

Tree-ring spot dates from archaeological samples: Crossrail Broadgate Ticket Hall, Liverpool Street, City of London (sitecode XSM10) group 2

Four additional samples were submitted from the Crossrail Broadgate Ticket Hall, Liverpool Street (sitecode XSM10, NGR *c.* TQ 3305 8161) site for dendrochronological assessment and analysis. These comprised 1 Roman timber and 3 later medieval or post-medieval timbers. 3 of the oak timbers were successfully dated, and are from the 3rd and 16th centuries AD. Seven samples analysed previously from the same site identified 4 datable timbers from a pair of Roman doors, indicating these were 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 4 oak (*Quercus* spp.) samples. All of these samples contained measurable tree-ring sequences. 3 of the samples retained identifiable sapwood, none retain identifiable bark-edge. Sample 6716 was a re-

used or residual piece of Roman timber, 3 others derived from 3 different 15th-17th century features, 6239 is a coffin board, 1266 is a post possibly from a building, and 8246 is from the edge of a ditch. All 4 samples were measured successfully (Table 1). Comparisons of these with reference chronologies identified that 6716 is of early 3rd century date (Table 2), this ends in sapwood at AD205, and was probably felled between AD205 & AD222. This is thought to be a residual timber within a later 3rd century water-lain context. 6239 & 1266 are both of 16th century date, though unrelated (Tables 3 & 4). Timber 8246 contained the least rings and this sequence is not dated.

Timber post 1266 was thought to be part of a building dating from 1666-76, however since the timber ends in sapwood at AD1563 and was probably felled between AD1563 & AD1596 it appears either to be re-used, or to be from an earlier feature on the same site. Coffin board 6239 ends in heartwood at AD1542, so is felled at some indeterminate point after AD1552. It is probably reasonable to assume it is of later 16th century in date, unless it was originally from an exceptionally large board that has been badly eroded.

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.

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Figure 1. Bar diagram showing the dating position of a Roman oak tree-ring sample from Crossrail site XSM10. Interpretation 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)

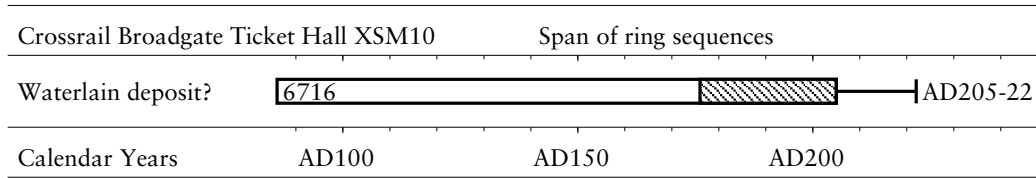


Figure 2. Bar diagram showing the dating positions of 2 later medieval oak tree-ring samples from Crossrail site XSM10. Interpretations are based on the minimum and maximum typical amounts of sapwood for London oaks, using a 10-46 ring sapwood estimate. Heartwood (white bars), sapwood (hatched bars)

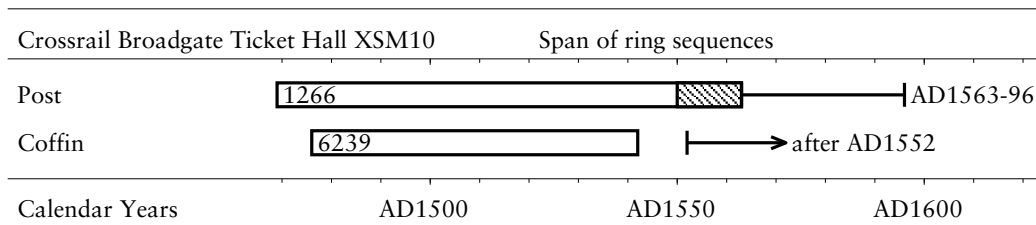


Table 1. 4 oak (*Quercus* spp.) samples from Crossrail site XSM10. Interpretations using a 10-46 ring sapwood estimate.

Sample	Size (mm)	Rings	Sap	Date of measured sequence	Interpreted result
1266	155 x 140	95	13	AD1469-1563	AD1563-96
6239	225 x 10	67	-	AD1476-1542	after AD1552
6716	160 x 45	120	29	AD86-AD205	AD205-22
8246	155 x 155	54	4	undated	-

Table 2. Showing example *t* values (Baillie & Pilcher 1973) between timber 6716 from Crossrail site XSM10, and 6 independent site series representative of the London Roman composite sequence.

	6716 AD86-205
Guys Hospital GHL89 (unpubl.)	6.06
Drapers Gardens DGT06 (Tyers 2007; 2008)	5.82
New Fresh Wharf NFW74 etc (Hillam & Morgan 1986)	5.80
Billingsgate Lorry Park BIG82 (Hillam 1990)	5.62
Bloomberg BZY10 (Tyers 2013; 2014a; b)	5.40
Three Quays TEQ10 (Tyers 2011; 2012)	5.07

Table 3. Showing example *t* values (Baillie & Pilcher 1973) between timber 1266 from Crossrail site XSM10, and 6 later medieval series from SE England.

	1266 AD1469-1563
Oxfordshire, Stanton St John Manor Farm panels (unpubl.)	6.68
Essex, Hill Hall Theydon Mount (Bridge 1999)	6.36
London, Southwark Hays Wharf (Tyers 1996a; b)	6.20
London, Osterley House (Tyers 2009)	6.07
London, Broomfield House Enfield (Bridge 1997)	5.94
Dorset, Lodge Farm Kingston Lacy (Groves 1994)	5.94

Table 4. Showing example *t* values (Baillie & Pilcher 1973) between timber 6239 from Crossrail site XSM10, and 6 later medieval series from SE England.

	6239 AD1476-1542
West Sussex, Cowfold Barn at Singleton (Tyers 1990)	6.09
London, Barking Abbey Rd AYR99 (Tyers 2001)	5.70
London, Southwark Hays Wharf (Tyers 1996a; b)	5.62
Surrey, Maytree Cottage (Miles & Worthington 2000)	5.50
Hampshire, Winchester College panels (Lewis 1995)	5.30
London, Victoria Wharf VIT96 (Tyers & Hall 1997)	5.20