THE DENDROCHRONOLOGY DEBATE

***Peter James** discusses the quest for an absolute chronology for the ancient Aegean.*

Every archaeologist's dream is a dating technique which can date finds to a precise year, and of all available methods dendrochronology comes nearest. In an ideal case bark will still be preserved and dendrochronology can tell us the exact year when the wood was felled. But while this might work well for prehistoric posts or firewood, matters are not so easy for artefacts where carpenters and sculptors have shaved off an unknown number of tree-rings. For this reason dendrochronology usually only offers a *terminus post quem*, a date after which the artefact was made.

All the same, the fact that dendrochronology deals in real, exact calendar years makes it more 'tangible' than radiocarbon, which can only express dates as a broad range in terms of statistical probability. To know that the last tree-ring in an artefact dates to 899 BC is far more rewarding than learning that it grew sometime between 1020 BC and 830 BC (at 95.4% probability). One reason for the vagueness in radiocarbon dating is that the amount of carbon 14 produced in the atmosphere (and hence absorbed by living organisms) has not remained constant. It is dendrochronology that has provided the key to this puzzle: by measuring amounts of C14 in well-dated tree-rings we can calibrate radiocarbon results. Hence the double importance of a sound dendrochronology.

The hopes of East Mediterranean archaeologists presently rest on the work of Professor Peter Kuniholm and his Cornell University team, who, for many years, have been working on a dendrochronology for the ancient Aegean and Anatolia. The Aegean Dendrochronology Project has had some major successes. In the late 1950s American archaeologists working at Gordion excavated a spectacular royal burial, believed to be the tomb of the famous Phrygian king Midas. (Though we know him best from Greek legend, Midas was a real king, mentioned in Assyrian records of the late 8th century BC, and the tomb could well be his.) It proved to be a gift to dendrochronology. Underneath a huge earth mound, the small building forming the tomb consists of large juniper logs with the bark still present. One log contained as many as 918 rings and the group, taken together, allowed Kuniholm to establish a sequence going back 1026 years. Next, the pattern of the earliest rings was found to overlap with the last rings of another long sequence from Porsuk in southern-central Turkey. Together they span 1503 years - from the Middle Bronze Age down to the assumed 8th-century date for the tomb.

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The problem, however, has always been to peg this 'Gordion Master Sequence' precisely in time. Ideally, dendrochronology works by counting back the rings on living trees, then matching their growth patterns with recent dead trees and so on. Unfortunately, Kuniholm and his team are far from completing an 'absolute' dendrochronology back to the Iron Age. The continuous sequence only goes back to AD 362, while between that date and Midas' time there are only patchy sequences. As there is no way of providing an exact date for the Midas tomb from history, radiocarbon has been turned to for an alternative answer. Over the years numerous samples from the Gordion master sequence have been radiocarbon dated at Heidelberg University. Kuniholm's first stab at interpreting these was to lower the date of the tomb (and all the attendant culture) to c. 547 BC. Later tests raised this date massively to c. 757, and in 1996 the improved calibration curves again changed the date - to c. 718 BC.

Most recently - in two papers in last December's *Science* journal - the date has been slightly raised again, to c. 740 BC. This time a large number of new radiocarbon tests were made on trees belonging to the upper and lower ends of the Gordion sequence. When 'wiggle-matched' against the central European dendrochronology, the dates from the two ends were found to be offset by over two decades (compared to the number of rings). The conclusion reached in the *Science* articles is that the upper dates should be preferred, raising the whole sequence by 22 years. As for the offset, it is explained by regional variations in the amounts of C14 - a possibility that has long been suspected. To use C14 dates calibrated by one tree-ring sequence (central Europe) in order to fix in time another (Anatolia), and then to use that sequence to modify our wider understanding of C14 behaviour, is clearly a perilous exercise. Yet the team may well be right in their Solomonic judgement in favour of the older Gordion results. The lower ones fall largely in the 8th century, which has long been known as the beginning of the 'radiocarbon disaster area' - a flat stretch of the calibration curve stretching from about 800 to 400 BC.

Other aspects remain worrying, however. The confident pronouncement that a firm chronology has now been achieved sounds disconcertingly like the claims made in 1996 (in *Nature*). Then, the dating allowed the team to match a tree-ring period of abnormal growth with a 'high' date for the Bronze Age explosion of Thera, ostensibly supported by an anomalous amount of sulphuric acid in the Greenland ice layer dated to c. 1625 BC. Since then particles of volcanic glass have been found in this layer, but analysis showed they are not from Thera. Now, we are told with the new dating that the growth anomaly in Anatolia conveniently matches c. 1645 BC, the other peak of Greenland sulphuric acid favoured by high chronologists. A sceptic might wonder how much the quest for a precise date for Thera (the 'holy grail' of the lab boys) is driving research, as much as the simple desire to sharpen up Aegean dendrochronology.

Dating a tree-ring sequence is one thing; using it to provide actual dates for archaeology is another. Unfortunately, Kuniholm's team have made some premature announcements which subsequent work has shown to be invalid. A date of 1305 BC for the Late Bronze Age shipwreck of Uluburun (off south-western Turkey) was trumpetted as confirmation of the generally accepted chronology of the Late Bronze Age. In the recent *Science* paper it was virtually retracted. (The sample used was badly gnarled and twisted.) Another date of 1621 BC for a wooden bowl from the Shaft Graves at Mycenae has been categorically withdrawn. (The rings were never properly measured.) While the fact has not been advertised by Kuniholm and his colleagues, these are the only two results so far declared for the Aegean Late Bronze Age, and both have proved to be faulty. For the same period, dates for a number of Anatolian sites have been announced in newsletters, but the results from only one have been fully published and these are clearly anomalous for the standard chronology. The salutary experience of Uluburun and Mycenae means that large question marks will remain over the other Anatolian sites until they are formally published for scrutiny.

About chronology-building Sir Mortimer Wheeler once remarked 'we have...been preparing time-tables; let us now have some trains'. With respect to the time-tables, the work of the Aegean Dendrochronology Project has been steady and apparently meticulous. As for the trains, some have already been derailed. Precision in archaeological dating is a desideratum, but it is not achieved by having a highly accurate time-table alone. It needs equal precision in the selection of high-quality samples from contexts with impeccable, and fully published, credentials. We still have a long way to go before the 'dream ticket' of Aegean/Anatolian dendrochronology is fully realised.