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The Shakespeare Hotel, 14–19 Chapel Street, Stratford-upon-Avon, Warwickshire

Tree-ring Analysis of Timbers

Martin Bridge

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Summary

Three species of timber were found in this building, the majority being oak, although the rear ranges contained a lot of elm and at least one ash. The front range, known as ‘Five Gables’ dated to the early AD 1620s, while a single timber from a range to the rear at the south end of this block had a likely felling date of after AD 1512, suggesting this either represented an earlier building on the site, or was a re-used timber. A single timber from one of the rear ranges to ‘Four Gables’ had a likely felling date range of AD 1695–1724, which may represent the construction of this range, currently a corridor from Reception to the rear entrance.

Contributors

Martin Bridge

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Front cover image

The Shakespeare Hotel, Chapel Street, Stratford-upon-Avon, Warwickshire [Photograph Martin Bridge]

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Contents

Introduction 1
The Shakespeare Hotel 2
Methodology 5
Ascribing felling dates and date ranges 5
Results and Interpretation 7
Discussion 19
References 20
Appendix 23

Illustrations

Figure 1: Maps to show the location of Shakespeare Hotel (red dot). Scale: top-right 1:200,000; bottom 1:1200. [© Crown Copyright and database right 2024. All rights reserved. Ordnance Survey Licence number 100024900].....3

Figure 2: Plan of the hotel complex, showing the lettered blocks into which it was divided for analysis. [drawing by Ric Tyler] 4

Figure 3: Plan of the Second Floor of Block A, showing the locations of samples taken for dendrochronology. [drawing by Ric Tyler].....10

Figure 4: Plan of the ground floor of Blocks B and C, showing the locations of samples taken for dendrochronology. [drawing by Ric Tyler].....11

Figure 5: Plan of the ground floor of Block E, showing the locations of samples taken for dendrochronology. [drawing by Ric Tyler].....12

Figure 6: Plan of Block F, showing the locations of samples taken for dendrochronology. [drawing by Ric Tyler] 13

Figure 7: Plan of Block G, showing the locations of samples taken for dendrochronology. [drawing by Ric Tyler] 14

Figure 8: Bar diagram showing the relative positions of overlap of the dated timbers from The Shakespeare Hotel, Stratford-upon-Avon. White sections represent heartwood rings, yellow hatched bars represent sapwood rings, with narrow sections representing additional unmeasured rings. 15

Tables

Table 1: Details of samples taken from The Shakespeare Hotel, Stratford-upon-Avon. 8

Table 2: Cross-matching between the dated series from Block A of the Shakespeare Hotel, Stratford-upon-Avon (*t*-values above 3.5 are significant)/ 15

Table 3: Strongest matches for site chronology SHAKAt4, dated AD 1506–1622. 16

Table 4: Strongest matches for site sequence shakE01, dated AD 1372–1503. 17

Table 5: Strongest matches for site chronology shakG01, dated AD 1620–95/ 18

Introduction

This building was investigated as part of the *StratFire* project, a project proposed by the Stratford-upon-Avon Society and subsequently supported by Historic England.

The project focuses on the impact of two major fires in the late-sixteenth century, in AD 1594 and AD 1595, as well as taking into account another major fire in AD 1614. Bearman (2000) investigated the two late sixteenth-century fires in detail using documentary sources. Subsequently the Stratford-upon-Avon Society have been highlighting the architectural heritage along the main thoroughfare through on-going volunteer-led research (Historic Spine (stratfordsociety.co.uk)) which has itself led to the development of the *StratFire* project (StratFire Project (stratfordsociety.co.uk)) which combines detailed archival research with comprehensive building recording and analysis, as well as dendrochronology. The project summary, as per the final agreed project design (Historic England Project number 8452) is as follows:

"The aim of this project, by means of high-level building recording and analysis, detailed archival research and dendrochronology, is to establish, following Stratford-upon-Avon's town fires of 1594 and 1595, the chronology, extent and nature of the reconstruction of buildings along High Street and Chapel Street, the epicentre of one or both of these fires. Post-fire documentary sources record damage to certain buildings, and architectural appraisal indicates that several timber-framed buildings surviving today date from the post-fire period. However, more needs to be established concerning the scale, nature and speed of this rebuilding, and the impact of the fires, both on the economic well-being of the town and the fortunes of the families most seriously affected. For many buildings there is simply no documentary evidence to draw on. Moreover, even when documentary evidence exists, it is either confusing or only establishes a date by which rebuilding had taken place. Conversely, it may record fire damage to properties that, from surviving architectural features, appear not to have been entirely rebuilt. High-level building analysis and dendrochronological investigation will resolve much of this uncertainty, provide a sound base for the interpretation of the documentary evidence, and throw definitive light on a crucial episode in the evolution of the architectural and cultural heritage of this internationally renowned town."

The Shakespeare Hotel

An important building in the town, the Grade II* listed hotel (LEN 1204394) sits on the east side of Chapel Street and is separated from Sheep Street by the Town Hall (Fig. 1). A complex of buildings, following initial investigations by the *Stratfire* Group, it was split into several sections (A–G) for analysis (Fig. 2). The frontage consists of at least three buildings. The largest block (A), also known as ‘Five Gables’, is thought to be the oldest section, with the section to the north being known as ‘Four Gables’ possibly representing two phases (B and C) adjacent to the Town Hall. The frontage of this section was rebuilt in the 1920s. To the south the hotel incorporates No 19 Chapel Street (D), which was originally a separate building. The ranges to the rear (E–F) are of uncertain age, and were investigated, but were a lower priority for dating.

Figure 1: Maps to show the location of Shakespeare Hotel (red dot). Scale: top-right 1:200,000; bottom 1:1200. [© Crown Copyright and database right 2024. All rights reserved. Ordnance Survey Licence number 100024900]

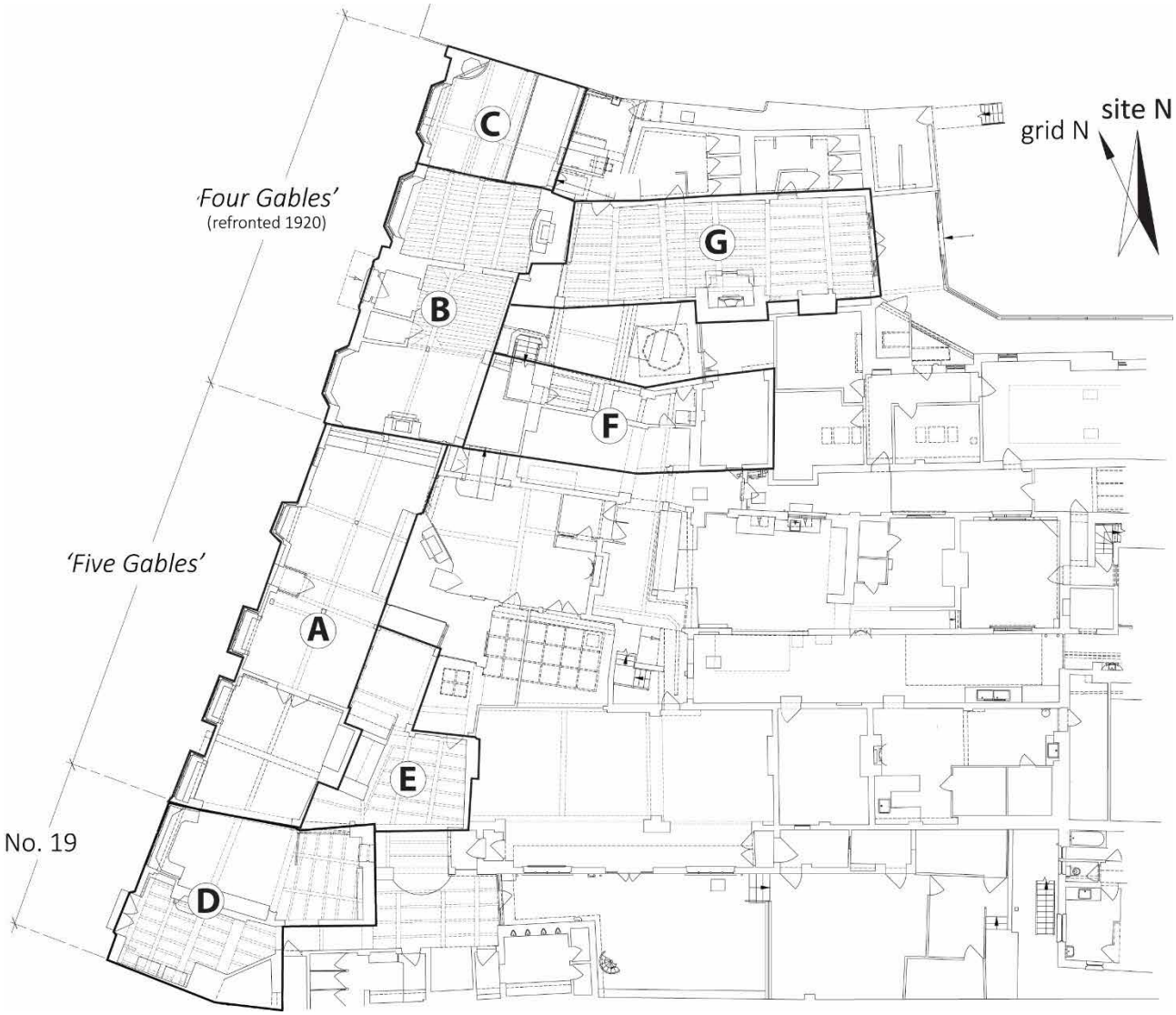

Figure 2: Plan of the hotel complex, showing the lettered blocks into which it was divided for analysis. [drawing by Ric Tyler]

Methodology

An initial assessment of the timbers for dendrochronological potential sought accessible timbers with more than 50 rings and with possible traces of sapwood, although slightly shorter sequences are sometimes sampled if little other material is available. Initial assessment suggested that most timbers were considered marginal in terms of the number of rings available. Those timbers judged to be potentially most useful were cored in January 2023, using a 16mm auger attached to an electric drill. The cores were labelled and stored for subsequent analysis.

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 process of qualified statistical comparison by computer, supported by visual checks. 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 on the computer monitor to allow visual comparisons to be made between sequences. 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*-values in the range 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 (i.e. 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* (*tpq*) 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 for oak in this area is 9–41 rings (Miles 1997). 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.

Results and Interpretation

Details of the samples taken are shown in Table 1, with the positions in the complex of all the sampled timbers, with the exception of shakBC01, being illustrated in Figures 3–7. Many timbers were assessed as having too few rings for conventional ring-width dendrochronology, but a few samples were taken in various areas to facilitate possible radiocarbon and/or oxygen isotope dendrochronology in the future. The oak (*Quercus* spp) timbers with the best potential for ring-width dendrochronology were found in the front range (Block A), which was of most interest in the interpretation of the building. Some areas, for example Block F, were thought to be entirely of elm (*Ulmus* spp), although in fact one timber here was found to be of ash (*Fraxinus* spp). Overall, 22 timbers were sampled (Table 1) of which 12 had less than 40 rings, and three (shakF01, F02, and G04) were of a species other than oak. The ring-width measurements of all samples are given in the Appendix. Only those series with 30 or more rings were analysed.

The ring-width series from four timbers from Block A cross-matched (Table 2) and were dated, producing a site master which was identified as covering the period AD 1506–1622 when compared to the reference chronologies. The strongest matches for the four-timber chronology (SHAKAt4) are given in Table 3. Three of the samples had complete sapwood, although this was detached from the main core in one sample (shakA03). The two intact samples indicate felling dates a year apart in winter AD 1621/2 and AD 1622/3, whereas shakA03, which is thought to have lost only a few rings at most at the break, was therefore given a narrow likely felling date range of *circa* AD 1619–24 (Table 1; Fig. 8). The remaining sample is clearly coeval producing a felling date range compatible with the precise felling dates obtained.

The ring series from a single beam in Block E was dated individually when compared to the reference chronologies to the period AD 1372–1503, the strongest matches being shown in Table 4. The heartwood/sapwood transition on this sample did not survive and so only a *terminus post quem* for felling of AD 1512 can be obtained for this timber.

The ring-width series from a single beam in Block G (which had several elm beams) was dated individually to the period AD 1620–95, the best matches being given in Table 5. This sample retained 12 rings of sapwood, allowing a felling date range of AD 1695−1724 to be estimated for this timber.

Table 1: Details of samples taken from The Shakespeare Hotel, Stratford-upon-Avon.

Sample No.	**Location**	**No. rings**	**Date of measured sequence (AD)**	**Sapwood**	**Mean ring width (mm)**	**Mean sensitivity**	**Felling date range (AD)**
Block A							
shakA01	East post, truss 5	36	-	h/s	1.84	0.23	-
shakA02	East post, truss 4	87	1509–95	h/s	1.67	0.19	1604–36
shakA03	Interrupted tie, truss 4	64	1544–1607	h/s (+11CNM)	1.86	0.19	*c.*1619–24
shakA04	Interrupted tie, truss 3	72	1550–1621	14C	1.66	0.25	winter 1621/2
shakA05	West post, truss 3	117	1506–1622	13C	1.15	0.20	winter 1622/3
shakA06	West wall-plate, bay 3	27	-	3	3.19	0.18	-
shakA07	West purlin, bay 2	34	-	h/s	2.83	0.18	-
Block B							
shakB01	Ground-floor moulded transverse beam (by phone cabin)	63	-	h/s	2.22	0.27	-
shakB02	South-west corner post	26	-	-	4.07	0.16	-
Block B/C							
shakBC01i	Arched brace outside Rm 201, inner rings	23	-	-	2.96	0.26	-
shakBC01ii	*ditto,* outer rings	17	-	10½C	2.70	0.19	-
Block C							
shakC01	Rear axial beam (by bar, ground-floor)	36	-	h/s	2.36	0.23	-
shakC02	Ground-floor partition wall, 3rd stud from front of building	42	-	h/s	2.24	0.22	-

Sample No.	Location	No. rings	Date of measured sequence (AD)	Sapwood	Mean ring width (mm)	Mean sensitivity	Felling date range (AD)
shakC03	Ground-floor partition wall, stud adjacent to front wall of building	15	-	-	3.62	0.32	-
shakC04	Ground-floor partition wall, sill beam	26	-	5	2.86	0.23	-
Block E							
shakE01	East beam in ground-floor bar	132	1372–1503	-	1.17	0.23	after 1512
shakE02	West beam in ground-floor bar	29	-	-	1.67	0.23	-
Block F							
shakF01	North-east corner post, room 115 (elm)	50	-	-	2.89	0.38	-
shakF02	West end tiebeam Rm 104 (ash)	52	-	-	3.37	0.26	-
Block G							
shakG01	South post near fireplace, ground floor	76	1620–95	12	1.94	0.21	1695–1724
shakG02	Transverse beam, east of fireplace, ground floor	31	-	h/s	2.64	0.14	-
shakG03	Furthest east ceiling beam, ground floor	39	-	h/s	2.21	0.23	-
shakG04	Ceiling beam adjacent to fireplace, ground-floor (elm)(beam to west also elm, not sampled)	33	-	-	1.88	0.23	-

Key: h/s = heartwood/sapwood boundary; C = complete sapwood, felled the following winter; ½C = complete sapwood, felled the following summer; NM = not measured

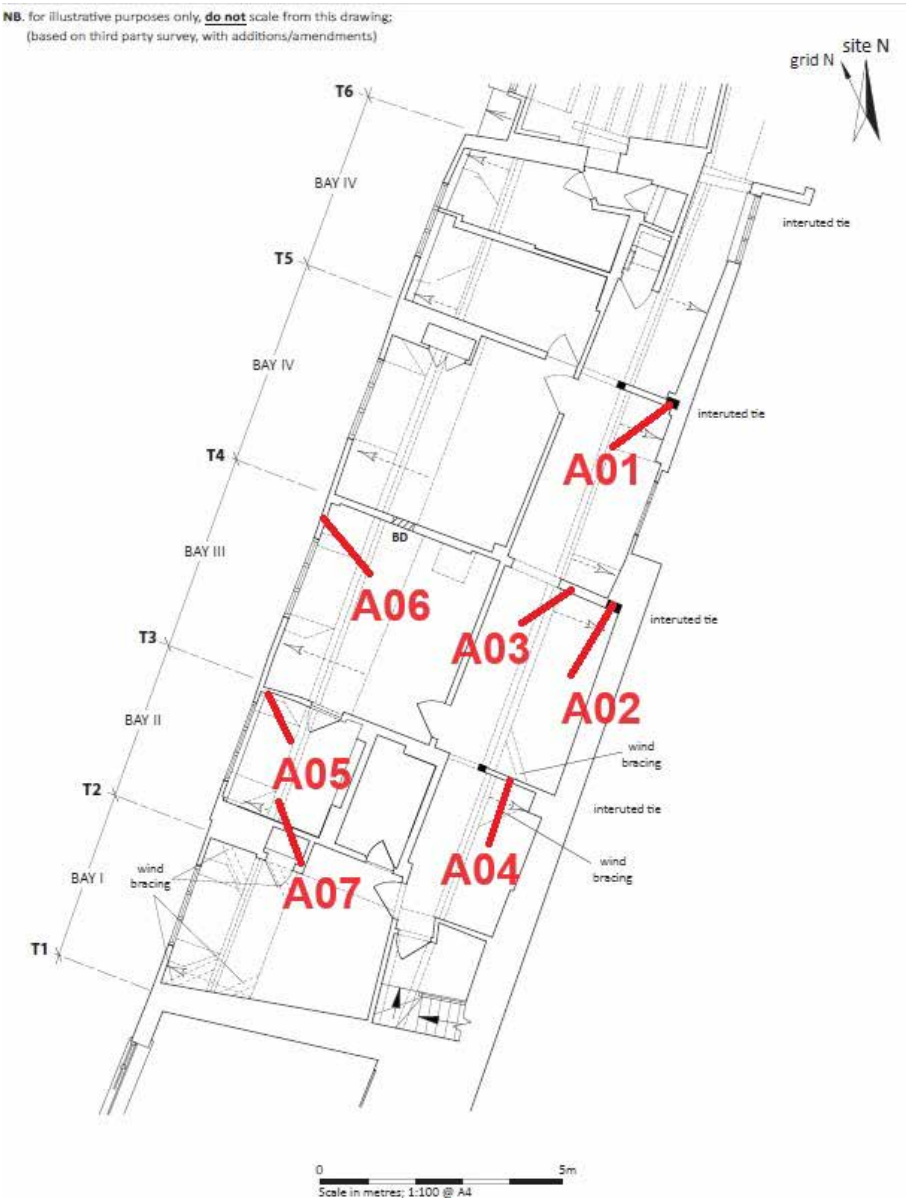

Figure 3: Plan of the Second Floor of Block A, showing the locations of samples taken for dendrochronology. [drawing by Ric Tyler]

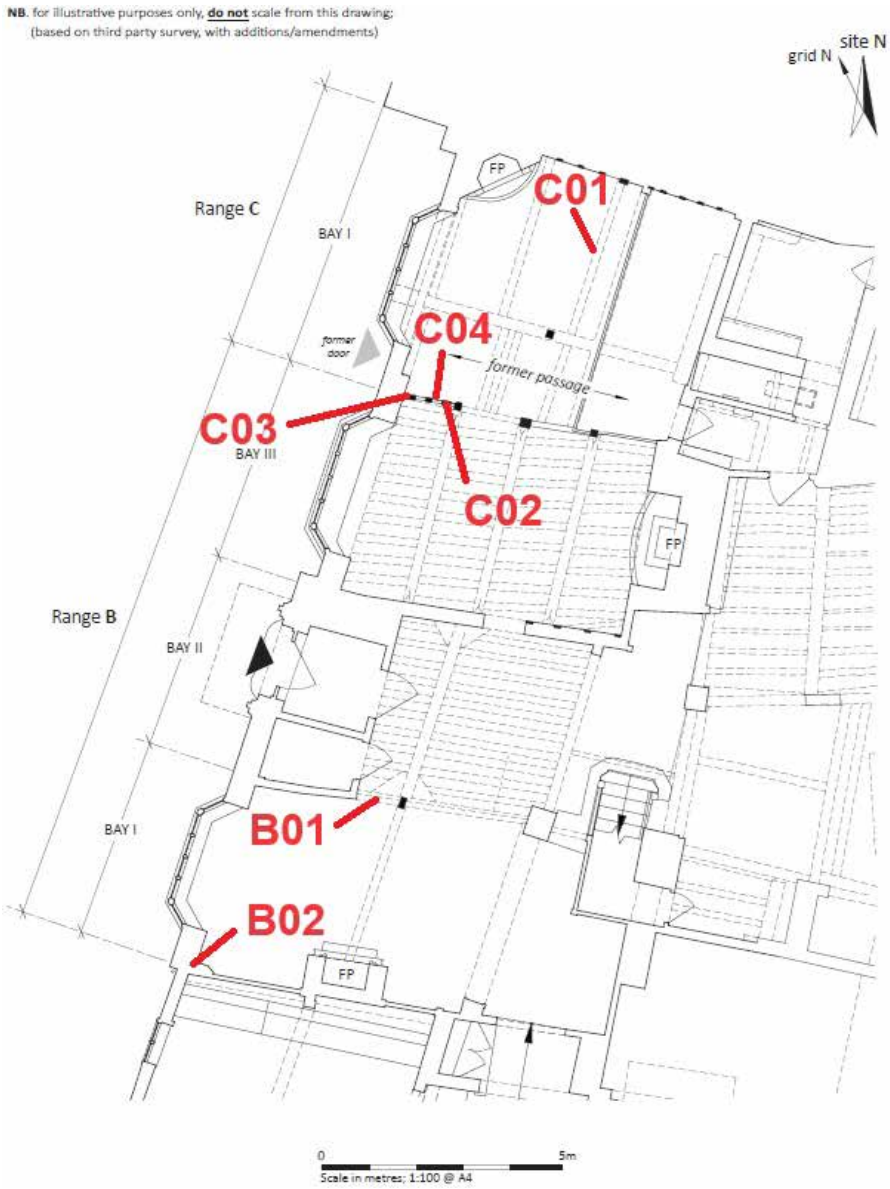

Figure 4: Plan of the ground floor of Blocks B and C, showing the locations of samples taken for dendrochronology. [drawing by Ric Tyler]

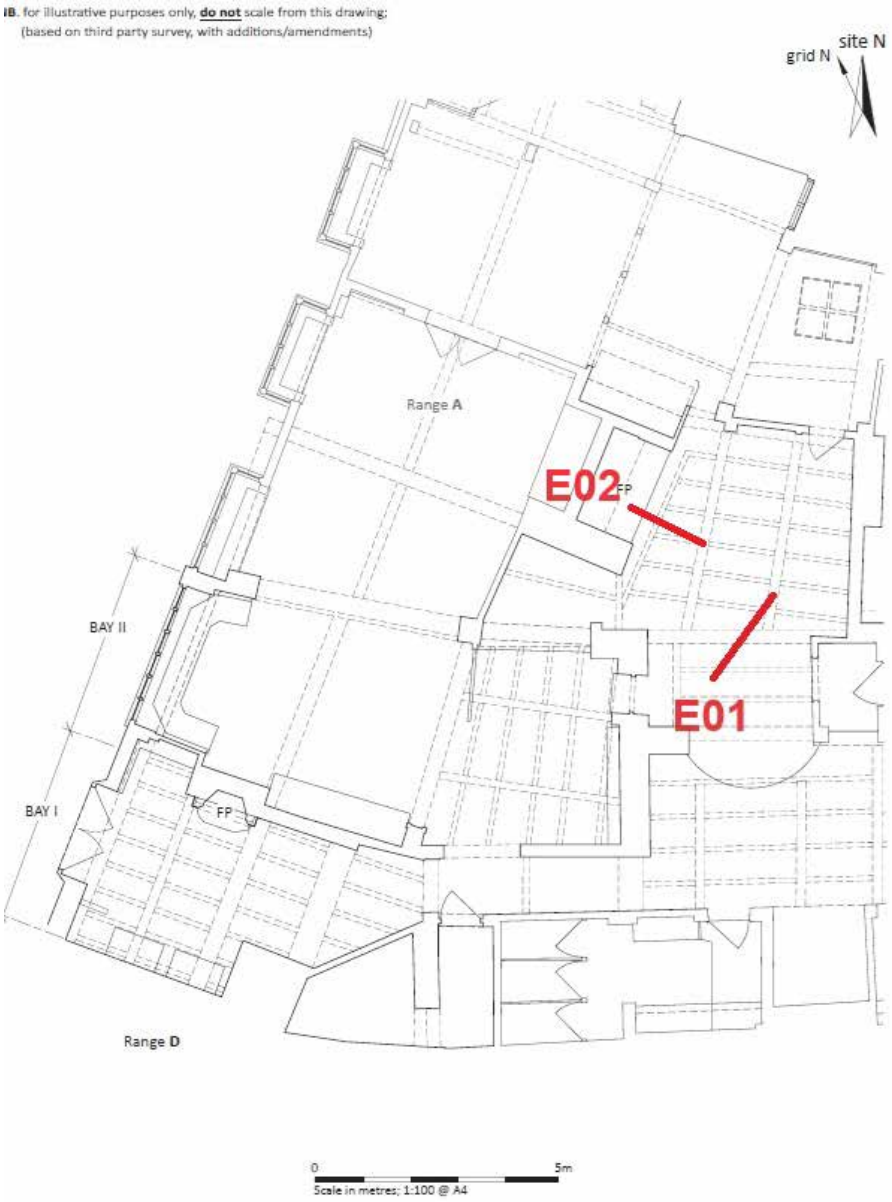

Figure 5: Plan of the ground floor of Block E, showing the locations of samples taken for dendrochronology. [drawing by Ric Tyler]

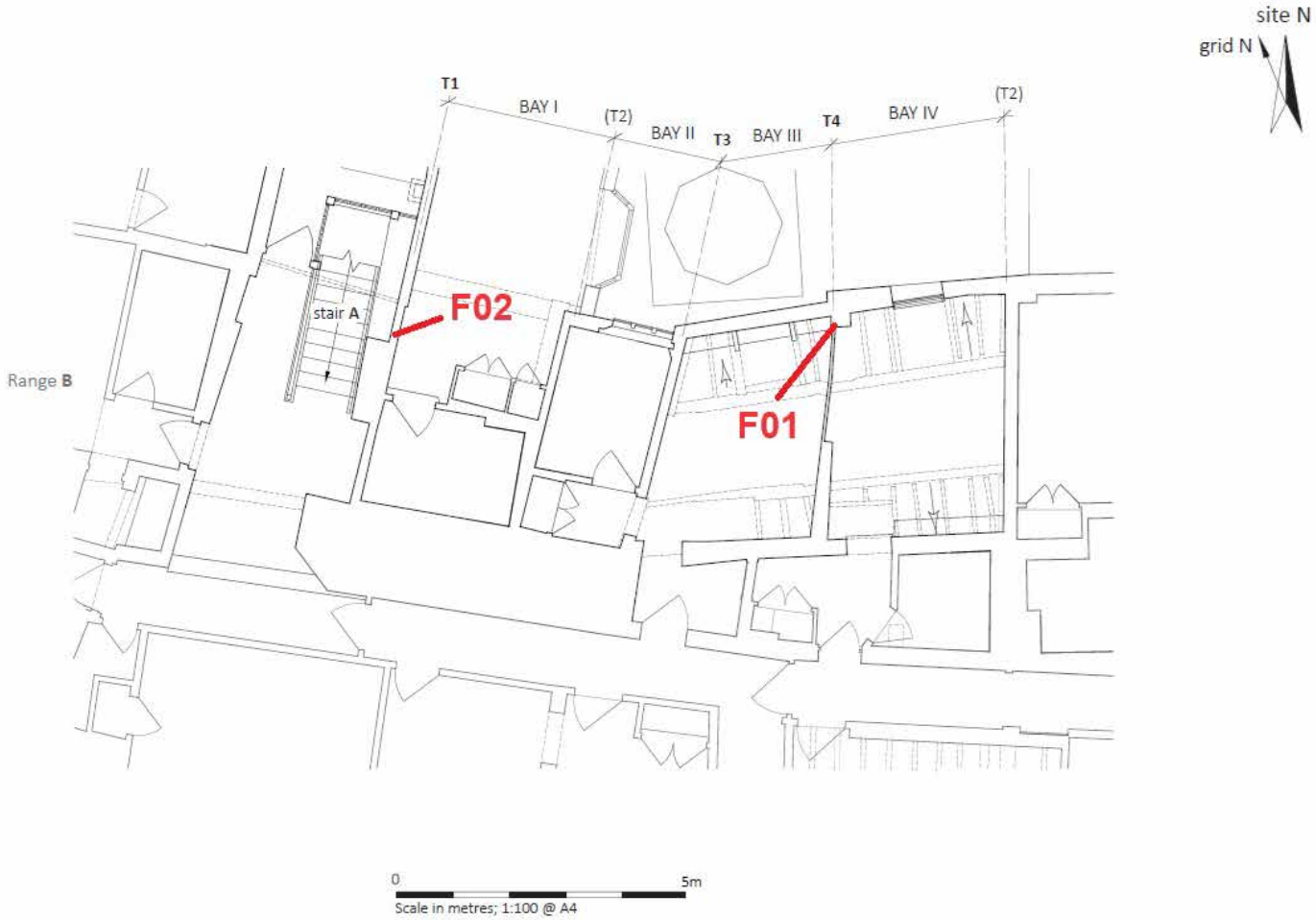

Figure 6: Plan of Block F, showing the locations of samples taken for dendrochronology. [drawing by Ric Tyler]

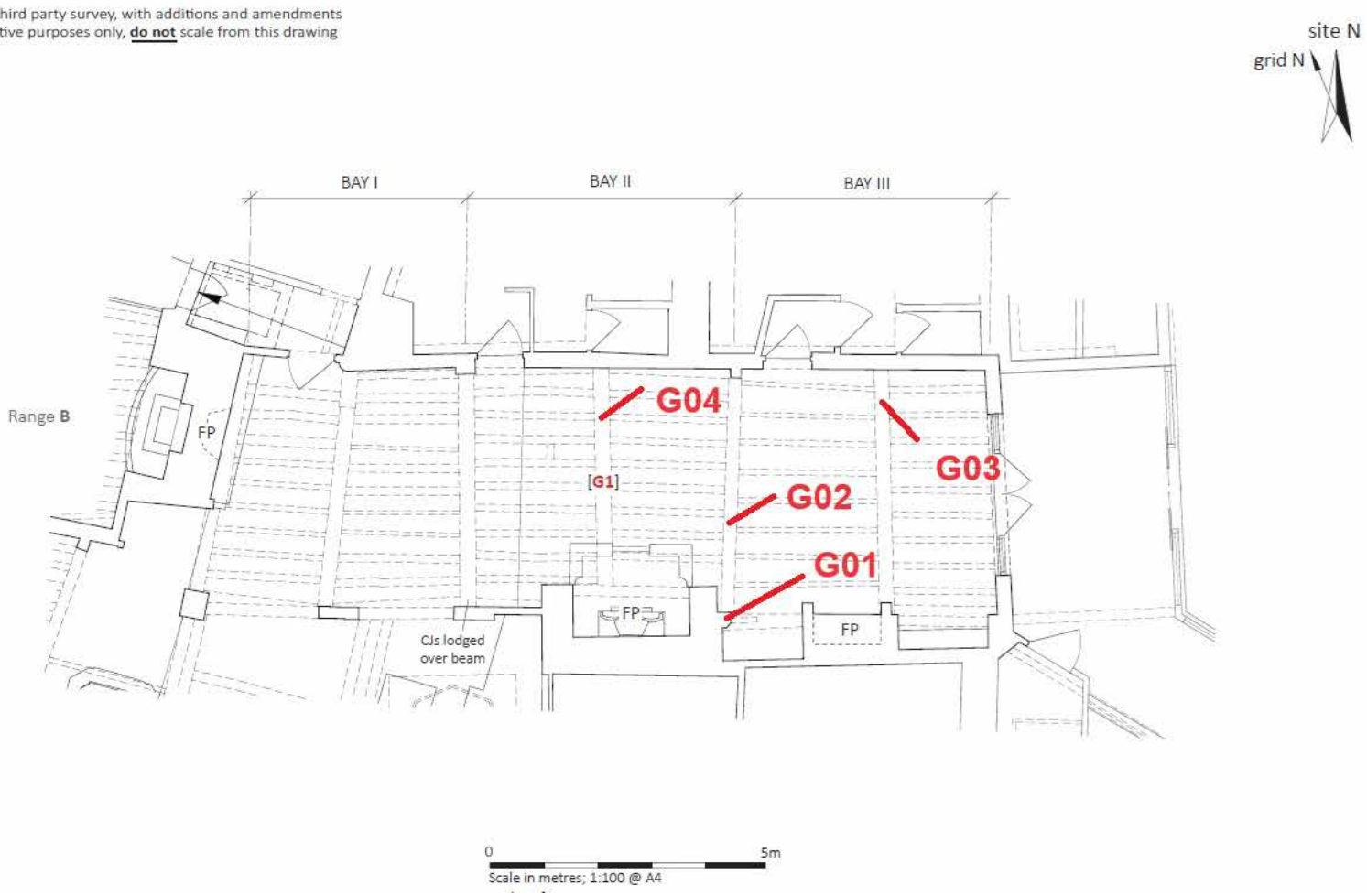

Figure 7: Plan of Block G, showing the locations of samples taken for dendrochronology. [drawing by Ric Tyler]

Table 2: Cross-matching between the dated series from Block A of the Shakespeare Hotel, Stratford-upon-Avon (*t*-values above 3.5 are significant)/

	t-values		
Sample No	shakA03	shakA04	shakA05
shakA02	5.4	3.9	3.4
shakA03		4.4	4.4
shakA04			4.0

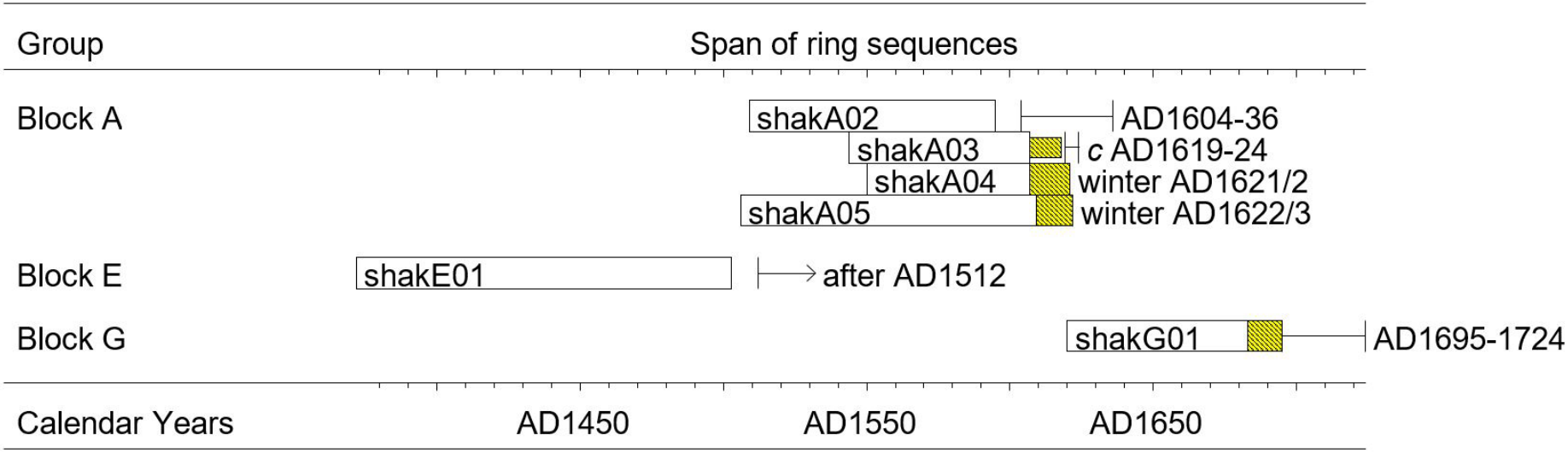

Figure 8: Bar diagram showing the relative positions of overlap of the dated timbers from The Shakespeare Hotel, Stratford-upon-Avon. White sections represent heartwood rings, yellow hatched bars represent sapwood rings, with narrow sections representing additional unmeasured rings.

Table 3: Strongest matches for site chronology SHAKAt4, dated AD 1506–1622.

Source region	Chronology	Publication reference	Filename	Span of chronology (AD)	Overlap (years)	*t*-value
Gloucestershire	Estcourt Grange, Tetbury	Bridge and Miles 2022	ESTCRTGt9	1379–1610	105	9.7
Warwickshire	Middleton Hall	Arnold et al. 2006	MIDHSQ02	1390–1646	117	8.5
Warwickshire	Coleshill Hall Farmhouse	Bridge and Miles 2023	COLESHILL	1550–1670	73	8.1
Lancashire	Tonge Hall, Middleton	Arnold and Howard 2014a	TNGBSQ01	1449–1687	117	8.1
Warwickshire	Halls Croft, Stratford-upon-Avon	Miles and Worthington 1999	HLSCROFT	1429–1648	117	8.0
Flintshire	Chirk Castle, Wrexham	Bridge et al. 2020	CHIRK18	1379–1796	117	7.6
Worcestershire	Upwich salt making site	Groves and Hillam 1997	UPWICH3	1454–1651	117	7.5
Shropshire	Cherrington Manor	Miles and Worthington 2000	CHERGTN	1386–1635	117	7.5
Hampshire	Berry Court Farm, Nether Wallop	Miles et al. 2003	BRRYCTFM	1429–1579	74	7.4

Table 4: Strongest matches for site sequence shakE01, dated AD 1372–1503.

Source region	Chronology	Publication reference	Filename	Span of chronology (AD)	Overlap (years)	*t*-value
Shropshire	The Peach Tree, Shrewsbury	Miles and Worthington 2000	PEACH2	1300–1430	59	6.6
Oxfordshire	Greys Court, Rotherfield Greys	Miles et al. 2009	GREYSCTA	1319–1618	132	6.4
Shropshire	Wyle Cop, Shrewsbury	Miles and Haddon-Reece 1994	LIONTAP	1353–1425	54	6.0
Shropshire	Moat House, Longnor	Miles and Haddon-Reece 1993	MOATHSE1	1391–1466	76	5.8
Oxfordshire	Charlbury Church	Miles and Bridge 2013	CHRLBRY	1404–1516	99	5.6
Herefordshire	Black Hall Barn, King's Pyon	Nayling 1999	BHALLKP2	1340–1430	59	5.5
Somerset	Gate House, Bristol Cathedral	Arnold et al. 2003	BRICSQ01	1306–1494	123	5.4
Radnorshire	White Hall, Presteigne	Miles and Worthington 1999	WHITEHLL	1352–1462	91	5.3
Worcestershire	The Farthings, Kemerton	Miles and Bridge 2014	KEMERTON	1363–1441	70	5.3
Buckinghamshire	Burrow Farm, Hambleden	Miles and Haddon-Reece 1995	BURROWFM	1350–1494	123	5.1

Table 5: Strongest matches for site chronology shakG01, dated AD 1620–95/

Source region	Chronology	Publication reference	Filename	Span of chronology (AD)	Overlap (years)	*t*-value
London	Breakspear House, Harefield	Arnold and Howard 2010	HFDBSQ01	1574–1694	75	6.7
Bedfordshire	Woburn Abbey, phase two	Miles pers. comm.	WOBURN2	1574–1752	76	5.7
Oxfordshire	Old Clarendon Building, Oxford	Worthington and Miles 2006	CLRNDNOX	1539–1711	76	5.5
Bedfordshire	Chicksands Priory	Howard et al.1998a	CHKSPQ02	1611–1814	76	5.4
Somerset	Barn at Fairfield House, Stogursey	Arnold and Howard 2014b	FRFBSQ01	1561–1771	76	5.3
Warwickshire	19 Clifford Chambers	Bridge and Miles 2017	CLCH21m	1587–1699	76	5.2
Oxfordshire	New College Oxford	Miles et al. 2014	NWCOLLG8	1587–1724	76	5.2
Shropshire	Buildwas Abbey	Miles 2002	BUILDWS3	1563–1687	68	5.2
Lincolnshire	Bay Hall, Benington	Howard et al. 1998b	BENASQ01	1591–1717	76	5.2
Bedfordshire	De Grey Mausoleum, Flitton	Howard et al. 2003	FLTASQ01	1510–1726	76	5.2

Discussion

The dated timbers, two posts and two interrupted ties, in Block A (‘Five Gables’) appear coeval and were all felled at a similar time, suggesting construction of this street-front range in the early AD 1620s shortly after felling (Table 1; Fig. 8). This therefore post-dates the two late sixteenth century fires and the one in 1614.

Unfortunately no samples were dated from the blocks B and C to the north (‘Four Gables’) or Block F to the rear of Block B.

Only two other timbers were dated. A beam in the ground floor ceiling of Block E, located behind the dated street-front range, Block A, has a *terminus post quem* for felling of AD 1512, indicating that it could potentially be about a century earlier than the Block A timbers and pre-date the fires. It may be a re-used timber or it may give a clue to an earlier building on the site but with only a single dated timber from this Block, it should be treated cautiously. Block G, extending back from the northern part of the complex, had a mix of oak and elm elements at ground-floor level, with a post formed from a tree felled in the period AD 1695–1724 perhaps representing the date of construction of this block, but again being only a single dated timber it should be treated with caution.

The results in Tables 3–5 suggest the trees used grew relatively locally.

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Appendix

Ring width values (0.01mm) for the sequences measured

shakA01

96	127	114	91	99	150	139	117	109	125
157	115	210	224	201	228	341	138	141	94
85	100	94	73	102	139	114	208	296	263
402	305	371	330	382	354				

shakA02

71	75	98	100	97	117	143	127	127	123
204	186	109	144	132	118	131	172	241	240
227	178	321	241	199	333	294	381	328	274
265	383	312	154	177	129	108	100	125	142
160	138	142	142	161	162	161	117	92	136
162	135	142	128	133	155	121	100	99	166
185	195	185	155	128	97	102	98	89	142
161	209	219	161	134	191	197	182	224	130
229	148	143	149	146	186	196			

shakA03

75	81	119	185	189	173	228	235	243	200
262	200	143	152	152	275	284	293	273	215
258	166	115	130	206	214	284	318	232	201
149	141	126	114	112	192	283	261	192	186
272	237	201	205	188	267	197	186	156	121
168	184	185	146	113	73	93	93	117	116
177	162	209	192						

shakA04

267	305	280	377	496	423	152	116	235	303
344	383	421	271	318	244	186	232	335	184
244	238	121	88	75	60	74	80	142	180
209	125	82	103	126	149	147	113	131	153
113	136	89	106	105	139	87	81	123	100
94	101	97	128	200	120	126	154	115	118
117	101	106	124	88	82	55	52	94	73
105	118								

shakA05

118	108	121	208	212	231	285	297	314	245
153	163	323	335	177	164	164	175	132	127
136	97	149	136	136	181	180	137	136	132
118	98	127	133	171	132	90	69	66	85
81	46	61	84	94	131	112	136	139	145
110	59	56	106	109	122	105	102	150	98
58	64	83	124	128	146	104	122	71	73
74	69	66	104	159	89	91	80	98	117
132	126	105	93	66	83	66	83	106	154
121	93	116	88	69	74	62	75	81	76

90 86 73 82 76 49 42 48 52 68
78 48 48 44 38 61 77

shakA06
467 349 292 400 296 343 309 341 431 371
204 199 231 195 203 327 302 418 335 347
327 255 360 344 367 304 290

shakA07
316 485 428 298 290 283 341 413 204 283
327 297 382 223 208 195 214 233 197 232
254 275 312 274 311 333 295 262 296 202
203 283 224 233

shakB01
359 398 362 216 133 138 83 120 212 321
195 301 323 246 256 173 218 291 207 207
281 268 274 223 316 386 208 115 88 93
98 145 115 220 307 372 340 134 80 129
232 196 257 258 246 180 246 291 287 337
294 174 192 122 177 218 265 208 195 180
165 135 175

shakB02
293 306 235 363 630 640 499 450 489 411
398 447 428 590 363 393 324 288 279 400
397 435 380 342 419 383

shakBC01i
210 397 304 303 267 261 337 304 296 272
385 301 191 363 378 259 311 184 254 211
439 282 300

shakBC01ii
343 308 314 374 227 294 332 281 268 349
233 208 228 221 149 179 275

shakC01
336 253 185 214 309 303 451 305 278 106
128 135 178 238 274 267 327 248 355 318
360 317 296 266 278 267 260 147 64 58
127 126 144 175 220 196

shakC02
364 409 429 266 230 270 215 268 259 230
118 76 91 137 162 190 134 232 174 239
319 244 218 229 230 261 165 250 265 202
229 168 184 168 205 242 205 222 236 221
173 267

shakC03
554 306 606 300 245 265 213 309 281 393
396 487 564 212 299

shakC04
478 531 363 303 148 142 263 446 387 381
328 283 263 267 302 402 318 237 153 134
131 233 187 253 281 225

shakE01
92 134 88 119 130 47 46 56 66 46
74 79 89 115 157 113 91 89 56 58
47 100 63 64 117 94 123 138 157 104
140 170 132 110 92 99 170 179 127 144
188 165 169 136 100 79 180 103 247 236
226 231 257 253 116 165 206 171 120 86
50 43 64 67 124 106 75 80 96 79
80 93 94 75 91 97 87 126 118 169
130 102 131 116 126 95 81 87 102 85
65 85 68 153 155 83 161 115 106 123
123 127 152 226 126 128 157 147 129 197
196 141 56 50 111 113 122 143 127 125
105 105 111 111 95 94 96 103 98 98
103 100

shakE02
192 188 159 132 122 335 200 191 228 161
121 130 192 273 237 153 150 188 164 153
100 122 99 194 148 139 132 119 114

shakF01
368 287 396 321 739 247 306 602 386 448
411 366 363 407 277 379 511 469 721 168
83 86 93 246 180 272 306 397 416 683
607 331 53 37 43 42 50 61 152 209
309 337 128 78 61 54 105 166 262 410

shakF02
208 207 234 149 77 125 169 183 157 253
383 246 256 219 379 257 290 193 325 274
333 297 370 434 422 401 361 233 342 305
343 250 320 273 359 224 158 167 162 509
453 377 394 386 650 537 612 740 535 760
805 427

shakG01
190 313 332 270 234 281 286 341 233 218
147 220 303 351 274 216 231 286 320 324
369 340 297 344 315 276 351 239 247 164
89 103 155 187 171 222 195 155 207 154
181 170 165 228 191 191 130 174 201 186

136 144 151 176 151 88 94 123 145 99
118 106 160 155 125 77 105 82 95 97
69 76 68 69 72 183

shakG02
267 382 321 325 277 326 312 308 274 281
225 217 226 312 334 313 357 281 226 256
255 203 253 226 179 255 226 181 199 187
194

shakG03
360 287 311 370 290 285 287 262 295 199
132 168 251 266 357 356 255 213 206 228
341 279 63 91 98 92 112 132 116 129
204 143 138 116 195 225 333 221 194

shakG04
309 327 285 164 139 149 156 241 261 199
194 186 190 204 188 277 151 132 145 87
115 123 137 155 341 262 172 100 95 89
258 207 177

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