Stratigraphic and Palaeoenvironmental Investigations along the A590 Bypass at High Newton, Cumbria: Final Report

Client: Laing O'Rourke

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By

Dr Benjamin Gearey MIFA, Dr Tom Hill and Dr Emma Tetlow

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Birmingham Archaeo-Environmental,
Institute of Archaeology and Antiquity,
University of Birmingham,
B15 2TT. Tel: 0121 414 5591
Email: B.R.Gearey@Bham.ac.uk

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Non-technical Summary

This report describes the survey of the subsurface sediments that are present along the route of the proposed A590 Bypass in Cumbria. A total of nine sediment cores were extracted along the proposed route in four areas where peat deposits had previously been identified. In addition, a walk-over survey of the route was also undertaken to assess any potential for further sedimentary deposits with potential to provide information regarding past environmental changes. The sediments at three of the locations (Ayside, Cartmel Lane and Barrow's Green) were investigated using a hand operated soil coring device and found to comprise a layer of gravel rich clay overlying peat deposits up to 3m thick. No organic deposits were recovered from the fourth location at Oak Head Rd. Samples of the sediment were recovered and analysed in the laboratory for pollen and insect remains. These remains had been preserved in the waterlogged peat deposits and can provide information on past environments that had existed on and near to the sampling sites. The ages of the peat sequences were established using the radiocarbon method. The results show that peat formation began around 11,000 years ago at Ayside, 10,000 years ago at Barrow's Green and 3,500 years ago at Cartmel Lane. The fossil pollen and insect remains reflect how clearance for farming and settlement from the prehistoric period onwards changed the environments around each site from woodland with trees such as alder and oak to more open, grassland habitats. The effects of farming and cultivation and climatic change, resulted in the breakup of the soils on the slopes around the sampling sites and the deposition of the gravel rich clay. The results are discussed in the context of similar work in this region.

1. Introduction: reasons for and circumstances of the study

This report presents the results of work undertaken to establish the palaeoenvironmental potential of the deposits present along the route of the A590 Bypass in Cumbria, as previously identified by 'The Specification for Palaeoenvironmental Assessment'. The route of the bypass is approximately northwest – southeast, parallel to the present A590, and to the south of the villages of High Newton, Low Newton and Ayside. An auger survey was required at four locations along the bypass to identify the character of the sediments. In addition, collection of subsamples for palynological and coleopteran (sub-fossil beetles) analyses, supported by radiocarbon dating was to be carried out. The four locations in question were:

- **Cartmel Lane** – located to the south of Low Newton, west of the A590, east of High Lane and north of Cartmel Lane at NGR SD 4054 8187;
- **Barrow's Green** – located to the north-west of High Newton, west of the A590 and north of Barrow's Green Road at NGR SD 3974 8302;
- **Ayside** – located to the east of Ayside, west of the A590 and south of Black Beck Hall at NGR SD 3963 8351; and
- **Oak Head Road** – located to the north of Ayside, south-west of the A590 and north-west of Old Head Road at NGR SD 3910 8406.

The aims of the palaeoenvironmental assessments were to a) determine the approximate age and chronological development of deposit sequences; and b) assess the potential of sediments for future palaeoenvironmental study. In addition, a walkover survey was to be undertaken to identify any other areas of palaeoenvironmental potential.

2. Methods

2.1 Stratigraphic Survey

The four site locations (Fig. 1) related to areas of low-lying topography in which organic sediments typically accumulate, although only two of these areas (Ayside and Barrow's Green) were obvious as such from their surface vegetation. Of these sites, an initial assessment identified that three locations contained significant organic deposits suitable for stratigraphic recording and sampling for palaeoenvironmental assessment (Ayside, Barrow's Green and Cartmel Lane).

Cores were extracted using a manual gauge 'Eijkelcamp' corer. Coring continued until bedrock or where basal gravels were encountered (typically 2-3m depth). In some locations however, the thickness and gravel content of the surficial sediments meant it was not possible to penetrate to a depth greater than c. 0.5m. The lithological characteristics of the sedimentary sequences were recorded, including colour, grain size, presence of organic material and the character of transition between different units. Any organic remains were sampled in the field for subsequent laboratory analysis, whilst wood fragments were also sampled for radiocarbon dating. Full sediment logs are provided in Appendix I.

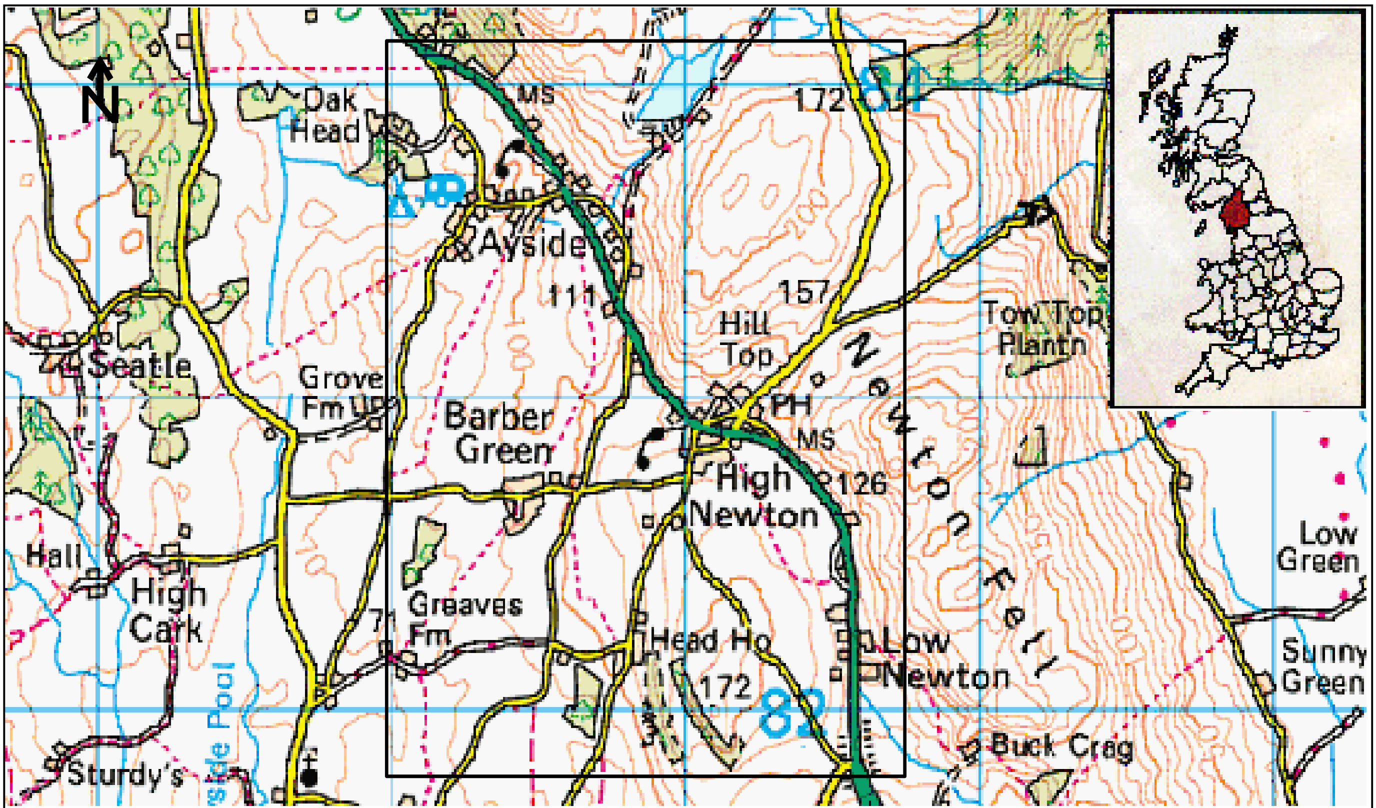


Figure 1: Site Location of High Netwon, Cumbria. Inset box refers to area in which site locations were positioned (see Figure 2)

2.2 Palaeoenvironmental Assessments

Samples were collected from organic deposits that were identified as having potential for the preservation of pollen and coleoptera. Generally, samples were taken from the top, middle and base of the deepest organic deposit identified at each location. Nine samples were selected for pollen analysis and seven bulk samples for coleoptera assessment (see Table 1). Pollen preparation followed standard techniques including KOH digestion and acetylation (Moore *et al*., 1991). At least 125 total land pollen grains (TLP) excluding aquatics and spores were counted for each sample, although pollen concentration and preservation was very low in one sample and a full count was hence not possible. The samples were processed for Coleopteran remains using the standard method of paraffin flotation as outlined in Kenward *et al*. (1980), weight and volume of the processed material is given in Table 5 (see below). This paraffin flot was then sorted and identified where possible under a binocular microscope. The system for "scanning" faunas as outlined by Kenward *et al.* (1985) was followed in this assessment.

2.3 Radiocarbon Dating

A total of eight samples (Table 1) were submitted for radiocarbon dating to Beta Analytic Inc., Miami, Florida to investigate the chronology of sediment accumulation. In general, samples were taken from the base (or as near to the base as possible) of the deepest organic sequence at each location with a further date from the top (or as near to the top as possible). As no material for analyses was recovered from Oak Head Road, extra dates were obtained from Barrow's Green and Cartmel Lane. Plant macrofossils were selected for dating where possible.

Site	Samples (pollen, coleoptera)	Radiocarbon samples: depth/material
Ayside Core 2	Pollen: 0.57m (top), 2.05m (middle), 2.79m (base) Coleoptera: 1.4-2m, 2-3m	1.00m (top): wood 2.79m (base): bulk peat
Barrow's Green Core 1	Coleoptera: 0.25-1.5m	-
Barrow's Green Core 2	Pollen: 0.25m (top), 1.45m (middle), 2.70m (base) Coleoptera: 1-1.8m, 2.15-2.75m	0.25m (top): bulk peat 1.80m (middle): wood 2.70m (base): bulk peat
Cartmel Lane Core 1	Coleoptera: 1.1-1.75m	1.55m (base): wood
Cartmel Lane Core 2	Pollen: 0.75m (top), 1.12m (middle), 1.50m (base) Coleoptera: 0.75-1.5m	0.75m (top): bulk peat 1.40m (base): wood

Table 1: Details of palaeoenvironmental and radiocarbon samples

3. Results

3.1 Stratigraphic Survey

3.1.1 Ayside (NGR SD 3963 8351)

This location (Plate 1) is adjacent to the area of water behind Black Beck Hall. Five boreholes were excavated (Fig 2) in a south-west/north-west transect across the wetland area immediately to the north of the tarn (Plate 2). The deposits were found to be a maximum of c. 3.20m deep (C2, see Appendix I for full borehole logs), although the presence of sub-surface obstacles hindered borehole excavation in places. The sequence in C2 consisted of a capping deposit of 0.50m of light grey silty clay with modern rootlets. This overlay 0.30m of dark brown well humified peat with occasional wood fragments. Below this, a 0.20m thick unit of light grey-brown, organic silty clay with some gravels was recorded. This trended into 2.0m of dark brown, well-humified peat with varying quantities of wood, fibrous material and the remains of herbaceous plants. The basal deposit was c.0.25m of light-grey silty organic sediment trending into grey-olive organic mud ('gyttja'). Samples were recovered from this sequence for pollen, coleoptera and radiocarbon dating (Table 1). In addition a single sample for diatom assessment was recovered from the basal silts.

3.1.2 Barrow's Green (NGR SD 3974 8302)

This site was an area of damp meadow (Plate 3) in low-lying ground to the north of the hamlet of Barrow's Green. The surficial deposits were too consolidated to core through; hence boreholes were excavated from the base of the field drain through the centre of the field. Two cores were recorded, the deepest of which (C2, see Appendix I) was c. 2.85m deep. The stratigraphy at this location consisted of overburden 0.25m thick, directly above 0.16m of dark grey brown, minerogenic, well-humified peat with detrital remains of wood and herbaceous plants. This deposit overlay 1.15m of dark brown well-humified peat with abundant wood remains, which became increasingly silty with depth. The basal deposit was light grey clayey gravel. Samples were recovered from this sequence for pollen, coleoptera and radiocarbon dating (Table 1).

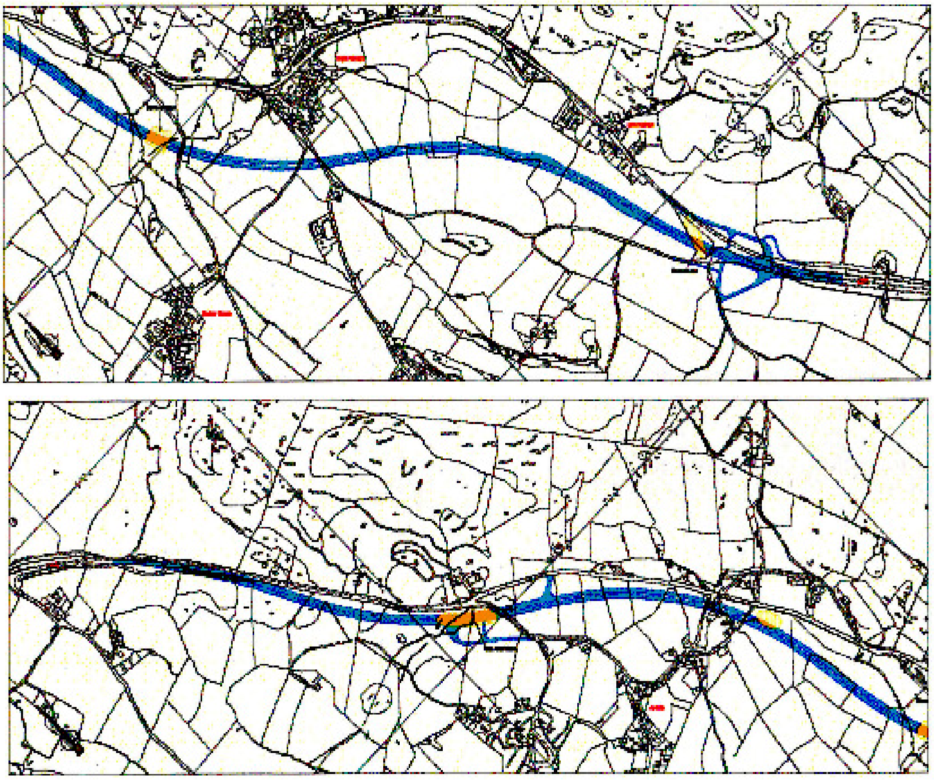
3.1.3 Cartmel Lane (NGR SD 4054 8187)

This location was an area of low-lying pasture immediately to the west of the current A590 (Plate 4). Two cores were excavated at this location. Dense, gravelly surficial deposits necessitated the excavation of test pits c.0.40m deep to permit core excavation. The upper deposits (C2, see Appendix I) consisted of 0.25m of grey brown, orange mottled clayey sub-angular gravel, trending into 0.50m of light grey, orange mottled clay with occasional gravel. The basal deposit was dark brown, well-humified fibrous peat with wood fragments and the remains of herbaceous plants (Plate 5). Samples were recovered from this sequence for pollen, coleoptera and radiocarbon dating (Table 1).

Plate 2: Auger survey at Ayside

Plate 3: Barrow's Green looking north-east

Plate 4: Cartmel Lane and **Plate 5 (below):** Cartmel Lane peat deposit in the gouge chamber



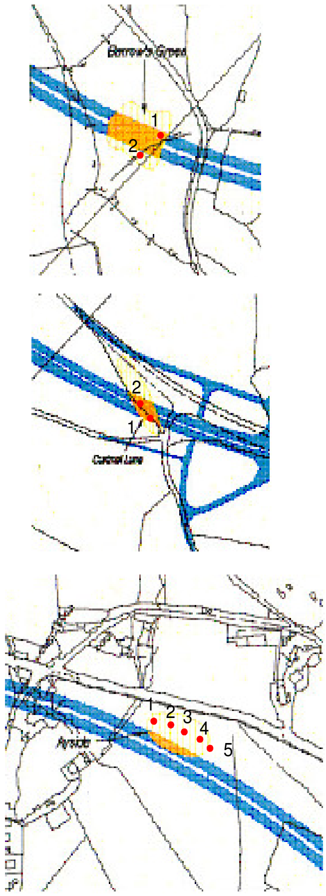


Figure 2: Site locations around High Newton relative to line of A590 bypass (indicated in blue), including location of boreholes. Top Barrow's Green, Middle Cartmel Lane, Bottom Ayside. Courtesy of Laing O'Rourke. Not to scale.

3.1.4 Oak Lane

This site was described in geotechnical borehole logs as comprising "fragments of organic remains within a gravelly clay, overlain by c. 2m gravels". Consequently, such organic deposits a) could not be accessed through the overlying gravels with the use of a hand-held gauge corer or through test pit excavation and b) are unlikely to be of significant palaeoenvironmental potential as the organics within the clays and gravels are likely to be reworked. The radiocarbon samples available to this site were thus re-allocated to the other areas.

3.1.5 Walkover survey

A walkover survey of the line of the bypass failed to locate any other areas with potential for the preservation of palaeoenvironmental material.

3.2 Palaeoenvironmental Assessments

3.2.1 Pollen Assessments

The samples recovered from Ayside, Barrow's Green and Cartmel Lane for pollen assessments are outlined in Table 1. The results of these analyses are presented as a pollen diagram for each location (Figs. 3-5). The main features of the assessed samples are also outlined in Tables 2-4. Pollen nomenclature follows Moore *et al.* (1991), with modifications suggested by Bennett *et al.* (1994). No diatoms were present in the single sample from Ayside.

Ayside: Pollen Data

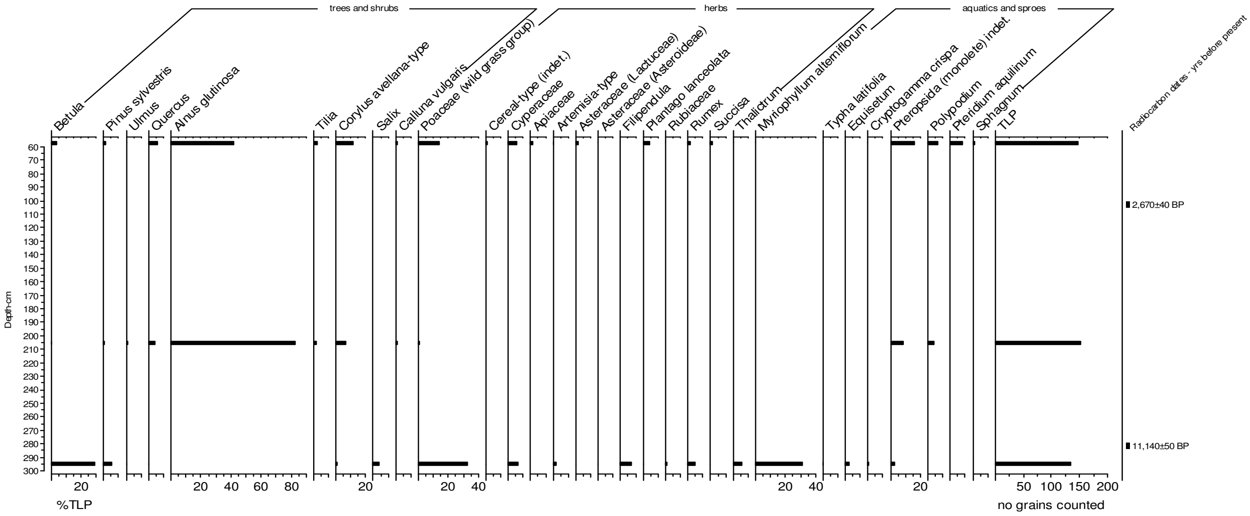


Figure 3: Ayside Pollen Diagram and **Table 2 (below):** Pollen data summary

Site/Sample depth m	Pollen Spectra: Main Features
AYSIDE TOP 0.57	**Trees and shrubs:** *Alnus glutinosa* (40%), *Corylus* (11%), *Quercus* (6%), *Tilia* (3%) **Herbs**: Poaceae (<1%) **Spores**: Pteropsida (9%), *Polypodium* (4%)
MIDDLE 2.05	**Trees and shrubs:** *Alnus glutinosa* (80%), *Corylus* (7%), *Quercus* (5%) **Herbs**: Poaceae (15%), Cyperaceae (5%), *Plantago lanceolata* (5%), Lactuceae indet. (2%), *Rumex* (1%), Cereal-type (<1%) **Spores**: Pteropsida (16%), *Polypodium* (6%), *Pteridium* (8%)
BASE 2.95	**Trees and shrubs**: *Betula* (30%), *Pinus sylvestris* (5%), *Salix* (4%) **Herbs**: Poaceae (30%), Cyperaceae (7%), *Filipendula* (7%), *Rumex* spp. (5%), *Thalictrum* spp. (5%), *Artemisia*-type (2%) **Aquatics**: *Myriophyllum alterniflorum* (30%TLP+aquatics)

Cartmel Lane: Pollen Data

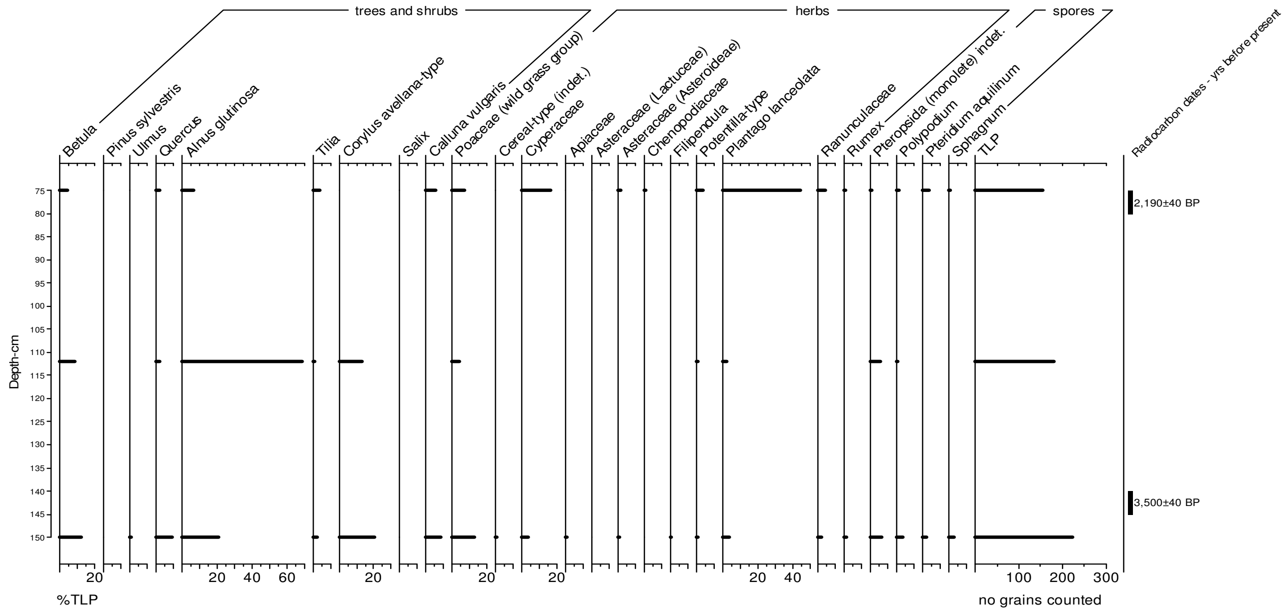


Figure 4: Cartmel Lane Pollen Diagram and **Table 3 (below):** Pollen data summary

Site/Sample depth m	Pollen Spectra: Main Features
CARTMEL LANE TOP 1.50	**Trees and shrubs:** *Alnus glutinosa* (6%), *Betula* (4%), *Quercus* (2%), *Tilia* (4%) **Herbs**: Poaceae (7%), Cyperaceae (16%), *Potentilla* (4%), *P.lanceolata* (44%), Ranunculaceae (4%), *Rumex* (1%) **Spores**: *Pteridium* (4%)
MIDDLE 1.12	**Trees and shrubs:** *Alnus glutinosa* (68%), *Corylus* (13%), *Quercus* (2%), *Betula* (8%) **Herbs**: Poaceae (4%), *P.lanceolata* (2%) **Spores**: Pteropsida (6%)
BASE 1.50	**Trees and shrubs**: *Alnus* (20%), *Betula* (12%), *Quercus* (9%), *Corylus* (20%), *Calluna* (8%) **Herbs**: Poaceae (12%), Cyperaceae (4%), *P.lanceolata* (5%), Ranunculaceae (2%), *Rumex* (1%) **Spores**: *Polypodium* (6%), *Pteridium* (2%)

Barrow's Green: Pollen Data

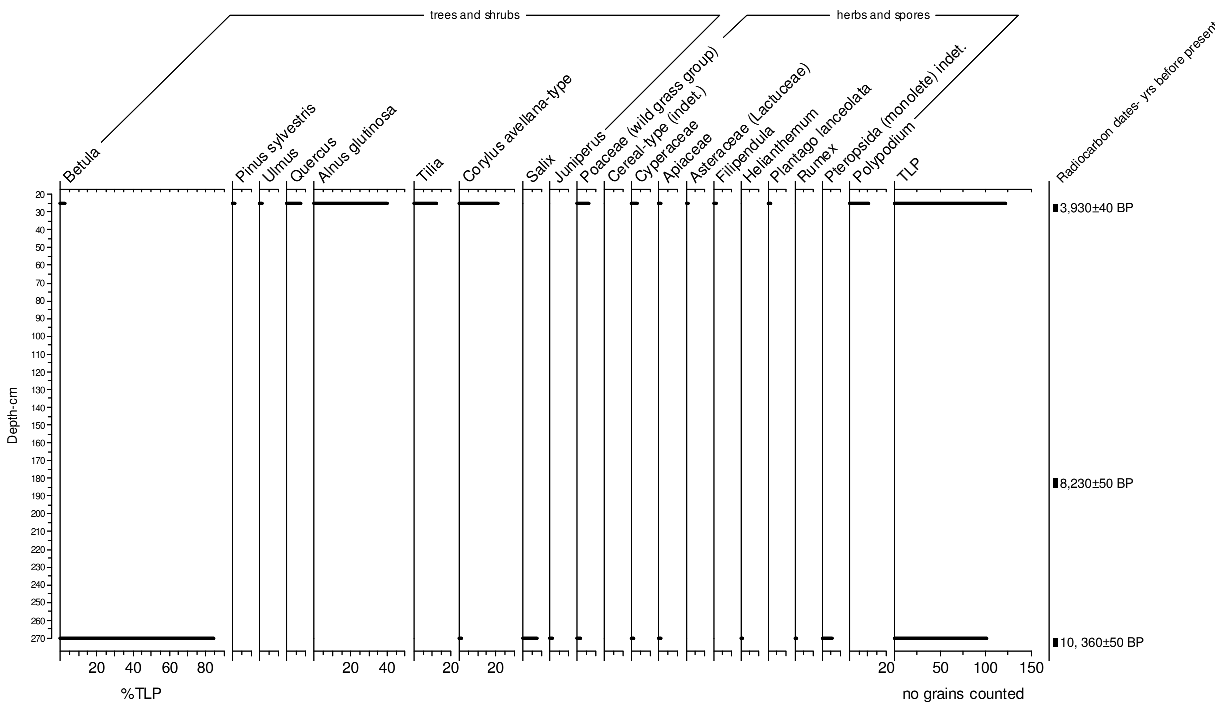


Figure 5: Barrow's Green Pollen Diagram and **Table 4 (below):** Pollen data summary

Site/Sample depth m	**Pollen Spectra: Main Features**
BARROW'S GREEN TOP-0.25	**Trees and shrubs:** *Alnus glutinosa* (40%), *Corylus* (21%), *Quercus* (7%), *Tilia* (12%) **Herbs**: Poaceae (7%), Cyperaceae (3%), *Filipendula* (2%), *P.lanceolata* (2%) **Spores**: *Polypodium* (10%)
MIDDLE-1.45 (low pollen concentration- presence only noted)	**Trees and shrubs:** *Pinus, Corylus*, *Quercus, Salix, Calluna* **Herbs**: Poaceae **Spores**: Pteropsida
BASE 2.70	**Trees and shrubs**: *Betula* (84%), *Salix* (8%) **Herbs**: Poaceae (2%), Cyperaceae (1%), *Filipendula* (1%), *Rumex* (1%) **Spores**: *Polypodium* (6%)

3.2.2 Coleoptera

It was hoped that an assessment of the insect remains from the samples would provide information on the following:

1. Are there any insect remains present that are of interpretative value?
2. Do any of the insects present suggest the nature of the environment at the time of the deposits' formation?

When discussing the faunas recovered, two considerations should be taken into account:

1) The identifications of the insects present are provisional. In addition, many of the taxa present could be identified down to species level during a full analysis, producing more detailed information. As a result, the data presented here should be regarded as preliminary.

2) The various proportions of insects are subjective assessments. Minimum numbers of individuals can be obtained through a full sample analysis.

The insect taxa recovered from the flots are listed in Table 5. The taxonomy used for the Coleoptera (beetles) follows that of Lucht (1987). A number of Dipterous (fly) puparia remains were found. The numbers of individuals present is estimated using the following scale: * = 1-2 individuals ** = 2-5 individuals *** = 5-10 individuals **** = 10+ individuals.

1. Are there any insect remains present that are of interpretative value?

Ayside and Cartmel Lane

The largest interpretable assemblages were recovered from Ayside; the insect faunas from both samples were well preserved and relatively diverse. The material from both samples recovered from Cartmel Lane also produced small but well-preserved and relatively diverse assemblages.

Barrow's Green

In contrast, in samples 1.0-1.8m and 2.15-2.75m from Barrow's Green core 2, the assemblages were limited, both in abundance and diversity. The contexts from which these samples were recovered are described as 'well humified' and 'compacted' and it seems likely that taphonomic processes have compromised the preservation of the insect remains. No further discussion of the Barrow's Green samples will be pursued.

Site	Ayside		Barrow's Green			Cartmel Lane	
Core	2	2	1	2	2	2	1
Sample	1.4-2m	2-3m	0.25-1.5m	1.0-1.8m	2.15-2.75m	0.75-1.5m	1.1-1.75m
Processed Volume	500ml	500ml	500ml	500ml	500ml	500ml	500ml
COLEOPTERA							
Carabidae							
Nebria spp.			*				
Pterostichus spp.							*
Agonum thoreyi Dej.						*	
Dytiscidae							
Hydroporous spp.					.	*	*
Agabus spp.					*		
Illybius spp.	*						
Gyrinidae							
Gyrinus spp.		*					
Hydraenidae							
Hydraena spp.	*		*				*
Hydrophilidae							
Aquatic *Cercyon* spp.							*
Hydrobius fuscipes Leach	*						
Staphylinidae							
Olophrum fuscum (Grav.)			*				
Lesteva spp.			*			*	*
Trogophloeus spp.	*					*	
Stenus spp.	*	*	*				*
Lathrobium spp.			*				
Xantholinus spp.				*			
Aleocharinae gen. & spp. Indet.							*
Elateridae							
Agriotes spp.		*					
Helodidae							
Helodidae gen. & spp. indet.	*						*
Dryopidae							
Esolus parallelepipedus (Mull.)					*		
Scarabaeidae							
Geotrupes spp.	*						
Phyllopertha horticola (L.)							*
Chrysomelidae							
*Chrysomela*spp.	*						
Plateumaris braccata (Scop.)		*					*
Trichoptera		*			*		

Table 5: Results of the coleoptera assessments

2. Do any of the insects present suggest the nature of the environment at the time of the deposits' formation and the aquatic regime at the sites?

Ayside

Indicators of the surrounding vegetation are limited to taxa of tall reeds, the phytophagous chrysomelid, *Plateumaris braccata*, which feeds exclusively upon the common reed (*Phragmites* spp.) (Menzies and Cox 1996). A single specimen of the 'dung beetle' or Scarabaeidae family, *Geotrupes* ssp. was recovered. As this family are ready fliers, it is unclear whether this species is an unequivocal indicator of large herbivores grazing in the near vicinity; but considering the size of the samples and the assemblages they produced, this cannot be completely discounted. A further family indicative of drier grassland is the elaterid, *Agriotes* spp., which feeds on the roots of grasses in meadows and scrub. A suite of larger, aquatic beetles such as the dytiscid *Ilybius* spp. and the large hydrophilid *Hydrobius fuscipes* present in these samples are generally found in standing or slow moving waters. A further dystiscid, *Gyrinius* spp., is also characteristic of deeper, standing waters (Hansen 1987, Nilsson and Holmen 1995). This suggests that the deposit formed in relatively deep, waterlain conditions. The Helodidae, and hydraenid, *Hydraena* spp. are both found at the muddy edges of ponds, pools and streams (Hansen 1987).

Cartmel Lane

Aquatic and hygrophilous (water-loving) taxa dominate the assemblages; many are associated with permanent, relatively deep water as well as muddy shorelines fringed by tall, emergent reeds. The carabid, *Agonum thoreyi*, is found amongst a variety of tall reeds such as bulrush (*Typha latifolia*) (Lindroth 1974). Although no evidence of grazing animals was recovered from the Cartmel Lane samples, nearby grassland is suggested by a member of the scarabaeidae family not associated with dung, *Phyllopertha horticola* or the 'garden chafer' which feeds on the roots of grasses in meadows and waste ground (Jessop 1986). The aquatic component at Cartmel Lane indicates hydrological conditions subtly different to those at Ayside. The Dytiscidae *Hydroporus* spp. are associated with shallower pools of standing water with less dense riparian vegetation (Nilsson and Holmen 1995).

3.3 Radiocarbon Dates

The results of the radiocarbon dating are set out in Table 2 (see also Appendix II). Calibration was undertaken using INTCAL98 (Stuiver and Van der Pilcht 1998). All samples provided sufficient carbon for accurate measurement and analyses are reported as having proceeded normally.

Sample	Code	Depth (m O.D.)	Sample description	Sample pre-treatment	Conventional radiocarbon age	Calibrated range BC/AD (2 sigma - 95% confidence)
AYSIDE C2-100	Beta-218741	1.00	wood	acid/alkali/acid	2,670 +/- 40 BP	900-790 Cal. BC
AYSIDE C2-279	Beta-218742	2.79	peat	acid/alkali/acid	11,140 +/- 50 BP	11,380-11,340 Cal. BC
BGREEN C2-025	Beta-218743	0.25	peat	acid/alkali/acid	3,930 +/- 40 BP	2,550-2,540 Cal. BC
BGREEN C2-270	Beta-218744	2.70	peat	acid/alkali/acid	10,360 +/- 50 BP	10,840-10,760 Cal. BC
BGREEN C2-180	Beta-218745	1.80	wood	acid/alkali/acid	8,230 +/- 50 BP	7,450-7,390 Cal. BC
C.LANE C1-155	Beta-218746	1.55	wood	acid/alkali/acid	2,730 +/- 40 BP	940-810 Cal. BC
C.LANE C2-075	Beta-218747	0.75	peat	acid/alkali/acid	2,190 +/- 40 BP	380-160 Cal. BC
C.LANE C2-140	Beta-218748	1.40	wood	acid/alkali/acid	3,500 +/- 40 BP	1,920-1,720 Cal. BC

Table 6: Results of the radiocarbon dates from Ayside, Barrow's Green and Cartmel Lane

4. Syntheses: stratigraphic, palaeoenvironmental and radiocarbon dating analyses

4.1 Ayside

Although it appears that the current area of open water at Ayside is a relatively recent result of the damming of the Belman Beck, the palaeoenvironmental and stratigraphic analyses demonstrate that there was open area of water present at Ayside before the start of the Holocene. Sediment accumulation at the sampling site began in aquatic conditions, perhaps in a kettle hole or on a floodplain environment related to the Beck, just before 11,140±50 BP (Beta-218742, 11380-11340 and 11250-11030 cal. BC), or around the end of the warmer phase of the Windermere Interstadial and prior to the cold phase of the Loch Lomond stadial (Hodgkinson *et al* 2000). The pollen sample from near to the base of the sequence (2.95m) indicates a largely open, 'tundra' like environment, with few trees other than birch (possibly the dwarf form of this, *Betula nana*) willow scrub. The *Pinus* (Scots pine) record probably reflects long distance transport of this mobile pollen grain rather than a local presence of pine. Damp, open habitats consisting of Poaceae (grasses) and Cyperaceae (sedges) were present locally, with tall herb communities including *Filipendula* (meadowsweet) whilst the suite of taxa *Artemisia*-type (mugwort), *Thalictrum* (meadowrue) and *Rumex* (sorrel) suggest bare, somewhat disturbed soils. The sediment was accumulating in a base-rich open water body at this time, with the high values for *Myriophyllum alterniflorum* (alternate flowered milfoil) reflecting the growth of this aquatic plant locally indicating that climatic conditions cannot have been so severe at this time. The insect evidence from the basal sample (2-3m depth) mainly reflects the local wetland environment of reeds and open water, but the presence of more open, dryland communities also indicated by the pollen are suggested by the record of *Agriotes* spp. ('click' beetles), a genus which includes feeders on roots or bark.

As sediment continued to accumulate, the basin began to infill and peat accumulation began in semi-terrestrial conditions. The middle sample (2.05m) reflects a very different environment, with dense alder carr clearly dominant on the damp soils also reflected in the wood-rich sediment stratigraphy. This indicates a period of landscape development after the mid-Holocene rise of alder, c. 6500-6000cal.BC (Godwin and Willis 1959). It is likely that the low and sparse record of other pollen is a result of the abundance of this local tree in the pollen record. Establishing the nature of the 'dryland' vegetation is hence difficult, but it is probable that it consisted of closed canopy lime-oak-hazel woodland. The record of ribwort plantain suggests a level of an anthropogenic disturbance to the dryland vegetation, but other herbs are rare and establishing the precise nature or extent of human activity is problematic on the basis of a single sample. The insect evidence from 1.4-2.0m again mainly reflects the nearby wetland environment of muddy pools and deeper aquatic habitats, although a single specimen of the 'dung' beetle *Geotrupes* spp. does reflect the presence of large herbivores. There is no way to establish whether such creatures were wild or domesticated.

The upper stages of peat accumulation (1.0m) are dated to 2670±40 BP (Beta-218741, 900-790cal.BC), or the later Bronze Age. The top pollen sample (0.57m) can be dated by linear interpolation from the previous radiocarbon date to around 430cal.AD, or the early Medieval period. This picture has changed by this time, with a more open landscape indicated. Whilst alder carr seems to have remained near to the sampling site, this appears to be less dense than in the previous sample. The higher values for other trees including oak and hazel probably reflect improved representation of pollen sources beyond the carr, rather than an actual areal increase in these trees locally. Whilst some lime-oak-hazel woodland seems to have been present on the dryland, the record of grasses and other taxa including ribwort plantain, sorrels and bracken suggest an extent of open grassland/pastoral vegetation in the pollen catchment. A single grain of cereal-type pollen also implies the presence of some arable land but it is not possible to determine the location of any such arable plots with respect to the sampling site. At some point shortly afterwards, organic accumulation was curtailed with the deposition of a layer of silty clay (0.50m) across the site. This presumably reflects human disturbance to the environment on and around the site leading to the inwash of minerogenic material from terrestrial sources.

4.2 Barrow's Green

The radiocarbon date from the base (2.70m) of the Barrow's Green sequence indicates that sediment accumulation began during the early Holocene at 10,360±50 BP (Beta-218745, 7450-7390 and 7370-7080 cal. BC). The basal sample (2.70m) is dominated by *Betula* with no other arboreal taxa recorded in significant quantity apart from *Salix*. This indicates the presence of birch dominated wood/scrub land near to the sampling site, with willow presumably on the damper soils. This vegetation must have been quite dense, as herbaceous pollen is low and few other taxa are recorded in any quantity. Tall herb communities with species of Apiaceae and *Filipendula* may have been present, with taxa typical of more disturbed and perhaps skeletal soils in the form of *Rumex* and *Helianthemum* (rock rose) also recorded.

Peat accumulation continued in what was probably an alder carr system similar to Ayside although poor pollen preservation at 1.45m means that no information on the vegetation at the corresponding date of 8,230±50 BP (Beta-218745, 7450-7390 and 7370-7080 cal. BC) is available. The top sample (0.25m) indicates that by 3,930±40 BP (Beta-218743, 2550-2540 and 2490-2300 cal. BC), or the later Neolithic/early Bronze Age, the local environment is dominated by alder, presumably in the form of carr woodland on the damper soils on and around the sampling site. Lime-dominated woodland was growing on the better-drained soils, such as the steeper slopes around the site. Oak and hazel also appear to have formed part of the dryland woodland. The record of grasses and ribwort plantain indicates more open habitats, although it is unclear whether the data indicate limited openings in close proximity to the sampling site, or more extensive grassland areas further away. Peat accumulation at this location was curtailed sometime after this point (0.24m), with the deposition of a layer of inorganic material presumably of colluvial origin, resulting from anthropogenic disturbance to the soils on the slopes around the site.

4.3 Cartmel Lane

Peat accumulation began at 3,500±40 BP (Beta-218748, 1920-1720 cal. BC), or during the earlier Bronze Age, at the Cartmel Lane site (Plate 4). It is possible that sediment accumulation began on the edge of a floodplain, which may explain the silt/clay component of the sediment. Substantial landscaping at this point along the current route of the A590 hinders establishing the precise context of the deposit. The basal sample (1.50m) suggests that mixed woodland consisting of alder, hazel, birch and oak was present around the sampling site. This woodland was either of a relatively open structure, or open extensive clearings were present in the nearby vicinity, as the pollen spectra reflect open grassy as well as heathland. The latter is suggested by the record of *Calluna* (heather, ling) – this plant may be associated with more open birch woodland on the higher fells to the north of the sampling site. Damp, slightly acid soils are also indicated by the presence of *Potentilla*-type (tormentil) and probably also Ranunculaceae (buttercups), although percentages of Cyperaceae are relatively low. Grasses may derive from open habitats on the wetter soils nearby as well as from open vegetation communities on drier soils, which are certainly indicated by ribwort plantain. The insect assemblage from the basal sample (1.1-1.75m) again indicates the presence of local wetland vegetation including tall emergent reeds and muddy pools. The insect assemblages may also reflect a slightly more open local environment compared to that of Ayside. It is unclear whether this is in part or whole due to human activity. However, supporting evidence for open grassland habitats suggested by the pollen is present in the form of *Phyllopertha horticola* (the 'garden chafer'), which feeds on the roots of grasses.

The middle sample (1.12m) can be dated approximately by linear interpolation between the two radiocarbon dates to 910 cal. BC, or the late Bronze Age. Alder has clearly expanded on and around the sampling site by this time. The pollen record is therefore strongly biased towards this local vegetation at this time, although there is evidence that beyond the wetland area, more open habitats with ribwort plantain remained extant. Likewise, mixed woodland with hazel, birch and elm was present. A very different picture is apparent by the top of the sequence (0.75m), dated to 2,190+40 BP (Beta-218747, 380-160cal. BC), the Iron Age. The tree cover has apparently disappeared almost completely from the local environment with a marked expansion in herbs and in particular an exceptionally high value (44%) for *Plantago lanceolata*. This implies an open habitat dominated by ribwort plantain, which must have been growing in very close proximity, if not on, the sampling site. Other herbs including grasses, sedges, buttercups and tormentil are recorded indicating damp, slightly acid meadow communities. Immediately above this level, peat accumulation is curtailed by the deposition of grey clay with gravel, presumably of colluvial-alluvial origin. As with the site at Barrow's Green, it is likely that this reflects the effects of woodland clearance/agriculture on the slopes around the site destabilising soils.

5. Discussion and Conclusions

This report has demonstrated that the peat deposits at Ayside and Barrow's Green began to accumulate in the Late-glacial and early Holocene. Peat accumulation at Cartmel Lane seems to have begun much later in the Holocene, during the Bronze Age. It has been suggested that the difference in chronology of accumulation may be due to the fact that the Cartmel Lane deposit is linked to processes of floodplain evolution in the later Holocene.

Other than this, following peat inception at all three sites, relative uniformity in stratigraphy is evident, with the deposits characterised by wood rich peats, which appear to have accumulated within alder fen carr systems during the mid-late Holocene. Previous work in Cumbria has demonstrated that deposits such as those at Ayside and Barrow's Green are relatively common, where small basin mires and kettleholes often preserve sedimentary archives dating to back to the Late-glacial (Hodgkinson *et al.* 2000). Indeed, many hundreds of small basin mires are present in south Cumbria due to the moraine-covered landscape south and west of Kendal, most of which are unmapped. The site locations in question around High Newton can therefore be seen in this context. The insect assemblages from Ayside and Cartmel Lane tend to reflect the nature of the local peat forming environment at these sites, with wetland and aquatic taxa generally well represented compared to dryland vegetation in the wider environment. The absence of any clear indication of woodland compared to the pollen spectra is notable. In particular, the pollen data demonstrate that alder was significant at all the sites during deposit accumulation.

The identification of alder woodland in the palaeoenvironmental record using entomological methods is problematic and is related at least in part to the paucity of insect species that feed upon alder (Bullock 1993). This and the disparity between entomological and other proxy methods, when attempting to identify alder-dominated woodland in the palaeoenvironmental record, have received considerable discussion elsewhere (Girling 1985; Robinson 1993; Smith *et al*. 2000; Paddock 2003; Tetlow 2004, 2005; Smith and Whitehouse in press). This problem is compounded by the lack of modern knowledge of entomological interactions within this ecotone. The insects provide some indication of dryland habitats, and at Cartmel Lane appear to support the palynological evidence for more open, grassy vegetation. This more open aspect may be related in whole or part to the nature of the sampling site, or alternatively indicates that the environment around Cartmel Lane had already been opened up somewhat as a result of human activity when peat started to form during the Bronze Age.

Another feature that is observed at all three sites is the influence of hillslope processes on the wetland environment during the later Holocene. The sequences are characterised by gravel-rich clays capping the peat deposits. Indeed these 'capping' deposits seem to have led to the preservation of the sedimentary archive at the Cartmel Lane and Barrow's Green, otherwise it seems probable that the wetlands would have been drained and/or cut for peat. The 'capping' deposits are of colluvial origin and result from instability in the site catchments, leading to the erosion of soils from the adjacent slopes and deposition of substantial thicknesses of inorganic material over the wetlands in the valley bottoms. At Cartmel Lane, the date of 2,190+40 BP (Beta-218747, 380-160 cal. BC), the Iron Age, provides a *terminus post quem* for this, although it seems likely that there is an erosive contact between the peat and the overlying colluvium at this location. Likewise at Barrow's Green, the top sample (0.25m) indicates the overlying colluvium was deposited after 3,930±40 BP (Beta-218743, 2550-2540 and 2490-2300 cal. BC), or the later Neolithic/early Bronze Age, but again the upper contact may be erosive. Chiverrell *et al. (*2006) identify a series of phases of Holocene landscape instability of this kind, and attribute them to both human and climatically induced changes leading to the crossing of geomorphic thresholds.

6. Recommendations

This report has demonstrated that the deposits at Ayside, Barrow's Green and Cartmel Lane have high potential for the reconstruction of Holocene environmental change at High and Low Newton. More detailed palynological analyses of sediment sequences from these sites, supported by radiocarbon dating, has the potential to investigate questions of vegetation change and human impact and to test some of the hypotheses advanced above regarding the respective influences of anthropogenic impacts and climatic changes on the environment of this part of Cumbria. The relatively small area of the deposits in question also means that the preserved pollen records should reflect predominantly 'local' vegetation changes and can thus be closely linked to the archaeological record from this area. It is recommended that such work should be considered if the current or any future programme of works is likely to result in the destruction of the deposits in question.

References

Bennett, K.D., Whittington, G. & Edwards, K.J. (1994). Recent plant nomenclature changes and pollen morphology in the British Isles. *Quaternary Newsletter* 73. 1-6.

Bullock, J. A. (1993) Host plants of British Beetles: A list of recorded associations. *Amateur Entomologist* 11a. 1-24

Chiverrell, R.C. (2006) Hillslope gullying in the Solway Firth – Morecambe Bay region, Great Britain: Responses to human impact and/or climatic deterioration. *Geomorphology* (http://dx.doi.org/10.1016/j.geomorph.2005.12.014)

Girling, M. A. (1985) An 'old forest' beetle fauna from Neolithic and Bronze Age peat deposit at Stileway. *Somerset Levels Papers* 5. 25-32.

Godwin, H. and Willis, E.H. (1959) Cambridge University natural radiocarbon measurements I. *Radiocarbon* **1**, 63-65.

Hansen, M. (1987) *The Hydrophilidae (Coleoptera) of Fennoscandia and Denmark Volume 18 – Fauna Entomologyca Scandinavica*. Leiden: E. J. Brill/Scandinavian Science Press.

Hodgkinson, D., Huckerby, E., Middleton, R. and Wells, C.E. (2000). *The Lowland Wetlands of Cumbria*. North West Wetlands Survey 6. Lancaster Imprints, Lancaster University Archaeological Unit.

Jessop, L. (1996) *Coleoptera: Scarabaeidae. Handbooks for the Identification of British Insects* 5,11. Royal Entomological Society of London.

Kenward H. K., Hall A.R., and Jones A.K.G. (1980) A Tested Set of Techniques for the Extraction of Plant and Animal Macrofossils from Waterlogged Archaeological Deposits. *Scientific Archaeology.* 22. 3-15.

Kenward, H.K., Engleman, C., Robertson, A. and Large, F. (1985) Rapid Scanning of Urban Archaeological Deposits for Insect Remains. *Circaea* 3. 163-72.

Lucht, W.H. (1987) *Die Käfer Mitteleuropas.* Katalog. Krefeld: Goecke and Evers.

Lindroth, C. H. (1974) Coleoptera: Carabidae. *Handbooks for the Identification of British Insects* 4 (2). London: Royal Entomological Society.

Menzies, I. S. and Cox, M. L. (1996) Notes on the natural history, distribution and identification of British Reed Beetles. *British Journal of Natural History* 9. 137-162

Moore, P.D., Webb, J.A. and Collinson, M.E. (1991) *Pollen Analysis*. London: Blackwell.

Nilsson, A. N. and Holman, M. (1995) *The Aquatic Adephaga (Coleoptera) of Fennoscandia and Denmark II. Dytiscidae – Fauna Entomologyca Scandinavica*. Leiden: E. J. Brill.

Paddock, E. A. (2003) A Sub-fossil insect assemblage from the 'Fourth Peat', Redwick, Gwent c. 4910 – 2930 BP. *Archaeology in the Severn Estuary* 13 (for 2002). 47-52.

Robinson, M. A (1993) The prehistoric landscape and Iron Age enclosed settlement at Mingies Ditch. In Allen, T. G. and Robinson, M. A. *Hardwick-with-Yelford, Oxon: Thames Valley Landscapes: the Windrush Valley Vol. 2.* Oxford Archaeology Unit.

Smith, D. N. & Whitehouse, N. J. (2006) Not seeing the Trees for the Woods: A Palaeoentomological perspective on Holocene Woodland composition. In Smith, D. N. and Brickley, M. *Fertile Ground: Papers in Honour of Professor Susan Limbrey*. Oxford: Oxbow.

Smith, D. N., Osborne, P. J. and Barrett, J. (2000) Beetles as indicators of past environments and human activity at Goldcliff. In Bell, M., Caseldine, A. and Neumann, H. (eds.) *Prehistoric Intertidal Archaeology in the Welsh Severn Estuary*. York: CBA Research Report 120. 245-260.

Stuiver, M. and Van der Pilcht, H. (1998). INTCAL 98. *Radiocarbon* 40, 3. 1041-1083.

Tetlow, E. A. (2004) A 'wildwood' insect fauna from Goldcliff East, Gwent. *Archaeology in the Severn Estuary* 14. 41-47.

Tetlow, E. A. (2005) *The Palaeoentomology of the Coastal Woodlands and Saltmarshes of the Severn Estuary.* Unpublished PhD Thesis, The University of Birmingham.

Appendix I – Core Logs

Ayside, High Newton
South of Black Beck Hall

Core 1 (WP59)

0.00 – 0.32m	Light grey-brown slightly gravelly silty clay with some rootlets

End of core at 0.32m due to obstacle

Core 2 (WP60)

0.00 – 0.50m	Light grey-brown slightly gravelly silty clay, increasing org. content with depth
0.50 – 0.80m	Dark brown very well humified peat with some vegetative remains. Wood fragment at 0.65m
0.80 – 1.00m	Light grey-brown slightly gravelly silty clay, organic mottling and some rootlets
1.00 – 1.95m	Dark brown woody w/h peat, abundant vegetative fragments and remains
1.95 – 2.85m	As above, but abundance of woody remains
2.85 – 3.02m	Light brown very well humified peat with vegetative remains, monocot fragments. Grading into grey organic mud with rootlets.
3.02 – 3.12m	Grey silty mud with some organics/rootlets.
3.12 – 3.24m	grey-olive poss. gyttja.

End of core at 3.24m

Core 3 (WP61)

0.00 – 0.48m	Light grey silty organic clay
0.48 – 0.60m	Light grey-brown well humified organic silty clay
0.60 – 1.00m	Dark brown woody, slightly silty peat.
1.00 – 1.35m	Woody, well humified peat.
1.35 – 2.70m	Dark brown well humified peat.
2.70 – 2.90m	Light grey organic clay.

End of core at 2.90m

Core 4 (WP62)

0.00 – 0.35m	Light grey slightly gravelly clay with occasional rootlets.
0.30 – 2.15m	Brown well humified peat with woody fragments and vegetative remains. Becoming looser and wetter with depth and increasing in fibrous material.
2.15 – 2.87m	Dark brown well humified peat.
2.87 – 3.08m	Light grey-olive mud with vegetative remains.

End of core at 3.08m

Core 5 (WP63)

0.00 – 0.30m	Light grey slightly gravelly clay with rootlets

End of core at 0.30m due to obstacle.

Barrow's Green, High Newton

Two cores extracted and sampled. Due to extensive possible surface colluvium, both cores were taken from within a stream running through the field.

Core 1 (WP64)

0.00 – 0.24m	Unsampled
0.24 – 0.40m	Dark grey-brown minerogenic peat, well humified peat with abundant detrital material
0.40 – 1.55m	Dark brown peat with an abundance of wood remains, becoming more compact and slightly silty with depth.
1.55 – 1.65m	Light grey clay and gravel.

End of core at 1.65m

Core 2 (WP65)

0.00 – 0.35m	Unsampled
0.35 – 2.15m	Dark brown woody fen peat, with abundant detrital material
2.15 – 2.40m	Red-brown well humified peat.
2.40 – 2.75m	Yellow-brown monocot peat, with vertical rootlets penetrating leaf litter
2.75 – 2.85m	Poorly sampled but possibly gravels at base

End of core at 2.85m

Cartmel Lane, Low Newton

Core 1 (WP66)

Pit dug to 0.40m before coring to remove surface gravel.

0.00 – 0.30m	Grey-brown (with orange mottling) clayey gravel. Gravel angular-subangular, med-coarse.
0.30 – 1.05m	Light grey (mottled orange) clay with occasional gravel.
1.05 – 1.75m	Brown fibrous, w/h peat (poss. erosive upper boundary), becoming light brown and slightly silty with depth. Woody remains at 1.55m, with fibrous peat below to 1.75m.

End of core at 1.75m

Core 2 (WP67)

Pit dug to 0.3m before coring to remove surface gravel.

0.00 – 0.25m	Grey-brown (orange mottling) clayey gravel.
0.25 – 0.75m	Light grey (mottled orange) clay with occasional gravel.
0.75 – 1.50m	Dark brown fibrous w/h peat. Slightly silty towards surface. Abundant vegetative remains.

End of core at 1.50m

Appendix II – Radiocarbon Dating Certificates

FROM: Darden Hood, Director (mailto:mailto:dhood@radiocarbon.com)
(This is a copy of the letter being mailed. Invoices/receipts follow only by mail.)

August 17, 2006

Dr. B. R. Gearey
University of Birmingham
Institute of Archaeology and Antiquity
Birmingham, B15 2TT, UK

RE: Radiocarbon Dating Results For Samples AYSIDEC2-100, AYSIDEC2-279, BGREENC2-025, BGREENC2-270, BGREENC2-180, C.LANEC1-155, C.LANEC2-075, C.LANEC2-140

Dear Ben:

Enclosed are the radiocarbon dating results for eight samples recently sent to us. They each provided plenty of carbon for accurate measurements and all the analyses proceeded normally. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analyses. We analyzed them with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

Our invoice is enclosed. Please, forward it to the appropriate officer or send VISA charge authorization. Thank you. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Darden Hood

Dr. B. R. Gearey | Report Date: 8/17/2006

University of Birmingham | Material Received: 7/17/2006

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 218741	2700 +/- 40 BP	-26.6 o/oo	2670 +/- 40 BP

SAMPLE : AYSIDEC2-100
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (wood): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 900 to 790 (Cal BP 2850 to 2740)

Beta - 218742	11150 +/- 50 BP	-25.9 o/oo	11140 +/- 50 BP

SAMPLE : AYSIDEC2-279
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (peat): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 11380 to 11340 (Cal BP 13330 to 13300) AND Cal BC 11250 to 11030 (Cal BP 13200 to 12980)

Beta - 218743	4010 +/- 40 BP	-29.8 o/oo	3930 +/- 40 BP

SAMPLE : BGREENC2-025
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (peat): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 2550 to 2540 (Cal BP 4500 to 4480) AND Cal BC 2490 to 2300 (Cal BP 4440 to 4250)

Beta - 218744	10460 +/- 50 BP	-31.3 o/oo	10360 +/- 50 BP

SAMPLE : BGREENC2-270
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (peat): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 10840 to 10760 (Cal BP 12790 to 12700) AND Cal BC 10730 to 9970 (Cal BP 12680 to 11920)

Beta - 218745	8250 +/- 50 BP	-26.5 o/oo	8230 +/- 50 BP

SAMPLE : BGREENC2-180
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (wood): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 7450 to 7390 (Cal BP 9400 to 9340) AND Cal BC 7370 to 7080 (Cal BP 9320 to 9030)

Dr. B. R. Gearey

Report Date: 8/17/2006

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 218746 SAMPLE : C.LANEC1-155 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (wood): acid/alkali/acid 2 SIGMA CALIBRATION : Cal BC 940 to 810 (Cal BP 2890 to 2760)	2780 +/- 40 BP	-28.2 o/oo	2730 +/- 40 BP
Beta - 218747 SAMPLE : C.LANEC2-075 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (peat): acid/alkali/acid 2 SIGMA CALIBRATION : Cal BC 380 to 160 (Cal BP 2330 to 2100)	2250 +/- 40 BP	-28.8 o/oo	2190 +/- 40 BP
Beta - 218748 SAMPLE : C.LANEC2-140 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (wood): acid/alkali/acid 2 SIGMA CALIBRATION : Cal BC 1920 to 1720 (Cal BP 3870 to 3670)	3540 +/- 40 BP	-27.6 o/oo	3500 +/- 40 BP

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-26.6:lab. mult=1)

Laboratory number: **Beta-218741**

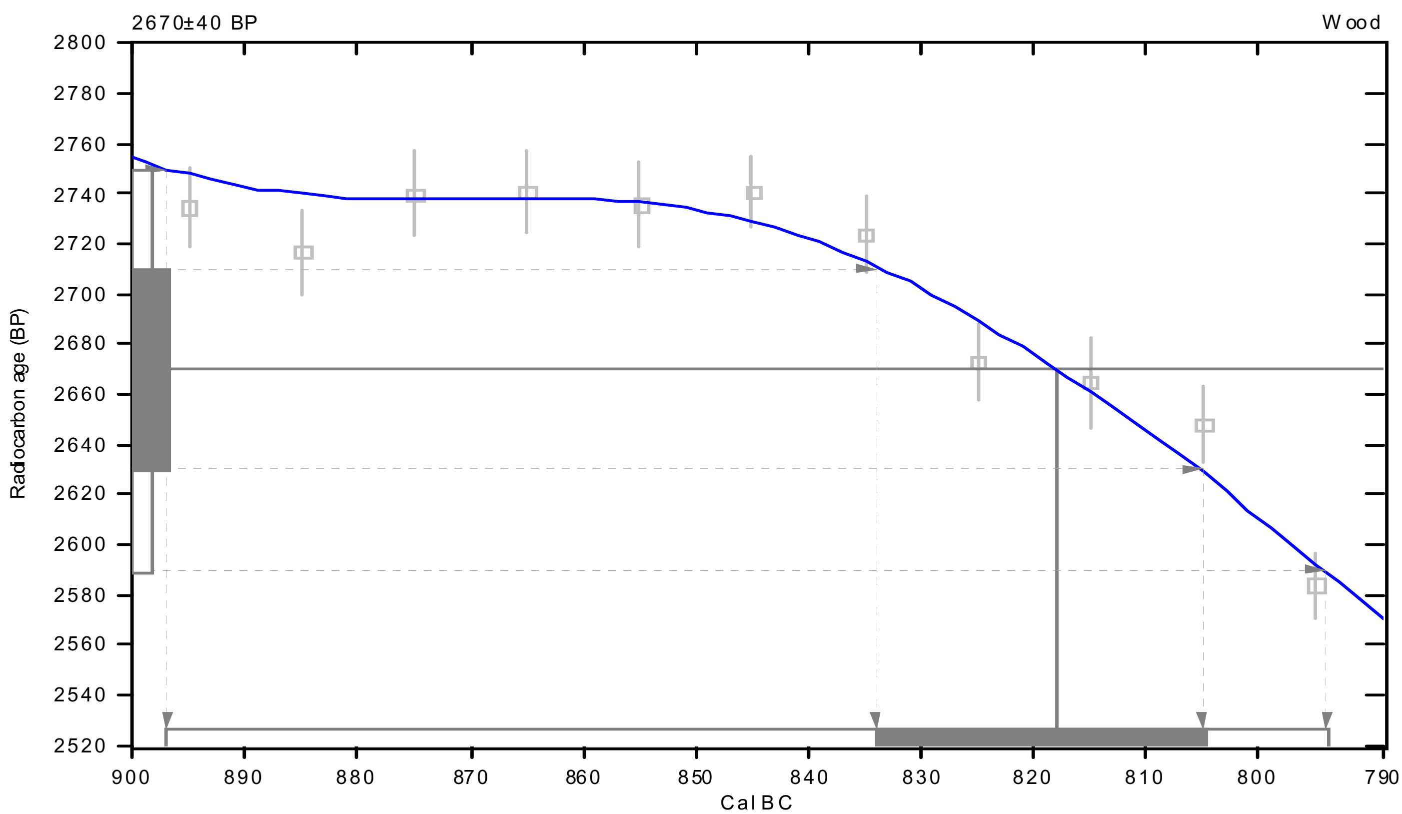
Conventional radiocarbon age: **2670±40 BP**

2 Sigma calibrated result: (95% probability) **Cal BC 900 to 790 (Cal BP 2850 to 2740)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 820 (Cal BP 2770)

1 Sigma calibrated result: (68% probability) Cal BC 830 to 800 (Cal BP 2780 to 2760)



References:

Database used

INTCAL98

Calibration Database

Editorial Comment

Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxii-xiii

INTCAL98 Radiocarbon Age Calibration

Stuiver, M., et. al., 1998, Radiocarbon 40(3), p1041-1083

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

4985 S.W. 74th Court, Miami, Florida 33155 • Tel: (305)667-5167 • Fax: (305)663-0964 • E-Mail: beta@radiocarbon.com

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-25.9:lab. mult=1)

Laboratory number: **Beta-218742**

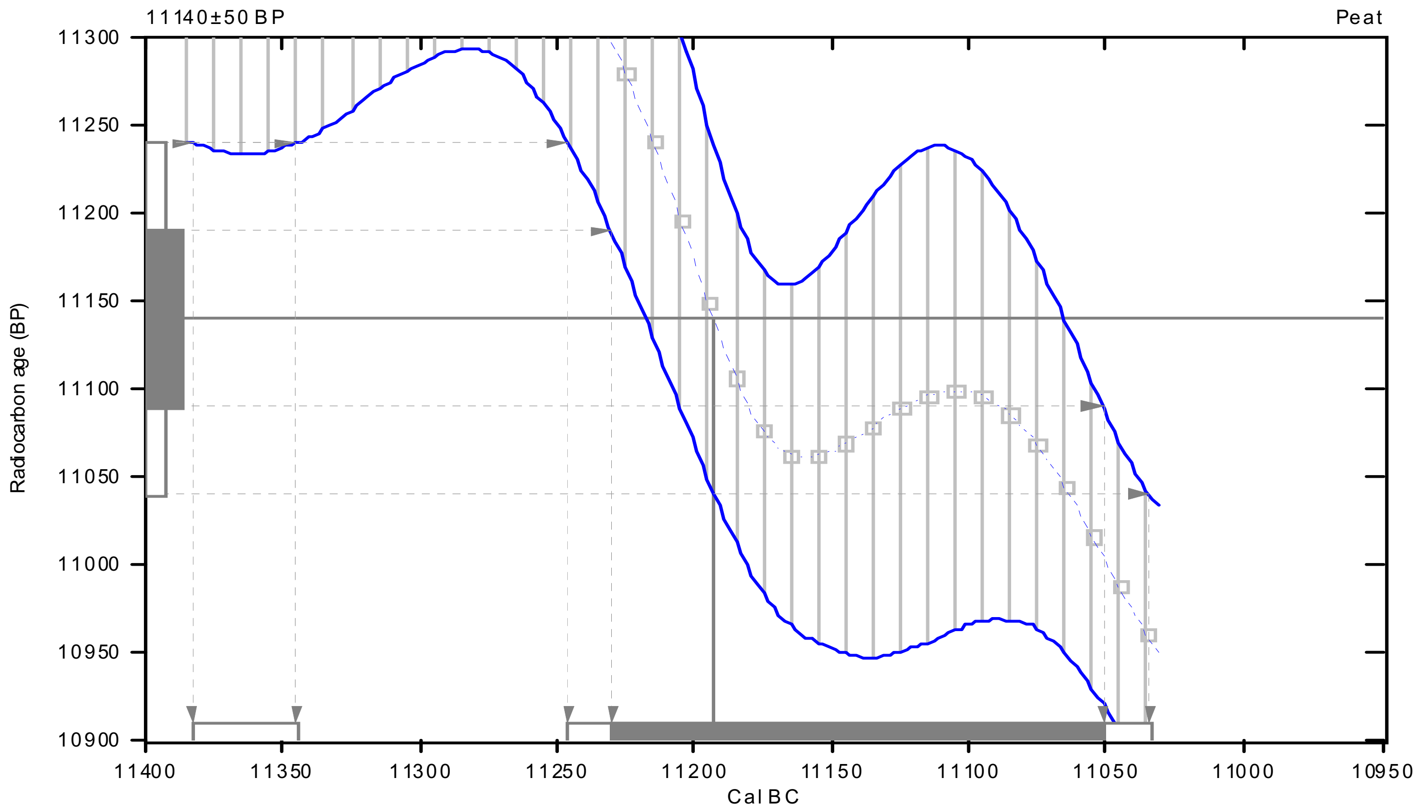
Conventional radiocarbon age: **11140±50 BP**

2 Sigma calibrated results: **Cal BC 11380 to 11340 (Cal BP 13330 to 13300) and**
(95% probability) **Cal BC 11250 to 11030 (Cal BP 13200 to 12980)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 11190 (Cal BP 13140)

1 Sigma calibrated result: Cal BC 11230 to 11050 (Cal BP 13180 to 13000)
(68% probability)



References:

Database used
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Calibration Database
Editorial Comment
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-29.8:lab. mult=1)

Laboratory number: **Beta-218743**

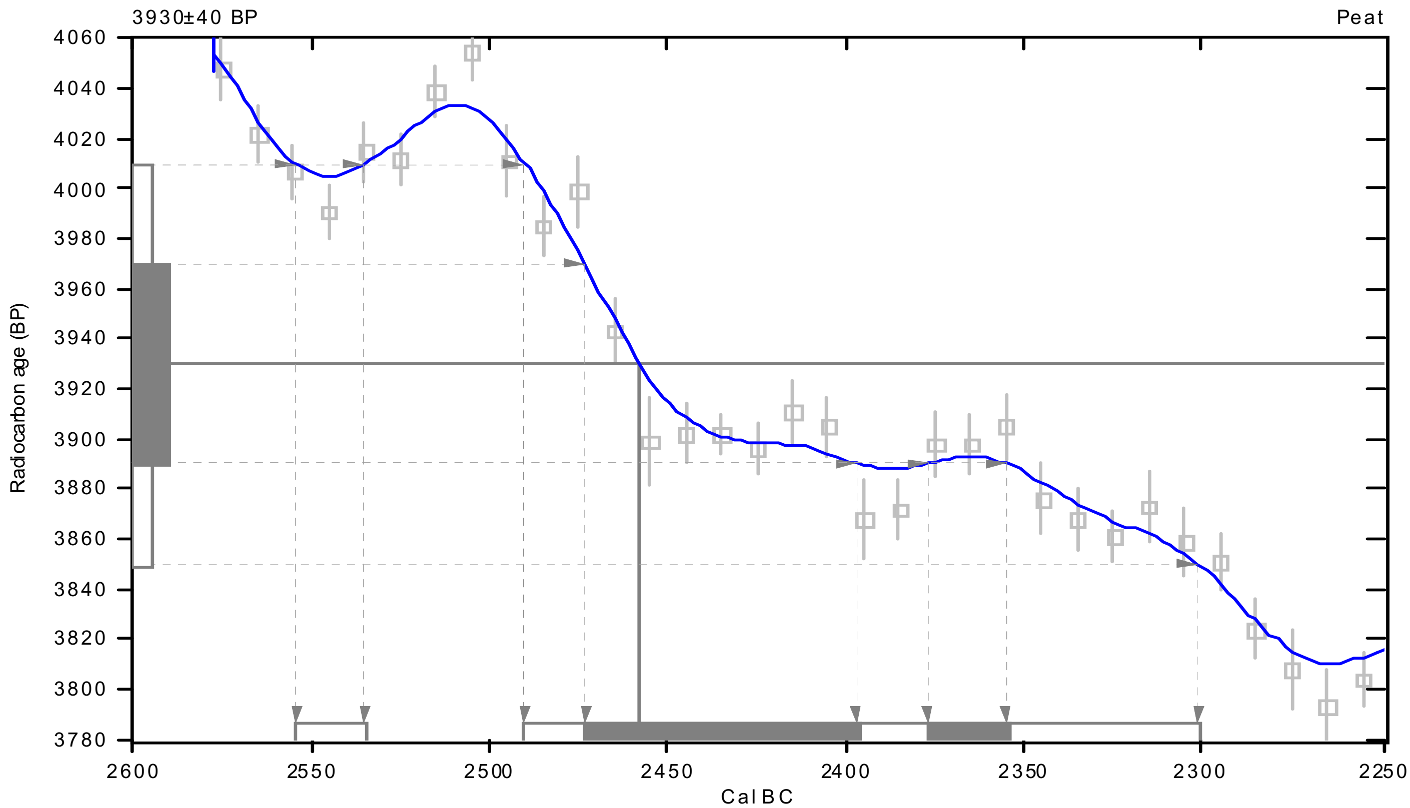
Conventional radiocarbon age: **3930±40 BP**

2 Sigma calibrated results: **Cal BC 2550 to 2540 (Cal BP 4500 to 4480) and**
(95% probability) **Cal BC 2490 to 2300 (Cal BP 4440 to 4250)**

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal BC 2460 (Cal BP 4410)

1 Sigma calibrated results: Cal BC 2470 to 2400 (Cal BP 4420 to 4350) and
(68% probability) Cal BC 2380 to 2360 (Cal BP 4330 to 4300)



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INTCAL98

Calibration Database

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INTCAL98 Radiocarbon Age Calibration

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-31.3:lab. mult=1)

Laboratory number: **Beta-218744**

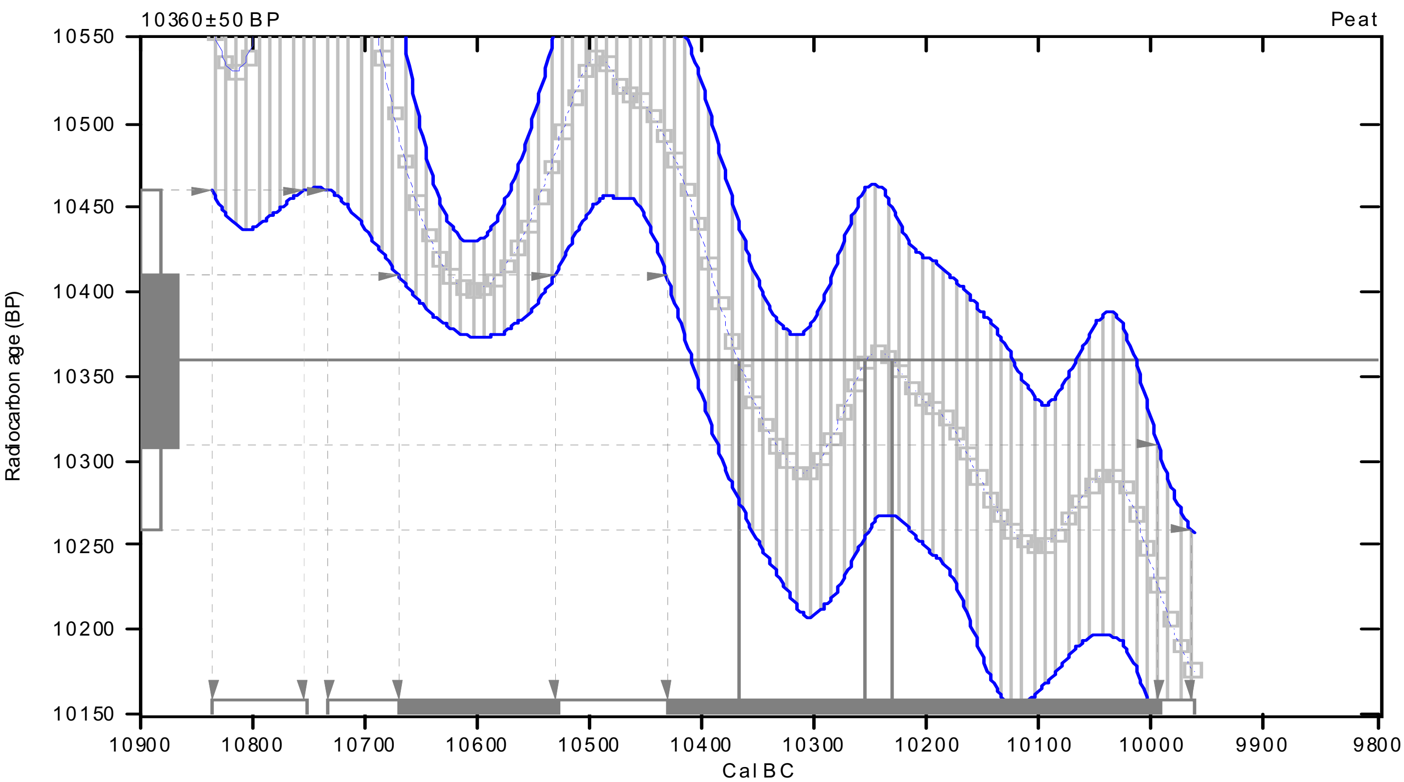
Conventional radiocarbon age: **10360±50 BP**

2 Sigma calibrated results: (95% probability) **Cal BC 10840 to 10760 (Cal BP 12790 to 12700) and Cal BC 10730 to 9970 (Cal BP 12680 to 11920)**

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal BC 10370 (Cal BP 12320) and Cal BC 10250 (Cal BP 12200) and Cal BC 10230 (Cal BP 12180)

1 Sigma calibrated results: (68% probability) Cal BC 10670 to 10530 (Cal BP 12620 to 12480) and Cal BC 10430 to 10000 (Cal BP 12380 to 11940)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-26.5:lab. mult=1)

Laboratory number: **Beta-218745**

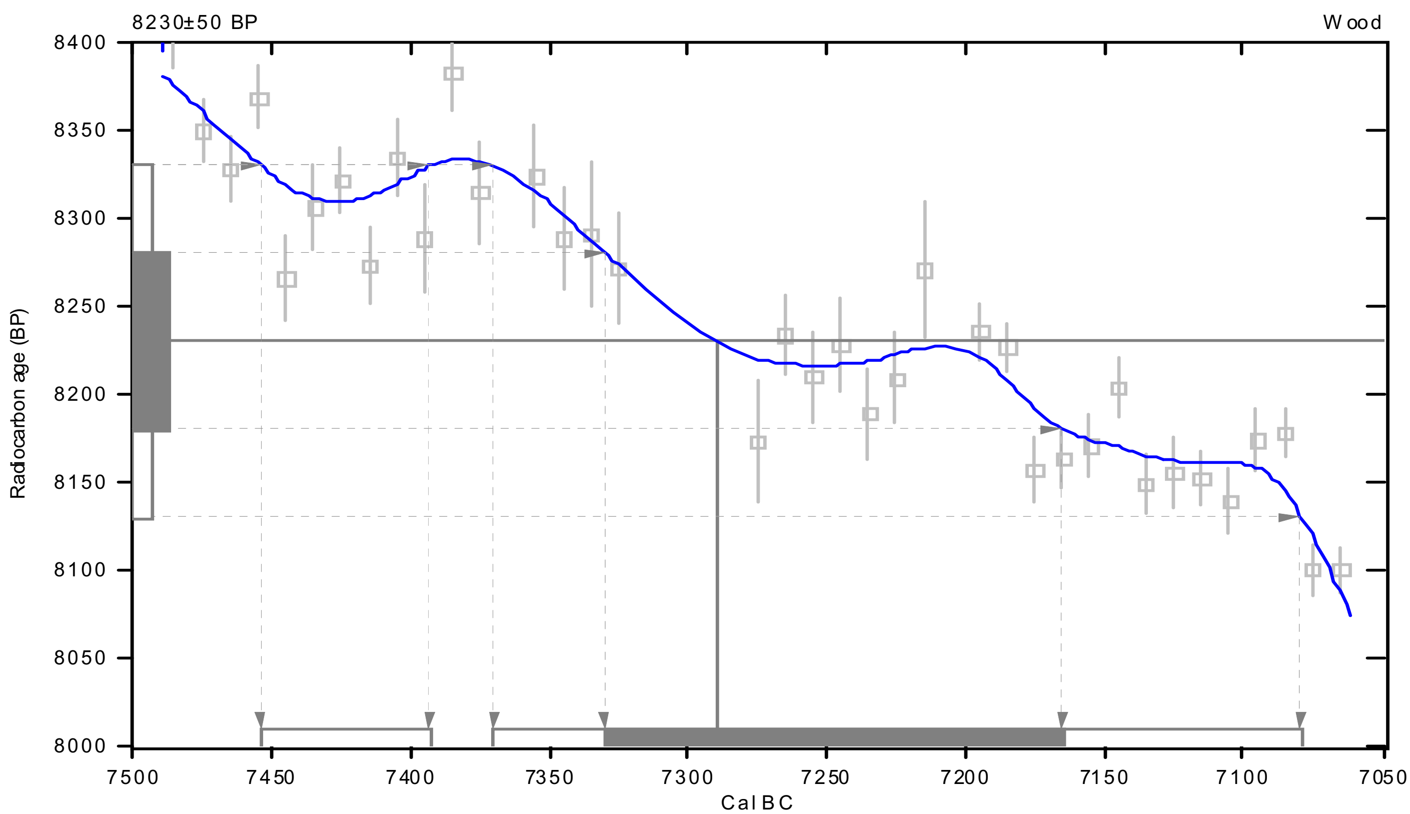
Conventional radiocarbon age: **8230±50 BP**

2 Sigma calibrated results: **Cal BC 7450 to 7390 (Cal BP 9400 to 9340) and**
(95% probability) **Cal BC 7370 to 7080 (Cal BP 9320 to 9030)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 7290 (Cal BP 9240)

1 Sigma calibrated result: Cal BC 7330 to 7160 (Cal BP 9280 to 9120)
(68% probability)



References:

Database used
INTCAL98
Calibration Database
Editorial Comment
Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxii-xiii
INTCAL98 Radiocarbon Age Calibration
Stuiver, M., et. al., 1998, Radiocarbon 40(3), p1041-1083
Mathematics
A Simplified Approach to Calibrating C14 Dates
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-28.2:lab. mult=1)

Laboratory number: **Beta-218746**

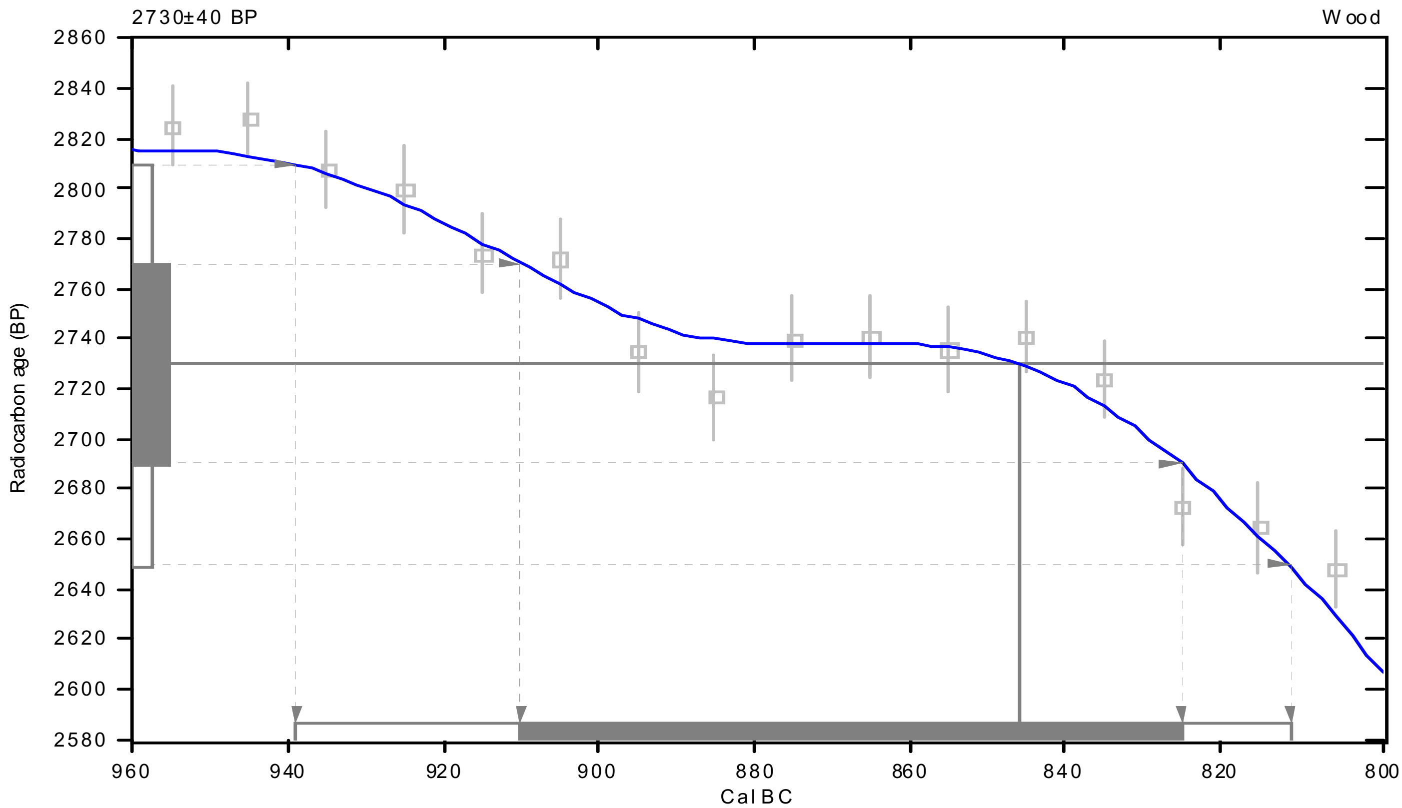
Conventional radiocarbon age: **2730±40 BP**

2 Sigma calibrated result: **Cal BC 940 to 810 (Cal BP 2890 to 2760)**
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 850 (Cal BP 2800)

1 Sigma calibrated result: Cal BC 910 to 820 (Cal BP 2860 to 2780)
(68% probability)



References:

Database used
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Editorial Comment
Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxii-xiii
INTCAL98 Radiocarbon Age Calibration
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-28.8:lab. mult=1)

Laboratory number: **Beta-218747**

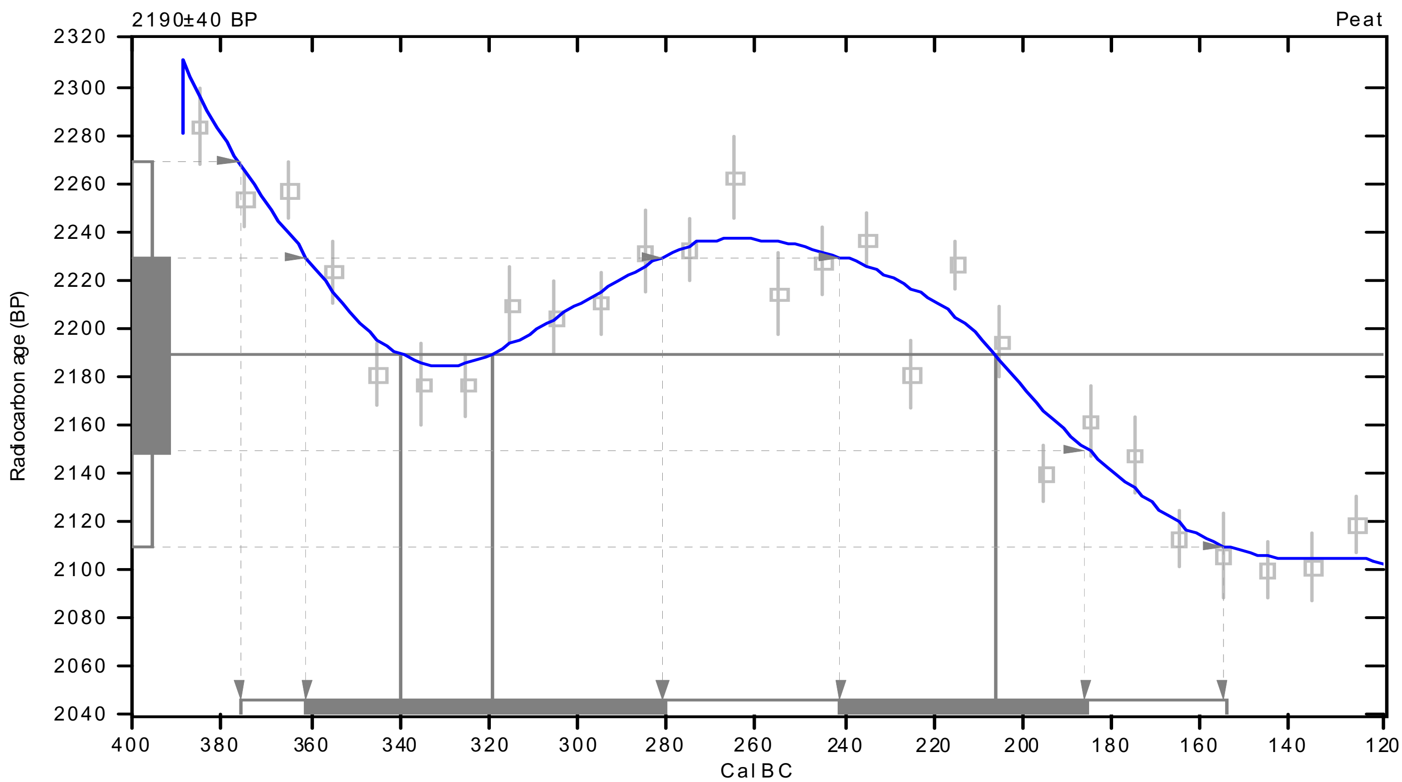
Conventional radiocarbon age: **2190±40 BP**

2 Sigma calibrated result: **Cal BC 380 to 160 (Cal BP 2330 to 2100)**
(95% probability)

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal BC 340 (Cal BP 2290) and
Cal BC 320 (Cal BP 2270) and
Cal BC 210 (Cal BP 2160)

1 Sigma calibrated results: Cal BC 360 to 280 (Cal BP 2310 to 2230) and
(68% probability) Cal BC 240 to 190 (Cal BP 2190 to 2140)



References:

Database used
INTCAL98

Calibration Database
Editorial Comment
Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxii-xiii

INTCAL98 Radiocarbon Age Calibration
Stuiver, M., et. al., 1998, Radiocarbon 40(3), p1041-1083

Mathematics
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-27.6:lab. mult=1)

Laboratory number: **Beta-218748**

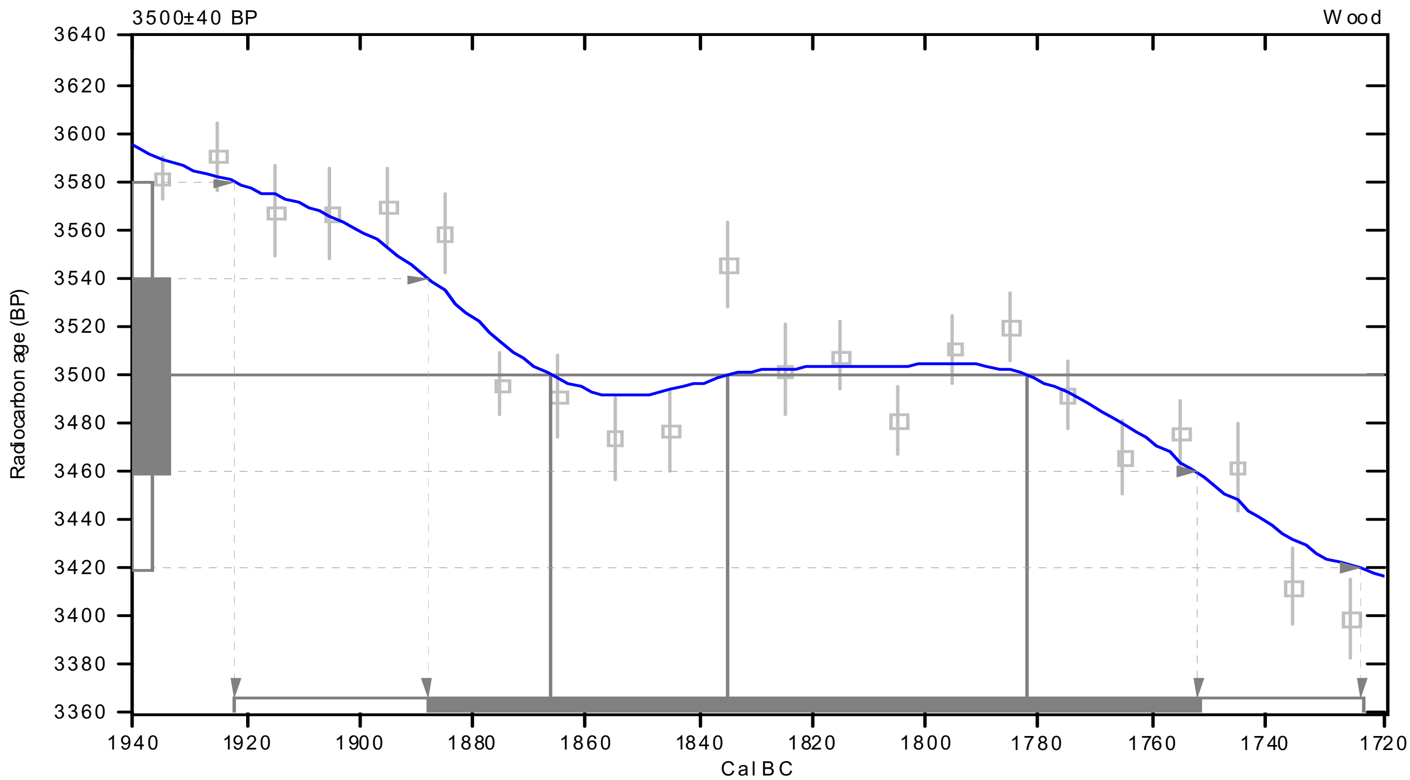
Conventional radiocarbon age: **3500±40 BP**

2 Sigma calibrated result: (95% probability) **Cal BC 1920 to 1720 (Cal BP 3870 to 3670)**

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal BC 1870 (Cal BP 3820) and
Cal BC 1840 (Cal BP 3780) and
Cal BC 1780 (Cal BP 3730)

1 Sigma calibrated result: (68% probability) Cal BC 1890 to 1750 (Cal BP 3840 to 3700)



References:

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INTCAL98

Calibration Database

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Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxii-xiii

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