	38	−51
LJ-1687	TRL 63-43	−335	10	−21.4	2129	45	−39
LJ-3419	D4 Becker	−334	1	−26.0	2192	38	69
LJ-3415	D4 Becker	−332	1	−25.5	2139	38	69
LJ-3412	D4 Becker	−330	1	−25.4	2265	39	−5
LJ-3345	D4 Becker	−326	1	−24.1	2197	55	M
LJ-3346	TRL 63-43	−325	10	−21.5	2165	38	−42
LJ-3411	D4 Becker	−324	1	−25.3	2267	39	−3
LJ-3422	D4 Becker	−320	1	−24.4	2257	39	208
LJ-3421	TRL 63-43	−315	10	−21.9	2213	38	144
LJ-1680	TRL 63-43	−315	10	−21.2	2146	45	13
LJ-1219	TRL 62-68	−312	25	−21.8	2305	71	B
LJ-3413	TRL 63-43	−305	10	−21.4	2178	39	−13
LJ-3414	D4 Becker	−300	1	−23.5	2151	38	−39
LJ-3340	TRL 63-43	−295	10	−21.7	2218	39	154
LJ-1686	TRL 63-43	−295	10	−20.7	2176	45	44
LJ-3339	D4 Becker	−295	1	−24.5	2215	38	−112
LJ-3333	D4 Becker	−289	1	−24.0	2221	38	74
LJ-3332	TRL 63-43	−285	10	−21.5	2215	38	−55
LJ-3416	TRL 63-43	−275	10	−21.3	2175	38	−57
LJ-1681	TRL 63-43	−275	10	−21.5	2195	45	−59
LJ-3343	D4 Becker	−268	1	−23.9	2168	38	−103
LJ-3344	TRL 63-43	−265	10	−21.6	2174	39	−135
LJ-3331	D4 Becker	−258	1	−23.4	2178	39	26
LJ-3418	TRL 63-43	−255	10	−22.4	2246	39	66
LJ-3334	TRL 63-43	−245	10	−22.5	2191	42	16
LJ-3335	D4 Becker	−240	1	−24.6	2221	38	95
LJ-3336	TRL 63-43	−235	10	−21.2	2197	38	108

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Appendix 1 (continued)

1.	2.	3.	4.	5.	6.	7.	8.
LJ-3338	TRL 63-43	−225	10	−22.4	2198	38	62
LJ-1232	TRL 62-68	−225	10	−23.2	2221	50	36
LJ-1231	TRL 62-68	−200	20	−22.1	2228	69	M
LJ-3420	D4 Becker	−190	1	−24.4	2196	38	−36
LJ-1233	TRL 62-68	−180	20	−22.4	2158	50	−54
LJ-1230	TRL 62-68	−160	20	−22.7	2119	50	−39
LJ-1229	TRL 62-68	−90	20	−23.2	2007	49	84
LJ-1216	TRL 62-68	−55	30	−23.1	2057	49	−19
LJ-1221	TRL 62-68	−30	20	−21.3	1979	49	76
LJ-1214	TRL 62-68	−10	20	−22.3	2036	49	87
LJ-2441	TRL 71-51	5	10	−20.7	1988	43	−78
LJ-2444	TRL 71-51	25	10	−21.3	1861	44	−224
LJ-2443	TRL 71-51	45	10	−20.0	1910	43	−18
LJ-2478	TRL 71-51	85	10	−21.8	1796	44	−34
LJ-2480	TRL 71-51	125	10	−21.2	1792	46	38
LJ-2624	TRL 71-51	185	10	−20.1	1831	45	−84
LJ-2626	TRL 71-51	205	10	−19.7	1857	44	100
LJ-2627	TRL 71-51	225	10	−19.8	1769	43	−32
LJ-2622	TRL 71-51	245	10	−20.3	1953	44	122
LJ-1746	TRL 63-48	285	10	−20.1	1722	45	68
LJ-2371	TRL 63-48	295	10	−19.6	1738	56	B
LJ-1759	TRL 63-48	305	10	−19.6	1682	45	−24
LJ-1752	TRL 63-48	315	10	−19.8	1691	45	−28
LJ-2383	TRL 63-48	335	10	−19.6	1704	43	−13
LJ-1747	TRL 63-48	345	10	−20.2	1635	45	134
LJ-1756	TRL 63-48	355	10	−20.7	1595	44	96
LJ-2385	TRL 63-48	375	10	−20.1	1566	43	75
LJ-1751	TRL 63-48	385	10	−20.1	1615	45	−54
LJ-2380	TRL 63-48	395	10	−19.8	1596	43	−38
LJ-1758	TRL 63-48	405	10	−19.2	1601	45	31
LJ-2389	TRL 63-48	415	10	−20.1	1625	43	−9
LJ-1748	TRL 63-48	425	10	−20.2	1572	45	77
LJ-2382	TRL 63-48	435	10	−19.6	1543	57	B
LJ-1757	TRL 63-48	455	10	−19.9	1544	45	28
LJ-1750	TRL 63-48	475	10	−19.8	1472	44	−60
LJ-2368	TRL 63-48	495	10	−19.9	1358	43	−83
LJ-1749	TRL 63-48	505	10	−19.9	1414	44	−32
LJ-1718	TRL 67-30	705	10	−21.1	1254	70	M
LJ-1815	TRL 67-30	715	10	−20.8	1228	45	−24
LJ-1744	TRL 67-30	728	4	−21.8	1266	44	19
LJ-1715	TRL 67-30	735	10	−21.1	1221	44	−32
LJ-1730	TRL 67-30	745	10	−20.7	1204	44	−134
LJ-1722	TRL 67-30	755	10	−20.7	1233	44	18
LJ-1724	TRL 67-30	775	10	−20.2	1210	44	54
LJ-1149	TRL 63-48	778	15	−22.4	1172	54	12
LJ-1811	TRL 67-30	785	10	−21.0	1153	45	89
LJ-1714	TRL 67-30	795	10	−20.3	1251	44	−6
LJ-1813	TRL 67-30	805	10	−21.4	1276	45	34
LJ-1721	TRL 67-30	815	10	−20.6	1097	44	−70
LJ-1743	TRL 67-30	821	3	−22.0	1201	44	4
LJ-1723	TRL 67-30	835	10	−20.2	1129	44	3
LJ-1731	TRL 67-30	845	10	−21.0	1160	44	24
LJ-1720	TRL 67-30	855	10	−20.7	1210	70	M
LJ-1814	TRL 67-30	865	10	−21.2	1217	45	11
LJ-1716	TRL 67-30	875	10	−20.4	1075	44	−32
LJ-1812	TRL 67-30	885	10	−20.5	1112	45	20
LJ-1719	TRL 67-30	895	10	−20.7	1080	44	28
LJ-3223	TRL 67-3	1085	10	−21.2	830	37	102
LJ-3228	TRL 67-3	1095	10	−21.7	961	37	43
LJ-3222	TRL 67-3	1105	10	−21.5	909	36	−43

APPENDIX 1 (continued)

1.	2.	3.	4.	5.	6.	7.	8.
LJ-3229	TRL 67-3	1115	10	−21.0	892	37	29
LJ-3250	Eschelbronn	1120	2	−24.9	977	37	0
LJ-3224	TRL 67-3	1125	10	−21.2	935	37	−70
LJ-3227	TRL 67-3	1135	10	−22.0	862	37	5
LJ-3249	Eschelbronn	1140	1	−24.5	853	37	−65
LJ-3226	TRL 67-3	1145	10	−20.9	864	36	−79
LJ-3259	Eschelbronn	1160	1	−25.6	801	36	118
LJ-3234	TRL 67-3	1165	10	−20.8	831	37	5
LJ-3256	Eschelbronn	1170	1	−25.6	858	36	96
LJ-3251	Eschelbronn	1180	1	−26.3	847	36	−4
LJ-3225	TRL 67-3	1185	10	−21.4	802	36	−131
LJ-3255	Eschelbronn	1190	1	−25.8	815	37	13
LJ-3277	Gottlieben	1193	7	−26.5	838	37	−100
LJ-3254	Eschelbronn	1200	1	−25.9	851	36	72
LJ-3231	TRL 67-3	1205	10	−21.7	769	37	−2
LJ-3275	Gottlieben	1206	4	−26.5	880	37	114
LJ-3257	Eschelbronn	1210	1	−26.0	784	36	32
LJ-3281	Eschelbronn	1214	2	−26.2	818	60	B
LJ-3276	Gottlieben	1216	4	−26.0	839	37	5
LJ-3260	Eschelbronn	1220	1	−25.8	847	37	−18
LJ-3232	TRL 67-3	1225	10	−21.0	782	36	−8
LJ-3253	Gottlieben	1230	1	−25.5	776	36	−63
LJ-3278	Gottlieben	1236	4	−26.0	669	52	M
LJ-3258	Eschelbronn	1241	3	−25.9	758	36	52
LJ-3233	TRL 67-3	1245	10	−21.2	744	37	−102
LJ-3261	Gottlieben	1252	4	−26.1	729	37	101
LJ-3297	TRL 67-3	1255	10	−21.0	696	36	37
LJ-3299	TRL 67-3	1265	10	−21.6	692	36	−167
LJ-3252	Gottlieben	1270	2	−25.3	705	36	18
LJ-3301	TRL 67-3	1275	10	−21.3	706	37	6
LJ-3230	TRL 67-3	1285	10	−21.8	579	36	−98
LJ-3298	Gottlieben	1290	2	−25.6	673	36	−9
LJ-3300	Gottlieben	1296	2	−25.4	617	36	−8

APPENDIX 2

Floating tree-ring series

1.	2.	3.	4.	5.	6.	7.	8.
Fischbeck series, estimated zero point ca 6120 BC							
LJ-3490	Fischbeck	30	5	−26.3	7098	52	−23
LJ-3489	Fischbeck	90	5	−25.2	7147	53	−50
LJ-3488	Fischbeck	270	5	−24.6	7016	52	−127
LJ-3491	Fischbeck	330	5	−24.0	6921	52	−66
Donau 11 incomplete series, B Becker							
LJ-2968	D11A	25	10	−25.6	7065	49	−74
LJ-3004	D11A	55	10	−25.0	6983	49	63
LJ-3000	D11A	75	10	−26.0	6904	50	26
LJ-3003	D11A	125	10	−26.6	6985	49	63
LJ-2999	D11A	175	10	−24.9	6710	49	−42
LJ-3033	D11A	195	10	−27.0	7027	51	82
LJ-3034	D11B	205	10	−26.4	6215	48	−71
LJ-2985	D11B	225	10	−24.8	6206	48	−43
LJ-3001	D11B	275	10	−26.3	6116	47	3
LJ-3002	D11B	325	10	−25.3	6101	47	−47
LJ-2984	D11B	365	10	−24.8	6070	47	−79

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APPENDIX 2 (continued)

1.	2.	3.	4.	5.	6.	7.	8.
Main 6 series, B Becker, estimated zero point ca 6075 BC							
LJ-3315	M6	100	1	−25.5	6992	51	−70
LJ-3305	M6	110	1	−26.2	6928	51	59
LJ-3307	M6	120	1	−26.1	6961	55	63
LJ-3316	M6	150	1	−25.3	7013	52	−101
LJ-3480	M6	190	1	−25.3	6841	52	−105
LJ-3309	M6	200	1	−25.9	7060	52	−10
LJ-3476	M6	210	1	−25.8	6933	52	33
LJ-3320	M6	235	10	−23.6	6902	52	127
LJ-3317	M6	300	1	−23.7	6886	52	28
LJ-3478	M6	310	1	−25.3	6668	51	6
LJ-3319	M6	350	1	−23.3	6717	51	−28
LJ-3318	M6	390	1	−24.1	6625	50	82
LJ-3477	M6	408	5	−23.5	6843	52	138
Donau 8 series, B Becker, estimated zero point ca 4430 BC							
LJ-3057	D8	5	1	−26.4	5534	47	8
LJ-3010	D8	12	1	−26.4	5635	45	−160
LJ-3039	D8	17	1	−26.7	5547	47	−103
LJ-3077	D8	19	1	−25.5	5578	47	69
LJ-2968	D8	23	1	−24.9	5552	46	3
LJ-3147	D8	26	1	−25.8	5502	47	15
LJ-3146	D8	29	1	−26.1	5509	48	72
LJ-3005	D8	33	1	−25.6	5508	47	−46
LJ-3072	D8	35	1	−25.5	5448	47	−146
LJ-3149	D8	37	1	−24.3	5497	47	50
LJ-2981	D8	39	1	−25.1	5443	63	M
LJ-3148	D8	41	1	−25.2	5461	47	37
LJ-3037	D8	44	1	−25.0	5551	70	M
LJ-3145	D8	49	1	−25.0	5441	47	−35
LJ-3144	D8	51	1	−24.1	5360	47	41
LJ-3060	D8	53	1	−24.9	5372	46	−10
LJ-3143	D8	58	1	−25.2	5365	47	−53
LJ-3142	D8	61	1	−25.3	5292	47	−195
LJ-2966	D8	65	1	−25.7	5417	46	−101
LJ-3062	D8	72	1	−24.5	5366	46	98
LJ-3500	D8	75	5	−24.7	5493	47	91
LJ-3502	D8	80	6	−25.8	5426	47	20
LJ-3038	D8	89	4	−27.5	5356	46	58
LJ-3117	D8	91	3	−26.7	5362	46	−125
LJ-3035	D8	99	3	−27.9	5471	46	122
LJ-3134	D8	102	1	−27.1	5351	46	15
LJ-2967	D8	104	1	−2[illegible].2	5457	46	32
LJ-3133	D8	106	1	−27.8	5363	45	177
LJ-3118	D8	110	3	−27.4	5363	46	11
LJ-3501	D8	114	6	−25.4	5371	47	28
LJ-3014	D8	115	1	−26.3	5546	46	165
LJ-3168	D8	118	1	−26.8	5476	46	30
LJ-3075	D8	120	1	−26.9	5380	46	68
LJ-3169	D8	124	1	−26.7	5374	46	−5
LJ-3040	D8	126	1	−26.9	5358	46	−93
LJ-3171	D8	130	1	−27.1	5372	47	81
LJ-3170	D8	133	1	−26.4	5351	47	−79
LJ-3167	D8	136	1	−26.6	5316	47	−19
LJ-3012	D8	138	1	−27.2	5328	45	−167
LJ-3193	D8	143	1	−26.4	5346	47	−17
LJ-2983	D8	151	1	−25.9	5307	45	49
LJ-3379	D8	157	1	−26.4	5339	45	78
LJ-3378	D8	158	9	−29.6	5343	45	−56

APPENDIX 2 (continued)

1.	2.	3.	4.	5.	6.	7.	8.
LJ-3194	D8	160	1	−26.6	5346	47	74
LJ-3380	D8	167	8	−28.3	5317	45	16
LJ-3013	D8	170	1	−26.5	5356	45	41
LJ-3195	D8	174	1	−26.9	5337	47	−30
LJ-3376	D8	174	7	−28.3	5293	46	−165
LJ-3377	D8	179	3	−27.9	5200	45	−44
LJ-3076	D8	179	1	−27.2	5345	46	153
LJ-3119	D8	189	1	−26.4	5261	46	−16
LJ-3381	D8	197	5	−27.7	5376	46	35
LJ-3197	D8	199	1	−27.8	5319	46	−132
LJ-2978	D8	204	1	−27.1	5274	45	−29
LJ-3382	D8	204	4	−27.1	5290	45	−35
LJ-3196	D8	206	1	−26.9	5381	47	33
LJ-3383	D8	208	4	−26.6	5317	45	−135
LJ-3179	D8	208	1	−27.1	5377	47	17
LJ-3192	D8	210	1	−26.8	5285	46	104
LJ-3386	D8	211	3	−26.1	5337	45	15
LJ-3387	D8	214	2	−25.4	5321	45	−7
LJ-3006	D8	214	1	−27.7	5433	45	41
LJ-3178	D8	216	1	−27.2	5251	46	72
LJ-3056	D8	218	1	−27.3	5282	46	114
LJ-3402	D8	223	3	−26.0	5287	45	36
LJ-3122	D8	224	1	−26.8	5300	46	−77
LJ-2964	D8	227	1	−27.3	5247	44	−8
LJ-2965	D8	231	1	−26.5	5230	44	95
LJ-3404	D8	234	4	−25.6	5298	45	78
LJ-3123	D8	238	6	−26.4	5295	46	−82
LJ-3403	D8	244	4	−25.9	5269	45	−35
LJ-3401	D8	252	4	−25.0	5297	44	166
LJ-3385	D8	262	6	−24.3	5362	45	−110
LJ-3503	D8	282	6	−25.6	5264	46	−70
LJ-3384	D8	288	6	−26.5	5323	45	124
Neolithic master chronology (see Becker, 1978) incorporating Thayngen-Burgaschisee series (Ferguson, Huber, and Suess, 1966), estimated zero point ca 4050 BC							
LJ-3610	D9/12	88	3	−26.5	5159	46	−265
LJ-1266	Thayngen	101	12	−26.3	5070	61	11
LJ-1262	Thayngen	137	40	−31.1	5037	60	87
LJ-3636	Thayngen	139	15	−24.2	5003	46	−14
LJ-3598	D9/12	141	2	−26.3	5058	46	130
LJ-3611	D9/12	174	1	−25.3	5023	47	76
LJ-1278	Thayngen	182	10	−26.4	4992	58	−116
LJ-3609	D9/12	197	1	−25.6	5029	46	42
LJ-1293	Burgasch	207	40	−35.2	5053	58	−71
LJ-1277	Thayngen	217	20	−25.3	4925	58	−106
LJ-3614	D9/12	222	1	−25.6	4976	46	−198
LJ-1261	Thayngen	227	20	−28.0	5050	60	−56
LJ-3596	D9/12	257	2	−24.5	4912	46	−90
LJ-3625	D9/12	277	2	−24.7	4963	46	−78
LJ-1279	Thayngen	287	20	−27.2	4917	58	−11
LJ-3626	D9/12	299	2	−24.1	4931	47	−106
LJ-1265	Thayngen	307	20	−25.6	4962	60	24
LJ-3608	D9/12	335	2	−23.9	4873	46	60
LJ-3627	D9/12	369	5	−24.5	4935	46	−129
LJ-3628	D9/12	396	3	−23.9	4723	45	−89
LJ-3613	D9/12	421	2	−24.5	4742	45	9
LJ-3615	D9/12	447	2	−24.5	4727	45	−52
LJ-3644	D7	460	1	−23.6	4881	46	−173
LJ-3655	D7	470	1	−24.3	4786	45	−62
LJ-3645	D7	480	1	−24.3	4758	45	20

APPENDIX 2 (continued)

1.	2.	3.	4.	5.	6.	7.	8.
LJ-3667	D7	490	1	−24.6	4766	46	−100
LJ-3597	D9/12	497	2	−25.9	4773	45	−44
LJ-3640	D7	500	1	−24.9	4797	46	−63
LJ-3656	D7	510	1	−24.5	4786	46	−104
LJ-3643	D7	520	1	−24.7	4773	46	−85
LJ-3654	D7	530	1	−24.6	4733	45	−86
LJ-3641	D7	540	1	−24.9	4650	45	27
LJ-3659	D7	550	1	−24.5	4642	47	−132
LJ-3646	D7	560	1	−24.6	4673	45	−55
LJ-3657	D7	570	1	−24.8	4608	45	20
LJ-3642	D7	580	1	−24.5	4597	46	−10
LJ-3666	D7	590	1	−24.4	4614	45	77
LJ-3658	D7	600	1	−24.7	4576	46	54
LJ-3007	D7	608	3	−28.5	4642	43	123
LJ-2957	D7	614	1	−28.1	4564	42	−58
LJ-2956	D7	619	1	−27.8	4612	42	−9
LJ-3081	D7	630	1	−26.8	4604	44	−26
LJ-3111	D7	636	1	−26.8	4647	45	−44
LJ-3015	D7	643	1	−26.2	4715	52	42
LJ-3938	D7	649	1	−26.6	4651	46	−15
LJ-3116	D7	651	1	−25.8	4663	44	−6
LJ-3931	D7	656	1	−26.7	4679	46	19
LJ-3017	D7	670	1	−26.0	4636	45	43
LJ-3078	D7	674	1	−26.1	4627	45	−48
LJ-3018	D7	680	1	−24.5	4552	45	47
LJ-3928	D7	689	1	−26.4	4449	46	140
LJ-2976	D7	693	1	−26.0	4487	43	−97
LJ-3930	D7	695	1	−25.6	4528	46	−108
LJ-3009	D7	698	1	−26.0	4458	42	26
LJ-2975	D7	712	1	−26.2	4498	42	−30
LJ-3132	D7	727	1	−25.1	4479	44	116
LJ-3082	D7	730	1	−25.8	4405	44	2
LJ-3935	D7	732	1	−25.4	4494	46	83
LJ-3131	D7	734	1	−25.2	4426	45	−14
LJ-3936	D7	751	1	−25.9	4417	46	−58
LJ-3113	D7	757	1	−25.6	4473	43	84
LJ-3933	D7	760	1	−25.8	4451	45	92
LJ-2960	D7	761	1	−25.7	4469	42	21
LJ-3016	D7	767	1	−24.4	4417	44	45
LJ-2958	D7	773	1	−24.9	4439	44	−86
LJ-2959	D7	799	1	(−26.2)	4441	42	−90
Main 5 series, B Becker, estimated zero point ca 3250 BC (uncertain)							
LJ-3698	M5	73	5	−25.0	4418	45	59
LJ-3739	M5	126	2	−26.2	4471	45	104
LJ-3591	M5	154	8	−26.3	4475	47	−88
LJ-3738	M5	200	1	−25.0	4392	44	−225
LJ-3740	M5	225	1	−25.2	4369	45	−121
LJ-3702	M5	256	1	−23.8	4315	44	−57
LJ-3742	M5	274	2	−24.9	4397	45	−1
LJ-3741	M5	305	1	−25.8	4296	44	23
LJ-3701	M5	325	1	−23.8	4335	44	−59
LJ-3694	M5	350	1	−24.1	4270	45	82
LJ-3737	M5	373	1	−25.9	4219	44	−81
LJ-3693	M5	399	1	−23.2	4192	44	23
LJ-3743	M5	440	2	−24.5	4080	44	75

APPENDIX 2 (continued)

1.	2.	3.	4.	5.	6.	7.	8.
Donau 3 and Donau 10 series, Bronze Age master chronology of B Becker, estimated zero point ca 2860 BC							
LJ-3458	D3/10 Ner 51-61	45	2	−24.9	4125	43	59
LJ-3696	D3/10 Ner 51-61	74	1	−23.9	4044	44	−26
LJ-3440	D3/10 Ner 51-61	80	1	−24.6	4118	43	−62
LJ-3436	D3/10 Ner 51-61	130	1	−24.7	4171	43	0
LJ-3691	D3/10 Ner 51-61	145	1	−25.7	4154	44	50
LJ-3692	D3/10 Ner 51-61	171	1	−26.3	4125	44	−83
LJ-3464	D3/10 Ner 51-61	209	1	−25.2	4088	60	B
LJ-3465	D3/10 Ner 51-61	226	1	−24.3	4072	61	B
LJ-3457	D3/10 Ner 51-61	250	1	−24.2	4041	43	6
LJ-3695	D3/10 Ner 51-61	250	2	−23.7	4040	44	−65
LJ-3699	D3/10 Ner 51-61	261	1	−24.2	4106	44	−67
LJ-3437	D3/10 Ner 51-61	270	1	−24.3	4076	43	75
LJ-3703	D3/10 Ner 51-61	280	2	−24.0	3978	44	−10
LJ-3294	D3/10 Ner 51-61	301	1	−24.2	3940	43	6
LJ-3700	D3/10 Ner 51-61	310	1	−24.1	4117	44	55
LJ-3290	D3/10 Ner 51-61	328	1	−24.4	3930	60	M
LJ-3291	D3/10 Ner 51-61	343	1	−25.0	3918	43	−56
LJ-3704	D3/10 Ner 47	388	1	−26.0	3911	44	−9
LJ-3706	D3/10 Ner 36	400	1	−23.9	3818	43	−42
LJ-3705	D3/10 Ner 1	420	1	−24.3	3824	43	64
LJ-3776	D3 Bur H534	430	1	−26.5	3788	81	M
LJ-3774	D3 Bur H52	470	1	−25.7	3791	43	31
LJ-3773	D3 Bur H52	476	1	−25.6	3823	62	M
LJ-3806	D3 Bur H52	490	1	−25.2	3992	42	202
LJ-3292	D3/10 Bur H26	500	1	−24.7	3842	43	−55
LJ-3779	D3 Bur H52	515	1	−25.4	3819	44	135
LJ-3793	D3 Bur H52	540	1	−24.6	3816	45	48
LJ-3293	D3/10 Bur H26	542	1	−25.2	3816	41	−95
LJ-3778	D3 Bur H52	560	1	−26.4	3754	48	−10
LJ-3791	D3 Ner 4	570	1	−25.6	3801	60	B
LJ-3792	D3 Ner 4	575	1	−24.0	3826	46	−129
LJ-3813	D3 Ner 4	590	1	−24.6	3793	46	−140
LJ-3439	D3/10 Bur H26	604	1	−24.7	3855	43	−96
LJ-3807	D3 Lei 42	645	1	−24.8	3699	45	−78
LJ-3441	D3/10 Lei 39	650	1	−25.3	3790	42	−84
LJ-3808	D3 Lei 42	665	1	−23.5	3715	60	B
LJ-3724	D3/10 Gun 34	676	1	−23.9	3685	43	−3
LJ-3782	D3 Lei 42	685	1	−24.5	3664	45	−32
LJ-3462	D3/10 Lei 39	700	1	−24.5	3667	42	18
LJ-3780	D3 Bur 15	710	1	−25.4	3659	45	30
LJ-3721	D3/10 Gun 34	725	1	−23.8	3789	43	−38
LJ-3775	D3 Bur 15	736	1	−26.4	3811	43	−82
LJ-3781	D3 Bur 15	745	1	−24.9	3710	45	49
LJ-3463	D3/10 Lei 39	750	1	−24.7	3668	42	−67
LJ-3789	D3 Bur 15	750	1	−24.3	3652	46	−9
LJ-3788	D3 Bur 15	765	1	−24.8	3606	46	19
LJ-3723	D3/10 Gun 34	774	1	−23.8	3641	43	49
LJ-3438	D3/10 Lei 39	800	1	−24.6	3716	42	−108
LJ-3765	D3/10 Bur 15	817	1	−26.0	3585	43	8
LJ-3725	D3/10 Gun 34	832	1	−24.5	3626	42	−213
LJ-3722	D3/10 Gun 37	856	1	−25.1	3566	42	1
LJ-3727	D3/10 Gun 37	873	1	−26.2	3631	43	8
LJ-3759	D3/10 Gun 37	897	1	−26.5	3749	43	62
LJ-3764	D3/10 Gun 37	925	1	−26.1	3516	42	35
LJ-3726	D3/10 Gun 37	947	1	−25.2	3520	42	−53
LJ-3766	D3/10 Gri 2	975	1	−23.9	3617	43	36
LJ-3785	D3 Bur 1	985	1	−24.9	3480	42	−19
LJ-3783	D3 Bur 1	995	1	−25.3	3429	42	−127

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APPENDIX 2 (continued)

1.	2.	3.	4.	5.	6.	7.	8.
LJ-3757	D3/10 Gri 2	1008	1	−24.2	3484	42	−15
LJ-3763	D3/10 Bur H	1027	3	−24.6	3500	42	−225
LJ-3814	D3 Bur 1	1035	1	−24.1	3444	45	9
LJ-3443	D3/10 Bur H22	1050	1	−25.3	3458	42	−64
LJ-3811	D3 Bur 1	1060	1	−23.6	3385	45	117
LJ-3767	D3/10 Bur H22	1070	2	−23.6	3451	42	−41
LJ-3784	D3 Bur 1	1090	1	−23.0	3471	42	−30
LJ-3459	D3/10 Bur H22	1100	1	−24.4	3485	42	33
LJ-3760	D3/10 Hoc 67	1125	1	−25.0	3439	42	8
LJ-3461	D3/10 Bur H22	1150	1	−25.3	3383	59	M
LJ-3758	D3/10 Hoc 67	1173	1	−25.3	3417	42	−32
LJ-3460	D3/10 Bur H22	1200	1	−25.6	3435	42	48
LJ-3442	D3/10 Bur H22	1250	1	−25.4	3338	41	123
Zug Sumpf series, obtained from Veronika Giertz Siebenlist, estimated zero point ca 1250 BC							
LJ-3028	Giertz	28	14	−27.3	2915	39	−36
LJ-2917	Giertz	50	10	−27.8	2899	39	−46
LJ-2949	Giertz	70	10	−26.5	2877	39	17
LJ-2918	Giertz	90	10	−27.9	2892	39	−40
LJ-2916	Giertz	110	10	−27.6	2951	39	20
LJ-2920	Giertz	130	10	−26.4	2815	39	−28
LJ-2919	Giertz	150	10	−26.4	2885	39	89
LJ-2915	Giertz	170	10	−28.6	2762	39	−70
LJ-2939	Giertz	190	10	−26.7	2842	39	78
LJ-2922	Giertz	210	10	−25.2	2796	39	56
LJ-3024	Giertz	245	10	−26.1	2787	38	−8
LJ-2921	Giertz	260	10	−26.6	2709	39	117
LJ-3025	Giertz	280	10	−27.8	2723	40	−17

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