

November 1988 No.56

QUATERNARY NEWSLETTER

A PUBLICATION OF THE
Quaternary Research Association

QN:

QUATERNARY NEWSLETTER

Editor: Dr D.T. Holyoak
Department of Geography and Geology
The College of St. Paul and St. Mary
The Park
Cheltenham, Glos. GL50 2RH

Quaternary Newsletter is issued in February, June and November. 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 1 January, 1 May and 1 October.

© Quaternary Research Association, Coventry 1988

Printed in England at the Department of Geography
University of Nottingham

All rights reserved. No part of this publication may be reprinted or reproduced or utilized in any form or by any means, now known or hereafter invented, including photocopying and recording, or in any storage system, without permission in writing from the publishers.

ISSN 0143-2826

A PRELIMINARY REPORT ON THE STRATIGRAPHY OF THE LOWER THAMES VALLEY

P L Gibbard, C A Whiteman and D R Bridgland

The Lower Thames Valley extends from central London downstream to Tilbury (Fig. 1). It is therefore intermediate between the Middle Thames region to the west, and southeast Essex to the east. This area contains a suite of fluvial and estuarine deposits that have been exposed in a vast number of localities. Many of the sites known have been studied in great detail, since they include abundant evidence of both palaeontological and archaeological importance. In spite of this abundance the interrelation of sequences has until now been poorly understood and this has given rise to controversies that have influenced thinking on the Pleistocene sequence in the country as a whole. In order to unravel the complexities of this area and to establish the answer to the controversy, a project has been undertaken, a summary of the results of which are presented here. Full details will be fully published elsewhere later.

Previous regional research on the Lower Thames Valley has been rather limited. Following pioneer studies by Hinton and Kennard (1900, 1901), the most detailed work to date was that by the Geological Survey (Dewey, Bromehead and Dines, 1924; Dines and Edmunds, 1925). These workers extended the now famous series of terraces (Boyn Hill, Taplow and, Floodplain) from the Middle Thames into this area. This sequence was still accepted as the standard until recently, and formed the basis of the synthesis of Wooldridge and Linton (1955), in spite of the more complex succession developed by King and Oakley (1936).

Detailed work upstream in the Middle Thames region has shown that a more complex sequence with additional aggradations occurs (Hare, 1947; Gibbard, 1985). With this and the detailed single site descriptions in mind, a thorough investigation of the region has been undertaken using litho- and biostratigraphical methods (e.g. section logging, palaeocurrent determination, clast lithological analysis, palaeontological analysis, etc.) to establish both areal and temporal relationships of the aggradations. The individual aggradational units recognised have been defined, as in previous recent work, following the recommendations of the International Stratigraphic Guide (Hedberg, 1976).

Stratigraphy

The following aggradational units of member status have been recognised (in chronological order). The original definition of previously used unit terms is given, where necessary. The positions of type localities are shown in Fig. 1:

- (a) High level gravels and Hornchurch Till.
- (b) Dartford Heath Gravel (Gibbard, 1979).
- (c) Swanscombe deposits.
- (d) Orsett Heath Gravel (Bridgland, 1983).
- (e) Corbets Tey Gravel (Gibbard, 1985).
- (f) Mucking Gravel (Bridgland, 1983).
- (g) Aveley/West Thurrock/Crayford Silts and Sands, etc.
- (h) West Thurrock Gravel.
- (i) East Tilbury Marshes Gravel (Bridgland, 1983).
- (j) Shepperton Gravel (Gibbard, 1985).
- (k) Tilbury Alluvium.

(a) High level gravels and Hornchurch Till

At several places in the area gravels and sands cap interfluvial areas at relatively high levels, well above altitudes reached by local Thames deposits. These gravels are best developed in the Epping Forest area, on the interfluvial area between the rivers Lea and Roding, but are also present at Chigwell, east of the Roding. They are lithologically distinct from Thames gravels by their lack of quartz, quartzite and other elements of northern origin. They appear to comprise materials derived from south of the present Thames, including rare Lower Greensand chert. Their disposition, lithology and similarity to deposits

south of the river associated with the River Wandle suggest that the gravels may record a pre-Lower Thames southbank tributary flowing northwestwards to the pre-diversion Thames in Essex. It is proposed to term these gravels the Epping Forest Formation (type locality: TQ 405 935).

Despite repeated attempts it has not been possible to unequivocally establish the relationship of the early gravels to the till sheet in the region. According to Dines *et al.* (1924) the till overlies these gravels and indeed laminated clays occur between the till and the gravels at Loughton and Chigwell. If this is correct then damming of the northeastward flowing stream would be indicated, paralleling events known to have occurred farther west at St Albans and Finchley.

High level gravels of southern origin also occur on high ground beneath Darenth Wood, adjacent to the modern valley of the River Darent. They may record a pre-Lower Thames equivalent of this stream, and are termed Darenth Wood Gravel (type section: TQ 572 718).

The occurrence of till as disconnected patches broadly north of the Lower Thames Valley is demonstrated by the geological map Romford (sheet 257). However, the classic discovery of till underlying Thames gravels at Hornchurch (TQ 547 874) is now universally known (cf. Wooldridge and Linton, 1955). Re-examination of the railway cutting sections in 1982 confirmed Holmes (1892) earlier observations, the till being overlain here by Orsett Heath Gravel. This till has been correlated with the Newney Green Member of the Lowestoft Formation in the Chelmsford area (Whiteman, 1987; Allen, Cheshire and Whiteman, in press).

(b) Dartford Heath Gravel

Following previous suggestions, Gibbard (1979) agreed that the gravels underlying Dartford Heath (type section: TQ 514 736) were the highest and therefore the oldest Thames deposits present in the area. These he equated with the late Anglian Black Park Gravel upstream. The Dartford Heath unit is distinct altitudinally from the deposits at Swanscombe, which it predates. An equivalent outlier of this member has been identified in the area around the Orsett Cock on the Essex side of the river. These and all the subsequent Thames gravels in the area comprise over 90% flint, with low frequencies of quartz, quartzite and Greensand chert. This and all younger members (b-k) are assigned to the Lower Thames Valley Formation.

(c) Swanscombe deposits

The complex of deposits in the Swanscombe area has been the subject of numerous studies, the most recent of which by Bridgland *et al.* (1985) concluded that the sequence comprised: Barnfield Upper Loam, a solifluction deposit capping the sections; Barnfield Middle and Upper Gravel, a fining upward fluvial sequence deposited under a cold climate; Barnfield Lower Loam, a channel infill to overbank sediment deposited during the first half of the Hoxnian Stage (a fossil soil developed on the upper surface of the Lower Loam was identified by Kemp, 1985); and Barnfield Lower Gravel, a fluvial deposit of cold climate character at the base and temperate character at the top. Local variation from pit to pit in the area reflects local facies changes from flow channel to marginal subenvironments.

(d) Orsett Heath Gravel

The extensive spread of gravels that underlie Orsett Heath (type section: TQ 668 803) at a level of 4-5 m below that at the Orsett Cock (see above) have been defined as the next youngest unit. The gravels exhibit braided river facies associations and are of cold climate origin. They can be traced upstream to Swanscombe where they abut, and therefore post-date, the Swanscombe Barnfield deposits described above. Further upstream they occur in the substantial meander (cf. Wiseman, 1978; Bridgland, 1988) at South Ockendon and Aveley. At Hornchurch they rest directly on the Hornchurch Till. The deposits can then be followed into central London (Islington). Altitudinal relationships unequivocally demonstrate that this member is the downstream equivalent of the Boyn Hill Gravel of the Middle Thames (Gibbard, 1985). The same author previously named the Orsett Heath Member the Fairlop Gravel. It is now clear that the latter refers to Lea/Thames gravel of Corbets Tey Gravel age.

(e) Corbets Tey Gravel

The next lowest member is the Corbets Tey Gravel (type section: TQ 570 844) and is the equivalent of deposits mapped as 'Taplow' by the Geological Survey (sheets 257, 271). The unit can be followed throughout the area, and is extremely well-developed in the Wanstead-Havering-Ockendon area, where a very wide spread fills the substantial meander north of the Purfleet Chalk ridge. The gravel can also be found as minor remnants at East Tilbury. A higher subface of this unit occurs in the Wanstead-Redbridge area and appears to represent contemporary extensive deposition in the Lea-Roding-Thames confluence zone. Indeed a Lea Valley equivalent of this unit occurs at Stamford Hill (NE London). The Corbets Tey Member has also locally yielded a variety of Palaeolithic artefacts from sites such as Thurrock and Purfleet (Botany Pit) (Wymer, 1985).

This unit is the downstream equivalent of the Lynch Hill Gravel, on the basis of downstream gradient and stratigraphical position.

(f) Mucking Gravel

The next lowest spread can again be followed from Central London downstream to Mucking, near Tilbury (type section: TQ 689 815), where it occurs at a height of c. 10–12 m OD. This unit is the first which by-passes the Ockendon meander, following a direct course from Rainham to Aveley. Having been abandoned by the Thames, the meander seems to have been occupied by a remnant stream, the proto-Mar Dyke, which cut a wide channel through the earlier deposits. This channel has subsequently been infilled and partially dissected. The Mucking Member is present in the Crayford and Gravesend areas and also underlies much of the City of London and the district immediately to the north. The latter comprises a large triangular gravel spread formed at the Thames-Lea confluence.

Throughout much of the area this and subsequent units are poorly exposed.

(g) Ipswichian deposits (Aveley/West Thurrock Silts and Sands)

A complex of sites in the Lower Thames area have yielded a range of palaeontological and sedimentary evidence for interglacial conditions. The localities include Peckham (Beck, unpublished), Aveley (West, 1969), Grays, West Thurrock and Crayford, all of which appear to be of Ipswichian age. The deep channel of the proto-Mar Dyke in the Ockendon meander also contains thick interglacial accumulations at Upminster, North Ockendon, Belhus Park and Purfleet. Similar tributary aggradations occur at Ilford (in reality a complex of sites of different ages) in the Roding-Seven Kings Water valleys, Northfleet in the Endbourne valley, Hackney Downs and Highbury in the Lea-Hackney Brook valleys.

There has been much written and discussed about the possibility that some of these localities may represent additional events as yet unrecognised in the British Pleistocene succession (e.g. Sutcliffe, 1975; Bowen, 1987). This is a consequence of the altitudinal distribution and palaeontological assemblage variation between individual sites assigned to the Ipswichian Stage. One of the aims of this research project was therefore to attempt to clarify local unit relationships to elucidate the problem. There is certainly a possibility that sites containing similar fossil assemblages might represent more than one event, as suggested by critics of palynologically-based biostratigraphy. For this reason some sequences may yet prove to represent hitherto unproven additional events. It is however, worth noting that very few of the sites studied in the Lower Thames had been fitted into any regional geological scheme for the area, making additional 'stage' claims of little merit. The best attempt at a synthesis of the evidence was that by Hollin (1977), who attempted to explain the evidence for high sea level during the interglacial stages.

It seems most likely however, that most, if not all of these sequences do indeed represent the Ipswichian Stage, the complexity and impact of which has not been previously fully appreciated. This conclusion is based on the palaeontology as a whole, the stratigraphical position and relationship to the palaeogeography of all the sites in the area. The abundance of such sites may have arisen as a consequence of widespread infill of the Lower Thames valley system by fine sediments during substantial contemporary eustatic sea level rise possibly to about 10 m OD. Beyond the influence of saline water in-

flux, freshwater sediments accumulated. On the basis of the fossil evidence assembled, this accumulation appears to have continued at least in the Thames Valley itself, until very late in the stage and possibly into the early Devensian to judge from the sequences at Crayford and West Thurrock.

(h) West Thurrock Gravel

Following a period of downcutting gravel and sand of characteristic braided river character was deposited at West Thurrock (type section: TQ 597 779). Here the gravels abut the temperate stage estuarine sediments and form an aggradational unit that is altitudinally distinct from other members in the area. Equivalent aggradations may be present at Crayford-Erith and upstream in the East London area. It is not certain precisely how this unit relates to those upstream. However, it occurs in the same stratigraphical position as the Reading Town Gravel of the Middle Thames of which it could be the correlative. On this basis it may be of broadly early Devensian age.

(i) East Tilbury Marshes Gravel

In the area east of Tilbury gravel quarrying in the Thames' floodplain at 0-1 m OD has shown that a unit of gravel and sands disposed into braided river type facies occurs (type section: TQ 688 784). The unit can be traced as remnants upstream where it underlies much of inner south London, such as Southwark, Camberwell, New Cross and Greenwich. In this area it is continuous with the Middle Thames' Kempton Park Gravel, that is known to be of Middle Devensian age. The unit also has tributary remnants in the Lea valley, but possibly also in the Roding.

(j) Shepperton Gravel

This final gravel and sand member has not been seen at exposure or sampled since it underlies the modern valley continuously throughout the region. Tributary equivalents have also been found and studied particularly that in the Darent valley. Here the deposits comprise gravels and sands showing facies in every respect similar to those of older members and therefore of similar origin. The stratigraphical position of this Lower Thames gravel member, underlying Flandrian Stage alluvial sediments in the valley bottom, strongly suggests that it is the lateral equivalent of the Late Devensian Shepperton Gravel of the Middle Thames.

(k) Tilbury Alluvium

The Flandrian sediments of the Lower Thames valley were not part of this research project, since they have been studied in detail and published recently by Devoy (1979). They record the interaction of fresh and saline estuarine sedimentation initiated by the Flandrian eustatic sea level rise that drowned the valley.

Conclusions

This study has demonstrated the complexity of the sequence represented in the Lower Thames region, particularly that resulting from sedimentation from initiation of the valley in the late Anglian up to the Flandrian Stage. Through this it is now possible to link the sequences in the Middle Thames with that in eastern Essex (Table 1), north Kent and ultimately the southern North Sea. It has also provided important new palaeontological records from several new sites, and further increased precision in the relationship of Palaeolithic archaeology to the geological succession.

Acknowledgement

PLG and CAW wish to acknowledge the support of a NERC research grant for this work.

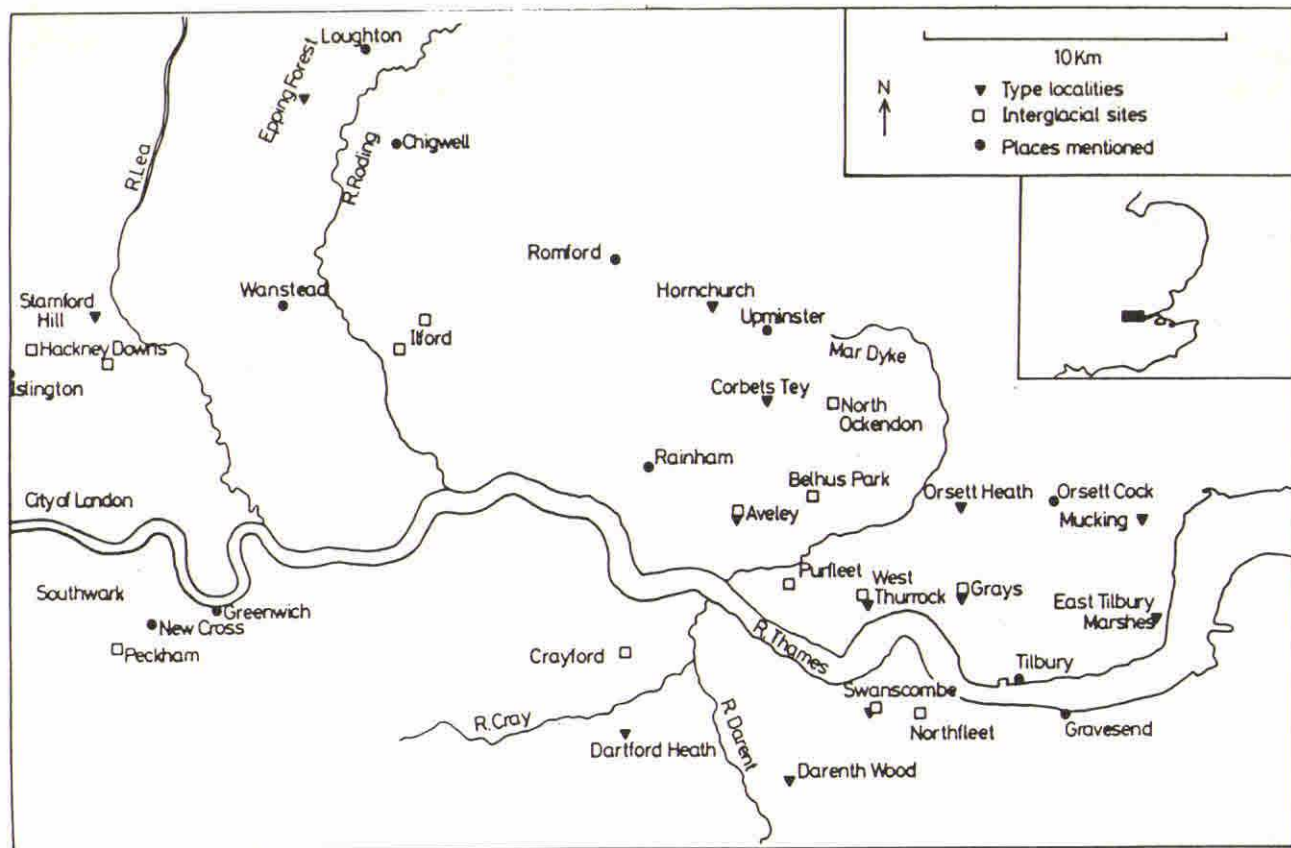


Figure 1 Location map showing the localities mentioned in the text.

Table 1 Proposed correlation of Lower Thames units with those in neighbouring parts of the Thames Valley.

Middle Thames (Gibbard, 1985)	Lower Thames (this work)	East Essex (Bridgland, 1983, 1988)	Stage
Staines Alluvial Deposits	Tilbury Alluvium ¹	alluvium	Flandrian
Shepperton Gravel	Shepperton Gravel	(offshore)	Late
Kempton Park Gravel	East Tilbury Marshes Gravel	(offshore)	Middle Devensian
Reading Town Gravel	West Thurrock Gravel	?	Early
Trafalgar Square deposits	Aveley/West Thurrock/ Crayford Silts and Sands		Ipswichian
Spring Gardens Gravel	?Sandy Lane Sand	?	?late
Taplow Gravel	Mucking Gravel	Barling/Dammer Wick Gravel	
Lynch Hill Gravel	Corbets Tey Gravel	Rochford Gravel	Wolstonian
Boyn Hill Gravel	Orsett Heath Gravel Barnfield Middle Gravel Barnfield Lower Loam Barnfield Lower Gravel	Southchurch/ Asheldham Gravel Clacton Channel sediments etc	?early Hoxnian
Black Park Gravel	Darford Heath Gravel initiation of Lower Thames valley	? -----	late Anglian
pre-diversion members	Epping Forest Formation etc.	pre-Thames Medway members	

¹ Devoy (1979)

REFERENCES cited

- Allen, P, Cheshire, D A, and Whiteman, C A. In press. Events on the southern margin of the Anglian ice sheet. In: Ehlers, J, Gibbard, P L, and Rose, J (eds.). *Glacial deposits in Britain and Ireland*. Balkema: Rotterdam.
- Bowen, D Q. 1978. *Quaternary Geology*. Pergamon Press: Oxford. 221 pp.
- Bridgland, D R. 1983. Eastern Essex. In: Rose, J (ed.). *Diversion of the Thames field guide*. Quaternary Research Association: Cambridge, 170-184.
- Bridgland, D R. 1988. The Pleistocene fluvial stratigraphy and palaeogeography of Essex. *Proceedings of the Geologists Association* (in press).
- Bridgland, D R, Gibbard, P L, Harding, P, Kemp, R A, and Southgate, G. 1985. New information and results from recent investigations at Barnfield Pit, Swanscombe. *Quaternary Newsletter*, 46, 25-39.
- Devoy, R J N. 1979. Flandrian sea level changes and vegetational history of the lower Thames Estuary. *Philosophical Transactions of the Royal Society of London*, B285, 355-410.
- Dewey, H, Bromhead, C E N, and Dines, H G. 1924. The geology of the country around Dartford. *Memoir of the Geological Survey of Great Britain*.
- Dines, H G, and Edmunds, F H. 1925. The geology of the country around Romford. *Memoir of the Geological Survey of Great Britain*.
- Gibbard, P L. 1979. Middle Pleistocene drainage in the Thames Valley. *Geological Magazine*, 116, 35-44.
- Gibbard, P L. 1985. *Pleistocene history of the Middle Thames Valley*. Cambridge University Press. 155 pp.
- Hare, F K. 1947. The geomorphology of a part of the Middle Thames. *Proceedings of the Geologists' Association*, 58, 294-339.
- Hedberg, H D. 1976. *International Stratigraphical Guide*. J. Wiley and Sons: New York.
- Hinton, M A C. 1900. The Pleistocene deposits of the Ilford and Wanstead district. *Proceedings of the Geologists' Association*, 16, 271-281.
- Hinton, M A C, and Kennard, A S. 1901. Contributions to the Pleistocene geology of the Thames Valley. The Grays Thurrock area, part 1. *Essex Naturalist*, 11, 336-370.
- Hollin, J. 1977. Thames interglacial sites, Ipswichian sea levels and Antarctic ice surges. *Boreas*, 6, 33-52.
- Holmes, T V. 1892. The new railway from Grays Thurrock to Romford. Sections between Upminster and Romford. *Quarterly Journal of the Geological Society of London*, 48, 365-372.
- Kemp, R. 1985. The decalcified Lower Loam at Swanscombe, Kent: a buried Quaternary soil. *Proceedings of the Geologists' Association*, 96, 343-355.
- King, W B R, and Oakley, K P. 1936. The Pleistocene succession in the lower part of the Thames Valley. *Proceedings of the Prehistorical Society*, 2, 52-76.
- Sutcliffe, A J. 1975. A hazard in the interpretation of glacial-interglacial sequences. *Quaternary Newsletter*, 17, 1-3.
- West, R G. 1969. Pollen analyses from Aveley and Grays, Essex. *Proceedings of the Geologists' Association*, 80, 271-282.
- Whiteman, C A. 1987. Till lithology and genesis near the southern margin of the Anglian ice sheet in Essex, England. In: J J M Van der Meer (ed.). *Tills and glaciotectonics*. Balkema: Rotterdam, 55-66.
- Wiseman, C R. 1978. *A palaeoenvironmental reconstruction of part of the Lower Thames terrace sequence based on sedimentological studies from Aveley, Essex*. MSc thesis City of London Polytechnic.

Wooldridge, S W, and Linton, D L. 1955. *Structure, surface and drainage in southeast England.* George Philip: London.

Wymer, J J. 1985. *The Palaeolithic sites of East Anglia.* Geobooks: Norwich. 440 pp.

Subdepartment of Quaternary Research
Botany School
University of Cambridge
Downing Street
Cambridge
CB2 3EA
England

Earth Sciences Division
Nature Conservancy Council
Northminster House
Peterborough
PE1 1UA
England

A LAST ICE AGE MOLLUSC FAUNA FROM CHESSELLS, GLOUCESTERSHIRE

P F Whitehead

The purpose of this note is to record briefly further biotic evidence from the Cotswold limestone gravels, which form sometimes isolated patches dissected by the scarp and dip streams. Richardson and Sandford (1960) accorded these gravels a pre-last ice-age date, whilst Brown et al (1980) refuted this and claimed a last ice-age date for them. I regard the latter view as being undoubtedly correct; furthermore, that view is also supported by a 14C date (Whitehead, 1979).

The Sections at Chessells

On October 14th 1981 I noted a hydraulic excavator undertaking reclamation work at Chessells at SP 183 234 in a gravel pit to the south of the Fosse Way.

A generalised section (I have a detailed photographic record) was composed entirely of roughly bedded to unbedded subrounded coarse Oolitic Limestone gravel, cryoturbated near its surface at 136 m OD. At my request the excavator cut a trial pit 6.5 m deep, without revealing any variation in the basic composition of the gravels. Distributed throughout the depth of the gravels were a number of beds and lenses of fine striped silts, (so-called 'loess-loams'), fine sands and clays, sometimes with ferruginous mottling, and bearing shells of molluscs.

A fragment of bone of an Elephantid was picked out of the gravels, at a depth of 6.0 m.

The Mollusc Fauna

Two samples of mollusc-bearing sediment were removed for study.

Sample A

5.62 kg fine orange sand in clayey matrix from lens up to 29 cm thick, 3.5 m from surface of gravels.

Sample B

1.92 kg cream/buff silt with some sand grains (quartzose) from lens up to 8 cm thick, 2.6 m from surface of gravels.

Wet sieving of the sediment through a 250 micron sieve was undertaken during July 1987 and the following taxa was recorded.

	A	%	B	%
<i>Lymnaea tuncatula</i> (Müller)	1	0.2	3	0.4
<i>Succinea oblonga</i> Draparnaud var <i>elongata</i> Sandberger	354	85.4	38	5.7
<i>Pupilla muscorum</i> (Linné)	55	13.2	459	69.7
<i>Deroceras</i> spp.	—	—	41	6.2
<i>Trichia hispida</i> (Linné)	—	—	119	18.0
<i>Pisidium casertanum</i> (Poli)	1	0.2	—	—
<i>Pisidium nitidum</i> Jenyns	4	1.0	—	—
	<hr/> 415		<hr/> 660	

Climate, Environment and Habitat

There are no taxa that are indicative of climate. The absence of cold stenotherms may have significance only at the level of microclimate. The fauna is species-poor and is likely to be entirely characteristic of

specialised environmental conditions. The silts and clays from which the molluscs were collected are the end products of weathered rock which accumulated in shallow depressions in the gravels and were entirely devoid of organic matter; frequently they were short-lived, and would doubtless have been overrun by the mass-movement of sediment in a periglacial environment.

The variation in frequency of species in the two samples may have no significance viewed against dynamically changing conditions within an unstable mass of gravel. The habitat almost certainly has no modern analogue in Britain today, and is probably a feature of cold climates (see Sparks, 1957, p.157), having occurred frequently during the last ice-age in the limestone gravels of the Main Terrace of the Worcestershire Carrant Brook (Whitehead, unpub.).

S. oblonga elongata is a hygrophilous mollusc tolerant of generally exposed environments, often burying itself in mud, and the species is now very localised in Britain. It is the same as what has in the past been called *Oxyloma pfeifferi* (Rossmassler) var. *schumacheri* Andreae, an evidently undescribed form. It is frequently a feature of habitats colonised by few species of invertebrates, that these colonists are able to reproduce rapidly to take advantage of favourable conditions. Thus in Sample A and Sample B, 81% and 71% respectively of the *Succinea* were immature, 42% and 63% of the *Pupilla* were immature, and in Sample B, 77% of the *Trichia* were immature.

Both *Pisidium casertanum* and *P. nitidum* are evidently eurytopic and eurythermic species.

That this fauna is characteristic of a strict environmental regime is witnessed by reference to that described by Brown et al from the correlating gravels at Bury Barn, which mirrors the Chessells fauna convincingly.

REFERENCES

- Brown, R C, Briggs, D J, and Gilbertson, D D. 1980. Depositional Environment of Late Pleistocene Terrace Gravels of the Vale of Bourton, Gloucestershire. *Mercian Geol.* 7: 4: 269-278.
- Richardson, L, and Sandford, K S. 1960. Great Chessells Gravel Pit near Bourton-on-the-Water, Glos., and the occurrence of mammalian remains. *Proc. Geol. Assoc. Lond.* 71: 40-46.
- Sparks, B W. 1957. The Taele Gravel near Thriplow, Cambridgeshire. *Geol. Mag.* 94: 3: 194-200.
- Whitehead, P F. 1979. Wild Bovidae from the Evesham Area, with notes on the status of Giant Oxen (*Bos primigenius* Boj.) in Britain *Vale of Evesham Hist. Soc. Research Papers.*: 7: 1-8.

Paul F Whitehead
Moor Leys
Little Comberton
Persnore
Worcestershire WR10 3EP

QN: field report

Field excursion and symposium report.

LATE QUATERNARY SEA LEVELS AND CRUSTAL DEFORMATION, SCOTLAND

September 9–15, 1988

INQUA Subcommission on Shorelines of N W Europe. Leaders, Drs A G Dawson and D G Sutherland and Professor D E Smith

For a novice in matters of the Scottish Quaternary, for whom the periglacial deposits and interglacial raised beaches of the South of England and Wales provide the norm, the contrast provided by this excursion was a thrilling experience. There is no analogy nearer than Norway and Canada.

To set the scene: Associated with the melting of the Devensian ice, isostatic uplift over much of Scotland, centred on Rannoch Moor, exceeded the regional eustatic rise of sea level that submerged the southern shores of our island, bringing above sea level a series of isostatically tilted shore line features which have no equivalent farther south, where their continuations pass below present sea level. Chronologically, also, there is a great difference. Whereas, in the south, raised shoreline and marine deposits have dates of hundreds of thousands or a few million years, back to the Pliocene, the Scottish part of the story, as seen during the excursion, covers only the last 20 000 years. The freshness of the raised beaches, the old sea cliffs with their many caves, of the raised estuarine deposits of the Firth of Forth, known as 'carse' and of the morainic and outwash deposits, could lead one to believe that it was only yesterday that glaciers covered the land, that waves reached pebble-footed cliffs now many metres above the sea, and when whales and seals (as shown by the fossil evidence) could swim up the Firth of Forth far west of Stirling. That the last glacial advance in the area (the Loch Lomond readvance, Younger Dryas, c.11–10 000 years BP) was less extensive than the Devensian maximum that preceded it, provides rich scope, from the evidence of wave-cut cliffs in till and of marine deposits overlain by glacial or glaciifluvial deposits, of reconstructing a more detailed chronology than would be possible in a uniformly glaciated area.

Our leaders were each specialists in different parts of the area of the excursion, David Smith in the carse area in the upper part of the Firth of Forth, Donald Sutherland in the S W Highlands, and Alastair Dawson in the islands of Islay and Jura, the sheltered estuary of the first mentioned area contrasting strikingly with the rocky coastline of the islands.

For the purpose of describing the excursion the climatic and sea level sequence of the area is simplified as follows:

- 1 Maximum Devensian ice advance, 20–18 000 years BP covering most of the area; Perth Stage; raised rock platforms of the Inner Hebrides; deglaciation by about 12 000 years BP.
- 2 Late glacial interstadial, glacier free.
- 3 Loch Lomond readvance (Younger Dryas), Mainland only. Main Rock Platform, C.11–10 000 years BP.
- 4 Main Postglacial shoreline (carse) c.8300–6500 years BP. Shoreline progressively lower.
- 5 Present day sea level, machair formation on western side of Islay.

DIARY

Saturday, September 10th, Leader: David Smith

Near Callander, Perth Stage moraine deposits.

Inchie, Lake of Menteith; End moraine zone deposits of Loch Lomond readvance overlying shelly marine clays with radiocarbon date of $11\,800 \pm 170$ years.

Carse. Broad level expanse of estuarine deposits, post-dating Loch Lomond readvance, Holocene. Peats and clays in cores and in river bank and drainage ditch sections. Many records of remains of whales and seals, especially from 19th century.

Flanders Moss (bog).

Sunday, September 11th Symposium at the University of Stirling

D E Smith (UK) Introduction

K Amundsen (Norway) Late Weichselian relative sea levels in S W Norway.

S Jennings (UK) The rate of relative sea level rise in E Sussex during the Holocene.

H Granja and G S de Carvalho (Portugal) Quaternary sea-level changes in N W Portugal.

C Firth (UK) Isostatic depression during the Loch Lomond Stadial—evidence from the Inner Moray Firth.

G Linke (W Germany) Dimension and velocity of the tectonic movement during the Quaternary in the Cuxhaven area, southern North Sea coast.

K S Peterson (Denmark) Holocene coastal development reflecting sea level rise and isostatic movement in N W Jutland, Denmark.

M Eronen (Finland) Last interglacial, interstadial and post-glacial sea levels in Eastern Fennoscandia.

S Björk (Sweden) Shore displacement curves in southern Sweden.

C Freden (Sweden) Swedish shore lines.

Monday, September 12th Lochgilphead—Crinan area, Leader: Donald Sutherland

Peacock's Clyde Beds deposit at Lochgilphead. Till overlain by a shelly marine deposit with a radiocarbon date of 12 100 years in its upper part.

The Ford-Kilmartin Valley with river and marine terraces; kettle holes in deposits of Loch Lomond readvance.

Moine Mhor. A broad west coast embayment with Lateglacial and Holocene marine, estuarine and fluvial deposits reminiscent of the Firth of Forth carse. Fortified island hill called Dunadd provides a magnificent view of the flatness of this area. Marine shells in river bank section.

Tuesday, September 13th Leaders: Alastair Dawson and Doug Benn

Island of Islay

View from Borichil Mor near Bridgend. Hummocky moraine, earlier than Loch Lomond readvance, (which did not extend to Islay).

Machir Bay, W Islay. High-level (up to 80 m OD) glaciomarine sediments of Devensian age.

Kilchiaran, W Islay. Striated bedrock and low-level glaciomarine sediments. Visit to Bowmore whisky distillery.

Wednesday, September 14th Leader: Alastair Dawson

Island of Jura.

Expedition by boat from Port Askaig (Islay) along the south west coast of Jura to Loch Tarbert, landing firstly near Rubh'an t-Sailein on the north shore (where five red deer hinds looked briefly down from the cliff top above the Main Rock Platform, before running away); then near Glenpatrick on the south shore.

This was a very special occasion indeed. The old shore lines of this part of the coastline, so familiar from student reading of Holmes' *Physical Geology* and yet so inaccessible, are spectacular almost beyond belief. Following the structures from the sea, active present day beaches merge into raised pebbly

deposits of the Main Postglacial Shoreline, behind which is a discontinuous cliff line with many old sea caves (the Main Rock Platform), capped at about 30–35 m by the High Platform, with extensive spreads of cobbles, remarkably still unvegetated except for some lichen growth on their upper surfaces. This backed by a higher cliff.

The great width of the Main Rock Platform, supposed to have formed in less than a thousand years during the Younger Dryas, was a topic of lively discussion. If this had developed so quickly, why had so little material fallen onto the High Platform beach from the earlier cliff behind? On the other hand, if the Main Rock Platform had been re-exposed from an earlier transgression, how had the Tertiary dykes which form such prominent ridges upon it survived so well?

The sea caves (of which the leader knows over 90) proved to be of unexpected palaeontological interest—not that they contained any fossils but through the analogy to palaeontological processes that the deer and goat bones accumulating in them at the present day provide. The largest cave has a wall across its entrance and great quantities of ungulate dung on the floor behind. In another were the skeletons of three red deer and two goats that had apparently died while sheltering there. Some of the bones had been chewed by red deer to show the forked ends so characteristic of deer-chewed bones. There is a record in a German publication of bones like this excavated from a Pleistocene deposit in a cave in Crete being attributed to the 'osteokeratic culture' of Palaeolithic Man! I would like to return to record this Jura analogy in greater detail in the future.

One last remarkable feature was observed from the boat on the return journey to Port Askaig. This is the ridge of boulders known as Sgriob Caillich—the Witches' Slide. It is a Devensian medial moraine from Beinn an Oir, one of the Paps of Jura.

In conclusion, grateful thanks from all the party to the organisers for a very special field excursion.

Copies of the excellently produced field guide (which, among other data, includes discussion of the possible processes of formation of the Main Rock Platform) are still available, price £4.00 + postage from Dr A Dawson, Department of Geography, Coventry Polytechnic, Priory Street, Coventry CV1 5FB.

Antony Sutcliffe
British Museum (Natural History)

MINERALOGICAL AND GEOCHEMICAL STUDIES OF TILLS IN SOUTH-WESTERN SCOTLAND

Mamdouh A. A. Abd-alla

Ph.D. Thesis, Department of Geology, University of Glasgow, 1988

Till deposits of the NW Glasgow area and Northern Ayrshire were studied. In Part I, previous research into Quaternary problems in these areas and the nature, origin and classification of till deposits are outlined, followed by a statement of the aims of the project and the techniques.

Part II contains detailed data obtained from grain-size, clay mineralogical and major and trace element analyses of the matrices of three categories of NW Glasgow tills—Red, Weathered Grey and Grey. The Red and Weathered Grey tills have coarser-grained compositions than the Grey till. Mean size and skewness are the most diagnostic grain-size parameters for distinguishing between Red and Weathered Grey till on one hand and Grey till on the other. All these categories contain kaolinite, illite and vermiculite. Chlorite is present only in the Grey till. The percentage of kaolinite is much lower and the percentage of vermiculite is higher in the Red till than in the Weathered Grey till. Three probable modes of origin of the clay minerals in the tills are proposed: direct inheritance, pre-glacial weathering and pedogenesis since till deposition.

All three categories of till have a high SiO_2 content, which is consistent with the tills having sources in the local sandstone bedrocks. With the exception of Zr, all the trace elements are preferentially concentrated in the silt and clay fractions. Zr appears to occur both in clay minerals and in the sand fraction as detrital zircon. Sr is concentrated in the calcium minerals and Ba in the K-feldspars.

Study of vertical profiles shows that leaching of fine-grained material and weathering of clay minerals are common. Weathering in the Red till is difficult to detect. However, the amount of vermiculite increases upwards in the profile at the expense of illite. In the case of profiles through both Grey and Weathered Grey till, chlorite disappears, and the amount of vermiculite increases up the profile at the expense of both illite and chlorite. The ratios $\text{Ga:Al}_2\text{O}_3$, MgO:Ni , FeO:Co and Ni:Co can be used to detect weathering trends in both Grey and Red till profiles.

Mineralogical and geochemical studies of bedrock in the NW Glasgow area, showing the presence of chlorite in Carboniferous shales and sandstones and its absence in Devonian (O.R.S.) sandstone, indicate that the Grey till was derived largely from Carboniferous shales and sandstones, and the Red till largely from Devonian sandstones.

Part III contains detailed data obtained by similar methods applied to the matrices of tills and associated Quaternary deposits in Northern Ayrshire. Marked similarities in the properties of samples of shelly till from five locations suggest similar sources for the shelly till at these locations. The shelly till has a high SiO_2 and a low clay content, suggesting that the proportion of shell-bearing marine clay in the shelly till is not nearly as great as previously thought. The high SiO_2 content in both the shelly and non-shelly tills of Northern Ayrshire reflects quartz-rich rocks for these tills. The matrices of non-shelly tills have higher CaO and CO_2 contents than the matrix of the shelly till. This may be due to the presence of finely ground limestone in the non-shelly till matrices.

Comparison of the properties of shell-bearing marine clays at Afton Lodge with those of the shelly till of N Ayrshire as a whole and with a shell-bearing deposit at Greenock Mains shows clearly that the last-mentioned is not a shelly till as formerly thought but is a marine sediment similar in composition to the deposit at Afton Lodge.

The matrices of Upper and Lower grey tills at Sourlie are similar in composition, indicating similar sources, probably mainly local Carboniferous shales and sandstones.

Finally, the thesis applies the results obtained to Quaternary stratigraphy. The properties of the matrices of red and grey facies of the proposed 'Wilderness Till' Formation of the Glasgow area can now be defined. The presence of Weathered Grey till overlain by Red till in the NW Glasgow area suggests at least a short period of exposure of Grey till before deposition of Red till on top of it. In Ayrshire, the discovery of shell-bearing marine deposits (at Greenock Mains) at c.180 m above present sea level and c.30 km inland from the present coast means that recent views regarding the maximum elevation and extent of Quaternary marine incursion in Ayrshire may have to be modified. The presence of these sediments also implies that the shelly till may have been derived from pockets of shell-bearing deposits picked up locally within inland Ayrshire rather than from the Firth of Clyde. The presence of shelly till at any given location, therefore, may not be indicative of any particular direction of ice movement, as formerly thought.

THE GENESIS OF THE NORTH EAST NORFOLK DRIFT

Jane K. Hart

Ph.D. Thesis, University of East Anglia, 1987.

This thesis has two aims, these are the study of:

- a) the way in which glaciers deform sediments, in particular subglacial sediments, with evidence from both modern and ancient environments.
- b) the deformational histories and sedimentary environments of the glacial deposits of north east Norfolk, and the relationship of these deposits to other drifts of East Anglia.

Three types of glaciotectionic deformation were defined and models produced for their formation: subglacial—beneath the glacier, proglacial—at the glacier margin, paraglacial—associated with dead ice. A modern analogue for subglacial deformation was studied at Cora Island in Spitsbergen. It was shown that sediment beneath the glacier was deformed by simple shear, and that deformation occurred when the sediments were water saturated. Superimposed on the subglacial deformation styles were later proglacial and paraglacial deformation.

It was shown that proglacial deformation results in pure strain and compressive deformation, whilst subglacial deformation results in simple shearing and extensional styles of deformation. These zones within the basal sediments are related to zones within the glacier itself. It is also shown how the processes in the subglacial environment are similar to those in a "hard rock" shear zone and thus the resultant diamicton appears similar to a rock found in a dynamic metamorphic rock.

However, there are differences because in the subglacial shear, deformation and *deposition* occur. As the glacier moves over a point in space so the bed conditions change, compressive to extensional, erosion to deposition, rigid/bed to soft bed, thus the resulting diamicton is a combination of these processes, with local material becoming a less dominant source of sediment supply as time increases. This is best displayed in the Laminated Diamicton at West Runton. It was concluded that deformed sediments such as these are very common and thus a reinterpretation will be needed of many Quaternary sites.

By combining all sedimentology and structural geology of the area a new glacial history of North east Norfolk and East Anglia was produced and the North Sea Drift Formation proposed. It was concluded:

- a) There were two northern ice advances separated by at least 2000 years (this time period is defined as the Trimmingham Sub-stage) during which time proglacial lakes developed and a glacier advanced from the south.
- b) Late Anglian/early Hoxnian deposits were found overlying the Cromer Ridge (which was shown to be in part a push moraine) at Trimmingham, which dates the formation of the Cromer Ridge and shows that there were late Anglian North Sea Drift glaciers in the North Norfolk area penecontemporaneously with Lowestoft Till glaciers farther east and south.

PAST AND PRESENT MIRE COMMUNITIES OF THE NEW FOREST AND THEIR CONSERVATION

Michael John Clarke

PhD Thesis, Department of Geography, University of Southampton, 1988

The origin, development, present status and conservation of the New Forest valley mires are investigated. Existing hypotheses of peat inception are tested and methodological problems are examined. A null model for peat inception has logical primacy over other causal hypotheses of mire origins and provides a framework for investigation. The proximate cause of valley mire formation is related to the present water regime. The stratigraphic record may be much simpler than the real history of New Forest mire communities.

Methods of macrofossil analysis are critically reviewed and are developed for vegetative remains. Valley mire development is investigated from the Lateglacial. The direction of succession is differentiated within the mire system and most communities have a high probability of self-replacement. Discussion is extended to the theoretical basis of palaeoecology.

Mire vegetation composition and the heathland transition are studied using ordination and classification techniques. The community types obtained are compared with other classificatory schemes. Although composition is closely related to environment, internal features of the vegetation are also important in determining the main gradients of floristic variation.

The nature conservation significance of the valley mires is discussed, and the ecological characteristics used in evaluation are reviewed. Past and present management impacts are assessed. Grazing is important in maintaining the diversity of open mire communities, especially where *Molinia* is potentially dominant. The constraints on the grazing system are reviewed and it is concluded, from ecological and behavioural evidence, that the mires play an important role during limiting periods of the year. Drainage continues to damage the nature conservation interest of the mires—yet may be counter-productive or neutral in benefits.

QN: book review & reference

PALEOSOLS—THEIR RECOGNITION AND INTERPRETATION

Edited by V Paul Wright. Blackwell Scientific Publications, Oxford, 1986, ISBN 0-632-01336-2, 315 pp, £27.50

his book is intended to bring together an up-to-date review of palaeosol studies throughout the globe (albeit with an emphasis on Britain), across a wide span of geological time, and in a wide range of geological contexts. The book consists of nine chapters: two general reviews of the contribution made by soils to the interpretation of the Earth's biological record and the interpretation of geological processes (Retallack, Macphail); two reviews of Quaternary palaeosol studies in specific regions (Campbell, Kemp); and five case studies of pre-Quaternary palaeosols formed within a particular period of geological time (Allen, Percival, Francis, Atkinson, Kraus and Bown). Without exception, each of the chapters is informative, well written, and makes a contribution to geological science.

The chapter by Retallack is an exciting and challenging exploration of the evidence of Earth history that may be derived from palaeosols. Fundamental topics such as origin of the Earth's early atmosphere, afforestation of the land and the development of grassland in dry continental interiors are investigated. In particular, attention is drawn to the fact that fossil soils may provide the best evidence by which to explain the proportion of oxygen in the Earth's atmosphere (Holland, 1984). Figure 15 (p.41) neatly summarizes the first occurrence of the main soil features and orders, emphasizing the antiquity of some (inceptisols, vertisols), and the very recent development of others (mollisols).

Chapters 3–6 consider pre-Quaternary palaeosols and are arranged roughly in chronological order. In a review of vertisols form the Old Red Sandstone of Wales and the Welsh Borderland, Allen emphasizes their relative abundance, their persistence as pedological features capable of surviving diagenesis, and their susceptibility to standard micromorphological analysis. Analogy is drawn between the internal stress pattern of these soils and the stress pattern associated with the development of *gilgai* currently forming in warm dry regions. The results of this work form the basis of an alluvial model for parts of the Devonian involving calcrete development in fine-grained overbank sediments with occasional channel sand-bodies.

In Chapter 3, Percival describes podzols, luvisols and podzoluvisols from the Upper Carboniferous of northern England. Beds familiarly known as ganisters and seat earths are identified respectively as Ae and Bt horizons of albic soils, and provide evidence that is used to interpret the climate of the period concerned. Chapter 4 by Francis, consists of a review of the 'Dirt Beds' of the Upper Jurassic of southern England. As a result of detailed descriptions and analyses, these units are considered to represent rendzinas developed across an area of low relief with an underlying calcrete horizon. This evidence is used to reconstruct the soil water and climatic history of the area.

In Chapter 5, Atkinson considers soils within Eocene basin sediments of northern Spain. In this study colour forms the prime evidence for soil development. Problems of interpreting the soils are compounded by the effects of diagenetic CaCO_3 . The parent material consists of coarse- to fine-grained overbank sediments with soil variability considered to be a function of drainage and duration. On this basis, a catenary sequence is proposed, although the actual relationship of soil types, one to another is not described, and the stratigraphical control is far from secure. Finally, in Chapter 6, Kraus and Bown take the case of exceedingly well exposed Triassic and Eocene soils from Arizona and Wyoming to evaluate the role of pedogenesis in the interpretation of alluvial stratigraphy. In many respects this chapter takes further many of the conclusions proposed in earlier chapters. It attempts to develop a conceptual framework in which stasis (during which pedogenesis occurs) is dominant and aggradation and incision (during which the evidence for river activity occurs) has a minimal role.

Chapters 6 and 7 review Quaternary palaeosols and palaeosol research in New Zealand and Britain. In both cases the palaeosol studies suffer from the problems caused by rapid erosion and terrestrial sedimentation in regions of irregular terrain. In New Zealand the palaeosol studies are facilitated by the development of extensive tephra and loess deposits, both of which provide a conditions suitable for soil development and preservation, and also provide an independent stratigraphic control. Nevertheless, Campbell's review still emphasizes the problems associated with the truncation of soil profiles, diachroneity of particular soil units and a frequently unresolved stratigraphic position. Similar problems emerge in a rather concise, but perceptive, review of British Quaternary soils by Kemp. The point is made that despite the very large numbers of soil studies in Britain, only four palaeosols deserve the status of soil stratigraphic units (Valley Farm, Barham, Troutbeck and Pitstone Soils), and in three of these cases, preservation is dependent upon burial beneath regionally extensive glacial deposits (Valley

Farm, Barham and Troutbeck Soils) (Rose et al., 1985). Throughout, reference is made to the discontinuous nature of soil fragments and the fact that most palaeosol profiles survive as truncated remnants.

The final chapter by MacPhail provides a wide ranging review of Holocene soils in an Archaeological context. Because the soils described in this chapter show little effect of diagenesis and can be dated with a high resolution, and related to processes that can be simulated such as ploughing and tree throw, these studies are especially important. For instance the rates of processes such as podzolization and leaching can be estimated with a high degree of accuracy, and can be related to reasonably well documented chemical (i.e. acidity) and physical (i.e. ploughing, colluviation) processes. In these respects this chapter is of much wider application than is perhaps apparent, and gives insight into a wide range of palaeopedological situations.

In the Preface to the book the Editor states that "the study of paleosols now involves two 'camps', the Quaternary and the pre-Quaternary groups" (p.xiv) in which "research into pre-Quaternary paleosols is only just beginning and much is to be learned from studying the methodology of those working on Quaternary paleosols" (p.xiv). On examination of the contents of the book the distinction between the status of Quaternary and pre-Quaternary paleosols is far from simple. Both sets of investigators apply a wide range of techniques involving chemical analysis, physical profile description, micromorphology and stratigraphic context. Quaternary palaeopedologists appear for more familiar with pedological terminology, whereas pre-Quaternary palaeopedologists tend to spell-out the basic pedological processes and environmental reconstructions. In some cases, such as that of Percival's work on the Carboniferous of northern England, definitions of Podzols, Luvisols and Podzolusols, are not necessary, but probably reflect the expected expertise of those familiar with Carboniferous stratigraphy. In a similar fashion, Atkinson's attempt to justify the catenary succession within the Eocene subsiding basin of northern Spain puts a major effort into demonstrating a regional catena, but fails to consider local catenary sequences related to the alluvial relief which could well be an equal, or even greater significance.

Perhaps the greatest contrast between the Quaternary and pre-Quaternary studies is the nature of the soils which are the subject of the research. Those of pre-Quaternary age which are described are mainly part of alluvial sequences which often extend across very large areas and represent relatively long periods of time. In these cases the great value of the palaeopedological study comes from its contribution to alluvial stratigraphy and architecture. In contrast, the Quaternary paleosols are usually discontinuous and highly variable in type. This is a result of the wide range of topographical, lithological and climatic controls. This point is also illustrated by the micromorphological studies referenced in the articles, where the detail associated with the Quaternary soils, contrasts with the relative simplicity of the pre-Quaternary soils.

Irrespective of the age of the soils, certain common factors emerge from the study of palaeosols. Firstly there is the inevitable bias to soils which have a high survival potential. In this respect vertisols tend to dominate the descriptions of soils developed in environments with a net moisture deficit, whereas the Bt horizon is an equally persistent symbol of eluviated soils Argillic horizons are also given attention because of their potential for microstratigraphy (Kemp, 1985a). Red colouration is another property that is given considerable attention throughout the book, if only because it is conspicuous. However this feature is considered to be caused by pedological haematite (a property that has only rarely been tested (Kemp, 1985b)), and therefore may be of palaeoclimatic significance.

Overall the book is very attractively presented with few typographic errors. The captions of Figures 14 and 15 on pages 107 and 108 are transposed and Figure 14 is on its side. Generally the photographic reproduction is satisfactory, although in some cases the detailed pedological information is not clear. Table 2, p.226-227 gives a radiocarbon age of 150 000, which requires some explanation! However, these are trivial points and taken together the package of papers provide a very useful review of the study of palaeosols. The attention, given by the Editor and other authors concerned with pre-Quaternary soils, to the contrast between the study of Quaternary and pre-Quaternary paleosols is far from obvious. The greatest differences are not so much in the approaches as in the nature of the evidence, and in particular the complexity caused by the wide range of environments and high rates of environmental change in the Quaternary, combined with relatively fine-tuned temporal resolution. However, in view of the current concern with global change, and the need to predict the future responses of soils to rapid changes in the environment, the justification for this type of study by Quaternary scientists is self-evident, and it is perhaps this evidence to which palaeopedologists should be giving most attention.

REFERENCES

- Kemp, R. A.** 1985a. Soil Micromorphology and the Quaternary. *Quaternary Research Association Technical Guide*, 2, 1-80.
- Kemp, R. A.** 1985b. The cause of redness in some buried and non-buried soils in eastern England. *Journal of Soil Science*, 36, 329-334.
- Holland, H. D.** 1984. *The Chemical Evolution of the Atmosphere and Oceans*. Princeton University Press, Princeton.
- Rose, J., Boardman, J., Kemp, R. A. and Whiteman, C. A.** 1985. Palaeosols and the interpretation of the British Quaternary Stratigraphy. In: **K. S. Richards, R. R. Arnett and S. Ellis** (eds.) *Geomorphology and Soils*, 348-375. George Allen and Unwin, London.

J. Rose
Department of Geography
Birkbeck College
University of London
7-15 Gresse Street
London W1P 1PA

RECENT PUBLICATIONS

LOESS AND PERIGLACIAL PHENOMENA

Proc. Symposium, Caen, August 1986 of INQUA Loess Commission and IGU Periglacial Commission.

Ed. M. PÉCSI and H.M. FRENCH

AKADÉMIAI KIADÓ BUDAPEST
Distributed by
HUNGARIAN FOREIGN TRADING CO.
P.O. Box 149
1389 BUDAPEST
HUNGARY

The book contains 21 papers and is divided into two sections:

I LITHOLOGY, GENESIS AND GEOTECHNICAL STUDY OF LOESS

II PERIGLACIAL STUDIES ON FIELD AND LABORATORY EXPERIMENTATION

NERC EXPERT GROUP REVIEW OF QUATERNARY SCIENCE

It must be evident to all members of the QRA that the production of the NERC Review of Quaternary Science was a milestone in the recognition of the import of Quaternary science and that it must have had the effect of encouraging its future survival within earth sciences.

As I have stressed recently in my own Editorial "The fall and rise of Quaternary geology" (*Modern Geology*, vol. 13, pp.1-12), "critical for the health of any science, is the fact that the first areas to be sacrificed for the good of the whole are peripheral areas at the interface of disciplines [and] by far and away the most vulnerable area has been Quaternary geology." I, too, published most of the NERC Report. The significance of the NERC Report is the acknowledgement of the need to protect and develop this aspect of earth science at just the historic moment, when it could so easily have been expected to have gone to the wall. The response to this Report should have been an enthusiastic welcome—it certainly got it in *Modern Geology*.

For the NERC Report to have been used as an excuse for someone to parade their naive views on the philosophy of methodology of science seems to me to be perverse (T. Culling, *QN* 55, 27-29). The NERC Report never set out to be an undergraduate essay on "induction and deduction in science with special reference to Quaternary science", it was a practical strategy for a research programme in the real world.

The pattern of the academic landscape in Britain is changing dramatically and it is up to every Quaternary scientist to do all within his or her power to ensure that in the restructuring now going on, the conclusions of the NERC Report are taken into account. Unless Quaternary scientists exert themselves at this juncture, they can have no complaints in the future if their discipline is ignored. If the only response is of the *ilk* we read in the June 1988 issue, then Quaternary science is not yet fit to be incorporated into the world of active scientific research.

L Beverly Halstead
Reader in Geology
University of Reading

AN APPEAL TO THOSE PRODUCING QRA FIELD GUIDES

Over the years, the Association has built up an impressive sequence of field guides covering the areas which have been visited in the course of the annual Easter excursion. Some hallowed ground has been covered more than once, and such is the progress in our science that the two accounts could well be describing quite different sequential histories. That's no problem; indeed it is a sign of health which is reassuring. What worries me more, however, is scale.

Scale comes in two aspects, both of which are disturbing. First, there is the sheer size of the recent guides. More and more facts are added recording assiduously applied studies of sedimentology, palaeontology, dating measurements and perhaps palaeomagnetism, to an extent which is almost 'overkill'. There's nothing wrong with detail, or the scientific scholarship involved, in a full-blown account. My moan is that the same detail may not be appropriate in a *field guide*. As it is, people tend to stagger out of the vehicles at a locality, deeply engaged in reading the pages describing the locality, and often spend less time actually studying the sections or collecting samples. They may get back on the road still not having got to the root of the facts offered by the exposure. This can't be right.

The second quantity which is troublesome these days is the scale of the illustrations. Very often it seems that these have been prepared for some other publication, much more generous in page size, and then reduced to guide book page size. The result is usually very small printing to the point where it is barely legible. Like true scale sections, which are all the rage currently, this may be very good for our appreciation of the shallowness or true proportions of profiles, but it does very little for our understanding. I know that my eyesight is poor and if anything getting worse with the years, but it isn't just we oldies who suffer from the fine print. You shouldn't need a hand lens to read the annotations to diagrams.

So, authors, please let us have some simpler guides which draw attention to what might be seen at a locality (even some space for notes we might add on the day), and do let's have some bolder sketches or diagrams which we can read without needing to peer closely or even use a magnifier. Let us say with the Prophet, "Behold, I shall do a simple thing!" Let it be so.

Eric Robinson

PROBLEMS IN THE APPLICATION OF LITHOSTRATIGRAPHIC CLASSIFICATION TO PLEISTOCENE TERRACE DEPOSITS

A reply: P L Gibbard

I write in response to the contribution in the last *QN* in which D Bridgland (1988) appealed to those investigating fluvial deposits to confront the detail of the lithostratigraphical codes. The thrust of his contribution was that individual terrace aggradations should be awarded *Formation* status in the lithostratigraphical heirarchical subdivision. Whilst I agree with much of what Dr Bridgland said in his note, I do not see the need to change the system that has been established over the last few years.

This system, as Dr Bridgland described, uses the term *Member* for individual fluvial aggradations, the latter being grouped together into formations as necessary. The changes proposed would seem to be small and simply semantic. However, an important point of principle and geological status of individual aggradations is expressed by the application of the heirarchical terminology in lithostratigraphy.

Dr Bridgland states in his note that "formation is the primary unit" (in lithostratigraphy) "whereas in terrace studies individual terrace aggradations are the primary units". I would contest the latter part of this statement. It may be true that individual fluvial aggradations are 'basic units' at a particular heirarchical level. However, our knowledge of the detailed sequence of deposits and, therefore, potential events represented beneath terrace surfaces suggests that individual 'terrace gravels' may hide a complex of information. Further, in many valleys it is impossible, because of a lack of input of exotic lithologies etc. to distinguish individual accumulations except by using altitude of the gross sediment body. In this case it would seem that the formation is the correct term to apply to the complete, lithologically-indistinguishable assemblage. Indeed in the instance of the early Thames system, the term Kesgrave Formation of Rose *et al.*, (1976) and Rose and Allen (1977) could also be argued to be the primary unit, in that it is characterised by quartz-rich gravel. This is the basis upon which it is distinguished from other formations in the region. Individual subunits of the Kesgrave Formation are distinguished only by subtle compositional changes. Similarly the individual aggradations in the Middle and Lower Thames (cf. Gibbard, 1985, Gibbard, unpublished) and south east Essex (Bridgland, 1980, 1983) can be separated in much the same way. These subtle changes, often of the order of a few to less than 1% of total lithology, are not of a scale for the separation of significantly different formations.

Lastly, it is important to bear in mind the question of compatibility in the application of an heirarchical terminology. In eastern England other formations defined include the Lowestoft Till Formation, North Sea Drift (Cromer Till) Formation (summary: Gibbard and Zalasiewicz, 1988), Cromer Forest Bed Formation (West, 1980), Norwich Crag Formation and the Red Crag Formation (Zalasiewicz *et al.*, 1988), all of which are significantly different in lithology and other geological criteria. In addition, they all include units of member status of the same order of scale as individual

fluvial aggradations. In the offshore North Sea area formation status units have also been defined using seismic methods (Balson and Cameron, 1985). These formations are of broadly the same scale as those on land in both eastern England, and also in the Netherlands (cf. Doppert *et al.*, 1975).

For these reasons, therefore, I do not support the need to redefine our fluvial member units as formations, and formations as groups etc. I believe that a hierarchy should be established that is meaningful geologically. Strict adherence to a generalised stratigraphic code is important as far as is practically possible. Nevertheless, since the codes are intended to be used for the entire stratigraphic column, they cannot be realistically applied equally to the Pleistocene and the Pre-Cambrian without some flexibility.

P L Gibbard
Subdepartment of Quaternary Research
University of Cambridge
Cambridge
CB2 3EA
England

REFERENCES

- Balson, P S, and Cameron, T D J. 1985. Quaternary mapping offshore East Anglia. *Modern Geology*, 9, 221-239.
- Bridgland, D R. 1980. A reappraisal of Pleistocene stratigraphy in north Kent and east Essex and new evidence concerning the former courses of the Thames and Medway. *Quaternary Newsletter*, 32, 15-24.
- Bridgland, D R. 1983. *The Quaternary fluvial deposits of north Kent and east Essex*. PhD thesis (CNA) City of London Polytechnic.
- Bridgland, D R. 1988. Problems of the application of lithostratigraphic classification to Pleistocene terrace deposits. *Quaternary Newsletter*, 55, 1-8.
- Doppert, J W C, Ruegg, G H J, van Staaldin, C J, Zagwijn, W H, and Zandstra, J G. 1975. Formaties van het Kwartair en Boven-Tertiair in Nederland. In: W H Zagwijn and C J van Staaldin (eds.). *Toelichtingen bij geologische overzichtskaarten van Nederland*. Haarlem: Rijks Geologische Dienst, 11-56.
- Gibbard, P L. 1985. *Pleistocene history of the Middle Thames Valley*. Cambridge University Press. 185 pp.
- Gibbard, P L and Zalasiewicz, J A. 1988. *Pliocene-Middle Pleistocene of East Anglia*. Field Guide. Quaternary Research Association: Cambridge.
- Rose, J, and Allen, P. 1977. Middle Pleistocene stratigraphy in southeastern Suffolk. *Journal of the Geological Society of London*, 133, 83-101.
- Rose, J, Allen, P, and Hey, R W. 1976. Middle Pleistocene stratigraphy in southern East Anglia. *Nature*, 263, 492-494.
- West, R G. 1980. *Pre-glacial Pleistocene of the Norfolk and Suffolk coasts*. Cambridge University Press.
- Zalasiewicz, J A, Mathers, S, Hughes, M J, Gibbard, P L, Peglar, S M, Harland, R, Nicholson, R A, Boulton, G S, Cambridge, P, and Wealthall, G P. 1988. Stratigraphy of the Red and Norwich Craggs between Aldeburgh and Sizewell, Suffolk, England. *Philosophical Transactions of the Royal Society of London*, 8, (in press).

PROBLEMS IN THE APPLICATION OF LITHOSTRATIGRAPHIC CLASSIFICATION TO PLEISTOCENE TERRACE DEPOSITS

Reply to P L Gibbard and further comments

I welcome Dr Gibbard's comments on this subject, fully respect his arguments and opinions and agree with much of what he says. I remain convinced, however, that a problem exists in this field, albeit one of definition and semantics. It is important that those working in this subject area confront this problem and come to a considered decision on the best approach.

Having considered Dr Gibbard's points, I would reaffirm my claim that individual terrace aggradations are primary units of lithostratigraphy and, therefore, should strictly be classified as formations. This, as Dr Gibbard recognises, is the thrust of my argument presented in the last QN (Bridgland, 1988). Dr Gibbard points out that "individual 'terrace gravels' may hide a complex of information", but this does not alter the fact that the sand and gravel of an individual terrace aggradation can be mapped as a body of sediment and traced, using projections where removed by erosion, downstream. As I emphasised in my original article, this method is quite different from geomorphological study of terrace surfaces. It is geological mapping and its purpose is to recognise primary lithostratigraphic units which by definition should be formations.

Dr Gibbard states that "in many valleys it is impossible . . . to distinguish individual aggradations except by using altitude of the gross sediment body" and implies that in such cases no lithostratigraphic separation is possible. This statement hints at the real core of the problem confronting those wishing to use a lithostratigraphical classification of terrace systems. In my opinion a formation which encompasses every terrace gravel within a particular valley is almost worthless as a unit of classification. In the Medway, for example, it would include everything from degraded remnants of probable late Tertiary age to the floodplain gravels deposited during the last glaciation. Although in the neighbouring Thames Valley individual terraces have been subdivided lithostratigraphically into 'members' (Gibbard, 1985), this would not be possible, according to Dr Gibbard's view, in the case of the Medway, where a geomorphological separation would have to be used. The unsatisfactory situation would arise, therefore, in which different methods were necessary to subdivide neighbouring terrace systems, leading to problems of incompatible nomenclature and correlation. If this were truly the case it might be argued that, if the lithostratigraphic approach cannot be used in all comparable valley systems, it would be better to use a method that can.

This was one reason why I originally suggested that a change was needed in the lithostratigraphic classification of fluvial deposits. The main benefit of the suggested alternative model (beyond the fact that it is geologically more correct, according to the codes) is that it allows lithostratigraphic classification of individual terrace aggradations, even when these contain identical gravel suites, on the basis that each is a primary 'mappable' unit (i.e. a formation).

Discussion of this question with a number of other workers since the publication of my article has drawn to my attention a number of other points of relevance to this argument. There appears to be, in Quaternary circles, an imagined link between lithostratigraphy and the technique of stone counting. In my opinion this is a mistake. Stone counting is a technique used to distinguish deposits which are lithostratigraphically similar by demonstrating differences in their clast content. It is debatable whether such a technique is actually valid for lithostratigraphic separation, since the codes prefer distinctions which can readily be made in the field, rather than in the laboratory (Hedberg, 1976, p.31). In terrace studies, lithostratigraphy should primarily involve the distinction of a gravel body from the underlying bedrock and from any overlying, later deposits. These distinctions are easily made, visually, in the field. Differences in clast composition can, of course, be used to distinguish between gravels, particularly when the difference is visually obvious.

In support of my arguments I would point out that Dr Gibbard has himself principally used a system of geological mapping in his work on the Middle Thames. Although he may place emphasis on the clast lithological differences between the various terraces, the recognition of individual bodies of sediment is in fact the primary method by which he distinguishes them. His clast lithological analyses and their statistical evaluations show overlapping characteristics between adjacent terraces. It is quite clear that a remnant of gravel occupying a position on the valley side indicating that it is part of the Boyn Hill

Gravel would be classified as such even if it had a clast composition suggestive of a different aggradation. Dr Gibbard's members are, therefore, principally defined by geological mapping as primary units rather than by lithological subdivision of an existing primary unit. For the reasons outlined in my original article, this means that they should be formations and not members. Exactly the same can be said of the subdivisions of the Kesgrave Sand and Gravels.

The only alternative to adopting this revised scheme would be to modify the criteria for the definition of lithostratigraphic units, so that primary units which are also fluvial terrace aggradations can be classified as members. The principal reasons for redefining the rules of lithostratigraphy in this way would be to maintain the *status quo* in the classification of terrace sequences and to promote comparability with other lithostratigraphic sequences elsewhere. Dr Gibbard argues in his penultimate paragraph that other formations defined in the Quaternary support the *status quo*, in that they include "units of member status of the same order of scale as individual fluvial aggradations". In reply to this I would ask what is meant by 'scale' in this sense. I suspect that an element of time is implied, but time is not a valid criterion for lithostratigraphy. Conversely, several of the formations cited by Dr Gibbard, namely the Lowestoft Till Formation, North Sea Drift (Cromer Till) Formation and the Cromer Forest Bed Formation, comprise sediments more closely associated than are the gravels of separate terraces; the two glacial formations result from a unique geological event. Importantly, none of these formations include unconformities of the type which separate individual terraces within fluvial systems. I would claim that formations which represent individual terrace aggradations are more closely compatible with these examples cited by Dr Gibbard than are his formations which encompass entire terrace systems.

Clearly Dr Gibbard is right to point out that formations recognised offshore in the North Sea Basin represent comparable parcels of sediment to the Kesgrave Sands and Gravels. This is because less definition is possible in subsiding areas where fluvial deposition is continuous, rather than punctuated by rejuvenations (unconformities). The primary units are therefore larger in such areas. It is ironic that less stratigraphic definition is possible in areas with the most complete sedimentary sequences, the reason being that unconformities (rejuvenations) provide the greater definition in non-subsiding areas. The same difference is apparent when comparing British terrace sequences with the Lower Rhine and Meuse formations recognised in the Netherlands. However, the lithostratigraphic codes are quite clear that different levels of subdivision are likely in different areas and therefore allow for formations in one area to be equivalent to groups in another (Hedberg, 1976, p.44). There is therefore no difficulty in correlating a 'Kesgrave Group' in East Anglia with a 'Yarmouth Roads Formation' offshore.

I therefore reaffirm the opinion expressed in my original paper, that individual terrace aggradations should be classified as formations. I agree with Dr Gibbard however, that the change required is small and semantic. The codes emphasise that the important part of a lithostratigraphic name is its geographical (first) part. Thus it is 'Boyn Hill' and 'Kesgrave' that are important; whether they should be followed by member, formation or group is a less significant factor which can be readily modified. Perhaps we should mainly use the optional lithological part of the nomenclature (e.g. 'gravel', 'sand'), without the hierarchical part, until this controversy is settled. After all, the Boyn Hill Gravel will remain the Boyn Hill Gravel, even if it ceases to be the Boyn Hill Gravel Member and becomes the Boyn Hill Gravel Formation.

D R Bridgland
Earth Sciences Division
Nature Conservancy Council
Northminster House
Peterborough PE1 1BR

REFERENCES

- Bridgland, D R. 1988. Problems in the application of lithostratigraphic classification to Pleistocene terrace deposits. *Quat. Newsl.* 55, 1-8.
- Gibbard, P L. 1985. *Pleistocene history of the Middle Thames Valley*. Cambridge University Press. 155 pp.
- Hedberg, H B. 1976. *International stratigraphic guide*. John Wiley & Sons, London and New York. 200 pp.

PROVISIONAL MAJOR SUBDIVISIONS OF THE PLEISTOCENE

At its meeting during the XII INQUA Congress in Ottawa, the INQUA Stratigraphic Commission approved the following proposal submitted by its Working Group on Major Subdivision of the Pleistocene.

"The Working Group on Major Subdivision of the Pleistocene recommends that, as evolutionary biostratigraphy is not able to provide boundaries that are as globally applicable and time parallel as are possible by other means, the lower/middle Pleistocene boundary should be taken provisionally at the Matuyama/Brunhes paleomagnetic reversal, and the middle/upper Pleistocene boundary at the base of deep sea oxygen isotope stage 5. The lower, middle, and upper Pleistocene units so defined are recommended as informal subseries of the Pleistocene Series.

The Working Group further recommends that studies should be undertaken on a regional basis to establish biostratigraphic and other criteria that will assist in positive recognition and correlation of the boundaries."

A subcommission on major subdivision of the Pleistocene to establish reference sections of the boundaries and their relationship to different biostratigraphic and other criteria available for extending them laterally in different regions of the world was approved by the INQUA International Council. G M Richmond, US Geological Survey, was named president *pro tem*.

Gerald M. Richmond

QN: INQUA

XIII INQUA CONGRESS IN BEIJING, CHINA, 1991

A decision was made by the XII INQUA CONGRESS held in Ottawa, Canada, August 1987 that the XIII INQUA CONGRESS is to be convened in Beijing, China, 1991.

Co-sponsored by the Chinese Academy of Sciences, the China Quaternary Research Association, the Geological Society of China and the Geographical Society of China, the XIII INQUA CONGRESS will take place in Beijing, August 2-9, 1991.

ORGANIZING COMMITTEE

President: Professor, Dr Liu Tungsheng

Secretary General: Professor Sun Shu

Address: Secretariat, XIII INQUA CONGRESS

Chinese Academy of Sciences, 52 Sanlihe, Beijing 100864 China

Tel: 863062, 868361-336.-568 Cable: Beijing SINICADEMY

Telex: 22474 ASCHI CN Telefax: 8011095

ACADEMIC ACTIVITIES

1. Theme of the CONGRESS

GLOBAL ENVIRONMENTAL CHANGES & THEIR RELATIONSHIP WITH ANTHROPOGENIC ACTIVITIES

2. Academic meetings

Plenary meetings, symposia, special sessions, general sessions, and poster presentations will be held.

3. Exhibitions

An exhibition of current Quaternary researches from all over the world as well as a special one showing the recent achievements of Chinese scientists will be presented.

GEOLOGICAL EXCURSIONS

About 30 pre- and post-CONGRESS geological excursions will be arranged, including those to the Chomolongma (Mt. Everest) glaciers, the Gobi desert, the loess plateau, the volcanic crater lake, the scenic karst province and the tropical coast, as well as to the famous Peking Man and other archaeological and palaeo-anthropological sites.

FIRST CIRCULAR

The first circular will be sent out in late 1988, presenting detailed information, such as various costs (registration fee about US\$290.00). Prices will be as low as possible. We are encouraging English for abstracts and paper presentations.

WORKING GROUP ON LONG TERRESTRIAL RECORDS—INQUA COMMISSION ON STRATIGRAPHY

A Working Group on Long Terrestrial Records under the sponsorship of the INQUA Stratigraphic Commission was formed at the XII INQUA Congress in Ottawa. The Working Group includes scientists from several countries who are actively working on or interested in substantially continuous stratigraphic records from terrestrial (i.e. non-marine) deposits that span at least one full glacial cycle or its equivalent (at least 100 000 years) and lie at least in part within the Quaternary.

The initial goals of the Working Group are:

- (1) to create a data base of activities dealing with long terrestrial records (location of sites, stratigraphic thickness, time span covered, who is working on what, etc.).
- (2) to develop a means of distributing the information in the data base, both to our members and to other groups.
- (3) to promote communication between projects and workers on long terrestrial records, initially through a newsletter.
- (4) to provide an international affiliation for projects that can benefit therefrom.
- (5) to assemble a bibliography.

Officers of the Working Group are:

David P ADAM (President)
US Geological Survey
345 Middlefield Road, M/S 915
Menlo Park, California 94025
USA

Telephone: (415) 329-4970

Denis-Didier ROUSSEAU (Secretary)
Centre de Géodynamique sédimentaire
et Evolution géobiologique UA CNRS 157
Centre des Sciences de la Terre
Université de Bourgogne, 6, boulevard Gabriel
21100 DIJON
France

Telephone: 80-39-63-64

Scientists who wish to become a part of the working group, to be placed on its mailing list, or to contribute to the bibliography are encouraged to write or telephone either of the officers.

QN: september meeting

RATES OF GEOLOGICAL, BIOLOGICAL AND CLIMATIC CHANGE IN THE QUATERNARY—A DISCUSSION MEETING HELD AT UNIVERSITY COLLEGE, LONDON, ON WEDNESDAY 21 SEPTEMBER, 1988

As part of the 7th Meeting of Geological Societies of the British Isles, with the theme: "Geological Sciences in the Service of Commerce and Industry", the Quaternary Research Association held an informal symposium on "Rates of Change" during Quaternary times.

Dennis Jeffery (BGS) compiled a summary of those parts of the proceedings not covered in the abstracts referred to below.

SESSION 1

Following an introduction by Geoffery Boulton on 'Rates of change in the Quaternary', the following papers were presented.

Long-term rates of climatic change—this topic was discussed by N. Shackleton who claimed that supposed long-term temperature trends in climate in the last 2.4 m.y. were artefacts, all interglacials tending to be of the same magnitude. The remainder of the talk was taken up with discussing recent oxygen- and carbon-isotope results for the last 15 000 years.

SHORT-TERM RATES OF CLIMATIC CHANGE

M. M. Goodess, University of East Anglia

The emphasis is on high resolution proxy and instrumental records from the late Holocene. Proxy data indicating summer temperature from North America, Greenland and Europe for the last 2000 years have been assessed and indicate three major episodes: a cold period between the 8th and 10th centuries, a "Medieval Warm Period" around the 12th century and the "Little Ice Age" spanning the 16th and 17th centuries (Williams and Wigley, 1983). Variations in the timing, rate and magnitude of change are, however, evident from place to place. Temperature trends for the last 300 years are estimated from the Central England Temperature series which has been compiled from instrumental data. The spatial representativeness of this series is considered.

A reliable, globally representative temperature series is available for the last 130 years (Jones et al., 1986). The globe has warmed by 0.5°C since the beginning of the century, but differences are seen in the spatial and seasonal distribution of this warming. The rate of warming observed over the oceans is greater than that observed over land. Linear trends are fitted to each annual grid-point time series in order to investigate spatial patterns of change. Over the period 1947–1986, for example, eastern North America and the North Atlantic region experienced significant cooling, whilst the hemisphere as a whole warmed. Differences in the spatial and seasonal patterns of change are also evident in the 130 year long record of land-based northern hemisphere precipitation (Bradley et al., 1987).

Analysis of the instrumental time-series thus raises questions about the spatial and seasonal representativeness of climate records. These issues are of importance in the detection of a potential greenhouse gas-induced warming, but must also be considered when interpreting historical and proxy records of longer-term climatic change.

REFERENCES

- Bradley, R S, Diaz, H F, Eischeid, J K, Jones, P D, Kelly, P M, and Goodess, C M. 1987. Precipitation fluctuations over Northern Hemisphere land areas since the mid-19th century. *Science*, 127, 171–175.

Jones, P D, Wigley, T M L, and Wright, P B. 1986. Global temperature variations between 1861 and 1984. *Nature*, 322, 430-434.

Williams, C D, and Wigley, T M L. 1983. A comparison of evidence for Late Holocene summer temperature variations in the Northern Hemisphere. *Quaternary Research*, 20, 286-307.

In the absence of D. Stow, R. Wingfield (of BGS) was invited to give an *ex tempore* talk on his interpretation of the large valleys cut into rocks and sediments during earlier glacial periods, together with calculated sedimentation rates of the various components of the valley fills. The views expressed generated much discussion.

SESSION 2

RATES OF GEOLOGIC CHANGE IN SHALLOW MARINE ENVIRONMENTS—TECTONICS, SEDIMENTATION AND GEOGRAPHIC CHANGE IN THE SOUTHERN NORTH SEA REGION OVER THE LAST 2.4 MILLION YEARS

D. Jeffery, British Geological Survey, Keyworth, Notts

A sequence of up to 850 m of late Pliocene to Recent ("Quaternary") sediments, as much as 90% of it composed of Lower to Middle Pleistocene deltaic deposits—is preserved in the still subsiding North Sea basin. By analyses of shallow-seismic profiles across the sequence, successive shoreline positions of the delta can be plotted and rough calculations made on rates of tectonic and geographic change. Subsidence appears to have been relatively rapid in the Early Pleistocene, slowing to about half the rate by the Middle Pleistocene (consistent with simple models of lithospheric extension). Rates since Middle Pleistocene times are harder to assess, owing to the complications of glaciation.

It is concluded that for most of pre-Anglian (pre-Elsterian) time glacio-eustatic effects were generally negligible, shoreline change being largely due to the excess of sediment input over basin subsidence, whereas since Anglian times, shoreline changes have been due to glacio-eustatic rise and fall of sea level superimposed on the trend of relative rise caused by excess of basin subsidence over sediment input. Hence, by Middle Pleistocene time the North Sea was reduced to a shallow body between Scotland and Norway, but since then has become larger (and perhaps deeper?) than it was in the Early Pleistocene. It is still growing at the expense of eastern Britain, even without melting of polar ice.

The implications of these drastically different palaeogeographies for current climatic models, which are based upon assemblages of pollen and other organisms, will be briefly outlined.

COUPLED ICE SHEET/CLIMATE BEHAVIOUR AS A CONTROL ON THE RATE OF CLIMATIC CHANGE

Professor G. S. Boulton, Edinburgh University

Measurements around the margins of modern glaciers demonstrate clearly that not only does climate control the behaviour of glaciers but that the presence of glaciers also restrains the rate at which the near glacier climate can change in response to large-scale climatic change.

Model studies permit us to estimate the rate at which glaciers of different size may grow or decay. Their restraining influence on the rate of climatic change in surrounding regions can thus be determined.

ABRUPT LAKE—LEVEL FLUCTUATIONS IN THE TROPICS—LINKS WITH THE OCEANIC THERMOHALINE CIRCULATION?

F. Alayne Street-Perrott, R. Alan Perrott, University of Oxford

During the late-glacial and Holocene, lake levels and other sensitive indicators of tropical palaeoclimates have recorded rapid climatic fluctuations of large amplitude, superimposed on the broad trends which can be attributed to orbital forcing. These rapid fluctuations were most pronounced in Sub-Saharan Africa and in similar latitudes (0–20°N) in the Americas. The transitions between dry and wet climates and *vice versa* often occurred so fast that they cannot be resolved by radiocarbon dating.

Today, drought in these sectors is strongly correlated with cold (warm) sea-surface temperature (SST) anomalies in the northern (southern) oceans, respectively. Similar SST patterns also prevailed in the Atlantic during the dry episodes dated ca. 17 000–13 000 and 11 000–10 000 yr BP, when the production of deep water in the North Atlantic was shut off. We argue that the abrupt late-glacial and Holocene fluctuations in tropical rainfall were linked to changes of mode in the thermohaline circulation, which today transports heat and salt in the upper layers of the ocean towards the northern North Atlantic, where cold, saline deep water is formed in winter. Modern oceanographic data suggest that significant changes in the deep-water production rate could occur within 10–10² yr.

SESSION 3

RATES OF CHANGE IN COLEOPTERA

G. R. Coope, University of Birmingham

G. R. Coope's entertaining lecture referred to his previous research work on the Coleoptera, which are much more abundant than plants and which have maintained evolutionary and ecological stability over the last 2 m.y., thus providing an excellent proxy for past climatic conditions. He emphasised that all events should be linked causally and *not* by their synchronicity. As an example, he demonstrated that the timing and rate of local climate change in NW Europe during the last 15 000 years varied significantly, largely because the proximity of ice could strongly inhibit climatic amelioration. He emphasised the west-to-east climatic gradient at our latitudes. His message was: "Beware of seductive curves".

RATES OF CHANGE IN VERTEBRATES

A. Currant

Because A. Stuart felt unable to attend, A. Currant delivered a summary of some of the changes which have taken place in vertebrates (mostly small mammals) during the Pleistocene.

SESSION 4

RATES OF CHANGE IN NON-MARINE MOLLUSCA

R. C. Preece, University of Cambridge

It is a widespread, almost proverbial, belief that because snails move so slowly, they must have only limited powers of dispersal. This view is challenged by reference to modern examples demonstrating the rapidity and pervasiveness of several recent range expansions documented during this century.

The Post-glacial colonisation sequence has now been established for various regions of the British Isles as the result of detailed biostratigraphical analyses. The rate of spread of certain critical species can be gauged by comparing radiocarbon dates for their first appearance datums. The broad synchronicity of several dates suggests rapid colonisation and spread, although many more dates are needed.

On a longer geological time-scale, species are found to have not just changed their distributions in response to climatic and environmental fluctuations but to have undergone evolutionary change. The pattern of faunal turnover (extinctions and originations) revealed in the British and Dutch successions will be discussed.

RATES OF CHANGE OF THE TERRESTRIAL FLORA

Professor R. G. West, University of Cambridge

Evidence of change of terrestrial floras in the Quaternary comes from two sources: pollen analysis and macroscopic plant remains. In contrast to much other palaeontological evidence, the quantity of data, especially from pollen analysis, makes it possible to reconstruct community history as well as the history of taxa in terms of migration and extinction. On the other hand, the fossils rarely give evidence of the evolutionary history of particular taxa.

Rates of change of communities can be clearly estimated where radiocarbon dating can be applied; examples will be given. Examples of extinctions in north-west Europe will also be given. Both community change and extinction are related to migration and climatic change. Since plants are "static" organisms migration rates can be low, and rapid climatic change can lead to local extinction. But population numbers can be high, and so can genetic variability, with the result that evolution at the biotype level is certain to occur. This is unfortunately not recognisable at the usual palaeontological level of identification, but may well be demonstrated in future in terms of chemical taxonomy.

The principles established by the study of Quaternary floras, their taphonomy and their history apply to the whole geological column. They also demonstrate that uniformitarianism is a dangerous precept for those interested in palaeoenvironments and extinct biota.

SUMMARY

During the ensuing discussions, it seemed as though several research workers in the Quaternary were not much interested in the genesis of the sediments from which they extracted their isotopic or biological data, and that therefore, the various specialities were as far apart as ever. Can this be true? (Ed.)

In addition to the papers referred to earlier, a number of excellent poster displays were prepared for this meeting. Abstracts for some of these are presented below.

RATES OF INCISION IN CENTRAL ENGLAND DURING THE QUATERNARY

Peter Rowe, University of East Anglia

Uranium-series and palaeomagnetic dating of speleothems from the Manifold Valley in the Southern Peak District indicate that some calcite deposits are probably 1.8–2.0 million years old. This shows that the cave in which they formed was vadose by that time and this information enables the maximum average incision rate to be calculated. This is 5.5 cm/ka.

Uranium-series dating of flowstones from Creswell Crags Gorge in south east Derbyshire, suggest that the gorge there has been formed at a maximum average rate of 6.3 cm/ka over the past 300–500 ka.

Little of the valley erosion in either case can be attributed to direct glacial activity and it is likely that river downcutting is a response to tectonic uplift which has probably been proceeding at a rate of something in excess of 6 cm/ka in Central England during the Quaternary.

PEAT HUMIFICATION IN BLANKET MIRES: A PROXY CLIMATIC RECORD?

J. J. Blackford and F. M. Chambers, University of Keele

The stratigraphy of raised mires has been claimed to provide a proxy record of climatic change over the past 5000 years. The validity of these records has since been questioned. An alternative record has been sought from studies of peat humification and microfossil analysis of blanket mires in Ireland, Wales and England.

Results show fluctuations in surface wetness throughout the period of peat growth, evidenced by possible cycles in the rates of decomposition and microfossil deposition. Initial calculations suggest a periodicity of 175–200 years, although radiocarbon dating is needed to confirm synchronicity or otherwise of these growth patterns.

MAJOR INCISIONS AND ENCLOSED DEEPS

R. T. R. Wingfield, British Geological Survey, Keyworth, Notts

Major incisions are defined as being at least 100 m deep and 2 km wide. They form oblong depressions or sumps cut into flat surfaces beneath the cool temperate or Arctic continental shelves or lowlands of Asia, Europe, Greenland and North America. The incised substrates include unlithified Pleistocene strata, commonly with horizontal stratification, and lithified Precambrian to Tertiary deposits or igneous rocks. The sizes of major incisions vary over a limited range: incised depths are down to at least 360, possibly 500 m, the widths up to c.5 km and the lengths up to c.40 km. Infills are of four types: chaotic, draped, cross-stratified and variegated; the first three being found in sequence, bottom to top, with the chaotic and draped to hundreds of metres thick and the cross-stratified only to some 30 m, while the variegated, Type 4, deposits either form a veneer a few metres thick or locally infill hollows to c.200 m deep within the other infill types.

Major incisions were cut during at least three 'generations' in the Middle to Upper Pleistocene: Generation 1—late Elsterian, Generation 2—late Saalian and Generation 3—late Weichselian. In Generation 3 major incisions the hollows with variegated, Type 4, deposits may be found incompletely filled as (bathymetric) enclosed deeps on the sea floor with enclosed depths from 30 to 160 m below surrounding sea bed. Some 100 enclosed deeps are known off Britain. It is estimated that some 1000 separate major incisions of the three generations occur about the British Isles.

It is believed that each oblong major incision was separately created by the catastrophic drainage of an intra-ice sheet lake. Backcutting of the resultant jokulhlaup plunge pool (JOPP) through the c.25 km wide frozen top of the ice sheet and into the underlying permafrost or bedrock led to a range of shapes dependant on the initial size of the individual lake.

H. M. Pantin's computations (1988) suggest that even a large major incision can be formed in less than 2 hours by the drainage of a lake of some 200 km³ volume. Discharges peaked by over 0.025 km³s⁻¹ with outfall velocities of more than 50 ms⁻¹. Another JOPP could reoccur on a single 20 km wide sector of an ice sheet margin after a few centuries.

The chaotic, Type 1, infills formed coevally with incision as backfill at the prodigious sedimentation rate of $c.100 \text{ m yr}^{-1}$ (10^6 m yr^{-1}); the draped, Type 2, infills represent sub-base level, lacustrine, estuarine or nearshore marine, ice-proximal deposits of a sandur or tidewater environment with 10^0 to 10^4 m yr^{-1} sedimentation rates; while the cross-stratified, Type 3, deposits represent reestablished-base-level (infill complete), fluvial or very shallow marine sediments laid down at some 10^{-1} to $10^{-3} \text{ m yr}^{-1}$. Types 1 and 3 were all deposited in periglacial conditions as is demonstrated by microfaunal and microfloral studies of borehole cores.

The initial post-incision period of JOPP infill resulted in a deep lake or estuary within an ice margin which inevitably acquired an ice shield cover. Due to high sediment influx (? at some 10^2 to 10^5 m yr^{-1}) burial of the shelf ice led to its preservation as massive ground-ice 'sleepers' in some infills. Sleepers survived as sub-aerial or submarine permafrost until the temperate conditions of the next (local) interglacial when they melted to leave an enormous kettle hole or 'grin'. Grins in Generation 3 major incisions formed in the early Holocene and survive in areas of slow sedimentation (10^{-4} to $10^{-2} \text{ m yr}^{-1}$) as the common enclosed deeps of the continental shelves or the rare enclosed valleys on land. Examples of on land grins may be the Old Rock Canyon, Idaho, and the Hald Sø, Jutland. The hollow-infill, variegated, Type 4 deposits are grin infills in major incisions of all three generations and preserve interglacial sequences.

RATES OF EVOLUTION IN QUATERNARY MAMMALS

A. M. Lister, University of Cambridge

Many mammalian species underwent striking morphological evolution in response to Quaternary climatic and vegetational changes. The study of these transitions through dated sequences of fossils is one of the most exciting growth areas of Quaternary science today.

Some species, such as red deer, developed "ecophenotypic" adaptive flexibility which enabled them to accommodate to habitat changes within only a couple of generations, and hence to survive a wide range of Quaternary environments without genetic modification or extensive range shifts.

The fastest genuine evolutionary changes are observed in species isolated on islands by high sea levels. Within a few thousand years of the Last Interglacial, populations of hippos, deer and other taxa underwent substantial alteration of size and other adaptive features.

Most significant are the longer-term anatomical trends displayed by several mainland lineages, which can in some cases be plausibly related to known palaeoenvironmental changes. Thus major transitions in mammoths (skull and dentition), elks (antlers) and water voles (teeth) can now be traced through a series of intermediate forms in the European Quaternary succession. Their evolutionary rates (species-level transitions in tens or hundreds of thousands of years) would in the broader geological record be classified as "punctuated", but the fine stratigraphy of the Quaternary allows them to be resolved as "fast gradualism".

RATES OF GEOLOGICAL AND BIOLOGICAL CHANGE AT SVINAFELL, SOUTH-EAST ICELAND

Arnold Jones, Liverpool Polytechnic

A major objective of the 1987 Liverpool Research Expedition to Svinafellsjökull in south-east Iceland was to quantify the dynamic nature of the processes and forms of the geological and biological systems.

Glaciological studies monitored the nature of ice flow in the terminal zone and produced a precise map of the entire glacier margin, using a Kern Total Station to obtain absolute precision.

Geomorphological and sedimentological studies included the detailed survey of the topography and sedimentology of a glacio-marginal braided outwash sandur, the influence of lithology upon coarse sediment transport, solute and suspended sediment loads of glacial meltwater streams, and palaeodischarge determination of abandoned channels.

A lichenometric age-growth curve from aerial photographs and historical maps allowed the dating of moraines and terraces. A Schmidt Hammer was used to test the degree of weathering on these dated surfaces in the hope that it could be applied to undated surfaces. Tephrochronological studies demonstrated the magnetic nature of historic volcanic eruptions and dated the age of the oldest moraine in the area. Argon/Argon dating is being employed to date the supposed Interglacial fossiliferous sedimentary succession of Svinafell, which were also subjected to detailed facies analyses.

In addition, several long term projects were initiated. Young pits and Pollen traps were installed and individual lichens were identified and measured. A subsequent visit in 1989 will provide evidence of the nature of these processes.

QN: january meeting

ANNUAL DISCUSSION MEETING AND MEETING OF THE JOINT ASSOCIATION FOR QUATERNARY RESEARCH, GEOLOGICAL SOCIETY OF LONDON, 4 AND 5 JANUARY, 1989

Further to several initial announcements related to this meeting (see, for example, the QRA *Circular* for June), the following abstracts here so far been submitted. These are arranged according to the speaker's rosta.

THE STRATIGRAPHIC SIGNIFICANCE OF PLEISTOCENE FLUVIAL SEDIMENTS AT WITHAM-ON-THE-HILL, LINCOLNSHIRE

S. Lewis, Birkbeck College, London

Exposures in sand and gravel pits at Witham-on-the-Hill, south Lincolnshire reveal a succession of fluvial gravels and overlying sands beneath a complex sequence of diamict and sands. A borehole survey of the area indicates the local geometry of the sedimentary units and has shown the presence of red/brown grading upwards into grey silt/clay sediments above the sands and below till, and a biogenic horizon within the gravels.

The lithostratigraphy and sedimentology of the fluvial deposits suggest that they were deposited by a river flowing from the east. The occurrence of a biogenic horizon within the gravels and a consistent facies change from gravel- to sand-dominated sediments suggests a complex history of fluvial activity. The relation of this sequence to the sequence in the west Midlands will be considered.

THE PLEISTOCENE DEPOSITS AROUND BRANDON, WARWICKSHIRE

D. Maddy, Birkbeck College, London

Recent excavations in the Brandon area have exposed extensive sections in the lower elements of the 'Wolstonian' type sequence. Detailed sedimentological, lithological, floral and faunal investigations suggest a more complex stratigraphy than was previously recognised and therefore, it is suggested that the existing stratigraphic model may have to be modified.

Exposures in the Pools Farm Pit show the transition from basal coarse, massive gravels (Baginton-Lillington Gravels) through to medium-fine, cross-bedded sands (Baginton Sands), all of which is considered to be of fluvial origin. Truncating this sequence is a complex unit believed to be in part alluvial and in part colluvial in origin.

Contained within the fluvial sequence are two fossiliferous channel fills. The lower channel fill, present within the gravels, has yielded a boreal forest type flora, although a more temperate episode is indicated by the enclosed Coleopteran fauna. The upper channel fill, contained within the sands, has yielded a fauna and flora of much colder aspects. The lower organics are believed to correlate with the organics at Waverley Wood which, using amino acid geochronology, have been shown to be of some antiquity.

In addition to the Pools Farm site, exposures in the River Avon terrace deposits previously assigned to Avon terraces No.3 and No.4 are now reinterpreted and assigned solely to Avon terrace No.4.

AMINO ACID GEOCHRONOLOGY OF QUATERNARY NON-MARINE DEPOSITS IN N.W. FRANCE

Martin Bates, The Museum of London

Fluvial and aeolian sediments in the river valleys of N.W. France, including the Somme and Seine, contain extensive non-marine molluscan faunas. Amino acid analysis has been used to construct local amino stratigraphies to allow inter and intra regional correlations. The significance of these results will be discussed with reference to the Quaternary history and Palaeolithic archaeology of the region.

UPPER PALAEOLITHIC FAUNAS FROM SOUTH WEST FRANCE: A ZOOGEOGRAPHIC PERSPECTIVE

K. V. Boyle, University of Cambridge

Given relevant background information on the physical geology of and environmental change experienced by the region, basic animal ecology and available seasonality indications, it is possible to begin to study the geographical distribution of faunal resources available in S.W. France between 32 000 and 10 000 B.P..

After a brief discussion of the assumptions under which it has been necessary to work when conducting the reported zoogeographic research, the aims, methods of analysis and data are described, followed by a more detailed consideration of the results obtained. Finally, the area of S.W. France from which data were devised is tentatively divided into a series of chronologically varying zoogeographic regions/provinces and their characteristic faunas are outlined.

JUNIPER AT HIGH FORCE, TEESDALE; THE FLANDRIAN HISTORY OF A SITE OF NATURE CONSERVATION IMPORTANCE

David M. Wilkinson, University of Durham and UWIST

Palaeoecological studies can potentially provide information of nature conservation interest. An example of such a study is work carried out on a mire next to a *Juniperus communis* woodland of nature conservation importance at High Force, Teesdale, in north east England. The site had developed from a area of open water early in the Flandrian to the topogenous mire which exists to-day.

Juniperus was found to have been growing along with *Betula* and *Pinus*. Low values of *Quercus* and *Ulmus* were recorded. The vegetational history of the site is compared with other sites in north east England and Scotland and is found to be similar to some Cairngorm pollen diagrams. This work confirms inferences that had previously been made about the antiquity of the *Juniperus* based on the unusual nature of the ground flora at High Force.

PEAT HUMIFICATION AND GROWTH RATES OF BLANKET MIRES:- A PROXY CLIMATIC INDICATOR?

Jeff Blackford and Dr Frank Chambers, University of Keele

The possible link between climate and peat growth has been known since the first studies of recurrence surfaces. This link has more recently been shown on a much shorter time scale by detailed, close interval macro- and microfossil analysis of raised mires.

Blanket mires, previously thought too slow growing and homogenous to show climatic changes may provide a proxy record of surface wetness that is less affected by past land use, differential preservation of Sphagnum leaves and base level changes than that obtained from raised bogs.

Analyses of humification, bulk density, pollen, fungal spores and other microfossils from locations of varying climate and hydrology have been used to test the value of blanket peat as a climatic record.

Data from sites in Co. Galway, Wales and North Yorkshire show fluctuations in humification throughout the period of peat accumulation, often coincident with changes in the bog surface vegetation. Initial results indicate some periodicity in these fluctuations, shown also in the curves of some pollen and fungal types.

Radiocarbon dating should show whether or not patterns in growth rates from the different sites are synchronous and allow the periodicities to be quantified.

TAPHONOMY OF DIATOM ASSEMBLAGES IN LAKE SEDIMENTS

Nigel Cameron, Palaeoecology Research Unit, University College, London

Loch Fleet, Galloway, S.W. Scotland was an acidified lake. Experimental liming of the lake catchment has produced changes in water quality and a consistently higher pH has been maintained. This resulted in a marked response of living diatom communities and has provided a means of testing some assumptions about the taphonomy of fossil diatom assemblages. The response (community composition, rate of change) of diatom communities to environmental change, the corresponding response of fossil assemblages and the representativity of the diatom fossil record are discussed.

WITHIN LAKE, BETWEEN CORE VARIATION IN DIATOM ASSEMBLAGES

N. J. Anderson, University of Umeå, Sweden

Palaeoecological interpretations of fossil diatom assemblages have become increasingly sophisticated through the use of a modern analogue approach, made possible by the use of new multivariate methods (eg. CANOCO), which permit the correlation of species abundance in surface-sediment samples with associated environmental data. Both this new approach to palaeolimnology, and more traditional ones, make a major assumption about the depositional environment of a diatom sediment assemblage: that is, a single core taken from the deepest part of the lake faithfully represents all the diatom communities within the lake. Heterogeneity of sediment accumulation within lake basins has been demonstrated by both sediment core and sediment trapping studies. While the representativity assumption is probably valid for percentage data, it is unlikely to be so, however, for diatom concentration and accumulation rate data.

Problems of within lake, between core variability of diatom assemblages will be demonstrated by reference to multi-core studies from different lake types: a lowland, eutrophic monomictic lake in N. Ireland (Lough Augher, Co. Tyrone); an upland wind-stressed lake in Galloway, S.W. Scotland (Loch Fleet); and a dimictic lake in Northern Sweden with varved sediments (Kassjön). Diatom percentage, concentrations and accumulation rates from a range of cores, of varying water depths will be given.

The general palaeoecological implications of these data sets will be assessed, and an attempt made to indicate the necessary methodological developments required to fully understand the causal processes responsible for the observed variation.

DIATOM: pH TRANSFER FUNCTIONS

Tony Stevenson, University of Newcastle-upon-Tyne

Current methods of environmental reconstruction by using transfer functions derived from biological data involves the use of linear multiple regression. This approach has theoretical limitations since it assumes inappropriately that biological variables are monotonically related to environmental variables (e.g. pH, salinity and temperature). An alternative approach using Canonical Correspondence Analysis and Weighted Averaging has greater validity, since it takes specific account of non-monotonic unimodal species responses. This method is illustrated with reference to quantitative pH reconstruction using diatom data from sediment cores. The potential of this method in other areas of palaeoecology will be outlined.

DIATOM/SALINITY TRANSFER FUNCTIONS

Steve Juggins, University College, London

Diatom analysis is widely used in the study of estuarine sediments to reconstruct salinity changes in the overlying waters. However there are problems in deriving accurate palaeosalinity estimates using established methods of interpretation based on the salinity classifications of Hustedt (1957) or Simonsen (1962). A comparative approach has therefore been taken to derive a quantitative relationship between the distribution and abundance of benthic diatoms in the modern Thames Estuary and water salinity. The transfer function is then used to estimate former salinity levels of the Thames from sub-fossil diatom assemblages obtained from waterfront archaeological sites in the City of London.

DIATOM DATABASES

M A R Munro, University College, London

There have been numerous studies of the response of diatoms to variations in some environmental variables such as pH and salinity, producing large bodies of data. A computerised diatom database can help reconstructions of changes in these variables through time by making it easy to select information on modern diatom assemblages for comparison with sub-fossil assemblages from sediment cores. It can function as a central repository of raw data for a variety of different techniques of statistical analysis and graphical display, and help large teams maintain standards of quality control by providing a standard for taxonomic nomenclature and a record of any local departures from it, as for example has been done within the SWAP project.

However it has considerably greater potential than this. By holding additional data (such as detailed water chemistry or catchment characteristics) within the database, one can use it as a powerful tool to investigate ecological hypotheses, such as the effects of trace metals or altitude on diatom assemblages. Once effects have been demonstrated using modern assemblages, the database should allow reconstructions from the sub-fossil assemblages of not just pH, but of a whole range of palaeoenvironmental variables; these should be of interest to Quaternary palaeoecologists and geologists.

GLACIOTECTONIC DEFORMATION

Jane K. Hart, University of East Anglia

This talk is a discussion of glaciotectonic deformation, with examples from both modern and ancient glacial environments.

Three types of glaciotectonic deformation were defined and models produced for their formation: subglacial—beneath the glacier, proglacial—at the glacier margin, paraglacial—associated with dead ice.

Subglacial deformation is characterised by highly attenuated folds and bondinage. It was shown that sediment beneath the glacier was deformed by simple shear, and that deformation occurred when the sediments were water saturated. The results of simple shear produce features beneath a glacier similar to those within a metamorphic shear zone. However, within the subglacial environment there are continual inputs from the glacier itself. Thus, the question of deposition and deformation within the subglacial zone shall be discussed and it shall be shown that the concept of "deformation till" is redundant as almost all basal tills have been deformed.

Proglacial deformation is characterised by open folding and thrusting, which are the result of longitudinal compression. It will be shown how the amount of strain varies longitudinally.

Thus, longitudinal compression occurs at the glacier margin and simple shearing occurs beneath the glacier. These zones within the basal sediments are related to zones within the glacier itself. As the glacier moves over a point in space so the bed conditions change, compressive to extensional, rigid/bed to soft bed, thus the resulting diamicton is a combination of these processes, with local material becoming a less dominant source of sediment supply as time increases.

DEBRIS SUPPLY AND LATEGLACIAL MORaine DEVELOPMENT IN THE NORTHERN HIGHLANDS OF SCOTLAND

Doug Benn, University of St. Andrews

The question of the glaciological and climatological significance of "hummocky moraine" in Scotland has been a vexed one. Some recent work suggests that a large proportion of Scottish hummocky moraine developed at the margins of valley glaciers in "active retreat", in association with substantial supraglacial loads of debris, principally derived from valley sides. This paper describes work that tests the significance of the association between glacially transported material and basinal controls on debris supply, particularly aspect, topography and lithology. Initial work on the within-valley asymmetry of latero-frontal moraines is used to demonstrate a strong association between debris supply and the aspect-related distribution of rock walls. This provides the basis for an investigation of the distribution of hummocky moraine in valleys in northern Scotland. Reference is also made to the sedimentology and internal structure of the moraines.

THE FORMATION OF VALLEY-WALL ROCK GLACIERS

Alison F. Maclean, University of St. Andrews

A rock glacier may be defined as a massive accumulation of debris that moves or has moved partly as a result of internal deformation of ice. Two major types of rock glacier are thought to exist. Valley-floor rock glaciers appear to be glacially derived and require the deformation of glacial ice for movement to occur. Valley-wall rock glaciers are less well understood, although some believe they comprise ice-rich perennially frozen sediments that move slowly downslope by creep. Detailed observations on the morphology and sedimentology of active, inactive and relict valley-wall rock glaciers studied in Switzerland, northern Norway and Scotland are discussed. Field measurements are then applied to theoretical models that test the feasibility of four major hypotheses of valley-wall rock glacier formation. Each hypothesis of formation has been proposed depending upon the supposed origin of the debris and internal ice. In these models, rock glacier movement and surface morphology reflects the deformation of internal ice which may be derived from: 1) buried glacier ice; 2) ice-rich perennially frozen sediments; 3) massive segregated ground ice; and 4) buried snow bank ice. Results from stable isotope analyses of ice obtained from active valley-wall rock glaciers in Switzerland are presented as additional evidence in establishing the formation of valley-wall rock glaciers.

QN: diary of events

LONDON QUATERNARY LECTURES

1988-89 PROGRAMME

It was suggested last year that it might be time for the 'founding fathers' of the LQL series to take the stage. (Some have greatness thrust upon them!) Accordingly, the lectures for the current academic session are as follows:-

TUESDAY, 13th DECEMBER, 1988

J. M. Gray (Queen Mary College, University of London)

'Late Quaternary land/sea/ice interactions on the W. Scottish coastline'

6.00 p.m., Geography Department, Birkbeck College

MONDAY, 20th FEBRUARY, 1989

J. Rose (Birkbeck College, University of London)

'Problems of glaciations in the British Middle Pleistocene'

6.00 p.m., Geography Department, Birkbeck College

WEDNESDAY, 15th MARCH, 1989

J. J. Lowe (City of London Polytechnic)

'Towards a better understanding of continental-scale environmental changes during the Last Glacial Lateglacial'

6.00 p.m., Geography Department, Birkbeck College

Details of individual lectures will be circulated in the usual way.

J. Murray Gray, John Lowe, Jim Rose

10 October, 1988

Q.R.A. MIDLAND QUATERNARY SEMINAR

The following seminars have been arranged for this academic year:

16th February 1989 Mark Roberts (Institute of Archaeology, London). Recent work on the Boxgrove Palaeolithic site and its bearing on the Pleistocene sequence of southern England. To be held in the Geography Department, Coventry Polytechnic at 5.00 pm.

8th March 1989 Albert Horton (BGS) and David Keen (Coventry Polytechnic). The Middle Pleistocene deposits of the Peterborough area with especial reference to the Hoxnian Woodston Beds. To be held at BGS, Keyworth at 4.30 pm.

All interested persons are invited to attend these seminars. For further details see the *Quaternary Newsletter* or phone David Keen or Alistair Dawson at Coventry Polytechnic (0203-224166 ext. 2692 or 2556).

GLACIMARINE ENVIRONMENTS: PROCESSES AND SEDIMENTS

16th–18th MARCH 1989: Geological Society and University College, London

Advanced notice is hereby given of a three-day meeting jointly sponsored by the Marine Studies Group of the Geological Society and the International Glaciological Society, and promoted under the aegis of IGCP-260. The meeting will consist of a two-day conference at the Geological Society, Burlington House, Piccadilly, London, followed by a one-day core workshop and poster session co-ordinated by the British Geological Survey which will be held in the Department of Geology, University College, London.

The emphasis of this meeting will be on the controlling processes of glacial marine sedimentation. It is hoped that the meeting will provide a forum for the interchange of ideas and information between scientists working on contemporary glacial marine environments and geologists interpreting glacial marine sequences. The meeting will be multidisciplinary in character, with contributions from glaciologists, high-latitude oceanographers, high-latitude marine ecologists, sedimentologists and stratigraphers/palaeontologists (both Pleistocene and pre-Pleistocene). The proceedings will be published as a Special Publication of the Society. Offers of papers and posters for this meeting are still welcome.

In addition to keynote presentations by R. Gilbert, R. Powell, N. Eyles and J. Syvitski other contributors will include E. Reimnitz, P. Carlson, E. Cowan, D. Drewry, A. Elverhøi, A. Solheim, A. Aitken, A. Lord, D. Huddart, M. Stoker, I. Selby, C. Eyles, E. Domack, M. Hambrey, C. Evans, C. Pereira, T. Vorren, D. Shearman, A. Smith, F. Stewart, D. Evans, C. James and C. Pudsey.

Deadline for abstracts (which should not be longer than 100 words); 1st November 1988. Abstracts for the meeting will be published in the January 1989 issue of the Geological Society Newsletter. Registration Forms will be available in the November 1988 and January 1989 issues of the Newsletter.

All enquiries, including offers of papers and posters, should be addressed to the convenors:

Dr J. D. Scourse,
School of Ocean Sciences,
University College of North Wales,
MENAI BRIDGE,
Gwynedd, LL59 5EY,
UK

Telephone: 0248 351151 X2872/6

Dr J. A. Dowdeswell,
Department of Geography,
University College of Wales,
Llandinam Building,
Penglais,
ABERYSTWYTH,
Dyfed, SY23 3DB,
UK

Tel: 0970 3111

Dr M. J. Hambrey (for IGCP-260),
Department of Earth Sciences,
University of Cambridge,
Downing Street,
Cambridge, CB2 3EQ,
UK

Telephone: 0223 333400

QUATERNARY SCIENCES IN EUROPE

The Biennial Meeting of the European Union of Geosciences is the largest regular geoscience meeting in Europe. *The 1989 meeting, EUG V*, will be held in Strasburg, France, March 20–23, 1989. The meeting provides an interdisciplinary scientific forum for a wide-ranging variety of modern earth science topics of general and specialised nature and a considerable part of the program is allocated to discuss topics in Quaternary in its broadest sense.

Below is a listing of scientific events that should be of interest to you:

OPEN SESSIONS:

- Quaternary geology (Larsen, Trondheim; Warren, Dublin).
- Ocean Drilling Programme (ODP)/Marine geology (Schrader, Bergen; Van Hinte, Amsterdam).

SPECIAL SYMPOSIA:

- Cainozoic geology of the N-W European continental margin and adjacent deep-sea areas (Vorren, Tromsø; Sejrup, Bergen; Thiede, Kiel).
- The last interglacial—glacial cycle (Mangerud, Bergen; de Beaulien, Marseille; Schlüchter, Zürich).
- Geology and the environment (Wolff, Trondheim; Cendrero, Santaner; Bolviken, Trondheim; Thornton, London; Jackson, Cambridge; Papazachos, Tessaioniki; Stephansson, Lulea; Peudecerf, Orleans; Hull, Edinburgh; Oele, Haarlem).
- Use of remote sensing in geological studies (Weber, Orléans; Cassinis, Milan; Follestad, Trondheim).
- Isotopes and climatic and environmental changes (Shackleton, Cambridge; Jansen, Bergen; Minster, Toulouse; O'Nions, Cambridge).
- Advances in the study of lacustrine sediments (Talbot, Bergen; Kelts, Zürich; Negendank, Trier; Bonifay, Marseille; Creer, Edinburgh).
- Milankovitch cyclicity in the Pre-Pleistocene stratigraphic record (Smith, Sunbury; Berger, Louvain; de Boer Utrecht).

POSTER PRESENTATIONS

The organizers would like to encourage the use of poster presentations.

For further information and/or registration circular, please contact:

Organizing Committee EUG V
Geological Survey of Norway
Box 3006—Lade
N-7002 Trondheim, Norway
Telex: 55417 NGU N
Telefax: (47) 7-92 16 20

ENGINEERING GROUP OF THE GEOLOGICAL SOCIETY

25th ANNUAL CONFERENCE

QUATERNARY ENGINEERING GEOLOGY

10-14 September 1989

Heriot-Watt University, Edinburgh.

The Conference will cover all aspects of Engineering Geology relating to the Quaternary. The theme is deliberately broad so as to provide an international forum for all academic and practising engineering geologists whose area of work is in the Quaternary. An important aspect of the Conference will be key thematic addresses on various aspects of the Quaternary and its engineering legacy.

TECHNICAL PROGRAMME

The Technical Programme will begin on Monday 11th September. The four day programme will include the presentation of general reports and selected papers, followed by open discussions.

The Tuesday will be reserved for field excursions to sites of engineering geological interest in Central Scotland.

Both glacial and non-glacial aspects of the Quaternary will be covered. Papers are invited on the following main themes:

THEME 1 ENGINEERING GEOLOGY

- Description of the geological and hydrogeological characteristics of Quaternary deposits.
- Geomorphological processes, e.g. weathering, periglaction etc.
- Remote sensing.
- Mapping.
- Databases.

THEME 2 GEOTECHNICAL PARAMETERS

- The selection of geotechnical parameters for use in analytical models.
- Field and laboratory measurements.
- Interpretation of measured data.

THEME 3 CONSTRUCTION CASE STUDIES

- Design and execution of works.
- Effects of construction works on the behaviour of Quaternary deposits.
- Monitoring of works.

For further information please contact:-

Dr J. A Little,
Department of Civil Engineering,
Heriot-Watt University,
Edinburgh, EH14 4AS,
Scotland

Telephone: (031) 449 5111

QN: Quaternary Research Association

QUATERNARY RESEARCH ASSOCIATION

The Quaternary Research Association is an organisation comprising geologists, geographers, botanists, zoologists, archaeologists, soil scientists, civil engineers and others interested in research into the problems of the Quaternary. Most members reside in Great Britain, but membership also extends to most European countries, North America, Africa and Australia. Current membership stands at *circa* 1000. Membership is open to all interested in the objectives of the Association. The annual subscription of £5.00 is due on January 1st for each calendar year.

The main meetings of the Association are the annual field meeting, usually lasting 3-4 days, held in April, and a 1-2 day discussion meeting held at the beginning of January. Additionally, short field meetings may be held in May or September and occasionally these visit overseas locations. Study courses on the techniques used in Quaternary work are also occasionally held. The publications of the Association are the *Quaternary Newsletter* issued with the Associations' *Circular* in February, June and November, the *Journal of Quaternary Science* published in association with Longmans and with three issues a year, the field guides series and the technical guides series.

The Association is run by an executive committee elected at an annual general meeting held during the course of the April field meeting. The current officers of the Association are:

President

J Rose, Department of Geography, Birkbeck College, University of London

Vice-President

Professor P Worsley, Department of Geography, University of Nottingham

Secretary

Dr D H Keen, Department of Geography, Coventry Polytechnic

Assistant Secretary (Publications)

Dr R V Dackombe, School of Applied Sciences, Wolverhampton Polytechnic

Treasurer

C A Whiteman, Botany School, University of Cambridge

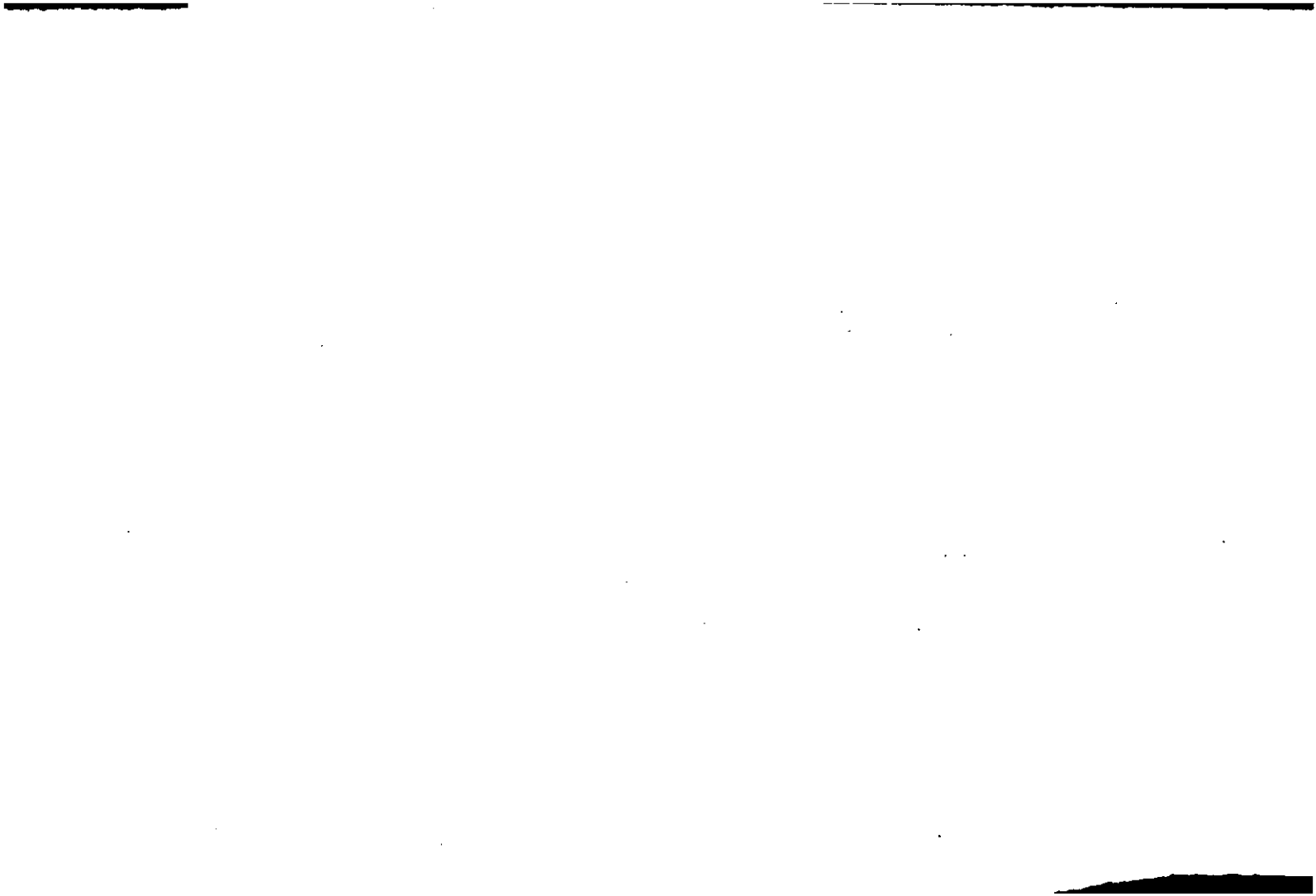
Editor, Quaternary Newsletter

Dr D T Holyoak, Department of Geography, College of St Paul and St Mary, Cheltenham

Editor, Journal of Quaternary Science

Dr J J Lowe, Department of Geography, City of London Polytechnic

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



QUATERNARY NEWSLETTER

QN:

November 1988 No.56

CONTENTS

Page

1	Articles
11	Field Report
14	Theses abstracts
17	Book review and reference
20	Correspondence
26	INQUA
28	September Meeting
35	January Meeting
40	Diary of events
44	Quaternary Research Association statement of intent and current affairs