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THE LONG-TERM RADIOCARBON TREND OF THE ABSOLUTE GERMAN OAK TREE-RING CHRONOLOGY, 2800 TO 800 BC

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INTRODUCTION

The Hohenheim Tree-Ring Laboratory has extended the Holocene oak tree-ring chronology back to prehistoric times by analyses of subfossil tree trunks from gravel deposits along the rivers of central Europe. Hundreds of subfossil oaks can be collected each year because of widespread gravel quarrying. Despite this nearly continuous source of samples (at present, 2200 trees are analyzed), even within these deposits some limitations do exist in linking together a Holocene tree-ring sequence.

The main problem is the relatively short growth period of the Holocene valley oaks, reaching only 100 to 400 tree-rings. This requires a close temporal sequence of tree trunk deposits over thousands of years. However, while phases of increased flooding accumulated large numbers of eroded trees, there also have been periods of low fluvial activity, which left only few buried wood remains. Unfortunately, such a phase of reduced floodings occurred during the first millennium BC, a period from which wood samples from prehistoric settlement constructions, the other source of dendrochronology, are rarely found in southern Germany. A comprehensive study of Holocene riverine oak forests and their inter-relation with the fluvial regime will soon be published (Becker, in press).

These remarks explain why bridging of the remaining gaps in the extended floating Holocene oak chronologies became increasingly difficult. To overcome this problem, we have established an exchange of chronologies with Burkhard Schmidt at the Köln Tree-Ring Laboratory. This cooperation has closed one of the long-standing gaps in the Hohenheim master chronology by crossmatches of Roman and Pre-Roman oak series from northwest Germany, recently established by Schmidt in Köln (Becker and Schmidt, 1982). Recently collected subfossil oaks from the Danube River have bridged the next gap in our oak chronology, at 1500 BC. At its present stage, the absolute Hohenheim master is extended continuously back to the year 2804 BC.

REPLICATION OF THE GERMAN ABSOLUTE OAK MASTER CHRONOLOGY

The implications of this absolute tree-ring calendar for dendrochronologic dating of an increasing number of prehistoric lake dwellings as well as for calibration of the ^{14}C time scale demand a very careful presentation of the significance of the crossmatches within this sequence. This applies particularly at the points where there is little replication.

The present configuration of the Hohenheim oak chronology is given in figure 1 where all established south central European chronologies are listed, together with the resulting master curve, showing the minimum number of crossdated trees per century. This method shows up the parts of the dendrochronology where links are based on a low number of individual tree-ring curves.

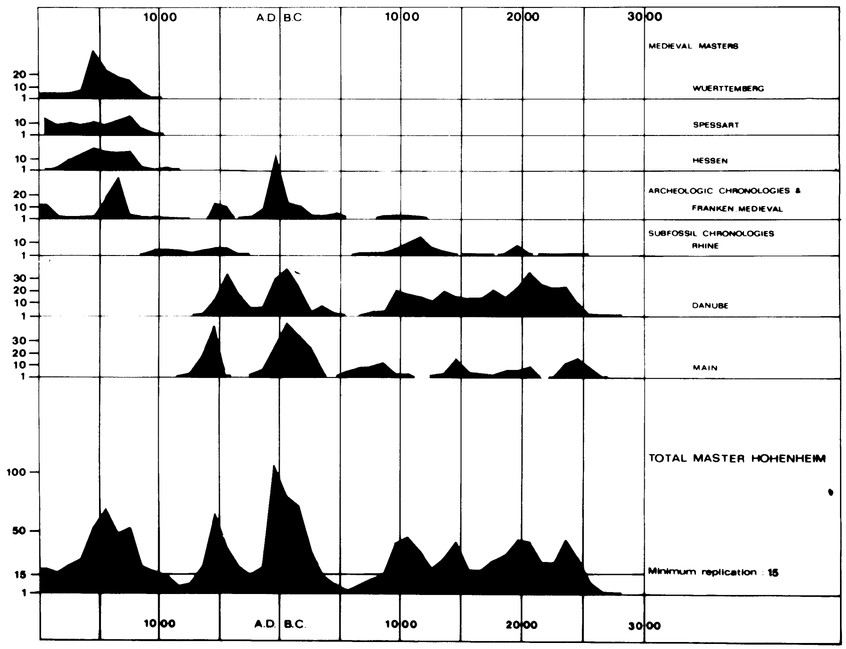

Fig 1. Replication of the south German absolute oak tree-ring chronology. Plotted are the minimum replications (per century) of the existing regional chronologies (upper part). These series are linked together to the absolute Hohenheim master reaching continuously back from the present to 2804 BC (lower part).

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Comparison of all 18 independently established regional chronologies clearly demonstrates that only two periods in the first five millennia are replicated by a minimum number below 15 trees. The first occurs from AD 800 to 1000, the second, from 800 to 400 BC. Of these, the overlap between the Medieval chronologies (back to AD 744) and the Early Medieval sequences (Rhine River, AD 254 to 1162) is problem-free. This crossmatch covers 419 years and is additionally confirmed by a significant cross-correlation with the western German oak chronology developed by Hollstein (1980) in Trier (Becker, 1981).

The second critical link occurs between 600 to 400 BC. Our Pre-Roman series, which was the beginning of the absolute master before its recently achieved extension, starts at 546 BC. The earlier floating well-replicated Late Bronze Age masters end at 469 BC. The existing 87-year overlap was recognized by crossmatching the northwest German archaeologic site chronologies, mentioned above, and the earliest part of the western German chronology of Hollstein together with both Hohenheim series (Becker and Schmidt, 1982). These three independent masters have a significant overlap of at least 223 years.

The older section of the Hohenheim master, from 800 to 2500 BC, is replicated at every point by more than 15 trees. In addition, the chronology is represented by independent regional series of subfossil oaks from the Rhine, Main, and Danube valleys, together with various chronologies of prehistoric Swiss lake dwelling sites (Becker et al, 1979).

To summarize, there is only one period (600 to 400 BC) in the south central European oak chronology when linking of all the Hohenheim data is not independently replicated. For this portion, the linking of our series relies on crossmatches with tree-ring chronologies from neighboring regions.

THE LONG-TERM RADIOCARBON TREND OF THE OAK CHRONOLOGY

Several laboratories have studied the ^{14}C content of our oak sequences which include the absolutely-dated sections (Bruns, Münnich, and Becker, 1980) and the older floating series (Suess and Becker, 1977; Suess, 1978, 1980; deJong, Mook, and Becker, 1979; Bruns et al, in press; Rehin, 1982). In particular, Suess has analyzed the ^{14}C activity from earlier floating oak series which can now be crossdated to our absolute master. From this study, the first independent comparison can be made between the ^{14}C variations of European oak and the bristlecone-pine calibration.

The result is shown in figure 2 where the La Jolla oak data are plotted against the bristlecone-pine data for the period, 2800 to 700 BC. The graph points out an obvious long-term trend in European oak which is very similar to that of bristlecone pine of the southwest United States. In the oak, the first deviation of the ^{14}C ages from the appropriate dendro-dates becomes evident from 1000 to 1400 BC (the recently established overlap to the Bronze Age series, 1400 to 1600 BC, has not yet been analyzed).

Between 1550 and 1700 BC, the ^{14}C ages are too young by ca 100-150 years, increasing more or less steadily at 2200 BC to ca 250 years. During the third millennium BC, this difference reaches a maximum value of ca 600 calendar years. This

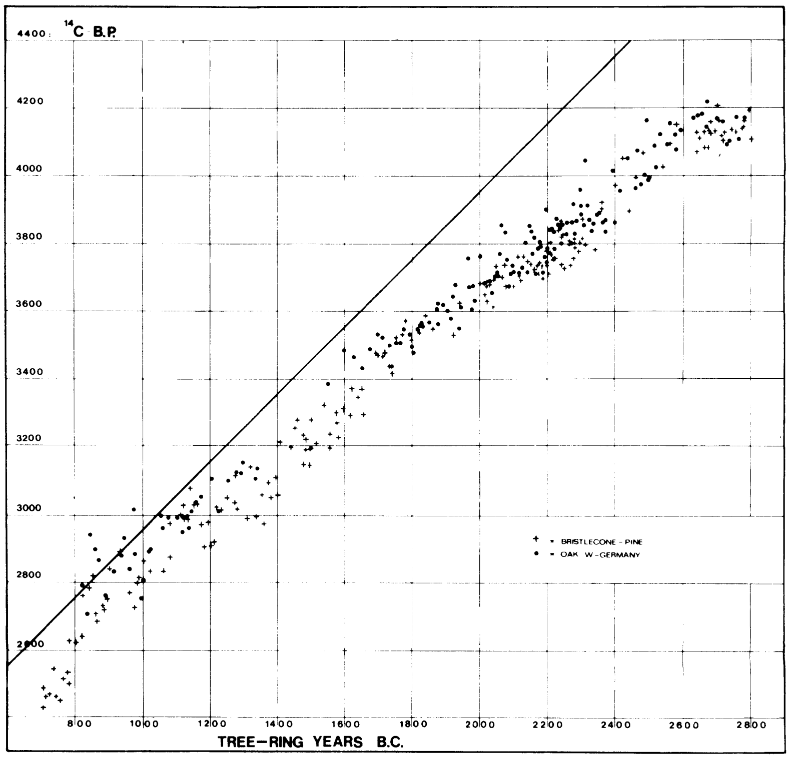

Fig 2. Comparison between the long-term ^{14}C variation of the bristlecone pine (crosses) and the German oak (dots) from 2800 to 700 BC, according to analyses of HE Suess, La Jolla (Suess, 1978). Within both series, a systematic long-term offset between the dendro-ages and the appropriate ^{14}C ages starts at ca 1200 BC and, during the 27th and 28th century BC, reaches a maximum value of ca 600 calendar years.

offset is almost the same as that observed in the La Jolla bristlecone-pine data for the same period.

Despite the general coincidence of increasing ^{14}C activity between bristlecone pine and German oak during the 2nd and 3rd millennia BC, a systematic offset occurs between the two series if one compares their medium-term variations. Wiggle matching of the earlier floating Late Bronze Age and Bronze Age masters of the bristlecone-pine calibration curve provided corrected zero-points of 1535 BC (dendro-age: 1462 BC) and 2871 BC (dendro-age: 2804 BC). This calibration placement had been based on a 300-year (Late Bronze Age series Donau 15 and Zug/Sumpf) and a 1250-year (Bronze Age master, Donau 3/10) measured tree-ring series and was statistically significant (Kruse et al, 1980). However, this calibration placement differs for both series from their dendro-dated zero-points by almost identical figures of 73 and 67 years, respectively.

If an error should exist within the Hohenheim dendrochronology, it very probably would not have occurred in the crossmatch between the Late Bronze Age and the Bronze Age series, since they both show the same offset as the bristlecone pine calibration curve. The German oak series 500 BC to present, on the other hand, is independently replicated by the significant cross-correlation with the western German master of Hollstein, as mentioned before. The only hypothetical mistake that could be considered is the link within the master between 600 and 400 BC. Nevertheless, it must be stressed that the crossmatches of the Trier, Köln, and Hohenheim series of that period are also significant as can be seen from the curves published by Becker and Schmidt (1982).

To check the offset between the German oak and the bristlecone pine wiggles definitively, the ^{14}C content of our sequence of the first millennium BC will be measured by Minze Stuiver in Seattle. Further conclusions relating to this offset should not be discussed until these results are available.

RADIOCARBON CALIBRATION OF THE GERMAN OAK CHRONOLOGIES, 2800 to 7600 BC

During the 11th International Radiocarbon Conference, a committee for high-precision calibration of tree-ring chronologies was formed. Therefore, it is relevant to include here an outline of the pre-existing calibrations of the older Holocene oak chronologies from Hohenheim.

Before 2800 BC, the south central European oak chronology consists of four large floating series. These have already been calibrated by conventional (La Jolla) and high-precision

(Heidelberg, Groningen) ^{14}C analyses. As shown in table 1, the older parts of the Hohenheim tree-ring chronology cover the period, 2600 to 7600 BC. It is evident that there are no major gaps remaining within the sequence.

TABLE 1. ^{14}C calibrated Holocene oak chronologies of the Hohenheim Laboratory

Chronology name	Ring-numbers	Calibrated age (BC)	Analyzed sections	Laboratory
Donau 7	1425	4058-2632	3970-3260 3920-3220	La Jolla Groningen
Donau 8	737	4850-4114	4420-4130	La Jolla
Main 6/13	1623	6515-4893	6450-5920 5960-5390 5380-5020	Heidelberg La Jolla Heidelberg
Main 4/11	846	7200-6355	7190-6370	Heidelberg
Main 9*	497	7600-7104*	7580-7190	Heidelberg

* Not calibrated

The earliest calibrated series (Main 4/11) extends beyond the beginning of the bristlecone-pine calibration curve (up to 7200 BC, Bruns et al, in press; Rhein, 1982). The Main 9 chronology must be even older. This can be derived from the comparison of the high-precision analyses of the Main 4/11 to the Main 9 series.

A further extension of the absolute master (starting at 2804 BC) is to be expected by the calibrated Neolithic master, Donau 7, which overlaps on its younger end (up to 2634 BC). In addition, this sequence, as well as the next older floating master, Donau 8, must already be covered by the four-millennia floating chronology from Northern Ireland. This chronology is calibrated to 5300-900 BC (Baillie, Pilcher, and Pearson, 1983).

The exchange of tree-ring data by Belfast, Köln, and Hohenheim and the projected intercalibration of the Holocene oak series from Northern Ireland and Germany should soon extend the European tree-ring standard further back into prehistory.

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