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## COLEOPTERA FROM TWO LATE DEVENSIAN SITES IN THE LOWER COLNE VALLEY, WEST LONDON, ENGLAND

By G. R. Coope

Two Late Devensian coleopteran assemblages are described here from the lower Colne Valley about two kilometres north-west of London (Heathrow) Airport. The insect remains came from organic silty clay layers interbedded in gravels below the floodplain deposits of the modern river. The precise geographical and geological contexts of these two sites are given by Gibbard and Hall (1982) who also provide radiocarbon dates and macroscopic plant records. Unfortunately samples were submitted to me for insect analysis too late to be included in that report. The beetle assemblages are remarkable for the large number of species present that are now extinct in the British Isles and also because the Colnbrook site yielded one of the few known insect faunas that date from the cold period immediately prior to the Windermere Interstadial. The naming of the sites follows the usage of Gibbard and Hall (1982).

### Faunal List

The numbers opposite each species are the minimum number of individuals present in the sample. \*Indicates species now extinct in the British Isles.

	Colnbrook A		West Drayton A
	Lower	Upper	
Carabidae			
<i>Carabus arvensis</i> Hbst.	-	1	-
<i>Notiophilus aquaticus</i> (L.)	3	-	-
* <i>Dyschirius septentrionum</i> Munst.	-	1	-

	Colnbrook A		West Drayton A
	Lower	Upper	
<i>Patrobis septentrionis</i> (Dej.)	-	-	1
<i>Trechus rivularis</i> (Gyll.)	-	-	1
<i>Bembidion bipunctatum</i> (L.)	-	1	-
* <i>Bembidion hasti</i> Sahlb.	-	-	2
<i>Bembidion virens</i> Gyll.	-	-	1
<i>Amara quenseli</i> (Sch.)	-	3	-
<b>Halipilidae</b>			
<i>Brychius elevatus</i> (Pz.)	-	-	1
<b>Dytiscidae</b>			
* <i>Oreodytes alpinus</i> Pk.	-	-	1
<i>Platambus maculatus</i> L.	1	-	-
<i>Agabus</i> sp.	-	-	1
<b>Hydrophilidae</b>			
<i>Helophorus aequalis</i> Thom.	-	-	1
<i>Helophorus grandis</i> Ill.	1	1	-
* <i>Helophorus glacialis</i> Villa	-	-	3
* <i>Helophorus obscurus</i> Popp.	3	2	1
* <i>Helophorus jacutus</i> Popp.	1	-	-
<i>Helophorus</i> small species	1	1	4
<i>Hydrobius fuscipes</i> (L.)	-	-	1
<b>Staphylinidae</b>			
* <i>Olophrum boreale</i> Pk.	-	-	1
<i>Olophrum</i> sp.	5	-	3
<i>Arpedium brachypterum</i> (Grav.) type	9	1	12
* <i>Pycnoglypta lurida</i> Gyll.	-	-	5
* <i>Boreaphilus henningianus</i> Sahlb.	1	-	-
* <i>Boreaphilus nordenskiöldi</i> Maki.	7	-	-
<i>Omalius</i> sp.	-	1	-
<i>Anotylus nitidulus</i> Grav.	-	-	1
<i>Stenus</i> sp.	2	-	-
<i>Quedius</i> sp.	-	1	-
* <i>Tachinus coelatus</i> Ullrich	-	-	1
* <i>Tachinus jacuticus</i> Popp.	1	2	-
<i>Aleocharinae</i> gen. et sp. indet.	1	1	13
<b>Elateridae</b>			
* <i>Hypnoidus rivularis</i> Gyll.	1	-	1
<b>Byrrhidae</b>			
* <i>Simplocaria metallica</i> Sturm	-	-	1
<i>Simplocaria semistriata</i> F.	1	-	-
<i>Byrrhus</i> sp.	-	-	1
* <i>Syncalyptra cyclolepidia</i> Munst.	-	-	1
<b>Anthicidae</b>			
<i>Anthicus</i> spp.	-	-	2
<b>Scarabaeidae</b>			
<i>Aphodius</i> sp.	-	1	1

	Colnbrook A		West Drayton A
	Lower	Upper	
Chrysomelidae			
<i>Plateumaris</i> sp.	1	-	-
* <i>Chrysolina septentrionalis</i> type	1	-	-
<i>Gastrophysa viridula</i> (Deg.)	2	1	-
<i>Phytodecta</i> sp.	-	-	1
<i>Galeruca tanacetii</i> (L.)	-	-	1
Curculionidae			
<i>Otiorhynchus nodosus</i> (Mull.)	-	1	1
<i>Otiorhynchus rugifrons</i> (Gyll.)	1	1	-
<i>Notaris acridulus</i> (L.)	-	1	-
<i>Notaris bimaculatus</i> (F.)	1	-	-

## Colnbrook A:

The insect bearing horizon occurred beneath about 3 m of orange gravel and sand which was overlain by 20 cm of brown silty clay. The organic deposit was 27 cm thick and, at the sampling site was divided into an upper and lower unit of about the same thickness by a 2 cm layer of grey pebbly coarse sand. Two samples were taken at this locality, one from above and one from below this parting. Each sample was of approximately 2 kg. A radiocarbon date of  $13450 \pm 170$  BP (Q2021) was obtained from plant detritus from the upper of these two units.

Out of a total of 22 named species, 8 of them (36%) are now absent from the British fauna. All but one of the species of this rather exotic assemblage live today in arctic Europe and northern Siberia. Two species, *Helophorus obscurus* and *Boreaphilus norden-skiöldi* have their nearest and most westerly occurrence on the Kanin peninsula whilst *Tachinus jacuticus* has a dominantly east Siberian and North American range with its most westerly limit in north east Russia at Vorkuta and at Yaroslavl. The non European species is *Helophorus jacutus* which is today an exclusively east-Siberian species extending northwards to the southern part of the Taymyr peninsula (Angus 1973). The climatic regime indicated by this insect assemblage is of extreme severity with average July temperatures at or below 10°C and average temperatures of the coldest winter months at or below -20°C.

This harsh climatic picture is supported by the local environmental implications of the fauna that suggest an open rather barren landscape with thin patchy vegetation with leaf and moss litter in places. Some running water is indicated by *Platambus maculatus* and small puddles by *Helophorus grandis* and *H. jacutus*. The paucity of phytophagous species is entirely in keeping with the arctic affinities of this fauna (Morgan 1973). *Gastrophysa viridula* feeds on various species of Polygonaceae. *Otiorhynchus nodosus* and *O. rugifrons* are polyphagous weevils that are largely nocturnal and in high latitudes are restricted to regions where cloud cover provides adequate shade from the arctic sun. *Notaris acridulus* is a weevil usually found feeding on *Glyceria maxima*, whilst *N. bimaculatus* feeds on *Typha latifolia* or *Phalaris arundinacea*.

The Colnbrook insect assemblage is one of the richest faunas of this age yet described from the British Isles, comparable only to the "northern" insect fauna from below the Lateglacial deposits at Glanllynau, North Wales (Coope and Brophy 1972). There are, however, some interesting new additions to our knowledge of the Late Devensian fauna. *Boreaphilus nordenskiöldi* is a frequent member of our Mid-Devensian fauna but has so far never been found in a Lateglacial context. It would now seem that it survived in Britain at least until the sudden climatic warming at the beginning of the Windermere Interstadial at about 13,000 BP. Two other species deserve special attention. *Helophorus jacutus* was an abundant Mid-Devensian species but there is only a single record from Britain, that dates from Loch Lomond Stadial (Younger Dryas) times i.e. Orleton, Herefordshire. Similarly *Tachinus jacuticus* was widespread and abundant in Britain during the Mid-Devensian period but has hitherto only one Late-Devensian occurrence, i.e. at Glen Ballyre, Isle of Man, where it also dated from Loch Lomond Stadial times (Coope 1971). These Colnbrook fossils thus provide a neat temporal link between the thriving Mid-Devensian population of these species and their meagre lateglacial survivors.

#### West Drayton A:

The insect fossils were obtained from a 2 kg sample of organic silty clay taken from the middle of a lens 22 cm thick and underlying about 2 metres of grey sand and gravel which in turn was capped by about 50 cm of mud and clay of the recent flood plain. A radiocarbon date of  $11,230 \pm 120$  BP (Q-2030) was obtained from the same horizons as the insect fossils.

This assemblage presents a mixture of high northern and relatively southern species with the boreal types in a clear majority. Out of a total of 21 named species, 10 of them (48%) are now absent from the fauna of the British Isles and have boreal or montane distributions. These include *Bembidion hasti*, *Oreodytes alpinus*, *Helophorus obscurus*, *Helophorus glacialis*, *Olophrum boreale*, *Pycnoglypta lurida*, *Tachinus coelatus*, *Hypnoidus rivularis*, *Simplocaria metallica* and *Synalypsa cyclolepidia*. We may add to these the following boreal species whose range extends as far south as northern Britain; *Patrobis septentrionis*, *Bembidion virens*, *Arpedium brachypterum* and *Otiorhynchus nodosus*. There are a number of species in the West Drayton assemblage that are very characteristic of Loch Lomond Stadial (Younger Dryas) deposits in Britain. Thus *O. boreale*, *P. lurida* and *H. glacialis* are always important components of faunas of this time but rare during other parts of the Devensian. The presence of *Trechus rivularis* is unexpected in this assemblage. It is a rare species in Britain today, common only in Wicken Fen (Lindroth 1974) while in Fennoscandia it only just reaches the northern edge of the Gulf of Bothnia (Lindroth 1943). This species is, however, common in deposits that date from the Windermere Interstadial, is unknown in Mid-Devensian sites but was abundant during the Early Devensian, Chelford Interstadial. At West Drayton it seems most likely that *T. rivularis* was a lingering survivor from the Windermere Interstadial. It is possible that *Brychius elevatus* and *Anotylus nitidulus*, which are both rare or absent from the extreme north of Europe today may also be remnants of this Interstadial fauna.

The beetle assemblage thus supports the tentative inference of Gibbard and Hall (1982) based on the macroscopic plant fossils, that the West Drayton deposit should rightly be placed in the Loch Lomond Stadial. An early Loch Lomond age is not incompatible with the radio-carbon date. It is further supported by the presence in the West Drayton deposit of the notostracan crustacean *Lepidurus arcticus* Pallas which was very common during Loch Lomond Stadial times but which has not been found in Windermere Interstadial deposits in England.

There remains one species that stands out as an exceptional occurrence in a Lateglacial fauna. *Tachinus coelatus* is a regular member of the Mid-Devensian fauna of Britain but has hitherto not been found in a Lateglacial assemblage. Today it is only recorded from the mountains of Mongolia where it is fairly abundant in the birch woodland south of Ulan Bator at altitudes between 1150 and 2000 m above sea level (Ullrich 1975). I have compared the West Drayton specimen (8th Q tergite) with paratypes of this species and the match is exact. Since there is no reason to believe that this specimen is a derived fossil from Mid-Devensian deposits, it joins the two other dominantly asiatic species, *Helophorus jacutus* and *Tachinus jacuticus* as the most exotic survivors into the Lateglacial fauna of the British Isles.

#### Acknowledgement

I would like to thank Dr. P.L. Gibbard who collected the samples in the first place without any evidence in the field that they contained such exotic insect assemblages.

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## RODENT REMAINS FROM THE CADDIS-BEARING TUFFA OF ELDER BUSH CAVE

By D. Bramwell and F.W. Shotton

In 1964, one of the authors assessed the results of excavations in Elder Bush Cave near Wetton, Staffordshire (Bramwell 1964). This is a small cave in Carboniferous Limestone and its fill was divided into 12 layers for descriptive purposes, No.1 being the lowest and 12 the highest. The site was visited on Excursion A2 during the 1977 X INQUA Congress at Birmingham and Bramwell's diagram and conclusions were reproduced without change in the guide book to the excursion (Shotton 1977, contribution G.T. Warwick).

Layers 12 to 9 consisted largely of frost breccia and cave earth with a vertebrate fauna that included grouse, mallard, reindeer, cave bear, fox, red deer, pig, hyaena, lion, bison, horse, woolly rhinoceros and lemmings. Part of this fauna clearly indicates a cold climate and layers 12-9 were regarded as extending back from the Roman period to well into the Devensian. Whether they embraced all or part only of the Devensian could not be stated on the available evidence.

Cave earth with this cold fauna extended to the cave entrance, where it lay upon a thin layer (3-4cm) of laminated, compact, fine-grained tuffa, interpreted as a deposit of a small pool. When split, certain layers of the tuffa revealed a profusion of impressions of caddis fly wings, truncated somewhat irregularly at their base and clearly the work of bats, biting off the tough, indigestible parts of the insect before eating the prey. Forewings were almost exclusively present, the much more delicate hind wings being very rare. There were, of course, no bodies. Preservation took the form of a very good impression of the outline and veins of the wings but the veins themselves and the thin chitin film between them had completely disappeared. With this had gone the very feeble, almost invisible colour pattern which the living insects sometimes show. The late Professor Zeuner identified the wings as *Micropterna* cf. *nycterobia*. This caddis fly is now a non-British, southern European species and despite the "cf" in the identification, there was thus an implication of a warm climate. This was supported dramatically by the only plant fossil found, a complete leaf of the Mediterranean Maple, *Acer monspessulanum*. So it was always assumed that the tuffa was of Ipswichian age (with which conclusion we are not disagreeing, though we shall qualify it somewhat).

Back in the cave, under the cave earth with its cold fauna, was a sandy cave earth (layer 7) regarded as the lateral equivalent of the tuffa layer, with lion, hyaena, wolf, giant deer, hare, bison and hippopotamus (though D.B. recalls that the single milk molar of hippopotamus was picked up loose, having apparently fallen from the layer being excavated). Apart from hippopotamus, the fauna is not obviously "warm". Lion, for example, is also found in cold-climate deposits such as Avon No.2 Terrace (Shotton 1976) and in the Devensian layers of this cave; but if the hippopotamus tooth came from layer 7, there is no reason why the bed should not be regarded as Ipswichian.

Although a further 6 feet (1.8m) were excavated below layer 7, they were unfossiliferous, though obvious glacial erratics in breccias and solifluction hinted at an interesting tale of erosion of pre-Ipswichian tills.

When the INQUA excursion visited the cave in 1977, Mr. P.F. Whitehead detected a molar of a rodent in a fragment of the tufa. Later, F.W.S. accompanied by Dr. G.T. Warwick and Mr. P.J. Osborne, revisited the cave, stripped off some of the cave earth above the tufa layer and collected a modest quantity of the latter. Of this very restricted deposit, enough has been left to demonstrate its position in the succession. Initially the collected tufa was divided into fractions according to whether it had been detached into the cave earth above or was still in an undisturbed state. After D.B. had identified the vertebrates which were present in the separate samples, it became clear that there was no point in treating these separately and that a single list would suffice for what must have been only a short period of time.

It was the intention to dissolve the tufa to reveal any contained teeth and bones but preliminary splitting along the laminations produced one slab with many wing impressions. This was kept and added to another rich piece which had come from the original excavation and these together provided the material for the analysis of wing shape and venation which follows later in this paper. Most of the material was treated with 5% acetic acid which removed the calcium carbonate and left bones and teeth in the residue. After sieving and washing, these were identified where possible by D.B. with the following list:-

*Arvicola terrestris*. Water vole. Small Pleistocene species.

r i, m<sub>1</sub>, m<sub>2</sub> associated with part of mandible.

r m<sub>2</sub>. r m<sub>1</sub>. l m<sub>2</sub>, m<sub>3</sub>. r m<sub>1</sub> (frag.) Also many bones and teeth fragments.

*Dicrostonyx torquatus* Arctic Lemming.

l m<sub>3</sub>. m<sub>1</sub>. r m<sub>2</sub> juv. r m<sub>3</sub>.

*Microtus oeconomus* Northern vole.

right mandible with m<sub>1</sub>. m<sub>1</sub> juv. r m<sub>1</sub>.

*Microtus* sp.

part maxilla with m<sup>1</sup>, m<sup>2</sup>, m<sup>3</sup>. m<sub>1</sub>, m<sub>2</sub>.

three additional teeth and numerous bones attributed to this.

*Clethrionomys* cf. *glareolus* Bank vole. r m<sub>3</sub>.

Bird species blackbird size. Distal articulation of tibiotarsus.

The surprise of this fauna is the occurrence of the arctic lemming and the northern vole, species no longer living in this country. They would not be expected in association with the Mediterranean maple. It might be argued that the rodent remains occupy a different level in time within the tufa bed but we cannot conceive that this pool deposit, so thin and with only a few laminations, took a long time to form. Moreover,



rodent remains occurred throughout the bed, though often tending to occur in clusters to which they had presumably been washed.

At this point it seemed expedient to re-examine Zeuner's caddis

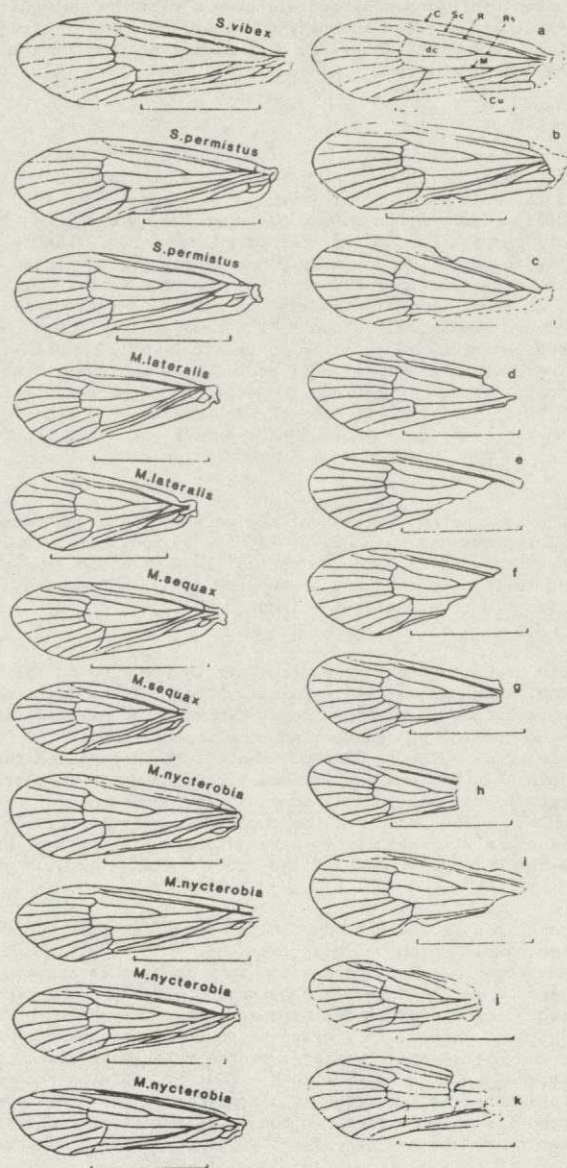


Fig.1 Left: Wing venation patterns of modern caddis fly forewings. Right: Patterns of forewings preserved in tufa layer. The scale against each drawing represents 10mm.

identifications, though we cannot be sure of the sample he examined. *Micropterna* is a genus closely related to *Stenophylax* (indeed, certain species have oscillated between these two genera). Their species are large (by Neuroptera standards) and all have a distinctive venation pattern on their wings. In identifying modern specimens, size and shape are of limited value, venation is rarely uniquely distinctive and everything hinges on the individuality of the genitalia - which are unavailable in the fossils.

In an attempt to enquire into the validity of Zeuner's comparison of the fossils with *Micropterna nycterobia*, F.W.S. examined the left forewings of the only four British species which could possibly be equated with the fossils (*Stenophylax vibex*, *S. permistus*, *Micropterna lateralis* and *M. sequax*) and a group of six *Micropterna nycterobia* kindly lent by Dr. Barnard of the British Museum (N.H.). This species showed a vast range of size in the museum collection but the four we have illustrated are as large as any. Both the modern specimens and the fossils were drawn with camera lucida, all close to the same scale, though there are minor differences which are resolved by the scale of 10mm with each drawing. There is more variation of proportions and overall shape within *M. nycterobia* than there is between the other four species, so it is worth noting that the first three are from the McLachlan collection, determined by him and that he was the author of the species - so they should be unimpeachable.

By the same method, eleven of the more complete and better preserved fossil impressions were drawn, as near as possible to the same scale. Where the wing appeared to be the right side one (though there was no way of telling if the wing was upside down) the drawing was reversed to facilitate visual comparison.

A word of caution may be appropriate in the case of the fossils. Veins Sc and R, which are strong proximally, become very faint distally and may be untraceable in the fossils. The wing may develop sharp folds before becoming covered by sediment and the impressions of these lines may be misinterpreted as veins. One specimen, j, is so puckered that vein M appears to join vein Rs, whereas it actually joins Cu. So there may well be minor errors in the drawings in some cases, though most of the venation is unmistakable. Close study of the succession of veins reveals that some of the fossils which appear to have natural hind margins, have a narrow slice removed, presumably by the bat's action (eg. g, h and i).

We think that more than one caddis species is represented, even in the limited sample which has been examined. It is difficult, for example, to believe that h and j are the same species as a,b,c,d or f. Also it appears to us that a,b,c and perhaps d have much more resemblance to the British species *Stenophylax permistus* than they have to *Micropterna nycterobia*. Indeed, this group of four possible *permistus* itself divides into two pairs, differentiated by the relative spacing of the fork in Rs to the junction of Cu with M; but it would be rash to assume that such a character is specifically diagnostic. So we believe that Zeuner went too far when he compared the fossils to *nycterobia* and it would be wiser to reduce the record to "wings of *Stenophylax* and/or *Micropterna*."

### Climate and Stratigraphical Inferences from the Tufa

Even though we believe that the Trichoptera remains cannot be determined specifically and thus used for climatic interpretation, there still remain the small rodents, including two non-British high latitude species which have to be reconciled with the leaf of *Acer monspessulanum*. Whether the biota should also include the critical Hippopotamus is somewhat doubtful, for Layer 7 (see earlier) was not conclusively proved to pass laterally into the tufa, nor was the hippopotamus tooth seen to be dug out of Layer 7, though any other interpretation would be difficult in view of the complete lack of remains from below Layer 7. *Acer monspessulanum* (almost unrecognised in British deposits, possibly because *Acer* pollen is usually assumed to come from the common Field Maple, *Acer campestre*) may reasonably be taken as evidence of an interglacial climate. The cave stratigraphy would make ascription to an interglacial older than the Ipswichian very difficult. The rodents, however, and especially *D. torquatus* and *M. oeconomus* are more typical of the Devensian with its cold climate. Nevertheless, both species also occur in undoubted pre-Devensian deposits, notably at Crayford in Kent. (Stuart 1976, Mayhew 1975, Sutcliffe and Kowalski 1976). The Lower Brickearth at Crayford which contains these two rodents, has a cold mammal fauna which includes *Oribos moschatus* (Dawkins 1872). The horizon has been placed in IpIV, i.e. in the final, temperature-declining stage of the interglacial, but it is difficult to reconcile this with Boyd Dawkins' record of *Corbicula fluminalis* in sands above the brickearth. The latter could possibly be early Ipswichian but might also belong to a colder phase of an earlier interglacial or even a glacial stage. It is in this way that Sutcliffe regards Crayford, as a pre-Ipswichian but nevertheless, a post-Wolstonian deposit.

If the northern rodents cannot be used for an exact dating of the tufa, the species of *Arvicola* certainly has importance. A second examination of these teeth by D.B. strengthens his identification of the species as *terrestris* and not *cantiana*. Heinrich (1982) maintains that exact ratios of the posterior and anterior thicknesses of the enamel bands on the cusps of the molar teeth not only separate *terrestris* from *cantiana* (as was previously well known) but also that their values progressively decrease towards modern times, so that a specimen may be placed precisely in the time scale. He places the transition from *cantiana* to *terrestris* around the Eemian/Weichselian boundary.

When the two molars associated with part of a mandible were examined under a microscope, the anterior enamel thickness was visibly thicker than the posterior, clearly denoting *terrestris*; but in all the other molars, there was no discernible difference between the two thicknesses, thus suggesting the transition between *cantiana* and *terrestris*.

Heinrich's determinations were made in Central Europe and it does not necessarily follow that evolution followed the same pace in Britain or Scandinavia. It does, however, render untenable any suggestion that the tufa belongs to an interglacial earlier than the Ipswichian. The possibility remains that the tufa could be early Devensian, despite the improbable occurrence of the Mediterranean Maple. As evidence of the ability of this plant to survive under cool conditions, D.B. has grown it in his garden at Bakewell continuously for the last 15 years and it has successfully withstood many severe frosts.

The hippopotamus tooth which has been attributed to Layer 7 would fit the Ipswichian, especially since it becomes increasingly probable that this animal occurred only in the Ipswichian and Cromerian interglacials and not in the intervening Hoxnian. On the other hand, Hippopotamus has not been found in deposits later than IpIII, which suggests either that Layer 7 may be earlier than the tufa and not strictly its lateral equivalent or alternatively, that the cold climate rodents came into north Staffordshire earlier than they did farther south.

In British caves, the largest list of vertebrate species from a single layer ascribed to the Ipswichian (Sutcliffe suggests IpIb) comes from Joint Mitnor cave near Buckfastleigh, Devonshire. From here Sutcliffe (1960) listed 16 species, including hippopotamus. Later, two small rodents were added. It is notable that, while only 7 species were identified in Layer 7, all these are also in the Joint Mitnor list, which strongly suggests their equivalence. Possibly of equal significance is the absence of certain animals, such as horse, which was absent also in the very abundant remains at Joint Mitnor.

#### Absolute Dating

The compact tufa seemed to have potential for U/Th dating and Dr. R. Harmon made a measurement on a sample. This was of a size smaller than was desired and the Uranium series elements were scanty, so that the figure of about 50 000 years was not very conclusive. Such a figure, if correct, would indicate the Mid-Devensian, at which time the Mediterranean Maple would be difficult to imagine. So perhaps the most that can be said of this figure is that it makes an interglacial earlier than the Ipswichian very improbable and to a small extent supports an age at the close of the Ipswichian or even in the early Devnsian. It is obviously desirable to have a more reliable date, especially in view of recently published figures from the hippopotamus-bearing speleothems of Victoria Cave, Settle which gave a figure of close to 120 Ka (Gascoyne *et al.*, 1982) for what is regarded as Ipswichian *sensu stricto*.

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#### SUB-SURFACE FORMATION OF CHARCOAL; AN UNLIKELY EVENT IN PEAT

By P.D. Moore

Boyd (1982) has proposed that charcoal can be formed beneath the peat surface of a mire as a consequence of fire in the peat-forming vegetation. If this process does indeed occur, the use of charcoal as an indicator of contemporaneous fire, and hence of possible human management of the environment, is placed in question.

Within soils it is recognized that charcoal can be encountered at levels which do not correspond to those at which it was originally incorporated. Dimbleby (1962) accepts only charcoal within root channels as *in situ*, but even in such a location there is the possibility of downwash. In peats, however, as in lake sediments, macrofossils can be regarded as stratified, even if their origin is allochthonous.

Boyd does not question this, but considers it possible that woody material, once incorporated into the peat could become converted to charcoal as a result of intense surface fire at a later date. Stratigraphically, the charcoal would then be situated below the horizon in which the fire took place.

The restricted access of oxygen to the sub-surface layers would not, of course, represent an impediment to charcoal formation. As Clark and Russell (1981) have pointed out, low oxygen availability is necessary for the production of charcoal in that it prevents total combustion. The temperature needed for this to take place is, however about 200°C (Cope and Chaloner 1981), so the strength of Boyd's proposal hinges upon the possibility of such a temperature being generated beneath the peat surface without destroying the intervening organic matrix. In the diagram from Shewalton Moss which Boyd discusses, charcoal peaks 10-20cm below the level (Horizon X) which he considers to have been formed under dry conditions conducive to sub-surface charcoal formation.

Many studies have been carried out on the temperatures attained in heathland and moorland fires and *Calluna* canopy temperatures of up to 940°C have been recorded (Kenworthy 1963). But as Whittaker (1961) has shown a *Calluna* canopy temperature of 500-800°C is accompanied by a ground surface temperature of 300-500°C and the accompanying subsurface temperature, just one centimeter down, is elevated by only 30°C. Temperature gradients in fires are thus very steep, especially below the soil surface. Also, the length of time for which such temperatures are maintained is usually very short, of the order of two minutes or so. Buried wood could not, I believe be converted into charcoal under these conditions.

It is possible that under very dry conditions, such as the summer of 1976, the intensity of moorland fires could be sufficiently long lasting, to permit ignition of the peat surface. In such circumstances, however, wood buried in the profile is still unlikely to be combusted until the peat above it has been burned off. Such an event is quite possible, and burning could continue until resistant layers were reached, either as a result of waterlogging or high density (*Eriophorum vaginatum*, *Molinia* and *Scirpus caespitosus* tussocks, for example, often survive such fires). If such a catastrophic fire as this were to occur, however, it would still be recorded stratigraphically for posterity as a single carbonized layer, bridging a temporal hiatus in the profile.

I consider it most unlikely, therefore, that the prerequisite conditions for Boyd's hypothesis could be satisfied in a peat environment. Charcoal layers in peat remain, in my opinion, a useful indicator of contemporaneous fire.

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## SUB-SURFACE FORMATION OF CHARCOAL: AN UNEXPLAINED EVENT IN PEAT

By W.E. Boyd

Boyd (1982) has tentatively proposed that charcoal present in peat may be formed below, rather than on, the surface, as is conventionally considered. The process is unknown, but during periods of unusually warm and dry weather, peat may become sufficiently dry to allow combustion. The ignition source may not be apparent. Although Boyd (1982, p.7) suggested that "the fires had been caused by solar heating", this is now considered unlikely. The role of solar heating lies only in the process of peat drying.

Moore (1982) introduces useful discussion regarding the processes involved in sub-surface formation of charcoal. However, the process which he discusses and dismisses as improbable, is not that suggested by Boyd. Moore suggests that a process - namely "that woody material, once incorporated into the peat could become converted to charcoal as a result of intense surface fires at a later date" (Moore, 1982 pps. 13-14) - is unlikely to operate, and on that basis, dismisses the possibility of the sub-surface formation of charcoal. The author agrees with Moore's discussion. However, Moore does not refer to the situation discussed by Boyd.

Buried peat ~~can~~ burn at a location where the surface peat is not burning. In the example from the Kilpatrick Hills (Boyd, 1982), the surface peat was generally unburnt and cold, whereas deeper peat was too hot to touch and was smoking; surface fires were limited in extent. This situation needs to be explained. Boyd (1982) is deliberately vague about the processes, since they are not apparent. However, the burning of surface vegetation at that location is not considered as a probable ignition source. It is possible that fire spread laterally through unusually dry peat, and perhaps under high-density layers of, for example, *Eriophorum vaginatum* peat, from some unidentified surface source at a distance from the location at which buried peat was burning. Although any charcoal formed would be related to such surface fire, its stratigraphical position is misleading, and the conclusions reached by Boyd are still valid.

In conclusion, the author regards Moore's criticisms as valid, within their own frame of reference. However, the proposed sub-surface formation of charcoal (Boyd, 1982) probably involves processes not considered by Moore. Although the author has no solution to the problem of how or why buried peat burns, clearly this phenomenon occurs. Whatever the process, the stratigraphical implications remain. It is not suggested that this accounts for all charcoal found in peat. Although in most cases charcoal layers in peat are probable indicators of contemporaneous fire, the possibility of sub-surface peat burning must be borne in mind.

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### THE COASTAL DEPOSITS OF THE SOUTHERN WEALD

By P.J. Burren

It has recently been suggested (Jennings and Smyth 1982) that the unconsolidated coastal alluvial sedimentary sequences in East Sussex have formed largely in response to changing local conditions superimposed upon the overall effects of the Flandrian rise in sea-level. Particular significance was attached to the periodic formation and subsequent breaching of coastal barriers during the deposition of these variable sediments, although other important factors were also recognized. The lithostratigraphies from three South Coast sites (fig. 1) were discussed: at Langney Point (TQ 642011), a small shingle promontory to the north-east of Eastbourne; Lotbridge Drive (TQ 61 01) in the Willingdon Levels, which lies on the western margins of Pevensey Levels (fig. 1), a much broader expanse of alluvium between Eastbourne and Bexhill; and finally, Combe Haven (TQ 77 09), a minor catchment in the Bulverhythe area between Bexhill and Hastings. The coastal sequences found at these locations were compared with those described by Jones (1971, 1981) within the Vale of the Brooks, a large tract of alluvium in the lower Ouse valley south of Lewes (TQ 41 10) located some 10-15 km from the present coastline. In their preliminary interpretation, Jennings and Smyth (*op. cit.*) stated that considerable differences are apparently evident in the lithostratigraphies, even though it has recently been argued (Jones 1981) that boreholes in near-coastal alluvial environments in South-East England tend to encounter the same tripartite sequence encountered in the Vale of the Brooks. Clearly, there is general disagreement here both in terms of fact and interpretation and hence, it is of relevance to describe briefly the coastal zone lithostratigraphies found in the valley fills of Southern Weald rivers, for in doing so, the emphasis placed on a general barrier-breaching model appears both unsupported and unnecessary. As the Vale of the Brooks forms one of the better known sites along this part of the South Coast, it is proposed to discuss the lithostratigraphy therein in some detail, prior to a brief discussion of sequences at other locations in the Sussex area.

One of the earliest to describe a schematic section of the alluvial deposits in the Vale of the Brooks was White (1926), who indicated that the Chalk rockhead is overlain by a sequence of variable thickness in which five layers were recognized:

5. Soil and made ground of various ages dating back to Roman times;
4. Brown floodloam with shells of "*Bithynia tentaculata*" and other freshwater species, with occasional interbedded peats;



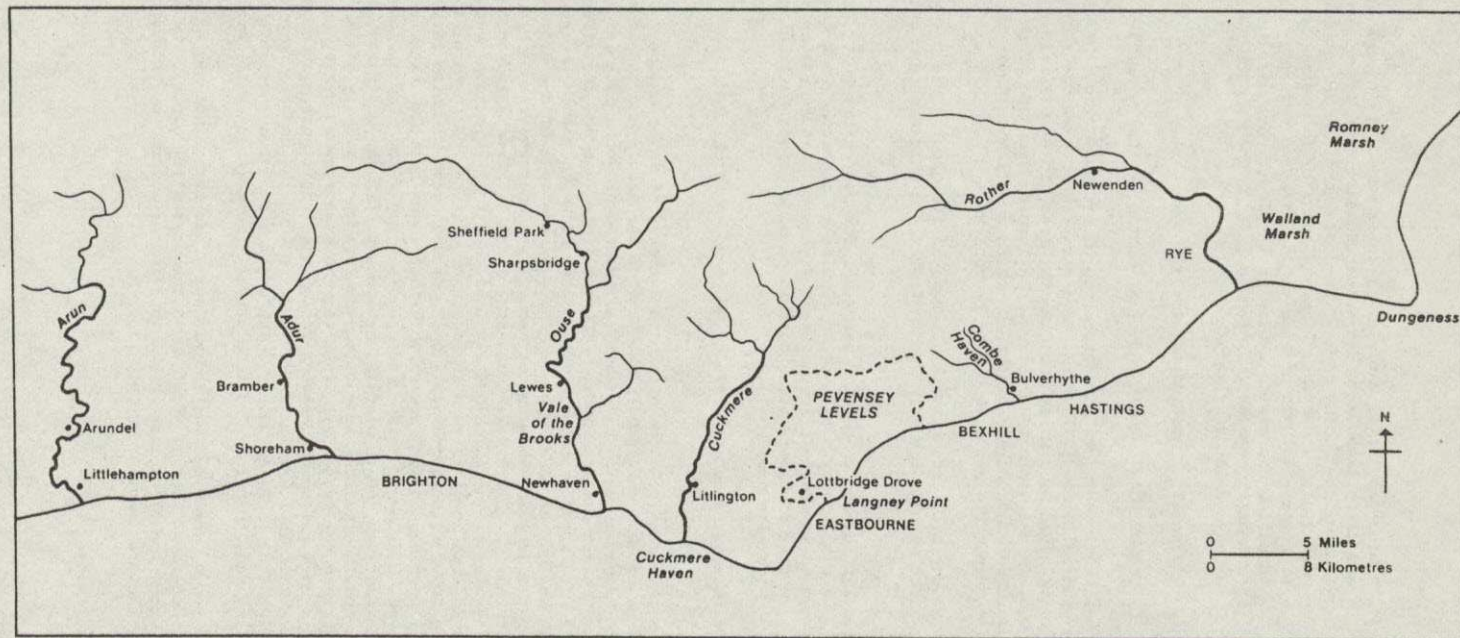


Fig.1: Location Map and Southern Weald Drainage Systems

3. A blue-grey stiff marly clay, interbedded with seams of sand and mixed freshwater and estuarine shells in its upper parts (including "*Cyclus cornea*, *Succinea amphibia*, *Planorbis carinatus*, *P. corneus*, *Limnea stagnalis*, *L. palustris*, *L. limosa*, *Valvata piscinalis* and *Paludina impura*") and estuarine and marine shells in its lower part (including "*Lutraria compressa*, *Tellina solidula*, *Cardium edule*, *Turbo ulvae* and *Scrobicularia plana*")
2. Old soil? (wood, nuts etc.);
1. Coombe Rock (chalk and flint rubble or chalky marl).

Detailed subsurface investigations undertaken during the late nineteen-sixties (Jones 1971, 1981) have established that the sub-alluvial thalweg is at -29.6 m. O.D. in the Newhaven area (TQ 44 01), rising to -12.2 m O.D. in the vicinity of Lewes. A complex sequence of interbedded arenaceous, argillaceous and organic deposits overlies the Chalk rockhead, in which a tripartite sequence can be recognized:

- Layer 1: Grey silt and silty clay, brown in the upper horizons, with inclusions of shelly sands of variable thickness and extent, up to 8 m thick.
- Layer 2: Interbedded freshwater oak-alder fenwood peats, peaty clays and greenish-grey clays, up to 10 m in thickness. Peat development is greatest in the upper layers of this fen-swamp deposit, whilst the lower peats contain considerable quantities of alder wood remnants;
- Layer 3: Clayey sands and gravels, up to 3.3 m thick.

More recently, there have been a number of major engineering projects undertaken within both the Vale of the Brooks and the lower Ouse valley at Newhaven, which have realized additional subsurface information regarding the lithostratigraphy. The threefold sequence described by Jones (*op. cit.*) can be recognized in these cores, although the uppermost layer can be further sub-divided. Thus, in the Vale of the Brooks, and overlying the grey estuarine sands and silts associated with a Flandrian transgression (c. 3000 B.P.), two units occur; a bluish- and greenish-grey silty clay of variable (usually less than 2 m) thickness, occasionally interbedded with local fragmented lenses of peat, which in turn, is overlain by a brown silt (floodloam), the uppermost part of which forms the present floodplain soil. However, further downstream, in the vicinity of Newhaven, the upper bluish- and greenish-grey silty clay is absent and the estuarine sequence is overlain by a brown silt only. Hence, it is apparent that the coastal zone lithostratigraphy is broadly similar to that described by Jones (1971, 1981) in the more seaward valley tracts, whilst its more inland composition includes an additional, predominantly freshwater unit (White 1926) interbedded between the underlying estuarine and overlying fluvial sediments. The coastal zone sequence in the lower Ouse valley can, therefore, be schematically summarized as follows:

- Unit 6 Brown, sometimes mottled with grey and orange, clayey silt, the uppermost part of which forms the present floodplain soil. In some locations this may be replaced or altered by anthropogenic factors (made ground etc.);

- Unit 5 Bluish- and greenish-grey, mottled with brown, silty clay, occasionally interbedded with peaty lenses and freshwater shells. Appears to be confined to more inland locations within the lower Ouse.
- Unit 4 Grey-black interbedded silts, silty clays and sands with estuarine and marine shells, thinning inland;
- Unit 3 Bluish- and greenish-grey silty clays interbedded with freshwater oak-alder fenwood peats and organic remnants;
- Unit 2 Fluvial clayey sands and gravels;
- Unit 1 Bedrock, weathered in places, including Head and Coombe Deposits.

As is evident from the above descriptions, unit four has been deposited in association with estuarine-marine conditions, whilst freshwater depositional environments are generally envisaged for the remaining unconsolidated sediments.

This interpretation differs markedly from the one presented by Jennings and Smyth (*op. cit.*). They indicate (see their figure 2) that large peat accumulations of up to 7 m thickness overlie 3 m or so of peaty clays within the Vale of the Brooks; the peats are in turn buried by 2 m of grey-black clays and silts. Even allowing for over-simplification in producing schematic diagrams, this is a misrepresentation in that first, freshwater deposits overlie the estuarine grey-black clays, silts and sands and second, that the peats (unit 3) are generally discontinuous and fragmented, are of variable thickness and extent and are interbedded within bluish- and greenish-grey silty clays. Consequently, their inference that from "time to time biogenic deposition was interrupted for short periods" and that "these interruptions could be due to small scale periodic breaching of the (coastal) barriers... which allowed marine sediments to be deposited briefly before the barriers reformed" (*op. cit.*, p. 16) is based on inadequate appreciation of the lithostratigraphy here. It is also totally unsupported in that they offer no evidence (lithostratigraphic or otherwise) from the lower Ouse valley to substantiate their claims. Their comment regarding the rate of sea-level rise and the nature of sedimentation (*op. cit.*, p. 17) is unfortunate, for although rising base-levels may have aided peat formation and alluviation within the Vale of the Brooks, they are unlikely to have controlled the sedimentological character of deposits well inland from former, or even contemporary, coastlines. Furthermore, although these authors acknowledge the possibility that the bluish-grey silts (unit 3 above) may represent "the migration of river channels.... or flood deposits" (*op. cit.*, p. 16), subsequent discussion virtually dismisses these processes as being of any significance, except in providing a freshwater input for peat development. Rather, they prefer a marine origin for these argillaceous sediments, forming in response to the breaching of coastal barriers.

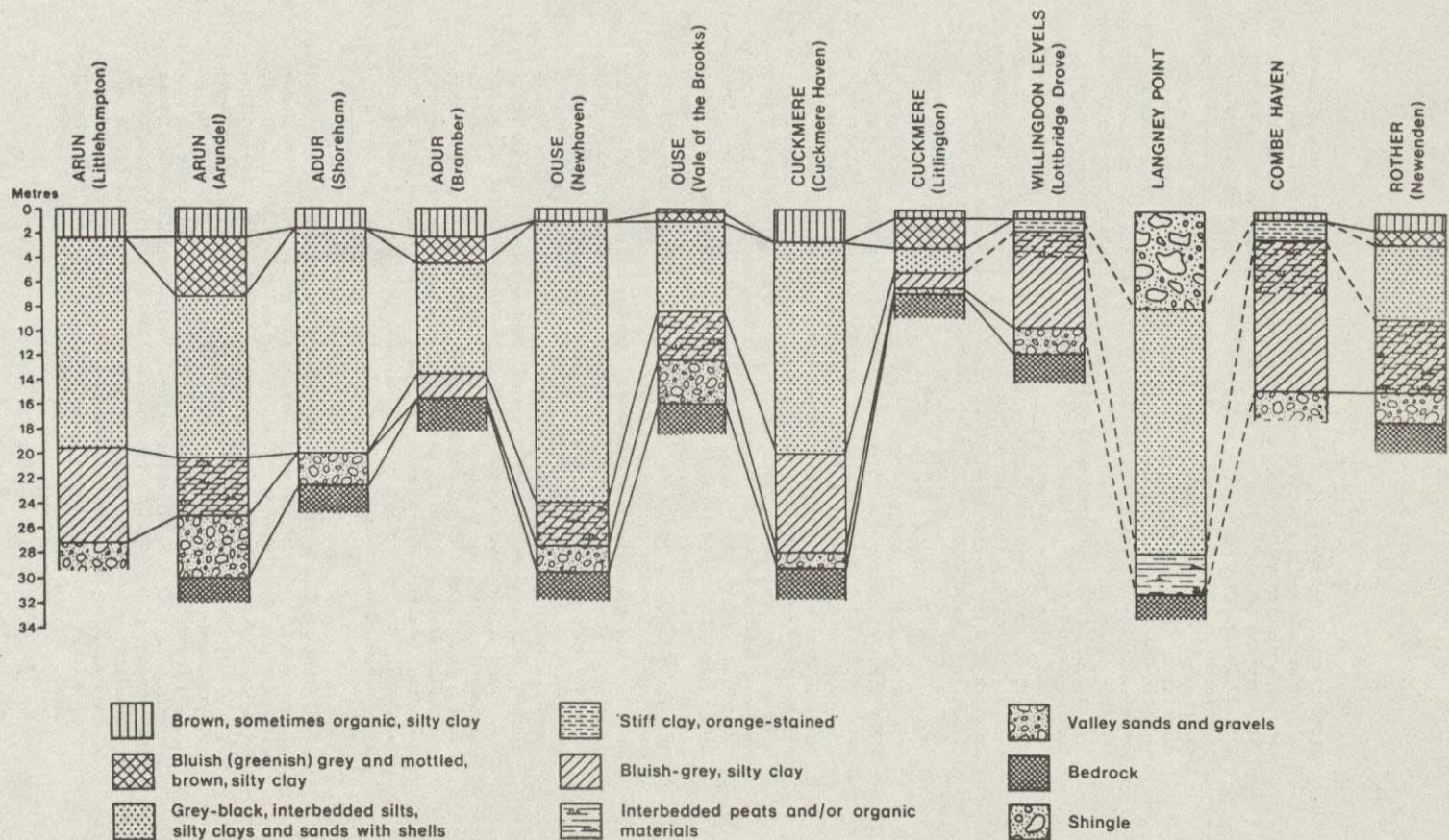
There are, however, several lines of evidence which strongly suggest that the bluish-grey argillaceous deposits within the Vale of the Brooks have developed in response to processes other than marine incursions. Subsurface investigations at several sites within the Ouse floodplain inland of Lewes have demonstrated that bluish grey silts of unit 3 penetrate into the Central Weald as far upstream as Sheffield Park (TQ 406235) (fig.1) and beyond, well inland from any possible marine

influence. Second, periodic marine incursions due to the breaching of barriers would inevitably give rise to short-term brackish conditions within the lower Ouse valley, as is known to have occurred during the earlier Flandrian in nearby Romney Marsh (Lewis and Balchin 1940, Smart *et al.*, 1966, Green 1968). However, in the lower Ouse valley, there is no evidence to support such events either in the lithostratigraphical (White 1926, Jones 1971, 1981) or pollen (Thorley 1971, 1981) records. The interbedded silts and peats comprising unit 3 in the Vale of the Brooks appear to be the product of fluvial processes (e.g. sedimentation in response to rising base levels or complex response mechanisms) rather than marine inundations. In which case, the "regressive overlap" which preceded the late Flandrian transgression could not have removed the "marine influence" (*op. cit.*, p. 17), although the subsequent transgressive overlap may have been responsible for the truncation of the underlying fen-swamp series. Finally, boreholes sunk in the lower Ouse valley, adjacent to the littoral area where shingle coastal barriers are clearly evident, reveal the lithostratigraphy described above. There is no evidence of significant shingle accumulations within these cores. It has been claimed (*op. cit.*, 1982) that the unconsolidated silts and clays might have been sculptured by coastal processes to form physical obstructions, behind which sedimentation could take place. It is considered more likely here, that the high energy levels associated with such geomorphic environments would prove more effective in denuding rather than constructing such argillaceous forms. As it is now believed that the bluish-grey silts within the floodplain tracts of the Ouse and Cuckmere are of a loessal origin (Burrin 1981) and as sediments with similar loessal characteristics can be found in all Wealden river valleys (Burrin, in press), it appears probable that there is a significant loessal component in these more downstream valley tracts. This is of relevance here, for such sediments would probably be unable to withstand the constant attrition by tidal scour and other coastal processes, evident along this stretch of coastline.

Examination of borehole records held by the Southern Water Authority, East and West Sussex, and Kent County Councils indicates that the general lithostratigraphy described for the lower Ouse valley can be found in the lower tracts of all the principal valleys of the Southern Weald (see fig. 2). The coastal zone sequence revealed at Newhaven is repeated at Littlehampton (TQ 02 02), in the lower Arun valley, and at Shoreham (TQ 20 06) and Cuckmere Haven (TQ 51 97) in the lower Adur and Cuckmere valleys respectively. Likewise, the more inland coastal sequence, as found in the Vale of the Brooks, is also encountered in the vicinity of Arundel (TQ 01 07), Bramber (TQ 19 10), Litlington (TQ 51 02) and Newenden (TQ 83 27), in the Arun, Adur, Cuckmere and Rother valleys respectively (fig. 2). These findings offer support for the assertion by Jones (1981) that this sequence is widespread in near-coastal locations in the Sussex area, but casts doubt on Jennings and Smyth's (1982) view as to the more variable nature of these deposits. Whilst thicknesses and the spatial complexity of the sequences can vary locally, as is evident with respect to the extent and significance of peat development between one site and another, the general model outlined above is clearly recognizable in the lower valley alluvial deposits along the Sussex coastline (fig. 2). The synchronicity or otherwise of this model has yet to be established.

It is not surprising, therefore, that the sequences described (*op. cit.*, 1982) at Lottbridge Drove, Combe Haven and Langney Point also appear to conform to this general trend (fig. 2). The Langney Point

Fig.2: The Coastal Zone Lithostratigraphy of the Southern Weald (Generalized)





lithostratigraphy consists of some 4 m of shingle, overlying approximately 10 m of arenaceous and argillaceous sediments containing remnants of estuarine gastropods. These in turn overlie an early Flandrian peat-bed which extends between -24.8 and -28.3 m. O.D. (Shephard-Thorn 1975) (cf. 27.10 to -27.00 O.D., *op. cit.*, 1982). The general thickness and description of the estuarine sequence here is similar to those encountered in the lower valleys of the Southern Weald (fig. 2) and a tentative correlation is, therefore, suggested. Whether such sediments were deposited behind a coastal barrier remains unknown. The claim that the presence of large amounts of *Juniperus* pollen within the deposits provides "further evidence" (*op. cit.*, pg. 14) for a protective barrier is unsound in that, at best, it merely demonstrates that *Juniperus* was probably growing locally. If a barrier did exist in this area during the early Flandrian, then *Juniperus* may well have been growing upon it, although there is no independent lithostratigraphical or other evidence to support this assertion, and it is known that *Juniperus* was widespread throughout Southern England at the close of the Late Glacial and beginning of the Flandrian (Scaife 1982).

It has also been inferred (*op. cit.*, 1982) that the bluish-grey silty clays at Lottbridge Drove are of a marine origin, although the evidence produced for this claim is somewhat obscure. Whilst few details are given of the results of the palynological analyses undertaken or the possible ages of the argillaceous deposits, a marine origin is invoked because the "assemblage is dominated by *Pinus* with some *Picea*,..... and have been recorded in fine-grained ocean sediments (elsewhere) suggesting that they are particularly susceptible to long distance marine transportation" (*op. cit.*, 1982, pg. 16). It is considered that this 'evidence' proves very little regarding the depositional environment of these deposits. Blue-grey silts and silty clays with high *Pinus* contents have been found in the Ouse valley fill deposits at Sharpsbridge (TQ 443 206) in the Central Weald (Burrin and Scaife, in preparation), an area well away from possible marine influences. On the basis of the evidence produced by Jennings and Smyth, the Lottbridge Drove and Combe Haven sequences appear to support the more general coastal zone lithostratigraphic model described above (fig. 2), for the blue-grey silts and clays could have been deposited in freshwater conditions (as in the lower Ouse valley), with the pollen assemblage reflecting local environmental conditions at the time of deposition or the incorporation of pollen from the reworking of older deposits. It has yet to be proven that this is not so, whilst the lack of any additional evidence, such as ostracods and foraminifers as found in the late Flandrian estuarine sequences, in support of a marine origin suggests a fluvial genesis is more probable. Undoubtedly diatom, rather than pollen, analysis would prove invaluable in resolving this problem.

That coastal barriers have played a significant role in coastline development in this and adjacent areas, especially during the latter stages of the Flandrian, is by now well known (Lewis and Balchin 1940, Brookfield 1952, Wooldridge and Goldring 1953, Robinson 1955, Kidson 1963, Smart *et al.* 1966, Green 1968, Jones 1971, 1981, Devoy 1982, Eddison 1982). Many of these physical barriers still occur along the Sussex and neighbouring coasts and have obviously played a significant role in the more recent history of coastal alluviation. Whilst offshore sand spits and bars, together with shingle ridges have been identified from subsurface information in the Romney Marsh area (Smart *et al.* 1966, Green 1968), no such findings have yet been made in the coastal margins of the lower river valleys of the Southern Weald. Future offshore subsurface investigations may indicate the possible existence of coastal barriers at

locations along the Sussex coast during the earlier stages of the Holocene, but on current evidence, the impact of such features on earlier phases of coastal alluviation in the Sussex area has yet to be determined.

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#### A REPLY TO "THE COASTAL DEPOSITS OF THE SOUTHERN WEALD".

By S. Jennings and C. Smyth

We would like to make the following points in reply to Paul Burrin's article:

- 1). We are not disputing that in general terms there are similarities between the lithostratigraphies of the Vale of the Brooks, Lottbridge Drove (Willingdon Levels) and Combe Haven. However, when analysed in detail there are considerable differences and our original paper was intended to suggest reasons for this. The tripartite sequence in the Vale of the Brooks as suggested by Jones (1971, 1981) and re-stated by Burrin in this Newsletter, does contain important differences when compared to the other two sites, most notably in the extent of peat formation. Our representation of the lithostratigraphy of the Vale of the Brooks was schematic but it had been based upon published information (Jones 1971, 1981) and a discussion with David Jones.
- 2). Our claim that marine sediments may have penetrated the lower Ouse Valley finds support in the description of the sediments by White as provided in Burrin's article where in Layer 3 estuarine shells were identified. Also in the schematic sequence suggested by Burrin, Unit 4 contains estuarine and marine shells.



they are unlikely to have controlled the sedimentological character of deposits well inland" (p. 3) is unfortunate for two reasons. First, we have never suggested that the upper reaches of rivers should contain estuarine facies. Our remarks upon the nature of estuarine deposits have always been confined to coastal areas. Secondly, although estuarine facies may be absent this does not mean that base-levels do not have an important influence on the nature of inland deposits which may have been formed in a perimarine zone as defined by Hageman (1969). He describes a perimarine zone as "one in which marine and estuarine facies are absent but continuous biogenic sedimentation is intimately related to movements of sea-level which are registered in the perimarine zone by the elevation of the water-table leading to the accumulation of gyttjas, freshwater clays and freshwater peats."

4). We did not "virtually dismiss" the possibility that clay and silt layers may be river channels or flood deposits as on pages 14 and 16 of our article we further suggested that the site which contained the largest river - the Vale of the Brooks - would, not unexpectedly, also contain the greatest extent of freshwater deposits not least because of the availability of sediment brought down by the river.

5). The suggestion is made (p. 3) that because "bluish-grey silts of Unit 3 penetrate into the Central Weald.... well inland from any possible marine influence" this can be used as evidence that these deposits cannot have developed due to marine incursions. The implication appears to be that because inland facies are not marine so neither can the coastal facies. This is an oversimplification of the relationship between events and processes that operate at the coast and those that operate further inland. It is interesting to note on this point that the upper clay at Combe Haven contains estuarine indicators e.g. *Serobicularia plana*, *Hydrobia* sp. Hystrichospheres and pollen of *Chenopodiaceae* close to the present-day coastline but further inland no such indicators have been found. At Lottbridge Drove (Willingdon Levels) a site with a small stream, estuarine forams and ostracods are abundant in the lower levels of the upper clay. Therefore, it appears that the landward extent of estuarine conditions will be directly influenced by local factors operating at each site - a point that was emphasised in our original article.

6). On page 3 it is stated that the Unit 3 deposits "appear to be the product of fluvial processes", a conclusion which seems to be based only on lithostratigraphical and pollen evidence. Such a conclusion would have greater credence if supported by other types of evidence e.g. ostracods, forams and diatoms.

7). Also on page 3 it is stated that shingle is not found inland of its present position. If the implication of this remark is to infer that its absence can be used to disprove the possibility of marine incursions then this is incorrect. From documented evidence (see for example Ballard 1910, Salzmann 1910, Millward and Robinson 1973) and from borehole evidence, it appears that the arrival of large quantities of shingle to the Sussex coast is a very recent event and it is, therefore, unjustified to use the absence of shingle as evidence in this way. Shingle barriers and beach deposits are recent additions to the coast and have accumulated on top of older marine silty-sand deposits e.g.

at Dungeness (Shephard-Thorn pers. comm.). This pattern of coastal accretion is supported by the sediments of the Langney Point borehole that show a clear coarsening upwards in the depositional sequence. The assumption on page 4 that silts and clays are more likely to be eroded by the sea rather than "sculptured...to form physical obstructions" is unconvincing. Sand and finer grained material can form bars and barriers as has been demonstrated in Holland and the river mouths along the present Sussex coast bear testimony to the presence of bars. At Dungeness, clays, silts and sands were probably deposited in a series of barriers before the arrival of shingle (Shephard-Thorn pers. comm.).

8). We suggest that the belief in a "significant loessal component in these more downstream valley tracts" (p. 4) may be open to question as East Sussex contains rock types that when weathered and eroded can provide substantial quantities of sediment which has a very similar grain size to loess. (Lake pers. comm., Gallois 1982).

9). It is unfortunate that so much emphasis appears to have been placed on borehole records (p. 4 and Fig. 2). We have found significant differences between the sediments as described in borehole records and the sediments that we found in the field. This is not surprising because many contractors do not need to analyse deposits in the same way or even in as much detail as Quaternary researchers. Thus borehole evidence should always be treated with caution (a lesson illustrated by the Vale of the Brooks.).

10). On page 4 a correlation is made between Langney Point and the "lower valleys of the Southern Weald". All the valleys would have been subjected to the same general trends of Flandrian sea-level changes and, therefore, general similarities of sequences can be found. However, the differences in detail between the sites cannot simply be dismissed with a passing recognition that "thicknesses and the spatial complexity of sequences can vary locally, as is evident with respect to the extent and significance of peat development between one site and another" (p. 4). By a detailed analysis of these important differences a clearer understanding of Flandrian environmental change can be achieved so that the inter-relationships between coastal, estuarine and fluvial processes and their influence on the type of sediments deposited can then be identified. To suggest the processes that operated at Langney Point have been similar to those at other coastal locations in East Sussex ignores the significance of local operations.

11). The presence of barriers at Langney Point is questioned (p. 4). Research is continuing in this area and the suggestion of barrier formation is based on this evidence:-

(a) The fine grained nature of the deposits that overlie the deep peat (approx. 70% silt/clay fraction). It is only in the upper horizons that coarser material is found, culminating in shingle. This suggests that a protected environment existed at Langney Point throughout most of the Flandrian.

(b) These fine grained deposits contain estuarine gastropods (e.g. *Hydrobia ulvae*, *H. ventrosa*) as well as brackish water Foraminiferids (e.g. *Ammonia beccarrit*, *Elphidium* sp., *Protephidium germanicum*) and ostracoda (e.g. *Laxoconcha elliptica*, *Leptocythere lasitosa*,

*Cypedeis torosa*, the latter being indicative of a sheltered creek environment). In the upper coarser sediments marine foraminiferids were found (e.g. *Quinqueloculina* and *Annonia beccarii batavus*) in association with more fully marine ostracoda (e.g. *Heterocythereis albomaculata*, *Laxoconcha rhomboidia*, *Leptocythere pallucida*, *Hemicythere vilosa*, *Pontocythere elongata*, *Semicytherura sella*) (Whittaker and Robinson pers. comm.) This again suggests that a sheltered estuarine-type environment was overrun and replaced by a more high energy open coastal type.

(c) Pollen in the fine grained deposits contains significant percentages of *Chenopodiaceae* with a high *Graminae* and *Cyperaceae* content suggesting the presence of a salt marsh. The occurrence of *Juniperus* pollen may be of importance because it is also found in large numbers on coastal dunes in Holland. With more funding offshore exploration may be possible and we agree that only if fossil offshore barriers were found could the presence of barriers at Langney Point throughout the Flandrian be more than a suggestion.

12). On page 5 the view is expressed that the deposits at Lotbridge Drove (Willingdon Levels) are a freshwater facies rather than marine. Such a conclusion appears to have been arrived at without using any evidence. We still maintain that the clays and silts were deposited under estuarine conditions. The evidence for this is:-

(a) The presence in considerable numbers of *Chenopodiaceae*, *Graminae* and *Cyperaceae* pollen.

(b) High percentages of *Pinus* grains with smaller amounts of *Picea*. These species are often found in high percentages in marine sediments (Stanley 1969).

(c) The identification of estuarine gastropods (e.g. *Hydrobia* sp.) together with, in the upper clay, abundant brackish water and salt marsh foraminiferids (e.g. *Elphidium* sp., *Protelphidium germanicum*, *Trochammina inflata*, *Jadammina macrescens*) and ostracoda (dominated by *Cypedeis torosa*.) (Whittaker and Robinson pers. comm.). It should be pointed out that the presence of foraminiferids and ostracoda in the silts and clays below the peat is very sparse. However, the deposition of fine grained material in a protected environment can create a liquid-mud habitat which is not suitable for the existence of these species. But, *Hydrobia* can survive in this and are present.

(d) The presence of *Hystriospheres* throughout the silts and clays.

(e) Documented evidence suggests that the sea has entered Willingdon Levels at least during historical times. For example, to the north of Lotbridge Drove on the Levels is the site of the Cinque Port of Hydneye.

13). Figure 2 of Burin's paper is an attempt to correlate the lithostratigraphies of the coastal sites of the Southern Weald. It is suggested in this diagram that the peat and underlying (estuarine) silts and clays on Willingdon Levels correlate with the deep peat and organic clay at Langney Point. This peat at Langney Point has been dated by the I.G.S. from  $9,510 \pm 75$  to  $8,760 \pm 75$  B.P. (Shephard-Thorn 1975). Thus if Figure 2 is to be believed then Flandrian estuarine deposits would have had to be deposited on Willingdon Levels up to approximately O.D. some time before 8,760 B.P. We believe that the shallow peat on Willingdon Levels is post-5,000 B.P. and probably very recent (Historical times). A grant has been obtained for C14 assays so that the association of this peat to sea-levels and coastal processes can be better understood.

### Conclusions.

We have received criticism following our article in Newsletter No. 37 mainly because we have not - as yet - published all our data. We intend to rectify this by publishing a more lengthy account of our work, but it may be pertinent to make some general points about our ideas on the nature of the sediments in the two areas that we have studied (Willingdon Levels and Combe Haven).

(1) The grey-blue silts and clays have been laid down under different environmental conditions ranging from estuarine to freshwater. The type of depositional environment may be determined by a variety of factors:-

(a) The configuration of and changes to the coastline (e.g. coastal erosion, formation and breaching of barriers, storm events, the affects of longshore drift). These coastal changes have been superimposed upon the rising sea-levels of the Flandrian.

(b) The action of rivers which will have a great influence on the local supply of sediment to the coast. Deposits of peats and freshwater clays and silts will be more extensive at sites with an important freshwater input.

(c) Anthropogenic factors (e.g. land drainage, forest clearance, coastal defence works).

(2) Important differences in detail exist between the litho-stratigraphies of the two sites and these may be due to a combination of the factors outlined in (1).

(3) Emphasis should be placed on the importance of local factors rather than on regional events in order to explain differences (or similarities) between sites. Having identified the important processes and events which operate at a particular site only then should the work be placed into a regional context in order to investigate the possibility of non-local events e.g. regional changes in sea-level.

### Acknowledgements.

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#### BARRIER BREACHING

By R.W.G. Carter

In their interesting report on the coastal deposits of East Sussex, Jennings and Smith (1982) make several references to the process of "barrier breaching". While it is widely recognised that presence or absence of seaward barriers may have an important role in the development of Holocene back barrier and near barrier facies (c.f. Wilks 1979 Heyworth and Kidson 1982) the actual means by which a barrier may be breached remains somewhat obscure. In fact the phenomenon is not widely reported in the literature, which suggests caution should be exercised when identifying the process in a vertical sedimentary sequence.

A few well-documented examples from the Californian and Oregon coast are provided by Johnston (1973, 1976) and Rice (1974), and from Lake Michigan by Visocky (1977). In all these cases breaching occurs through an increase in hydraulic pressure on the landward side of the barrier. Either the barrier crest may be overtopped or, more likely, the lower barrier becomes saturated and fails (sloughs or washouts) suddenly. In both cases water ponded in the back barrier area is drawdown, hydraulic pressure is reduced and eventually resealing by littoral drift occurs. Complete breaching from the seaward side appears to be extremely rare; although there are many examples of overwashing and overtopping of barriers e.g. Carr and Blackley (1974), Carter and Orford (1980), Orford and Carter (1982a, 1982b), up to several metres above the HWMOST.

Around the coast of the British Isles most barriers are composed of heterogenous, glacially-derived sediments and include a substantial coarse (gravel or boulder) element. (Such barriers should not be

by extreme event magnitude of wave processes (Orford 1977) so that slight oscillations in long term sea-level (less than 10% annual significant wave height) are probably ineffectual in morphodynamic terms. Many barriers appear capable of keeping pace in a transgressive sense with rising sea-levels, without losing coherency of form (Carter and Orford 1980). Often barriers cut-off terrestrial drainage lines causing an outlet or inlet to form, although in a few cases discharge is effected by throughflow. In a recent study of coastal barriers in S.E. Ireland (Carter *et al* in prep.) we have defined the seepage outlet to channel outlet transition as occurring at mean annual discharges of 1.5 to 2.5 cumecs for mixed coarse sand or gravel barriers (permeability coefficients (k) 0.02 to 0.04) and at 0.3 to 1.0 cumecs for sand barriers (k = 0.0025 to 0.01). Only in about 5% of streams is there any evidence of transition from seepage to channel drainage, caused by discharge variability. From these, or similar data, potential for barrier breaching by streams may be crudely assessed. In the Irish examples, with rainfall averages between 700 and 1500 mm/year, it would appear that breaching is most likely in catchments with areas between 30 and 70 km<sup>2</sup>.

On a scale more appropriate to the Holocene, it is feasible that outlet type may change permanently, due to climate variations or coastal changes. More specifically increases in total discharge, or increased variability, would be conducive to a seepage + channel transition. An increase in longshore sediment transport volume and shoreline progradation might lead to a channel outlet closure. A period of "switching" might take place prior to stabilisation. A further possibility is that fine lagoonal or marine sediments may "choke" the barrier, reducing transmissability and eventually forcing a channel to form. A possible example of this exists at Cushendun, Co. Antrim where anomalous high-level lacustrine and fluvial sediments occur on the landward flanks of a bay barrier (Carter 1982).

Where breaching has occurred through stream action it is likely to be preserved in the sedimentary record. A sudden fall in lagoon water level will manifest itself in disturbed layers, erosional contacts, erosional channels, alluvial bedforms and sub-aerial drawdown and dessication structures. Refilling of the lagoon will re-establish lacustrine facies development, but overall they may provide only a minor part of the total record. Except where the outlet acts more as an inlet (tidal conditions exist) marine influences may be exceedingly limited.

Where barrier overwashing or overtopping has occurred, sequences should show rapid alterations in sediment type near the barrier and less marked fluctuations in autochthonous floral and faunal remains away from the barrier.

The aim of this short note has been to draw attention to some of the more obvious facets of the barrier breaching process, and to provide an indication of where and when such a process might be expected. As such geologically catastrophic events have a great bearing on the interpretation of Holocene coastal sequences (particularly

where they relate to sea-level changes) it is important to know something of the conditions under which they occur.

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# REPORT ON AN OVERSEAS FIELD MEETING IN NORMANDY

28th May - 1st June 1982

By D H Keen and J-P Lautridou

Twenty-nine members managed to beat ferry strikes and reservation complications to assemble at Dieppe Maritime at 6 am for the start of the meeting.

Day 1. The first stop was at St Romain de Colbosc where J-PL explained the sequence of loess in Normandy and the origin of the limons à doublets facies. The excellently cleaned section allowed the party to closely examine the banding of the limons à doublets and the deep sounding and ladders enabled the full 15m thickness of the loess to be examined.

The age of the sequence at St Romain caused some discussion. The well-developed palaeosols below the St Romain soil at 4m depth suggest an age for the base of the deposit well back into the Middle Pleistocene, but preliminary thermoluminescence dates by A.Wintle (Cambridge) indicate dates around 70,000 for loess below the St Romain soil which is generally regarded as of Saalian date.

Although palaeoliths have been found at St Romain, and these were shown by G Fosse (Rouen) assisted by P Callow (Cambridge), these are of little assistance in determining the age of the deposits as a whole as they are found only in the top 4m of the deposit and related to terminal Middle or early Upper Palaeolithic industries.

After an extremely welcome brew of coffee beside the bus, the party drove down from the Chalk plateau to Tancarville to examine the sections around the northern pier of the Tancarville Bridge. At the first section, at the bridge itself, the party examined the cliff cut into the chalk and its cover of estuarine deposits and coombe rock. A cleaned section a little to the north of the transverse cliff showed the details of these deposits clearly and allowed members of the party to collect the molluscan fauna typical of early glacial conditions described by Puissegur and Lautridou. The cooling character of this deposit was confirmed by the pollen described by M F Huault which is largely of *Pinus* and *Picea*.



About 200m to the west higher deposits in the sequence were examined in newly cut or cleaned sections. In the first section good exposures of Saalian fluvial sands and interglacial calcareous dune sands were seen. Their age here could not be demonstrated but old sections now missing and boreholes in the base of the pit proved that they overlie the head seen in the first section. A newly opened section slightly to the west of the older section also showed the dune sands and in the base of the sands gravels derived from the top of the earlier beds by the rising sea. In the sands in this new section were a range of palaeoliths discovered during the cutting of the section for the QRA meeting. Together these three sections at Tancarville show a cliff and estuarine deposit which relate to a high sea level in the Saale, a head also of Saalian age and then the overlying dune of the Eemian high sea level.

After an excellent lunch at Sandouville the party crossed the river via the Tancarville Bridge and drove to the Phare de la Rocque. A short stop was made beside the N815 to see some spectacular solution pipes in the chalk then the party drove to the beacon at the Phare de la Rocque itself where excellent views of the whole lower Seine were obtained. From this viewpoint M Huault and D Lefebvre explained their work on the Flandrian deposits of the Seine estuary where cores from 33m of deposits beginning in the Boreal, have been analysed.

The final stop of the day was at La Londe where the party visited the partly flooded western quarry and saw the top of the sequence of the Plio-Pleistocene deposits of the La Londe and were shown a vast pollen diagram from a 15m core completed by M Clet which suggests ages from the Reuverian to the Pre-Tiglian. Several members of the party remarked on the general similarity of the deposits to those of the type area in the Dutch-German border seen during the 1982 annual field meeting. The altitude of the deposits (100-120m) suggests a Plio-Pleistocene boundary age for the widespread plateau at this height on the Normandy chalk, but the clear evidence of tectonic activity at La Londe perhaps shows the strong influence of neo-tectonics on the geomorphology of Normandy.

The first evening of the meeting was spent in Elbeuf where the last stragglers joined the party in time for a good dinner.

Day II. The second day began with the characteristic early start and a short bus journey from Elbeuf to the Devaux Quarry at Tourville-la-Rivière. The details of the sequence in the quarry were outlined by Lautridou from the work since 1968 of Carpentier, Lefebvre and Huault (Rouen) and Descombes (Poitiers). The party then moved on into the quarry, which is still being worked, to see the sequence which consists of a cold climate terrace sequence intercalated with estuarine deposits formed in warmer periods and the whole covered by slope deposits and head from the valley side which forms the SSE side of the quarry.

As well as the complex stratigraphy in the quarry which suggests ages from ?early Saalian to the Weichselian, the quarry is very important for its palaeontology and the party were shown extremely well preserved specimens of bones of Mammoth, horse and a range of other cold and interglacial climate mammals collected since 1968 by Carpentier. In the terrestrial deposits rich molluscan faunas have also been found and these were also examined by the party.

The second stop was in the Patin Quarry at Cleon c.5km downstream of Tourville. This abandoned quarry is in the same terrace as that of Tourville but exhibits better developed warm climate deposits which suggest a marine transgression to 11m NGF (equivalent to British OD) and a complex of warm and cold episodes which may date back into the lower part of the middle Pleistocene.

After lunch at Tourville the party drove to the south bank of the Seine to visit the classic loess site of St Pierre-les-Elbeuf. The first section in the bank of the car park of the Witco works which now occupies part of the quarry, shows Weichselian deposits with numerous palaeosols resting on an Eemian soil. The majority of these soils are early Weichselian in age and representative of the forest soils of Central Europe. These were described by Lautridou and by Fedoroff (Grignon) as being formed in an early Weichselian cool climate. These soils are covered by Middle and Upper Weichselian loess in which the Kesselt horizon is prominent.

The second section examined at St Pierre-les-Elbeuf was the 20m wall of the old Chedeville Brickworks which is now a protected site of especial scientific interest. The section (immaculately cleaned and labelled) was described by Lautridou who demonstrated the four major palaeosols in the loess of which the highest is Eemian and the three lower ones relate to warm periods in the Saalian and Holsteinian (Elbeuf IV) and may be correlated with the estuarine deposits seen in the morning of day II at Tourville-la-Rivière. As well as the interest for the loess sequence, a dug section in the south-west side of the site showed the terrace gravels at 35m NGF on which the whole sequence of loess rests, although the tufa with its fauna of southern French mollusca could not be located. In former times the Chedeville pit was a prolific source of excellently preserved palaeoliths, and large collections were built up by such famous names as Abbe Breuil, but a large part of these early collections was lost in the 1939-45 war. However, G Fosse still managed to show a reminder of the rich industry of St Pierre-les-Elbeuf by exhibiting several fine Acheulian handaxes found in 1980 by G Carpentier in the course of extending the factory car park.

The final stop of the day was at Iville where the party was shown a section in older loess which exhibited very deep reddening indicative of prolonged weathering. This sequence is covered by Weichselian loess with evidence of tundra gleyed soils and limons à doublets. Because of the flooded state of the quarry close examination of the section was difficult but photos of the sections and of the micromorphology of the individual units, shown by Federoff and Dembet (Grignon) clearly showed the nature of the loess and palaeosols for those not brave enough to cling to the side of the pit.

In the evening, after a "light dinner" in Rouen the party was shown round the Museum in Rouen by G Fosse. Particular interest was shown in the exhibit on the archaeology of Normandy (and also in the Normandy cider which was a high point of the reception at the end of the visit).

Day III. Again an early start was made from Elbeuf and the party travelled to Caen where the remainder of the morning was spent in a tour of the Centre de Géomorphologie to see the laboratory and the results of the many freeze-thaw experiments conducted over the past fifteen years, and to see the other work of the Centre.

After lunch the party drove to Grandcamp to get an introduction to the raised beach sequences of western Normandy. The first stop was at a cliff section 1km east of Grandcamp harbour where Coutard (Caen) explained the stratigraphy of loess and beach gravels. The latter which are very decalcified despite the fact that they rest on Bathonian limestone, are dated to a pre-Eemian phase of high sea level. At Grandcamp Harbour the sediments in the harbour basin shown in excavations in 1978 were described by Coutard and Lautridou with the aid of a range of large photographs and diagrams. These deposits are of Eemian age and show evidence of a second occupation of the rock platform and at least two sea levels at the same height.

The final stop of the day was on the cliff top at St Côme-de-Fresne where Lautridou and Clet describe the work of Pellerin, and earlier of West and Sparks and Guillaume, on the late Eemian deposits of the coast from St Côme east to Luc-sur-Mer. The lack of sections meant that these regression sediments and their overlying freshwater organic deposits, loess and head could only be illustrated by maps and diagrams but from these the party obtained a clear idea of the pattern of the retreat of the Eemian sea from fossil cliff which was just visible in the mist.

In the evening, after a short visit to the ramparts of Caen, the party had a memorable dinner in a restaurant by the Caen Canal basin, which ended with the health of our hosts being drunk in that other remarkable Normandy drink - Calvados.

Day IV. Day IV was taken up with an examination of a range of marine sediments on the west coast of the Cotentin peninsula. The first stop was at Bec d'Andaine where a long walk out across the sands of the Baie de Mont-St-Michel gave a graphic illustration of the huge tidal range prevailing in this part of the Channel coast. The party was joined here by M Morzadec (Rennes) who described her detailed work on the Flandrian rise in sea level in the Bay.

The second stop was at Genêts 2km inland from the coast. Here J-PL described a thin series of cover sands in the valley of the small R Lerne. These sands are dated to the late glacial although exactly which phase is uncertain in view of the lack of accurate C14 dates. These sands are rare in the oceanic part of west Normandy and are thought to have formed by the blowing of sand from the river bed in the cold phases of the Upper Weichselian.

After a picnic lunch on the beach at Hauteville-Annoville the party climbed the Flandrian dune barrier for a description of the Flandrian deposits of the coast, the Eemian repression sediments which underlie them and the derived Waltonian fauna also found in this area.

The Flandrian deposits are largely known from boreholes and show a succession of peats and silts overlain by dune and shingle barriers which are still developing. A clear view of the extent of these barriers was stopped by the mist which affected the day but J-PL and M Clet's diagrams were sufficient illustration of the succession.

The Eemian present in the same area occurs at the same height (Om NGF) and represents the late Eemian retreat of the sea from its high interglacial level. A graphic illustration of the antiquity of the age of the rock platform on which these sediments rest was given here, as a little to the north at Blainville the same platform is overlain by Miocene deposits, thus an original shore zone perhaps dating to the Neogene is suggested.

Further occupation by the sea of the area in the Waltonian is shown by the occurrence of a lower Pleistocene fauna found derived in the Flandrian beach. These shells have been known for forty years but never traced to outcrop, which is probably submerged at shallow depth offshore and rests on the rock platform in the same way as the Miocene deposits already noted.

The rest of the day was also concerned with the early Quaternary. The party drove inland to St Sauveur de Pierrepont where C. Pareyn (Caen) describe the sequence of the Pierrepont-en-Cotentin formation. These marine sediments are primarily sands formed in a cold climate and they occupy what was probably a "tidal channel cut through the Cotentin Peninsula. At a maximum the deposits exceed 70m in thickness and are thus only known from boreholes. The age of the sands is unclear. The fauna suggests Ludhamian but pollen analysis of finer grained sediments with the sands leads Clet to suggest an age in the Tiglian.

The general succession of the formation was described by Pareyn, then the party examined the site of one of the boreholes where the thickness of the formation was proved and where numerous mollusca still covered the ground around the cap over the hole.

The night was spent at Carteret and dinner was at the appropriately named Hotel d'Angleterre!

Day V. The final day was spent on the northern tip of the Contentin which for most of the day was characteristically shrouded in mist.

The first stop was at Port Racine where Cliquet and Fosse described the archaeology of the site below the head, and Coutard and Lautridou described the head and raised beach sequence. The head here covers the whole of the Weichselian and the underlying raised beach is thought to be of Eemian age. This probability is increased by the occurrence of Mousterian artefacts at the base of the head. Considerable discussion occurred at the site and all agreed that the sequences and suggested dating were similar to those presumed by most for south-west England and south Wales.

The second stop was at Roche Galletan where Madame Michel showed her new excavation on a site resting on a raised beach at C20m NGF.

The site has yielded a crude, flake type industry with few handaxes made partly on beach flint. The age of the site is uncertain. The industry appears to be very ancient in type but as it rests on a 20m beach a much younger age (Saale?) seems possible.

After the lunch stop at Auderville the party stopped at Goury in a largely vain attempt, due to the fog, to see the wide rock platform stretching out from the present coast.

The main stop of the afternoon was at Ecalgrain. Here the major controversy of the meeting occurred. First J-PL outlined the sequence of raised beach, organic muds and head and gave his reasons for assuming a pre-Weichselian age for the lower parts of the head and pre-Eemian date for the raised beach. Then M. Clet presented her pollen results from the organic horizons and Jones (Coventry) added to these with details from other similar sites on the same coast at Herquemoulin and on the northern coast of the peninsula at Omonville-la-Rogue. The information at Ecalgrain was added to by Jones' presentation of the work of Coope on the insects from Ecalgrain which confirm the views of the palynologists that the high sea level was closely followed by an episode of open, near treeless landscape and a cool climate.

The major point of contention at Ecalgrain was the age of the sequence. J-PL suggested that the stratigraphy over the raised beach was too complex to allow the heads to have been deposited in one glacial period only and that they, therefore, must have been the product of two periods of severe climate. Several of the British participants pointed out that the beach appeared to be in the same geomorphological position as that at Port Racine and thus it should be of similar age. DHK tried to reconcile the two views with reference to the early 1970's controversies in Britain between Bowen and Mitchell, and brought in the argument that the Grandcamp sequence and the occurrence of the Neogene on the rock platform at Hauteville suggests that several raised beaches may be present. No general agreement could, however, be reached on the ages of the deposits at Ecalgrain.

Finally the party travelled south to Petit Beaumont and traversed the beach section between Vauville and Petit Beaumont. The magnificent sections in head and occasionally of raised beach were described by J-PL. At Petit Beaumont the head of the cliffs was shown (by J-PL and B Lanoe) to be divided by a pedo-complex suggested to be of interglacial age. The stratigraphy of the deposit was divided by these soils into Weichselian above and Saalian below with the soil being of Eemian age. This chronology was then proposed as further evidence for the stratigraphy described at Ecalgrain and several of the arguments at the previous stop were continued.

After the thanks of the Association to our hosts were proposed by John Wymer, the party joined the ferry at Cherbourg for the return

to England. For excellently prepared sites, for a vast range of interesting Quaternary deposits and for outstanding hospitality, the Normandy meeting will be long remembered by the participants.

D H Keen  
Coventry

J-P Lautridou  
Caen

ABSTRACTS OF PAPERS TO BE PRESENTED AT THE Q.R.A. DISCUSSION  
MEETING IN COVENTRY, JANUARY 7-8TH 1983

THE RECONSTRUCTION OF COLD, NON-GLACIAL ENVIRONMENTS

Nonsorted Patterned ground on mountains in the  
Northern Highlands of Scotland

C.K. Ballantyne, University of St. Andrews

The characteristics of nonsorted patterned ground on two massifs in the Northern Highlands of Scotland are described and discussed with particular reference to age and mode of formation. On the frost-susceptible regolith of the Ben Wyvis massif, earth hummocks on level ground and gentle slopes grade into hummock stripes (bands of hummocks aligned downslope) then relief stripes ("ridge and furrow" features) as gradient increases. These features appeared to have formed through modification by mass displacement of nonsorted vegetation-defined patterns of Lateglacial age, and are essentially inactive at present. On the An Teallach massif (where the regolith is not frost-susceptible) equivalent features are absent, but large sand hummocks have developed within the last 100 years on recent niveo-aeolian deposits. These are interpreted as having formed through the trapping of niveo-aeolian sand by tussocks on slopes that are sufficiently steep to allow eluviation of sand from between the tussocks by nival meltwater. The wider significance of these findings is discussed with reference to previous literature on non-sorted patterned ground in upland Britain.

River terraces as indicators of climatic change

C.P. Green, Bedford College, London

The keynote of this paper is the complexity of the terrace record. Drawing on evidence mainly from Britain and from Western, Mediterranean and Central Europe, the great diversity of the evidence preserved in the terrace record is emphasised. Particular attention is given to the different ways in which indications of cold and warm environments are juxtaposed. At the same time, an attempt is made to develop a model in which this diversity can be accommodated. The main features of this model are (i) the close relationship of the principal stages of terrace

formation to periods of environmental change, and (ii) the existence of spatial variations in the nature of environmental change and in the response of the fluvial system to such variations. The spatial variations considered include those of scale, catchment relief, and climate, looking particularly at differences between the oceanic regimes of Western Europe and the more seasonal regimes of Southern and Central Europe.

The aim of the paper is to examine the impact of cold environments on fluvial systems in terms of terrace formation, looking at the extent to which response to climatic cooling is conditioned by the behaviour of other environmental variables, and examining the possibility that the characteristic evidence of cold environments in terraces and terrace deposits may vary considerably even within temperate mid latitudes.

#### South West Banks Island N.W.T. Canada - An Example of a Continuous Permafrost Environment.

Peter Worsley, University of Reading

Banks Island is the westernmost part of the Canadian Arctic archipelago. It is underlain by Cretaceous sedimentary rocks and unconsolidated Miocene sands and gravels. In terms of lithology and relief there are parallels with parts of southern England. The entire south west has been subject to Quaternary glaciation but escaped during the classical late Wisconsin. A probable early Wisconsin glacial advance encroached upon the coastal lowlands. Current (interglacial) mean annual temperatures are about - 15°C and the permafrost is hundreds of metres in thickness. Summer active layers range from a few cm to a maximum of circa 2 m dependent upon the location.

At the macro scale the landscape is dominated by a fluvial erosional system. The rivers are characterised by a 'nival' discharge regime with a single flood event each year. Channel types are very varied and gullying is common. Aeolian activity is locally intense but dunes are absent. Although impressive solifluction striping is evident on slopes underlain by till net transport is less than might be expected. Fluvial sediments are little affected by mass movements. Patterned ground is ubiquitous but sectional information is not easy to come by. Both open and closed system pingos are paradoxically found in the same area. Coastal erosion and deposition is active despite the short open water season.

It is suggested that the transition from a glacial stage to an interglacial stage is an important element in the understanding of former periglacial environments and contemporary analogues are not available.

Glacier-dammed lake investigations in the Lake Hullet area,  
South-west Greenland

A.G. Dawson, Coventry (Lanchester) Polytechnic

Geomorphological investigations were undertaken at Lake Hullet, an ice-dammed lake in south-west Greenland. The lake is regularly emptied by catastrophic drainage through a c.23 km sub-glacial tunnel beneath the Kiatut Sermiat glacier. Results are presented on the formation of ice-dammed lake shorelines and on the geomorphological significance of icebergs. The last jokulhlaup of Lake Hullet took place in October, 1981. The October jokulhlaup was associated with the drainage of c.  $520 \times 10^6 \text{ m}^3$  of water. During August, 1982, the measured rise in lake level ranged between 0.2 and 1.2 m/day.

In the area adjacent to Lake Hullet numerous ice-dammed lake shorelines correspond with the margins of former Neoglacial lakes. The largest Neoglacial lake had a volume c.  $1100 \times 10^6 \text{ m}^3$  and produced a shoreline up to 50 m wide. The associated jokulhlaup had an estimated maximum discharge of c.  $8140 \text{ m}^3 \text{ s}^{-1}$  and is considered responsible for local tectonic deformation of the shoreline. Instrumental levelling of this shoreline also indicates negligible glacio-isostatic shoreline deformation since the main Neoglacial expansion of glacier ice.

Evidence from Ice-wedge Casts of Local Permafrost Degradation  
on River Floodplains during the Middle-Devensian in  
Southern Britain

Mary B. Seddon, University of Reading

Ice-wedge casts are one of the few reliable indicators of former permafrost environments. Structures identified as ice-wedge casts have been noted by many workers, but detailed descriptions are often lacking, and re-examination of sections suggests that some of these structures had other origins.

Hitherto, workers in the Arctic have concentrated on the mechanisms of formation of ice-wedges rather than on structures resulting from their degradation. Recent studies on Banks Island and Svalbard revealed the importance of local degradation of permafrost in causing casting of ice-wedges, i.e. casting occurs within the continuous permafrost region. This arises where lateral migration of river channels across the floodplain causes extension of the subchannel river talik (unfrozen zone). The subsequent degradation of ice-wedges may result in complete or partial casting, or gully formation.

Casts may later be reactivated by thermal contraction cracking at the same foci, if the talik migrates away from a given locality, thus producing 'complex superposed casts'. In addition, reactivation of cracking may follow sediment accumulation on top of a cast and this may ultimately lead to 'stratigraphically superimposed casts.' Further complexity may result from an ice-wedge cast continuing activity as a primary sediment wedge.



In southern England both 'complex superposed casts' and 'stratigraphically superimposed casts' are preserved in middle-Devensian terrace gravels. The sedimentology shows deposition in a braided river environment. Stratigraphically superimposed casts and closely adjacent casts within these sediments provide evidence of a syndepositional regional permafrost environment. The casts are not of a syngenetic origin in the true sense.

Independent evidence of sustained cold climates during the successive phases of ice-wedge casting is provided by fossil plants, Mollusca and Coleoptera deposited in the silt-filled channels within some of these gravel sequences.

#### Modelling Molluscan Taphonomy in a Braided River Environment

A.L. Harris, University of Sheffield

Processes by which organisms may be removed from their "Life Habitat" to be deposited elsewhere, ultimately entering into the fossil record are described as "Taphonomic". Often fossil assemblages do not represent single living communities but are a product of accumulation by taphonomic processes. An understanding of these processes is necessary for valid reconstruction of the living communities and their palaeoecology. Attention is focussed on molluscan fossil faunas laid down in a braided fluvial environment, as the Pleistocene terrace gravels of many British rivers are thought to have formed in such conditions. There is a need to delineate the variables that control transport of organic remains in order to determine the means of accumulation of fossil assemblages. Experimental methods are being used to identify factors that are significant in controlling shell transport by water, both in terms of shell destructability and shell "transportability". The models developed have been applied to a modern braided river environment, where also further studies on the distributions of living and dead mollusc populations, and the routeways linking these, have been carried out. Therefore some concept is gained of the factors controlling taphonomic processes, and the effect of these on accumulations of sub-fossil assemblages.

#### Changes in Vegetation and Molluscan Faunas during the Middle-Devensian Associated with Development of Permafrost

D.T. Holyoak, University of Reading

Stratigraphical evidence of syndepositional permafrost has been obtained from sites in south-eastern England at which fossil floras (pollen, macrofossils) and molluscan faunas have been studied, and at which the sedimentology of the deposits was investigated. After permafrost became re-established during the middle-Devensian (some time between 38 and 34 k.a. B.P.) the floras and molluscan faunas contain fewer species than those from 43-38 k.a. B.P. Many of the species that were lost had southern modern ranges, whilst many arctic-alpine species persisted.

Development of permafrost appears to have been associated with changes in river floodplain habitats as well as changes in the means by which the fossil materials accumulated. Deposits from prior to development of permafrost commonly represent floodplain pools and adjacent fens. After regional permafrost developed these relatively stable pool and fen habitats on river floodplains appear to have become much scarcer, while most fossiliferous deposits are of inwashed material deposited with silt in distributary channels that were active only at high stage. This change could be attributable to occurrence of higher peak (nival) discharges when spring snow-melt occurs over permafrost, leading to an annual widespread flood event.

Prior to development of permafrost fossils from floodplain habitats are probably over-represented in the fossil record relative to other habitats, due to semi-autochthonous deposition in pools. On the other hand, after permafrost developed floodplain habitats are under-represented because deposition of those materials likely to survive occurs mainly at falling stage, after the floodplain has been inundated and flushed clear.

#### Unstable Ecosystems following Episodes of Sudden Climatic Change

G.R. Coope, University of Birmingham

Evidence is accumulating that suggests that Quaternary climatic changes were sudden and often on a large scale. The response rate of organisms to such changes varies greatly both in terms of its local extinction and colonisation of newly available ground. For example, forest trees in northern Canada can continue to survive, and every so often produce pollen, long after the climate has deteriorated below the threshold for their successful reproduction. Alternatively, the arrival time of a species in an area after an episode of climatic warming depends, not merely upon the suitability of the environment but also on the rate of spread and the distance that the species has had to come. Under such circumstances, unstable ecosystems develop that are essentially transitory but which may well last for thousands of years. The recognition of such ecosystems is important in our interpretation of Quaternary environments particularly in glacial contexts where climatic warmings of interstadial status may be incompletely understood or even overlooked altogether if we adopt too narrow an approach to our biological indicators.

#### Soil Pollen Analysis and Environmental Change in Areas Outside Present Glacial Limits in Southern Norway

C.J. Caseldine, University of Exeter

Problems inherent in the use of pollen analysis as a means for determining environmental change in areas immediately outside the present extent of glaciers are briefly reviewed. Apart from the relative paucity of suitable sampling sites to be found around the margins of glaciers considerable difficulties arise from the interpretation of the character of the vegetation in the immediate vicinity of the site under analysis from pollen evidence. The possible use of soil pollen analysis in such environments is considered and results from analyses of soils buried

beneath moraines of 'Little Ice Age' date in the Jostedals and Jotunheimen Mountains are discussed. Detailed  $^{14}\text{C}$  dating of one of the buried soil profiles, a podsol from Haugabreen in the Jostedals, has allowed the derivation of the rate of organic matter accumulation in the Ah horizon, and thus enabled calculation of pollen incorporation rates into the horizon. Although significant changes are found in the pollen assemblages, both in relative and absolute terms, it is questioned as to whether these changes are a reflection of the character of the soil profile at the sampling site or have wider significance in terms of environmental and climatic change.

Pleniglacial Stratigraphy and Pingo Growth in the Netherlands  
with a Special Reference to the Drentsche Aa Valley System

W. de Gans, Free University, Amsterdam

In the Drentsche Aa valley system the top of the Middle Pleniglacial fluvial sequence is composed of one or more cryoturbated humic loam layers. These layers are interpreted as thaw-lake deposits.

The pollen diagrams of these levels represent a wet tundra vegetation. They are comparable with the Middle Pleniglacial Interstadial diagrams as described in the Netherlands. However, these diagrams are quite identical and their stratigraphic position cannot be established on palynological arguments only. The radio-carbon dates from these Aa valley Middle Pleniglacial deposits vary randomly between 27,350 and 43,000 BP and an analysis of all available Pleniglacial radio-carbon dates in the Netherlands also does not support the standard Pleniglacial Interstadial stratigraphy.

Consequently, the bio- and chronostratigraphy of the Pleniglacial might be more complex than the standard subdivision into a Moershoofd, Hengelo- and Denekamp-Interstadial.

In the Aa valley system at least 77 topographic depressions occur that can be interpreted as pingo remnants.

The ramparts which surround these remnants are mainly composed of stratified sand and loam deposits, with sedimentary structures indicating deposition in a wet aeolian environment. The ramparts are capped by a stone-line, from which level small ice-wedge casts, cracks or cryoturbation structures may penetrate the underlying rampart material.

As the pingo remnants are situated in small valleys, the rampart material locally overlies the Middle-Pleniglacial thaw-lake deposits. Thus the position of the ramparts and the dating of the infilling organic material in the remnants enables a dating of the pingo remnants between 19,000 and 13,000 BP.

The preceding pingos developed between 25,000 and 19,000 BP, probably as hydrostatic ones. This suggests the presence of a continuous permafrost. The maximum depth of 17 metres of the infill of the remnants gives the minimal depth of the permafrost base during pingo growth.

#### REVIEWS

*The Palaeolithic Age.* By John Wymer. Croom Helm Ltd., London.  
310 pp., 21 plates, 79 figs., 26 tables. ISBN 0-7099-2710-X. £16.95

A serious problem in recent years for the teacher of early pre-history - whether his students are adults attending evening classes or university undergraduates - has been the lack of a satisfactory general text on the Old Stone Age. Those by Bordes and by Coles and Higgs were published as long ago as the late 1960s, but until now have remained the best available; moreover, one of these was very much a personal statement, with few supporting references, and the other was clearly best suited to university applications.

John Wymer is well known as a field archaeologist of distinction. His new book, in Croom Helm's series 'Studies in Archaeology', shows that he has also given a lot of thought to the practicalities of communicating a difficult subject - above all one which is prone to interpretational upheavals from time to time. For teacher and taught alike, structural conception is no less important than content. This volume's great strength is the care which has been taken to provide the reader with the means to take his enquiries further into the literature, at almost any level. For each chapter there are sources given for the specific points mentioned, and also a commentary on the most useful references for each area or topic. A nice balance is struck between the chronological and thematic approaches to the subject matter, and certainly helps to maintain interest; too much of the former can lead to the feeling of a boring recitation of facts, too much of the latter to a state of confusion about 'how it all fits together'.

Inevitably, some areas are better covered than others; in a book published in 1982, a total of just over four pages devoted to Australia and the New World together seems a little parsimonious. There are some irritating mis-spellings of site names, and, inevitably, critical reviewers will find the odd statement which seems a little out-dated. More serious, in my view, is the provision of only a single site photograph. Such faults do not greatly detract from the book's usefulness, however; nor, given the wide readership for which it is clearly intended, does the author's avoidance of the more abstruse theoretical questions which will preoccupy advanced students. It deserves to succeed and it is to be hoped that a paperback edition will not be too long in appearing.

A word of warning to the more jaded reviewer: contents, figures and tables, yes - but table of plates is there none!

Paul Callow

*Quaternary Science Reviews* Vol 1, No.1 1982. Edited by D.Q. Bowen. Subscriptions £32.14 \$70.00 (one year). (Specimen copies available on application to Pergamon Press).

Although the fields of interest of Quaternary Scientists cover a vast range of ground from the earth sciences to archaeology, it has usually been the fashion for workers in their individual branches of the subject to submit papers to the journals dealing with their own corner of the science.

Since 1970 journals devoted to an interdisciplinary approach to the Quaternary have been started in both North America (*Quaternary Research*) and Europe (*Boreas*) but these valuable additions to the literature have concerned themselves primarily with papers on original research, rather than reviews of the literature or of techniques of investigation. The need for such a journal has been long expressed and this need has now been filled by the first publication of *Quaternary Science Reviews*.

The first number contains three long papers on the reconstruction of Pleistocene ice sheets, on the Chronology of the Late Wisconsinian glaciation and on the Thermoluminescence dating of sediments, plus book reviews and meeting reports. The individual papers are on average twenty-seven pages (C.10,000 words in length) and therefore cover a wide compass of material within their titles. Papers of this length, on a range of aspects of the Quaternary are probably limitless in terms of subject material particularly when the "Forth Bridge syndrome" is invoked, so that updating of the original papers will provide a ready source of new material every ten years or so, as original review subjects become exhausted. As befits review papers, long bibliographies are provided with each and these may form a vital part of any of the work published in *Quaternary Science Reviews*.

In addition to the papers, *Quaternary Science Reviews* also as befits a review journal, publishes extended book reviews which are longer than is often the case in many journals and give the reader a clear idea of the subject matter of the volumes under review. The one criticism which this reviewer would aim at the book reviews in *Quaternary Science Reviews* Vol.1, No.1 is that two out of the three relate to books published in 1980 and, therefore, to volumes already seen by the majority of Quaternary Scientists. As the new journal gets into its stride no doubt new books will be reviewed as they appear.

The final section of the new journal is concerned with the reports of meetings. This section will be especially useful if it can be built upon. Readers of the *Quaternary Newsletter* will be well informed about the annual discussion meeting through the published abstracts and about field meetings through the reports on these, but not many British readers will have ready access to the proceedings of AMQUA or the American Meteorological Society reported here. The publication of the controversies and discussions at such meetings form a necessary part of the advancement of Quaternary science and even if one cannot attend each meeting, some contact can be kept if the proceedings of meetings are to be so readily available.

All in all, this new journal has had a promising start and if the editor and editorial board can keep this up, *Quaternary Science Reviews* will become a valuable addition to the literature of our science.

D H Keen

#### NOTICES

##### Map showing thickness of peat in the Somerset Moors

D.W. Cope, Soil Survey of England and Wales, Long Ashton, Bristol.

This map at a scale of 1:50,000 is published by the Soil Survey, price £3 including post and packing from The Publications Officer, Soil Survey of England and Wales, Rothamsted Experimental Station, Harpenden, Herts. AL5 2JQ. Thickness of peat is shown by generalised contours at 1 metre intervals and by colour banding in purple at varying depth intervals. The map sheets also include two sketch maps at 100,000 scale showing Types of Peat and Thickness of Clay over Peat.

In Somerset the traditional use of peatland is dairying, based on summer grass, usually with a water-table within 50cm throughout most of the year. Recently pump drainage schemes have allowed the introduction of arable crops, though more extensive changes would depend on large scale improvements in arterial drainage. Running in parallel with agricultural development has been an escalation of peat extraction and Somerset now supplies a significant proportion of production in England and Wales. Both these changes conflict with the indigenous wetland flora and with the large populations of migratory wetland birds in spring.

These competing uses for a limited and shrinking resource demand a land use policy based on a systematic inventory. Published soil surveys show the location of about 18,000 ha of peat in central Somerset but little was known about properties in depth. The basis of the new survey was 325 borings by gouge auger at 1 x 0.5 km spacing.

**Peat thickness.** The peats form two separate basins, north and south of the Poldens, with an overall pattern of increasing thickness inland. In the western end of the northern Brue basin peat ranges in thickness from 50 to 250cm. Elsewhere west of a line from Hartlake in the north to Stathe in the South the peat is moderately thick, between 250 and 400cm. East of this line lie the thicker peats, usually 400-600cm, but occasionally exceeding 700cm in Queen's Sedgemoor and South Moor. The peats rest nearly everywhere on soft grey silty clay near to the level of Ordnance Datum.

**Peat type.** Thin remnants of *Sphagnum*, cotton-grass and heather extend beyond the main raised moss deposits in the Brue basin but no mappable occurrences of this type were found elsewhere. Woody peats attain considerable thickness and, within the upper 2m, peat of this kind is dominant in south-east King's Sedgemoor and almost all the peatland to the south excepting West Sedgemoor. Elsewhere the deposits are essentially sedge peat with a layer of reeds at the base. Reeds also

occur throughout in Godney Moor and the Lower Brue basin.

**Fibre content and humification.** Rubbed fibre content was determined from a range of peat types in which samples were treated with pyrophosphate solution, stirred in a blender and sieved through a 200µm sieve. Rubbed fibre constituted 15-33% by weight in samples from 50-100cm. But evidence of soil formation is seen in thin layers of well structured peat usually between 25 and 45cm depth which are blacker in colour than the dark brown to reddish brown peat below. Vertical cracking outlines a well developed prismatic or coarse blocky structure and fibre content, on samples from the same sites as above, ranged from 8-25% indicating fibre loss of about 7%. These subsurface horizons were also characterised by a greater bulk density ( $0.3-0.4\text{ g cm}^{-3}$ ) than lower wetter layers ( $0.15\text{ g cm}^{-3}$ ).

**Hydraulic properties.** Effective water control at both arterial and field scale is the prime factor in peatland management. Measurement of hydraulic conductivity of the peat by the auger hole method gave values of  $0.5-2.0\text{ m day}^{-1}$  in the lower layers and more rapid rates in the structured upper layers. Performance of slotted pipe drains in recent field drainage works does not always meet these modest rates because of blockage of slots by peat fibres.

**Mineral topsoils.** The survey also distinguishes land with less than 30cm of clay over peat from that with 30-80cm and more than 80cm of clay over peat. Soils with thin clayey topsoils are more or less confined to the moors south of Othry, the remainder of this unit to the north being dominated by topsoils classed as either peat or loamy peat in which thin clay layers were never present or have been incorporated by cultivation in former times. The recognition of these distinctions is of importance when choosing land for small seeded cash crops where a fine tilth is required. Even thin clay layers, particularly where broken from old pasture require many seasons of careful cultivations to produce fine even tilth. Most pH values are in the range 5.0 - 6.0. The occurrence of appreciable amounts of gypsum in the peat and clayey cover of the pump drained land on West Sedgemoor is a local phenomenon and other deposits such as shell marl are rare.

**Further Surveys.** Studies of peat are continuing and during 1982-3 a survey of peat depth and pH is to be made in lowland peat throughout England and Wales.

#### Palaeohydrology of the Temperate Zone During the Last 15000 Years

An international meeting associated with this IGCP Project 158 will be held at Attingham Park, Concord Conference Centre, Shrewsbury from 19-26 September 1983. The programme will include paper sessions and field excursions associated with Subproject A Fluvial and Subproject B Lakes and Mires. Further details may be obtained from Professor K.J. Gregory, Department of Geography, The University, Southampton SO9 5NH.

Fourth International Flint Symposium, Brighton, England  
10-15th April 1983.

The International Flint Symposium meets every 4/5 years in a different European country. The fourth meeting will take place in England, at Brighton in April 1983. The Symposium is concerned equally with flint and other cherts and with the chalk sediment in which the flint occurs. The meeting is interdisciplinary in character and is concerned with the Geology and Geochemistry of flint and with its use as a raw material by Prehistoric man.

The 1983 Symposium will be divided into seminars on different topics, concentrating in Geology on the origin of flint and of its Geochemical constituents, on SEM studies of surface textures and in Quaternary studies on the behaviour of chalk and flint under Periglacial conditions. Archaeological seminars include those on flint mining and quarrying, experimental archaeology, Microwear analysis of flint tools, replication of flint manufacturing techniques, and analysis of the patterning of flint debris on prehistoric sites.

In addition to the formal proceedings, excursions during the course of the meeting and afterwards are a feature of the Symposium. The present meeting has been arranged at Brighton on the Chalk of the South Downs, to take advantage of recent stratigraphical researches on chalk and on the flint bands they contain. These will be demonstrated during the excursions as will research on chalk cliff erosion, periglacial chalk slope deposits at Devils Dyke (Brighton) and the results of the Harrow Hill flint mine excavations which are in progress for the Symposium.

An additional two-day optional excursion after the Symposium has been arranged. It is open to any Symposium participant to join this excursion but a limit of 50 has had to be set and places will be allocated on a "first come, first served" basis.

The Fourth International Flint Symposium will be held at Brighton Polytechnic (Falmer Campus) between 10-15 April 1983. Those wishing to attend are required to complete the Registration Form and return it, together with the Registration fee, as soon as possible but not later than 3 January 1983.

Further bookings and enquiries should be addressed to the local organising secretary, R.N. Mortimore, to whom the registration form should be returned.

The full address is:

Dr. R.N. Mortimore,  
Secretary Organising International Flint Symposium,  
Brighton Polytechnic,  
Department of Civil Engineering,  
Geotechnical Section,  
Cockcroft Building,  
Moulsecoomb,  
BRIGHTON, England.  
BN2 4GJ.



### University of Durham Palaeoenvironmental Studies Service

The Department of Botany is setting up a Palaeoenvironmental Studies Service for archaeologists or earth scientists working in northern England and southern Scotland. The Department offers site visits for sampling, pollen analysis and the identification of wood, fruits and seeds. Reports will be written on samples collected or sent to the Department.

For further details and scale of costs contact:

Dr. Judith Turner,  
Department of Botany,  
Science Laboratories,  
South Road,  
DURHAM, DH1 3LE.  
Telephone: 0385-64971 extension 250

### Archaeological Tour to France

A trip to visit the painted caves and other archaeological sites in the Dordogne and Pyrenees is being organised for Easter 1983. The trip will be for eleven days and costs £275-£295 inclusive depending on numbers. For further details contact Mrs. S. Palmer, The Museum, Priory, Church Hill, Orpington, Kent (0689-31551).

### New Ph.D. registrations and completed Thesis abstracts.

It is hoped to publish from time to time lists of newly registered Ph.D. topics and short abstracts of newly awarded Ph.D. theses.

Any members wishing to have details of new registration or of a completed thesis in the *Newsletter* is asked to write to the Editor, Dr. D.H. Keen, with in the first case, information including the name of the candidate, the name of the supervisor or director of studies, the department in which the research is to be conducted and the title of the work. In the second case, the author's name, the title of the Ph.D. as awarded and a short abstract of the work.

It is the Editor's intention to provide a list of new registrations in the February edition of the *Newsletter* each year and to publish completed thesis abstracts as space permits.

## Abbey Piston Corers (Peat Samplers)

2 Models available - heavy and light duty - also model for taking of lake sediments and sand etc. at present under development.

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Kelso, Roxburghshire, Scotland.  
Tel: Kelso 24861

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## CALENDAR OF MEETINGS

- 12th December 1982 Day field meeting at Barnfield Pit, Swanscombe. For further details see the Circular with this Newsletter.
- 7th-8th January 1983 Quaternary Research Association Discussion Meeting at Coventry (Lanchester) Polytechnic. Theme "The reconstruction of cold non-glacial environments". Organiser Dr. D.H. Keen. For further details and a registration form see the Circular accompanying this Newsletter.
- 4th-7th April 1983 Quaternary Research Association Annual Field Meeting on the "Divisions of the River Thames". Organiser D.A. Cheshire. For further details and registration forms see the Circular with this Newsletter.
- 10th-15th April 1983 Fourth International Flint Symposium to be held at Brighton Polytechnic, Falmer, Brighton. Local secretary Dr. R.N. Mortimore. Further details may be found in the notice on p.48 of this Newsletter.
- 25th-29th May 1983 Quaternary Research Association short Field Meeting to Islay and Jura. Leader Dr. A.G. Dawson. Further details may be found in the Circular issued with this Newsletter and a registration form will be issued with Newsletter 39.
- 28th August - 2nd September 1983 International Symposium on Late Cainozoic Palaeoclimates of the southern hemisphere, organised by SASQUA. Organising Chairman Dr. D. Price Williams. Further details can be found on p.32 of Newsletter 37.
- 19th-26th September 1983 Anglo-French Karst Symposium. Organised by Dr. M.M. Sweeting and Dr. K. Paterson. Further details may be found on p.31 of Newsletter 37.

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