Tree-ring spot dates from archaeological samples: Crossrail Broadgate Ticket Hall, Liverpool Street, City of London (sitecode XSM10)

Seven samples from oak timbers excavated from Crossrail Broadgate Ticket Hall, Liverpool Street (sitecode XSM10, NGR *c*. TQ 3305 8161) were submitted for dendrochronological assessment and analysis. 4 of the oak timbers were successfully dated, and are from the early 2nd century AD.

Methodology

Each dendrochronological sample was supplied as a complete cross section, it is assumed in the absence of other information that these were obtained from the optimum location for outermost rings or sapwood survival from these timbers.

Each dendrochronological sample was assessed for the wood type, the number of rings it contained, and whether the sequence of ring widths could be reliably resolved. For dendrochronological analysis samples usually need to be oak (*Quercus* spp.), to contain 50 or more annual rings, and the sequence needs to be free of aberrant anatomical features such as those caused by physical damage to the tree whilst it was still alive. Standard dendrochronological analysis methods (see e.g. English Heritage 1998) were applied to each suitable sample. The sequence of ring widths in each sample were revealed by preparing a surface equivalent to the original horizontal plane of the parent tree with a variety of bladed tools. The width of each successive annual growth ring was revealed by this preparation method. The complete sequence of the annual growth rings in the suitable samples were then measured to an accuracy of 0.01mm using a micro-computer based travelling stage. The sequence of ring widths were then plotted onto semi-log graph paper to enable visual comparisons to be made between the sequences and reference data. In addition cross-correlation algorithms (e.g. Baillie & Pilcher 1973) were employed to search for positions where the ring sequences were highly correlated. Highly correlated positions were checked using the graphs and where these were satisfactory, these locations were used to identify the calendar dates of the measured series.

The *t*-values reported below were derived from the original CROS algorithm (Baillie & Pilcher 1973). A *t*-value of 3.5 or over is usually indicative of a good match, although this is with the proviso that high *t*-values at the same relative or absolute position needs to have

been obtained from a range of independent sequences, and that these positions were supported by satisfactory visual matching.

The tree-ring analysis initially dates the rings present in the sample. The interpretation of these dates relies upon the nature of the final rings in the sequence. Oak timber contains 2 types of wood, heartwood and sapwood, the latter is on the outside of the tree and thus contains the most recent growth rings. Sapwood is softer and is not always preserved under archaeological conditions. If the sample ends in the heartwood of the original tree, a *terminus post quem (tpq)* date for the felling of the tree is indicated by the date of the last ring plus the addition of the minimum expected number of sapwood rings which are missing. This *tpq* may be many decades prior to the actual date that a tree was felled, particularly where poor preservation or other loss of outer heartwood has occurred. Where some of the outer sapwood or the heartwood/sapwood boundary survives on the sample, a date range for the felling of a tree can be calculated by using the maximum and minimum number of sapwood rings likely to have been present. The sapwood estimates used here are a minimum of 10 and maximum of 46 annual rings, where these figures indicate the 95% confidence limits of the range. If bark-edge survives then a felling date can be directly utilised from the date of the last surviving ring.

Results

The submitted material comprised 7 oak (*Quercus* spp.) samples. All of these samples contained measurable tree-ring sequences. All of the samples retained identifiable sapwood, none retain identifiable bark-edge. 6 of the samples were thin planking from 2 Roman gates, contexts *1423* and *1428*. All 7 samples were measured successfully (Table 1). Comparisons between these 7 series identified 2 planks from gate *1423* were derived from a single tree (Figure 1). Cross-matching to reference chronologies identified that 4 of the series were of early 2nd century Roman date (Table 2).

The 4 dated timbers were planks derived from 2 Roman gates, 2 from each gate. The tree-ring results indicate the 4 dated gate planks are broadly contemporaneous (Figure 2). The end dates of these 4 samples vary between AD90 and AD110, with the 4 heartwood/sapwood transitions dated to AD88 & AD89 from gate *1423* and both at AD96 from gate *1428*. The close proximity of the dates obtained results in overlapping interpretations that prevent identifying if one of these gates is earlier than the other. The observable diversity of sapwood

number between trees and within a single tree means that either of these gates could be earlier than the other one, or they could be contemporaneous. If the stratigraphy suggests that they are from different periods or unrelated structures then gate *1423* can be expected to date from *c*. AD99-134, and gate *1428* from *c*. AD110-142. If the results can be combined they indicate both are from the period *c*. AD110-134.

All the dated series cross-match to most datasets from contemporaneous sites in London. These timbers can therefore be assumed to be originally derived from trees grown in the London region.

References

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Figure 1. The tree-ring sequences from 1423 1 (black) and 1423 2 (red). These are derived from a single tree, *t* value 14.23. The composite sequence constructed from these is used in Table 2.
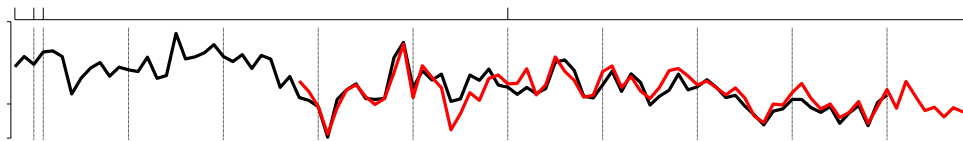

Figure 2. Bar diagram showing the dating positions of 4 Roman oak tree-ring samples from Crossrail site XSM10. Interpretations are based on the minimum and maximum typical amounts of sapwood for London oaks, using a 10-46 ring sapwood estimate. Heartwood (white bars), sapwood (hatched bars)
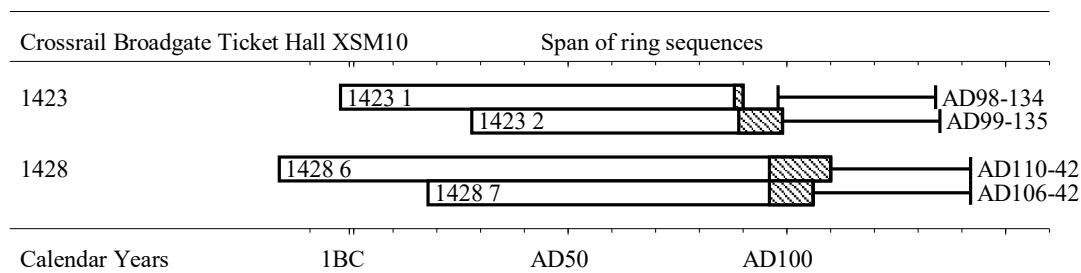

Table 1. 7 oak (*Quercus* spp.) samples from Crossrail site XSM10. Interpretations using a 10-46 ring sapwood estimate.

Context Sample	Size (mm)	Rings	Sap	Date of measured sequence	Interpreted result
1423 1	155 x 5	93	2	3BC-AD90	AD98-134
1423 2	95 x 5	72	10	AD28-AD99	AD99-135
1423 4	170 x 5	120	4	undated	-
1428 5	165 x 5	120	16	undated	-
1428 6	165 x 5	127	14	17BC-AD110	AD110-142
1428 7	135 x 10	89	10	AD18-AD106	AD106-142
1295	125 x 110	86	11	undated	-

Table 2. Showing example *t* values (Baillie & Pilcher 1973) between the composite 1423 1 & 1423 2 sequence and the 2 other dated timbers from Crossrail site XSM10, and 6 independent site series representative of the London composite sequence.

1423 1+2	1428 6	1428 7	
5.14	6.24	4.46	Guys Hospital St Thomas St GHL89 (unpubl.)
5.96	7.62	4.15	Blossoms Inn Gresham St GHT00 (Crone & Tyers 2002)
6.23	7.39	5.64	Guildhall Yard GYE92 (Tyers 2001)
7.28	6.90	5.03	Regis, King William St KWS94 (Tyers & Boswijk 1996)
5.90	5.06	4.78	52-63 London Wall LOW88 (Nayling 1990)
5.27	6.08	4.98	Suffolk, Upper Thames St SUF94 (Tyers & Boswijk 2001)