Chapter 53

Dating

Peter Ian Kuniholm, Maryanne W. Newton, Roy Switsur & Nicholas Postgate

Dendrochronology
by Peter Ian Kuniholm & Maryanne W. Newton

Over the years of the Kilise Tepe excavations, 1994–1998, Professor Postgate kindly furnished the Aegean Dendrochronology Project with twenty sets of charcoal. One lot was Cedrus sp., one Salix sp., one Populus sp., and seventeen were Pinus sp. The most common variety of pine in the region today is P. brutia. In its carbonized state with no bark or needles or cones preserved, a distinction between the subspecies of pine cannot be made.

One pine sequence from a single tree, a combination of three charcoal samples, KLT-3 (J20/172), KLT-6 (J20/180), and KLT-7 (also J20/180), forms a ring-sequence 194 years long. The sample is from Unit 5703, in the excavator’s phase IIId. Some years ago we reported to Professor Postgate that the combined ring-sequence looked good against the Bronze Age/Iron Age tree-ring chronology at 1381 BC +4/–7 (t-score 4.61, overlap 194 years, r-correlation .32, trend coefficient 59.1%, D-score 41.7), but since then (1996) additional work on the radiocarbon basis upon which the absolute dates were based required the shifting up of all dates connected to that floating dendrochronology, i.e. everything is now older by 22 years. Because this floating chronology is not yet connected to the living trees of the Anatolian plateau, largely because of a major gap in the Roman period, we have been using radiocarbon wiggle-matching to approximate absolute dates for the Bronze Age/Iron Age tree-ring chronology until such time as it can stand on its own.

The argumentation for the first placement was set out by Kuniholm et al. in Nature in 1996 (and see also the comment by Renfrew in the same volume, 733–4) and then, with more than triple the number of radiocarbon determinations for the wiggle-match of Gordion timbers, in Science in 2001 (Manning et al. 2001; Kromer et al. 2001, and see also comment by Reimer in the same volume, 2494–5). The revised date for the whole dendrochronological sequence (up 22 years) plus additional radiocarbon dates obtained since 2001, support the placement for KLT-3&6 at 1403 BC ± 3.

Since this dendrochronological fit for KLT-3&6 was less robust than we might have wished, we submitted samples to Bernd Kromer at the Institut für Umweltphysik radiocarbon facility in Heidelberg to try to confirm it by radiocarbon wiggle-matching. The 1403 BC tree-ring date is now reinforced by two near-decadal radiocarbon dates from the Heidelberg laboratory (see Fig. 356b). Because of the shape of the calibration
curve in the sixteenth century BC (i.e., relatively flat) and the low sample number (only two dates, and those for years earlier in the tree’s life) for the wiggle-match model, the match is not conclusive; it does, however, support an end date for the tree ring sequence in the last half of the fifteenth century BC.

A second pine sequence from a single tree, a combination of KLT-9 and KLT-15 (J18/398 from 6504 in the excavator’s phase IIc: see Fig. 122), has 134 years preserved, but with no bark present. We first reported...
Dating to Professor Postgate what we thought was a good crossdate against the Bronze Age/Iron Age Master Tree-Ring Chronology at 1350 BC (using the dating scheme published in *Nature* in 1996), but re-analysis of samples KLT-9 & KLT-15, prompted by results of a second radiocarbon wiggle-match (Fig. 357a), produced a revision of the series. What had previously been measured as an annual ring proved to be a false ring, thereby ruining the ‘fit’ we had reported. We also found four additional rings on another radius at the exterior. Now nothing at all in the second millennium looks good dendrochronologically.

Because the 1350 BC date for KLT-9 & 15 that we had first reported was from a single tree (and not a very long-lived one at that), we selected five decadal or near-decadal samples and sent them to Kromer at Heidelberg for a second exercise in radiocarbon wiggle-matching. Fig. 357a shows where Kromer thinks the five Kilise Tepe samples (shown as triangles) fit on the 2004 radiocarbon calibration curve. The best visual fit is at 1346 BC ± 17 (95.4% probability), so that the last preserved ring is dated to 1345±9 (1σ), 1346±17 (2σ), and 1349±30 (3σ) BC. There is no longer any dendrochronological fit with which this determination can be matched, so any scientific dating for KLT-9 & 15 will have to be based on the radiocarbon alone.

A third piece of pine, KLT-11 (K19/467 from 6212, also phase IIc), although it has 128 rings preserved, does not crossdate with either our Bronze Age/Iron Age master tree-ring chronology or with KLT-9 & 15.

### Table 43. Radiocarbon data. The date ranges for the samples that comprise dendrochronological radiocarbon wiggle-matches are the same for each sample that is part of the wiggle-match; in each case the samples are ten-year segments of carbonized wood, and the date ranges reflect the date of the last preserved ring of the wiggle-match.

<table>
<thead>
<tr>
<th>Sample code</th>
<th>Unit</th>
<th>Level</th>
<th>14C lab ID</th>
<th>14C yrs BP</th>
<th>Relative years (for DWM)</th>
<th>Calibrated date range cal. sc at 1σ (68.2% probability)</th>
<th>Calibrated date range cal. sc at 2σ (95.4% probability)</th>
<th>Calibrated date range cal. sc at 3σ (99.7% probability)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H20/456 wood charcoal</td>
<td>1838</td>
<td>Vg/h</td>
<td>Q</td>
<td>4290±75</td>
<td>3080–3070 (1.2%) 3030–2860 (59.0%) 2810–2760 (8.0%)</td>
<td>3300–3200 (1.0%) 3150–2600 (94.4%)</td>
<td>3350–2550</td>
<td></td>
</tr>
<tr>
<td>H19/357 wood charcoal</td>
<td>4278</td>
<td>IVa</td>
<td>Q</td>
<td>3610±60</td>
<td>2120–2100 (2.8%) 2040–1880 (65.4%)</td>
<td>2140–1860 (87.8%) 1850–1770 (7.6%)</td>
<td>2300–1650</td>
<td></td>
</tr>
<tr>
<td>H19/197 wood charcoal</td>
<td>4249</td>
<td>IVb</td>
<td>Q</td>
<td>3585±45</td>
<td>2020–1990 (9.9%) 1980–1880 (58.3%)</td>
<td>2120–2090 (2.1%) 2040–1860 (82.8%) 1850–1770 (10.5%)</td>
<td>2140–1740</td>
<td></td>
</tr>
<tr>
<td>H19/157 wood charcoal</td>
<td>4245</td>
<td>IIIb</td>
<td>Q</td>
<td>3450±55</td>
<td>1880–1840 (15.8%) 1830–1680 (52.4%)</td>
<td>1920–1610</td>
<td>1980–1520</td>
<td></td>
</tr>
<tr>
<td>J20/172 Architectural timber/dendro sequence</td>
<td>5703</td>
<td>Illd</td>
<td></td>
<td>3286±17</td>
<td>KLT-3 RY 1030–1040 (mid 1035)</td>
<td>1448–1411 (65.1%) 1401–1399 (3.1%)</td>
<td>1456–1396</td>
<td>1471–1366</td>
</tr>
<tr>
<td>J20/172 Architectural timber/dendro sequence</td>
<td>5703</td>
<td>Illd</td>
<td></td>
<td>3303±17</td>
<td>KLT-3 RY 1050–1070 (mid 1060)</td>
<td>1448–1411 (65.1%) 1401–1399 (3.1%)</td>
<td>1456–1396</td>
<td>1471–1366</td>
</tr>
<tr>
<td>J20/125 burned figs</td>
<td>1372</td>
<td>IIle</td>
<td>Q</td>
<td>3070±45</td>
<td>1410–1290</td>
<td>1440–1210</td>
<td>1460–1120</td>
<td></td>
</tr>
<tr>
<td>J18/398 Architectural timber/dendro sequence</td>
<td>6504</td>
<td>IIc</td>
<td></td>
<td>3210±17</td>
<td>KLT-9 RY 1001–1030 (mid 1015.5)</td>
<td>1353.6–1336.4</td>
<td>1362.4–1329.3</td>
<td>1379–1319</td>
</tr>
<tr>
<td>J18/398 Architectural timber/dendro sequence</td>
<td>6504</td>
<td>IIc</td>
<td></td>
<td>3136±17</td>
<td>KLT-9 RY 1031–1040 (mid 1035.5)</td>
<td>1353.6–1336.4</td>
<td>1362.4–1329.3</td>
<td>1379–1319</td>
</tr>
<tr>
<td>J18/398 Architectural timber/dendro sequence</td>
<td>6504</td>
<td>IIc</td>
<td></td>
<td>3165±26</td>
<td>KLT-9 RY 1041–1050 (mid 1045.5)</td>
<td>1353.6–1336.4</td>
<td>1362.4–1329.3</td>
<td>1379–1319</td>
</tr>
<tr>
<td>J18/398 Architectural timber/dendro sequence</td>
<td>6504</td>
<td>IIc</td>
<td></td>
<td>3121±27</td>
<td>KLT-9 RY 1051–1060 (mid 1055.5)</td>
<td>1353.6–1336.4</td>
<td>1362.4–1329.3</td>
<td>1379–1319</td>
</tr>
<tr>
<td>J18/398 Architectural timber/dendro sequence</td>
<td>6504</td>
<td>IIc</td>
<td></td>
<td>3143±26</td>
<td>KLT-9 RY 1061–1086 (mid 1073.5)</td>
<td>1353.6–1336.4</td>
<td>1362.4–1329.3</td>
<td>1379–1319</td>
</tr>
</tbody>
</table>
Experience has shown us that we can usually get cross-dating in Anatolian conifers when we have a century and a quarter’s worth of rings preserved, but KLT-11 is one of the exceptions.\(^8\)

While the dendrochronological results are less than we had hoped to provide, we can at least incorporate them into a model that takes advantage of both the radiocarbon results, and the archaeologists’ recording of the stratigraphy.\(^9\)

**Radiocarbon dating**  
by Roy Switsur

Five samples were submitted to the Environmental Sciences Research Centre Radiocarbon Dating Research Laboratory at Anglia University in Cambridge. With the exception of the carbonized figs (J20/125), the samples consisted of carbonized wood.

The results are shown in Table 43. The ‘conventional radiocarbon ages’ are based on the Libby half-life of 5568 years for the radiocarbon isotope and the base year \(AD 1950\), using the \(BP\) notation. The numbers have been rounded to the nearest 5 years. The uncertainty is based on the one standard deviation of the counting statistics of the sample and the standards.

The radiocarbon ages and uncertainty have been calibrated with INTCAL04 to give date ranges on the Christian calendar. These ranges have the notation cal. bc. Because of the properties of the calibration curve, it is not correct to take the mid point of the date range and allocate an uncertainty as is possible with the radiocarbon age. The calibrated date ranges are given at 1\(\sigma\) (68.2\%), 2\(\sigma\) (95.4\%) and 3\(\sigma\) (99.7\%) probability levels (Table 43), and were calculated with the program OxCal v3.10 (Bronk Ramsey 1995; 2001) using the INTCAL04 calibration data set (Reimer et al. 2004).

**Excavator’s comment**  
by J.N. Postgate

The dates seem generally quite plausible, not least because their chronological sequence agrees with their stratigraphic sequence. In several cases they come out earlier than we would have predicted. The likelyest reasons for this would be the re-use of timbers or mistaken assumptions about the position of our Levels in the historical and cultural sequence. At present the number of determinations is not adequate to enable us to opt for one or another explanation. These comments begin with the most recent samples.

**J18/398** These dendrochronological samples (KLT-9 and KLT-15) were taken from timbers in the foundation of Rm 7 in the IIc Stele Building. If the trees were felled around 1350 bc, the implication would be that about two centuries elapsed between the construction of the IIc building and the burning of the IId phase (if we accept a broad date of 1150 bc for the Mycenaean ceramics caught up in that destruction). This is rather longer than might have been predicted on stratigraphic grounds, and puts the new ceramics of Level Ila–c further back in time than we expected. The date for this timber also falls towards the earlier end of the date range for the burnt figs from phase IIIe, given to us by J20/125. These considerations mean, I think, that we may have to allow for the timber in the foundations being recycled from an earlier building.

**J20/125** This date from carbonized figs belongs in our latest Level III phase. A date between 1410 and 1290 would be quite acceptable in the context of our expected historical dates, and the earlier part of this range falls before the dendrochronological/radiocarbon date of about 1350 for J18/398.

**J20/172, 180** These dendrochronological samples (KLT-3, -6, -7) come from a relatively small unshaped branch in the remains of a large hearth of phase IIIId. With the agreement between the revised dendrochronological date of 1403±3 and the Heidelberg radiocarbon range pointing to the second half of the fifteenth century bc, it seems increasingly possible that the transition from Level III to Level II falls earlier than we guessed.

**H19/157** This is close to the beginning of the dense sequence of occupation layers constituting our Level III, and in conventional terms belonging to ‘Late Bronze Age I’. Given the dendrochronologically determined dates of about 1770 and about 1830 for the construction of the major Middle Bronze Age palaces at Acem Höyük and Kültepe respectively (Manning et al. 2001, 2534), a calendar date of between 1880–1680 seems surprisingly early, although the fact that 1830–1680 is the most likely helps a little. These pieces were not found in a primary context (e.g. in a destruction level) and one cannot therefore exclude the possibility that they are recycled material from an earlier phase.

**H19/197** These pieces were, by contrast, found among burnt debris on an occupation surface. This phase (IVb) is the later of our two ‘Middle Bronze Age’ strata. We expect it to be close in time to H19/157 above, and H19/357 below. Its highest and lowest ranges do in fact overlap with them, but the likeliest range (1980–1880) seems very acceptable (especially since before 1500 bc, our conventional historical dates still have at least a century of leeway).
Dating

H19/357 This sample also came from primary debris on a well-preserved floor. It is the occupation phase immediately preceding Level IVb and a date in the range 2040–1880 would therefore fit well.

H20/456 The context (packing below phase Vg floors) means that this material should be contemporary with phase Vh, which is separated from Level IVa by three distinct building levels, each with a number of phases. It should therefore be separated from the other samples by a considerable length of time. In conventional terms, on the basis of the ceramics, this should be the later part of Early Bronze Age I, and I think we would have expected a date later, but perhaps not much later, than 2700. It follows that the likeliest range of 3030–2860 is earlier than we would have predicted, but here again, as with H19/157, the sample was contained within packing material, and we have to admit the possibility that it is recycled material from an earlier time.10

Notes

2. In this report ‘wiggle-matching’ means the matching of radiocarbon determinations from sets of selected tree-rings, say rings 1–10 and rings 50–60 from a single tree-ring sequence (i.e. with mid-points precisely 50 years apart) against the master radiocarbon curve. It is therefore different from ‘archaeological’ wiggle-matching as discussed by Manning & Weninger 1992, where the difference between the samples from one stratum to another is on the basis of best-estimates by the excavator.
3. The placement of KLT-3&6 versus the master chronology is the same as it was when we made our first report. The only difference is that the master chronology itself (and therefore KLT-3&6) had to be moved back in time. For the low calculated error estimate, see Manning et al. 2003.
4. The ring series is long, but it is, after all, from only a single tree. It is perhaps because the mean sensitivity of this tree-ring sequence, at .331, is comparable to those from the Anatolian Juniperus spp. trees that make up most of the samples in the Bronze Age–Iron Age master dendrochronology, that the crossdate was identified at all.
5. The average ring size for the entire series is .28 mm, but .47 for the first 70 years of the tree’s life (from which we retrieved the samples), and only .18 mm for the last 124 years. Because the rings are so small, we have been unable to cut charcoal of sufficient weight for sampling the whole of the series at the Heidelberg Laboratory.
6. Note that in Figure 5:2a the two triangles have been set at the lowest possible fit (in accord with the dendrochronological fit). If there were nothing else to confirm this late placement, it would be equally easy to slide the triangles to the left, i.e. back in time, by some thirty years.
7. As sloppy as Figure 357a appears to be, with an outlier to the left and another to the right of the radiocarbon curve, there is nowhere else for KLT-9&15 to go. The last ring remains in the middle of the fourteenth century.
8. The reader is reminded that we are talking about a total of three potentially datable trees with ring-sequences of 128 years to 194 years. Additional charcoal collection at sites in the Mut basin might very well show us where these trees fit. Compare the situation at Kilise Tepe with Urartian Ayanis where we have almost 500 samples from many trees, several dozen of which have the bark preserved. We are able to make a number of informed estimates about Ayanis where we can do nothing of the sort at Kilise Tepe.
9. Of course, rings missing from the exterior of any of these pieces, either from shaping by the carpenter or by the action of the fire which destroyed the building, could bring down the date. The excavator must also consider whether the building was long-lived, and whether the timber could have been re-used. Lacking additional dateable samples from these levels, there is nothing more we can say other than to remind the reader of the various possibilities posed when one has only single trees representing a building, or archaeological phase, to analyze.
10. Our thanks go to John Meadows for his advice on radiocarbon matters, and for modelling some of our determinations with OxCal 3.10. The samples cannot be pin-pointed sufficiently accurately to single events to call for the publication of these ‘modelled’ results, but they do add further weight to the arguments that H19/357 pre-dates 1880 bc and H19/197 post-dates 2030 bc.