RESEARCH DEPARTMENT REPORT SERIES no. 108-2007 ISSN 1749-8775

CLIFTON QUARRY, WORCESTERSHIRE
DENDROCHRONOLOGICAL ANALYSIS OF OAK TIMBERS

SCIENTIFIC DATING REPORT

Ian Tyers

ARCHAEOLOGICAL SCIENCE

ENGLISH HERITAGE

Research Department Report Series 108-2007

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IAN TYERS

NGR SO 846 467

ISSN 1749-8775

SUMMARY

A tree-ring dating programme was commissioned on timbers excavated at Clifton Quarry Worcestershire. The results indicated that the structure, possibly a well, included timbers felled in AD 704/5. This dating evidence was used to inform the publication of the archaeological excavations. This report archives the dendrochronological results.

CONTRIBUTORS

Ian Tyers

ACKNOWLEDGEMENTS

The analysis of the samples from the Clifton Quarry site was funded by York Archaeological Trust (YAT), on behalf of Worcestershire County Council. Practical help and valuable discussions were provided by Ian Panter and Steve Allen from YAT. Andrew Mann from Worcestershire Historic Environment and Archaeology Service (WHEAS) provided site interim reports, plans, and valuable discussion. In 2006, WHEAS undertook an archaeological watching brief and contingency excavation at Clifton Quarry on behalf of Tarmac Limited. Following the discovery of unexpectedly significant deposits of local, regional, and national importance, PPG16 Assistance funding was provided by the Aggregates Levy Sustainability Fund, administered by English Heritage (project 5379), to allow completion of a full programme of analysis.

ARCHIVE LOCATION

Historic Environment Record
Worcestershire Historic Environment and Archaeology Service
University of Worcester
Worcester WR2 6AJ

DATE OF INVESTIGATION

2007

CONTACT DETAILS

Ian Tyers
Dendrochronological Consultancy Ltd, 65 Crimicar Drive Sheffield S10 4EF
Email: ian@dendro.co.uk

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INTRODUCTION

This document is a technical archive report on the tree-ring analysis of six oak timbers excavated at Clifton Quarry, Severn Stoke, Worcestershire (sitecode WSM35069, NGR *c* SO 846 467). Clifton Quarry lies on the eastern side of the river Severn, *c* 7km east of Great Malvern (Fig 1). In 2006, an archaeological watching brief and salvage excavation in advance of a quarry extension was undertaken by the Worcestershire County Council, Historic Environment and Archaeology Service, on behalf of Tarmac Ltd. One of the features excavated consisted of a large pit *c* 3m across and *c* 1m deep that contained a wooden structure, interpreted as a well. The structure consisted of sharpened vertical posts, with substantial planks around the outside of them. This report describes the analytical results of the dendrochronological analysis of some of this material.

METHODOLOGY

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.

Each sample was placed in a deep-freeze for 48 hours in order to consolidate the timber. A surface equivalent to the original horizontal plane of the parent tree was then prepared with a variety of bladed tools. This preparation revealed the width of each successive annual tree ring. Each prepared sample could then be accurately assessed for the number of rings it contained, and at this stage it was also possible to determine whether the sequence of ring widths within it could be reliably resolved. Dendrochronological samples 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 (eg English Heritage 1998) were applied to each suitable sample. The complete sequence of the annual growth rings in the suitable samples were measured to an accuracy of 0.01mm using a micro-computer based travelling stage. The sequence of ring widths were then plotted onto semi-log graph paper to enable visual comparisons to be made between sequences. In addition, cross-correlation algorithms (eg Baillie and Pilcher 1973) were employed to search for positions where the ring sequences were highly correlated (Tyers 2004). 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 cannot be reliably cross-matched, even when enough rings are obtained. With the additional problems of archaeological material it is typically found that less than 80% of apparently suitable archaeological oak samples are datable.

Converting the date obtained for a tree-ring sequence into a useful archaeological 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 10 rings and a maximum of 46 rings as a sapwood estimate.

Where bark-edge or bark survives, the season of felling can be determined by examining the completeness or otherwise of the terminal ring lying directly under the bark. Complete material can be divided into three major categories:

- 'early spring', where only the initial cells of the new growth have begun – this is equivalent to a period in March/April, when the oaks begin leaf-bud formation;
- 'later spring/summer' where the early wood is complete but the late wood is evidently incomplete, which is equivalent to May-through-September of a normal year, and
- 'winter' where the latewood is complete and this is roughly equivalent to September-to-March (of the following year) since the tree is dormant throughout this period and there is no additional growth put on the trunk.

These categories can overlap as not all oaks simultaneously initiate leaf-bud formation at the same time. It should also be noted that slow growing or compressed material cannot always be safely categorised.

Timber technology studies demonstrate that many of the tool marks recorded on archaeological timbers can only have been done on green timber. There is little evidence for long-term storage of timber or of widespread use of seasoned, rather than green, timber in the early medieval period.

Reused timbers can only provide tree-ring dates for the original usage date, not their reuse. Identifying reused timbers requires careful timber recording during or after archaeological field work, which notes the presence of features which are not functional in the structure. It is always possible that some timbers exhibit no evidence of earlier usage, and are thus 'hidden reused' timbers. The dendrochronological impact of this problem is particularly acute where only single timbers have been dated from a structure.

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 slices each have lots of rings but only one has any sapwood or where same-tree identifications yield linkages between different structures.

RESULTS

In September 2007, six subsamples of the plank timbers from the site were supplied by York Archaeological Trust, where they had been sent for detailed recording and conservation. Each sample was provided as a complete cross section. Each was assumed to have been obtained by sawing a cross section from the timber at the optimum location to maximise the dendrochronological potential. Each sample was assessed for the wood type, the number of rings it contained, and whether the sequence of ring widths could be reliably resolved. This assessment confirmed that this material was oak (*Quercus* spp.) and that each appeared to be suitable for dendrochronological analysis.

The six samples were large sections of radial and tangential split oak planks, between 200–345mm in height and 35–90mm thick. One was complete with sapwood and bark. The details of these samples are provided in Table 1.

The six samples were prepared for analysis, measured and then compared with each other. Five of the samples were found to cross-match each other (Table 2). The cross-matched data was combined to create a single composite data set which was then compared with prehistoric, Roman, and medieval tree-ring data from throughout England and Wales. The composite sequence was found to cross-match against mid-Saxon data from chronologies of the Midlands and elsewhere. This cross-matching provided consistent calendar dates for this sequence (Table 3). A summary of the results for the five component samples of the composite sequence are provided in Table 1 and Figure 2. The measurement data are listed in Appendix 1.

DISCUSSION

The site composite sequence was found to strongly match the sequence obtained from the Tamworth horizontal mill (Table 3) as well as other series from across the London, South-East, and Yorkshire regions. There is a general lack of early- and mid-Saxon tree-ring data from the western counties of England. This cross-dating indicated an early 8th century AD date for this group of timbers with the composite tree-ring sequence dated to AD 458–704 inclusive. Five of the six samples were cross-matched; the undated timber does not appear to be different in character from the others. None of the sequences from these samples were sufficiently alike such that they are considered to be derived from a single tree.

The tree-ring analysis dates the rings present in the datable samples. The correct interpretation of those dates relies upon the characteristics of the final rings in the dated samples. One of the dated samples is complete to bark-edge, but the other dated sequences were exclusively heartwood samples, two of which were identified as retaining the terminal heartwood ring. The felling date of the timber complete to bark-edge was identified as having occurred in the winter of AD 704/5, since the timber does not include the preliminary cells of the growth ring for the subsequent year. The other dated samples appear likely to have been felled at the same time, but in the absence of sapwood this cannot be proven. Figure 2 and Table 1 include an interpreted felling date for each of the datable samples. The dated material comprised samples from a selection of timbers forming the plank lining of this wooden structure. The felling date of AD 704/5 identified for these timbers indicates that the structure was in use during the early eighth century. Further archaeological information is required to determine whether the selected timbers represent the initial construction of the structure as opposed to a later repair and whether they are primary rather than reused timbers.

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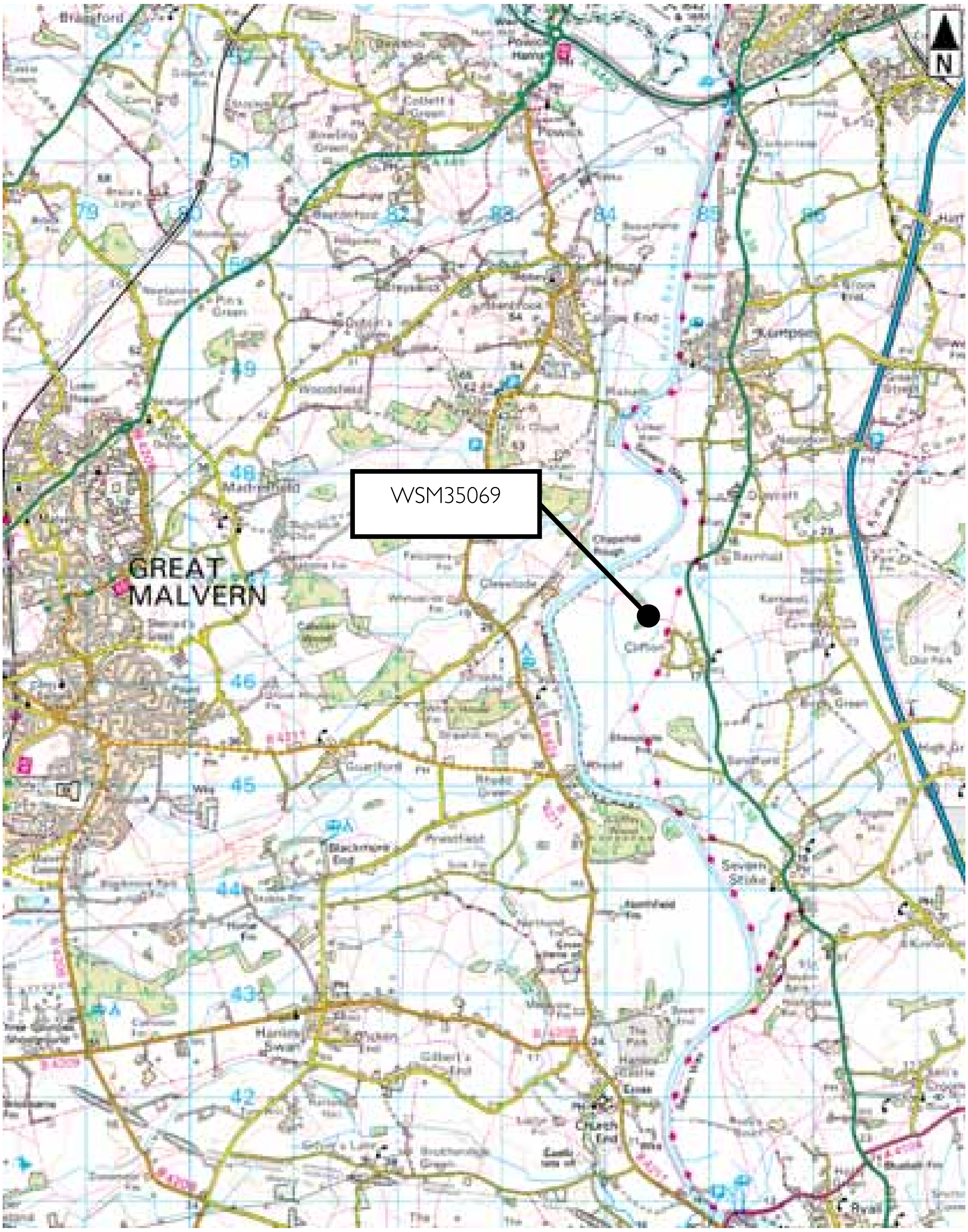


Figure 1. Location of Clifton Quarry, Worcestershire (WSM35069). © Crown Copyright.

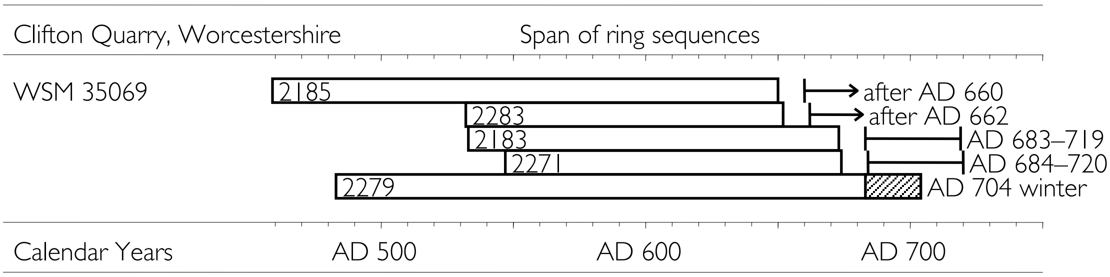


Figure 2. Bar diagram showing the absolute dating positions of the five dated tree-ring sequences for samples from Clifton Quarry site WSM35069. The interpreted felling dates are also shown.

KEY White bars are oak heartwood, hatched bars are oak sapwood.

Table 1. Details of the six oak samples from Clifton Quarry site WSM35069.

Sample	Size (mm)	Rings	Sap	Date of measured sequence	Interpreted result
2183 36	210 x 55	141	H/S	AD 533–673	AD 683–719
2185 47	295 x 45	192	-	AD 459–650	after AD 660
2271 46	200 x 50	128	H/S	AD 547–674	AD 684–720
2278 51	315 x 70	147	?H/S	undated	-
2279 54	345 x 90	222	21+Bw	AD 483–704	AD 704 winter
2283 56	210 x 35	121	-	AD 532–652	after AD 662

KEY In the sap column H/S is heartwood/sapwood edge, ?H/S is possible heartwood/sapwood edge, Bw is bark-edge winter felled.

Table 2. The t-*values (Baillie and Pilcher 1973) between the individual series from the five dated timbers from Clifton Quarry site WSM35069. –* t-*value less than 3.0.*

	2185	2271	2279	2283
2183	3.05	4.61	4.28	4.51
2185		-	4.09	4.72
2271			4.90	4.22
2279				-

Table 3. Showing example t-*values (Baillie and Pilcher 1973) between the composite sequence from the Clifton Quarry site WSM35069 and oak reference data.*

Reference chronology	Clifton Quarry T5 AD 459–704
Berkshire, Old Windsor (Fletcher unpubl data)	4.48
Hampshire, Winchester The Brooks (Hillam 1992)	4.09
Kent, Ebbsfleet horizontal mill (Tyers 2007a)	4.09
London, Bull Wharf UPT90 (Tyers 1994)	4.58
London, Jewel Tower Wharf Abingdon St (Brett unpubl data)	4.39
Staffordshire, Tamworth 72–4 Bolebridge Street (Baillie 1992)	7.36
Yorkshire, Skerne (Hillam unpubl data)	4.37
Yorkshire, Welham Bridge logboat (Tyers 2007b)	5.45

APPENDIX 1

CLQ2183

129	150	144	170	222	181	148	127	130	127
99	108	105	153	185	186	177	210	132	114
127	127	111	115	101	140	134	143	129	123
88	106	117	113	161	180	184	221	223	193
160	153	105	96	83	146	142	138	207	202
136	117	160	154	160	138	156	166	110	125
188	177	196	153	134	138	225	210	224	126
175	209	184	166	186	175	160	142	195	191
160	202	157	171	170	208	160	168	175	144
181	133	87	124	104	124	115	106	132	150
110	99	105	98	90	87	83	100	97	88
135	124	138	180	115	96	88	146	150	129
131	146	131	131	161	167	137	139	141	159
139	100	70	111	153	135	133	110	135	75
78									

CLQ2185

343	383	453	385	371	429	425	490	455	359
285	325	313	268	330	307	334	282	219	118
165	141	170	250	221	179	201	269	266	234
188	185	205	196	244	188	192	172	117	154
156	165	160	169	138	128	143	148	108	77
109	101	99	85	97	97	113	100	150	100
108	98	91	82	98	110	121	139	85	97
99	117	76	60	72	101	83	97	116	84
65	72	86	77	77	101	94	104	99	96
85	71	93	87	63	66	94	96	82	86
89	82	100	87	73	101	69	81	122	154
163	158	154	165	140	166	131	138	199	221
220	177	166	126	117	132	177	138	198	122
173	138	143	146	220	167	173	130	154	133
180	121	106	94	132	136	120	89	112	82
88	150	130	95	125	109	106	137	175	142
149	122	129	123	170	129	89	108	125	156
93	71	95	94	98	119	124	128	132	111
125	107	108	86	103	99	117	114	143	140
96	92								

CLQ2271

97	87	107	143	162	119	143	189	163	84
97	113	144	165	119	115	62	114	82	93
83	142	163	171	165	174	98	106	145	115
93	141	137	89	105	130	147	143	184	189
146	172	180	198	103	97	217	165	169	132
136	95	241	241	183	151	151	135	93	108
149	110	99	131	149	115	118	194	167	112
125	179	112	175	150	176	232	148	150	158
123	188	149	129	167	189	212	181	208	143
260	182	211	267	163	136	137	178	200	147
231	142	179	146	138	173	165	193	163	174
162	171	171	156	102	125	213	155	188	214
185	135	148	178	155	126	125	189		

CLQ2278

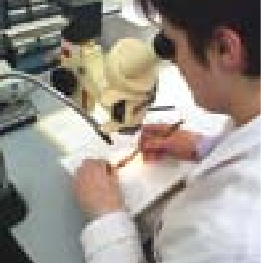
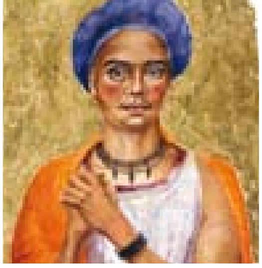
381	585	408	336	351	402	351	349	467	408
254	313	331	295	217	276	290	442	304	353
319	276	261	319	454	346	430	439	396	327
187	227	226	293	257	343	194	277	198	196
163	113	172	229	182	152	133	165	222	179
192	156	105	165	90	140	151	251	114	146
132	118	143	146	115	89	106	105	135	144
176	113	54	89	81	73	82	84	85	101
111	83	92	72	69	63	49	73	44	68
90	77	85	84	97	96	58	55	80	67
109	107	130	117	138	122	128	83	80	66
105	127	188	161	119	131	74	82	70	117
129	177	153	95	114	137	237	218	119	134
210	152	127	151	151	103	99	146	146	102
68	81	56	75	87	106	75			

CLQ2279

492	448	351	337	471	377	350	327	304	416
415	606	561	574	554	455	352	328	253	289
164	231	210	264	245	176	260	231	277	226
194	161	207	161	238	216	167	146	233	155
230	220	230	245	271	241	293	278	322	184
285	251	205	208	249	243	162	160	204	150
166	224	179	204	170	205	154	168	190	146
191	216	227	143	142	150	135	135	144	151
88	128	146	164	159	163	187	202	181	147
107	126	118	127	154	220	205	159	157	179
112	68	76	82	125	80	72	73	76	93
102	66	67	62	67	67	97	102	67	47
51	82	61	42	61	40	48	68	47	38
37	49	41	30	30	41	36	39	40	40
46	56	56	45	34	39	51	39	35	31
39	53	57	56	78	44	45	32	24	26
27	22	24	22	34	32	31	45	38	44
62	102	75	53	94	98	114	87	121	148
158	105	115	204	161	116	124	119	118	95
118	170	203	146	167	131	102	95	104	72
89	117	100	144	125	136	131	140	156	164
161	147	142	162	176	108	108	141	166	125
144	114								

CLQ2283

160	217	149	121	108	190	99	122	119	143
212	137	155	142	157	122	146	123	93	105
123	148	93	115	101	133	118	119	99	127
86	96	112	96	100	91	114	154	170	186
212	156	180	169	145	175	170	176	140	212
191	156	174	285	212	285	212	195	151	146
159	199	174	198	194	193	147	228	196	186
176	207	199	195	193	233	213	164	167	198
156	160	170	133	148	179	243	218	243	286
207	300	184	175	201	170	235	203	146	155
145	187	141	173	129	133	140	140	156	126
119	163	157	185	163	172	163	166	154	193
177									



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