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Merchant Adventures Hall, Fossgate, York, North Yorkshire
Oxygen Isotope Dendrochronology of Oak Timbers

Neil J Loader, Darren Davies, Danny McCarroll, Dan Miles, Robert Howard, Cathy Tyers, and Giles HF Young

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SUMMARY
As part of an initiative to investigate the practical extent of the south-central England chronology for isotopic dating, two timbers that had been securely dated by ring-width dendrochronology from the Merchant Adventurers Hall, York were sampled for oxygen isotope analysis. Seventy-eight measurements were obtained on latewood from single growth-rings of core YOR-A05 from a king post, truss 13, (rings 1–78 of the measured ring-width series spanning AD 1265–1346) and 68 measurements were obtained on latewood from single growth-rings of core YOR-A08 a tie-beam, truss 14 (rings 2–69 of the measured ring-width series spanning AD 1272–1355).

The two isotopic series cross-match when offset by two years. This is consistent with the ring-width cross-matching. The 78-year isotopic mean cross-dates (t =7.07, 1/p>1 million, IF>1000) with the south-central England oxygen isotope master chronology, at a position that is compatible with that provided by ring-width dendrochronology. Independently, YOR-A08 cross-dates at a position consistent with the ring-width dendrochronology, (t =7.52, 1/p>1 million, IF>1000). YOR-A05 returns a tentative result consistent with the ring-width dating (t =5.22, 1/p=1415, IF=63).

The location of the Merchant Adventurers Hall in York, well to the north-east of the south-central England master chronology is currently challenging for oxygen isotope dendrochronology. Isotopic analysis has returned dates consistent with ring-width dendrochronology, but this study suggests that whilst secure dating is possible, it may not routinely be obtained from isotopic measurements on single timbers in this region. This demonstrates that an oxygen isotope master chronology for northern England is required to enhance the potential for applying oxygen isotope dendrochronology in this region.

CONTRIBUTORS
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CONTENTS

INTRODUCTION

In 2018, Historic England and Swansea University established a collaborative research initiative to explore the applicability of oxygen isotope dendrochronology in England, with a view to transferring this method into professional practice. This project investigates, firstly, the geographic limits and practical boundaries of the present reference chronology (Loader *et al* 2019) which relates closely to the region covered by the England and Wales Precipitation record (Young *et al* 2015). A second objective was to explore whether shorter ring sequences that commonly remain undated by traditional dendrochronology can be dated by the isotopic approach.

Six buildings were selected for study, each located well beyond the periphery of the south-central England chronology (Cumbria, Northumbria, the Vale of York, Cornwall, Kent, and East Anglia). These buildings were chosen specifically for this study because the site master chronologies obtained through ring-width cross-dating exhibited strong correlations with local ring-width reference chronologies rather than with ring-width reference chronologies across a broader region. To provide a degree of replication, bearing in mind the locations of the selected sites, two ring-width dated samples were selected from each building. This also provided the opportunity to explore the cross-matching of isotope series. The other five buildings included in this study are individually reported in the Historic England Research Report Series (Loader *et al* 2020; 2021a–d).

Selection of individual core samples from each building was guided by strong ring-width intra-site cross-matching combined with the aim of obtaining a mean isotope record of a minimum of *c* 80 rings. The selected core samples were typical of those routinely retrieved through dendrochronological sampling in the selected locations with some providing practical challenges in relation to the presence of potential contaminants (glue, ink, charring) and narrow growth rings with little or no latewood. All timbers were provided to the isotope laboratory "blind" without information on the site location or age of the samples.

The Merchant Adventurers Hall, York (Fig 1) is a large guildhall of the mid-fourteenth century, comprising a brick- and stone-built undercroft with a timber-framed hall above (LEN 1257828 here). A central arcade of timber posts divides the building into two parallel aisles of eight bays. The roof contains the earliest examples of truncated principal trusses yet recorded. There are two distinct types of truss, the first of which has a crown post with expanded head, down-braced to a cambered tiebeam. The crown post is braced to the collar purlin. On either side, a curved principal runs between collar and tiebeam supporting the single row of side purlins. These are clasped between the principal and the overlying common rafter. The principals of the trusses nearest the dais end in each aisle are cusped. The second type of truss is similar, but without the crown post and associated braces. Instead, a second collar, into which the principals are tenoned, supports the collar purlin. Documentary evidence exists for the construction of the building, including a contract for the felling of the timbers in AD 1358. In this year, 60 trees were purchased from Bolton Percy for 27s.6d. and 100 oaks from Thorpe Underwood for £21 (RCHME 1981; Howard *et al* 1992).

Ring-width dendrochronology has been undertaken on nine timbers associated with trusses 13 and 14 of the Hall (YRK-A01–YRK-A09; Table 1; Figs 2–4) using the 'Litton-Zainodin Grouping Procedure' (Litton and Zainodin 1991). Eight samples cross-matched each other at a minimum *t*-value of 4.6 and were combined at the relevant offset positions to form YRKASQ01, a site sequence of 117 rings (Fig 5). This was compared against a series of relevant reference chronologies for oak where it was found to cross-date at a first-measured ring date of AD 1241 and a last-measured ring date of AD 1357 (Table 2). The raw ring-width data of the measured samples are provided in the Appendix.

STABLE OXYGEN ISOTOPE DENDROCHRONOLOGY

Sample selection

Two core samples from YRKASQ01 (Table 3) were selected for inclusion in this study (YRK-A05 and YRK-A08, relabelled YOR-A05 and YOR-A08 for isotopic study) because the individual ring-width series that are combined to form this chronology strongly cross-match by ring-width dendrochronology, and the chronology itself has the highest level of similarity with other sites located predominantly across northern England (Table 2), but elsewhere in Yorkshire in particular. These samples, therefore, have typical growth characteristics of timber used in historic buildings in this region. Although these samples had a sufficient number of rings for this study, cores YOR-A05 and YOR-A08 both exhibited cracks and some degradation in their outermost sections (Fig 6). This meant that latewood was unavailable for measurement from the outer parts of these samples (rings 79–82 from YOR-A05 and rings 70–84 from YOR-A08).

Methods

Oxygen isotope dendrochronology relies upon the same fundamental principles, limitations, and assumptions as conventional (ring-width-based) dendrochronology. However, rather than using ring-width measurements, it uses the ratio of heavy to light oxygen isotopes (McCarroll and Loader 2004) in the latewood cellulose ($\delta^{18}O$). The isotopes can have a higher signal to noise ratio than ring-width measurements and strong signals do not require the trees to be growing under any environmental stress (Young *et al* 2015).

The method relies on a regional master chronology (Loader *et al* 2019) constructed using ring-width dendrochronologically-dated oak timbers sourced from across a *c* 45,200km^2 (20,000 mile^2) region centred on Oxfordshire, in south-central England. The chronology was developed as part of a Leverhulme Trust funded project (RPG-2014-327) and currently covers a period from AD 1200–2000 with replication (sample depth) of 10 trees throughout the chronology.

A thin slice (4mm) is removed from the base of the sample cores selected for isotopic analysis. This initial sub-sampling ensures that the original measured surface from which the reported ring-width measurements were derived is physically preserved and archived for future scientific analysis, as is the case for all Historic England site cores.

Several physiological studies of oak trees have shown that the earlywood is partially formed from carbohydrates fixed in previous years (Richardson *et al* 2013; McCarroll *et al* 2017). To avoid this chemical carry-over effect in oak, only the latewood of each tree-ring is prepared for chemical analysis and dating. Each annual latewood increment is carefully removed as thin slivers (*c* 40μm thick) using a scalpel and dissecting microscope. Where tree rings are indistinct, physically degraded, contaminated, or comprise only earlywood then these rings are not sampled for isotopic analysis. Consequently, the isotope sequence used for dating may not provide an isotope measurement for each ring that forms part of the measured ring-width series.

Wood samples are converted to α-cellulose using an acidified sodium chlorite solution with removal of hemicelluloses by sodium hydroxide (after Loader *et al* 1997). Samples are homogenised using an ultrasonic probe and vacuum-dried at −50˚C for 48 hours. 0.30–0.35mg of dry α-cellulose is weighed into individual silver foil capsules for pyrolysis to carbon monoxide (CO) at 1400°C (Woodley *et al* 2012). The resulting carbon monoxide is analysed using a Delta V isotope-ratio mass spectrometer. Data are expressed as per mille (‰) deviations relative to the Vienna Standard Mean Ocean Water (VSMOW) international standard. Analytical precision is typically 0.30‰ (σ_{n-1}, n=10) (Loader *et al* 2015). The master chronology was prepared as two independent pools of five trees to ensure quality control and the resulting data combined to form the ten-tree master chronology. Individual samples for dating are prepared and analysed separately, using identical preparation protocols. The resulting stable isotopic data are presented as chronologies (time series).

Statistical analysis and dating

Tree-ring oxygen isotope data have statistical properties that are quite different from ring-widths, requiring different pre-treatment. The Baillie-Pilcher filter that works well for ring width dating (Baillie and Pilcher 1973) is not appropriate for isotope data and would result in unrealistically high *t*-values (Loader *et al* 2019). The isotope data are filtered using a simple nine-year rectangular filter, with indices derived by subtraction. Degrees of freedom are corrected for autocorrelation and filtering resulting in *t*-values that conform to a Student's *t*-distribution and can be used to calculate one-tail probabilities of error. The probabilities are corrected for multiple testing by division by the number of possible matches against the master chronology (a 'Bonferroni' correction) (Dunn 1959; 1961). The ratio of probabilities for the first and second highest *t*-values provides an 'isolation factor'. All *t*-values pertaining to isotope data in this report are Student's *t*-values, not 'Baillie-Pilcher' *t*-values.

Loader *et al* (2019) have suggested that potential stable isotope dates should only be considered for acceptance when the corrected probability of error (1/p) is less than one in a hundred and the probability for the best match is more than an order of magnitude less likely to be in error than the next best match (ie the isolation factor > 10). The level for these thresholds necessary for isotopic dating to have equivalent security to traditional ring-width dendrochronology is currently uncertain. As the aim of this study is to explore the spatial extent of the south-central England chronology using dendrochronologically-dated samples of known age, dating results are reported irrespective of whether or not they pass these thresholds to enable an assessment of dating performance across the study region.

Cross-matching between individual isotope series is achieved using the same approach, with the number of possible matches determined by setting a minimum size of overlap. Student's *t*-values, corrected one-tail probabilities, and the isolation factor are reported as well as the highest correlation coefficient, offset in ring number from the most recent ring measured for oxygen isotope analysis, and the number of overlapping isotopic measurements. When cross-dating individual series, a Student's *t* value of 3.5 is currently used as a working indication of match position to inform chronology development, although it is again currently unclear what this threshold should be to be of equivalent security to the Baillie-Pilcher *t*-value threshold of 3.5 commonly used for cross-matching oak series in ring-width dendrochronology in England.

In isotope dendrochronology it is not always necessary or possible to measure isotopically each tree-ring, in which case the last ring measured isotopically must be placed within the context of the entire sequence of tree-rings present in the sample. This may require addition of years present in the sample, but not measured isotopically. Once a date for the last ring has been calculated, a felling date, or felling date range based on an appropriate sapwood estimate, may be assigned using identical methods to those in ring-width dendrochronology (English Heritage 1998).

Results

Sample YOR-A05 comprises 82 ring-width measurements and 78 isotope measurements (rings 1–78 of the ring-width series; *see* Appendix) and YOR-A08 comprises 84 ring-width measurements and 68 isotope measurements (rings 2–69 of the ring-width series; *see* Appendix). In both instances the isotope measurements were only carried out on the un-degraded wider growth rings forming the inner sections of the cores, as the outermost rings were too degraded and friable to precisely excise sufficient latewood for isotopic analysis (Fig 6). The innermost ring of the ring-width series for YOR-A08 (ring 1) was also excluded from analysis as its ring boundary was indistinct and the wood exhibited discolouration.

The isotopic series from YOR-A05 cross-matches with a relative offset of +2 years against the last (most recent) isotopic measurement from YOR-A08 (Table 4; Fig 7), which is consistent with the relative position of these samples produced by the ring-width dendrochronology (Fig 5). The Student's *t*-value (7.06) between the isotopic series compares with the Baillie-Pilcher *t*-value (4.13) between the ring-width series for these samples.

A 78-year mean isotope series was compiled at this offset which, when compared against the south-central England oxygen isotope master chronology, produced the strongest cross-matching where the last ring of the mean isotopic series dates to AD 1342 (Table 5; Fig 8). This suggests that the last ring on which isotopic measurements could be obtained from YOR-A05 (ring 78) dates to AD 1342, and that the last ring on which isotopic measurements could be obtained from YOR-A08 (ring 69) dates to AD 1340. This is compatible with the cross-dating for these timbers suggested by ring-width dendrochronology (Table 2; Howard *et al* 1997).

The cross-dating of the mean isotopic series from the Merchant Adventurers Hall passes the thresholds for consideration as dated suggested by Loader *et al* (2019) (Student's t=7.07, df=67, 1/p>1 million, IF>1000). In this test case, there is independent ring-width dendrochronology available which supports the date suggested by the oxygen isotope dendrochronology. Individually both timbers return isotope results that are consistent with the ring-width dating (YOR-A08, t =7.52, df=58, 1/p>1 million, IF>1000; YOR-A05, t =5.22, df=66, 1/p=1415, IF=63). For the purpose of this investigation, only YOR-A08 may be considered as dating independently against the south-central England master chronology, as it returns cross-dating statistics that pass the thresholds for consideration. YOR-A08 also passes the criteria for consideration as dated proposed by Loader *et al* (2019), but with lower match statistics, and for this experiment may be considered as dated tentatively by isotopic analysis.

Although dates were obtained that were in agreement with those attained using ring-width dendrochronology, the variability in the dating statistics of the two individual cores may indicate that the oxygen isotope signals recorded in these trees from Yorkshire share only a part of their variability with the south-central England signal than contemporaneous trees growing within the region from which the chronology originates (Loader *et al* 2019). Although successful dating was demonstrated, this would suggest that development of an isotopic reference chronology developed from trees growing closer to this study site may provide more locally representative dating signals.

CONCLUSIONS

The two oxygen isotopic series developed for this project cross-match with each other with an offset consistent with the ring-width analysis performed previously (Table 2; Fig 5). Combination of these two series into a 78-year mean record cross-matches against the south central England oxygen isotope master chronology (Loader *et al* 2019), providing a date of AD 1342 for the last (most recent) ring of the measured isotope series. This date is consistent with that obtained for the same ring using conventional ring-width dendrochronology. Merchant Adventurers Hall is located well beyond the south-central England region where the master chronology was constructed. The dominant control on the latewood oxygen isotope composition of tree-rings across the UK is summer precipitation, it is therefore likely that the weaker dating against the master chronology observed in YOR-A05 may reflect, at least in part, differences in the precipitation regimes between the sample and chronology regions. Whilst this study suggests that dates may be obtained from series of isotopic measurements on single timbers in this region (YOR-A08), the development of a more local master chronology would enhance the potential for applying oxygen isotope dendrochronology across the North of England.

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TABLES

Table 1: Details of tree-ring samples from Merchant Adventurers Hall, Fossgate, York

Sample number	Sample location	Total rings	Sapwood rings	First measured ring date AD	Last heartwood ring date AD	Last measured ring date AD
YRK-A01	Truss 13, west/front inner archbrace, kingpost to tiebeam	90	26	1262	1325	1351
YRK-A02	North brace, kingpost truss 13 to collar purlin	48	1	------	------	------
YRK-A03	Truss 13, tiebeam	79	h/s	1266	1344	1344
YRK-A04	Truss 13, east/rear inner archbrace, kingpost to tiebeam	77	19	1273	1330	1349
YRK-A05	Truss 13, kingpost	82	3	1265	1343	1346
YRK-A06	Truss 14, east/rear inner archbrace, kingpost to tiebeam	42	11	1316	1346	1357
YRK-A07	Truss 14, kingpost	77	18	1276	1334	1352
YRK-A08	Truss 14, tiebeam	84	16	1272	1339	1355
YRK-A09	Truss 13, west/front main post	98	h/s	1241	1338	1338

Table 2: Results of the cross-dating of 116-year ring-width site chronology YRKASQ01 against a selection of independent ring-width reference chronologies when the first-ring date is AD 1241 and the last-ring date is AD 1357 against the enhanced network of oak site reference chronologies now available

Reference chronology	Span of chronology	*t*-value	Reference
Magistrates Court Site coffin 1790, Hull, Yorkshire	AD 1155–1319	6.7	Tyers 1998
60 Stonegate, York, Yorkshire	AD 1150–1322	6.5	Tyers and Groves 2000
Chethams Library, Manchester, Greater Manchester	AD 1185–1428	6.3	Tyers 2002
St Anthony's Hall, Peasholme Green, York, Yorkshire	AD 1215–1443	6.2	Arnold and Howard 2009
Flore's House, High Street, Oakham, Rutland	AD 1173–1392	5.7	Hurford *et al* 2008
51/2 High Street, Burton on Trent, Staffordshire	AD 1156–1387	5.7	Howard *et al* 1997
Bedern Hall, York, Yorkshire	AD 1231–1369	5.5	Hillam 1982
Coppergate, York, Yorkshire	AD 950–1395	5.5	Hillam 2002
Central Tower, York Minster, York, Yorkshire	AD 1214–1462	5.5	Hillam 1997 unpubl
Black Hostelry (crown post roof), Ely Cathedral, Cambridgeshire	AD 1233–1376	5.4	Arnold *et al* 2004

Table 3: Sample description: timber type and position, material analysed, number of complete tree rings (N), number (N_i) and range of rings for which $\delta^{18}O$ measurements were undertaken, and laboratory code

Sample	Timber and Position	Species	N	N_i	$\delta^{18}O$ (Measured rings)	Code
YOR-A05	King post, truss 13 (3)	Latewood α-cellulose *Quercus* spp	82	78	1–78	SWAN-35a
YOR-A08	Tiebeam, truss 14 (16)	Latewood α-cellulose *Quercus* spp	84	68	2–69	SWAN-35b

Key: h/s=heartwood/sapwood boundary; (3) = number of sapwood rings preserved

Table 4: Cross-dating matrix for samples YOR-A05 and YOR-A08 identifying number of rings [N_i] for which δ¹⁸O measurements have been undertaken. Upper right: significant Student's t-*value and position (offset; the YOR-A05 isotopic series ends 2 years after that of YOR-A08). Lower left (shaded cell): Pearson's correlation coefficient and degrees of freedom for position of best match (series compared column versus row)*

	YOR-A05 [78]	YOR-A08 [68]
YOR-A05 [78]	-	7.06 -2
YOR-A08 [68]	0.683 57	-

Table 5: Stable oxygen isotope dating of the composite and individual samples from the Merchant Adventurers Hall against the south-central England master chronology (Loader et al *2019) over the period AD 1200–AD 2000. Number of whole rings present in core sample (N), number of rings on which $\delta^{18}O$ measurements were undertaken (N_i), Pearson's correlation coefficient (r), degrees of freedom (adjusted for autocorrelation and multiple sampling), Student's* t-*value, probability (1/p), isolation factor (IF), and date*

Sample	Description	N	N_i	R	df	*T*	1/p	IF	Date
YOR-x	Mean of YOR-A05 & YOR-A08	91	78	0.654	67	7.07	>1 million	>1000	AD 1342
YOR-A05	King post, truss 13 (3)	82	78	0.541	66	5.22	1415	63	AD 1340
YOR-A08	Tiebeam, truss 14 (16)	84	68	0.703	58	7.52	>1 million	>1000	AD 1340

FIGURES

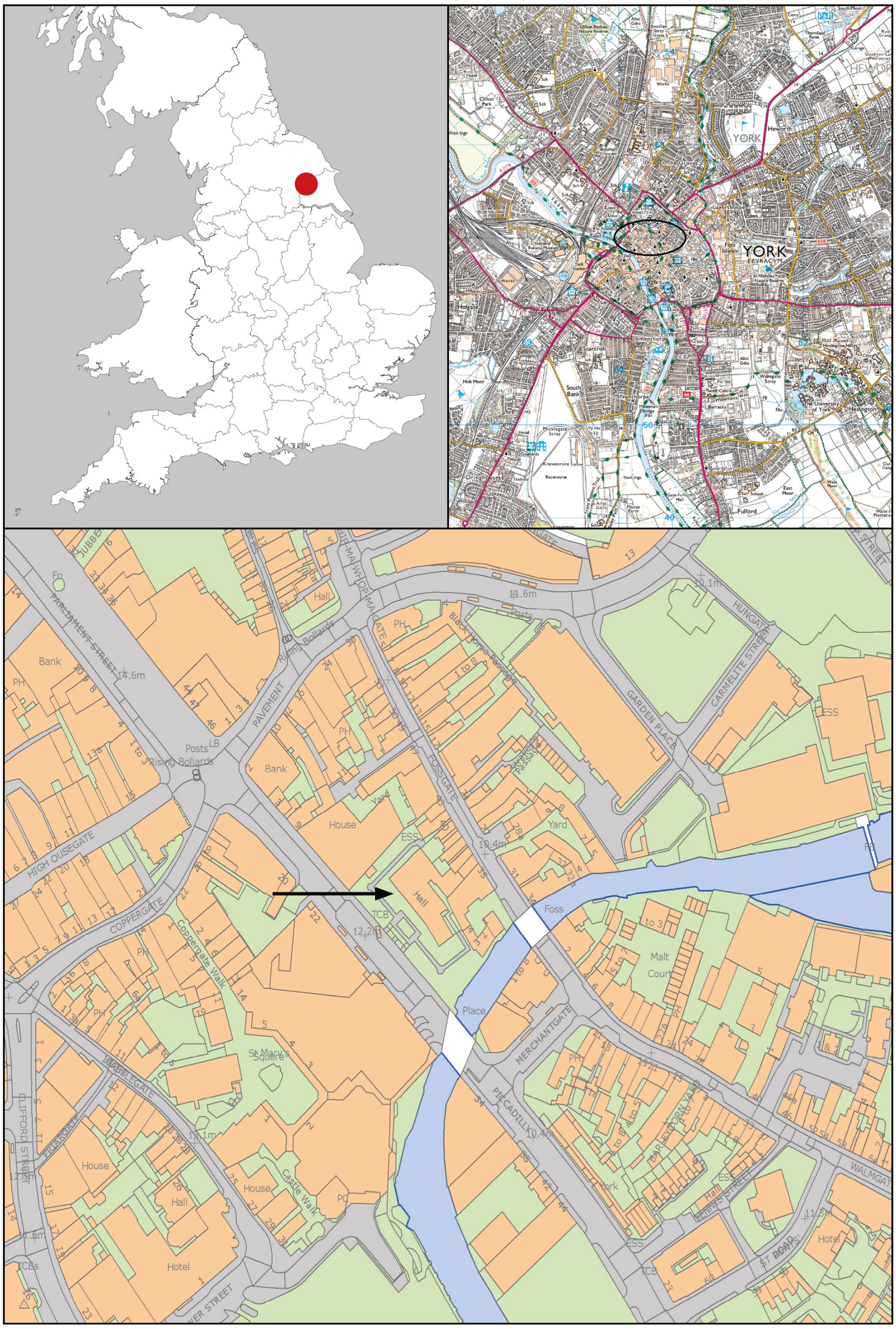

Figure 1: Maps to show the location of York (red dot), Merchant Adventurers Hall (circled) and (arrow). Scale: top right 1:25000; bottom 1:2000. © Crown Copyright and database right 2022. All rights reserved. Ordnance Survey Licence number 100024900.

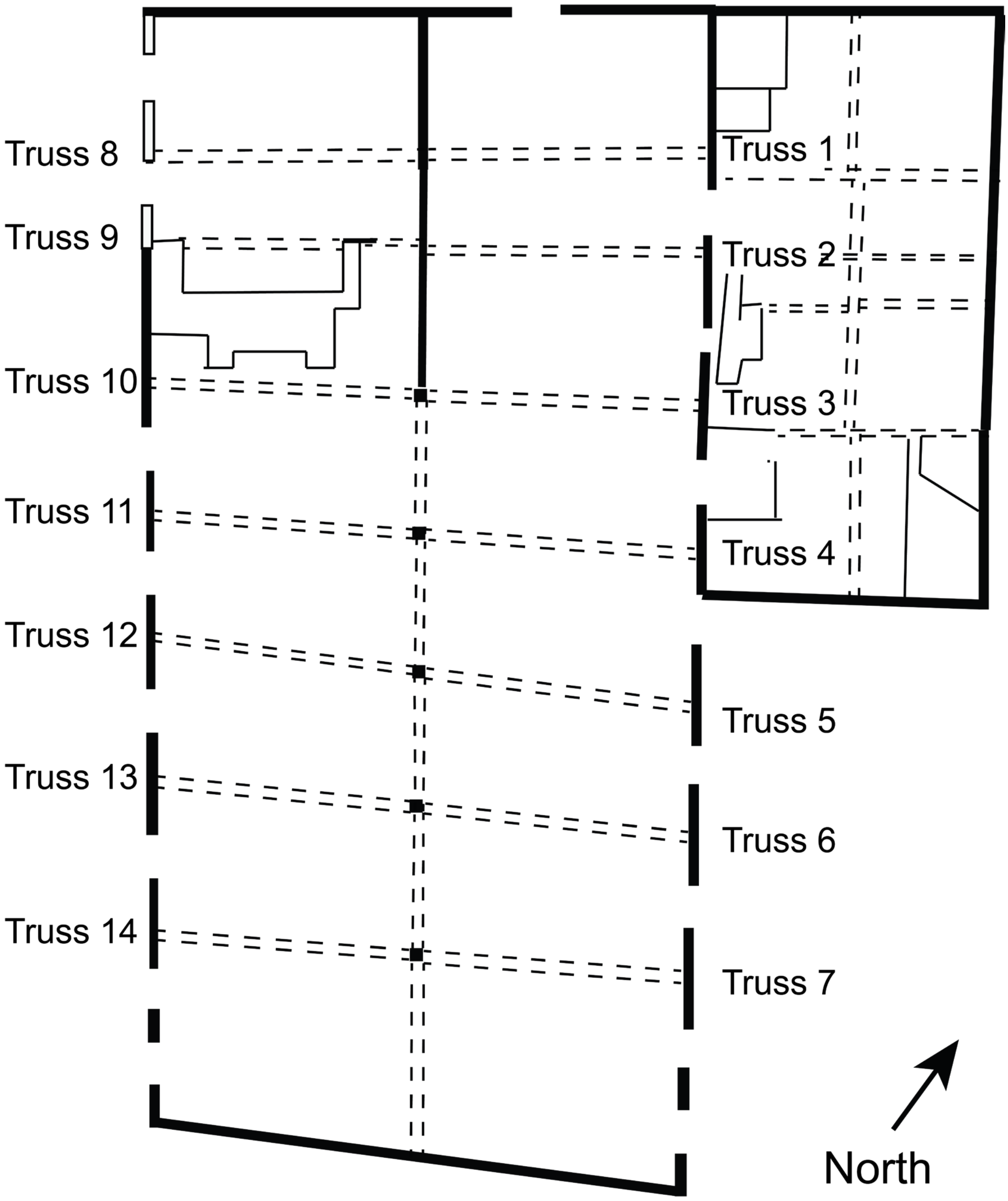

Figure 2: Merchant Adventures Hall first-floor plan showing truss numbering used in this report (drawing by P Marshall)

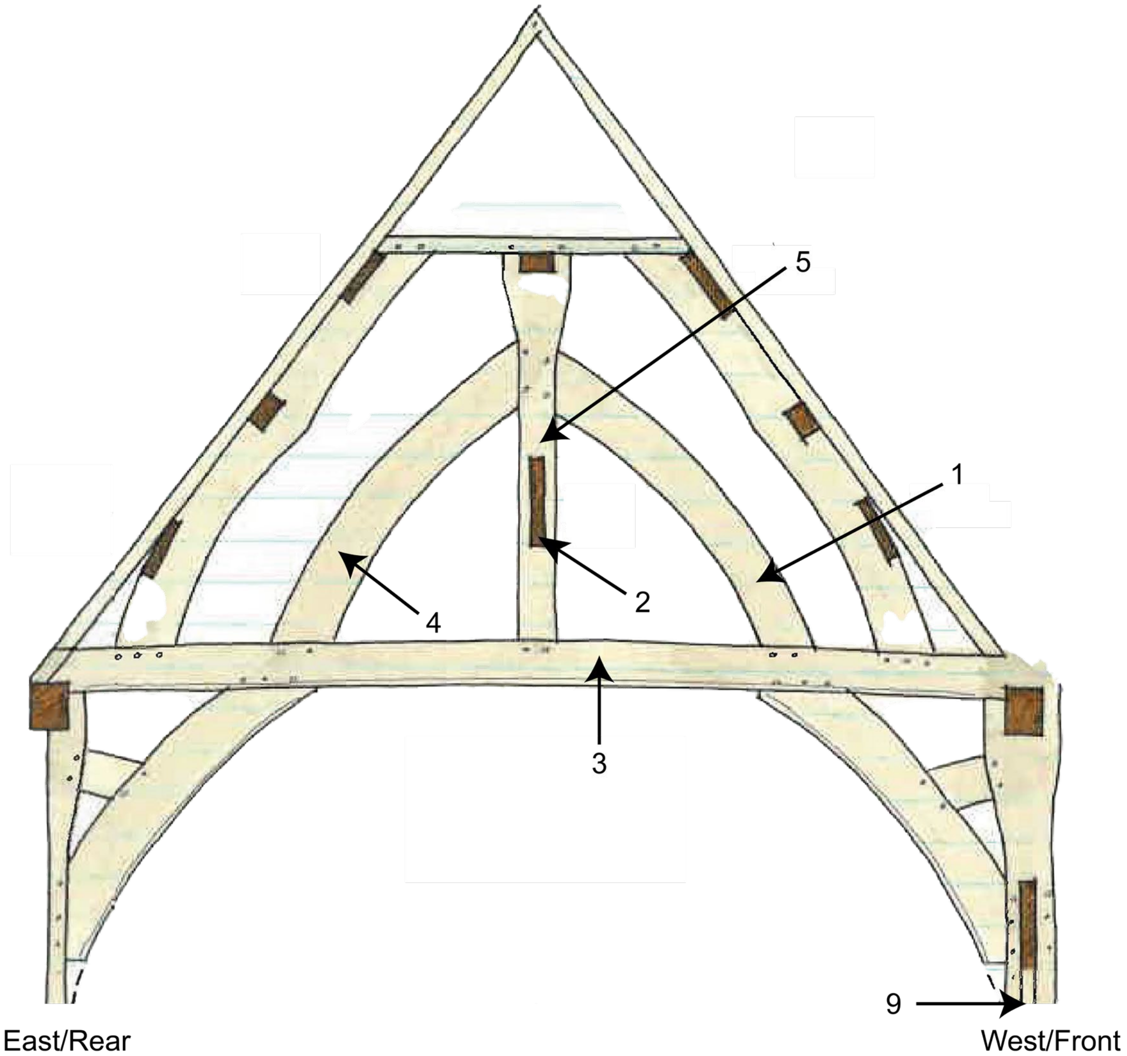

Figure 3: Merchant Adventures Hall truss 13 showing location of samples taken for ring-width dendrochronology (drawing by P Marshall)

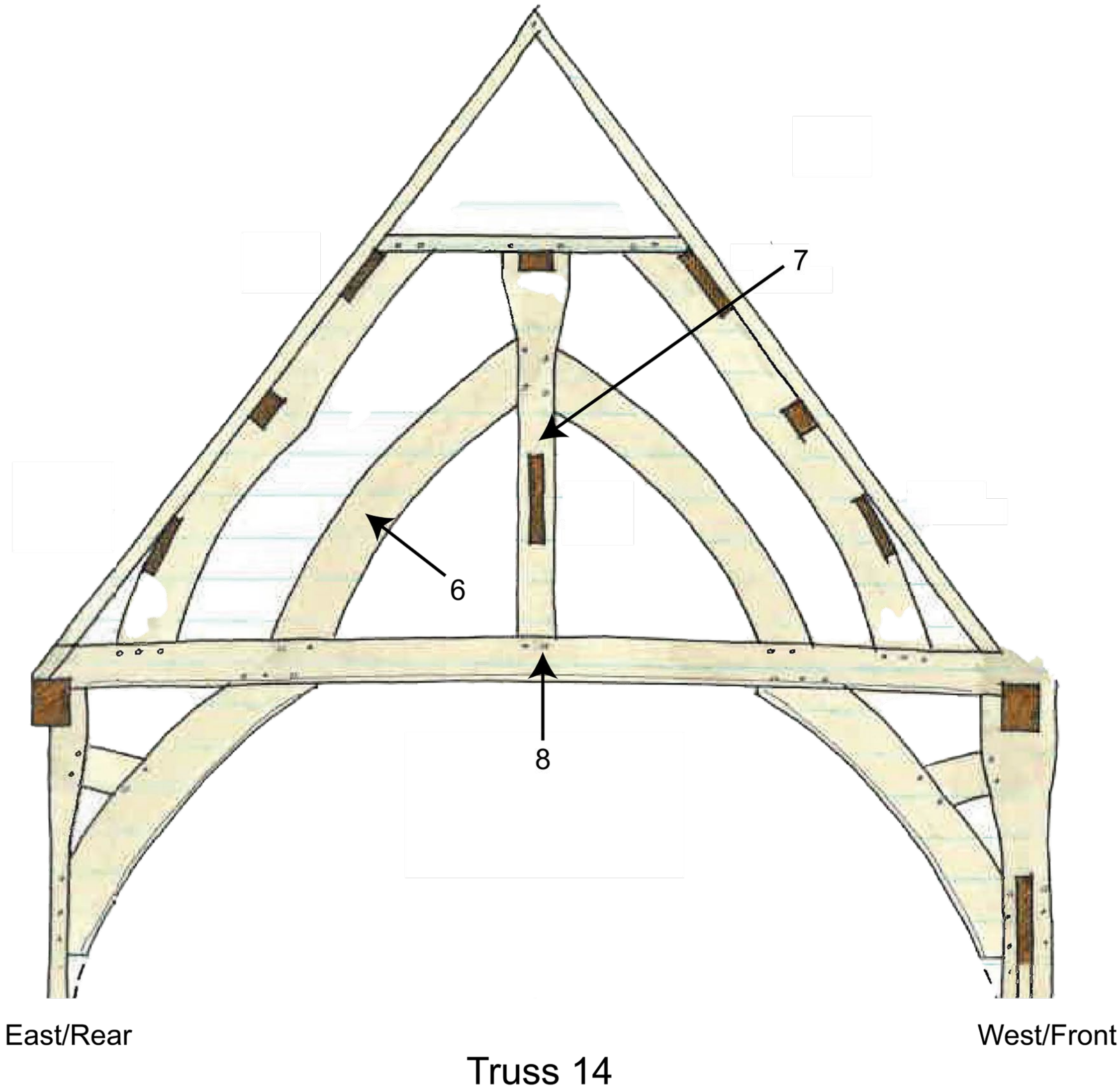

Figure 4: Merchant Adventures Hall truss 14 showing location of samples taken for ring-width dendrochronology (drawing by P Marshall)

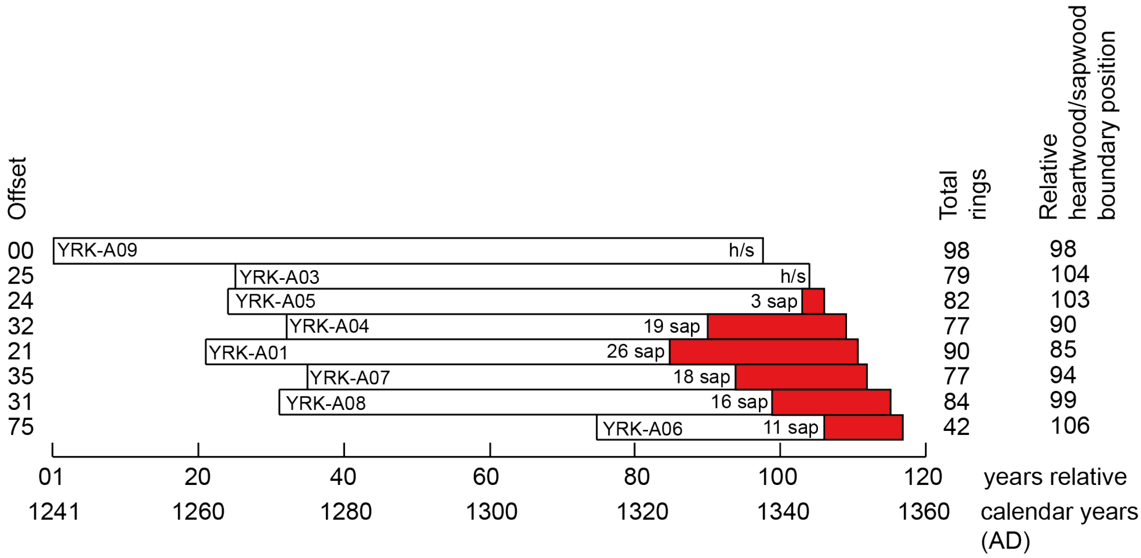

Figure 5: Bar diagram showing the relative positions of overlap between of all the timbers included in site chronology YRKASQ01

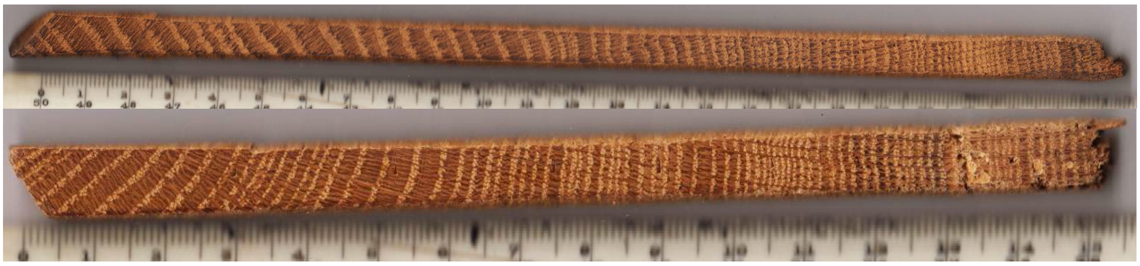

Figure 6: Samples YOR-A05 (top) and YOR-A08 (bottom) showing the cracks and degradation, most apparent in the latter (sapwood) sections of these cores

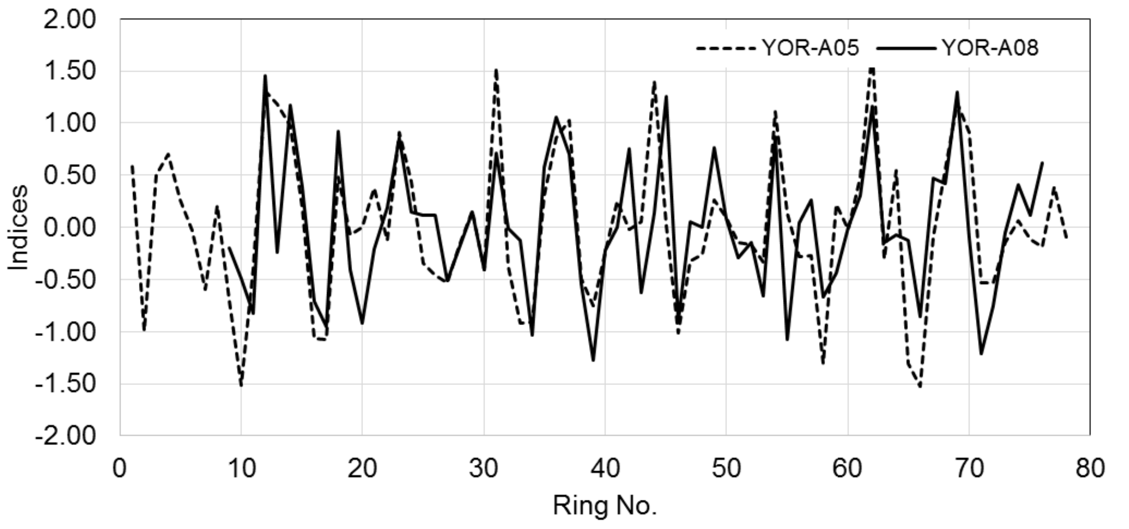

Figure 7: Time series of the filtered and indexed δ¹⁸O values from the two samples plotted at the position of strongest match

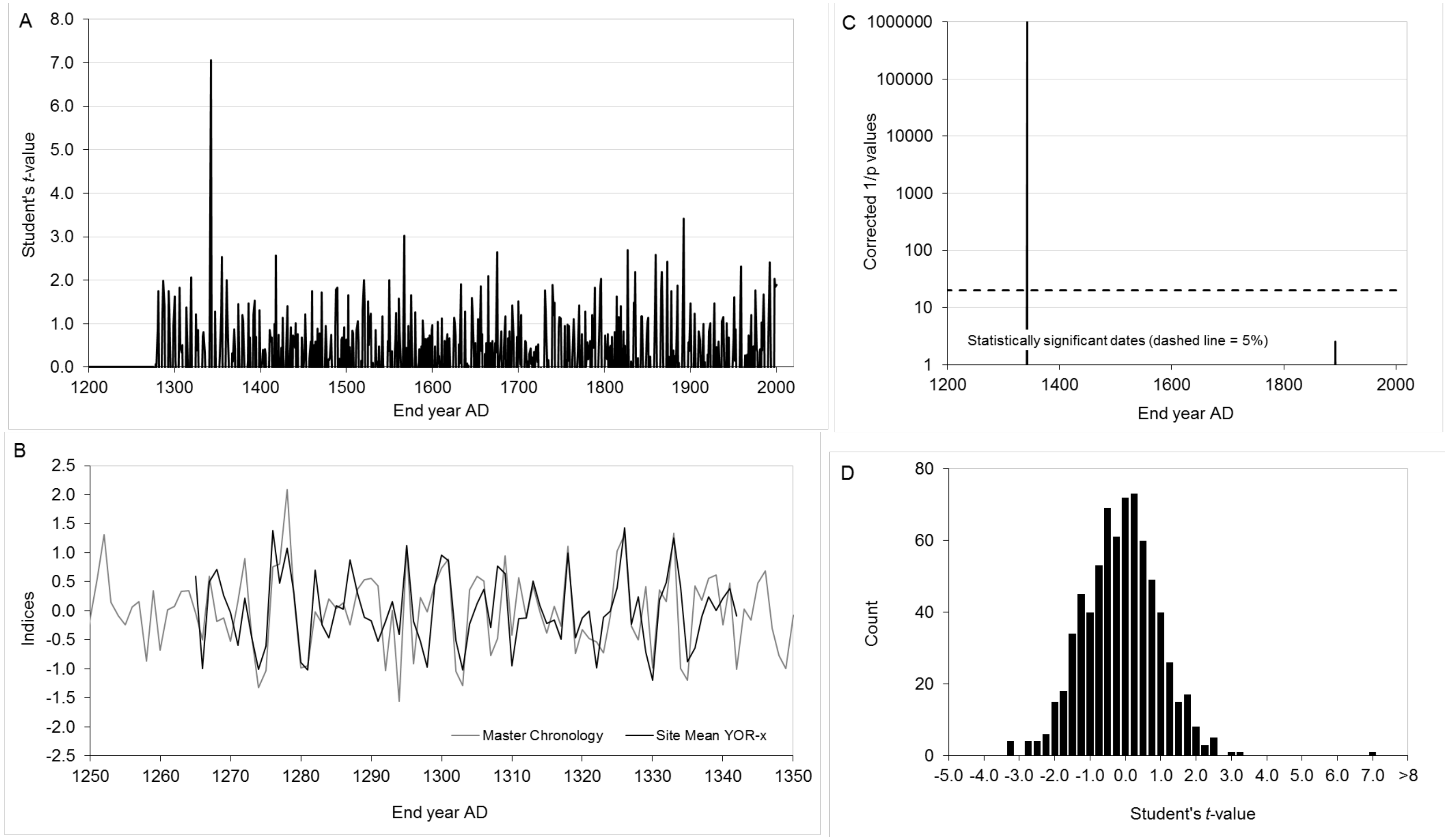

Figure 8: Dating results for the 78-year mean isotope chronology (YOR-A05 and YOR-A08). A: Student's t*-values for all possible end dates with full overlap against the master chronology. B: Time series of the site isotopic mean plotted against the master chronology. C: End dates with corrected probabilities (1/p) of more than one. Those below the dashed line (1/p = 20) are not statistically significant. D: Distribution of Student's* t*-values for all possible matches*

APPENDIX

Oxygen isotope ratios (δ18O) for the measured tree ring series

Data are reported as per mille (‰) deviations relative to the VSMOW standard (Coplen 1995)

Sample YOR-A05

Ring	δ18O	Ring	δ18O	Ring	δ18O
1	29.23	31	29.63	61	28.76
2	27.59	32	27.84	62	29.89
3	28.93	33	27.42	63	28.04
4	29.09	34	27.37	64	28.96
5	28.67	35	28.59	65	27.24
6	28.14	36	29.00	66	27.11
7	27.66	37	29.25	67	28.35
8	28.59	38	27.81	68	29.02
9	27.77	39	27.64	69	29.62
10	27.09	40	28.27	70	29.48
11	28.34	41	28.66	71	28.19
12	30.09	42	28.16	72	28.20
13	29.89	43	28.22	73	28.57
14	29.87	44	29.57	74	28.66
15	29.28	45	28.16	75	28.42
16	28.09	46	27.04	76	28.37
17	27.99	47	27.70	77	28.96
18	29.44	48	27.72	78	28.50
19	28.86	49	28.02		
20	28.92	50	27.94		
21	29.32	51	27.81		
22	28.82	52	27.79		
23	29.69	53	27.63		
24	29.14	54	28.96		
25	28.29	55	28.05		
26	27.99	56	27.68		
27	28.00	57	27.80		
28	28.15	58	27.02		
29	28.30	59	28.43		
30	27.63	60	28.30		

Sample YOR-A08

Ring	δ18O	Ring	δ18O	Ring	δ18O
1		31	28.14	61	29.15
2	28.86	32	27.41	62	30.04
3	28.74	33	28.40	63	28.68
4	28.28	34	28.65	64	27.64
5	30.56	35	29.23	65	28.13
6	28.77	36	27.89	66	28.80
7	30.28	37	28.78	67	29.17
8	29.45	38	29.97	68	28.89
9	28.29	39	27.78	69	29.44
10	27.83	40	28.57		
11	29.74	41	28.51		
12	28.33	42	29.10		
13	27.77	43	28.27		
14	28.57	44	27.76		
15	29.09	45	27.81		
16	29.62	46	27.25		
17	28.95	47	28.59		
18	29.05	48	26.57		
19	29.03	49	27.74		
20	28.44	50	28.06		
21	28.69	51	27.39		
22	29.02	52	27.60		
23	28.34	53	28.28		
24	29.49	54	28.71		
25	28.91	55	29.57		
26	28.86	56	28.47		
27	27.86	57	28.72		
28	29.37	58	28.87		
29	29.72	59	28.13		
30	29.34	60	29.24		

Raw ring-width data
(in units of 0.01mm)

YRK-A01A 90
428 260 164 250 352 235 326 289 160 256 197 133 175 196 200 226 139 216 170 198
232 231 251 282 200 106 115 187 189 202 116 149 143 129 93 124 85 110 106 112
65 48 78 82 77 56 86 122 112 100 66 96 114 182 128 115 215 130 78 96
66 90 102 98 98 131 85 92 70 114 92 78 93 111 64 73 96 118 144 136
121 128 70 86 83 91 116 138 100 108

YRK-A01B 90
436 264 168 250 355 236 318 284 161 246 208 137 173 186 202 230 138 216 173 194
223 232 254 284 214 110 109 185 170 206 118 156 139 124 102 105 94 110 110 100
86 48 72 85 77 55 89 128 116 98 70 109 108 186 112 119 220 116 87 97
67 104 89 104 100 124 90 87 68 115 100 82 82 111 63 74 87 117 142 139
130 123 64 92 76 88 122 129 109 101

YRK-A02A 48
283 235 175 206 245 240 208 180 127 200 220 242 160 229 198 178 149 188 180 263
248 267 168 226 136 196 158 145 175 142 200 128 102 132 105 128 153 162 171 226
181 115 152 207 238 261 285 237

YRK-A02B 48
290 221 170 213 236 237 200 178 132 198 210 251 156 221 196 179 150 188 174 237
248 259 175 227 134 182 155 142 162 147 201 141 105 137 106 128 144 150 187 244
187 115 146 209 230 262 287 197

YRK-A03A 79
211 254 239 313 304 365 309 248 206 275 337 356 313 371 265 243 144 84 127 126
121 78 84 78 93 85 114 110 68 68 76 119 101 98 131 97 90 64 131 145
113 110 145 207 205 166 154 227 281 300 308 268 288 266 208 207 225 176 164 180
162 147 211 241 277 235 275 267 317 389 422 247 344 353 407 288 302 252 199

YRK-A03B 79
228 241 219 323 348 342 304 240 199 287 314 360 328 356 258 226 147 77 130 141
118 82 84 87 96 80 115 113 73 75 86 126 100 90 128 100 87 63 121 145
118 103 150 205 202 156 160 226 276 311 306 267 291 267 198 236 203 163 164 185
164 148 211 238 303 241 271 251 322 392 452 256 339 367 437 282 303 248 218

YRK-A04A 77
184 256 292 245 342 216 296 297 280 252 230 318 250 292 125 128 271 229 245 242
296 228 156 158 168 175 127 160 162 118 56 111 139 157 87 120 211 183 144 102
136 132 190 160 164 191 208 129 156 122 128 158 156 136 142 124 116 118 120 116
124 145 162 113 109 124 171 215 179 158 132 88 139 77 102 149 193

YRK-A04B 77
242 239 302 235 323 217 295 295 277 241 233 312 247 286 149 121 258 216 264 250
291 231 157 153 168 160 128 162 163 120 64 105 131 155 92 124 210 175 137 109
123 132 187 158 170 190 207 132 162 118 139 153 157 139 140 119 128 114 123 130
125 138 163 114 111 127 178 227 187 154 142 90 143 84 101 162 167

YRK-A05A 82
187 360 311 585 537 581 511 445 376 326 490 543 710 601 418 543 563 458 387 551

494 428 358 287 448 336 357 429 363 288 295 323 273 242 198 185 230 173 155 196
248 179 145 171 250 220 204 185 140 214 268 242 166 244 226 111 185 194 171 120
130 145 153 156 145 93 91 129 143 189 286 220 174 171 162 268 210 225 234 133
227 187

YRK-A05B 82
179 364 309 578 586 593 541 418 353 329 473 522 700 562 459 510 548 466 379 558
511 425 359 286 461 315 352 426 362 293 309 320 278 252 199 197 225 173 154 185
255 182 139 174 253 213 197 166 177 197 260 289 242 249 218 132 172 198 165 129
113 167 155 149 120 103 105 98 156 220 292 204 180 166 160 274 204 220 230 158
225 177

YRK-A06A 42
968 849 741 616 437 439 506 552 448 440 429 484 648 451 494 504 606 556 494 398
380 339 264 295 331 217 292 193 134 160 172 208 444 511 275 223 214 312 229 300
293 330

YRK-A06B 42
984 866 728 634 429 459 505 553 460 428 465 471 654 457 489 526 619 550 495 414
392 344 281 299 324 200 283 194 142 158 172 222 461 536 269 238 226 336 253 332
323 313

YRK-A07A 77
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180 150 140 104 93 109 117 127 100 97 111 98 89 107 87 81 83 83 154 146
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YRK-A07B 77
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185 144 144 103 97 110 111 124 102 106 117 95 94 106 90 77 82 86 147 153
194 123 95 125 161 219 187 181 134 66 159 100 123 147 163 115 195

YRK-A08A 84
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376 276 196 190 147 193 154 163 163 238 124 91 124 188 143 100 115 187 193 161
196 234 270 183 173 130 133 111 89 80 82 85 83 93 111 154 147 166 146 172
147 175 144 124 77 127 148 148 186 184 169 126 103 113 81 95 186 179 136 140
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YRK-A08B 84
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385 265 197 188 150 195 152 165 166 229 124 90 129 184 131 111 114 188 188 165
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151 176 148 112 77 127 150 139 194 186 179 123 106 111 90 94 180 183 134 136
162 172 122 180

YRK-A09A 98
333 480 712 474 517 423 491 398 493 306 341 348 481 425 630 453 524 380 457 501
414 424 326 202 216 306 272 372 348 301 377 261 232 230 198 233 279 187 182 230
244 218 142 170 194 193 135 118 100 196 181 207 165 163 137 105 106 109 87 98
116 78 69 60 84 101 77 74 115 111 97 75 79 116 132 150 150 142 84 128

156 188 219 226 263 171 185 160 173 122 118 161 217 233 268 176 122 136

YRK-A09B 98
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409 433 320 201 208 310 266 361 356 276 372 247 248 245 204 224 306 161 174 228
240 234 129 166 199 191 134 116 168 195 187 207 169 156 138 105 101 116 87 93
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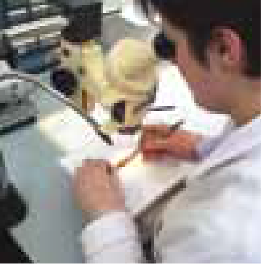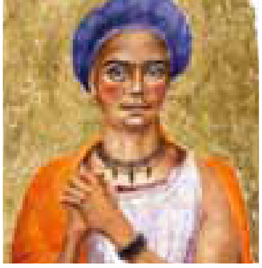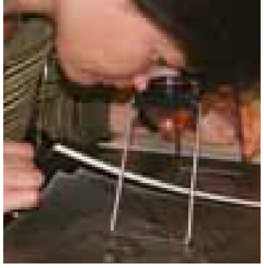

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