In The Steps Of James Harvey Gaul
Volume 1

JAMES HARVEY GAUL

IN MEMORIAM

Edited by
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An Early Bronze Age Settlement at Sozopol, near Burgas, Bulgaria

Dated by Dendrochronology and Radiocarbon

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The Site

In 1988 and 1989 eighty-three cross-sections of oak pilings and two of boxwood were collected from the submerged Early Bronze Age site of Burgas, Sozopol, Primorsko, Kiten on the Black Sea coast of Bulgaria[1]. The date of the settlement is thought by the excavators to be the middle of the Early Bronze Age, or about the same as Ezero (Porozhanov 1991; Merpert 1979). We have not yet seen copies of the plans, but we were informed at the time of collection that the pilings all come from house foundations. A combination of sea-level change and tectonic subsidence is thought to explain why apparent habitation sites are now eight to ten meters under water.

The 285-Year Oak Chronology

The wood from Kiten was combined fairly easily into a 285-year tree-ring sequence. Standard dendrochronological analytical techniques, both visual and statistical, were employed to match one set of tree-rings with another[2]. Kiten provides the longest Early Bronze Age oak chronology from the Balkans and the Aegean and is made up of more samples than any other chronology. An oak chronology from the EBA site of Demircihüyük (Kuniholm 1987; Korfmann and Kromer 1993) only 360 km to the southeast of Kiten, thought to date some time after 2730 B.C., crossdates with Kiten with its last ring ten years after the last ring at Kiten. There is no convincing crossdate between Kiten and Sozopol, the only other oak master chronology of that approximate period. The only available chronology from EBA Troy is pine (Pinus brutia). Another long chronology from EBA Acemhüyük is juniper (Juniperus sp.) These two conifer chronologies do not crossdate with the Kiten oak.

The Phases at Kiten

Four major building phases and possibly a fifth were identified as the master chronology was put together[3]. See the catalogue at the end of this report for building phase numbers for each individual sample. Figure 2 gives the information in graphic form as well as demonstrates the quality of the crossdating.

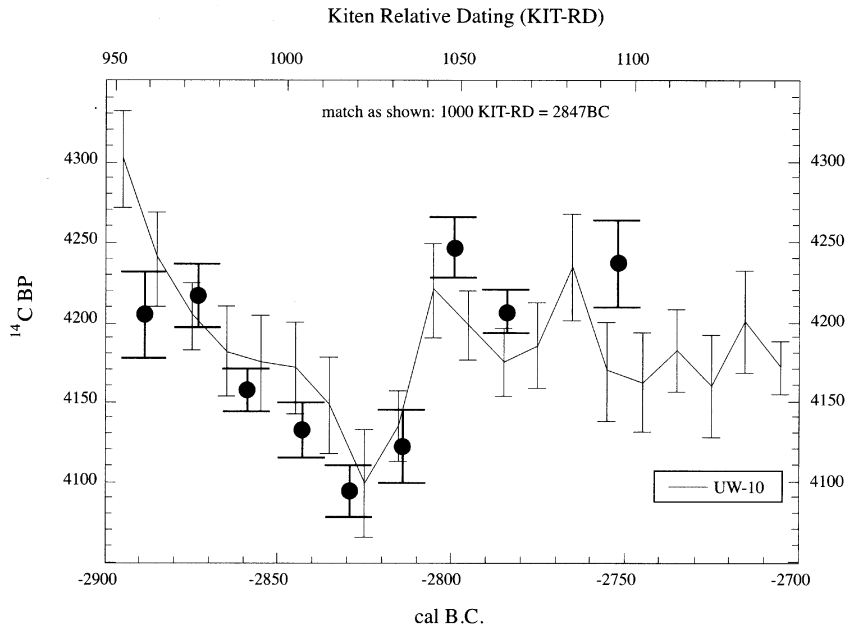

Fig.1. Wiggle-match of nine Kiten tree-ring samples with the decadal calibration curve of the University of Washington (UW-10, Stuiver and Becker 1993). The width of the bars indicates the length of the ring interval used in the measurements. The graph of the nine Kiten determinations, when placed on the radiocarbon time-scale, shows them clustering around a major V-shaped anomaly in the 29th century B.C. The Kiten floating 14C series can be matched with an uncertainty of less than ±10 years.

Table 1: **Relative Tree-Ring dates for the Kiten Samples**

Phase 1:	trees cut ca. 1073	(Kiten Relative Date)
Phase 2:	〃 〃 〃 1080	〃 〃 〃 seven years after Phase 1
Phase 3:	〃 〃 〃 1100	〃 〃 〃 twenty years after Phase 2
Phase 4:	〃 〃 〃 1114	〃 〃 〃 fourteen years after Phase 3
Phase 5?	〃 〃 〃 1136	〃 〃 〃 twenty-two years after Phase 4

There are at least ten samples in each of the first four phases. It is reasonable to conclude that there was major building activity in each of the phases. There are four other possible phases of fewer than six samples each which occur every four to six years between phases 2, 3, and 4. We consider them maintenance activity. Samples with no sapwood (i.e., the exterior 20-30 rings) have not been assigned to phases. The three samples that were cut after phase 4 are labeled "Phase 5?" These latter samples may also be from more maintenance work rather than from a true phase. To keep our crossdating secure, we did not collect samples with fewer than fifty rings. Therefore, other short-lived samples from a possible "Phase 5" would have been excluded from the sampling, and we are therefore unable to distinguish between "phase" and maintenance work[4].

All pieces crossdate very well with one another. There is sufficient sapwood preserved for us to estimate that the terminal rings are near. At the end of the dendrochronological analysis we were able to state that the original construction appeared to have been around 1073 Kiten Relative Dating (KIT—RD) System, with more pilings added to it over a sixty-four-year period, ending in 1136 KIT—RD, with surges of activity about every ten to twenty years.

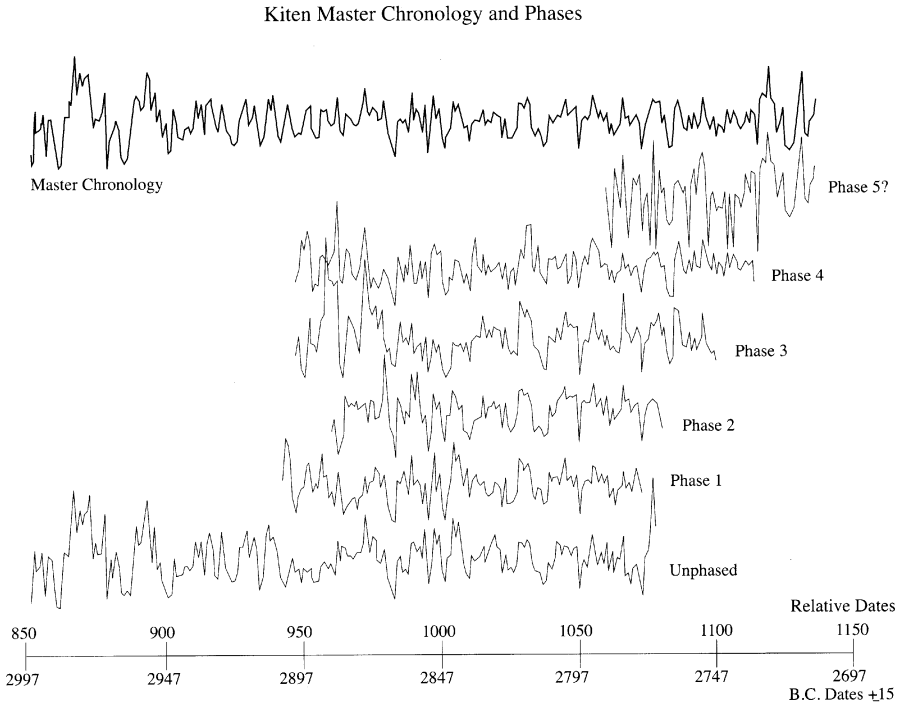

Fig. 2. The Kiten Master Tree-Ring Chronology and its Phases.

Radiocarbon Analysis

Nine fifteen-year long sections of Kiten wood were wiggle-matched to the decadal calibration curve (Stuiver and Becker 1993). "Wiggle-matching" means comparing all possible fits of selected groups of tree-rings, whose dates relative to each other are known, against the fluctuations of the radiocarbon curve. The results are shown in Table 2 and Figure 1.

Table 2. **Converted 14C Ages of the Kiten Samples:**

LAB.NUMBER	KITEN RELATIVE YEAR	DATE B.P.
Hd 15460	951- 965	4204 ± 27
Hd 15209	966- 980	4216 ± 20
Hd 15139	981- 995	4157 ± 15
Hd 15879	996- 1010	4132 ± 17
Hd 15987	1011- 1025	4094 ± 16
Hd 15964	1026- 1040	4122 ± 23
Hd 15567	1041- 1055	4246 ± 19
Hd 15208	1056- 1070	4206 ± 15
Hd 15458	1086- 1100	4236 ± 27

Discussion

The samples were pretreated in the Heidelberg laboratory according to standard procedures: soxhlet extraction followed by the 'AAA' procedure (Kromer and Becker 1993). After combustion to CO_2 the samples were measured in Heidelberg's high-precision proportional counters (Kromer and Münnich 1992).

Figure 1 shows the Kiten data matched against the calibration curve obtained from decade-long samples of German oak (Stuiver and Becker 1993). Usually, for wiggle-matching of an unknown tree-ring series with the master calibration curve, it is of crucial importance to know precisely any offset (i.e., non-random inter-laboratory bias) between the two 14C laboratories involved in the measurements, in this case Heidelberg and Seattle. For the Kiten samples, the extraordinary V-shaped anomaly at Kiten Relative Date 1000 to 1030 (see Fig. 1, where the Kiten determinations are matched against the same V-shaped anomaly of the late 29th century B.C. on the calibration curve) would have helped anchor the floating Kiten chronology even if a significant laboratory offset between the Heidelberg and the Seattle 14C laboratories had existed. However, recent comparative measurements on dendrochronologically dated wood have established that the offset between the Heidelberg and the Seattle laboratories is below 10 years[5]. The match shown in Fig. 1 was the best visual fit between the Kiten 14C sequence and the calibration curve, thus the equation: Kiten Relative Date 1000 = 2847 B.C.±15. Subsequently, the sequence was matched using the statistical procedures of the Oxford calibration program OXCAL 2.0 (Ramsey 1994). The result is as follows:

Kiten Relative Date 1000 = 2851 ± 5 years = 2856-2846 B.C. (1 sigma), or
Kiten Relative Date 1000 = 2851 ± 10 years = 2861-2840 B.C. (2 sigma)

It is encouraging that the visual method and the statistical method agree so closely.

All the dates shown in the tables below have been numbered to conform to the Oxford calibration: Kiten Relative Years minus 2851 yield the year B.C. with a plus-or-minus factor of 10 years (2 sigma).

B.C. Dates for Early Bronze Age Kiten

The phasing for the Kiten settlement may now be restated as follows in Tabl.3. The notation "Bark" or "Waney Edge" means the terminal ring which grew in the last year of the tree's life is present. The notation "v" means that approximately 1 to 5 years are missing from the exterior of the piece.

Table 3: **B.C. Dates for the Kiten Phases**

Phase 1: trees cut ca.	1073 (Kiten Relative Date)	= 2778 B.C. ± 10 Bark
Phase 2: " " "	1080 " " "	= 2771 B.C. ± 10 v
Phase 3: " " "	1100 " " "	= 2751 B.C. ± 10 Waney Edge
Phase 4: " " "	1114 " " "	= 2737 B.C. ± 10 Waney Edge
Possible Phase 5:	1136 " " "	= 2715 B.C. ± 10 v

Discussion

The original dating estimate kindly provided for us by Prof. Henrieta Todorova was "the beginning of the second phase of the Early Bronze Age on the West Black Sea Coast, exemplified in the forming phases of the Cernavodă - Ezerovo culture / Ezero VI-IX = 2900-2700 Cal. B.C."[6] We can now refine this to four phases or sub-phases between 2778 B.C. and 2737 B.C., and a possible fifth phase around 2715 B.C., with an error margin of 10 years[7].

Moreover, the Demircihüyük chronology noted above as crossdating dendro-chronologically at Kiten Relative Date 1146 thus has a last existing ring at 2705 B.C.±10.

Table 4: Catalogue

SAMPLE	PROVENIENCE	RINGS=	RELATIVE DATES	BC DATES
PHASE 1		(Kiten Rel. Year 1000-2851 = B.C.Year±10)		
KIT-63	Quadrant F, #227. Sapwood begins at 1054.	A=125	942p -1066v	2909 -2785
KIT-20	Excavator's #64. Sapwood begins in 1059.	A= 55	1015p -1069v	2836 -2782
KIT-41	Quadrant K, excavator's # 2. Sapwood begins at 1060.	A=126	944p -1069vv	2907 -2782
KIT-25	Excavator's #48. Sapwood begins at 1057.	A= 61	1010p -1070v	2841 -2781
KIT-34	Excavator's # 1. Sapwood begins at 1055.	A= 84	988p -1071v	2863 -2780
KIT-53	Quadrant H, #247. Sapwood begins at 1055.	A=125+5	942p -1071++v	2909 -2780
KIT-21	No number. Half-section, sapwood begins in 1056.	A= 52	1021 -1072W	2830 -2779
KIT-22	Excavator's #36. Sapwood begins in 1060.	A= 62	1011p -1072W	2840 -2779
KIT-30	Quadrant D, excavator's #26. Sapwood begins in 1055.	A= 85+1	987p -1072+v	2864 -2779
KIT-14	Bucket 14. Sapwood begins at 1063. Sapwood begins at 1069.	A= 50 B= 60 AB= 62	1023 -1072vv 1011±p-1070vv 1011±p-1072vv	2828 -2779 2840 -2781 2840 -2779
KIT-31	Excavator's #30, A.3 sondage. present at time of sampling. Sapwood begins at 1059.	Bark A= 66	 1008p -1073B	 2843 -2778
PHASE 2				
KIT-77	Quadrant G, #10. Sapwood begins at 1049.	A= 89+1	984p -1073+W	2867 -2778
KIT-47	Quadrant I, # 1. Sapwood begins at 1066.	A= 89+1	989p -1078+v	2862 -2773
KIT- 2	Bucket 2. Sapwood begins at 1066.	A= 78	1001p -1078vv	2850 -2773
KIT-57	Quadrant H, #229. Sapwood begins at 1072.	A=119+1	960 -1079+vv	2891 -2772
KIT- 1	Bucket 1. Sapwood begins at 1060. Sapwood begins at 1062. Sapwood begins at 1060.	 A= 72 B= 84 C= 76 ABC= 84	 1007±p -1078v 997±p -1080v 1004±p -1079v 997±p -1080v	 2844 -2773 2854 -2771 2847 -2772 2854 -2771

Table 4: Catalogue

SAMPLE	PROVENIENCE	RINGS=	RELATIVE DATES	BC DATES
KIT-46	Quadrant I, #11. Box All sapwood.	A= 69	(1012p -1080v)	(2839 -2771)
KIT-64	Quadrant F, #222. Sapwood begins at 1067.	A= 90+1	990p -1080+v	2861 -2771
KIT-37	Quadrant D, II. Sapwood begins at 1064.	A=104+5	972p -1080++v	2879 -2771
KIT- 8	Bucket 17. Sapwood begins at 1072.	A= 65	1016p -1080vv	2835 -2771
KIT-72	Quadrant E, #209. Sapwood begins at 1063.	AB=117+1	963p -1080+v	2888 -2771
KIT-36	Excavator's #___. Sapwood begins at 1049.	A=111+1	970p -1081+v	2881 -2770
Between PHASE 2 and PHASE 3				
KIT-66	Quadrant F, #225. Sapwood begins at 1066.	A=121+1	962p -1083+v	2889 -2768
KIT-69	Quadrant E, #197. Sapwood begins at 1057.	A=113+2	971p -1085++v	2880 -2766
KIT-70	Quadrant E, #196. Sapwood begins at 1067.	A=106+1	979p -1085+v	2872 -2766
KIT-68	Quadrant E, #201. Sapwood begins at 1067.	A= 79+1	1006p -1085+v	2845 -2766
KIT-44	Quadrant H, #266. Sapwood begins at 1074.	A=107	982p -1088v	2869 -2763
KIT-40	Quadrant K, excavator's #50. Sapwood begins at 1071.	A=104+6	980p -1089++v	2871 -2762
KIT-45	Quadrant I, excavator's #14. Sapwood begins at 1074.	A=104	986 -1089v	2865 -2762
KIT-13	Bucket 13. Sapwood begins at 1083.	A= 76	1015p -1090vv	2836 -2761
KIT-15	Bucket 15. Sapwood begins at 1074. Last five rings unmeasurable.	A= 92+5	994p -1090++v	2857 -2761
KIT-79	Quadrant G, #17. Sapwood begins at 1080.	A=124	970p -1093v	2881 -2758
KIT-38	Excavator's # 3. Sapwood begins at 1079.	A=123	971p -1093v	2880 -2758
KIT-49	Quadrant I, # 9. Sapwood begins at 1077.	A=105+3	986p -1093++v	2865 -2759

Table 4: Catalogue

SAMPLE	PROVENIENCE	RINGS=	RELATIVE DATES	BC DATES
KIT-83	Quadrant G, #66. Sapwood begins at 1071.	A=148+3	943p -1093++v	2908 -2758
KIT- 4	Bucket B. Sapwood begins at 1084.	A= 72	1023p -1094vv	2826 -2757
PHASE 3				
KIT-58	Quadrant L, #66. Sapwood begins at 1086.	A=134+1	957p -1091+vv	2894 -2760
KIT-43	Quadrant J, excavator's #20. Sapwood begins at 1077.	A= 88+5	1006p -1098++v	2845 -2753
KIT-62	Quadrant F, #214. Sapwood begins at 1081.	A= 78	1021p -1098v	2830 -2753
KIT-18	Excavator's #34. Sapwood begins in 1086.	A= 78	1021p -1098v	2830 -2753
KIT-29B	Quadrant D, #71 Sapwood begins in 1085.	B=113	987p -1099W	2864 -2752
KIT-84	No quadrant, no number. Sapwood begins at 1076.	A=118+1	982p -1100+W	2869 -2751
KIT-65	Quadrant F, #234. Sapwood begins at 1087.	A= 82+1	1018p -1100+v	2833 -2751
KIT-39	Quadrant K, #48. Sapwood begins at 1085.	A=153+1	947p -1100+v	2904 -2751
KIT-59	Quadrant L, #58. Sapwood begins at 1080.	A= 50+1	1051 -1101+v	2800 -2750
KIT-78	Quadrant G, #12. Sapwood begins at 1086.	A= 88+1	1015p -1103+W	2836 -2748
Between PHASE 3 AND PHASE 4				
KIT-71	Quadrant E, #200. No sapwood.	A=204+10	873p -1086++vv	2978 -2765
KIT-29A	See KIT-29B. Quadrant D, #71, No sapwood.	A= 93+1	1005p -1098+vv	2846 -2753
KIT-76	Quadrant K, #53. Sapwood begins at 1094.	A= 45+1	1062p -1107+W	2789 -2744
KIT-75	Quadrant K, # 1. Sapwood begins at 1089.	A=126+1	981p -1107+W	2870 -2744
KIT-73	Quadrant E, #205. Sapwood begins at 1092.	A= 87+2	1020p -1108++v	2831 -2743

Table 4: Catalogue

SAMPLE	PROVENIENCE	RINGS=	RELATIVE DATES	BC DATES
KIT-61	Quadrant L, #64. Sapwood begins at 1092.	A= 77+1	1032-1109+v	2819 -2742
PHASE 4				
KIT- 6	Bucket 14A. No sapwood.	A= 79	1019p -1097vv	2832 -2754
KIT-50	Quadrant I, # 2. Sapwood begins at 1101.	A= 95+1	1017-1112+v	2834 -2739
KIT-56	Quadrant H, #267. Sapwood begins at 1097.	A= 83+3	1027-1112++W	2824 -2739
KIT-55	Quadrant H, #253. Sapwood begins at 1097.	A= 82+1	1031p-1113+W	2820 -2738
KIT-52	Quadrant H, #259. Sapwood begins at 1101.	A= 67+1	1046p -1113+v	2805 -2738
KIT-80	Quadrant G, #22. Sapwood begins at 1098.	A= 45+2	1067p-1113++W	2784 -2738
KIT-48	Quadrant I, # 8. Sapwood begins at 1102.	A= 63+5	1047-1114++v	2804 -2737
KIT-54	Quadrant H, #254. Sapwood begins at 1100.	A= 80+3	1032p -1114++v	2819 -2737
KIT-74	Quadrant E, #199. Sapwood begins at 1102.	A=100	1015p -1114W	2836 -2737
KIT-60	Quadrant L, #60. Sapwood begins at 1086.	A=167+1	947 -1114+v	2904 -2737
KIT-42	Quadrant J, excavator's #22. Sapwood begins approx.1091.	A= 75+90	950p -1114++v	2901 -2737
AFTER PHASE 4 (POSSIBLY = PHASE 5?)				
KIT-32	Excavator's #67. Sapwood begins at 1113.	A= 45+2	1076p - 1122++vv	2775 -2729
KIT-17	Excavator's #101. Sapwood begins at 1110.	A= 53	1076p -1128v	2775 -2723
KIT-81	Quadrant G, #31. Sapwood begins at 1124.	A= 75	1060p -1136v	2791 -2715
Crossdated But Not Assigned To A Specific Phase Because Of The Absence Of Sapwood:				
KIT-16	Bucket 25. No sapwood preserved. Last 15 rings unmeasurable.	A= 82+15	905p -1001++vv	2946 -2850
KIT-33	Quadrant D, no number. No sapwood.	A= 73	970p -1042vv	2881 -2809

Table 4: Catalogue

SAMPLE	PROVENIENCE	RINGS=	RELATIVE DATES	BC DATES
KIT-35	Excavator's #46. No sapwood.	A=172+20	852p -1043++vv	2999 -
KIT- 7	Bucket 7A. No sapwood.	A= 76	974p -1049vv	2877 -2802
KIT-12	Bucket 22 (Same tree as KIT-3).	A=145	908p -1052vv	2943 -2799
KIT- 3	Bucket A (Same tree as KIT-12). Last 15 rings on KIT-3 unmeasurable. No sapwood preserved.	A=115+15 ?	908p -1037++vv	2943 -2814
KIT-3&12		A=145	908p -1052vv	2943 -2799
KIT-23	Sondage E, no number. No sapwood.	A= 89+1	966+p-1055+vv	2885 -2796
KIT-51	Quadrant I, #17. No sapwood.	A= 50+1	1010 -1060+vv	2841 -2791
KIT-67	Quadrant E, #194. No sapwood.	A= 97+1	970p -1067+vv	2881 -2784
KIT-82	Quadrant G, #44. No sapwood.	A= 76	1003p -1078vv	2848 -2773
THE FOLLOWING PIECES ARE UNDATED:				
KIT- 5	Bucket C. Root? Branch?	A=? B= ? C= ?	undated " "	
KIT- 9	Bucket 20. Badly eroded.	A=?	undated	
KIT-10	Bucket 20A. Badly distorted.	A=? B=?	undated "	
KIT-11	Bucket 21. Too few rings.	A=±20 B=±20	undated "	
KIT-19	Excavator's #180, sondage Legnali Radi(?). 5 rings of sapwood.	A= 45	undated	
KIT-24	Excavator's #16. Box	A= 88+1	undated	
KIT-26	Excavator's #1. No sapwood.	A= 44	undated	
KIT-27	Excavator's #6. 10 sapwood rings.	A= 45+1	undated	
KIT-28	Excavator's #2. 16+ sapwood rings. An erratic piece.	A= 77	undated	
KITEN MASTER CHRONOLOGY		M=285	852 -1136v	2999 -2715

(Master chronology includes KIT-1,2,3&12,4,6-8,13-18, 20-23,25,29-45, and 47-84: a total of 75 different trees.)

Notes:

1 Sixteen cross-sections of oak (Quercus sp.) pilings were collected from water-filled plastic buckets in the Sozopol Museum on 20 August 1988. The sections had been cut in 1986 at the start of excavations according to the excavator Dr. Kalin Porožanov, Institute of Thracology, Moskovska 13, Sofia 1000, Bulgaria, and his assistant Elizabeth Triandafilova. Sixty-nine more cross-sections of pilings were collected from the site of Primorsko, Kiten, on 11 September 1989, sixty-seven of which are oak and two of which are box (Buxus spp.) The pilings were sawn by divers working about ten meters under the Black Sea. Thus we did not see the site itself.

2 For a recent survey of the method and its applications, see Schweingruber, 1988. For Demircihüyük see Kuniholm 1987. For tree-ring work in the Aegean in general, see Kuniholm and Striker 1987; Kuniholm 1995; Kuniholm, in press.

3 The 1988 samples are listed by Dr. Porožanov's bucket number. Processing numbers (KIT-1 through KIT-16) for our computerized filing system were assigned here in Ithaca, N.Y. Most of the 1989 samples have excavator's numbers. Our processing numbers were assigned at the site as we chose the samples for their ring count. KIT-29 was mistakenly assigned to two samples (KIT-29A and -29B), so that the total number of samples is actually 85 even though the last sample number is KIT-84. When the architectural plans for Kiten are completed, it will be instructive to compare the provenience for each piece and see whether there is any architectural coherence to our proposed dendrochronological phasing.

4 N.B.: The preparation of the samples tended to distort the outer rings of the pieces; therefore the exact ring count and the determination of a waney edge or terminal ring (German Waldkante) or bark date (German Rinde) is difficult. All the pieces with a single 'v' after the date have, in our opinion, a last preserved ring within 1-5 years of the bark date. Any piece with no sapwood that has been assigned to a phase is to be treated cautiously. All samples were assigned because of their superior crossdating with the other samples in that phase.

5 In addition, the Heidelberg laboratory has participated in two international 14C intercomparison programs (Scott et al. 1992; Rozanski et al. 1992); the results prove that the Heidelberg laboratory agrees with the consensus values (quoted errors under 20 years).

6 Letter from Professor Todorova 31 January 1991.

7 We thank Robert Pohl and Eleanor Kuniholm for help in sample collection, Christine Latini for editing and graphics, and Mary Jaye Bruce for editing and manuscript preparation.

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