

Ancient Monuments Laboratory
Report 63/1999

TREE-RING ANALYSIS OF TIMBERS
FROM THE MANOR HOUSE,
MEDBOURNE, LEICESTERSHIRE

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Summary

Thirty-two samples from Medbourne Manor were analysed by tree-ring dating. This analysis produced two site chronologies. The first, consisting of twenty samples, has 220 rings spanning the period AD 1068-1287. The site chronology, composed of three samples, has 102 rings spanning the period AD 1045-1146. A single sample of 121 rings was dated as spanning the period AD 1393-1467.

Interpretation of the sapwood on the dated samples would indicate that there are at least four phases of felling represented. It would appear that the north bay of the hall is the earliest, with an estimated felling date in the range AD 1212-1232.

The next phase is represented by the timbers reused as arcade plates and the timbers of truss B, which have a felling date of AD 1237.

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Introduction

The Manor House, Medbourne (SP 803930; Fig 1) is a grade II* listed building consisting of a medieval hall with a base cruck and a service wing. The surviving hall is of two bays with a central truss (plans and long sections are provided in Figs 2a-c). The roof of the hall range consists of coupled rafters with notched lapped collars and soulaces. The rafters have scotched seatings into longitudinal plates. These plates are square set like arcade plates on the both the east and west sides. Both have splayed and tabled scarf joints near the central truss of early "trait de Jupiter" type with several face pegs.

The central truss (A; see Fig 3) dividing the 2 bays of the hall range is of base cruck/short principal type, but with only one blade, on the east side. The surviving structure appears as a single-aisled base-cruck, the arcade plate supported by the base cruck forming an aisle on the east side, with the stone wall built up higher to support the plate directly on the west side. The central truss has two tiebeams which sandwich the arcade plates, the plate being trenched into the lower tie. A feature of this truss is a trench for a former passing brace on the upper tiebeam at both ends, suggesting it is reused. The single cruck blade is slightly curved and has a tenoned joint to the tiebeam. It disappears into the stone wall at a high level and may therefore have been a "short principal rafter" rather than a base cruck reaching further down towards the ground. A heavy squarish brace runs up from a tenoned joint in the blade to join the tiebeam, but this section has been cut out for a later doorway. A similar brace is tenoned to the tiebeam on the west side, which suggests it may have joined to a matching cruck blade, now gone. Only the underside of the tiebeam and braces have plain chamfers. On the east side the arcade plate is supported by straight, squarish braces chamfered to the underside with run-out stops and tenoned to the blade. Similar braces rise from the stone walls at the end of each bay to support the plate. The south brace is tenoned to the plate, but the next brace now has only a birdsmouth joint; joints to the remaining two braces are not visible.

The roof also has an upper truss structure (truss B; see Fig 4) which is located slightly to one side of the central base cruck truss (truss A). This has a tiebeam seated on the arcade plate and a complex upper structure of rafters, collar, and passing braces with notch-lap or straight lap-joints. Its peculiar asymmetry is unusual, the normal form having parallel rafters with scissors bracing. The passing braces on both the east and west sides are trenched right across the tiebeam and appear to have been cut off, suggesting that they continued downwards to join lower members, possibly aisle posts, in the normal arrangement of such passing braces.

On structural grounds it is difficult to explain the presence of this braced upper truss structure, truss B, in this location, offset and seemingly unrelated to the central base cruck truss, truss A. This is especially so as the features of both trusses are consistent with an early date of AD 1300 or before.

A few other features point to further complexities. The southwest arcade plate has matrices for two early lap joints on its top face and there are indications of a possible similar matrix on the southeast arcade plate, all suggesting that the timbers are reused. Even clearer is a lap matrix to the underside of the northeast arcade plate, just underneath the "trait de Jupiter" scarf joint. The most likely previous use for such large timbers with big lap joints is as aisle posts - an intriguing pointer to an even earlier aisled building on the site.

The crosswing roof has been completely replaced with a purlin and rafter roof of late-nineteenth century date. One surviving rafter couple now located over the stone wall with the cross-passage doorways is smoke-blackened, with notch-lapped matrices of a different arrangement to the hall roof, suggesting a continuation of an early in-line roof over the service end. At first-floor level two slightly curved timbers against the south wall must be cruck blades from an earlier structure. The stone walls have been built to accommodate and support the blades below first-floor level, and they have both been cut off at first-floor ceiling level. The only other feature possibly relating to the earlier roof is an odd timber projecting at a strange angle from the first-floor ceiling by the west wall, possibly a brace.

The documentary evidence suggests that Medbourne Manor was built principally by Thomas de Chaworth, some time between his grant of free warren on the Medbourne demesne in AD 1257 and his death before AD 1315. The plainness of the cross passage doorways makes them difficult to date precisely, and the complications of the hall roof timbers are also confusing. Nevertheless, both point towards a late-thirteenth century date which is consistent with construction by Thomas de Chaworth. However, the documentary evidence indicates that the Chaworth family were in occupation of the site from at least AD 1235, and it is likely that there were several earlier phases dating back to the late-eleventh century or even earlier.

The principal early phase of the building includes both the hall and crosswing, and dates from the later thirteenth century. There was an open hall of two bays, divided by a central truss of base cruck/short principal type (short principal roofs are similar to base crucks, but the principals are seated at a higher level in stone walls). The upper roof structure of the hall survives fairly intact, with arcade plates to either side, jointed with "trait de Jupiter" scarfs, which support a common rafter roof with notch-lapped joints to collar and soulaces. Big square braces run from the base crucks to the lower tiebeam and also up to the arcade plates. All the features of the roof timbers, including the joint types and squarish scantling, are consistent with an early date, certainly pre- AD 1300.

As originally built, the hall was wider but the "aisle" to the west was removed and a stone wall built up to the underside of the arcade plate. At the lower end of the hall was the cross-passage, with its fine set of three late thirteenth-century stone doorways, with two-centred arched heads, hood moulding, and plain chamfered jambs with big pyramid stops. The typical medieval arrangement at the service end had doors to either side for pantry and buttery, with the central door leading via a passage to a separate kitchen, at this date a detached block. No doubt this was the arrangement here, but the ground floor has since been reformed. Above the service rooms on the first floor it seems there was a fine solar, which must have formed the principal chamber of the early house. Evidence for this is contained in an account of a visit in AD 1858 by the Leicestershire Architectural Society. There were then two arched timbers in the roof with nail-head ornament and, high in the east gable, an unglazed two-light pointed window with an octagonal mullion and capital. Both these features are consistent with the late thirteenth-century phase of the building. Unfortunately, both the upper roof timbers and the gable window were lost in the nineteenth century, but two cruck-shaped blades remain in the south wall, cut off both above and below, but no doubt dating from this early structure, and indicating that the solar was three bays in length. It is unclear whether the solar roof was of base cruck or cruck type; use of base crucks in a crosswing would be unusual, though it would give a more likely location for nail-head ornament, while use of crucks at this date would be very early.

The walls to both hall and crosswing of this later thirteenth-century building were of stone not timber, as indicated by the cross-passage doorways and the base cruck/short principal blade seated at high level in the wall. It seems highly probable that this substantial house was built by Thomas de Chaworth, some time between his grant of free warren on the Medbourne demesnes in AD 1257 and well before his death by AD 1315.

However, some anomalies in the hall roof point to other complexities. There is a strange asymmetric truss with notch-lapped joints and cut-off passing braces, oddly located very close to the base cruck truss. This truss also appears to be of thirteenth-century date, but might relate to an earlier phase, the passing braces connecting to aisle posts. The arcade plates have three matrices for early lap joints on their upper faces, which suggest re-use and one on the underside of a scarf joint which certainly proves the timber had a previous use in an even earlier building, perhaps as an aisle post. As the documentary evidence shows that the Chaworths were in occupation of the site from at least AD 1235, it seems likely that there were earlier phases, perhaps even reaching back into the twelfth century. There are interesting lines of earthworks discernible in the grassland immediately to the east and north of the house which are suggestive of an early enclosure sweeping around here, as might be expected for such an early date. The extent of later changes here, with the farmyard and a railway cutting, make interpretation uncertain.

Some time after AD 1300 the west aisle was removed and the new west wall was built up in stone underneath the arcade plate. The ironstone walling here, more random than the later coursed facings, may well be of early date. A further bay may also have been added to the north end of the hall, probably of two floors, though later

reduced to a single storey. The principal chamber over the service area seems to have retained its status for a long period, with the insertion in the west gable of a fine heavily moulded two-light stone window which can be ascribed to c AD 1500, though later re-set with square heads to the lights.

The next major development probably occurred in the later-sixteenth century. A great chimney stack was inserted in the hall, replacing the open hearth, accompanied by the insertion of the first floor, with a heavy beamed ceiling. The fine wall painting series, of which only a fragment is now visible, would also date to this period and indicate the high status of the manor before the slow decline which was to follow. In a reversal of roles the hall probably now became the kitchen block, with service rooms to its north. The former service crosswing was much rebuilt and refaced, with an impressive parlour and modern fireplace on the ground floor, though retaining the earlier cruck-framed roof structure and first-floor window. On the first floor two chambers were created in the crosswing, apparently unheated, divided by timber partitions from the stairway access, with further accommodation (also unheated) over the former hall.

With the sale of the manor to Henry Nevill of Holt in AD 1631 and occupation by a Nevill tenant, the manor's greatest period was over. Piecemeal development continued throughout the seventeenth and eighteenth centuries, with various new stone mullioned windows and re-facing of walls. The service end to the north of the hall, having declined in status, may have been further reduced to a single storey in this period, with the further extension of the crosswing to the east. The house was renovated in AD 1878 when it passed out of use as a farmhouse, with the loss of much of the farmyard to the new road and railway line. This was probably the point when the former cruck-framed roof structure to the crosswing was replaced; one of the sawn-off blades may have been used as the lintel for the new front porch. Major roof repairs were carried out in AD 1974, with new replacement oak rafter couples to the south end of the hall block.

Sampling and analysis by tree-ring dating was commissioned by English Heritage. The purpose of this was to establish the relative dating of the two trusses, truss A and truss B, and to confirm whether or not the roof of each bay of the hall range was of the same date. Analysis was also requested for reused timbers to determine a possible date for their original use.

The Laboratory would like to take this opportunity to thank Mr and Mrs Heyman, the owners of the Manor House, for allowing sampling and for their generous hospitality. The Laboratory would also like to thank Nicholas Hill of English Heritage for his unstinting help in sampling and for providing the introduction to the site given above.

Sampling

For the purposes of sample location all the frames and bays have been numbered from north to south. Sampling of the timbers was undertaken after discussion with Nicholas Hill, who suggested that there were possibly four main periods of timber felling represented, plus one or more period of reused timbers. It was believed that the timbers of truss A and the timbers of the south bay of the hall roof were of one phase, the timbers of truss B a second phase, and the north bay of the hall roof a third phase. The timbers of the cross-wing represented the fourth major felling phase. A few timbers within the south bay of the hall roof showed signs of reuse, as evidenced by the presence of redundant mortises.

A total of thirty-two core samples were obtained from this building. Each sample was given the code MDB-A (for Medbourne, site A") and numbered 01–32. The positions of the samples were recorded on plans provided by Nicholas Hill. These are reproduced here as Figures 5a/b/c.

Eleven samples, MDB-A01-11, were obtained from the timbers of truss A and the roof of the south bay of the hall, including one timber showing evidence for reuse (the southwest arcade plate, sample MDB-A01). Only one timber from the cross-wing, the south blade of truss D, appeared to be suitable for tree-ring analysis and this was sampled as MDB-A12. Five samples, MDB-A13-17, were obtained from truss B. Twelve samples, MDB-

A18-29, were obtained from the north bay of the hall range roof, with two samples, MDB-A30 and A31, being obtained from reused timbers in this roof. A single sample, MDB-A32, was obtained from what was believed to be a cruck blade from the cross-wing, now reused as a door lintel. Details of the samples are given in Table 1. In this table timbers are described and located by their truss or frame number, as given in the plans provided by English Heritage and after discussion with Nicholas Hill.

Analysis

Each sample was prepared by sanding and polishing and the growth-ring widths of all thirty-two were measured. The data of these measurements are given at the end of the report. The growth-ring widths of the samples were compared with each other by the Litton/Zainodin grouping procedure (see appendix) and at a minimum t-value of 4.5 two groups of samples formed.

The twenty samples of the first group cross-matched with each other at relative positions as shown in the bar diagram Figure 6. The growth-ring widths of the twenty samples were combined at these relative off-set positions to form MDBASQ01, a site chronology of 220 rings. Site chronology MDBASQ01 was compared with a series of relevant reference chronologies for oak, giving it a first ring date of AD 1068 and a last measured ring date of AD 1287. Evidence for this dating is given in the t-values of Table 2.

The relative positions of the heartwood/sapwood boundaries on the samples in this site chronology suggest that there are possibly as many as four phases of felling. Each of these four felling phases appears to correspond in general with a distinct constructional element of the building: truss A, truss B, and the north and south bays of the hall roof.

The three samples of the second group cross-matched with each other at relative positions as shown in the bar diagram Figure 7. The growth-ring widths of these three samples were combined at these relative off-set positions to form MDBASQ02, a site chronology of 102 rings. Site chronology MDBASQ02 was compared with a series of relevant reference chronologies for oak, giving it a first ring date of AD 1045 and a last measured ring date of AD 1146. Evidence for this dating is given in the t-values of Table 3.

The two site chronologies were compared with the nine remaining ungrouped samples, and with each other. In neither case was there any satisfactory cross-matching. Each of the nine remaining ungrouped samples was therefore compared individually with a full range of reference chronologies. This indicated a satisfactory cross-match for sample MDB-A12 only (from the blade of truss D of the cross-wing), with a first ring date of AD 1393 and a last measured ring date of AD 1467. Evidence for this dating is given in the t-values of Table 4.

Interpretation

It appears that in total four, or possibly five, phases of felling may be represented. The earliest possible phase is probably represented by samples A19, A20, A22, A23, and A26 of site chronology MDBASQ01 and probably by samples MDB-A24, A28, and A29 of site chronology MDBASQ02; all these samples are from timbers of the north bay of the hall roof. Taking the heartwood/sapwood boundary on the four samples in this group where it exists (MDB-A19, A22, A23, and A26) gives an average last heartwood ring date of AD 1197. Using a 95% confidence limit for the amount of sapwood on oaks from this part of England of 15–35 rings would give these timbers an estimated felling date in the range AD 1212-1232.

The next phase of felling may be represented by samples MDB-A01, A30, and A31, the timbers reused as arcade plates. The average last heartwood ring date of these is AD 1213. Using the same 95% confidence limits for sapwood would give these timbers an estimated felling date in the range AD 1228-1248.

The third phase of felling is represented by the samples from Truss B: MDB-A13, A15, A16, and A17. Three of these samples retain complete sapwood and have the same last measured complete sapwood ring date, AD 1237. It is probable that this phase is also represented by sample MDB-A11. Although from a timber in the south bay of the hall roof this sample too has complete sapwood with a last measured sapwood ring date of AD 1238. Such a felling date is quite at odds with all the other timbers from the south bay and it is probably reused here.

It is possible that the timbers of truss B and the timbers reused as arcade plates are of the same felling phase. The estimated felling date range of the reused timbers, AD 1228 – 1248, encompasses the felling date of the timbers of truss B, AD 1237.

The fourth phase of felling appears to be represented by samples MDB-A01, A02, A03, A04, A07, A08, A09, and A10, from truss A and the south bay of the hall roof. One sample in this group, MDB-A02, retains complete sapwood with a last measured ring date of AD 1287. The relative positions of the heartwood/sapwood boundaries on the other samples in this group where they exist are highly consistent with such a felling date.

The fifth and final possible felling date is represented by sample MDB-A12 from truss D of the cross-wing. This sample has the heartwood/sapwood boundary, dated to AD 1467, and using the usual confidence limits for sapwood would give it an estimated felling date in the range AD 1482-1502.

Conclusion

It is likely that four phases of felling are represented by the samples here analysed and that dendrochronology supports the structural and documentary evidence. It would appear that the north bay of the hall is the earliest, with an estimated felling date in the range AD 1212-1232, and may be part of an earlier aisled building.

The next phase is represented by the timbers reused as arcade plates and the timbers of Truss B which have a felling date of AD 1237. It is possible that this phase relates to early alterations by the Chaworth family who were in occupation of the site from at least AD 1235.

The third phase is represented by the timbers of truss A and the south bay of the hall. These were felled in AD 1287 and this work may have been undertaken by Thomas de Chaworth, who died before AD 1315.

The fourth phase is represented by truss D of the cross-wing, having an estimated felling date in the range AD 1482-1502. This may represent work ascribed to *c* AD 1500.

Eight samples remain undated. Six of these samples have rather too few rings for satisfactory analysis and cannot be dated with confidence. The remaining two undated samples, MDB-A06 and MDB-A21, do have sufficient rings but show distorted growth which probably make cross-matching and dating difficult.

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Table 1: Details of samples from Medbourne Manor, Medbourne, Leicestershire

Sample no.	Sample location	Total rings	*Sapwood rings	First measured ring date	Last heartwood ring date	Last measured ring date
Truss A and south bay of hall roof						
MDB-A01	Southwest arcade plate (re-used)	89	h/s	AD 1120	1208	1208
MDB-A02	Lower tiebeam (1)	148	20C	AD 1140	1267	1287
MDB-A03	East brace	75	h/s	AD 1187	1261	1261
MDB-A04	West brace	76	15	AD 1201	1261	1276
MDB-A05	South strut to southeast arcade plate	54	no h/s	-----	-----	-----
MDB-A06	East common rafter, frame 9	115	h/s	-----	-----	-----
MDB-A07	East common rafter, frame 7	54	no h/s	AD 1171	-----	1224
MDB-A08	Lower tiebeam (2)	80	no h/s	AD 1156	-----	1235
MDB-A09	Lower tiebeam (3)	107	h/s	AD 1162	1268	1268
MDB-A10	West common rafter, frame 1	68	no h/s	AD 1110	-----	1177
MDB-A11	Collar, frame 11	56	20C	AD 1183	1218	1238
Cross-wing, truss D						
MDB-A12	South blade	75	h/s	AD 1393	1467	1467
Truss B						
MDB-A13	Strut	58	13C	AD 1180	1224	1237
MDB-A14	Brace	50	h/s	-----	-----	-----
MDB-A15	Tiebeam	68	h/s	AD 1156	1223	1223
MDB-A16	Brace	76	19C	AD 1162	1218	1237
MDB-A17	Strut	63	11C	AD 1175	1226	1237

Table 1: Continued

Sample no.	Sample location	Total Rings	*Sapwood rings	First measured ring date	Last heartwood ring date	Last measured ring date
North bay of hall roof						
MDB-A18	Collar, frame 1	51	6	-----	-----	-----
MDB-A19	East soulace, frame 1	126	h/s	AD 1068	1193	1193
MDB-A20	Collar, frame 2	73	no h/s	AD 1111	-----	1183
MDB-A21	East common rafter, frame 2	85	no h/s	-----	-----	-----
MDB-A22	West common rafter, frame 2	96	h/s	AD 1104	1199	1199
MDB-A23	East soulace, frame 4	80	5	AD 1114	1188	1193
MDB-A24	Collar, frame 5	55	no h/s	AD 1084	-----	1138
MDB-A25	East rafter, frame 3	52	no h/s	-----	-----	-----
MDB-A26	Collar, frame 4	72	h/s	AD 1135	1206	1206
MDB-A27	West soulace, frame 4	55	no h/s	-----	-----	-----
MDB-A28	West soulace, frame 5	69	no h/s	AD 1066	-----	1134
MDB-A29	West soulace, frame 6	102	no h/s	AD 1045	-----	1146
Reused timbers						
MDB-A30	Northeast arcade plate	54	h/s	AD 1161	1214	1214
MDB-A31	Southeast arcade plate	62	h/s	AD 1155	1216	1216
Other timbers						
MDB-A32	Door lintel (re-used)	46	16C	-----	-----	-----

*h/s = the heartwood/sapwood boundary is the last ring on the sample

C = complete sapwood is retained on sample

Table 2: Results of the cross-matching of site chronology MDBASQ01 and relevant reference chronologies when first ring date is AD 1068 and last ring date is AD 1287

Reference chronology	Span of chronology	t-value	
East Midlands	AD 882 – 1981	12.2	(Laxton and Litton 1988)
England	AD 401 – 1981	7.9	(Baillie and Pilcher 1982 unpubl)
Southern England	AD 1083 – 1589	9.0	(Bridge 1988)
Kent-88	AD 1158 – 1540	5.7	(Laxton and Litton 1989)
Donington-le-Heath Manor, Leics	AD 1127 – 1269	7.2	(Esling <i>et al</i> 1989)
Severns, Castle Road, Nottm	AD 1030 – 1334	8.5	(Howard <i>et al</i> 1996)
Cross Keys Inn, Leicester	AD 1104 – 1309	6.9	(Howard <i>et al</i> 1988)
Quaintree House, Braunston, Leics	AD 1165 – 1305	9.1	(Alcock <i>et al</i> 1991)
Angel Choir, Lincoln Cathedral	AD 912 – 1248	11.0	(Howard <i>et al</i> 1985)

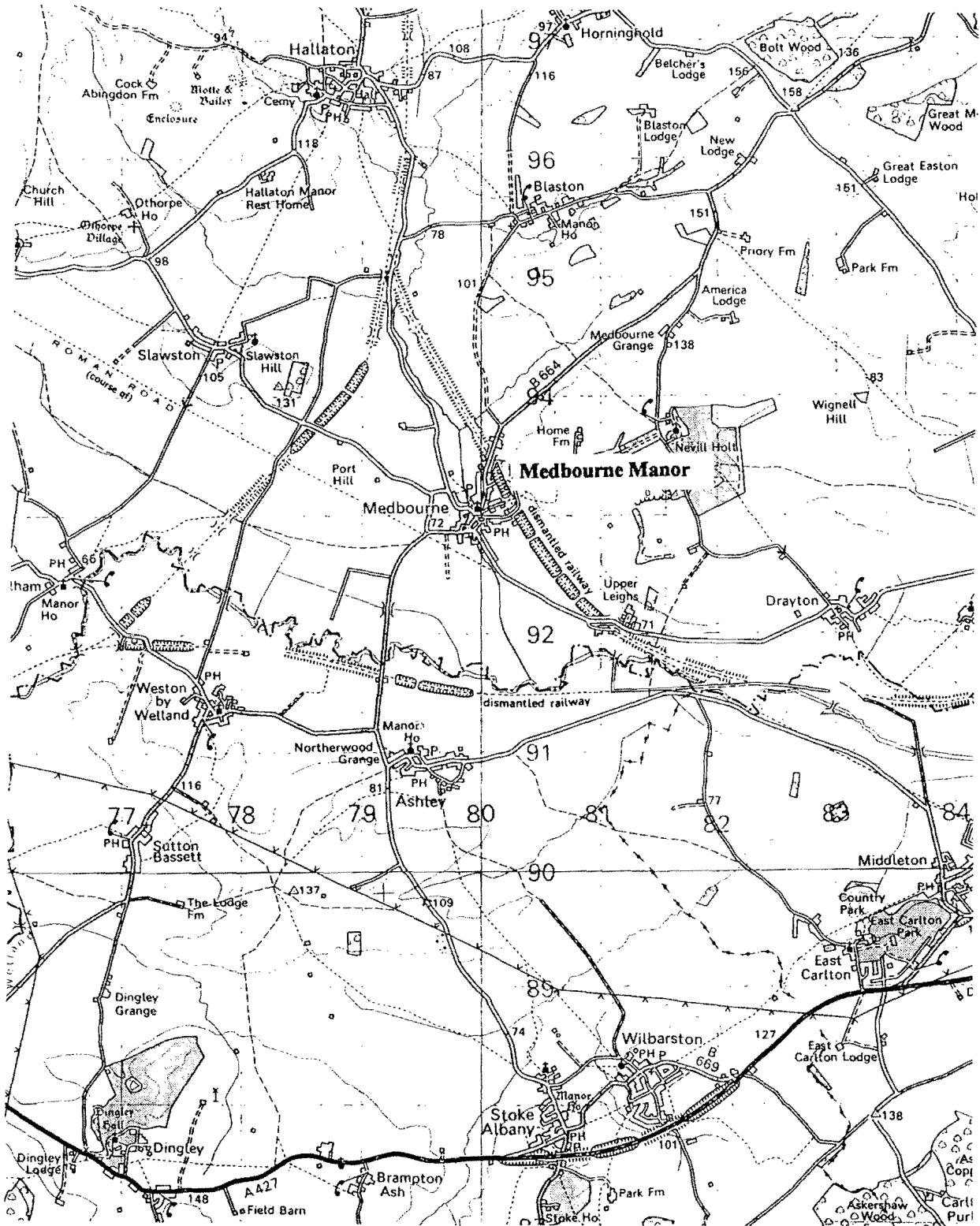
Table 3: Results of the cross-matching of site chronology MDBASQ02 and relevant reference chronologies when first ring date is AD 1045 and last ring date is AD 1146

Reference chronology	Span of chronology	t-value	
East Midlands	AD 882 – 1981	7.4	(Laxton and Litton 1988)
England	AD 401 – 1981	6.2	(Baillie and Pilcher 1982 unpubl)
St Hugh's Choir, Lincoln Cathedral	AD 1083 – 1589	8.2	(Laxton and Litton 1988)
Angel Choir, Lincoln Cathedral	AD 912 – 1248	7.2	(Howard <i>et al</i> 1985)
Ely Cathedral 9	AD 903 – 1159	5.6	(Howard <i>et al</i> 1992 unpubl)
Hansacre Hall, Staffs	AD 965 - 1279	5.2	(Esling <i>et al</i> 1990)

Table 4: Results of the cross-matching of sample MDB-A12 and relevant reference chronologies when first ring date is AD 1393 and last ring date is AD 1467

East Midlands	AD 882 – 1981	8.3	(Laxton and Litton 1988)
Wales and West Midlands	AD 1341 – 1636	5.0	(Siebenlist-Kerner)
Southern England	AD 1083 – 1589	4.6	(Bridge 1988)
MC10---H	AD 1386 – 1585	5.3	(Fletcher 1978 unpubl)
Shardlow, Derbys	AD 1380 – 1455	7.1	(Howard <i>et al</i> 1993)
Leicester Castle	AD 1337 – 1486	8.3	(Howard <i>et al</i> 1986)
Hagworthingham Church, Lincs	AD 1336 – 1533	7.0	(Laxton <i>et al</i> 1984)

Figure 1: Map to show general location of Medbourne Manor



(based upon the Ordnance Survey 1:50000 map with permission of The Controller of Her Majesty's Stationery Office, ©Crown Copyright).

Figure 2a: Plan of ground floor

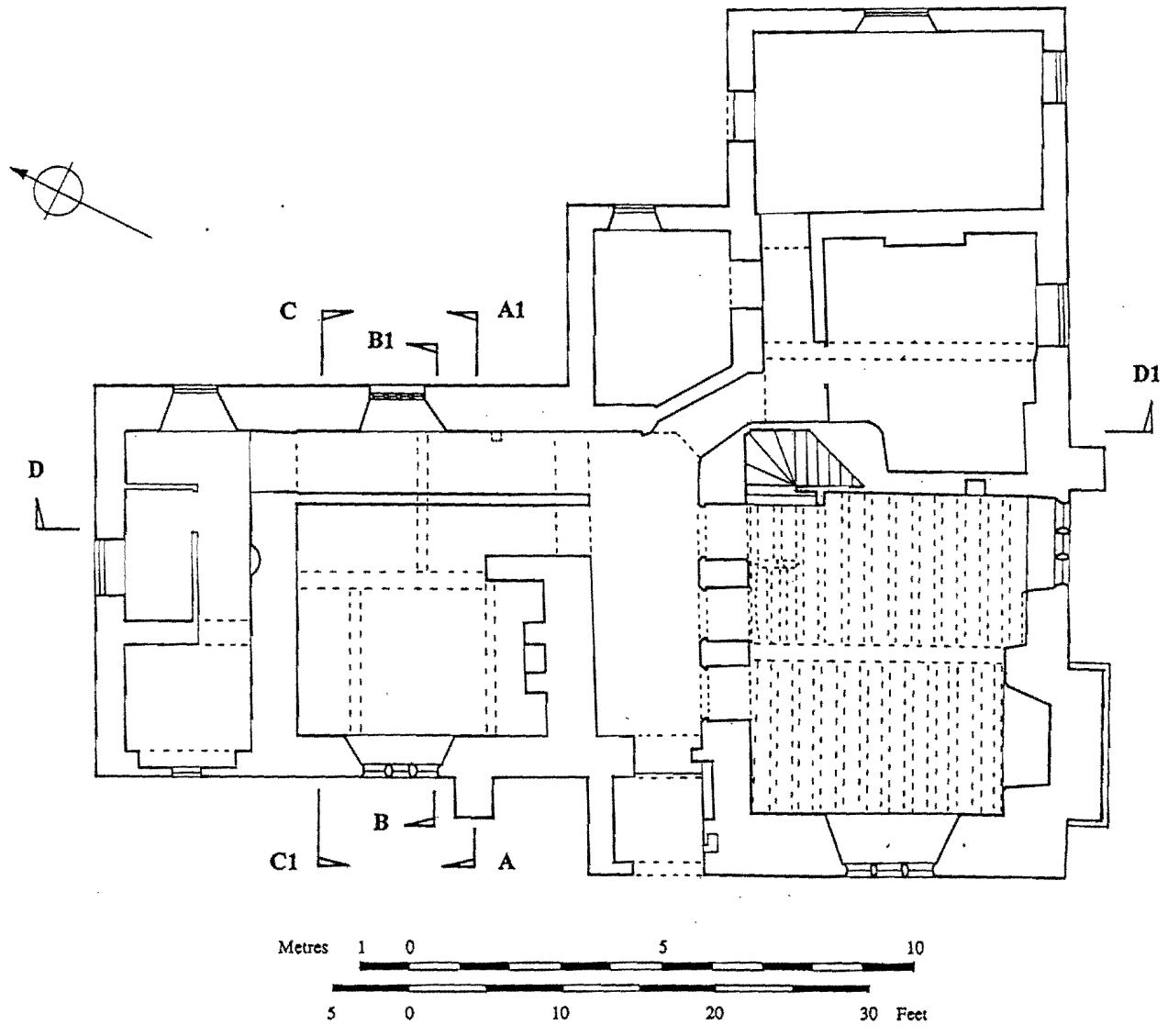


Figure 2b: Plan of first floor

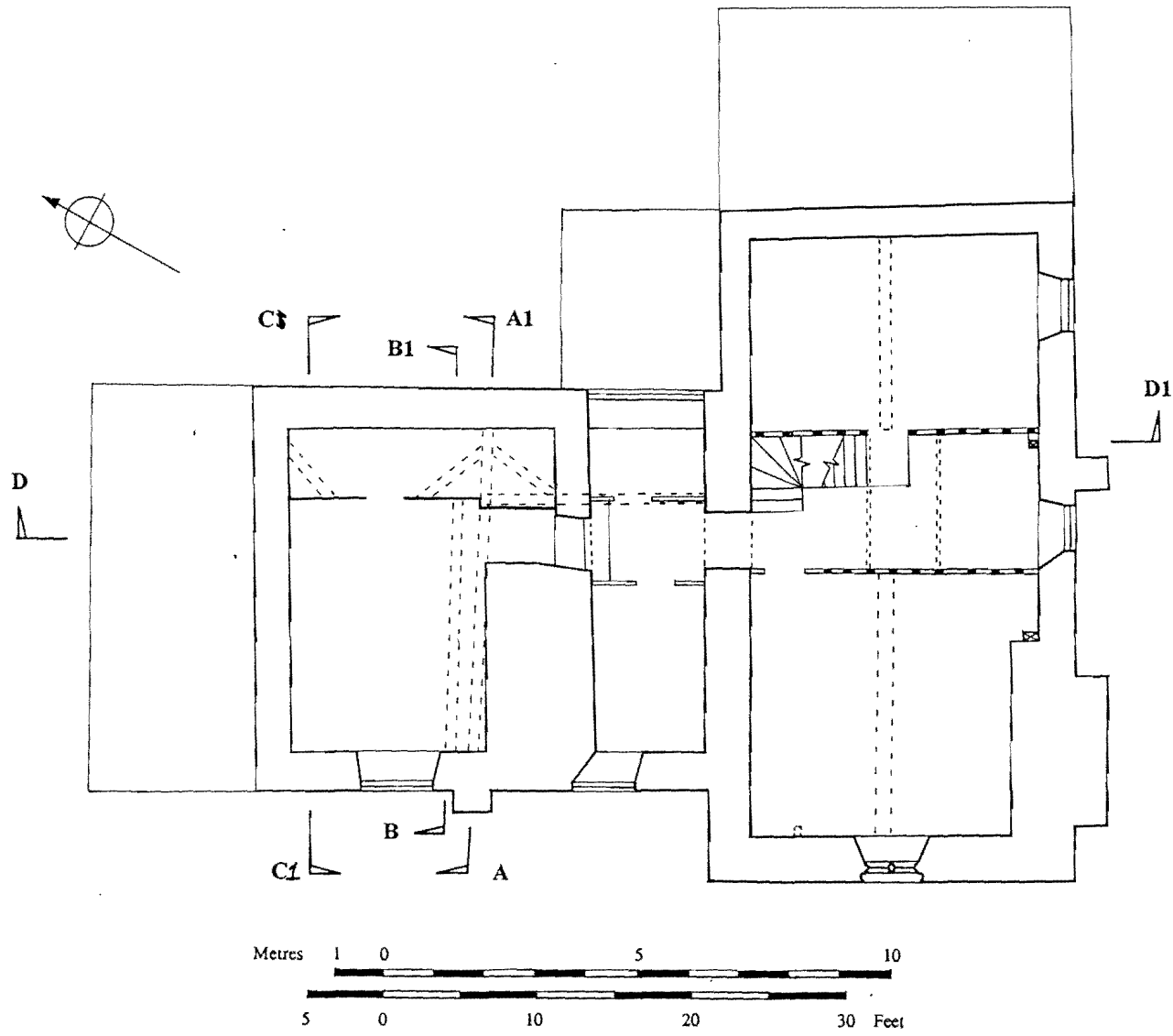


Figure 2c: Long section D - D1

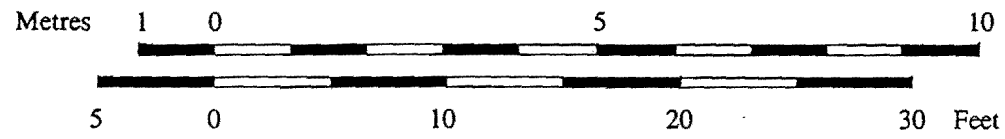
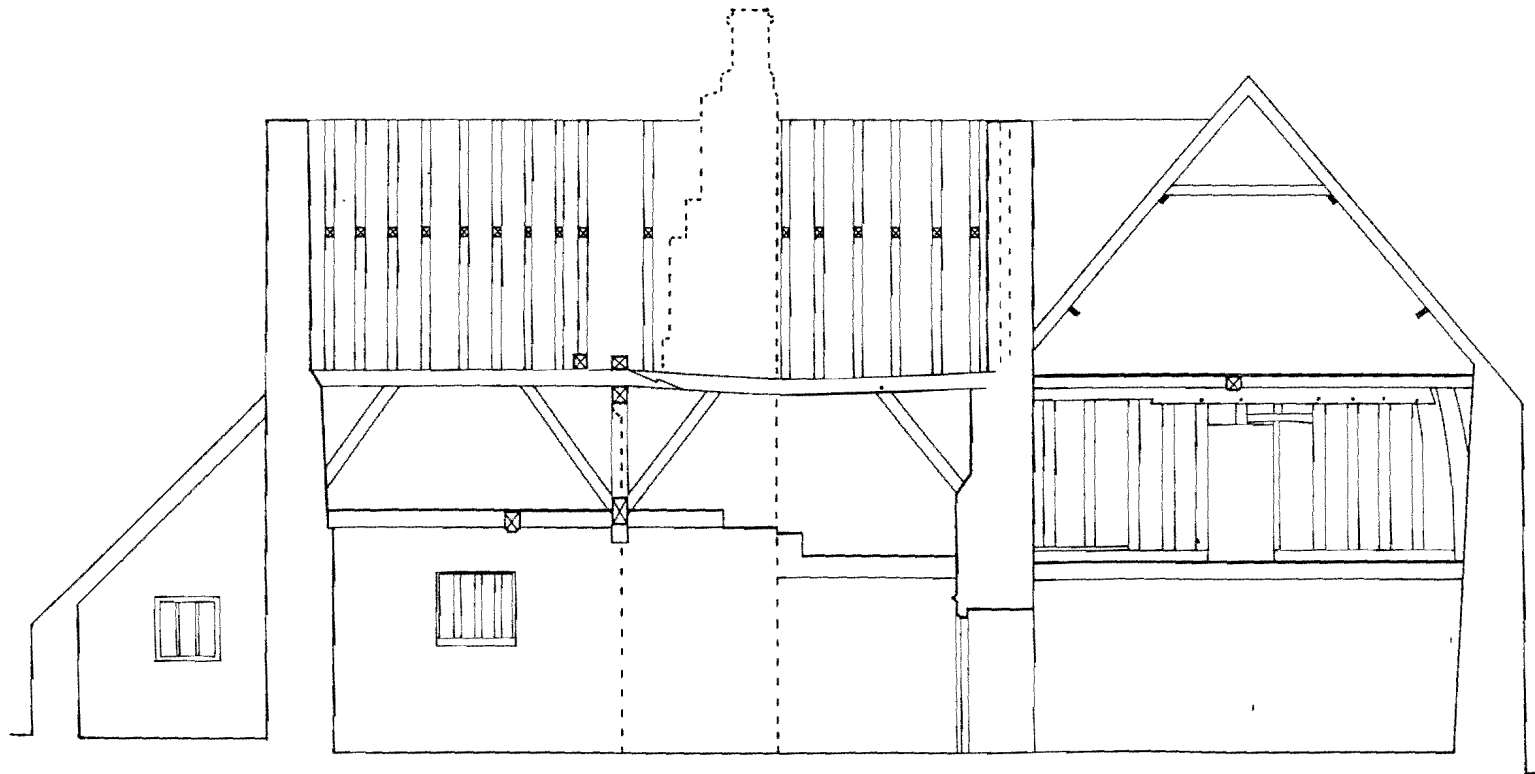


Figure 3: Cross section A – A1; central truss A

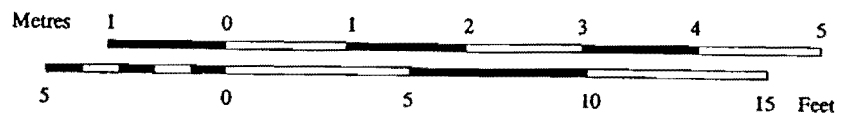
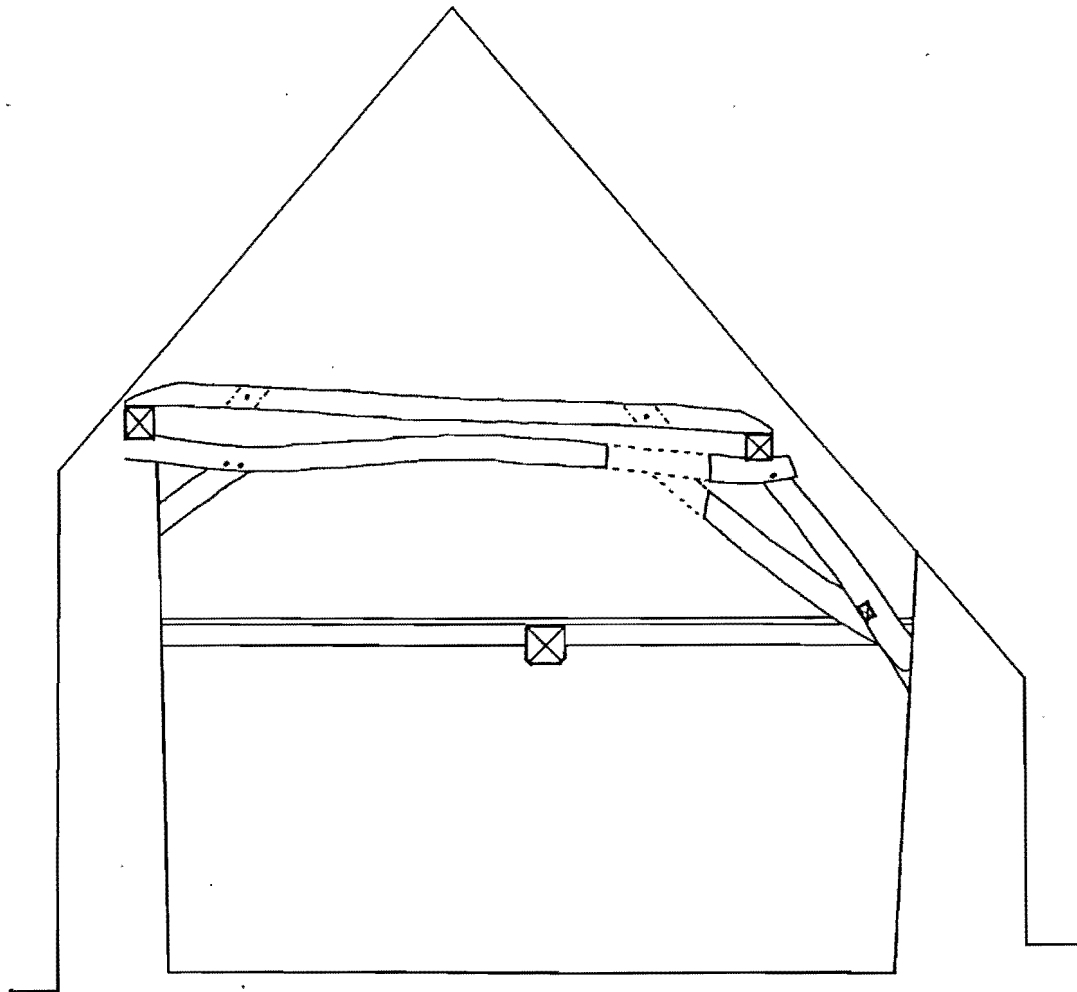


Figure 4: Cross section B – B1; truss B

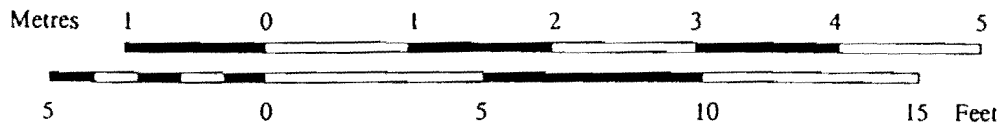
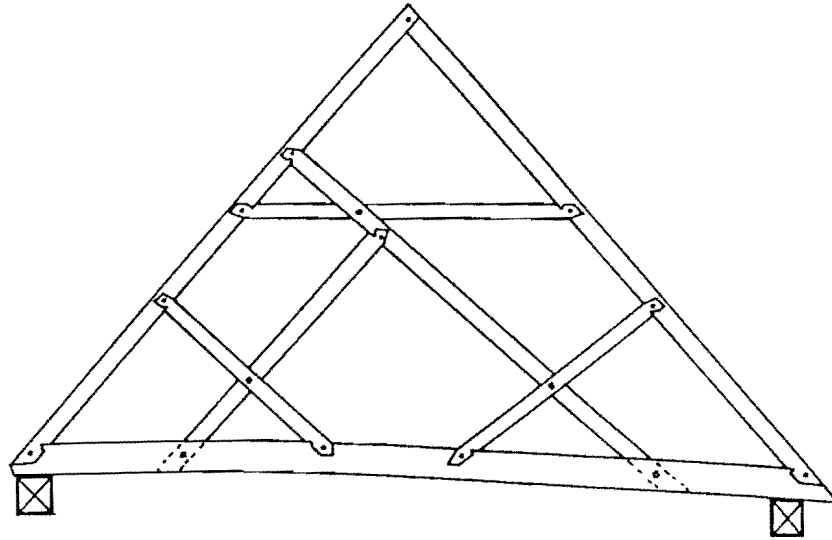


Figure 5a: Drawing to show sample locations

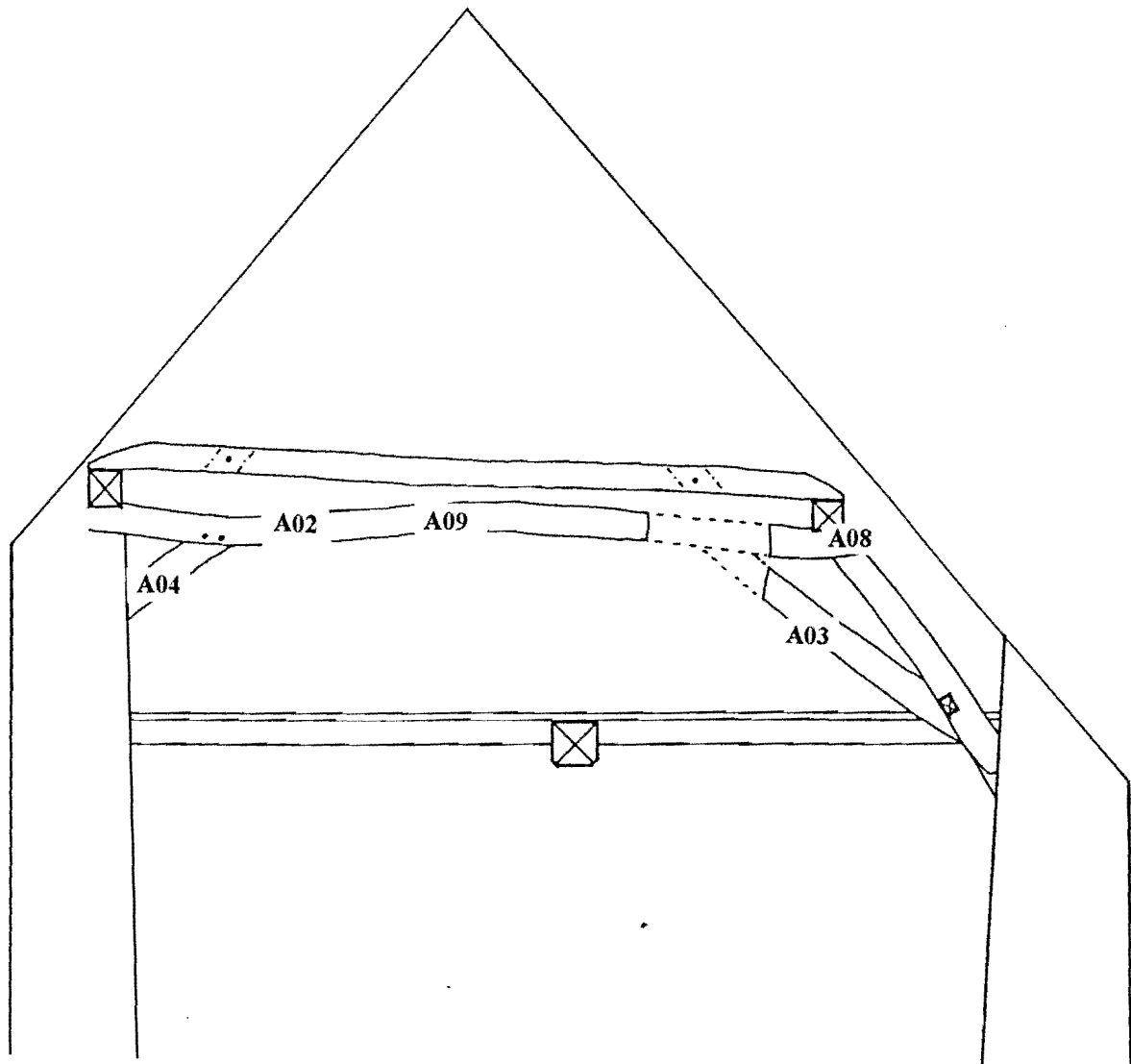
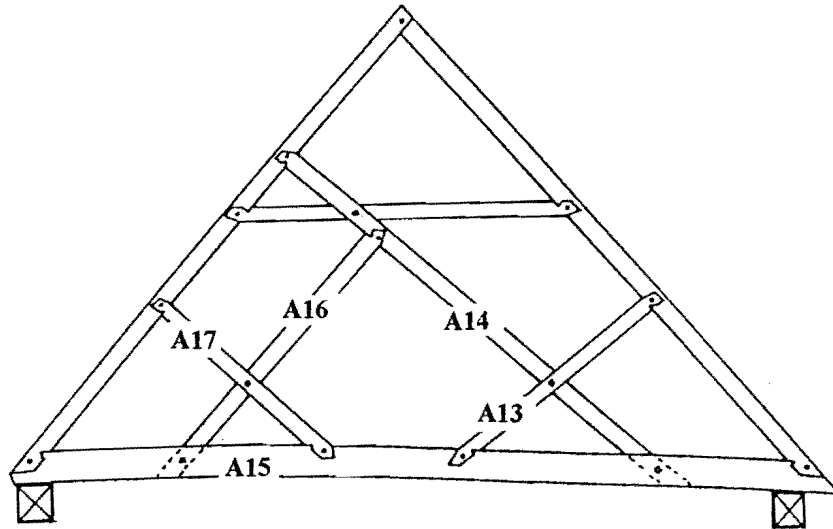


Figure 5b: Drawing to show sample locations

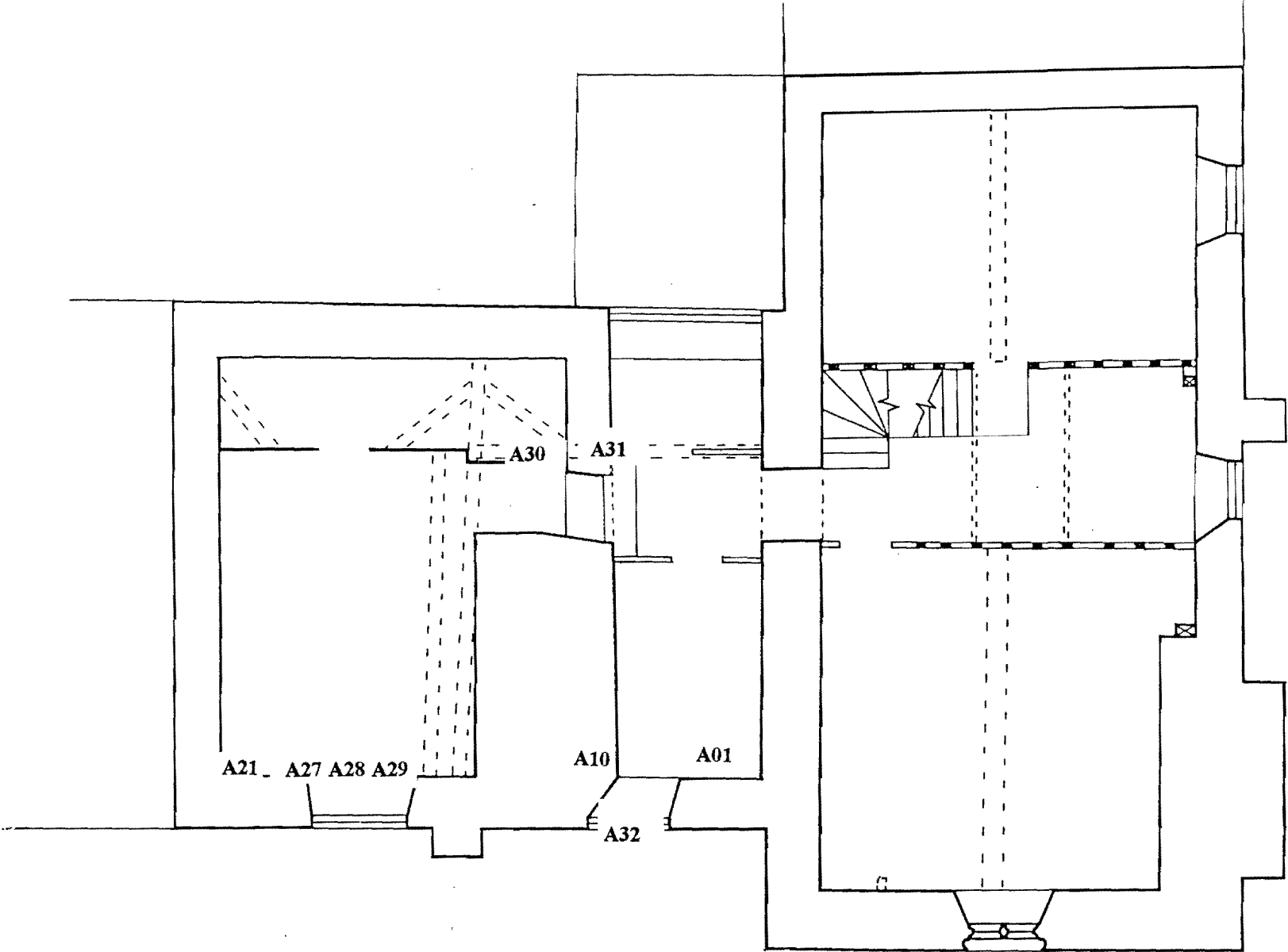


Figure 5c: Drawing to show sample locations

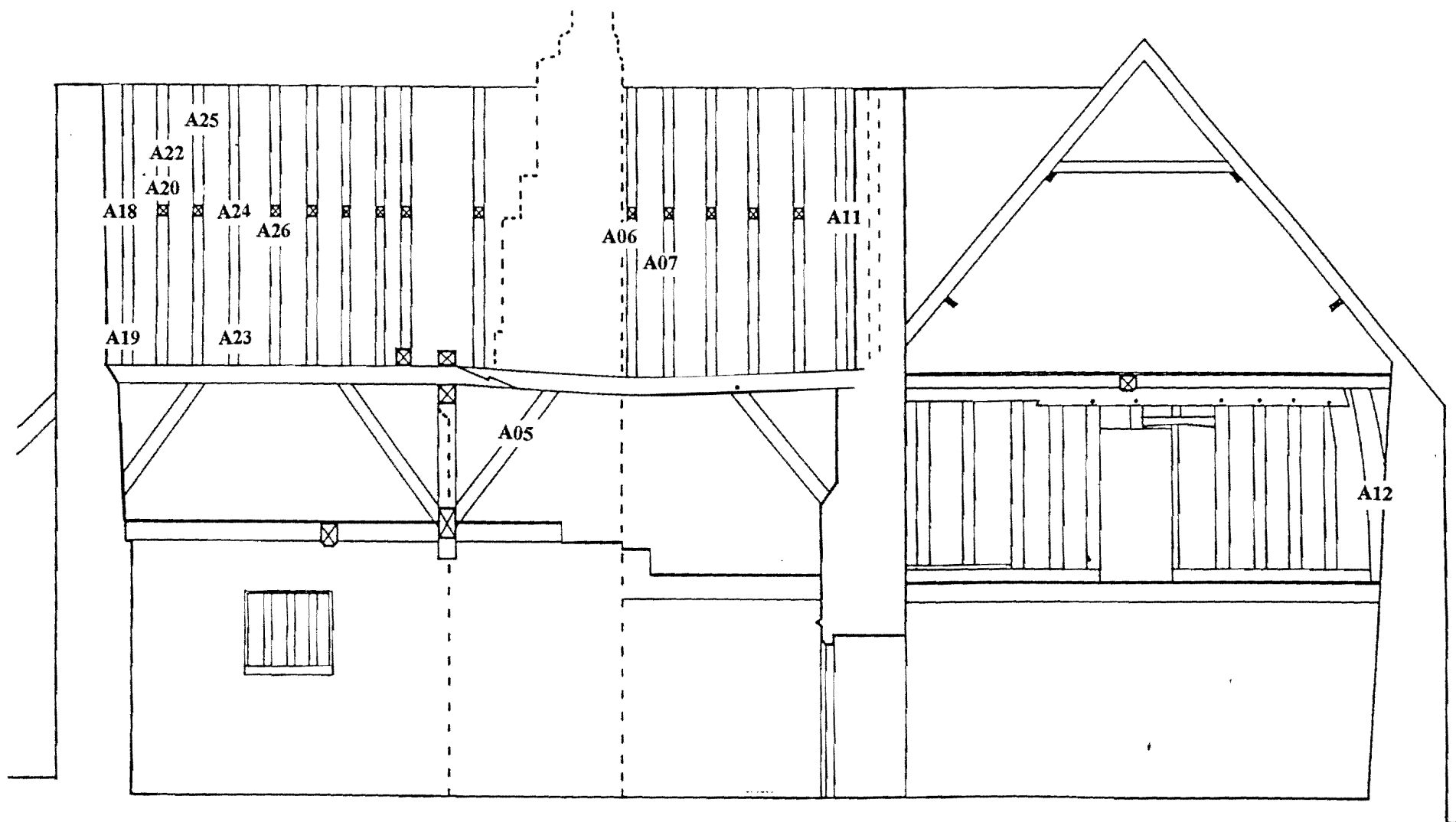


Figure 6: Bar diagram of samples in site chronology MDBASQ01

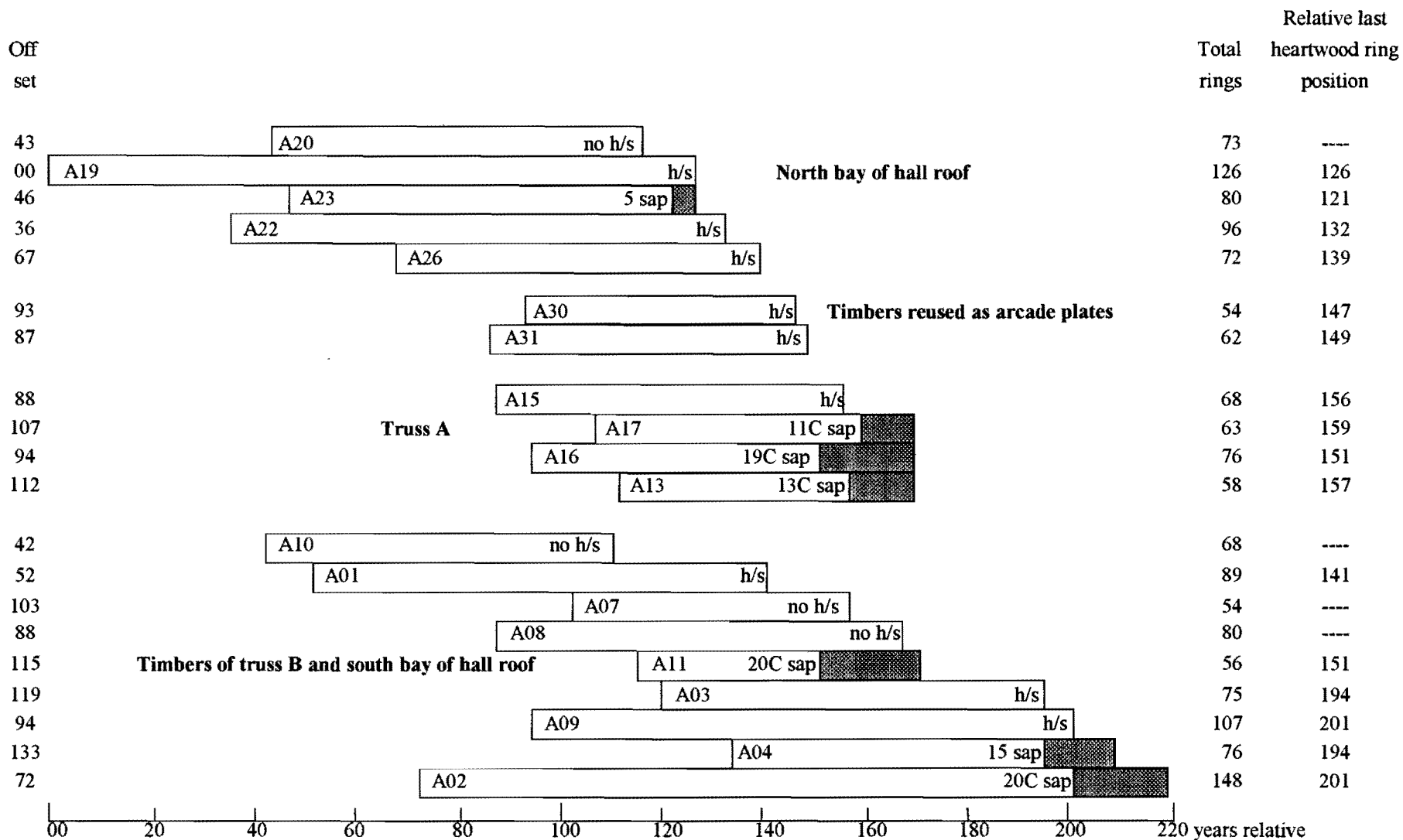
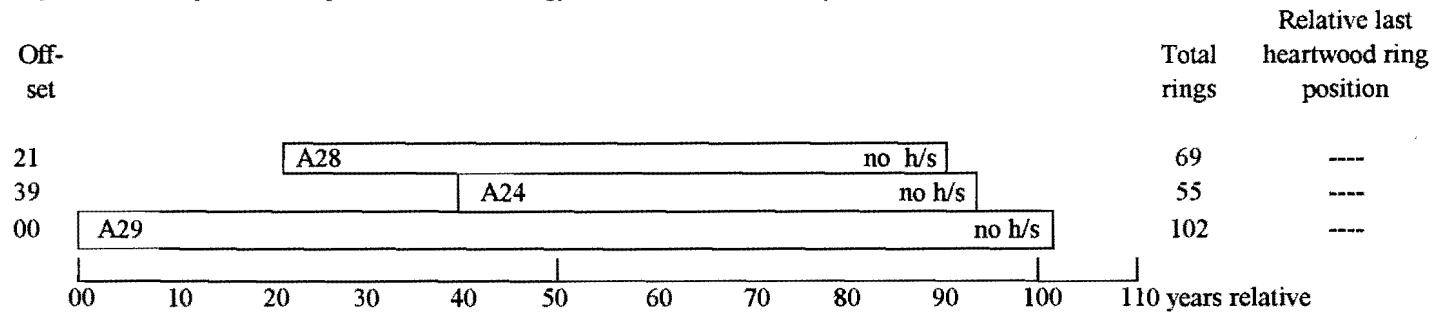


Figure 7 Bar diagram of samples in site chronology MDBASQ02 (north bay of hall roof)



Key for bar diagrams

White bars = heartwood rings, shaded area = sapwood rings

h/s = heartwood/sapwood boundary is last ring on sample

C = complete sapwood on sample, last ring date is felling date of timber

Data of measured samples – measurements in 0.01 mm units

MDB-A01A 89

119 160 120 154 136 105 132 80 109 57 101 97 97 104 62 55 68 38 42 57
194 134 143 117 154 129 172 163 199 261 135 145 158 239 228 246 293 294 286 251
286 195 139 222 200 282 184 208 272 212 224 238 244 218 170 171 233 107 116 250
127 179 193 353 152 200 228 390 129 90 191 194 109 272 247 220 284 191 185 137
137 156 103 153 172 201 264 172 291

MDB-A01B 89

96 156 121 153 138 103 135 80 116 58 97 102 96 102 63 56 66 40 43 50
187 112 109 120 147 114 169 149 219 200 160 147 155 272 218 243 301 299 288 244
288 177 166 194 206 292 177 207 274 203 252 245 254 206 159 176 244 108 101 245
121 177 200 350 143 208 235 377 129 92 190 196 104 278 246 213 272 205 182 125
124 160 110 147 167 215 263 167 284

MDB-A02A 148

319 487 407 291 194 111 69 61 63 57 54 72 77 184 201 234 175 187 137 157
188 181 152 157 149 144 109 81 119 181 141 112 136 137 129 127 153 131 118 136
133 108 128 117 62 89 90 108 82 92 119 125 94 124 87 66 71 54 85 74
86 109 129 147 162 117 84 78 98 92 116 109 85 100 103 104 100 96 70 65
71 104 86 80 52 54 40 65 70 93 89 69 74 54 44 50 59 60 58 86
56 51 34 41 58 76 87 86 55 66 90 91 96 138 135 164 99 86 49 70
83 121 126 101 102 131 87 86 77 70 80 94 64 77 103 73 66 73 87 93
135 138 172 169 198 173 180 142

MDB-A02B 148

319 513 375 297 210 161 95 60 42 63 66 63 81 167 181 220 179 181 150 188
209 181 171 169 160 136 92 98 143 207 139 110 132 135 128 123 153 119 118 150
130 110 131 114 65 90 86 113 91 79 131 124 87 131 87 69 69 62 72 79
83 112 128 151 163 122 88 73 91 96 112 111 76 101 108 102 92 92 77 64
69 109 92 82 49 56 41 65 67 90 95 70 72 53 44 45 57 68 64 73
59 45 37 39 60 66 86 80 59 64 101 91 95 157 143 168 80 90 52 73
86 122 126 94 108 129 79 81 90 65 100 86 62 85 90 81 57 78 91 107
134 140 166 178 187 186 184 165

MDB-A03A 75

449 192 155 288 376 364 656 414 410 466 294 303 301 259 508 426 221 137 186 282
229 373 245 224 264 303 349 216 267 306 263 147 158 101 125 120 150 151 116 88
79 116 231 288 232 158 208 218 294 248 354 260 382 336 176 135 181 143 182 176
155 99 125 137 124 90 140 233 283 150 247 117 161 166 275

MDB-A03B 75

474 210 143 286 372 360 647 418 380 454 286 305 294 261 467 444 228 135 175 297
212 392 243 248 270 291 357 218 271 329 259 144 158 105 113 123 158 154 118 105
96 137 205 274 210 174 231 279 320 261 301 259 367 323 175 118 187 136 188 163
165 87 131 128 126 91 125 228 279 137 274 101 168 182 242

MDB-A04A 76

315 234 238 198 204 221 134 168 153 206 236 169 237 193 175 202 169 124 196 181
141 100 121 150 136 87 109 153 145 189 137 108 111 85 119 96 184 138 165 105
66 47 84 94 119 110 124 69 75 121 90 85 123 91 116 81 118 65 88 96
132 147 124 114 121 103 68 99 64 73 89 98 69 97 75 106

MDB-A04B 76

278 226 258 222 206 216 134 173 136 203 246 170 233 190 191 166 162 116 190 195
132 107 120 157 126 93 106 161 145 182 129 109 108 95 119 88 189 136 166 103
68 64 68 85 126 123 112 72 77 110 97 83 128 91 110 93 114 67 89 85
104 168 108 116 127 84 90 85 69 71 88 90 82 87 86 136

MDB-A05A 54

183 216 139 152 163 114 78 68 58 49 42 37 35 88 64 50 64 47 57 65
85 144 117 68 92 65 116 68 77 65 94 92 110 190 113 89 92 130 100 117
97 139 144 161 224 73 75 96 102 103 102 83 117 112

DB-A05B 54

189 215 133 156 172 127 76 61 57 39 36 36 34 74 78 56 64 45 49 77
102 146 106 72 95 71 111 68 73 76 101 80 112 178 102 97 93 128 108 105
88 141 145 140 190 96 71 82 87 108 101 97 106 108

MDB-A06A 115

169 135 167 123 205 126 127 140 118 103 132 119 138 125 142 173 156 151 178 100
109 69 74 121 86 127 124 143 121 160 113 143 118 117 169 120 118 182 146 145
142 79 126 116 96 99 76 123 127 98 157 187 114 141 109 102 101 72 79 94
83 78 104 87 87 93 84 86 80 82 79 76 78 82 90 101 125 138 129 148
142 166 102 113 100 107 90 85 104 78 95 126 114 126 121 118 115 200 248 164
130 152 163 203 194 181 172 128 173 105 79 73 80 92 120

MDB-A06B 115

129 147 163 128 204 120 120 145 122 108 126 129 127 121 137 156 161 122 166 97
107 70 85 118 84 139 119 139 108 154 125 138 128 114 160 127 126 169 153 141
141 80 125 113 105 97 86 122 123 95 162 174 130 129 113 103 97 74 94 83
84 75 100 92 95 89 78 97 90 65 87 75 93 70 82 114 121 119 140 155
132 174 98 120 105 106 100 75 99 80 94 123 116 138 100 113 142 186 248 173
124 166 151 177 196 189 170 114 180 122 88 68 83 99 111

MDB-A07A 54

279 212 269 191 184 220 144 272 391 376 454 386 366 255 342 263 281 143 98 120
139 110 183 190 190 299 257 328 448 478 568 471 312 253 324 192 241 300 199 226
125 134 108 186 188 332 354 450 479 367 430 380 326 283

MDB-A07B 54

294 210 280 195 180 229 175 254 412 351 483 468 367 236 329 284 273 131 98 104
156 108 196 181 191 296 259 344 464 470 561 462 328 276 321 202 254 304 202 204
138 111 181 186 333 253 459 469 558 344 376 234 272 120

MDB-A08A 80

258 282 247 298 353 216 236 188 141 164 114 128 201 341 221 236 172 204 207 183
248 175 170 210 146 119 158 197 99 125 118 195 108 111 147 153 84 117 106 94
134 87 75 84 108 121 116 148 93 114 88 75 126 95 113 92 74 73 90 107
96 85 70 49 45 49 45 61 44 53 45 59 79 103 129 85 73 47 44 53

MDB-A08B 80

253 287 250 292 357 237 222 178 135 157 111 131 201 351 197 236 194 205 196 175
259 180 159 198 157 119 165 185 95 123 124 200 100 113 156 153 80 111 110 99
118 90 76 85 104 124 115 158 91 109 95 85 116 106 101 90 73 74 93 109
112 76 78 51 45 53 47 62 50 54 40 67 83 109 131 86 71 57 52 43

MDB-A09A 107

247 182 142 185 130 90 172 241 245 270 238 285 239 190 271 174 162 201 152 104
146 183 100 108 169 264 128 110 166 161 97 128 124 92 94 76 69 66 74 89
88 159 108 112 94 71 107 103 101 94 85 75 113 108 92 92 67 54 44 56
48 47 45 50 39 58 89 127 145 92 88 48 49 38 57 104 101 93 62 48
37 47 60 87 130 111 55 92 111 131 93 195 243 309 176 190 70 156 204 171
250 170 145 177 108 97 164

MDB-A09B 107

203 187 139 178 114 118 152 237 240 285 221 308 242 197 280 178 176 188 147 113
114 197 85 126 161 261 137 108 144 167 98 133 121 92 97 46 66 67 77 87
87 166 104 111 88 85 105 103 103 97 84 71 104 106 100 87 71 56 52 50
38 61 50 46 37 59 96 114 135 102 90 45 51 42 58 98 97 95 61 51
36 39 64 99 119 115 53 89 107 132 94 203 230 300 182 197 66 162 211 168
257 160 156 175 111 91 134

MDB-A10A 68

310 339 208 263 217 277 155 140 164 88 112 105 120 158 143 133 160 139 166 99
131 153 93 78 88 56 66 36 58 62 119 121 87 92 71 87 97 98 143 144
99 104 68 116 103 133 148 102 95 116 135 111 90 123 101 93 83 71 102 114
150 130 95 87 88 149 165 93

MDB-A10B 68

312 344 216 250 226 279 162 139 158 85 105 115 119 151 141 135 165 147 162 97
108 138 106 77 86 57 67 29 57 67 119 115 92 91 69 94 103 103 138 144
94 113 74 120 107 138 123 85 98 108 133 119 92 118 100 97 79 68 98 117
148 134 95 73 93 140 168 94

MDB-A11A 55

141 79 187 204 287 150 167 322 198 139 260 164 157 205 119 104 135 213 226 198
157 160 181 188 115 165 136 169 219 195 196 170 214 202 100 72 45 50 63 91
111 128 102 74 84 106 121 125 78 57 76 61 68 61 79

MDB-A11B 56

125 76 186 221 279 158 150 326 199 144 253 162 160 203 120 102 135 208 236 198
154 168 195 195 121 167 136 167 218 192 180 167 218 207 122 57 44 55 76 81
119 141 105 70 91 106 118 121 88 62 69 78 53 66 64 96

MDB-A12A 75

379 363 266 411 344 376 354 330 308 293 404 401 380 354 267 299 313 165 168 240
266 224 161 192 171 218 148 203 206 174 235 183 159 98 200 226 191 112 189 204
99 118 111 107 108 76 41 65 106 72 127 98 89 71 77 120 120 113 154 120
146 158 213 251 202 173 160 203 155 162 115 99 111 119 178

MDB-A12B 75

358 343 272 465 344 370 352 305 303 303 399 414 360 366 260 307 301 176 150 239
288 224 166 186 175 220 146 206 206 169 242 200 163 74 211 233 184 116 191 190
113 123 109 108 101 83 54 63 94 79 130 121 91 71 74 116 120 117 158 114
137 165 215 264 193 181 163 208 166 160 117 93 115 119 182

MDB-A13A 58

327 407 356 323 143 234 218 226 92 106 222 189 130 177 169 244 231 138 136 152
123 216 207 226 149 159 196 133 214 212 197 331 192 272 185 153 169 234 216 269
284 247 146 157 244 257 258 200 197 165 149 180 147 229 127 214 103 237

MDB-A13B 58

305 414 350 324 147 224 219 219 102 102 215 202 124 169 165 254 231 149 159 162
143 199 204 224 155 170 178 144 204 223 203 344 179 284 188 166 160 227 213 270
267 257 129 185 239 242 262 189 191 177 152 177 159 226 128 217 124 203

MDB-A14A 50

73 135 107 107 94 84 177 197 156 204 185 128 57 72 108 145 112 101 191 292
443 418 260 199 196 155 128 153 151 229 203 156 136 192 247 165 279 163 269 267
195 259 161 251 284 316 178 186 204 239

MDB-A14B 50

85 134 101 114 102 74 189 205 155 217 194 135 55 75 105 154 113 114 230 318
444 413 260 202 200 152 124 156 153 251 196 160 133 201 223 180 280 168 267 245
187 255 154 267 273 323 173 175 238 253

MDB-A15A 68

162 158 181 213 332 337 409 234 215 194 267 244 330 413 303 394 345 325 302 287
285 201 191 229 182 261 299 300 172 269 300 381 211 250 434 314 200 314 297 240
310 244 177 180 204 278 216 209 175 219 194 171 207 164 213 285 212 246 169 209
143 164 155 178 188 149 127 169

MDB-A15B 68

153 156 195 232 339 340 397 237 219 198 266 230 332 416 306 373 350 331 307 289
288 203 194 228 177 245 304 317 168 289 337 381 207 257 437 314 202 323 310 228
300 251 172 189 201 259 221 216 175 221 194 168 222 164 220 275 211 248 177 190
148 175 156 183 167 161 106 174

MDB-A16A 76

212 146 165 168 130 113 95 129 125 158 118 150 90 117 135 111 189 167 113 212
256 230 111 126 134 154 79 91 184 133 168 293 239 221 459 136 91 175 221 263
213 222 149 208 204 179 269 160 189 378 201 240 208 218 214 203 195 196 130 159
102 107 143 116 87 194 221 174 263 167 111 111 79 78 68 195

MDB-A16B 76

214 158 156 178 124 116 92 132 123 148 133 145 92 122 135 109 195 177 98 217
265 221 106 135 129 150 85 87 189 134 130 299 241 238 449 125 92 186 198 282
206 215 124 198 209 177 269 152 183 364 220 241 211 227 214 197 197 189 152 142
106 100 149 99 77 221 200 213 284 156 104 109 78 78 73 173

MDB-A17A 63

178 216 127 233 271 270 452 425 321 104 241 332 328 121 130 376 242 157 326 273
395 395 323 314 170 164 347 285 228 196 160 289 96 147 70 66 93 84 171 156
136 106 127 94 105 116 91 87 88 89 98 112 89 86 88 88 111 85 131 138
183 77 93

MDB-A17B 63

163 216 121 219 287 256 462 416 298 104 230 347 324 125 140 414 233 141 319 295
405 390 319 318 175 166 341 287 256 192 177 290 109 142 82 60 94 93 171 143
147 86 134 104 114 120 100 76 84 91 88 114 85 81 89 96 102 99 120 162
167 76 115

MDB-A18A 51

594 410 483 398 272 205 178 182 150 193 370 140 258 273 177 69 136 133 230 132
136 193 146 81 166 148 191 181 135 120 202 236 331 287 172 136 226 216 96 174
105 176 224 175 232 217 222 220 200 131 99

MDB-A18B 51

562 430 499 417 283 237 179 174 153 205 364 135 254 252 211 76 131 131 239 147
111 215 153 84 167 160 173 166 128 101 183 271 337 273 191 134 235 212 90 185
138 179 206 195 217 218 212 231 193 141 122

MDB-A19A 126

46 39 50 44 45 43 44 41 47 48 63 43 58 44 60 36 38 69 60 52
62 58 54 64 58 61 63 62 61 54 70 61 74 79 77 81 76 87 66 80
100 56 64 68 73 74 93 84 82 70 95 67 68 95 96 104 106 110 73 86
116 96 80 101 117 93 102 104 78 85 104 70 118 103 89 83 90 70 69 70
99 96 96 70 78 101 98 78 100 81 95 102 99 58 48 64 116 94 63 55
61 84 61 84 75 94 61 87 96 94 108 110 114 82 111 107 77 94 97 111
90 89 148 108 133 156

MDB-A19B 126

61 51 54 40 44 50 33 45 53 49 58 47 43 44 62 43 43 60 64 61
61 54 57 58 68 57 55 73 54 47 75 60 78 72 85 92 74 77 76 86
79 67 62 75 67 73 87 93 86 71 87 63 72 104 85 91 106 99 83 91
102 93 93 87 122 89 114 105 83 62 103 66 103 123 85 81 91 63 80 73
97 90 108 68 67 113 96 73 104 75 94 116 95 64 76 65 119 97 63 55
63 73 59 89 78 88 70 93 97 90 98 118 116 77 108 101 77 103 88 121
82 96 141 104 144 157

MDB-A20A 73

240 138 242 218 171 167 223 200 184 231 186 192 201 210 141 149 154 179 109 132
178 100 108 110 112 69 61 89 76 177 120 89 82 65 87 93 100 102 137 64
100 68 110 124 133 128 135 119 153 200 168 185 164 172 161 170 157 222 256 179
163 259 187 170 158 176 119 109 158 118 195 183 263

MDB-A20B 73

231 143 261 196 167 164 211 195 182 211 184 185 197 198 148 138 150 158 114 115
172 98 105 115 99 85 56 96 82 171 124 92 83 74 69 95 102 104 140 72
76 71 121 112 124 145 104 149 167 210 160 189 139 175 169 175 155 214 255 190
156 263 185 188 137 196 93 101 162 126 194 199 229

MDB-A21A 85

249 208 248 193 214 206 256 254 219 183 262 246 206 180 118 131 146 122 148 168
127 122 123 160 168 136 167 196 184 193 190 175 201 213 239 240 227 306 238 188
288 202 263 284 216 217 185 178 181 186 161 186 188 148 121 218 160 139 182 229
169 140 179 165 171 147 117 145 112 114 121 149 140 115 116 118 110 148 145 150
137 160 190 219 145

MDB-A21B 85

197 216 252 184 215 203 262 266 207 200 243 244 202 187 127 136 128 129 157 172
139 136 106 162 167 130 171 196 176 190 217 181 201 228 236 243 211 289 226 192
260 170 250 240 231 223 185 155 198 190 151 185 189 154 117 209 168 137 184 214
189 147 179 188 170 150 129 132 104 124 108 149 141 115 114 123 119 153 140 132
156 159 165 215 191

MDB-A22A 96

170 187 163 181 206 192 157 139 113 139 154 148 177 187 191 97 114 212 230 220
225 184 151 213 251 195 163 224 223 208 177 184 127 162 214 102 240 231 124 143
136 110 168 184 149 239 199 131 128 313 217 193 197 186 220 209 320 195 205 185
148 182 120 121 159 224 136 108 130 140 104 164 176 124 129 186 121 140 179 228
121 173 147 221 106 138 204 136 170 235 163 199 160 168 106 212

MDB-A22B 96

180 188 161 186 199 184 166 123 93 128 163 163 171 204 172 108 112 223 212 200
201 190 164 221 258 211 172 209 208 198 200 182 124 161 202 138 226 244 154 166
123 115 179 184 157 219 215 143 119 307 226 180 198 182 219 219 304 216 200 194
161 168 130 124 149 221 137 114 133 138 125 176 170 116 131 179 127 140 177 218
140 196 146 206 124 147 176 155 181 215 134 198 169 176 107 205

MDB-A23A 80

91 76 79 84 93 68 99 102 100 119 104 127 71 104 109 99 97 101 106 103
100 96 81 97 111 75 123 104 85 91 87 76 71 89 88 83 105 80 62 83
80 58 90 64 88 91 94 53 88 78 73 82 61 67 70 73 68 97 60 77
76 98 56 63 77 78 69 60 59 82 59 73 57 82 74 57 87 78 72 87

MDB-A23B 80

96 75 82 67 97 65 97 100 102 116 103 118 91 92 107 93 100 103 107 103
108 93 78 90 124 81 112 111 91 84 81 78 67 88 80 88 104 82 51 87
76 73 78 68 82 84 96 57 76 79 86 80 59 58 83 86 68 87 63 85
76 89 70 57 85 73 66 62 69 77 53 80 59 85 66 72 73 82 65 98

MDB-A24A 55

437 461 345 286 276 254 172 214 257 297 310 250 268 256 281 315 267 243 301 262
194 154 232 178 270 235 182 146 150 160 208 219 186 209 234 188 160 191 221 232
198 204 124 187 187 158 155 203 148 191 154 160 165 154 180

MDB-A24B 55

412 477 352 291 260 247 178 208 286 278 258 263 256 248 278 303 267 237 287 278
219 193 229 173 247 249 180 161 144 166 208 223 186 193 243 198 155 186 249 229
208 197 134 165 205 175 143 194 160 179 163 180 161 149 183

MDB-A25A 52

203 278 320 340 261 231 227 214 247 250 209 203 253 263 231 195 257 205 261 231
156 155 160 139 222 192 170 147 218 145 180 174 235 265 188 205 155 205 256 164
173 209 169 186 145 185 195 158 165 182 260 282

MDB-A25B 52

198 282 314 349 283 219 221 237 242 247 237 200 259 273 216 196 222 220 258 238
162 152 169 141 228 199 163 167 214 154 167 171 231 224 209 214 147 200 220 170
139 215 158 194 152 188 197 162 176 175 248 296

MDB-A26A 72

104 138 64 88 84 186 174 81 80 78 60 70 130 178 169 78 88 81 135 124
121 206 241 234 334 305 162 259 188 224 263 248 206 236 316 265 253 218 200 160
145 198 91 106 108 68 136 164 210 101 191 151 263 92 75 252 185 101 170 178
150 133 120 86 72 91 142 130 140 163 307 285

MDB-A26B 72

123 131 61 88 82 173 176 84 78 80 68 65 143 179 169 76 93 82 134 128
113 210 242 232 333 312 160 255 194 231 233 189 202 214 312 259 252 238 206 178
159 193 105 106 111 65 153 160 218 101 182 142 253 97 73 258 174 106 168 184
133 136 119 97 70 83 144 112 157 173 298 295

MDB-A27A 55

187 189 161 159 185 259 217 166 281 292 276 155 123 159 249 195 246 234 121 118
91 111 103 156 302 140 207 268 368 282 181 141 149 132 291 214 261 228 167 178
167 180 183 255 220 227 303 265 183 159 227 271 261 322 227

MDB-A27B 55

188 191 151 154 189 266 209 170 288 313 266 155 144 179 253 188 254 212 119 124
92 99 107 164 305 155 198 268 352 277 179 143 155 125 280 240 269 213 163 167
173 176 174 222 233 218 305 254 196 157 224 275 242 315 225

MDB-A28A 69

204 282 204 203 121 120 108 153 185 228 163 193 277 157 181 113 165 178 191 190
165 180 173 141 131 201 174 234 156 178 209 163 200 215 196 149 168 212 122 162
178 135 182 196 161 131 154 149 189 185 175 168 164 142 142 163 308 306 258 272
218 219 281 247 191 254 162 216 222

MDB-A28B 69

193 292 198 199 120 120 118 147 184 227 168 190 275 133 170 119 165 167 198 188
166 175 171 134 127 205 185 226 144 171 197 177 193 222 206 160 162 218 150 159
176 144 164 204 161 139 158 140 188 187 180 163 166 142 139 167 310 297 260 275
209 247 274 246 192 260 175 213 237

MDB-A29A 102

222 265 229 195 211 195 144 98 81 77 97 133 116 150 136 156 133 134 123 133
95 157 183 190 124 124 93 91 108 133 146 132 151 144 106 140 139 140 170 150
155 114 116 140 136 109 116 162 159 102 111 121 87 111 151 134 140 120 160 99
106 115 122 120 134 102 95 88 100 108 122 104 95 81 80 73 78 88 116 108
113 107 153 135 122 113 158 157 168 153 183 130 94 115 104 126 118 117 100 107
86 104

MDB-A29B 102

215 254 222 206 215 196 152 96 65 68 106 116 125 149 120 156 138 124 131 132
100 144 192 181 131 118 91 88 104 140 136 136 143 143 117 135 148 139 165 149
150 124 116 121 142 115 113 139 167 103 134 101 102 113 150 136 145 114 163 107
116 107 110 119 129 104 89 90 93 128 118 108 96 90 75 72 83 88 100 115
102 121 145 137 120 118 156 145 168 145 179 133 95 113 107 130 116 113 112 84
101 113

MDB-A30A 54

483 223 395 367 372 286 182 290 406 256 231 254 265 217 220 360 198 194 303 221
342 343 356 115 156 148 185 101 101 166 131 95 199 238 146 157 158 165 112 125
168 175 147 142 127 135 115 148 123 122 121 119 254 201

MDB-A30B 54

493 243 390 361 399 239 192 279 415 258 217 265 272 195 206 365 191 162 339 218
354 332 353 110 146 142 182 105 96 161 137 98 200 205 147 154 164 155 113 113
176 178 147 142 120 144 111 134 134 127 153 105 272 134

MDB-A31A 62

171 199 211 237 273 247 237 210 196 196 249 194 218 232 264 237 235 214 166 196
219 223 147 184 203 182 176 292 266 146 205 213 298 149 168 347 231 125 245 175
211 198 221 219 139 171 203 200 166 175 181 188 167 233 166 161 177 121 196 168
119 173

MDB-A31B 62

168 222 187 234 308 241 220 197 192 188 205 215 218 234 266 232 234 215 162 184
231 217 139 185 193 170 196 282 275 120 212 216 292 151 170 338 228 128 249 170
211 187 222 216 139 159 198 215 171 171 173 196 172 228 173 138 191 120 226 144
142 189

MDB-A32A 46

379 589 418 388 411 253 356 376 377 366 276 338 446 418 378 181 303 172 214 334
288 326 298 307 332 343 195 183 240 249 239 207 210 209 172 284 344 382 366 273
252 240 192 164 155 264

MDB-A32B 46

390 586 442 356 440 223 363 352 377 366 318 313 451 425 375 184 285 173 218 341
274 337 285 314 310 355 193 179 210 273 230 207 219 198 177 280 329 376 361 289
242 229 179 165 163 272