NUMBER 82 JUNE 1997

# QN

# Quaternary Newsletter

*A publication of the*

Quaternary Research Association

# QUATERNARY NEWSLETTER

EDITOR:
Dr Stewart Campbell
Countryside Council for Wales
Hafod Elfyn
Ffordd Penrhos
BANGOR
Gwynedd
LL57 2LQ
Tel: 01248 385693 Fax: 01248 385510

*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.



Argraff/Printed by:
Gwasg Ffrancon Press
BETHESDA
Gwynedd
North Wales
Tel: 01248 601669 Fax: 01248 602634.



*COVER PHOTOGRAPH*:
Stanton Harcourt gravel pit, Oxfordshire - channel deposits with *in situ* mammoth remains seen during excavations in 1990. These temperate deposits are ascribed to Oxygen Isotope Stage 7. Photograph by Stewart Campbell (see Report of QRA Annual Field Meeting by David Keen in this issue).

# ARTICLES

## VERTEBRATE FAUNAS OF THE BRITISH LATE PLEISTOCENE AND THE CHRONOLOGY OF HUMAN SETTLEMENT

**Andrew Currant and Roger Jacobi**

Reconstructions of Late Pleistocene vertebrate faunal history rely heavily on radiocarbon dating, while comparatively little attention has been paid to traditional stratigraphic methods. Recent experimentation with new dating techniques may be hindering rather than helping our understanding. The following observations are based on the revision and reinterpretation of fossil vertebrate collections, with new fieldwork to test the validity of conclusions so derived.

There is abundant artefactual evidence for periodic human occupation of Britain during the Middle Pleistocene (Wymer, 1988), the faunal chronology of which is currently under review by Danielle Schreve, University College London. A vertebrate assemblage in which *Hippopotamus amphibius* is the most distinctive element has long been attributed to the 'Last Interglacial' period (King, 1955; Sutcliffe, 1959) and is now believed to be restricted to Substage 5e of the marine oxygen isotope record (Gascoyne *et al.*, 1981). Joint Mitnor Cave (Sutcliffe, 1960) is chosen here as the defining locality for this widespread faunal assemblage (Table 1). At this stage, Britain is believed to have been isolated from continental Europe (Keen, 1995) and we know of no evidence for contemporary human presence in Britain.

**Table 1.** The mammal fauna from Joint Mitnor Cave, Buckfastleigh, Devon.

| | |
|---|---|
| *Sorex araneus* | Eurasian common shrew |
| *Lepus timidus* | Mountain hare |
| *Canis lupus* | Wolf |
| *Vulpes vulpes* | Red fox |
| *Ursus arctos* | Brown bear |
| *Meles meles* | Badger |
| *Crocuta crocuta* | Spotted hyaena |
| *Felis sylvestris* | Wild cat |
| *Panthera leo* | Lion |
| *Palaeoloxodon antiquus* | Straight-tusked elephant |
| *Stephanorhinus hemitoechus* | Narrow-nosed rhinoceros |
| *Sus scrofa* | Wild boar |
| *Hippopotamus amphibius* | Hippopotamus |
| *Cervus elaphus* | Red deer |
| *Dama dama* | Fallow deer |
| *Megaloceros giganteus* | Giant deer |
| *Bison priscus* | Bison |
| *Clethrionomys glareolus* | Bank vole |
| *Arvicola cantiana / terrestris* | Water vole |
| *Microtus agrestis* | Field vole |
| *Apodemus sylvaticus* | Wood mouse |

The aurochs *Bos primigenius* is not known from Joint Mitnor Cave, but has been recorded from other vertebrate assemblages of this age, notably that from Barrington, Cambridgeshire (Gibbard and Stuart, 1975). Later Stage 5 faunas, still thoroughly interglacial in character, but lacking hippopotamus are known from a number of sites, notably Bacon Hole, Gower (Sutcliffe *et al.*, 1987) and are likewise without evidence for human presence. A notable addition to these later Stage 5 faunas is the northern vole *Microtus oeconomus*. On faunal grounds there appears to be no convincing reason to place the start of the Devensian within Stage 5. Whether Britain remained an island throughout all of Stage 5 is uncertain, but this has also been argued by Keen (1995).

There continues to be no evidence for human occupation of Britain for some considerable period after these interglacial faunas. This conclusion is based on the identification of a low species diversity vertebrate fauna of widespread occurrence and remarkably consistent composition which occupies the British region during a period later than the interglacial faunas but earlier than assemblages usually attributed to the Middle Devensian (Stuart, 1977). Bison and reindeer *Rangifer tarandus* are the dominant elements of this fauna, with wolf, wolverine *Gulo gulo*, arctic hare *Lepus timidus* and an extremely large variety of brown bear (e.g. Kurten, 1964) as their consistent companions. The small mammal fauna is dominated by northern vole. This assemblage is very similar to that found in the higher latitudes of North America up to modern times. This is very clearly the vertebrate assemblage of a major cold stage. Banwell Bone Cave in Somerset is chosen here as the defining locality for this assemblage (Rutter, 1829; Table 2). At Banwell, the sheer volume of bone accumulation argues for a long period of relative faunal stability. We feel that Stage 4 is the only realistic attribution for the Banwell-type fauna. Other significant occurrences of this assemblage, several of which establish its stratigraphic position beyond reasonable doubt, include the lower fauna from Ash Tree Cave, Whitwell, Derbyshire; Bosco's Den, Gower (Murchison, 1868); the lower fauna from Limekiln Hill Quarry, Mells, Somerset; Unit 5 at Picken's Hole, Compton Bishop, Somerset (Tratman, 1964); Port Eynon Point Cave, Gower; Steetley Wood Cave, Steetley, Nottinghamshire; Stump Cross Cave, Pateley Bridge, North Yorkshire (Sutcliffe *et al.*, 1985); the upper silt bed at Tattershall Castle, Lincolnshire (Rackham, 1978); the internal 'Reindeer Stratum' at Tornewton Cave, Devon (Sutcliffe and Zeuner, 1962); the basal silts at Willments Pit, Isleworth, Middlesex (Coope and Angus, 1975) and Windy Knoll Cave, Castleton, Derbyshire (Dawkins, 1877b). At Tornewton Cave, the internal Reindeer Stratum overlies deposits spanning the Last Interglacial complex, and the same stratigraphic relationship is probably true at Bacon Hole, but in this case further collecting from the breccias overlying the Last Interglacial sequence is desirable as faunal remains are sparse.

**Table 2.** The mammal fauna from Banwell Bone Cave, Banwell, Somerset.

| | |
|---|---|
| *Lepus timidus* | Arctic hare |
| *Panthera pardus* | Leopard |
| *Canis lupus* | Wolf |
| *Vulpes vulpes* | Red fox |
| *Alopex lagopus* | Arctic fox |
| *Ursus arctos* | Brown bear; a very large form |
| *Gulo gulo* | Wolverine |
| *Rangifer tarandus* | Reindeer |
| *Bison priscus* | Bison |

Human populations appear to return to Britain in association with a vertebrate fauna including *Mammuthus primigenius, Coelodonta antiquitatis, Equus ferus* and *Crocuta crocuta*. Coygan Cave, Laugharne, Dyfed is chosen here as the defining locality for this assemblage (Table 3; Aldhouse-Green *et al.*, 1995). Although this is the classic cold-stage fauna of older literature, this assemblage is actually quite difficult to interpret in terms of its environmental signal. It has a much higher species diversity than the Banwell-type fauna and is particularly rich in large mammalian herbivores. This is suggestive of a very productive environment, in many ways more akin to interglacial conditions. It seems to us highly unlikely that this fauna can be indicative of anything other than oxygen isotope Stage 3 and we have found nothing to contradict this interpretation. It has often been noticed that Stage 3 is something of an anomaly in the context of the longer Quaternary sequence and has many of the characteristics of a series of rapidly superimposed interstadials (e.g. Woillard and Mook, 1982).

The Coygan-type fauna (Table 3) is the characteristic later Quaternary assemblage of central Asia north of the Himalayas. As such we may assume that its occurrence in Britain indicates the westward extension of extreme continental conditions right up to the Atlantic seaboard (cf. Coope, 1973; Ullrich and Coope, 1974). If we take modern conditions as our database, then continental interiors are noted for extreme seasonal temperature ranges and predominantly arid environments. We are probably dealing with a long-established faunal grouping which is pre-adapted to highly variable conditions. It should be noted that no investigator has so far reported any internal stratigraphic patterning within these Coygan-type faunas in spite of the climatic instability documented for this period by the Greenland ice core data (e.g. Bond *et al.*, 1993).

The Coygan-type fauna is well represented throughout England and Wales and the justly famous hyaena den assemblages have figured greatly in nineteenth century accounts of our extinct fauna, though they are rather less common than might generally be supposed. Examples include Boughton Monchelsea, Maidstone, Kent (Anon., 1827); the Cae Gwyn and Ffynnon Beuno caves, St Asaph, Clwyd (Hicks, 1886); Church Hole, Pin Hole and Robin Hood Cave, Creswell Crags, Nottinghamshire/Derbyshire (Dawkins, 1877a); the Hyaena

Den at Wookey Hole, Somerset (Dawkins, 1863); the cave earth at Kent's Cavern, Torquay, Devon; and Unit 3 at Picken's Hole. Recent uranium-series age determinations on flowstone at Creswell Crags confirms that this hyaena den assemblage is later than 60,000 to 70,000 years old (P. Rowe and M.A. Gilmour, pers. comm.).

**Table 3.** The mammal fauna from Coygan Cave, Laugharne, Dyfed.

| | |
|---|---|
| *Homo* sp. | Artefacts |
| *Canis lupus* | Wolf |
| *Vulpes vulpes* | Red fox |
| *Alopex lagopus* | Arctic fox |
| *Crocuta crocuta* | Spotted hyaena |
| *Ursus arctos* | Brown bear |
| *Mammuthus primigenius* | Woolly mammoth |
| *Coelodonta antiquitatis* | Woolly rhinoceros |
| *Equus ferus* | Wild horse |
| *Megaloceros giganteus* | Giant deer |
| *Cervus elaphus* | Red deer |
| *Rangifer tarandus* | Reindeer |
| *Bison priscus* | Bison |

Lion is also recorded from Coygan Cave by Laws (1888), which is consistent with its occurrence in faunas of this age at other localities. The human artefacts associated with these Stage 3 faunas are Middle Palaeolithic (Mousterian) and Early Upper Palaeolithic in typology.

Recent fieldwork and associated research at at least five localities confirm Banwell-type faunas as being older than those of Coygan-type; Ash Tree Cave, Brean Down, Somerset (ApSimon *et al.*, 1961), the Hyaena Den at Wookey Hole, Limekiln Hill Quarry and Picken's Hole. Nowhere can a Coygan-type fauna be shown to underlie or be interstratified with a Banwell-type fauna. Single specimens of spotted hyaena, woolly mammoth, woolly rhinoceros and horse from Coygan-type faunas, mainly from Creswell Crags, have given radiocarbon ages in excess of 40,000 BP (Table 4).

**Table 4.** Selected radiocarbon age determinations, close to the limit of the method, derived from elements of the Coygan-type mammal fauna.

| | | | |
|---|---|---|---|
| *Homo* sp. (represented by cut-marks): | | | |
| Hyaena Den | 40,400 ± 1,600 | OxA-4782 | 1. |
| Creswell Crags | >42,700 | OxA-3418 | 2. |
| ***Crocuta crocuta:*** | | | |
| Pin Hole | 42,200 ± 3,000 | OxA-1448 | 3. |
| ***Mammuthus primigenius:*** | | | |
| King Arthur's Cave | >39,500 | OxA-1566 | 3. |
| Pin Hole | 42,700 ± 2,100 | OxA-4431 | 2. |

| | | | |
|---|---|---|---|
| *Coelodonta antiquitatis:* | | | |
| Ash Tree Cave | 40,900 ± 1,800 | OxA-4103 | 2. |
| Pin Hole Cave | >41,400 | OxA-1813 | 3. |
| Pin Hole Cave | >42,300 | OxA-4429 | 2. |
| Pin Hole Cave | 42,700 ± 2,200 | OxA-4428 | 2. |
| Robin Hood Cave | 42,900 ± 2,400 | OxA-3454 | 2. |
| *Equus ferus:* | | | |
| Pin Hole Cave | 44,900 ± 2,800 | OxA-4430 | 2. |
| *Cervus elaphus:* | | | |
| Hyaena Den | 40,400 ± 1,600 | OxA-4782 | 1. |

Table references: 1. Hedges *et al.* (1996); 2. Hedges *et al.* (1994); 3. Hedges *et al.* (1989).

If we assume that many of these radiocarbon age determinations are likely to be minimum estimates for the age of components of the Coygan-type fauna (cf. Chappell *et al.*, 1996) the obvious implication is that the Banwell-type fauna is of much greater age - something which our model predicts. Uranium-series age determinations on stalagmite enclosing a Banwell-type fauna from Stump Cross Cave, Pateley Bridge, North Yorkshire in the range of 83,000 BP are more realistic, but take us back into what some authors have interpreted as the later part of isotope Stage 5 (Sutcliffe *et al.*, 1985). Given the ecological implications of the assemblage, we consider it more likely that this is an early Stage 4 fauna, an interpretation which is not inconsistent with the error ranges quoted for the critical dates at this site.

More recent age determinations on stalagmites from Stump Cross Cave (Baker *et al.*, 1996) cannot be directly related to the fauna but have been interpreted as evidence for interstadial conditions within oxygen isotope Stage 4. Following from this, the association of Banwell-type faunas with thermophilous beetle assemblages at Isleworth and Tattershall Castle need not conflict with the chronology suggested in this paper.

On this model of events, human settlement of Britain during the last cold stage would seem to be limited to the time-equivalent of Stage 3 and the 'Late-glacial Interstadial'.

## References


Aldhouse-Green, S., Scott, K., Schwarcz, H., Grun, R., Housley, R., Rae, A., Bevins, R. and Redknap, M. (1995). Coygan Cave, Laugharne, South Wales, a Mousterian site and hyaena den: a report on the University of Cambridge excavation. *Proceedings of the Prehistoric Society*, 61, 37-79.

Anon. (1827). Discovery of fossil hyaenas in Kent. *The Philosophical Magazine and Annals of Philosophy*, 2(7), 73-74.

ApSimon, A.M., Donovan, D.T. and Taylor, H. (1961). The stratigraphy and archaeology of the Late-Glacial and Post-Glacial deposits at Brean Down, Somerset. *Proceedings of the University of Bristol Spelaeological Society*, 9(2) for 1960-61, 67-136.

Baker, A., Smart, P.L. and Edwards, R.L. (1996). Mass spectrometric dating of flowstones from Stump Cross Caverns and Lancaster Hole, Yorkshire: palaeoclimate implications. *Journal of Quaternary Science*, 11(2), 107-114.

Bond, G., Broecker, W., Johnsen, S., McManus, J., Labeyrie, L., Jouzel, J. and Bonani, G. (1993). Correlations between climate records from North Atlantic sediments and Greenland ice. *Nature*, 365, 143-147.

Chappell, J., Head, J. and Magee, J. (1996). Beyond the radiocarbon limit in Australian archaeology and Quaternary research. *Antiquity*, 70, 543-552.

Coope, G.R. (1973). Tibetan species of Dung Beetle from Late Pleistocene deposits in England. *Nature*, 245, 335-336.

Coope, G.R. and Angus, R.B. (1975). An ecological study of a temperate interlude in the middle of the last glaciation, based on fossil Coleoptera from Isleworth, Middlesex. *Journal of Animal Ecology*, 44, 365-391.

Dawkins, W.B. (1863). On a Hyaena-den at Wookey Hole, near Wells. No. II. *Quarterly Journal of the Geological Society of London*, 19(1), 260-274.

Dawkins, W.B. (1877a). On the mammal-fauna of the caves of Creswell Crags. *Quarterly Journal of the Geological Society of London*, 33(3), 589-612.

Dawkins, W.B. (1877b). The exploration of the ossiferous deposit at Windy Knoll, Castleton, Derbyshire, by Rooke Pennington, Esq., LL.B., F.G.S., and Prof. Boyd Dawkins, M.A., F.R.S. *Quarterly Journal of the Geological Society of London*, 33(4), 724-729.

Gascoyne, M., Currant, A.P. and Lord, T.C. (1981). Ipswichian fauna of Victoria Cave and the marine palaeoclimatic record. *Nature*, 294, 652-654.

Gibbard, P.L. and Stuart, A.J. (1975). Flora and vertebrate fauna of the Barrington Beds. *Geological Magazine*, 112, 493-501.

Hedges, R.E.M., Housley, R.A., Law, I.A. and Bronk, C.R. (1989). Radiocarbon dates from the Oxford AMS system: *Archaeometry* datelist 9. *Archaeometry*, 31(2), 207-234.

Hedges, R.E.M., Housley, R.A., Bronk, C.R. and Van Klinken, G.J. (1994). Radiocarbon dates from the Oxford AMS system: *Archaeometry* datelist 18. *Archaeometry*, 36(2), 337-374.

Hedges, R.E.M., Pettitt, P.B., Bronk, C.R. and Van Klinken, G.J. (1996). Radiocarbon dates from the Oxford AMS system: *Archaeometry* datelist 22. *Archaeometry*, 38(2), 391-415.

Hicks, H. (1886). Results of recent researches in some bone caves in North Wales (Ffynnon Beuno and Cae Gwyn); with a note on the animal remains, by W. Davies, Esq., F.G.S. *Quarterly Journal of the Geological Society of London*, 42(1), 3-19.

Keen, D.H. (1995). Raised beaches and sea-levels in the English Channel in the Middle and Late Pleistocene: problems of interpretation and implications for the isolation of the British Isles. In: Preece, R.C. (ed.) *Island Britain: a Quaternary Perspective.* Geological Society Special Publication No.96, London, 63-74.

King, W.B.R. (1955). The Pleistocene epoch in England. *Quarterly Journal of the Geological Society of London*, 111, 187-208.

Kurten, B. (1964). The evolution of the polar bear, *Ursus maritimus* Phipps. *Acta Zoologica Fennica*, 108, 1-26.

Laws, E. (1888). *The History of Little England Beyond Wales.* George Bell and Sons, London.

Murchison, C. (1868). *Palaeontological memoirs and notes of the late Hugh Falconer, A.M., M.D. Vol. II. Mastodon, Elephant, Rhinoceros, Ossiferous Caves, Primeval Man and his contemporaries.* Robert Hardwicke, London.

Rackham, D.J. (1978). Evidence for changing vertebrate communities in the Middle Devensian. *Quaternary Newsletter*, 25, 1-3.

Rutter, J. (1829). *Delineations of the north western division of the County of Somerset, and of its antediluvian bone caverns, with a geological sketch of the district.* Longman, Rees and Co., London.

Stuart, A.J. (1977). British Quaternary Vertebrates. In: Shotton, F.W. (ed.) *British Quaternary Studies: Recent Advances.* Clarendon Press, Oxford, 69-81.

Stuart, A.J. (1982). *Pleistocene Vertebrates in the British Isles.* Longman, London.

Sutcliffe, A.J. (1959). The Hippopotamus in Britain. *Bulletin of the Mammal Society of the British Isles*, 11, 36-40.

Sutcliffe, A.J. (1960). Joint Mitnor Cave, Buckfastleigh. *Transactions and Proceedings of the Torquay Natural History and Scientific Society*, 13(1) for 1958-59, 1-26.

Sutcliffe, A.J., Currant, A.P. and Stringer, C.B. (1987). Evidence of sea-level change from coastal caves with raised beach deposits, terrestrial faunas and dated stalagmites. *Progress in Oceanography*, 18, 243-271.

Sutcliffe, A.J., Lord, T.C., Harmon, R.S., Ivanovich, M., Rae, A. and Hess, J.W. (1985). Wolverine in northern England at about 83,000 yr BP: faunal evidence for climatic change during Isotope Stage 5. *Quaternary Research*, 24, 73-86.

Sutcliffe, A.J. and Zeuner, F.E. (1962). Excavations in the Torbryan Caves, Devonshire. I. Tornewton Cave. *Proceedings of the Devonshire Archaeological Exploration Society*, 5(5-6) for 1957-8, 127-145.

Tratman, E.K. (1964). Picken's Hole, Crook Peak, Somerset. A Pleistocene site, preliminary note. *Proceedings of the University of Bristol Spelaeological Society*, 10(2) for 1963-4, 112-115.

Ullrich, W.G. and Coope, G.R. (1974). Occurrence of the east palaearctic beetle *Tachinus jacuticus* Poppius (Col. Staphylinidae) in deposits of the last glacial period in England. *Journal of Entomology*, 42(2), 207-212.

Wymer, J.J. (1988). Palaeolithic archaeology and the British Quaternary sequence. *Quaternary Science Reviews*, 7, 79-98.

**Andrew Currant**
**Natural History Museum**
**Cromwell Road**
**London SW7 5BD**

**Roger Jacobi**
**British Museum**
**38-46 Orsman Road**
**London N1 5QJ**

# HOLOCENE (FLANDRIAN) ORGANIC DEPOSITS PRESERVED IN AN ICING HOLLOW AT BARDFIELD BRIDGE, BORLEY, ESSEX

**S. Boreham**

## Introduction

In June 1992 Essex County Council Highways Department contacted Dr P. L. Gibbard, concerning an organic deposit which had been encountered during borehole investigations for engineering work at Bardfield Bridge, Borley (near Sudbury), Essex (Figure 1). Four boreholes (BH1-4) had been sunk around the bridge, and organic material had been encountered in three of these, reaching more than 3 m thickness in BH1. The author was asked to investigate the site to determine the extent and nature of the deposit. As part of this investigation, ten boreholes (BH5-14) were sunk around the bridge to determine the stratigraphic relationship of the deposits. A hand auger was used for BH5, and a 'Minuteman' mobile drill was used for the remaining boreholes. In addition, a single borehole record (BH15) was made available by the National Rivers Authority. The borehole data have been used to construct sections through the deposit (Figure 2), and to produce contour plots of the basin morphology and thickness of the organic deposit (Figure 3). The sequence from BH5 was sampled for pollen analysis and yielded a skeletal pollen diagram of 10 levels (Figure 4). Some problems were encountered in recovering samples from the base of the sequence due to the extremely unconsolidated nature of the sediment.

## Site description and stratigraphy

Bardfield Bridge (TQ 84674212) is located in the valley of the Belchamp Brook; a tributary of the River Stour, draining the eastward-facing dip slope of the Chalk escarpment. At Bardfield Bridge the valley floor of the Belchamp Brook is at *c.* 29 m OD, with the river channel incised some 2 m lower (Figure 1). The valley is underlain by Chalk bedrock, and contains a buried channel with a base at *c.* 21 m OD filled by up to 5 m of (presumed) Devensian gravels, and overlain by post-glacial deposits. The Holocene sequence can be summarised as: (i) sandy silt; (ii) organic detrital mud with a small minerogenic (<20%) component; (iii) a thin sand and gravel unit; and (iv) an alluvial silty clay. The sections in Figure 2 show that the sandy silt and organic deposits occupy a hollow in the surface of the underlying gravels, and that in some places they rest directly on the Chalk bedrock. The contour plots in Figure 3 show that the hollow occupied by the sandy silt and organic deposits is enclosed, and tear-drop shaped, with steep slopes on the upstream (west) side and an elongated 'tail' extending downstream.

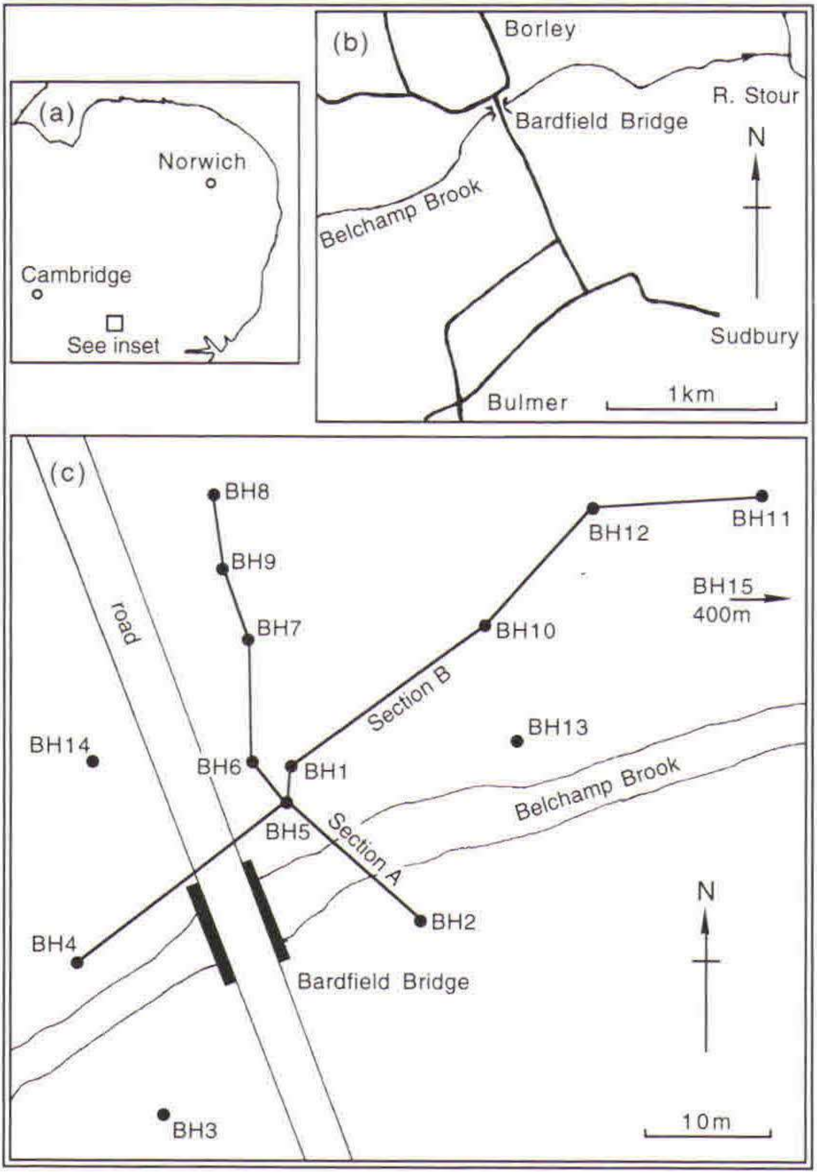


**Figure 1.** The position of the study site in East Anglia (a), the surrounding area (b), and the location of boreholes around Bardfield Bridge, Borley, Essex (c).

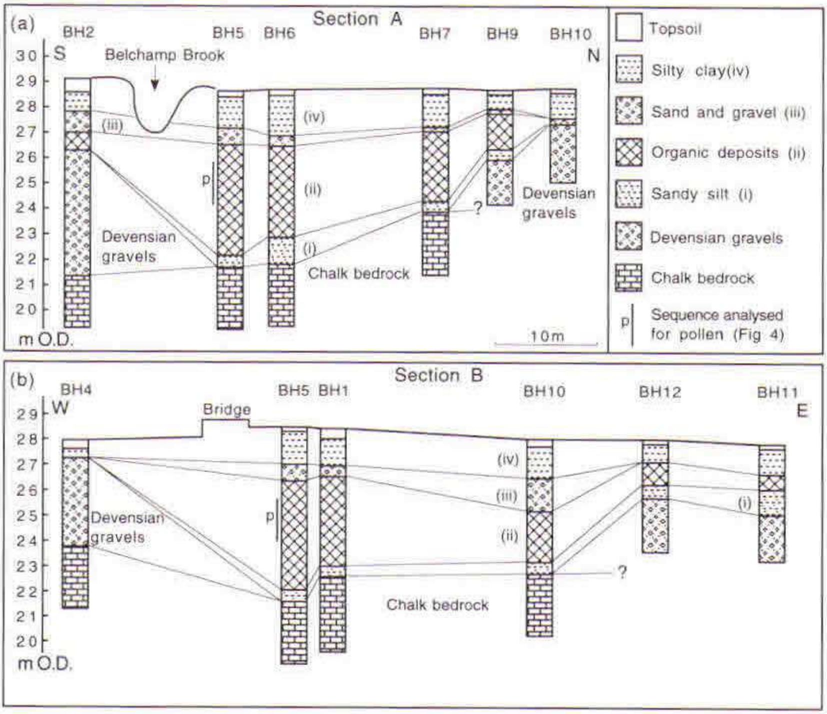


**Figure 2**. Sections constructed (a) S-N and (b) W-E from boreholes in the vicinity of Bardfield Bridge.

## Pollen analysis

Although the organic deposit in BH5 extended down to 6.50 m depth, undisturbed material could not be recovered from the base of the core. Therefore, ten sub-samples from the upper part (3.10 - 4.25 m) of the organic deposit were taken for pollen analysis. Pollen preparation, counting and identification were as described by Bennett (1983). Plant taxonomy follows Stace (1991), and incorporates the suggestions of Bennett *et al.* (1994). A minimum of 300 land-pollen and spores was counted at each level. The skeletal pollen diagram (Figure 4) shows a high proportion of *Betula* from the lowest part of the sequence analysed (4.25 m). Above this there are marked peaks of

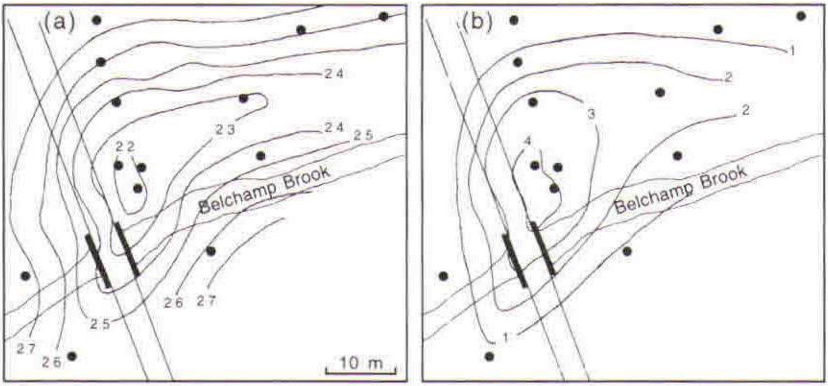


**Figure 3.** Contour plots of (a) the basin morphology (surface elevation of the basement gravels, and where absent the Chalk bedrock in metres OD) and (b) the thickness of the sandy silt and organic deposits, in metres, at Bardfield Bridge.

*Corylus* and *Pinus*, and above 3.95 m the pollen of *Quercus*, *Tilia* and *Alnus* become more abundant.

## Discussion and conclusions

The organic deposits appear to have accumulated in a tear-drop shaped hollow, left by an icing (also known as a naled or an aufeis); a body of ice formed by spring activity in the bed of a stream during periglacial conditions (Coxon, 1978). It is envisaged that during the late Devensian, gravel was deposited around such an ice-body in a braided river environment. As the climate warmed, the ice thawed leaving a deep hollow in the gravel of the valley floor. This hollow formed a pool which accumulated first sandy silt (unit i), and then organic detrital mud (unit ii). Although the pool was undoubtedly affected by river flood events, it appears to have remained open and largely separate from the main river channel until changes in the catchment, possibly woodland clearance, increased the sediment supply to the river. In response, the channel of the Belchamp Brook moved across the valley floor leaving a thin sand and gravel lag (unit iii), and subsequently deposited the alluvium (unit iv) of the present floodplain.

The pollen sequence from BH5 (Figure 4) exhibits part of the classic Holocene vegetational succession known from other sites in East Anglia (Bennett, 1988), and is attributable to the period *c.* 10,000 - 5,000 BP. This succession is characterised by the development of birch scrub, giving way to pine and hazel, and subsequently replaced by mixed oak woodland with lime, hazel and alder. The presence of sandy silt and organic deposits more than 2 m below the observed birch pollen peak in BH5 strongly suggests the possibility that Devensian late-glacial and very early Holocene deposits are preserved in this hollow.

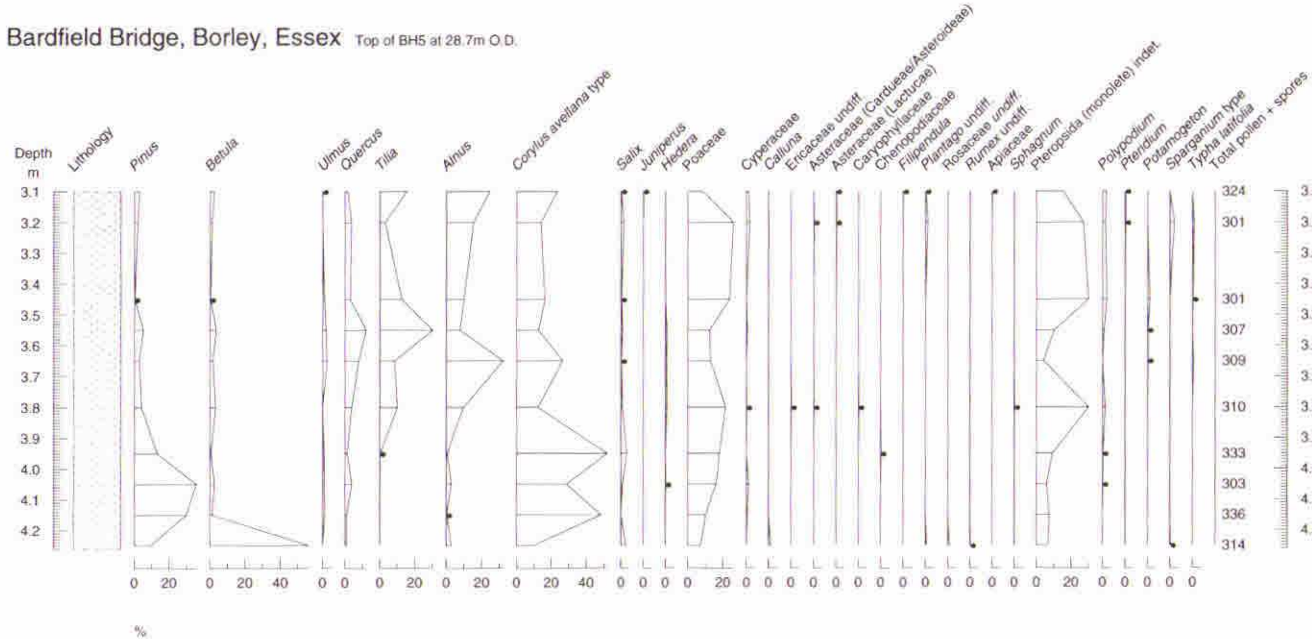


**Figure 4.** Skeletal percentage pollen diagram from BH5, Bardfield Bridge. The main pollen sum is the total land pollen and spores, excluding aquatics. A dot is used to indicate the presence of a taxon at frequencies below 0.5%.

Detailed Holocene pollen records from East Anglia include: Hockham Mere (Godwin and Tallantire, 1951; Bennett, 1983), Quiddenham Mere (Bennett *et al.*, 1990), Diss Mere (Peglar *et al.*, 1989) and Old Buckenham Mere (Godwin, 1968). However, these sites are at least 40 km to the north of Bardfield Bridge, and there are no nearer sites of a similar age, so that the site appears to fill a spatial gap in the Holocene vegetation record for East Anglia. The organic deposits at Bardfield Bridge clearly present the opportunity for further detailed work.

**Acknowledgements**

The author would like to thank R. Brian of Essex County Council Highways Department for alerting us to the site, K. Gibson of the NRA, S. Rattigan and M. McKenna of Galliford Eastern, and K. D. Bennett and K. Marr for assistance with the boreholes.

**References**

Bennett, K. D. (1983). Devensian late-glacial and Flandrian vegetational history at Hockham Mere, Norfolk, England. I. Pollen percentages and concentrations. *New Phytologist*, 95, 457-487.

Bennett, K. D. (1988). Holocene pollen stratigraphy of central East Anglia, England, and comparison of pollen zones across the British Isles. *New Phytologist*, 109, 237-253.

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

Coxon, P. (1978). The first record of a fossil naled in Britain. *Quaternary Newsletter*, 1, 9-11.

Godwin, H. (1968). Studies of the post-glacial history of British vegetation. XV. Organic deposits of Old Buckenham Mere, Norfolk. *New Phytologist*, 67, 95-107.

Godwin, H. and Tallantire, P. A. (1951). Studies in the post-glacial history of British vegetation. XII. Hockham Mere, Norfolk. *Journal of Ecology*, 39, 285-307.

Peglar, S. M., Fritz, S. C. and Birks, H. J. B. (1989). Vegetation and land-use history at Diss, Norfolk, U.K. *Journal of Ecology*, 77, 203-222.

Stace, C. (1991). *New flora of the British Isles*. Cambridge University Press, Cambridge.

**S. Boreham**
**Quaternary Stratigraphy Group**
**Godwin Institute for Quaternary Research**
**Department of Geography**
**University of Cambridge**
**Downing Place**
**Cambridge, CB2 3EN**

# AN ANGLIAN TILL AT LONG HANBOROUGH, OXFORDSHIRE? SOME ADDITIONAL DATA AND AN ALTERNATIVE INTERPRETATION

**M.G. Sumbler**

## Introduction

A small exposure [SP 4189 1470] of diamicton in the car park of Crystal Water Spring Co. Ltd at Long Hanborough, Oxfordshire, was recorded by J. Coe (*Quaternary Newsletter*, **80**, 10-16, 1996), who tentatively concluded that it may be a till, possibly ice-rafted, of Anglian age. However, in my opinion, the nature and physical composition of the material, and more especially its local topographical and stratigraphical context, do not lend support to this conclusion.

## Description

The site, on the southern bank of the Evenlode Valley (or 'Gorge'; Arkell, 1947), is immediately adjacent to the old Layshill Wood Quarry, in which the mineral water extraction borehole and bottling plant are situated. This quarry (Sumbler, 1984) is excavated into the White Limestone and Forest Marble formations (Great Oolite Group, Middle Jurassic), which form the lower slopes of the hillside. The hill is capped by younger Jurassic formations, overlain by gravels of the Hanborough Terrace, on which the village of Long Hanborough is built. The small car park and loading area lies at the foot of the hill, where the original trackway into the quarry would have lain; indeed the area is shown as part of the quarry working on the BGS surveyor's field map of the area (1:10,560 Sheet SP 41 SW, by S.R. Mills, 1973; BGS archive). The car park extends onto a broad bench which flanks the Evenlode River hereabouts. This bench, though mapped largely as brickearth by Arkell (1947, plate 3), and as 'head' by the British Geological Survey (BGS 1:50,000 Sheet 236, Witney, 1982) is, in fact, a river terrace, characterised by a limestone gravel soil with sporadic quartzite pebbles and flints, which is well seen in an arable field across the road from the car park. Its elevation is *c.* 78 to 80 m above OD, that is up to about 10 m above the modern floodplain of the Evenlode at this locality. On this basis it may be classified as Wolvercote Terrace (e.g. Sumbler, 1995, fig. 4), and is one of the best preserved remnants of this terrace in the 'Gorge'.

The southern boundary of the car park is excavated into the foot of the hillside, providing modest exposures in a face up to *c.* 1 m high and *c.* 30 m long. Nearby exposures in the incised trackway leading from the quarry show angular White Limestone scree passing downhill into more rounded solifluction gravel with sporadic quartz/quartzite pebbles, the latter presumably derived from the Hanborough Gravel on the hilltop. Traced eastwards and downhill to the car park, this material passes into better-sorted and more well-rounded limestone-rich gravel, representing the fluvial Wolvercote Gravel, which is evidently broadly contemporaneous. The latter deposit is well exposed in the western part of the car park. The middle part of the car park section appears to be excavated in (or obscured by) dumped quarry waste, comprising marl and angular limestone pieces. The diamicton recorded by Coe (1996) is exposed only at the eastern end of the car park, where it is overlain by mounded-up deposits of fill, an estimated 1 m or so in thickness. Some 0.5 m of diamicton is exposed, and augering proved it to extend another *c.* 1 m below the level of the car park, and to rest on limestone gravel, presumably the solifluction or Wolvercote Gravel. The lateral extent of the diamicton, as indicated by the exposures and augering, can be no more than *c.* 10 m.

The diamicton has a matrix of reddish- to yellowish-brown, sandy, silty clay as described by Coe (1966), and contains a highly variable proportion of rock clasts. A bulk sample of *c.* 5 kg, after sieving and washing through 8 mm mesh, yielded 2.5 kg of pebbles as follows:

| | | |
|---|---|---|
| Limestone (Middle Jurassic) | 98 | (24.0%) |
| Limestone (Lower Jurassic) | 1 | (0.2%) |
| Ironstone (Lower Jurassic) | 4 | (1.0%) |
| Flint | 11 | (2.7%) |
| Chert | 2 | (0.5%) |
| Quartzite | 124 | (30.3%) |
| Quartz | 164 | (40.1%) |
| Other | 5 | (1.2%) |
| **Total** | **409** | **(100%)** |

The 'Quartzite' category includes other lithologies, including schorl rock, which derive from the Triassic Kidderminster ('Bunter') Conglomerate of the Midlands. Coal, recorded by Coe (1996), was not encountered in this sample, but was present in a bulk sample taken on a previous occasion.

## Interpretation

The composition of the diamicton is quite unlike the Anglian 'Moreton Drift' (Tomlinson, 1929) which is characterised by a high proportion of flint associated with chalk and Lias (Lower Jurassic) lithologies. Lithologically, it is more akin to the pre-Anglian Northern Drift (Hey, 1986) which, however, is normally (though not invariably) decalcified, and lacking limestone. Intriguingly, the durable (non-limestone) clasts are heavily dominated by well-rounded, yellowish-white quartz pebbles; these are thought to be derived from the Old Red Sandstone (Whiteman and Rose, 1992). These quartz pebbles substantially outnumber the 'Bunter' quartzite pebbles. This dominance of quartz pebbles is specifically characteristic of the oldest and highest-level unit of the Northern

Drift, namely the Waterman's Lodge Member (Hey, 1986; Whiteman and Rose, 1992), which occurs at elevations of over 180 m OD in areas bordering the Evenlode Valley, to the north-west of Long Hanborough. Indeed the Quartzite:Quartz (0.76) and Quartzite + Quartz:Flint (0.04) ratios are very close to those quoted for that unit (0.62 and 0.06, respectively).

However, given its situation overlying the latest or post-Anglian Wolvercote Gravel (Sumbler, 1995), it is hard to see how this diamicton, if in its original depositional context, could be either Northern Drift or Anglian till.

The five pebbles in the 'Other' category listed above comprise three angular fragments of tooth of a large herbivore (probably a horse), one fragment of possible brick and one of possible foundry slag/clinker. Uncounted washings included one fragment of a modern snail shell and several pieces of charcoal. Other pieces of charcoal were encountered in auger samples. Whilst these evident contaminants could conceivably have been introduced during recent disturbance of the diamicton, perhaps during the construction of the car park, their presence in a deposit of such local extent, overlying Wolvercote Gravel and, most importantly, situated at the entrance to an old quarry, and overlain by what is self evidently made ground, leads me to conclude that the deposit is, in all probability, an artificially emplaced fill. One can only speculate on its origin; it appears to have a large component of Northern Drift, but that the limestone fraction, dominated by sub-rounded pebbles of Cornbrash and Forest Marble, may perhaps originate from the younger Hanborough Gravel. I regard the 'thin veneer of limestone gravel' (Coe, 1996) which overlies the diamicton in places, also as artificial fill.

Whilst the preceding evidence is by no means conclusive, there currently seems no need to speculate on the presence of Anglian tills so far down the Evenlode Valley. Indeed ongoing work by BGS in the headwaters of the Evenlode (Sheet 217, Moreton in Marsh) suggests that the southern extent of the glacial component of the Anglian Moreton Drift, may be even less than indicated by Tomlinson (1929) and Sumbler (1995, fig. 1).

**Acknowledgements**

I am grateful to the Crystal Water Spring Co. Ltd for permission to investigate and sample the deposit on two occasions, and for the company of Dr Adrian Parker, Professor Andrew Goudie and Dr Julian Murton on the second visit. These individuals do not necessarily share my conclusions. This note is published by permission of the Director, British Geological Survey (NERC).

## References

Arkell, W. J. (1947). The geology of the Evenlode Gorge, Oxfordshire. *Proceedings of the Geologists' Association*, 58, 87-113.

Coe, J. (1996). An Anglian Till at Long Hanborough, Oxfordshire. *Quaternary Newsletter*, 80, 10-16

Hey, R.W. (1986). A re-examination of the Northern Drift of Oxfordshire. *Proceedings of the Geologists' Association*, 97, 291-302.

Sumbler, M G. (1984). The stratigraphy of the Bathonian White Limestone and Forest Marble Formations of Oxfordshire. *Proceedings of the Geologists' Association*, 95, 51-64.

Sumbler, M.G. (1995). The terraces of the rivers Thame and Thames and their bearing on the chronology of glaciation in central and eastern England. *Proceedings of the Geologists' Association*, 106, 93-106.

Tomlinson, M.E. (1929). The drifts of the Stour-Evenlode watershed and their extension into the valleys of the Warwickshire Stour and Upper Evenlode. *Proceedings of the Birmingham Natural History and Philosophical Society*, 15, 157-196.

Whiteman C.A. and Rose, J. (1992). Thames river sediments of the British Early and Middle Pleistocene. *Quaternary Science Reviews*, 11, 363-375.

**M.G. Sumbler**
**British Geological Survey**
**Keyworth**
**Nottingham**
**NG12 5GG**

# *REPORTS*

## FIRST ANNUAL QRA POSTGRADUATE SYMPOSIUM: CHELTENHAM AND GLOUCESTER COLLEGE OF HIGHER EDUCATION

### 6th-7th November, 1996

All the ingredients were there; the Georgian delights of Cheltenham, the opportunity to meet 40 postgraduates working in very diverse fields of Quaternary research and, arguably the nicest option, the chance to socialise *en masse* with old and new friends. Despite the best efforts of the weather, the symposium was a great success, and our hosts at the Centre for Environmental Change and Quaternary Research made us extremely welcome. From start to finish the symposium was very well organised and **Leri Roberts, Gill Thomas, Matt Goodwin**, and **Kathryn Sharp** are to be congratulated for their hard work, cheerfulness and professionalism.

During the course of the one and a half day symposium, 22 talks were presented, covering a wide range of subjects, some of which were very innovative. The pioneering research of **Chris Gleed-Owen** (Coventry University) is a case in point, as bones of the natterjack toad may reveal the existence of possible land-bridges during the Late Devensian. The palaeohydraulic reconstruction research presented by **Philip Marren** (Keele University), where the role of high magnitude/low frequency events such as Jökulhlaups is being investigated, was particularly interesting, given the current large-scale flooding that occurred recently in Iceland. Research of a very novel nature was presented by **Duncan Irving** (UWC Cardiff), where a 6 m beam centrifuge is being used to model permafrost rheology. Duncan gave the audiénce an idea of the power of this (very large) piece of equipment, by showing slides of crushed Mars bars. This occurs at 20 gravities, well below the machine's maximum of 150 gravities!

A striking feature of many research projects was their cosmopolitan nature. Examples included; analysis of debris-rich basal ice in Iceland, palaeoenvironmental reconstructions in Central Mexico, glacial chronology from Eastern Zanskar, India, and palaeoecological analytical research from Mt Kenya. It was a great pity the talks were limited to only twenty minutes, as many of the participants had to finish off their presentations rapidly to leave time for questions, but since time was limited, there was clearly no other alternative.

After adjourning for a very civilised wine reception, **Professor D.Q. Bowen** frankly shared his thoughts with us in his talk, 'Quaternary Priorities and

Prospects'. Rather than using slides and overheads (which at this juncture came as a very welcome change), he shared his thoughts with us on this subject and suggested ways in which we might want to approach our research projects and science in general. This very refreshing talk stimulated much debate, which unfortunately had to be curtailed, as our hosts had arranged a meal for us at a local Spanish restaurant.

The next morning the final presentations were given, which again covered a wide range of subjects, for example, **Steve Morton** (CECQR) discussed his tephrachronological work from the Northern Antarctic, whilst **Kenneth Rijsdijk** (University of Wales, Swansea) presented some of the findings from his investigation into the subglacial and paraglacial sediments at Abermawr, Pembrokeshire.

On behalf of all the postgraduates, I would like to thank once again our hosts at the Centre for Environmental Change and Quaternary Research, and wish the University of Wales team good luck with the organisation of the next Quaternary Postgraduate Symposium.

**Dmitri Mauquoy**
**Department of Geography**
**University of Southampton**

# QRA ANNUAL DISCUSSION MEETING - MOUNTAIN GLACIATIONS: CHRONOLOGIES, FORMS AND PROCESSES

## 9th-10th January, 1997

This two-day meeting attracted over 50 scientists with interests in glaciology and palaeoclimate change. **Lewis Owen** (Royal Holloway, London) opened proceedings by commenting on the broad range of research interests to be covered. Keynote papers were then given by **Stephen Porter** (Washington) and **Edward Derbyshire** (Royal Holloway, London).

Porter gave a fascinating lecture on *Hawaiian glacial ages.* He presented a more or less continuous record of glaciation back to the Early Pleistocene by using radiometric dates obtained from lava flows interstratified with glacial drift, and by considering the eruption history of Hawaiian volcanoes. A semi-permanent ice cap existed on Haleakala volcano between isotope stages 28 and 10. Ice caps were present on Mauna Kea during stages 2, 4 and 6, and a discontinuous ice body existed here during Stage 3. Future glaciations on Mauna Kea could be expected in 22 and 60 ka, but by 100 ka from now the summit will have subsided below the equilibrium line altitude (ELA). Depression of the ELA on Mauna Kea by 935 m, during full glacial times, could be attributed to increased cyclone genesis, together with the expected lowering of air temperature, producing increased snowfall from the east.

Derbyshire's paper, *Glaciation of Tibet*, appraised detailed sedimentological and geomorphological evidence from across the Tibetan Plateau, to assess the extent of ice in this area during glacial times. He suggested that the misinterpretation of diamictons, which were often the product of periglacially degraded bedrock or tectonism, rather than glacial processes, had led to inaccurate estimations of past glacial distribution. Similarly, he thought that the evidence derived from landforms was equivocal. For example, fan features to the north-east of Tibet, which have previously been mapped as ice-contact fans (Kuhle), are in fact often the result of differential erosion of piedmont slopes (i.e. flat-irons), or are bedrock ramps which have been offset by faulting. Derbyshire gave compelling evidence for a limited glacial distribution across Tibet during the Quaternary. Semi-arid conditions across much of this area preclude the existence of a plateau-wide ice sheet.

In *Recent glacier fluctuations and climate change on the north Patagonian Icefield, Chile*, **Stephan Harrison** (Coventry) reported on extensive fieldwork carried out on some of the world's least understood glaciers. Whilst the general 20th century tendency is towards retreat, he noted a post-1990 trend towards advance, due to an increase in precipitation in the 1970s and 1980s. **Chalmers Clapperton** (Aberdeen) questioned whether these very recent glacial advances were significant, noting that similar past advances were not retained within the geological records.

**Matthew Bennett** (Greenwich) discussed *The role of glacial thrusting in moraine mound formation: examples from Svalbard and Scotland*. He explained how advancing ice produces abundant thrusts, where englacial material can be concentrated. Following glacial retreat, arcuate belts of moraine mound complexes are formed. He suggests this model can be applied to some of the Loch Lomand Stadial moraines in Scotland, most notably those of the Valley of the Hundred Hills in Torridon. **Jane Hart's** (Southampton) paper, *The deforming bed/debris-rich basal ice continuum illustrated from contrasting glacial environments*, used examples from Alaskan glaciers to examine processes occurring in the deforming bed and debris-rich basal ice layers. These two dynamic subglacial regions contribute enormously towards movement of the glacier and exhibit many process similarities. However, melt-out from the debris-rich basal ice layer, whilst being significant, must always pass through the deforming bed layer and is, therefore, difficult to identify.

**Mike Hambrey's** (Liverpool) lecture, *Debris-entrainment in polythermal valley glaciers, Svalbard*, proposed that the best modern analogue for the formation of European and North American LGM landforms was arctic valley glaciers. Fold, lineation and thrust features enable both supraglacial and subglacial debris to be entrained and to follow an englacial pathway. Medial moraines are formed where the hinge axis of a fold intercepts the surface of a glacier. Constriction of the glacier below the accumulation basin results in pronounced folding, which, Hambrey speculates, can cause basal debris to reach the top of a glacier.

**David Collins** (Oxford) reported on quantifying the *Rates of contemporary glacial erosion in the Karakoram Mountains*. By calculating the total sediment flux and cationic flux of the meltwaters draining the Batura Glacier, he showed that the annual denudation rate of a glacierised Karakoram basin was considerably higher than the average continental value and higher than values obtained from glaciers in the Alps. Himalayan glaciers, he concluded, contribute significantly to solute transport from the continents to the oceans.

**Andy Dugmore's** (Edinburgh) thought-provoking paper, *Can rates of glacial valley formation be determined using landslide morphology?*, aimed to determine the depth of erosion occurring through a single glacial cycle, in northern Iceland. This was achieved by investigating the degree of alteration exhibited by last interglacial landslides within glacial valleys. Whilst the larger landslide events (1-5 km) had been modified, the smaller last interglacial landslides (<1 km) had been completely destroyed. Dugmore considers that ~40 m of valley-wall erosion would be required to remove the smaller slides, a value which equates to the degree of erosion per interglacial/glacial cycle.

In *Plateau icefields: dynamics and geomorpholgy*, **Brian Whalley** (Belfast) considered modern-day analogues for Last Glacial conditions in the UK. In northern Norway, many valley glaciers exist as outlets of high elevation plateau icefields and, therefore, fluctuate in response to changes in the plateau ice mass. The plateau icefields are predominantly cold-based and tend to leave little or no evidence of their presence following ice wastage. He suggested that former valley glaciers in northern Britain (e.g. the Cairngorms) may be better interpreted as outlets from plateau icefields than as palaeo-corrie glaciers.

During the discussion that followed, Porter asked if Whalley thought that the Norwegian icefields had been in existence during isotope Stage 5e, when ELAs would have been considerably higher. Whalley suggested that although temperatures were higher during Stage 5e, so was precipitation, which was likely to be the key factor controlling the presence of the icefields. Referring back to earlier talks, the discussion continued on the possible thermal régimes beneath Scottish glaciers during Last Glacial times and also on methods of subglacial debris entrapment.

Clapperton's keynote address, *Late Quaternary glacier fluctuations in the Andes: an updated overview*, started Friday morning's session. He discussed the degree of synchroneity between northern and southern hemisphere climate change events. A well-dated moraine complex to the east of Bogotá (N. Hemisphere), together with palynological evidence of tree-line fluctuations, identifies 7 cold spells in the northern Andes; which can be correlated with Greenland ice-core evidence. In the equatorial Andes, tight dating control has been obtained for moraines of a Younger Dryas age, backing up Clapperton's long-held belief that this event was global in extent. Excellent dating control has shown a close correspondence between ice advance in the Chilean Lake Region (S. Hemisphere) and northern hemisphere Heinrich events. Clapperton's absorbing and profusely illustrated lecture, presented a convincing case for synchronous, inter-hemispheric climate change, on a millennial and decadal time span.

**Monique Fort** (Paris) then reviewed data on *The glaciation of Nepal*. She showed how the style, extent and pattern of glaciation, together with its preservation potential, have varied considerably between sites to the north and south of the Greater Himalaya. She appraised evidence from the southern slopes of the Annapurna Range, across the Greater Himalaya to the northern side of Everest and finally from the Mustang graben in southern Tibet. ELA depressions had been as great at 1,000 m to the south of the Greater Himalaya, whereas they had only been around 400 m to the north of this range. The most favourable locations for future palaeoclimatic work would be the environmentally sensitive isolated massifs to the north and south of the Greater Himalaya.

Lewis Owen discussed the *Timing and style of glaciations in the Himalayas* and used evidence from different locations to show how glaciers respond to varying climatic systems. Glaciers influenced principally by the south Asian monsoon, such as those in the Garwhal Himalaya, appear to have reached their greatest extent not during the global LGM, when the monsoon was subdued, but between ~60-30 ka, a time coincident with increased insolation and enhanced monsoon circulation. The strength of the Westerlies, however, was increased during the LGM in parts of the western Himalayas and Tibet, and glaciers controlled by this wind system, such as those in the Karakoram and the Kunlun Shan, advanced during this time. **Wishart Mitchell** (Luton) then described geomorphic evidence from Lahul, Zanskar and Ladakh, in support of *Early glaciations in the Himalaya.* Pre-glacial, fluvial valleys are still retained as valley benches, some 200-300 m above the present rivers. A well indurated tillite is evidence of the first widespread glaciation, which field mapping shows to have been more extensive than subsequent glaciations. Mitchell suggests that a reduction in glacier extent during successive glacial stages in this area is due to the development of a valley system which can contain ice volumes more efficiently. Striations, drumlins and erratics indicate a south-easterly ice-flow direction for this early glaciation, transverse to the present valley system.

In *Quaternary glaciations in central and western Mongolia*, **Frank Lehmkuhl** (Göttingen) presented tentative conclusions from field investigations, aimed at determining the nature of former glaciations in the Changai and Mongolian Altay mountains. He noticed a different style of glaciation between the two mountain ranges. Past glaciations in the Changai were characterised by ice caps on ancient peneplains, whereas in the Mongolian Altay, Pleistocene alpine glaciation has resulted in cirques and U-shaped valleys. He observed two major glaciations in the study areas, each linked to a distinct episode of gravel-floor and terrace formation. During the LGM, an ELA depression of ~500 m was calculated for the Mongolian Altay; Changai ELAs may have been up to 1,000 m lower than today's value.

**Martin Kirkbride's** (Dundee) *How many cold phases? An assessment of proxy evidence of Holocene climate in New Zealand*, raised the question of how representative moraine sequences were of climate change episodes. He used examples to discuss the validity of cross-correlating between different areas, where: climate may vary at different wavelengths and amplitudes; individual landforms may have different climatic sensitivities; and the palaeoclimate record may be censored by erosion. The paper suggests that geomorphic environments may be classified by the type of chronology they can provide.

**Derek McDougall** (Worcester) discussed *The Loch Lomond readvance in the Lake District.....* He suggested that small ice caps may have been a common feature of the Loch Lomond readvance here. He used aerial photography to map faint landforms indicative of ice-marginal moraines, and traced palaeo-outlet glaciers up-valley. The clearest evidence for an icefield was to the south-west of High Raise, where the presence of blockfields suggests the ice cap was cold-based. **Ed Anderson** (Middlesex) presented evidence for *Younger Dryas glaciation in the Macgillycuddy's Reeks, south-west Ireland*, where climatic conditions for post-Midlandian mountain glaciation may have been favourable. Reconstructed Younger Dryas glaciers, which were restricted to cirque basins, reveal an eastwardly rise in ELAs, characteristic of precipitation advection from the west. He used palaeoenvironmental reconstructions to suggest a mean July sea-level temperature of 9°C.

**Nick Spedding** (Aberdeen) discussed *A model of large moraine formation: two examples from southern Iceland.* Despite being relatively free from supraglacial debris, the two glaciers under investigation have developed large, composite, 'rampart-type' moraine complexes. These are derived mainly from subglacial bedrock, which is transported to ice-marginal positions by drainage well above the level of the glacier bed. Spedding points to the presence of over-deepening beneath both glaciers, suggesting this may instigate and perpetuate the subglacial processes necessary to build these large moraines.

The closing lecture of the conference was given by **Jim Rose** (Royal Holloway, London), on *Glaciation of the eastern Qilian Shan, north-west China.* He described the style of glaciation in these dry, cold mountains to the north-east of the Tibetan Plateau. He illustrated how the glacial system in the Qilian Shan is predominantly cold- and wet-based and, together with the proglacial environment, is responsible for the transfer of vast quantities of material from the dynamic mountain régime to the adjacent sedimentary basins. Although he found evidence to support a maximum glacier extent in this area during the LGM, subsequent marginal oscillations were also considered to have occurred.

Poster's were presented by: Kirkbride (Dundee) and Warren (St Andrews) - *Calving processes at a grounded ice sheet*; Taylor and Mitchell (Luton) - *Observations on the glacial geology of eastern Zanskar, north-west India*; Smith (Manchester Metropolitan) *et al. - Late Pleistocene glaciation in a Mediterranean mountain environment: the northern Pinus range*; Hillcox (Loughborough) - *Glacier fluctuations in the eastern Black Sea*; and Richards (Royal Holloway, London) - *Timing and styles of glaciation in the Trans-Himalayan mountains.*

The meeting highlighted how a better understanding of mountain glaciation, from all corners of the globe, is fundamental in furthering our knowledge of Quaternary palaeoenvironmental change. Thanks go to Lewis Owen for the organisation and to all those who helped in the smooth running of the conference.

**Patrick Fothergill**
**Royal Holloway**
**University of London**

# THE QUATERNARY OF THE SOUTH MIDLANDS AND THE WELSH MARCHES: ANNUAL FIELD MEETING

## 24th-27th March, 1997

Fifty eight QRA members, including visitors from Germany and Poland, attended this meeting which was organised by the Cheltenham-based team of **Darrel Maddy** and **Simon Lewis**, assisted by **Gill Thomas, Matthew Goodwin** and **Simon Risdon**. The first evening in Cheltenham was begun by **Darrel Maddy** with a lecture on the Quaternary of the area to be visited and with numerous references to continuing controversies about the region. Members agreed not to let these controversies get too acrimonious before seeing the field evidence, and retired to a cavernous student bar which required about 300 further people present to make it seem comfortable.

### Tuesday 25th March

After a scenic journey from Cheltenham through Herefordshire into Monmouthshire, the party walked beside the Usk to have Holocene river terrace development in the valley explained by **Geoff Thomas** (Geography, Liverpool). Some convincing geomorphology was backed up by good river-cliff sections made accessible by the low level of the river. Geoff explained that the detail recorded in the area was largely the result of a sand and gravel survey done in the late 1980s for the Welsh Office by a team from Liverpool. The survey had concentrated on resources and there was still much scientific work to be done on the sediments identified. At the Bryn, between Usk and Abergavenny, organic sediments beneath gravel and sand prompted discussion, led by **Frank Chambers** (CECQR, Cheltenham). He suggested that the deposits could have accumulated either in the early Holocene or that they could have formed later by alluviation associated with forest clearance and early agriculture. In the absence of pollen data and radiocarbon dates, such speculations could run free, but the sight of uninvestigated organics whetted appetites for members with a Holocene interest. A short journey in the bus led to the complex of moraine, sandur and alluvial fan sediments around Gilwern. Like all such sequences, these would best be viewed from a balloon (not yet included in any QRA trip), but they were described by **Geoff Thomas** with the aid of detailed geomorphological maps some of which are also published in the meeting guide.

The afternoon was spent in the Wye Gorge. The first stop was King Arthur's Cave, where **Nick Barton** (Archaeology, Oxford Brookes), **Cath Price** (Quaternary Section, British Museum) and **Chris Proctor** (Geography, Exeter) demonstrated their work with total *sang-froid* despite the news that their parked cars had been broken into at the forestry car park. Like most cave sites in the area, this one had been extensively dug in the 19th century and in the 1920s, but some *in situ* deposits still remain and a shallow section outside the cave had been opened for the party to see. These deposits seem to be of Devensian late-glacial age, but earlier excavations had recorded mammoth, woolly rhino and hyaena, dated by radiocarbon to Middle Devensian times, associated with an Upper Palaeolithic industry. The excavators hope to locate untouched sediments of this age for modern palaeoecological analysis.

A short walk through the woods brought the party to the edge of the Wye Gorge, where the view along the famous incised meanders was explained by **Darrel Maddy** (CECQR, Cheltenham). Davisian landscape evolution was taken from its closet and dusted down as an explanation of the summit surface as a sub-aerial peneplain. The incised meanders were suggested to have been formed on a uniform cover of Cretaceous Chalk which was then stripped leaving the river to cut deeply into the underlying Palaeozoic rocks regardless of lithology or structure. Discussion focussed on the problems of the age of the incision, the possibility or not of superimposition from a cover of Chalk, and the tectonic controls which might have generated such incision. **David Keen** (Centre for Quaternary Science, Coventry) and **David Bridgland** (Geography, Durham) were both sceptical of an incision from the Chalk and asked the leader to account for the long period of time between the end of Chalk deposition and the cutting of the gorge which may only have occurred in the Late Cenozoic. **David Bridgland** offered an alternative explanation that the river may have begun its incision only in the Late Cenozoic, from a surface of low relief mantled with fluvial deposits which masked the solid geological structures and lithologies, an explanation which seemed to find favour with many in the party. Despite attempts to prompt **Alan Brandon, Tim Charsley** and **Mike Sumbler** (British Geological Survey, Keyworth) to surmise about residual deposits that may or may not be present on the Forest of Dean plateau, and provide a hint of the conditions of the surface on which incision began, no such sediments have been found. Clearly there is still more discussion to be had on these spectacular landforms.

**Wednesday 26th March**

The first stop was at Newton Farm, Cricks Green, south of Bromyard, where **Andy Richards** (Geography, Kingston) demonstrated Anglian retreat phenomena in the form of Gilbert-type delta gravels. Discussion centred on the direction of ice advance with **Andy Richards** arguing for a central Wales origin, but **Alan Brandon** (BGS, Keyworth) being firmly of the opinion that as the sediments contained no fragments of Lower Palaeozoic rock types, the major bedrock lithology to the west, the ice must have had a more northerly Welsh origin.

At the second stop, Windmill Hill, Stoke Lacey, more Anglian glaciofluvial sediment was described by **Andy Richards**. These sands and fine gravels were held to be from a "hyperconcentrated" flow of gravel occasioned by a jökulhlaup from a glacial lake (Lake Bromyard) held up against the ice. Discussion centred on the fine-grained nature of the sediments and several members commented that these were atypical of jökulhlaup flows seen elsewhere, although **Andy Richards** suggested that these were only part of the sediment accumulation and that much coarser gravels could be seen elsewhere in the sediment body.

After lunch at the Whittington Inn, near Stourport, the first stop was Roger Constant's Pit, Stourport. This working gravel quarry was last visited by the QRA in 1989, but more extensive sequences were now demonstrated by **Matthew Goodwin** and **Darrel Maddy** (CECQR, Cheltenham). The key part of the succession here is the diamicton which underlies the fluvial deposits of the diverted Severn downstream of Ironbridge Gorge. All were agreed that the deposit was most likely a till, but that its position deep in the valley bottom, supposedly carved out by meltwater in the Late Devensian, presented considerable problems for glacial limits in the area. The preferred explanation offered by **Darrel Maddy** was that this till was deposited by a glaciation in Oxygen Isotope Stage 6 as its low topographic position in the valley ruled out an Anglian age, and the lack of Irish Sea erratics characteristic of Late Devensian tills around Bridgnorth precluded the latter age.

The final stop of the day was Stewponey Pit, Stourbridge. Here the theme of a glaciation between the Anglian and Devensian was further developed by **Simon Lewis**, **Darrel Maddy** and **Matthew Goodwin** (CECQR, Cheltenham). The pit here has been a source of sand since the 1930s and is now up to 50 m deep. The site was difficult for the party to examine because of the size and steepness of the faces and the huge area of the excavation. The evidence for the age and origin of this large body of sediment was difficult to obtain, but gravels in the succession have none of the erratic types associated with Devensian glacial deposits, so a greater age is likely. The depth of incision to the base of the channel would seem to make an Anglian age unlikely, leaving a date in a younger glaciation, perhaps in Stage 6, a possibility. The origin of the sediment is also difficult to determine, although the predominance of sand over gravel and the lack of diamict suggests deposition as outwash, perhaps in an ice-marginal channel. Discussion was curtailed due to the closure of the quarry at the end of the day.

In the evening, after a wine reception, a lecture by **Manfred Frechen** (CECQR, Cheltenham), on luminesence dating and the new laboratory being installed at Cheltenham, provided time for further sharpening of appetites for dinner at a nearby Indian restaurant.

**Thursday 27th March**

After a drive over the Cotswolds, the party arrived at Daisy Banks Fen, Abingdon. Here, in the somewhat incongruous surroundings of a housing estate, **Adrian Parker** (Geography, Oxford) described the Holocene vegetational history and archaeology of this valley-bottom bog. A first phase of deposition started at 5,240 BP and revealed pollen associated with the activities of Neolithic farmers. Following interruptions in organic sedimentation caused by soil erosion, the area was occupied by Bronze Age farmers and then became an effective sediment trap once again on the construction of a Mediaeval dam and fishpond for Abingdon Abbey. Sedimentation came to an end shortly after 1538 when the fishponds fell into disuse at the dissolution of the monasteries. Fluctuations in lake level, caused by climatic events, add to the complexity of the record to be unravelled.

The second stop of the day was Stanton Harcourt where deposits of Stage 7 age were demonstrated by **Christine Buckingham** and **Kate Scott** (Donald Baden-Powell Quaternary Research Centre, Oxford). These temperate deposits, at the base of the Summertown-Radley Terrace of the Thames, have been well known for twenty years for their accumulations of mammoth bone, together with the remains of other vertebrates and prolific mollusc and insect faunas. The site is now greatly reduced due to the construction of cells for rubbish tipping, but enough remained of the gravel to show the nature of the channel sediments. Numerous shells of the 'temperate' bivalves *Corbicula fluminalis* and *Potomida littoralis* were found in the pit, and an exhibition of some of the more spectacular large vertebrate bones was also assembled. There was a general acceptance that the channels were of Stage 7 age, rather than any later temperate stage, although some whispers of dissent could still be heard at the fringes of the party.

Lunch was taken in Eynsham, where many of us slaked our thirsts on pints of Morrells at the Red Lion. The final stop was at Cassington pit, where **Darrel Maddy, Simon Lewis** and **David Keen** summarised the work done by a team also including **David Bowen** (Geology, Cardiff), **Russell Coope** (Centre for Quaternary Science, RHBNC), **Simon Parfitt** (Natural History Museum), **Rob Scaife** (Geography, Southampton) and **Kate Scott** (Oxford), on these terrace sediments of the Northmoor Member. The sections visited showed none of the channel features or fossil fauna and flora revealed in the various phases of quarrying since 1992, but the description of these remains by the leaders gave strong indications of a Stage 5 age. Whether the channel deposits belong to the end of Stage 5e, or to Stage 5a, as preferred by Darrel Maddy, remains open to question.

After a vote of thanks to the organisers given by **John Wymer**, the meeting dispersed after three days of good Quaternary sections and discussion. The reporters of the last annual field meeting (**Stewart Campbell** and **James Scourse**, see *QN* 79, pp. 48-54) bemoaned the fact that the Devon and Cornwall meeting attracted few senior QRA members. This years' meeting produced two former Presidents and two former Secretaries, so the veterans of the Association were more in evidence, but there was a noticeable lack of current research students. Perhaps meeting organisers should think of subsidising a few places for the next generation as the Association will wither away without the support of research students.

**David Keen**
**Centre for Quaternary Science**
**Coventry University**

# YOUNG RESEARCH WORKERS AWARDS 1996

## EXCAVATIONS AT THE LATER MIDDLE PLEISTOCENE SITE OF GREENLANDS PIT, PURFLEET, ESSEX

**Danielle C. Schreve**
**Department of Biology, University of London**

In September 1995, prior to the QRA Lower Thames field meeting, two sections were excavated in the north-east corner of Greenlands Pit, Purfleet (part of the Purfleet Chalk Pits SSSI). One of these sections yielded a sequence of coarse gravels, sands and silts stratified above a fine sandy bed containing abundant shells, associated with Lower Palaeolithic flint artefacts. Preliminary investigation of the shell bed proved it to be extraordinarily rich in well-preserved fossil vertebrates, including numerous species of fish, herpetiles and mammals. On the strength of these findings, it was decided to return to the quarry to carry out further research in 1996.

The geological, palaeontological and archaeological significance of the Purfleet deposits has been known since the 1960s, although the age of the site has remained highly controversial. The position of the Pleistocene deposits, which are banked against the northern flank of the Chalk ridge at Purfleet, together with evidence from bedding structures within the gravels which suggested deposition by currents flowing towards the west and south-west (clearly contrary to the present-day direction of flow of the Thames), led other workers to conclude that the Purfleet deposits were laid down by the tributary Mar Dyke stream during the Ipswichian (Wymer, 1968, 1985; Palmer, 1975; Gibbard, 1995). However, recent studies by Bridgland (1988, 1994) have demonstrated that during the later Middle Pleistocene, the Thames once occupied a more sinuous course across the area now drained by the Mar Dyke and that the Purfleet deposits represent an abandoned loop of this early river. Bridgland (1994) has further suggested that the fluvial deposits at Purfleet belong to the middle of three terraces recognised in the Lower Thames, that formed by the Corbets Tey Gravel Formation, and has correlated the interglacial sediments with Oxygen Isotope Stage 9. A primary objective of the project was therefore to test this correlation through the application of both terrace stratigraphy and mammalian biostratigraphy.

The present investigation exposed the edge of the former river channel and revealed extensive chalky solifluction deposits at the base, overlain by a sequence of interglacial grey clays (thought to be of estuarine origin) and a shell bed, containing densely-packed, intact molluscan remains, many of which were still articulated. This in turn was overlain by horizontally-bedded Thames gravels, indicative of renewed fluvial activity and the onset of cooler climatic conditions. These gravels proved to be the source of abundant flint artefacts, including a biface (hand-axe). Examination of the interglacial shelly sediments has to date yielded 14 mammal taxa, together with remains of fish, reptiles and amphibians. The mammalian assemblage from Purfleet reflects fully interglacial conditions and is indicative of a range of habitats, encompassing woodland, grassland and riparian environments. Species of biostratigraphic significance include white-toothed shrew (*Crocidura* sp.), a primitive morphotype of water vole (*Arvicola cantiana*) and macaque monkey (*Macaca sylvanus*). The characteristic composition of the mammalian assemblage provides a compelling argument against correlation of the Purfleet deposits with either the traditional Hoxnian or Ipswichian interglacials or with the interglacial considered to represent Stage 7 of the marine isotope record. On the basis of the position of the Purfleet deposits within the Thames terrace sequence and evidence from mammalian biostratigraphy, the interglacial represented at Greenlands Pit, Purfleet, has been correlated with Oxygen Isotope Stage 9 (*c.* 300 ka BP), a major but still poorly-known temperate stage in Britain (Bridgland, 1994; Schreve, in prep.)

I would like to acknowledge the financial support of the QRA, the Geologists' Association, English Nature and the Bill Bishop Memorial Trust for this project.

**References**

Bridgland, D.R. (1988). The Pleistocene fluvial stratigraphy and palaeogeography of Essex. *Proceedings of the Geologists' Association*, 99, 291-314.

Bridgland, D.R. (1994). *Quaternary of the Thames.* Geological Conservation Review Series No. 7. Chapman and Hall, London, 441 pp.

Gibbard, P.L. (1995). Palaeogeographical evolution of the Lower Thames Valley. In: Bridgland, D.R., Allen, P. and Haggart, B.A. (eds) *The Quaternary of the lower reaches of the Thames. Field Guide.* Quaternary Research Association, Durham, 5-34.

Palmer, S. (1975). A Palaeolithic site at North Road, Purfleet, Essex. *Transactions of the Essex Archaeological Society*, 7, 1-13.

Schreve, D.C. (in prep). *Mammalian biostratigraphy of the later Middle Pleistocene in Britain.* Unpublished Ph.D. thesis, University of London.

Wymer, J.J. (1968). *Lower Palaeolithic Archaeology in Britain as represented by the Thames Valley.* John Baker, London.

Wymer, J.J. (1985). *Palaeolithic Sites of East Anglia.* Geo Books, Norwich.

# PRELIMINARY INVESTIGATIONS OF PRE-LATE MIDLANDIAN ORGANIC DEPOSITS IN COUNTY MONAGHAN

**Sebastian von Engelbrechten**
**Trinity College Dublin**

This project aims to provide new palaeoecological data on the last cold stage in Ireland. Preliminary investigations of an organic sequence lying beneath *c.* 50 m of glacial till deposits in County Monaghan are reported here. These organic deposits became exposed during the removal of Quaternary sediments for mining purposes. Initially the organic section had a thickness of approximately 230 cm, then further cutting back of the Quaternary sequence revealed a much thicker and more complex organic deposit with a very variable thickness due in part to the variable morphology of the depositional basin and also to post-depositional deformation. The organic deposit consists of two distinct units. The lower unit is of dark brown, compact wood peat with an organic silt matrix, which is rich in wood fragments and other plant macrofossils. This is overlain by a generally much thicker unit of organic and pebbly organic silts which grades into clay towards the top. The organic sequence is underlain by weathered dolerite and in places by a thin layer of clast-supported gravels. Subsamples for pollen and macrofossil analysis were taken at several points along the exposed section where there was least evidence of deformation; some of these have been analysed for fossil pollen content. Pollen preservation and concentrations in the samples so far analysed are generally poor.

The preliminary results indicate that the lower wood peat records woodland vegetation (*c.* 75% AP) which was particularly rich in *Alnus*, *Corylus*, *Betula*, *Taxus* and *Ilex*. Within this unit, macrofossils of *Taxus* were also identified. The upper unit records a much more open habitat (*c.* 85% NAP) and is dominated by the pollen of grasses and herbaceous taxa. The age of the sequence is still very unclear. Biostratigraphical correlation with published pollen sequences of Midlandian age from other sites in Ireland is difficult at this stage, and further pollen analysis is necessary before any correlation can be attempted. In addition, the importance and extent of reworked sediments in the sequence needs to be assessed. A striking feature of the deposit is the abundance of large pieces of wood in the wood peat layer which are often well preserved. These are in the process of being identified and two samples have been submitted for AMS $^{14}C$ dating.

# THE VEGETATION HISTORY OF TWO LAKE SITES ADJACENT TO ESKERS IN CENTRAL IRELAND

**Alyson Heery**
**Trinity College Dublin**

The main focus of this research is to reconstruct in detail the vegetation history of selected eskers in the Midlands and also to compare their palaeoecological records. Irish eskers are meandering ridges composed of sand and gravel laid down by subglacial streams during the recession of the ice masses at the end of the last cold stage. The distribution of eskers lies mainly over the Central Plain where they are a salient feature of the landscape. Eskers are important from a historical, geomorphological and botanical view, although most have been cleared of woodland and are largely used for grazing. Locally, patches of native woodland survive (Cross, 1993).

In a part of Ireland largely devoid of woodland since Mediaeval times, eskers are likely to have been the last refugia for native woodlands otherwise fragmented by the development of lakes, raised bogs and clearance by Man. As a result, eskers are important in determining past woodland cover and clearance in the Midlands. Small lake sites adjacent to eskers were chosen to maximise the local pollen representation from the esker flora.

An essential requirement for any palaeoecological investigation is an accurate sediment chronology for each side. Because of the highly calcareous nature of the sediment from both sites, conventional radiocarbon dating suffers from 'old carbon' problems. This risk posed by contamination is unfortunate as this method of absolute dating is the most cost-effective and widely used of all the radiometric dating methods. Accelerator Mass Spectroscopy was the only available solution for dating the pollen sequences. This method allows age determination of only very small samples (5 mg or less), such as concentrated samples of pollen or plant macrofossils.

On completing a short course on macrofossil analysis in UCL, funded by a Trinity Travel Grant, I spent 4 months analysing cores from Cornaher Lough. The results include a macrofossil diagram for the site (Figure 1), and three Accelerator Mass Spectroscopy dates which provide an accurate timescale for the pollen record (Figure 2). The pollen record from this site varies significantly from the records of coastal lake sites in Ireland. Elm comprised a much larger component of the vegetation in the midlands than in the west of Ireland due to the richer soils. Pine was far less important. Vegetation was largely herbaceous and undiversified until about 9,500 BP when Birch woodlands developed. These were quickly succeeded by a more diverse woodland community comprising mainly hazel scrub mixed with oak, elm, alder and later ash and yew. However, pine was already declining towards the end of this period, probably marking its extinction from the esker and the lake catchment.

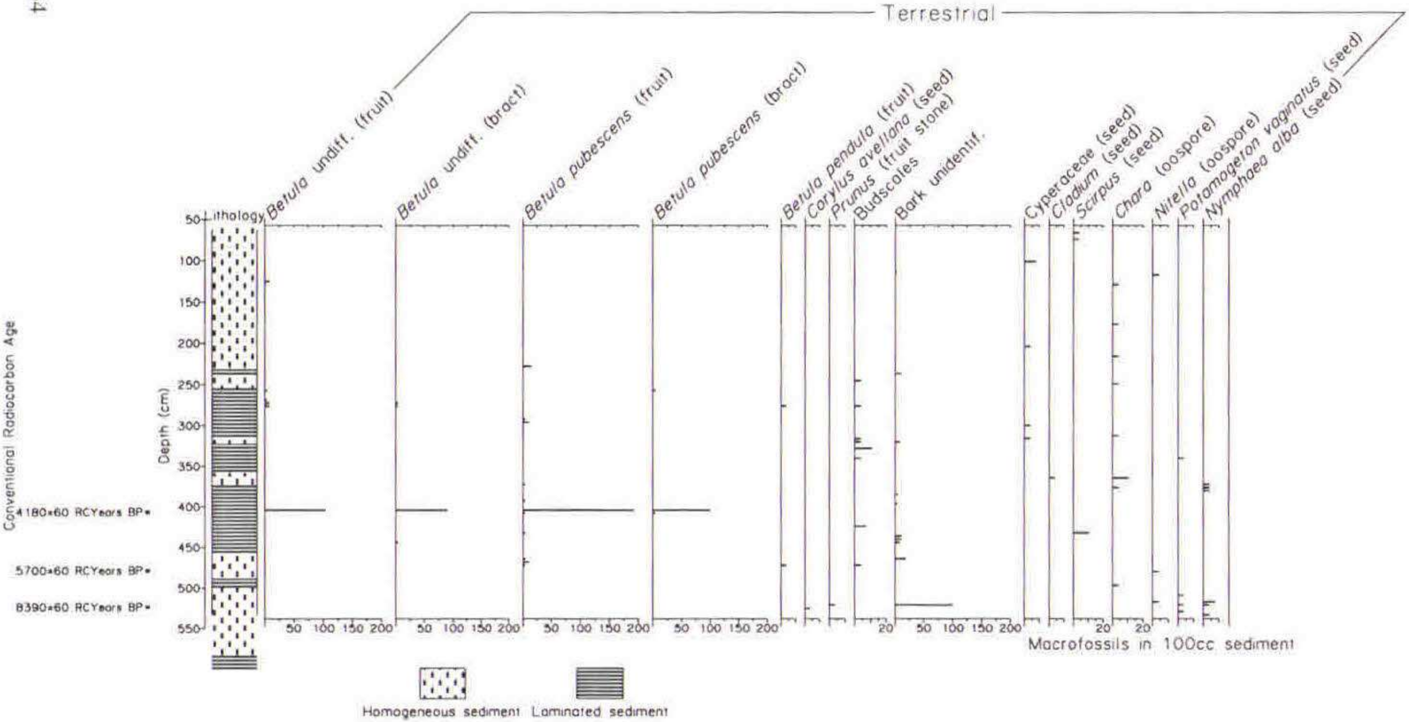


**Figure 1.** Cornaher Lough, Co. Westmeath. Macrofossil Diagram.

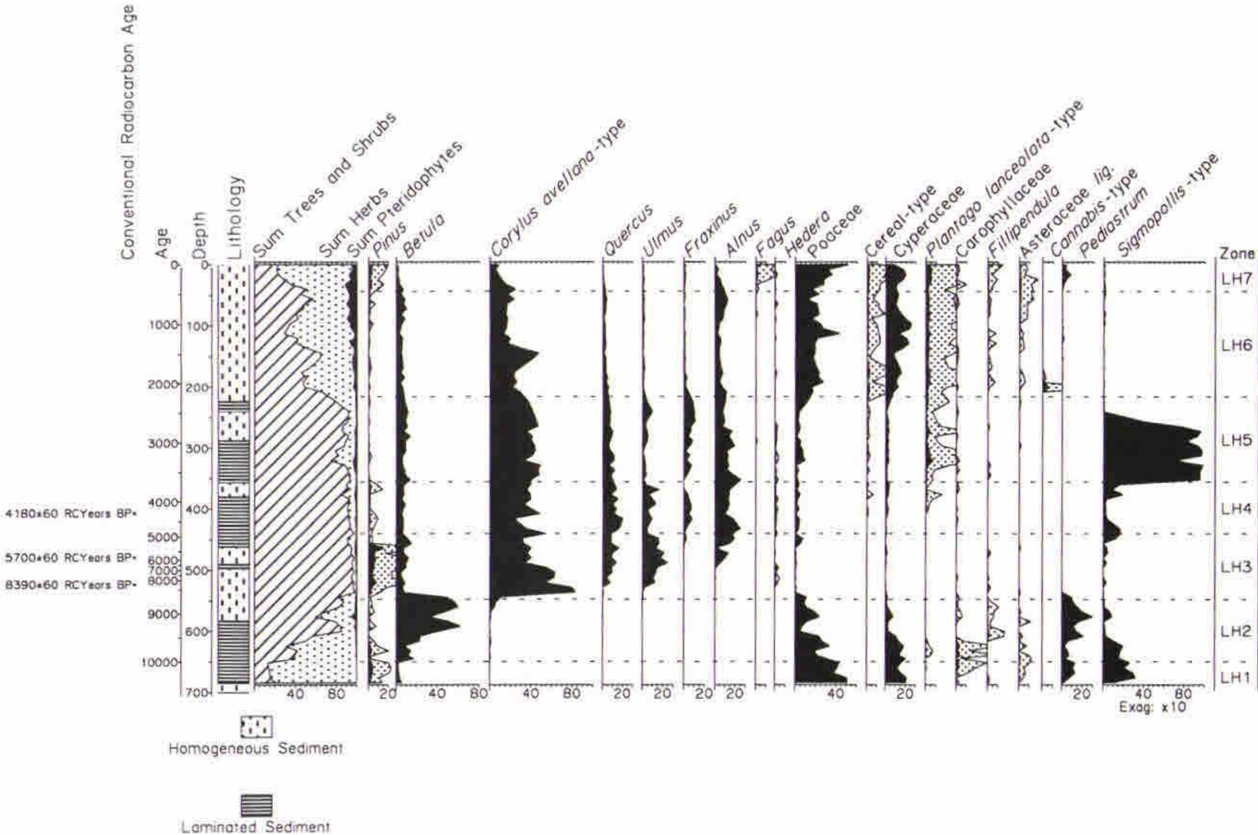


**Figure 2.** Cornaher Lough, Co. Westmeath. Percentage Summary Pollen Diagram.

The lake sediments were quite stable throughout this period, as indicated by the presence of visible laminations. During this period, tree cover changed very little and woodlands dominated the Irish landscape.

From 5,100 BP there was a series of major changes in the landscape beginning with an initial decline in elm, followed by two subsequent declines and recoveries in its pollen values until *c.* 2,000 BP when values continued to remain below 5%.

The beginning of anthropogenic influence, in the form of arable farming, is indicated at around 4,000 BP by the presence of *Plantago lanceolata*-type pollen, cereal and *Rumex* pollen and also an increase in Poaceae. *Sigmopollis* abundance peaks sharply at the onset of this anthropogenic activity, possibly in response to increased nutrient input to the lake.

During the last 2,000 years, there was a complete decline in aboreal taxa coinciding with an increased dominance of grassland and reflecting the present-day situation. Pine also reappeared in the sequence along with introduced species such as beech, again indicating their planting in recent centuries.

The AMS dates were partially funded by the QRA Young Research Workers Award and by the Trinity Trust for which many thanks are given.

**Reference**

Cross, J.R. (1992). The distribution, character and conservation of woodlands on esker ridges in Ireland. *Proceedings of the Royal Irish Academy*, **92B**.

# THE GEOMORPHIC EVOLUTION OF THE GUIDE BASIN, QINGHAI, CHINA

**Patrick Fothergill**
**Department of Geography, Royal Holloway**

## Introduction

Recent field investigations in the Guide Basin (Figure 1), assisted financially by a generous donation from the QRA, have been aimed at assessing the contribution of tectonics to the geomorphological development of this area. Previous studies from sedimentary basins on the north-east margin of the Tibetan Plateau propose that this region was at a low altitude (<1,000 m) until the late Pliocene, but was then subjected to strong, episodic Quaternary uplift (Li, 1991; Li *et al.*, 1996). This theory, however, conflicts with structural investigations, which suggest that thrusting, crustal thickening and uplift to the north-east of the Plateau may have begun in late Miocene times (Guademer *et al.*, 1995).

The Guide Basin contains a thick (~1,000 m) Neogene sequence of lacustrine and fluvial sediments, covered in places by Pleistocene sands and gravels and a variable thickness of loess. Dramatic incision of this basin fill, by the Yellow River and its tributaries, has lowered the drainage level by 500-600 m and resulted in the formation of large flat-topped landforms in the south of the basin and a series of piedmont terraces along the Guide Basin's south-eastern margin.

## Morphostratigraphy

The highest piedmont terrace coincides in altitude with a number of large, elevated grassland surfaces (~3,200 m), which once comprised the main basin surface. The edge of the highest piedmont terrace can be seen on SPOT satellite imagery as a sharply defined lineation (NW-SE), which is interpreted as a fault trace. In the field, the steep slopes at the edge of the highest piedmont terrace are often characterised by triangular facets and sand-filled gullies, strongly suggestive of fault activity. The northern edge of the largest grassland plateau (Yezhang Grassland) is also delimited by a steep fault scarp.

Two hundred metres below the northern edge of Yezhang Grassland lies Dong Gou Grassland, a 5 $km^2$ table landform (mesa) (Figure 2). Its top, which is at the same altitude as the summits of a number of residual hills further east (~ 3,000 m), represents a former drainage level within Guide Basin. Dissection of this surface is a result of powerful fluvial downcutting by tributaries of the Yellow River.

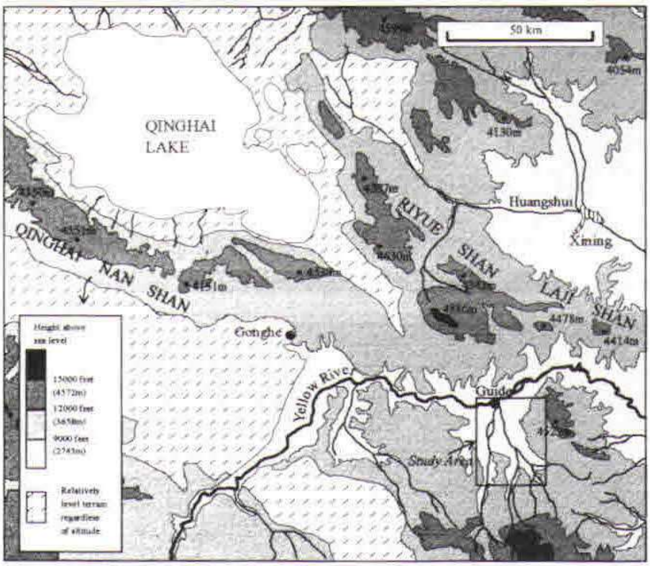


**Figure 1.** The field area, to the north-east of the Tibetan Plateau.

**Figure 2.** Table landform (mesa) developed in the Guide Basin.

At the base of the mountains to the east of the Guide Basin, the most recent piedmont surface consists of very poorly-sorted coarse sands and gravels, deposited in braided river and alluvial fan systems. Dissection of this surface is restricted to the fan-foot area, suggesting that formation of the lowermost piedmont terrace is a very recent event. Within one of the main tributaries of the Yellow River (the Moqugou River) the development of a thick (>100 m) sediment terrace reflects fluvial aggradation, followed by recent downcutting.

## Conclusion

Initial dissection of the Guide Basin surface is thought to be a result of fault activity, associated with renewed thrusting and uplift in the surrounding mountain ranges. This tectonic event was probably closely followed by the first appearance of the Yellow River in the Guide Basin, facilitating deep fluvial incision. Subsequent landform formation, however, shows no direct evidence of tectonic control and is more likely to be a response to glacial/interglacial Quaternary climate change. The Guide Basin is an intermontane basin formed by thrust faulting and associated footwall flexure and, therefore, its very existence in the Neogene suggests that the north-east margin of Tibet had already undergone substantial crustal thickening.

## References

Gaudemer, Y., Tapponier, P., Meyer, B., Peltzer, G., Gou, S., Chen, Z., Dai, H. and Cifuentes, I. (1995). Partitioning of crustal slip between active faults in the eastern Qilian Shan, and evidence for a major seismic gap, the 'Tianzhu Gap', on the western Haiyuan fault, Gansu (China). *Geophysical Journal*, 120, 599-645.

Li, J. (1991). The environmental effects of the uplift of the Qinghai-Xizang Plateau. *Quaternary Science Reviews*, 10, 479-483.

Li, J., Fang, X., Ma, H., Zhu, J., Pan, B. and Chen, H. (1996). Geomorphological and environmental evolution in the upper reaches of the Yellow River during the late Cenozoic. *Science in China*, D39(4), 380-390.

# GLACIATION AND SEA-LEVEL CHANGE, RAANES PENINSULA, WESTERN ELLESMERE ISLAND, ARCTIC CANADA

**Colm O'Cofaigh**
**Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Canada**

This research concerns the reconstruction of past glaciations and their associated relative sea-level fluctuations on Raanes Peninsula, western Ellesmere Island, with particular emphasis on the extent of the last glaciation and the magnitude and chronology of post-glacial emergence. This research is conducted in the context of ongoing debate regarding the extent of ice cover during the Last Glacial Maximum in the Canadian High Arctic, and the relationship of this ice cover to the large amount of Holocene emergence documented throughout the Queen Elizabeth Islands (Blake, 1992; Bell, 1996; England, 1996). Fieldwork involved geomorphic mapping of glacial and raised marine landforms, sedimentological logging of exposures of glacigenic deposits, surveying of the elevation of raised marine shorelines by micro-altimetry, and the extensive collection of marine shells and driftwood for radiocarbon dating and amino-acid analysis, in addition to samples of bedrock and erratics for $^{36}Cl$ and $^{10}Be$ dating.

Results indicate significant ice cover on Raanes Peninsula during the last glaciation. The distribution of deglacial landforms and associated Holocene raised marine sediments indicates that deglaciation was characterised by initial break-up in the fiords and retreat onshore (>8.5-9.2 ka BP), where the ice margin temporarily stabilised, before retreating inland to several centres. In some fiords, the pattern of Holocene marine limit and associated radiocarbon dates, in conjunction with the location of deglacial sediment/landform associations, demonstrate that deglaciation was catastrophic throughout. However, in other fiords, ice retreat appears to have been more staggered and characterised by ice-marginal re-equilibration at successive pinning points, with ice-contact glaciomarine sedimentation and formation of morainal banks and ice-contact deltas. A key result of this work is that most of the high Holocene marine limits (>140 m asl) observed on Raanes Peninsula are categorically *deglacial* in origin, and do not appear to exhibit a distinct pattern relation to the regional geological structure. This suggests that glacioisostasy, as distinct from a neotectonic influence (cf. England, in press), was the predominant factor controlling the high post-glacial emergence in this area.

A subsidiary component of this research involves the distribution and age of granite erratics across Raanes Peninsula, with regard to whether they were deposited by northward-flowing Laurentide ice from the Canadian mainland or by westward expansion of indigenous Ellesmere ice. Field mapping demonstrates that the granites form a major east-west dispersal train centred through Bay Fiord to the north, and a less distinct train through Baumann Fiord to the south. Both dispersal trains can be traced back to a source under the Prince of Wales Icefield to the east, and this distribution indicates deposition by westward-flowing Ellesmere ice. In outer Baumann Fiord, an abrupt and pronounced southward deflection in the dispersal train, points to strong ice flow from Raanes Peninsula which pushed granite-carrying ice in the fiord offshore. This, and the presence of granites on Bjorne Peninsula to the south-west, raises the possibility that granite erratics on the western Arctic Islands (e.g. Cornwall Island and Amund Ringnes), may have been deposited by westerly-flowing Ellesmere ice rather than Laurentide ice as was previously conceived. Along northern Eureka Sound, granite erratics have commonly been interpreted as late Tertiary/early Quaternary in age (Bell, 1992). On Raanes Peninsula, their association with deglacial raised marine sediments of Holocene age suggests that the erratics may date from the last glaciation (late Quaternary). The results of $^{36}Cl$ and $^{10}Be$ dating of erratics (in collaboration with workers from the University of Arizona), in conjunction with radiocarbon dating and amino-acid analysis of marine shell fragments in granitic till, will allow this interpretation to be tested.

**References**

Bell, T. (1992). *Glacial and sea level history of western Fosheim Peninsula, Ellesmere Island, Arctic Canada.* Unpublished Ph.D. thesis, University of Alberta, Edmonton, 172pp.

Bell, T. (1996). Late Quaternary glacial and sea level history of Fosheim Peninsula, Ellesmere Island, Canadian High Arctic. *Canadian Journal of Earth Sciences*, 33, 1075-1086.

Blake, W., Jr. (1992). Holocene emergence at Cape Herschel, east-central Ellesmere Island, Arctic Canada: implications for ice sheet configuration. *Canadian Journal of Earth Sciences*, 29, 1958-1980.

England, J. (1996). Glacier dynamics and paleoclimate during the last glaciation of eastern Ellesmere Island, N.W.T., Canada. *Canadian Journal of Earth Sciences*, 33, 779-799.

England, J. (in press). Holocene emergence in the Canadian High Arctic: evidence for unusual rates and patterns. *Journal of the Geological Society of London.*

# EXPANSIONS OF THE ARID REALM: LATE QUATERNARY ENVIRONMENTAL CHANGE, CENTRAL MEGA-KALAHARI, SOUTHERN AFRICA

**Peter O'Connor**
**Sheffield Centre for International Drylands Research (SCIDR), Department of Geography, University of Sheffield**

Absolute chronologies of the extent and timing of past episodes of desert expansion are vital, both to improve palaeodata for general circulation model (GCM) validation and to facilitate inter-regional palaeoenvironmental comparisons. Extensive systems of fossilised aeolian landforms dominate many parts of the central Mega-Kalahari, forming 'impressive pieces of evidence for the widespread nature of late Quaternary climatic change' (Deacon and Lancaster, 1988, p. 62).

Despite their significance at regional and hemispheric palaeoclimatic reconstruction levels, these forms have not been directly dated, with phases of aridity and dune development inferred from gaps within subcontential humid chronologies (for discussion see Thomas and Shaw, 1991). Constant adjustments to the arid chronology have occurred as further research has reduced or moved the gaps in the humid record. This has exemplified the underlying fragility of the evidence and the uncertainty associated with delimiting the nature and timing of aridity. Conclusions emphasising the importance of aeolian activity between 18-20 ka BP (e.g. Lancaster, 1980) support the widely cited view that the Last Glacial Maximum (LGM, 18-20 radiocarbon ka BP, *c.* 21-23 ka BP) was the peak of late Quaternary aridity and dunefield construction in global desert basins (Sarnthein, 1978). Although it has been estimated that over 40% of all desert dunes are linear (Fryberger and Goudie, 1981), many issues regarding the nature of dune building still remain uncertain or controversial (e.g. Lancaster, 1982; Livingstone and Thomas, 1993).

By applying the optically stimulated luminescence (OSL) method to samples collected from the fossilised dunefields of Western Zambia and the Caprivi Strip, northern Namibia, various questions relating to the timing and nature of linear dune dynamics are currently under investigation. The relevance of the glacial/aridity hypothesis and the validity of current palaeoclimatic models of aridity are also being considered for this region.

Preliminary results from 44 OSL dates indicate four periods of dune building between *c.* 35-45, 20-30, 8-13 and 3-5 ka BP. OSL ages from vertical sections of linear dunes indicate that these forms evolved from multiple phases of reworking and/or accretion. The age ranges identified by this investigation directly demonstrate that multiple episodes of aridity have occurred in the central Mega-Kalahari during the Late Pleistocene and Holocene. The period corresponding to the LGM is not specifically identified as the most critical period of enhanced aeolian deposition. As a result, it should be recognised that aridity in southern Africa has responded in a temporally complex manner and is not exclusively a function of glacial climate. The remainder of this investigation focuses on current palaeoclimate models of aridity in southern Africa, using the data collected to test, interpret and where necessary develop new perspectives on climate change within this region.

I would sincerely like to thank the QRA for supporting this research.

**References**

Deacon, J. and Lancaster, N. (1988). *Late Quaternary Palaeoenvironments of Southern Africa.* Oxford Science Publications.

Fryberger, S.G. and Goudie, A.S. (1981). Arid geomorphology. *Progress in Physical Geography*, 5, 420-428.

Lancaster N. (1980). Dune systems and palaeoenvironments in Southern Africa. *Palaeontologia Africana*, 23, 185-189.

Lancaster, N. (1982). Linear dunes. *Progress in Physical Geography*, 6, 475-504.

Livingstone, I. and Thomas, D.S.G. (1993). Modes of linear dune activity and their palaeoenvironmental significance: an evaluation with reference to Southern African examples. In: Pye, K. (ed.) *The Dynamics and Environmental context of Aeolian Sedimentary Systems.* Geological Society Special Publication No. 72, 91-102.

Sarnthein, M. (1978). Sand deserts during Glacial Maximum and Climatic Optima. *Nature*, 272, 43-46.

Thomas, D.S.G. and Shaw, P.A. (1991). *The Kalahari Environment.* Cambridge University Press.

# SHALLOW MARINE OSTRACOD BIOGEOCHEMISTRY OF THE SAND HOLE FORMATION, INNER SILVER PIT, SOUTHERN NORTH SEA

**Caroline Ingram**
**School of Ocean Sciences, University of Wales (Bangor), Menai Bridge, Anglesey**

This study has focused on the fossil ostracod fauna from the Inner Silver Pit, an enclosed trench-like basin in the southern North Sea, east of the Humber. A borehole was obtained from the flank of the Pit by the British Geological Survey (BGS) in 1981, and described by Tappin (1991). The borehole has previously been examined for dinoflagellates (BGS) and pollen (Ansari, 1992) and placed in a seismic-stratigraphic framework (BGS). The basal Quaternary unit in the borehole is the Swarte Bank Formation (SBK), which rests directly on Upper Cretaceous chalk. Overlying this is the Sand Hole Formation (SH), which only occurs in the Inner Silver Pit area, and was defined by Tappin (1991). It consists of grey, partly calcareous, silty clay. This formation is overlain by 16 m of fine- to medium-grained sands and gravels of marine origin, the Egmond Ground Formation. The Sand Hole Formation yielded temperate-stage pollen suggesting correlation with the Hoxnian interglacial stage (Ansari, 1992).

Over the last two years I have undertaken a detailed study of the ostracod stratigraphy of the Sand Hole Formation alongside a similar study of the foraminiferal stratigraphy (P.H. Kristensen, Aarhus University, Denmark). The microfossils appear to show that there were glaciomarine conditions in the basal section. The overlying pollen-based temperate interval yielded microfossils indicating interglacial conditions, with a bottom water temperature colder than that observed in the southern North Sea in the Holocene. The top of this section showed signs of a deterioration in climate, exhibited by another change of fauna back to glaciomarine species, and a reduction in diversity.

Two hypotheses were to be tested in the Inner Silver Pit during this research: a) the sea-level implications; and b) the water mass characteristics at the time of deposition. Pollen and sedimentary evidence suggest that the sediments were deposited in the latter half of an interglacial cycle. If this is the case, then a temperature decline and sea-level fall, together with increasing fresh water influence should be documented in the ostracod shell chemistry.

Trace element analyses (Mg:Ca and Sr:Ca) on ostracods from this sequence indicate that in the main temperate interval of the Sand Hole Formation there was a reduction in bottom water temperature (all the ostracods studied were benthic) of 10°C, pointing to a distinct deterioration in climate, or a shallowing of the water column concurrent with a slight reduction in ambient temperature.

The money kindly donated by the QRA towards this project has been used to obtain oxygen and carbon isotope data which it was hoped could be used to correlate to the change in temperature indicated by the trace element data and indicate salinity changes consistent with falling eustatic sea level in a fluvially influenced setting.

The isotope data were obtained for 20 levels down-core concurrent with the trace element analyses. The oxygen isotope results seem to indicate that the Inner Silver Pit was fully marine during the entire time of deposition of the Sand Hole Formation. The sample from the Swarte Bank Formation indicates that the water was considerably cooler and less saline, confirming the hypothesis that water mass characteristics changed over the time of deposition represented by the core. There is no firm evidence for increased freshwater influence from the isotope data, perhaps because the Sand Hole Formation was deposited too far offshore.

I am very grateful to the QRA for the grant which helped to finance the costs of the analyses, which have been beneficial to my research. I would also like to thank the University of Wales (Bangor) for the funds which covered the rest of the expense of the analyses.

**References**

Ansari, M.H. (1992). *Stratigraphy and palaeobotany of Middle Pleistocene interglacial deposits in the North Sea.* Unpublished Ph.D. thesis, University of Wales.

Tappin, D.R. (1991). *Spurn.* Sheet 53°N-00°. Quaternary Geology 1:25,000 map series, BGS.

# REVIEWS

## LATE QUATERNARY PALAEOCEANOGRAPHY OF THE NORTH ATLANTIC MARGINS

**J.T. Andrews, W.E.N. Austin, H. Bergsten, and A.E.J. Jennings**
**The Geological Society, London**
**ISBN 1-897799-61-6 1996. 376pp, Hardback £59 (£29 to Members of the Geological Society)**

In the last decades the paleoceanographic scientific community has experienced an explosive growth. Through this period, scientists from this community have greatly expanded our knowledge of changes in ocean circulation, on climate change and the role of the oceans in the earth climate system. Continental margins and especially shelf areas have seen a limited attention in terms of paleoceanography. This probably reflects their often fragmentary record, problems related to establishing secure chronologies and the fact that a wider range of geological processes is at play making them more difficult to read. However, after the development of the records triggered by ice-core findings, there has been an increased research effort on paleoceanography of shelf and slope areas.

With this development in mind it is very appropriate that this book has appeared. The book is a collection of individually authored papers presented at a meeting held at the Royal Society of Edinburgh in January 1995. The 24 papers are organised into three geographic subdivisions: Canadian North Atlantic margins (5 papers); Arctic Ocean, East Greenland margin and North-eastern North Atlantic (5 papers); and North-western European Arctic margins (10). In addition, there are two introductory papers and two final ones covering related topics.

When reading the book I was impressed by the quality and the focus on the theme in most of the papers. The range of topics clearly demonstrates the need for utilising a variety of techniques to attack this subject. The book also includes more baseline work on developing methods exemplified by the interesting contribution by **Cronin** *et al.* on utilising ostracod shell chemistry for paleotemperature estimates. The book also reflects the need for high quality acoustic data in combination with core material in approaching the young geologic history of the margin. The paper by **Syvitski** *et al.* provides us with insight into the state-of-the-art of high resolution seismic and shows also how important good multibeam data are to understand sea-bottom processes and thus develop the potential for high resolution paleoceanographic studies on continental margins. All the papers deal with formerly glaciated regions and focus on the last deglaciation (18 of the papers) and subsequent marine sedimentation. Paleoceanographic evidence for older parts of the records is sparse from the margins but hopefully in the near future we will see much more of the older shelf-margin history as a result of recent and planned shallow drilling activities on the margins.

The editors and authors should be credited for producing a book of generally high technical quality. However some of the art work, especially a few maps, provides an exception. Overall I find the book very useful and am sure to make frequent references to it. The book is a must for those of us involved in research related to geology of glaciated margins. I think that also for the more purist deep-sea paleoceanographic scientist, there is a message in this collection of papers with respect to the complexity in linking terrestrial/coastal climate and glaciation with deep-sea stratigraphy. It is not a textbook and only students at the graduate level will benefit from it. Hopefully we will also see a book in the near future covering this important discipline in a more overall review style.

**Hans Petter Sejrup**
**Department of Geology**
**University of Bergen**

## GLOBAL CONTINENTAL CHANGES: THE CONTEXT OF PALAEOHYDROLOGY

**Edited by J. Branson, A.G. Brown and K.J. Gregory**
**The Geological Society, London**
**ISBN 1-897799-69-1 1996. Hardback £59 (£32 to Members of the Geological Society)**

This book presents papers from two international meetings: the first was organised by the INQUA Commission on Global Continental Palaeohydrology (GLOCOPH) at Chilworth Manor, Southampton in 1992, and the second by the Commission in conjunction with the British Geomorphological Research Group at the Geological Society, London, in 1994.

The book is organised into three sections (*The Context of Palaeohydrology; Approaches to Palaeohydrological Analysis*; and *The Future for Palaeohydrology*) and twenty chapters, providing a broad overview written by many of the best known researchers in the field.

In the first section, various of perspectives on palaeohydrological analysis are presented. An introductory chapter establishing the scientific and management significance of palaeohydrology (**Gregory**) is followed by discussion of reconstructions of components of the water budget (**Starkel**), problems of modelling global climate change (**Arnell**), the influence of changing moisture balances as a result of glacial/interglacial conditions on carbon cycle processes (**Adams** and **Faure**), the sensitivity of river sediment loads to environmental change (**Walling**), the significance of human impacts and responses to hydrological change (**Brown**), and a philosophical appraisal of palaeohydrological reasoning (**Baker**). All of these chapters combine to provide a thought-provoking summary of concepts, approaches and methods of palaeohydrological research.

The second section of the book includes ten chapters which illustrate palaeohydrological investigations in particular field areas under varied environmental conditions. I found three chapters particularly stimulating. **Enzel** *et al.* present an investigation of palaeoflood magnitude and timing in the lower Colorado to identify regional flood envelope curves and a clustering of large floods in particular time periods. **Carling** develops a methodology for reconstructing the flow characteristics and flood magnitude of a glacial outbreak flood which produced large fossil gravel dunes at Kuray in Siberia. **Kalicki** meticulously reconstructs and attempts to explain the evolution of the Vistula river valley during the late-glacial and Holocene.

The final section explores future research directions (**Brown**). It includes an evaluation of the potential for information sharing to develop a global palaeohydrological data set organised within a public domain, computer database (**Branson** *et al.*), and a summary of the activities and tasks of the International Geosphere Biosphere Program core project PAGES (**Pilcher**).

As a hydrologist with a contemporary research focus, I found this book varied and informative. It is undoubtedly a good introduction to the field of palaeohydrology.

**Angela Gurnell**
**School of Geography**
**University of Birmingham**

# ABSTRACTS

## PALEOBOTANY AND PALYNOLOGY OF NEOGENE SEDIMENTS FROM THE HIGH PLAIN OF BOGATÁ (COLOMBIA)

### Evolution of the Andean flora from a paleoecological perspective

**Vincent M. Wijninga (Doctor of Philosophy)**
**University of Amsterdam**

The thesis presents the history of neotropical vegetation and environment in the area of the high plain of Bogotá (2,550 m, Cordillera Oriental, Colombia) during the Neogene. The aim of the study was to document the history and development of the montane Andean vegetation, in relation to the final uplift of the Eastern Cordillera, by means of pollen and plant macrofossil analysis. **Chapter 1** includes a historical overview of paleobotanical research in tropical South America, a geographical description of the study area, and a description of the present vegetation in the Eastern Cordillera. In addition, an overview of the geology of the study area, and the lithostratigraphy and biostratigraphy of the Neogene-Quaternary sediment sequence are presented.

**Chapter 2** discusses the results of a geochemical study, which was carried out on the fossil plant material from a selection of the studied sections of Neogene age. The objective of this study was to assess the chemical composition and the degree of decomposition of the neotropical plant material. The chemical composition of the fossil organic material was revealed by means of pyrolysis gas chromatography mass spectrometry. The chemical analyses were performed on total organic matter samples and on selected plant tissues (wood and cuticles). A chemical fingerprint of each deposit was obtained from the total organic matter samples. These fingerprints reflect primarily the type of depositional environment. The results of the analysis of the woods show that the preservation of organic matter in the sections studied is primarily controlled by the prevailing biotic and abiotic conditions during sediment deposition. Apparently, the time factor explains only a minor part of the differences in preservation.

**Chapter 3** describes the paleovegetation and environment before uplift of the study area had taken place. This phase is represented by the sediments of sections Salto de Tequendama I and II, which belong to the Tequendama Member of the Lower Tilatá Formation. Sediments of section Salto de Tequendama I were deposited in a low energy river, those of section Salto de

Tequendama II accumulated in a depression on the river floodplain. The pollen and macrofossils of the former section are suggestive of a tropical lowland floodplain forest. At present similar forests are found in north-western Amazonia. The presence of montane pollen taxa, transported by river, indicate that mountains in the proximity of the deposition site were covered by *Podocarpus*-rich forest. Pollen and macrofossils from the latter section are indicative of a swamp forest, dominated by the palm *Mauritia* and with representatives of Cyclanthaceae and Cyperaceae in the understorey, situated on the lowland floodplain. Paleovegetational characteristics suggest that sediment deposition occurred at approximately 700 ± 500 m elevation. Based on the lowland paleovegetation and the absence of pollen of *Hedyosmum*, the sediments of both Salto de Tequendama sections belong to Biozone I. The presence of *Crassoretiriletes vanraadshooveni* (not redeposited) and scanty presence of Compositae is suggestive of a Middle? Miocene age for the sediments of both sections.

**Chapters 4** and **5** describe the first stage in the uplift of the study area. The fossil plant assemblages of sections Río Frío 17 and Subachoque 39 consist predominantly of Andean and sub-Andean pollen taxa associated with pollen and macrofossils of tropical lowland elements. Recorded montane taxa include *Podocarpus, Hedyosmum, Ilex, Viburnum, Myrsine, Symplocos* and *Clethra*-type. The lowland forest taxa include *Amanoa, Mauritia, Iriartea, Sacoglottis, Humiriastrum* and *Vantanea*. The concurring presence of lowland and montane taxa is explained by assuming a relatively small area covered with lowland forest, whereas the area of the surrounding mountain slopes covered with Andean and sub-Andean forest was relatively large. Sediment deposition is thought to have occurred at approximately 1,000 ± 500 m altitude. Based on new palynological evidence, the sediments of section Río Frío 17 belong to Biozone IIA, instead of Biozone I. A volcanic ash layer intercalated within this section was fission-track dated at 5.3 ± 1 Ma. The sediments of section Subachoque 39 belong to the same biostratigraphical zone as section Río Frío 17, but belong to the younger Tibagota Member of the Lower Tilatá Formation.

In **Chapter 6** the fossil plant assemblage of peat section Facatativá 13 is described. The assemblage represents a *Podocarpus* forest mire, which consisted of scattered *Podocarpus* trees accompanied by shrubs of Melastomataceae. Modern analogues of this forest are unknown in northern South America, although podocarpaceous swamp forests are found in New Guinea. The forest surrounding the mire included taxa such as *Myrsine, Weinmannia, Vallea*, Melastomataceae, *Alchornea, Ilex*, and *Hedyosmum*. The presence of the latter taxon and the absence of *Myrica* are indicative of Biozone IIB. The composition of the fossil plant assemblage suggests that sedimentation occurred at approximately 2,000 ± 500 m elevation. Fission-track dating on zircon from an intercalated volcanic ash layer gave an age of 3.7 ± 0.5 Ma.

The paleoecological interpretation of the fossil plant assemblage of section Guasca 103 is presented in **Chapter 7**. The fluvio-lacustrine sediments belong to the Guasca Member of the Upper Tilatá Formation. The recorded plant fossils are indicative of a forest near the present-day upper limit of the sub-Andean vegetation belt, that is 2,200 ± 500 m elevation. The sub-Andean forest shows marked fluctuations in its floristic composition. Several of the aforementioned taxa have adapted to disturbance. Alternation of paludal and aquatic environments suggest water-level fluctuations. These dynamic conditions might be related to the initial stage in the formation of the sedimentary basin of Bogotá near the end of the Pliocene uplift. The presence of *Myrica* suggests that the sediments of section Guasca 103 belong to Biozone III. The Guasca sediments are estimated to be of Late Pliocene age.

Based on the palynological and paleobotanical evidence, **Chapter 8** provides a synthesis of the development of the Andean flora in relation to the final Pliocene uplift of the Eastern Cordillera. The change in forest composition in terms of phytogeographical origin of plant taxa during Neogene time is presented. The issue of explaining the current high plant diversity in the Amazon basin is addressed. The problem focuses on whether speciation or extinction processes dominated among plants in the Amazonian lowland as a result of Quaternary climatic fluctuations. Pollen counts of Neogene pollen sections were compared with those from late Quaternary pollen sections in order to evaluate plant diversity in Neogene time.

The plant microfossils and macrofossils recorded in the studied Neogene sediments from the high plain of Bogotá are described and illustrated in the **appendix** of the thesis. The light-microscope and SEM photographs of the plant fossils are compiled in 69 plates that include 66 microfossil types (mainly pollen) and 226 plant macrofossil types (seeds, fruits, leaves and wood). Type-number and taxonomical indexes are included.

For more information and orders: wijninga@bio.uva.nl or fax: +31 20 5257662.

# VEGETATION, PHYTOGEOGRAPHY AND PALEOECOLOGY OF THE LAST 20,000 YEARS IN MONTANE CENTRAL AMERICA

**G.A. Islebe (Doctor of Philosophy)**
**University of Amsterdam**

The dissertation deals in nine chapters with different aspects of Central American plant sociology, phytogeography and paleoecology. Especial attention was given to the mountainous areas of Guatemala (Sierra de los Cuchumatanes, Volcanic Chain) and Costa Rica (Cordillera de Talamanca).

**Chapter 1** gives a thorough description of the most important plant communities in the Guatemalan highlands, including mixed pine forest, fir forest and pine-juniper forest. **Chapter 2** presents phytosociological data from the three high volcanoes where characteristic alpine bunchgrassland - zacatonales - are found. **Chapter 3** documents affinities of plant communities between Mexico and Guatemala. Classification, ordination, alpha-log series, biodiversity-index and floristic information show that ecological conditions differ significantly in the Megamexico area. In **Chapter 4** similarities between the vascular generic flora of Central American subalpine forests is investigated. The Guatemalan subalpine flora consists mainly of temperate and holarctic genera, while the Costa Rican subalpine flora is made up of neotropical and wide tropical genera.

In **Chapter 5** modern pollen deposition is related to the present vegetation by multivariate methods and association indices. With the exception of the alpine bunchgrassland, all vegetation types have characteristic pollen rain.

**Chapter 6** presents paleoecological data from a complete Holocene sedimentation record. An accurate age-depth relationship, based on AMS $^{14}C$ datings of terrestrial wood fragments, provides a reliable chronology in this karst region where hardwater lake error has typically confounded sediment geochronology. In the early Holocene, widespread tropical forest is indicated by the Moraceae-Urticaceae group. High forest taxa started to decline as early as 5.6 ka BP, indicating climatic drying or perhaps initial land clearance. Deforestation by prehistoric Mayan inhabitants is documented clearly in the pollen record beginning about 2 ka BP by the appearance of disturbance taxa and the presence of corn. Forest re-growth occurred following the classic Mayan collapse, *c.* 900 AD, as reflected by a relative increase in Moraceae-Urticaceae pollen.

In **Chapter 7** the first AMS radiocarbon-dated evidence of a temperature decrease during the Younger Dryas Chron is presented from the Costa Rican Cordillera de Talamanca. This cooling event is named La Chonta Stadial after the bog at 2,310 m altitude. High resolution pollen analysis revealed that between 11,070 ± 130 and 10,400 BP, vegetation comparable to present-day subalpine forest occurred about 300-400 m lower than in the previous warmer interval. The downslope shift of the upper forest line indicates an estimated temperature drop of 2-3°C during the La Chonta Stadial.

In **Chapter 8** sediment cores from two bogs elucidate the development of montane vegetation during the Holocene. During the early Holocene, alder vegetation covered both bogs and their adjacent hills. A *Podocarpus-Quercus* forest characterised the mid-Holocene. The upper forest line is located at > 3,000 m elevation. The later Holocene seems to be drier than at present. In order to improve the paleoecological interpretation, the local vegetation was described and moss samples were used as pollen traps.

**Chapter 9** gives new palynological data of montane vegetation development, including a new La Chonta Stadial from La Trinidad bog. A soil section from the páramo belt shows vegetation recovery after fire in the late Holocene. A comparison with other paleoecological data from Central America is given. Data show a cooling of 7-8°C during the Last Glacial Maximum (LGM) for montane Costa Rica, which is in accordance with data from lowland Guatemala. The late-glacial/Holocene transition in montane Costa Rica is established at 10,400 BP. Between 9 and 8.5 ka BP, moist forest developed in mountainous Costa Rica as well as in lowland Guatemala. Distribution maps of páramo and montane vegetation in Costa Rica are reconstructed for 10 ka, 14 ka and 18 ka. These data indicate that during the LGM possibly a páramo vegetation corridor existed between northern Costa Rica and northern Panama.

Thesis is available at the Hugo de Vries Laboratory (e-mail: santos@bio.uva.nl, 30 $ including shipping and handling).

# THE HISTORY OF THE *PINUS SYLVESTRIS* TREE-LINE AT CREAG FHIACLACH, INVERNESS-SHIRE

**Jennifer McConnell (Doctor of Philosophy)**
**Institute of Ecology and Resource Management,**
**University of Edinburgh**

The history of the *Pinus sylvestris* L. tree-line at Creag Fhiaclach was investigated using a palynological approach. A modern pollen rain study demonstrated that the current tree-line was detectable from a significant ($p > 0.0001$) reduction in the *Pinus*/(*Pinus* + *Calluna vulgaris* (L.) Hull) pollen quotient. Heath vegetation typically has a $P*100/(P+C)$ pollen quotient of less than 30%. Quotients higher than 30% represent *Pinus* woodland. A three-year study on variation in *Calluna* flowering with altitude showed that the relative reduction in the *Pinus* pollen component at the tree-line is caused primarily by changes in the density of *Calluna* flowering rather than *Pinus* pollen influx. The results have implications for the design of palynological studies, indicating the importance of replication, as well as aiding interpretation of sub-fossil pollen data.

Five replicate cores from six altitudes spanning the tree-line were subjected to pollen analysis for the historical investigation. Twenty six palynomorphs including four Rhizopod taxa were described. Discriminant analysis was used in addition to quotients to classify the sub-fossil pollen assemblages as either heath or forest types. The palynological data were reduced using PCA and RDA and showed that a higher tree-line may have been previously present at the more sheltered southern end of the tree-line. However, an alternative hypothesis, of pollen assemblages similar to those of *Pinus* forest being produced by relatively infertile *Juniperus communis* L. canopies, was also tested by looking at the pollen spectra from transects across *Juniperus communis* patches. Dense patches of *Juniperus communis* result in pollen assemblages which cannot be distinguished from those of *Pinus sylvestris* woodland.

$^{210}Pb$ and $^{14}C$ dates, while indicating stratigraphic validity, gave conflicting evidence for the ages of the peat deposit at Creag Fhiaclach. Evidence from dendrochronology on the site suggests that the $^{14}C$ dates are more correct and that the peat deposit dates from 1227-940 BP.

A model of pollen distribution at the tree-line on the basis of modern pollen deposition is proposed. The relative stability of this tree-line poses interesting questions about how the tree-line established and the inertia of this type of vegetation boundary to changes in climate.

# PALAEO-ARGILLIC SOILS IN SOUTH-EAST ENGLAND

**Fiona M. Clayton (Doctor of Philosophy)**
**Department of Geography, Royal Holloway, University of London**

Soils classified by the Soil Survey of England and Wales (SSEW) as having palaeo-argillic B horizons (here termed palaeo-argillic soils) occur beyond the limits of the last glaciation and contain 'relict features' assumed to have developed during previous unnamed interglacials and glacials. The aim of this thesis was to divide palaeo-argillic soils into units representing soil formation over different time intervals.

Following preliminary analysis of the SSEW thin-section library, palaeo-argillic soils were examined at a number of sites on the palaeo-Thames terraces and Lowestoft Till in South-East England. The ages of the parent materials range from Early to Late Pleistocene. Detailed pedosedimentary and palaeoenvironmental histories were reconstructed for each site using macro- and micromorphological techniques.

Palaeo-argillic soils have been recorded for the first time on Anglian and post-Anglian Lower Thames terraces. Most of the soils examined on the pre-Anglian Kesgrave Thames terraces appear to contain relict components of the composite Valley Farm and Barham Soil. Comparisons of palaeo-argillic soils and profiles of the buried composite Valley Farm and Barham Soil on equivalent terraces support the notion that the Valley Farm Soil can be divided into 'simple' and 'complex' units. At all sites where some age control is possible, the number of interglacials inferred from the palaeoenvironmental reconstructions is fewer than would be anticipated from correlation with the deep-sea oxygen isotope curve. Possible reasons for this discrepancy include the lack of micromorphological resolution and the variable severity of periglacial activity during cold stages.

A formal proposal is made for the division of palaeo-argillic soils into 'simple' and 'complex' units. The 'simple' unit contains evidence for soil formation extending over at least two interglacials and the 'complex' unit contains evidence for at least three interglacials. The 'complex' unit comprises soils whose development could span different intervals sometimes including at least two pre-Anglian interglacials. It is further subdivided into three subunits dependent on their correlation with the Anglian and Devensian stages of the British Quaternary stratigraphy.

# GLACIAL SEDIMENTOLOGY AND THE CONSERVATION OF SAND AND GRAVEL RESOURCES IN THE OMAGH BASIN, SOUTH-WESTERN NORTHERN IRELAND

**Jasper Knight (Doctor of Philosophy)**
**School of Environmental Studies, University of Ulster**

This thesis examines late Midlandian (Devensian) glacial geology and sedimentology in the Omagh Basin (*c.* 1,700 $km^2$). Ice flows and deglacial stages are reconstructed from patterns of subglacially-streamlined rock ridges, drumlins and Rogen moraines, and patterns of glaciofluvial moraines, eskers and deltas. Sedimentary and erratic characteristics are also used. Rogen moraines form part of the largest such field identified in western Europe. Ice dome development in and migration from upland to lowland centres involved changes in thermal régime, level of ice activity and sediment/meltwater availability. Subglacial bedforms were generated after ice centre migration from Co. Donegal to a lowland dome in the central Omagh Basin. Rogen moraines with variably preserved, overprinted and streamlined crests reflect changes in ice activity levels related to changes in subglacial thermal régime. Deglaciation involved sedimentation in locally-impounded lakes during emergence of the Sperrin Mountains and Fintona Hills. Ice margins were locally active, retreating by both stagnation and backwasting into core areas in the Lower Lough Erne Basin and western Clogher Valley. Sedimentary and morphological evidence for flow reversal from impounded lakes is also observed. Basal ice switched rapidly between clean and dirty régimes. Readvance of a Sperrin Mountain ice cap east of Omagh emplaced rock rafts by marginal thrusting. Discontinuous permafrost (1-3 m thick) and periglacial activity were also present. Glacioisostatic unloading led to metre-scale neotectonic activity associated with fault reactivation and hydrothermal fluid flow.

Style of subglacial deformation cannot be accounted for by previous models. It is dependent strongly on changing shear stress régimes acting on heterogeneous sediment admixtures. Major structures affecting shear stress régime include rock rafts and clast lines. Clast lines acted as 'pinning points' stabilizing the deformation front. Rock rafts separated by sediment 'pools' formed a chequerboard of alternating high and low shear stress régimes. Rafts acted as 'stick spots', suggesting 'slip-stick' ice motion.

Changes in ice mass thermal régime, ice activity levels and sediment/meltwater availability, describing ice mass oscillations, closely match millennial-scale climate changes across the circum-North Atlantic derived from $\delta^{18}O$ (Greenland GRIP ice core) and ice rafting records (north-eastern Atlantic marine core V23-81). This suggests Omagh Basin ice mass changes were climate-driven and that sediment streamlining (drumlinization) resulted from ice drawdown into western Ireland marine embayments during Heinrich event 1 and its precusor event 'a'.

# ABRUPT HOLOCENE CLIMATIC CHANGE RECORDED IN TERRESTRIAL PEAT SEQUENCES FROM WESTER ROSS, SCOTLAND

**David E. Anderson (Doctor of Philosophy)**
**Department of Geography, University of Oxford**

A continuous, high resolution palaeoenvironmental record is constructed from Holocene peat sequences in Wester Ross, and reveals several abrupt and distinct palaeoclimatic changes involving shifts in effective precipitation. Three mires were cored, and a principal core from each was radiocarbon dated and analysed in detail for bulk density, humification, C:N ratio, mineral magnetics, macrofossils, pollen and non-pollen microfossils. Chronologies have been constructed using radiocarbon dating and colorimetric humification-based estimates of past peat accumulation rates. The combined techniques enable a reconstruction of past changes in mire hydrology which provides a basis for palaeoclimatic interpretation.

Two large climatic shifts to wetter and/or cooler conditions are interpreted from the peat sequences at *c.* 7.4 and 3.6 ka BP, and other episodes of deteriorating climate are inferred at *c.* 5.8, 4.5 and 1.0 ka BP. A shift to wetter mire conditions is also inferred at *c.* 3.0 ka BP which may have been caused by climatic deterioration and/or human land-use. Shifts to drier and/or warmer conditions are inferred at *c.* 8.1, 6.9, 5.3, 4.1 and 1.6 ka BP. To investigate the influence of small-scale changes in North Atlantic sea surface temperatures and thermohaline circulation on terrestrial climate, the palaeoclimatic time series has been compared with Holocene proxies of marine conditions from North Atlantic deep-sea sediment cores. It has also been compared with proxy data of solar variability and palaeo-volcanism. Comparisons indicate that ocean-core data show the best overall agreement, although it is not possible to dismiss conclusively the subordinate effects of solar variability and volcanism.

This study provides estimates of long-term carbon accumulation rates for Scottish peatlands which are compared with estimates from elsewhere. Pollen data suggest that the most important phase of Scots pine afforestation in the region occurred after 7.0 ka BP, and that the early post-glacial pine woodlands previously documented may not have been widespread. Pollen data from this study also suggest that the mid-Holocene decline of Scots pine about 4,000 years ago was regionally non-synchronous, and that the causal factors were complex. It is likely that the timing of pine deforestation in different catchments was highly dependent upon local edaphic, climatic and hydrological conditions.

# SEDIMENTOLOGY AND DATING OF GLACIGENIC SEQUENCES: EASTERN IRISH SEA BASIN

**Endaf Edwards (Doctor of Philosophy)**
**Institute of Earth Studies, University of Wales, Aberystwyth**

This thesis tests the hypothesis proposed by Eyles and McCabe (1989) that glaciomarine environments existed during the last (Late Devensian) deglaciation of the Irish Sea Basin. Detailed sedimentological studies were carried out at four sites along the eastern margins of the basin: Mwnt (west Wales), Dinas Dinlle (northern Lleyn Peninsula), St Bees (west Cumbria) and the north-east coast of the Isle of Man. The relationships between glaciotectonic and glaciodepositional processes in an ice-marginal setting were also investigated.

Amino-acid dating was carried out on shell fragments from Mwnt and the Isle of Man and the ratios were correlated with the oxygen isotope stratigraphy. These results confirm a Late Devensian age for these sequences.

The micropalaeontology of fine-grained deposits from Mwnt was investigated and a number of microfaunal elements were identified. The assemblage is dominated by a well-preserved boreo-arctic element with a less well-preserved temperate microfauna. These elements suggest that glaciomarine conditions existed at Mwnt following ice retreat.

Alternative depositional models (glacioterrestrial and glaciomarine) for each site are discussed. It is argued that glaciomarine models are more consistent with the sedimentology of each site, and that glaciomarine environments accompanied deglaciation of the basin. A glaciomarine facies model is proposed for the Irish Sea Basin, in which growth and decay of the last British Isles ice sheet, glacioisostatic depression and uplift, and glacigenic sedimentation patterns are integrated.

# THE GEOMORPHOLOGY AND SEDIMENTOLOGY OF FIVE TSUNAMIS IN THE AEGEAN SEA REGION, GREECE

**Dale Dominey-Howes (Doctor of Philosophy)**
**Coventry University**

This dissertation presents the detailed results of investigations of the geomorphological and sedimentary processes associated with five Holocene tsunamis reported to have occurred in the Aegean Sea region of Greece. This research considers the effects of the widely quoted and archaeologically important Minoan tsunami of the 17th century BC; the central southern Aegean tsunami of 66 AD; a hugely destructive tsunami reported to have followed a massive earthquake on the 21st July 365 AD; a tsunami of volcanic origin which affected the island of Thira on 29th September 1650 AD; and the destructive southern Aegean tsunami of 9th July 1956 AD. The last account is believed to be the first systematic investigation of the geomorphology and sedimentology of a modern Aegean tsunami.

This research is primarily concerned with the investigation of Holocene coastal sedimentary sequences in order to identify any geological traces of the former tsunamis and it is hoped that this evidence can be used to supplement the fragmentary historic accounts. This dissertation also considers whether microfossils can be used in the identification of individual stratigraphic horizons associated with tsunami-deposited sediments and investigates whether it is possible to determine the generative origins of individual tsunamis on the basis of the sediments associated with them. Whilst the findings of this research are not intended to provide a definitive account of the tsunamis considered, they do provide important evidence where the prevailing geological conditions of the Aegean Sea region would otherwise combine to limit the data available. The results of this investigation supplement existing knowledge and will be of value to archaeologists seeking to explore the relationships between archaeological sites, landscape evolution and environmental change.

# MORPHOLOGY, STRATIGRAPHY AND GENESIS OF BURIED MID-PLEISTOCENE TUNNEL-VALLEYS IN THE SOUTHERN NORTH SEA BASIN

**Daniel Praeg (Doctor of Philosophy)**
**Department of Geology and Geophysics, University of Edinburgh**

Conflicting views of the hydrology and dynamics of ice sheets apply to tunnel-valleys in sedimentary basins. Models of diachronous, deglacial formation by submarginal drainage over and through the bed oppose those of synchronous, catastrophic formation by subglacial floods. Large buried tunnel-valleys, locally over 400 m in relief, formed beneath the southern reaches of the Elsterian glaciation. These are examined over a 100 x 150 km area of the UK/Dutch offshore, using grids of seismic reflection data (including a 3D-volume over a 39 x 22 km area) supplemented by downhole data (logs and drilling debris from 13 wells and short cores from one borehole), mainly collected for hydrocarbon exploration. Information on tunnel-valley basal morphology and fill stratigraphy support a diachronous formation beneath the northwards-receding ice margin.

Basal contours define elongate basins up to 500 m in relief (575 m bsl), shallow relative to their widths (0.5-6 km) and steep-sided (5-40°). The basins contain nested axial sub-basins 10-170 m in relief and 1-45 km long. A rectilinear arborescent plan-form records erosion convergent to the south. Local divergent or anastomosing patterns, and angular offsets of basal segments up to 20 km long, result from erosional overlap by younger basal elements to the north. The basal morphology is superimposed on trends in the incised Plio-Pleistocene substrata, which have locally influenced cross-sectional form (stratal benches) and orientation (across faults). However, the basins increase eastwards in size and spacing in parallel with the thickness of sandy Pleistocene sediments.

Contoured reflecting surfaces within the fill indicate three seismic sequences, separated by discordant boundaries of basinal relief. From bottom to top: **I** - axially downlapping clinoform surfaces 0.5-3.5° in gradient and 3-20 km in extent, up to 400 m in thickness, which record northwards progradation; the generally concordant clinoforms include discordant surfaces of erosion which coincide with plan-form complexity, indicating progradation during valley incision; **II** - subhorizontal surfaces up to 150 m in thickness which onlap basins up to 120 m in relief at the surface of I and the upper walls; **III** - complex surfaces up to 100 m in thickness which fill incised basins up to 70 m in axial relief at the surface of II and extend between some adjacent tunnel-valleys. Downhole data show sand-dominated assemblages beneath a mud-dominated cap. The sediments contain microfossils and secondary components (lignite, shell fragments, glauconite) reworked from series as young as early Pleistocene.

A marine foraminiferal zone occurs within the upper muds. The succession records glaciofluvial to lacustrine deposition prior to marine conditions of the Holsteinian interglacial. Correlation to the seismic stratigraphy shows that progradation of glaciofluvial sands (**I**) was followed by subhorizontal deposition of sands and then muds in lake basins (**II**) and finally complex deposition of muds in and between marine basins (**III**).

Evidence for basal erosion to the south versus glaciofluvial fill progradation to the north are reconciled in a model of the contemporaneous excavation and backfilling of basins beneath the northwards-receding ice margin. Clinoform surfaces (**I**) represent glaciofluvial backsets, previously observed or inferred within eskerine ridges. They are attributed to a distributed system of subglacial streams rising to feed over- and backlapping subaqueous outwash fans along a migrating grounding line. Overlying surfaces (**II**) record pro-glacial outwash of sands and increasingly distal accumulation of muds in lake basins, which elongated with ice recession and persisted until the marine transgression. The tunnel-valleys thus record reworking of sedimentary materials beneath the outer 50 km of the ice sheet during deglaciation. Similar models for the diachronous formation of eskers indicate that englacial recharge of surface water dominates the sub-marginal drainage system, by several orders of magnitude. The relation of tunnel-valley size and spacing to aquifer thickness is consistent with network development in response to high discharges over and through a deformable bed. The tunnel-valleys are argued to record the interplay of englacial with substrate hydrology during deglaciation, as the melting ice sheet drains through its mobile margin.

# OSTRACODS AS INDICATORS OF CHANGING ENVIRONMENTS OF CENTRAL NORTHAMPTONSHIRE

**Kathleen Ann Smith (Master of Philosophy)**
**University of Leicester**

This work sets out to contribute to the Quaternary knowledge of ostracods as environmental indicators in coarse sediments. Ostracods from the early, middle and late Quaternary have been examined, in association with stratigraphic, lithological and sedimentological analyses, from two suites of sands and gravels, in the Milton Sands and in the valley bottom of the Nene in central Northamptonshire. The ostracod data include the presence, absence and relative abundance of ostracod species and individuals of each species and knowledge of their present-day habitats, which have enabled the pattern of environmental change in the sediments to be determined. The data may allow comparison with other fluvial sediments in lowland England.

The ostracods confirm that the Milton Sands, derived from local bedrock, are pre-Anglian in age. Analyses show that an early Milton River flowed under temperate climatic conditions with long dry summers and wet winters. Later in the depositional record the climate cooled, as indicated by changes within the ostracod assemblage, and the deposits were bisected by down-cutting. Sedimentation took place in the newly-cut channel during a boreal period. The whole width of the valley was then filled with the type Milton Sands sediment under a periglacial climate and the fossiliferous sediments remained as a buried terrace.

The stratigraphic, lithological and sedimentological analyses of the Nene valley-bottom sediments between Northampton and Wellingborough showed vestigial terraces, the oldest of which was decalcified before down-cutting occurred. The following sequence of deposition and down-cutting included a series of organic deposits. Ostracods from these were found to represent several different temperate stages. The combined data show that the deposits at Northampton contain remnants of terraces and reworked channels that date back to the early Anglian cold stage and include six cold and six warm episodes up to the present day.

Species new to the Pleistocene record were recovered from both deposits.

# HOLOCENE ENVIRONMENTAL CHANGE IN THE SCOTTISH HIGHLANDS: MULTI-PROXY EVIDENCE FROM BLANKET PEATS

**Heather Binney (Doctor of Philosophy)**
**London Guildhall University**

Evidence for Holocene environmental change in two upland areas of Northern Scotland, with specific reference to variations in the density of pine woodland cover, is examined. The evidence is derived from blanket peat profiles sampled along two altitudinal transects: i) the Cairngorms (Gleann Einich between *c.* 500 and 930 m OD); and ii) in the North-west Highlands (near Beinn Dearg between *c.* 270 and 600 m OD).

The pollen stratigraphy, plant macrofossils, fungal and algal remains and the degree of humification of each of the eight peat profiles was studied. The results demonstrate the importance of multi-proxy investigations and the need for investigations of the inter-relationship of these sources of evidence.

The pollen stratigraphy of each profile is assessed in terms of variations in the density of pine woodland and a model is proposed for temporal changes in the relative altitude of the tree-line for each transect area (using linear interpolation of radiocarbon age estimates). Both transects show a regional decline in tree-lines (and a corresponding decrease in pine woodland density at the lower sites) shortly before *c.* 6,400 BP and at *c.* 5,400 BP and an increase in tree-lines shortly before *c.* 6,000 BP and before *c.* 4,000 BP. A regional model for pine woodland cover and tree-line dynamics is proposed and is compared with published evidence from Scotland and other parts of North-west Europe.

The degree of humification provides new insights into factors controlling the burial and subsequent preservation of pine stumps within blanket peat. Peat profiles from each of the transect areas show evidence for synchronous shifts in the degree of humification (inferred as wet/cool and dry/warm episodes) and hypotheses are proposed to explain the correspondence (or otherwise) between the two sampling regions. The humification records are supported by the fungal and algal remains data. A comparison is made with existing palaeoclimatic models (largely based on peat-stratigraphy and deuterium isotopic analyses of pine macrofossils).

This study highlights the potential of upland blanket peats as important sources of palaeoecological and palaeoclimatic data. In addition, since all the sites investigated were sampled within geographically constrained altitudinal transects (and investigated using established and consistent methodologies) the inferences can be tested at local, regional and inter-regional scales.

# *LETTER TO THE EDITOR*

## COMMENT ON THE ACCOUNT OF THE EXCURSION TO THE COAST OF WALES, SOUTH OF ABERYSTWYTH

I read with pleasure and interest the account of the Cryostratigraphy Research Group excursion in west Wales reported in *QN* 81, February 1997. My thoughts on the theory regarding the origin of the Blue Head at Morfa Bychan as a paraglacial fan, were expressed in a letter to *QN* 78, February 1996. Further points are given below.

The fabric of the diamicton sheets was measured in considerable detail and invariably conformed to the changes in aspect of the hillslopes above. There was at no point any suggestion of a fan.

The head had been sheet-washed, leaving lag gravel above with sand and finally silt lenses washed further down slope. This produces the effect called "pseudo bedding". Because of the muddy wash down the cliff face, the detail of stratification can only be seen clearly after a cliff fall. It would be of interest to have the pollen and vegetation remains in the silt lenses examined by an expert. My own untrained efforts revealed much material which was kindly examined by the Botany Department, UCW which could identify only tattered plant remains and moss spores. All this seems to indicate at least one summer's rain with sheet flow as would occur if the deposits were head-derived.

The Blue Head lies unconformably on the Yellow Head. The junction can be followed on the foreshore at low tide. Frost-shattered mudstones create much clay and silt which may have caused a more rapid accumulation of the head sheets. Certainly, as we observed in Normandy, it increases the edge-rounding of the clasts. Nowhere could I find any trace of till *in situ* such as was recorded in the foundations of the Aberystwyth Hospital. Its fabric analysis was 350°-170°.

Following a considerable period of erosion of the Blue Head, the Brown Head was deposited. A curious deposit can be seen intermittently immediately below the Brown Head. This is a thin layer of pinkish silt, often <1 cm thick. At the head of two stream gullies, one at Cwm Ceirw, one at Ffos-las, the pinkish material thickens to round 15 cm and tiny pebbles from the Irish Sea ice were found, jasper and a black igneous clast amongst others. The pebbles were well rounded and polished and about perhaps 50 mm in diameter. Professor Albert Pissart suggested "loess" which apparently often contains similar tiny pebbles. Unlike the earlier deposits, the Brown Head overlies both Heads and solid rock. As with the earlier deposits, considerable landslips of unbroken greywacke occur at its base, buried in a much less weathered diamicton than either the Blue or Yellow Heads, containing less clay and about 20% coarse sand. Frost cracks averaging *c.* 2.7 m in depth, at one point reaching 4.3 m, developed in the Brown Head and were filled by the overlying 1 - 1.2 m thickness of silt. As with sand wedges, clasts in the sides of the cracks retain their original fabric. Sometimes a layer of flat-lying stones occurs at the base of the silt. These strongly resemble similar features at the base of loess deposits. Similar frost cracks filled and overlain by "loess" can be seen in the head of west Dale (Pembrokeshire), Gower (South Wales) and Croyde Bay (Devon), also in parts of Cornwall.

The silt at Morfa Bychan contains 3% coarse sand and 25% clay. Being non-calcareous it must not be termed "loess". In the metamorphic Alps wind-blown silt with a similar clay content is termed "dust-loam" (Staub-lehm) and replaces the loess of the calcareous Alps. The silt when dry splits vertically into prisms. During an IGU trip to the Yukon in 1972, Rutter had dug a pit to show us very similar though shallower dust cracks than in Wales and inquired if they had been seen by any of the party. Matte Seppala of Helsinki later showed us a slide of similar cracks in Finland.

Next the party moved on to the huge fan at Llanon. This is of great interest. The succession of deposits observed when the beach had been combed down by a storm is - Welsh till (north-east fabric) under a thin bed of Irish Sea ice till. This had been widely truncated by the River Peris, laying down an enormous fan of coarse gravels, well imbricate back to the point where the Peris emerges from the steep hill slope behind, falling abruptly from >152 m . The imbrication of the clasts changes through about 90° from one side to the other of the fan. After this bed of gravels, the river seems to have returned to its old course and a layer of silt (deemed loess by some INQUA members in 1977, but could well be river silt) was laid over the basal cone. Similar deeply cryoturbated deposits can be seen at Kilmore Quay and Valentia Island in southern Ireland. Deep cryoturbation followed, forming festoons with vertical stones. The river again spread out truncating the cryoturbated bed and spreading coarse gravels, again all imbricate back to the Peris mouth. This process was repeated several times, more clearly seen at the centre and varying in width, making the succession very difficult to decipher towards the southern edge of the fan. Finally, a thin bed of less coarse uncryoturbated gravel completed the build-up on the fan; now overlain by a thin modern soil just below the footpath along the cliff edge.

Probably in 1976, Eddie and I laid a chain and took a series of overlapping photographs for the full extent of the cliff exposure. These, I believe, are stored in Cardiff, by courtesy of Professor Jim Rose and the Welsh Geological Survey.

As regards dating these fans, a few miles to the south, the River Arth formed a much coarser, steeper cone which at its south end overlies Irish Sea till (with a north-south fabric) on Welsh till (with a similar fabric) lower down the beach.

A few metres (perhaps 10?) from the thinned-out fan edge, an organic silt lies at the erosive base of the fan. Eddie and I hoped to interest a pollen expert in a 25 cm square block we cut out, but this was later unfortunately destroyed. Again I inexpertly extracted pollen and found *Abies*, confirmed by Professor Frank Mitchell. To Charles Turner, this indicates that the ice sheet had been pre-Hoxnian (if the pollen was not derived!). This organic silt emerged for some 20 years, always after a severe storm and high tide and for all I know may still be doing so. Unluckily the Irish Sea ice deposits into which the fan had cut, contain montmorillonite and similar clays and are therefore highly mobile, burying the silt very rapidly. I used to visit the site the day after the storm.

The Group visited the Cledlyn pingos next. These relict ice mounds were the subject of a letter from me to *QN* 80, October 1996. I am delighted that the work Eddie and I did, has again become a matter of interest to the present generation. New ideas and new techniques may perhaps advance fresh evidence on the many points which perplexed us. Good luck to them.

To anyone interested in this coast, the 37 m high drift cliffs immediately north of the River Arth, are very complex. There are two Irish Sea tills. One soliflucted at the base, still calcareous, contains many northern erratics including a fairly large Jurassic limestone boulder (provisionally identified by Dennis Bates), containing jasper, serpentine and flint. A short account and sketch is included in the INQUA handbook of 1977. Professor Mangerud advised us strongly that this very important section should be fully investigated. The work was never completed.

**Sybil Watson**
**85 Rawbrae Road**
**Whitehead**
**Carrickfergus**
**Northern Ireland BG38 9SX**

# *NOTICES*

## 1. THE ECOLOGICAL SETTING OF EUROPE: FROM THE PAST TO THE FUTURE

### The Impact of Humans on the Environment of Europe Since the End of the Ice Age

**Castelvecchio Pascoli, Italy, 20-25 September 1997**
**Chairman: Peter C. Woodman (Cork)**
**Vice-Chairman: Bent Aaby (Copenhagen)**

### Scope of the Conference

The issues of identification of human impact on the prehistoric environment of Europe, the age of commencement, their extent and significance have been key areas of debate in many related disciplines interested in environmental schemes.

The theme of this conference will be to discuss the criteria by which human impact is normally identified and to establish whether there is a common consensus in approaches. The conference will also examine the utility of differing approaches to establishing reliable chronologies and examine their application in a number of archaeological contexts.

The conference is open to researchers world-wide, whether from industry or academia. Participation will be limited to 100. The emphasis will be on discussion about new developments. A poster session will be organised. The Registration Fee covers full board and lodging. Grants will be available for younger scientists, in particular those from less favoured regions in Europe.

For information and application forms, contact:

**Dr Josip Hendekovic**
**Head of the EURESCO Unit**
**European Science Foundation**
**1 quai Lezay-Marnésia**
**67080 Strasbourg Cedex**
**France.**
**Tel: +33 3 88 76 71 35; Fax: +33 3 88 36 69 87**
**e-mail: euresco@esf.org**
**on-line information on WWW server at: httpL//www.esf.org/euresco**

## 2. POLAR REGIONS & QUATERNARY CLIMATES

### Coupling Between Northern and Southern Hemisphere Climates During the Last Climatic Cycles

**Acquafredda di Maratea, Italy, 20-25 September 1997**
**Chairman: Jean Jouzel (Gif-sur-Yvette, France)**
**Vice-Chairman: Bernard Stauffer (Bern, Switzerland)**

### Scope of the Conference

One of the challenging tasks of palaeoclimatologists involved in the study of the last glacial-interglacial cycles is to establish the correlation between deep-sea cores and ice cores because they provide the records which contain most of the information about climate forcings and climate mechanisms driving Quaternary climate. It is crucial to determine lead and lags between Northern and Southern Hemisphere climates because they are indispensable for answering such questions as:

- Do transitions from glacial to warm periods and back always follow the same pattern or is there a variety of mechanisms involved?
- Are global climate changes always triggered in the Northern Hemisphere or is the opposite sequence possible?
- How are global climate changes coupled between the two hemispheres?

These are the questions that will be discussed during the meeting. Various approaches to place records recovered from ice cores, deep-sea cores and also from terrestrial deposits in a common temporal framework, will be examined. Interaction with climate modellers will focus on the implications for climate mechanisms and, in particular, on the respective role of the atmosphere and of the ocean in the interhemispheric coupling.

The conference is open to researchers world-wide, whether from industry or academia. Participation will be limited to 100. The emphasis will be on discussion about new developments. The Registration Fee covers full board and lodging. Grants will be available for younger scientists, in particular those from less favoured regions in Europe.

For information and application forms, contact:

**Dr Josip Hendekovic**
**Head of the EURESCO Unit**
**European Science Foundation**
**1 quai Lezay-Marnésia**
**67080 Strasbourg Cedex, France.**
**Tel: +33 3 88 76 71 35; Fax: +33 3 88 36 69 87**
**e-mail: euresco@esf.org**
**on-line information on WWW server at: httpL//www.esf.org/euresco**

## 3. INTIMATE

### (INTegration of Ice Core, MArine and TErrestrial Records)

### Programme 1997-1999

The INTIMATE project, first discussed at the INQUA Congress in Berlin, has now been accepted as a core programme of the INQUA Palaeoclimate Commission. INTIMATE is a successor to the North Atlantic Seaboard Programme of IGCP-253 'Termination of the Pleistocene', and has a broader remit than NASP. The aim of the programme is to synthesise data from the marine, terrestrial and ice-core realms for the North Atlantic region during the course of the Last Termination. Very broadly, the timescale extends from the Last Glacial Maximum (*c.* 25 ka BP) until the early Holocene. It is anticipated that the meetings and workshops to be held over the coming two years will involve scientists from a range of disciplines, and from both Europe and North America. The first meeting will be held in Sweden in September of this year. This will be followed by a second major meeting in Atlantic Canada in September 1998, and the final meeting will be at the INQUA Congress in Durban, South Africa, in June 1999. It is anticipated that, in addition to these major international meetings, regional workshops will also be held, and one of these is already planned for the British community in April 1998. Details of the programme so far are as follows:

**International Meeting: 'Towards a common time-scale for the Last Termination: comparison of ice-core, terrestrial and marine records'**
Date: 28-30th September 1997
Place: Lund, Sweden
Convenors: B. Wohlfarth (Lund); S. Björck and S. Johnsen (Copenhagen); K.-L. Knudsen (Aarhus)

**Regional Workshop: One-day INTIMATE workshop to be held at GEOSCIENCES 1998 (Biennial Meeting of the Geological Society)**
Date: 9-14th April 1998
Place: Keele, Staffordshire, England
Convenors: J.J. Lowe (London) and M.J.C. Walker (Wales)

**International Meeting**
Date: September 1998 (dates to be finalised)
Place: Fredericton, New Brunswick, Canada
Convenor: L.C. Cwynar (New Brunswick)

**International Meeting: Final meeting of the INTIMATE programme**
Date: July 1999
Place: Durban, South Africa
Convenors: J.J. Lowe (London) and M.J.C. Walker (Wales)

Anyone who would like to be involved in the IMTIMATE programme, or who would like to be kept informed of events, should contact either the Co-ordinator of the programme, John Lowe, or the Secretary, Mike Walker, at the addresses below. Please include your e-mail number in any correspondence:

**Professor John Lowe**
**Department of Geography**
**Royal Holloway, University of London**
**Egham, Surrey TW20 0EX, UK**
**Tel: 01784-443565; Fax 01784-472836**
**e-mail: j.lowe@rhbnc.ac.uk**

**Professor Mike Walker**
**Department of Geography**
**University of Wales**
**Lampeter SA48 7ED, Wales, UK**
**Tel: 01570-424736; Fax 01570-424714**
**e-mail: walker@lamp.ac.uk**

## 4. GEOSCIENCES '98

### Ultra-Rapid Climatic Change and its Signature in the Geological Record

**Keele University, 14-18 April 1998**
**Convenors: G.S. Boulton and J.J. Lowe**

### Scope of Conference

One of the *Major Symposia* of the GEOSCIENCES '98 programme will be devoted to the above theme. The main focus of this symposium will be evidence for climatic and environment events which recur at sub-Milankovitch frequencies, particularly those where there is evidence of causes. Of particular interest to the convenors, therefore, will be contributions that present the results of high-resolution studies of recurrent climatic shifts operating at decadal to millennial frequencies and discussion of possible causal mechanisms. A wide spectrum of methods and geographical perspectives will be considered, and it is anticipated that evidence from ice-core, marine and terrestrial records will be represented in the proceedings. The intention is to address such important issues as (i) the quantification of palaeoclimatic interpretations, (ii) closing the gap between the resolution of geological studies and that of the instrumental record, and (iii) developing a predictive capability from geological reconstructions.

Prospective contributors should submit the following information to the symposium convenors by Monday, 1 September, 1997:

1. Title of contribution (max. 20 words)
2. List of authors of contribution (please underline name of person who will present the paper at the GEOSCIENCES '98 meeting)
3. Address, telephone number, fax. number and e-mail address of speaker
4. Full addresses of co-authors
5. An ABSTRACT (max. 300 words)
6. Up to 6 keywords or short phrases

Presentations will be limited to a maximum of 20 minutes.

Please send offers of contributions to, or seek advice from, either:

Professor G.S. Boulton
Deptartment of Geology and Geophysics
The University of Edinburgh
Grant Institute, King's Buildings
West Mains Road
Edinburgh EH9 3JW
Tel: +44 (0) 131 650 4844
Fax: +44 (0) 131 650 4761
e-mail: Geoff.Boulton@ed.ac.uk

Professor J.J. Lowe
Centre for Quaternary Research
Department of Geography
Royal Holloway
University of London
Egham, Surrey TW20 0EX
Tel: +44 (0) 1784 443565 / 443563
Fax: +44 (0) 1784 472836
e-mail: j.lowe@rhbnc.ac.uk

## 5. GLACIAL DEBRIS TRANSPORT AND DEPOSITION: PROCESSES AND PRODUCTS

**Joint IGS British Branch, QRA, BGRG and BSRG Meeting**
**School of Geography, University of Leeds, 9-11 January 1998**

### Scope of the Conference

To provide a forum for the dissemination and development of ideas concerning the manner by which debris is entrained, transported and deposited by glaciers, and how these processes can explain the development of glacial landforms and landscapes. It is hoped that the meeting will bring together glaciologists, sedimentologists, geomorphologists and Quaternary geologists to promote the cross-fertilisation of ideas.

The meeting has support from the International Glaciological Society British Branch, Quaternary Research Association, British Geomorphological Research Group and British Sedimentological Research Group. The conference will take place between 9-11 January 1998. The first two days will comprise oral and poster sessions, and the third day will be a hands-on workshop on the use of thin-sections in glacial geology and sedimentology. Postgraduate students are especially encouraged to attend. We envisage a publication arising from the conference. The proposed publication schedule is: 30 September 1997 - submission of abstracts; 1 December 1997- deadline for papers; 9 January 1998 - referees' comments to be distributed at the meeting; 15 February 1998 - revised papers due.

### Meeting themes:

- Debris entrainment processes
- Role of structural glaciology
- Basal ice processes
- Deformable beds
- Ice/bed interface
- Water and sediment within and beneath glaciers
- Suspended sediment and bedload and solute transfer
- Role of glaciotectonics
- Sediment transfer to the glaciomarine environment
- Glacial sedimentary facies and facies associations
- Glacial landforms and landscapes
- Ice sheet reconstructions from field evidence

For information please contact:

Tavi Murray
School of Geography, University of Leeds
Leeds LS2 9JT
e-mail: tavi@geog.leeds.ac.uk
or see our WWW page at:
http://www.geog.leeds.ac.uk/conferences/glacial98/glacial.htm

QUATERNARY SCIENCE REVIEWS

# LQL

## LONDON QUATERNARY LECTURES

Organised by

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

Sponsored by

*Quaternary Science Reviews*

### Wednesday, 26th November, 1997

15.30 - 1630

**DR S. G. ROBINSON**
(Department of Geography, Manchester University)

**'High-frequency (Sub-Milankovitch) variability in North Atlantic ice-rafting events throughout the Pleistocene'**
[LQL No. 58]

16.30 - 17.00 Tea

17.00 - 18.00

**DR M. A. MASLIN**
(Department of Geography, University College London)

**'Evidence of sea-level change, gas hydrate release, catastrophic failures, deep-water temperatures and Heinrich Events in the Amazon Fan'**
[LQL No. 59]

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.* 1,250) 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 P. Coxon,* Department of Geography, Museum Building, Trinity College, Dublin 2, Ireland (e-mail: pcoxon@tcd.ie)

**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)

**Treasurer:** *Dr D. McCarroll,* Department of Geography, University College Swansea, Singleton Park, Swansea, SA2 8PP (e-mail: D.McCarroll@swansea.ac.uk)

**Editor, Quaternary Newsletter:**
*Dr S. Campbell,* Earth Science Division, Countryside Council for Wales, Hafod Elfyn, Ffordd Penrhos, Bangor, Gwynedd, LL57 2LQ

**Editor, Journal of Quaternary Science:**
*Professor M.J.C. Walker,* Department of Geography, University of Wales, Lampeter, Dyfed, SA48 7ED (e-mail: walker@lamp.ac.uk)

**Publicity Officer:** *Dr D.R. Bridgland,* Department of Geography, Durham University, South Road, Durham DH1 3LE (e-mail: d.r.bridgland@durham.ac.uk)

All questions regarding membership are dealt with by the **Secretary**, the Association's publications are sold by the **Publications Secretary** and all subscription matters are dealt with by the **Treasurer**.

**QRA home page on the world wide web at: http://www2.tcd.ie/QRA**

## June 1997 No. 82

## Contents


Page
1 **ARTICLES**
1 Vertebrate Faunas of the British Late Pleistocene and the Chronology of Human Settlement *A. Currant and R. Jacobi*
9 Holocene (Flandrian) Organic Deposits Preserved in an Icing Hollow at Bardfield Bridge, Borley, Essex *S. Boreham*
15 An Anglian Till at Long Hanborough, Oxfordshire? Some Additional Data and an Alternative Interpretation *M.G. Sumbler*
19 **REPORTS**
19 First Annual QRA Postgraduate Symposium: Cheltenham and Gloucester College of Higher Education
21 QRA Annual Discussion Meeting - Mountain Glaciations: Chronologies, Forms and Processes
26 The Quaternary of the South Midlands and the Welsh Marches: Annual Field Meeting
30 Young Research Workers Awards 1996
30 Excavations at the Later Middle Pleistocene Site of Greenlands Pit, Purfleet, Essex
32 Preliminary Investigations of Pre-Late Midlandian Organic Deposits in County Monaghan
33 The Vegetation History of Two Lake Sites Adjacent to Eskers in Central Ireland
37 The Geomorphic Evolution of the Guide Basin, Qinghai, China
40 Glaciation and Sea-Level Change, Raanes Peninsula, Western Ellesmere Island, Arctic Canada
42 Expansions of the Arid Realm: Late Quaternary Environmental Change, Central Mega-Kalahari, Southern Africa
44 Shallow Marine Ostracod Biogeochemistry of the Sand Hole Formation, Inner Silver Pit, Southern North Sea
46 **REVIEWS**
46 Late Quaternary Palaeoceanography of the North Atlantic Margins by *J.T. Andrews, W.E.N. Austin, H. Bergsten and A.E.J. Jennings*
47 Global Continental Changes: The Context of Palaeohydrology, edited by *J. Branson, A.G. Brown and K.J. Gregory*
49 **ABSTRACTS**
49 Paleobotany and Palynology of Neogene Sediments from the High Plain of Bogatá (Colombia) *Vincent M. Wijninga*
52 Vegetation, Phytogeography and Paleoecology of the Last 20,000 Years in Montane Central America *G.A. Islebe*
54 The History of the *Pinus Sylvestris* Tree-Line at Creag Fhiaclach, Inverness-shire *Jennifer McConnell*
55 Palaeo-Argillic Soils in South-East England *Fiona M. Clayton*
56 Glacial Sedimentology and the Conservation of Sand and Gravel Resources in the Omagh Basin, South-Western Northern Ireland *Jasper Knight*
57 Abrupt Holocene Climatic Change Recorded in Terrestrial Peat Sequences from Wester Ross, Scotland *David E. Anderson*
58 Sedimentology and Dating of Glacigenic Sequences: Eastern Irish Sea Basin *Endaf Edwards*
59 The Geomorphology and Sedimentology of Five Tsunamis in the Aegean Sea Region, Greece *Dale Dominey-Howes*
60 Morphology, Stratigraphy and Genesis of Buried Mid-Pleistocene Tunnel-Valleys in the Southern North Sea Basin *Daniel Praeg*
62 Ostracods as Indicators of Changing Environments of Central Northamptonshire *Kathleen Ann Smith*
63 Holocene Environmental Change in the Scottish Highlands: Multi-Proxy Evidence from Blanket Peats *Heather Binney*
64 **LETTER TO THE EDITOR**
64 Comment on the Account of the Excursion to the Coast of Wales, South of Aberystwyth *Sybil Watson*
67 **NOTICES**


**ISSN 0 143-2826**