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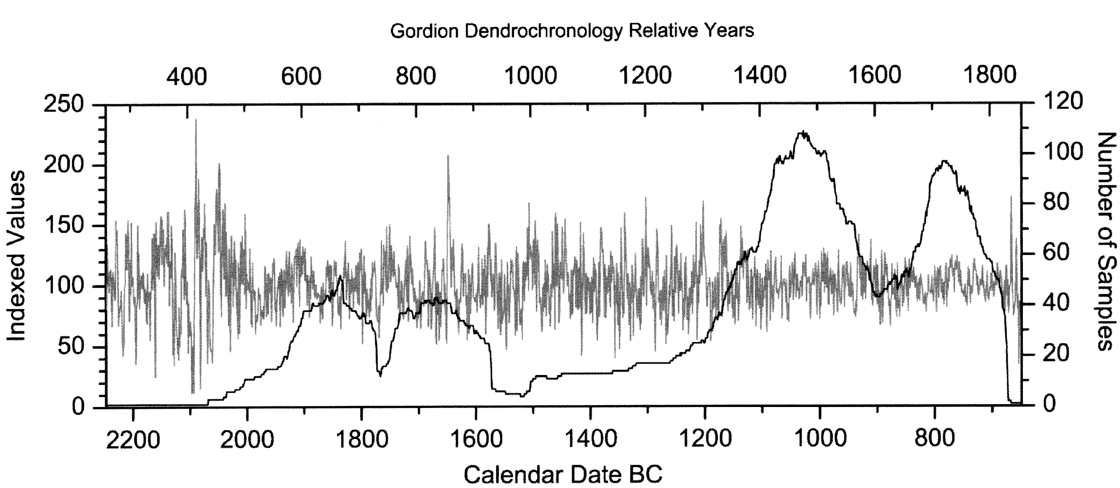
Dendrochronological Dating in Anatolia: The Second Millennium BC

In contrast to the sketchy summary of dendrochronological information for the third and earlier millennia presented at the previous Bochum meeting (for a listing of sites and disconnected wiggle-matched dates see Kuniholm 1996), we report here a complete, robust, and continuous tree-ring chronology for the second millennium BC +4/-7 years (Kromer et al. 2001; Manning et al. 2001). The error margin may actually be slightly lower (see Manning et al. 2003), and see now Figures 1 and 2. All BC dates published here supersede those reported in earlier years. The relative dates remain the same.

Figure 1:

Aegean Dendrochronology Project (ADP) Bronze-Iron Master Chronology as of AD 2003, shown in terms of the 20-year moving average of the percent variation in ring-widths around normal (defined as 100) from all constituent data by year (the 'Index Values' – grey line). The number of securely cross-dated samples, an average of 32 trees per year, which comprise this chronology is shown by the black line. The calendar date scale shown is the near-absolute dating proposed in Manning et al. (2001). For the specific trees from this chronology employed in the ^{14}C wiggle-match dating, see Figure 2. Although sample numbers are not especially large in the mid-16th century BC, we note that for the ^{14}C wiggle-match we employed a long-lived tree, GOR-161 with 861 tree-rings, which grew from the 18th-10th centuries BC. It is securely cross-dated on the early end against dozens of juniper trees from Porsuk (Kuniholm et al. 1992 and on-going work since), and then against, progressively, dozens, scores, and finally over 100 trees from Gordion and environs. In addition to the data summarised above, newly developed juniper and pine dendrochronologies from the Hittite site of Kuşaklı match and so reinforce the earlier 17th to later 16th century BC interval. There is thus no possibility of dendrochronological error in the placement of the data shown in Figure 2.

The sample high is 108 trees per year; the low is 4 trees per year (but only for 8 years, and these are multi-century-lived trees with long overlaps, so the fit is secure). The average is over 32 trees per year for the whole second millennium. Since



Bronze/Iron Age Master Chronology for the Second Millennium BC

Tree-Growth Indices for the Second Millennium BC

DATE	0	9	8	7	6	5	4	3	2	1
-2030	915	510	992	1307	1146	1272	874	1144	1220	1222
-2020	974	1210	819	790	610	1224	957	646	1040	1295
-2010	1070	1038	1306	1115	1007	1186	839	1383	1043	861
-2000	1093	913	1028	955	967	1223	1111	903	1102	816
-1990	1146	1010	933	905	1033	663	763	767	763	800
-1980	979	969	876	957	735	898	832	849	810	990
-1970	854	1270	1309	1060	780	899	1143	791	1087	1071
-1960	970	1118	1079	775	1044	1155	1091	1297	1212	837
-1950	766	641	840	886	919	957	858	999	654	984
-1940	1086	1095	838	738	961	1099	815	971	1025	1283
-1930	1118	956	937	1139	1248	927	1067	858	1182	1090
-1920	938	707	1037	1253	1274	1272	1294	1013	1232	1336
-1910	1248	1088	786	1315	1009	1202	1117	1099	1302	1243
-1900	1281	1028	1312	1043	1084	826	1103	921	1012	725
-1890	1049	892	1239	1157	1109	1000	1021	1114	914	918
-1880	1015	1006	891	910	931	923	923	919	704	896
-1870	997	822	714	1013	872	923	918	913	1042	1179
-1860	1094	1233	1167	970	1109	1168	863	1005	1142	667
-1850	822	883	1121	1219	1153	1088	1218	1081	1007	821
-1840	789	779	916	897	647	941	1001	994	933	1151
-1830	1067	1200	1295	1041	837	971	1105	1182	1101	699
-1820	846	1049	951	1154	1013	1047	816	1071	1027	958
-1810	1138	1192	1015	842	1170	863	865	1280	1121	1136
-1800	1283	988	521	885	1101	1216	934	1107	767	768
-1790	974	830	895	798	760	995	819	1056	895	1175
-1780	1052	1121	1099	1168	1107	1124	748	750	715	741
-1770	815	559	750	908	1045	1370	937	1058	834	1331
-1760	1178	1281	1160	958	1483	942	1053	985	1230	1487
-1750	1461	1045	1063	1301	1094	1193	1059	1280	1101	1148
-1740	1062	981	1018	988	815	1173	1113	705	896	861
-1730	1027	971	746	724	720	964	1034	1164	1204	863
-1720	1262	1325	715	1014	1154	1415	1270	1143	1020	1140
-1710	1062	959	868	987	953	902	842	661	901	737
-1700	843	850	1052	655	638	904	883	929	921	817
-1690	996	1165	1349	1200	1167	1200	1075	664	1107	1137
-1680	1054	955	652	746	920	1015	1125	1215	1466	1307
-1670	578	522	1012	1021	758	988	538	924	907	650
-1660	940	1111	1109	1217	1171	834	1016	838	568	524
-1650	1202	1656	2070	1842	1674	1550	1243	998	1322	1143
-1640	1187	1398	1194	933	953	797	880	979	785	719
-1630	614	895	891	861	977	1156	1332	1270	926	1050
-1620	1083	1003	1083	814	904	545	699	1119	592	1074
-1610	808	755	993	1120	1176	1052	895	897	884	866
-1600	908	929	765	962	1086	1318	951	910	831	927
-1590	906	1225	832	1135	906	1095	1256	596	798	995
-1580	1298	897	1320	1480	1408	1178	984	1095	905	967
-1570	1022	1088	793	841	1346	1336	1192	940	808	644
-1560	951	1102	768	588	1051	1207	682	733	759	790
-1550	1085	992	706	471	750	1190	926	1002	692	858
-1540	899	1214	1106	1201	1202	971	980	938	856	585
-1530	1166	1318	626	1238	1264	1011	807	673	719	761
-1520	807	555	1151	1194	1032	867	1190	1036	1078	1080
-1510	1473	1390	955	1679	1216	1329	1314	1243	1202	961
-1500	1301	1373	1213	1009	1530	1360	786	1105	1372	1276
-1490	1271	855	867	899	762	616	639	983	778	1008
-1480	820	1205	1003	746	885	1173	947	1088	770	873
-1470	661	1005	980	903	1442	1121	975	1172	635	1554
-1460	1595	992	1077	1504	1116	688	736	1162	1190	1092
-1450	1050	1478	1133	932	993	1153	1542	1253	1304	992
-1440	1046	1106	1033	864	919	725	839	1125	762	769
-1430	1120	1082	1162	1231	1237	815	1208	1154	796	816
-1420	1140	807	1062	1519	1068	421	891	1042	1431	1270
-1410	1212	764	1046	1095	771	1071	956	1059	974	760
-1400	1018	774	1061	841	688	923	1224	944	1169	977

Number of Samples per Year

DATE	0	9	8	7	6	5	4	3	2	1
-2030	10	10	10	10	10	10	10	10	10	11
-2020	11	11	11	11	11	11	11	11	13	13
-2010	13	14	14	15	15	16	17	17	17	17
-2000	17	17	17	17	17	17	17	17	17	16
-1990	16	16	16	16	16	16	16	16	16	15
-1980	15	15	15	15	15	16	16	16	16	16
-1970	17	17	17	18	18	18	18	18	18	18
-1960	18	18	18	18	18	18	18	18	18	18
-1950	18	18	18	18	19	19	19	19	18	18
-1940	19	19	20	20	20	21	21	21	21	21
-1930	20	21	23	23	24	26	26	27	28	28
-1920	28	29	29	29	29	30	30	31	31	31
-1910	32	32	32	32	33	34	34	34	35	36
-1900	36	36	36	36	36	36	35	35	35	35
-1890	35	35	35	36	37	38	38	37	37	37
-1880	37	37	37	37	37	37	38	38	38	38
-1870	38	38	38	38	38	39	39	39	40	40
-1860	40	40	40	39	38	39	39	41	41	42
-1850	41	40	40	41	42	43	43	43	46	46
-1840	47	49	49	50	50	48	49	48	45	40
-1830	40	40	40	40	39	39	39	39	39	38
-1820	38	38	38	37	37	37	37	37	37	37
-1810	37	36	36	36	36	36	35	35	35	35
-1800	36	36	37	36	37	36	36	35	34	34
-1790	34	34	34	34	34	35	35	35	34	32
-1780	32	31	31	31	30	28	23	15	14	14
-1770	14	14	13	13	14	15	15	16	16	16
-1760	16	16	16	16	17	17	18	19	19	20
-1750	22	24	26	27	27	27	28	29	30	31
-1740	31	31	31	31	32	33	36	37	37	37
-1730	37	37	37	37	37	37	37	37	37	38
-1720	38	39	39	39	38	38	38	38	38	37
-1710	36	35	35	35	36	36	36	36	36	36
-1700	36	36	36	37	40	40	40	40	40	40
-1690	41	41	41	40	41	41	41	41	41	41
-1680	40	40	40	40	40	39	39	40	42	42
-1670	42	42	42	41	41	40	40	40	40	40
-1660	40	40	40	41	41	41	41	41	41	40
-1650	40	40	40	40	40	40	39	38	36	36
-1640	36	36	36	36	36	37	36	35	35	34
-1630	34	34	33	33	33	33	33	33	33	33
-1620	32	32	31	31	31	31	31	31	30	30
-1610	31	31	31	31	31	31	30	28	28	28
-1600	29	29	28	28	28	27	27	27	26	26
-1590	26	26	26	26	26	25	24	24	24	24
-1580	24	24	24	23	21	21	17	10	7	7
-1570	7	7	7	7	7	6	6	6	6	6
-1560	6	6	6	6	6	6	6	6	6	6
-1550	6	6	5	5	5	5	5	5	5	5
-1540	5	5	5	5	5	5	5	5	5	5
-1530	5	5	5	5	5	5	5	5	4	4
-1520	4	4	4	4	4	5	5	5	5	6
-1510	6	6	6	6	6	8	10	10	10	10
-1500	11	11	11	11	11	12	12	12	12	12
-1490	12	12	12	12	12	12	12	12	12	12
-1480	12	12	12	12	11	11	11	11	11	11
-1470	11	11	11	11	11	11	11	11	11	11
-1460	11	11	11	12	12	12	12	12	12	12
-1450	13	13	13	13	13	13	13	13	13	13
-1440	13	13	13	13	13	13	13	13	13	13
-1430	13	13	13	13	13	13	13	13	13	13
-1420	13	13	13	13	13	13	13	13	13	13
-1410	13	13	13	13	13	13	13	13	13	13
-1400	13	13	13	13	13	13	13	13	13	13

Tree-Growth Indices for the Second Millennium BC

Number of Samples per Year

DATE	0	9	8	7	6	5	4	3	2	1	0	9	8	7	6	5	4	3	2	1
-1390	1123	738	545	720	856	1183	740	1167	1458	1478	13	13	13	13	13	13	13	13	13	13
-1380	1450	1270	1293	1183	741	985	1168	730	810	1061	13	13	13	13	13	13	13	13	13	13
-1370	935	1047	1159	1124	868	819	1275	1027	1196	1235	13	13	13	13	13	13	13	13	13	14
-1360	1102	1147	877	397	991	860	1174	850	673	1097	14	14	14	14	14	14	14	14	14	14
-1350	705	478	811	1163	1472	1171	1016	728	939	769	14	14	14	14	14	14	14	14	14	14
-1340	1595	1448	1332	1084	892	896	1090	756	671	1016	14	14	14	14	14	14	14	15	15	15
-1330	540	948	854	1157	1072	583	992	936	1045	1262	15	15	15	15	16	16	16	16	16	16
-1320	991	782	725	768	954	966	748	630	1065	684	17	17	17	17	17	17	17	17	17	17
-1310	991	1383	1273	905	952	1111	1171	1722	831	1156	17	17	17	17	17	17	17	17	17	17
-1300	1144	1309	1242	1139	1167	972	917	934	1110	803	17	17	17	17	17	17	17	17	17	17
-1290	999	1020	795	454	620	1044	1461	1411	1248	863	17	17	17	17	17	17	17	17	17	17
-1280	940	821	717	954	671	806	998	1064	790	1120	17	17	17	17	17	17	17	17	17	17
-1270	874	925	515	1241	602	594	715	820	994	912	17	17	17	17	17	17	17	17	17	17
-1260	1145	1149	1489	745	957	856	698	1228	1112	936	18	18	18	18	18	19	19	19	19	19
-1250	1305	1330	1180	1032	763	993	1116	954	1255	987	20	20	20	20	20	20	20	21	20	21
-1240	1028	818	626	887	737	1177	877	1232	715	903	21	21	21	21	21	21	21	22	22	22
-1230	895	593	655	967	819	982	851	1107	761	969	22	22	22	22	23	24	24	24	24	25
-1220	1246	981	989	1176	1141	1515	547	777	1074	853	25	25	25	25	25	25	25	25	25	25
-1210	1191	1010	1492	1354	1190	1078	1500	1692	1373	1232	25	25	25	25	26	26	26	26	25	25
-1200	1233	1152	1090	821	835	915	1011	997	1058	990	25	27	27	27	27	29	29	30	30	30
-1190	535	611	620	1023	858	803	842	1036	1064	736	30	30	30	31	31	33	33	34	35	35
-1180	780	800	1099	956	738	1008	1491	1346	1552	1289	35	35	34	36	37	37	36	36	36	37
-1170	733	779	1371	1154	1254	1395	1145	1450	1246	982	38	39	40	42	42	43	44	45	45	45
-1160	784	1098	950	846	1008	976	1114	806	1045	722	46	46	47	47	47	48	49	49	50	50
-1150	882	910	676	953	1127	886	1184	976	705	769	52	52	54	54	54	54	55	57	57	56
-1140	921	1165	1275	1484	1144	1384	1214	1044	1276	1231	56	57	57	56	57	58	58	58	58	60
-1130	1191	1262	1141	853	1285	1119	996	791	852	812	61	59	59	58	58	59	59	60	62	62
-1120	1127	1125	1089	717	1045	1068	1092	1230	1038	657	62	62	63	62	61	61	61	61	61	61
-1110	1026	1125	1090	836	963	809	1091	632	712	813	62	63	63	63	65	65	67	69	70	72
-1100	1054	819	979	889	1060	957	1172	659	612	953	72	73	73	74	75	77	77	77	78	79
-1090	1202	1045	1066	1103	704	1277	890	995	811	773	80	82	83	83	84	85	86	89	90	90
-1080	969	1035	1149	1226	1125	938	930	958	884	926	91	95	96	96	96	97	98	98	96	97
-1070	971	1012	1015	1238	723	988	1002	1035	1050	986	99	99	98	97	97	96	96	96	97	98
-1060	1016	853	1044	711	728	842	695	1112	1153	894	98	99	98	98	98	98	98	98	99	100
-1050	984	1026	1180	1116	876	968	1212	1264	1156	897	101	99	98	99	98	100	103	104	104	105
-1040	1081	1083	951	970	883	897	1026	993	1065	903	106	106	106	108	108	108	108	108	108	108
-1030	954	1187	1178	1117	1066	1133	1247	864	1051	1010	108	107	109	106	106	107	108	107	108	106
-1020	1060	1050	1059	748	719	1004	995	1026	1134	1017	105	107	106	105	104	104	103	103	103	102
-1010	994	1047	1166	1174	1158	754	1049	1080	1196	1086	102	102	102	102	101	100	100	100	101	101
-1000	721	938	829	1275	1084	1023	1106	1297	932	1231	100	100	99	99	100	100	100	101	101	101
-990	1255	1010	976	1195	1267	856	836	1030	1089	1142	101	100	100	97	97	97	95	92	90	90
-980	1038										90									

Number of samples in data set: 284

Number of rings in data set: 35484

Length of data set: 1051 years

Table 1: Supplement to Figure 1.

For readers who wish to study the second millennium BC Aegean year-by-year, we provide a set of tree-growth indices for the entire period, plus some 50 extra years on the ends. The small error margins are as noted in paragraph one of the text.

Instructions for reading the table:

Information for the 1051 years from 2030 BC to 980 BC is presented as a growth index for each year (the left column), ten years to a line numbered 0-1, and a histogram (the right column) showing the sample abundance for each year. The indices include a (mental) decimal point. Thus the information for 1957 BC (which reads 775) should be understood as follows: average ring-growth was 77.5 % of normal ("normal" is the mean growth index for the period 1947-1967 BC), and this value is the average annual growth index of 18 different trees in a hot, dry year. Similarly, the information for 1648 BC (which reads 2070) should be read as 207.0 % of normal, an average derived from 40 different trees in an extraordinarily cool, wet year. These 1051 years are part of a continuous 2009 year sequence which runs from 2657 BC to 649 BC.

we lack a continuous chronology through the AD/BC transition to allow us to assign absolute years, this floating chronology was pinned down by 58 ^{14}C dates by Bernd Kromer at Heidelberg as part of Sturt Manning's Eastern Mediterranean Radiocarbon Calibration Project (EMRCP).

A preliminary attempt to place the tree-ring chronology securely in time on the basis of some 22 determinations was reported in *Nature* seven years ago (Kuniholm et al. 1996). Since then Maryanne Newton caught the steep downturn in the radiocarbon graph in the 8th century BC, getting us away from the relatively flat radiocarbon plateau of the centuries preceding the mid-8th century BC. Moreover, the discovery of a radiocarbon offset in the 9th/8th centuries BC, an apparent period of global cooling rather like the Little Ice Age in the 15th and 16th centuries AD, was reported on in the December 21st, 2001 issue of *Science* (Kromer et al. 2001; Manning et al. 2001; Reimer 2001) and demonstrated the need for an upward shift of some 22 years from the placement we had offered five years earlier. Accordingly, all the construction dates from the Middle and Late Bronze Ages and Early Iron Age that we have been quoting over the years have to be raised by 22 years (+4/-7).

As a further test of this new placement, Bernd Kromer tried to catch the 1325 BC blip in the radiocarbon curve with six small segments of the Gordion wood, and as may be seen in the dotted circle in Figure 2 (Manning et al. 2003) he has done so successfully. We cannot offer a quantification yet of what this might mean for a modified precision range. For the time being we are holding to +4/-7 years, but the error may be somewhat lower.[1]

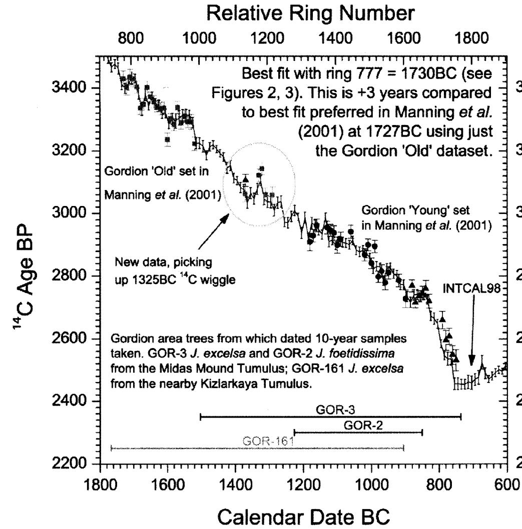


Figure 2:

High-precision radiocarbon data, including six new data (Hd-21711, 21712, 21721, 21722, 21761, 21774) centered around the 1325 BC 'wiggle' in the radiocarbon calibration curve, from 10-ring samples of the Aegean Dendrochronology Project Bronze-Iron tree-ring series (Figure 1). The data are shown at their best-fit placement against the current (AD2002) internationally recommended INTCAL98 radiocarbon calibration data set (Stuiver *et al.* 1998). Samples were taken from three of the constituent trees of the well-replicated Gordion-area dendrochronology forming one of the ADP's longest floating sequences for the prehistoric Mediterranean and Near East. All radiocarbon measurements were made at the Heidelberg radiocarbon laboratory (see Kromer *et al.* 2001; Manning *et al.* 2001 for details). All data shown with 1σ errors. (Figure courtesy S. W. Manning. See Manning et al. 2003 for further discussion).

Lacking a bridge through Roman times to living trees of the present, this is as close to precision as we could seriously hope for (in fact, it is rather better). An error margin of +4/-7 years is not all that bad for three to four thousand years ago.

The reader will have noted four or five big peaks or bumps in Figure 1 on the histogram (dark line) of sample frequency, followed by a steep drop on the right-hand side of the bump, indicating major building activity at the sites from which these samples were collected. Let us look at them from right to left, or from late to early, to see what they might mean.

Bump 1 (ca. 673 BC) - Ayanis

The Haldi-Temple of Urartian King Rusa II was built in 673 +4/-7 cal BC, rather early in Rusa's reign which might explain the lack of significant accomplishments with which he usually embellishes his inscriptions (and which at the time of excavation puzzled the epigraphers). There is no evidence of earlier or later construction at the site, so Ayanis seems to have been a one-period affair. See Çilingiroğlu & Salvini (2001) and contribution by Kuniholm & Newton (2001; 2002) therein for extended discussion. Note that the publication of this book preceded the discovery of our need to raise the date (Kuniholm & Newton forthcoming).

Bump 2 (ca. 740 BC) - Gordion

The so-called MM Tumulus at Gordion, built around 740 +4/-7 cal BC, 22 years earlier than we reported in 1996 in *Nature*, is therefore not the tomb of the quasi-historical Midas who flourished and died around 700 BC but rather the tomb of someone a generation or two earlier. This finding has helped force a re-examination of the entire Gordion City Mound stratigraphic sequence. The June 2003 *Antiquity* (De Vries et al. 2003) has the latest restatement of the implications of this date for Gordion and Iron Age Anatolia[2]. What had been thought at Gordion for the last 50 years to be the Kimmerian destruction level of the early 7th century BC we now realize is an otherwise-undocumented early Iron Age destruction of the late 9th century BC. The dendrochronological date of 883 for the joists of Terrace Building 2A (but no bark visible and therefore possibly slightly later) is complemented by radiocarbon tests of the thatch of the roof and of a variety of seeds found in separate pots in the destruction debris (the latter all clustering between 830-800), also by ceramic links with imported Greek pottery in the levels above the burned layer.

If there ever was a Kimmerian attack on Gordion, it was on the upper buildings above the clay which for years were called the 'Persian' buildings and are now more properly termed Middle Phrygian. Early Iron Age buildings at Gordion such as Megarons 5 and 6 are 10th century (specifically 940 and 944 +4/-7 cal BC), and so forth.

Bump 3 (circa 1549 BC) - Porsuk

At this Hittite site just north of the entrance to the Cilician Gates to the Taurus Mountains the timbers in the substrate of the postern gate are much earlier than what has been deemed to be 14th/13th century pottery found in the destruction debris above. The junipers, cedars, and pines found under the floor of the postern gate on the west side of the mound were all cut in 1549 +4/-7 cal BC. An inner part of the gate was built 31 years earlier (Kuniholm et al. 1992; Pelon 1992).

An oddity at Porsuk is an enormous spike in growth at ca. 1650 BC. The spike occurs in 61 out of 61 junipers, cedars, and pines, ranging in age from 19 to 244 years, and reflects a spring/summer growing season that was extraordinarily cool and moist. This is the most remarkable such anomaly in the last 9000 years, and we think it is a reaction to the eruption of Thera/ Santorini some 820 kms to the west.The spikes taper off a year or two or three later, and the trees resume their normal lives until they are cut down. See Hammer (2003) for the latest statement about the Greenland ice core evidence and possible linkage with the Porsuk evidence.

Bump 4 (ca. 1774 BC) - Acemhöyük: Sarıkaya Palace and Hatipler Tepesi

In these two Middle Bronze Age buildings, both of them built in the same year, we have quantities of burned logs with the bark preserved. The last rings from timbers in both buildings cluster at 1774 +4/-7 cal BC. That is the construction date. A single repair log in the Sarıkaya Palace has a ring preserved from 1766 +4/-7 cal BC with an unknown number of rings burned off. So the building had at least an eight-year life-span before the fire. A full report on these two important monuments has yet to appear. For prelimary reports see Özgüç (1966; 1979).

A third MBA building in the central part of the mound at Acemhöyük was excavated and sampled by Prof. Aliye Öztan last summer, but the samples, sent to us the week before the Bochum meeting in October 2002, have so far turned out to be undatable.

Bump 5 (ca. 1832 BC) - Kültepe, Waršama Sarayı

The extra little blip or bump one sees on the left of Figure 1 is from the timbers in the Waršama Sarayı at Kültepe (1999; and earlier dendrochronological comment by Kuniholm and Newton 1990), the construction date of which is 1832 +4/-7 cal BC. Repair timbers, however, extending down to at least 1771 (but with no bark preserved) show that the palace had a life-span of at least 61 years before the burning. For the most recent statement about the chronology of the Assyrian Colony Period and the lengthening of the Karum II period, see Veenhof 2003, but note that he employs the old dendrochronological dates from the 1996 *Nature* report.

Metallurgy and Dendrochronology in the Second Millennium

The sites we showed the audience at Bochum in October 2002 were sampled and studied so that we could build a tree-ring chronology. They were not necessarily selected because they had metallurgical potential, although some of them, such as Kültepe, clearly do. It is one of our continued frustrations that the charcoal emerging from the Karum, either levels II or Ib, at Kültepe is usually so badly and thoroughly burned that no dendrochronological dating is possible. We keep visiting the Karum every summer, however, in the hope that suitable charcoal will some day emerge.

But now the long master tree-ring chronology exists and at a placement likely not very far from absolute. It should be possible to plug in any site with well-preserved charcoal, including sites from the millennia on either side of the second. Just before the Bochum meeting we received an e-mail from Walter Gauss in Salzburg to the effect that in the Aegina excavations in the 1970s considerable quantities of charcoal were discovered in a *Kupferschmelzofen* and sent to Austria for radiocarbon dating. They were then put on a shelf and forgotten until Dr. Gauss rediscovered them. So he has packed them and sent them to us, and we will see what we can do to date the oven[3].

Minor Sites in or near the Second Millennium

We use the term "minor" for sites which have few samples, or ones with difficult ring-sequences where not all of the problems have been worked out. Moreover, it is easy to work with a site from which several hundred samples have been collected. Sites which produce one, or two, or three samples, if not impossible, are difficult at best.

One site which is not really minor nor a really a problem is Karahöyük bei Konya where the last existing ring is 1768 +4/-7 cal BC, at least eight years later than Acemhöyük. We wish only that more charcoal had been saved from this extraordinary site (Alp 1991; 1992).

At least three pieces of wood (MAS-4,6,8) from Maşat Höyük date from 1375 +4/-7 cal BC. This is particularly interesting because of the existence of LHIIIA pottery mixed in with the Hittite pots (Özgüç 1978).

Also in central Anatolia we have a date of 1529 (with the bark present) for Building "C" at Kuşaklı, but an additional piece recently collected has a last ring (no bark) at 1523. For an update on Kuşaklı see the most recent *MDOG* (Müller-Karpe et al. 2003, and Kuniholm & Newton therein).

The Hittite site of Ortaköy/Şapinuwa is still giving us problems, and we are holding back on reporting dates until we determine what is going on there, but the excavator, Prof. Aygül Süel, has now reported major quantities of charcoal collected in 2002 and we will retrieve them in the summer of 2003.

Tille Höyük, currently submerged under the Euphrates, has a last preserved ring in the gateway from 1123 +4/-7 cal BC. Although the Tille wood is oak, we are confident of the crossdate with the junipers and pines of the Bronze Age/Iron Age chronology (Kuniholm et al. 1993, but note that these original 1990 calculations do not take into account the revised chronology).

Another site in Central Anatolia with long-lived oak, Kaman-Kalehöyük IId, has a last-preserved-ring in 884 BC +4/-7 (Newton & Kuniholm 2001; annual excavation reports summarized in Omura 2001).

Out east in Urartu, we have dates for Adilcevaz with its last ring at 776 +4/-7 cal BC (but no bark), Yukarı Anzaf at 807 +4/-7 cal BC, and we have just been promised wood from Karmir Blur next to Yerevan which ought to crossdate with both these sites and Ayanis.

Down south at Kilisetepe, Nicholas Postgate has a last preserved ring at 1403 +4/-7 cal BC. Another site from this general region, the Kaş/Uluburun shipwreck, is having its cedar sequence wiggle-matched at Heidelberg to confirm or refute our original placement in the 14th century.

In the west, in the Athenian Agora, are two juniper bed legs excavated in the 1930s in a well that was sealed in the 4th quarter of the 6th century BC (Shear 1940). The last existing ring is 781 +4/-7 cal BC. We know that there is crossdating across the Aegean, but the fit between Athens and Gordion is so extraordinarily good, that one wonders whether Midas in addition to sending his wooden throne to Delphi, a thing well worth looking at according to Herodotos, might have sent a wooden bed to Athens, too.

Finally, also in the west, specifically from Shaft Grave V at Mycenae, there is a wooden bowl which was measured years ago under less than optimum circumstances. It was measured after a long transatlantic airplane flight with the measurements taken off the surface of the bowl, and one would have to go back to the National Museum in Athens in order to remeasure it. It is a single piece of wood, and who knows how long it had been around when it was placed in the grave. We have played down this piece for some years as nothing more than a curiosity, but we are happy with a last-preserved ring at 1602 +4/-7 cal BC. The real answer to the Shaft Grave question is in the National Museum where there is a joist from one of the graves with an estimated 200 rings, saved by Schliemann and cut off by his carpenter. Polishing and measuring that would be much more satisfactory.

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Note:

For all the dates cited above, any change must be consistent. That is to say, one cannot have +4 years for one date and –7 years for another. If –3 years turns out to be the final solution, then that is –3 years across the spectrum of cited dates throughout the millennium. The graph must move as a whole. Filling in the gaps in the AD/BC transition period and relying on convnetional dendrochronological dating instead of radiocarbon wiggle-matching would of course eliminate the need for this +4/-7 estimate.

1 See the March 2003 Antiquity on-line at (http://antiquity.ac.uk/ProjGall/Manning/Manning.html), also our web-site (http://www.arts.cornell.edu/dendro) for the actual numbers of the radiocarbon determinations on which these calculations are based.
2 See *http://antiquity.ac.uk/ProjGall/DeVries/DeVries. html*
3 At Bochum Prof. J. D. Muhly took serious issue with this identification by the excavators, but whether it is a Kupferschmelzofen or not, a date might still tell us something about the period to which this construction – whatever it is – belongs.

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