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Summary

A number of *ex situ* samples from the nave roof were identified on-site during recent repair work. Though the timbers were found to have unusually sensitive tree-ring series (ie their year-to-year variations were higher than average), six of the timbers subsequently dated. Only two timbers exhibited a heartwood-sapwood boundary. If all the dated timbers are considered to be a single group of primary timbers, their felling date range of **AD 1397 - AD 1409** would suggest that the roof was constructed a little earlier than had been suggested on stylistic grounds. A second site chronology consisting of three timbers failed to date, as did some individual series, though all of these showed similar ring characteristics to the dated samples, strongly suggesting that they might have been contemporaneous with the dated timbers.

Keywords

Dendrochronology
Standing Building

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TREE-RING ANALYSIS OF TIMBERS FROM THE CHURCH OF ST MARY MAGDALENE, DEBENHAM, SUFFOLK

Introduction

The church of St Mary Magdalene (NGR TM 174632; Fig 1) is a grade I listed building of medieval origin, extensively repaired and renovated in Victorian times. This report is a record of dendrochronological studies carried out at the request of Colin Jeffries (English Heritage) on oak timbers removed from the nave roof during recent repairs in an attempt to give a better understanding of the date of this eight-bay roof. The roof has alternate tie beams and hammerbeams from which spring short, moulded, arch braces (Figs 2 and 3). The principal rafters, purlins, and the ridge piece are also moulded and the cornice is embattled. The roof has been stylistically attributed to the fifteenth century by some. Rackham (pers comm 1998) reports the earlier work of Birkin Haward who points out that the arcades at Debenham bear remarkable similarity to those at Bildeston, and that both are thought to be part of a group of about ten churches identified as being worked on by the architect Hawes of Occold in the AD 1420s, though he himself regards the nave roof as more likely of late fifteenth-century origin.

Methodology

The site was visited in January AD 1999 whilst repairs were being undertaken. A number of timbers had been removed during the work and these were assessed for their potential use in dendrochronological study. Oak timbers with more than 50 rings and traces of sapwood were the main considerations in the initial assessment. Those timbers judged to be potentially useful were sliced with a saw, labelled, and stored for subsequent analysis. Their origin within the roof was identified, where possible, by the contractors on site. The sampling included some slices from *ex situ* timbers thought possibly to have been later repairs to the roof, these were labelled A-D. The slices were prepared for measuring by sanding using an electric belt-sander with progressively finer grit papers down to 400 grit. Any further preparation necessary, eg where bands of narrow rings occurred, was done manually. Only samples with more than 45-50 rings were measured and used in subsequent analyses as sequences with fewer than this number of rings rarely give reliable crossmatching. Suitable samples had their tree-ring sequences measured to an accuracy of 0.01 mm using a specially constructed system utilizing a binocular microscope with the sample mounted on a travelling stage with a linear transducer linked to a PC. The software used in measuring and subsequent analysis was written by Ian Tyers (1999a).

Ring sequences were plotted to allow visual comparisons to be made between sequences on a light table. This activity also acts as a measure of quality control in identifying any errors in the measurements when the samples crossmatch. Statistical comparisons were made using Student's *t*-test (Baillie and Pilcher 1973; Munro 1984). The *t*-values quoted below were derived from the original CROS program (Baillie and Pilcher 1973). Those *t*-values in excess of 3.5 are taken to be indicative of acceptable matching positions provided that they are supported by satisfactory visual matches, and give consistent matching positions.

When crossmatching between samples is found, their ring-width sequences are meaned to form an internal site mean sequence which is then compared with a number of reference chronologies (multi-site chronologies from a region) and dated individual site masters in an attempt to date it.

Individual long series which are not included in the site mean(s) are also compared with the database to see if they can be dated.

The dates thus obtained represent the time of formation of the rings available on each sample. Interpretation of these dates then has to be undertaken to relate these findings to the construction date of the phase under investigation. An important aspect of this interpretation is the estimate of the number of sapwood rings missing. In this instance, the sapwood estimates are based on those proposed for this area by Miles (1997), in which 95% of samples are likely to have from 9 to 41 sapwood rings. Where bark is present on the sample the exact date of felling of the tree used may be determined.

The dates derived for the felling of the trees used in construction do not necessarily relate directly to the date of construction of the building. However, evidence suggests that, except in the re-use of timbers, construction in most historical periods took place within a very few years after felling (Salzman 1952; Hollstein 1965).

Results

All the timbers sampled were oak (*Quercus* spp.). Details of each sample are given in Table 1. The year-to-year variation in ring-width was greater than is often encountered in historic oak timbers (their sequences are said to be 'sensitive'), and the levels of crossmatching within the samples were in most cases quite low, though timbers DBM 07, 12, and 14 crossmatched well (Tables 2 and 3). Individual samples were crossmatched with a range of reference series in order to confirm the internal crossmatching found (Table 4). Whilst the shortest sequence (DBM11) did not match so well with the reference material, it matched well against a combined series made from DBM 04, 05, 06, 09, and 10. Two site chronologies were eventually formed, DEBENHAM1 (comprising samples DBM 04, 05 , 06, 09, 10, and 11) and DEBENHAM2 (comprising samples DBM 07, 12, and 14). Both were compared with available reference chronologies from both regional and site chronologies, with the result that DEBENHAM1 was dated to the period AD 1256-1388 (Table 5) and DEBENHAM2 (Figure 6) remains undated. Possible crossmatches in the late fourteenth-century were found both for DEBENHAM2 and some of the other undated individual sample ring-width series, though these were neither strong enough, nor sufficiently consistent to be considered as having been dated. The relative positions of overlap of the sequences in each site chronology are shown in Figures 4 and 5. The data for the two site chronologies are given in Table 6.

Interpretation and Discussion

Many of the undated sequences showed parts of their ring-width patterns that resembled the other sequences, but they did not show consistent crossmatching. All the sequences of the timbers thought to be original to the nave roof showed similar characteristics of sensitivity, and it is thought that they probably all form a single batch. Only five of the sequences gave consistent crossmatches with the reference material, but DBM11 was added to these because of its strong internal crossmatching with a working chronology formed from the five dated sequences. The resulting dated chronology DEBENHAM1 gave very strong matches with a number of reference chronologies, mostly from the East Anglian region, perhaps indicating that the timbers were relatively local, although the individual sequences dated against chronologies

from a wide geographical area. The sensitivity of the data, exemplified by the plot in Figure 6, may result from micro-site peculiarities or management of the trees, and these unusual sudden growth changes render the series less likely to date.

The lack of sapwood and bark edge makes interpretation of the felling date of the timbers used more difficult. If the timbers really are from a single batch, then the combined felling dates from the dated timbers would suggest a felling date range of **AD 1397 – 1409**. This date is rather earlier than had previously been proposed on stylistic grounds, and would suggest that this church roof may not be the work of the architect Hawes. The four timbers DBM A-D were thought possibly to represent later repairs to the roof. Sadly none of these sequences dated and therefore they do not add any further information at present.

Acknowledgements

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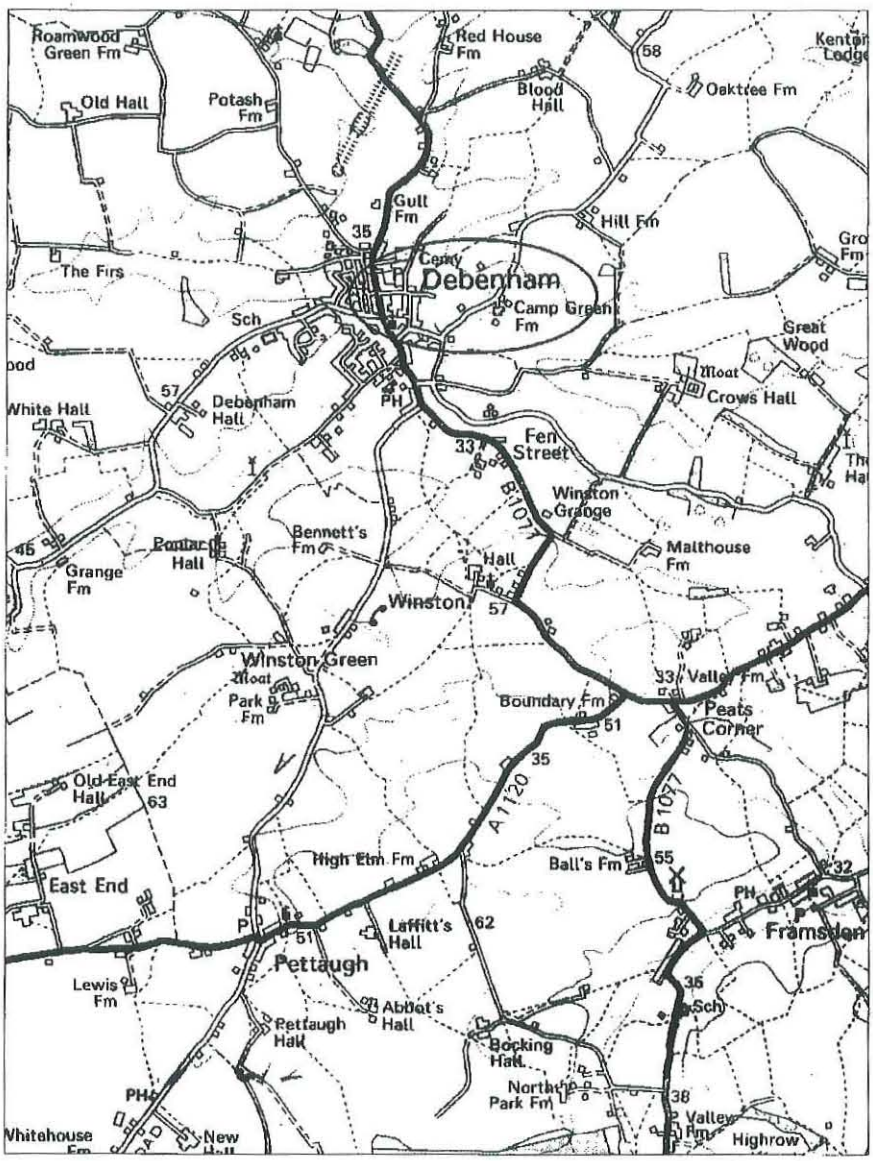

Figure 1: Map to show the general location of Church of St Mary Magdalene, Debenham,

Figure 2: View of the nave roof showing moulded purlins and principal rafter and embattled tie beam (photo A F Knight Builders of Debenham)

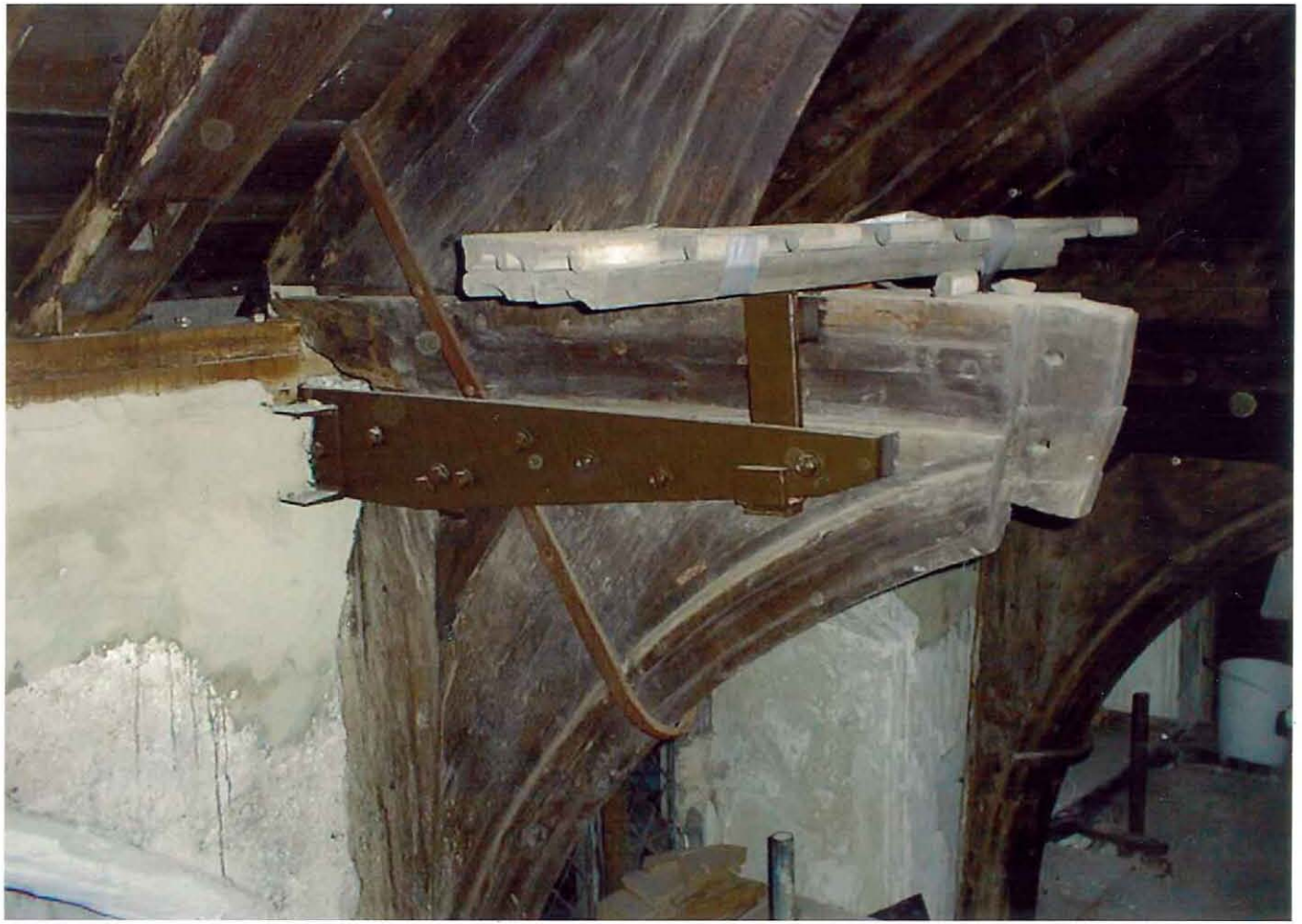

Figure 3: View of the nave roof showing arch brace and hammerbeam under repair (photo A F Knight Builders of Debenham)

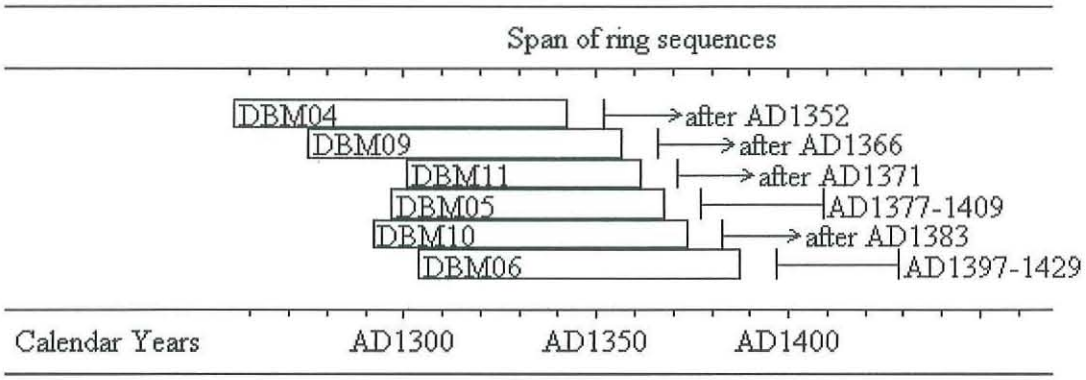

Figure 4: Bar diagram showing the relative positions of overlap of the dated samples in site chronology DEBENHAM1, along with the interpreted dates of felling.

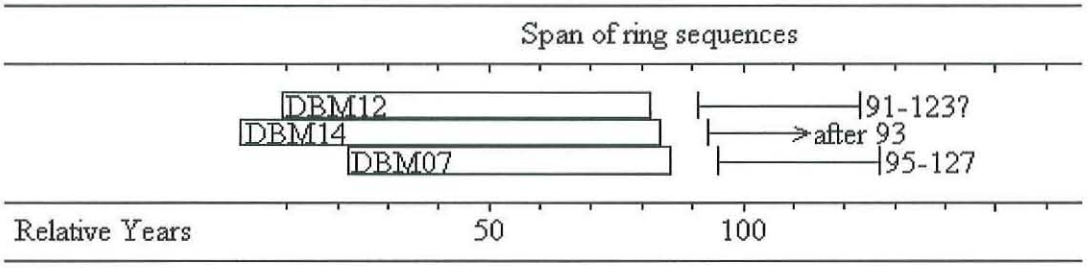

Figure 5: Bar diagram showing the relative positions of overlap of the samples included in site chronology DEBENHAM2

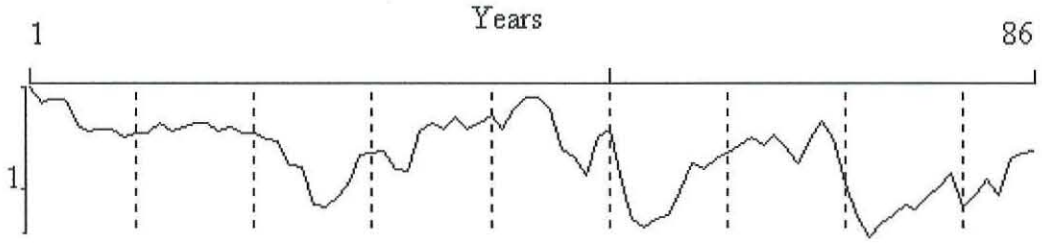

Figure 6: Plot of DEBENHAM2, showing the 'sensitive' nature of the series with its pronounced changes in ring width

Table 1: Oak (*Quercus* spp.) timbers sampled from St Mary Magdalene Church, Debenham, Suffolk. h/s = heartwood-sapwood boundary

Sample number	Origin of slice	Mark on timber	Total no of years	Average growth rate (mm yr^{-1})	Sapwood details	Date of sequence AD	Felling date of timber AD
DBM01	Rafter		61	2.57	-	undated	unknown
DBM02	?Rafter		27	unmeasured	-	undated	unknown
DBM03	?Rafter		>40	unmeasured	-	undated	unknown
DBM04	Wall plate		88	1.73	-	1256 - 1343	after 1352
DBM05	ashlar piece		72	1.52	h/s	1297 - 1368	1377 - 1409
DBM06	?Rafter		85	1.60	h/s	1304 - 88	1397 - 1429
DBM07	Ashlar piece		65	2.09	h/s	undated	unknown
DBM08	Ashlar piece		95	1.61	-	undated	unknown
DBM09	Ashlar piece		83	1.86	-	1275 - 1357	after 1366
DBM10	Ashlar piece		83	1.24	-	1292 - 1374	after 1383
DBM11	Cornice piece		62	1.92	-	1301 - 62	after 1371
DBM12	Ashlar piece		74	1.73	?h/s	undated	unknown
DBM13	Ashlar piece		>40	unmeasured	-	undated	unknown
DBM14	?Rafter		84	1.75	-	undated	unknown
DBM15	uncertain		77	2.06	-	undated	unknown
DBM16	uncertain		>40	unmeasured	-	undated	unknown
DBM17	uncertain		60	2.00	-	undated	unknown

Table 1 continued:

Sample number	Origin of slice	Mark on timber	Total no of years	Average growth rate (mm yr^{-1})	Sapwood details	Date of sequence AD	Felling date of timber AD
DBM'A'	Nailed on repair to wall plate		60	2.11	17 sap + bark	undated	unknown
DBM'B'	Repair		>40	unmeasured	-	undated	unknown
DBM'C'	Repair		94	1.43	h/s	undated	unknown
DBM'D'	Repair		>40	unmeasured	-	undated	unknown

Table 2: Crossmatching between the dated timbers in the site chronology DEBENHAM1. (-) represents *t*-value less than 3.0

	***t*-value**				
SAMPLE	**DBM05**	**DBM06**	**DBM09**	**DBM10**	**DBM11**
DBM04	-	4.7	-	-	3.3
DBM05		3.3	3.9	3.6	3.1
DBM06			3.9	4.9	4.3
DBM09				-	-
DBM10					-

Table 3: Crossmatching between the dated timbers in the site chronology DEBENHAM2. (-) represents *t*-value less than 3.0

	***t*-value**	
SAMPLE	**DBM12**	**DBM14**
DBM07	7.9	8.4
DBM12		6.9

Table 4: Independent dating of the elements of site chronology DEBENHAM1. (-) represents value less than 3.0

	t-value and overlap (yrs)					
Series	**DBM04** **AD1256 - 1343**	**DBM05** **AD 1297 - 1368**	**DBM06** **AD 1304 - 88**	**DBM09** **AD 1275 - 1357**	**DBM10** **AD 1292 - 1374**	**DBM11** **AD 1301 - 62**
Feb2000 (Bridge unpubl)	4.7 (88)	5.3 (72)	4.6 (85)	5.0 (83)	7.0 (83)	3.5 (62)
London1175 (Tyers pers comm)	4.3 (88)	4.5 (72)	3.5 (85)	4.6 (83)	5.1 (83)	-
East Midlands (Laxton and Litton 1988)	4.8 (88)	-	4.0 (85)	4.0 (83)	3.9 (83)	-
Hants97 (Miles pers comm)	4.6 (88)	3.6 (72)	3.7 (85)	4.5 (83)	4.9 (83)	-
Oxon93 (Miles pers comm)	5.2 (88)	3.9 (72)	4.5 (85)	3.4 (83)	3.9 (83)	-
Kent (Laxton and Litton 1989)	-	4.6 (72)	6.4 (85)	5.5 (83)	5.0 (83)	-
Thetford, Norfolk (Howard *et al* 2000)	5.1 (88)	3.1 (72)	5.8 (85)	3.3 (83)	3.9 (83)	3.9 (62)
Toddington, Bedfordshire (Bridge forthcoming)	6.0 (88)	3.6 (72)	4.6 (85)	-	6.4 (83)	5.7 (62)
Twyning, Gloucestershire (1996a)	5.4 (88)	5.3 (72)	3.5 (85)	3.3 (83)	5.8 (83)	4.3 (62)

Table 5: Dating of the oak site chronology DEBENHAM1

	DEBENHAM1 AD 1256 - 1388	
Dated reference or site master chronology	*t*-value	Overlap (yrs)
Feb2000 (Bridge unpubl)	6.4	133
Hants97 (Miles pers comm)	5.6	133
London1175 (Tyers pers comm)	5.5	133
Kent88 (Laxton and Litton 1989)	5.4	133
Thetford, Norfolk (Howard *et al* 2000)	7.2	133
High Halden, Kent (Bridge 1987)	6.5	90
Twyning, Gloucestershire (Tyers 1996a)	6.1	133
Chicksands, Bedfordshire (Howard *et al* 1998)	5.9	133
Dunmow, Essex (Bridge 1999)	5.6	62
Cann Hall, Essex (Tyers 1998)	5.2	88
Marriots, Norfolk (Tyers 1999b)	4.9	79
Bletchley, Buckinghamshire (Bridge 1987)	4.8	83
Woodham Walter, Essex (Tyers 1996b)	4.6	97
Toddington, Bedfordshire (Bridge forthcoming)	4.5	133

Table 6: Ring-width data for the site chronologies DEBENHAM1 and DEBENHAM2

Year	ring widths (0.01mm)										no of samples									
DEBENHAM1																				
AD 1256	112	311	206	159	215	169	221	198	193	165	1	1	1	1	1	1	1	1	1	1
	148	145	162	169	137	162	153	209	81	139	1	1	1	1	1	1	1	1	1	2
	171	151	119	130	141	140	255	160	171	193	2	2	2	2	2	2	2	2	2	2
	231	156	139	267	320	241	266	194	220	175	2	2	2	2	2	2	3	3	3	3
	229	133	148	149	176	176	163	145	173	171	3	4	4	4	4	5	5	5	6	6
AD 1306	183	230	229	214	183	146	201	212	265	266	6	6	6	6	6	6	6	6	6	6
	223	167	117	166	201	184	160	161	158	133	6	6	6	6	6	6	6	6	6	6
	92	135	162	216	148	108	119	121	149	195	6	6	6	6	6	6	6	6	6	6
	144	155	138	164	147	133	148	136	116	135	6	6	6	6	6	6	6	6	5	5
	132	127	115	94	127	174	138	170	158	104	5	5	5	5	5	5	5	5	5	5
AD 1356	116	140	127	109	135	127	153	220	178	130	5	5	4	4	4	4	4	3	3	3
	111	116	116	184	196	157	183	148	147	165	3	3	3	2	2	2	2	2	2	1
	195	170	187	94	135	244	255	225	92	166	1	1	1	1	1	1	1	1	1	1
	199	251	255								1	1	1							
DEBENHAM2																				
1	482	373	409	394	272	245	251	253	221	236	1	1	1	1	1	1	1	1	2	2
	237	276	247	260	278	273	243	257	234	235	2	2	2	2	2	2	2	2	2	2
	214	212	148	143	79	77	90	114	168	176	2	3	3	3	3	3	3	3	3	3
	179	139	134	242	277	249	299	255	280	315	3	3	3	3	3	3	3	3	3	3
	251	338	415	408	340	185	167	127	223	254	3	3	3	3	3	3	3	3	3	3
51	110	64	58	64	68	98	151	137	161	177	3	3	3	3	3	3	3	3	3	3
	198	221	197	228	193	150	219	288	218	110	3	3	3	3	3	3	3	3	3	3
	66	50	61	68	80	74	91	106	128	78	3	3	3	3	3	3	3	3	3	3
	93	119	94	158	174	182					3	3	2	2	1	1				