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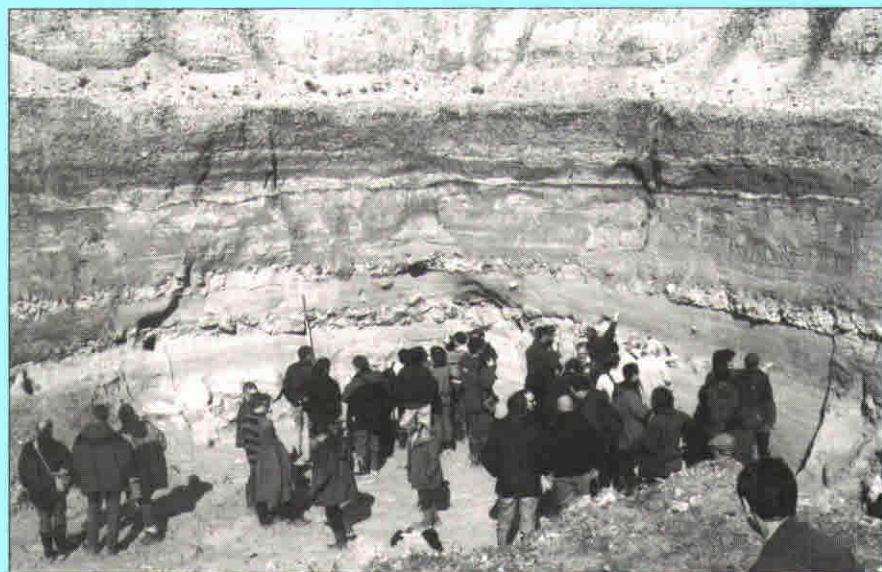
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# QN

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# QUATERNARY NEWSLETTER

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*Quaternary Newsletter* is issued in February, June and October. Contributions comprising articles, reviews, notices of forthcoming meetings, news of personal and joint research projects, etc. are invited. They should be sent to the Quaternary Research Association Newsletter Editor. Closing dates for submission of copy (news, notices, reports etc.) for the relevant numbers are 1st January, 1st May and 1st September. *Articles should be submitted well in advance of these dates.* The publication of articles is expedited if manuscripts are submitted both as hard copy and on floppy disc. The preferred type for the latter is 3.5" floppy disc in Apple Macintosh format, but IBM PC compatible formats are also acceptable.

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## COVER PHOTOGRAPH:

QRA members examining magnificent sections through Quaternary sediments at Boxgrove, Sussex, during the Annual QRA Field Meeting in April 1998. Could this be the last major excursion of this kind to the site? - see report on the QRA Annual Field Meeting to Kent and Letters to the Editor in this issue. Photograph by James Scourse.

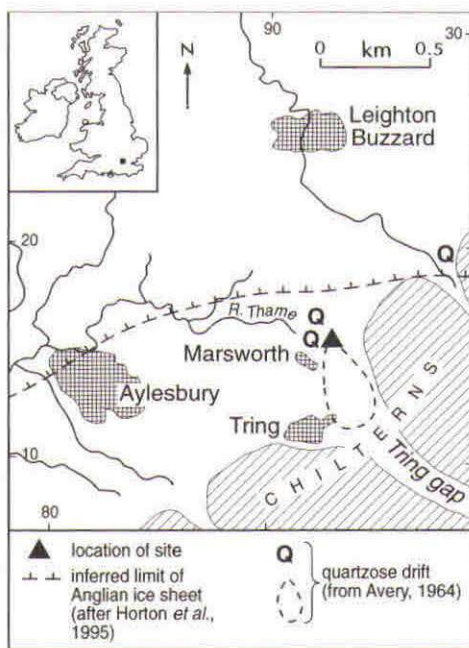
# ARTICLES

## PRELIMINARY REPORT OF NEW EVIDENCE FOR GLACIATION AT MARSWORTH, BUCKINGHAMSHIRE

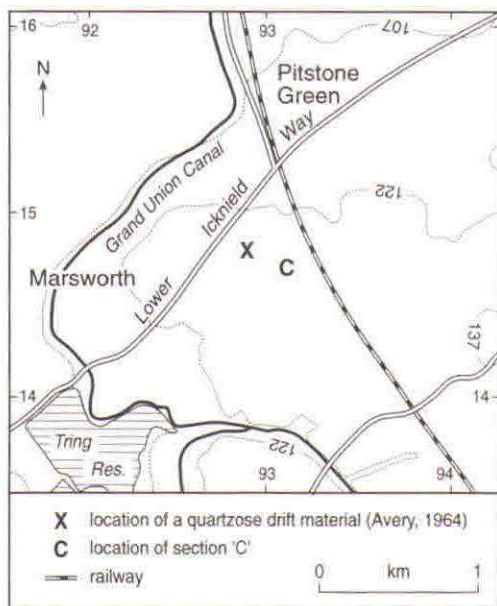
Colin Whiteman

### Introduction

The Quaternary site near Marsworth, Buckinghamshire (SP 9314; Figure 1) is well-known as the location of channel sediments containing flora and fauna belonging to more than one warm period between the Hoxnian and Devensian stages (Green *et al.*, 1984). The site also possesses an extensive array of periglacial involutions (Worsley, 1987) and these attracted the attention of Dr Julian Murton while he was investigating the impact of periglacial processes on chalk landscapes in southern Britain. An important element of Murton's periglacial project is the dating of these processes. Relatively few absolute dates were obtainable from material associated with the Marsworth interglacial deposits (Uranium-series disequilibrium ratios; Green *et al.*, 1984) and Murton



**Figure 1.** Location of the Marsworth site. Note: marginal numbers refer to National Grid.



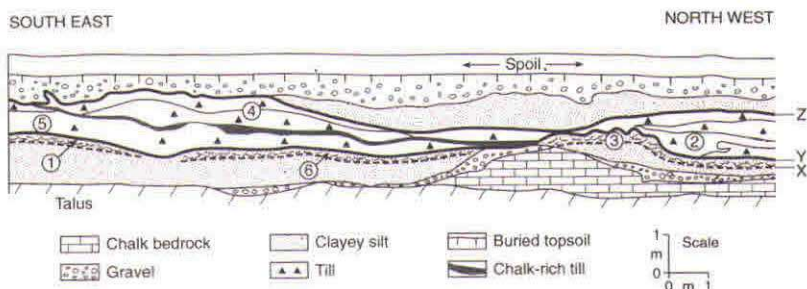
**Figure 2.** Location of Section C at Marsworth and the bluff (x) referred to in Avery (1964). Note: marginal numbers refer to National Grid.

extended his dating programme to include both the interglacial and periglacial deposits using a wider range of dating techniques which have since become available. The opportunity has also been taken to extend the investigation at Marsworth to an additional section (C on Figure 2) where substantial unpublished work was conducted during the 1960s and 1970s by Professor John Evans. As a result of these decisions, a multidisciplinary team was assembled under Murton's chairmanship and this work is now well advanced.

The author was invited to visit the site on 29 October 1995 with Dr Murton and Dr Chris Green in order to comment on a particularly enigmatic diamicton in Section C. The purpose of this brief paper is to set out preliminary results of investigations into this unit because they have important implications for the extent of glaciation in south-central England, and for environmental reconstruction and dating of the site.

The deposit (Figure 3) consists largely of a series of four or five, mostly dark reddish-brown, slightly stony layers of sandy loam, individually not more than c. 1 m thick, and containing clusters and stringers of angular to subangular flint clasts and dispersed flint, quartz, quartzite and other pebbles. The clast stringers are generally only one or two clasts thick and a few metres in length. The brown





**Figure 3.** Schematic diagram of Section C at Marsworth, showing sediments and key structural boundaries ( X = base of brittle fracture; Y = plane of décollement; Z = surface of glacial diamictons). Numbers refer to list in the text.

layers undulate. Individual beds rarely if at all extend for the whole length of the exposure and tend to rise gently towards the south-east until truncated along an upper erosive boundary. In the southern part of the section a prominent, thin (up to 10 cm) but discontinuous layer of chalk-rich clayey-silt occurs as a parting between two of the reddish-brown beds. The brown bed below the chalk-rich layer shows prominent, narrow (5-10 mm) colour banding parallel to its upper boundary, apparently related to textural differences. Iron and manganese oxides are concentrated at the base of the chalky bed and the brown layers themselves show evidence of strong oxidation in addition to clay illuviation and, possibly, decalcification, the latter indicated by secondary calcium carbonate nodules in the sediments beneath. The general consensus of opinion seems to have been that the dark brown beds between the grey silts below and the erosion surface above represented mass wasting of material from the neighbouring Chiltern Hills and/or a soil of interglacial origin.

### Evidence for glaciation

The author's initial impression (personal communication to JM and CG, 29/10/95), based on structure, colour, texture and clast distribution, was of a strongly oxidised diamicton sequence reminiscent of deeply weathered Lowestoft Till (e.g. Sturdy *et al.*, 1979). Strong oxidation, illuvial clay coatings and secondary calcium carbonate are obvious indications of pedogenesis but this is to be expected in a deposit now underlying permeable sediments within 1.5-2.5 m of the former ground surface (at present buried by quarry spoil) and is consistent

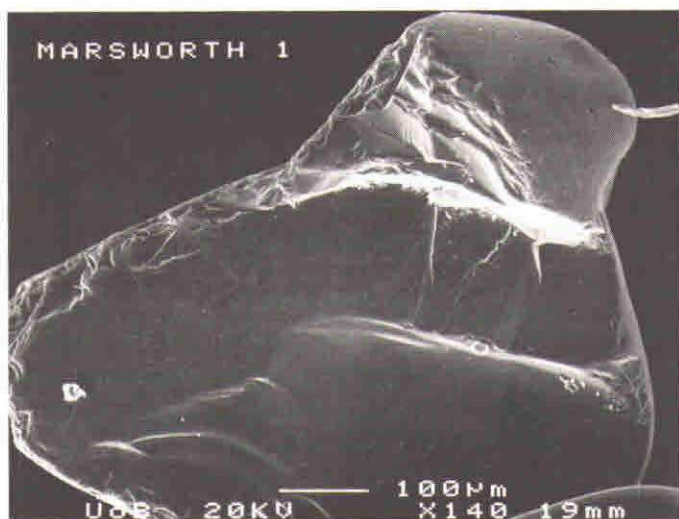
with findings elsewhere in southern Britain (Whiteman and Kemp, 1990). The presence of these soil features in no way precludes a glacial origin for these sediments. Furthermore, the sediments are quite unlike the solifluction or slope wash deposits typically associated with scarp-foot locations in British chalk terrains such as the Chiltern Hills (cf. Evans, 1966) which are usually greyish, more coarsely textured, more chalk-rich and less consolidated.

A more detailed inspection of the whole exposure of Section C (c. 75 m in length by 3-4 m in height) revealed significant additional features which are listed below and summarised schematically in Figure 3:

1. a plane of décollement;
2. over-folding and boudinage structures near the base of the sequence;
3. lateral displacement of the grey silts up the ice-proximal side of a chalk knoll;
4. apparent shearing of the dark brown layers over each other, including the thin chalk-rich bed;
5. apparent mobilisation and mixing of the grey lacustrine silts into a position above the décollement to form the lowest diamicton unit;
6. brittle fracture of the upper 10-20 cm of the grey silts, beneath the décollement;
7. over-consolidation of all sediments between the décollement and the erosion surface above the brown beds, in contrast to the sediments above and below;
8. lithology - quartz and quartzite are assumed to have a northerly provenance. Chris Green (personal communication) has found similarly provenanced Jurassic material in the gravels above the unconformity at the top the diamicton, which are probably outwash deposits from the glacier.

Together these features constitute strong evidence for a deposit produced by glacier ice; in particular, they point to subglacial deformation (cf. Banham, 1975, 1977). The ice sheet appears to have over-ridden and eroded chalk bedrock and the gravels and lacustrine silts overlying it. In places the silts and gravels have been mobilised and redeposited as the lowermost unit of till; below the plane of décollement the silts have undergone brittle fracture *in situ*, or been left undeformed. Towards the southern end of the exposure the plane of décollement between *in situ* silts and those that have been glacially mobilised is indicated by a thin (1 cm) brown layer. Towards the north-western end of the exposure sediments adjacent to the plane of décollement are over-folded, the strike of the fold being approximately WSW-ENE.

Detailed laboratory analyses on the sediments are in progress. Scanning Electron Microscopy (Figure 4) reveals possible glacially induced fractures on



**Figure 4.** Electron micrograph of quartz grain from glacial diamicton in Section C at Marsworth.

some sand grains (Krinsley and Doornkamp, 1973), though a degree of circumspection is always necessary when using this type of evidence (Whalley, 1995). Thin sections show evidence of shearing and till pebble structures indicative of glacial deformation (van der Meer, 1993, 1997).

Individually, some of the deformational features mentioned above could have resulted from slope movement and/or the solution of the underlying chalk but, *in toto*, the whole suite of evidence indicates that the dark brown clayey diamictons in Section C at Marsworth are of primary glaciogenic origin and that sediments below the décollement have been glaciogenically modified. The glacial sequence as a whole may conform to a model of 'constructional glacial deformation' (Hart, 1995), a view supported by Hart (personal communication to Murton, 10/1/98) following her brief visit to the site. That these diamictons have been pedogenically modified is clear, and to be expected this close to the land surface. Whether this pedogenesis has significant stratigraphical implications is under investigation and not the subject of this communication.

Although the present paper is the first publication to summarise the detailed evidence for glaciation, it is not the first time that glacial sediments have been recognised at, or adjacent to, this site. In 1964 (if not earlier; see comments in Brown, 1964) Avery arrived at this conclusion following his mapping of soils and land-use in the district around Aylesbury and Hemel Hempstead. In the Soil Survey memoir for the area, Avery (1964, p. 18) states that:



"thin...patches of stony drift with quartzose pebbles occur...on the bluff east of Marsworth (grid ref. SP/928148; [X on Figure 2]) [which] lies on the up-raised, terminal edge of the fan-shaped platform at around 425 ft. [130 m] which extends southwards to the neck of the gap near Tring station. Beneath the surface of this flat is a **brown clay containing scattered sub-angular flints and quartzose pebbles, resembling weathered Chalky Boulder Clay**, and resting on chalky drift with gravelly and sandy layers, the whole being mapped [in 1922, Sherlock] as Valley Gravel by the Geological Survey. The presence of foreign stones indicates that the clay, at least, came from the north, and almost certainly derives from an early **incursion of ice** into the [Tring] gap".

Apparently, Avery had recognised over thirty years ago the obvious resemblance between the brown diamicton deposits near Marsworth and deeply weathered patches of Lowestoft Till, formerly known as chalky boulder clay. What was lacking was detailed data from the sediments and an appropriate model of glacial deposition. With hindsight it can be seen that these sediments are consistent with the known pattern of glacial deposition elsewhere along the Lowestoft ice-sheet margin (cf. Allen *et al.*, 1991).

### Implications

A number of implications follow from this confirmation of Avery's prescient interpretation:

- a) It confirms Avery's (1964) view that the southern margin of glaciation in the Vale of Aylesbury (presumed to be Anglian) extended farther than is generally indicated on maps.
- b) It constrains the age of the grey lacustrine silts and the gravels between the plane of décollement and the chalk bedrock to no later than the early Anglian Stage, though which Oxygen Isotope Stage this is equivalent to (12? or 10? or another?) remains questionable (Sumbler, 1995).
- c) It provides a useful temporal marker (depending on b, above) against which to compare the results of the different dating experiments being conducted on Marsworth sediments.
- d) It may provide an opportunity to obtain additional evidence for the nature and degree of post-Anglian pedogenesis in south-eastern Britain.

### Acknowledgements

I thank Julian Murton for inviting me to visit Marsworth and to join the multidisciplinary team working on the project, and for supplying the diagram from which Figure 3 is derived. I am grateful to Jane Hart for responding to my



invitation to visit the site and for making her views known to us. Paul Fish, Chris Green, Rob Kemp, Julian Murton and Mike Sumbler stimulated discussion in the field, and subsequently, for which I thank them. Rob Kemp also discussed thin sections at some length, David Keen advised on molluscs and Julian Murton and Jim Rose contributed significant comments on a draft of the manuscript. Alan Piercy of the SEM unit at the University of Brighton and Paul Fish assisted with SEM, Sue Rowland and Hazel Lintott of Sussex University Cartography Unit drew the diagrams and Graham Atkins kindly gave permission for access to the site. The constructive comments of the referees, Chris Green and Jaap van der Meer, are appreciated.

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# HOLOCENE SEDIMENTS FROM THE RIVER THAMES FORESHORE AT BERMONDSEY, LONDON

Kevin P. Woodbridge

## Introduction

The Late Devensian and Holocene (Flandrian) geology of the lower Thames Valley is fairly well known. In central London, the basic stratigraphic sequence is one of gravel and sand deposits (typically 2-12 m thick), overlain by clay/silt and biogenic deposits (typically 1-7 m thick), usually overlain by modern fill (Gibbard, 1994).

The gravels and sands are considered to be the "lower floodplain" or "buried channel" infill of a braided river system. Evidence from the middle Thames Valley indicates that they were laid down in a cold, probably periglacial, climate between about 15,000 BP and 10,000 BP. These deposits of Late Devensian age are usually termed the Shepperton Gravel, after the type site of Shepperton Quarry in Surrey (TQ 070669) (Gibbard, 1985, 1994).

The clay/silt and biogenic deposits are considered to be the floodplain alluvium of a meandering river system laid down in a generally temperate climate between about 10,000 BP and the present. These Holocene deposits are often termed the Tilbury Deposits, after the type site of Tilbury in Essex (TQ 647754) (Devoy, 1979; Gibbard, 1994). At Tilbury, Devoy (1979, 1982) subdivided these materials into alternating biogenic deposits (Tilbury I-V) and inorganic clay/silt deposits (Thames I-V), and farther upstream at Woolwich East (TQ 44627942) he found the following sequence:

- Elevation about -1.5 m OD to -0.3 m OD Thames III inorganic clay/silt deposits (about 4,000/3,850 BP - 3,400/2,800 BP).
- Elevation about -3.8 m OD to -1.5 m OD Tilbury III biogenic deposits (about 5,500/4,930 BP - 4,000/3,850 BP).
- Elevation about -4.8 m OD to -3.8 m OD Thames II inorganic clay/silt deposits (about 6,700/6,575 BP - 5,500/4,930 BP).

During the Holocene, global eustatic sea-level rise greatly affected south-east England, and Devoy (1979) considered that the Thames sedimentary phases were marine transgressions and that the Tilbury phases represented marine regressions. Re-evaluations of Devoy's work have shown that this interpretation has various short-comings (e.g. Haggart (1995) considered that the bulk of the



Tilbury III peat formed under conditions of rising relative sea level, which was then followed by a fall), but the basic lithostratigraphic sequence does seem to be valid for the Thames Estuary area. However, when correlating Devoy's work at Tilbury with sediments in central London there have been many difficulties (see Rackham, 1994), mainly because of the differing conditions upstream and also because the River Thames has migrated across its floodplain (generally in a northward direction) during the Holocene (Nunn, 1983).

To determine the Late Devensian and Holocene stratigraphic sequence in the upper 2 m of the River Thames foreshore at Bermondsey, London (c. TQ 344798), an undergraduate geology project (Woodbridge, 1997) was carried out. Following recognition and initial examination of a number of ancient and distinct horizons exposed on the Thames foreshore at Bermondsey (Hill, 1996), this project was undertaken to determine the stratigraphic sequence by invasive techniques. Hill's work was based on surface evidence, including biological and prehistoric anthropic material, and samples extracted from surface exposures.

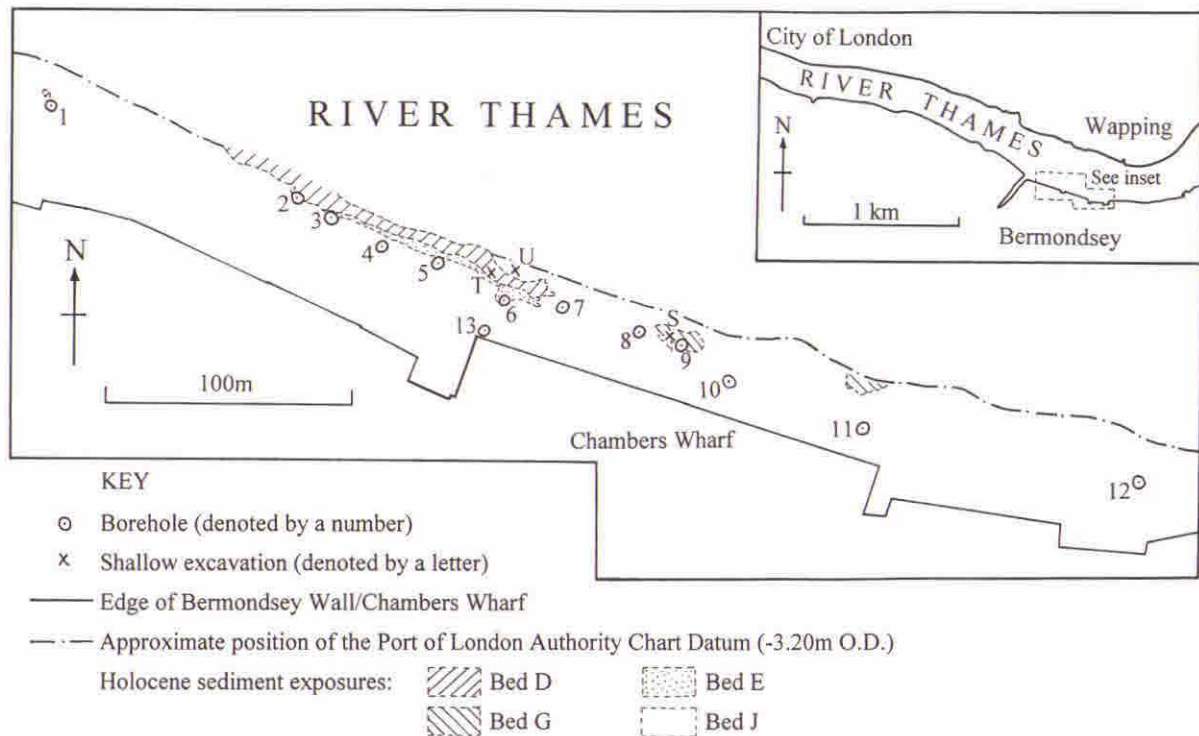
## Methods and results

The study area (Figure 1) is a short stretch of the foreshore near Chambers Wharf on the south bank of the River Thames, about 33 km downstream from the present-day tidal head at Teddington Weir. The Thames at this location is about 300 m wide with a 4 km-wide floodplain, an average tidal range of about 5.8 m and an annual mean half-tide salinity of about 0.25g/l (Juggins, 1988).

This area was investigated by surface survey, 13 shallow boreholes and 3 shallow excavations taken along a transect which ran in an approximately WNW-ESE direction and which extended over a distance of about 500 m (Figure 1). The 13 shallow boreholes were made by a 'Cobra' percussion corer and reached a maximum depth of 2 m, and the 3 shallow excavations were of maximum depth 0.1-0.25 m. The sediments encountered were logged (Figure 2) and subdivided into beds, mainly on the basis of grain size and texture, colour, lithology, and fossils. The stratigraphic sequence (Table 1) can be summarised as:

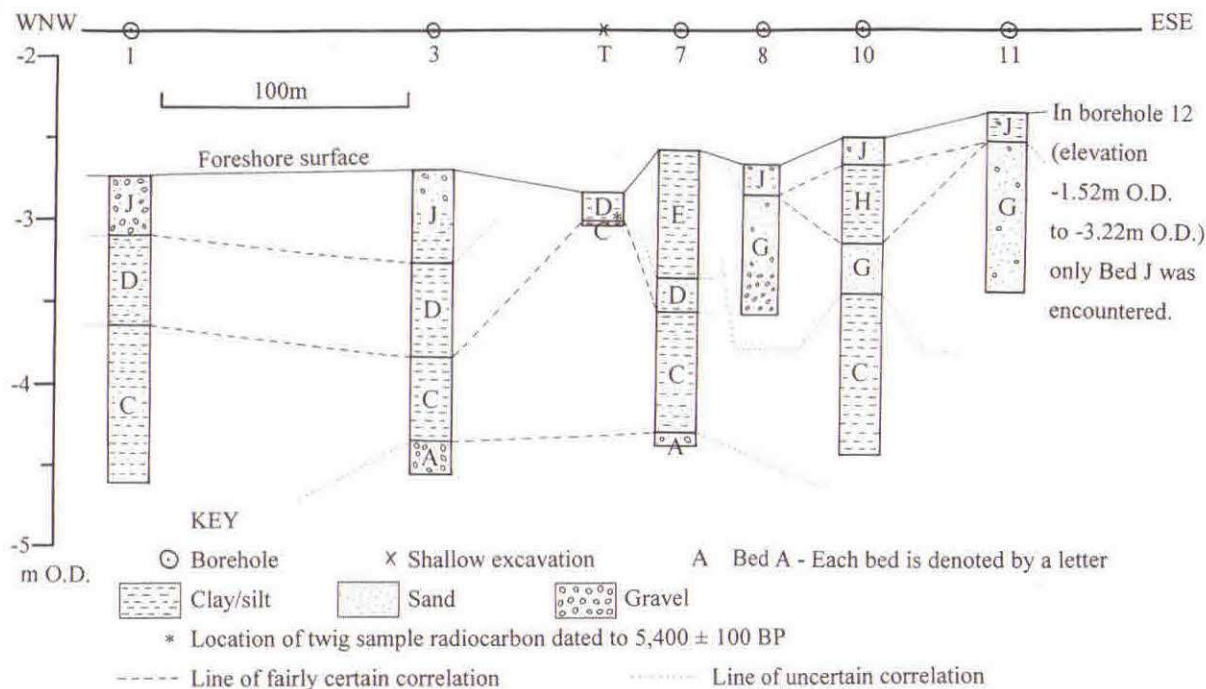
- (i) (bed A) gravel and coarse sand;
- (ii) (beds C, D and E) calcareous and organic-rich clay/silts and fine sands;
- (iii) (beds G and H) sand and gravel overlain (in borehole 10) by clay/silt; and
- (iv) (bed J) variable sands, gravels and clay/silts.

Sediment samples from one borehole (No. 3) were subjected to basic diatom analysis using extraction, preparation and counting methods similar to those



**Figure 1.** The study area.

(Made with reference to O.S. (1996), P.L.A. (1993), and Hill (1996)).



**Figure 2.** An approximately WNW-ESE section constructed from simplified sedimentary logs of six boreholes (numbers 1,3,7,8,10 and 11) and one shallow excavation (T).



Table 1. Summary of the stratigraphic sequence.

Stratigraphic Unit	Notable characteristics	Probable correlation	Probable age
Bed J. Sand, gravel and clay/silt.	Variable grain size and sorting, diatom assemblage dominated by <i>Cyclotella striata</i> (Table 2), modern objects such as brick fragments.	Modern fill and alluvium.	About 1,000 BP - present.
Bed H. Clay/silt.	Small mean grain size, well sorted, very few fossils apart from mollusc shell fragments.	Local stream deposits?	Uncertain.
Bed G. Sand and gravel.	Large mean grain size (typically 1mm), poorly sorted, very few fossils apart from mollusc shell fragments, including <i>Margaritifera auricularia</i> (Spengler) (a freshwater mussel now extinct in Britain, but which was probably living in the Thames in Neolithic times (Preece <i>et al.</i> , 1983)).	Local stream deposits?	Uncertain.
Bed E. Calcareous clay/silt.	Small mean grain size (0.06mm), well sorted, few plant remains (including <i>Salix</i> sp. buds and leaf fragments, grass fruits, and two, probably <i>in situ</i> , <i>Alnus glutinosa</i> tree bases), few mollusc shell fragments, few diatoms.	Inorganic clay/silt deposits of the Thames III transgression phase or possibly clay/silt deposits laid down during the Tilbury III regression phase (Devoy, 1979, 1982).	Thames III (about 4,000/3,850 BP - 3,400/2,800 BP) or Tilbury III (about 5,500/4,930 BP - 4,000/3,850 BP) (Devoy, 1979, 1982).
Bed D. Organic-rich clay/silt and fine sand (7% - 75% organic matter by loss on ignition).	Small mean grain size (typically 0.03mm), moderately sorted, some <i>Turfa lignosa</i> , <i>Detritus lignosus</i> , and <i>Detritus granosus</i> , some comminuted plant remains (including <i>Alnus glutinosa</i> , <i>Glyceria</i> sp., and <i>Sparganium</i> sp. fruits), few mollusc shell fragments, diatom assemblage dominated by <i>Cyclotella striata</i> (Table 2).	Biogenic deposits of the Tilbury III regression phase (Devoy, 1979, 1982).	Tilbury III (about 5,500/4,930 BP - 4,000/3,850 BP) (Devoy, 1979, 1982). Twig sample of mass 10g taken from near the base of bed D at elevation -3.02 m OD in excavation T dated by conventional radiocarbon dating to 5,400 $\pm$ 100 BP (GrN - 22181).
Bed C. Calcareous clay/silt and fine sand.	Small mean grain size (typically 0.04mm), very well sorted, occasional <i>Detritus lignosus</i> and <i>Detritus granosus</i> , few highly comminuted plant remains (including <i>Alnus glutinosa</i> fruits), few mollusc shell fragments, sparse diatom assemblage dominated by <i>Opephora martyi</i> (Table 2).	Inorganic clay/silt deposits of the Thames II transgression phase or possibly clay/silt deposits laid down during the Tilbury III regression phase (Devoy, 1979, 1982).	Thames II (about 6,700/6,575 BP - 5,500/4,930 BP) or Tilbury III (about 5,500/4,930 BP - 4,000/3,850 BP) (Devoy, 1979, 1982).
Bed A. Gravel and coarse sand.	Large mean grain size (typically 5-6mm), poorly sorted, very few fossils.	Shepperton Gravel (Gibbard, 1985, 1994).	About 15,000 BP - 10,000 BP (Late Devensian) (Gibbard, 1985, 1994).

Table 2. Results of the diatom analysis of sediment samples from borehole 3.

Taxon	Ecology	% of total diatom valve count		
		Bed C, elevation -4.32m OD (total valve count=83 1/2)	Bed D, elevation -3.49m OD (total valve count=178 1/2)	Bed J, elevation -2.95m OD (total valve count=99)
<i>Achnantes hauckiana</i> Grun.	B ey	-	1.1	-
<i>Achnantes minutissima</i> Kutz.	F ey	2.4	-	-
<i>Actinocyclus normanii</i> (Greg.) Hust.	B pl	-	1.7	-
<i>Actinocyclus</i> sp.	? pl	-	1.1	-
<i>Amphora ovalis</i> var. <i>libyca</i> (Ehr.) Cleve	F el	4.8	-	-
<i>Amphora ovalis</i> var. <i>pediculus</i> (Kutz.) Hvh.	B/M es	-	2.2	3.0
<i>Aulocoseira arenaria</i> (Moore) Crawford	F/B ae	2.4	-	-
<i>Aulacoseira westii</i> W. Smith	B be	1.2	-	-
<i>Cocconeis diminuta</i> Pant.	F ey	4.8	-	-
<i>Cocconeis disculus</i> (Schum.) Cleve	F/B ey	8.4	-	-
<i>Cocconeis pediculus</i> Ehr.	F/B ey	2.4	1.1	-
<i>Cocconeis peltoides</i> Hust.	B/M es	-	1.1	6.1
<i>Cocconeis placentula</i> Ehr.	F/B ey	-	1.1	2.0
<i>Cocconeis placentula</i> var. <i>euglypta</i> (Ehr.) Cleve	F/B ey	1.2	-	-
<i>Cocconeis scutellum</i> Ehr.	B/M ey	-	3.4	2.0
<i>Coscinodiscus</i> sp.	M pl	-	1.7	-
<i>Cyclotella meneghiniana</i> Kutz.	F/B pl	-	2.2	1.0
<i>Cyclotella striata</i> (Kutz.) Grun.	B pl	1.2	26.3	22.2
<i>Cymatosira belgica</i> Grun.	M tp	-	1.1	2.0
<i>Cymatosira lorenziana</i> Grun.	M ?	-	-	2.0
<i>Cymbella silesiaca</i> Bleisch ex Rabenh.	F ey	-	1.1	1.0
<i>Diatoma vulgare</i> Bory	F ey	-	-	1.0
<i>Diploneis interrupta</i> (Kutz.) Cleve	B/M ae	1.2	-	-
<i>Fragilaria brevistriata</i> Grun.	F/B tp	2.4	-	-
<i>Fragilaria construens</i> var. <i>venter</i> (Ehr.) Grun.	F/B tp	2.4	-	-
<i>Fragilaria lapponica</i> Grun.	F/B ey	-	0.6	3.0
<i>Fragilaria pinnata</i> Ehr.	F/B tp	6.0	2.2	2.0
<i>Gomphonema</i> sp.	F/B ?	1.2	-	-
<i>Gyrosigma</i> sp.	? be	2.4	-	-
<i>Navicula crytocephala</i> var. <i>veneta</i> (Kutz.) Grun.	F/B be	-	-	4.0

<i>Navicula halophila</i> (Grun.) Cleve	B	be	-	1.1	-
<i>Navicula menisculus</i> Schum.	F/B	be	-	2.8	2.0
<i>Navicula peregrina</i> (Ehr.) Kutz	B/M	el	-	1.1	-
<i>Navicula pygmea</i> Kutz.	B/M	el	-	0.6	-
<i>Navicula</i> sp.	?	be	3.6	1.1	1.0
<i>Nitzschia acuminata</i> (W. Smith) Grun.	M	be	-	-	2.0
<i>Nitzschia angustata</i> (W. Smith) Grun.	F/B	be	-	1.1	-
<i>Nitzschia granulata</i> Grun.	B/M	el	2.4	-	-
<i>Nitzschia hustediana</i> Salah	B	be	-	2.8	5.1
<i>Nitzschia sigma</i> W. Smith	B/M	el	-	0.6	-
<i>Nitzschia triblionella</i> Hanz.	B/M	el	-	1.7	-
<i>Nitzschia triblionella</i> var. <i>victoriae</i> Grun.	F/B	be	-	1.1	-
<i>Nitzschia</i> sp.	?	?	0.6	2.5	2.0
<i>Opephora martyi</i> Herib.	F/B	ey	24.0	-	1.0
<i>Paralia sulcata</i> (Ehr.) Cleve	M	tp	6.0	1.1	-
<i>Plagiogramma vanheurckii</i> Grun.	M	tp	-	2.2	1.0
<i>Rhaphoneis ampiceros</i> Ehr.	M	tp	3.6	3.4	2.0
<i>Rhaphoneis minutissima</i> Hust.	M	tp	-	1.1	1.0
<i>Rhaphoneis surirella</i> (Ehr.) Grun.	M	tp	-	-	3.0
<i>Surirella ovalis</i> Breb.	B/M	el	-	1.1	-
<i>Surirella ovata</i> Kutz.	B/M	el	-	2.8	2.0
<i>Synedra tabulata</i> (Ag.) Kutz.	B/M	ey	1.2	-	-
<i>Thalassiosira decipiens</i> (Grun.) Joerg.	B/M	pl	3.6	12.9	15.2
<i>Thalassiosira tenera</i> Proshkina - Lavrenko.	F/B	pl	-	4.5	5.1
Unknown centric diatoms	?	?	6.0	3.4	2.0
Unknown pennate diatoms	?	?	4.8	2.8	4.0

**Key to abbreviations used for ecology** (Largely determined by reference to De Wolf (1982) and Vos and De Wolf (1993))

#### Salinity

M	Marine (salinity approx. greater than 30g/l)
B/M	Brackish/Marine (salinity approx. 9 - 30g/l)
B	Brackish (salinity approx. 1.8 - 9g/l)
F/B	Freshwater/Brackish (salinity approx. 0.2 - 1.8g/l)
F	Freshwater (salinity approx. less than 0.2g/l)
?	Unknown

) These 3 categories  
) largely overlap

#### Life form

Plankton
Periphyton
Unknown

pl - plankton	tp - tychoplankton	
ae - aerophilous	be - benthos	el - epipelon
es - epipsammon	ey - epiphyte	
? - unknown		



described by Battarbee (1986). Diatoms were identified by various standard floras (particularly Van de Werff and Huls (1976) and Hartley (1996)) and their ecology was largely determined by reference to De Wolf (1982) and Vos and De Wolf (1993). In general, the diatom preservation was poor, with large numbers of broken valves. Total valve counts for all samples were below the recommended minimum of 300 (Battarbee, 1986) and no diatoms were seen on microscope slides made from samples from bed A, elevation -4.44 m OD and bed C, elevation -4.03 m OD. The results of the diatom analysis are summarised in Table 2 and, as is often the case with diatom assemblages from fluvial and estuarine environments, they include species from a wide range of diatom salinity categories.

### Interpretations and discussion

Unit (i) (bed A) can be correlated with the Shepperton Gravel with reasonable confidence, mainly on the basis of its large mean grain size and top contact elevation (-4.37 m OD to -3.39 m OD). The Shepperton Gravel has a top contact elevation of approximately -6 m OD to +2 m OD in the eastern part of central London (Gibbard, 1994), and borehole records from near to the study area supplied by the British Geological Survey show a gravel unit which is probably the Shepperton Gravel that has top contact elevations of -4.6 m OD, -1.9 m OD and +0.2 m OD in the Bermondsey area and -7.2 m OD beneath the present-day River Thames. Thus, unit (i) was probably deposited in a braided river environment in a cold, probably periglacial, climate between about 15,000 BP and 10,000 BP (Gibbard, 1985, 1994).

Unit (ii) (beds C, D and E) can be correlated with the Tilbury Deposits on account of their small mean grain size and stratigraphic position above the unit correlated with the Shepperton Gravel. The subdivision into beds C, D and E is essentially based on the high organic matter content of bed D. Thus the correlation of beds C, D and E with the specific Tilbury and Thames phases of Devoy (1979, 1982) given in Table 1 is tentative. Nevertheless, bed D (organic-rich with wood peat components, elevation of -4.04 m OD to higher than -2.80 m OD, uncalibrated radiocarbon age of  $5,400 \pm 100$  BP near its base) can be quite confidently correlated with the biogenic deposits of the Tilbury III regression phase (organic-rich with wood peat components, elevation of about -3.8 m OD to -1.5 m OD at Woolwich East, uncalibrated radiocarbon age of about 5,500/4,930 BP - 4,000/3,850 BP (Devoy, 1979, 1982)).

This correlation is interesting when the depositional environments of beds C, D and E are considered. These fine-grained deposits were most probably laid down in a temperate climate in low energy, very wet, fluvial to estuarine environments, such as floodplain ponds and willow and alder carr backswamps.

The generally comminuted state of the plant remains and diatoms indicates significant post-mortem transport, probably as a result of inputs of floodwater.

What is interesting is that the diatom assemblages from borehole 3 indicate that this water was essentially brackish. The periphyton (i.e. those diatoms most likely to be autochthonous) in the sample from bed C are mostly from the freshwater/brackish salinity category (56% of the periphyton valve count) and the bed C assemblage as a whole is dominated by the species *Opephora martyi* (24.0% of the total valve count). Though the ecology of this species is debated, it is generally considered to prefer the fresher end of the brackish water spectrum and to live attached to macro-algae. Thus, the local water salinity for bed C at elevation -4.32 m OD was probably fresh to brackish. The periphyton in the sample from bed D are mostly from the brackish/marine, brackish, and freshwater/brackish salinity categories (these 3 categories comprised 81% of the periphyton valve count). Thus, the local water salinity for bed D at elevation -3.49 m OD was probably brackish. The bed D assemblage as a whole mainly comprises plankton (66% of the total valve count), possibly indicating the proximity of fairly deep water, with the dominant species being *Cyclotella striata* (26.3% of the total valve count). This is a brackish water planktonic species that is very common in European estuaries. Therefore, these findings imply that the tidal head of the River Thames was upstream of Bermondsey as early as 5,400 BP, and possibly prior to that date as well.

This interpretation is unexpected in the light of archaeological evidence and diatom assemblages (2% marine forms, dominant species *Cyclotella striata*) from the City of London which suggest that the River Thames tidal head was only a short distance upstream of the City in the 1<sup>st</sup> Century AD, when sea levels were closer to those of today (Milne *et al.*, 1983). It is also in apparent conflict with the work of Sidell *et al.* (1995) on pollen and molluscs from Bryan Road, Rotherhithe (TQ 79943653) which indicates essentially freshwater conditions at that locality around 5,000 BP. Nevertheless, it is possible. The higher elevation of the Bryan Road site (about -2.7 m OD to -1.4 m OD for the organic-rich deposits) could explain the lack of tidal influence found there. Also, though the reconstruction of past tidal levels is complex (see Haggart, 1995), the highest reconstructed elevations of the mean high water spring tides in the Thames Estuary in the Thames II and Tilbury III phases given by Devoy (1982) (-2.54 m OD and -0.81 m OD respectively, after allowance for compaction) are considerably higher than those of the diatom samples from beds C and D (-4.32 m OD and -3.49 m OD respectively). Furthermore, at Tilbury, Devoy (1979) found that marine species made up about 50% or more of the diatom assemblage in the deposits assigned to the Thames II and Thames III phases between approximate elevations -10 m OD and -2 m OD. Thus, if the average gradient of the lower Thames Valley in those periods was gentler than that of today (due

to subsequent sedimentation "filling" the valley), then tidal influence could have extended a long way upstream. The presence of foraminiferids in a sample taken from bed D (Hill, 1996), clearly suggested the possibility of a brackish water factor.

Since unit (iii) (beds G and H) is only encountered in boreholes 8-11 and 13, and appears to cut into beds D and E, it probably represents local stream deposits. If this is the case then bed G can be considered to be the deposits of a tributary stream channel environment (its very thin deposits in borehole 10 and overall small lateral extent are indicative of a stream, rather than a river) with bed H being fine-grained fill associated with channel abandonment. However, since the Shepperton Gravel has an undulatory upper surface (Bates and Barham, 1995), the possibility that some parts of bed G correlate with the Shepperton Gravel cannot be ruled out. Either way, the depositional environment was a fluvial one, with finds of the mollusc *Margaritifera auricularia* suggesting a temperate climate (recent finds have only been from the rivers of west and south-west Europe and North Africa) and freshwater conditions (Preece *et al.*, 1983).

Unit (iv) can be correlated with modern fill (such as "barge-bed" components) and alluvium (such as gravel lag deposits) on account of the various modern objects found within it. These modern objects indicate that it was deposited after 1,000 BP, and most probably mainly in about the last 250 years since the Industrial Revolution.

In summary, these findings are generally consistent with previous work. Although little of Hill's work is detailed here and whilst some differences exist, the findings of this project largely support his observations and interpretations, notably in the tentative application of Devoy's (1979) scheme to beds D and E. The main new finding compared to previously published work is that the River Thames tidal head was probably upstream of Bermondsey as early as 5,400 BP, and possibly prior to that date as well. However, it should be borne in mind that this interpretation is based on only one site and diatom analysis from only one borehole. Therefore, it is hoped that this work will stimulate further research on the past extent of tidal influence in the lower Thames Valley, particularly in the middle Holocene.

### Acknowledgements

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# NEW OPTICALLY STIMULATED LUMINESCENCE (OSL) DATES FROM A LATE-GLACIAL SITE IN THE KENNET VALLEY AT AVINGTON VI, BERKSHIRE, UK

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## Introduction

The history of human habitation of the British Isles in the Pleistocene is characterised by phases of occupation punctuating sometimes long periods of absence (Sutcliffe, 1995). One of the latest phases of abandonment and recolonisation seems to have occurred towards the end of the Pleistocene during the short-lived Younger Dryas (Loch Lomond Stadial). Following the maximum cold of the stadial, human groups again re-established themselves in southern Britain, although the nature and the precise timing of these events are still a matter of conjecture (Wymer and Rose, 1976; Barton, 1989). AMS radiocarbon dates of late stadial age now exist for one well-stratified lithic artefact assemblage at Three Ways Wharf, Greater London (Lewis, 1991; Hedges *et al.*, 1990) but efforts to date other archaeological sites of potentially contemporary age have been hampered by the lack of associated organic remains. In this paper we report on the OSL (Optically Stimulated Luminescence) dating of sediments enclosing a late-glacial lithic assemblage at Avington VI (Berkshire).

## Site location and background

The site of Avington VI is located at NGR SU 37686714 in the Kennet Valley. It lies approximately 0.5 km west of Kintbury in Berkshire and is situated near the present floodplain at 89.4 m OD (Figure 1). Attention was first drawn to the site during construction of an electricity sub-station in 1964 (Froom, 1970). Excavations by Froom in 1972 and again between 1978-81 in the area immediately outside the sub-station revealed a sequence of deposits of late-glacial/Holocene age. The site provided evidence of Later Mesolithic artefacts and an underlying flint industry of Final Upper Palaeolithic aspect.

The sequence of sediments described by Roy Froom and David Holyoak consisted of slope-derived brownish clays and loams overlying flint gravels (Holyoak, 1980, p. 130). The two archaeological assemblages lay within distinctive horizons of an undifferentiated upper deposit of 'brown silty clay with scattered flint pebbles'. A Later Mesolithic industry typified by small scalene microlith triangles occurred as a diffuse band of artefacts 75-95 cm below the surface; whilst lower down, between 95-115 cm, was an undisturbed knapping floor (Froom, 1970). The lower industry contained long flint blades



greater than 12 cm in length, sometimes with distinctive 'bruised damage' along their edges (Figure 2) (Barton and Froom, 1986). Although difficult to assign culturally because of a scarcity of diagnostic retouched tool types, it is believed that the Avington assemblage and others like it occupy an intermediate chronological position between the Late Upper Palaeolithic and Early Mesolithic (Wymer and Rose, 1976; Barton, 1991).

In addition to the archaeological horizons, interest at Avington has also focussed on a distinctive 'blackish clay (horizon) with high organic content', farther down the sequence, 162-175 cm below the surface (Holyoak, 1980). Despite the fact that pollen counts were extremely low from all depths, Holyoak's analysis of the 'blackish clay' showed a dominance of Gramineae and Cyperaceae pollen as well as traces of tree birch pollen, pine, willow and juniper (1980, Figure 5.4). Based on comparisons with much richer pollen sequences from his work in the Kennet Valley (Holyoak, 1980) and of Hawkins in the Enborne Valley (1953) he tentatively correlated the 'blackish clay' with the 'Alleröd' oscillation (*ibid*).

Since publication of Froom and Holyoak's work, other more detailed late-glacial sequences have been described for the Kennet Valley. In particular, a recent study at Woolhampton (Collins *et al.*, 1996) has established that organic silty sands (known locally as the Wasing Sand) beneath the floodplain date to the latter half of the 'Lateglacial Interstadial'. Pollen evidence and radiocarbon results also reveal that gravels in the overlying sequence have infilled channels dating to around 10,380-9,850 radiocarbon years BP, towards the end of the Younger Dryas/Loch Lomond Stadial (*ibid*, p. 368).

Despite these positive indications the evidence for the late-glacial age of the Avington VI deposits has remained largely circumstantial and up until now no other methods have been applied which would help in dating the archaeological assemblages.

### **New research at Avington VI**

In October 1995, permission was granted by the landowners for renewed investigations of the site by two of the authors (RNEB and SD). The purpose of the work, which was funded by the British Museum, was to re-examine the sections opened by Froom to obtain fresh samples for dating analysis and palaeoenvironmental work. A second objective, which involved extensive trenching of the field, was to establish the maximum lateral extent of the archaeological deposits and underlying sediments (Figure 1).

In the course of the fieldwork three sediment samples were taken from a vertical section of Froom's main excavation trench for OSL dating. The samples were

obtained from the two re-located artefact horizons and from a level below Holyoak's 'blackish clay' (Figure 3). The measured values for the palaeodoses,  $a$ -values and dose rates are presented in Table 1. Monoliths for pollen and sediment thin-section analysis were also taken from the same section.

### Measurement procedures for OSL dating

The samples were treated with dilute hydrochloric acid to remove calcium carbonate, hydrogen peroxide to remove any organic material and Calgon with ultrasonic treatment to remove clays. The material was then thoroughly rinsed in distilled water and the polymineral fine grains (4-11  $\mu\text{m}$ ) separated.

The luminescence signal was measured using an Elsec optical dating system. The luminescence signals from the polymineral grains of each prepared sample were measured by exposure to infrared light, which stimulates a luminescence signal only from feldspars (Spooner *et al.*, 1990). A preheat was also required to remove the unstable signal, resulting from laboratory irradiation, that is not present in the natural signal.

A preheat temperature of 160°C was used and a preheat test was carried out to find the appropriate preheat duration. This involved irradiating aliquots with increasing beta doses from a  $\text{Sr}^{90}\text{-Y}^{90}$  source and making short shine measurements after preheats of increasing duration. For each preheat temperature an additive dose curve was constructed and an equivalent dose, ED (the beta dose giving rise to a luminescence signal equivalent to that of the natural signal), was calculated. These EDs increase in value with preheat time until the time is sufficient to remove all charge unstable over the burial time. The results showed that a preheat of 4 hours at 160°C was required for samples 1523a and 1523b but sample 1523c required a preheat of six hours.

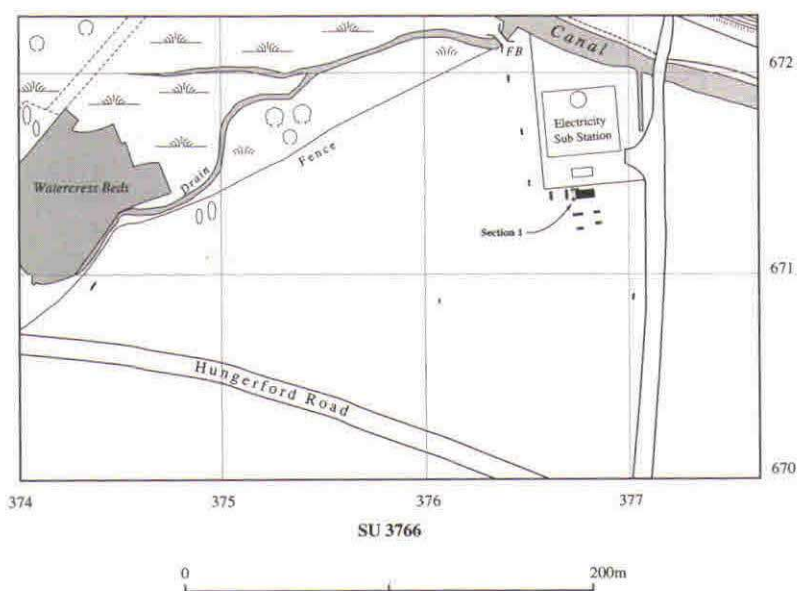
The OSL dating procedure is identical to that described for infrared stimulated luminescence (IRSL) in Rees-Jones and Tite (1997). The annual dose rate received by the sediments during burial was calculated using portable gamma spectrometry, inductively coupled plasma mass spectrometry (ICPMS) and potassium flame photometry. The final dose rate used for the age calculation was a combination of these sets of measurements: the total gamma dose rate and the beta dose rate due to uranium and thorium was determined by on-site gamma spectroscopy and the remaining beta dose due to potassium was determined by flame photometry. The alpha dose was determined using the results of the ICPMS analysis. The water contents of the sediments were also measured at the time of sampling and found to be between 20 and 60% of the saturation values. An assumed value of  $80 \pm 20\%$  was used to indicate the fraction of saturation to which the average water content during burial corresponded.

The errors quoted in association with the age estimates take into account both systematic and random errors (at a 68% confidence level) in OSL measurements, dose-rate measurements and calibrations radioactive sources and equipment. In Table 1 the errors quoted in association with the dose rate only take into account the random errors. However, the systematic error associated with the uncertainty in average water content of the sample during burial is quoted in the final error limit on the age. The calculation of these errors follows the method of Aitken (1976, 1985). The largest contribution to the errors for these samples was that related to the dose rate and the assumed value for the water content of the sediment during the burial period. No tests for anomalous fading were carried out but all the samples were stored for four weeks following irradiation to minimise the effects of anomalous fading. It should also be noted that Rees-Jones and Tite (1997) observed no such fading in 21 of their samples analysed using IRSL.

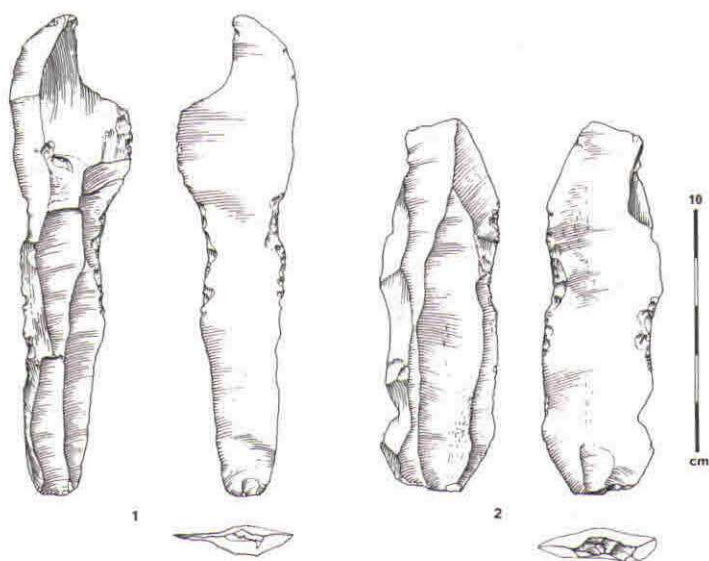
## Discussion and conclusions

Test-trenching of the field at Avington VI (Figure 1) revealed that the thick (lower) sequence of sediments, including unit 2 with the 'bruised blade' flint assemblage, was not well developed laterally. The deposits shelve and thin rapidly in all directions except northwards in the area currently underlying the electricity sub-station. Very few long blade artefacts were found outside the immediate area of the Froom excavations. Four palynological samples were examined by AVM. The pollen preservation and content were too poor to give meaningful pollen counts; they largely confirmed the previous findings of Holyoak (1980) who noted only a slight rise in pollen values in the 'blackish clay', as mentioned above.

The three OSL dates occur in the correct stratigraphic order and the central values are broadly in agreement with the expected ages of these units. Despite the wide error margins, 1523c lies below the 'blackish' clay' and does not contradict the proposed late-glacial age of the basal deposits. However, it is not possible on present grounds to establish whether or not unit 3 correlates with the 'Alleröd soil' observed elsewhere in Britain (e.g. Preece, 1994). This is particularly disappointing given the rich biostratigraphic evidence associated with interstadial-age deposits farther upstream at Woolhampton (Collins *et al.*, 1996). An alternative hypothesis is that the blackish clay deposits are somewhat younger in age. Possible parallels for the Avington sequence may be found in northern France, where observations have shown that well-developed humic-rich horizons can occur within Younger Dryas sediments (Antoine, 1996; Leroyer and Pastre, 1996). It is conceivable, therefore, that the interstadial is missing from the Avington sequence and that the main group of units (especially, units 5-2) belongs to the Younger Dryas/Loch Lomond Stadial. The coherent nature of the stratigraphy and the archaeological indicators would not support a post-glacial age for unit 3.



**Figure 1.** Location of Avington VI and distribution of test trenches. Section 1 is marked.



**Figure 2.** Bruised blades from the Long Blade industry at Avington VI.

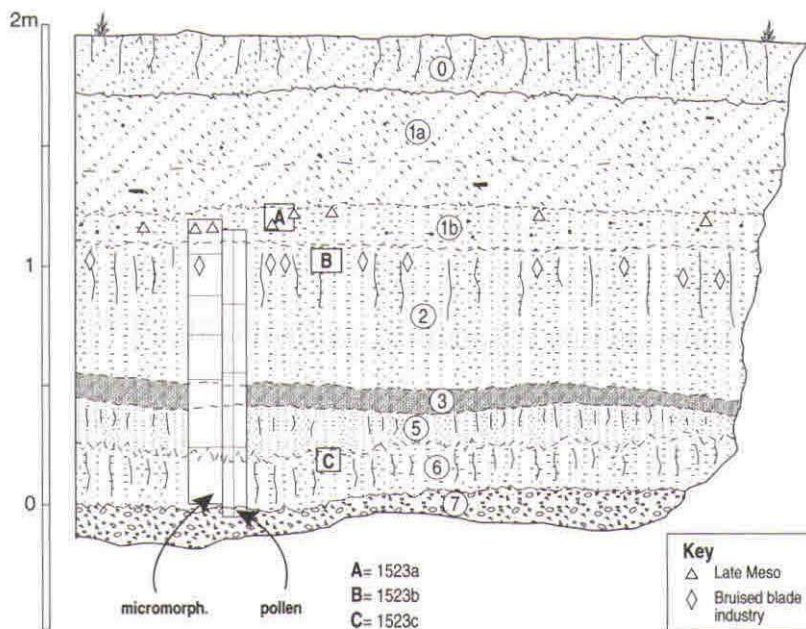
The OSL date 1523b is potentially the most interesting since it provides rare absolute dating evidence for a 'bruised blade' lithic assemblage. There are now some 28 findspots of this kind known in southern Britain (Barton, 1997). The lithic assemblages are all identifiable to a Final Upper Palaeolithic grouping which has parallels in northern France and northern Germany (Barton, 1989). One of the linking characteristics of these industries is the presence of large blades (> 12 cm) and blade cores with formal retouched tools making up less than 2% of the whole lithic assemblage (Barton, 1989). A further characteristic is the presence of heavily edge-damaged long blades or flakes. These are typified by invasive scalar retouch and distinct battering-damage (bruising) along their edges (Figure 2). The damage is often observed on stouter pieces, with a thick or triangular cross-section, as in the case of crested blades. The function of these artefacts has been the subject of long-term debate. Various authors have demonstrated experimentally that the heavily invasive edge-damage can be caused by chopping through organic materials such as hardwood, bone or antler (Bordes, 1967, 1969; Barton, 1989). Others, however, prefer to see them as effective tools for honing or shaping soft sandstone hammers (Fagnart, 1993; Bodu *et al.*, 1997; Fagnart and Plisson, 1997). Whichever is the case, many if not all of the British and European sites provide substantial evidence of knapping manufacture. The sites are often located in valley bottoms near good sources of flakeable raw material, and there is frequently an absence of fire or any sustained evidence of domestic activity. From a technological standpoint the industries are generally very uniform and share more in common with the Upper Palaeolithic than the Mesolithic (Barton, 1991).

The central value of the OSL date from the long blade level at Avington is consistent with the view that assemblages of this type are of terminal Pleistocene or early Holocene age. The only other directly dated long blade site from southern Britain is that of Three Ways Wharf (Uxbridge, Greater London). Here two AMS dates of  $10,270 \pm 100$  radiocarbon years BP (OxA-1788) and  $10,010 \pm 120$  radiocarbon years BP (OxA-1902), were obtained on individual horse bones within a scatter of long and bruised blades (Lewis, 1991; Hedges *et al.*, 1990). These estimates are comparable with radiocarbon ages obtained for the Ahrensburgian level at Stellmoor in northern Germany (Fischer and Tauber, 1986) and the upper industry at Belloy-sur-Somme (Fagnart, 1993, p. 142) where assemblages of equivalent type have been recorded. Interpretation of the radiocarbon record for this period is however complicated by the influence of the 'plateau effect' around 10,000 BP (Becker and Kromer, 1991). The OSL date from Avington, although slightly younger than the radiocarbon estimates, in absolute terms, provides a useful comparison of age from an independent dating source.

The very exceptional preservation of the long blade flint scatters in unit 2 is highly unusual. The fact that millimetre-size chip debris also survives at the site



# AVINGTON VI 1995 Section 1 (S-N)



**Figure 3.** Avington VI, Section 1. Key to unit descriptions: [0] - Grey-brown sandy loam with scattered flints and roots (Plough horizon AP); [1a] - Brown sandy colluvium with reworked Mesolithic flakes; [1b] - Grey-brown sandy loam, with numerous Late Mesolithic artefacts and burnt flints; [2] - Orange-brown (7.5 YR 4/4) fine silty clay with grey hydromorphic patches (10 YR 5/1) and little sandy beds (2-3 cm thick). The structure of this unit is characterised by fine rootlets (<1 mm). The late-glacial bruised blade assemblage is located about 5 cm below the top of this unit. The boundary with the overlying unit (1b) is disturbed by bioturbation; [3] - Grey-black (2.5 Y 3.0) 'humic', compact clayey horizon with iron oxide coatings on the rootlets. This unit contains numerous black root remains (2-3 mm diameter) and very fine vegetal remains (<1 mm); [4] (not visible in this section) - gravel bed with clayey matrix; [5] - Grey-green, compact, non-calcareous very fine silty clay with orange oxidised patches. This unit shows very abundant rootlets (<1 mm) and some black roots (2-3 mm diameter); [6] - Grey-green (5Y 4/2), non-calcareous sandy clayey silt with numerous oxidised patches. The lower 10 cm of this unit is sandier; there is a very clear boundary and the appearance of a calcareous facies with numerous chalk grains, vegetal remains including *Juncus* seeds and sub-vertical black roots; 7 - Chalky fluvial gravels with abundant sandy calcareous matrix, roots and vegetal remains including *Juncus* seeds (note: the chalk is primary chalk, the sediments are not tufaceous).



implies that the artefacts were buried fairly rapidly and by low-energy processes. Possible analogies for this type of sedimentation might be evidenced in deposits filling a late-stage channel not far from Avington cut into the top of the Heales Lock Gravel at Woolhampton. According to Collins *et al.* (1991, p. 367) the gentler flow regime might have been induced by colder year-round temperatures. The radiocarbon dates within the channel of  $9,900 \pm 100$  radiocarbon years BP (AA-11977) and  $9,900 \pm 70$  radiocarbon years BP (AA-11974) indicate that the period of channel infilling took place towards the end of the Pleistocene/earliest Holocene. It is also significant that the pollen assemblages extracted from the channel show an open environment dominated by Gramineae and *Filipendula*, types also recognised by Holyoak in the upper part of the Avington sequence. Farther afield, in northern France, parallels for the infilling of channels with fine silts in the Younger Dryas have likewise been noted (Antoine, 1997).

Finally, the OSL date 1523a from the uppermost archaeological level is broadly consistent with the identification of the Later Mesolithic assemblage. At one standard deviation the age is slightly younger than might normally be expected for a microlith scalene industry of this type (Barton *et al.*, 1995), but since the date is on the enclosing sediment rather than the artefacts themselves, it would seem to be acceptable as an estimated minimum value.

**Table 1. OSL Measurements**

Lab. ref.	Palaeodose (Gy)	a-value	Dose-rate (mGy/year)	Age (years)
1523a	$11.40 \pm 0.63$	0.06	$2.19 \pm 0.08$	$5,200 \pm 800$
1523b	$28.78 \pm 0.47$	0.06	$2.81 \pm 0.07$	$10,250 \pm 1,100$
1523c	$38.30 \pm 1.66$	0.07	$2.95 \pm 0.07$	$13,000 \pm 1,350$

### Acknowledgements

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# REPORTS

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## QRA BRITTANY FIELD EXCURSION

12th-15th September, 1997

The majority of the party for the excursion gathered at the Inter Hotel in St Malo on the 11th September, enjoying a pleasant meal and company after a long journey, with the later evening arrivals managing to obtain cold food from the kitchens, having travelled down from the preceding Netherlands field excursion. The remaining members of the party joined the group from the St Malo ferry terminal on the morning of the 12th.

For the purposes of the excursion, the organisers (**Brigitte Van Vliet-Lanoë**, **Bernard Hallégouët**, and **Jean Laurent Monnier**) divided Brittany into 5 geographical regions: St Brieuc Bay, the Finistere, the Crozon Peninsula, Audierne Bay and the Vilaine Valley. The field guide to the excursion was produced in two sections, the first with a background to the geology, sea-level history, archaeology and dating methods used in the region, and the second detailing the sections visited during the course of the meeting.

The first region visited was St Brieuc Bay (Friday). Sections were examined at Nantois, Piegu and Port Lazo. Nantois provided a sequence of calcareous Saalian loesses, an Eemian soil complex and a last glacial succession, in a 24 m high cliff sequence, topped with Holocene dunes. The dating of the sequences relied mainly on TL and ESR dating (**Manfred Frechen**) in the absence of other stratigraphic markers or biostratigraphic information, bar the identification of molluscan fauna from both Nantois and Piegu by **David Keen**, which serves to provide climatic information.

The first day was finished at Port Lazo, another loess complex, containing multiple palaeosols, attributed by the organisers to Oxygen Isotope Stage 11 to the Holocene, based upon a count-from-the-top approach, and correlation with other deposits in the region. The programme for the day finished early enough for an unscheduled trip to an extensive (3 km+) Holocene spit, which had an interesting history of seaweed exploitation by locals for fertiliser.

The Saturday began with a morning visit to Barrenness Cairn, an impressive megalithic structure, with a colourful guided tour by **P. Giot**, who excavated the Cairn between 1955 and 1968 following damage to the tombs by local builders in search of stone. Lunch was taken at Le Vougot, another beach site with splendid palaeosols recording the last interglacial/glacial cycle. Interesting

comparisons between the sites visited and those seen in Cornwall were noted, especially more humid palaeoclimatic conditions during the Younger Dryas. The night was spent in a hotel at Châteaulain, where the bar was shared with an active French wedding party.

An early rise on the Sunday morning afforded splendid views across the Crozon Peninsula from a regional high point, allowing the party to obtain a physical overview of the local topography. The Trez Rouz section on the northern branch of the Crozon Peninsula includes a shore complex, with an alluvial folded peat (Holsteinian by palynology) in periglacial slope deposits. ESR dating is also underway at the section. The further implications for the age of the peat are in consideration of neotectonic activity in the area. The next site, at Pen Hat, is a bay site, with an important lithic assemblage, creating a prehistoric settlement landmark for the south-Armorican coast.

Audierne Bay included the site at Menez Dregan, a multi-discipline study of a spectacular collapsed sea-cave site with multiple occupation horizons and an abundance of artefacts (over 20,000 worked flints at present excavated) and hearths, with primary occupation thought to occur in Oxygen Isotope Stage 13. A stroll along the coast from this site allowed various raised beach sections and the exposures at Gwendez to be viewed.

The final day of the excursion was spent in the Vilaine Valley. Throughout the region the underlying geology was described by **J. Chauvel**, with the expertise of **J. Renouf** as translator. The first stop was the section at Penestin, a location which records successive transgressions from the Eocene to the Middle Pleistocene, and provides evidence of the westward shift of estuaries along the southern coast of Brittany since the Neogene. Ice wedges and stone wedges in the sediments are the most southerly evidence for continuous permafrost in Western Europe. The final stop for the group was a high terrace of the Vilaine, exposed by a quarry, with a crude archaeological industry which has been placed at the beginning of the Middle Pleistocene.

At this point praise for the hospitality shown by our hosts must be mentioned, with every detail (lunches, comfortable hotels with good bars!, local specialities for evening meals) thought of. The organisation required to move a large group of foreign academics is certainly appreciated, and our hosts did everything possible to ensure our enjoyment of the meeting. Possibly the only slight disappointment about the excursion was the low number of postgraduate students that attended. The QRA field visits provide a good format to meet academics as well as a chance to meet fellow postgraduates in an informal non-conference situation.

**Ralph Fyfe**  
**University of Exeter**



## CRYOSTRATIGRAPHY RESEARCH GROUP FIELD MEETING IN KENT

2nd-4th April, 1998

The second meeting of the *Cryostratigraphy Research Group* took place in Kent. The meeting had two themes, Devensian late-glacial environments and chalkland periglacial stratigraphy. The meeting was based at Wye College, attended by 36 participants and organised by **Julian Murton** (Sussex).

### Day 1: Late-glacial environments

The first site visit, led by **Charles Harris** (Cardiff), was to the foot of Hubbard's Hill (TQ 534518), on the south-facing scarp of the Lower Greensand Hythe Beds, near Sevenoaks. Extending south from the scarp are three head deposits, the upper - of Younger Dryas (Loch Lomond Stadial) age - terminating in a lobate frontal bank. Within and at the base of the two upper head deposits occur shear surfaces, suggesting that downslope displacement was principally by shearing over distinct slip surfaces. Shearing is thought to have occurred during late summer thaw consolidation of a former ice-rich layer, a possible analogy being drawn by Charles with modern active-layer detachment slides on Ellesmere Island, arctic Canada. Discussion of the site focussed on the frozen-ground conditions and the time of movement of the upper head deposit. **Frans Gullentops** (Leuven) questioned whether permafrost was present in this area during the Younger Dryas, suggesting that slope movement may have occurred during thaw of deep seasonal frost. In addition, Frans noted the freshness of the lobe morphology, inferring that downslope movement of at least some of the material probably took place during the Holocene, perhaps even in the latter part. Clear evidence of such recent movement on a similar lobe was examined at the next locality.

The second locality, c. 1 km to the east of Hubbard's Hill, was at Romshed Farm (TQ 547518), also below the Lower Greensand scarp. At this site **Peter Allen** (Cheshunt), **Andy Haggart** (Greenwich and Royal Holloway) and **Colin Whiteman** (Brighton) described their study of a large 'solifluction' lobe with three, possibly four, orders of smaller lobate features superimposed on it. At least one of the lobate features may have collapsed and been breached, leading to the formation of a lower order lobe extending out in front of it. Although the main lobe is thought to be of equivalent age to the lobes at Hubbard's Hill (Younger Dryas), the smaller superimposed lobes are probably significantly younger, based on the freshness of the lobe morphology and on farmers' reports of minor ground movements. A pit excavated through the front of a second-order lobe was examined by the group, revealing a clay-rich head deposit. Macrofabric data from a number of pits generally show patterns less tightly

comparisons between the sites visited and those seen in Cornwall were noted, especially more humid palaeoclimatic conditions during the Younger Dryas. The night was spent in a hotel at Châteaulain, where the bar was shared with an active French wedding party.

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constrained in orientation and range of dip than those typical of solifluction deposits.

Following lunch in Sevenoaks, the group visited Upper Halling (TQ 692635), where **Richard Preece** (Cambridge) showed us a new trench through a perfectly exposed sequence of Late Devensian and Holocene chalky deposits. Prominent in the sequence was a buried, grey rendzina palaeosol of Alleröd age; this horizon, at a nearby site, has provided charcoal fragments with AMS  $^{14}\text{C}$  age estimates of  $10,900 \pm 120$  BP and  $11,240 \pm 110$  BP. The land snail fauna from an adjacent section shows a marked maximum abundance of snails in the Alleröd soil and a smaller maximum in a lower unit of white chalk mud attributed partly to the Bölling Oscillation. Above the Alleröd soil is a crudely stratified chalk rubble and mud assigned to the Younger Dryas. Would that such an excellent section through these late-glacial deposits were permanently open for teaching and research purposes.

The final locality of the day was the Devil's Kneadingtrough (TR 077453), a dry valley (coombe) incising the North Downs scarp, near Wye. This striking dry valley is notable for its steep sides, flat bottom (cross-profile) and floor deposits, as described by Richard Preece. The upper ~1.5 m of these deposits, examined in a section near the head of the valley, included earthy, humic hillwash from which Neolithic pottery fragments, flint flakes and charcoal have been observed previously, the charcoal providing a radiocarbon age estimate of  $4,540 \pm 145$  BP. Lower deposits, not currently exposed, comprise chalky rubble and silt of periglacial origin that extend out from the valley mouth to form a large fan that overlies deposits of Windermere Interstadial age, indicating that significant valley erosion and deposition took place during the Younger Dryas. The erosion may have been due in part to meltwater from a former snowbank which Frans Gullentops inferred to have existed in a shallow hollow in the scarp crest.

An evening lecture on "Chalkland periglaciation, Isle of Thanet", was given by Julian Murton at Wye College, in preparation for the following day's fieldwork. Julian described the Quaternary stratigraphy of Thanet, drawing comparisons of the brecciated chalk and involutions with similar features in modern permafrost terrain. The ensuing discussion focussed on the timing of involution formation by soft-sediment deformation: recurrently in the active layer and/or episodically during thermokarst activity.

## **Day 2: Chalkland periglaciation, Isle of Thanet**

The second day of the field meeting, on the Isle of Thanet, was led by Julian Murton, **Colin Baker** (St Lawrence College), **Mark Bateman** (Sheffield) and

Colin Whiteman. It began with a walk from Grenham Bay (TR 292700; Figure 1) east to Epple Bay (TR 307697), stopping en route to observe the stratigraphy exposed in coastal cliffs. The stratigraphy, in ascending sequence, comprises unweathered chalk, brecciated chalk, an involuted layer and sand. The upward transition from unweathered to brecciated chalk is particularly well exposed near Beresford Gap (TR 298699), where Julian attributed the brecciation to the growth of segregated ice just beneath the former permafrost table, similar to brecciated, ice-rich limestones, arkoses and shales in Svalbard and Canada.

More problematic to interpret are the involuted layer and the sand-filled depressions above the brecciated chalk. Although many involutions closely resemble soft-sediment deformation structures, several uncertainties remain, for example the exact timing of deformation (e.g. seasonal and/or during a thermokarst episode), the role of differential frost heave, the local concentrations of flints and the origin of the depressions (? patterned ground), as discussed by Julian, Colin Baker and Charles Harris. Recent luminescence dating of sand at the base of and above the involuted layer by Mark Bateman suggests that the involuted layer formed between ~27 and ~17 ka BP, that is, within the period when a regionally extensive involuted layer formed in countries such as Belgium and The Netherlands. An interesting suggestion was made by Frans



**Figure 1.** Periglacial stratigraphy at Grenham Bay, Birchington, on the Isle of Thanet, Kent. Brecciated chalk is overlain by an involuted layer ( $\leq \sim 1.5$  m thick) of probable Late Devensian age. Extending down into the involuted layer is a sand-filled depression thought to represent large-scale patterned ground. Photograph by Julian Murton.

Gullentops that a dark brown clayey loam present within parts of the involuted layer may be an Eemian (Ipswichian) palaeosol.

Other features examined at Grenham Bay included vein structures and infilled cavities within the brecciated chalk. The vein structures are 1.3–3 m high, commonly a few cm wide and have a fill of pasty and pebbly chalk distinctly finer than the host brecciated chalk; possibly they mark the sites of former ice veins in permafrost. The infilled cavities are 2–3 m wide, at least 2 m deep and truncate both the involuted layer and underlying brecciated chalk. They contain massive to steeply stratified loam and chalky debris, with pottery fragments and abundant marine shells. These features may have been used by humans for dumping waste materials during the mid- to late Holocene.

The second locality was at Palm Bay (TR 372715), Cliftonville. Here the brecciated chalk comprises a deformed upper layer with small open folds, and a lower, undeformed layer characterised by undisplaced chalk blocks with 'matched' sides. Above the brecciated chalk are well-developed involutions, some with prominent 'necks', developed in chalk diamicton and pebbly silt.

After lunch beside Kingsgate Bay, the group briefly visited Joss Bay (TR 399701), North Foreland, to examine a section through an asymmetric dry valley. In the valley centre, a flint band (Whitaker's Three Inch), passes through the brecciated chalk, where it has been fragmented and folded, presumably by frost heave and/or thaw consolidation. Above it, the involuted layer contains a large flame structure of chalk diamicton and, at the base, an involuted sand - probably coversand. Discussion centred on the origin of flints within the involuted layer: down-valley movement of part of the involuted layer by solifluction; and crudely stratified loam and gravel, probably meltwater deposits.

The Field Meeting ended at Pegwell Bay (TR 360642), Cliffsend, where a complex stratigraphy remains to be fully recorded and interpreted. Brecciated chalk underlies a well-developed involuted layer that is locally cut by sand-filled depressions and overlain by Late Devensian loess. At least two generations of involutions are present, the main generation comprising the involuted layer itself, and a later generation extending up into, and therefore post-dating, the basal loess. Some of the loess has probably been redeposited, based on the occurrence of faint, low-angle strata and granule-pebble stringers near the base. The lower contact of the loess is in places sharp, truncating involutions, and may represent an erosion surface formed by meltwater and/or aeolian activity, perhaps of similar age to the Beuningen Gravel Bed on the Continent.

An infilled, asymmetric dry valley is also exposed at Pegwell Bay. The valley fill comprises a basal flinty gravel (~1–2 m thick) overlain by several metres of



silty loam. Two samples of loam, analysed by Mark Bateman, have yielded provisional luminescence age estimates of between ~ 100 and 110 ka BP. Frans Gullentops interpreted the loam as Saalian loess, noting that a slightly iron-stained horizon near the top of the valley fill possibly represents an Eemian (Ipswichian) soil.

Perhaps the most puzzling feature at Pegwell Bay is the origin of a coarse chalk diamicton that underlies the Palaeocene Thanet Beds at Redcliffe Point (TR 354644) and fringes the infilled dry valley. The diamicton closely resembles Coombe Rock, which is generally regarded as a chalk solifluction deposit. However, solifluction can be discounted out at Redcliffe Point because the overlying Thanet Beds appear to be *in situ*. As emphasised by **Peter Hopson** (BGS, Keyworth), the exact provenance of the chalk clasts needs to be established by detailed microfossil biostratigraphy.

The Kent Field Meeting proved both enjoyable and successful, generating valuable discussion and identifying promising avenues for future research. In addition, two important lessons were underlined: first, the necessity for integrating detailed, comparative studies of periglacial sequences in both modern and former permafrost to appreciate the stratigraphic and geomorphic significance of ground ice; and second, the inestimable value of senior QRA members attending field meetings, to pass on their field experience to those keen to learn from them.

**Julian Murton**  
University of Sussex

## THE QUATERNARY OF KENT AND SUSSEX: ANNUAL QRA FIELD MEETING

4th-7th April, 1998

This year's Annual Field Meeting commenced on the afternoon of Saturday 4th April in the Medieval surroundings of Wye College, Kent. Here over 60 QRA members assembled, many already in a 'field meeting mood' following two days at the Cryostratigraphy Research Group Meeting. After dinner, the party reconvened in the 14th century College Hall, where **Martyn Waller** (Kingston) and **Antony Long** (Durham) set the scientific scene with an introductory lecture on the tectonic and vegetational history of south-east England. Appropriately enthused, the group dispersed, many to the village pub.

### Day 1: Canterbury area

The first morning's excursions focussed on the terrace deposits of the Kentish Stour. At Fordwich, the first stop, **Dave Bridgland** (Durham) gave a brief history of the river, explaining how during Pleistocene times the Stour had formed a south bank tributary of the Thames. **Mark White** (Archaeology, Cambridge) went on to describe the archaeology of the site, which is significant because it includes the 'Fordwich Industry', a distinctive technology characterised by simple tools. He put forward his view that the typology of the artefacts has no bearing on their antiquity, but instead reflects the shape of the local flint. There followed a lively discussion on the age of the Fordwich deposits. In a cheerfully provocative mood, Dave Bridgland argued that if **Darrel Maddy's** (Cheltenham) recently published model of tectonic uplift (Maddy, 1998) is applied to the Stour, then the Fordwich deposits could be of considerable antiquity, possibly of early Middle Pleistocene age. **John Wymer** disagreed, arguing that at 48 m OD, the deposits are only a few metres higher than the late Anglian Black Park terrace deposits of the Thames.

After negotiating a circuitous route around Fordwich village, the party arrived at Sturry, less than a kilometre to the north. In contrast to Fordwich, the Sturry deposits are assigned to a younger Stour aggradation, formed after the river had established a new, more entrenched course in the Chalk. Undeterred by the miserable weather, Dave Bridgland drew the party's attention to one of the significant characteristics of the site: the record of Levallois flintwork in the upper part of the sequence. He argued that this might support a correlation with the Corbets Tey Formation of the Thames, which he assigns to Oxygen Isotope Stage 8.

To an onlooker, the party must have presented a somewhat unusual spectacle at the next site, Chislet, where access to the sections required a single-file procession through a flowering rape field. The exposures were worth the effort; with a variety of temperate fossil remains, the site proved to be one of the most

interesting in the Stour sequence. The age of the site again prompted much discussion. **David Keen** (Coventry) drew attention to the presence of *Corbicula fluminalis* in the molluscan fauna, arguing that this supports a correlation with Stage 7 or earlier. Dave Bridgland commented that a Stage 7 age would tally well with the position of the deposits in the terrace sequence. **Danielle Schreve** (Durham) favoured a slightly greater age, arguing that the record of Russian Desman in the vertebrate assemblages is more consistent with a Hoxnian age.

After lunch in Chislet, the party made its way northwards to the coast, to Swalecliffe, where **Chris Green** (Royal Holloway) described two suites of fossiliferous Late Pleistocene sediment which occur in the vicinity. **Tim Allen** (Canterbury Archaeological Trust) explained how the area also has a long history of human occupation, spanning a range of time periods. Pointing across the foreshore, he gave a vivid account of how the occupied sites have moved progressively inland since the 13th Century in response to marine encroachment.

From the north Kent coast, the group headed swiftly southwards to Holywell Coombe on the south coast, where **Richard Preece** (Zoology, Cambridge) gave a rapid review of the 13,000-year history of the site. From a vantage point on top of Castle Hill, it was possible to make out a small mound on the valley floor which now conceals the Channel Tunnel. Previously, this was the location of a richly fossiliferous sequence of colluvial and tufa deposits - probably the most important of its kind in southern Britain.

## Day 2: Dungeness and the marshes

Stutfall Castle, near Lympne, was the rather unusual meeting point for the second day's excursions. Perched on top of a fossil cliff-line, the castle offers an impressive view over Romney Marsh and the English Channel. **John Hutchinson** gave a fascinating account of his work on the stability of the underlying cliff slope, explaining how a series of excavations around the castle's foundations have provided a wealth of geotechnical information. One of the most exciting discoveries was the record of a large landslide dating from around 600 AD. This tilted the castle's Roman foundations and carried material over 30 m down the slope.

A convoy of 21 cars, two minibuses and a coach made its way south-westwards to the next stop at Church Brookland. Here Antony Long outlined the history of the Romney Marsh depositional complex, explaining how a long transect of borings has recently shed much light on the local stratigraphy. Martyn Waller described the palaeobotany of some of the marsh sediments. Contrary to early interpretations, his work has shown that the pattern of peat development was locally highly variable. The peat lovers amongst the group had a chance to see some of this material close-hand in a series of newly extruded cores.

After a couple of unscheduled U-turns, the convoy arrived at Midley, the next stop, where a long ridge of sand generated much discussion. Assigned to the 'Midley Sands', this deposit was once thought to have formed a large barrier,

behind which much of the peat sequence originally developed. Recent coring investigations by Antony Long and others have shown that this was not the case; the sand actually post-dates the peat. A number of explanations were put forward to explain the origin of the sand, amongst them aeolian processes and sedimentation in a local tidal channel.

After lunch, the party re-assembled at the top of the Dungeness Lighthouse, where the shingle barrier can be seen in its entirety. The Dungeness Nuclear Power Station loomed large in the foreground, separated from the sea by a narrow strip of shingle. In the more sheltered surroundings of the lighthouse foyer, Antony described the complex history of the barrier, explaining that whilst its formation dates back to mid-Holocene times, it is currently in a phase of reorganisation. Under a scenario of rising sea level, continued sediment starvation and changing storm activity, the barrier has an uncertain future.

At the last two excursion points of the day, Broomhill and Winchelsea, **Mark Gardiner** (Queen's University, Belfast) showed how the barrier and marsh complex have had a major impact on human activity. Of the many examples, the most vivid was the abandonment of the town of Winchelsea during the 13th Century following a period of rapid barrier erosion. A short stop at the site of New Winchelsea, several kilometres inland, gave Martyn Waller the chance to describe some of his work on the vegetational history of the neighbouring Brede Valley.

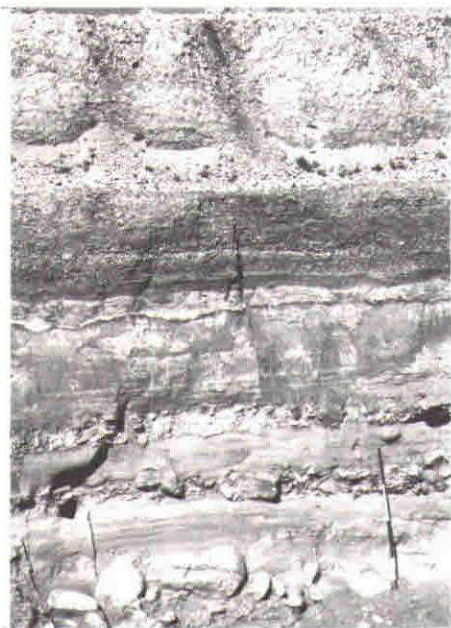
The day ended at the Booth Natural History Museum in Brighton where a drinks reception was held to celebrate the launch of Richard Preece's and Dave Bridgland's eagerly awaited book on Holywell Coombe (Preece and Bridgland, 1998). It was a pity the publishers weren't in attendance; they not only missed a pleasant evening but also an excellent marketing opportunity.

### **Day 3: West Sussex raised beaches**

On the final day, the group assembled beneath the towering cliffs at Black Rock, Brighton to observe the raised beach and 'head' sequences. With the 30 m high sections in full view, John Hutchinson drew attention to the difficulties of obtaining accurate height data from this type of site, and explained how this problem had been overcome at Black Rock by using a new type of reflective levelling instrument. David Keen and **Simon Parfitt** (Natural History Museum) described the biostratigraphy of the raised beach unit, both agreeing that the sequence could be assigned to Stage 7. For energetic members of the group, a ladder was provided to allow close inspection of the sections.

In terms of its sea-level history, the flight of raised beach and marine terraces of the West Sussex coastal plain is without doubt one of the most important sequences in Britain, spanning the early Middle Pleistocene to the Late Pleistocene. At the second stop of the day, Norton Farm, **Martin Bates** (Institute of Archaeology, London) described some of his work on the middle part of this sequence, explaining how a series of borings, geophysical surveys and biostratigraphical investigations have shed much light on the distribution

and age of the sediments. Two late Middle Pleistocene raised beach units, the Norton Raised Beach and the Aldingbourne Raised Beach, were described and assessed in the context of the records from Black Rock and other sites in the region. Simon Parfitt, Richard Preece and **John Whitaker** (Natural History Museum) contributed to the biostratigraphical discussions, John Whitaker noting that the Norton Farm foraminifera and ostracod assemblages are unique in that they include a combination of elements unknown in modern shallow marine environments. It was interesting to hear his verdict on this finding; we should apply caution when applying uniformitarian principles to Pleistocene assemblages.



**Figure 1.** One of the Boxgrove sections viewed by QRA members. The three cycles of the Slindon Sands can be seen at the base of the sections overlain by the Eartham Gravels.

The climb up the flight of West Sussex raised beaches ended at Boxgrove (Cover photograph; Figure 1), where the rich variety of sediments and archaeological remains and the superb sections provided a fitting climax both to the day and to the meeting's proceedings. **Mark Roberts** (Institute of Archaeology, London) led the party around a series of exposures, describing the stratigraphy and history of research at the site. The lively discussions which followed focussed not only on the age of the interglacial beds (which are widely assigned to the Cromerian Complex) but also on the record of animal butchery.

All the sections, including a new exposure of the Slindon Silts, were truly outstanding; clearly a great deal of effort had gone into their preparation. This provided a timely opportunity to discuss the long-term conservation of the site. **Natalie Perkins** (English Nature) reassured the group that this is high on English Nature's agenda and outlined some of the conservation options.

Notwithstanding the variable April weather, this was an excellent meeting. It had the perfect blend of varied and interesting sites, good exposures and lively discussions. Together these made for a most enjoyable three days. The organisers, **Julian Murton** (Sussex) and **Colin Whiteman** (Brighton) are to be congratulated.

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**Department of Geographical Sciences**  
**University of Plymouth**

## **QRA NEW RESEARCH WORKERS' AWARDS SCHEME**

Since its introduction just over a decade ago, the *Young Research Workers' Awards Scheme* has achieved great popularity and success, supporting many field expeditions, geological surveys, coring activities and visits to laboratories. Funds have also been used to purchase essential field equipment and to assist with the cost of laboratory analyses.

With the same goals as the previous scheme, the newly named *New Research Workers' Awards Scheme* will continue to provide financial support to new researchers engaged in all aspects of Quaternary research.

The scheme is primarily aimed at researchers studying for higher degrees, although applications are also welcomed from other new researchers. Preference will be given to those who have no source of fieldwork funding, or whose access to such funds is limited. To be eligible for the scheme you must have been a QRA Member for at least six months and must **not** hold a doctoral degree or a tenured academic position. The scheme is not open to undergraduate researchers.

In order to provide more rapid access to funds than in previous years, the new scheme will have three annual deadlines:

15th January

15th May

15th September

Applications should state clearly the purpose for which the award is intended and should contain full details of all sources of funding to which the applicant has access. Applicants should note that these awards are essentially contributions to research and would not normally be expected to cover the costs of an entire project. The maximum limit for each application is £250.

On completion of their investigations, successful applicants will be expected to submit a short report (500-800 words) to the Awards Committee detailing the work for which the award was made. This will be published in *Quaternary Newsletter*. Potential applicants take note: this provides an excellent publishing and publicity opportunity.

For further details and an application form please contact:

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## **YOUNG RESEARCH WORKERS' AWARDS 1997**

### **ENVIRONMENTAL RESPONSE TO EARLY HOLOCENE HUMAN ACTIVITY: FURTHER RESEARCH IN NORTH- CENTRAL HUNGARY**

**Adam Gardner**

**Godwin Institute for Quaternary Research, University of Cambridge**

Generous assistance by the QRA contributed towards the expenses of fieldwork in north-central Hungary. The aim of this work was to obtain a core for palaeoecological analysis to complement an existing core from Sirok Nyírestő, a small bog in the same region. This is in addition to cores previously obtained from 4 sites elsewhere in south-east Europe; 2 from Slovenia and 2 from Greece, all of which form the basis of a Ph.D. project. Entitled *The Impact of the Neolithic Transition upon the Landscape of South-East Europe*, this project aims to address the question of scale of activity of prehistoric populations for the first time in a European palaeoecological study. Palaeoecological investigations into the Neolithic transition have hitherto failed to correlate with published archaeological chronologies for agricultural settlements, with excavated finds of domesticates preceding palaeoecological evidence for land clearance by at least 2,000 years. The earliest agricultural activity in Europe is hypothesised to have occurred on a localised scale, exploiting small anthropogenically cleared plots and natural open land which remain palynologically invisible in conventional palaeoecological studies. This study has concentrated on detecting these small clearings by analysing the cumulative effect on forest composition of repeated canopy-opening.

In order to address the principal issue of scale of activity, only basins of less than 300 m diameter have been selected for analysis. In addition, coring sites are all in a region of excavated Neolithic settlement and contain two basins, one on-site (within 200 m of the settlement) and the other off-site. Cores have been collected from Hungary, Slovenia and Greece and have been subject to a suite of analytical techniques including pollen, charcoal, sedimentological and geochemical analysis. Correlation with the archaeological record is essential, therefore a rigid dating control supplied by five AMS dates per sequence has been implemented. Geochemistry has been performed by inductively-coupled plasma atomic-emission spectrophotometry (ICP-AES).

This most recent period of fieldwork commenced with surveys of potential coring sites and visits to well-known archaeological sites (such as Tisza-Polgár) in order to gain impressions of the spatial distribution of Neolithic settlement, in the area. The coring site selected is a small oxbow lake 200 m



from the double tell site of Tarnabod-Templőnföld, a former meander of the river Tarna cut off at approximately 29,000 BP. The tells are dated to 5,240 (cal.) BC (Kohl and Quitta, 1963) and form part of a dense pattern of settlement, on the floodplains, which has existed since the late Mesolithic (Kertész *et al.*, 1994). Overlapping cores were obtained from the lake and laboratory analysis is in progress. Loss-on-ignition and geochemical profiles have been completed and pollen and microscopic charcoal analysis is under way. Malacological analysis is being performed by colleagues at Kossuth Lajos University, Debrecen, Hungary. The completed data set will be used to assess the initial impacts of early agricultural sites and then be correlated with the record from Sirok to assess the spatial extent of these impacts. Together with the records from Slovenia and Greece, these data will then be used to assess the response from differing ecological conditions across the south-east European peninsula.

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## PARAGLACIAL MODIFICATION OF DRIFT-MANTLED HILLSLOPES

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### Introduction

Glacier retreat introduces an abrupt and radical change in the upland environment, exposing vast quantities of drift which is often vulnerable to erosion, reworking and mass-movement by hillslope processes. This 'paraglacial' activity relates to the work of 'non-glacial processes that are directly conditioned by glaciation' (Church and Ryder, 1972), a concept recognised as offering new light on the development of deglaciated mountain environments. The aim of this research is threefold: 1) to identify and establish the extent of paraglaciation on deglaciated drift slopes; 2) to diagnose the conditioning factors (both extrinsic and intrinsic) for ancient and renewed/delayed activity; and 3) to model the temporal pattern of paraglacial hillslope adjustment.

## Research programme

Fieldwork supported by the QRA Young Research Workers' Awards was undertaken in the Jotunheimen massif in western Norway to test initial theories regarding paraglacial slope adjustment and sediment reworking. Four weeks of fieldwork were carried out in June-July 1997 in and around Leirdalen and Visdalen. This included: 1) mapping and field survey of both *in situ* and reworked glacial drift; 2) EDM survey of gullied drift to establish the nature of hillslope modification, slope thresholds for sediment reworking and the volume of reworked drift; 3) excavation and logging of gully sections to obtain a three-dimensional picture of the architecture in both *in situ* and reworked drift deposits; and 4) sedimentological analyses of representative units to distinguish the characteristics of reworked and *in situ* drift, and to allow reconstruction of reworking processes.

## Extent and conditions

Mapping has provided a quantitative and qualitative impression of the extent of paraglacial activity at the two sites in the Jotunheimen. Whilst evidence is plentiful for widespread paraglacial modification of steep valley-side drift sequences of Preboreal age, drift within Little Ice Age glacier limits is largely intact. However, where paraglacial slope modification has occurred within Little Ice Age limits, it is limited to reworking of lateral moraines that exceed 35° in gradient and are overlooked by gullies in the headwall upslope. Similarly, in the trunk valleys unoccupied by Little Ice Age ice, drift slope gullying has primarily occurred where drift is thick, steep and downslope of either rock gullies or natural hollows. Although most of these gullies are currently inactive, there is evidence for localised renewed reworking of drift outside the Little Ice Age limits, suggesting that the widely recognised increase in storminess during the Little Ice Age may have initiated renewed reworking of drift slopes exposed at that time.

## Slope adjustment

To establish the nature of paraglacial adjustment of drift slope form, 14 pairs of slope profiles were surveyed on terrain exposed by recent and ancient ice retreat, where fragments of the extant slope have survived beside gullies. Transects were also surveyed across these gullies to permit estimation of sediment loss and mean ground surface lowering, as well as to help establish a model of gully evolution. In some cases where further gully floor modification has been limited through a reduction of gully floor gradient and/or incision to bedrock, renewed reworking of ancient tills has occurred on ridges of hitherto ungullied terrain.

## Sediment sources

Valley-side gully sections outside Little Ice Age limits have been excavated and logged to obtain a three-dimensional picture of the architecture of both *in situ* and reworked drift deposits. Many of the gully sections examined contain two sediment associations, the upper interpreted as massive debris flow facies and the lower, the upper surfaces of which are locally truncated, as an *in situ* glacial deposit, probably deposited during the Preboreal. Thus the sediment sources for current localised renewed reworking include not only ancient glacial deposits, but also paraglacial sediments deposited shortly after shrinkage of glacier ice during the Preboreal. The absence of a palaeosol between the two associations indicates that paraglacial resedimentation of the underlying glacial drift marked a rapid response to deglaciation.

## Sedimentological modification

Findings from earlier work confirm that glacial deposits are sedimentologically modified through paraglacial resedimentation, and can be distinguished from *in situ* deposits on structural grounds, preferred clast orientation and fine-fraction granulometry. Further sediment sampling has cast doubt on the use of fine-fraction granulometry as a general diagnostic criterion for the correct identification and distinction of *in situ* and resedimented drift samples from sites of varying lithology. Samples have also been withdrawn from reworked and *in situ* drift for calculation of void ratio, which, as a surrogate for sediment consolidation, may provide another aid for the differentiation of *in situ* and paraglacially resedimented glacial deposits.

## Conclusions

Although these initial findings are pending further analysis, it is already apparent that the data collected provide a valuable source of information regarding the extent, nature and timing of modification of drift-mantled slopes following ice retreat. Initial results complement findings from other areas, and support the view that the concept of paraglacial hillslope modification offers an important contribution to the understanding of deglaciated mountain environments, their dynamism and susceptibility to future change.

**UNIVERSITY OF SOUTHAMPTON PALAEOECOLOGY  
VISIT TO HUGO DE VRIES LABORATORY, AMSTERDAM  
6th-11th October, 1997**

**Peter Langdon, Andy McMullen, Dmitri Mauquoy and Sarah Morriss  
University of Southampton**

Thanks to help with funding from the QRA, the Southampton Palaeoecology postgraduates were able to visit the Hugo de Vries Laboratory at the Faculty of Biology, University of Amsterdam. The party consisted of the 'old and new' including Dr Dmitri Mauquoy who has recently been awarded his Ph.D., entitled, 'Testing the sensitivity of the palaeoclimatic signal from ombrotrophic peat stratigraphy', Andy McMullen who is working on peatlands and conservation, Pete Langdon who is studying Holocene climate change in Scotland from peat stratigraphy, and Sarah Morriss who has just started her Ph.D. on pollen analysis and human impact over the last 2,000 years.

On arrival at the laboratory we met our host for the trip, Dr Bas van Geel, who helped us enormously during our stay in The Netherlands. He spent considerable amounts of his time with us and allowed complete access to his superb collection of peat macro- and microfossils. It was particularly interesting to analyse the various fungal 'type' spores, which Bas has extensively catalogued from Dutch raised peat bogs.

The first site we visited was a small field near Diemen. Around 20-30 'bog oaks' have been unearthed following the removal of the surface meadow layers during construction activities. These trees have been dated to around 500-1,000 BC. Further palaeoecological analysis of the *in situ* environment of the oak trees (fruits and seeds) is ongoing. Preliminary results suggest the oak trees were growing on peat, since *Quercus* leaves have been found in the peat matrices immediately below the oak trunks. There is much more analysis to be carried out at this site, since bog oaks are a relatively rare occurrence. The peat on which they are resting is at least 3 m deep and contains *Phragmites* as well as woody fractions. The base of this sequence is composed of silts and clays and may have been deposited during a marine transgression.

The next site we visited, Lutterzand, contains exposures of sands and palaeosols spanning the last *c.* 30 ka. Fine peat deposits can be found intercalated between some of the sand layers, and we retrieved material possibly deposited during the Allerød interstadial for pollen analysis. In certain places below the Allerød layers the Bölling gravel bed was exposed, within which small frost-heave features were visible.

The top of the exposure is covered in Holocene organic deposits, although in places these are obscured by aeolian sand which may date to the Medieval

period. Human impact has been suggested as the likely explanation for the origin of these sands.

Wietmarschen Moor was our final destination, and the one we had really come to see. It is the last remaining area of living bog in south-east Drenthe. All the other bogs have disappeared, mainly as a result of peat extraction and cultivation. However, a concerted effort is being made by the Dutch forestry service to improve the water management in the area. Ditches are being filled with boulder clay and well-humified, impermeable peat placed on top. The former material acts as an aquiclude, whilst the low permeability, humified peat approximates to catotelmic peat. High local water tables are being maintained in these areas targeted for restoration and peat-forming vegetation is now developing. Some of us had been sceptical as to how effective this method would be but the results were truly impressive, most especially in terms of scale. Peat restoration in the UK focusses much more upon smaller, discrete areas of bog that retain their surface vegetation. Restoration of bogs in the UK is thus marked by a shift from dry, ericaceous vegetation to that dominated by the water-retaining *Sphagnum* species. This is achieved, as at Wietmarschen Moor, by the damming of ditches. However, those of Wietmarschen Moor are best described as canals in their size as opposed to the much smaller ditches prevalent in the UK. Restoration in The Netherlands, as opposed to the general UK situation, is also impeded by the absence of typical bog vegetation on bare, cut-over surfaces which are often colonised instead by ruderal species of a more general occurrence than upon bogs alone. To achieve this, flooding of bare surfaces is undertaken to promote the growth of aquatic *Sphagna* (most notably *S. cuspidata*) which form a raft upon which other species may colonise and remain in intimate contact with the water table as the raft follows its seasonal fluctuations. We were able to see that a full vegetation cover, dominated by these rafts of *S. cuspidata*, has recolonised these restored areas. This natural recolonisation process (intentionally, none of the plant species has been introduced), has occurred in as little as two years. There was one area that had been restored 20 years ago (work started in 1977), which contained a flora similar to that found on some of the best-preserved British raised peat bogs. For example, we encountered *S. fimbriatum*, *S. recurvum*, *Sphagnum capillifolium* var. *rubellum*, *S. cuspidatum*, *S. magellanicum*, and *S. papillosum*; *Andromeda polifolia*, *Calluna vulgaris*, *Drosera rotundifolia*, *Erica tetralix*, *Nathecium ossifragum*, *Rhynchospora alba* and *Vaccinium oxycoccus*. The Dutch mire restoration team has really done a first-class job, and can surely encourage ecologists working on British mires, whose techniques on raising and maintaining local water tables were pioneered by the Dutch.

There is a small area of peat that has not been lost to cultivation, and a large peat face has been cut into it exposing most of the Holocene deposits. Large areas of *Scheuchzeria* exist in the section, a plant that is not often found in raised peats

in Britain. The main Sub-Boreal/Sub-Atlantic change is very visible as a climatic deterioration represented by a thin band of *Sphagnum cuspidatum* peat, above which *Sphagnum imbricatum* dominates. The Dutch call the mats containing lots of *Sphagnum* section *Cuspidata* 'Bible peat', as the leaves settle horizontally in pools and can be peeled back like pages of the Bible.

The remaining days of our visit were spent in the Hugo de Vries Laboratory looking at type material from Bas' vast collection. We were very pleased to find some fungal and algal material mounted on slides which, until now, we have been unable to identify.

The trip made a fantastic contribution to our palaeoecological training. We have witnessed bog regeneration, obtained samples from classic Dutch sites, and perused the type collection at the Hugo de Vries Laboratory. In addition to this we renewed our links, formerly established by Dr Keith Barber, with one of the most famous laboratories for peat studies in Europe - a link which will hopefully get stronger with future planned collaboration.

Andy McMullen would like to acknowledge the financial support of English Nature. The financial support of the QRA is also gratefully acknowledged.

# THE LATE DEVENSIAN DEGLACIATION OF SOUTH-WEST WALES: EVIDENCE FOR ADVANCE AND DECAY OF TERRESTRIAL IRISH SEA ICE IN ABERMAWR AND DRUIDSTON

Kenneth F. Rijdsdijk

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Traditionally, glacial sequences at the coast in south-west Wales have been interpreted as having been deposited by terrestrial ice. Recently, these sediments have been re-interpreted by some as the products of glacial marine deposition. It is argued that accelerated ice retreat occurred under glacial marine conditions in a glaci-isostatically depressed basin and that elevated relative sea levels led to calving of the ice sheet and caused fast ice flow. Both terrestrial and glacial marine interpretations have important implications for glaci-isostasy and for evaluating the role of climatic factors in triggering deglaciation.

Fieldwork was carried out at the key sites of Abermawr and Druidston (Pembrokeshire). Both sites lie within the generally accepted Late Devensian maximum ice limit and contain shell-debris-rich Irish Sea diamicts. The glacial sequences were re-investigated with an emphasis on process reconstruction and critical testing of competing hypotheses. The sequences were logged, and based upon the logs the sequences were sketched in the field. When possible three-dimensional sediment and structure geometries were reconstructed and detailed sketches were made. Where relevant, clast fabric analyses were carried out and micromorphological samples taken. At Abermawr there is strong evidence for glacial overriding and subglacial deposition. At the base of the sequence a head is present which is highly overconsolidated due to geostatic compression and in places overthrust into the overlying diamict. Fluid escape structures are also present at the interface of the head and in the overlying diamict. Basal silty Irish Sea diamict overlying the head shows glacial-tectonic macro-structures such as low-angle overthrust faults, hydrofractures and compressional conjugate joint sets, as well as micro-structures such as boudins and conjugate shears. Sandy and gravelly Irish Sea diamicts overlying these basal sediments show sedimentary macro-structures diagnostic of supraglacial deposition such as collapse structures, gradings and variable clast orientations which are all bedrock-slope independent. Micro-structures indicative of subaerial sediment flow include vesicles and associated mammillated vugs.

At Druidston, closer to the Late Devensian maximum ice limit, sediments of similar lithology were deposited in different environments. Here, mainly supra- and proglacial deposition took place. Basal silty Irish Sea diamicts



interfinger with sand and silt layers and gravelly silty diamicts. The silty diamicts show density-driven deformation structures such as synformal folded gravels, sunk clast clusters and localised clast re-alignments into gravitationally oversteep positions. Fabrics reveal girdle distributions of clasts typical for sediment flows. Based on the presence of these structures it can be concluded that the viscosity of the diamict during deposition was low like that of fluid mud (flow tills). Further post-depositional collapse structures independent of bedrock slope, such as small-scale tight synclinal folds were observed, indicative of melting buried ice lumps. In a last phase, glaci-proximal coarse-grained sand and gravels were deposited. At both sites striated, multi-faceted and bullet-shaped clasts occur commonly within the units. The properties of the Irish Sea sediments at both sites are inconsistent with glacialmarine deposition or bedrock-controlled subaqueous re-sedimentation of glacialmarine sediments.

Diagnostic properties for glacialmarine deposition are absent from sediments exposed in Druidston and Abermawr. The sedimentology of sequences deposited near the Late Devensian maximum extent of the ice sheet in south-west Wales point to regional *in situ* decay of a stagnant terrestrial Irish Sea ice sheet. Deglaciation cannot have been triggered by high relative sea levels due to glacialisostasy.

The QRA is thanked for the financial support which contributed towards the costs of transport and accommodation. This work constitutes part of a Ph.D. thesis (Rijsdijk, in prep.).

# REVIEWS

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## PALAEOCLIMATOLOGY AND PALAEOCEANOGRAPHY FROM LAMINATED SEDIMENTS

Edited by A.E.S. Kemp

Special Publication of the Geological Society 116

ISBN 1-897799-67-5 1996. 258pp, Hardback £65

The seminal importance of annually resolved palaeoenvironmental records in the calibration of dating techniques, and in ultra high-resolution investigations of climatic and environmental change, has become abundantly clear over the past few years. In the biosphere, annual growth bands are possessed by organisms as diverse as trees, bivalve molluscs and corals, and the use of these layers as priceless geochronological tools (dendrochronology, sclerochronology) has enabled calibration of the radiocarbon timescale (Stuiver *et al.*, 1986), enhanced resolution of important small wavelength cyclic climatic changes such as El Niño - Southern Oscillation (ENSO) events (Tudhope *et al.*, 1994) and, in the Atlantic, novel methods for reconstructing ocean palaeotemperatures (Weidman *et al.*, 1994). In the cryosphere, the annually resolved ice-core record is now established as the prime stratigraphic and global palaeoenvironmental (particularly palaeoatmospheric) template for the last glacial-interglacial cycle (Johnsen *et al.*, 1992). In the lithosphere, laminated sediments also provide similar potential for high-resolution palaeoclimatic and palaeoceanographic studies, especially if their annual status as varves can be demonstrated. It is this potential which is addressed in this volume. The book comprises a collection of 18 papers arising out of a meeting organised at the Geological Society in London in September 1993 by the editor of the volume, Alan Kemp. As is usual with this series of Geological Society Special Publications, presentation, production and editorial standards are high.

Any geologist who has ever encountered laminated sediments in the field knows that these sequences are both scientifically fascinating and aesthetically 'magnetic'. The miracle of annual preservation provides a resonance between the human and geological timescales; this is as close the natural world comes to providing a diary of events which can be read. This enthusiasm obviously motivates the editor, whose five papers included in the volume (not including the Preface) contain immaculate backscattered electron (BSE) images of resin-impregnated blocks of laminated sequences from diverse sedimentary contexts. As I read through the papers in the volume, however, I became aware of a sense

in which this fascination with the varves themselves had overtaken the scientific goals which they were being used to address. Intimate description of lamination style, content and origin predominate over concrete demonstrations of the "potential" much-trumpeted on the back cover and throughout the book. It is as if the diary itself is the thing of wonder rather than the story it tells. This focus towards the laminations themselves, and the techniques used to investigate them, makes the volume more of a methodological monograph than a discussion of palaeoceanographic and palaeoclimatic data derived from laminated sequences. In this regard the title of the volume is something of a misnomer. The non-initiated will, I suspect, fail to be convinced by the studies in this volume alone that laminated sequences can fulfill the potential invested in them by the editor. There are few contributions here which convincingly demonstrate why laminated sequences are important; too many of the papers included are concerned with techniques, some appear to represent dumps of probably unpublishable material whilst others give the impression of scraps left over from full-blooded contributions presented elsewhere.

The "potential" is explained in all its diversity in an excellent Preface by Kemp; geochronometers, palaeo-oxygenation and palaeoproductivity indicators, anthropogenic effects, correlation tools for rapid global events - a mouth-watering *hors d'oeuvres*! This Preface also succinctly outlines the conditions required for lamination formation and preservation, and provides a very useful review of lamina types and origins. This contribution will be of great value for teaching. This very positive introduction is followed by what seems to me to be an extraordinary contribution by R.Y. Anderson. A purported "review" of seasonal sedimentation, it is a veritable riot of self-citation; of a total of 64 references, only 11 do not contain the author as first or co-author and, of these, 34 are mentioned only in Table 1 which is a kind of CV synthesis. The paper gives the impression of preaching to the converted with the use of "etc." and undefined reference to "La Niña", neither of which are helpful to students. The paper serves only to demonstrate the existence of laminations and pays only lip-service to their use in addressing specific scientific problems or for testing hypotheses.

O'Brien's review of shale lamination and sedimentary processes focusses on lithified laminites of Proterozoic, Palaeozoic and Mesozoic ages. An implicit assumption here is that black means anoxic whilst later authors (e.g. Schulz *et al.*) clearly implicate productivity as a major or accessory control. The suggestion here that laminated facies could indicate deposition in a stratified water column seems inherently unlikely based on studies of contemporary stratified seas; it is improbable that "the presence of lamination may be a clue to the presence of a pycnocline which facilitated sediment segregation into laminae".

Pike and Kemp provide a useful review of the use of SEM in the investigation of laminated sediments. In fact, this well-written paper constitutes a valuable summary of analytical procedures relevant to all consolidated and unconsolidated sediments whether laminated or not, and contains a description of fluid-displacive drying and resin-embedding of wet specimens which causes less disturbance to samples than other drying methods. Again, this paper will be useful material for students, and probably also for Quaternary scientists investigating analagous materials in thin section (e.g. soil micromorphology, till microfabric). Another techniques contribution (image analysis) by Zolitschka opens "During the last few years, reconstruction of palaeoenvironmental conditions from high-resolution lacustrine and marine sediments has added much to the understanding of past global changes". My response to this - yes, but what? - was not answered by this paper, nor the next (by Hughen *et al.*), nor the next (Peterson).

So it was that I raised a small cheer when I reached the paper by Leslie *et al.* - a real scientific question addressed through the analysis of laminated sediments! The Upper Permian Castile Formation of the Delaware Basin (Texas and New Mexico) has been interpreted as a deep-water sequence and used as a reference for the development of evaporite basin depositional models. But the occurrence of pseudomorphs after gypsum in this laminated sequence indicates deposition in depths of less than 200 m, so forcing a revision of some established truths.

Four papers on the well-known California Borderland Basins follow, introduced in the first by Gorsline *et al.* The second, by Hagadorn, is a detailed analysis of the laminations of the Santa Monica Basin and, in establishing that the sequence is not dominated by ENSO (El Niño - Southern Oscillation) cyclicity but by longer-term decadal forcing, is only the second paper of the volume to use the laminations to answer some palaeoenvironmental questions. This paper also includes some interesting interpretations of stable (mainly carbon) isotopic data. The following two papers (by Schimmelmann and Lange, and Bull and Kemp) reverted to type, the first simply reviewing previous investigations and the latter providing detailed descriptions of laminae from the Santa Barbara Basin. The following paper by Pike and Kemp on the Gulf of California promised "high-resolution palaeoceanographic and palaeoclimatic reconstructions throughout the Holocene" but, again, did not deliver.

An interesting paper by Hughen *et al.* on varves from the very shallow silled (<100 m) Cariaco Basin (>1,400 m), Venezuela, goes beyond description of the laminae to extract some important palaeoenvironmental data; increased varve thicknesses during the Younger Dryas are interpreted as reflecting increased regional precipitation and primary productivity. This was the only paper which explicitly addressed the significance of late Quaternary laminated sequences in

calibrating the radiocarbon timescale and the marine reservoir effect; it concluded by stating that this sequence represents an annually resolved sequence which will in time come to be seen as important for the low latitudes as the ice-core record is for high latitudes. Recent developments suggest that this prediction is accurate.

Schulz *et al.* consider the oceanographic and sedimentary conditions which result in the formation of laminated sequences in association with the mid-water (200-1,200 m) oxygen minimum zone of the north-east Arabian Sea but do not use these sequences to address any deeper questions. Disturbance horizons within laminated Oligocene Paratethys coccolith limestones in the Polish Carpathians are attributed by Haczewski to palaeoseismicity, a useful and refreshing contribution.

I cannot see any good reason for the separation of the final two papers. Combined they would constitute a single substantial account of the character, origin and significance of open-ocean, Middle Miocene to early Pliocene, laminated diatomaceous sediments from the eastern equatorial Pacific (ODP Leg 138). As it is, the first, by Pearce *et al.*, once again simply describes the laminations, whilst the second, by Kemp *et al.*, goes on to discuss the significance of these data in terms of massive and episodic flux of diatom mats produced along fronts. These mats are of such strength that they suppress benthic activity and are thus preserved. The record of such events is significant because it demonstrates the importance of discrete "events" in contributing to deep-sea sequences which are often regarded as the products of quasi-continuous sedimentation, and which therefore invalidate linear sedimentation rate assumptions between age datums.

All in all, then, a mixed bag (as I suppose is usual with conference proceedings), but in many ways somewhat disappointing. The dangers of becoming mesmerised by the beauty of laminae are well expressed by Sancetta in her short review article on diatomaceous varves: "Laminated sediments represent an embarrassment of riches. There is an understandable temptation to generate huge datasets simply because it is possible to do so". She advocates first identifying key questions, then selecting key sections to test specific hypotheses, using analysis of variance (ANOVA) to compare key sections. It is a pity that none of the papers presented really demonstrated the use of laminated sequences to tackle hypotheses in this way. Her comments certainly bring into focus some of the questionmarks over the volume as a whole: "It is generally agreed that laminated sediments have great potential to provide insights into short-term climatic variability. The trick will be to develop creative ways to exploit this potential without becoming bogged down in masses of data". Hear, hear!

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# **ABSTRACTS**

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## **MAMMALIAN BIOSTRATIGRAPHY OF THE LATER MIDDLE PLEISTOCENE IN BRITAIN**

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This study explores and develops the potential of fossil mammals to differentiate between the various climatic episodes of the post-Anglian Middle Pleistocene in Britain. Mammalian fossils are particularly valuable as biostratigraphic indicators on account of their morphological evolution and rapid turnover, through origination and extinction of species. Furthermore, the large-scale climatic fluctuations that affected north-west Europe during the Quaternary produced major shifts in the geographical distributions of many species, resulting in discernible patterns of presence and absence in the fossil record of a particular region.

The development of a globally applicable climatostratigraphic framework, based on the oxygen isotope record from deep-ocean sediments, has provided a new and challenging scheme for the interpretation of the British Quaternary record. Long fluvial sequences in Britain have been related to this record with considerable success, thereby providing a detailed archive of climatic change through the Pleistocene. The Thames Valley was selected as a framework for the relative dating of the various climatic fluctuations, since it has been claimed to have the most reliably dated long terrestrial sequence in the later Middle Pleistocene. The Thames model was therefore adopted as a testable hypothesis against which the mammalian evidence could be compared.

The findings of this study confirm the presence of four complete climatic cycles between the Anglian and the Holocene, each with its own distinctive mammalian suite. In addition, it has been possible to identify subdivisions within these temperate stages, probably representing smaller-scale climatic fluctuations within an interglacial, and perhaps corresponding to isotopic substages. It has also been possible to resolve a long-standing controversy concerning the age of the British type Hoxnian Interglacial. Amino-acid geochronology had suggested that sediments at Hoxne belonged to a later interglacial than deposits from the first post-Anglian temperate episode in the Thames Valley, such as



Swanscombe. The results of the present study reveal close similarity between the mammalian fauna from Hoxne and that from Swanscombe, suggesting that there was indeed a single Hoxnian Interglacial, and that it directly post-dated the Anglian (*i.e.* Stage 11). Sediments of this age can be distinguished from those attributable to two other late Middle Pleistocene interglacials, all of them distinct from and older than, the Ipswichian. It has been suggested that distinctive mammalian assemblages can be identified from interglacials equivalent to Oxygen Isotope stages 9 and 7; moreover, it is apparent that the assemblages from warm substages 7c and 7a differed from one another in species composition. Certain useful characters have also been determined, which can permit useful separation of some of the late Middle Pleistocene cold episodes, although in comparison with the interglacials, the evidence from these is scanty.

The present study has provided a new biostratigraphic framework that may be both tested and refined as new sites become available in Britain, and also compared with the evidence from continental north-west Europe.

# LETTERS TO THE EDITOR

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## 1. STRATIGRAPHIC DATA REPRESENTATION

With reference to the article by Steve Boreham in *Quaternary Newsletter*, 84 (February, 1998), it may be of interest to *QN* readers to know that there is another tier (in expense and sophistication) of three-dimensional modelling systems suitable for stratigraphic representation. These are available to geoscientists in a number of university laboratories, going beyond those mentioned in the article.

I have tabulated web pages for many of these along with some relevant research projects at the following address:

<http://www.bbk.ac.uk/Departments/Geography/jfrBookmarks.html>

This collection of web sites was an output of a recent European Science Foundation meeting entitled 'Virtual environments for the geosciences', the abstract volume for which can be obtained from Robert Hack at the ITC, Centre for Technical Geoscience, Kanaalweg 3, 2628 Delft, The Netherlands (hack@itcdelft.itc.nl).

I hope this information proves useful to *QN* readers.

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## 2. QUATERNARY RESEARCH ASSOCIATION MEETING IN JURA, 1997

The QRA meeting in Jura, 1997, reported in *Quaternary Newsletter*, 83, appears to have been a most interesting trip. The famous 100 foot (35 m) raised beach was visited and was much discussed. It has never been possible to date its storm beaches owing to acid groundwater which would have destroyed any possible shells which might have existed. Another problem discussed was the origin of the beach pebbles.

It is possible that similar features on Rathlin Island, north Antrim could be helpful. The 100 ft beach occurs in Inisowen, north Donegal but no sections have been recorded in the prominent beach ridges. Rathlin Island was surveyed by H.E. Wilson of the Geological Survey, who mapped and recorded several such benches cut in basalt. He had mapped the feature on morphology and the occasional chalk pebble alone and was pleased to have been proved correct.

In 1991 during a visit to Rathlin the raised beach north of Church Bay was observed to have had a small pit excavated into one beach ridge, showing it to be formed of chalk pebbles. Strike bedding was parallel to the beach crest with a dip inland of  $10^\circ$ . Dr Bill Carter of the University of Ulster, Coleraine was notified and some months later he collected 'temperate' shells similar to those of the present beach, at 60 ft OD, and dated to 17,200 BP  $^{13}\text{C}$ , adjusted age  $12,740 \pm 80$  BP, by Beta Analytic Incorporated, University Branch, Coral Gables near Miami, Florida. Since this result was so much older than expected, the work was checked three times.

As regards the origin of the beach pebbles on Jura, those on Rathlin must have been carried onshore from the chalk floor of Church Bay.

At present another very steep beach ridge occurs a short distance away; the 100 ft contour follows its crest. The only exposures are animal burrows but chalk pebbles and shells have been extracted from the roof of the burrows. A considerable marshy bog lies behind the ridge but unfortunately no interest has yet been expressed to auger the bog for pollen as a possible check on the accuracy of the shell  $^{14}\text{C}$  date which may well suffer from 'hard water' effect.

No periglacial disturbance such as is seen in the beach gravels of the Cotentin Peninsula was observed in the bedding of the pit exposure. This is of interest as regards the relative dating of the 'Scottish Readvance' moraine which crosses Northern Ireland from east to west known as the 'Armoy moraine'; it contains Scottish erratics and reaches its farthest point inland at the small

village of Armoy. Some 15 miles inland in the Bann lowland, sections were exposed by the Ballymoney by-pass, recorded by Bill Carter in *Irish Naturalists' Journal*, and showing the moraine at this point to consist of lake silts and clays much disturbed. Since the Armoy moraine contains many considerable ice-wedge pseudocasts throughout its length, it must be older than the Rathlin storm beaches but younger than the withdrawal of any Irish ice sheets in that area.

## References

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Wilson, H.E. (1966). *Geological Survey of Northern Ireland, Geology of the Country around Ballycastle*. Memoir 8.

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### 3. BOXGROVE - TO SEE OR NOT TO SEE?

In early April, as reported elsewhere in this issue, the Quaternary Research Association's annual field meeting concluded with a visit to Boxgrove, the celebrated Middle Pleistocene hominid site near Chichester, Sussex. To those familiar with the site, there was less to see than hitherto, with no archaeological excavations on view (1996 was the last full digging season). However, to many it was still the highlight of the meeting, especially for those who had never seen the splendid exposures in the interglacial and cold-climate sediments banked against the fossil chalk cliff, cut by the sea around half a million years ago. Mark Roberts, the Director of the Boxgrove excavations for the last decade, had cleaned up the remaining sections over the preceding few days and gave his usual exemplary presentation of this exciting site. This is arguably Britain's most important Quaternary locality, that has international significance that does not relate exclusively to its Palaeolithic archaeology.

Members of the excursion party were aghast to learn that efforts to conserve the Boxgrove exposures are on the brink of failure. Indeed, it looks very much as though the fossil-cliff site will be backfilled and the sections covered by about four metres of overburden, so that the roots of future vegetation cover do not penetrate and damage them; this is despite efforts by English Nature to secure this part of the site as a geological SSSI. Part of the problem is that planning for the gravel pit, in the floor of which the excavations have taken place, has always included an intention for restoration and return to agriculture. A substantial sum of money would presumably be required to compensate the landowner for any alteration to this plan, such as the provision of a series of permanent geological exposures to the type viewed by the QRA party. Yet this would seem the very minimum that should be provided at this, the most celebrated Quaternary site of recent times. The present *impasse* is also symptomatic of differences between the conservation philosophies of the geological and archaeological communities. Geological interests have been subsumed within the nature conservation system, with SSSI (Sites of Special Scientific Interest) and NNR (National Nature Reserves) of geological interest enjoying the same level of protection as their biological equivalents. Archaeological sites, on the other hand, are conserved through their scheduling as 'ancient monuments' by English Heritage. It has proved difficult to justify the designation of Palaeolithic sites as ancient monuments, even in cases like Boxgrove where tool manufacture and butchery sites are preserved *in situ*, because of the absence of built structures. Meanwhile attempts to designate part of the east quarry at Boxgrove (this includes the buried cliff sections) as SSSI have fallen foul of the existing planning consent for restoration to agriculture and of the different conservation agendas of the geological and archaeological communities. The former desire an open site with exposures that can be cleaned up with minimal effort to meet

the needs of visiting parties. The latter are concerned to protect the existing reserve of sediments from damage by the elements, by plant roots and by casual collectors and vandals. There are also safety and liability factors to consider, as some of the sections are extremely deep with near-vertical sides.

So what can be done? After much discussion amongst the QRA party about the plight of this jewel in Britain's heritage, the suggestion was made that the Quaternary scientific community should make its feelings known and, if sufficient momentum can be achieved, should explore the possibility of establishing a manageable conservation site at Boxgrove. This would require agreement amongst the various interested parties, a degree of proactive site management, with sufficient funding to ensure the future continuation of essential maintenance of the site. To overcome the safety issues it might be necessary to remodel the site into a series of shallower sections, involving the removal of *in situ* deposits under controlled archaeological conditions. Protection of part of the site under a building might seem an extreme measure, but it is a course of action taken in other countries, such as at the Abbeville type section in northern France. The importance of Boxgrove must exceed that of Abbeville and if the British are ever to pursue this line of conservation activity, then Boxgrove would be an excellent candidate. Potential sources of funding are not obvious, but there are possibilities for involving local communities and authorities, as well as national institutions. Success will require considerable organisation and effort. If anyone has any ideas or wishes to be involved, they should contact the writers.

**Richard Preece**  
**David Bridgland**

# **NOTICES**

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## **1. BIBLIOGRAPHY OF EUROPEAN PALAEOBOTANY AND PALYNOLOGY 1996-1997**

The fourth Bibliography of European Palaeobotany and Palynology is currently being compiled. The aim of the report is to provide a comprehensive list of relevant papers published in 1996 and 1997, together with details of current research projects. Any worker from the British Isles who has not received a form and who would like to contribute to this publication should contact:

**Heather Pardoe / Helen Fraser**  
**Department of Biodiversity and Systematic Biology**  
**National Museums and Galleries of Wales**  
**Cathays Park**  
**Cardiff CF1 3NP**  
**Tel: 01222 573294**

## **2. 1998 ANNUAL MEETING OF IGCP 415**

**Glaciation and Reorganisation of Asia's Network of Drainage**

**Manali and the Lahul Himalaya, India**  
**20th-31st August, 1998**

The first annual meeting of IGCP 415 will be held in Manali and the Lahul Himalaya, India in August 1998. The meeting will comprise three days of seminars on the glaciation and reorganisation of Asia's network of drainage followed by a week-long field excursion into the Lahul Himalaya to examine evidence for Quaternary paleoenvironmental change and landscape evolution. The meeting will concentrate on the work and activities of Working Group 2 (Glaciation in the Tibetan Plateau and bordering mountains) and Working Group 7 (Drainage off the Tibetan Plateau). An open session for all the working groups to report their activities will also be convened.



Researchers interested in participating in the activities of IGCP 415 and attending the meeting can find further information on the following web pages:

IGCP 415 home page:

<http://mercury.eas.ualberta.ca/igcp/IGCP415.html>

Working Group leaders' addresses:

<http://mercury.eas.ualberta.ca/igcp/people/wgl.html>

Working Group 2 home page:

<http://lakeview.ucr.edu/2.html> or

<http://earth457.ucr.edu/2.html>

IGCP 415 Annual Meeting home page:

<http://lakeview.ucr.edu/Meeting.html> or

<http://earth457.ucr.edu/Meeting.html>

Alternatively, further information on the Annual Meeting is available from:

**Lewis A. Owen**  
**University of California, Riverside**  
**Department of Earth Sciences**  
**Riverside**  
**CA 92521-0423, USA**  
**Tel: (909) 787-3106**  
**Fax: (909) 787-4324**  
**e-mail: [Lewis.Owen@ucr.edu](mailto:Lewis.Owen@ucr.edu)**  
**<http://lakeview.ucr.edu>**

# QUATERNARY SCIENCE REVIEWS



## LONDON QUATERNARY LECTURES

Organised by

*The Centre for Quaternary Research, Department of Geography,  
Royal Holloway, University of London*

Sponsored by

*Quaternary Science Reviews*

**Wednesday, 11th November, 1998**

15.30

### **PROFESSOR JULIAN DOWDESWELL**

Institute of Geography & Earth Sciences, University of Wales, Aberystwyth  
(From summer 1998: School of Geographical Sciences, University of Bristol)

**'Ice in the Eurasian Arctic: past, present and future'**

[LQL No. 60]

16.30 - 17.15 Tea

17.15

### **PROFESSOR JAN MANGERUD**

Department of Geology, University of Bergen

**'The last interglacial-glacial cycle of the Barents-Kara  
ice sheets in Svalbard and Northern Russia'**

[LQL No. 61]

in

The Main Lecture Theatre,  
Queen's Building, Royal Holloway,  
University of London

## QUATERNARY RESEARCH ASSOCIATION

The Quaternary Research Association is an organisation comprising archaeologists, botanists, civil engineers, geographers, geologists, soil scientists, zoologists and others interested in research into the problems of the Quaternary. The majority of members reside in Great Britain, but membership also extends to most European countries, North America, Africa, Asia and Australasia. Membership (currently c. 1,000) is open to all interested in the objectives of the Association. The annual subscription is £15 with reduced rates (£5) for students and unwaged members and an Institutional rate of £25.

The main meetings of the Association are the Annual Field Meeting, usually lasting 3-4 days, in April, and a 1 or 2 day Discussion Meeting at the beginning of January. Additionally, there are Short Field Meetings in May and/or September, while Short Study Courses on techniques used in Quaternary work are also occasionally held. The publications of the Association are the *Quaternary Newsletter* issued with the Association's *Circular* in February, June and October; the *Journal of Quaternary Science* published in association with Wiley, with six issues a year; the monograph series *Quaternary Proceedings* also in association with Wiley, the Field Guides Series and the Technical Guide Series.

The Association is run by an Executive Committee elected at an Annual General Meeting held during the April Field Meeting. The current officers of the Association are:

**President:** *Professor B.M. Funnell*, School of Environmental Sciences, University of East Anglia, Norwich, NR4 7TJ (e-mail: b.funnell@uea.ac.uk)

**Vice-President:** *Dr P.L. Gibbard*, Quaternary Stratigraphy Group, Department of Geography, Downing Place, Cambridge, CB2 3EN (e-mail: PLG1@cus.cam.ac.uk)

**Secretary:** *Dr C.A. Whiteman*, School of the Environment, University of Brighton, Cockcroft Building, Lewes Road, Brighton, BN2 4GJ (e-mail: C.A.Whiteman@brighton.ac.uk)

### **Publications Secretary:**

*Dr S.G. Lewis*, Centre for Environmental Change and Quaternary Research, Department of Geography and Geology, Cheltenham and Gloucester College of Higher Education, Swindon Road, Cheltenham, GL50 4AZ (e-mail: slewis@chelt.ac.uk)

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