Anh Report 3/5K

SITE 1204

THE DATING OF ROMAN TIMBERS FROM FRIAR STREET 1, DROITWICH

Final Report (replaces 1978 report no.2552)

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Summary

Sixteen oak planks from pit 262 were examined dendrochronologically: fourteen had lined the pit whilst timbers 106 and 112 were from superstructure thrown into the pit. The planks had been split from four or five trees which were felled in summer. The ring sequences crossmatched to produce a 185-year chronology. This was dated to 141BC - AD44 by comparison with reference chronologies from London. The timber for the pit lining was felled during the summer of AD19 whilst that for the superstructure was cut 26 years later in AD45.

## Introduction

The 1975 excavations at Friar Street 1, Droitwich, uncovered numerous waterlogged oak timbers from context 262. Most of the timbers formed part of a pit lining but samples 106 and 112 were from superstrucure thrown into the 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 woodlands.

Tree-ring analysis was undertaken to provide relative, and if possible absolute, dating for the site. Samples 106, 112, 137, 138 and 139 were examined in 1977 by Mrs Ruth Morgan, and the remainder in 1978 by the author. The original work produced only relative dating but recent advances in British dendrochronology (Hillam & Morgan, 1981) made it possible to date the timbers absolutely in 1981.

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. Trees growing under similar conditions in the same geographical area therefore 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 matching overlapping tree-ring curves from the present day back in time, each ring being equivalent to a calender year. The chronology can then be used to date samples of unknown age: when the position of best fit between two curves is found, the outer year of the sample is read off from the reference chronology in calender years. It is difficult to define the geographical area over which cross-dating is possible. Research is still in progress on this aspect but it seems likely that the British Isles constitute a single tree-ring area (Baillie, 1982), although there will obviously always be exceptions.

Oak has been used extensively for tree-ring dating in temperate Europe. It is a long-lived tree, often attaining 200 years of age. Because of its hardness and durability, it was commonly used as a building timber and so is preserved in standing buildings and on waterlogged archaeological sites. It is therefore possible to construct long tree-ring chronologies using oak timbers (e.g. Hillam, 1981). Oak also has the advantage in that each ring really does represent one year unlike conifers or alder, for example, 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 of the ring widths can therefore be carried out using only a low-power binocular microscope. Finally the outer portion of an oak trunk is of a different colour and structure to the inside. It is called sapwood and represents the living part of the tree. The number of sapwood rings in oak is relatively constant so its presence on archaeological timbers is very important. If the heartwood-sapwood transition has been preserved, a close approximation to the felling date can be obtained. An exact felling date can only be determined if all the sapwood is present.

## Method

Any large samples were split and sawn into smaller sections of c.5-10cm thickness. Most of them however were thin planks and great care had to be taken to avoid any breakage which would have destroyed the tree-ring record. The samples were deep-frozen for 48 hours 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 ring widths were measured to an accuracy of 0.1mm on the Sheffield tree-ring measuring equipment. This consists of a travelling stage connected by a linear transducer to a display panel. The sample on the stage is observed through a 10X binocular microscope. As each ring is traversed, the width is shown on the display panel and is recorded manually. The ring widths were plotted on transparent semi-logarithmic recorder paper which enables the tree-ring curves to be compared visually by sliding one over and past another. A computer program (Baillie & Pilcher, 1973) is also available for the comparison of tree-ring data. This calculates the correlation value, Student's $t$, for each position of overlap between two ring sequences. Values greater than $t$ = 3.5 indicate a match, provided they are accompanied by an acceptable visual match.

## Results

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 timbers which had been split from the same tree. Table 1 also gives the average ring widths and a rough sketch of the measured cross-sections. The average widths vary from 1.03mm to 2.48mm, indicating that the timber came from slow-grown oak trees. 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 in Roman times (Hollstein, 1965).

Visual comparison of the graphs showed that much of the timber did come from the same tree (Table 2). There are no standard criteria for establishing when samples are from one tree but an almost perfect match between ring sequences, plus similarities between the timbers, usually signifies such an occurrance. It was relatively simple with the Droitwich samples as the pieces of wood were often identical: many of them could be crossmatched before the ring widths were measured. This is generally only possible with oak when dealing with samples from one tree. It was estimated that the sixteen samples came from four or five trees. 139 and 154 could be from the same or different trees (Fig.1).

The constituents of each tree were meaned. The ring sequences from the five trees crossmatched with each other, and their relative positions are shown in Fig.1. 'Tree 1' is made up of 159, 160, 164, 165, 166 and 168. 168 has only 34 rings; this ring sequence would have been impossible to match if the other samples had been from different trees. This study shows that such samples should not be ignored by dendrochronologists since in certain circumstances they can be dated. 137, 138, 170, 171, 174 and

175 were called 'tree 2', whilst trees 3, 4 and 5 are represented by 106/112, 139 and 154 respectively. The felling date of trees 1 and 2 is identical. Some of the tree 2 components did not contain their outer rings. 170, for example, had c.45 rings removed when it was converted into a plank (Fig.1). It demonstrates the difficulty of estimating the felling date if there is no sapwood present. 139 shows this in practice since there is no way of knowing when it was felled. The plank may have been split from the inside of one of the other trees. 154 shows a possible heartwood-sapwood transition, making it likely that it was felled at the same time as trees 1 and 2. It would therefore have 25 rings of missing sapwood. This falls within the limits of 32±9, a figure derived by Baillie (1982) for the number of sapwood rings in oak (for further discussion see also Hillam, 1979, and Hughes et al, 1981). Tree 3 appears to have its full complement of sapwood so it must have been felled 26 years later than the remaining samples. The pit lining therefore predates the 'superstructure' by 26 years.

Trees 1 and 2 were cut down in summer since only the spring wood of the outer ring is present (the width of this incomplete ring was never measured giving a discrepancy of one year between the number of rings measured and the felling date). Nowadays timber is frequently felled in winter but summer felling was quite common in the past (Hollstein, 1965). The size of the trees used for the Droitwich timbers cannot be determined accurately since none of the samples consisted of a complete radius from the pith to the bark edge. At a rough estimate they must have been at least 40cm in diameter.

The crossmatching between the five trees was confirmed using the computer program. Some of the resulting t-values are set out in Table 3. The high value of 10.55 is from a comparison between some of the components of tree 2 and 137/138, which is itself part of that tree. When the first Droitwich samples were examined in 1977, 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. This demonstrates the necessity of sampling the maximum number of timbers from any one site, and may explain why some sites with only 3 or 4 timbers have produced few results.

## Dating the timbers

A site master curve was constructed by averaging the ring width data from the five trees. The data from all the samples were used and the master curve had 185 rings (Table 4). In 1978 there were very few reference chronologies by which to date this master curve. The only dated sequences were from Germany (Hollstein, 1972, 1974), one of which gave a possible match with Droitwich. It was felt that further proof was needed before the match could be accepted with confidence. Such proof was never found. Several floating chronologies were also available in 1978. Droitwich matched well ($t$ = 5.14) with a sequence from London (Morgan & Schofield, 1978). However this match did not help to date the Droitwich timbers so instead a radiocarbon sample was taken from the outer 20 rings of 106 and 112. The radiocarbon date was 1950 ±70bp (HAR-2263).

Since 1978 many timbers have been examined at the DoE Dendrochronology Laboratory in Sheffield and much progress has been made. Several Roman chronologies have been constructed from timbers excavated in the City of London in addition to the one which matched with Droitwich. Sequences from Thames Street Tunnel and Peninsular House gave _t_-values of 4.74 and 5.12 respectively with Droitwich. In 1981 the London chronologies were absolutely dated by comparison with two sequences from Germany (Hillam & Morgan, 1981). This in its turn dated the Droitwich master curve to 141BC - AD44, and the felling dates could at last be converted into calender years (Table 2). The timber for the lining of the pit was felled in AD19 and that for the superstructure in AD45. Although it has taken four years to produce these results, the analysis of the Driotwich timbers well illustrates the potential of dendrochronology as a dating method.

Acknowledgements

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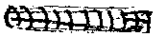
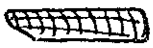
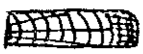
| sample no. | no. of rings | sapwood rings | average ring width (mm) | sketch | dimensions (cm) |
|---|---|---|---|---|---|
| *106/112 | 159 | 27 | 2.34 |  | 2.5-3.5 x 35<br>3.0-5.0 x 34 |
| *137/138 | 93 | - | 1.52 |  | 2.0-3.0 x 13 |
| *139 | 71 | - | 1.03 |  | 4.5 x 8 |
| 154 | 52 | 1? | 1.65 |  | 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 |

Table 1: Details of timber samples; sketches not to scale. Samples measured by Ruth Morgan are indicated by asterisks.

| sample no. | tree no. | years spanned | felling date |
|---|---|---|---|
| 159 | 1 | 35BC - 18AD | 19AD |
| 160 | 1 | 34BC - 18AD | 19AD |
| 164 | 1 | 55BC - 18AD | 19AD |
| 165 | 1 | 37BC - 18AD | 19AD |
| 166 | 1 | 45BC - 18AD | 19AD |
| 168 | 1 | 16BC - 18AD | 19AD |
| 137/138 | 2 | 125BC - 32BC | 19AD |
| 170 | 2 | 116BC - 31BC | 19AD |
| 171 | 2 | 61BC - 18AD | 19AD |
| 174 | 2 | 49BC - 18AD | 19AD |
| 175 | 2 | 70BC - 1AD | 19AD |
| 106/112 | 3 | 115BC - 44AD | 45AD |
| 139 | 4 | 141BC - 71BC | ? |
| 154 | 5 | 59BC - 8BC | 19AD? |

Table 2: Dating of the Droitwich timbers. The tree number indicates which samples are from the same tree. Where total sapwood is present, the incomplete outer ring was not measured, giving a discrepancy of one year between the years spanned by the ring sequence and the felling date.

| | tree 2 | tree 1 | (tree 2) 137/138 | tree 5 154 | tree 4 139 |
|---|---|---|---|---|---|
| tree 3 106/112 | 5.23 | 3.05 | 3.06 | 4.26 | - |
| tree 2 | - | 4.59 | 10.55 | 4.65 | 4.81 |

Table 3: Summary of *t*-values

| year | ring width(0.1mm) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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 | | | | | |

Table 4: Droitwich Roman master curve, 141BC - AD44. 'n' represents the number of trees per decade. The data from a maximum number of 5 trees (16 samples) is included.

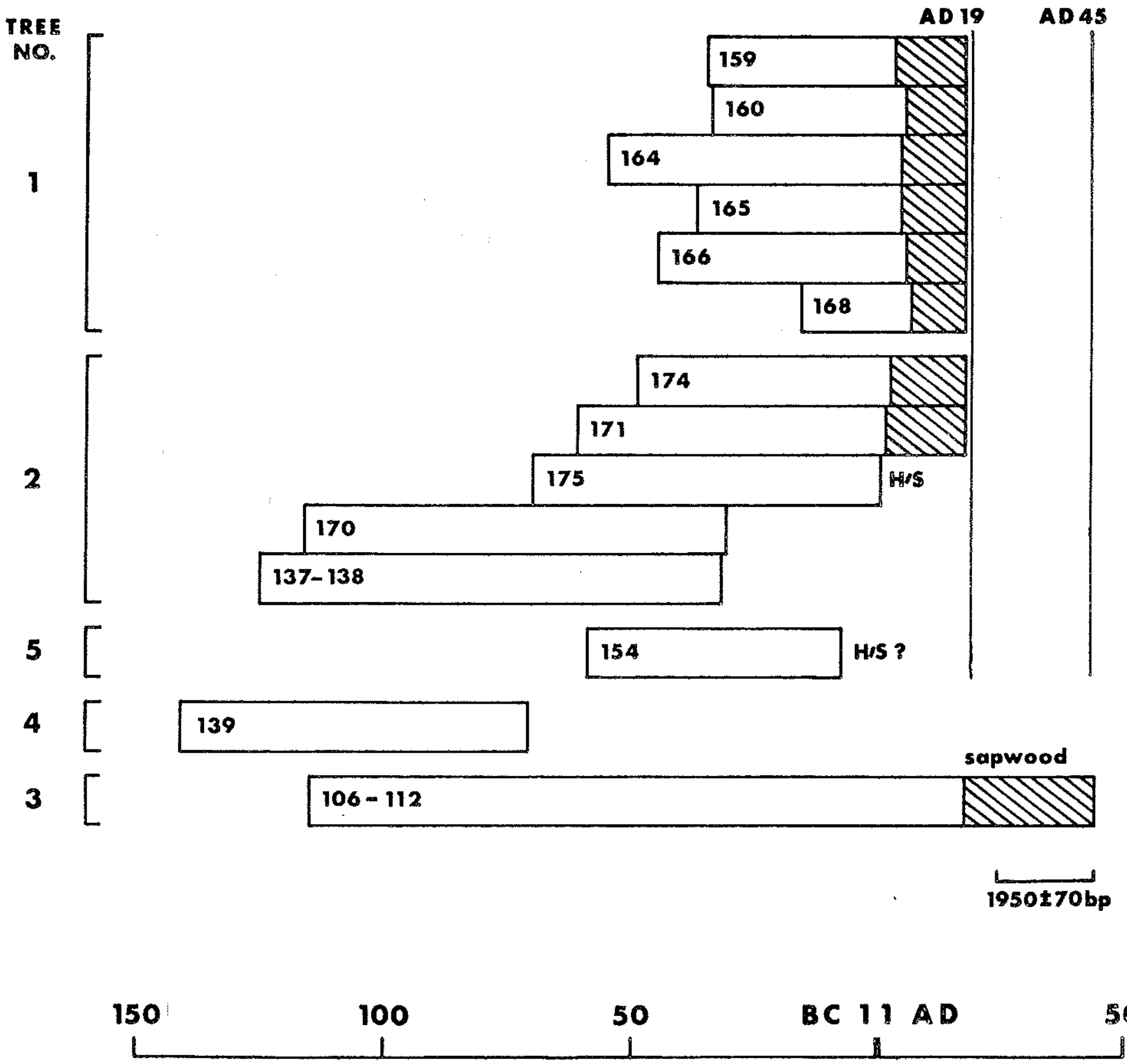



Fig.1: Bar diagram illustrating the years spanned by the individual Droitwich ring sequences. H/S - heartwood/sapwood transition.