Dendrochronological analysis of the Roman timbers from Friar Street 1, Droitwich.

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The 1975 excavations at Friar Street, Site 1, in Droitwich, uncovered numerous waterlogged oak timbers from context 262. These either formed part of a pit lining or were superstructure thrown into that pit. It was suggested that the pit, dated archaeologically to the 1st or 2nd centuries AD, had some connection with the Droitwich salt-working. This industry, although active long before, was greatly expanded by the Romans and caused large demands to be made on the local forest timber.

Tree-ring analysis of the oak timbers was undertaken to provide relative, and if possible absolute, dating for the site. The samples were sent to Sheffield, where the work was supported by the DoE. This report covers the examination of all the Roman timbers, including those analysed in 1977 by Mrs Ruth Morgan.

As a dating technique, dendrochronology is deceptively simple. It relies on the fact that every year a tree produces a new annual ring, the width of which is controlled by environmental factors, such as climate and soil type. Thus, trees growing under similar conditions in the same geographical area will show similar patterns of wide and narrow rings. These can be represented graphically by plotting the measured ring-widths against time in years. Contemporary ring plots are crossmatched either visually or with the aid of a computer program. A tree-ring chronology is constructed by overlapping matching curves from the present day back in time, each ring being equivalent to a calender year. The chronology can then be used to compare samples of unknown age: when the position of best fit between the two curves is found, the outer year of the sample is read off from the reference curve in calender years. It is difficult to define the geographical areas over which cross-dating is possible. Usually the further the distance, the weaker the match but correlations over very long distances are beginning to be found in the British Isles, as will be demonstrated below.

Oak has been used extensively by dendrochronologists in temperate Europe. It is a long lived tree, often attaining 200 years of age. Because of its hardness, it was commonly used as a building timber and so is preserved in standing buildings and in waterlogged archaeological sites. For these reasons it is possible to construct long chronologies using oak timbers. It also has the advantage in that each ring really does equal one year unlike e.g. conifers, which frequently have missing or double rings. In cross-section, the annual bands show up clearly because of the contrast between the large vessels of spring wood and the small cells of the summer wood. Measurement is thus possible using only a low-power binocular microscope. Finally, the outer portion of an oak is of a different colour and structure to the inside. It is called sapwood and represents the living part of the tree. As the tree grows and produces new wood, the older sapwood dies and is strengthened with lignin, being now known as heartwood. The number of sapwood rings is relatively constant. Provided that the heartwood-sapwood transition has been preserved, it is possible to deduce the amount of sapwood and so obtain a very close approximation to the felling date.

Method

Any large samples were split and sawn into smaller sections of c. 5-10 cms thickness. Most of them, however, were thin planks. Great care had to be taken with these to avoid any breakage, which would have destroyed the tree-ring record. The samples were deep-frozen to harden the wood. The cross-sections were cleaned, whilst still frozen, with a surform plane. This gave a smooth surface on which the individual rings were clearly visible.

The rings were measured on a travelling stage which was connected, via a linear transducer, to a digital voltmeter. The latter flashed up the ring-width, in 0.1 mms., after each complete ring had been traversed. The value was recorded and, after all the rings had been scanned, the widths were plotted on transparent semi-logarithmic recorder paper. Crossmatching was attempted, first visually by sliding one graph over another and then, if necessary, using a computer program.

Results and Discussion

The details of all the Roman samples, except for two small stakes examined by Ruth Morgan, are given in Table 1. 106 and 112 were found in the ashy fill of the pit and were considered to be superstructure, whilst the remaining timbers formed part of the pit lining. 106/112 and 137/138 are both means of two samples which had been split from the same tree. These, together with 139, were measured by Ruth Morgan. Table 1 also gives the average ring widths and a rough sketch of the samples. The widths vary from 1.03 to 2.48 mms., making the timber ideal for dendrochronology. It suggests that slow grown oaks were being selected; a situation that would be expected if the timber was being taken from nearby woodland. Here narrow rings would be formed as a result of shading and competition from other trees. After felling, the trunks were radially split into thin planks, a method which produces many boards from one section of tree trunk. It is unlikely that the wood would have been seasoned. Timber was usually felled when required and used almost immediately (Hollstein, 1965).

Visual comparison of the graphs showed that much of the wood did come from the same tree. There are no standard criteria for establishing which samples derive from the same tree. An almost perfect match, plus similarities between the timbers, usually signifies that they were cut from one tree. With the Droitwich samples it was relatively simple as the pieces of wood were identical: many of them could be crossmatched before measurement. This is generally only possible with oak when dealing with one tree. It was estimated that four or five trees were represented by the samples examined; 139 and 154 could be from the same or different trees(Figure 1).

The constituents of each tree were meaned. The five trees themselves crossmatched and their relative positions are shown in Figure 1. 'Tree 1' is made up of 159, 160, 164, 165, 166 and 168. It will be noted that 168 has only 34 rings. This would have been impossible to match if the other samples had been from different trees. However, it shows that such samples should not be ignored by dendrochronologists since, in certain situations, they can be dated. 137, 138, 170, 171, 174 and 175 were called 'tree 2', whilst trees 3, 4, 5 are represented by 106/112, 139 and 154 respectively. The felling date of trees 1 and 2 are identical. Some of the tree 2 components did not contain their outer rings e.g. 170 had c.45 years missing (Figure 1; Table 1). It demonstrates the difficulty of estimating the felling date if there is no remaining sapwood. 139 shows this in practice; there is no way of knowing when it was felled. 154 shows a possible transition from heartwood to sapwood, making it likely that it has the same felling date as trees 1 and 2. That would necessitate it having 25 years of missing sapwood which falls within the limits of 32 ± 9, a figure derived for the number of sapwood rings (Baillie,1973). Tree 3 appears to have its full complement of sapwood so that it must have been felled 26 years later than the remaining samples. Thus, the pit lining predates the 'super-structure' by 26 years.

Trees 1 and 2 were cut down sometime after spring, but before winter, since only the spring wood is present in the last ring. This contrasts with the modern method which is to fell timber during winter. It seems that summer felling was commoner in the past than was once believed as other examples have been found (Hollstein,1965). Because none of the samples consisted of a complete radius (from pith to outer sapwood), no accurate deductions could be made as to the size of trees used at Droitwich. At a rough estimate, they must have been at least 40 cms. in diameter.

The crossmatching between the five trees was confirmed by the Belfast computer program (Baillie and Pilcher,1973). This compares two sets of ring width data and calculates the value of Student's 't' for each position of overlap. Any value greater than 3.5 can be considered as being of possible significance, whist e.g. 7.5 would indicate a high level of correlation. Some of the Droitwich t-values are illustrated below:

	Tree 2	Tree 1	137/138	154	139
106/112	5.23	3.05	3.06	4.26	-
Tree 2	-	4.59	10.55	4.65	4.81

The high value of 10.55 results from a comparison between some components of tree 2 and 137/138, which is itself part of that tree.

Another point of interest here is that when the original five samples were examined, no crossmatching could be found between 139, 106/112 and 137/138. Since the computer comparison between 106/112 and 137/138 gave a t-value of only 3.06 this is not surprising. Only when further samples were examined did matching become possible. It demonstrates the necessity of analysing the maximum number of available samples from any one site and may explain why some sites, with only 3 or 4 timbers, have produced few results.

A floating mean curve was constructed by averaging the ring width data of the 5 trees. It contained all the samples under investigation and had 185 rings (Table 3). The curve was dated to 1950 ± 70bp by radiocarbon measurement. The sample for analysis (HAR-2263) was taken from the 20 outer years of 112 by Ruth Morgan (Figure 1). The date given is a temporary one; it could alter by up to 50 years. After calibration, the date becomes AD 70 (Ralph et al,1973), but this figure must be taken as approximate.

The Droitwich curve was compared, using the computer, with absolutely-dated chronologies from Wederath, Belgium (Hollstein, 1972) and Saarland, Germany (Hollstein,1974). The former showed no indication of crossmatching but the latter gave a t-value of possible significance. However, because of the long distance between Droitwich and Saarland, it was felt that further proof was necessary before the match could be accepted with confidence. No other dated reference curves are available for the Roman period, but there are several floating chronologies; in particular, the London Waterfront sequence (Morgan and Schofield,1978), dated by radiocarbon to c. 1-300 AD, and a northern Irish curve (Hillam and Baillie, unpublished), dated to c. BC100 - AD700 by radiocarbon (Pilcher et al,1977). Droitwich matched with both of these, giving t = 5.14 with London and 3.89 with Ireland (Figure 2). In order to obtain an absolute date for Droitwich, a link must be found between these sequences and the Saarland curve. At present, this looks possible but since the matches cannot be accepted with complete confidence, no absolute date will yet be given. When further confirmation is found, dendrochronology will have provided a very accurate date for the Droitwich timbers.

Summary

All the samples were found to match, including those measured by Ruth Morgan in 1977. 4 or 5 trees, which had been felled during summer, were used to produce the planks examined. As several samples had preserved their full complement of sapwood, some felling dates could be determined: the 'superstructure', 106 and 112, were cut 26 years later than the timber forming the pit lining. A mean curve of 185 years was constructed. Although it crossmatched with floating chronologies from London and the north of Ireland, it remains undated at the present, except for a radiocarbon date of c. AD 70. The possibility of a match with a dated German curve is an encouraging sign that the Droitwich timber may shortly be absolutely dated.

References

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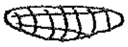
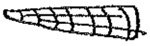
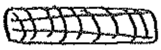
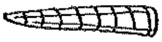
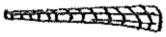
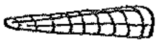
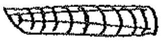
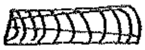
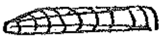
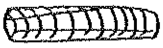
** Tree-rings and the Archaeology of the Thames Waterfront in the City of London.

Table 1

Details of timber samples

Sample no.	No. of rings	Sapwood rings	Average ring widths(mms)	Sketch	Dimensions (cms)
*106/112	159	27	2.34		2.5-3.5 x 35 3.0-5.0 x 34
*137/138	93	-	1.52		2.0-3.0 x 13
*139	71	-	1.03		4.5 x 8
154	52	17	1.65		2.0-3.0 x 8.5
159	53	15	1.97		0.5-2.5 x 10
160	52	13	2.13		2.0 x 10
164	73	14	1.59		0.5-2.0 x 11
165	55	14	2.08		0.25-2.0 x 11
166	63	13	1.85		1.5 x 11
168	34	12	2.48		0.5-2.0 x 8
170	86	-	1.47		1.5 x 12
171	79	17	1.26		2.5 x 8-9
174	67	16	1.46		1.5 x 10
175	71	1	1.15		2.0 x 8

* samples measured by Mrs Ruth Morgan.

Table 2

Sample no.	Tree no.	Years spanned*	Felling date*
159	1	107 - 159	160
160	1	108 - 159	160
164	1	87 - 159	160
165	1	105 - 159	160
166	1	97 - 159	160
168	1	126 - 159	160
137/138	2	17 - 110	160
170	2	26 - 111	160
171	2	81 - 159	160
174	2	93 - 159	160
175	2	72 - 142	160
106/112	3	27 - 185	186
139	4	1 - 71	?
154	5	83 - 134	160?
Mean	-	1 - 185	-

* Scale used in these two columns is an arbitrary one, until the Droitwich chronology can be absolutely dated; see also Figure 1. The tree number is the convention used to show which samples belong to the same tree.

(Where the 'total' sapwood is present, the incomplete last year is not measured, giving a discrepancy of one year between the years spanned and the felling date.)

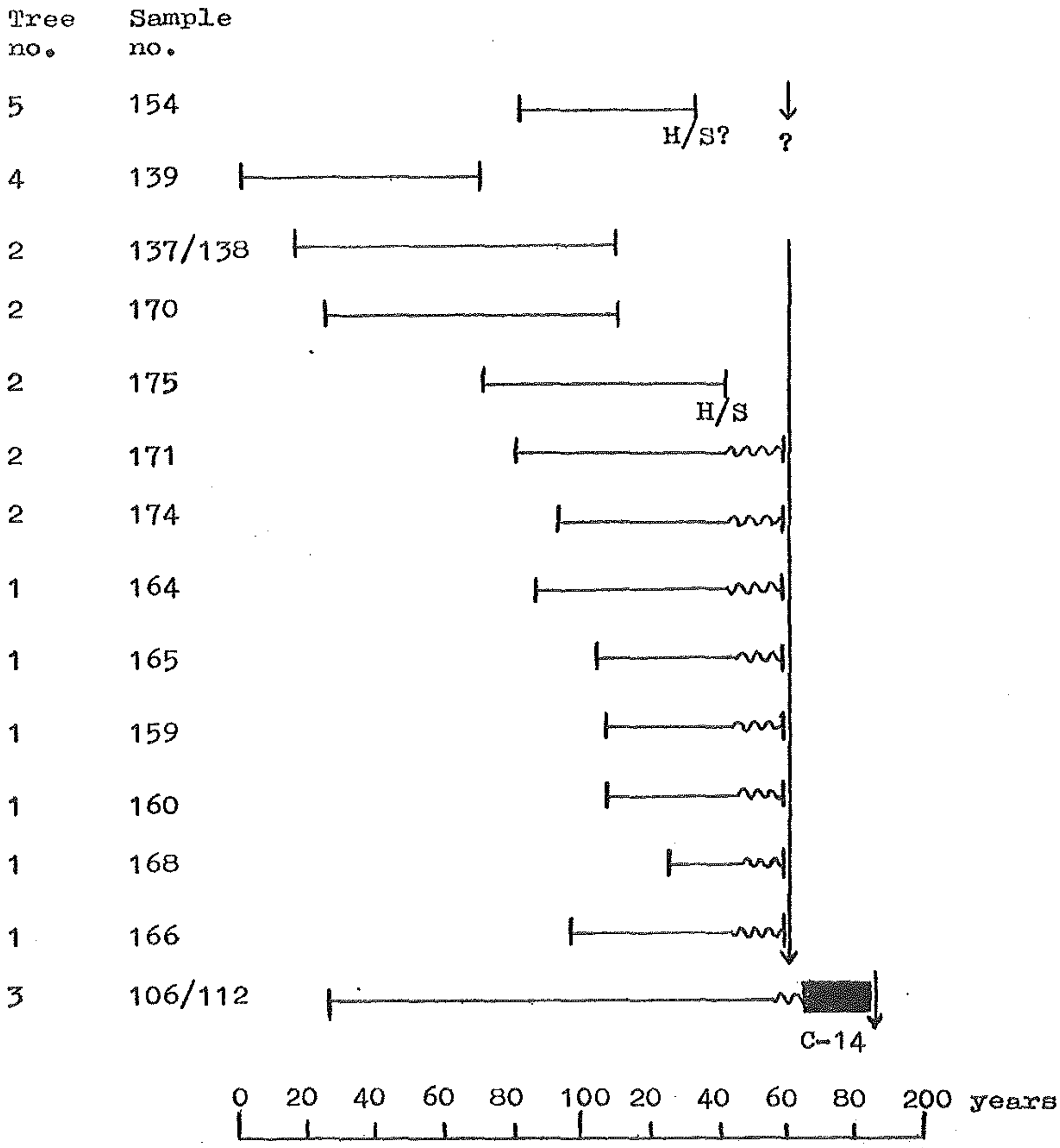
Table 3

Droitwich Roman Mean Curve

years	0	1	2	3	4	5	6	7	8	9	n
0		8	12	9	11	12	14	12	9	9	1
10	11	10	9	12	10	12	14	15	17	16	2
20	15	17	16	15	22	13	16	14	11	11	2
30	14	17	13	12	11	14	19	17	17	19	3
40	21	15	23	21	20	21	23	24	14	14	3
50	15	14	17	20	19	18	21	19	18	27	3
60	20	22	18	20	18	16	19	18	17	16	3
70	19	16	20	19	18	15	17	20	19	16	2
80	19	19	18	15	17	15	16	18	10	14	3
90	17	15	14	12	15	16	13	14	13	15	4
100	16	13	11	11	18	15	17	16	15	14	4
110	12	20	17	14	15	21	19	17	15	18	4
120	20	17	13	16	24	18	14	17	16	19	4
130	17	12	11	18	16	19	21	18	18	21	3
140	20	19	18	22	21	17	17	23	18	12	3
150	21	17	18	15	16	19	14	16	19	18	3
160	17	17	15	13	12	13	20	12	15	18	1
170	15	11	16	12	13	20	15	14	19	18	1
180	13	11	12	12	12	18					

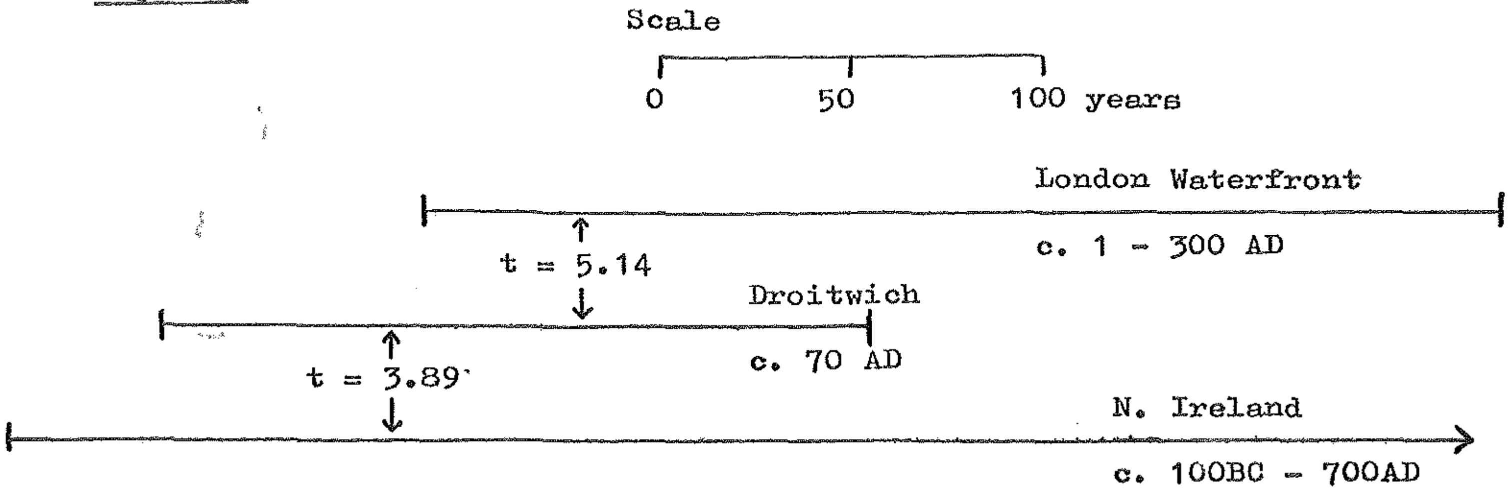
The floating chronology is made up of 5 trees (16 samples). The mean ring widths are given in 0.1 mms.. 'n' represents the number of trees per decade.

Figure 1



Block diagram showing relative positions of the matching samples. Wavy line signifies sapwood years; arrows - felling year; H/S - heartwood/sapwood transition. The radiocarbon sample (1950 ± 70bp) is represented by the block on 106/112.

Figure 2



Block diagram to show positions of crossmatches between Droitwich and floating chronologies from London and Ireland. All dates given are approximate, being radiocarbon measurements which have been roughly calibrated. The author is grateful to Mrs Ruth Morgan for making available her London data.