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GLACIOFLUVIAL CHANNELS BELOW THE BLAKENEY ESKER, NORFOLK

J.M. Gray

Abstract

Recent renewed quarrying in the Blakeney ridge, north Norfolk, has confirmed the presence of several glaciofluvial channels below the ridge sediments. The coincidence of the channel pattern with the ridge itself, and the relationship between the channels and the infilling sediments support the view that the ridge is an esker and suggest that it was essentially deposited subglacially.

Introduction

Recent sedimentological research by Hoare & Gale (1986) has supported the view that the controversial Blakeney ridge in north Norfolk is an esker formed under full pipe-flow conditions by a subglacial or englacial river. Thus they rejected previous explanations that it was formed ice-marginally (e.g. West 1957), is the linear erosional remnant of a larger mass of sand and gravel (e.g. Straw 1965, 1973) or is an open crevasse filling (e.g. Sparks & West 1964). The latter authors mentioned p. 33) that sections towards the highest point in the underlying relief "show gravel to rest in a channel cut in the marly boulder-clay". They used this and other evidence to suggest meltwater overflow westwards from a water-filled crevasse to the east. Subsequently little attention appears to have been paid to this channelling below the ridge, but recent renewed quarrying has revealed several channels which provide important evidence concerning the origin of the ridge itself.

Description of the Channels

Figs. 1a-c show the location of the main sand and gravel pit in the Blakeney ridge. Fig. 1c shows the position of 4 channels so far discovered. At present the best exposed channel is A, close to the entrance to the pit. It can be traced for a distance of about 100 m parallel to and a few metres away from the southern boundary of the esker. It has side slopes of c. 40-70^{o} and is up to 5 m deep and 15 m wide at the top narrowing to less than 2 m in places on its floor, though quarrying has obviously disturbed its original morphology. Apart from the western section, it has been partly infilled, but throughout, till is exposed in its sides, overlain in places by patches of unexcavated sand and gravel. To the west, the original sediment infilling of the channel remains in the western face of the quarry close to the access road.

Channel B is a wider but shallower feature largely excavated and partially infilled. Part of the original northern bank remains, however, on which the esker sediments overlie till on a c. 50^{o} slope. The channel may narrow eastwards before disappearing below stockpiles and plant in the central area of the pit.

At the eastern end of the pit, however, two further channels have recently been revealed by quarrying. Channel C is exposed in the face immediately below the copse of trees opposite the entrance to the picnic site. The base of the channel is not fully exposed but till is present

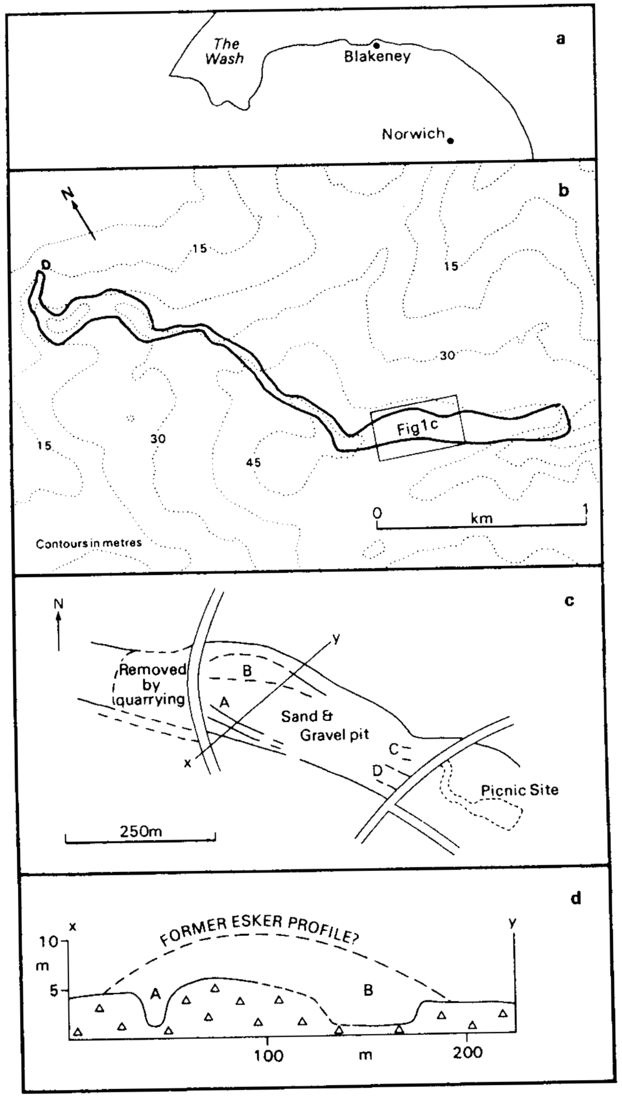

Figure 1. (a) Location of Blakeney
(b) Plan of the esker (after Hoare & Gale 1986)
(c) Plan of pit showing location of Channels A-D and line of section X-Y
(d) Cross-section of till surface along X-Y.

at a high level in both banks and the broad synclinal infilling of the sand and gravel beds is well exposed at present. The channel top width is estimated at c. 20-25 m. Channel C was separated from the large Channel D by a narrow rounded ridge of till (R. Powell, pers. comm.) now largely graded. The predominantly sand infilling of Channel D is presently being excavated and its full morphology is unclear at present.

In terms of the stratigraphy proposed by Hoare & Gale (1986), the channels are cut predominantly in the middle till, a very pale brown, chalk and flint rich till, probably equivalent to the Marly Drift of others workers. Stratification similar to that described by Hoare & Gale in the upper part of the till is clearly exposed in the northern side of Channel A. An overlying diamicton, probably equivalent to the "upper till" of Hoare & Gale, was also observed as a thin (up to 30 cm) veneer over most of area studied, including the channel floors. Thus the stratigraphic sequence appears to be:

4 Deposition of the glaciofluvial ridge sediments;
3 Formation of the "upper till";
2 Cutting of the channels;
1 Deposition of middle till.

Interpretation

The coincidence of the location of the channels and their trend, with the location and trend of the ridge (Figs. 1c and d) suggests a close association in terms of origin, i.e. the ridge was formed by streams flowing along its length. The possibility that the ridge is an erosional remnant of a larger sand and gravel mass is effectively eliminated.

That the ridge is an esker is demonstrated by the undulating long profile of the underlying bed (Fig. 1b) and by the analysis of the ridge sediments demonstrating pipe-flow conditions (Hoare & Gale 1986).

That the esker was formed subglacially rather than englacially is indicated by the fact that the rivers that eroded the channels and deposited the infilling channel sediments at Channel C described above, were clearly flowing on the land surface. The widespread formation of the thin upper till between channel erosion and deposition of the esker sediments suggests that it is a subglacial meltout till deposited during a pause in glaciofluvial activity. Similar diamicts have been observed interstratified within the basal esker sediments, e.g. north bank of Channel A. Thus, it seems reasonable to conclude that the Blakeney ridge is a subglacial esker.

The observations reported here are provisional since the present pit operator intends to work out the quarry fully prior to landscaping. Thus the extent, number and morphology of the channels may well be clarified over the next few years and a fuller report will follow.

Acknowledgements

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A PRELIMINARY STUDY OF THE DEVELOPMENT OF BEILIBEDW MIRE IN MID WALES

David M. Wilkinson

A preliminary study of the palaeocology of a raised basin mire in mid Wales outlines the history of its development and suggests it would be a good site for more detailed studies. The hydroseral sucession in the early Flandrian lake which occupied the site corresponds well with the model outlined by Walker.

Introduction

Beilibedw Mire (Grid Reference SO 164566) is a slightly raised basin mire at an altitude of 400 m in the hills of mid Wales. The only work carried out at the site prior to this study appears to be that of Wisniewski & Paull (1980) who, as part of a general survey of peatlands in Powys, listed the mire flora and provided a brief description of a single sediment core. The stratigraphy and vegetational history have been described at five other near-by sites (Fig.1); Elan Valley Bog

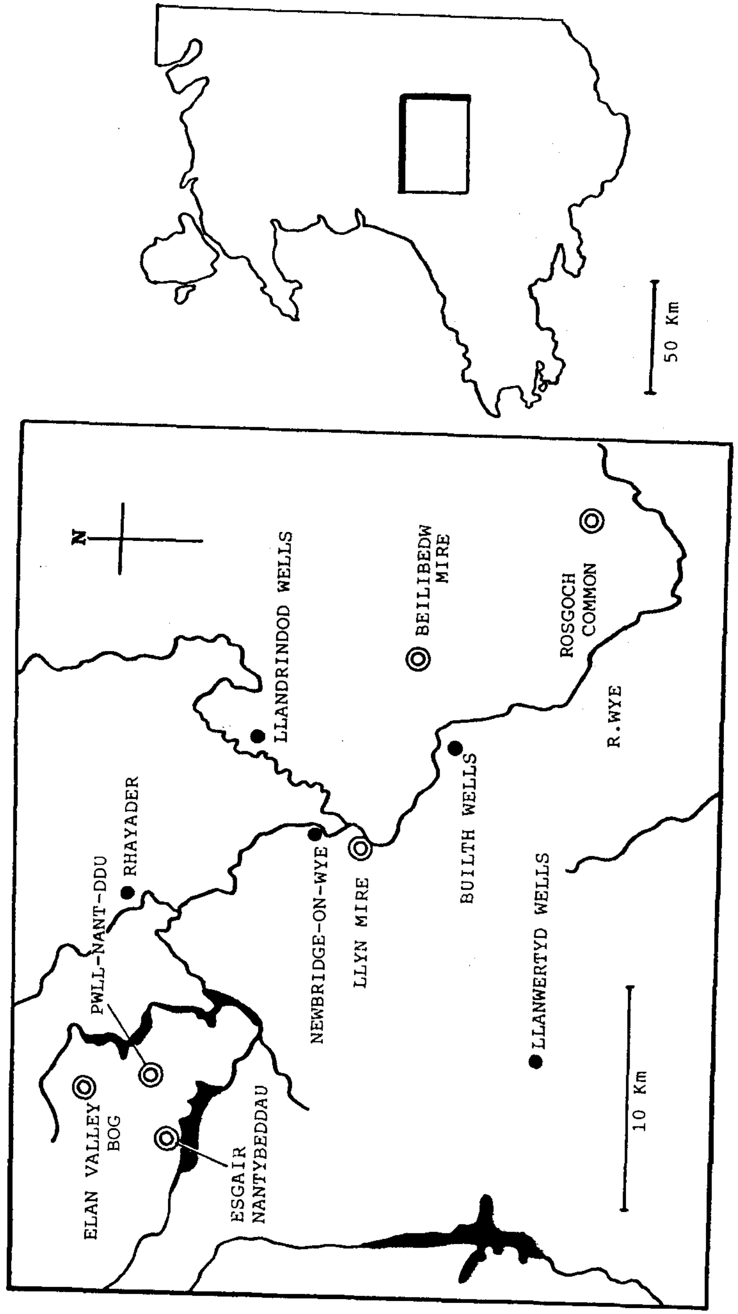

Fig. 1. Location of study area showing the sites referred to in the text.

(Moore & Chater 1969, Moore 1970), Llyn Mire (Moore & Beckett 1971, Moore 1970) Rhosgoch Common (Bartley 1960), Pwll-Nant-Ddu and Esgair Nantybeddau (Wiltshire & Moore 1983). While there are more sites described from western mid Wales there are none to the east of these sites, Beilibedw Mire partly fills this gap.

Site Characteristics and Vegetation

The mire is roughly elliptical, with a major axis of approximately 200 m and a minor axis of 130 m. It is slightly domed, the centre of the mire being about 0.50 m higher than the edge (Fig. 2). At the south east edge of the mire are a series of steep sided pools which cut down through the peat into alkaline clay to a depth of two or three metres. The pH of the steep sided pools was 8.1 while the pH of water in the small mire surface pools was 4.4. The steep sided nature of these pools suggests that they are anthropogenic, possibly the clay had been extracted for use as marl. it is also possible that the mire itself has suffered slight peat cutting in the past as there is a long history of peat cutting in mid Wales (Wisniewski *et al*. 1982).

Plant species recorded growing on the mire are listed in Table 1.

Stratigraphy

A series of five cores were taken using a Russian sediment borer (Jowsey 1966). A main core was taken from near the centre of the mire, this reached a depth of 8.5 m where a whitish clay was discovered. The top 1.5 m of the deposit was wet and fibrous and could not be sampled with the borer. In September 1987 when the water level was low a till could be seen underlying the clay at a depth of about two metres in one of the ponds at the mire edge. The main core was transported to the laboratory for analysis, the results of which are shown in Fig. 3. It showed a transition from organic lacustrine sediments rich in diatom frustules to terrestrial peats as the post glacial lake which occupied the site silted up. A transect of cores was taken on either side of the main core (along line AB in Fig. 2), these were examined in the field and found to show a similar stratigraphy. Cores taken at the edge of the mire showed bands of inwashed clay and darker peat in the top 0.30 m suggesting recent erosion in the catchment.

In an attempt to approximately date these events fossil pollen was extracted by standard methods (Moore & Webb 1978) from sediment at both ends of the lacustrine section of the main core. None of the local sites for which pollen diagrams are available are radiocarbon dated, so it is impossible to put exact dates to the different vegetational events. The pollen sample from the bottom of the core had very high *Corylus* values (54% of the total pollen sum) and matched the early Flandrian parts of local pollen diagrams. The samples from the top of the lacustrine sediments contained *Tilia* pollen and were similar to zone VII of Moore & Chater (1969) suggesting a date of perhaps 5000-7000 BP. This suggests that lake and fen conditions existed at the site for the first three or four thousand years of the Flandrian before mire development. Walker (1970) suggests a time scale of between 2500 and 4000 years for mire formation from open water by way of a fen stage. This is consistent with the present data.

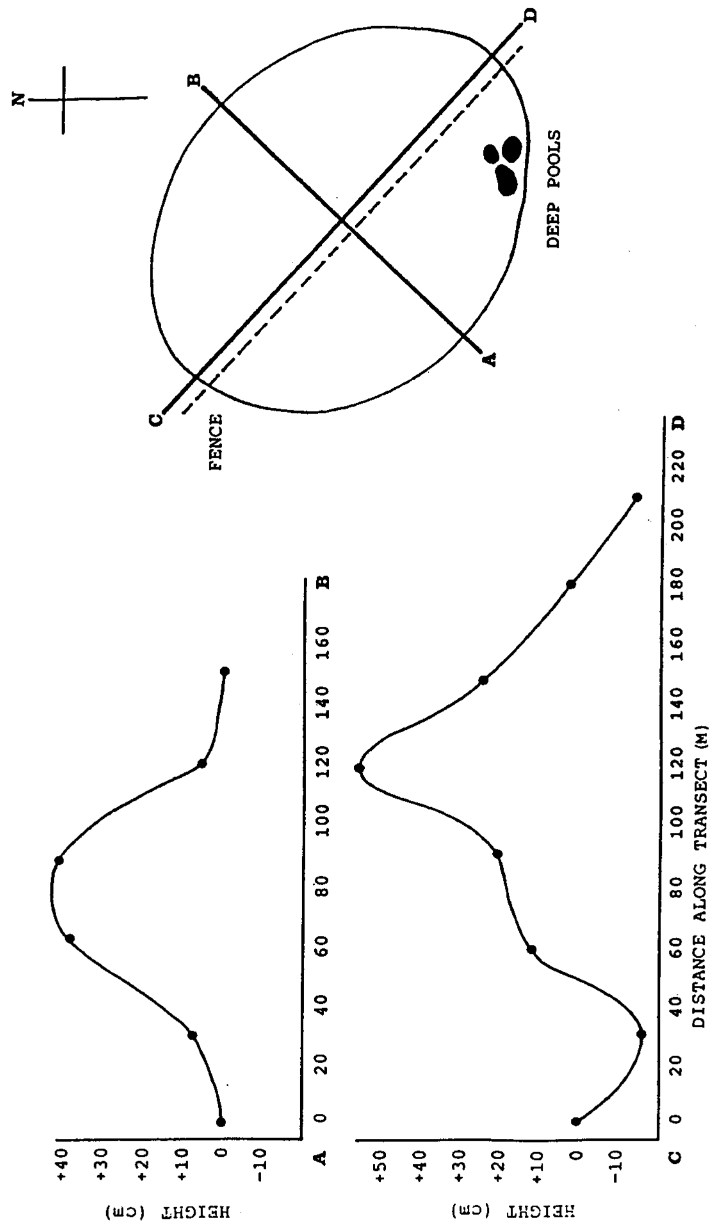

Fig. 2. Plan and profile of Beilibedw Mire with the results of two levelling transects showing the domed nature of the mire.

Table 1. Plant species recorded growing on the mire. Data from Wisniewski & Paull (1980) and Wilkinson (pers. obs.). Nomenclature follows Smith (1978) for bryophytes and Clapham et al. (1981) for vascular plants.

Lichens and Bryophytes.	Vascular Plants.
Cladonia impexa	Ranunculus repens
Hypogymnia sp.	R. flammula
	Cardamine pratensis
Sphagnum palustre	Viola palustris
S. fimbriatum	Potentilla palustris
S. capillifolium	P. erecta
S. subsecundum	Calitriche stagnalis
S. cuspidatum	Hydrocotyle vulgaris
S. recurvum	Rumex acetosa
Polytrichum formosum	R. obtusifolius
P. commune	Urtica dioica
Dicranum scoparium	Calluna vulgaris
Aulacomnium palustre	Erica tetralix
Drepanocladus fluitans	Vaccinium vitis-idaea
Hypnum cupressiforme	V. myrtillus
Rhytidiadelphus squarrosus	Empetrum nigrum
	Cirsium palustre
	Potamogeton polygonifolius
	Juncus effusus
	J. conglomeratus
	Eriophorum angustifolium
	E. vaginatum
	Festuca ovina
	Glyceria fluitans
	Molinia caerulea

Macrofossil Analysis of Hydroseral Sucession

The use of palaeocological techniques has proved a powerful approach for the investigation of the theory of hydroseral sucession (Walker 1970). This prompted an attempt at investigating the sucession from open water to the start of mire development at the site using macrofossil analysis. The sediment for macrofossil analysis was separated in 10% nitric acid and all potentially identifiable material was removed for further examination. The results are shown in Table 2 in which the degree of reliability of the identifications is indicated by a standard set of conventions (Dickson 1970). All Potamogeton fruits which were tentatively identified to species level using the criteria of Aalto (1970) were identified as P. natans. Thelypteris (probably T. palustris) was identified from the illustrations in Grosse-Brauckmann (1972). Other material was identified by comparison with reference material and standard floras. Bryophytes identified as Sphagnum section Sphagnum include any members of this section other than S. papillosum or S. imbricatum. Two commonly occurring macrofossils, bryophyte X and Leaf X, could not be identified. A fragment of leaf X is illustrated in Fig. 4.

Hydroseral succession was consistent with the general scheme identified by Walker (1970). The fossil succession starts with totally submerged macrophytes (Walker stage 3) e.g. Potamogeton spp., however 'floating leaved macrophytes' such as Nymphaea quickly appear (Walker stage 4). At a depth of 6.5 m 'reedswamp' starts to develop (Walker stages 5-7) and at a depth of around 5.75 m carr is starting to develop with tree species such as Betula and Salix growing with the fern Thelypteris (Walker stages 8 and 9). Pollen analysis revealed Alnus pollen in the carr sediments. The succession eventually progresses to 'bog' (Walker stage 11). In relation to the development of carr vegetation it is of interest that the small light Betula fruit appear in the core before the larger Betula leaf and wood remains. This probably mirrors the encroachment of Betula onto the site, the smaller fruits being able to reach the site of sedimentation from a greater distance than the leaves or twigs.

Several interesting invertebrate fossils were also extracted from the core. Two beetles were recovered from the early Flandrian deposits. Ptinus pusillus is today a rare British species found in dead wood and plant litter, now only known from a few sites in southern England (Key, pers. comm.) and Coccinella hieroglyphica is a ladybird which feeds on the larvae of the heather beetle Lochmaea suturalis (Pearsall 1971). A Cryptostigmatid mite was found along with an egg within the remains of a Phragmites leaf. These mites tend to be associated with plant litter and soils although some species spend part of their life cycle on living plants (Evans et al. 1961). The statoblasts of two species of Bryozoans were found, unfortunately there are few clear relationships between habitat type (such as water chemistry) and the occurrence of particular species. However Cristatella mucedo is most often found in eutrophic conditions (Mundy 1980). The commonest invertebrate macrofossils were the cocoons of leeches in the family Erpobdellidae (Fig. 4). The best preserved of the cocoons was tentatively identified as Erpobdella octoculata, this is one of the commonest fresh water leeches found in a wide variety of habitats (Elliott & Mann 1979).

Table 2. Results of macrofossil analysis of the lacustrine section of the Beilibedw Mire main core.

	5.00–5.25–	5.25–5.50	5.50–5.75	5.75–6.00	6.00–6.25	6.25–6.50	60.50–6.75	6.75–7.00	7.00–7.25	7.25–7.50	7.50–7.75	7.75–8.00	8.00–8.25	8.25–8.50
Potamogeton fruits		x		x	x	x	x	x	x	x	x	x	x	x
Potamogeton leaves					x									
Chara oospores						x	x	x						
Nymphaea seeds							x		x	x	x	x	x	
cf. Nuphar seeds												x		
Carex fruits	x		x	x		x	x	x				x	x	
Cyperaceae fruits	x		x	x	x									
Leaf X							x	x	x	x				
cf. Equisetum	x	x												
Phragmites	x				x	x								
Thelypteris	x	x	x											
Sphagnum section Sphagnum		x	x	x										
Sphagnum papillosum					x								x	
Sphagnum cf. recurvum												x		
Aulacomnium palustre													x	
Dicranella heteromalla												x		
cf. Drepanocladus		x												
Dicranum cf. majus			x											
cf. Plagiothecium			x											
Bryophyte X				x				x	x	x				x
Betula fruit	x		x			x		x						
Betula wood		x	x	x										
Betula cf. pubescens leaf			x	x										
cf. Salix leaf				x										
Calluna shoot						x			x		x			
Ericaceae wood		x												
Ericaceae flower													x	
Erpobdellidae cocoons	x	x	x	x										
Plumatella statoblasts	x	x												
Cristella mucedo statoblasts								x						
Porifera spicules											x			
Cryptostigmatid mite						x								
Coccinella hieroglyphica													x	
Ptinus pusillus														x

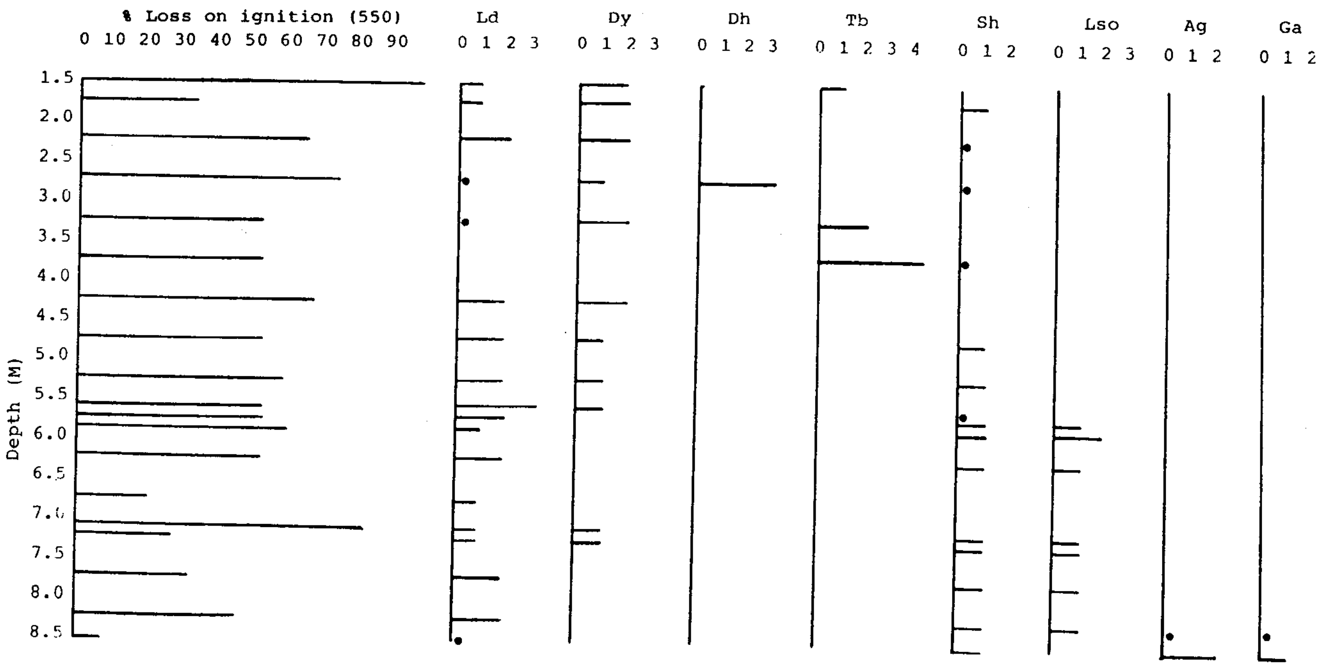

Fig. 3. Results of sedimentological analysis of the main core from Beilibedw Mire. The histograms show the results of percentage loss on ignition at 550°C. and the proportions of the different sediment types characterised according to the scheme of Troels-Smith (1955).

Conclusions

During the Flandrian the site developed from an area of open water to the basin mire which exists to-day. In doing so it corresponded well with the model of hydroseral sucession outlined by Walker (1970). The abundance of different types of biological remains (pollen, diatoms, plant and invertebrate macrofossils) and its location, as probably the most easterly basin mire in Wales, suggests that the site would repay more intensive study.

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Help with the field work was provided by Steve Richards and Fred Slater. M.L. Cock, Brian Huntley, Roger Key, Fred Slater, A.G. Smith and Roy Wiles provided help with fossil identifications. John O'Halloran and Fred Slater provided constructive comments on the manuscript and Steve Whitehouse drew the figures. I would also like to thank the Manpower Services Commission and the Llysdinam Charitable Trust for facilities provided.

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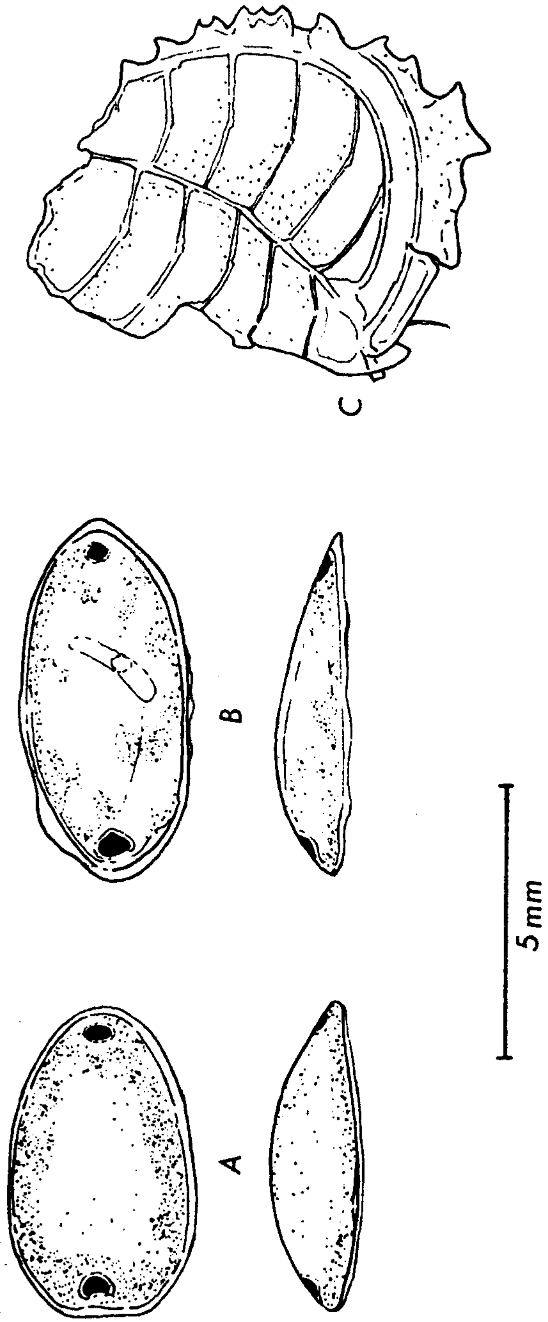

Fig. 4. Macrofossils from Beilibedw Mire. A Modern cocoon of Erpobdella octoculata from mid Wales. B Fossil Erpobdellidae cocoon. C Leaf X, fragments of this unidentified spiky leaf were found at several different levels in the core.

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LATE QUATERNARY OF THE KOPAIS BASIN, GREECE: SEDIMENTARY AND ENVIRONMENTAL HISTORY

Harriet Allen

Ph.D. Thesis, Dept of Geography, University of Cambridge
1986

The Kopais basin, about 80 km northwest of Athens, is one of the most fertile regions of Greece. Before it was reclaimed at the end of the nineteenth century it was a large seasonal marsh. It is an area of considerable archaeological importance because of an attempt by the Mycenaeans to drain it approximately 3,500 years ago. The sediment record (Turner & Greig 1975; this thesis) shows that for most of the Late Quaternary the basin was occupied by a lake and there has been some debate about the nature of the basin at the time of the Mycenaean drainage: whether they drained a lake or a marsh. In an attempt to answer this question and to complement the vegetation history of the basin provided by Turner & Greig two sediment cores were collected and the lake's sediment record, in terms of the erosional history of the catchment, was interpreted from the mineral magnetic properties of the sediment.

The mineral magnetic record together with particle size analysis, carbonate content and radiocarbon dates show that there are two sedimentary units present in the core material: the lower unit has an estimated basal date of 27,000 years BP and ends at 12,500 years BP, while the upper unit is estimated to end between 5,000 and 3,500 years BP. Values of magnetic susceptibility are low throughout the sediment cores but are higher in the lower unit than in the upper unit. The ratio of $IRM_{0\cdot 08T}$ to $IRM_{1\cdot 0T}$ indicates that haematite is the dominant magnetic mineral in the lower unit and magnetite in the upper unit. The profiles of the ratio of $IRM_{1\cdot 0T}$ to susceptibility for both cores show little change in magnetic grain size within each unit. Particle size analysis reveals coarser material (about 50% of each sample finer than 6 um) in the lower unit than in the upper unit (about 80% of each sample finer than 6 um) but there appears to be no relationship between the magnetic parameters and particle size. Carbonate content is higher in the upper unit than in the lower unit and SEM shows that the carbonate in the lower unit is detrital while that of the upper unit is endogenic. X-ray diffraction also shows that the sediment in the upper unit is mostly calcite while that in the lower unit is more heterogeneous. Pollen analysis of the two cores was carried out by Prof. J.C. Ritchie, University of Toronto, who kindly made available the results and these confirm the findings of Turner & Greig (1975).

The interpretation of the two units is in terms of the Greek equivalents of the Last Glacial Stage and the Holocene. In the earlier period conditions were cool and arid with open steppe vegetation. The haematite in the sediments reflects the aerobic nature of the soils. During this period the lake was probably shallower than during the Holocene. In the later period the climate was wetter and warmer with