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Panel Paintings from the Suffolk Collection and the Wernher Collection English Heritage

Tree-ring Analysis and Wood Identification of Panels

Ian Tyers

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Front Cover: Rangers House, Chesterfield Walk, Greenwich - home of the Wernher Collection and English Heritage Conservation Studio where the tree-ring analysis was undertaken © Historic England Archive. Ref: DP040447

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PANEL PAINTINGS FROM THE SUFFOLK COLLECTION AND THE WERNHER COLLECTION ENGLISH HERITAGE

Tree-ring Analysis and Wood Identification of Panels

Ian Tyers

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SUMMARY
A programme of tree-ring assessment, measurement, and analysis was commissioned on three panel paintings from the English Heritage Suffolk Collection and Wernher Collection whilst the panels were undergoing conservation treatment at the Rangers House Laboratory in 2018. Direct tree-ring measurement was undertaken on six boards in two oak panel paintings, both of which were portraits of English sitters. The tree-ring results dated five of these boards and identified that all the dated boards were derived from timbers imported from the eastern Baltic. The timbers provide likely usage dates for these two panels supporting previous attributions. Microscopic samples were taken from the boards of the third painting, an Italian panel to determine its wood type. One of these boards retained sapwood. The identification analysis indicates a Botticelli panel is made of a timber from the Salicaceae family; likely to be poplar (*Populus* spp).

CONTRIBUTOR
Ian Tyers

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Historic England Archive
The Engine House
Firefly Avenue
Swindon SN2 2EH

HISTORIC ENVIRONMENT RECORD OFFICE
Greater London Historic Environment Record
4th Floor Cannon Bridge House
25 Dowgate Hill
London EC4R 2YA

DATE OF INVESTIGATION
2018

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INTRODUCTION

This document is a technical archive report on the tree-ring analysis of oak boards from three panel paintings, and timber identification of boards in a further panel. These are attributed as the Suffolk Collection, normally housed at Kenwood House and the Wernher Collection at Rangers House, which were undergoing conservation at the English Heritage Conservation Studios at Rangers House, Greenwich, at the time of the analysis. It is beyond the dendrochronological brief to describe these objects in detail here although elements of this report may be combined with detailed descriptions, photographs, and other technical reports at some point in the future.

METHODOLOGY

These panels were constructed from one or more horizontally or vertically aligned oak boards. Typically, these boards taper slightly from one end to the other. They are typically bevelled around the edges and have original surfaces on the reverse face. Most panel paintings utilise boards from a radial, or near radial oak board. Most boards use straight-grained slow growing oak (*Quercus* spp). Each panel was given an analysis number, and each board in each individual panel was labelled from A onwards from either top or left as viewed from the front.

Tree-ring dating employs the patterns of tree-growth to determine the calendar dates for the period during which the sampled trees were alive. The amount of wood laid down in any one year by most trees is determined by the climate and other environmental factors. Trees over relatively wide geographical areas can exhibit similar patterns of growth, and this enables dendrochronologists to assign dates to some samples by matching the growth pattern with other ring-sequences that have already been linked together to form reference chronologies.

Timbers intended for dendrochronological analysis need to be free of aberrant anatomical features such as those caused by physical damage to the tree, which may prevent or significantly reduce the chances of successful dating.

Standard dendrochronological analysis methods (see eg English Heritage 1998) were applied to each suitable board in each panel. Complete or partial sequences of the annual growth rings were measured to an accuracy of 0.01mm using a micro-computer based travelling stage. The sequences of ring widths were then plotted onto semi-log graph paper to enable visual comparisons to be made between sequences. In addition, cross-correlation algorithms (eg Baillie and Pilcher 1973) were employed to search for positions where the ring sequences were highly correlated. Highly correlated positions were checked using the graphs and, if any of these were satisfactory, new composite sequences were constructed from the synchronised sequences. Any *t*-values reported below were derived from the original CROS algorithm (Baillie and 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 need to have been obtained from a range of independent sequences, and that these positions were supported by satisfactory visual matching.

Not every tree can be correlated by the statistical tools or the visual examination of the graphs. There are thought to be a number of reasons for this: genetic variations; site-specific issues (for example a tree growing in a stream bed will be less responsive to rainfall); or some traumatic experience in the tree's lifetime, such as injury by pollarding, defoliation events by caterpillars, or similar. These could each produce a sequence dominated by a non-climatic signal. Experimental work with modern trees shows that 5–20% of all oak trees, even when enough rings are obtained, cannot be reliably cross-matched.

Converting the date obtained for a tree-ring sequence into a useful date requires a record of the nature of the outermost rings of the sample. If bark or bark-edge survives, a felling date precise to the year or season can be obtained. If no sapwood survives, the date obtained from the sample gives a *terminus post quem* for its use. If some sapwood survives, an estimate for the number of missing rings can be applied to the end-date of the heartwood. This estimate is quite broad and varies by region. This report uses a minimum of 8 rings, and a maximum of 24 rings, 95% confidence limits, as a sapwood estimate for the eastern Baltic boards based on comparative data from other groups of eastern Baltic data (eg Tyers 1998a; Sohar *et al* 2012).

The analysis may highlight potential same-tree identifications if two or more tree-ring sequences are obtained that are exceptionally highly correlated. Such pairs, or sometimes more, are then used as a same-tree group and each can be given the interpreted date of the most complete of the samples. They are most useful where several timbers date but only one has any sapwood, or where same-tree identifications yield linkages within or between objects.

Eastern Baltic boards of *c* 270–310mm width are likely to have been minimally trimmed as this appears to have been the typical maximum usable width of the traded boards. The tree-ring results obtained from boards of these sizes thus appear to be broadly indicating the usage period for these panels. In this case an estimated usage date based on a range of 8–40 trimmed rings is used following Baillie (1984).

RESULTS

Two of the three panel paintings comprised three oak boards each, all six of which were suitable for measurement. Five were dated, all being eastern Baltic in origin, whilst the remaining board was not dated. One of the panels contained three additional, and presumed later, fillets, which prevented access to the upper ends of the primary boards. A third large circular panel comprised three lightweight hardwood boards which were sampled to determine their wood type. None of these were suitable for tree-ring analysis.

The following three sub-sections provide results for each panel painting with associated figures and tables. These sub-sections are in EH accession number order:

two use the painting descriptions and artist attributions provided at the onset of the analysis, whilst the Botticelli has been reattributed in the intervening period and this is followed here.

The measurement data for the measured boards are listed in Appendix 1.

88019173 Margaret Hallyday, Lady Hungerford, Cornelius Johnson

This panel is *c* 786mm high and *c* 626mm wide. It comprised three vertical oak boards (Fig 1; Table 1). The boards were labelled A to C from the left. All three boards were suitable for measurement. Complete sequences were obtained from one end of boards A and B, and both ends of board C. The board C series were synchronised and combined into a single sequence. The series from boards A and C matched each other (*t*-value 5.93) and, despite their relatively low correlation, these sequences are very similar and appear to be derived from the same tree. The board B sequence matches both quite strongly but has quite a different growth rate and a dissimilar life trend and is, therefore, unlikely to be from the same tree. The sequences from boards A and C were combined and this, and the board B series were compared with reference data of historic date from throughout England and northern Europe. A number of statistically significant matches were obtained between these board sequences and reference series, along with other contemporaneous objects. These indicate the three sequences date (Fig 2; Tables 2 and 3).

The three dated boards are of eastern Baltic origin.

Neither board A or board B retained sapwood and thus the interpretations given to these boards are *terminus post quem* dates based on a minimum estimate of eight sapwood rings. The interpreted dates represent the earliest possible felling dates for board A after AD 1621, and board B after AD 1606. Board C retained four rings of sapwood and thus, the interpretation given to this board, is a felling date range based on the minimum and maximum estimated number of missing sapwood rings, using a range of 8–24 annual rings. The interpreted date given to board C, thus represents the likeliest felling date range for this board. This indicates that board C was felled between AD 1622 and AD 1638.

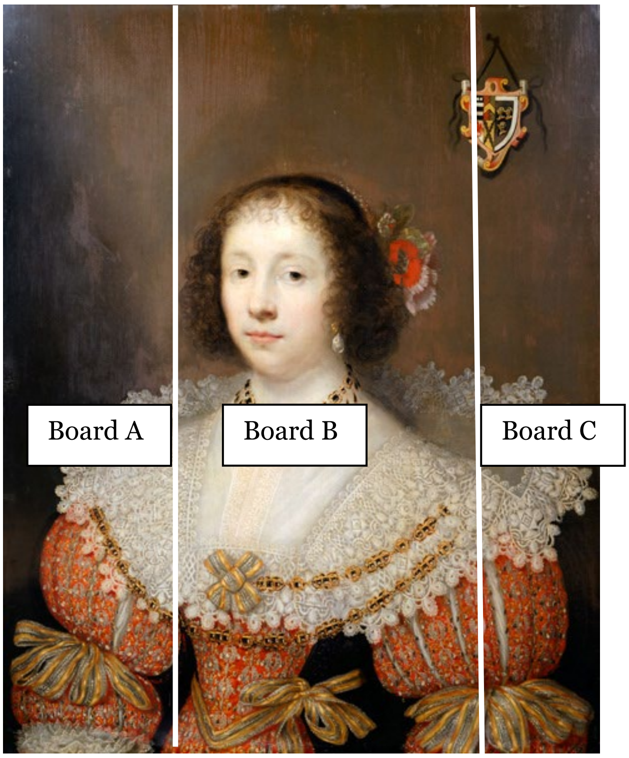

Figure 1: The construction of the Lady Hungerford panel painting. The locations of the board joints are approximate (photograph kindly supplied by English Heritage

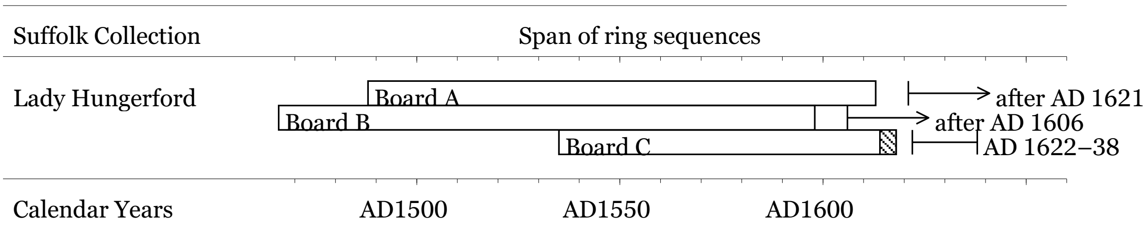

Figure 2: Bar diagram showing the absolute dating positions of the dated tree-ring sequences for boards from the Lady Hungerford panel painting. The interpreted felling dates are also shown for these dated boards

KEY. White bars are eastern Baltic oak heartwood, the hatched section is sapwood

Table 1: Details of the three oak boards from the Lady Hungerford panel painting

OS1270 Board	Width (mm)	Rings	AGR (mm)	Date of measured sequence	Interpreted result
Board A	200–201	126	1.59	AD 1488–1613	after AD 1621
Board B	283–303	133	2.28	AD 1466–1598	after AD 1606
Board C	142–122	84 (4 sap)	1.60	AD 1535–1618	AD 1622–38

KEY: sequences obtained from the lower edges of the boards A and B, and the upper and lower edges of board C; AGR = average growth rate per year

Table 2: Example t*-values between the composite sequence from boards A and C from the Lady Hungerford panel painting and eastern Baltic oak reference data*

	Boards A+C AD 1488–1618
Sir Henry Vane Senior, after Mierevelt, NPG1118 (Tyers 2012)	8.34
Poland, Lower Silesia/Dolny Śląsk (M Krapiec pers comm)	7.60
Lady Hungerford board B (this panel)	7.18
Still life with a Nautilus Cup, JD de Heem (Tyers 2013)	6.62
Suffolk, Otley Hall wall panels (Tyers 2000)	6.04
The Judgement of Solomon, Middle Temple (Tyers 2011b)	5.76

Table 3: Example t*-values between the sequence from board B from the Lady Hungerford panel painting and eastern Baltic oak reference data*

	Board B AD 1466–1598
Still life with a Nautilus Cup, JD de Heem (Tyers 2013)	7.32
Lady Hungerford boards A & C (this panel)	7.18
Suffolk, Otley Hall wall panels (Tyers 2000)	6.70
Sir Henry Vane Senior, after Mierevelt, NPG1118 (Tyers 2012)	6.23
Thames at Westminster Stairs, de Jongh, Yale (Tyers 2011a)	6.07
Francis Bacon Viscount St Alban, Trinity (Tyers 2009)	5.77

88019200 Thomas More

This panel is *c* 647mm high and *c* 479mm wide. It comprised three vertical oak boards (Fig 3; Table 4), which were a maximum of *c* 10–12mm thick. The panel was surrounded on the left, right, and upper edges by *c* 18, 20, and 14mm wide fillets respectively. The lower edge had no fillet and the grain of the three boards could be analysed along this edge, where it appeared to have had a tenon trimmed off. All three boards were suitable for measurement, although board C contained only 40 rings. Complete sequences were measured from the lower edges of all three boards, but the three series did not match each other. These three individual series were compared with reference data of historic date from throughout England and northern Europe. Several statistically significant matches were obtained between the board A and board B sequences and reference series, along with other contemporaneous objects (Fig 4; Tables 5, 6).

Both dated boards are of eastern Baltic origin. Board C, which was not dated, is not, however, obviously different in character from boards B and C in this panel.

Neither of the dated boards retained sapwood and thus the interpretations given to the dated boards are *terminus post quem* dates based on the minimum estimate of eight missing sapwood rings. The interpreted date represents the earliest possible felling date for the dated individual boards. Board A contains the latest heartwood rings, and this indicates this board was felled after AD 1566.

Assuming only minimal trimming has occurred provides a suggested usage date of AD 1566–98 for this panel.

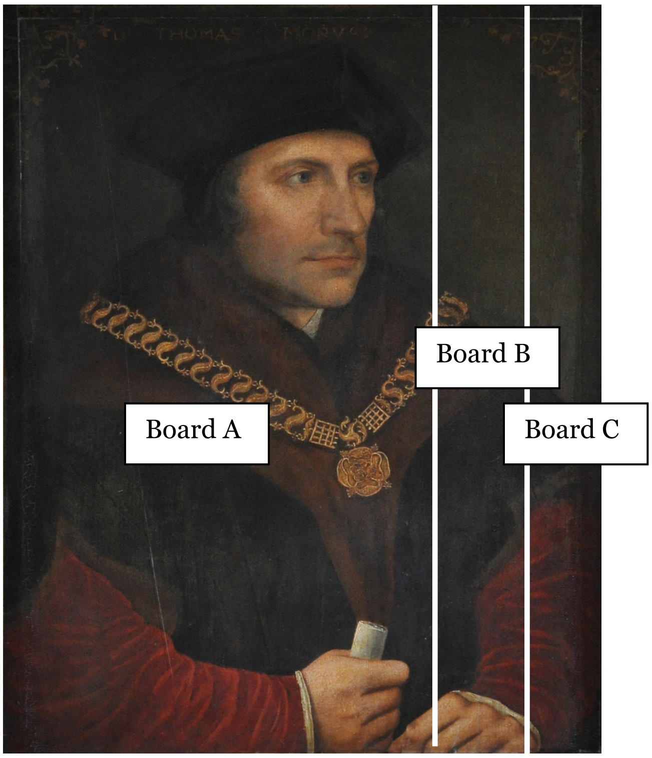

Figure 3: The construction of the Thomas More panel painting (photograph kindly supplied by the English Heritage

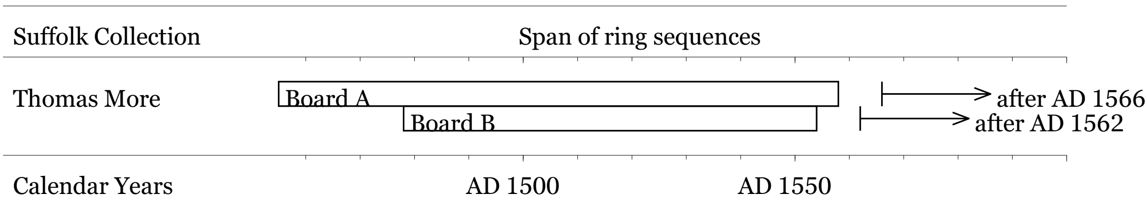

Figure 4: Bar diagram showing the absolute dating positions of the dated tree-ring sequences for the boards from the Thomas More panel painting. The interpreted felling dates are also shown for these dated boards

KEY. White bars are eastern Baltic oak heartwood

Table 4: Details of the oak boards from the Thomas More panel painting

OS01271 Board	Width (mm)	Rings	AGR (mm)	Date of measured sequence	Interpreted result
Board A	294–268	104	2.61	AD 1455–1558	after AD 1566
Board B	73–90	77	1.18	AD 1478–1554	after AD 1562
Board C	74–80	40	2.02	undated	-

KEY: sequences obtained from the lower edges of all three boards; AGR = average growth rate per year

Table 5: Example t*-values between the sequence from board A from the Thomas More panel painting and eastern Baltic oak reference data*

	Board A AD 1455–1558
Mary I, Trinity (Tyers 2009)	8.72
Henry IV, NPG (Tyers 2007)	7.80
Lady in Black (Tyers 2016)	7.46
Baltic2, Fletcher panel paintings (Hillam and Tyers 1995)	7.24
Elizabeth I in her Robes of Office (Tyers 2014)	7.08
Richard III (Tyers 1992)	6.70

Table 6: Example t*-values between the sequence from board B from the Thomas More panel painting and eastern Baltic oak reference data*

	Board B AD 1478–1554
William Cecil 1st Baron Burghley, Bronckhorst, Hatfield (Tyers 2010)	6.99
Sir Francis Walsingham, de Critz, Yale (Tyers 2011a)	6.42
Mary I without Carnation, Trinity (Tyers 2009)	6.17
Baltic1, Fletcher panel paintings (Hillam and Tyers 1995)	5.82
Peace & Plenty Binding the Arrows of War, Janssens (Tyers 1998b)	5.47
Henry VIII after Holbein, Trinity (Tyers 2002)	5.46

88259032 Madonna of the Pomegranate, Sandro Botticelli

This is a large circular panel, or tondo, of *c* 972–977mm diameter. It comprises three boards set at *c* 60° clockwise from the vertical axis of the panel (Fig 5; Table 7), which are *c* 32mm thick. X-ray imagery suggests the widest central board contains *c* 20 annual rings mirror-imaged across the middle of the tree, whilst the upper and lower boards each appear to contain *c* 20 rings as a single radius. These outer boards are visually similar, and it is possible they were derived from a single log. All three timbers, however, contain too few rings for tree-ring analysis.

Samples were taken from each board for timber identification. Identification of wood structure compares microscopic anatomical features in order to constrain the type of timber to a botanical family, a group of species, or a single species of tree. Identifications are based on the comparative examination of microscopic thin sections of a cell structure in three planes (radial, transverse, and tangential sections). The comparison of these sections with reference slides, and with identification keys, enables reliable identifications to be made.

Small blocks or flakes containing the three desired cross-sectional planes were removed from pre-existing areas of physical damage around the edges of the boards. These were mounted on glass slides and examined using a high magnification microscope. This light coloured, low density timber had the following characteristics: diffuse or semi-ring porous with small evenly distributed pores, uniseriate rays, no spiral thickenings, simple, or non-scalariform, perforation plates.

Following Schweingruber's key (1978), for the relatively restricted European tree flora, these characteristics key out at the family Salicaceae, which includes willows (*Salix spp*), and poplar (*Populus spp*). Comparison with permanent reference slides supported this identification. Botanically there are several dozen types of willow in the European flora, as well as half a dozen poplars, and countless hybrids. These 2 genera are both widely distributed worldwide, and several individual species have extensive European distributions. In earlier periods the differentiation of these timber types was routinely undertaken in Europe, which Schweingruber's key follows. Research during the amalgamation of the worldwide database has determined this is unsafe however, and current view is that earlier references to poplar timbers in art-historical literature should be ignored when it is derived from wood anatomy (Wheeler 2011).

Olsen (2015) suggests diagonal boards were a common feature of Botticelli's tondo panels, and that they may have been intended to distribute stress and minimise warping. Bruzzone and Galassi (2011) review *c* 500 wood identification records for Italianate panels, which indicate poplar (*ie* a Salicaceae) is the predominant type (>50% of panels), with walnut the next most common.

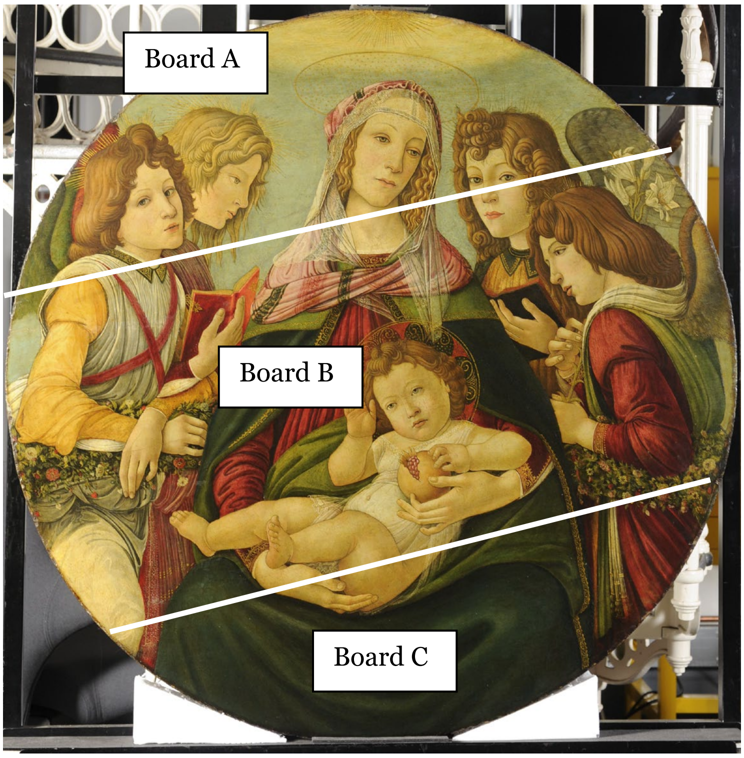

Figure 5: The construction of the Madonna of the Pomegranate panel painting. The locations of the board joints are approximate (photograph kindly supplied by English Heritage

Table 7: Details of the three boards from the Madonna of the Pomegranate panel painting, the ring estimates are based on an X-ray image kindly supplied for English Heritage

OS1269 Board	Width (mm)	Rings	Timber type
Board A	*c* 294	*c* 20	Salicaceae
Board B	*c* 423	*c* 20	Salicaceae
Board C	*c* 255	*c* 20	Salicaceae

DISCUSSION

Both dated panels discussed here utilise three original oak boards. All these boards are of a single radius ranging from true radials to moderately tangential sections, with no centres or centrelines within the boards. As is usual in a portrait format panel (that is taller than it is wide) these boards are arranged with vertical grain. Typically, each of these boards' tapers both slightly from one end of the panel to the other and also in thickness, with the thicker sections towards the middle of the panel. Contemporaneous panels were mostly constructed using boards of a maximum of 6–11mm thick, sometimes tapering down to only 2–3mm thickness. The joiners used irregular sectioned and tapering boards to construct flat and right-angled panels. The Thomas More panel exhibit riven and sawn surfaces on its reverse face with simple butt joints.

Most groups of panels from English collections that have been examined hitherto are dominated by eastern Baltic oak boards and very few retain any sapwood. This material thus conforms to expectations with both panels using eastern Baltic sources for their boards, even though both are probably English productions. In addition, there is a common construction methodology where the panel makers appear to be deliberately removing sapwood. This feature has been identified in many other panel paintings from both England and the rest of western Europe, and is known to be a formal statute of the panel makers guild in seventeenth-century Antwerp (Wadum 1998). Just one of these six oak boards seen in this study retains some measurable sapwood.

Both oak panels include one board each that are typically of the Baltic board width of *c* 270–310mm wide: the Thomas More board is 294mm wide and the Lady Hungerford 303mm wide. The frequency of this board size suggests it represents the usable width of the Baltic boards after trimming of the feathered edges and removal of their sapwood. This possibly indicates choices and convention of panel making at the time; to use the more substantial sections of boards in order to make satisfactory joints. The format seen in the Lady Hungerford panel, that is with a wide central board with two narrow outer boards, is typical of many seventeenth century portraits and this may have been a deliberate choice to avoid joints across the faces of the sitters.

An overall uniformity of board size and panel construction can be seen in most groups of panels; however, caution is required for those that fall into the non-conventional group and tree-ring evidence must always be considered in context of the date of the painting. For instance, the Thomas More format is unusual in that the use of a wide board on one side and then two narrow boards has no clear rationale, beyond perhaps the efficient use of scraps of timber left over from other panels. In this case the tree-ring evidence is not significantly affected by this since its wide left-hand board is arranged with its latest rings running rightwards and therefore additional outermost rings are relatively unlikely to have been lost.

Eastern Baltic tree-ring data is not internally uniform. There are three major sub-groups that probably indicate different zones of export across the region. The identification of these zones is the subject of on-going research and debate amongst dendrochronologists. Currently the two major sixteenth-century zones are called Baltic1 and Baltic2 (following Hillam and Tyers 1995), pending the identification of their geographical source region. A third group was originally identified in seventeenth-century Netherlandish panels (Eckstein *et al* 1975) but is now also known to be present in many English seventeenth-century panels, and now usually known as sub-type Baltic3. These panels contain examples of the Baltic1 and Baltic2 sub-types.

There were no same-tree matches observed from these series to any other analysed panels.

Any additional technical evidence for either seasoning or reuse of these boards (such as X-ray images showing earlier painting underneath) would make these panels later, possibly much later, than the dates given here. The analysis of panels with good attributions has demonstrated that panels were mostly made from unseasoned oak.

In contrast the third panel examined was constructed from three thick boards of a lightweight and light-coloured timber identified as willow or poplar. These three boards were c 32mm thick, and were tangential slabs, at least one of which was cut through the whole trunk of a tree. Thick boards, cut through tangential slabs and the use of a timber from the Salicaceae botanical family is typical of many fifteenth-, sixteenth-, and seventeenth-century Italian panels. These are quite unlike the single radius boards of slow grown and dense oak used for most English and Netherlandish panels. Dendrochronological analysis of Italian panels is severely hampered due to the use of timber which can grow so fast that even the largest boards typically contain too few annual rings to be able to provide reliable cross-matching of tree-ring data either within, or between, panels.

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DATA OF MEASURED SAMPLES

Measurements in 0.01mm units

os1270al

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134	185	105	146	90	153	153	123	158	179
131	205	211	144	162	140	141	130	117	113
178	206	212	182	152	181	136	154	184	294
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145	169	109	126	146	143	123	161	181	150
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os1270bl

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os1270cl

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os1270cu

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176									

os1271al

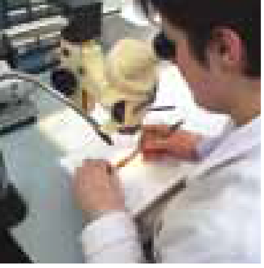
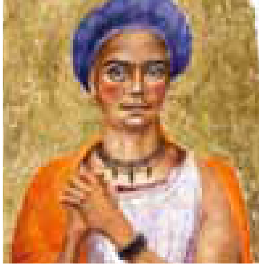
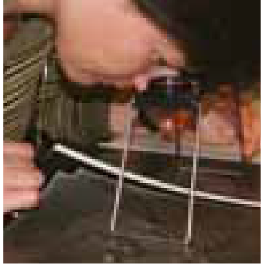
230	192	224	304	189	281	244	264	293	208
121	231	246	290	289	250	245	292	331	184
332	292	265	447	443	404	393	326	256	302
314	449	452	428	445	346	273	286	268	217
245	280	182	211	232	222	326	262	260	228
280	411	307	319	246	268	256	250	184	228
315	324	286	265	211	192	172	210	304	261
300	260	263	227	190	230	227	161	285	208
219	181	198	212	321	276	265	258	261	212
185	181	189	246	244	211	175	178	187	154
232	241	206	203						

os1271bl

113	75	134	116	86	63	76	105	120	95
98	112	111	94	79	99	101	101	101	88
102	102	109	139	118	119	111	114	125	125
125	102	97	120	87	97	143	157	227	181
142	132	92	166	149	115	102	93	104	83
100	67	90	72	88	109	104	103	119	135
119	101	92	127	165	165	143	176	126	137
150	149	132	162	156	191	148			

os1271cl

120	100	208	149	147	152	160	111	191	210
166	148	197	156	143	151	226	166	254	242
351	249	170	240	188	223	229	237	219	212
251	250	219	257	261	252	213	226	194	254

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A good understanding of the historic environment is fundamental to ensuring people appreciate and enjoy their heritage and provides the essential first step towards its effective protection.

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