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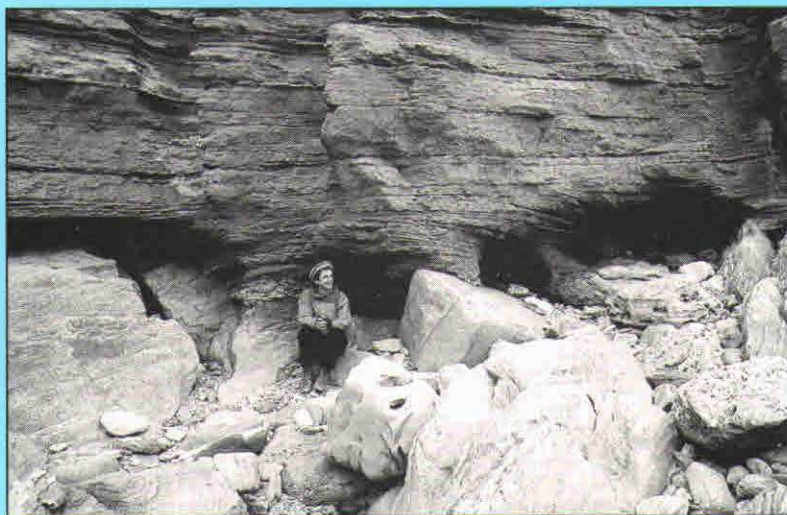
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# QN

Quaternary Newsletter

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# QUATERNARY NEWSLETTER

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Quaternary Newsletter is issued in February, June and October. Contributions comprising articles, reviews, notices of forthcoming meetings, news of personal and joint research projects, etc. are invited. They should be sent to the Quaternary Research Association Newsletter Editor. Closing dates for submission of copy for the relevant numbers are 20 January, 20 May and 20 September. The publication of articles is expedited if manuscripts are submitted as floppy discs in addition to hard copies. The preferred type is 3.5" floppy disc in Apple Macintosh format, but IBM PC compatible formats are also acceptable.

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## COVER PHOTOGRAPH:

Pink granite erratic underlying raised beach sands at Saunton, North Devon. Photograph (by Stewart Campbell) taken during the 1996 Annual Field Meeting (see report by Stewart Campbell and James Scourse in this issue).

# EDITORIAL

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With this issue of *Quaternary Newsletter* my four year term of office as editor comes to an end. Throughout this period I have found the task to be an enjoyable and fulfilling experience. Much of the credit for this must go to those with whom I have interacted in this role, in particular Richard Jones at Gwasg Ffroncon and Val Siviter (both in Bethesda) who have been models of calm efficiency in printing and production respectively. I am delighted that the *Newsletter* will continue to be produced by this effective "team" in future. I would also like to acknowledge the support and good cheer of all other members of the QRA Executive Committee for which I am very grateful. Most of all, however, I would like to thank the QRA membership for the very healthy, and growing, supply of copy for the *Newsletter* which should ensure its future vigour.

All articles submitted to the *Newsletter* are "lightly" refereed, lightly because I believe the role of QN is to stimulate debate, even controversy (see articles in this issue on the passion of gravel), to take smaller articles on new techniques or site reports and to publish material very quickly. The "heavy" refereeing characteristic of some high profile journals would have a stifling effect on all these aspects to the detriment of the science and the QRA. I would like to take this opportunity to thank all the hitherto unacknowledged reviewers of manuscripts submitted to QN over the past four years. They are:

Bill Austin  
Colin Ballantyne  
Keith Barber (twice)  
Doug Benn  
John Birks (twice)  
Jackie Birnie  
Alan Brandon  
David Bridgland  
Dick Bryant  
Stewart Campbell (twice)  
Pete Coxon  
Roger Dackombe  
Nick Davey  
Brian Funnell  
Phil Gibbard (twice)  
John Gordon  
Murray Gray  
Charles Harris (twice)  
Richard Hey

John Hunt  
Simon Jennings  
David Keen  
Edward Koster  
Henry Lamb  
Adrian Lister (twice)  
Darrell Maddy  
John Merritt  
Frank Oldfield  
Mike Paul  
Mary Seddon  
Ian Shennan  
David Smith  
Tony Stevenson  
Mike Walker  
Richard West  
Colin Whiteman  
Peter Worsley

The new editor of QN is Stewart Campbell of the Countryside Council for Wales in Bangor. Stewart hails from the West Country (an important prerequisite for QN editorship), having been educated in Cirencester. He moved to Swansea in 1976 to study geology and geography, and gained a First Class Honours Degree in Geography in 1979. His interest in the Quaternary was awakened as an undergraduate, when he undertook a dissertation on the effects of sand and gravel extraction on the water resources of the upper Thames Valley. Stewart stayed at Swansea to carry out research for a Ph.D. on the Pleistocene deposits of the Cross Hands area and west Gower. A lucky break for him was the discovery of a new Pleistocene site - Broughton Bay - where he was able to apply amino-acid geochronology and a variety of other sedimentological techniques including scanning electron microscopy. The results of his work here yielded the first 'dating' of raised beach deposits in conjunction with shelly glacial deposits in Britain. After gaining his Ph.D., Stewart stayed at Swansea to undertake a comprehensive review of Quaternary sites in Wales for the Nature Conservancy Council (NCC). This was to result in publication of the first volume of the Geological Conservation Review, the *Quaternary of Wales* (Campbell and Bowen, 1989), and to set Stewart on a career in earth-science conservation. From 1987 to 1991 he worked in the Chief Scientist's Directorate at the NCC headquarters in Peterborough. Here he was responsible for advising on the scientific aspects of conservation for a wide range of Quaternary sites all over southern Britain, visiting virtually all of the premier Quaternary and geomorphological localities. In 1991, with the disbandment of NCC, he moved to Bangor in North Wales to set up an earth-science department in the newly-formed Countryside Council for Wales. Today, as head of the Earth-Science section of CCW, he has responsibility for a team of geologists which monitors, documents and conserves Wales' prime geological and geomorphological sites.

In addition to a range of major academic publications, Stewart has taken a keen interest in promoting earth-science conservation: he played a major role in the Crewe (1992) and Malvern (1993) earth-science and landscape conferences and is joint editor of the journal *Earth Heritage*. He is an accomplished and enthusiastic landscape photographer. His current research interests include the Quaternary deposits of Anglesey, and his second *magnum opus*, the GCR volume for the *Quaternary of South-West England*, is nearing completion and will be published in late 1996/early 1997.

James Scourse

# ARTICLES

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## THE KESGRAVE AND BYTHAM SANDS AND GRAVELS OF EASTERN SUFFOLK: A LITHOSTRATIGRAPHIC COMMENT

C.P. Green and D.F.M. McGregor

### Introduction

An ancestral course of the River Thames, well to the north of the present estuary, has been recognised for nearly a century (Salter, 1905), while a further extension of this course northward into East Anglia was indicated in the work of Hey (1980) and has been supported in studies by Green and McGregor (1990), Whiteman (1992) and Lewis (1993).

Hamblin and Moorlock, (*Quaternary Newsletter* 77, 17-31, 1995) now argue that no such northerly course of the proto-Thames can be identified and that within the area of Essex and East Anglia the ancestral river throughout its history occupied a valley with an easterly alignment towards the North Sea. They propose a major drainage divide to the north of this valley, passing between Bury St Edmunds and Sudbury in the west and extending to the coast in the neighbourhood of Dunwich (TM 47 70). To the north of this watershed they suggest that the main drainage artery was the river described by Rose (1994) - the Bytham River - flowing from the west out of the English Midlands.

This reinterpretation by Hamblin and Moorlock of the early drainage history of East Anglia is based on the belief that gravels of Kesgrave Formation type (Rose and Allen, 1977; Hey, 1980; Whiteman and Rose, 1992) representing deposition by the proto-Thames are nowhere present to the north of Leiston (TM 44 62) and that to the north of this locality, sediments are exclusively of western and northern derivation. Hamblin and Moorlock believe that this material entered East Anglia directly from those source areas by way of the Bytham River. They argue that there is no evidence of a connection at any time between the Thames drainage system and the Bytham River drainage system.

This revised history of Quaternary drainage development in East Anglia and Essex, as set out by Hamblin and Moorlock, fails however to explore fully the complexity of the depositional record. In particular it offers no explanation for the presence in gravel deposits in many places in Suffolk and Norfolk of rock

types that are characteristic of Kesgrave Formation gravels and have entered East Anglia exclusively or predominantly from the south. In fact, this issue is not examined. Three rock types deserve particular attention and are discussed here.

### **Spicular cherts and cherty sandstones derived from the Hythe Beds in the Lower Greensand of the Weald**

Although rocks of Lower Greensand age (Aptian) outcrop in Cambridgeshire and Norfolk, and also to the north of the Wash, spicular cherts and cherty sandstones are not present outside the Weald.

Thus, Lower Greensand lithologies entered Essex and East Anglia by way of right bank tributaries of the proto-Thames, from the proto-Wey in the west to the proto-Medway in the east (Green *et al.*, 1982). Lower Greensand chert and cherty sandstone are present in Thames gravels east of the proto-Wey confluence at all levels in the terrace sequence from the high level Pebble Gravels downward. The northward carriage of this material into East Anglia is demonstrated in many clast lithological analyses from sites in both Suffolk and Norfolk. Hey (1976) reports six samples with Lower Greensand chert from sites on the north Norfolk coast, and in later papers (1980, 1982) identified a further seven sites in the Norwich and Bury St Edmunds areas and at Holton (TM 405 773; the site near Southwold dismissed by Hamblin and Moorlock, along with the sites around Bury St Edmunds, as most probably Anglian glacial outwash). The present authors (Green and McGregor, 1990) report eight samples with Lower Greensand chert from the north Norfolk coast, and have a further thirteen unpublished analyses with Lower Greensand chert from sites between Badwell Ash (TL 988 688), to the north-east of Bury St Edmunds, in the south, to Coltishall (TG 246 208), north of Norwich, in the north. These unpublished analyses include one from an 'upper' gravel at Holton which confirms Hey's recognition there of Kesgrave-type material.

In some cases, including samples from as far north as the north Norfolk coast, these gravels with Lower Greensand are indistinguishable in composition from Kesgrave Formation gravels further south. They appear therefore to mark the course of a proto-Thames river that received no accession within East Anglia of northern and western material from a Bytham River tributary. In other cases, the Lower Greensand cherts and cherty sandstones are found in association with rock types of northern and western derivation. These sediments appear to represent either the deposits of a later Thames with which the Bytham River was confluent, or the reworking of Thames-derived material by later rivers, or by marine processes. In all cases, the presence in East Anglia of material derived from the Weald of Kent, Surrey and Sussex shows that the River

Thames, for part of its history, flowed northward from Essex into Suffolk and Norfolk.

None of the analyses mentioned in the previous paragraph are of gravels of Westleton Beds type. The occurrence of Lower Greensand cherts in the Westleton Beds has been the subject of some uncertainty. Hey (1967) recorded Lower Greensand chert in all his samples, but in his 1976 paper he indicated his belief that the Westleton Beds "contain little or no chert from the Weald". However, Sinclair (1994) mentions Lower Greensand chert among the components in the Westleton Beds samples examined by him, and the present authors have also identified it in several unpublished Westleton Beds analyses. This is evidently a subject awaiting fuller investigation.

### **Acid volcanic rocks**

Acid volcanic rocks, as a component in the Quaternary gravels of East Anglia, were first described in detail by Hey and Brenchley (1977). They proposed a provenance among the Ordovician volcanic rocks of North Wales. Green *et al.* (1980) subsequently recognised the presence of these acid volcanic rock types in gravels throughout the length of a proto-Thames drainage line from the present headwaters of the Evenlode downstream through the Vale of St Albans into East Anglia. Thus, the proto-Thames valley was confirmed as the route by which Welsh volcanic rocks entered East Anglia. Rocks of this suite have never been reported from the Midland course of the Bytham River. There is therefore no record of such rocks entering East Anglia except from the south. Rocks of the Welsh volcanic suite have been recorded from at least five sites to the north of Leiston (Hey and Brenchley, 1977) and therefore north of the drainage divide regarded by Moorlock and Hamblin as separating the Thames drainage system from the Bytham River drainage system. As is the case with Greensand lithologies, and for the same reasons, acid volcanic rocks are found in gravels of Kesgrave Formation type and in gravels of mixed Kesgrave and Bytham origin.

### **Quartz**

Although quartz is ubiquitous in the gravels of Essex and East Anglia, it is relatively more abundant in the Thames-derived gravels of the Kesgrave Formation than in gravels of the Bytham River, or in gravels of northern derivation such as those described by Green and McGregor (1990) in the Weybourne Crag (their gravel groups B and C). In gravels of the Kesgrave Formation, the *quartz: other far-travelled (qz/oftr)* ratio is generally greater than 1.0. In the Ingham (Bytham River) and Weybourne Crag gravels this ratio is

invariably less than 1.0. Both Hey (1976) and Green and McGregor (1990) have reported Kesgrave Formation type gravels with  $qz/oft$  ratios greater than 1.0 as far north as the north Norfolk coast. In north Norfolk, gravels of this type are at the base of the Quaternary succession and rest directly on the Chalk. This evidence tends to confirm that at an early stage in the development of the Quaternary drainage of East Anglia the proto-Thames reached the latitude of the present north Norfolk coast without receiving an accession of Midland or northern material via left-bank tributaries following a Bytham River route. It is interesting to note in this context that the clast lithological analyses reported by Hamblin and Moorlock lend support to this interpretation. It is in the most elevated and oldest of the Bytham River terraces - Terrace 3 - that  $qz/oft$  ratios are highest, including three localities with  $qz/oft$  ratios greater than 1.0, which may prove on further investigation to mark the position of a former course of the Thames.

## Conclusion

The pre-Anglian drainage history of East Anglia remains problematic in many respects, but there is ample evidence that an early course of the Thames extended from Essex in the south to the present-day north Norfolk coast in the north. When and why this course was abandoned are important unresolved questions in the Quaternary geological history of this region and, as Hamblin and Moorlock rightly observe, the answers must take account of both the depositional record and its geomorphological setting.

## References

- Green, C.P. and McGregor, D.F.M. (1990). Pleistocene gravels of the north Norfolk coast. *Proceedings of the Geologists' Association*, 101, 197-202.
- Green, C.P., Hey, R.W. and McGregor, D.F.M. (1980). Volcanic pebbles in Pleistocene gravels of the Thames in Buckinghamshire and Hertfordshire. *Geological Magazine*, 117, 59-64.
- Green, C.P., McGregor, D.F.M. and Evans, A.H. (1982). Development of the Thames drainage system in Early and Middle Pleistocene times. *Geological Magazine*, 119, 281-290.
- Hey, R.W. (1967). The Westleton Beds reconsidered. *Proceedings of the Geologists' Association*, 78, 427-445.
- Hey, R.W. (1976). Provenance of far-travelled pebbles in the pre-Anglian Pleistocene of East Anglia. *Proceedings of the Geologists' Association*, 87, 69-81.



Hey, R.W. (1980). Equivalents of the Westland Green Gravels in Essex and East Anglia. *Proceedings of the Geologists' Association*, 91, 279-290.

Hey, R.W. (1982). Composition of pre-Anglian gravels in Norfolk. *Bulletin of the Geological Society of Norfolk*, 32, 51-59.

Hey, R.W. and Brenchley, P.J. (1977). Volcanic pebbles from Pleistocene gravels in Norfolk and Essex. *Geological Magazine*, 114, 219-225.

Lewis, S.G. (1993). *The status of the Wolstonian glaciation in the English Midlands and East Anglia*. Unpublished Ph.D. thesis, University of London.

Hamblin, R.J.O. and Moorlock, B.S.P. (1995). The Kesgrave and Bytham Sands and Gravels of eastern Suffolk. *Quaternary Newsletter*, 77, 17-31.

Rose, J. (1994). Major river systems of central and southern Britain during the Early and Middle Pleistocene. *Terra Nova*, 6, 435-443.

Rose, J. and Allen, P. (1977). Middle Pleistocene stratigraphy in south-east Suffolk. *Journal of the Geological Society of London*, 133, 85-102.

Salter, A.E. (1905). On the superficial deposits of central and parts of southern England. *Proceedings of the Geologists' Association*, 19, 1-56.

Sinclair, J.M. (1994). The origin and sedimentology of the Lower Pleistocene Westleton Beds, East Anglia UK. M.Phil. thesis, London Guildhall University (Abstract). *Quaternary Newsletter*, 72, 47-48.

Whiteman, C.A. (1992). The palaeogeography and correlation of pre-Anglian-Glaciation terraces of the River Thames in Essex and the London Basin. *Proceedings of the Geologists' Association*, 103, 37-56.

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

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**THE KESGRAVE AND BYTHAM SANDS AND  
GRAVELS OF EASTERN SUFFOLK:  
REPLY TO A LITHOSTRATIGRAPHIC COMMENT  
BY C.P. GREEN AND D.F.M. MCGREGOR**

**R.J.O. Hamblin, B.S.P. Moorlock, and J. Rose**

We welcome the comments made by Green and McGregor (1996) regarding the course of the ancestral River Thames in northern East Anglia, and their useful synopsis of the spread throughout that area of Lower Greensand chert from the Weald and acid volcanics from Wales. We would agree that, in fluvial gravels, the presence of clasts of these species can be important indicators of provenance; Green *et al.*, (1980) have effectively demonstrated this by tracing volcanic clasts in proto-Thames gravels along a drainage line from the present headwaters of the Evenlode downstream through the Vale of St Albans and into East Anglia.

We accept that the Greensand chert and Welsh volcanic rocks recorded in East Anglia were transported by the proto-Thames, and also that many Norfolk sites reveal quartz/other-far-travelled ratios more indicative of a proto-Thames than a Bytham source. However, we contend that these data fail to support Green and McGregor's conclusion that "there is ample evidence that an early course of the Thames extended from Essex in the south to the present-day north Norfolk coast in the north" since in northern East Anglia the material with this lithology is recognised as occurring in *marine* deposits (Green & McGregor, 1990).

Specifically, Green and McGregor use the presence of Lower Greensand chert in eight samples of quartz/quartzite-bearing gravels from the north Norfolk coast (Green & McGregor, 1990) as evidence that the River Thames once flowed through this part of Norfolk. However, this conclusion is unsound since three of their samples are stated to be from marine gravels, which contain marine shells, four are from questionably marine gravels, and the remaining sample is from the overlying Anglian glacial deposits (Green & McGregor, 1990, table 1, column 1).

Since the original paper by Hamblin and Moorlock (1995), collaborative work between BGS and the Centre for Quaternary Research at the Geography Department of Royal Holloway, University of London, has demonstrated the presence of quartz/quartzite-bearing gravels and sands beneath Anglian diamicton in a series of trial pits at How Hill [TG 377 199], near Ludham (Rose *et al.*, in press). These gravels are interpreted as coastal/marine and contain Lower Greensand chert and Welsh volcanics.

Therefore, it is our contention that, whilst the quartz/quartzite-bearing gravels which contain Lower Greensand chert and Welsh volcanics in north and central Norfolk may be derived from the proto-Thames and other drainage systems, no evidence has been found to suggest that they were deposited directly by a river. Sedimentary structures studied so far suggest that sediments were transported by tidal currents in a coastal location.

### **Acknowledgement**

With respect to JHOH and BSPM, this paper is published with the permission of the Director, British Geological Survey (NERC).

### **References**

- Green, C.P., Hey, R.W. and McGregor, D.F.M. (1980). Volcanic pebbles in Pleistocene gravels of the Thames in Buckinghamshire and Hertfordshire. *Geological Magazine*, 117, 59-64.
- Green, C.P. and McGregor, D.F.M. (1990). Pleistocene gravels of the north Norfolk coast. *Proceedings of the Geologists' Association*, 101, 197-202.
- Green, C.P. and McGregor, D.F.M. (1996). The Kesgrave and Bytham Sands and Gravels of Eastern Suffolk: a lithostratigraphic comment. *Quaternary Newsletter*, 79, 3-7.
- Hamblin, R.J.O. and Moorlock, B.S.P. (1995). The Kesgrave and Bytham Sands and Gravels of Eastern Suffolk. *Quaternary Newsletter*, 77, 17-31.
- Hamblin, R.J.O. and Moorlock, B.S.P. (1996). Quartz- and quartzite-bearing gravels of the Caistor St. Edmund Pit, Norwich, Norfolk: reply to a letter from Brian Funnell. *Quaternary Newsletter*, 78, 43-44.
- Rose, J., Gulamali, N., Moorlock, B.S.P., Hamblin, R.J.O., Jeffery, D.H., Anderson, E., Lee, J.A. and Riding, J.B. (in press). Pre-glacial and glacial Quaternary sediments, How Hill, near Ludham, Norfolk, England. *Bulletin of the Geological Society of Norfolk*.

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# THE KESGRAVE AND BYTHAM SANDS AND GRAVELS OF EAST ANGLIA

J. Rose, P. Allen, C.P. Green, R.W. Hey, S.G. Lewis, J.M. Sinclair and  
C.A. Whiteman

## Introduction

We welcome the publication of The Kesgrave and Bytham Sands and Gravels of Eastern Suffolk by Richard Hamblin and Brian Moorlock in *Quaternary Newsletter* 77. Currently, these deposits are the subject of collaborative work between members of the Centre for Quaternary Research at the Department of Geography at RHUL and staff of the Southern and Eastern England Group of BGS. The paper in *Quaternary Newsletter* reflects a consensus view regarding the importance of the Thames and the fact that the Bytham river is a "river system with a long history of independence" (p 27). However the paper does also highlight a critical difference between the two groups. It is our belief that the Thames drained across a far larger area in East Anglia (Figure 1), and that Figure 1 of Hamblin and Moorlock (1995) omits many sites and represents only a snapshot of one (relatively late) stage in the depositional history of the Kesgrave and Bytham Sands and Gravels, and hence only one late phase in the development of the Thames and Bytham river systems in eastern England. Investigation of this problem is one of the key issues of the collaboration referred to above, and the first scientific contributions from this work will be published in the near future (Rose *et al.*, 1996).

This reply is concerned with: i) issues of process relating to particular topics that are developed in Hamblin and Moorlock; ii) points of clarification where debate exists about the interpretation of specific sites.

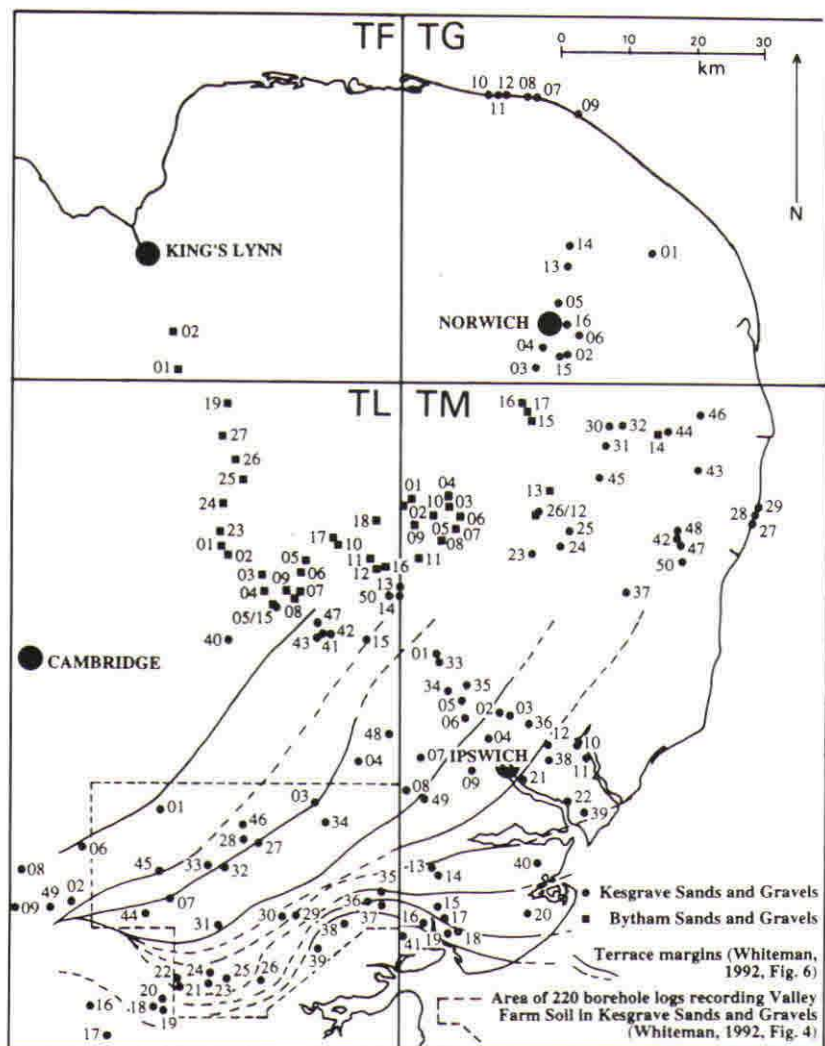
As far as possible the issues are taken in order dealt with in Hamblin and Moorlock.

## Distribution of the Kesgrave and Bytham Sands and Gravels in East Anglia and Essex

Hamblin and Moorlock (p 18, Figure 1) make a fundamental case that the Kesgrave Sands and Gravels are significantly less extensive than suggested by Hey (1980), Rose *et al.* (1985), Green and McGregor (1990), Whiteman (1992), and many others, including other officers of the British Geological Survey (see Hamblin and Moorlock for references). We believe that the case

for the Kesgrave Sands and Gravels being more extensive than is suggested by Hamblin and Moorlock is made in Figure 1 of this paper which shows localities where these deposits have been recorded. Most of these sites refer to sands and gravels beneath Anglian glaciogenic deposits. Although the distribution of sites is uneven, the number and position of boreholes and exposures gives a close control on the geometry of the sediment body, and this control is improving as research progresses. Specific terraces/aggradations, new associations with tributary rivers and the location of intervening interfluvies are clearly recognised, although to some degree progress will always be difficult because of glacial erosion across parts of the region. Figure 1 of Hamblin and Moorlock omits many sites. The criteria for the identification of Kesgrave Sands and Gravels are given in Rose and Allen (1977), Hey (1980), Whiteman (1992) and Whiteman and Rose (1992). Criteria for the identification of Bytham Sands and Gravels are given in Clark and Auton (1982) and Bridgland and Lewis (1991). However, it must be stressed that this definition is lithological and does not differentiate between fluvial and marine depositional environments where the river provides the sediment source for the coastal environment. Although the Bytham and Kesgrave Sands and Gravels (*sensu stricto*) are fluvial, marine deposits with an equivalent lithology are known in north Norfolk (Hey, 1976). Figure 1 identifies sites only on the basis of lithology and does not differentiate between a fluvial and marine origin.

Hamblin and Moorlock suggested that it is unlikely that the river Thames would follow a northward route through East Anglia (p 28) and suggest that a north-easterly or easterly route to the present North Sea is more probable. This alternative route does not take into consideration the fact that lithologies which fulfil the criteria of the Kesgrave Sands and Gravels occur in Norfolk (Hey, 1976; Hey and Brenchley, 1977; Hey, 1980; Green and McGregor, 1990; Rose *et al.*, 1996). Furthermore, a northerly route for the river Thames through the area that is now Norfolk would not create the geomorphological problems which they seem to believe. Such a route would be normal to the coastline of the time (see Cameron *et al.*, 1992, Fig. 104) and parallel with the surface slope of the great delta of the Rhine and "Baltic rivers" that, during the Early and early Middle Pleistocene, filled the region now occupied by the southern North Sea (Cameron *et al.*, 1992). In other words the river Thames flowed down the western margin of this delta, similar to the river Kasat which flows down the western side of the Ganges delta at the present day. The change from an east-west coastline in the Early and early Middle Pleistocene, to a south-north trending coastline of eastern east Anglia at the present day is due to subsidence towards the centre of the southern North Sea basin (Cameron *et al.*, 1992). At the same time the adjacent land areas, such as central England and western East Anglia, have been uplifted (Funnell, 1987, 1990).



**Figure 1.** Sites at which Kesgrave and Bytham Sands and Gravels have been recorded in East Anglia. Each site is indicated by a number which is identified in the key. Sites that have been cited in publications are identified by reference to the reference list. This figure should not be considered as comprehensive and reflects only the knowledge available to the authors at the present time.

**KEY to FIGURE 1:  
SITES IN KESGRAVE SANDS AND GRAVEL**

100 km grid square	Grid ref.	Site No.	Name	Borehole/ (B) Exposure (E)	Height m O.D. at surface top of unit	Palaeosol at surface Y/N (M)= marine	Citation
TG	377 197	01	How Hill	E	>07	N	Rose <i>et al.</i> 1996
	239 046	02	Caistor St. Edmund	E	25	Y	Hey 1980, Postma & Hodson, 1988
	204 028	03	Swardeston	E			Hey 1980
	209 064	04	Eaton	E			Hey 1980
	234 130	05	Catton	E			Hey 1980
	267 076	06	Whitlingham	E			Hey 1980
	193 432	07	West Runton	E		(M)	Green & McGregor, 1990
	169 434	08	Beeston Regis	E		(M)	Hey 1976
	273 405	09	Sidestrand	E		(M)	Green & McGregor, 1990
	137 435	10	Sheringham	E		(M)	Green & McGregor, 1990
	141 435	11	Sheringham	E		(M)	Green & McGregor, 1990
	151 435	12	Sheringham	E		(M)	Green & McGregor, 1990
	246 174	13	Frettenham	E			CPG pers. obs.
	246 208	14	Coltishall	E			CPG pers. obs.
	238 047	15	Caistor St. Edmund	E			CPG pers. obs.
	248 104	16	Norwich	E			CPG pers. obs.
TL	641 361	01	Great Sampford	E		Y	Hey, 1980, Read, 1994
	520 218	02	Birchanger	E		N	Hey, 1980
	871 357	03	Alphamstone	E	58	Y	Rose <i>et al.</i> 1976, Hey 1980
	932 432	04	Edwardstone	E	53	Y	Rose <i>et al.</i> 1976, Read 1994
	816 681	05/15	Hengrave	E		N	Rose and Wymer, 1994
	529 309	06	Widdington	E	>95	Y	Rose <i>et al.</i> 1976
	671 233	07	Stebbing	E		Y	Whiteman, 1983, Whiteman & Kemp, 1990.
	442 267	08	Furneux Pelham	E		N	Hey 1983
	422 215	09	Westland Green	E			Hey 1965, Whiteman, 1992
	995 693	13	Badwell Ash	E	44	Y	Rose <i>et al.</i> 1976, Hey 1980, Allen 1984
	988 686	14	Badwell Ash	E		N	Allen 1984, JR pers. obs.
	956 627	15	Tostock	E	50	Y	Rose <i>et al.</i> 1976
	536 072	16	Moreton	E	60	Y	Rose <i>et al.</i> 1976
	563 024	17	Hallsford	E	>45	N	Rose <i>et al.</i> 1976
	647 064	18	Newney Green	E	58	Y	Rose <i>et al.</i> 1976, Read, 1994 Bridgland 1994
	656 064	19	Twitch Cross	E	>60	N	Rose <i>et al.</i> 1976
	662 093	20	Roxwell	E		N	JR pers. obs.
	687 117	21	Great Waltham	E	50	Y	Rose <i>et al.</i> 1976, Whiteman, 1983, Whiteman, 1990.
	685 124	22	Great Waltham	E		Y	Read 1994
	718 107	23	Broomfield	E	50	Y	Rose <i>et al.</i> 1976, Whiteman, 1990.
	722 113	24	Broomfield	E	50	Y	Rose <i>et al.</i> 1976, Whiteman, 1990

	724 117	25	Broomfield	E		Y	JR pers. obs.
	082 116	26	Hatfield Peveril	E	35	Y	Rose <i>et al.</i> 1976, Whiteman, 1990
	789 321	27	Cutmaple	E		Y	JR pers. obs.
	774 318	28	Southey Green	B		Y	JR pers. obs.
	817 215	29	Coggeshall	E		N	JR pers. obs.
	815 208	30	Bradwell	E		N	JR pers. obs.
	733 193	31	Show Ground	B		N	JR pers. obs.
	741 287	32	Beazley End	E	80		Rose <i>et al.</i> 1976, Hey 1980
	772 283	33	Shalford	E	>50		Rose <i>et al.</i> 1976, Hey 1980
	896 342	34	Bures	E			JR pers. obs.
	945 235	35	Stanway	E	35	Y	Rose <i>et al.</i> 1976
	944 229	36	Stanway	E			JR pers. obs.
	953 226	37	Stanway	E			JR pers. obs.
	928 196	38	Birch	E	40	Y	Rose <i>et al.</i> 1976
	881 162	39	Tiptree	E	61	Y	Rose <i>et al.</i> 1976
	750 613	40	Denham	E	90	Y	Rose <i>et al.</i> 1976, JR pers. obs.
	891 626	41	Rushbrooke	B			BGS - IMAU
	896 626	42	Blackthorpe	B			BGS - IMAU
	886 606	43	Rushbrooke	B			Bridgland & Lewis, 1991
	620 215	44	Great Dunmow	E			Hey 1980
	651 274	45	Lindsell	E			Hey 1980
	773 333	46	Sible Hedingham	E			Hey 1980
	873 635	47	Bury St. Edmunds	E			Hey 1980
	987 483	48	Chelsworth	E			Hey 1980
	472 219	49	Bishop's Stortford	E			Hey 1965, Whiteman 1992
	988 688	50	Badwell Ash	E			CPG pers. obs.
<hr/>							
TM	059 596	01	Stowmarket	E		N	JR pers. obs.
	134 513	02	Barham	E	42	Y	Rose <i>et al.</i> 1976, Allen 1984
	135 515	03	Barham	E	42	Y	JR pers. obs., Hey 1980
	129 482	04	Bramford	E		Y	BGS guide, Hey 1980, Allen 1984
	095 526	05	Darmsden	E		N	Allen 1984, JR pers. obs.
	111 503	06	Great Blakenham	E	53	Y	Rose <i>et al.</i> 1976, Allen 1984, Kemp 1987b, Allen 1988.
	031 445	07	Hadleigh	E		N	JR pers. obs.
	013 399	08	Layham	E		Y	JR pers. obs.
	116 434	09	Valley Farm	E	41	Y	Rose <i>et al.</i> 1976, Rose & Allen 1977, Hey 1980, Allen 1984
	245 465	10	Marlesham	E		N	JR pers. obs.
	260 448	11	Waldringfield	E	24	Y	Rose <i>et al.</i> 1976, Allen 1984
	227 464	12	Kesgrave	E	26	Y	Rose <i>et al.</i> 1976, Allen 1984
	049 284	13	Ardleigh	E	35	Y	Rose <i>et al.</i> 1976
	055 283	14	Ardleigh	E			Bridgland, 1994
	047 229	15	Wivenhoe	E	30	Y	Rose <i>et al.</i> 1976, Bridgland, 1994.
	036 198	16	Fingringhoe	E	>15	N	Rose <i>et al.</i> 1976
	059 206	17	Arlesford	E	23	Y	Rose <i>et al.</i> 1976
	123 170	18	St. Osyth, Wellwick Fm	E		Y	JR pers. obs.
	117 172	19	St. Osyth	E	>15	N	Rose <i>et al.</i> 1976
	191 216	20	Thorpe le Soken	E	25	Y	Rose <i>et al.</i> 1976
	187 409	21	Ipswich Airport	E		Y	Kemp, 1987a, Allen 1984



248 383	22	Levington Marina	E	N	JR pers. obs.
203 751	23	Denham	B	N	BGS - IMAU
239 759	24	Wingfield Hall	B	Y	BGS - IMAU
256 787	25	Fressingfield	B	Y	BGS - IMAU
203 809	26/12	Brockdish	B	N	BGS - IMAU
525 812	27	Covehithe	E	N	JR pers. obs.
526 815	28	Covehithe	E	Y	JR pers. obs.
528 818	29	Covehithe	E	N	JR/ PA pers. obs.
311 941	30	Hedenham	B	Y	BGS - IMAU
318 921	31	Ditchingham	B	Y	BGS - IMAU
326 942	32	Thwaite St. Mary	B	Y	BGS - IMAU
053 592	33	Stowmarket	E		Hey 1980
061 536	34	Battisford	E		Hey 1980
095 555	35	Creeting	E		Hey 1980, Allen 1984
194 492	36	Tuddenham	E		Hey 1980
348 692	37	Peasenhall	E		Hey 1980
238 438	38	Foxhall Heath	E		Allen 1984, Whiteman 1992
270 378	39	Trimley	E		Allen 1984, Whiteman 1992
218 288	40	Little Oakley	E		Whiteman, 1990, 1992
071 187	41	Moverons	E		Bridgland, 1988, Whiteman, 1992
405 776	42	Holton	E		CPG pers. obs.
438 872	43	Ellough	E		CPG pers. obs.
427 932	44	Waterloo	E		CPG pers. obs.
295 864	45	Flixton	E		CPG pers. obs.
446 965	46	Haddiscoe	E		CPG pers. obs.
410 767	47	Wenhaston	E		CPG pers. obs.
405 773	48	Holton	E		RWH pers. obs.
040 388	49	Lower Raydon	E		Hey 1980
422 728	50	Thorrington	E		JMS pers. obs.

## SITES IN BYTHAM SANDS AND GRAVELS

100 km grid square	Grid ref.	Site No.	Name	Borehole/ (B) Exposure (E)	Height m O.D. top of unit	Palaeosol at surface Y/N	Citation
TF	675 024	01	West Dereham	E		N	JR pers. obs.
	657085	02	Shouldham Thorpe	E		N	Lewis, 1989, 1991, JR pers. obs., RWH pers. obs.
TL	739 754	01	High Lodge	E		N	Ashton <i>et al.</i> 1992, Cook <i>et al.</i> 1991
	744 743	02	Warren Hill	E	20.1	N	JR pers. obs., Wymer <i>et al.</i> 1991
	787 717	03	Rampart Field	E		N	JR pers. obs.
	799 693	04	Hall Heath	E		N	Hunt <i>et al.</i> , 1991, Bridgland & Lewis, 1991.
	862 734	05	Seven Hills	B		N	Bridgland and Lewis, 1991.
	855 715	06	Ingham	E		Y	Clarke and Auton, 1982, Lewis and Bridgland, 1991, Bridgland and Lewis, 1991, Read, 1994

	853 692	07	Timworth	E	N	Lewis and Bridgand 1991
	844 684	08	Fornham Park	E	N	JR pers. obs.
	842 686	09	Fornham Park	E	N	JR pers. obs.
	907 754	10	Little Fakenham	E	N	JR pers. obs.
	951 731	11	Bardwell	E		Hey, 1980
	955 722	12	Stanton	E		Hey, 1980
	816 681	15/05	Hengrave	E	N	Rose and Wymmer, 1994
	956 722	16	Stanton	E	N	JR pers. obs.
	906 758	17	Little Fakenham	E	Y	JR pers. obs.
	951 798	18	Knettishall	E	32 Y	Lewis and Rose 1991
	739 976	19	Northwold	E	N	JR pers. obs.
	736 776	23	Foxbole Heath	E	N	JR pers. obs.
	727 825	24	Lakenheath	E	30 N	JR pers. obs.
	757 855	25	Brandon, Brickkiln Farm	E	N	JR pers. obs.
	750 885	26	Hockham cum Wilton	E		Wymmer, 1985
	739 925	27	Feltwell	E	N	JR pers. obs.
<hr/>						
TM	017 824	01	Garboldisham, Ling Farm	B >22.8	N	BGS - IMAU
	005 821	02	Garboldisham	B >18.1	N	BGS - IMAU
	063 821	03	Fersfield, Hill Fm	B >18.0	N	BGS - IMAU
	067 830	04	Fersfield	B >15.8	N	BGS - IMAU
	059 814	05	Pooley St.	B >14.6	N	BGS - IMAU
	092 804	06	Roydon	B >21.6	N	BGS - IMAU
	083 789	07	Wortham, Hall Fm	E		Hey, 1980
	048 780	08	Redgrave	E	N	Clark and Auton, 1982
	011 798	09	Blo' Norton	B >16.4	N	BGS - IMAU
	047 812	10	South Lopham	B >22.2	N	BGS - IMAU
	023 748	11	Wattisfield	E		Hey, 1980
	203 809	12/26	Brockdish	B >30.9	N	BGS - IMAU
	229 841	13	Strarston	B >13.1	N	BGS - IMAU
	382 929	14	Leet Hill	E	N	JR pers. obs. Bridge and Hopson, 1985
	182 974	15	Flordon	E		Hey 1980
	178 976	16	Flordon	E		Sinclair 1993
	176 975	17	Flordon	E		Sinclair 1993

Pers. obs. = personal observation (unpublished)

BGS - IMAU = British Geological Survey, Industrial Mineral Assessment Unit.

These results are covered in the IMAU Report covering the National Grid location concerned.

In response to the statement by Hamblin and Moorlock (p 21), regarding "the dangers of placing too much reliance on the supposed derivation of particular clast types" it is essential to recall that the lithological properties of the sands and gravels in East Anglia have been the critical factor in distinguishing the pre-glacial Thames sands and gravels from the Anglian glaciofluvial, sands and gravels (Rose *et al.*, 1976; Rose and Allen, 1977). Indeed, along with the existence of the Valley Farm Soil, this evidence is the main factor responsible for the extensive revision of BGS maps in the region over the last 15 years or so.

### **The presence of chalk as an indicator of the glacial origin of sands and gravel**

As Rose and Allen (1977) and McGregor and Green (1978) have shown, the presence of chalk clasts in sands and gravels may be indicative of a glaciogenic origin due to glaciers providing a ready supply of highly non-durable rock at localities where such material is not readily supplied by river erosion of adjacent bedrock. Hamblin and Moorlock apply this principle at Caistor St. Edmund (p 21) to suggest that the gravels at this site are Anglian (outwash), whereas hitherto they have been interpreted as Kesgrave Sands and Gravels (Hey, 1980). This application by Hamblin and Moorlock is unsound as the underlying bedrock in the region of Caistor St. Edmund is chalk. Their supplementary statement (p 21) that "whether Hey's other Norwich-area sites are also Anglian we do not know, but if they are indeed pre-Anglian and fluvial, then their quartz: quartzite ratios (Hey, 1980, Figure 4) would tend to relate them to the Bytham Sands and Gravels rather than the Kesgraves" is also unsound. Kesgrave indicator lithologies, such as Welsh acid volcanic rocks and Lower Greensand chert, exist in gravels at sites shown and listed on Figure 1 (Hey, 1980; Green and McGregor, 1990; Sinclair, 1993; Rose *et al.*, 1996). These lithologies are absent from the Bytham Sands and Gravels.

### **Bytham Sands and Gravels at Hall Heath, Suffolk**

Following Mottram (1994), Hamblin and Moorlock state that the sands and gravels at Hall Heath, west of Bury St. Edmunds in Suffolk are not Bytham Sands and Gravels as suggested by Bridgland and Lewis (1991) and Hunt *et al.* (1991) but are glaciofluvial in origin. This debate appears to be nothing more than a distraction, as Bridgland and Lewis, and Mottram, give different map references. The conflicting interpretations of the sediments at Hall Heath most probably reflect the investigation of different deposits in a region where there are rapid changes in lithology due to glacial re-working (cf. High Lodge, Ashton *et al.* (1992) and Ingham, Lewis and Bridgland (1991)). In any case the debate is irrelevant to the argument proposed by Hamblin and Moorlock.

## **Kesgrave and Bytham sands and gravels at Hengrave, Suffolk**

Hamblin and Moorlock (1995, p 21) disagree with the results published in Rose and Wymer (1994) which suggests that the Bytham and Kesgrave sands and gravels interdigitate at this site because of confluence of the Thames and Bytham rivers in the Early Pleistocene. Hamblin and Moorlock are of this opinion because the site is located north of a Chalk interfluvium between the Bytham valley and the Thames valley. They suggest that all the sediments at Hengrave were deposited by the Bytham river. This is accepted as a valid problem although the lithological basis of the interpretation provided by Rose and Wymer still remains.

It is worth restating that the critical evidence at Hengrave is the sediments which contain indicator lithologies from different provenances. One assemblage includes Jurassic rocks and Spilsby Sandstone from the east Midlands, and the other includes such rocks as Greensand chert from the London Basin (Rose and Wymer, Table 1). In addition a large block of Hertfordshire Puddingstone, which is assumed to be derived from the Thames basin was observed *in situ* by Jim Rose and Simon Lewis and subsequently observed at the site by officers of BGS including Drs Hamblin and Moorlock. Deposition of a fan across the Bytham river floodplain by the river Thames may provide a possible explanation for transport up the Bytham valley north of the interfluvium if one of the buried cols through the interfluvium, subsequently eroded by Anglian subglacial meltwater rivers, was initially used by the Thames. Alternatively the sedimentary unit with Kesgrave lithologies may be derived from earlier Kesgrave deposits at a higher level.

## **The Bytham Sands and Gravels in east Suffolk**

It is gratifying to see that Hamblin and Moorlock have confirmed the extent and strengthened the case for the Bytham Sands and Gravels in east Suffolk, and in particular have confirmed the observation of Lewis (1993) and Bridgland and Lewis (1991) that this unit can be sub-divided into different aggradations which are related to specific terrace surface levels. However, their statement (p 24) that there is no evidence "that these gravels were deposited in a tributary of a northward-flowing proto-Thames" is difficult to follow as the detailed work by Lewis (1993) and Whiteman (unpublished) have shown that terraces of the two systems can be traced into one another, and the sediments at Hengrave suggest interdigitation of the two depositional systems (Rose and Wymer, 1994; also see above). This relationship occurred during the earlier history of the two river systems. During the later stages, when the Thames no longer reached Norfolk, the two rivers made their own way to the area of the present North Sea and it

is not yet possible to say whether they converged before joining the Rhine, whether they joined the Rhine as separate rivers, or whether they entered the contemporary North Sea as separate rivers.

### **Lithological composition of the gravel fraction of the Bytham Sands and Gravels**

There is need to qualify the description of the clast composition of the Bytham Sands and Gravels as given by Hamblin and Moorlock on page 24 as this is one of the main criteria by which the stratigraphic unit is defined. They state that the Bytham Sands and Gravels contain "rounded and angular flint, vein quartz, grey and purple quartzite..., traces of chalk, silicified limestone, shell, igneous and metamorphic rocks and iron pan". Providing such a list without qualification is very misleading. Although the clast lithology varies along the route of the Bytham river in relation to the adjacent channel- and valley-side lithology, the examination of 10,000s of pebbles has revealed only two pieces of igneous rock (both at Snitterfield near Stratford upon Avon), three pieces of metamorphic rock from Charnwood (all at Witham-on-the-Hill, south Lincolnshire), and less than 10 rounded (chatter-marked) flints west of Bury St Edmunds (one at Witham-on-the-Hill, all others between Shouldham Thorpe and Hengrave (also at Feltwell; T. O'Connor, pers. comm.)). The quantity of chalk depends upon proximity of the sample point to chalk bedrock and can be very high at localities such as Feltwell, Lakenheath or Warren Hill. Shell is mainly Jurassic, but may also be Cretaceous and again is related to proximity of a bedrock outcrop source. We assume 'silicified limestone' refers to Carboniferous chert and 'iron pan' refers to ironstone from the Jurassic or Cretaceous (Carstone) strata, the first of which is common throughout the Bytham Sands and Gravels, the second of which occurs in proximity to, and downstream of, bedrock outcrops.

The typical lithological character of the Bytham Sands and Gravels is coloured quartzite and quartz and Carboniferous chert, with additions of local rocks that vary in composition and frequency along the channel. Comparison of the quartz: quartzite ratios with the same ratio from the Kesgrave Sands and Gravels is spurious as there is no geological reason why this property should be equivalent in the two systems.

The need for high quality clast lithological analysis is illustrated by the data provided in Table 1 of Hamblin and Moorlock (1995, p26). This table is of restricted value as it does not include critical information about provenance indicator lithologies such as Spilsby Sandstone, Carboniferous, Greensand, and *Rhaxella* chert, specific igneous lithologies, etc. Additionally, it does not give an indication of the sample sizes used in the analyses. (We recognise that this may be a consequence of the source from which the data were derived).

## Record of palaeosols in the Bytham Sands and Gravels

The statement made on page 26 of Hamblin and Moorlock that within the Bytham Sands and Gravels there are two localities with palaeosols separating different gravel units, and one locality with a gravel unit between two palaeosols is of outstanding importance for the British Quaternary. It is the first time that palaeosols have been recorded in stacked fluvial sequences in Britain - the Valley Farm Soil is always on offlapping sequences (Rose and Allen, 1977; Kemp *et al.*, 1993). It is also the first record of a stacked sequence in the downstream part of the Bytham river, in contrast to the usual terraces associated with net river incision. However, experience with the analysis of palaeosols in eastern England prompts a degree of caution when evidence is restricted to borehole descriptions alone. Description of these features in terms of standard soil properties would seem to be required before the interpretation given above should be accepted.

## Correlation of Bytham river with the deposition of the Westleton gravels and Easton Bavents Clay (p 27)

The rationale behind the statement (p 27) that "it is reasonable to assume that the Westleton gravels and Easton Bavents Clay are respectively shoreface and estuarine deposits... formed at the mouth of a river which flowed from the English Midlands... and it is reasonable to assume that this was the early Bytham River" is difficult to follow, as the lithologies of the Bytham Sands and Gravels, which are rich in coloured quartz and quartzites, are totally different from the Westleton gravels which do not contain any of this lithology and are dominated (c. >95%) by chatter-marked flints and any quartz or quartzites in the deposits are white. The Westleton Beds also contain traces of Greensand chert and *Rhaxella* chert (Sinclair, 1993) and 'spicular flint' (Sinclair, 1990) none of which occur in the Bytham Sands and Gravels. While the geomorphological model that they propose is realistic, the stratigraphic basis is at variance with the fundamental stratigraphic subdivision of the British Early Pleistocene which places sediment systems dominated by local lithology in the interval prior to the later part of Tiglian C4c (Gibbard *et al.*, 1991), and sediment systems dominated by far-travelled lithologies from the later part of Tiglian C4c until the onset of the Anglian Glaciation (Gibbard *et al.*, 1991; Whiteman and Rose, 1992; Rose, 1994). In order to test the model proposed by Hamblin and Moorlock new, independent, stratigraphic evidence is needed to establish a correlation between the Bytham Sands and Gravels and the Westleton gravels and Easton Bavents Clays.

## References

- Allen, P. (1983). *Middle Pleistocene stratigraphy and landform development in South-east Suffolk*. Unpublished PhD thesis, University of London.
- Allen, P. (1984). *Field Guide to the Gipping and Waveney valleys, Suffolk, May 1982*. Quaternary Research Association, Cambridge, 116 pp.
- Allen, P. (1988). Great Blakenham (TM 102 500 to TM 117 500). In Gibbard, P.L. and Zalasiewicz, J.A. (eds.) *Pliocene - Middle Pleistocene of East Anglia. Field Guide*, Quaternary Research Association, Cambridge, 87-99.
- Ashton, N.M., Cook, J., Lewis, S.G. and Rose, J. (1992). *High Lodge: Excavations by G. de G Sieveking, 1962 and J. Cook, 1988*. British Museum Press, London.
- Bridge, D.McC. and Hopson, P.M. (1985). Fine gravel, heavy mineral and grain-size analysis of Mid-Pleistocene glacial deposits in the Lower Waveney valley, East Anglia. *Modern Geology*, 9, 129-144.
- 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*. Chapman and Hall, London.
- Bridgland, D.R. and Lewis, S.G. (1991). Introduction to the Pleistocene geology and drainage history of the Lark Valley. In Lewis, S.G., Whiteman, C. and Bridgland, D.R. (eds.) *Central East Anglia and the Fen Basin: Field Guide*. Quaternary Research Association, London, 37-44.
- Cameron, T.D.J., Crosby, A., Balson, P.S., Jeffery D.H., Lott, G.K., Bulat, J. and Harrison, D.J. (1992). *The Geology of the southern North Sea*. HMSO, London.
- Clark, M.R. and Auton, C. (1982). The Pleistocene depositional history of the Norfolk-Suffolk borderland. *Report of the Institute of Geological Sciences*, 82/1, 23-29.
- Cook, J., Ashton, N., Coope, G.R., Hunt, C.O., Lewis, S.G. and Rose, J. (1991). High Lodge, Mildenhall, Suffolk (TL 739754). In Lewis, S.G., Whiteman, C. and Bridgland, D.R. (eds.) *Central East Anglia and the Fen Basin. Field Guide*. Quaternary Research Association, London, 59-69.
- Funnell, B.M. (1987). Late Pliocene and Early Pleistocene stages of East Anglia and the adjacent North Sea. *Quaternary Newsletter*, 52, 1-11.

Funnell, B.M. (1990). Palaeogeographical maps of the southern North Sea Basin. *Bulletin of the Geological Society of Norfolk*, 40, 53-66.

Gibbard, P.L., West, R.G., Zagwijn, W.H., Balson, P.S., Burger, A.W., Funnell, B.M., Jeffery, D.H., De Jong, J., Van Kolfschoten, T., Lister, A.M., Meijer, T., Norton, P.E.P., Preece, R.C., Rose, J., Stuart, A.J., Whiteman, C.A. and Zalasiewicz, J.A. 1991. Early and early Middle Pleistocene correlations in the southern North Sea Basin. *Quaternary Science Reviews*, 10, 23-52.

Green, C.P. and McGregor, D.F.M. (1990). Pleistocene gravels of the north Norfolk Coast. *Proceedings of the Geologists' Association*, 101, 197-202.

Hamblin, R.J.O. and Moorlock, B.S.P. (1995). The Kesgrave and Bytham Sands and Gravels of Eastern Suffolk. *Quaternary Newsletter*, 77, 17-31.

Hey, R.W. (1965). Highly quartzose pebble gravels in the London Basin. *Proceedings of the Geologists' Association*, 76, 403-420.

Hey, R.W. (1976). Provenance of far-travelled pebbles in the pre-Anglian Pleistocene of East Anglia. *Proceedings of the Geologists' Association*, 87, 69-82.

Hey, R.W. (1980). Equivalents of the Westland Green Gravels in Essex and East Anglia. *Proceedings of the Geologists' Association*, 91, 279-290.

Hey, R.W. (1983). Furneux Pelham. In Rose, J. (ed.), *The Diversion of the Thames. Field Guide*. Quaternary Research Association, London, 94-95.

Hey, R.W. and Brenchley, P.J. (1977). Volcanic pebbles from the Pleistocene gravels in Norfolk and Essex. *Geological Magazine*, 114, 219-225.

Hunt, C.O., Lewis, S.G., Rose, J. and Wymer, J.J. (1991). Lackford, Suffolk (TL 815704). In Lewis, S.G., Whiteman, C. and Bridgland, D.R. (ed.) *Central East Anglia and the Fen Basin. Field Guide*. Quaternary Research Association, London, 85-92.

Kemp, R.A. (1987a). The interpretation and environmental significance of a buried Middle Pleistocene soil near Ipswich Airport, Suffolk, England. *Philosophical Transactions of the Royal Society of London*, B317, 365-391.

Kemp, R.A. (1987b). Genesis and environmental significance of a buried Middle Pleistocene soil in eastern England. *Geoderma*, 41, 49-77.

Kemp, R.A., Whiteman, C.A. and Rose, J. (1993). Palaeoenvironmental and stratigraphic significance of the Valley Farm and Barham Soils in Eastern England. *Quaternary Science Reviews*, 12, 833-848.

Lewis, S.G. (1989). Shouldham Thorpe. In Keen D.H. (ed.) *West Midlands. Field Guide*. Quaternary Research Association, Cambridge, 134-135.



Lewis, S.G. (1991). Shouldham Thorpe (TF 657085). In: Lewis, S.G., Whiteman, C. and Bridgland, D.R. (eds.) *Central East Anglia and the Fen Basin. Field Guide*. Quaternary Research Association, London, 127-130.

Lewis, S.G. (1993). *The status of the Wolstonian Glaciation in the English Midlands and East Anglia*. Unpublished PhD Thesis, University of London.

Lewis, S.G. and Bridgland, D.R. (1991). Ingham (TL 855715) and Timworth (TL 853692), Suffolk. In Lewis, S.G., Whiteman, C. and Bridgland, D.R. (eds.) *Central East Anglia and the Fen Basin. Field Guide*. Quaternary Research Association, London, 71-84.

Lewis, S.G. and Rose, J. (1991). Knettishall, Suffolk (TL 951798). In Lewis, S.G., Whiteman, C. and Bridgland, D.R. (eds.) *Central East Anglia and the Fen Basin. Field Guide*. Quaternary Research Association, London, 105-109.

McGregor, D.F.M. and Green, C.P. (1978). Gravels of the River Thames as a guide to catchment changes. *Boreas*, 7, 197-203.

Mottram, H.B. (1994). The geology of Hall Heath, Lackford. *Transactions of the Suffolk Naturalists' Society*, 30, 48-49.

Postma, G. and Hodson, G.E. (1987). Caister St. Edmund Pit (TG 240048). In Gibbard, P.L. and Zalasiewicz, J.A. (eds.) *Pliocene - Middle Pleistocene of East Anglia. Field Guide*, Quaternary Research Association, Cambridge, 131-139.

Read, G. 1994. *Buried Pleistocene Soils in Essex and Suffolk*, U.K. Unpublished PhD thesis, University of London.

Rose, J. (1987). The status of the Wolstonian Glaciation in the British Quaternary. *Quaternary Newsletter*, 53, 1-9.

Rose, J. (1989). Tracing the Baginton-Lillington Sands and Gravels from the West Midlands to East Anglia. In Keen, D.H. (ed.), *The Pleistocene of the West Midlands, Field Guide*. Quaternary Research Association, Cambridge, 102-110.

Rose, J. (1994). Major river systems of central and southern Britain during the Early and Middle Pleistocene. *Terra Nova*, 6, 435-443.

Rose, J. and Allen, P. (1977). Middle Pleistocene stratigraphy in south-east Suffolk. *Journal of the Geological Society*, 133, 85-102.

Rose, J., Allen P. and Hey, R.W. (1976). Middle Pleistocene stratigraphy in southern East Anglia. *Nature*, 263, 492-494.

Rose, J., Boardman, J., Kemp., R.A. and Whiteman, C.A. (1985). Palaeosols and the interpretation of British Quaternary stratigraphy. In Richards, K.S., Arnett, R.R. and Ellis, S. (eds.) *Geomorphology and Soils*. Allen and Unwin, London, 348-375.

Rose, J., Gulamali, N., Moorlock, B.S.P., Hamblin, R.J.O., Jeffrey, D.H., Anderson, E. and Lee, J.A. (1996). Pre-glacial Quaternary sediments, How Hill near Ludham, Norfolk, England. *Bulletin of the Geological Society of Norfolk*, 42.

Rose, J. and Wymer, J.J. (1994). Record of a struck flake and the lithological composition of 'pre-glacial' river deposits at Hengrave, Suffolk, UK. *Proceedings of the Suffolk Institute of Archaeology and History*, 38, 119-125.

Sinclair, J.M. (1990). Flint pebbles of northern provenance in East Anglian Quaternary gravels. *Quaternary Newsletter*, 62, 26-28.

Sinclair, J.M. (1993). *The origin and sedimentology of the lower Pleistocene Westleton Beds, East Anglia, U.K.* Unpublished M.Phil thesis, London Guildhall University.

Whiteman, C.A. (1983). Stebbing. In Rose, J. (ed.) *The Diversion of the Thames: Field Guide*. Quaternary Research Association, London, 149-154, 158-160.

Whiteman, C.A. (1990). *Early and Middle Pleistocene stratigraphy in central Essex, England*. Unpublished PhD thesis, University of London.

Whiteman, C.A. (1992). The palaeogeography and correlation of pre-Anglian-Glaciation terraces of the River Thames in Essex and the London Basin. *Proceedings of the Geologists' Association*, 103, 37-56.

Whiteman, C.A. and Kemp, R.A. (1990). Pleistocene sediments, soils and landscape evolution at Stebbing, Essex, U.K. *Journal of Quaternary Science*, 5, 145-161.

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

Wymer, J.J. (1985). *Palaeolithic sites of East Anglia*. Geobooks, Norwich.

Wymer, J.J., Lewis, S.G., and Bridgland, D.R. (1991). Warren Hill, Mildenhall, Suffolk (TL 744743). In Lewis, S.G., Whiteman, C. and Bridgland, D.R. (eds.) *Central East Anglia and the Fen Basin. Field Guide*. Quaternary Research Association, London, 50-58.

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# THE KESGRAVE AND BYTHAM SANDS AND GRAVELS OF EAST ANGLIA

A REPLY TO J. ROSE, P. ALLEN, C.P. GREEN, R.W. HEY,  
S.G. LEWIS, J.M. SINCLAIR, AND C.A. WHITEMAN

R. J. O. Hamblin and B. S. P. Moorlock

## Introduction

We had envisaged that our paper would provoke a response from researchers into the Pleistocene stratigraphy of East Anglia and we were not disappointed! We thank Jim Rose and his colleagues for their joint reply. Funding for the collaboration between BGS and RHUL (Rose *et al.*, in press) has recently been secured for a further three years. Our paper and the response by Rose *et al.* (1966) emphasize the different views currently held on the distribution of the Kesgrave Sands and Gravels in East Anglia: collaboration between teams with opposing views is at times difficult but is conducive to good science with long discussion and full scrutiny of results.

Because our original paper was concerned with eastern Suffolk, we did omit discussion of many sites elsewhere in East Anglia and Essex (Rose *et al.* 1996, Figure 1), but in reaching our conclusions we did consider those of which we were aware.

Figure 1 in Hamblin and Moorlock (1995) indeed illustrates a relatively late snapshot in the depositional history of the Kesgrave and Bytham sands and gravels, because of the need to illustrate the entire outcrop of the Bythams. The diagram is also somewhat generalised, but we do believe that during its pre-Anglian history the proto-Thames never flowed far outside the stippled area shown.

We discuss the issues in the order dealt with by Rose *et al.* (1966)

## Distribution of the Kesgrave and Bytham sands and gravels in East Anglia and Essex

We would like to thank Rose *et al.* for their useful map and listing of those sites in East Anglia which exhibit lithologies with Kesgrave and Bytham affinities. Such a map has long been needed. However, we do not accept the statement that "lithologies which fulfil the criteria of the Kesgrave Sands and Gravels occur in Norfolk". The references cited by Rose *et al.* for the criteria of identification

of the Kesgraves (Rose and Allen, 1977; Hey, 1980; Whiteman, 1992) all describe the deposits as fluvial, and we believe that the fluvial nature of the deposits is an important criterion in the definition of the Kesgrave Group as a lithostratigraphical unit. We contend that it is good geological practice to restrict the Kesgrave Group to these fluvial deposits of the proto-Thames, while the downstream marine equivalents of the Kesgrave and Bytham sands and gravels, deposited within the Crag basin, remain a part of the Crag Group.

It is now possible to interpret Figure 1 of Rose *et al.* in terms of our current model. Their Bytham sites agree well with Figure 1 of Hamblin and Moorlock (1995), except that they include Flordon ([TM 182 974], their Bytham sites TG 15, 16 and 17). Although Flordon yielded gravels with very low quartz:quartzite ratios, these contained Welsh volcanics of presumed proto-Thames origin (Hey, 1980). If the deposits are indeed fluvial then we would agree that they must belong to the Bytham Sands and Gravels, and we would suggest that they have acquired proto-Thames material reworked from the Crag, since marine gravels with proto-Thames-derived material are known in Norfolk (Hamblin *et al.*, 1996).

The large group of 'Kesgrave' sites extending northward from 'Kesgrave Sites' TM 37 (Peasenhall) and TM 23 (Denham) as far as the north Norfolk coast we believe are mostly marine Crag. Such deposits are now widely known in Norfolk (Hamblin *et al.*, 1996), whilst in Suffolk we have recorded quartz/quartzite-rich gravels and sands high in the Crag at Holton [TM 405 773] and Thorington [TM 423 728] (Hamblin and Moorlock, 1995). In the specific cases of Hey's (1980) sites at Peasenhall [TM 348 692] and Holton, we remain confident that we found Anglian outwash at the grid references and OD levels quoted by Hey, but we suggest that he found proto-Thames-derived material within the Crag at lower levels at these sites. We know of no proven Kesgrave Group deposits within this area, and if any fluvial deposits are found containing proto-Thames-derived material, then the possibility would have to be considered that they were local reworking of this Crag rather than Kesgrave Group *sensu stricto*. Bed H at Caistor St Edmund (Postma and Hodgson, 1987) could be such a case. However, we would not exclude the possibility that in east Suffolk the proto-Thames might have flowed rather farther north than shown on our Figure 1, possibly as far north as Southwold in the extreme east of the county.

All of the 'Kesgrave' sites shown by Figure 1 of Rose *et al.* southwards from their Kesgrave Site TM 02 (Barham) fall within the area shown as Kesgrave Group in Figure 1 of Hamblin and Moorlock (1995), although we would not rule out the possibility that on re-examination some might prove to be marine

and hence belong to the Crag Group. This leaves a number of 'Kesgrave' sites, extending north-westward from TM 05 (Darmsden) to TL 40 (Denham) and TL 13 (Badwell Ash), which we accept do exhibit proto-Thames-derived lithologies, but which we did not show as Kesgrave Group in our figure. We prefer for the moment to keep an open mind about these sites until further work can be done, although we discuss several of them below in answer to Rose *et al.*'s further specific points. At least three possibilities must be considered for each such site: 1. the site is marine Crag, 2. the site contains Kesgrave material, but this has been recycled during the erosion of Kesgrave Group or Crag by tributaries of the Bytham River, 3. the site is genuine Kesgrave Group. If 3. were to prove the case, and we accept that this is possible, then we would need to extend somewhat the northern extent of the Kesgrave Group shown in Hamblin and Moorlock (1995), possibly as far as Badwell Ash, but this in itself would not alter our opinions as to the proto-Thames continuing to Norfolk.

#### Figure 104 of Cameron *et al.* (1992)

The figure does indeed show an east-west coastline which would be normal to the proposed northward-flowing Thames, as required by Rose *et al.*, but this coastline is irrelevant to the current discussion since it lies well to the north of Norfolk and thus must relate to a period much later than that in which Rose *et al.* believe the Thames flowed to Norfolk. Since Rose *et al.*'s Kesgraves undoubtedly include marine deposits in Norfolk, they must relate to one of the coastlines shown on Figure 104 as lying within Norfolk, and these lie roughly NNW-SSE. This is in accord with the current directions at the How Hill site (Kesgrave Site TG 01 of Rose *et al.*, 1996; Rose *et al.* in press), but hardly in accord with a northward-flowing Thames. We believe that the Thames at this time was flowing ENE as shown in Figure 104, although we would put its course rather farther to the south than do Cameron *et al.* These authors (1992, figures 96-98) demonstrate that during the period that the shoreline remained within Norfolk, the centre of deposition of the delta of the proto-Rhine remained well to the south end of the North Sea, in accord with this orientation for the Thames.

#### Geomorphological problems created by a northerly route of the Thames to Norfolk

Any course postulated for the Thames during Kesgrave Group times must take account of the previous history of the river, including the evidence from our surveys of the Crag Group in Suffolk (Hamblin, in Moorlock *et al.*, in press; Hamblin *et al.*, in preparation). At Sudbourne in south-east Suffolk, the

estuarine/intertidal Chillesford Clay (a Crag Group member of Baventian age) yielded probable Silurian acritarchs, along with other reworked palynomorphs of Carboniferous, Jurassic, Cretaceous and Palaeogene age (Riding *et al.*, in prep.). Their presence indicates the existence of a river with a large catchment extending to the Welsh borders: we believe this river could have been none other than the proto-Thames. A similar range of palynomorphs in the clays at Easton Bavents and Covehithe, minus the probable Silurian acritarchs (Riding *et al.*, in prep.), suggests the existence during the Baventian of a further, broadly easterly-flowing river, but with a rather more limited catchment. This we believe to have been the early Bytham River. The catchments of the two rivers were separated by the Bildeston-Sudbury-Framlingham chalk ridge, a topographical feature which remains today. We cannot envisage any model whereby, after the Baventian, the proto-Thames could or would abandon its east-north-eastward course to Chillesford, cross the chalk ridge and the catchment of the eastward-flowing Bytham River, and adopt a route to the north Norfolk coast.

### **The dangers of placing too much reliance on the supposed derivation of particular clast types**

We agree that clast derivation is an extremely important tool, but it must be used in connection with other lithological and geomorphological evidence; the use of clast derivation in isolation can lead to mistaken conclusions, as we pointed out (Hamblin and Moorlock, 1995, p21). Considerations which must be taken into account include 1. clasts may have a long history of re-derivation which may not be immediately obvious; 2. clasts may behave differently in different environments, *eg* marine and fluvial transport; 3. present known sources for particular clasts may not be exhaustive, since other hidden sources may exist, or else sources may once have existed but have been destroyed. We cite examples of all these situations in this article.

### **The presence of chalk as an indicator of the glacial origin of sand and gravel**

We agree that the presence of chalk in sand and gravel does not necessarily imply a glaciofluvial origin, but we do not accept that our conclusion was unsound "as the underlying bedrock in the region of Caistor St Edmund is chalk", since at the Caistor St Edmund quarry, several metres of chalk-free Crag overlies the Upper Chalk. However, we feel that we have already adequately discussed this aspect of our paper (Funnell, 1996; Hamblin and Moorlock, 1996).

We stand by our statement that the quartz:quartzite ratios of the gravels around Norwich “tend to relate them to the Bytham Sands and Gravels rather than the Kesgraves”, even though, as Rose *et al.* (1996) rightly point out, the presence of Lower Greensand chert and Welsh acid volcanics in these gravels indicates a proto-Thames input. However our original statement has been overtaken by events since, after our excavations at How Hill (Rose *et al.*, in press) and further examination of Caistor St Edmund, we now believe the Norwich sites to be marine (Hamblin *et al.*, 1996). This mixture of proto-Thames and Bytham elements is thus not unreasonable.

### **Bytham Sands and Gravels at Hall Heath, Suffolk**

Our reference to the sands and gravels at Hall Heath was to emphasize the problem of distinguishing between *in situ* deposits of the Bytham river and similar deposits reworked by later glacial agencies.

### **Kesgrave and Bytham sands and gravels at Hengrave, Suffolk**

Rose and Wymer (1994) recorded an interdigitation of deposits attributed to the Kesgrave and Bytham sands and gravels at this site, and used this as evidence that the rivers were confluent near Bury St Edmunds. However we are convinced from the position of the site that none of the deposits could have been derived directly from the proto-Thames: the site not only lies north of a chalk interfluvium between the Bytham and Thames valleys, it lies within the confines of a well-defined east-west valley with chalk ridges both to the north and south. Also the field evidence does not support the suggestion given by Rose *et al.* (1996) for a fan across the Bytham floodplain, with the proto-Thames using a col to reach the valley. Although contours on the top of the Chalk (Bury St Edmunds 1:50 000 Geological Sheet 189) indicate the presence of a narrow NNW-SSE buried channel extending through Bury St Edmunds into the Lark valley, such a narrow channel, even if it had existed in pre-Anglian times (which we doubt), would have provided an unlikely course for the ‘great’ River Thames.

A more likely explanation for this mixing of Bytham and proto-Thames material is that the latter was derived from pre-existing deposits at a higher level, as alternatively suggested by Rose *et al.* (1996), by a tributary of the Bytham River. These deposits may either have been Crag or Kesgrave Group gravels to the south.

We did indeed observe the large boulder of Hertfordshire Puddingstone referred to by Rose *et al.* (1996), but we would dispute that it necessarily was



derived from the proto-Thames. We suspect that a more local source was available from Palaeogene strata to the west of the Crag outcrop, although in this now drift-covered area there is no evidence to indicate the continued presence of such deposits. We have argued elsewhere (Hamblin *et al.*, in prep.) for the presence of gravelly Palaeogene deposits in central or western Suffolk to provide the source of the black well-rounded flints in the Westleton gravels.

### **The Bytham Sands and Gravels in east Suffolk**

We stand by our statement that there *is no evidence* that the Bytham and proto-Thames rivers ever joined within the present United Kingdom. Hengrave we consider to be irrelevant to this argument in the light of our comments above. We cannot comment specifically on the unpublished work of Lewis (1993) or Whiteman, but we are confident that whilst they may have produced a *correlation* of the the Kesgrave and Bytham terrace systems, they have no evidence that the two rivers actually *joined*. Unless proven fluvial sites of the highest Kesgrave terraces are found farther downstream than any known at present, it is quite possible that both rivers flowed into the Crag sea without joining, since the position of the coastline early in Kesgrave/Bytham times is as yet unknown.

### **Lithological composition of the gravel fraction of the Bytham Sands and Gravels**

We are grateful to Rose *et al.* for their comments on the composition of the Bythams, but we would repeat that our paper was concerned specifically with east Suffolk, where our compositional data was restricted to borehole sources. Inevitably the Bythams in our area include locally-derived materials not recorded farther west. For instance the igneous rocks *may* be Welsh volcanics derived from the highest Crag Group, whilst the rounded chatter-marked flints could be derived either from the Crag or from unknown outcrops of Palaeogene to the west of the Crag outcrop. 'Iron pan' could similarly be derived from the Crag. We realise that it is unfortunate that much critical information about provenance indicators and sample sizes was not available for Table 1 but this data was not recorded when the analyses were carried out for aggregate assessment purposes in the early 1980s. Unfortunately the samples were not kept.

### **Record of palaeosols in the Bytham Sands and Gravels**

We appreciate the importance of these observations, which is why we included them even though we realised that a degree of caution must be applied to such interpretations based on borehole descriptions alone. Unfortunately the aggregate assessment boreholes were our only source of these data.

## Correlation of the Bytham river with the deposition of the Westleton gravels and Easton Bavents Clay

Palynomorphs within the Easton Bavents Clay are dominated by Carboniferous, Jurassic, Cretaceous and Palaeogene forms (Riding *et al.*, in prep.). We believe that these can only have been transported directly from the west by the early Bytham River, since any other route, including marine transport from the mouth of the proto-Thames farther south, would have led to their becoming swamped with contemporary (Quaternary) forms within the Crag sea. Similar clays with the same derived species of palynomorphs have been found interbedded with Westleton-type gravels at Thorington Pit [TM 423 728]. The localised nature of the Westleton gravels and their very high concentration of rounded chatter-marked flints implies a nearby, readily eroded source for such flints, and we believe this can only have been to the west, with transport to the coast by the Bytham River, either directly from erosion of Palaeogene strata or from reworking of earlier Crag deposits which themselves contained reworked Palaeogene gravels. We know of no possible submarine sources, and longshore drift from a distant Palaeogene or Chalk source would surely have introduced more non-flint material and also spread the gravels over a wider area of Suffolk and Norfolk. The presence of *traces* of Greensand chert implies a proto-Thames input, presumably by longshore drift from the south. Equally, the presence of *Rhaxella* chert (Sinclair, 1993) implies input from the north.

The explanation for the absence of significant quantities of quartz/quartzite and other far-travelled Bytham lithologies in the Westleton gravels is that different far-travelled species reached the sea at different times (Rose, 1994; Rose, pers. comm. to RJOH, 1995). During the Baventian, the Bytham river carried microfossils from the Midlands to the coast, and flints from a Palaeogene source much nearer to its mouth, whilst the far-travelled quartz and quartzite reached the sea much later. A similar sequence can be seen in deposits derived from the proto-Thames: during the Baventian that river carried microfossils from the Midlands and Welsh borders along with more-locally-derived Greensand chert, then quartz and quartzite became abundant early in the Sudbury Formation (Bushett Farm Member), but Welsh volcanics only appear in the subsequent Stebbing Member (Whiteman, 1992). Since certain ?Pastonian sites in Norfolk have yielded quartz/quartzite populations of Kesgrave rather than Bytham aspect, these species would appear to have reached the sea via the proto-Thames earlier than via the Bytham, which is not unreasonable since the proto-Thames would have been the larger river, with a large precipitation catchment in the Welsh uplands.

We see no conflict with the statement that sediment systems are dominated by

local lithology before the later part of Tiglian C4c, then become dominated by far-travelled lithologies until the onset of the Anglian glaciation. In English terms, the Baventian deposits (Chillesford, Easton Bavents and Covehithe clays, Westleton Beds) are characterised by local lithology, and the succeeding deposits, presumably Pastonian, by far-travelled lithologies.

### Acknowledgement

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### References

Bury St. Edmunds 1:50 000 Geological Sheet 189. HMSO: British Geological Survey.

Cameron, T.D.J., Crosby, A., Balson, P.S., Jeffery, D.H., Lott, G.K., Bulat, J. and Harrison, D.J. (1992). *UK offshore regional report: The geology of the southern North Sea*. HMSO: British Geological Survey.

Funnell, B.M. (1996). Quartz- and quartzite-bearing gravels of the Caistor St Edmund Pit, Norwich, Norfolk. *Quaternary Newsletter*, 78, 42.

Green, C.P., Hey, R.W. and McGregor, D.F.M. (1980). Volcanic pebbles in Pleistocene gravels of the Thames in Buckinghamshire and Hertfordshire. *Geological Magazine*, 117, 59-64.

Green, C.P. and McGregor, D.F.M. (1990). Pleistocene gravels of the north Norfolk coast. *Proceedings of the Geologists' Association*, 101, 197-202.

Green, C.P. and McGregor, D.F.M. (1996). The Kesgrave and Bytham Sands and Gravels of eastern Suffolk: a lithostratigraphic comment. *Quaternary Newsletter*, 79, 3-7.

Hamblin, R.J.O. and Moorlock, B.S.P. (1995). The Kesgrave and Bytham Sands and Gravels of eastern Suffolk. *Quaternary Newsletter*, 77, 17-31.

Hamblin, R.J.O. and Moorlock, B.S.P. (1996). Quartz- and quartzite-bearing gravels of the Caistor St. Edmund Pit, Norwich, Norfolk: reply to a letter from Brian Funnell. *Quaternary Newsletter*, 78, 43-44.

Hamblin, R.J.O., Moorlock, B.S.P., Booth, S.J., Jeffery, D.H. and Morigi, A.N. (in prep). The Crag Group of eastern Suffolk.

Hey, R.W. (1980). Equivalent of the Westland Green Gravels in Essex and East Anglia. *Proceedings of the Geologists' Association*, 91, 279-290.

Lewis, S.G. (1993). *The status of the Wolstonian Glaciation in the English Midlands and East Anglia*. Unpublished PhD thesis, University of London.

Moorlock, B.S.P., Hamblin, R.J.O., Morigi, A.N., Booth, S.J. and Jeffery, D.H. (in press). The geology of the country around Lowestoft and Saxmundham. *Memoir of the British Geological Survey*. Sheets 176 and 191 (England and Wales).

Postma, G. and Hodgson, G.E. (1987). Caistor St. Edmund Pit (TG 240048). In Gibbard, P.L. and Zalasiewicz, J.A. (eds.) *Pliocene - Middle Pleistocene of East Anglia. Field Guide*. Quaternary Research Association, Cambridge, 131-139.

Riding, J.B., Moorlock, B.S.P., Jeffery, D.H., and Hamblin, R.J.O. (in prep.). Reworked and indigenous palynomorphs from the Norwich Crag formation of eastern Suffolk: implications for provenance, palaeogeography and climate.

Rose, J. (1994). Major river systems of central and southern Britain during the Early and middle Pleistocene. *Terra Nova*, 6, 435-443.

Rose, J. and Allen, P. (1977). Middle Pleistocene stratigraphy in south-east Suffolk. *Journal of the Geological Society of London*, 133, 83-102.

Rose, J., Allen, P., Green, C.P., Hey, R.W., Lewis, S.G., Sinclair, and Whiteman, C.A. (1996). The Kesgrave and Bytham Sands and Gravels of East Anglia. *Quaternary Newsletter*, 79, 10-20.

Rose, J., Gulamali, N., Moorlock, B.S.P., Hamblin, R.J.O., Jeffery, D.H., Anderson, E., Lee, J.A. and Riding, J.B. (in press). Pre-glacial and glacial Quaternary sediments, How Hill, near Ludham, Norfolk, England. *Bulletin of the Geological Society of Norfolk*.

Rose, J. and Wymer, J.J. (1994). Record of a struck flake and the lithological composition of 'pre-glacial' river deposits at Hengrave, Suffolk. *Proceedings of the Suffolk Institute of Archaeology and History*, 38, 119-125.

Sinclair, J.M. (1993). *The origin and sedimentology of the lower Pleistocene Westleton Beds, East Anglia, U.K.* Unpublished M.Phil thesis, London Guildhall University.

Whiteman, C.A. (1992). The palaeogeography and correlation of pre-Anglian-glaciation terraces of the River Thames in Essex and the London Basin. *Proceedings of the Geologists' Association*, 103, 37-56.

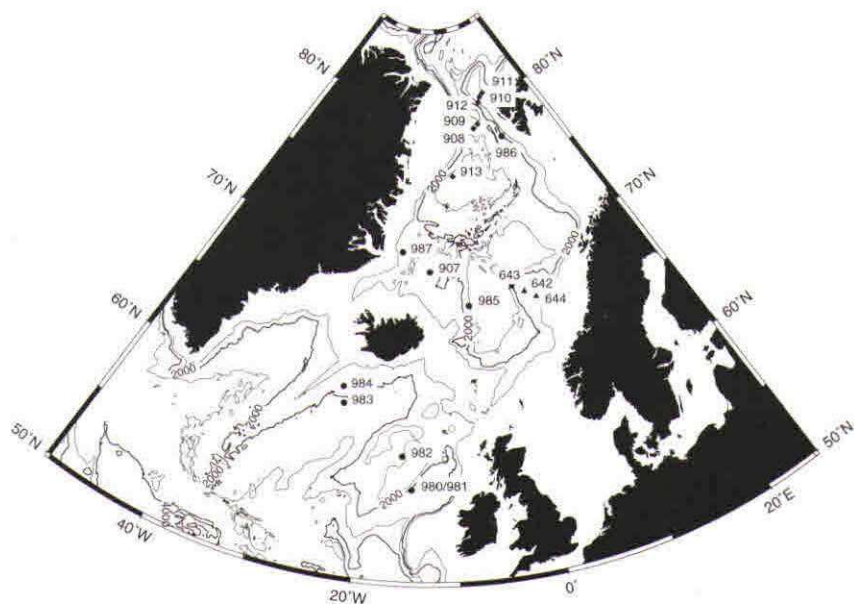
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# ERRATUM

## *Quaternary Newsletter 78*

**Report on Cenozoic climate evolution of the North Atlantic Arctic gateways: preliminary results from ODP Leg 162 by W.E.N. Austin and R.D. Larter, 16-18.**

Page 17 of QN 78 was blank. This was because a map accompanying the above report, showing the drillsites of ODP Leg 162, was inadvertently left out of the final master copy before printing. The map is reproduced here. Apologies to Bill Austin and Rob Larter from the production team.



# REPORTS

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## 14TH INQUA CONGRESS, BERLIN 1995

The INQUA Congress scientific programmes are largely devoted to the presentation of research results through a number of symposia with well defined topics. In addition, however, they provide excellent opportunities for specialist groups to develop or create science agendas, while the INQUA Executive and its Commissions undertake much administrative work during the Congress period. The brief notes that follow are intended to bring to the attention of QRA members some of the 'background' developments that took place at the 14th INQUA Congress held in Berlin in August 1995.

**J. John Lowe**  
**Centre for Quaternary Research**  
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## THE XIV INQUA CONGRESS: COUNCIL AND EXECUTIVE COMMITTEE BUSINESS

The four-yearly Congresses convened by INQUA are thought of primarily as major scientific get-togethers but, of course, they are important landmarks in INQUA's governance and strategic planning. The supreme legislative body of INQUA, the International Council, can meet only on these occasions. So it was that, faced with an Agenda of 20 items, the Council convened three times during the Berlin Congress (4, 7 and 9 August, 1995). A number of major items were discussed, notably those bearing upon National Membership categories, financial affairs, Commissions, external affairs, and Constitutional amendments. The essential decisions reached are summarised below, but greater detail may be found in the pages of *The Quaternary Perspective*, number 6/2 (1995).

There was much discussion on the number of national categories of INQUA membership, and the new Executive Committee asked to look for ways to reduce this number. An increase in National subscriptions of 1.25% per year over the next four years (*ie* an inter-Congress increase of 5%) was approved. This will not apply to Category 6 because of the large increase in that category's subscription in 1991.

The number, mode of operation, structure and longevity of INQUA's Commissions was vigorously discussed. A formal document on this subject had been circulated to all Commissions in the summer of 1994. Reactions to the

new policy proposed by the Executive Committee ranged from congratulations on the general thrust to suggestions that the Executive Committee is too interfering! It was recognised that the proposed strategy could not match closely the needs of certain Commissions, *eg* Palaeoclimate and Stratigraphy. A formal motion by the United Kingdom, seconded by Italy, emphasised the application of Bye law 8.3(v) to all Commissions including those with apparently "permanent" status such as the Commission on Stratigraphy. This important motion was approved *nem con*.

The Executive Committee's financial and scientific auditing of the Commissions for the period 1991-94 was commended, and the following recommendations agreed.

The Commission on **Stratigraphy** should continue on condition that it produce a research plan for the inter-Congress period 1995-1999. Continuation was also approved in the case of the (re-named) Commission on **Glaciation**, with a request that this Commission's research programme be re-examined and re-shaped. The Commission on **Quaternary Shorelines** was commended and will continue. High levels of activity were also noted in the case of the Commission on **Loess** and the Commission on **Tephrochronology**, including PAGES recognition of the latter. The work and organisation of the Commission on **Palaeopedology**, the Commission on **Neotectonics** and the Commission on the **Holocene**, were also commended. It was recommended that the Commission on **Early Man** be discontinued, but that it be re-shaped and revived under a new name within a year. It was resolved that the Commission on **Palaeoclimate** be continued subject to submission of a strategy document. The Commission on the **Quaternary of South America** was terminated, with the assurance that links between South American regional research activities and PASH will be enhanced. The Commission on **Applied Quaternary Research** was terminated. On the recommendation of its Chairman, Past-President N. Rutter, the Committee on **Global Change** was terminated on completion of the task set it in 1991. Continuation was recommended in the case of the Commission on **Global Palaeohydrology**, and also for the Committee on **Palaeogeographic Atlases of the Quaternary** with the proviso that the latter develop a sharper focus and closer collaboration with PASH. Finally, the proposed new Commission on **Terrestrial Carbon** was approved under the Presidency of Professor Hugues Faure (France).

A document entitled "**Guidelines for INQUA Commissions**" was placed before the Council by the Executive Committee and approved. More details of this important document, with its aim of enhancing further INQUA's research efforts, can be found in *The Quaternary Perspective* 6/2 (1995).

It was reported that the INQUA house journal, *Quaternary International*, will appear at an increased frequency (from 4 to 6 volumes per year), and that *The*

*Quaternary Perspective* will appear in a new format in 1996, and negotiations for its appearance on the Internet are in hand. An INQUA Brochure, commissioned by the International Council in 1991, was distributed.

There was extended discussion of INQUA's external relations. The Executive Committee set out the case for INQUA's proposed full membership status within ICSU, and it was resolved that the incoming Executive Committee should proceed to negotiate full ICSU membership status for INQUA.

The Treasurer was commended for his professional management of INQUA's funds. The low costs of administration achieved by the outgoing Executive Committee was noted.

The amendments to wording in several clauses of the INQUA Constitution, proposed by the Executive Committee on instruction of the General Assembly at the XIII Congress in 1991, were approved. Full details can be found in *The Quaternary Perspective* 6/2 (1995).

The formal application by the South African National Delegate that the XV INQUA Congress be held at the International Convention Centre in Durban, South Africa, 4-12 August 1999 was approved by acclamation.

The following new Honorary Members were proposed by the Council and subsequently approved by the General Assembly: G.R. Coope (United Kingdom); F. Gullentops (Belgium); W. Hageman (The Netherlands); G.W. Lüttig (Germany); H. Maruszczak (Poland); F. Mitchell (Ireland); J.E. Mojski (Poland); N. Watanabe (Japan); A. Yanshin (Russia).

The following members were elected to form the INQUA Executive Committee for the inter-Congress period 1995-1999.

<i>President:</i>	S.C. Porter (U.S.A.)
<i>Secretary:</i>	S. Haldorsen (Norway)
<i>Treasurer:</i>	E.F.J. de Mulder (The Netherlands)
<i>Vice Presidents:</i>	M. Iriondo (Argentina)
	Y. Ota (Japan)
	T.C. Partridge (South Africa)
	N.J. Shackleton (U.K.)
<i>Past President:</i>	Liu Tungsheng (China)

Finally, a vote of thanks to the outgoing Executive Committee for their four years of valuable work was approved by acclamation.

Edward Derbyshire  
Secretary-General of INQUA (1991-1995)  
Centre for Quaternary Research  
Royal Holloway, University of London



## FIFTH INTERNATIONAL DRUMLIN SYMPOSIUM HELD DURING THE 14th CONGRESS IN BERLIN, GERMANY

The Fifth International Drumlin Symposium was held during the 14th INQUA Congress in Berlin. The symposium was organised by **Jan Piotrowski** (Kiel) and chaired by **Piotrowski**, **Habbe** (Erlangen) and **Ellwanger** (Baden-Württemberg). This was one of the most successful symposia held at INQUA since the program of speakers were almost all in attendance and the program ran virtually on schedule as planned. The symposium was subdivided into several interdependent sections viz. sedimentology, regional geological considerations, and process mechanics.

The first paper of the symposium to be presented was by **Hart** (Southampton) who discussed the concept of subglacial deforming bed conditions *vis a vis* drumlin formation, suggesting that at least three drumlin types can be recognised: depositional, deformational and erosional. This recurring theme of subglacial deformation continued throughout the symposium. A paper by **Meehan**, **Warren** and **Gallagher** (Dublin) discussed in detail the sedimentology of a single drumlin in which large scale rafting and emplacement of bedrock slabs had occurred within a clast-poor diamicton. Extensive large-scale shearing and deformation was observed that was interpreted as indicative of diamicton ductility due to a bedrock obstruction. **Dardis** (Belfast) took a rather more unconventional view of drumlin fields and concentrated upon those areas between individual drumlins and those other areas within drumlin fields where drumlins do not occur. Using a somewhat idiosyncratic term from a "field mapper's ditty" - these areas Dardis termed *numlins*. The basic thesis, however, that not only do we need to explain why drumlins are formed where they are but also why they don't form in other locales is valid. From detailed sedimentology and morphological analyses, Dardis suggested that where thick diamicton, non-drumlinised till plains occurred effective evacuation of meltwater must have occurred. From work based upon drift prospecting principles, **Aario**, **Peuraniemi** and **Sarala** (Oulu) mapped in detail an area 10km<sup>2</sup> of morainic ridges and from this research established a two-phase process of moraine ridge formation ultimately ending in Rogen moraine development. The paper by **Menzies** (St. Catharines), **Zaniewski** (Amsterdam) and **Dreger** (Kiel) presented details of the sedimentology of several New York drumlins using micromorphology. Evidence of non-pervasive deformation was noted and an interpretation of subglacial deforming bed conditions similar to those invoked by **Hart** are suggested as the cause of drumlin formation in this specific instance.

In the only paper to deal with modern glacial environments, **van der Meer** (Amsterdam) discussed a detailed mapping program for fluted moraine both immediately beneath the frontal margin of a Swiss glacier and in the proximal proglacial zone. This work revealed the impact of deformation processes in the evolution of fluted moraine.

**Warburton** and **Smalley** (Leicester) presented, with considerable panache, an innovative concept of self-organization criticality - the idea that for maximum entropy over a "bumpy" bed a glacier/ice sheet might necessitate drumlin development!

On a "larger canvas" **Patterson** (Minneapolis) presented a paper on the Des Moines Ice lobe in Minnesota illustrating the work of three years of glacial geologic mapping and introduced the concept of ice sheet and specifically ice stream dynamics to aid in understanding subglacial bed conditions. **Colgan** and **Mickelson** (Madison) presented a paper on the subglacial bed conditions under the Green Bay Lobe in Wisconsin. From detailed mapping it was demonstrated that drumlin and fluted moraine formation occurred over a repeated series of phases of ice movement resulting from erosion of pre-existing glacial sediments and associated glaciotectonism. A paper by **Piotrowski** (Kiel) returned to the topic began by **Patterson** in which a large regional scale approach to ice dynamics and subglacial bed conditions, in this instance, across the Northwest German Plain was adopted. **Piotrowski** suggested that little large-scale areal evidence exists for pervasive subglacial deformation and only in those areas (linear) where conditions due to porewater pressure build-up did deformation occur. The large-scale "stability" was strongly influenced by the presence of numerous tunnel valleys permitting porewater dissipation. Satellite imagery coupled with ground truth data of subglacial bedform morphology, permitted **Knight** and **McCabe** (Coleraine) to suggest major regional ice sheet bed conditions in which glaciomarine environments appear to have transmuted into terrestrial based conditions. Where unstable glaciomarine margins occurred rapid drawdown of large portions of the ice sheet may have occurred "triggering" drumlinisation as a subglacial hydraulic "jump" corollary or "short-circuit". The paper by **Zelcs** (Riga) and **Dreimanis** (London, Canada) demonstrated the coming together of regional geology, morphological mapping and detailed sedimentology in a single research work. The dominant observation from work on the Burtneiks drumlin field in Latvia was the dominance of glaciotectonism in the formative mechanisms of this particular set of drumlins. From detailed work done in the German Alpine Foreland, **Habbe** (Erlangen) described a sequence of ice advances and retreats to explain the general glacial geomorphology and in particular drumlinisation.

In an invited paper, **Menzies** (St. Catherines) reviewed the past history of drumlin research and attempted to place that research into a projected perspective in terms of likely research goals and possible novel approaches to drumlin research.

After over a century of intense research, drumlins and associated bedforms retain their fascination and to some degree mystification. Beginning in 1985 at Manchester (UK) when the First International Drumlin Symposium was

organised, symposia in Canada, Finland and Ireland have continued the "tradition" of drumlin enquiry and accumulation of evermore data. If a criticism can be levelled at this particular symposium it was that too little new data and ideas were presented and a considerable time seemed to be spent going over well-travelled ground. If a plea can be made it might be to permit more time to pass before a Sixth Symposium is convened at which time more data and novel ideas on drumlins and their formation might be presented. Drumlins remain that tantalising talisman of glacial studies - inability to fully comprehend the subglacial environment. This highly successful symposium confirms and affirms the continued and pivotal importance that drumlins retain!

**John Menzies**  
**Department of Geography**  
**Brock University, St Catherine's, Ontario**

### **REPORT ON SEA-LEVEL CONTRIBUTIONS AT THE BERLIN INQUA CONGRESS**

Despite many changes to the original programme, a common feature of the whole Congress, there were two very successfully symposia, and business meetings of the INQUA Shorelines Commission and IGCP Project 367.

Important results were presented on analytical techniques, on investigations in new areas, and on re-evaluating existing ideas.

**Eisenhauer** introduced preliminary results on the use of ostracods as quantitative palaeosalinity indicators, using sites from the Fleet, behind Chesil Beach, UK. **Twiddy** investigated the oxygen and carbon isotope properties of coastal plants, especially *Phragmites australis*, as indicators of environmental parameters, such as soil water salinity and level of tidal inundation. Although not conclusive at this stage both authors suggest that the techniques could provide valuable information for environmental reconstruction when applied to sub-fossil material.

**Islam** presented the results of the first investigation to combine the techniques of lithostratigraphy, radiocarbon dating, pollen and diatom analyses to the estuarine sediments of Bangladesh. Although much more work will be required to elucidate the complex interaction of the range of processes which operate in the area, this investigation illustrates that detailed analyses are feasible and can have a direct application to the environmental issues in the region. **Zong** and **Tooley** reported new data from NW England, revealing a detailed Holocene sea-level record, including periods of accelerated rates of sea-level rise. Catastrophic discharge of meltwater contributed to a maximum rise of 36mm/yr during the early-Holocene. They also analysed the storm-surge record based on tide-gauge, historical and stratigraphic data. The theme of decoupling the

effects of sea-level rise, storm surges and changes in coastal geomorphology was further developed by **Plater *et al.*** in a multi-disciplinary project at Romney Marsh, SE England. **Christensen** also reported a very high rate of sea-level rise during the early-Holocene in Denmark. **Yim** addressed the issue of correlating marine and terrestrial records, a topic further discussed in other symposia. He argued that inner shelf sediments, using data obtained during the construction of the new Hong Kong International Airport, have important advantages, including continuity of sedimentation at critical periods, over both loess deposits and deep sea sediments. The theme of erosion and sedimentation associated with the last sea-level rise offshore from Hong Kong was developed further by **Fyfe**. **Shennan *et al.*** showed how numerical analyses of pollen and diatom data from tidal marsh sediments in Washington, USA, could be used to quantify the amount of coseismic subsidence associated with large earthquakes on an active plate boundary. They provided evidence for eight events during the last 5000 years, with subsidence varying from less than 0.5m for two events, to more than 1.5m for the largest.

Of those papers challenging previously established views **Ota** and **Chappell** provided new U-series dates for some of the terraces on the Huon Peninsula, which must now be accommodated in those studies using the Huon sequence as a long record of environmental change. They also showed that many of the small steps have a coseismic origin, and that coseismic uplift is an important tectonic process during at least the last 50 ka. In a detailed study of Middle Pleistocene marine sequences from Essex, **Roe** challenged existing ideas on the sea-level history of the southern North Sea basin and she concluded that two models could explain the empirical data. **Shennan *et al.*** reported detailed radiocarbon and stratigraphic data from NW Scotland which are not compatible with existing models of relative sea-level change and argued that they will provide excellent controls on new models of ice-lithosphere interactions. **Kiden** presented convincing evidence for significant differential crustal movement, up to 2m/ka during the early Holocene, over 180km between Belgium and the Netherlands. In contrast, relative crustal movement during the Weichselian was small, or probably the inverse on the movement during the Holocene. There are major implications for a number of Quaternary investigations arising from all of these papers.

A major theme of the discussions during the business meetings of the INQUA Commission on Quaternary Shorelines was the need to provide a stimulus to research on a focused theme during the intercongress period. The approved theme for the intercongress period is "Understanding coastal dynamics during the Quaternary" and the research will be promoted via seven projects, details of which can be obtained from the Secretary of the Commission (Dr Patrick Nunn, University of the South Pacific, Suva, Fiji, email NUNN\_P@usp.ac.fj).

**Tooley** was elected President and these arrangements should effect a period of renewed vigour and originality to sea-level research.

**Ian Shennan**  
Department of Geography  
University of Durham

## **INQUA PALAEOCLIMATE COMMISSION: 'INTIMATE' PROJECT**

A new international collaborative research project was launched at the 14th INQUA Congress in Berlin in August, 1995. The project, named INTIMATE (INTEgration of Ice-core, MARine and TERrestrial data for the North Atlantic region, 25-9 ka BP) has been formally adopted as a component of the INQUA Palaeoclimate Commission (leader J-L. de Beaulieu, Marseille). It is planned to run the INTIMATE project until the year 2000, with a series of annual international workshops, and a formal report of the major outcome of the project will be delivered at the 15th INQUA Congress in South Africa.

### **Objectives**

The principle objectives of INTIMATE are to produce a comprehensive synthesis of ice-core, marine and terrestrial data from the circum-North Atlantic region for the interval between the Last Glacial Maximum and the early Holocene; to construct a series of palaeoenvironmental maps illustrating the ice-land-sea-atmosphere interactions during that period; and to test existing models concerning the principal feed-backs that operate during a glacial-interglacial transition.

### **Methods/approach**

INTIMATE is an extension of the successful North Atlantic Seaboard Programme (NASP) of IGCP-253, which ran from 1990-94. One of the achievements of the NASP programme was the construction of a comprehensive synthesis of terrestrial data obtained from regions adjacent to the North Atlantic and spanning the last glacial-interglacial transition. The results have been published in several special issues of international journals (including the QRA's own *Journal of Quaternary Science* - vol 9 no. 2, 1994) and were reported at the Berlin INQUA Congress. The programme was organised through four annual, international workshops, where specific goals were set and the results published on a regular basis. This same format will be followed in the INTIMATE project. Towards the end of the NASP project, the workshops included some preliminary comparisons between terrestrial, marine and ice-core data, and the idea of continuing this dialogue in a new collaborative project was born. The matter was discussed and planning arrangements were agreed

during a symposium and business meeting at the Berlin INQUA Congress. The INTIMATE project business will be organised by a number of specialist teams, each with an appointed leader who will be responsible for co-ordinating a database of a sub-set of the palaeoenvironmental information relevant to the project. Special attention will be given to high resolution stratigraphical information, quantified reconstructions of environmental change and the development of a common timescale for synthesising the data.

Leaders of specialist topics have been agreed, these being individuals who have access to up-to-date and comprehensive data-sets of direct relevance to the aims of INTIMATE. These include: **J-P Steffenson** (Copenhagen) for ice-core records, **G. Bond** (Lamont-Doherty, New York) for open ocean records, **D. Kroon** (Edinburgh) for shallow marine records, **I. Shennan** (Durham) for sea-level variations, **E. Jansen** (Bergen) for sea surface temperatures, **L. Cwynar** (Fredericton) for N. American continental records and **S. Bohncke** (Amsterdam) for European continental records. Other positions have still to be filled, including someone to co-ordinate the geochronological framework, a leader for ice cover and ice-melt variations, and an individual or team to handle the overall data-synthesis/modelling. **J. Lowe** (London) will act as overall co-ordinator, and **M.J.C. Walker** (Wales, Lampeter) as Secretary of INTIMATE.

It is hoped to hold the first INTIMATE international workshop in late 1996 or early 1997.

#### **For further information:**

QRA Members wishing to receive copies of future INTIMATE bulletins should contact the Secretary, Professor M.J.C. Walker, Department of Geography, University of Wales, Lampeter, Dyfed, Wales, SA48 7ED, U.K., and those with access to major data-sets who wish to become involved in INTIMATE can either write to the Secretary or to the Co-ordinator, Professor J.J. Lowe, Centre for Quaternary Research, Department of Geography, Royal Holloway, University of London, Egham, Surrey, TW20 0EX, U.K.

**J. John Lowe**  
**Centre for Quaternary Research**  
**Royal Holloway, University of London**

### **REPORT ON PALAEOPEDOLOGY COMMISSION ACTIVITIES IN INQUA CONGRESS, BERLIN 1995**

The main activity of Commission 6 (Paleopedology) was a full day symposium entitled *Reconstruction and Climate Implications of Quaternary Paleosols and Paleosol Sequences*. In its final form after extensive last-minute reorganisation,

this included 20 papers, starting with a general introduction to the subject of palaeoclimatic interpretation of soils from the Russian viewpoint by **Victor Targulian**, titled Soil as a Recording System: Recent and Inherited Soil Memory. The subsequent papers covered frost effects in soils (**Brigitte Van Vliet-Lanoë**), the micromorphology of loess paleosols in Central Asia (**Arnt Bronger** and **L. Wei**), magnetic susceptibility and climatic change in a loess-paleosol sequence in China (**Ken Verosub**), grain size analysis and climatology of the Chinese loess (**Jef Vandenberghe**), correlation of Quaternary paleosols in Europe (**Helmut Stremme**) and general accounts of paleosol sequences in Slovenia (**Natasa Vidic**), Kwazulu-Natal (**Greg Botha**), the Upper Mississippi driftless area (**Peter Jacobs**), NW Bangladesh (**M. Alam**), Siberia (**Anton Yamskikh** and **V. Zykina**), Japan (**M. Watanabe**), Norway (**Lars Olsen**), the Tibetan Plateau (**X.M. Fang**), Easter Island (**Linus Jacob**), the Russian plain (**Arno Kleber** and **Alex Makeev**) and the Wallertheim archaeological site in Rheinhessen (**Roger Langohr**). Most of these papers are currently being edited for a special volume of *Catena*.

There were also six poster papers describing soils of the central Sahara (**Mauro Cremaschi**), Mongolia (**A. Kowalkowski**) and Hungary (**L. Hum**), phytoliths in African soils (**F. Runge**), luminescence dating of German soils and sediments (**M. Krbetschek**) and radiocarbon dating of E. European forest steppe Holocene paleosols (**A. Alexandrovsky**).

In addition several members of the Commission contributed papers to other symposia, notably one organized by the Loess Commission entitled Pleistocene Loess and Paleoclimate (Land and Ocean Records).

At the Commission's business meeting **John Catt** (UK) resigned as President and was replaced by **Arnt Bronger** (Germany), and **Leon Follmer** (USA) was replaced as Secretary/Treasurer by **Alex Makeev** (Russia). **John Catt** will be Vice-President until the next INQUA Congress. Several new working groups were formed at this meeting, including an Inter-American Working Group to be organised by **M. Singer** (USA). In addition, four new projects were agreed as foci for the Commission's activities until the next INQUA Congress in S. Africa in 1999. These were:

1. To develop a classification for paleosols that can be used with both truncated and diagenetically modified profiles
2. To improve the current palaeoclimatic interpretation of loess soils by developing mathematical relationships between soil properties and climatic factors and by establishing climatic thresholds of soil development processes for both temperate and cold climates

3. To produce guidelines for pedostratigraphy which can be used with both Quaternary and pre-Quaternary paleosols and to eliminate the confusion resulting from the N.American stratigraphic code
4. To strengthen collaboration with soil scientists, pre-Quaternary geologists and archaeologists, many of whom work on paleosols but often fail to recognise and interpret them correctly.

**J.A. Catt**  
**IACR - Rothamsted**

### **14th INQUA CONGRESS, BERLIN, 1995** **INQUA STRATIGRAPHY COMMISSION**

1. **Jim Rose, Charles Turner, Tom Litt and Lothar Eissmann** chaired a two day symposium on European Quaternary Stratigraphy. This attracted papers on a variety of topics and stimulated much discussion as a result of conflicting radiometric dates obtained by a variety of luminescence methods, ESR and U-Series, and the conflict between these dates and the litho- soil- and biostratigraphic evidence from the relevant sites. In addition there was the inevitable conflict between those who believe that the Earth behaves as an integrated system and the records of climate change derived from ocean cores have some value in understanding the behaviour and history of the terrestrial climatic and environmental systems, and those who do not. In a challenging paper by George Kukla, this apparently un-resolvable divergence of views was resolved by the introduction of the concept of 'megacycle' or 'supercycle' which identifies a major sequence of climatic change beginning with a major glaciation and followed by a major interglaciation with high global sea-level. This 'cycle' then continues until the next major sequence of climatic change. By giving attention to these megacycles as the signatures for defining climatic episodes we are back to Elster+Holstein/Anglian+ Hoxnian, Saale+Eemian/'Wolstonian'+Ipswichian, and Weichsel+ Holocene/Devensian+Holocene with all the climatic changes in between reduced to the status of noise!

2. **Jim Rose** was elected to continue as a full member of the INQUA Stratigraphy Commission for the forthcoming inter-congress period. The new President of this Commission is **Dr. Tim Partridge** of South Africa, with **Dr. Christian Schlüchter** of Switzerland as Vice President and **Dr. Dirk van Husen** of Austria as Secretary. One of the main issues concerning this commission is the resolution of the problem of the date and definition of the Plio-Pleistocene boundary.

3. **Jim Rose** was elected to continue as a full member of the INQUA Sub-Commission on European Quaternary Stratigraphy. The new President of this Commission is **Dr. Thijs van Kolfschoten** of the Netherlands, with **Dr. Mauro**



**Coltorti** of Italy as Vice-President and **Dr. Tom Litt** of Germany as Secretary. The main task of this commission is to continue the evaluation of European type sections with the next meeting to take place in the southern Netherlands looking at evidence for the base of the Pleistocene.

4. **Jim Rose** was invited to become Chairman of the Working Group on Subglacial Processes which comes under the authority of the Commission on Glacial Deposits. **Dr. Jane Hart** has been invited to be Chairman of the Working Group on Glaciotectonic Processes. It is the intention of the Subglacial Processes Working Group to concentrate on research that has been carried out in areas of active glaciation, and possible venues for meetings include northern Sweden (Storglaciaren) and Alaska (Trapridge glacier). It is intended that the programme of inter-congress meetings will lead to a major symposium at the 1999 INQUA Congress in South Africa on recent discoveries and model exercises derived from the measurements of the behaviour of actual glaciers on deformable and non-deformable bed materials.

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Centre for Quaternary Research  
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### INQUA LOESS COMMISSION

Eight months now since Berlin INQUA and the LC Inter-Congress Programme is getting under way. The LC had two long business meetings at Berlin (how do the other commissions manage with just one?) and a set of research topics was discussed and some useful decisions reached. A two-pronged approach is being developed; the two major topics are Climate Dynamics (organised by **An Zhi-sheng**) and Engineering Problems (with Environmental Aspects) organised by **Ian Jefferson**, **Ian Smalley** and **Marton Pecs**i. Projects have been submitted to the INQUA Secretariat for consideration.

Loess Letter 35 is about to be published. This contains reports and extracts from three major loess publications: the NATO book on collapsing soils; the *Quaternary Proceedings* special issue and the *Quaternary Science Reviews* special issue - both deriving from the QRA/INQUA conference in 1994. LL37 also announces a new special issue of *Engineering Geology* on the topic of collapsing soils. Anyone interested in submitting a paper to this issue should contact Ian Jefferson at Nottingham Trent University (civ3jefei@ntu.ac.uk).

**Ian Smalley**  
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## REPORT ON THE ANNUAL FIELD MEETING: DEVON AND EAST CORNWALL

12th-16th April 1996

Saturday 13th April

A procession of minibuses and private cars arrived at Tews Lane, Bickington, slightly before 11 a.m. Over 40 members of the QRA braved the rather overcast and cold conditions as they congregated in the old workings at Brannam's Clay Pit. Although the clay workings are now abandoned and have been used for land-fill, the party was shown the surviving but overgrown faces to the north of the site. These presented **Dave Bridgland** (Durham) with an immediate 'site clearance' challenge and, within a few minutes, intensive excavation had provided sections through slope deposits and into the weathered deposits of the Fremington Clay Series. The organiser of the meeting, **Dave Croot** (Plymouth), gave an excellent summary of previous work at the site, explaining how the clays had originally been likened to the Ballycraheen Till of Eire by Mitchell and Stephens in the 1960s, and how a glacial origin and 'Wolstonian' age had thence been widely proposed. Both he and **Adam Gilbert** (Plymouth) went on to outline their recent work at the site which included detailed studies of clast lithology and fabrics, the micromorphology, micropalaeontology and engineering characteristics of the sediments and a 'very preliminary' series of Optically Stimulated Luminescence (OSL) 'dates'.

**Dave Croot** emphasised that all (but one) of the clasts they had recovered from the Fremington Clay Series were of bedrock lithologies found within a 10km radius of the site. The single exception was a well-striated, faceted, cobble-sized microdolerite clast upon which, he argued, a glacial origin for the sequence largely hinged. He stressed the preliminary nature of the OSL dates explaining that they probably ruled out a Late Devensian age for the deposits and indicated an age at least as great as Anglian. He argued that previous stratigraphic schemes showing the relationship of the Fremington Clay Series to deposits exposed on the coast at Fremington Pill and elsewhere were now demonstrably untenable.

The highly controversial nature of the evidence inevitably stimulated much debate, particularly concerning ice limits. There was a broad consensus that the 'Wolstonian' and Anglian limits drawn from the Isles of Scilly, through Trebetherick to North Devon were now completely redundant: **James Scourse** (Bangor) reiterated his view that at least some of the glacial deposits in the Isles of Scilly are *in situ* and of Late Devensian age; that a glacial origin for the Trebetherick 'boulder bed' can no longer be sustained; and that the glaciation

of the Somerset and Avon lowlands is demonstrably older than Late Devensian but of uncertain age. Several members expressed the view that, the Fremington Clay apart, there was a lack of clear evidence for glacial activity in North Devon. **Stewart Campbell** (CCW, Bangor), perhaps unwisely, raised the issue of the coastal erratics and the 'peculiar dry valleys' of North Devon - opening a 'can of worms' and much debate from **James Scourse**, **Peter Keene** (Oxford Brookes) and **David Keen** (Coventry), in particular, on the origin of the coastal valleys, the mechanisms of erratic transport and emplacement and a variety of other subjects for which there seemed little hard scientific evidence. The party left Brannam's Clay Pit secure in the knowledge that, despite over 130 years' research, the precise age and origin of the sequence remain unknown!

After what was, for private car owners, a heart-stopping traverse of unmetalled, cratered local lanes, and an outdoor lunch at Fremington Quay, the party viewed exposures on both sides of the Fremington Pill. Those on the west side drew most interest and comment. Here, **David Croot** outlined the history of research on the so-called 'pebbly drift' of the Taw Estuary. There was surprisingly wide agreement among the party that the sediments here were more of 'glaciofluvial' character than the 'raised beach' origin previously assumed. The party viewed an exposure adjacent to a broken-down sea defence wall. This was believed to be the locality previously described by **Nick Stephens** as showing 'striated stones and till'. Here, members were intrigued by a large mass of what initially appeared to be 'rotted' but intact bedrock beneath the pebbly gravels. Closer inspection showed that this mass of rock was in fact separated from *in situ* bedrock beneath by a major slip plane. In the absence of any local evidence for land-slip, some members concluded that the bedrock mass had been glacially 'rafted' in much the same way as the famous Sidestrand Chalk 'rafts'. Further interest was stimulated by a dark, possibly organic, deposit in the adjacent clays which sent **Brigitte Van Vliet-Lanoë** (CNRS Rennes) rooting for a trowel and sampling bags. The party left appreciative of the considerable research potential of the locality.

The last stop of Day 1 was at Saunton Sands, where the party viewed the spectacular wavecut platforms, raised beach, 'sandrock' and head deposits in increasingly kind weather. With the party assembled at the famous 'pink granite' erratic (cover photograph), **Adam Gilbert** gave a convincing presentation of his recent sedimentological and OSL dating work at the site. He argued that previous interpretations of the raised beach-sandrock sequence had been over-simplified. Instead, he proposed that five facies, widespread along the coast here, could be recognised in the deposits. These showed the progression from: an initial marine transgression (facies 1 - the well-cemented raised beach

conglomerate described by numerous previous workers); to a foreshore environment dominated by nearshore intertidal activity (facies 2); to a deeper water environment on the flank of a wave-/tide-dominated river-fed embayment (facies 3); to a backshore environment with palaeosol development (facies 4); finally to a backshore dune environment (facies 5). Although this classification was well received, considerable debate was generated by Adam's proposed chronology based on OSL dates - which places the lowest marine deposits in Stage 5e (Ipswichian) with the aeolian sediments in Stage 4 (c. 70,000 BP - Early Devensian). **David Keen** and **Stewart Campbell** were quick to note that these dates were somewhat at odds with existing AAR data which showed the possibility of several high sea-level stands, including one of Stage 7 age, at the site. After kicking the subject around for some time, there seemed to be general agreement that the vast thicknesses of head present above the marine/aeolian sequence, and its complex stratigraphy, were probably more consistent with a Stage 7 age for the shoreline deposits - thus allowing the possibility that both the windblown and periglacial 'head' deposits had accumulated during a variety of subsequent cold stages. On the return to Plymouth, the party was able to reflect on a day of stimulating and informed debate - exactly what a QRA trip should be about.

### Sunday 14th April (SC)

Day 2 began at Postbridge on Dartmoor in characteristic grey drizzly weather. The morning's theme was the Holocene vegetation history of Dartmoor and the impact of human activity. **Chris Caseldine** (Exeter) provided an introduction to the Holocene vegetational history of Dartmoor, and then outlined details of work that he and **Jackie Hatton** (Exeter) had carried out at Bellever. The Bellever pollen diagram provides good evidence for conditions on Dartmoor during the first 3,000 years or so of the Holocene and discussion centred on causes for the apparently slow invasion of *Betula* and the persistence of herb taxa well after 10,000 BP. The perennial problem of why no complete 'Late-glacial' sites have been found on Dartmoor was also mulled over: **James Scourse** suggested a lack of suitable depositional basins, perhaps related to differences in the degree of kaolinisation (cf. Bodmin Moor), as the most likely cause. **Debbie Griffith**, the National Park's archaeologist, went on to outline the evidence for human activity and occupation on the moor, in particular the landscape changes initiated by Neolithic Man and the relationship of the reaves (major Bronze Age boundary structures) to the contemporary vegetation of the moor.

As the weather conditions deteriorated, **Steve West** (Plymouth) had the unenviable task of outlining his recent work at nearby Tor Royal Bog. There,

over 6m of deposits have yielded a high resolution pollen and geochemical record of environmental conditions during the last 8,000 years. In the absence of sections or cores, the party was shown the salient features of the (waterproof!) Tor Royal pollen diagram. Although again, the elusive 'Late-glacial' element is missing, Steve was able to describe the early Holocene landscape history of Dartmoor and the gradual deforestation which occurred throughout the Holocene but which was accelerated following the 'elm decline'.

A somewhat bedraggled party then made its way to Princetown for a lunch stop. As the buses and cars moved toward the first afternoon stop in the rain, even the austere greyness of H.M.'s Prison took on a cosy glow! Not dispirited, the party trudged in full protective gear to the summit of Cox Tor where the weather improved sufficiently for members to see the superb altiplanation terraces developed on the Cox Tor dolerite and surrounding rocks of the metamorphic aureole. Near the summit of Cox Tor, the party was shown an extensive and spectacular area of 'earth hummocks' previously attributed to periglacial ground-ice phenomena. Here, **Matthew Bennett** (Greenwich) outlined his work on hummock morphology, distribution and internal structure. He also described sections excavated through the hummocks and speculated on the role of soil movement and vegetation growth in their formation. **Tony Brown** (Exeter) thought the hummocks were completely unrelated to periglacial activity, and that they were simply degraded *Molinia* tussocks: this conflicted somewhat with **Matthew Bennett's** assertion that soil type was a prime determinant in hummock distribution, since the hummocks comprised well-drained fibrous brown loam whereas the hummock-free areas were characterised by peat-rich soil. From the excellent vantage point of Cox Tor, **Stephan Harrison** (Coventry) drew the party's attention to the stunning boulder runs and other clitter accumulations on the west-facing slopes beneath Great Staple and Middle Staple tors. On the basis of boulder lobe thicknesses and calculations of theoretical basal shear stress in a boulder/ice mix, Stephan proposed a 'rock glacier' mechanism or 'permafrost creep' to explain the accumulations. This controversial suggestion generated much discussion as did **Matthew Bennett's** proposal that some of the stone runs were simply gullies where soil and vegetation had been stripped from the underlying clitter. An unconvinced but impressed party left for the next stop.

A brief 'natural' break in Tavistock was followed by a visit to Rough Tor on Bodmin Moor. Here, amidst deteriorating weather conditions, **Dan Charman** (Plymouth) gave a clear and concise presentation on the distribution of Mesolithic, Neolithic, Bronze Age and Medieval artefacts and settlements on the moor and their relationship to a new, radiocarbon-dated pollen diagram. He stressed that the importance of the site lay in the proximity of the dated peat



Figure 1. Late-glacial stratigraphy at Hawk's Tor, Bodmin Moor. Minerogenic Loch Lomond Stadial sediments underlain by Interstadial organic sediments and overlain by Holocene peats.

profile to the well-preserved archaeological remains. The second day ended with an *impromptu* visit to Hawks Tor, where **James Scourse** was invited to explain the history of research and palaeoenvironmental significance of a site he had never visited before! Undaunted, James located the sections where the pioneering work of Conolly, Godwin and Megaw had been carried out between the wars and where monoliths had been taken for Brown's reappraisal in the 1970s. This was the first site where the Late-glacial climatic oscillations were identified in mainland Britain (though not the first published), and remains one of the few open sections in the country where minerogenic Loch Lomond Stadial sediments can be observed underlain and overlain by organic interstadial and Holocene sediments respectively (Figure 1). A famous and impressive site.

#### **Monday 15th April (JDS)**

As Monday attempted to dawn it was clear that the murk had deepened. In the gathering gloom the convoy of vehicles set out to visit sites along the singularly

misnamed English Riviera. First stop was Slapton Ley wetland where **Paddy O'Sullivan** (Plymouth) gave an excellent account of both his work in illuminating the palaeolimnology of the site and also the results of over 30 years of previous investigations. Particularly impressive was the demonstration by Paddy of the association between nutrient loading of the wetland and historical developments within the catchment, in particular eutrophication associated with intensification in agriculture around 1910 and in 1945, and caused by sewage phosphorus after 1960. In order to illustrate his work Paddy demonstrated freshly-acquired cores, and a Mackereth corer of the kind used in his work at the site. The whole question of the evolution of the wetland and its barrier, Slapton Sands, appeared more controversial, though **Colin Morey** (Luton) was on site to report the results of his earlier investigations on this problem in the 1970s.

First visits to previously published sites usually result in one of two reactions: either it seems that the published account overemphasizes the significance of the evidence or overinterprets that evidence leaving one muttering something like "I don't believe it!"; or, more rarely, one is so deeply impressed by the quality of the evidence and research that it sends one scuttling back to the published work for a second look. The work on the caves of Berry Head by **Chris Proctor** (Exeter; published in the *Journal of Quaternary Science*, 1991, volume 6, p233), falls into the latter category. For me this was the real highlight of the entire trip. Karstification of the Devonian limestones of Berry Head has resulted in cave development at a variety of elevations controlled by sea-level. Uranium-series dating demonstrates stage 5e high water spring tides at 5.8mOD, with a stage 7 sea-level rise to at least 7.2mOD and a transgression to at least 25mOD in stage 9 or earlier. These are important results with considerable implications for long-term crustal stability in the Channel area. **Andy Baker** (Exeter) followed up **Chris Proctor's** excellent description of the evolution and chronology of the cave systems with a fascinating account of his work on the luminescence properties of cave speleothem which enable the detection of annual growth bands. Apparently growth occurred for several thousand years between 190ka and 160ka which suggests conditions suitable for speleothem growth in South Devon during stage 6, a conclusion with potentially important palaeoclimatic implications.

**Chris Proctor** then took the party on a tour through Kent's Cavern, a site long recognised for its importance in the history of Pleistocene geology and the quality of its vertebrate faunal and artefact evidence. Given the weather it was something of a relief to descend underground to view the spectacular speleothem formations and listen to Chris's enthusiastic account of generations of excavations and finds. Perhaps the most significant evidence currently emerging

from the site is the vertebrate fauna and associated Acheulian (Lower Palaeolithic) industry recovered from the Breccia associated with uranium-series and ESR dates of 300-400ka. This fauna, dominated by the Middle Pleistocene cave bear *Ursus deningeri*, is similar to the vertebrate faunas recovered from the sites at Westbury-sub-Mendip and Ostend and probably of the same age. The Ostend site is demonstrably pre-Anglian in age (and thought by some to be post-Cromerian). If these U-series and ESR dates are reliable then this might suggest that the Anglian is represented by oxygen isotope stage 10 rather than stage 12 which is the currently held consensus in the British Isles.

This tour provided a fitting climax to the field excursion, and the organisers and site leaders were deservedly praised by **Pete Coxon** (Dublin) on behalf of the QRA for their efforts once the party had re-emerged from the Cave. A few hardy raised beachers followed **David Keen** to Hope's Nose for an impromptu demonstration of the sequence there, whilst the majority had to depart on their return journeys.

The field guide, edited by **Dan Charman**, **R.M. Newnham** and **David Croot** is first-class and should be purchased by all QRA members !

This was an excellent field meeting embodying all the essential ingredients of a QRA Annual Field Excursion; debate, controversy, variety, all enlivened by the imaginative comments and pranks of **Maria Street-Perrott** (aged 10). It was a pity, however, that so few senior members of the UK Quaternary fraternity were present to add their experience to the discussions.

**Dr Stewart Campbell**  
**CCW**  
**Bangor**

**James Scourse**  
**School of Ocean Sciences**  
**Bangor**



# REVIEWS

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## BOG BODIES: NEW DISCOVERIES AND PERSPECTIVES

Edited by R.C. Turner and R.G. Scaife

British Museum Press, London.

ISBN 0-7141-2305-6 1995. 256pp Hardback £25

A series of essays reviewing developments in the study of bog bodies since publication of the Lindow Man volume (Stead *et al.*, 1986) shows how understanding of this enigmatic phenomenon has advanced within a decade in Britain and North West Europe. The remarkably preserved body of Lindow Man was the archaeological find of the 1980s, attracting world attention. Less well known are other discoveries of human remains in Lindow bog. Turner tells the story of these discoveries in a narrative so interesting and highly accessible that it was a hard act to follow for the authors of some more specialised chapters. Lindow I, a human skull found in 1983, had some hair and part of the eye, played a key role in a modern murder mystery, but was subsequently dated to the Romano-British period; Lindow II (Lindow Man) found in 1984 was published by Stead *et al.*, 1986; Lindow III, a human body chopped up by peat cutting into 70 pieces, was found in 1987 and is probably from the same young adult male as Lindow I; and Lindow IV, found in 1988, the buttocks and leg of Lindow II. The 1987-8 discoveries, of which this is the main publication, provided the stimulus for more detailed investigation of the bog and its environmental history. Branch and Scaife examined the pollen sequence spanning the period 3724-1488 BP. The stratigraphic context of the unstratified Lindow III find was identified by pollen analysis of a peat block containing a leg bone. Deposition of Lindow II and III occurred at a time when clearance and human activity was increasing on the dry land. It followed a peat recurrence horizon c. 2400 BP which Barber associates with widely attested climatic deterioration.

A particular problem in relation to the earlier Lindow study was reconciling conflicting radiocarbon dates for the body and the peat and indeed conflicting dates from different laboratories. It was thought that this might be explained by contamination of bodies by carbon bearing molecules of different date. Accordingly Stead *et al.* (1986) favoured the peat dates indicating a middle Iron Age date for deposition. Buckland has pointed out that contrasting dates could be caused by the longevity of bog pools although this argument is not accepted by Barber (p50). Most writers now favour the dates on the bodies themselves

which are in the first century BC or first or second centuries AD. Given the dating issues it is unfortunate that for Lindow III there are only dates on the body and not on the associated peat; this is understandable, however, because of the unstratified nature of the Lindow III finds.

Holden has done some important work on the last meals of these bodies, demonstrating that those from Lindow are mainly cereal-based in contrast to higher proportions of non-domesticates associated with some Danish bodies.

The Lindow project has stimulated work on other bodies and a number of regional syntheses form the second part of this volume: Garland on Worsley Man; Turner on British bodies; Delaney and O'Floinn on the Meenybraddan find from Ireland; O'Floinn on Irish bodies, and a remarkable, thorough and productive survey by van der Sanden on continental bodies, particularly from the Netherlands. Discussion of the Meenybraddan find returns to dating conflicts. Here an originally published radiocarbon date was subsequently revised to almost twice the age, *ie c.* AD1190-1330, a much earlier date than was suggested by the style of associated clothing. Given this, and the previous problems with dating bog bodies, it is unfortunate that no explanation is given for Harwell's revision of the original date. It is only partly reassuring to be told (p131) that the laboratory said "there is no reason to question the reliability of the result".

What then do these bodies mean in terms of past human behaviour? In bringing together the evidence from a wide geographical area it is clear that they cover a long timespan from the Neolithic, with a significant number of the Irish examples relating to the Medieval period. Such a temporal range makes a single causative explanation improbable. Van der Sanden nonetheless seems to suggest (p.161) that they were mostly sacrifices, although only two of the examples from the Netherlands have evidence of an unnatural death. Briggs takes a contrasting sceptical view of the evidence for sacrifice and reviews many of the assumptions and theories about bog bodies in a way which reminds us of the need for critical examination of the evidence. However, scepticism about the radiocarbon dating of bog bodies and an argument that some injuries relate to post-mortem, rather than at death, damage seem to be pressed too far and to reflect a line of reasoning which predates some of the detailed studies presented in the same volume.

Although by 32 authors, the contributions are well integrated with frequent cross-reference between different sources. This does not, however, mean they all agree. Conflicts on the issue of sacrifice, on dating reliability, the longevity

of bog pools or possible evidence for body painting are untidy but represent a particular strength of this book. It is not a nanny knows best view, in which archaeological science just provides answers, but has a more self-reflective spirit in which conflicting views are expressed, and debated even if they are not, at the time of writing, all capable of neat resolution. At times some authors do not seem to be fully aware of the strength of the conflicting evidence presented by others. At least, however, the reader is not sold an artificially simplistic storyline but participates, to some extent, in the uncertainties and excitement of detective work for which the scene was set in the first chapter. This report provides a full survey of an important topic which is of much relevance to Quaternary science. It is highly recommended.

**Martin Bell**  
**University of Wales**  
**Lampeter**

## **Reference**

Stead, I.M., Bourke, J.B. and Brothwell, D.R. (1986). *Lindow Man: the Body in the Bog*. British Museum Publications, London.

## MAMMOTHS

By Adrian Lister and Paul Bahn

Boxwood, London

ISBN 0 7522 1604 X 1995. 168pp. Hardback £17.99

The aims of this work as stated in the introduction are to be a popular book devoted to all aspects of the mammoth and to clarify the distinction between these recently extinct mammals which co-existed with humans until 4000 BP and the non-mammalian dinosaurs which died out 65 million years ago. It is very well illustrated with many photographs of remains (eg bones, tusks and skin, wool), expeditions, and excavations, together with many artistic reconstructions of mammoths in their contemporary landscapes. The book is in five chapters: Origins, Mammoths unearthed, The natural history of mammoths, Mammoths and human culture, and Extinction.

The first chapter covers the origins, taxonomic relationships, evolution and migration of mammoths. The Proboscidean family tree is explained showing the relationship of the mammoths to the still extant members of the order, the African and Asian elephants and their other closest extant relatives, the dugong and the hyrax. The parallel evolution in Eurasia and North America of the woolly mammoth (*Mammuthus primigenius*) and the larger Columbian Mammoth (*Mammuthus columbi*) is also carefully described, as is the island dwarfing of both these species.

The second chapter "Mammoths unearthed" deals with the various mechanisms of preservation of mammoths and their subsequent discovery. The authors explain how in the late 17th century it was realised that these enormous bones were not those of giants but of "an extinct elephant" and the subsequent efforts to reconstruct the animal. The expeditions to recover remains from the Siberian permafrost and the excavations of tar pits in Los Angeles are described in detail. Other sources of mammoth remains, such as gravel pits and even fishing trawls, are also discussed.

The natural history of mammoths is described in the third and longest chapter of the book. Not only their size, morphology and internal anatomy, but also their habitat and diet, feeding habits, life cycle and behaviour, health and disease are covered. The many lines of evidence contributing to this body of knowledge are described in accessible detail. Dramatic artistic reconstructions are again used to illustrate likely scenes in the lives of mammoths.

The fourth chapter, *Mammoths and human culture*, deals with the coexistence of mammoths with humans. There are sections on cave art and carvings, the use of bones and hides in buildings, the use of mammoth bones to make tools and art objects, and the pre-historic and modern uses of mammoth ivory

The final chapter covers the theories of the likely causes of the extinction of the mammoths about 10,000 years ago. Was human exploitation or climate change at the start of the Holocene the crucial factor in the ultimate demise of this magnificent species?

*Mammoths* has been written as a popular book and so the flow of the text is not interrupted by references to other works; however, to satisfy the more inquisitive at the end of the book there is a comprehensive bibliography. There is also a glossary and a guide to mammoth sites and museums world-wide. I have no hesitation in recommending this publication to anyone who wants to own a readable and beautifully produced book packed with information about an animal which has caught the imagination of generations.

Dr Judy R.M. Allen  
Environmental Research Centre  
Department of Biological Sciences  
University of Durham  
DH1 3LE

# NEWS

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## QRA RESEARCH GROUPS

Two new research groups have been established with financial support from the QRA. These are concerned with 1. Long Terrestrial Records: The Fluvial Archive, and 2. Cryostratigraphy.

### LONG TERRESTRIAL RECORDS: THE FLUVIAL ARCHIVE

Organisers: Dr Darrell Maddy (CECQR, Cheltenham),  
Dr. David Bridgland (Durham)  
Treasurer: Dr Simon Lewis (CECQR, Cheltenham)

The proposed Research Group will build on the extensive involvement of QRA members in researching Quaternary fluvial sequences. The investigation of fluvial sequences exemplifies the multidisciplinary nature of the discipline by drawing on large resources of personnel from widely differing backgrounds.

Fluvial records span a considerable temporal range and together with their wealth of palaeoecological data and dateable materials represent the best terrestrial archive of environmental change. Recent ice-core and ocean studies have revealed the complexities in the frequency and magnitude of Quaternary environmental change. These exciting records serve to identify the critical need to re-evaluate terrestrial records. This research imperative pushes the investigation of fluvial records to the forefront of the research agenda. However, given the current financial constraints on scientific investigation, the need for collaboration and co-ordination of our research effort has never been greater.

#### Aims

- To promote the value of investigating fluvial archives; through the production of widely available and readily accessible published information
- To attempt intercorrelation of major fluvial sequences through comparison with the  $\delta^{18}\text{O}$  record from the oceans
- To establish a forum for the exchange of information and ideas
- To identify foci for future research and in particular to identify the gaps in current knowledge
- To facilitate joint 'focused' initiatives to formulate strategies for addressing problems.

## Research Plan:

The research group will conduct its business largely via email / snail mail but will meet once a year as follows:

Year 1: 1996-1997

Co-ordination meeting: Durham (1 day) December 1996

To establish the remit and themes to be addressed by the group.

Year 2: 1997-1998

Workshop meeting: Continental Europe (3 days, to include 1 field day)

This workshop will discuss the themes identified in year 1 abstracts to be published in *Quaternary Newsletter*.

Year 3: 1998-1999

Symposium: Cheltenham (3 days, to include 1 field day)

A formal open meeting to present the conclusions of the group.

Updates of the groups activities will be reported in the QRA circular and an informal newsletter will be established on the World-Wide-Web (in Cheltenham) with links to and from the QRA Web site. If required a separate Newsgroup could be established.

## Planned Outcomes:

- Publication of pan-European fluvial sequence correlations as a special addition of *Quaternary Proceedings*
- Publication of papers presented at the Cheltenham symposium. Routledge publication of a book entitled *River Terraces: Archives of environmental change* (agreement in principal already reached)
- Update reports to Geological Society concerning forthcoming Quaternary Correlations volume with special reference to fluvial sequences
- Co-ordination of pan-European study for submission of bids to European funding agencies
- Preparation of document for INQUA working group proposal. To be presented at INQUA in South Africa 1999
- Proposal and co-ordination of INQUA special session at 1999 conference.

Anyone interested in joining the group please contact either: Dr Darrel Maddy (email: [Dmaddy@chelt.ac.uk](mailto:Dmaddy@chelt.ac.uk) Fax: 01242 532959) or David Bridgland (email: [d.r.bridgland@Durham.ac.uk](mailto:d.r.bridgland@Durham.ac.uk) Fax: 0191 374 2456)

## CRYOSTRATIGRAPHY RESEARCH GROUP

A *Cryostratigraphy Research Group* (CRG) is being set up to promote discussion and interdisciplinary research between Quaternary scientists and geomorphologists sharing interests in periglaciation. The CRG is a fixed term research group of the QRA and is affiliated with the British National Adhering Body of the *International Permafrost Association*.

### Background

Cryostratigraphy describes and correlated permafrost sequences on the basis of their contained ground ice. Variation in the nature and distribution of ground ice facilitates identification of cryostratigraphic units. Such units record past differences in freezing and thawing, and their interpretation and dating permit reconstruction of ground thermal and hydrological conditions. Thus cryostratigraphy provides a valuable tool for interpreting permafrost history.

### Rationale

Understanding of cryostratigraphy is fundamental to the British Quaternary because repeated growth and thaw of Pleistocene ground ice has formed distinctive landforms and sedimentary structures, and caused widespread disturbance in certain sediments and bedrocks. The application of cryostratigraphy to Quaternary research requires discussion between those experienced in modern and Pleistocene cold environments. This discussion will be mutually beneficial, adding a process perspective to Quaternary scientists studying features such as periglacial river gravels and colluvium, and adding a stratigraphic context for those studying contemporary periglacial environments where large natural exposures of permafrost are generally rare.

### Aims

The aims of the Cryostratigraphy Research Group are to:

- exchange ideas between periglacial geomorphology and Quaternary science
- address key problems in British cryostratigraphy (*eg* evidence for growth and thaw of Pleistocene ground ice, dating, palaeoclimatic significance, correlations with mainland Europe)
- stimulate the training of graduate students in periglacial problems
- plan and submit collaborative research proposals to potential funding bodies.



## Organisation

The Group will hold one to two meetings each year at key periglacial localities in Britain. The meetings will comprise guided fieldtrips and informal research seminars. Leading periglacial scientists will be invited to present keynote talks. Graduate and undergraduate students will be encouraged to participate and discuss projects with potential supervisors. The Group will function in a similar manner to the highly successful *Subglacial Working Group* of the *British Geomorphological Research Group*.

The first meeting will take place in western Wales, probably in autumn 1996. Details of meetings will be publicised in the *Quaternary Newsletter* and on the QRA web site (WWW URL: <http://www2.tcd.ie/~pcoxon/qra.html>). QRA members and others interested in joining the Group are encouraged to send their names, addresses and phone/fax/email numbers to:

**Dr Julian Murton**  
**Department of Earth Sciences**  
**University of Wales**  
**Cardiff CF1 3YE**  
**Tel. 01222 874830 Tax 01222 874326**  
**Email: Murton@cardiff.ac.uk**

# NOTICES

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## 1. BIODIVERSITY FROM PALAEOECOLOGICAL DATA

**A One-day Symposium of the Biogeography Study Group at Exeter '97  
(IBG-RGS) to be held on January 8th or 9th**

### **Call for Papers**

In recent years much attention has been focussed on the loss of biodiversity associated with human environmental impacts. The data used to document changes in biodiversity has largely been derived from monitoring and historical records. Palaeoecology provides a potentially very powerful tool in the assessment of biodiversity in remote areas and over a longer timescale than historical records. However, there are serious methodological and philosophical problems in the use of palaeoecological data for the assessment of the diversity of a past ecosystem. Palaeoecological records represent biased samples in which traditionally absence of presence cannot be taken to equate with presence of absence in the real population. Palaeoecology is not, however, alone in this respect and has inevitably been used in the assessment of changes in biodiversity (*eg* extinctions).

Papers are invited which address the ways in which concept and methods of the assessment of diversity can be applied to palaeoecological data and the confidence limits of such reconstructions. It is hoped that papers will confront both the theoretical and statistical problems involved in the assessment of taphonomic bias and so advance the use of palaeoecology in the quantification of human impact on global ecology.

Those who would like to contribute a paper are invited to send an abstract of *c.* 500 words to the conveners before 25th July 1996. Publication of accepted papers is expected.

#### **Conveners:**

**Dr. A.G. Brown and Dr. C. Caseldine**  
**Department of Geography**  
**University of Exeter**  
**Amory Building**  
**Rennes Drive**  
**Exeter EX4 4RJ**

Abstracts may be sent as hard copy to the address above or by Email (preferably as an attached WORD for Windows file) to [a.g.brown@exeter.ac.uk](mailto:a.g.brown@exeter.ac.uk)

## 2. UNIVERSITY OF LONDON

short courses offered by:

Centre for Quaternary Research  
Royal Holloway, University of London (RHUL)  
and  
Environmental Change Research Centre  
University College London (UCL)

in consortium with staff from:

Oxford University, (PRIS) Reading University, Kingston University,  
Natural History Museum (London), University of Amsterdam, Bergen  
University, Max Planck Institute of Limnology, Dino-Data Services,  
National Museum of Wales

The University of London MSc degree course in *Quaternary Science* is taught jointly by Royal Holloway and University College in consortium with personnel based in other institutions in Europe, most of whom are affiliated with the University of London. The course has been recognised by the NERC since 1992 and has received a studentship award since 1994.

The short courses listed below form components of the NERC-recognised MSc degree course in *Quaternary Science* and these are open to entry by post-graduate students and staff from other institutions who would like to undertake training in one of more of these specialist subjects. Each course unit comprises up to 10 working days' tuition and is taught either at the CQR, RHUL or at the ECRC, UCL, though other centres in the UK are also occasionally used. The registration fee per course unit for external participants varies between c. £150 and £450, and includes all tuition, analytical materials used during the time-tabled sessions, and laboratory instruction manuals (where appropriate). A *Course Completion Certificate* is awarded to each participant who completes each course unit.

- Numerical Analysis of Quaternary Data (*H.J.B. Birks, Bergen-UCL*)
- Quaternary Sedimentology (*L.A. Owen, RHUL*)
- Periglacial Geomorphology, Soils and Sedimentology (*P. Worsley, Reading-RHUL*)
- Palynology (*H.J.B. Birks, Bergen-UCL*)
- Diatom Analysis (*R.W. Battarbee, UCL*)
- Quaternary Soils (*R.A. Kemp, RHUL*)
- Ostracod Analysis (*J. Holmes, Kingston*)
- Coleoptera & Chironomids (*G.R. Coope, RHUL & S. Brooks, NHM*)

- Plant Macrofossil Analysis (*H.H. Birks, Bergen-UCL*)
- Micromorphology of glacial deposits (*J. van der Meer, Amsterdam & J. Rose, RHUL*)
- Lithological analysis of Quaternary sediments (*C.P. Green, RHUL*)
- Palaeoenvironmental Reconstruction in Low Latitudes (*S. Stokes, Oxford*)
- Theory and Applications of Luminescence Dating (*E.J. Rhodes, RHUL*)
- British Quaternary Stratigraphy and Correlation with other Sequences (*J. Rose, RHUL*)
- Quaternary Minerals: Exploitation, Extraction & Restoration (*J. Rose, RHUL*)
- Fungal spores, vegetative plant remains, and other additional environmental indicators in Quaternary Palynology (*B. van Geel, Amsterdam*)
- Soil Micromorphology (*R.A. Kemp, RHUL*)
- Quaternary Mollusca (*M.B. Seddon, Nat. Museum Wales & RHUL*)
- High Precision Geochronology of the Late Quaternary (*J.J. Lowe, RHUL*)
- Dinoflagellates, their cysts and Quaternary Science (*R. Harland, Dino-Data Services & RHUL*)
- Cladoceran Analysis (*W. Hofmann, Max Planck Inst. for Limnology*)

The courses are usually offered between late December and end April.

For details and application forms for the courses prefixed by the symbol ◦, and for information on the *MSc Quaternary Science* degree course, please write to:

**Professor J.J. Lowe (MSc Quaternary Science)**  
**Centre for Quaternary Research**  
**Royal Holloway**  
**University of London**  
**Egham, Surrey**  
**U.K. TW20 0EX**  
**Tel: 01784-443563      FAX: 01784-472386**

For further details and course application forms for those courses prefixed by the symbol • please write to:

**Professor R.W. Battarbee**  
**Environmental Change Research Centre**  
**University College London**  
**Bedford Way**  
**London WC1H 0A**  
**Tel: 0171-380-7575 FAX: 0171-380-7565**

### 3. CECQR

Centre for Environmental Change & Quaternary Research (CECQR), Francis Close Hall, Swindon Road, Cheltenham GL50 4AZ.

The CECQR was formed in early 1995 as an umbrella for the research activities of several members of staff in cognate disciplines. The aim of the Centre is to promote research activities and foster collaborative research initiatives in the Environmental Change arena. The CECQR comprises, amongst others, a concentration of staff with specific Quaternary Research interests. These include on permanent staff:

Dr Jacky Birnie (Late Glacial Studies and Sea Level Change)

Dr Manfred Frechen (from September 1996) (Geochronology)

Dr John Hunt (Tephrochronology)

Dr Simon Lewis (Lithostratigraphy, Geoarchaeology)

Dr Bill McGuire (Volcanic Studies)

Dr Darrel Maddy (Lithostratigraphy, Holocene, Palaeoclimates)  
together with Research Associates:

John Brew (Numerical Analysis and Statistical Modelling)

Dr Richard Hey (Pleistocene Lithostratigraphy)

Dr Rob Scaife (Archaeobotany, Palaeoecology)

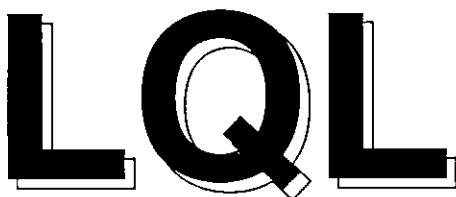
Dr Keith Wilkinson (Geoarchaeology)

and a thriving postgraduate research school

As part of our activities we will be offering a number of programmes which may be of interest to members of the QRA. These include a Technical Workshop Series and a Masters Programme entitled Environmental Investigation.

**For further details concerning the Technical Workshops, the Masters Programme or any other issues relating to the activities of the CECQR please contact Dr Darrel Maddy (email: [dmaddy@chelt.ac.uk](mailto:dmaddy@chelt.ac.uk)) or why not try our WEB site, pint your browser to: <http://www.chelt.ac.uk/cwis/faculty/el/gg/cecqr>**

# QUATERNARY SCIENCE REVIEWS



## LONDON QUATERNARY LECTURES

Organised by

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

Sponsored by

*Quaternary Science Reviews*

**Wednesday, 20th November, 1996**

15.30

**DR K. E. BARBER**

(University of Southampton)

**'New Results from Old Bogs: the Revival  
of a Climatic Archive'**

[LQL No. 56]

16.30 Tea

17.00

**PROFESSOR B. HUNTLEY**

(Durham University)

**'Quaternary Palaeovegetation and Palaeoclimates-  
Temporal and Spatial Scale Considerations'**

[LQL No. 57]

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. 1100) is open to all interested in the objectives of the Association. The annual subscription is £15 with reduced rates for students and unwaged members.

The main meetings of the Association are the Annual Field Meeting, usually lasting 3 or 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 four issues a year; the monograph series *Quaternary Proceedings*; 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 F. Oldfield*, Department of Geography, University of Liverpool, Liverpool L69 3BX

**Vice-President:** *Professor J.J. Lowe*, Department of Geography, Royal Holloway, University of London, Egham, Surrey TW20 0EX

**Secretary:** *Dr. P. Coxon*, Department of Geography, Trinity College, Dublin 2, Ireland (E-mail: pcoxon@vax1.tcd.ie)

**Publications Secretary:**

*Dr. W.A. Mitchell*, School of Geological and Environmental Sciences, University of Luton, Park Square, Luton LU1 3JU

**Treasurer:** *Dr. D. McCarroll*, Department of Geography, University College, Swansea, SA2 8PP

**Editor, Quaternary Newsletter:**

*Dr. S. Campbell*, Countryside Council for Wales, Plas Penrhos, 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

**Publicity Officer:** *Dr. D.R. Bridgland*, 41 Geneva Road, Darlington, Co. Durham DL1 4NE

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.



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