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Summary

A tree-ring dating programme was commissioned on timbers in the late fifteenth-century Old Castle at Dartmouth Castle, Devon, by English Heritage in AD 2003. The tree-ring results indicate that at least one timber felled between AD 1472 and AD 1508 survives in the building.

Keywords

Dendrochronology
Standing Building

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Introduction

This document is a technical archive report on the tree-ring analysis of oak timbers from the Old Castle of Dartmouth Castle nr Dartmouth, Devon (NGR SX 887 503). It is beyond the dendrochronological brief to describe the building in detail or to undertake the production of detailed drawings. Elements of this report may be combined with detailed descriptions, drawings, and other technical reports at some point in the future to form either a comprehensive publication or an archive deposition on the building.

Dartmouth Castle is a Scheduled Ancient Monument that lies on the headland overlooking the mouth of the River Dart (Figs 1 and 2). The dominant structures on the headland are St Petrox church and a series of nineteenth- and twentieth-century defences. To the south-west are the remains of a fourteenth-century castle, whilst to the north-east of the church is the Old Castle, a later fifteenth-century combination of a round and a square tower (Fig 3). The walls of these two elements of the structure are different, and it is usually suggested the round tower was incomplete when the structure was redesigned as a square tower. The construction of this castle was probably begun *c* AD 1481 and not completed till *c* AD 1495. The present guidebook quotes records for the purchase of beams for both parts of the tower roofs during AD 1493-5 (English Heritage 1983, 23).

Tree-ring analysis of floor/ceiling timbers in the round and square parts of the Old Castle, and the framing around the entry hole for a defensive chain across the estuary was commissioned by David Morgan, the local English Heritage Historic Buildings Inspector. It was hoped that the results would help to clarify the construction sequence.

Methodology

The general methodology and working practises used at the Sheffield Dendrochronology Laboratory are described in English Heritage (1998). The methodology used for this building was as follows.

The Old Castle was visited, and an assessment of the dendrochronological potential of the various parts of the structure was undertaken. This assessment aimed to identify whether oak timbers with sufficient numbers of rings for analysis existed in the structure. This assessment identified that there were some suitable timbers. It was also concluded that the Old Castle would have to be sampled on an occasion when it was closed to visitors.

A subsequent visit was made for the dendrochronological sampling. The sampling programme aimed to obtain samples from as broad a range of timbers, in terms of structural element types, scantling sizes, carpentry features, and surface condition as

was possible with respect to their suitability for analysis, their safe access, and within the terms of the request and the relevant Class VII Scheduled Monument Consent.

The most promising timbers were sampled using a 15mm diameter corer attached to an electric drill. The cores were taken as closely as possible along the radius of the timbers so that the maximum number of rings could be obtained for subsequent analysis. The core holes were filled with oak plugs. The ring sequences in the cores were revealed by sanding.

The complete sequences of growth rings in the cores were measured to an accuracy of 0.01mm using a micro-computer based travelling stage (Tyers 1999). The ring sequences were plotted onto semi-log graph paper to enable visual comparisons to be made between sequences. In addition a cross-correlation algorithm (Baillie and Pilcher 1973) was employed to search for positions where the ring sequences were highly correlated. These positions were checked visually using the graphs and, where these were satisfactory, new mean sequences were constructed from the synchronised sequences. The *t*-values reported below are 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 must be obtained from a range of independent sequences, and that these positions are supported by satisfactory visual matching.

All the measured sequences from this assemblage were compared with each other and any found to cross-match were combined to form a site master curve. These, and any remaining unmatched ring sequences, were tested against a range of reference chronologies, using the same matching criteria: high *t*-values, replicated values against a range of chronologies at the same position, and satisfactory visual matching. Where such positions are found these provide calendar dates for the ring-sequence.

The tree-ring dates produced by this process initially only date the rings present in the timber. The interpretation of these dates relies upon the nature of the final rings in the sequence. If the sample ends in the heartwood of the original tree, a *terminus post quem (tpq)* for the felling of the tree is indicated by the date of the last ring plus the addition of the minimum expected number of sapwood rings which are missing. This *tpq* may be many decades prior to the real felling date. Where some of the outer sapwood or the heartwood/sapwood boundary survives on the sample, a felling date range can be calculated using the maximum and minimum number of sapwood rings likely to have been present. The sapwood estimates applied throughout this report are a minimum of 10 and maximum of 46 annual rings, where these figures indicate the 95% confidence limits of the range (Tyers 1998). These figures are applicable to oaks from England and

Wales. Alternatively, if bark-edge survives, then a felling date can be directly utilised from the date of the last surviving ring. The dates obtained by the technique do not by themselves necessarily indicate the date of the structure from which they are derived. It is necessary to incorporate other specialist evidence concerning the re-use of timbers, seasoning, and the repairs of structures before the dendrochronological dates given here can be reliably interpreted as reflecting the construction date of phases within the structure.

Results

In between the assessment and the sampling Rob Harding from the EH regional office had been able to supply diagrams showing some of the repairs that had been undertaken on various occasions in the twentieth century. Once at the Old Castle with these plans, it became apparent that the ground-floor ceiling timbers which had been assessed as suitable on the first visit had been strengthened with steel bars and resin. As a result these timbers could not be sampled. The basement ceiling had been repaired with re-used softwood beams and had already been eliminated at assessment. This left the first-floor ceiling. This consists of just three visible beams running roughly east-west (Fig 3). One of these is in the round tower, one on the square tower, and one is in both. All three timbers were selected for sampling. The only other timber structure for which sampling was requested consists of multiple sills, posts, and lintels around a hole through which a defensive chain could be raised across the estuary. This structure could not be assessed on the original visit because of the number of visitors (it is normally inaccessible to visitors) and, when it was accessed for sampling it was found to be much less suitable than had been hoped. One sample was attempted from one of the three lintels. The samples were numbered **1-4** (Table 1; Fig 3).

All the sampled timbers are oak (*Quercus* spp.). The sample from the chain hole lintel was unsuitable for analysis since it had fragmented during sampling. The tree-ring series from the remaining three sampled timbers from the first-floor ceiling were measured and the resultant series were then compared with each other. None were found to match together. The individual series were then compared with dated reference chronologies from throughout the British Isles and northern Europe. A single well correlated position was identified for the sequence from sample **2**. Table 2 shows example correlations at its identified dating position against independent reference chronologies. Table 1 provides the chronological dates identified for the sample by this process and its interpretation. Figure 4 shows the chronological position identified for the sample. Appendix 1 lists the individual sample series. The other two samples were also compared to the reference chronologies but they are undated by the analysis reported here.

Interpretation and discussion

The 112-year sequence from sample DARTMOUTH2 is dated AD 1351 to AD 1462 inclusive. It is complete to the heartwood/sapwood boundary. Adding the minimum and maximum expected number of sapwood rings to the date of the heartwood/sapwood boundary on this sample suggests it was felled between AD 1472 and AD 1508 (Fig 4; Table 1).

Conclusion

Assuming the timber was felled for immediate usage, which was normal practice in this period (Charles and Charles 1995), then the first-floor ceiling contains at least one timber from the original construction period. Unfortunately the absence of surviving sapwood on any of these timbers, and the inability to date timbers from both parts of the Old Castle structure, prevent the tree-ring analysis from making a significant contribution to the interpretation of the phasing and construction sequence of the Old Castle. It seems possible that this timber is one of those referred to in the extant building accounts for the roofing of the square and round tower during AD 1493-5. These beams cost 13s 4d, 7s 1d, or 5s each depending on size and length (English Heritage 1983, 23).

Acknowledgements

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Figure 1 Location of Dartmouth, Devon, within England and Wales.

Figure 2 Location of Dartmouth Castle, nr Dartmouth, Devon

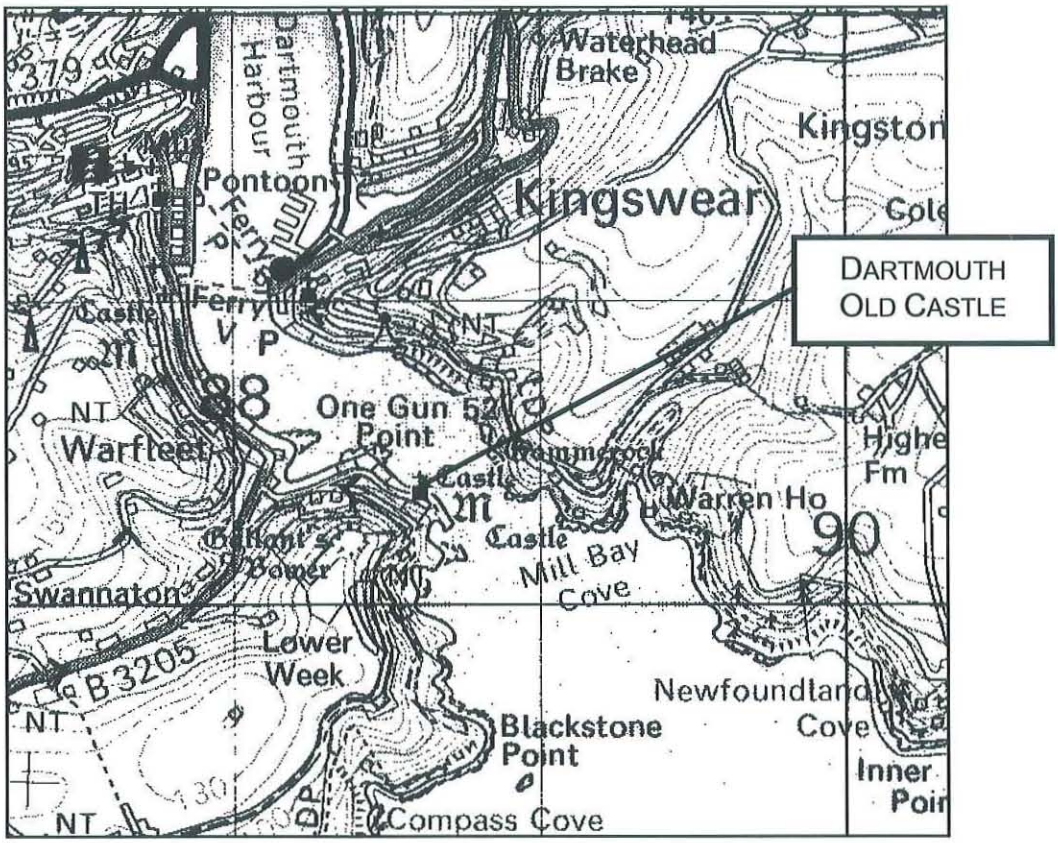


Figure 3 Plan of the basement and first floor ceiling of Dartmouth Castle, nr Dartmouth, Devon. The labelled arrows indicate the approximate locations of the sampled timbers (figure based upon English Heritage 1983, 7)

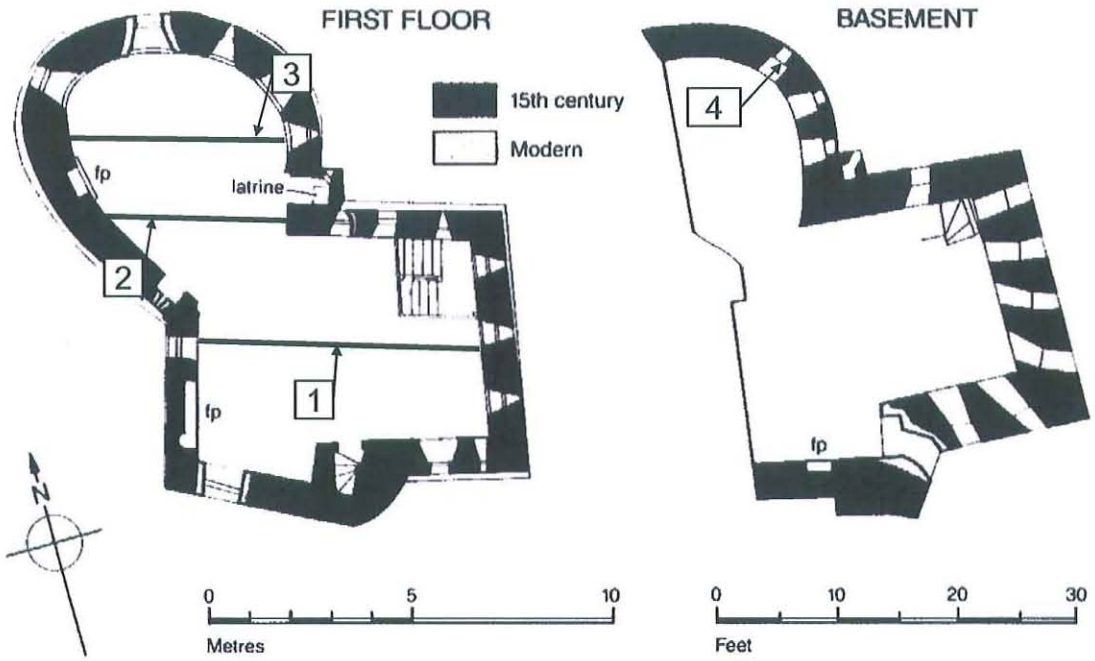
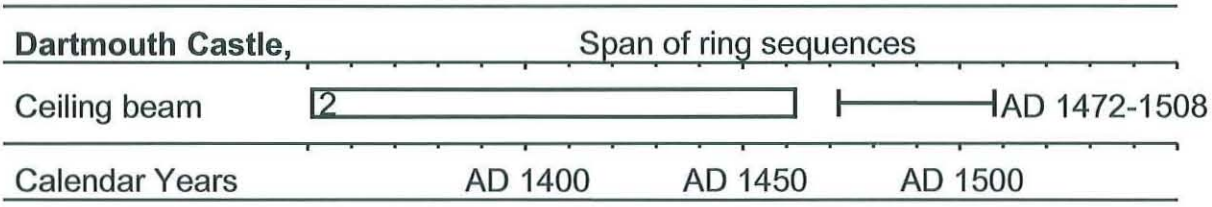


Figure 4 Bar diagram showing the chronological position of the dated timber from Dartmouth Castle, nr Dartmouth, Devon. The estimated felling period for the sample is also shown



KEY for figure 4

heartwood

Table 1 List of samples from the Old Castle at Dartmouth Castle, nr Dartmouth, Devon

Core No	Origin of core	Cross-section size (mm)	Total rings	Sapwood rings	ARW (mm/year)	Date of sequence	Felling period
1	First floor ceiling beam	460 x 400	77	H/S	1.57	undated	-
2	First floor ceiling beam	320 x 300	112	H/S	1.30	AD1351-AD1462	AD1472-1508
3	First floor ceiling beam	260 x 260	57	H/S	2.57	undated	-
4	Chain hole middle lintel	-	-	-	-	unmeasured	-

KEY for Table 1 See Fig 3 for sample locations. The timber from which sample **4** was taken is embedded in the wall and its cross-section dimensions could not be measured. Total rings = all measured rings. Sapwood rings: H/S heartwood/sapwood boundary, ARW = average ring width of the measured rings

Table 2

Dating the sequence DARTMOUTH2, AD 1351-1462 inclusive. Example *t*-values with independent reference chronologies

Reference chronology	*t*-value
Berkshire, Windsor Castle Kitchen (Tyers *et al* 1997)	5.02
Cornwall, Pendennis Castle nr Falmouth (author in prep)	4.23
Cornwall, Roscarrock nr St Endellion (Tyers 2004a)	6.05
Devon, Broomham Kings Nympton (Tyers *et al* 1997)	5.38
Devon, Crediton Holy Cross church (Tyers 2004b)	4.18
Devon, Exeter Bowhill (Tyers and Groves 1999)	4.84
Devon, Prowse Farm Barn (Tyers *et al* 1997)	4.72
Dorset, Sherborne Abbey Church (Bridge 1993)	4.99
London, Hays Wharf Southwark (Tyers 1996a; 1996b)	5.25
Somerset, Muchelney Abbey (Bridge 2002)	4.38

Appendix 1 Ring width data for measured samples from Dartmouth Castle, nr Dartmouth, Devon, 100 = 1mm

dmc1

126	161	196	153	160	194	156	108	147	87
78	58	40	55	195	266	419	350	355	227
145	175	346	211	247	213	120	148	152	166
158	364	264	164	192	240	173	148	215	170
198	208	113	96	130	178	183	186	159	145
128	230	135	179	150	144	111	179	153	133
143	85	103	60	100	88	104	112	72	85
71	66	54	81	45	87	86			

dmc2

168	230	395	163	150	171	291	251	324	258
215	277	187	202	229	141	143	154	148	118
106	121	132	169	142	186	132	120	106	107
93	101	88	89	83	97	109	102	116	84
84	68	90	77	105	79	94	114	129	105
119	102	102	112	111	135	114	129	123	87
67	76	88	127	94	71	53	71	50	76
77	61	113	103	94	83	67	137	131	122
148	159	124	170	200	207	211	193	174	135
123	94	137	96	111	138	121	134	124	98
122	102	98	123	86	116	104	92	98	160
98	110								

dmc3

258	270	332	330	317	320	280	399	394	405
402	365	433	418	289	293	376	333	395	353
312	197	310	304	263	252	265	282	320	271
232	161	180	238	167	159	189	180	161	163
191	195	172	165	179	201	109	258	204	188
198	211	186	139	171	163	176			