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STUDIES IN AEGEAN ARCHAEOLOGY PRESENTED TO MALCOLM H. WIENER AS HE ENTERS HIS 65th YEAR

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WIGGLES WORTH WATCHING - MAKING RADIOCARBON WORK. THE CASE OF ÇATAL HÖYÜK*

Abstract

Selected decade-long samples from a 576-year tree-ring sequence at Çatal Höyük have been radiocarbon wiggle-matched, providing calendrical dates beginning at 7024 B.C. and ending at 6449 +26/-39 B.C. Puzzling radiocarbon dates that have been in the literature for over 30 years, expressed variably in both BP and B.C. terms, are now closer to resolution. Furthermore, we offer a tentative framework for the internal site chronology, based on tree-ring dates combined with a reanalysis of earlier radiocarbon dates and extrapolation from plaster counts, as a preliminary step toward a (re)founding of the chronology of the Neolithic.

The Problem:

There is a serious problem with the way in which radiocarbon measurements have been interpreted or misinterpreted in the study of prehistory; but it is a problem, we believe, less of intention than of misunderstanding. The radiocarbon method itself has been described as a classical example of the break-down in communication between humanists and hard scientists.[1] The unfortunate result is that what appears to be a substantial chronological framework for the study of Neolithic sites across the eastern Mediterranean and Near East–one with long lists of radiocarbon dates arranged neatly into "phases" and "horizons" and the like–is rather a shaky scaffolding for prehistory; such schemas do not address the vagaries of excavation method, the blanks for sites excavated before radiocarbon became known or popular, inadequate sampling, laboratory errors, misunderstanding of statistics, and the general incomprehension of the wiggles in the radiocarbon curve. Thus, while radiocarbon dates are available for virtually all excavated sites of this period, *i.e.,* the 9th through 6th millennia B.C., precise control over their interpretation has been notably lacking.

While we may guess at site contemporaneity based on radiocarbon date ranges on the order of centuries, we cannot yet with any degree of precision address questions of site interaction and trade. And with respect to both intra- and inter-site chronologies, nothing in

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1 See R.W. EHRICH, (ed.), *Chronologies in Old World Archaeology* (1992, 3rd. ed.) and S.W. MANNING's review in *Antiquity* Vol. 67, (1993) 928-930. This paper updates M.W. NEWTON *Dendrochronology at Çatal Höyük: A 576-Year Tree-Ring Chronology for the Early Neolithic of Anatolia* (1996) Cornell University, unpublished M.A. thesis, and P.I. KUNIHOLM and M.W. NEWTON "Interim Dendrochronological Progress Report 1995/6," which appeared in I. HODDER, *On the Surface: Çatal Höyük 1993-95*, McDonald Institute Monographs (1996) 346-347. To the relevant Aegean Dendrochronology Project bibliography cited there now add P.I. KUNIHOLM, "Long Tree-Ring Chronologies for the Eastern Mediteranean," in *29th International Symposium on Archaeometry*, a paper delivered in May 1994 (Ankara: TÜBITAK, 1996) 401-409; ID. "The Prehistoric Aegean: Dendrochronological Progress as of 1995," in K. RANDSBORG, ed., *Acta Archaeologica* Vol. 67 (1996) 327-335; P.I. KUNIHOLM, B. KROMER, S.W. MANNING, M.W. NEWTON, C.E. LATINI, and M.J. BRUCE, "Anatolian tree rings and the absolute chronology of the eastern Mediterranean, 2220-718 B.C.," *Nature* Vol. 381 (27 June 1996) 780-783; and P.I. KUNIHOLM, B. KROMER, S.L. TARTER, and C.B. GRIGGS, "An Early Bronze Age Settlement at Sozopol, near Burgas, Bulgaria," *Studia Praehistorica* 15: *James Harvey Gaul–In Memoriam* (1998) 399-409.

the Aegean[2] approaches what has been achieved in the studies of northern European prehistory or southwest American prehistory.[3]

The difference is that in northern Europe continuous, absolutely-dated dendrochronologies, extending from the present back to the 10th millennium B.C., have been available for some years (8th millennium in the American southwest), and archaeologists in both places have learned how to take full advantage of this chronological tool. Furthermore, the nature of European Neolithic and Bronze Age lake settlements built on wood pilings has permitted the retrieval of large numbers of wood samples for dendrochronological analysis. In the American southwest a combination of dryness and isolation from human intervention has preserved the prehistoric timbers. However, in the Aegean and the Near East, with wattle-and-daub and timber-reinforced-mudbrick and stone architecture prevalent from the earliest settlements onward, well-preserved timbers are not as abundant as in the lake dwellings or on the Arizona mesas. Nevertheless, in the Aegean where wooden elements were used in structures that subsequently burned, wood charcoal provides good samples for tree-ring dating. Çatal Höyük, where charcoal from architectural timbers is preserved in abundance, is a convenient case study for this kind of chronological research.[4]

Radiocarbon Dating – The First Step:

Çatal Höyük was first excavated by James Mellaart[5] and his team in 1961-1965, only a decade after the discovery of radiocarbon and long before the advances of either calibration or wiggle-matching. While most of the charred wooden timbers were not saved, the fact that twenty-four representative samples were retrieved and sent to the Museum Applied Science Center for Archaeology (MASCA) at the University of Pennsylvania and to the British Museum for radiocarbon testing is a tribute both to Mellaart's foresight and to his appreciation of the potential of the radiocarbon method.

The Mellaart samples spanned his levels X through II, and appeared to indicate a range of occupation from 6400-5700 B.C. (uncalibrated, based on a 5730 year half-life). The number of determinations, the attention to types of material dated, and Mellaart's concern with presenting dates with the revised half-life of 5730 were new to the study of all prehistory in the mid-1960s. With the first calibration of the radiocarbon time scale announced in the early

2 That we are able to interpret the word "Aegean" on the door of our laboratory to include sites as far west as Italy, as far east as Iran, as far north as the Balkans, and as far south as Egypt is due in part to the creative imagination and generosity of Malcolm Wiener to whom we dedicate this paper.

3 See collected articles in RANDSBORG (ed.) (*supra* n. 1), *passim*; E. VOGT, "Pfalbaustudien," *Schweizerische Gesellschaft für Urgeschichte* (1954); A. ORCEL, *Les fouilles néolithiques de Douanne: Les vestiges des villages Cortaillod* (1981); B. BECKER, A. BILLAMBOZ, H. EGGER, P. GASSMANN, A. ORCEL, Chr. ORCEL, and U. RUOFF, "Dendrochronologie in der Ur- und Frühgeschichte. Die absolute Datierung von Pfahlbausiedlungen nördlich der Alpen im Jahrring-kalender Mitteleuropas," *Antiqua* 11 (1985); Chr. Strahm, "Kontinuität und Kulturwandel im Neolithikum der Westschweiz," *Fundberichte aus Baden Württemberg* 3 (1977) 115-143; J.S. DEAN, *Chronological Analysis of Tsegi Phase Sites in Northeastern Arizona* (1969), from Papers of the Laboratory of Tree-Ring Research Number 3; ID., "Dendrochronology," in R.E. TAYLOR and M.J. AITKEN (eds) *Chronometric Dating in Archaeology* (1997).

4 Other early sites that have yielded material suitable for analysis include Late Neolithic Hacılar, Köşk Höyük, Kuruçay Höyük, and Chalcolithic Can Hasan 2b in Anatolia, and Dispilio in Greece. The results of our ongoing analyses of this material are on file in the Malcolm and Carolyn Wiener Laboratory for Aegean and Near Eastern Dendrochronology at Cornell University and are listed as well on our web-site at http://www.arts.cornell.edu/dendro/ along with appropriate bibliographies. This paper is, in part, a plea for help to all active excavators in both the Aegean and the Near East. Wood or charcoal that has been sitting on storeroom shelves for decades is of just as much interest as wood that has been freshly excavated.

5 J. MELLAART, "Excavations at Çatal Hüyük, 1963, Third Preliminary Report," *Anatolian Studies* XIV (1964) 39-119; ID, "Excavations at Çatal Hüyük, 1965, Fourth Preliminary Report," *Anatolian Studies* XVI (1966) 165-191; ID., *Çatal Hüyük: A Neolithic Town in Anatolia* (1967).

1970s[6] (based on absolutely dated samples from dendrochronologies in the American southwest), these dates had to be revised upward some 400 years, but the general chronological framework remained firm.

Table 1 reproduces Mellaart's dates to which we have added a column on the right with their calibrated calendar date equivalents from the 1993 calibration curve.[7] What becomes clear from even a glance at this scattering is the difficulty of arranging these dates in groups according to stratigraphic level. For his 1967 ordering of the chronology of the site Mellaart dismissed outliers, and relied on the more accurate dates from short-lived vegetal material retrieved from hearths of "living floors."[8] His scheme suggests a period of occupation of approximately 800 years.

Radiocarbon Dating – A New Look:

For this paper we sum selected samples that we believe are most representative of distinct phases, or, in some cases, the beginning or end of a phase. Admittedly, this is a subjective process, and one in which we have made a number of fairly conventional assumptions: (i) dates on grain or other short-lived material are considered more reliable than those on wood; (ii) dates on material from hearths or living-floors are considered to date toward the end of a phase (*i.e.*, just prior to destruction); (iii) dates on wood that is not demonstrably long-lived but is nevertheless used as a timber in the primary construction of a building can be considered to date in the early part of the phase during which the building was erected.

Radiocarbon dates were not collected from all levels at the site. Level II is represented by a single date on grain from a grain deposit. The end of Level VIA is likewise represented by a single date on grain. For the beginning of Level VIA we have summed the probability distributions on dates from three samples. Two of those (P-772 and P-1375) are from wood charcoal (oak and elm, respectively) from posts presumably used in the primary construction of building units from that level. P-827 is the charred human brain from a burial underneath a Level VIA floor. The report in *Radiocarbon* for this date includes the comment that the "skeleton [was] found under central platform where stratification of skeletons indicates that this burial was rather early in the sequence found there; sample probably represents Level

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6 Hans Suess was the first to publish a report about the inconstancy of atmospheric radiocarbon (H. SUESS, "Secular variations of the cosmic-ray produced carbon 14 in the atmosphere and their interpretations," *Journal of Geophysical Research* 70 (1965) 5397-5951), but the first calibration of the radiocarbon time scale was not available until 1973 (E.K. RALPH, H.N. MICHAEL, and M.C. HAN, "Radiocarbon Dates and Reality," *MASCA Newsletter* 9:1 [1973]).

7 See M. STUIVER and P.J. REIMER CALIB 3.0.3 (1993) Quaternary Isotope Lab, University of Washington. For the 18 samples sent to our laboratory by Dr. Mellaart in 1992, the corresponding identification code for dendrochronology is listed in column 2. Column 3 describes the type of material dated. For charcoal samples we specify those known to be from architectural timbers, and thus as likely as not to suffer the 'old wood' phenomenon (i.e., if it is not known which rings were measured, the dates may be from the earlier part of a tree's life and thus give an aberrantly early date). Since not all trees are necessarily long-lived, we give the species where determination was possible. Juniper is almost always long-lived, oak sometimes so, and elm rarely. In some cases we describe the charcoal as 'speck'; in all these cases the charcoal derives from a hearth or fill deposit. In theory, as these 'specks' are most likely the remains of wood used as fuel, such bits could be considered short-lived. However, fill deposits at Çatal Höyük can include construction material (wood, bricks, plaster). And CTL-10, described as from a "burnt kitchen" (hearth/oven?), included bits of long-lived juniper. We point this out as an additional caveat. Samples are listed in order of their stratigraphic relationship, from most recent to oldest. The radiocarbon dates are calculated with the Libby half-life (5568). By international convention, radiocarbon dates have continued to be published at this half-life, as are the data sets in the calibration curves. Thus, with respect to calibration, the associated calendar dates are unaffected. We list the calibrated dates at their 1σ range, i.e., the confidence interval within which there is a 68.2% probability that the 'true' date falls. The dates in parentheses are the points at which the given radiocarbon age intersects the calibration curve.

8 Of course, Mellaart used additional information (e.g., plaster counts as an indication of duration of certain building units, and, by extension, certain phases) as clues to the intra-site chronology.

VIB, or very early phase of VIA."[9] Since its date is consistent with P-772 and P-1375, we chose to consider it as representative of the beginning of Level VIA.

Sample P-781 represents a later period in Level VIB. It is an oak roof-beam from the storeroom of Shrine 1. This shrine was built in Level VIB and restored in VIA. The radiocarbon date for this sample, which falls between the beginning of Level VIB and the beginning of Level VIA, suggests that this beam may have been a repair or later addition, and thus we list it as VIB Late (*i.e.,* late in the VIB period). For the beginning of Level VIB, we have summed two samples, P-1362 and P-1364, both elm posts.

The end of Level VII is represented by a single date on grain (P-778). Sample P-1366, charcoal specks from the fill of a shrine in Level VIII, has a date suggesting that the fill originated at some time, perhaps early, in Level VII. Level VIII is represented by a single date on elm or oak charcoal specks from a hearth deposit. Level IX is dated by summing the probability distributions of dates on samples from fill deposits in Level X. Though a distinction was noted between "upper" and "lower" fill deposits, the three dates (P-1369, P-1371, and P-1372) are sufficiently similar that we take them to represent a single context. The dates fall stratigraphically as one would expect between Levels X and VIII, and thus we consider them representative of Level IX. The dates for the end of Level X (P-782 and P-1370, summed) are derived from charcoal from hearths.

The probability distributions at the 1σ range are not as tightly arranged as those in the 2σ range. This is more apparent for the summed series, since the summing process itself expands ranges rather than reducing them as would be the case with averaging. The problem in interpretation of the intra-site phasing is clear. As Manning has stated, "the width of the distribution on the calendar scale does not offer more than vague guidance concerning the duration of a culture, or a stratigraphic level."[10] A fall-back order conforming to the stratigraphy of the site is indeed noticeable, though some overlaps confuse the picture. First, the samples that were summed as representative of the beginning of Level VIB seem to be too old in comparison with Levels VIA and VII. This could be due to a number of factors: (i) the wood (in this case elm) was long-lived and thus subject to the old wood phenomenon; (ii) the wood was re-used; (iii) there is some overlap between the end of Level VII and the beginning of Level VIB.

Note that the date for Level II (which is three phases later than Level VIA) seems too early. Mellaart does conclude from plaster counts that the Levels V through II were relatively short-lived (a total of approximately 160 years),[11] and thus the date for this level could be accommodated within the error margins at 2σ. But given that this sample was from grain, as was that from the end of Level VII, and that both fall within the same radiocarbon year range, the possibility raised by Manning of dates clustering at "preferential regions" of the calibration curve should be considered.[12] By this Manning is referring to flat parts of the calibration curve; the ranges of the two samples from Level II and the end of Level VII span several such areas, but the error margins incorporate such wide ranges of the calendar scale that further levels of precision are not tenable. In fact, if one were to try to run a line through the ranges illustrated in Pl. CXIVc, staying within the 2σ range and heeding archaeological considerations, a bit of a zig-zag would be the result. Furthermore, would one even know where to start?

One possible answer is offered by dendrochronology. If a single bark date can be accurately attributed to one of the phases, can additional information be used to link together an intra-site chronology? We make an attempt here to specify a more accurate date for the

9 R. STUCKENRATH, Jr. and E.K. RALPH, "University of Pennsylvania Radiocarbon Dates VIII," *Radiocarbon* 7 (1965) 192. See also R. STUCKENRATH, Jr. and B. LAWN, "University of Pennsylvania Radiocarbon Dates XI," *Radiocarbon* 11:1 (1969) 150-162.

10 S.W. MANNING, *The Absolute Chronology of the Aegean Early Bronze Age: Archaeology, Radiocarbon and History* (1995) 131, n. 15 (cf. B. WENINGER, "High-precision Calibration of Archaeological Radiocarbon Dates," in *Acta Interdisciplinaria Archaeologica* IV [1986] 11-53).

11 MELLAART (*supra* n. 5, 1964) 116.

12 MANNING (*supra* n. 10) 137.

beginnings of Level VII and Level VIB by applying the bark dates for samples from those levels to a newly-developed wiggle-matched sequence from Çatal Höyük.

Dendrochronology:

Thirty years after the radiocarbon samples were collected, analyzed, and published, Dr. Mellaart kindly gave us all the remaining bits and pieces of charcoal from the MASCA laboratory, not one of which is larger than a golfball yet some of which have as many as 249 rings. These include oak, elm, and extraordinarily long-lived juniper. From hundreds of these carbonized juniper fragments we reconstructed ring sequences from seven trees. In addition, in September 1994 with the kind help of excavators Ian Hodder and Wendy Matthews, we excavated five samples from the newly cleaned eastern scarp of Mellaart's trench E which provided long-lived sequences from two more trees. These nine sequences cross-date with each other and form a 576-year tree-ring chronology for the site[13] (see Pl. CXIVa). This long Çatal Höyük sequence provides the basis against which other eastern Mediterranean Neolithic tree-ring chronologies can be dated.

Once the current excavators at Çatal Höyük expand their exposures to reveal the timbers in use at times equivalent to the early and middle levels of the Mellaart trenches, then the prospects for studying the differential build-up of the site and the use and reuse of wood in construction are very good. Dating[14] one building phase relative to another progressively across the site as samples emerge will give us a chronological and therefore interpretive control hitherto unknown in the study of the Aegean and Near Eastern Neolithic. We may begin, then, to think in terms of real time, *i.e.,* years, even seasons, that governed the temporal life of Çatal Höyük's prehistoric inhabitants during this important period of incipient agriculture and animal domestication.

The problems in interpreting the Mellaart radiocarbon dates after calibration are manifest. First, the samples: for wood charcoal we do not know which rings (in the long juniper or shorter oak or elm sequences) were analyzed. The problem is best illustrated by dendrochronological sample CTL-1. This tree was at least 576 years old at the time it was cut. Clearly, the MASCA radiocarbon laboratory measured the innermost rings of this tree, giving a date some 500 years too early.[15] Second, the calibration curve: the "flat" portions of the curve give wide ranges to any date that falls between the calender years 7300-7050, 7000-6700, and 6400-6250 (see Pl. CXIVb).

But in hindsight sample CTL-1 can be turned to advantage. Precisely because of the great age of this tree we are in a position to use the technique of radiocarbon wiggle-matching to improve the absolute dating of this site.

Radiocarbon Dating – The Wiggle-Matched Sequence:

Radiocarbon wiggle-matching is a technique that followed advancements in radiocarbon dating that came with calibration.[16] The variations in the production of atmospheric radiocarbon causes the dates derived from the decay of the radioactive isotope ^{14}C to vary in a

13 The backbone of the Çatal Höyük chronology is a single 10" (25 cm.) diameter post, constructed from 42 fragments left over from the MASCA analyses, against which all the other sequences were matched. Mellaart found intact burned beams of similar size–with the bark preserved–throughout his excavation area (Mellaart, pers. comm.), so careful excavation and retrieval by the present excavation team should bring us much of what we need to flesh out this chronology.

14 An absolute dendrochronology for the prehistoric period is not yet complete for Anatolia. For the most recent summary see KUNIHOLM (*supra* n. 1, *Acta Archaeologica* 1996).

15 Mellaart recognized the date as aberrant, attributing the cause to the likelihood that the wood was re-used or that the sample analyzed came from "the core of a large tree, evidently of considerable age" (*cf.* MELLAART [*supra* n. 5, 1964] 116).

16 For a useful summary and other applications see S.W. MANNING and B. WENINGER, "A light in the dark: archaeological wiggle matching and the absolute chronology of the close of the Aegean Late Bronze Age," *Antiquity* 66 (1992) 636-663.

non-monotonic relationship to the calendar scale through time. The variations are illustrated by the wiggly nature of the calibration curve.[17] Since these wiggles were derived by measuring the decay of ^{14}C in dendrochronologically-dated tree-ring samples of known age, it was recognized that by measuring the decay of ^{14}C in a series of tree-ring samples of unknown age, it should be possible to match the resulting wiggles with those of the calibration curve at their 'true' (*i.e.*, calendrical) age.

But to apply the technique a number of conditions must be met. First, the series of tree-ring samples measured should span a sufficiently long sequence of time.[18] The absolute time difference between samples in the series is known because the samples are selected from replicated and cross-dated tree-ring sequences. Second, the morphology of the calibration curve at the point where the sequence is expected to fit should have features that can be replicated (*i.e.*, the curve should not be 'flat'). Third, a reputable laboratory, familiar with and experienced in the technique, should be used.

The Çatal Höyük series of ten samples was analyzed at the University of Arizona AMS Facility. We took the longest lived tree, CTL-1, and from it prepared 56 radiocarbon samples, either decadal or shorter, covering the entire span of this 576-year sequence. We then chose a ten-year slice of charcoal from the beginning and one from the end. With just these two dates, knowing the calendar year difference between them, we could select the point at which the two best fit the calibration curve.[19] Once we had found the approximate best placement of the two-sample wiggle-match on the calibration curve, we selected additional samples for analysis. The radiocarbon dates for these samples are listed in column four of Table 2. The corresponding calendar years for the mid-point in each of these decade or shorter samples, as determined by the wiggle-match, are listed in column six.

In reviewing Table 2, note how the wiggle-matched dates are more specific than the calibrated date for each sample individually. The wiggle-match and position of the dates on the calibration curve are illustrated in Pl. CXIVb. Unfortunately, the sequence is not long enough on the early end to bracket the 7050-7010 B.C. dip.[20] The wiggle-matched dates for the chronology are 7024-6449 +26/-39 B.C.[21]

The dates corresponding to the sequences of the components of the master chronology (from the nine trees, from contexts spanning Mellaart's levels VII to IV) are listed in Table 3. The most important of these dates are those for samples CTL-6 and CTL-16&20. 6456 +26/-

17 MANNING (*supra* n. 10) 130, n. 15.

18 150 years is about the minimum for the technique to replicate the wiggles demonstrably in the calibration curve. The nature of the calibration curve itself will affect how long a sequence will be sufficient. For an area of the calibration curve that is relatively flat for a long time span (*e.g.*, the first half of the first millennium B.C.), a very long sequence of tree-rings may not suffice. Conversely, for an area of the curve with a steep dip, a relatively short sequence may be enough. Prior to committing financial resources to such a project, it is useful to consult the calibration curve (where the general date of the sequence to be wiggle-matched is known) to see whether the selected sequence spans an area of the curve that has what is likely to be a replicable morphology.

19 The preliminary wiggle-match, derived from the accelerator dates of only Lots A and B, dated the original chronology (without the extension provided by CTL-1EG) to 7032-6462 ± 40 B.C. This date was published in the volume edited by Ian Hodder on renewed excavations at Çatal Höyük (KUNIHOLM and NEWTON [*supra* n. 1] 345-347).

20 Indeed, the purpose of selecting additional samples that clustered at the ends of the sequence was with the hope that the first two dates might bracket this significant wiggle. They did not.

21 The error on the wiggle-match is ± 24 radiocarbon years. Translated into calendar years, the margins become +26/-39. The narrower upper limit is due to the constraints imposed by the steep drop from 7050-7010 B.C. on the calibration curve. The calendar errors are a conservative estimate and incorporate adjustments for (i) the errors associated with the selected calibration data; (ii) the potential laboratory offset between Arizona (these data) and Seattle (the calibration data); (iii) the potential mismatch between CTL dated samples and the decades dated for calibration; (iv) an error possibly associated with regional differences in atmospheric radiocarbon. We are most appreciative of Sturt Manning's calculation of this error for the Çatal Höyük sequence. Note also that the calendar dates require an upward shift of 41 years due to a recently discovered error in the German oak dendrochronology on which part of the INTCAL93 calibration program is based (Bernd Kromer, personal communication, May 1996). The INTCAL98 (in press) will no doubt incorporate this change.

39 B.C. thus represents the felling date of CTL-6, a tree cut for use as a roof-beam in Shrine 1 of Level VIB. If CTL-6 was a late addition then this date should fall toward the end of Level VIB. CTL-16&20 was cut in 6588 +26/-39 B.C. for use (probably) as a post in a building unit of Level VII. It was cut 132 years prior to CTL-6.

Using these two dates as markers, we can again consult the earlier radiocarbon date ranges presented in Table 1. Using Mellaart's approximation of plaster counts for Levels VIB through II, we provide horizon markers for the different phases at Çatal Höyük in Pl. CXIVc. Some of the dates as presented fall out of range through probability distributions. But recall some of the additional variations inherent in the radiocarbon dates. The 99% confidence interval (3σ) expands the ranges by almost 1/3 as much on either end. This in itself would be enough to account for the internal phasing as revised through dendrochronology and the wiggle-matched sequence.

While we await retrieval of more charcoal samples from Çatal Höyük in anticipation of further refinement of the internal site chronology, we offer the above as the most comprehensive and accurate dating yet available for a multi-phase ancient Near Eastern site. We hope that more prehistoric sites will yield material suitable for combined dendrochronological/radiometric analyses, and that tree-ring sequences from neighboring sites can be connected to that from Çatal Höyük. Until that time, we present this revised chronology as a small contribution to our understanding of this flourishing Neolithic culture.

Methodological comment for future work:

Ever since the discovery of the radiocarbon method, Aegean archaeologists have concentrated on trying to collect small samples–seeds, grains, twigs, scraps of charcoal–with often inconclusive results. See the tables at the end of Manning 1995 for a rather dismal summary of what has been accomplished for the Aegean EBA from 1950 to 1995. We propose a modification—that there is also merit in collecting long-lived charcoal samples, regardless of the size of the piece—where wiggle-matching may be used judiciously and carefully in a suite of analyses.

A refined intra-site chronology, combining tree-ring sequences from constructional timbers for the building of a given structure, carefully selected radiocarbon dates for the use-phase of the structure, and even more carefully selected radiocarbon dates from short-lived material that dates from near the destruction of the structure should be the goal of this effort.

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^{14}C ID	Dendro ID	Material	Provenience	Date BP	Calib. Date(s) B.C.
P- 796	CTL-25	Grain (2 types)	Shrine 1, Level II	7521 ± 77	6419 (6372) 6223
P- 774		Charcoal–timber (?)	Shrine 1, Level III	7767 ± 94	
P- 775	CTL-1	Charcoal–juniper	House 4, Level IV, upper floor	8037 ± 96	7045 (7008) 6719
P-1361	CTL-2	Charcoal–juniper	Hearth, Shrine 1, Level V	7499 ± 93	6417 (6363, 6271, 6268) 6188
P- 776	CTL-3	Charcoal–juniper	House 4, Level V	7640 ± 91	6533 (6453) 6383
P- 769		Grain	Shrine 25, Level VIA	7505 ± 93	6419 (6366) 6190
P-1365	CTL-7	Charcoal–juniper	Shrine 70, Level VIA	7729 ± 99	6600 (6530, 6529, 6481) 6427
P- 772	CTL-5	Charcoal–oak	House 1, Level VIA	7572 ± 91	6459 (6410) 6253
P- 827		Charred human brain	Skeleton 3, House 1, Level VIA/B	7579 ± 86	6460 (6412) 6262
P-1363		Charcoal–timber (?)	Room 49, Level VIA	7911 ± 103	7004 (6701) 6595
P-1375	CTL-34	Charcoal–elm	Shrine 25, Level VIA	7661 ± 99	6545 (6458) 6389
P- 770	CTL-6	Charcoal–juniper/oak	Shrine 1, Level VIB	7912 ± 94	7003 (6701) 6598
P- 781	CTL-8	Charcoal–oak	Storeroom, Shrine 1, Level VIB	7524 ± 90	6424 (6374) 6219
P- 797	CTL-4	Charcoal–juniper	House 28, Level VIB	7629 ± 90	6476 (6451, 6443, 6428) 6379
P- 777	CTL-13&14	Charcoal–juniper	Shrine 10, Level VIB	7704 ± 91	6595 (6468) 6422
P-1362	CTL-26	Charcoal–elm	Room 27, Level VIB	7904 ± 111	7005 (6696, 6673, 6667) 6561
P-1364	CTL-27	Charcoal–elm	Shrine 70, Level VIB	7936 ± 98	7008 (6759, 6740, 6718) 6605
P- 778	CTL-24	Grain	House 24, Level VII	7538 ± 89	6451 (6379) 6225
P-1366		Charcoal–specks (?)	Fill, Shrine 45, Level VIII	7684 ± 90	6553 (6464) 6416
P-1367	CTL-28&29	Charcoal–elm/oak	Hearth, Shrine 45, Level VIII	7853 ± 97	6992 (6613) 6506
P- 779		Charcoal–specks (?)	Fill, Shrine 8, Level IX	8190 ± 99	7411 (7241, 7223, 7201, 7180, 7142, 7119, 7096) 7036
P- 782		Charcoal–specks (?)	Hearth, Shrine 1, Level X	8092 ± 98	7244 (7037) 6789
P-1372	CTL-31	Charcoal–elm; Bone	Upper fill, Courtyard 29, Level X	7915 ± 85	7002 (6703) 6602
P-1369		Charcoal–specks (?)	Lower fill, Courtyard 29, Level X	7937 ± 109	7030 (6759, 6739, 6718) 6602
P-1371		Charcoal–specks (?)	Lower fill, Courtyard 29, Level X	7844 ± 102	6991 (6609) 6487
P-1370	CTL-30	Ash; Charcoal–elm	Hearth, Room 28, Level X	8036 ± 104	7046 (7008) 6712
P-1374	CTL-33	Charcoal–elm; Ash	Fill in Room 29, Level XII	7757 ± 92	6614 (6543, 6510) 6459

Table 1: Radiocarbon Determinations for Çatal Höyük.
Calibrated dates using intercepts method from CALIB 3.0.3, listed at 1 standard deviation

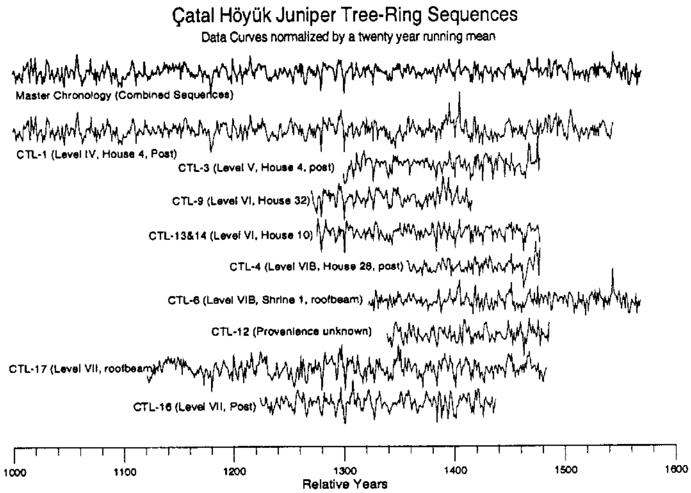
Dendro ID	Rel. Years	^{14}C ID	^{14}C Date	Calibrated B.C. (at 1σ) - Intercepts	Wiggle-Match B.C.
Lot A	1007- 1016	A-18104	8065 ± 50	7042 (7033) 6822	7014 +26/-39
Lot B	1527- 1536	A-18105	7710 ± 100	6599 (6470) 6421	6493 +26/-39
Lot C	1503- 1508	A-19344	7620 ± 50	6461 (6425) 6397	6520 +26/-39
Lot D	1550- 1558	A-19345	7626 ± 52	6463 (6450, 6448, 6427) 6407	6469 +26/-39
Lot E	1560- 1567	A-19346	7670 ± 50	6477 (6460) 6424	6459 +26/-39
Lot F	1027- 1036	A-19347	7998 ± 54	7032 (7000, 6911, 6909, 6836, 6817) 6719	6994 +26/-39
Lot G	1037- 1046	A-19348	7982 ± 52	7009 (6997, 6919, 6897, 6840, 6785) 6708	6983 +26/-39
Lot H	1077- 1086	A-19349	7944 ± 65	7004 (6850, 6763, 6735, 6724) 6624	6943 +26/-39
Lot I	1117- 1126	A-19350	7918 ± 54	6997 (6705) 6614	6903 +26/-39
Lot J	1496- 1507	A-19351	7747 ± 65	6601 (6538, 6517, 6493) 6463	6523 +26/-39
Lots C&J, Averaged	1496- 1508	N/A	7669 ± 42	6472 (6460) 6425	6521 +26/-39

Table 2: Wiggle-Matched Series Radiocarbon Dates

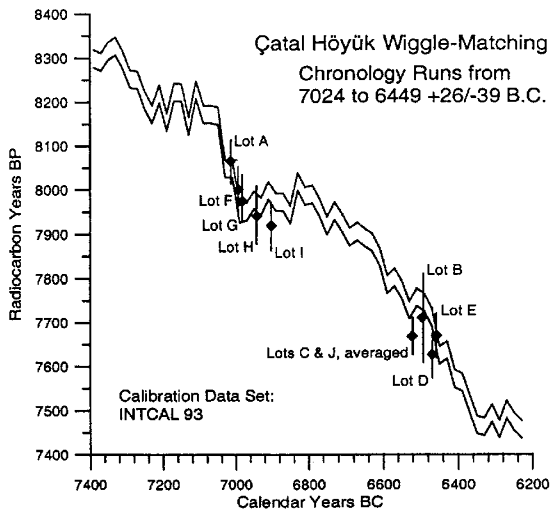
Dendro ID	Relative Years	Level	Wiggle-matched B.C. Years
CTL-1	1000 - 1544	IV	7025 - 6481 +26/-39 (*t.p.q.*)
CTL-1EG	1483 - 1576	IV	6542 - 6449 +26/-39 (*t.p.q.*)
CTL-3	1300 - 1478	V	6725 - 6547 +26/-39 (*t.p.q.*)
CTL-9	1271 - 1416	VIA	6754 - 6609 +26/-39 (*t.p.q.*)
CTL-13&14	1276 - 1478	VIB	6749 - 6547 +26/-39 (*t.p.q.*)
CTL-4	1357 - 1478	VIB	6668 - 6547 +26/-39 (*t.p.q.*)
CTL-6	1322 - 1569	VIB	6703 - 6456 +26/-39 (bark/felling date)
CTL-12	1339 - 1486	Unknown	6686 - 6539 +26/-39 (*t.p.q.*)
CTL-17	1121 - 1483	VII	6904 - 6542 +26/-39 (*t.p.q.*?)
CTL-16&20	1224 - 1437	VII	6801 - 6588 +26/-39 (bark/felling date)

Table 3: Calendar Dates for Components of Çatal Höyük Wiggle-Matched Series

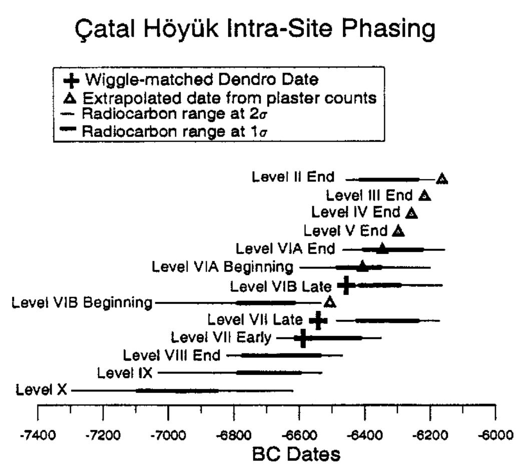
LIST OF ILLUSTRATIONS


Çatal Höyük Juniper Tree-Ring Sequences
Data Curves normalized by a twenty year running mean
Master Chronology (Combined Sequences)
CTL-1 (Level IV, House 4, Post)
CTL-3 (Level V, House 4, post)
CTL-9 (Level VI, House 32)
CTL-13&14 (Level VI, House 10)
CTL-4 (Level VIB, House 28, post)
CTL-6 (Level VIB, Shrine 1, roofbeam)
CTL-12 (Provenience unknown)
CTL-17 (Level VII, roofbeam)
CTL-16 (Level VII, Post)
1000
1100
1200
1300
1400
1500
1600
Relative Years

a


Çatal Höyük Wiggle-Matching
Chronology Runs from
7024 to 6449 +26/-39 B.C.
Radiocarbon Years BP
8400
8300
8200
8100
8000
7900
7800
7700
7600
7500
7400
Lot A
Lot F
Lot G
Lot H
Lot I
Lot B
Lot E
Lots C & J, averaged
Lot D
Calibration Data Set:
INTCAL 93
7400
7200
7000
6800
6600
6400
6200
Calendar Years BC

b


Çatal Höyük Intra-Site Phasing
Wiggle-matched Dendro Date
Extrapolated date from plaster counts
Radiocarbon range at 2σ
Radiocarbon range at 1σ
Level II End
Level III End
Level IV End
Level V End
Level VIA End
Level VIA Beginning
Level VIB Late
Level VIB Beginning
Level VII Late
Level VII Early
Level VIII End
Level IX
Level X
-7400
-7200
-7000
-6800
-6600
-6400
-6200
-6000
BC Dates

c