
November 1987 No 53

QUATERNARY NEWSLETTER

A PUBLICATION OF THE
Quaternary Research Association

Q.N.:

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 1987

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

STATUS OF THE WOLSTONIAN GLACIATION IN THE BRITISH QUATERNARY

J. Rose

Abstract

Conventionally, the last three glacial Stages of the British Quaternary have been accepted as Anglian, Wolstonian and Devensian, largely by relation to interglacial biostratigraphy (Mitchell *et al.* 1973) (Fig. 2). However, a regional study of the Baginton/Lillingdon Gravels, which form the lower part of the Wolstonian at its type site (Shotton 1953, 1976, 1983a, b), shows that these sediments can be traced to East Anglia where they lie beneath glacial deposits of Anglian age (West 1956, 1980, Perrin *et al.* 1979, Rose *in press*). Thus, the sediments at the type site, and other 'Wolstonian' deposits in Midland England were formed prior to, and not after the Anglian glacial. Consequently, the extent of glaciation in England between the Anglian and Devensian Stages is in need of revision, and the use of the term 'Wolstonian' to describe the glaciation at this time is no longer appropriate.

Introduction

Ever since the Wolstonian Stage was so named (Mitchell *et al.* 1973) its validity has been subject to controversy (Bristow & Cox 1973, Bowen 1978, Oele & Schuttenhelm 1979, Perrin *et al.* 1979, Sumbler 1983a, 1983b, Shotton 1983b, Bowen *et al.* 1986, Rose *in press*). Nevertheless, this stage and all its implications for British Quaternary stratigraphy, extent of glaciation, palaeoclimatology, geomorphology, and archaeology, have been retained and remained influential. Essentially the palynostratigraphic control (Kelly 1964, Horton 1974) was based on inference or ambiguous and imprecise description, the quality of the macrofaunal evidence has been considered unacceptable (Sumbler 1983a, b), and the lithostratigraphy required the assumption that a lithologically continuous till should be sub-divided without observational basis (Perrin *et al.* 1979, Sumbler 1983, Shotton 1983). Arguments for its retention have restated known facts without additional evidence (Shotton 1983a, b, Straw 1979, 1983). This paper describes new lithostratigraphic evidence, by which it is possible, for the first time, to place the 'Wolstonian' deposits in a wider stratigraphic context. The results are discussed in terms of their implications for the Quaternary stratigraphy of Britain and Europe, and the glacial history of the northeast Atlantic climatic province (Bowen *in press*).

Nature and extent of 'Wolstonian' sediments

The type succession for the Wolstonian Stage consists of (Shotton 1953, 1976, 1983a, b, Sumbler 1983a):

Dunsmore Gravel	
Upper Wolston Clay]
Wolston Sand] Thrussington Till/Oadby Till
Lower Wolston Clay]
Baginton Sand	
Baginton/Lillington Gravel	

which are considered to represent a full cycle consisting of the onset of glaciation, glaciation and deglaciation.

The Baginton/Lillington Gravels and the Baginton Sands are located in a buried valley which has a northeastward slope (which is at variance with the present relief), and have sedimentary properties that indicate that they were deposited by a river which drained northeastward (Fig. 1) (Shotton 1953, 1976, 1983a, b). The buried valley and the associated sediments can be traced beyond the type area through south Lincolnshire to East Anglia (Fig. 1) as indicated by others (Rice, 1968, 1981, Wyatt 1971, Wyatt *et al.* 1971, Straw 1979, 1983, Douglas 1980, Hey 1980, Hawkins 1981, Auton 1982, Auton *et al.* 1985, Clarke & Auton 1982, 1984, Clarke 1983) although with the exception of Clarke & Auton (1982, 1984) their regional continuity has not been perceived, and their significance has been discussed only in a local context with little reference to the wider stratigraphic position. In Leicestershire these sediments have been called the Thurmaston Sand and Gravels (Rice 1968), and in Suffolk and Norfolk the Ingham Sand and Gravel (Hawkins 1981, Auton 1982, Clarke & Auton 1982, 1984, Clarke 1983).

The extent and elevation of the buried valley and associated sediments are shown in Figure 1. Essentially, the base of the buried valley floor falls from around 90 m O.D. near Stratford upon Avon, to 65 m near Leicester, 45 m near Castle Bytham, 16 m south of Kings Lynn, 9 m at Lakenheath, and close to sea-level near Diss. The top of the sediment body falls from around 94 m O.D. near Stratford upon Avon, 76 m just west of Melton Mowbray, to 65 m near Castle Bytham. Further east it is more heavily dissected, but lies within a band that has an upper boundary around 60 m south of Kings Lynn and 50 m near Diss. This eastward slope is in accordance with the depositional sedimentary structures which show palaeocurrent directions parallel with the trend and slope of the valley.

The gravel size fraction is most distinctive and is dominated by quartz and quartzite pebbles from the Triassic Kidderminster Formation of west Midland England. This characteristic persists throughout despite entrainment of local material (Rice 1968, 1981, Hey 1980, Hawkins 1981, Auton 1982, Clarke & Auton 1982, 1984, Clarke 1983). Less abundant, but significant as an indicator of provenance and transport-path is Carboniferous chert (most probably from the south Pennines) that invariably occurs within the deposit. In west Norfolk and Suffolk the absence of flints derived from Tertiary rocks of the London Basin distinguishes it from the sand and gravels of the Kesgrave Formation (Rose *et al.* 1976, Rose & Allen 1977, Rose 1983,

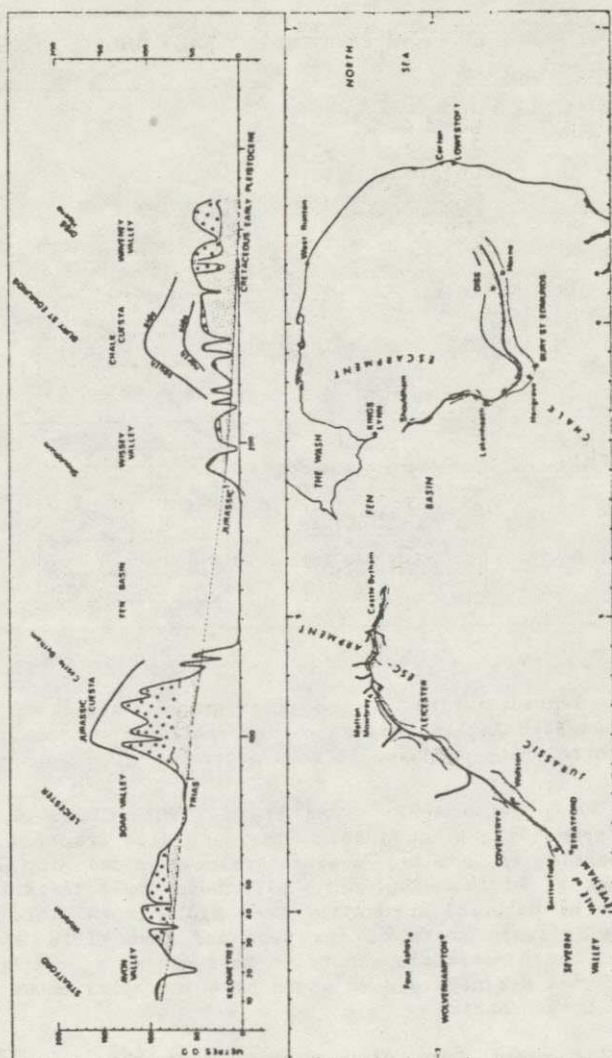


Figure 1. Geographical, altitudinal and stratigraphical position of the Baginton/Lillington Gravels. In the lower diagram stipple indicates the presently known extent of the sediment body, and the solid line indicates the inferred axis of the buried valley. Also indicated are localities referred to in the text. In the upper diagram stipple also indicates the river sediment, and glaciogenic sediment is represented by solid triangles. Relief forms are exaggerated in order to demonstrate the location and thickness of the Quaternary sediments. Bedrock into which the valley is eroded is shown, with the boundaries between the different strata indicated by a short vertical line. The positions of the Jurassic and Cretaceous escarpments are shown by a thick black line. Scale and orientation are indicated by 10 km National Grid coordinates.


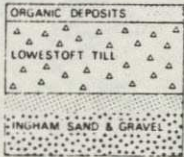

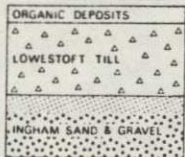
	MIDLAND ENGLAND	EAST ANGLIA	STAGE NAMES
TRADITIONAL CORRELATION			WOLSTONIAN
			HOXNIAN
			ANGLIAN
			PRE-ANGLIAN
REVISED CORRELATION			HOXNIAN
			ANGLIAN
			AND EARLIER

Figure 2. Representation of the stratigraphic sequences in Midland England and East Anglia showing the conventional correlation and the revised correlation proposed in this paper.

Hawkins 1981, Auton 1982, Auton *et al.* 1985, Clarke & Auton 1982, 1984, Clarke 1983, Allen 1984). The sand size fraction is composed predominantly of rounded quartz grains typical of the Triassic sandstones of Midland England. All these characteristics indicate transport of material across the East Midlands and into East Anglia from the Triassic rocks of the West and East Midlands. No other source of these materials exists in East Anglia as transport *via* the proto-Thames drainage system would have incorporated Tertiary rocks from the London Basin.

Material other than that derived from the area of the west Midlands and south Pennines is rare and never exceeds a value greater than 1%. Thus, there are virtually no materials contained within this deposit that could be interpreted as glacial erratics, and it seems that within the area concerned the sediments are essentially 'pre-glacial' in age.

The stratigraphic position of these fluvial deposits can be observed at 16 sites in addition to Wolston (Fig. 2). The complete succession is:

4. Till (composed predominantly of:
 - Triassic lithologies in the west (Thrussington Till),
 - interdigitating Triassic/Jurassic lithologies around Leicester (Thrussington/Oadby Tills),

- Jurassic lithologies in east Leicestershire and south Lincolnshire (Oadby/Heath Tills),
Jurassic and Cretaceous lithologies in East Anglia (Lowestoft Till).
3. Glaciolacustrine clays and sands (consisting predominantly of: Wolston Clays and Sands of Warwickshire, Rotherby Clay, Glen Parva Clay, Bosworth Clays and Silt and Wigston Sand and Gravel of Leicestershire).
 2. Fluviatile sands and gravels (consisting predominantly of: Baginton/Lillington Gravels, and Baginton Sands of Warwickshire and Leicestershire, (at sites such as Waverley Wood (Shotton 1986) and Brooksby (Rice 1986) this deposit is associated with biogenic materials. Ingham Sand and Gravel of East Anglia).
 1. pre-Quaternary bedrock.

Critical stratigraphic relationships

Of particular importance are the following observations:

1) At Snitterfield near Stratford upon Avon the top of the Baginton Sands interdigitates with the base of the Wolston Clay (formed in a proglacial lake) confirming the continuity of sedimentation initially suggested by Shotton (1953, 1976, 1983a, b) and demonstrating that the upper part of the Baginton Sands immediately preceded the succeeding event of glaciation.

2) Around Diss the Ingham Sand and Gravel underlie the Lowestoft Till which is, in turn, overlain by organic deposits of Hoxnian age, including those at the stratotype at Hoxne.

3) At Hengrave near Bury St. Edmunds the Ingham Sand and Gravel interdigitate with the Kesgrave Sands and Gravels Formation (Early and Middle Pleistocene Thames river deposits (Rose *et al.* 1976, Rose & Allen 1977, Rose 1983, Hey 1980, Allen 1984, Bowen *et al.* 1986)). At a number of sites east of Bury St. Edmunds the Ingham Sand and Gravel are deposited in a valley cut through the Kesgrave Formation.

4) The Valley containing the Baginton/Lillington Gravels cuts across the Jurassic and Cretaceous escarpments indicating that the river system was initiated before the intervening lowlands came into existence (Figure 2).

Conclusions

From this evidence the following conclusions are proposed:

1) The quartz/quartzite gravels, known in the west Midlands as the Baginton/Lillington Gravels form a spatially continuous lithostratigraphic unit deposited by a river which drained, at its fullest extent, a catchment extending from around Stratford upon Avon in the west, eastwards to the area around Diss and beyond.

2) The unit began to form during the Early Pleistocene when the quartz/quartzite gravels interdigitated with the oldest part of the

Kesgrave Formation (Bowen et al. 1986). It continued to accumulate until it was overridden by the ice sheets of the Anglian glaciation.

Implications for British Quaternary stratigraphy and landscape evolution

1) The Type Wolstonian glacial sediments were deposited prior to, and during the earlier part of the Anglian Stage, and not in the glaciation succeeding the Anglian Stage (Fig. 2).

2) The Thrussington/Oadby/Lowestoft Tillis which cover most of Midland and eastern England form a single lithostratigraphic unit that is of Anglian age (Perrin et al. 1979, Rose in press). Quartz and quartzite pebbles in the Oadby and Lowestoft Till, respectively east of the Trias and north of the Kesgrave Formation are eroded from the Baginton/Lillington Gravels in south Lincolnshire and the Fen Basin.

3) The term 'Wolstonian' should be abandoned for the Stage between the Hoxnian and Ipswichian Stages. In view of the current debate on the British Middle Pleistocene (Bowen et al. 1986), it is proposed that until further evidence is available glacial episodes during this interval should be referred to as 'those occurring between the Hoxnian (s.s.) and the Ipswichian (s.s.) Stages'.

4) The Wash and Fen basin was eroded during the Anglian glaciation as suggested by Perrin et al. (1979) subsequent to the deposition of the Baginton/Lillington Gravels.

5) The Middle Severn and Avon valleys, and the full extent of the Cotswold escarpment were formed in the interval between, and possibly partly including, the Anglian and the Beestonian Stages. This is inferred from the information given above and the fact that the River Thames drained a much larger catchment, which included the west Midlands in the Beestonian Stage (Bowen et al. 1986). This represents one of the major changes in the landscape of England.

7) Much of Midland England was not covered by ice during the interval between the Hoxnian and Ipswichian interglacial stages. This is at variance with the interpretation of the evidence from the Netherlands and western Germany which suggests that the same interval saw the maximum expansion of glaciers (Ehlers et al. 1984). Such differences in the response of regional ice sheets to climatic forcing within the northeast Atlantic region is of importance for climatic modelling.

Acknowledgements

I wish to dedicate this paper to the late Roger Bullimore whose sand pits were the source of the ideas expressed above. I also wish to acknowledge the insight of Mr. Mike Rice, a Birkbeck College undergraduate who saw the wider implications of some of this research long before this investigation began, and to C.A. Auton, M.R. Clarke, R.W. Hey, D. Maddy, S.J. Mathers and R.J. Rice who have been concerned with aspects of this topic and have very generously contributed information, read the original manuscript and discussed the problem with me. I also wish to thank D.R. Bridgland, D.Q.

Bowen, K.M. Clayton, T.D. Douglas, J.K. Elliot, C.C. Ferguson, P.L. Gibbard, A. Straw, F.W. Shotton, M.G. Sumbler, R.G. West, C.A. Whiteman and P. Worsley for commenting on the original manuscript. This paper was originally submitted to Nature and I wish to thank the two anonymous referees who made constructive comments and recommended its publication in that journal. The comments of all those listed above have been given detailed consideration and, as far as possible, incorporated in this manuscript. However the opinions expressed are the responsibility of the author.

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

References

- Allen, P. (ed) 1984. Field Guide to the Gipping and Waveney Valleys, Suffolk. Q.R.A., Cambridge.
- Auton, C.A. 1982. The sand and gravel resources of the country around Redgrave, Suffolk. Min. Assessment Rept 117. I.G.S., Keyworth.
- Auton, C.A., Morigi, A.N. & Price, D. 1985. Sand and gravel resources of the country around Harleston and Bungay, Norfolk and Suffolk. Min. Assessment Rept 145. B.G.S., Keyworth.
- Bowen, D.Q. in press. Correlation of the marine and continental glaciation records of the past three million years. Phil. Trans. R. Soc. Lond.
- Bowen, D.Q. 1978. Quaternary Geology, Pergamon, Oxford.
- Bowen, D.Q., Rose, J., McCabe, A.M. & Sutherland D.G. 1986. Correlation of Quaternary Glaciation in England, Ireland, Scotland and Wales. Quat. Sci. Rev. 5, pp. 299-340.
- Bristow, C.R. & Cox, F.C. 1973. The Gipping Till: a reappraisal of East Anglian glacial stratigraphy. Jl Geol. Soc. Lond. 129, pp. 1-37.
- Clarke, M.R. 1983. Sand and gravel resources of the country around Woolpit, Suffolk. Min. Assessment Rept 127. I.G.S. Keyworth.
- Clarke, M.R., & Auton, C.A. 1982. The Pleistocene depositional history of the Norfolk-Suffolk borderlands. Inst. Geol. Sci. Rept 82/1, pp. 23-29.
- Clark, M.R., & Auton, C.A. 1984. Ingham Sand and Gravel. In: P. Allen (ed), Field Guide to the Gipping and Waveney Valleys, Suffolk, Q.R.A., Cambridge.

- Douglas, T.D. 1980. The Quaternary deposits of western Leicestershire. Phil. Trans. R. Soc. Lond. B288, pp. 259-286.
- Ehlers, J., Meyer, K.-D. & Stephan, H.-J. 1984. The pre-Weichselian glaciations of North-west Europe. Quat. Sci. Rev. 3, pp. 1-40.
- Hawkins, M.R. 1981. The sand and gravel resources of the country around Bury St. Edmunds, Suffolk. Min. Assessment Rept 72. I.G.S., Keyworth.
- Hey, R.W. 1980. Equivalents of the Westland Green Gravels in Essex and East Anglia. Proc. Geol. Ass. 91, pp. 279-290.
- Horton, A. 1974. The sequence of Pleistocene deposits proved during the construction of the Birmingham motorways. Inst. Geol. Sci. Rept 74/11, 30 pp.
- Kelley M.R. 1964. The middle Pleistocene of north Birmingham. Phil. Trans. R. Soc. Lond. B247, pp. 533-592.
- Mitchell, G.F., Penny, L.F., Shotton F.W. & West R.G. 1973. A correlation of Quaternary deposits in the British Isles. Geol. Soc. Lond., Special Report 4, 99 pp.
- Oele, E., & Schuttenhelm, R.T.E. 1979. Development of the North Sea after the Saalian Glaciation. In: Quaternary History of the North Sea, Acta Universitatis Upsaliensis, Uppsala.
- Perrin, R.M.S., Rose, J. & Davies H. 1979. The distribution, variations and origins of pre-Devensian tills in eastern England. Phil. Trans. R. Soc. Lond. B287, pp. 535-570.
- Rice, R.J. 1968. The Quaternary deposits of central Leicestershire. Phil. Trans. R. Soc. Lond. A262, pp. 459-509.
- Rice, R.J. 1981. The Pleistocene deposits of the area around Croft in south Leicestershire. Phil. Trans. R. Soc. Lond. B293, pp. 385-418.
- Rice, R.J. 1986. A new interglacial site at Brooksby Leicestershire. Quat. Newsl. 50, p. 30.
- Rose, J. (ed.) 1983. The Diversion of the Thames. Q.R.A. Cambridge.
- Rose, J. in press. Stadial type sections in the British Quaternary. In: Schluchter, Ch. (ed), Quaternary Type Sections. Balkema, Rotterdam.
- Rose, J. & Allen, P. 1977. Middle Pleistocene stratigraphy in south-east Suffolk. Jl Geol. Soc. Lond. 133, pp. 83-102.
- Rose, J., Allen, P. & Hey, R.W. 1976. Middle pleistocene stratigraphy in southern East Anglia. Nature, Lond. 263, pp. 492-494.

Shotton, F.W. 1953. Pleistocene deposits in the area between Coventry, Rugby and Leamington and their bearing on the topographic development of the Midlands. Phil. Trans. R. Soc. Lond. B237, pp. 209-260.

Shotton, F.W. 1976. Amplification of the Wolstonian Stage of the British Pleistocene. Geol. Mag. 113, pp. 241-250.

Shotton, F.W. 1983a. Observations on the type Wolstonian glacial sequence. Quat. Newsl. 40, pp. 28-36.

Shotton, F.W. 1983b. The Wolstonian stage of the British Pleistocene in and around its type area of the English Midlands. Quat. Sci. Rev. 2, pp. 261-280.

Shotton, F.W. 1986. The Pleistocene deposits at Waverley Wood Farm Pit: their age and stratigraphic significance. Quat. Newsl. 50, p. 30.

Straw, A. 1979. The geomorphological significance of the Wolstonian glaciation of eastern England. Trans. Inst. Brit. Geog. NS 4, pp. 540-549.

Straw, A. 1983. Pre-Devensian glaciation of Lincolnshire (eastern England) and adjacent areas. Quat. Sci. Rev. 2, pp. 239-260.

Sumbler, M.G. 1983a. A new look at the type Wolstonian glacial deposits of central England. Proc. Geol. Ass. 94, pp. 23-31.

Sumbler, M.G. 1983b. The type Wolstonian sequence - some further observations. Quat. Newsl. 40, pp. 36-39.

West, R.G. 1956. The Quaternary deposits at Hoxne, Suffolk. Phil. Trans. R. Soc. Lond. B239, pp. 265-356.

West, R.G. 1980. The pre-glacial Pleistocene of the Norfolk and Suffolk Coasts. C.U.P., Cambridge.

Wyatt, R.J. 1971. New evidence for drift-filled valleys in north-east Leicestershire and south Lincolnshire. Bull. Geol. Surv. G.B. 37, pp. 29-55.

Wyatt, R.J., Horton, A. & Kenna, R.J. 1971. Drift filled channels on the Leicestershire-Lincolnshire border. Bull. Geol. Surv. G.B. 37, pp. 57-79.

S. Jennings and C. Smyth

The increasing commercial and residential pressures on lowlying coastal areas require planning decisions that take account of sediment budget and relative sea-level change, both of which show important temporal variations within different time scales. Research undertaken at Eastbourne, East Sussex (Fig. 1) highlights the necessity of observing morphological changes to coastlines over different time scales, and suggests that planning decisions be taken in the light of longer-term (hundreds to thousands of years) as well as short term changes (up to a few decades). Four time scales are considered in this article: long term coastal changes measured over thousands of years covering the Holocene epoch, the last 400 years, the yearly changes since 1973 and possible future changes to the year 2100.

The coastal zone at Eastbourne can be divided into two related morphological areas. On the coast the Crumbles Shingle forms a barrier beach at its western end and a broader cusate foreland at Langney Point (Fig. 1). The natural elevation of the Crumbles lies at around +5 m O.D., but gravel extraction has lowered much of the landward surface to +3 m O.D. Nevertheless, the Crumbles protects the lower lying Willingdon Levels to the north which, at +2 m to +3 m O.D. are approximately 1 m below MHWST. This study concentrates on the western section of the Crumbles as this is the area most sensitive to erosion. Coastal retreat here would have important implications for the planned developments of a country park on Willingdon Levels and a yacht marina and village on the Crumbles.

Holocene time scale

The ephemeral nature of the present coastal form and surface sediment type at Eastbourne is emphasised when the evolution of the Crumbles is examined over the long time scale of the Holocene. 33 m of sediments have been deposited, representing major infilling as base levels rose. Studies of the Holocene evolution of the Eastbourne coastline have suggested that the pattern of sedimentation reflects the progressive shoreward movement of barriers, composed initially of sand, but culminating in the development of a gravel cusate foreland (Jennings 1985, Jennings & Smyth 1987). According to documented sources (Dulley 1966) this accumulation of gravel had begun by 800 a B.P.

Lithostratigraphic and biostratigraphic evidence indicates that on Willingdon Levels, throughout most of the Holocene, there has been extensive minerogenic sedimentation in a low energy estuarine environment behind the developing barrier system. There have been only two brief episodes of freshwater conditions, the first of which is recorded in the sediments by a thin organic layer radiocarbon dated from 3750 ± 40 a B.P. (SRR 2455) to 3390 ± 40 a B.P. (SRR 2454). The second episode is represented by the present environment of the Levels which became established due to the formation of the Crumbles Shingle only some 800 years ago (Jennings & Smyth 1987). However, the on-shore movement of sediment that has been so important

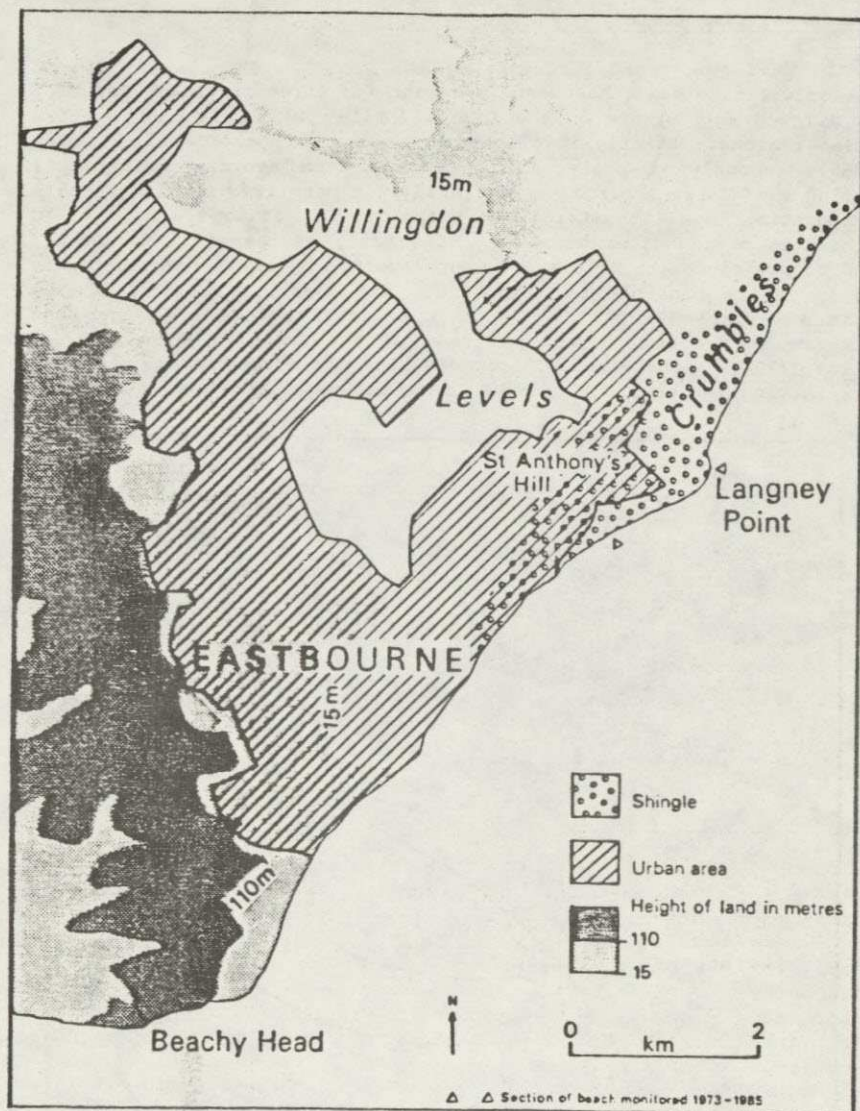


Figure 1. Location map of Eastbourne showing the extent of the Crumbles Shingle and urban area. The section of the Crumbles monitored for beach volume changes 1973-1985 is indicated.

for coastal development during the Holocene appears to have ceased, the Channel now being fairly clean of coarse material, and this has resulted in severe erosion of the Crumbles Shingle during the historical time scale.

Historical time scale

The development and influence of the Crumbles Shingle throughout historical time scale has been important for three reasons. Firstly, it allowed agriculture on the Levels (Dulley 1966), secondly, itfor three reasons. Firstly it allowed agriculture on the Levels (Dulley 1966), secondly it protected the Levels from storms, for example during the Medieval period, and finally, it permitted the large scale residential and industrial development of lowland that would otherwise be inundated at MHWST. The area has been well documented and mapped since the 1700's and, supplemented by earlier accounts, it is therefore possible to reconstruct the coastline changes of the last 400 years (Fig. 2). The most salient feature shown by this diagram is the considerable retreat of the Crumbles Shingle since circa 1730. In fact from 1736 to 1844 the sea advanced more that 0.8 km, giving an average annual retreat rate of 7.4 m (Redman

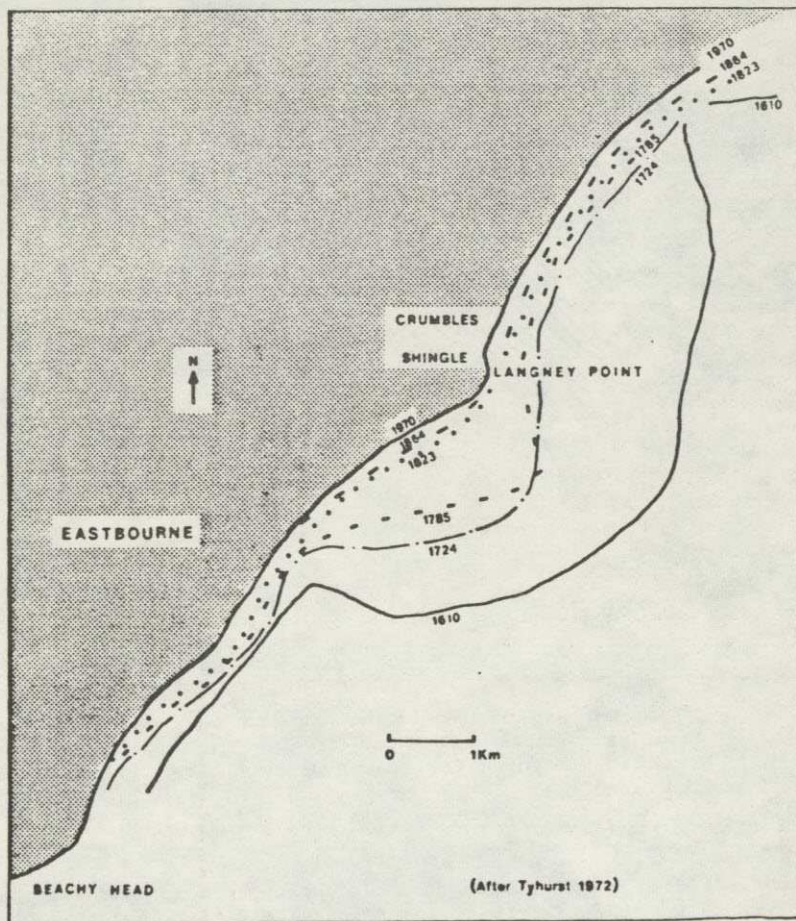


Figure 2. Retreat of the coastline at Eastbourne since 1610.

1851-1852). Significantly, this erosion predates building of groynes further west (for example at Newhaven) and therefore up-drift of littoral sediment movement. Groyning since 1893 has decelerated the erosion of the Crumbles Shingle and apparently produced stability (Tyhurst 1972), but a more accurate assessment may be gained by studying yearly variations in the sediment volume.

Yearly time scale

In recent years there have been interesting variations in the sediment volume on the western part of the Crumbles (Fig. 3). The 13 years of data obtained from the Southern Water Authority are based upon a beach monitoring survey. These data suggest a cyclical pattern but with a trend towards diminishing beach volume over the period 1982 to 1985. Storm damage to the Crumbles in November 1984 and April 1985 indicates a possible link between sediment volume and overtopping of the shingle.

To assess the importance of these trends for engineering purposes, two factors must be considered. First, whether the pattern of beach volume is cyclical, thereby leading to a reversal of the current

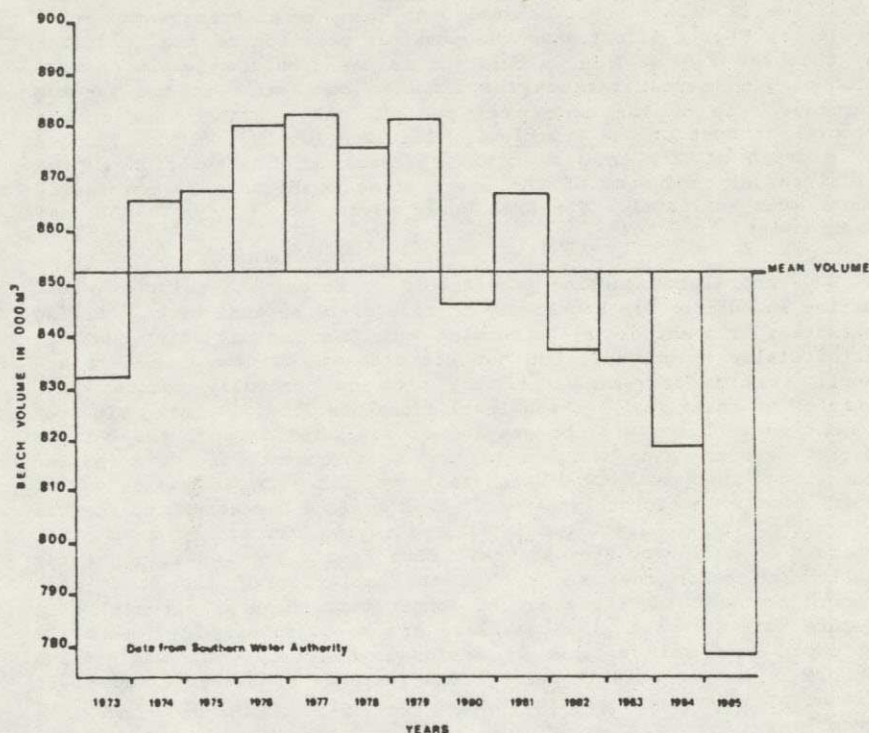


Figure 3. Beach volume changes on the western Crumbles 1973-1985. Section of the Crumbles monitored for these data indicated on Figure 1.

trend and back to more normal or above average volumes. The rate of sea-level rise may be influential in this. The period of maximum coincided with a fall in relative sea-level as recorded at a number of tide gauge stations in Europe (Woodworth 1987). This relationship requires further investigation. Second, whether there are pulses of sediment moving along this coast, one of which may have traversed the western part of the Crumbles between 1974 to 1979. By broadening the area and period over which the spatial and temporal dimensions are considered it may be possible to identify sensitive areas of coastline which, if used for development, should be the focus for coastal protection schemes.

Future time scale

The increasing use of the Crumbles makes it imperative to identify possible future coastal change. This is especially important because of the predictions concerning accelerated sea-level rise over the next century. The rate of this rise is not clearly understood and estimates by the U.S. Environmental Protection Agency vary from 0.56 m to 3.45 m (Hull & Titus 1986), the most likely rate falling within the mid-range predictions of 1.44 m to 2.16 m. Clearly this sea-level rise is likely to compound the problem of erosion at Eastbourne, but the prediction of future recession rates of the coastline is problematic. Assuming no counter-balancing engineering projects, Fig. 4 illustrates the possible position of the coastline by the year 2100. This calculation is based on the sea-level rise producing a retreat rate on the Crumbles comparable to the maximum recorded rate of the historical period. As a consequence of the removal of most of the Crumbles, Willingdon Levels would be flooded to a depth of 2 m to 3 m at MHWST (assuming no alteration to the tidal range), and some of the lower areas would only be marginally above mean sea-level. The area would revert to its normal Holocene environment.

However, these alarming predictions of future coastal change and marine inundation are not likely to take place because of engineering measures. The shingle ridge running west from Langney Point has been artificially heightened, but the storm damage of November 1984 and April 1985 is a reminder of the need to carefully monitor this stretch of coastline. As sea-level rises the likely warning signs of impending problems will be seepage of sea-water through the barrier during storms and HWST, with an encroachment of more saline conditions into the ground water-table below the Crumbles. It may be worth monitoring for this effect. This article has attempted to draw attention to the requirement for studying coastal changes that operate on different time scales. Data from a short section of the Eastbourne beach have shown that the ambiguity of the short term record necessitates the study of longer term changes, especially if future alterations to the coastline are to be modelled. It must be stressed that this article is designed to identify an engineering problem, that of coastal retreat and response to sea-level rise, it is not an argument against the commercial development of the Crumbles.

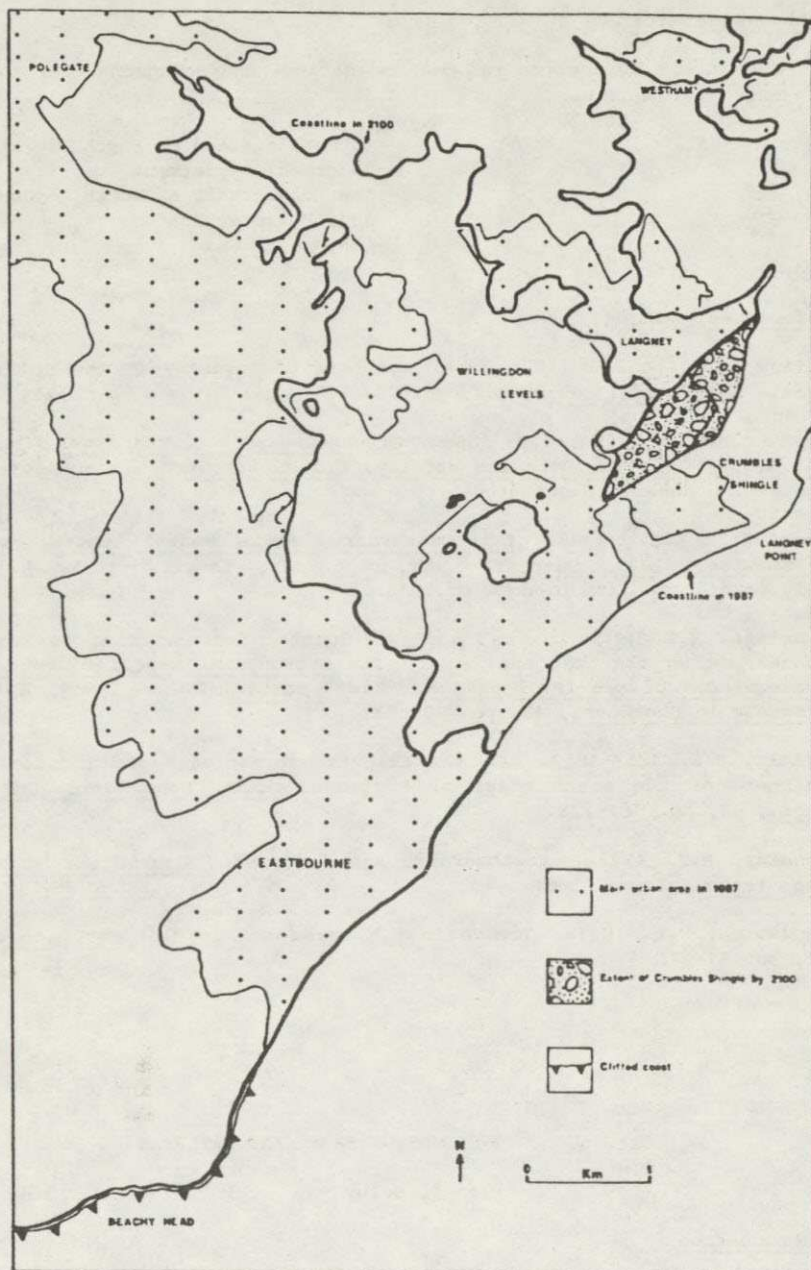


Figure 4. Projected coastline changes and extent of Crumbles Shingle by 2100. Main urban area in 1987 is indicated to illustrate amount of residential and commercial land-use lying within possible flood zone.

Acknowledgements

We thank N.E.R.C. for the radiocarbon dating, and Southern Water for the beach volume data.

S. Jennings and C. Smyth
Geography Department
The Polytechnic of North London
383, Holloway Road
London N7 6PN.

References

Dulley, A.J.F. 1966. The level and port of Pevensey in the Middle Ages. Suss. Arch. Coll., 104, pp. 27-45.

Hull, C.H.J. & Titus, J.G. 1986. Greenhouse effect, sea level rise, and salinity in the Delaware estuary, United States. Environmental Protection Agency, Washington.

Jennings, S.C. 1985. Late-Quaternary environmental change at Eastbourne, East Sussex. Unpub. Ph.D. thesis, (C.N.A.A.), Polytechnic of North London. pp. 240.

Jennings, S.C. & Smyth, C.T. 1987. Coastal sedimentation in East Sussex during the Holocene. In: The hydrodynamic and sedimentary consequences of sea-level change. Eds. Carter, R.W. & Devoy, R.J. Progress in Oceanogr., 18, pp. 205-241.

Redman, J.B. 1851-1852. On the alluvial formations, and the local changes, of the south coast of England. Mins. Proc. Inst. Civ. Engs., 11, pp. 162-223.

Tyhurst, M.F. 1972. Eastbourne's sea defences. Journ. Soc. Civ. Eng. Techn., 2, pp. 3-8.

Woodworth, P.L. 1987. Trends in U.K. mean sea levels. Mar. Geod., 11, pp. 57-87.

GLACIATED SHORELINES ON BARRA AND VATERSAY

Ian C. Selby

Introduction

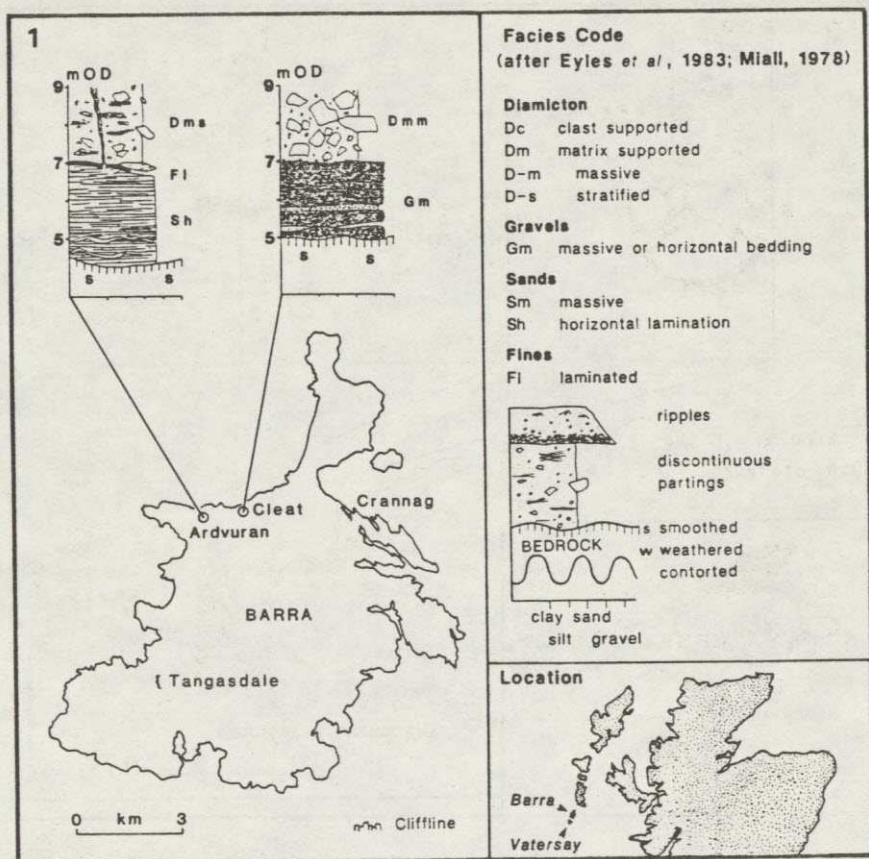
Recent fieldwork (1986-87) on the islands of Barra and Vatersay on the southern tip of the Outer Hebrides (Location map - Fig. 1) has revealed further evidence of a higher "pre-glacial" sea level. The only pre-existing record is that of Peacock (1984), who described an isolated raised beach deposit from Cleat [NF 674 049] on Barra. In addition, fragmentary raised rock platforms and clifflines are

present and are covered in places by sediments interpreted as beach and foreshore deposits. Glacial erosion has modified the rock-cut features and stratified diamictons, considered to be lodgement tills, overlie the beach deposits.

Rock platforms and clifflines

The islands are composed of Lewisian gneisses. The foliation of these resilient lithologies exerts a crucial influence on their erosion which often leads to rounded coastal profiles. However, several distinct rock-cut features are preserved, commonly on northerly facing coastlines.

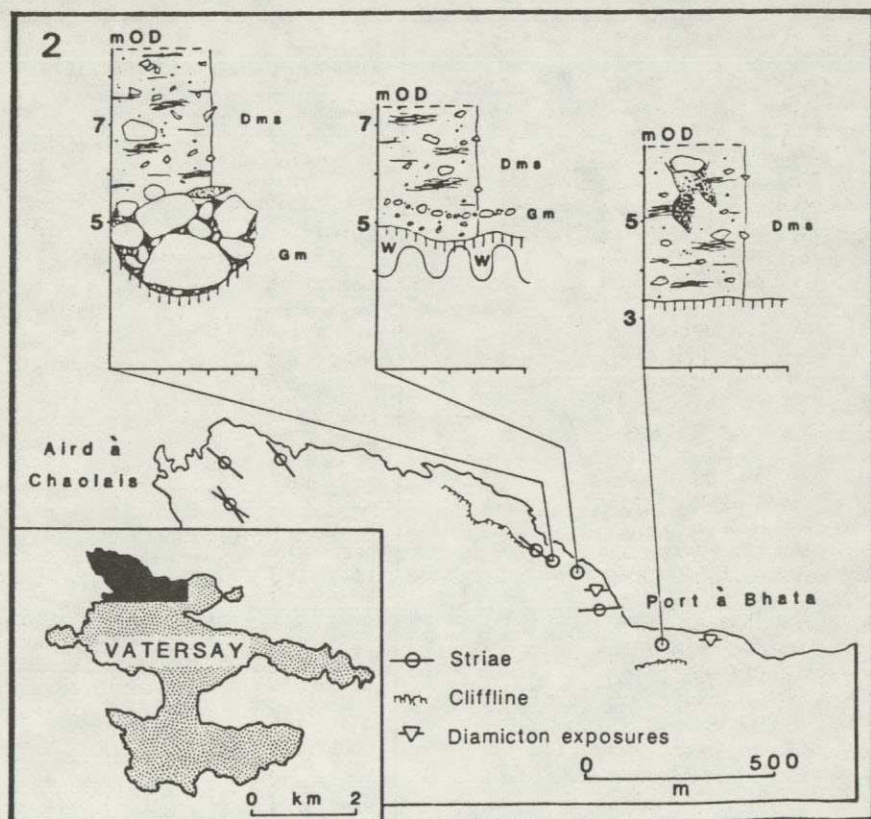
On Barra relict vertical clifflines up to 8 m high with a well defined top occur at Crannag [NF 704 047], in an area of limited wave fetch. They are associated with a horizontal platform up to 30 m wide lying at around +7 m local O.D. which extends for over 150 m (Fig. 1). Also on Barra, a similar series of discontinuous, steeply



sloping ($>45^\circ$) to near vertical cliffs up to 8 m high in places, for example at Tangasdale [NF 650 001], occur behind sand dunes on the western coast. In view of their form, position and the new evidence presented below, it is proposed that these are likely to be glacially degraded former sea cliffs.

On north-west Watersay a raised rock platform up to 20 m wide and lying at around +6 m local O.D. east of Aird à Chaolais [at NL 622 979], is exposed for over 50 m in front of a 3.5 m high vertical cliffline.

This cliffline is preserved discontinuously for over 750 m to the east and is commonly overlain by diamictons. Striations on ice smoothed bedrock up to 5 m behind the clear cliffline top at this locality indicate an ice flow trend around 120° (Fig. 2).



Beach and glacial deposits

(a) Sands and gravels

In places clastic sediments overlie smoothed rock platforms, for example at Cleat [NF 674 049] on Barra, but they are more commonly preserved in bedrock hollows. (See sedimentary logs in Figs. 1 and 2).

Laminated, angular to rounded medium sands at Ardvuran [NF 663 048] dip around 30° seawards and contain erosional scours and associated ripples. About 1 km to the east at Cleat, horizontally bedded, rounded gravels with a poorly sorted sandy matrix are exposed (Peacock 1984, p. 6). In contrast, a massive sandy gravel with boulders with well rounded clasts over 1.5 m across occurs east of Aird à Chaloais at NL 624 977 on north-west Vatersay. Layering (possibly original lamination) in the sandy matrix is deformed, probably by loading, to lie parallel to the clast sides. These sediments are interpreted as beach and foreshore deposits with the size and rounded nature of the clasts indicative of a high energy depositional environment.

(b) Diamictons

The last glacial advance across this area deposited diamictons locally as sheets, generally up to 3 m thick and more particularly as gully fills. Stiff, matrix-supported, massive and stratified diamictons consist mainly of local angular to rounded Lewisian clasts up to 3 m across in a gritty matrix.

A characteristic matrix stratification in many exposures takes the form of closely spaced (<1 cm), wavy discontinuous partings and a more persistent planar fabric of variable separation (>1 cm) occasionally defining beds composed of slightly differing grain sizes. Evidence that this stratification is a depositional rather than a resedimented fabric is provided by strain shadows around clasts considered to be glacially induced by large vertical stresses. In addition, flat iron clasts and boulder collision zones support a basal environment of deposition. The local geometry together with the sedimentology of these stratified diamictons is suggestive of lodgement tills. These overlie the sands and gravels described above (Figs. 1 and 2).

The stiffness of the tills discourages post-depositional modification. An exception to this is the matrix-free areas often forming narrow funnels in stratified diamictons at Ardvuran [NF 663 048] on Barra (Fig. 1), which were probably formed by loading during the final stages of till deposition. Dewatering of the laminated sands underlying the till led to fluidisation producing matrix-free pipes and zones comparable to the Type B pillars of Lowe (1975). It is considered unlikely that these structures could form during or after resedimentation.

Erratics

Erratics, most commonly red sandstones and white quartzites, are frequent on the western coasts of the islands in the modern and raised beach deposits (Jehu & Craig 1923).

Locally, erratic clasts derived from the gravels appear to have been reworked into the overlying diamictons. Although rounded red sandstone clasts over 1 m across occur in the sandy gravels with boulders on north-west Vatersay, only cobble sized clasts are visible in the basal 1.5 m of the till.

Discussion

A chronology of events affecting the southern tip of the Outer Hebrides can now be attempted. Glacial event(s) led to the deposition of the red sandstone and quartzite erratics. The provenance of this suite of clasts may be either: derivation from small faulted offshore basins (probably Permo-Triassic) visible on seismic profiles 15 km to the west of the island or from the Permo-Triassic, Torridonian and Cambrian sediments of north-west Scotland. These clasts were reworked, possibly several times, prior to deposition as a beach deposit at a higher relative sea level of about +8 m local O.D. The erosion of the rock platform and cliffline probably occurred contemporaneously with adjacent beach deposition, although the possibility exists that the beach may lie on a considerably older rock platform.

A subsequent glacial advance covering the whole of the islands including the highest point (Heaval, 383 m - Peacock 1980), then eroded these earlier formed cliffines and beaches. Where isolated fragments are preserved, the cliffline is generally of a greater height than the adjacent present day cliffs. The final glacial advance along a trend of 120° (direction uncertain) in this area was mainly erosional with only limited deposition. (For comparison see Peacock 1984, Fig. 1). There is no evidence to suggest resedimentation of the glacial deposits.

Glaciated raised rock platforms are visible on Lewis (e.g. McCann 1968, von Weymarn 1979) and in other areas of western Scotland (Dawson 1984). Sutherland & Walker (1984) believe the raised rock platform on Lewis was formed prior to at least two glacial phases. However, on Barra and Vatersay there is only evidence of one succeeding glacial advance affecting the rock platform and raised beach sediments. Sutherland & Walker also considered that the formation of the raised rock platform occurred earlier than the deposition of the raised beach (Galsion Beach). Thus correlation of the beach or raised rock platform on Lewis with those on Barra and Vatersay is tentative. The mode of formation of the cliffines and platforms on Barra and Vatersay is open to debate. Erosion in a periglacial regime (e.g. Dawson 1980, Matthews *et al.* 1986) may adequately explain the cliffines and platforms in areas of limited fetch, although erosion over a long warmer period cannot be discounted.

Conclusion

A raised rock platform with a cliffline and associated beach deposits are considered to ante-date the last glaciation of Barra and Vatersay. Correlations with the features and sediments on Lewis are thought to be speculative. The series of glaciated platforms (Dawson 1980, Sissons 1981) can now be extended to the southern islands of the Outer Isles.

Acknowledgements

This fieldwork was carried out whilst in receipt of a NERC studentship. Thanks to Bob Dugdale, Chris Evans, Peter Worsley and Dr. D. Peacock for help with this article.

I.C. Selby
Department of Geography
University of Nottingham
University Park
Nottingham NG7 2RD.

References

- Dawson, A.G. 1980a. The Low Rock Platform in western Scotland. Proc. Geol. Ass., 91, pp. 339-344.
- Dawson, A.G. 1980b. Shore erosion by frost: an example from the Scottish Lateglacial. In: Gray, J.M. & Lowe, J.J. (eds.), Studies in the Lateglacial of North-West Europe, pp. 45-54. Pergamon.
- Dawson, A.G. 1984. Quaternary Sea-level changes in Western Scotland. Quatern. Sci. Rev., 3, pp. 345-368.
- Eyles, N., Eyles, C.H. & Miall, A.D. 1983. Lithofacies types and vertical profile models; an alternative approach to the description and environmental interpretation of glacial diamict and diamictite sequences. Sedimentology, 30, pp. 393-410.
- Jehu, T.J. & Craig, R.M. 1923. Geology of the Outer Hebrides. Part I - The Barra Isles. Trans. R. Soc. Edinb., 53, pp. 419-441.
- Lowe, D.R. 1975. Water escape structures in coarse-grained sediments. Sedimentology, 22, pp. 157-204.
- Matthews, J.A., Dawson, A.G. & Shakesby, R.A. 1986. Lake shoreline development, frost weathering and rock platform erosion in an alpine periglacial environment, Jotunheim, southern Norway. Boreas, 15, pp. 33-50.
- McCann, S.B. 1968. Revised shore platforms in the Western Isles of Scotland. In: Bowen, E.G., Carter, H. & Taylor, J.A. (eds) Geography at Aberystwyth, pp. 22-34. University of Wales Press, Cardiff.
- Miall, A.D., 1978. Lithofacies types and vertical profile models in braided rivers: A summary. In: Miall, A.D. (ed) Fluvial Sedimentology. Can. Soc. petr. Geol. Mem., 5, pp. 597-604.
- Peacock, J.D. 1980. Glaciation of the Outer Hebrides: A Reply. Scot. J. Geol., 16, pp. 87-89.
- Peacock, J.D. 1984. Quaternary geology of the Outer Hebrides. Rept. Brit. Geol. Surv., 16/2, 44 pp.
- Sissons, J.B. 1981. British shore platforms and ice-sheets. Nature, Lond., 291, pp. 473-475.

Sutherland, D.G. & Walker, M.J.C. 1984. A Late Devensian ice-free area and possible interglacial site on the Isle of Lewis, Scotland. Nature, Lond., 309, pp. 701-703.

von Weymarn, J. 1979. A new concept of glaciation in Lewis and Harris. Proc. R. Soc. Edinb., B 77, pp. 97-105.

QN: field meeting report

REPORT ON THE FIELD MEETING OF IGCP-200 (UK WORKING GROUP) AND INQUA NORTHWEST EUROPEAN SHORELINES SUBCOMMISSION, HELD IN THE LINCOLNSHIRE FENLAND, 18 - 20th SEPTEMBER 1987

This was the final Field Meeting of IGCP-200 (UK Working Group) and was attended by over 20 participants including four from the Netherlands. The Field Meeting was based at the very comfortable and well equipped Freiston Hall Field Centre near Boston.

An introductory talk on Quaternary sea-level and research in the Fenland was given by the organiser of the meeting, Dr. Ian Shennan, on Friday evening.

The field excursions on Saturday and Sunday (September 19-20) visited sites that had been chosen to illustrate some of the evidence used to study relative sea-level change in the Fenland, and to look at new evidence that is likely to further our understanding of Holocene development of the area. The first site visited was Baston Fen Nature Reserve. The reserve serves as an important analogue for the peat-forming environment that was so widespread over much of the Fenland during the Holocene. The recognition of modern day analogues of past environments was an important theme of the meeting. From Baston Fen the excursion moved to Bourne Fen where the stratigraphy is similar to many other sites investigated in the Fenland. Transgressive and regressive overlaps were exposed in a pit section and in pre-sampled cores. Discussion centred around the nature of the conditions responsible for the marine/brackish sediment. Ian Shennan believed it represented MHWS rather than MHW, and this highlighted the importance of trying to establish the relationship between a deposit and a specific water-level. A number of radiocarbon dates have been obtained from Bourne Fen, but the problem of age reversals, probably caused by the incorporation of allochthonous, older sediment, illustrate the caution necessary when sampling for radiocarbon analysis and establishing reliable chronologies.

The third site visited, Morton Fen, is currently being investigated. An interdisciplinary research project has been established involving an airborne multispectral survey by Danny Donoghue from the University of Durham, augerhole and pollen

analyses, and archaeological investigations by the Fenland Project. Despite the 'Fenland drizzle' (heavy rain, to those not used to the local dialect) which had set-in, a debate on the lateral extent of the sediments and their relationship to anthropogenic features, for example a 'Roman' aqueduct and salterns, culminated in an unplanned augerhole to test the theories being discussed. There was, however, agreement on the value of remote sensing for the mapping of archaeological and palaeogeographic features. The visit to Morton Fen ended with field walking during which some participants managed to find genuine articles of archaeological interest. Many contented themselves with the 'discovery' of bits of drain.

The persistence of the Fenland drizzle meant the cancellation of a visit to the site of a 14 m deep hand-augerhole, mostly through sand, undertaken by three members of the University of Durham in 1986.

This brought to a close the first day's excursion, but in the evening at Freiston Hall, Peter Hayes of the Fenland Project presented a lecture on the archaeology of the 'Romano-British transgression' in the Fenland. He argued that the main environmental factor which led to the abandonment of settlements in this period was the spread of fen, not an incursion of the sea. Peter Hayes' lecture was followed by an IGCP Business Meeting chaired by Dr. Michael Tooley. The possibilities of a new IGCP sea-level project were discussed, and participants were encouraged to contribute to the INQUA Shorelines Subcommittee for Northwest Europe who are already organising a field excursion to Scotland in September 1988. Details were announced of the final meeting of IGCP 200 (UK Working Group) comprising a one day symposium on 11 December 1987 at the Royal Society.

On the second day, a visit to Leverton Marsh occupied most of the morning. Leverton Marsh contains a saltmarsh and intertidal flats fronting a succession of seabanks that represent stages of reclamation. During a pleasant walk across the marsh in warm sunshine, the variation, often over no more than a few metres, in topographic features, particle size of the surface sediments and composition of the flora, provided a salutary lesson for all palaeoenvironmentalists researching sea-level/coastal changes in areas containing sediments associated with former saltmarsh and intertidal flats. It is clearly necessary to study in detail these local variations within our present saltmarshes, in order to interpret more accurately stratigraphic sequences through former saltmarsh environments.

In the afternoon, Martyn Waller of the Fenland Project demonstrated the sequence of sediments at the Hobhole Section in East Fen. Pollen analysis at this site has revealed the environmental changes associated with the transgressive and regressive overlap sequence. The vegetational succession tends to be repeated at each episode of marine incursion and withdrawal, so radiocarbon dating of the overlaps is important to confirm correlation between sites. The presence of palaeochannels ('roddons') cutting through the peat again emphasised the value of studying the sedimentary characteristics of present day creeks in order to more fully appreciate the palaeoenvironments associated with them.

This concluded a well planned, very enjoyable and informative field meeting.

Simon Jennings
Department of Geography,
The Polytechnic of North
London,
383 Holloway Road,
London N7 8DB.

QN: correspondence

THE ROLE OF WOMEN IN THE Q.R.A.

I should like to respond to the invitation, issued by Esmée Webb in QN 52, to contribute to the discussion on the role of women in the QRA. I was not one of the female members canvassed by her when she registered increasing dissatisfaction. I have never felt other than fully integrated in the Association.

Many years ago in my naïveté, I had ideas on how to improve the management of the Association's finances. I went as far as putting my ideas in writing to the Committee and the next thing I knew I was nominated and elected as Treasurer. It was then I discovered the real problem of the Treasurer was to part the members from their money! It also became clear how much time and effort is put into the running of the Association by the Committee members in their Honorary capacity. I can assure Ms. Webb that one of the most time-consuming tasks was finding members who were willing to be nominated to serve as Officers and Committee members and who could represent the full range of Quaternary disciplines.

Our Committee was always pleased to receive ideas for future meetings or suggestions on better management but they were even more delighted to receive firm offers to organise events, carry out surveys, etc. Today's Committee will I am sure feel the same. If, as Ms. Webb says, the public visibility of women is only 1%, then women have only themselves to blame. The way to get the dents out of a tin can is from the inside, not the outside.

Richard West, in his address entitled "The Future of Quaternary Research" at the 20th Anniversary Meeting of the Association, emphasised the dwindling size of the cake from which Quaternary research takes its slice. I doubt even he had foreseen the present extent of this problem. The recent editorial by Christian Schlüchter in Quaternary Science Reviews indicates that, even on an international level, Quaternary research has to fight extra hard for its voice to be heard. The Committee needs all our support if it is to fulfil its duties under Article 3 of the Constitution which states: "The object of the Association is the advancement of education and research into the problems of the Quaternary".

I would, therefore, plead for united rather than divided loyalties. If we give priority to sectional interests, which have only social not Quaternary significance, we dissipate our energies and reduce our overall impact.

References

Schluchter, C. 1987. INQUA at the crossroads? Quat. Sci. Rev., 6, p. 179.

West, R.G. 1984. The future of Quaternary research. Quat. News 1., 43, pp. 30-33.

Hilary Davies
Pharm House
Neston Road
Willaston
South Wirral L64 2TF.

FAUNAS OF THE WARWICKSHIRE AVON

I wish to comment briefly on the paper by Maddy et al. (QN 52, pp. 16-22) entitled 'Investigation of a probable Upton Warren Interstadial Site near Bengeworth, Worcestershire'. Sections in Avon No. 4 terrace at Twynning, Gloucestershire opened up in 1972 revealed a fauna of 'full-glacial' type with reindeer (Rangifer tarandus L.) and cold stenothermic molluscs. The fauna from Avon No. 4 terrace at Ailstone (Tomlinson 1925) does reflect much warmer conditions, but it may well be significant there that the sediments under the terrace surface were not bottomed.

A single Bison bone (or even a single Bison!) cannot be used to aid the determination of climate and time. The Bison from Avon No. 4 terrace at Twynning (Whitehead unpub.) regarded as early-Devensian are no different in size from those of the mid-Devensian. Bison priscus Boj. is markedly sexually dimorphic.

In fairness to Maddy et al., I am speaking with unpublished inside knowledge, although a definitive section through No. 4 terrace at Twynning is, hopefully, in the press, and will somewhat aid future workers in the field. There is nothing in the Bengeworth fauna that could not originate within No. 4 terrace feature of the Avon.

P.F. Whitehead
Moor Leys
Little Comberton
Pershore
Worcestershire.

INVESTIGATION OF A PROBABLE UPTON WARREN INTERSTADIAL SITE NEAR
BENGOWORTH, WORCESTERSHIRE: A REPLY

The authors would like to thank Mr. Whitehead for his comments. However, much of the substance of his note is based on unpublished data of which we had no knowledge, and therefore could not consider in our original paper. Although as Whitehead states, the fauna from Bengeworth is not diagnostic to any particular age, the balance of evidence suggests that the channel infill is younger than, and separate from the deposits of Terrace No. 4. In particular the usage of the normal geological criteria of superposition must date the infill of the Bengeworth channel after the deposits of Terrace No. 4. As this terrace is conventionally dated (Shotton 1953) to the early Devensian, an age for the Bengeworth channel and its interstadial fauna in a mid-Devensian interstadial seems at least possible.

However, the evidence from Ailstone near Stratford described by Tomlinson (1925), suggests that Terrace No. 4 was deposited under a much warmer climate than that indicated by Whitehead for the site at Twynning. It seems probable that the stratigraphy and depositional environment of Terrace No. 4 were in fact more complicated than proposed by previous authors, and the publication of the results from Twynning may allow reassessment of this sequence.

References

Shotton, F.W. 1953. The Pleistocene deposits of the area between Coventry, Rugby and Leamington, and their bearing upon the topographic development of the Midlands. Phil. Trans. R. Soc. Lond., B237, pp. 209-260.

Tomlinson, M.E. 1925. River terraces of the lower valley of the Warwickshire Avon. Q. Jl. Geol. Soc. Lond., 94, pp. 137-165.

D. Maddy
Dept. of Geography
Royal Holloway and Bedford New College
Egham Hill
Egham, Surrey TW20 0EX.

D.H. Keen
Dept. of Geography
Coventry Polytechnic
Priory Street
Coventry CV1 5FB.

D.R. Bridgland
Nature Conservancy Council
Northminster House
Peterborough PE1 1UA.

AN ANALYSIS OF THE LITERATURE ON DRUMLINS AND RELATED STREAMLINED FORMS

W. Everett

M. Phil. Thesis, Geography Department, Birkbeck College,
University of London

There is a vast literature specifically or in part dealing with drumlins and related streamlined forms, and this thesis draws together and analyses that literature wholly or in abstract published in English, French and German. An analysis is made of the factors influencing choice of reference for citation, choice of journal for publication, and the subsequent effect on dissemination of knowledge that these basic factors have exerted. Reasons for a subject largely studied by geographers being overwhelmingly published in non-geographical journals are considered. Emphasis is laid on perception of a drumlin, on how critical this is to our observation and understanding of it; the various factors that affect understanding and the extent to which what can be called "mental conditioning" can affect critical ability particularly in the field are stressed. The development of generalisation from the reality of drumlins is traced, and the poor foundations of these generalisations, and the profound effect they have had on our beliefs, is also stressed. From generalisations followed circular arguments and pre-supposition, resulting in conformity being required and expected of a feature that is far more highly variable than normally realised in all its aspects - the terminology of and pertaining to the subject, definition, distribution and siting, age, composition, shape, and mode of formation. The terms drumlin, flute and drumlinoid are shown to have no definitive meaning. There is no certainty of national or international comparability of features called drumlins. Doubt is expressed on the reliability, validity and value of statistical analyses and models based on drumlins being of an easily and universally definable shape, composition, and occurrence. From the sum of the literature it is clear that the concept of the typical or classical drumlin - the elongated whaleback mound of boulder clay, with or without the appellation streamlined - is not universally valid; this is just one form within a continuum of streamlined forms. Similarly invalid is the concept of a recognisably-bounded drumlin field. From these latter two findings a theory of global drumlin zones is developed. A theory of formation for drumlins and related forms which seeks to encompass all the variables that have for so long been obscured by generalisation is proposed. (A bedform theory). Distribution maps with a selection of limits of glaciation are presented for the U.K. and Ireland, Scandinavia, the North European Plain, Alpine Foreland, Italian Alps, eastern Alps, France, Switzerland, southern Germany, the Arctic circum-Polar area, James Ross Island in the Antarctic, the U.S.A. and Canada.

A PALAEOECOLOGICAL STUDY OF THE JUNIPERUS COMMUNIS WOODLAND
AT HIGH FORCE, TEESDALE

David M. Wilkinson
M.Sc. Thesis, University of Durham, 1986

Sedimentological and palynological studies were made of a mire next to a Juniperus communis woodland of nature conservation interest at High Force, Teesdale, in the north east of England. These showed that during the Flandrian the site had developed from an area of open water to the topogenous mire which exists today. Juniperus was found to have been growing around the site throughout the Flandrian. Also low values of Quercus and Ulmus were recorded in the pollen diagram. 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.

Because of problems in obtaining countable amounts of well preserved pollen from the peat a study of the spatial variation in pollen preservation in the mire was carried out. Differences in pollen preservation within the mire of an order of magnitude were found on a scale of a few metres. The implications of this for various theories of mire development are discussed and it is suggested that it provides further evidence for the persistence of pools on a mire surface over time scales of several thousand years.

QN: reviews

La Cotte de St. Brelade 1961-1978 Excavations by C.B.M. McBurney.
Edited by P. Callow & J.M. Cornford (1986), (ISBN 0-86094-207-4).
433 pp., 242 figs. or plates in the text, 13 figs. or plates in the
appendices; 124 tables in the text, 5 tables in the appendices; one
colour plate and 5 further appendices on one plate of microfiche.
Geo Books, Norwich. Price £65.00.

This is more than a highly detailed report on a complex Palaeolithic site on the island of Jersey for it is also something of a landmark in European Quaternary studies. Oakley and Zeuner were paramount in leading archaeologists concerned with the palaeolithic period towards a multi-disciplinary approach, and I and many others owe much to them. This monograph does full justice to this concept. It ranks with de Lumley's "Hortus" and Mary Leakey's "Olduvai", with its breadth of approach and meticulous presentation. For Britain we now have the first volume of "Pontnewydd", "Hoxne" should appear next year, "High Lodge", alas, seems as distant as ever.

The late Charles McBurney, in his preliminary report on La Cotte in the Proceedings of the Prehistoric Society in 1971 described the site as "the largest and most productive cave or rock shelter in the

British Isles." This verges on nationalistic fantasy as the site is clearly both geographically and archaeologically French. At times of low sea level, palaeolithic people did not wander across dry land from Britain to the Channel Islands but from Brittany to Les Isles de la Manche. Hence, it is not surprising that the archaeological evidence relates to Northern France and not Southern England. To some extent, the same can be said of the stratigraphical succession.

La Cotte St. Brelade has as long a history of investigation and publication as any palaeolithic site in Europe. Discovered in 1881, it became especially famous for the fine series of Neanderthal teeth discovered in 1910-11. Many archaeologists and scientists have been involved and, behind them all, has always been that progressive and well-endowed Société Jersiaise. As discoveries increased, so did the complexities of the sequence become apparent and the interpretation correspondingly difficult. Father Christian Burdo was excavating until 1956 but his health was failing. He had discussions about the site with McBurney and the outcome was that the Société very sensibly entrusted the Department of Archaeology of the University of Cambridge with the future excavation programme. Such was the background to the ensuing 15 years of fieldwork at La Cotte (1961-1962, 1966-1978). Sadly, McBurney died in 1979 and so never lived to see this magnificent publication. The task of publishing was taken over by John Coles and a post-excavation team was formed comprising Paul Callow, Jean Cornford and Kate Scott. It was a formidable task. As Professor Coles points out in the preface, when an excavation report is prepared by someone other than the person who directed it "the problems are compounded." Paul Callow was fortunately to hand; the one man who had first-hand experience on the site itself and had also already made a special study of the Lower and Middle Palaeolithic of Britain and adjacent areas of Europe for his doctoral thesis. It is unlikely that anyone else could or would have put together this report so competently, nor without the assistance of Jean Cornford and Kate Scott. For many years I observed them studiously occupied on the work, when making my intermittent visits to the department. Sometimes they were in one room, sometimes in another, and there was always something to show me.

Excluding the post-excavation team, 28 other specialists have been involved. Between them they have produced not only a detailed statement and assessment of the 1961-78 excavations, but also of all the previous work. As one of the interim summaries stated: it supersedes all accounts written earlier. The editors and Geo Books between them have produced a volume that is attractive, coherent, balanced and easy of reference. I found it a pleasure to read or consult. Even the photographic plates are of a standard much higher than the average scientific publication. Obviously there is a full bibliography and the index is rendered doubly useful by having sub-headings to many of the subjects indexed.

The cost may seem high and fellow Quaternarians will wish to know exactly what they would get for £65.00. Be assured that you will get quality and quantity. There are 33 papers of varying lengths and 4 appendices plus microfiche. The whole is divided into five parts, viz.: I Introduction and Background, II Stratigraphy, environment and dating, III Non-industrial aspects of the human occupation, IV

The Lithic Industries and V Discussion. The History of the site is surveyed by Mourant and Callow and there are major contributions by Callow on the stratigraphy, chronology and interpretation of the sequence. As all the other contributions are concerned with material that relates to this, some idea of the scope of the work can be indicated by a brief summary of the sequence as concluded, followed by a list of some of the subjects dealt with by the specialists.

From the most recent deposits downwards:

1. Weichselian Head with typical Mousterian Industry and Neanderthal teeth;
2. Alternating temperate and periglacial deposits assigned to Oxygen isotope Stages 5d-4;
3. Fossil beach at 9 m a.m.s.l., attributed to the Eemian transgression (isotope Stage 5e);
4. The same deposits of Stages 5d-4 banked against a wave-cut cornice and cliff composed of pre-Eemian deposits;
5. The upper part of the Pre-Eemian (Saalian) deposits contains two rich implementiferous layers probably associated with minor interstadials. At the same levels are two 'bone heaps' of mammoth and rhino.
6. Truncated sol lessivé above temperate deposits, related to Stage 7 of the isotope scale.

This sequence is backed by papers on the Geological Setting (Renouf), a survey of the Quaternary deposits of the Channel Islands (Keen), Sedimentology (Lautridou, Duroy, Giresse, Le Coustumer and Levant), Micromorphology (Vliet-Lanoë), flora and vegetation (Jones), and Phosphatic mineralisation (Giresse and Vliet-Lanoë). The large mammals are dealt with by Scott and constitute a major part of the report; the rodents by Chaline; Charcoals (Cartwright); Hominids (Stringer and Curren - N.B. only the 1910-11 and 1915 discoveries, for no hominid remains were found 1961-78); cut and scratch marks on bone and ivory (Jones and Vincent) and the Use of Fire (Callow, Walton and Shell). The description of the lithic industries (flint, quartz and other) is very full (154 pages), contributed by Callow, Hutcheson, Hivernel, Cornford and Frame. It includes some new insights into technology and the first serious study I have encountered on right and left handedness among the knappers (conclusion: they were 4:1 right handed (Cornford)). There are also positive results from microwear studies. TL Dating of Layers C and D (Huxtable) is calculated as 238 ± 35 ka. Uranium series (Szabo) gives a date of 120 ± 8 ka for layers stratigraphically beneath the TL dated layers, although reasons are given for regarding this as a minimum age. The concluding discussions in Part V are by Callow.

There will be criticism, comment and discussion on much of this, hopefully, for some time to come. Much criticism has already been seen in advance, such as the use of small numbers of pollen grains for interpreting climates and landscapes, but everywhere there is a professional awareness and a clear distinction between the data and

its meaning. Thus, Callow's speculations on Site Exploitation Territories, Resources, Band size, Economic inferences and multivariate analyses of the La Cotte and comparable industries are placed tidily into the Discussion. There is so much in this volume that, in the total absence of flagrant or even non-flagrant absurdities, slips, errors or misprints, this reviewer can only applaud the editors and contributors and recommend it as an essential volume for any library, personal or institutional, with a Quaternary bias.

In conclusion, it should be noted that when last year a volume was published in memory of Charles McBurney containing papers by a number of his ex-students, there was no contribution by Paul Callow. This volume on La Cotte is the most fitting testimony to him that could be offered.

J.J. Wymer
Norfolk Archaeological Unit
Union House, Gressenhall
Dereham NR20 4DR.

Shell guide to reading the Irish landscape, by Frank Mitchell, (1986). London: Michael Joseph and Country House. xv + 228 pages. ISBN 0-7181-2825-7. £15.95 (cloth).

Although much of this book is familiar, the publishers claim that it is a completely revised and redesigned edition of The Irish Landscape, published in 1976 by the same author. The book consists of eight chapters which are illustrated with 33 new colour plates and numerous black-and-white figures and photographs, many of which appeared in the first edition. In Chapter 1 ('The growth of the rock foundation'), Mitchell attempts to summarise Ireland's geological history up to approximately 2 Ma ago. The coverage is highly superficial and may in places mislead an unwary reader. Furthermore, there is no geological map to aid understanding of the material (although a rather generalised example appears within Chapter 2).

Although Chapter 2 is entitled 'The Ice Age: 1,700,000 to 10,000 years ago', the term 'Ice Ages' appears on the dust-jacket and Professor Mitchell claims that "... opinion is now beginning to swing away from the concept that great masses of ice were the chief features of the Ice Age." (p. 24). The Chapter contains a considerable number of mistakes, a few of which are cited here. Oxygen occurs in three isotopic forms (and not two) (p. 23), and so does carbon (p. 24). Radiocarbon decays to nitrogen and not into "... the more normal form of carbon." (p. 24). Permafrost in Siberia (and in other parts of the world) is far in excess of 500 m deep (p. 25). Particle-size descriptions are used in a very cavalier fashion: thus 'sand and pebbles' become 'pebbles and clay' a few lines later (p. 28), and we are told that subglacial meltwater channels may silt up with sand and gravel (p. 28). If the rate of ablation of an ice mass exceeds the rate of advance, the ice does not necessarily become almost stationary or 'dead' as Mitchell states (p. 28). Scotland is not larger than Ireland (pp. 39-40).

Chapter 3 ('The end of the Ice Age') covers the climatic fluctuations at the close of the Midlandian Cold Stage - the Woodgrange Interstadial and the Nahanagan Stadial - and brings us to the beginning of the present (Littletonian) warm stage.

For the remainder of the book, Mitchell is concerned primarily with the changes that have occurred to the Irish vegetation and to the quality of the soils during the Littletonian, both as a result of natural and of human influences. Chapter 4 ('Response to warm conditions: 10,000 to 5100 years ago') first examines the way in which plants and animals returned to the country at the start of the warm stage. Inevitably, the role of land-bridges as migration routes and of the Atlantic continental shelf as a biological sanctuary during Midlandian glacial events is explored, and an explanation is sought for the relative poverty of the Irish fauna and flora: the author is unable to reach firm conclusions. For the first 1000 years or so of the Littletonian, changes apparently occurred without interference from man. About 9000 years ago, Sandelian people reached Ireland, to be followed approximately 900 years later by the Larnians. The former appear not to have made a significant impact on the Irish vegetation although the latter may have done so as small, short-lived, fluctuations in pollen values suggest interference with the woodlands. A significant, if temporary, change occurred about 5100 years ago when the incidence of elm pollen in sediments was reduced dramatically. Mitchell prefers to explain the elm decline as a result of disease, rather than as a consequence of the activity of Neolithic farmers.

Devastating changes have occurred to the Irish vegetation, and to the fauna, from the time of the Neolithic farmers to the present day. Those modifications that took place up to the opening of the twentieth century are documented in Chapters 5 ('The first farmers: 5700 to 1650 years ago') and 6 ('The rise and fall of population: AD 300 to 1900'). Professor Mitchell uses a variety of methods to determine or to conjecture upon what was happening to the Irish countryside: he presents a fascinating picture of change. We are told that excavation and botanical detective work has revealed that downtrodden agricultural labourers were forced to carry poor sods to help build the Neolithic hilltop 'royal pyramids' of Newgrange and Knowth, County Meath; and that recent excavations of some medieval refuse tips of Dublin have shown that for the more fastidious inhabitant moss served as a substitute for toilet-paper! Eighth-century farmers may have brewed ale but cannot have produced beer (p. 167) as hops were not available to them. Mitchell is especially concerned about the way in which the forest cover of Ireland has been destroyed, more or less totally, on a number of occasions as a result of the appearance of groups of immigrants including those associated with the somewhat confusingly named 'plantations'.

Chapter 7 ('Modern Ireland: AD 1903 to 1986') covers briefly the developments of the present century. Mitchell documents the rise of a so-called national concern for the condition of the country's soils and forests, and describes the demands for crops that were placed upon the country by the two world wars. He draws attention to the rate at which both blanket-bog and raised-bog are being destroyed to supply peat-fired electricity generating stations (and calls for the

conservation of some of the bogs), and to the way in which politics and economics have clashed over the manner in which the country's water resources are managed.

In the final chapter ('The future'), Mitchell looks at the influence of the EEC and, in particular, of this organisation's Common Agricultural Policy. He suggests that significant changes will have to take place as many aspects of the CAP cannot be sustained either on moral or on economic grounds.

To be fair to Professor Mitchell, the reviewer of his book must bear in mind that his intention is "... to interest the many rather than to provide a treatise for the few." Such a task puts particular demands upon the author who must try to satisfy an amateur reader who may not be familiar with the geography of the country. It is thus possible to forgive the use of terms such as 'time-telescope' (p. 3), 'plant steeplechase' (p. 73), 'water-jump' (p. 73), 'handicapped gold rush' (p. 71) and the Littletonian 'thermostat' (p. 71). The author says that he endeavours to explain terms as they arise, but does not always do so, and it is a pity that the book does not contain a Glossary. There are insufficient maps to assist the reader; the complete absence of grid references and the failure in many cases to give the county in which a named site appears is regrettable. The most generous comment that may be made about those maps that are provided is that they are functional! Proof-reading has not been carried out very carefully, and about twenty typographical errors have escaped correction.

In the caption to Figure 6.5 (p. 174), 100 years should read 1000 years, and on Figure 5.7 (p. 109) there appear to be 4000 feet in a mile. Most of the black-and-white photographs are not acknowledged. Figure 4.7 (p. 78) is not 'actual size'. Conversion from Imperial to metric units (and vice versa) has been done in a carefree manner, and in a single paragraph (pp. 155-156) inches, acres, hectares, square miles and square kilometres are used.

There are far too many technical errors in the first two chapters, and it might also be argued that it is not possible adequately to cover the subject matter concerned in such a few pages. The relationship between rocks and relief is not brought out as it might have been in Chapter 1, and in Chapter 2 unhelpful statements of the type "Deposits of head are common in Ireland." (p. 26) appear all too frequently. It is difficult to see how 'the many', for whom the book is intended, could understand this early material. For this reviewer, the book 'came alive' with the start of Chapter 3 and it emerged as a fascinating and thought-provoking, if sometimes speculative, text, despite a significant number of reservations. It is, in short, an excellent book that requires a considerable amount of editing before publication of the next edition. It is clear that Professor Mitchell cares greatly about the way in which the Irish landscape has developed, and that his concern for the future is equally passionate.

Peter G. Hoare
Sedimentology and Palaeobiology
Laboratory
CCAT, East Road
CAMBRIDGE CB1 1PT.

Environmental Magnetism, by R. Thompson and F. Oldfield, (1986).
London: Allen and Unwin. (ISBN 0 04 538003 1). 227 pp. price £35.00.

From time to time the transfer of techniques from one well established discipline to another yields positive results and the blossoming of new insights and new research strategies. This book represents the outcome of such a transfer where methods of studying rock magnetism developed by geomagnetists and palaeomagnetists have been adapted, extended and applied to a range of investigations of superficial deposits and environmental processes.

Many naturally occurring material assemblages can be characterised and differentiated to a greater or lesser extent by a their magnetic properties. The measurements normally needed to type material can be rapidly carried out and are non-destructive. Additionally it is now clear that a variety of sedimentological, pedological, hydrological, biological, and anthropogenic processes may produce or modify the magnetic minerals present within a deposit in ways which are systematically inter-related and ordered.

This book provides an introduction to mineral magnetic methods at a level which is of practical use but which is not too difficult for the non-physicist. A good bibliography and a glossary of terms are included.

The early chapters (1-6) introduce magnetic properties of materials and discuss the forms of naturally occurring magnetic minerals and ways of characterising them. They describe the instrumentation and measuring strategies, and give an introduction to the relevant aspects of the Earth's magnetic field.

Chapters 7 to 12 deal with the use of mineral magnetic methods for the study of materials and processes in various environments; these include soils, peats, marine sediments, fluvial and limnic systems, and the atmosphere. In each case the basic patterns of magnetic behaviour are described, and then amplified by the discussion of particular applications and research results.

The Quaternary scientist will find a number of sections in this part of the book particularly useful. Soil magnetism and its application to the study of archeological sites and palaeosols is discussed. The section on lake sediments shows that methods of rapid core correlation offer the realistic possibility of obtaining accurate estimates of deposition and erosion rates. The ways in which magnetic signatures within lake sediment sequences can complement and extend other methods of palaeoenvironmental interpretation are demonstrated.

Of equal interest are the mineral magnetic studies on deep sea cores. Here the magnetic signatures correlate with classic foraminiferal and oxygen isotope profiles suggesting palaeoclimatic control on the particulate fluxes to oceanic sediments. Indeed, the variations in mineral magnetic properties seem to provide greater resolution within the palaeoclimate record, and insights into both terrestrial and oceanic environmental change.

Chapters 13 and 14 deal with aspects of naturally occurring remanence in rocks and sediments. The geomagnetic polarity timescale is well reviewed and there is a discussion of the validation and use of secular variation magnetostratigraphy. This provides a very useful account of methods applicable to the investigation of recent (c. 10,000 year) sediment sequences. Chapter 15 briefly discusses biomagnetism.

Chapter 16 illustrates the application of mineral magnetic methods using as a case study an estuarine environment. Here the methodological approaches, types of data yielded and interpretations made are discussed in a thoroughly worked example. This enables readers to assess the usefulness of magnetic methods and compare them with those with which they may be more familiar.

Because application of magnetic measurements to environmental processes and surface materials has been developed by only a small number of research workers, the degree of coverage is patchy. For example, more seems to be known about the mineral magnetic properties of lake sediments than of fluvial sediments, and little is said about coastal or near shore sediments. This must be expected where research strategies reflect individual preferences and the pragmatic application of newly developed instrumentation.

Perhaps the biggest contrast that emerges between magnetic methods and more conventional means of sediment characterisation (using, say, gross mineralogy or elemental chemistry) lies in the differences in the inferential framework that one needs to adopt. The geochemist or sedimentologist is used to receiving analytical quality data with defined values for accuracy, precision and detection levels. By contrast magnetic data is generally only of semi-analytical quality. A given set of magnetic measurements cannot easily be converted into a precise picture of the magnetic minerals involved, or of their concentration in ppm. Nevertheless the sensitivity of the measurements responds to small and subtle differences in magnetic mineralogy occurring at levels of organisation much smaller than that detectable by, for example, conventional XRD. These differences are often related in an ordered way to the environmental history of a sediment in terms of provenance and subsequent modification. The inherently conservative nature of magnetic signatures also means that sediments can be systematically altered and introduced back into the environment in tracing experiments.

For many people the application of these methods to surface materials will be completely new. The research area is expanding and of considerable promise. Not only does this book provide an excellent introduction to the subject but it is so far the only one. Unfortunately the book is expensive and may have priced itself out of the undergraduate market. The quality of presentation and binding is good; the text and most of the diagrams are clearly understandable, although in one or two of the tables the layout appears to be askew.

Overall then, this is a significant publication both for what it contains and for the insights it provides into the future usefulness of mineral magnetic methods in other areas of research in the Earth and Environmental Sciences.

J.P. Smith
School of Applied Sciences
The Polytechnic: Wolverhampton

ABSTRACTS OF PAPERS TO BE PRESENTED AT THE MARINE STUDIES
GROUP/Q.R.A. JOINT MEETING AT B.G.S., KEYWORTH, NOTTINGHAM,
8-9 JANUARY 1988

OFFSHORE-ONSHORE QUATERNARY CORRELATIONS AROUND THE BRITISH ISLES

LATE TERTIARY AND LOWER PLEISTOCENE DELTAS IN THE SOUTHERN NORTH SEA

G.S. Boulton
(Grant Institute of Geology, University of Edinburgh)

A series of stacked deltaic units of Neogene to Mid-Pleistocene age occurs in the Southern North Sea Basin. They were deposited by ancestors of the present Scheldt, Rhine-Meuse, Weser-Ebe and Thames systems. The internal structures of these masses inferred from seismic reflection profiling, reflect a pattern of sea level change which may in turn mirror the major phases of global eustatic change. The sequence is preserved by strong subsidence which has led to an accumulation of up to 700 m of sediment. Cumulation rates of subsidence and patterns of warping can be established within the basin as can the changing patterns of sedimentation in relation to sea level fluctuation.

A CORRELATION OF THE ONSHORE AND OFFSHORE
COURSES OF THE RIVERS THAMES AND MEDWAY DURING
THE MIDDLE AND UPPER PLEISTOCENE

D.R. Bridgland* and B. D'Olier**
(*Nature Conservancy Council; **City of London Polytechnic)

Clast lithological analysis has enabled two distinct litho-statigraphical divisions to be recognised in Eastern Essex: the 'High Level' and 'Low Level' East Essex Gravel Formations. Within these a succession of gravel terraces can be discerned descending towards the east, the 'High Level' members attributed to the River Medway, the 'Low Level' to the combined rivers Thames and Medway. Offshore a series of terraces and a buried channel can be traced. Evidence is presented to enable a correlation to be made between these onshore and offshore terraces and their associated aggradational deposits, and in addition linking their development with that of a channel system in the Southern Bight and Dover Straights.

THE FREMINGTON SUCCESSION (N. DEVON): A RE-EVALUATION

D.G. Croot
(Plymouth Polytechnic)

Recent excavations at Brannams Claypit, revealed a vertical section of sediments over 11 m thick over bedrock. At the base were 2.25 m of subangular, locally derived, current-bedded river gravels. A sharp planar boundary separated these gravels from 7 m of clayey deposits above. The clays were red/red brown, and free of coarse material for the most part. Only 200 clasts were recovered from the several hundred tonnes of clay excavated. Of these four clasts are of doubtful origin, the remainder are locally derived. They are considered to be dropstones. Structures within the clay suggest a lacustrine or marine, rather than glacial origin. The clays are overlain by 2.5 m of locally derived head. There is no evidence for direct glacial activity. The age of the deposits cannot yet be ascertained by stratigraphic correlations or pollen analysis, hence the Fremington succession cannot be used to extrapolate a "Wolstonian" ice limit to the west of Bristol.

QUATERNARY SEDIMENTS IN THE HEBRIDEAN SEA AREA

Howard C. Davies*, R.J. Whittington* and Dan E. Evans**
(*U.C.W., Aberystwyth; **B.G.S.)

Seismic and borehole data in the Hebridean sea area allow an eightfold stratigraphy to be proposed in which the sixth and seventh formations are areally and volumetrically the most important. Generally, Tertiary igneous rocks and the Lewisian have little Quaternary cover whilst up to 300 m of Quaternary deposits occur in parts of the Mesozoic basin of the Sea of the Hebrides.

The bulk of the Quaternary sequence probably accumulated under tidewater glacier regions during the Middle and Upper Pleistocene.

THE QUATERNARY SEDIMENTS OF THE SOUTH IRISH SEA

M.A. Hession*, R.J. Whittington* and R.T.R. Wingfield**
(*U.C.W., Aberystwyth; **B.G.S.)

The Quaternary sediments of the southern Irish sea between 52°N. and 54°N. have been investigated by seismic profiling correlated to seabed and sub-seabed geological samples. The Quaternary sediments average 30 m thickness on the Irish and Welsh coastal platforms whereas in St. George's Channel thicknesses mappable down to 180 m occur. Six formations separated by unconformities have been defined, their three dimensional distribution is complex such that no one area contains the complete vertical stratigraphy. Quantitatively the most important formation is of glaciomarine origin which dominates the central zone. A model for the late Devensian evolution of the area is proposed.

THE NATURE AND ORIGIN OF THE LATE QUATERNARY GLACIAL SEQUENCE IN
NORTH NORFOLK AND IN THE ADJOINING PART OF THE NORTH SEA BASIN

Peter G. Hoare* and Stephen J. Gale**
(*CCAT, Cambridge; **University of New England)

The first detailed examination of the lithology of the Hunstanton Till and of other sediments associated with the most recent glaciation of north Norfolk is discussed. The deposits have been examined to test the proposal that this material is the result of a surging ice-lobe. The relationship between this drift and the subjacent deposits is also described. The maximum inland extent of the glaciation has been re-investigated, and the possible connection between the Hunstanton Till and the extensive glacial outwash sediments in the Glaven Valley has been explored. The way in which the Hunstanton Till has been weathered and the depth to which these alterations has occurred have been used to reconstruct the post-depositional history of the unit. Lithological and stratigraphic comparisons have been made with the offshore sequence as revealed in borehole records and by seismic studies.

QUATERNARY STRATIGRAPHY - SOUTHERN NORTH SEA

D. Jeffery (B.G.S.)

The contribution summarises progress by the geological surveys of Britain and The Netherlands in the development of a Quaternary stratigraphy in the southern North Sea.

A series of (allo-) formations interpreted from seismic profiles and cores, spans the whole Quaternary period. Whereas the well developed early Pleistocene formations probably contain few major hiatuses, younger more diverse formations reflect drastic changes in regional geographic and depositional settings.

Such features allow crude correlation with certain onshore deposits. If the inferences made are correct, then Saalian glaciation in Britain was restricted (to highland areas only?), and the deposits at Wolston are probably Anglian.

PROBLEMS OF STRATIGRAPHY AND CORRELATION OF RAISED MARINE DEPOSITS
WITH SOME CASE STUDIES FROM THE SHORES OF THE ENGLISH CHANNEL

D.H. Keen (Coventry Polytechnic)

Raised marine deposits are at the interface between the off-shore sequences of the continental shelf and the terrestrial sequences where many Pleistocene stratigraphic schemes have been developed. As such they should provide a link between marine and land-based chronologies. This paper will examine the evidence for correlation of both marine and terrestrial deposits with raised beaches, and critically review some of the criteria which have been used for such correlations. Examples of the uses of the methods to be discussed from the shores of the English Channel will be reviewed.

LATE AND POST GLACIAL STRATIGRAPHIES OFFSHORE SCOTLAND

D. Long, D. Evans & R. Harland
(British Geological Survey)

Regional surveys and Quaternary mapping of the U.K. continental shelf have revealed basins of readily identifiable sediments of late Devensian and early Flandrian age in many areas around Scotland. These sediments are generally acoustically transparent and multilayered and usually comprise very soft, slightly sandy muds. Palaeontological studies have revealed a series of warm and cold climatic episodes within the general warming since the last glacial maximum. Various sites will be compared and an attempt made to correlate them and in some instances to link them to a chronostratigraphy.

GLACIOMARINE DEPOSITS OF THE WESTERN IRISH SEA BASIN - THE ROLE OF GLACIOISOSTATIC DISEQUILIBRIUM

A. Marshall McCabe (University of Ulster)

Late Pleistocene sedimentary sequences exposed along the margins of the Irish Sea Basin consist of stacked sequences of muds, diamictic muds, sands and gravels (Basal tills are typically absent). Their stratigraphic architecture is variable but both channelled sequences and stacked sequences with a tabular form are common and are characterised by rapid and well-defined facies changes. Patterns of sedimentation are complex, and are more closely controlled by crustal behaviour, water depth changes and sediment supply in glacially influenced environments, than simple climatically driven and regionally synchronous glacier advance/retreat cycles. The recognition of glaciomarine conditions and high relative 'glacial' sea levels in the Irish Sea Basin may have ramifications for British Quaternary stratigraphy which extend far beyond the basin itself.

CHARTING POLAR AND TEMPERATE WATER IN THE NORTH-EAST ATLANTIC FROM 19,000 BP TO PRESENT USING SCOTTISH NEAR-SHORE MARINE DEPOSITS

J.D. Peacock (B.G.S.)

Marine deposits preserved in coastal and immediately offshore shelf areas provide a record of oceanic climate which is comparable to, but of higher resolution than that derived from deep sea cores. Prior to 13,000 BP conditions were arctic, but a high boreal fauna indicating the presence of a weak North Atlantic Drift was established before 12,600 BP and flourished throughout the Windermere Interstadial. A 'warm blip' in the faunal record a little before 11,000 BP may mark a short-lived strengthening of the North Atlantic circulation in response to the southward movement of the oceanic polar front during the return to the arctic conditions of the Younger Dryas interval. Arctic species survived until almost 10,000 BP, at least in the vicinity of tidewater glaciers. A low boreal fauna similar to that of the present day had immigrated into the area by 9,400 BP. No evidence is yet forthcoming for a Holocene climatic optimum.

THE KESGRAVE FORMATION OF EAST ANGLIA AND EQUIVALENT DEPOSITS IN
THE NETHERLANDS AND THE SOUTHERN NORTH SEA REGION

J. Rose
(Birkbeck College, University of London)

The Kesgrave Formation of East Anglia comprises a complex and extensive body of sands and gravels deposited during the later part of the Early Pleistocene by a precursor of the River Thames. A distinctive petrology enables the deposits to be related to a catchment that included the West Midlands and North Wales and can be associated with episodes of glaciation in the upland regions. Offshore it is represented by the Yarmouth Roads Formation. In the Netherlands the equivalent is the Sterksel Formation related to a precursor of the Rhine. It is also associated with a more extensive catchment and episodes of glaciation. These formations are the first major input of glacially derived, coarse grained sediment in the Pleistocene of the area, and reflect a response to moderate amplitude climatic oscillations that were sufficient only to generate glaciation in western upland and high mountain regions.

ICE THICKNESSES, SEA LEVELS, SHORE AND GROUNDING
LINES AT 19,000 YEARS BP IN THE CELTIC SEA,
SOUTHERN EUROPEAN SHELF

J.D. Scourse
(U.C.N.W., Menai Bridge)

A model concerning the advance of Irish Sea ice into the Celtic Sea at 19,000 years BP is proposed. The model is based on stratigraphical, sedimentological and geomorphological data from the Isles of Scilly and the surrounding continental shelf, and attempts to synthesise the effects of glacio-isostatic rebound, global sea levels, ice thicknesses, shore and grounding line altitudes. A possible surge hypothesis is invoked to explain this extensive thin ice lobe resting on deformable marine sediments at the southern terminus of the Irish Sea ice.

QUATERNARY HISTORY OF THE OUTER HEBRIDES AND THE
HEBRIDEAN SHELF AND SLOPE

Ian Selby (B.G.S./Nottingham University)

High resolution seismic profiling and coring by the British Geological Survey has revealed glacial features and sediments on the Hebridean shelf and slope. A seismic stratigraphy has been established and other specialised studies attempted. As a result, a model for the last glacial event affecting the Hebridean shelf and slope will be proposed. This will be considered in the context of the erosional and sedimentological records of glaciation on the Outer Hebrides and St. Kilda.

QUATERNARY SEDIMENTS IN THE CENTRAL CELTIC SEA

R.J. Whittington* and R.T.R. Wingfield**
(*U.C.W., Aberystwyth; **B.G.S.)

Preliminary assessment of seismic coverage in the central Celtic Sea shows that a trough of Quaternary sediments extends down from St. George's Channel through the Celtic Deep area where up to 300 m of unambiguous Quaternary occurs. These sediments rest upon a unit which may be of older Quaternary or Tertiary age. The un-ambiguous Quaternary may be divided into four major groups within which numerous seismic sub-units occur. Although some sub-units have the seismic character of tills they are restricted to the north of the area and may be of Devensian age, the majority of the sediment sequence appears to be of glacial-marine origin.

MIDDLE AND UPPER PLEISTOCENE ICE LIMITS OFF BRITAIN

R.T.R. Wingfield (B.G.S.)

Three generations of infilled oval depressions, each less than 5 by 25 km and over 100 m deep, are incised into Quaternary and older strata on the continental shelf around Britain. These incisions formed as jökulhlaup plunge pools at low relief ice sheet margins. The present deeps within the Weichselian-aged incisions are large kettle holes.

Mapping these features' distributions delimits the Elsterian, Saalian and Weichselian ice sheets.

Bathymetric deeps on the shelf define four Weichselian ice sheets lobes: Nordrøys, Dogger, Quessant-Casquets and St. George's; which were from 100 to 350 km wide and separated by extensive ice-free areas.

CAVE ARCHAEOLOGY STUDY WEEKEND

This joint meeting of the British Cave Research Association and Creswell Crags Centre will be held on 13th-15th May 1988 at Creswell Crags. The weekend will include short talks by cave archaeologists. The meeting is aimed at both archaeologists and cavers and there will be opportunity to visit caves in the area. Details from: Rogan Jenkinson, Creswell Crags Visitors Centre, Crags Road, Welbeck, Worksop, Notts. S80 3LH, or Charlotte Roberts, School of Archaeological Sciences, University of Bradford, Bradford BD7 1DP.

FIELD MEETING AND WORKSHOP ON GLACIOTECTONICS

The Work Group on Glaciotectonics (WGGT) of the INQUA Commission on the Genesis and Lithology of Glacial Deposits will hold a five-day meeting based in Norfolk, U.K. from 2nd-6th October 1988. The meeting will bring together glaciotectonics researchers from all over the world to examine the classic Norfolk coastal sites and present results of their own research in paper sessions. Details from: Dr. D.G. Croot, Dept. of Geographical Sciences, Plymouth Polytechnic, Drake Circus, Plymouth PL4 8AA, U.K.

SECOND IBERIAN QUATERNARY MEETING

AEQUA (The Spanish Association for Study of the Quaternary), GTPEQ (The Portuguese working Group for the Study of the Quaternary) and the Spanish Committee of INQUA are sponsoring this meeting, to be held at the Geological Sciences Faculty of the Complutense University of Madrid from 25th-29th September 1989. First Circular and other details from: Dra. Trinidad Aleixandre Campos, Secretaria II Reunion del Cuaternario Iberico, Institut de Edafologia y Biologia Vegetal (CSIC), Serrano, 115, dpdo., 28006 Madrid, Spain.

CORRECTION

The Editor apologises to John Catt for giving his address incorrectly as "Acting Head of Soils Division", Rothamsted Experimental Station in QN 52.

CALENDAR OF MEETINGS

(NOTE Q.R.A. Meetings are listed in the accompanying Circular)

- | | |
|--------------------------------|--|
| 6th-7th
January
1988 | International Conference on Recent Research on the European Palaeolithic, London (see Newsletter 52, p. 42) |
| 8th-11th
April
1988 | Symposium on the Geomorphology of Southern Africa, University of Transkei, Southern Africa (see Newsletter 50, p. 52) |
| 13th-15th
May 1988 | Cave Archaeology Study Weekend at Creswell Crags, Nottinghamshire (see notice above). |
| 22nd-25th
May 1988 | Geological Association of Canada, Mineralogical Association of Canada, Canadian Association of Petroleum Geologists, Joint Meeting at St. John's, Newfoundland (see Newsletter 49, p. 48). |
| 10th-15th
July 1988 | International Working Meeting on Soil Micromorphology, at San Antonio, Texas, U.S.A. (see Newsletter 51, p. 23). |
| 19th-23rd
September
1988 | International Symposium on Engineering Geology, at Athens, Greece (see Newsletter 51, p. 22). |
| 2nd-6th
October
1988 | Field Meeting and Workshop on Glaciotectonics (WGGT/INQUA) in Norfolk, U.K. (see notice above). |
| 9th-19th
July 1989 | 28th International Geological Congress to be held at Washington, D.C., U.S.A. (see Newsletter 48, p. 44). |
| 25th-29th
September
1989 | Second Iberian Quaternary Meeting in Madrid, Spain (see notice above). |

QUATERNARY NEWSLETTER

QN:

November 1987 No 53

Contents

Articles

- 1 - 9 Rose, J.: Status of the Wolstonian Glaciation in the British Quaternary.
- 10 - 16 Jennings, S. and Smythe, C.: Coastal Erosion and Planning at Eastbourne, East Sussex.
- 16 - 22 Selby, I.C.: Glaciated Shorelines on Barra and Vatersay.
- 22 - 24 Field Meeting Report.
- 24 - 26 Correspondence.
- 27 - 28 Thesis Abstracts.
- 28 - 35 Reviews.
- 36 - 41 Abstracts.
- 42 Notices.
- 43 Calendar.