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THE JEWEL TOWER, ABINGDON STREET, WESTMINSTER, LONDON
TREE-RING ANALYSIS OF TIMBERS

SCIENTIFIC DATING REPORT

Martin Bridge

INTERVENTION AND ANALYSIS

ENGLISH HERITAGE

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SUMMARY
A combination of cores and photographs from structural oak timbers thought to be associated with the original fourteenth century roof and foundations of the Jewel Tower failed to date, whilst the elm piles from the foundations were rejected as unsuitable for analysis.
A combination of photographs and 'Fimo' impressions from the boards of the door to the second floor chamber resulted in the successful dating of a single partial board sequence to the period AD 1175-1257. This was found to be of imported oak from a likely German or Baltic region source. Allowing for the additional rings present in the outer section of this board and the minimum likely number of sapwood rings, an estimated *terminus post quem* for felling of this board of AD 1336 is produced. It seems likely therefore that the door is part of the original AD 1360s building.

CONTRIBUTORS
Dr M C Bridge

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CONTENTS

INTRODUCTION

The Jewel Tower is an L-shaped three-storey building of Kentish ragstone that once formed part of the medieval Palace of Westminster (Fig 1). It was built in AD 1364–66 as a personal treasure house for Edward III and was known as the King's Privy Wardrobe. The windows and parapet were renewed in AD 1718–19. It is now a Scheduled Ancient Monument and Grade I listed building in the care of English Heritage.

The roof was largely renewed during the twentieth century, following damage during World War Two, but is thought to contain a small number of original fourteenth-century timbers, including rafters and possibly a wallplate. A photograph in the National Monuments Record dated 17 November 1949 (Fig 2) is labelled "*The new roof of the main upper chamber looking north-west (the far wall beam and principal beam in the middle picture are original timbers repaired. The beam in the top foreground is wholly new)*."

On display in the main chamber are a series of elm piles and an oak plate which were thought to potentially represent part of the original foundations of the tower (Fig 3). A door leading to the second floor chamber is of eight lapped panels, cross-framed and heavily studded, hung from two strap hinges with the gudgeons set tightly in the stone jamb (Fig 4). Whilst the lock panel has been inserted, the door is otherwise thought to be an original fourteenth-century fitting.

Dendrochronological investigation was requested in order to aid the overall understanding of this historic property in the care of English Heritage. It was hoped to confirm that some original timbers were present within the modern roof, that the elm piling with oak plate represented part of the original foundations, and that the door was part of the original building.

Figure 1: Map to show the location of The Jewel Tower (based on the Ordnance Survey map with permission of the Controller of Her Majesty's Stationery Office, ©Crown Copyright)

METHODOLOGY

An assessment of timbers of potential interest was undertaken in August 2009. The aim of the assessment was to ascertain whether timbers with sufficient rings to warrant analysis were present and also to allow assessment of the 'sampling' methods that it would be necessary to employ. Following further discussion it was agreed to attempt analysis of the few extant original roof timbers, the oak and elm foundation section on display and the second floor door using a combination of coring, photography and 'Fimo' impressions. The sampling of the roof timbers by coring, using a 15mm auger attached to an electric drill, was carried out in June 2010, with a series of subsequent visits being made to undertake work on the door and the foundation section. The cores obtained were glued to wooden laths, labelled, and stored for subsequent analysis. The top cross-sectional surfaces of the central four door boards were cleaned using a Dremmel hand tool with a variety of attachments and photographed. Casts of these cleaned surfaces were also taken using 'Fimo' modelling clay.

The photographs were examined in two ways. Firstly they were printed and then the series were measured directly from the prints as if they were actual physical samples (see below) and the series adjusted to make the values as close as possible to actual dimensions of the wood. Subsequently, as a further check on these initial measurements, the digital photographs were also measured using CooRecorder, software designed for just such an application by Lars-Ake Larsson (www.cybis.se). The cores were polished on a belt sander using 80 to 400 grit abrasive paper to allow the ring boundaries to be clearly distinguished. The samples had their tree-ring sequences measured to an accuracy of 0.01mm, using a specially constructed system utilising a binocular microscope with the sample mounted on a travelling stage with a linear transducer linked to a PC, which recorded the ring widths into a dataset. The software used in measuring and subsequent analysis was written by Ian Tyers (2004). Cross-matching was attempted by a combination of visual matching and a process of qualified statistical comparison by computer. The ring-width series were compared for statistical cross-matching, using a variant of the Belfast CROS program (Baillie and Pilcher 1973). Ring sequences were plotted to allow visual comparisons to be made between sequences on a light table. This method provides a measure of quality control in identifying any potential errors in the measurements when the samples cross-match.

In comparing one sample or site master against other samples or chronologies, t-values over 3.5 are considered significant, although in reality it is common to find demonstrably spurious t-values of 4 and 5 because more than one matching position is indicated. For this reason, dendrochronologists prefer to see some t-value ranges of 5, 6, and higher, and for these to be well replicated from different, independent chronologies with both local and regional chronologies well represented, except where imported timbers are identified. Where two individual samples match together with a t-value of 10 or above, and visually exhibit exceptionally similar ring patterns, they may have originated from the same parent tree. Same-tree matches can also be identified through the external characteristics of the timber itself, such as knots and shake patterns. Lower t-values however do not preclude same tree derivation.

Ascribing felling dates and date ranges

Once a tree-ring sequence has been firmly dated in time, a felling date, or date range, is ascribed where possible. With samples which have sapwood complete to the underside of, or including bark, this process is relatively straightforward. Depending on the completeness of the final ring, ie if it has only the spring vessels or early wood formed, or the latewood or summer growth, a precise felling date and season can be given. If the sapwood is partially missing, or if only a heartwood/sapwood transition boundary survives, then an estimated felling date range can be given for each sample. The number of sapwood rings can be estimated by using an empirically derived sapwood estimate with a given confidence limit. If no sapwood or heartwood/sapwood boundary survives then the minimum number of sapwood rings from the appropriate sapwood estimate is added to the last measured ring to give a *terminus post quem* or felled-after date.

A review of the geographical distribution of dated sapwood data from historic timbers has shown that a sapwood estimate relevant to the region of origin should be used in interpretation, which in this area is 9–41 rings (Miles 1997) or 8–24 rings for Baltic timbers (Tyers 1998) and 8-38 rings for German timbers (Hillam et al 1987). It must be emphasised that dendrochronology can only date when a tree has been felled, not when the timber was used to construct the structure or object under study.

Figure 2: The roof of the main upper chamber (photograph from the National Monuments Record)

Figure 3: The elm piles and oak plate on display in the main chamber

Figure 4: The door to the second floor chamber, indicating the position of the dated board

RESULTS AND DISCUSSION

Basic information about the ring sequences obtained by coring for analysis is presented in Table 1, whilst the raw ring width data is presented in the Appendix.

Table 1: Details of the 'samples' obtained; sequences with less than 40 rings were not measured

Sample	Description	Rings	Sapwood	Mean ring-width (mm)	Date of measured sequence (AD)
jwl01	North tie beam	47	-	2.92	unknown
jwl02	North rafter in the East Room, 3rd from west end	80	h/s	1.52	unknown
jwl03i	North rafter in the East room at west end	<40	-	-	-
jwl03ii	ditto	<40	h/s	-	-
jwl04*	Pile on display in main second floor chamber	<40	-	-	-
Jwl05	Top plate to foundation piles	58	-	c2.73**	unknown
jwlBD3	Door board 3	c65	-	-	unknown
jwlBD4	Door board 4	c80	-	-	unknown
jwlBD5i	Door board 5, inner part	83	-	c2.69**	1175–1257
jwlBD5ii	Door board 5, outer part	c70	-	-	unknown
jwlBD6	Door board 6	c110	-	-	unknown

h/s = heartwood-sapwood boundary; * = elm (Ulmus spp); ** - the ring width sequence was derived from photographs and whilst the relative values are acceptable, they are not absolute measurements

Roof

The north tie beam (jwl01) in the main chamber is the timber described in the 1949 photograph as original. It was found on coring to be thinner than its external appearance would suggest, and to have a pine timber behind the façade which is carrying most of the structural load. The sequence obtained did not match other samples from the site and, not surprisingly in view of its short length, nor did it date against reference material. The rafters in the main chamber were all replacements (as seen in the 1949 photograph). Only two rafters in the east chamber roof were sampled; these were the only original rafters to have sufficient numbers of rings to have the potential to yield results and, in addition, both have a heartwood-sapwood boundary present. The ring-width series for jwl02 did not match other timbers from the site, and could not be dated against reference material. The core taken from the other rafter, jwl03, had broken. The two sections could not be reliably joined and unfortunately neither section contained sufficient rings to make measurement worthwhile.

Foundations

A series of photographs of the oak plate holding the elm piles on display in the main second floor chamber (Figs 5a-c) yielded a sequence of 58 rings. This sequence, jwl05, did not match other samples from the site, nor did it give acceptable matches to the reference material. A core was taken from the most promising looking elm pile, but this produced a sequence of less than 40 rings, and was not therefore measured.

Door

The outer boards of the door (Fig 4) were not investigated further because of the curved nature of their tops. This made cleaning, impression taking, and photographing very difficult, as well as distorting the ring width pattern. The exposed top cross-sectional surfaces of the central four boards were highly degraded but only minimal cleaning was undertaken as any greater intervention was deemed unacceptable. 'Fimo' impressions and photographs (eg Fig 6) were taken of these very slow-grown V-edged oak boards. The 'Fimo' impressions proved impossible to measure as the resolution from the minimally cleaned surface was very poor. The photographs were more useful on this occasion but were still problematic resulting in the attempted measurement of only partial sequences for each of the four central boards including two from board 5. The reliability of all but one of these sequences was considered questionable, thus only the raw data for jwlBD5i is presented in the Appendix.

All five sequences derived were compared with each other but, not surprisingly bearing in mind the potential measurement problems, no cross-matching was identified. These five sequences were subsequently compared to a wide range of reference material. Only one sequence, jwlBD5i, from the fifth board from the hinge side of the door gave any acceptable matches (Table 2). This 83-year sequence was dated to the period AD 1175–1257 against reference chronologies derived from the Baltic region and to a lesser extent Germany. This partial sequence represented the inner part of the board up to the split evident in Figure 6. The ring sequence measured after the split could not be dated, in spite of knowing its approximate date. Overall, bearing in mind the measurement difficulties, this outer part of the board contained c70 outer rings. Experience has shown that door boards (eg Miles and Bridge 2005), like boards used in room panelling, panel paintings and other art-historical objects (Tyers 2003) often had minimal amounts of sapwood trimmed from them, so, allowing for the minimum likely number of sapwood rings to be present, an estimated terminus post quem for felling of AD 1336 is obtained for this one board. It seems likely therefore that this door is original to the AD1360s building of the Jewel Tower and used oak most probably imported from the Baltic region.

If it had been possible to make use of the micro-borer, as has been used in the analysis of some doors (eg Miles and Bridge 2005), it may have been possible to resolve the measurement issues encountered and also may have been possible to obtain longer sequences which may have been more readily dated, thus potentially refining the dating evidence produced. However the initial assessment considered the boards likely to be too thin for such an approach which would also have caused a significant level of disruption to this public attraction. Following the limited nature of the analytical work undertaken on the door it is suggested that, should the opportunity arise in future years, then further analytical work should be seriously considered either through reconsideration of the use of a micro-borer or access to the cross-sectional surfaces of the bottom of the boards which are currently inaccessible.

Figure 5a

Figure 5b

Figure 5c

Figures 5a-c: Photographs of the cross-sectional surface of the oak plate holding the elm piles in the display in the second floor main chamber

Figure 6: Photograph of board 5 of the door

Table 2: Dating evidence for the partial sequence representing the inner part of the fifth board of the second floor chamber door which spans AD 1175–1257

Source region:	Chronology name:	Publication reference:	File name:	Span of chronology (AD)	Overlap (years)	t-value
German	Schleswig-Holstein	(Eckstein et al 1970)	GER_SH1	436–1968	83	6.7
Baltic	Southwark boat planks	(Tyers 1996)	SYM-SHIP	1133–1333	83	6.4
German	Westminster Abbey, Deep Chest	(Miles and Bridge 2008)	WMNSTR11	1031–1265	83	5.7
German	Southwark boat planks	(Tyers 1996)	ABB185M	1196–1334	62	5.7
Baltic	Hull Magistrates Court	(Tyers 1998)	HMC_T165	1078–1369	83	5.5
Baltic	Groningen Wolters Noordhof	(Jansma 1995)	NETH_GRN	1092–1287	83	5.2
Baltic	Vejby Skib Hanseatic cog	(Bonde and Jensen 1995)	VEJBY_26	1109–1370	83	5.2
Baltic	Gdansk regional chronology	(Wazny pers comm)	GDANSK	996–1985	83	5.0
Baltic	Presbytery Roof, St Albans	(Howard et al 2001)	STACSQ01	1050–1264	83	4.8
Baltic	Westminster Abbey, partition	(Miles and Bridge 2008)	WMNSTR19	1146–1345	83	4.6

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APPENDIX

Ring width values (0.01mm) for the sequences measured

jwl01

508	438	462	388	506	378	429	453	441	432
303	518	351	409	292	176	370	425	418	493
402	216	234	282	224	220	244	232	200	160
127	219	187	207	262	178	207	168	155	175
140	165	203	181	148	188	207			

jwl02

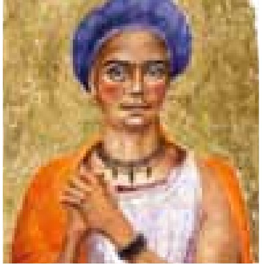
146	155	118	124	120	118	207	357	377	378
288	314	258	159	147	169	185	193	199	185
214	196	197	174	140	131	207	158	115	121
217	149	176	201	144	164	125	194	156	143
149	184	171	139	104	84	109	126	118	58
74	81	68	86	51	44	36	52	71	62
67	64	83	100	124	170	232	169	154	181
144	174	154	85	101	183	135	182	148	139

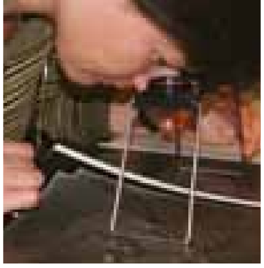
jwl05 (from photographs)

342	364	258	346	322	328	416	436	422	628
612	542	536	544	474	336	278	318	330	298
260	320	346	264	208	160	208	242	298	212
174	278	266	326	250	210	132	112	170	226
164	130	148	180	170	164	168	196	182	186
176	92	130	188	202	214	162	168		

jwlBD5i (from photograph)

219	210	187	282	290	374	149	222	321	367
332	545	549	408	230	219	379	254	161	278
313	323	331	408	326	430	418	324	433	324
272	217	294	339	221	281	310	403	409	335
395	272	195	228	333	351	238	267	212	238
242	207	252	360	355	288	247	286	193	206
195	198	236	225	299	286	181	160	139	145
143	131	105	106	129	201	148	157	240	200
223	162	230							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