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Ancient Monuments Laboratory
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Summary

The trees at Abercynafon were discovered during the construction of a pond in Talybont Forest when large timbers appeared in the spoil heaps. 114 timbers from the spoil heaps and subsequent archaeological excavation were sampled for dendrochronology. A tree-ring chronology was produced for the period 3098-2730 BC. Dates were produced for 25 timbers; these indicated that the dated trees died in the first half of the third millenium BC. The trees probably came from a small area of primary woodland, where conditions were often very unfavourable to growth. Comparison with contemporary trees from the Isle of Wight suggests that a general climatic decline may have affected the growth of the trees.

Authors' addresses :-

Miss J Hillam
SHEFFIELD DENDROCHRONOLOGY LABORATORY
Archaeology Research School
University of Sheffield West Court 2 Mappin
Sheffield
S1 4DT

C Hall
SHEFFIELD DENDROCHRONOLOGY LABORATORY
Archaeological Science Research School
Dept. Archaeology, Sheffield University
Sheffield
S10 2TN

TREE-RING ANALYSIS OF NEOLITHIC OAKS FROM ABERCYNAFON, TALYBONT-ON-USK, BRECON

INTRODUCTION

This document is a technical archive report on the tree-ring analysis of oak timbers from Abercynafon (NGR SO07631730). It is beyond the dendrochronological brief to describe the site 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. The conclusions presented here may therefore have to be modified in the light of subsequent work.

The site at Abercynafon is situated within Talybont Forest (Fig 1). It was discovered in 1994 during the construction of a conservation pond by Forest Enterprises when large timbers, one of which (sample 001) appeared to have tool marks, were uncovered in the peat. Following a site visit by members of the Clwyd-Powys Archaeological Trust, arrangements were made for a small excavation during the summer of 1995. Tree-ring spot dates on three of the timbers from the 1994 spoil heap created by Forest Enterprises indicated that they were of Neolithic date.

The excavated area (Figs 2 and 3) revealed a stratigraphy of five major horizons, although within them were some local variations (Earwood pers comm). The basal layer was red clay mixed with red sandstone. Above that was a layer of red clay sediment in which were found sandstone fragments and the remains of large trunks of oak (*Quercus* spp.). This layer was interpreted as being a landslide which was deposited at some point after the last glaciation. A pale blue-grey sediment lay above the landslide material; this was thought to have been deposited within a small pond created by the landslide. The upper two horizons were an organic layer containing fragments of wood and plant macrofossils covered by a layer of peaty clay. Between these two horizons were found more large tree trunks, which were interpreted as a timber structure (Earwood pers comm).

The timbers were mostly oak, and consisted mainly of horizontally arranged wood, a large proportion of which were half tree trunks laid split side up and aligned along a south-east/north-west axis. The largest of these timbers, a few of which had pointed ends, were over three metres in length with the side branches removed (Earwood pers comm). The largest concentration of bigger timbers was found on the eastern side of the pond, especially towards the northern end, where large, roundwood uprights were visible below the horizontal timbers. The structure at the southern end of the pond was less substantial and was mostly comprised of roundwood of less than 100mm in diameter, much of it lying horizontally.

Dendrochronology was undertaken initially as part of a wider research project to construct a prehistoric tree-ring chronology for the southern part of Britain. The chief aim at Abercynafon therefore was to construct a strong site chronology using a selection of the longer-lived trees. As more timbers were uncovered, the opportunity arose to use the assemblage as part of a masters dissertation (Hall 1996) and the study was widened to include all the timbers. The analysis was carried out in three stages:

- spot-dates on three timbers uncovered in 1994 by Forest Enterprises machinery (samples 001-003)
- analysis of the tree-ring samples from the excavation; these included timbers from both the landslide material and the organic layers (samples 507-999)
- analysis of timbers from the spoil heaps, most of which were probably from the organic layers as opposed to the landslide material (samples 120-460)

Although the analyses were undertaken in three stages, the assemblage is treated as a single unit for the summary of results given below. Further details of the archaeology and geology of the site can be found in Hall (1996) and the excavation report (Earwood in prep).

METHODS

The samples were examined and a note made of the approximate number and orientation of the rings in relation to the parent tree trunk (Table 1; Hall 1996). Any samples with less than 50 rings were rejected at this stage since their ring patterns are unlikely to be unique. Non-oak samples and those with ring sequences made unmeasurable by narrowness or knots were also rejected. The remaining samples were cut into manageable slices and then frozen for at least 48 hours. The cross-sections were cleaned whilst still frozen to reveal the boundaries of the annual rings. Where necessary, further preparation was done by paring the surface with a Stanley knife.

Many of the samples had very narrow rings. In order to ensure the reliability of the ring width data, their ring patterns were measured across two radii. The two sets of measurements were then averaged to produce a single sequence. The ring widths were measured to an accuracy of 0.01mm on a travelling stage connected to a microcomputer which uses a suite of dendrochronology programs written by Ian Tyers (1997). The ring width data were plotted as graphs. Crossmatching was carried out visually by comparing the graphs on a light box, and also by using a computer program to measure the amount of correlation between two ring sequences. The program uses crossmatching routines which are based on the Belfast CROS program (Baillie and Pilcher 1973; Munro 1984). This calculates the correlation coefficient r between two ring sequences, and then tests the significance of the results using Student's t test. Generally t-values of 3.5 or above indicate a match provided that the visual match between the tree-ring graphs is acceptable (Baillie 1982, 82-5). t-values over *c.* 10 usually indicate an origin in the same tree, although t-values less than 10 may be produced when different radii are measured on the same trunk. This is particularly true for young trees. Visual matching can sometimes aid the decision as to whether timbers come from the same tree but inevitably some same-tree samples will go undetected by dendrochronology.

The data from matching ring sequences are averaged to produce a structure or site master curve. Unmatched sequences are then compared to the master. Matching is accepted if the sequence to be dated matches visually and statistically with the working master and with several of the individual components of that master. The data from the newly matched sequences are then incorporated into the master and the process repeated until no more samples can be crossmatched. The site master is tested for similarity against dated reference chronologies. Master curves are used for dating whenever possible because they enhance the general climatic signal at the expense of the background noise from the growth characteristics of the individual samples. Any unmatched sequences are tested individually against the reference chronologies.

If a sample has bark or bark edge, the date of the last measured ring is the year in which the tree died or was felled. A complete outer ring indicates that the tree was felled during its period of dormancy between autumn and early spring (referred to as "winter felled"). A partially formed ring indicates that the tree died in late spring or summer (known as "summer felled") or, if the springwood is just beginning to form, in spring (Baillie 1982, fig 2.1). Partially formed rings are not measured so, for spring- and summer-felled trees, there will be a one-year discrepancy between the date of the measured ring sequence and the felling date. It is not always possible to distinguish between an incomplete ring and a complete narrow ring and therefore the season of felling may be indistinguishable. Sometimes the outer edge of a sample may be damaged because of the delicate nature of sapwood and, whilst it is known that bark edge was originally present, a few outer rings may have been lost or become so compressed that they are unmeasurable. In such cases the felling dates are precise to within a few years. Where bark edge is absent, felling dates are calculated using the sapwood estimate of 10-55 rings. These are the 95% confidence limits for the number of sapwood rings in British oak trees over 30 years old (Hillam *et al* 1987). Although an estimate of 10-46 rings is now thought to be more representative for England (Tyers pers comm), it may not be appropriate for Welsh sites and therefore the original 10-55 range is used throughout this report. Where sapwood is absent, felling dates are given as *termini post quem* by adding 10 years, the estimated minimum number of missing sapwood rings, to the date of the last measured heartwood ring. This is the earliest possible felling date but the actual felling date could be much later depending on how many heartwood rings have been removed either during conversion of the trunk into its component timbers or as a result of decay in natural assemblages.

The above gives a brief introduction to dendrochronology. Further information about the history, principles, and methodology of dendrochronology can be found in Baillie (1982) and Hillam (forthcoming (a)).

RESULTS

The Timbers

Of the 114 samples sent for analysis, 35 were from excavated contexts and 79 from the spoil heaps (Table 1). Twenty samples, including twelve from the excavation, were rejected, mainly because their rings were too narrow to measure with accuracy. Details of the rejected samples can be found in Hall (1996).

The samples were mostly from whole or half trunks which often showed signs of weathering. Sapwood had been lost from many of the timbers but bark edge was present on 17 of the measured samples. Where it was possible to determine the nature of the outer ring, the season of death was winter. The sapwood rings were often difficult to measure, and sometimes to count, because of extremely narrow rings. The number of sapwood rings is therefore sometimes approximate (Table 1), but seems to vary from 28 to 70 with five of the samples having more than 55 rings, the 95% confidence limit for the maximum number of expected sapwood rings (Hillam *et al* 1987). These results therefore justify the use of the 10-55 sapwood estimate but they do not necessarily imply that trees from all sites in Wales will have a high number of sapwood rings. This may be due to the specific conditions in which the Abercynafon trees were growing.

The measured samples contained 54-352 rings. Many samples contained more rings than those measured but the extreme narrowness of the rings made measurement impossible. More than half the samples sent for analysis came from trees which were over 100 years old (Hall 1996). Many were over 200 years, and sample 434, with 352 measured rings and no sapwood, was probably nearly 400 years old. The size of tree varied, but some of them (eg 003) must have been at least 1m in diameter.

The growth of many of the Abercynafon trees was slow with many average ring widths below 1mm (Table 1). The average growth for all the measured samples was 0.9mm per year. None of the trees had average ring widths greater than 2.0mm; four samples (407, 417, 422, and 617) had average ring widths of about 0.5mm or less. This indicates that at least some of the trees were growing under extremely stressful conditions.

Crossmatching

When the ring sequences were compared together, 23 samples were found to crossmatch (Fig 4 and Table 2). The level of correlation between the matching group was high. Some of the ring sequences were almost identical with *t*-values well over 10; samples 434 and 439, for example, gave a *t*-value of 16.38. This suggests that many of the samples were from the same tree or a stand of adjacent trees and that all the matching group were from a single area of woodland.

The following could be same-tree groups:

- 003, 404, 405, 419, 429, 435, 436
- 400, 408, 459, 460
- 001, 002, 434, 438, 439

Where same-tree groups occur, the usual procedure is to average their ring widths before inclusion in the site master, but it proved impossible to determine exactly which Abercynafon samples were from the same tree. Each ring sequence was therefore included as a single "tree", and the 23 matching ring sequences were averaged to form a 369-year master curve (Table 3). Unmatched sequences from Abercynafon were checked against the site master. Matches were found for samples 258 and 403, which gave *t*-values of 6.85 and 8.42 respectively with the master. These were not included to form a new master because both contained extreme bands of narrow rings. None of the remaining ring sequences appeared to match the master. Comparisons with dated reference chronologies indicated that the Abercynafon master spanned the period 3098-2730 BC (Table 4).

Within the unmatched sequences, several sub-groups were found:

- 120, 279, 428 - some same-tree (Table 5a)
- 257, 259, 453 (Table 5b)
- 266, 445, 446, 818 - some same-tree (Table 5c)
- 401, 413, 414, 416, 423 - possible same-tree group; matches 409, 430, and 829 (Table 5d)
- 406, 412, 424 - possible same-tree group (Table 5e)
- 431, 432 - probable same-tree, t=14.7
- 441, 452 - probable same-tree, t=9.7
- 447, 458 - probably not the same-tree, t=9.2
- 451, 454, 872 (Table 5f)
- 856, 857 - probable same-tree, t=9.5

There was no apparent crossmatching between these sub-groups, nor did they appear to match any of the dated reference chronologies covering the period 6000 BC to the present. 37 other ring sequences remain unmatched and undated. The ring widths from the sub-group masters and all the individual tree-ring samples are stored in the Sheffield Dendrochronology Laboratory.

INTERPRETATION

Of the 25 dated timbers, all but three were from the spoil heaps and were all totally unstratified. The exceptions are 602, a trunk from trench 3, which was felled or died in 2867-2838 BC; 660, a branch from trench 8, which was felled or died in the winter of 2861/60 BC, and 999, the 1994 timber from the west side of the site, which was felled or died after 2917 BC. It is possible that all three timbers were felled or died at the same time.

The exact chronological relationship of the dated trees from the spoil heaps cannot be determined because most of them had no sapwood. The only sample with sapwood was 436; this died during 2755-2737 BC. The heartwood-sapwood boundary was present on 400, indicating that this died during the period 2829-2784 BC. Four timbers are likely to be more recent than 434 since their *termini post quem* for felling are the same or younger than 2737. The chronology of the dated trees is summarised below:

602 660 999	2867-2838 BC winter 2861/60 BC after 2917 BC	602, 660, and 999 could be contemporary
400	2829-2784 BC	408, 459, 460 could be same tree as 400
436	2755-2737 BC	003, 404-5, 419, 429, 435 could be same tree as 436
434 001	after 2737 BC after 2695 BC	could be same tree; 002, 438, 439 could also belong to this tree
433 403	after 2720 BC after 2717 BC	could be contemporary with each other and with above two

A total of 69 timbers remain undated which suggests that oak trees were growing in Abercynafon area for a longer period than that covered by the tree-ring chronology and/or that the undated trees were responding to different conditions of growth. The timbers from the landslide material are stratigraphically earlier than the dated timbers but no dates were obtained for these and therefore the temporal relationship between the two horizons cannot yet be determined by dendrochronology. The chronology of the landslide timbers and other undated timbers may be revealed when all the radiocarbon results from the material submitted by the excavator become available.

DISCUSSION

Tree-ring analysis indicates that the Abercynafon timbers come from a predominantly mature oak woodland which also contains a few younger trees. It was probably part of the "wildwood", primary woodland not yet subject to human interference (Rackham 1990). Such a woodland would probably be a dense mix of oak and hazel with small clearings containing dead and fallen trees in which new trees could germinate.

Two assemblages from natural woodland which are broadly contemporary with the dated trees from Abercynafon are Thorne and Hatfield Moors, South Yorkshire/Lincolnshire (Boswijk forthcoming), and Wootton Quarr, Isle of Wight (Hillam 1994 and forthcoming (b)). The Thorne and Hatfield oaks are slightly earlier than the dated trees from Abercynafon. They grew throughout the period 3777-3017 BC with an average growth rate of 1.4mm per year. They were rooted in peat and gradually killed by increased wetness across the Moors. The Isle of Wight trees lived during 3463-2557 BC and thus are more directly comparable to Abercynafon. They grew at a rate of about 1mm per year and were killed by an increase in wetness and salinity. The average growth of the dated trees from these three assemblages is illustrated in Figure 5. The trees from Thorne/Hatfield and the Isle of Wight are responding to different factors for most of the period they overlap. By contrast, those from Abercynafon and the Isle of Wight show the same gradual decrease in growth throughout 3000-2750 BC. This is a period of rising sea level, when conditions throughout the British Isles were getting wetter. If the trees at Abercynafon were growing on the edge of a pond formed by an earlier landslide (see above), it is possible that a general rise in the water table may have caused the banks to crumble and the trees to fall. This is a comparable situation to that at Wootton Quarr, except that it was a direct effect of rising sea levels which caused the death of the Isle of Wight trees.

A picture therefore emerges from the tree-ring analysis of the Abercynafon trees, many of them large and mature, in a setting which was not particularly favourable to growth. Many of the timbers probably came from the same tree or from trees growing very close together. They would have been competing for light, water, and nutrients, as well as coping with a general increase in wetness. Such a woodland would not be inviting to exploitation by man, nor is it likely that trees would have been moved very far. Although toolmarks and signs of worked timbers were found at the site (Earwood pers comm - see Table 1), it is possible that the trees were killed and moved by one or more natural disasters such as a landslide, flash flood, or strong gale. This would explain why most of the timbers were aligned in the same direction and why there are so many same tree groups. The toolmarks may therefore represent an opportunistic use of timber which has been felled by natural causes.

CONCLUSION

The primary aim of the study has been achieved in that a tree-ring chronology was produced for the period 3098-2730 BC thereby broadening the geographical spread of chronologies for this period. The number of samples dated was disappointing and emphasises the need for further research on prehistoric timbers so that the network of chronologies can be extended and replicated. The results from 25 trees in the organic layers showed that these trees died during the first half of the third millennium BC. It was not possible to date any of the samples from the landslide material. Most of the material examined came from mature or middle-aged oak trees which were probably part of the primary "wildwood". Local conditions inhibited the growth of at least some of the trees but comparison with broadly contemporary trees from Wootton Quarr in the Isle of Wight indicates that a general increase in wetness was probably also responsible for poor growth during the period covered by the Abercynafon chronology.

ACKNOWLEDGEMENTS

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REFERENCES

Baillie, M G L, 1982 *Tree-Ring Dating and Archaeology*, London

Baillie, M G L, and Pilcher, J R, 1973 A simple crossdating program for tree-ring research, *Tree Ring Bulletin*, **33**, 7-14

Boswijk, I G, forthcoming A dendrochronological study of oak and pine from the raised mires of the Humberhead Levels, Eastern England, PhD thesis, Univ Sheffield

Brown, D M, and Baillie, M G L, 1992 Construction and dating of a 5000 year English bog oak tree-ring chronology, in *Tree Rings and Environment*, LUNDQUA report, **34**, 72-75

Brown, D M, Munro, M A R, Baillie, M G L, and Pilcher, J R, 1986 Dendrochronology - the absolute Irish standard, *Radiocarbon*, **28** (2A), 279-83

Hall, C, 1996 Dendrochronological dating of wood samples from Abercynafon, Talybont-on-Usk, in Wales, unpubl MSc dissertation, Univ Sheffield

Hillam, J, 1994 *The dating of oak timbers from the Wootton Quarr survey, Isle of Wight*, Anc Mon Lab Rep, **10/94**

Hillam, J, forthcoming (a) *Guidelines for Dendrochronology*, English Heritage

Hillam, J, forthcoming (b) Tree-ring analysis of oak timbers from the Wootton Quarr survey, Isle of Wight, in Tomlin *et al*, English Heritage monograph, London (exact author/title to be decided)

Hillam, J, Morgan, R A, and Tyers, I, 1987 Sapwood estimates and the dating of short ring sequences, in *Applications of tree-ring studies: current research in dendrochronology and related areas* (ed R G W Ward), BAR Int Ser, **333**, 165-85, Oxford

Munro, M A R, 1984 An improved algorithm for crossdating tree-ring series, *Tree Ring Bulletin*, **44**, 17-27

Rackham, O, 1990 *Trees and woodland in the British Landscape*, 2nd edn, London

Tyers, I G, 1997 *Dendro for Windows Program Guide*, ARCUS Rep, **340**

Fig 1: Location of Abercynafon and some of the other sites mentioned in the report.

Fig 2: The area of the Abercynafon conservation pond.

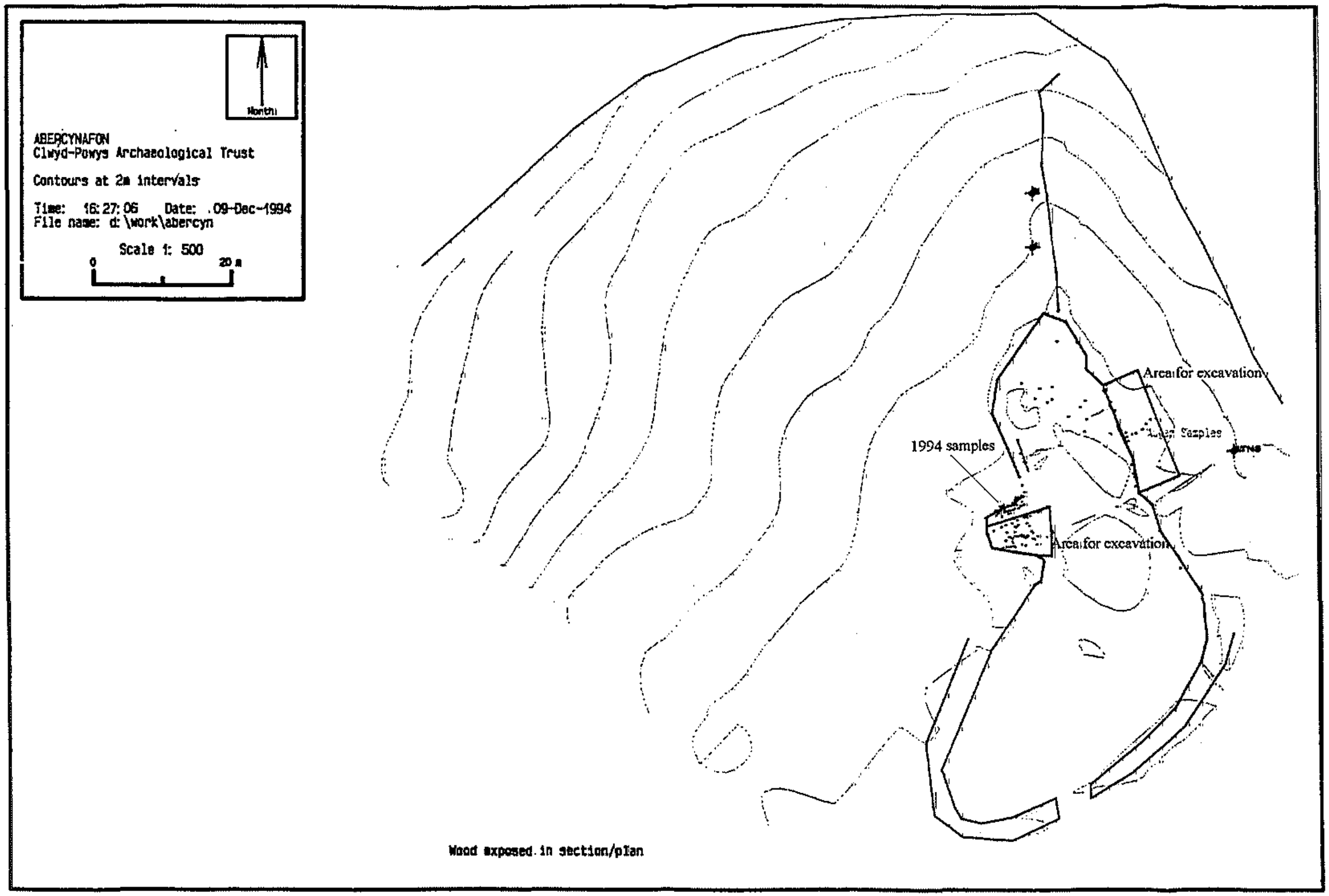

Fig 3: Location of trenches with tree-ring samples (after a drawing by the Clwyd-Powys Archaeological Trust)

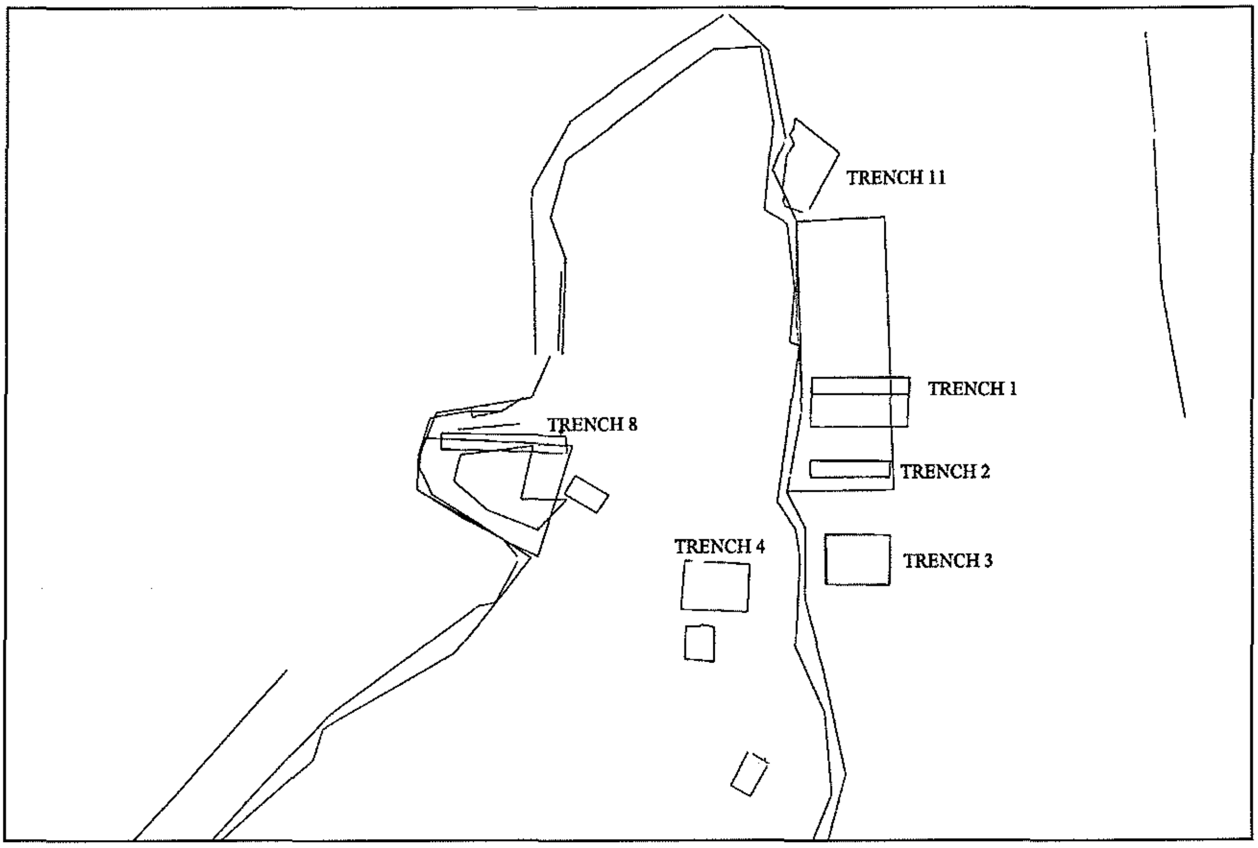

Figure 4: Bar diagram showing the relative positions of the dated ring sequences. Possible same-tree groups are shown by shading. ++ - felled after.

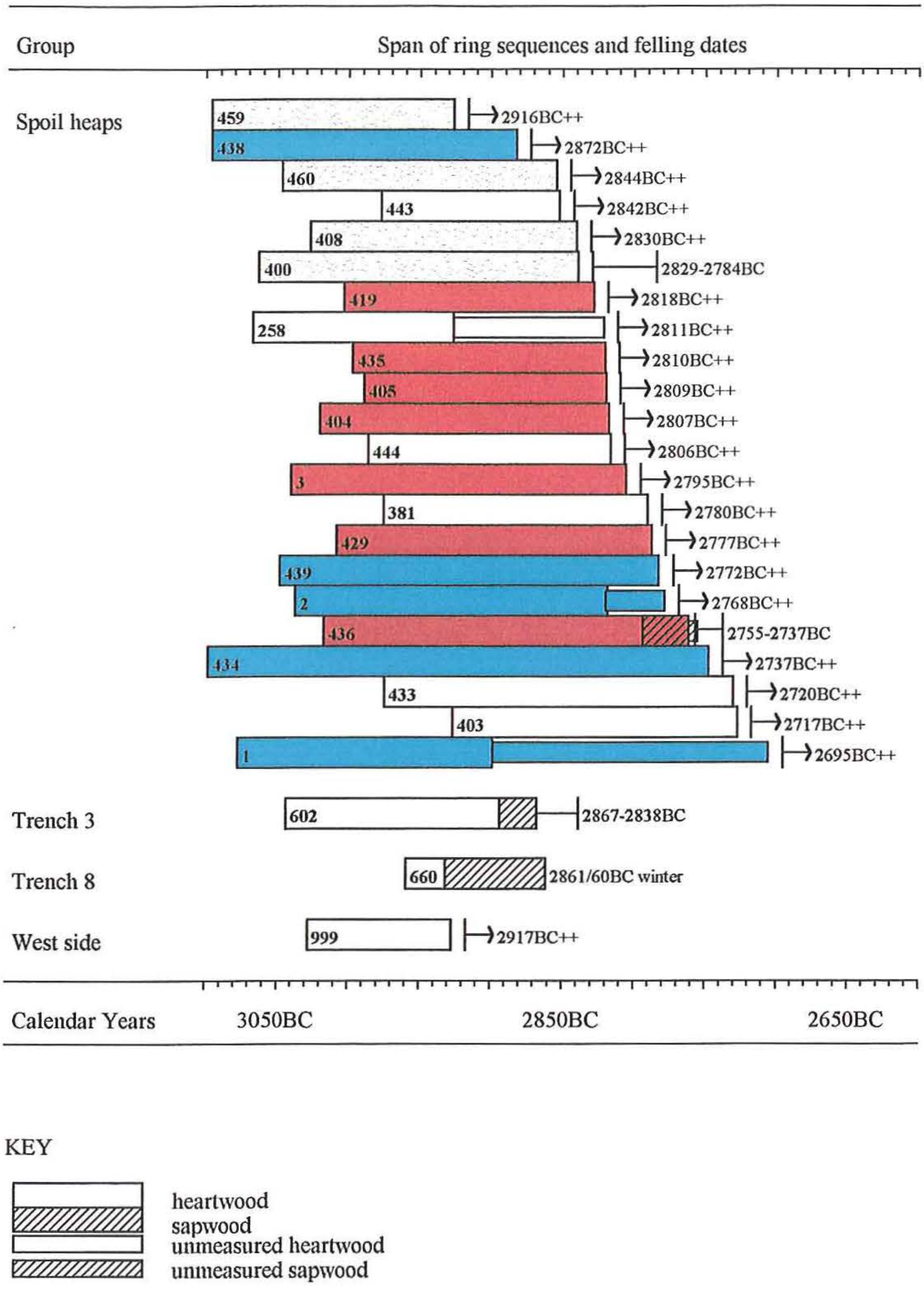

Figure 5: Growth trends of the dated trees from Abercynafon compared to those from Thorne and Hatfield Moors, South Yorkshire/Lincolnshire, and Wootton Quarr, Isle of Wight.

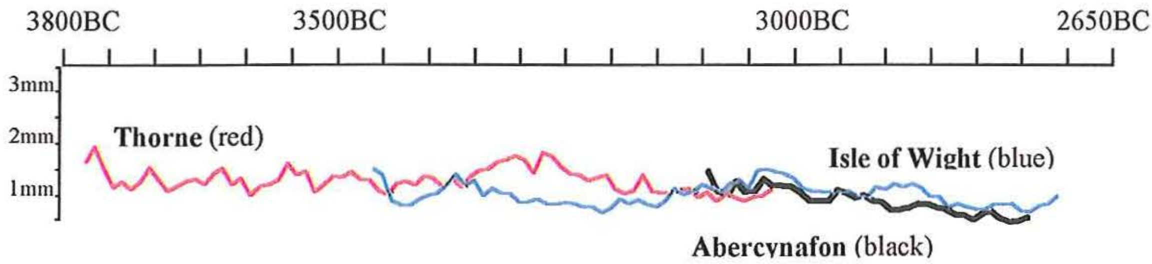

Table 1: Details of the tree-ring samples. ARW - average ring width; BE - bark edge; HS - heartwood-sapwood transition; + - unmeasured rings present; ++ - felled after. Cross-section types are divided crudely into whole, half, or quarter; within these categories, some are complete with sapwood and bark edge, others have lost rings through weathering.

Sample no (Site wood no)	Site sample no	Timber description (Earwood pers comm)	Total no of rings	Sapwood rings	Bark edge	ARW (mm)	Cross-section type	Maximum cross-section dimensions (mm)	Date span (BC)	Felled (BC)
1994 spoil heap										
001	-	pile with pointed end	180+139	+*c*54 to BE	-	0.85	half	390x225	3077-2898	2695++
002	-	half tree trunk	220+40	-	-	0.73	half	400x225	3037-2818	2768++
003	-	half tree trunk	236	-	-	1.42	half	700x400	3040-2805	2795++
1995 spoil heaps										
120	-	split timber - pile?	99	1	-	1.11	half	215x125	-	-
257	-	trunk - pile?	199	39	yes?	0.51	whole	195x160	-	-
258	-	trunk	142+105	-	-	0.60	whole	210x190	3067 -2926	2811++
259	-	trunk, pointed each end	145	-	-	0.60	whole	175x165	-	-
260	-	trunk	78	-	-	0.91	whole	195x175	-	-
261	-	trunk, pointed each end	96	22	-	0.61	whole	135x110	-	-
262	-	half trunk	118	42	yes?	0.85	whole	175x150	-	-
263	-	half trunk	106+2	-	-	0.94	half	220x125	-	-
264	-	trunk	151+3	-	-	0.51	whole	185x155	-	-
265	-	pile? with pointed end	122+	27+5	-	0.94	half/whole	175x145	-	-
266	-	half trunk	116	-	-	0.83	half	140x100	-	-
267	-	?	74	-	-	1.37	half	230x120	-	-
268	-	trunk	131	-	-	0.70	whole	175x155	-	-
269	-	trunk	57+2	-	-	1.57	half	205x105	-	-
270	-	pile? with pointed end	103	44	yes?	0.60	whole	130x115	-	-
279	-	?	84	-	-	1.41	half	230x120	-	-
381	-	split timber with point	186	-	-	0.61	half	280x130	2975-2790	2780++
382	-	trunk	224	40	yes?	0.56	half	195x145	-	-
400	-	trunk	225	HS	-	0.80	whole	345x290	3063-2839	2829-2784
401	-	split timber - pile?	124	-	-	0.97	whole	220x170	-	-
402	-	trunk	140	-	-	0.85	whole	245x175	-	-
403	-	half trunk	200	-	-	0.57	half	345x250	2926-2727	2717++
404	-	split timber, pointed end	204	-	-	1.36	half	345x265	3020-2817	2807++
405	-	trunk	171	-	-	1.40	half	385x365	2989-2819	2809++
406	-	trunk	89	-	-	0.74	whole	175x125	-	-
407	-	roundwood/branch	120+65 to HS	-	-	0.40	whole	225x165	-	-

408	-	half trunk	188	-	-	0.91	half	235x170	3027-2840	2830++
409	-	half trunk	79	7	-	1.00	half	145x90	-	-
410	-	roundwood/branch	62	-	-	0.71	whole	115x100	-	-
411	-	half roundwood/branch	70	-	-	1.64	half	160x135	-	-
412	-	roundwood, rough point	121	36	-	0.99	whole	210x185	-	-
413	-	quarter roundwood	141+	31+39 to ?BE	-	0.79	quarter	190x140	-	-
414	-	half roundwood	129	28	-	0.65	half	225x135	-	-
416	-	part trunk	156	47	yes?	0.71	quarter	210x135	-	-
417	-	roundwood, curved piece with pencil point	91	-	-	0.50	whole	95x90	-	-
418	-	roundwood, pointed end?	75	-	-	1.13	whole	130x130	-	-
419	-	half trunk	176	-	-	0.93	half	250x190	3003-2828	2818++
420	-	roundwood with branch	63	-	-	1.51	quarter	125x95	-	-
422	-	split roundwood	147+	10+12	-	0.52	half	130x120	-	-
423	-	half roundwood, pointed end?	98	-	-	0.92	half	200x105	-	-
424	-	half roundwood	110	37	-	0.66	half	145x90	-	-
428	-	half roundwood	128	-	-	0.60	half	195x85	-	-
429	-	half trunk, squared end	222	-	-	0.96	half	190x80	3008-2787	2777++
430	-	roughly squared timber	75	-	-	1.21	quarter/half	135x100	-	-
431	-	squared timber	102	-	-	1.60	half	275x190	-	-
432	-	squared timber	105	-	-	1.74	half	280x185	-	-
433	-	roundwood with branch	245	-	-	0.69	half	440x210	2974-2730	2720++
434	-	trunk with branch	352	-	-	0.68	half	500x310	3098-2747	2737++
435	-	trunk with side branch removed	178	-	-	0.98	half	360x250	2997-2820	2810++
436	-	trunk	257+	31+6	-	0.73	half	290x205	3017-2761	2755-2737
437	-	half trunk	184	28	yes?	0.65	half	260x150	-	-
438	-	trunk	215	-	-	0.62	half	370x220	3096-2882	2872++
439	-	trunk, partly split end	267	-	-	0.73	quarter	215x115	3048-2782	2772++
440	-	roundwood	96+2	-	-	0.82	whole	160x140	-	-
441	-	split timber pile?	63	-	-	1.44	half	215x115	-	-
442	-	half roundwood, pointed	78	-	-	1.10	whole	160x125	-	-
443	-	split timber pile?	126	-	-	1.09	quarter	175x155	2977-2852	2842++
444	-	split timber pile?	171	-	-	1.25	half	275x230	2986-2816	2806++
445	-	half trunk	230	-	-	0.70	whole	295x245	-	-
446	-	half roundwood	173	-	-	0.84	half	320x170	-	-
447	-	roundwood	109	-	-	0.68	whole	190x140	-	-

451	-	half roundwood	134	-	-	0.72	half	290x140	-	-
452	-	half roundwood	87	-	-	1.15	half	290x115	-	-
453	-	part roundwood	176+	27+16 to ?BE	-	1.17	half	295x230	-	-
454	-	half trunk with side branches removed	185	-	-	0.83	half	415x170	-	-
456	-	roundwood with side branch removed	134	60	yes	0.58	whole	200x170	-	-
458	-	trunk with branch	133	-	-	1.39	whole	380x340	-	-
459	-	trunk	171	-	-	1.39	quarter/half	250x185	3096-2926	2916++
460	-	trunk with branch	194	-	-	0.66	half	225x180	3047-2854	2844++
Excavation										
507	158	landslide material	134	53+6 to BE	-	0.79	whole	230x190	-	-
529	273	trench 2, split pile?	78	-	-	0.98	half	140x90	-	-
530	276	trench 2, horizontal trunk	77	-	-	1.10	half	190x105	-	-
589	289	trench 4, roundwood - upright?	60	+ 33 to BE	-	0.67	whole	95x90	-	-
595	159	trench 1, split half trunk?	119	-	-	0.82	half/whole	155x85	-	-
596	188	trench 1, upright pile?	54	37	-	0.65	whole	70x60	-	-
599	274	trench 1, half trunk	84+34	+30 to BE	-	0.77	half	210x115	-	-
602	178	trench 3, trunk	177	26	-	1.10	half	420x230	3043-2867	2867-2838
617	277	trench 4, timber	66+	+ 56 to ?BE	-	0.47	whole	105x95	-	-
660	154	trench 8, branch	99	70	yes	0.58	whole	105x95	2959-2861	2861/60
818	211	west facing section, horizontal, pointed end	121	-	-	0.83	whole	155x125	-	-
819/820	210	trench 11, split half trunk?	95	-	-	0.95	half	240x110	-	-
829	292	trench 11, horizontal	87	-	-	0.69	whole	125x115	-	-
855 (1051)	295	landslide material	110	28	yes	0.97	whole	170x120	-	-
856 (1050)	294	landslide material	95	HS +24	-	0.69	whole	195x180	-	-
857 (1052)	296	landslide material	86	HS	-	0.93	half	175x110	-	-
858 (1053)	297	landslide material	178	41	yes	0.70	half	240x130	-	-
870	272	trench 11, trunk	68+70	-	-	0.66	whole	215x195	-	-
872	275	trench 11, split horizontal	152	-	-	0.62	half	180x100	-	-
873	280	trench 11, horizontal half trunk	110	-	-	0.72	half	200x90	-	-
876	281	trench 11, upright trunk	70+80	-	-	0.56	whole	175x165	-	-
885	279	trench 11, trunk with point	141	44	yes	0.61	whole	170x155	-	-
999	291	west side (1994), branch	102	-	-	0.87	whole	160x135	3028-2927	2917++

Table 2: *t*-value matrix showing the level of crossmatching between the dated Abercynafon ring sequences. Values over 10, which might indicate same tree matches, are shown in bold; values less than 3.0 are not printed.

	381	400	404	405	408	419	429	433	434	435	436	438	439	443	444	459	460	602	660	999	001	002	003
381	*	5.03	6.97	7.97	5.94	6.67	6.03	8.24	8.54	5.09	8.50	4.53	9.74	7.01	5.66	3.92	5.06	6.20	5.01	3.30	5.86	**10.74**	7.63
400	*	*	8.13	6.45	**10.12**	6.16	4.26	5.40	**10.15**	5.80	6.35	9.72	8.85	7.94	5.59	9.04	**11.23**	7.44	3.66	9.87	8.01	6.82	7.64
404	*	*	*	**10.93**	8.44	9.41	7.25	5.53	8.40	7.38	5.69	6.68	7.63	6.81	5.30	6.91	8.93	7.49	4.30	6.10	5.47	6.76	**15.84**
405	*	*	*	*	7.28	**14.06**	9.49	6.24	6.07	**14.29**	**11.69**	4.64	7.63	7.14	6.40	-	5.11	5.60	4.54	4.54	4.91	6.54	**12.38**
408	*	*	*	*	*	6.90	5.85	7.50	8.71	6.92	7.95	7.14	8.08	7.92	7.64	8.01	8.59	7.26	3.76	8.25	6.84	6.21	7.84
419	*	*	*	*	*	*	**11.12**	6.46	6.08	**15.29**	9.46	3.56	6.37	6.90	6.06	4.44	5.83	5.12	6.28	5.60	3.30	5.37	**11.20**
429	*	*	*	*	*	*	*	7.49	6.27	9.52	**10.59**	3.46	7.34	5.77	5.14	-	5.53	-	5.64	3.61	-	4.89	8.88
433	*	*	*	*	*	*	*	*	9.55	5.84	8.26	4.59	9.71	**10.12**	7.55	5.98	4.56	6.79	5.12	6.86	4.85	6.41	7.50
434	*	*	*	*	*	*	*	*	*	6.08	6.95	**11.24**	**16.38**	7.72	5.36	**10.84**	8.28	7.64	4.48	7.16	**14.56**	**11.50**	9.11
435	*	*	*	*	*	*	*	*	*	*	9.53	3.88	5.94	5.62	6.49	4.29	4.81	4.71	5.94	5.92	3.27	4.81	**10.06**
436	*	*	*	*	*	*	*	*	*	*	*	4.35	9.13	6.30	6.32	4.29	5.24	4.87	4.91	4.74	3.77	6.32	7.63
438	*	*	*	*	*	*	*	*	*	*	*	*	**10.98**	4.21	4.05	7.37	9.30	4.53	4.48	7.44	**10.97**	8.54	5.20
439	*	*	*	*	*	*	*	*	*	*	*	*	*	6.84	5.57	6.24	8.74	5.07	4.09	5.12	**11.78**	**12.42**	7.61
443	*	*	*	*	*	*	*	*	*	*	*	*	*	*	7.98	3.53	5.41	7.81	4.39	4.54	4.92	7.13	8.12
444	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	3.92	5.09	4.83	3.64	4.65	4.29	6.28	7.66
459	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	9.37	7.59	-	8.26	8.53	4.52	7.01
460	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	5.59	3.44	6.16	8.42	6.28	8.39
602	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	-	6.31	6.37	7.13	7.63
660	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	-	-	4.07	4.07
999	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	6.16	3.80	7.11
001	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	9.19	5.05
002	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	6.86
003	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

Table 3: The Abercynafon tree-ring chronology, 3098-2730 BC

Year	Ring widths (0.01mm)										No of samples									
3098BC			145	137	198	198	224	173	119	108			1	1	3	3	3	3	3	3
-	69	87	134	116	67	100	135	119	118	99	3	3	3	3	3	3	3	3	3	3
-	114	71	92	121	96	103	124	138	83	106	3	3	3	4	4	4	4	4	4	4
-	82	58	116	129	123	120	137	137	149	126	4	4	4	4	4	4	4	5	5	5
-	93	130	123	129	127	117	143	121	84	69	5	5	5	5	5	5	5	5	5	5
3050BC	79	65	101	116	82	108	104	98	145	94	5	5	6	7	7	7	7	8	8	8
-	103	130	148	159	158	108	134	127	144	125	9	9	9	10	10	10	10	10	10	10
-	95	117	109	106	122	112	133	135	146	113	10	10	11	12	12	12	12	12	12	12
-	130	81	83	134	130	125	148	126	119	116	13	13	13	14	14	14	14	14	14	14
-	81	118	119	138	113	97	135	105	83	119	14	14	15	15	15	15	15	16	16	16
3000BC	141	126	126	127	99	109	106	91	78	91	16	16	16	17	17	17	17	17	17	17
-	111	106	98	101	68	73	75	84	86	101	17	18	18	18	19	19	19	19	19	19
-	107	92	90	92	83	75	78	79	104	99	19	19	19	20	20	21	22	22	22	22
-	88	101	91	91	60	60	87	89	107	97	22	22	22	22	22	22	22	22	22	22
-	105	99	83	97	109	100	137	113	119	117	22	23	23	23	23	23	23	23	23	23
2950BC	119	101	99	103	139	107	130	105	110	83	23	23	23	23	23	23	23	23	23	23
-	59	101	101	87	119	95	108	113	90	73	23	23	23	23	23	23	23	23	23	23
-	74	88	114	106	105	99	96	95	99	94	23	23	23	23	22	21	21	21	21	21
-	100	88	83	110	85	87	86	110	95	71	21	21	21	21	21	21	21	21	21	21
-	72	92	91	95	95	89	73	91	66	71	21	21	21	21	21	21	21	21	21	21
2900BC	78	113	82	77	79	82	70	61	47	63	21	21	21	20	20	20	20	20	20	20
-	76	82	77	85	85	64	50	55	68	65	20	20	20	20	20	20	20	20	20	19
-	78	102	99	70	61	53	74	92	77	82	19	19	19	19	19	19	19	19	19	19
-	83	76	78	79	103	77	64	78	83	88	19	19	19	19	18	18	18	18	18	18
-	92	97	94	101	98	69	74	61	87	81	17	17	17	17	17	17	17	16	16	15
2850BC	68	87	92	78	77	60	56	72	86	76	15	15	15	15	15	15	15	15	15	15
-	90	81	75	81	65	64	66	73	94	75	15	14	13	13	13	13	13	13	13	13
-	72	66	68	68	50	42	58	55	70	81	13	13	13	12	12	12	12	12	12	12
-	69	78	66	51	55	64	63	69	62	62	12	11	10	9	8	7	7	7	7	7
-	60	60	58	54	56	55	42	54	45	54	7	7	7	7	7	7	6	6	6	6
2800BC	53	59	53	53	80	75	62	48	67	75	6	6	6	6	6	6	6	6	6	6
-	69	81	86	86	52	42	55	75	89	74	6	5	5	5	4	4	4	4	4	3
-	69	56	65	57	57	45	61	56	70	48	3	3	3	3	3	3	3	3	3	3
-	46	44	35	55	55	49	48	52	50	45	3	3	3	3	3	3	3	3	3	3
-	49	49	55	54	48	41	50	52	53	41	2	2	2	2	2	2	2	2	2	2
2750BC	58	56	43	55	52	50	55	62	61	67	2	2	2	2	1	1	1	1	1	1
-	56	62	70	52	51	48	61	63	55	72	1	1	1	1	1	1	1	1	1	1
-	65										1									

Table 4: Dating the Abercynafon chronology; *t*-values with dated reference chronologies.

Chronology	Date span (BC)	*t*-value
ENGLAND		
Catsholm House, E Anglia (Brown and Baillie 1992)	2867-2624 BC	3.69
Colwick Hall 1, Notts (Brown and Baillie 1992)	3045-2697 BC	5.11
Colwick Hall 2, Notts (Brown and Baillie 1992)	2792-2583 BC	3.07
Croston Moss 1, Lancs (Brown and Baillie 1992)	3198-1682 BC	3.31
Feltwell Moss, E Anglia (Brown and Baillie 1992)	3044-2645 BC	4.11
Hilgay Fen, E Anglia (Brown and Baillie 1992)	2894-2563 BC	3.28
HW-T2, Hereford and Worcester (Hillam unpubl)	2869-2698 BC	4.45
Wootton Quarr, Isle of Wight (Hillam 1994; forthcoming b)	3463-2557 BC	5.10
Isleham, E Anglia (Brown and Baillie 1992)	3148-2813 BC	3.73
Mildenhall, E Anglia (Brown and Baillie 1992)	3169-2661 BC	4.84
Thorne/Hatfield Moors (Boswijk forthcoming)	3777-3017 BC	3.53
Wicken Sedge Fen, E Anglia (Brown and Baillie 1992)	3088-2585 BC	6.05
Wood Hall, E Anglia (Brown and Baillie 1992)	2978-2622 BC	5.71
Wood Walton Fen, E Anglia (Brown and Baillie 1992)	3196-2307 BC	6.30
GERMANY		
North Germany (Leuschner pers comm)	6069 BC-AD 928	4.86
IRELAND		
Belfast Long Chronology (Brown *et al* 1986)	5289 BC-AD 1983	4.07

Table 5: Crossmatching between the various sub-groups from Abercynafon. The timescale in each case is relative and applies to only that sub-group; there is no obvious crossmatching between the sub-groups. Values under 3.0 are not printed.

Table 5a: 120, 279, and 428

		120	**279**	**428**
	years	3-101	1-84	28-155
120	3-101	*	14.79	7.09
279	1-84	*	*	5.40
428	28-155	*	*	*

Table 5b: 257, 259, and 453

		257	**259**	**453**
	years	1-199	8-152	4-179
257	1-199	*	10.55	6.17
259	8-152	*	*	8.16
453	4-179	*	*	*

Table 5c: 266, 445, 446, and 818

	years	**266** 82-197	**445** 1-230	**446** 38-210	**818** 32-152
266	82-197	*	7.08	11.47	7.45
445	1-230	*	*	10.28	8.14
446	38-210	*	*	*	6.96
818	32-152	*	*	*	*

Table 5d: Same tree group: 401, 413, 414, 416, and 423; plus 409, 430, and 829

	years	**401** 6-129	**413** 1-141	**414** 11-139	**416** 2-157	**423** 21-118	**409** 24-102	**430** 46-120	**829** 44-130
401	6-129	*	**13.55**	**11.76**	**10.47**	**11.66**	5.40	4.75	5.38
413	1-141	*	*	**16.82**	**10.60**	**10.58**	5.78	4.38	4.41
414	11-139	*	*	*	**14.31**	**10.11**	5.18	3.54	5.78
416	2-157	*	*	*	*	**12.15**	5.14	3.92	4.37
423	21-118	*	*	*	*	*	5.90	5.46	5.85
409	24-102	*	*	*	*	*	*	7.65	4.34
430	46-120	*	*	*	*	*	*	*	4.05
829	44-130	*	*	*	*	*	*	*	*

Table 5e: 406, 412, and 424

	years	**406** 1-89	**412** 7-127	**424** 14-123
406	1-89	*	9.97	6.18
412	7-127	*	*	10.02
424	14-123	*	*	*

Table 5f: 451, 454, and 872

	years	**451** 47-180	**454** 62-246	**872** 81-232
451	47-180	*	5.75	5.02
454	62-246	*	*	6.68
872	81-872	*	*	*