

“A 677 YEAR TREE-RING CHRONOLOGY FOR THE MIDDLE BRONZE AGE”

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INTRODUCTION

In 1973 when I proposed to Prof. Rodney S. Young to undertake the dendrochronology of Anatolia as a dissertation topic, one of his immediate suggestions was: “Go to Tahsin and get some Kültepe wood!” Over the years we have collected wood at Kültepe thanks to Prof. Özgüç’s generosity, and, since it is difficult to study the dendrochronology of one site alone, we have also collected comparative wood from Achemhüyük thanks to Prof. Nimet Özgüç. It is therefore our pleasant duty to publish this first report on Middle Bronze Age dendrochronology in honor of both the Man from Kanesh and the Lady from Purushkanda who after Dr. Young’s death became the god-parents of this project. We also thank all the assistant field directors and site supervisors, especially Prof. Kutlu Emre, Dr. Aykut Çınaroğlu, and Dr. Aliye Özten who helped to welcome us and make work so much easier by discussing the excavations which were still in progress and by sharing their ideas at every step.

Kültepe and Achemhüyük will always be focal points of any study of the Middle Bronze Age, as the type sites for the Assyrian Colony Period, as vast resources of textual and art-stylistic information, and as centers to which many famous Near Eastern rulers of the 18th century BC sent rich gifts, thereby establishing for us the cultural and temporal cross-links so necessary for an understanding of the period. Thus, it is only appropriate that any dendrochronological study of the MBA begin with the wood of Kültepe and Achemhüyük.

Our Middle Bronze Age work occurred at a time when we were also trying to develop long tree-ring chronologies which would span the approximately 3700 years from the present to the MBA. The most recent summary of this effort is P.I.Kuniholm and C.L.Striker, “Dendrochronological Investigations in the Aegean and Neighboring Regions, 1983-1986,” *Journal of Field Archaeology* 14 (1987) 385-398.

GOALS:

Several questions immediately came to mind as we started to measure the Middle Bronze Age wood (actually charcoal). They are listed below with the results as of October 1988:

QUESTION

ANSWER

1. Relative construction date for the Warşama Sarayı at Kültepe?
58 years before the Achemhüyük buildings.
2. Relative construction date for the Sarıkaya Palace at Achemhüyük?
58 years after Warşama Sarayı and the same year as Hatipler Tepesi.
3. Relative construction date for the Hatipler Tepesi at Achemhüyük?
58 years after Warşama Sarayı and the same year as Sarıkaya.

4. Relative construction date(s) for the Kültepe II buildings and therefore the difference in time between Kültepe II and Kültepe Ib? (Present system based principally on *limu*-names and to a lesser extent on pottery and sealings.) No wood yet from Kültepe II.
5. Relative dates between the Palace and Karum at Kültepe? No suitable wood yet from the Karum.
6. Destruction dates for any of these buildings? No.
or at least an indication from repairs to the buildings that would give us an idea of approximately how many years they were in use before they burned to the ground? One indication from Kültepe.
7. Relative construction dates for the lesser buildings at Acemhöyük? One.
8. Could we construct a long Middle Bronze Age tree-ring chronology by means of which other Anatolian MBA sites could be dated? Yes.
9. Could we "wobble-match" this long chronology to find where it fits on the radiocarbon time-scale? Results only 3/7 complete.
10. Absolute dates for the Middle Bronze Age? Not yet.

COMMENT ON HOW TO READ THE FOLLOWING CATALOGUES OF SAMPLES:

SAMPLES

Sampling numbers (KÜL-1, KÜL-2, etc.) refer to the order in which the specimens were collected.

PROVENIENCES

Grid square references and room numbers, in the absence of a published plan of the Warşama Sarayı and of Hatıpler Tepesi, were kindly provided by the excavators, Prof. Tahsin Özgüç, Prof. Kutlu Emre, and Prof. Nimet Özgüç. The name of the scientist who provided a species identification is listed in parentheses. Other information includes the function of the timber, if known.

RINGS

A,B,C,D, etc., refer to the fragment that was measured. Sometimes more than one fragment could be combined into a longer sequence (CDEF COMB). The numbers refer to the measurable rings on each sample.

RELATIVE DATES

The counting system is a purely arbitrary one based on KÜL-13, one of the longest and clearest ring-sequences from this building. Its innermost ring, the pith (Turkish *merkez*), was arbitrarily assigned a date of Relative Year 1001. All other dates at Kültepe and Acemhöyük are given on the basis of this counting system. Thus KÜL-17 starts at Relative Year 998 or three years earlier than KÜL-13, and so forth. Both the innermost ring and the outermost ring for each sample are given. If no numbers are given in the column marked RELATIVE DATES, this means that we have not been able to find an acceptable fit, and the sample remains undated. The measurements for each piece, however, are on our computer file and the pieces may some day be datable as we continue to collect Middle Bronze Age wood for comparison.

After the last preserved ring is one of the following notations:

- B = Bark (Turkish *kabuk*). This means that the last preserved ring is from the year in which the tree was cut. No rings have been lost either to the carpenter's tools or to the action of the fire which destroyed the building. (This is the most desirable kind of sample.)
- v = Very few rings, if any, are missing. This is a subjective judgment on the part of the person measuring the piece and is based on the condition of the exterior of the wood (for example, with the bark peeled off but with no rings removed).

- vv = This means that we have no way of proving how many rings are missing. (This is the least desirable kind of sample.)
- ++ = The last rings can be counted but not measured, either because the sample is in bad condition or because the rings are impossibly small. The last measured ring is listed in the text under PROVENIENCES.

KÜLTEPE, WARŞAMA SARAYI, CATALOGUE

SAMPLE	PROVENIENCE	RINGS	RELATIVE DATES	
			First Year	Last Year
<i>CITADEL, BURNED LATE PALACE (WARŞAMA SARAYI) (KÜLTEPE KARUM Ib)</i>				
<i>CROSSDATED SAMPLES:</i>				
KÜL - 3	No Grid No. Charred board, adzed on four sides. found on floor. Submitted 12 August 1975 by Prof. Kutlu Emre.	A = 68	1095	-1162vv
KÜL - 5	Grid No. Y/22. Part of transverse beam in N-S wall, just above socle. Charcoal fragments. Submitted 3 October 1975.	B = 135	1038	-1172v
		5A, 7AD COMB. = 73		
		5C, 7BE COMB. = 84		
KÜL - 6	Grid No. V/23. W side of palace. From SW corner of room S of one from which KÜL-5 was collected Five <i>kerpiç</i> pylons to E, dividing the room in two. Charcoal fragments. <i>Pinus</i> sp. (<i>silvestris</i> group) (Dr. B. F. Kukachka).	A = 73		
		B = 53		
		AB COMB. = 73		
		C = 70		
		D = 81		
		E = 66		
		F = 91		
		CDEF COMB. = 134	1039	-1172v
The following charcoal samples were collected in 1987. All are transverse beams at floor level from the E W wall in Grid Squares Z/23 and aa/23.				
KÜL - 11	Measured to RD 1166. Last six rings can be counted but not measured.	A = 72+6	1095	-1172++v
KÜL - 12		A = 76	1080	-1155vv
KÜL - 13		A = 173	1001	-1173v
KÜL - 14		A = 153	1020	-1172v
KÜL - 15		A = 82	1092	-1173v
KÜL - 16		A = 153	969	-1121vv

KÜLTEPE, WARŞAMA SARAYI, CATALOGUE

SAMPLE	PROVENIENCE	RINGS	RELATIVE DATES	
			First Year	Last Year
<i>CITADEL, BURNED LATE PALACE (WARŞAMA SARAYI) (KÜLTEPE KARUM Ib) CROSS-DATED SAMPLES (continued):</i>				
KÜL - 17		A = 74	1100	-1173v
KÜL - 18	<i>Juniperus</i> sp. (Dr. W. H. Schoch).	A = 174	998	-1171B
KÜL - 19	Later repair. See discussion below.	A = 90	1145	-1234vv
KÜL - 20		A = 88 B = 91 C = 77 ABC COMB. = 92	1082	-1173v
KÜL - 21		ABC COMB. = 93	1077	-1169v
KÜL - 23	Extremely difficult piece to measure. The first 328 years are secure, but there appears to be a missing ring at Relative Year 1080. This piece and the problems with the last rings are discussed below. <i>Juniperus</i> sp. (Dr. W. H. Schoch). Also a repair or part of a later building program.	ABCDEFGH COMB. = 428 ±	763	-1191vv
<i>CITADEL, BURNED LATE PALACE (WARŞAMA SARAYI) (KÜLTEPE KARUM Ib) SAMPLES WHICH DO NOT CROSSDATE:</i>				
KÜL - 1	Grid No. Z/19-20. Heavily eroded lumps of wood, slightly charred on outside. Excavated in 1973, submitted in Feb. 1974 by Uğur Silistreli. KÜL - 1A identified as <i>Cedrus libani</i> Loud., KÜL - 1B identified as <i>Pinus silvestris</i> L. (Dr. B. Aytuğ).	A = 34 B = 28		
KÜL - 2	Grid No. Y/20. <i>Pinus silvestris</i> L. (Dr. B. Aytuğ). Excavated and submitted as above.	A = 51		
KÜL - 4	East retaining wall of palace terrace. 26 m. ± from NE corner. Transverse beam, in fragments. Centered .74 m. above bottom of foundation course. Submitted 3 October 1975 by Prof. Kutlu Emre.	A = unmeasurable		
KÜL - 7	S side of palace, room with some stone paving on sides, 5th room from E side of palace. Grid square AA/23. Charcoal lumps (full cross-sections), found piled on N wall. 7A identified as <i>Pinus</i> sp. (<i>silvestris</i> group), 7BC identified as <i>Juniperus</i> sp. (Dr. B. F. Kukachka).	7AD, 5A COMB. = 73 7BE, 5C COMB. = 84		

KÜLTEPE, WARŞAMA SARAYI, CATALOGUE

SAMPLE	PROVENIENCE	RINGS	RELATIVE DATES	
			First Year	Last Year

CITADEL, BURNED PALACE (WARŞAMA SARAYI) (KÜLTEPE KARUM Ib) SAMPLES WHICH DO NOT CROSSDATE (continued):

KÜL – 8 Grid No. AA/31 and bb/29. Bag of oak fragments, eleven of which have been combined to form a small master chronology 84 years long which does not crossdate well with the Kültepe conifer master.

MASTER = 48

KÜL – 9 Collected 1982. Provenience unknown.

A = 84

1987 sampling. This specimen is a transverse beam at floor level from the E-W wall in Grid Squares Z/23 and aa/23.

KÜL – 22 (Erratic growth.)

A = 91

DISCUSSION:

First, note in the catalogue and in the Kültepe bar graph (fig. 1) how many pieces have last preserved rings in Relative Year 1173 or have last preserved rings at the most one or two years earlier. In one instance, KÜL – 18, the bark (*kabuk*) is present in 1172. We propose, therefore, that Relative Years 1172/3 are the construction years for the Warşama Sarayı. Of course, other pieces lost a number of rings due to the action of the wood-cutters and to the fire which destroyed the palace.

Second, we always look to see if there are some pieces which are later than the master chronology, thereby indicating that they are from later repairs. This would be especially likely if the Warşama Sarayı were long-lived. Here the excavator's opinion regarding the life-span of the building is important. We understand from the excavators of both Kültepe and Acemhöyük that their palaces may have had long lives (100 years or more). Thus it was with great interest that we recently discovered that one hitherto uncrossdated piece, KÜL – 19 from Grid Squares Z/23 and aa/3, fits at Relative Date 1234 or 61 years after most of the Kültepe timbers were cut. This means that the building was at least 61 years old at the time KÜL – 19 was cut, possibly older if we make an allowance for missing exterior rings on KÜL – 19. KÜL – 23 from the same Grid Squares is also later than the majority. So far these are the only indications of later building activity. It is essential for determining the longevity of these buildings for additional wood of this kind to be recovered. We note that other pieces of wood from the same wall have terminal rings in 1173, but we do not have a ready explanation why there should be this difference unless KÜL – 19 were a fallen timber from a repair to the roof or some kind of intervention in the wall, traces of which have disappeared since it was excavated several years ago.

Third, undated pieces are sometimes as interesting as the dated pieces. Note in the catalogue that there are no undated pieces with 100+ rings, seven with 50+ rings (which *may* some day be crossdated), and only two with 50- rings (which have almost no chance of ever being crossdated). Work on newly-collected samples from the Warşama Sarayı continues.

The heartwood-sapwood boundary, so often useful in determining the nearness of the terminal growth-ring in oaks, is less useful in conifers and completely indistinguishable in the charcoal which makes up almost 100 % of our Bronze Age dendrochronological material.

KULTEPE, WARSAMA SARAYI

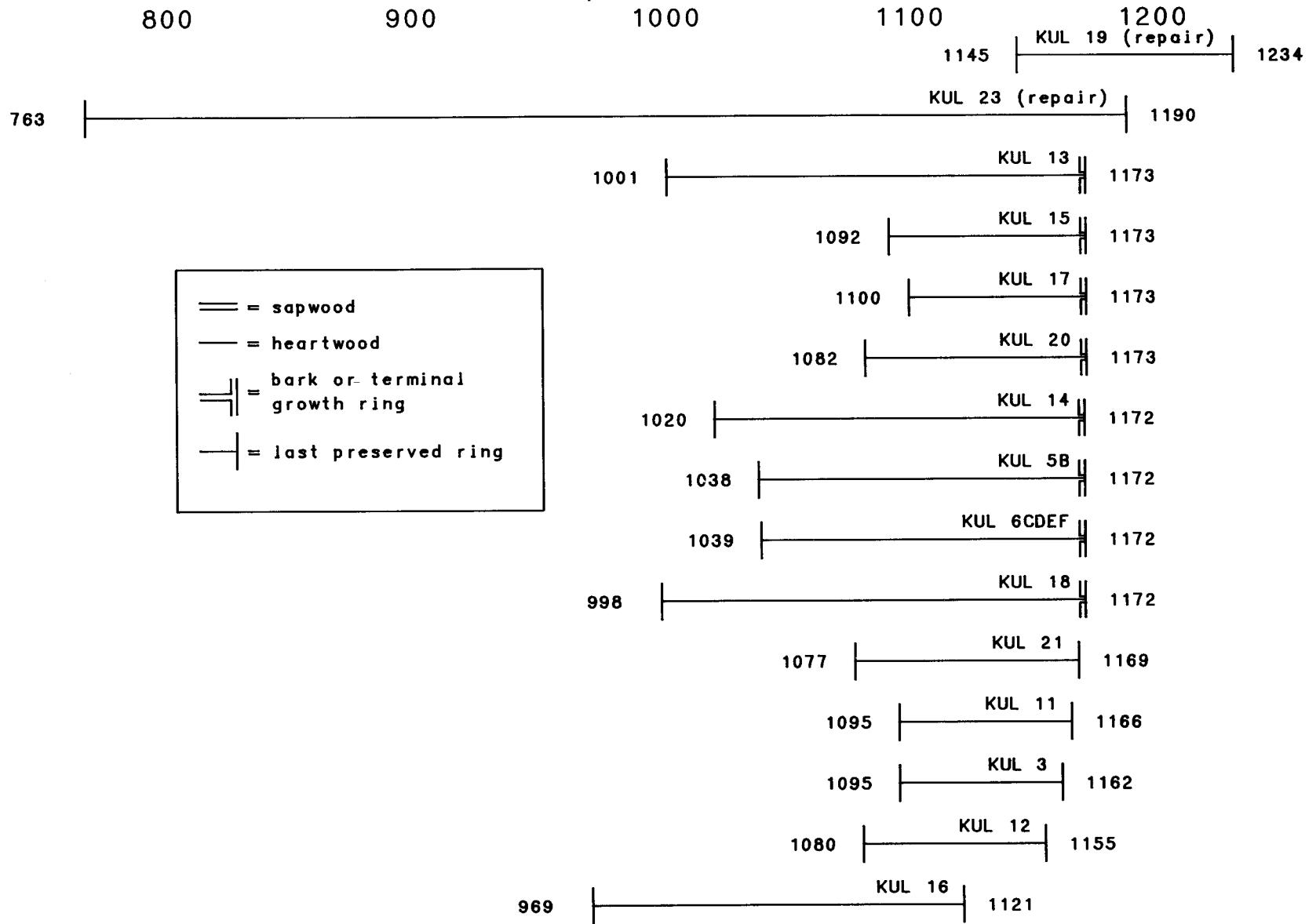


Figure 1, Kültepe Bar Graph

ACEMHÜYÜK, SARIKAYA PALACE, CATALOGUE

SAMPLE	PROVENIENCE	RINGS	RELATIVE DATES	
			First Year	Last Year
<i>SARIKAYA PALACE, Second level, CROSSDATED SAMPLES</i> (for room locations see notations on plan from <i>Bellesten</i> 1979). All samples are carbonized:				
Collected 10 October 1973.				
ACM - 5	Grid No. PA/46, Room 29. <i>Cedrus libani</i> , sp. (Dr. W. H. Schoch). Two beam fragments.	A = 171 B = 222	* 969	-1139vv -1229vv
ACM 6	Grid No. PA/46, Room 29. <i>Cedrus libani</i> sp. (Dr. W. H. Schoch). Beam fragment, (last ring present on all that could be seen of the beam.)	A = 275	* 964	-1238v
ACM - 7	Grid No. PA/46, Room 29. <i>Cedrus libani</i> Loud. (Dr. B. Aytuğ). Charcoal beam fragment.	A = 182	*1035	-1239v
ACM -- 8	Grid No. PA/46, Room 29. Stored in room 17, Grid No. NA/45. <i>Cedrus libani</i> Loud. (Dr. B. Aytuğ). Charcoal lump. Charred outer face.	A = 100	*1042	-1141vv
Collected from the depot of the Ankara Museum 19 February 1974:				
ACM - 12	Cross-section of charcoal log. <i>Cedrus libani</i> , sp. (Dr. W. H. Schoch). Unknown provenience.	A = 254	* 910	-1163vv
*These six cedar pieces form a tightly fitting master chronology called ACM - 666, but because of the idiosyncratic nature of cedar they have been averaged separately from the pieces in the ACM - 999 Master composed of other conifers from Acemhüyük. The problems which ACM - 6 and 7 cause with the interpretation of the Acemhüyük wood are discussed below. NOTE: All Acemhüyük dates are based on the Kültepe Relative Dating system.				
Collected 10 August 1974:				
ACM - 13	N side of palace, 3rd room from E, doorway to E-W hall between Rooms 1 and 4. E reveal of door. Half-section, <i>juniperus</i> sp. L. (Dr. B. Aytuğ).	AB = 156	1076	-1231v
ACM - 14	See ACM - 13. Also from E reveal of door. <i>Juniperus</i> sp. (Dr. W. H. Schoch). Three-quarter section.	AB = 126	1104	-1229v
ACM - 15	See ACM - 13. Also E reveal of door. <i>Juniperus</i> sp. L. (Dr. B. Aytuğ). Quarter-section. Squared on two sides.	AB = 142	1090	-1231v

ACEMHÜYÜK, HATIPLER TEPESİ, CATALOGUE

SAMPLE	PROVENIENCE	RINGS	RELATIVE DATES	
			First Year	Last Year
<i>HATIPLER TEPESİ, LARGE BURNED BUILDING, CROSSDATED SAMPLES:</i>				
Collected 10 August 1974:				
ACM - 17	Grid No. FA/29. Threshold between rooms 1 and 2. Door jamb, N reveal. (Tenon in side = ACM - 17B). <i>Pinus nigra / silvestris</i> (Dr. W. H. Schoch).	A = 95	1118	-1212vv
ACM - 18	Grid No. FA/30. Room 3. SE corner of grid near wall (party wall with Room 2) Beam beds run N-S. "Döşeme tahtalarının izlerinin olduğu oda." <i>Pinus silvestris</i> L. (Dr. B. Aytuğ). Section.	A = 67	1165	-1231v
ACM - 20	Grid No. HA/GA-28. Room 23. Half-section. Charcoal. Round side down, = ?threshold. Ring 64 complete all around arc. <i>Pinus nigra/silvestris</i> (Dr. W. H. Schoch).	A = 64	1168	-1231v
Collected 11 August 1974:				
ACM - 21	Grid No. HA/28. Room 23. West side of room. Westernmost transverse beam (of 15) projecting N-S from S wall. Footing for S wall of room. <i>Juniperus</i> sp. L. (Dr. B. Aytuğ and Dr. W. H. Schoch).	A = 64 E = 156	1166	-1229v -1231v
ACM - 22	Random from HTP. Room 24. Not in situ when recovered. Probably a continuation of N-S wall in GA/28 and GA/29. Radial section. <i>Pinus nigra / silvestris</i> (Dr. W. H. Schoch).	A = 65	1166	-1230v
ACM - 23	Grid. No. GA/30. NE corner of Room 3. N wall foundation, SW corner of wall. Cross-section. <i>Buxus</i> sp. (Dr. W. H. Schoch). Bark preserved.	A = 207	1024	-1230B
ACM - 24	SE corner of HTP palace. Entryway from S. Beams laid parallel for entryway. Ring 158 on one radius only. <i>Cedrus libani</i> Loud. (Dr. B. Aytuğ).	A = 158	1074	-1231v

DISCUSSION:

Sarkaya and Hatipler Tepesi have a large number of timbers which were cut in Relative Year (Kültepe Dating System) 1231 (see fig. 2). In spite of the disastrous fire which destroyed these structures, at least ten pieces have a last preserved ring ranging from 1229-1231. Apparently the practice of the Acemhüyük carpenters was to peel their timbers but not to shape them in any radical fashion. Our first conclusion, then, is that both structures at Acemhüyük were built in the same year. Prof. Nimet Özgüç now informs us that she thinks that they may be wings of the same palatial building with Sarkaya serving as the "palace" and Hatipler Tepesi serving as a storage or support building. Two cedar pieces, ACM - 6 and 7 from Room 29, have last rings in 1238 and 1239 respectively. We do not have a ready explanation for the 7-8 year discrepancy other than that Room 29 may have undergone a modification 7-8 years after the basic construction.

NON-CHRONOLOGICAL COMMENT ABOUT WOOD SPECIES:

Of the 35 samples which have received specialist identification, 12 are pine, 12 are juniper, 9 are cedar, 1 is boxwood, and 1 is oak. Pines and junipers thus represent two-thirds of the wood used in construction at Kültepe and Acemhüyük. Note the remarkable absence of oak, so common in medieval structures in Anatolia.

Cedars are always of interest for the Bronze Age because of the vast quantity of cedar wood presumably exported from the Levant to Egypt and preserved in Egyptological collections around the world. The 330 year Cedar of Lebanon chronology from Sarkaya immediately becomes something with which we can try to match Egyptian (= Lebanese) cedar wood. We are already at work on a comparative study of the growth characteristics of living cedars from Anatolia and Lebanon.

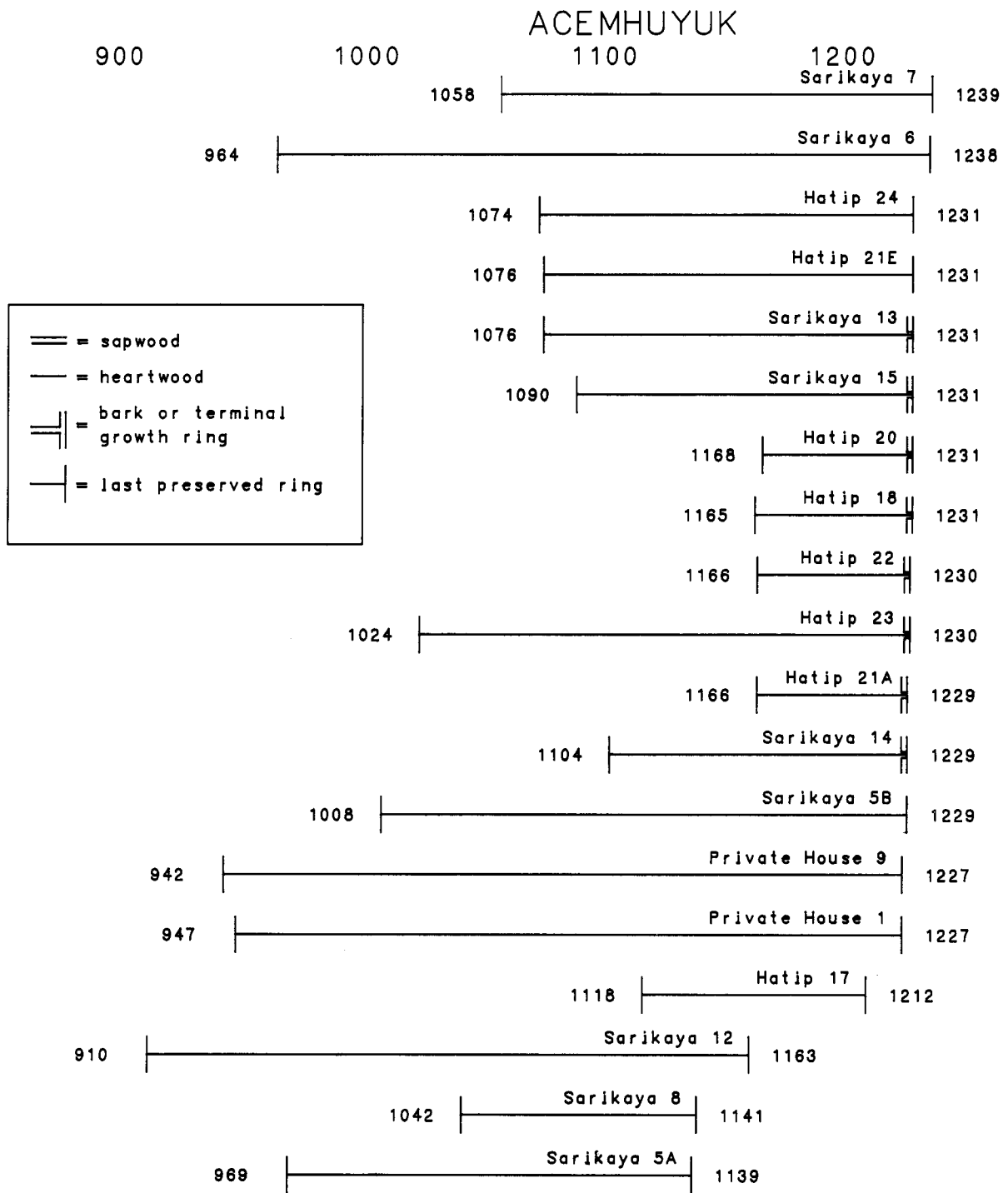


Figure 2, Acemhuyuk Bar Graph

ACEMHÜYÜK, SARIKAYA PALACE, CATALOGUE

SAMPLE	PROVENIENCE	RINGS	RELATIVE DATES	
			First Year	Last Year

SARIKAYA PALACE, second level, SAMPLES WHICH DO NOT CROSSDATE:

Collected 10 October 1973:

ACM – 3 Grid No. PA/42. Collected from Room 5, original provenience lost. From fallen roof beams? Last ring is complete around circumference except for adzed area. Wrapped in *hasır* or matting. *Pinus silvestris* (Dr. B. Aytuğ).

A = 56

ACM – 4 Same room and context as ACM –3. *Pinus silvestris* (Dr. B. Aytuğ). Two cross-sections.

A = 39

B = 47

Collected from the Ankara Museum Depot 19 February 1974:

ACM – 11 End of charcoal beam. Full section. Chiselled holes for tenons (which are still in place) on opposite sides. *Pinus nigra / silvestris* (Dr. W. H. Schoch). Unknown provenience (but from Sarıkaya).

A = 91

Collected 10 August 1974.

ACM – 16 E side of Sarıkaya Palace, Room 7. Narrow ? hallway S of stone wall footing. Bark? on outside. *Juniperus* sp. (Dr. W. H. Schoch). Erratic growth.

A = 141

Collected 3 July 1981:

ACM = 27 Same provenience as ACM-28. Half of a whole fallen log. Erratic growth.

A = 91

ACM – 28 Recovered from Room 5. Original provenience lost, but from Sarıkaya. Fallen roof? beam. A = Section of carbonized whole log. Evidence of peeling/adzing on one side. B = small additional piece which may preserve terminal ring. *Pinus nigra / silvestris*. (Dr. W. H. Schoch). Erratic growth.

A = 103

B = Not measured

ACEMHÜYÜK, HATIPLER TEPESİ, CATALOGUE

SAMPLE	PROVENIENCE	RING	RELATIVE DATES	
			First Year	Last Year

HATIPLER TEPESİ, LARGE BURNED BUILDING, SAMPLES WHICH DO NOT CROSS-DATE:

Collected 10 August, 1974:

ACM - 19 Grid No. FA/29. Beam end found lying loose in NE corner of Room 11. Beetle galleries on two opposite sides. Flat on one side. Bevelled at 45° on other. Very crudely chopped. *Juniperus* sp. (Dr. W. H. Schoch).

A = 85

ACM - 25 No Grid No. NE room, near N wall (next to door to E-W gallery). Wood cross-section. Perhaps threshold between Rooms 12 and 23. *Juniperus* sp. (Dr. W. H. Schoch).

A = 152

MISCELLANEOUS PIECES FROM ACEMHÜYÜK FROM CONTEXTS OTHER THAN SARIKAYA AND HATIPLER TEPESİ

PRIVATE HOUSE ON THE HÜYÜK: thought to be approximately contemporary with Kültepe Karum Ib)

Collected 10 October 1973. From NW trench.

ACM - 1 Charcoal beam section collected in the depot of the Niğde Museum. *Cedrus libani* (Dr. W. H. Schoch).

A = 281

947 -1227v

ACM - 2 Charcoal beam section collected in the depot of the Niğde Museum. From same log as ACM - 1.

A = not measured

ACM - 9 Charcoal beam collected 19 February 1974 from the depot of the Ankara Museum. Remainder left in Ankara. From same log as ACM - 1.

A = 286

942 -1227v

DISCUSSION:

The last rings of ACM - 1 and 9 make the timber approximately contemporary with the Sarıkaya Palace. However, this is one timber only, and any data from such a small sampling should be treated with extreme caution.

Collected 3 July 1981:

ACM - 26 Grid No. U/55, West trench, Layer III (Excavator's comment: same as Sarıkaya, 3rd Palace.) Possibly fallen from W side of building (as yet unexcavated). Lies above floor.

A = 35

ACM - 29 West trench, N side, post, burned on top. Max. D. =. 285m. Max. preserved Ht. =. 55m. *Juniperus* sp. (Dr. W. H. Schoch).

A = 190

Collected 12 July 1982 from M.T.A. Ankara:

ACM - 31 Central trench, Level II. *Juniperus foetidissima*. 2 FH cores from badly rotted log.

Not measured.

PORSUK/ULUKIŞLA:

In the spring and summer of 1988, just as this report was being prepared, Prof. Olivier Pelon kindly provided us with a number of samples from his excavations at Porsuk/Uluqişla. We also thank Dr. Sylvestre Dupré for his help and commentary. Although the Porsuk work is far from complete, and a final Porsuk dendrochronological report can be written only after at least another season's excavations and collection, it is clear that we have already a 321 year long master chronology from Porsuk that overlaps the 469 year long Kültepe/Acemhüyük chronology by 113 years and extends it downward by 208 years. We therefore have added the measurements from Porsuk/Uluqişla to the Middle Bronze Age Master Chronology, making it 677 years long. See Table 1, below.

METHODS BY WHICH THE CHRONOLOGIES WERE MATCHED:

Study of the living conifer forests of Anatolia has shown us that it is possible to achieve synchronisms over long distances, as far as from Kars to the Aegean and even to central Greece. Thus, it is not surprising that we find excellent visual and statistical fits between our three sites. The visual fit can be seen in the composite graph in Fig. 3. The statistics used to support our fits are as follows:

Site A	Site B	Distance	t-score	Overlap	Trend	D-Score
Kültepe	Acemhüyük	160 km.	7.37	100 yrs.	65.7 %	117.7
KÜL/ACM	Porsuk	120-180	6.65	113 yrs.	66.1 %	106.9
Acemhüyük	Porsuk	120 km.	6.60	113 yrs.	63.4 %	88.4
Kültepe	Porsuk	180 km.	2.68	55 yrs.	64.8 %	n/a

NOTE: These are standard statistical tests. The trend coefficient or percentage of agreement is described by B. Huber in J. Fletcher, ed., *Dendrochronology in Europe*, BAR 51 (1978) 23. The t-test is described by M.G.L. Baillie and J.R. Pilcher, "A Simple Crossdating Program for Tree-Ring Research," *Tree-Ring Bulletin* 33 (1973) 7-14. The D-Score (significant only if the overlap or n is over 100 years) is described by B. Schmidt, *Dendrochronologie und Ur- und Frühgeschichte*, Köln, Habilitation thesis, 1987, 13.

NOTE ON HOW READ THE TABLE OF TREE-RING INDICES:

Growth percentages for each year are shown in the left-hand table, and the numbers of samples from which each percentage was derived are shown in the right-hand table. For example, in the Middle Bronze Age Master Table which follows, Relative Year 1335's ring-growth was 45% of normal, an average that was derived from 39 specimens from 39 trees. Note also that the last half of this table is more significant than the first half because it is based on a greater number of samples. For example, in Relative Years 792 and 793 ring growth was only 44% of normal, but this observation is based on only one sample from one tree. When more wood is collected from the earlier centuries of this period and if the new samples show the same fluctuation in the same two years, then we will be able to say that this is indeed a significant deviation from normal growth. "Problem" pieces have been omitted from the indices, as were the cedars which have their own growth curve.

RELATIVE OR COMPARATIVE CHRONOLOGIES AND DATES:

We now have a 677 year long skeleton to which we hope to attach the flesh of Middle Bronze Age history. As new information becomes available, our challenge will be to see where specific Bronze Age events fit in. The approximate time-scale of this combined chronology from the three sites is from the Early Bronze Age or the 23rd century BC (the birthdate of the oldest sample at Kültepe) to the 16th century BC or the time of the Old Kingdom Hittites (the latest rings at Porsuk/Ulukışla). This is a non-dendrochronological estimate, based on the finding of bullae, in the destruction of the Sarıkaya Palace, from the early part of the reign of Şamşı-Adad I. Four of these have been attributed to his tenth year (Prof. Nimet Özgüç, pers. comm.) This year of Şamşı-Adad's becomes the *terminus ante quem* for our Relative Year 1231. If the Achemhüyük buildings had the century or century-and-a-half life-span that Prof. Nimet Özgüç has suggested, the effect would be to move the entire dendrochronology upward (earlier) by that amount of time so that it would begin in approximately the 24th century and end in the 17th century. If more wood from repairs at the continuing excavations at Achemhüyük can be found, we will have an idea of how much earlier the absolute chronology should be adjusted. At any rate, the parts of the whole dendrochronology will move upward or downward together.

Moreover, a glance at the composite graph (Fig. 3) and the 68 year difference between the building years at Kültepe and Achemhüyük also raises the question as to whether the Warşama Sarayı could have been built as early as Kültepe II and destroyed during Kültepe Ib.

We are informed by Messrs. Pelon and Dupré that an Old Kingdom Hittite date for the Porsuk destruction from which our charcoal comes is probable. We have not yet found either bark or terminal rings there. The continuing work at Porsuk will no doubt add useful information to what we already have in hand, especially if the data include bullae and tablets attributable to specific kings.

The gap between the end of the 677 year Middle Bronze Age tree-ring chronology and the beginning of the 806 year Gordion chronology is now approximately one century or less. We had hoped that wood from Maşat might fill part of the gap, but unfortunately it was not long-lived. The best hope appears to be the latest Hittite levels at Porsuk. When the chronologies are bridged we will have a continuous sequence that is over a millennium and a half long, covering the period from Early Bronze into the Iron Age.

ABSOLUTE RADIOCARBON DATES FOR NUMBERED RINGS FROM KÜLTEPE AND ACEMHÜYÜK

In the absence of a continuous tree-ring chronology which extends back from the present to the Middle Bronze Age, we thought it would be worth trying to "wobble-match" the Kültepe/Achemhüyük ring-sequence with the radiocarbon time-scale. In theory, it should be possible to pin the sequence down to within ± 20 years. Seven samples of numbered rings spread over the length of the master chronology were sent last spring for radiocarbon analysis to Dr. Bernd Kromer at the University of Heidelberg and more are going to him now that the chronology has been extended, but as of this writing only three of the tests are complete. A joint report will be published as soon as the data become available.

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