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EARLY HUMAN RESETTLEMENT OF THE BRITISH ISLES FOLLOWING THE LAST GLACIAL MAXIMUM: NEW EVIDENCE FROM GOUGH'S CAVE, CHEDDAR

by R. Burleigh, E.B. Jacobi and R.M. Jacobi

The present show-cave, 'Gough's Cave' or 'The New Cave' at Cheddar (NGR ST467539), was opened to the public by Richard Cox Gough, in the 1890's. Around Christmas 1903, during drainage work within a small fissure, on the left hand (northern) side of the 'vestibule' at the entrance to the cave a contracted burial now known as 'Cheddar Man' was found (Gray, 1904; Jex-Blake, 1904). In 1970 collagen from the left tibia of this partial skeleton was dated at the British Museum radiocarbon laboratory to 9080 ± 150 bp (BM-525; Barker, Burleigh & Meeks, 1971, p.180), indicating an early post-Pleistocene age for this inhumation. Finds made at the time of its discovery had included stone artifacts identified as Magdalenian in type, together with teeth of horse (Davies, 1904, 1905), but there is no evidence to suggest that these were necessarily contemporaneous with the skeleton.

Some time before 1914, a decorated bâton-de-commandement, most probably made of reindeer antler, was found in the cave. This was illustrated by Seligman and Parsons (1914) who re-described and re-illustrated the finds that had been made in the cave in 1903. Their account provided the basis of Dorothy Garrod's entry for the cave in her book *The Upper Palaeolithic Age in Britain* (1926).

In November 1927 R.F. Parry, who had long acted as agent to the Marquis of Bath at Cheddar, began an excavation in Gough's Cave. Working up to the winter of 1930-31, he excavated a large part of the Pleistocene and post-Pleistocene sediments that had survived earlier clearance along both sides of the entrance and within the vestibule (Parry, 1929, 1931). Parry divided these sediments into twenty-five 15 centimetre spits, numbered from top to base. The spits were measured from above and below a 'datum line' established midway up the sediment profile and oriented along a colour change which followed the natural dip of these sediments as they entered the cave. By measuring upwards from this datum as well as downwards, compensation could be made for the cratering and removal of the upper part of the deposits which had taken place during the opening up of the cave. Excavation took place by electric light and all the sediment removed was sieved outside the cave. Each find was attributed a spit number. Parry is explicit in stating that from his records '...it (was) possible to refer any specimen to both its horizontal and vertical position in the deposits...' (1928, p.735). These records cannot now be found.

Spits 1-16 Parry reported as a cave earth with angular limestone and pebbles, more rich in clay in its upper part and with an increasing sand content and marked lamination in its lower part (spit 7 and below). This sediment overlay an older Pleistocene fill with water worn pebbles of limestone and sandstone (spits 17-25).

Sherds of later prehistoric and Roman pottery were recovered from spits 1-9 and bones of domestic animals were reported as deep as spit 11. A single partial maxilla of pig can also be recognised from spit 12 and a broken metapodial of sheep or goat may have come from spit 14. Stone artifacts occurred from spit 4 to spit 25 although those found below spit 16 were considered to have been carried downwards by flood water into cracks between the wall of the cave and the older Pleistocene fill. There is thus a substantial overlap between the distribution of stone artifacts, always regarded as terminal Pleistocene (late glacial) in age, and pottery and animal bones which are quite clearly of more recent date. We may suspect processes of both downward mixing of the younger items as well as upward migration of the older, this latter effect being of decreased significance as the zone of disturbance associated with human and animal occupancy of the cave rose with continuing sedimentation (Matthews, 1965; Hughes & Lampert, 1977).

The total of stone artifacts recovered by Parry was roughly 7000. Though the greater part of this collection is not now to be found, a substantial sample, if not the majority, of the retouched component identified during excavation is housed in the Cheddar Caves Museum and Exhibition. Other smaller clutches of finds from the excavation have found their way to the Bristol City Museum and Art Gallery and Wells Museum. The main stone tool forms are backed pieces, burins, scrapers and perforators. The majority of the backed pieces are of trapezoidal outline with either a shoulder, or a 'gibbosity' at one angle. There are also numerous 'Azilian points' shaped rather like the segments of an orange. There are many more burins than scrapers and the majority of these are developed on snaps or prepared truncations. Most of the scrapers are made on blades, and many possess lateral retouch. Structurally, the assemblage is not dissimilar to the Late Magdalenian. The stone technology from this site has been termed 'Cheddarian' (Bohmers, 1956) and equivalent assemblages come from other sites along Cheddar Gorge, for example, Soldier's Hole and Sun Hole. Similar material can probably be identified amongst finds from Kent's Cavern near Torquay and Hoyle's Mouth near Tenby.

Other finds made by Parry, include a bâton of antler, a 'rod' of ivory, piercers made on tibiae of mountain hare, fox-tooth beads, sea-shells and two cores from the manufacture of bone needles. There were also further human remains which were reported upon by Sir Arthur Keith and Dr. N.C. Cooper. With a number of documented exceptions (returned to Cheddar) the potentially identifiable part of the mammal fauna from this excavation was preserved in the Natural History Museum in London, following original study and partial publication by Dorothea Bate. Recently, Andrew Currant of the Department of Palaeontology at the B.M. (N.H.) has confirmed horse, red deer and mountain hare, and recognised specimens of Saiga antelope from the Pleistocene part of the cave sediments. Many bones of horse and red deer carry clear cut-marks and these are being worked upon by Ruth Parkin, Peter Rowley-Conwy and Dale Serjeantson. Re-study of the small sample of bird bones from the Pleistocene deposits by Dr. C.J.O. Harrison at Tring strongly suggests that several species of birds were also taken by the human occupants of the cave.

As part of a programme for investigating the history of the introduction and extinction of the larger terrestrial mammals in Britain at the end of the Pleistocene and in the Holocene (Clutton-Brock and Burleigh, 1983), six individual bones of horse *(Equus ferus)* from Gough's Cave, from the collection preserved in the Natural History Museum, were dated at the British Museum Research Laboratory by the liquid scintillation technique, and gave the following results (Ambers, Matthews and Burleigh, 1985).

Radiocarbon dates for bones of wild horse, *Equus ferus*, from Gough's Cave, Cheddar

spit	material	radiocarbon age (5570 yr)	lab. no.
10	atlas vertebra (collagen)	12,120 +/- 120 bp (10,170 bc)	BM-2183
12	calcaneum (collagen)	12,020 +/- 120 bp (10,070 bc)	BM-2184
13	metapodial (collagen)	11,970 +/- 230 bp (10,020 bc)	BM-2185
14	:	12,240 +/- 220 bp (10,290 bc)	BM-2186
16	:	12,070 +/- 170 bp (10,120 bc)	BM-2187
18	:	12,160 +/- 210 bp (10,210 bc)	BM-2188

These dates form a remarkably tightly clustered group with an unrounded weighted mean value of 12,085 radiocarbon years bp, and corresponding standard error on the mean of ± 33 years (based on the variation of the dates about the mean rather than the individual errors based on counting statistics given in the table). At the 95% confidence level the limits of age about the mean are 12,020-12,150 bp.

Any discussion of the relevance of these dates to the terminal Pleistocene artifacts recovered from the same apparent depth range within the cave must be qualified in several ways: firstly, it should be reiterated that the bones that were dated came from an excavation conducted many years ago. Loss of the relevant notebooks may have deprived us of contextual information beyond just their spit allocations. Secondly, Gough's Cave would have been open to species other than man. Thus bones of wolf from several spits suggest one agency by which animal remains found within the cave may have a history totally or partially unconnected with its human occupancy. Human introduction of bones for food or for manufacture of tools can only certainly be recognised where these have been cut or modified. With the exception of the atlas vertebra from spit 10 (BM-2183) none of the bones that we have dated showed clear cut-marks. On the other hand, none showed signs of damage inflicted by carnivores. Thirdly, conjoins have been possible between parts of 71 anciently broken stone tools recovered from spits 8-17. In 59 instances parts of the one item were found within the same or in adjacent spits. Implied vertical separation would thus be 30 centimetres at most, a distance no greater than that reported for items from sites believed affected by processes of 'treadage and scuffage' (Stockton, 1973; Villa and Courtin, 1983). In seven other cases one spit intervenes, in one other two, and in another three. In two instances, separation is by four intervening spits and in one by six, that is by an implied minimum vertical distance of 90 centimetres.

In the absence of the relevant notebooks and the information on horizontal distributions they would have contained, detailed interpretation of our conjoin data is not possible. Taken at face value, however, they would suggest that we should expect some blurring of the typological, taphonomic and chronological evidence, leading to problems in the interpretation of this site. Nevertheless, we would again stress the closeness of the individual radiocarbon determinations obtained, including that for the single cut bone from spit 10. That the terminal Pleistocene human activity within the cave is indeed of this age (*circa* 12,100 bp) will, we hope, be confirmed by dating, possibly by the accelerator (AMS) technique, further bone specimens which carry clear evidence of cutting.

Our research at this site is relevant to an expanding body of information on the chronology of human resettlement of the North European plain after the maximum of the last Ice Age. For Britain the rapidity of this return appears to receive support from these results from the New Show Cave opened by Mr. Gough almost a century ago.

We would like to thank Andrew Currant, Department of Palaeontology, British Museum (Natural History) for allowing us to date material in his care and for making available the results of his unpublished study, and Dr. Morven Leese, Research Laboratory, The British Museum for statistical analysis of the radiocarbon dates. We would also like to extend thanks to the Management of the Cheddar Caves who continue to do so much to assist our study of the artifacts and faunal collections preserved there, also Professor D.T. Donovan for his comments on the manuscript.

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A CONSIDERATION OF THE USE OF THE TERMS 'PALEOSOL' AND 'RUBIFICATION'

By R.A. Kemp

Problems relating to red colours in Quaternary soils of Britain have been discussed in several recent articles in the Quaternary Newsletter (Lawson, 1983; Boardman, 1984; Atkinson and Burrin, 1984). These discussions reveal some confusion amongst Quaternary scientists over the use of the terms 'paleosol' and 'rubification'. This paper briefly reviews the various meanings attached to these terms and provides guidelines for their definition and significance to the Quaternary scientist.

Paleosols

The term 'paleosol' was initially restricted to buried soils of 'obvious' 'antiquity' (Morrison, 1967, p.10). Subsequent definitions, however, have expanded the concept and led to increased confusion and controversy over usage of the term. Ruhe (1956, p. 441) defined a paleosol as 'a fossil soil that was formed on a landscape during the geologic past'. He recognised both buried and exhumed paleosols, the latter resulting from re-exposure of a buried landsurface. Soils continually exposed and containing pedological features attributable to previous environments different from the present have been termed relict paleosols (Ruhe, 1969; Valentine and Dalrymple, 1976a). Layered paleosols (Valentine and Dalrymple, 1976a) are defined as soils covered by only thin layers of sediment and thus not completely isolated from subsequent pedogenic processes.

Following the recommendations of the Working Group on the Origin and Nature of Paleosols (Yaalon, 1971), a paleosol is usually now defined as 'a soil formed on a landsurface of the past or in environmental conditions different from those of the present day' (Fenwick, 1981, p.342). Catt (1979) and Fenwick (1981) have criticised this definition for the emphasis it places on present environmental conditions which are often difficult to define and delimit. Furthermore, response rates of particular soil processes to changes in environmental factors are poorly documented and there are still considerable gaps in our knowledge over the effect that different environments have on soil formation and pedological properties. Climate, vegetation and anthropogenic influences have not been constant in Britain even during the last 10,000 years. Many of the pedological features of surface soils attributed to this period are not in equilibrium with the present environment because they date from times when conditions were dissimilar to the present. These may be as much 'relict features' (Catt, 1979) as those inherited from pre-Flandrian temperate or cold stages. As almost all British surface soils would then be considered relict paleosols, Catt (1979) suggested that the concept loses any special significance.

The introduction of the paleo-argillic horizon into the classification system used by the Soil Survey of England and Wales (Avery, 1973; 1980) has led to a tendency to restrict relict paleosols to those soils containing pre-Devensian relict features. Confusion results, however, from the fact that this arbitrary age limit is not always applied to buried paleosols. For instance, Boardman (1979) reported a *buried pre-Devensian paleosol* at Laddray Wood, Cumbria but later reassigned it to the Flandrian and referred to as a *buried Flandrian soil* (Boardman, 1984), whereas Valentine and Dalrymple (1976b) reported a *buried Flandrian paleosol* from Pitstone, Buckinghamshire. In any case, the use of an arbitrary age limit that restricts paleosols to buried pre-Devensian soils or non-buried soils containing pre-Devensian relict features is not rational and raises considerable difficulties. Too much emphasis is given to the relevant stage boundaries which are presently confused and inadequately defined (Catt, 1979). Additionally it would be hard to apply the concept in regions having different Quaternary histories to Britain. There are also difficulties in establishing criteria by which some relict features may be accurately dated and assigned to particular stages.

In accordance with the conclusions of Catt (1979), *it is recommended that the use of the term 'paleosol' be discontinued.* This is justified by the realisation that in the absence of a particular age connotation the word has no function other than as a general non-specific term covering any one of a number of situations. When qualified by an adjective (e.g. buried) it implies no more than the term 'soil' qualified by the same adjective. Thus, there is no difference between a 'buried soil' and a 'buried paleosol'. Similarly, an 'exhumed soil' is an adequate term to describe what has previously been thought of (often by circuitous reasoning) as a specific type of paleosol. The concept of a relict paleosol should be replaced by one of a soil forming at the present which contains 'relict' features originating from some specified or unspecified past periods (Catt, 1979).

Rubification

The term 'rubification' is usually used interchangeably with 'reddening' to represent non-specific processes by which a non-red parent material attains red colours during the course of soil formation. In Britain reddish colours are traditionally associated with buried pre-Devensian temperate stage or interglacial soils (Rose and Allen, 1977), and also occur within non-buried paleo-argillic horizons where they are considered to be relict features resulting from pre-Devensian pedogenic processes (Catt, 1979; Avery, 1980). Paleo-argillic horizons have matrix colours with Munsell hues of 7.5YR or redder, chromas of more than 4 and values of 4 or more in fine textured materials, or 5YR hues in coarser materials. Additionally, non-inherited 5YR or redder mottles are considered as paleo-argillic relict features provided they have at least a common distribution (Avery, 1980).

In the past reddish colours in soils have been casually related to the presence of amorphous iron oxides (Segalen, 1969) but the present consensus of opinion indicates a strong relationship between redness and hematite content (Torrent et al., 1980; 1983; Schwertmann et al., 1982). Torrent et al. (1980) suggested that earlier misconceptions concerning the form of iron oxides present were due to technical difficulties in recognising hematite. Very small amounts of hematite are thought to be capable of conferring reddish pigments on soils and recently improved techniques (e.g. Mossbauer spectroscopy and differential x-ray diffraction) permit the identification and measurement of the crystalline mineral even when it is present in small quantities or exhibits a poorly crystalline structure (Torrent et al., 1980; 1983; Schwertmann et al., 1982). Although Avery (1980) did not directly relate the red colours in paleo-argillic horizons to hematite concentrations, the necessary presence of the iron oxide in this diagnostic soil horizon is implied in other publications by staff of the Soil Survey of England and Wales (Sturdy et al., 1979; Avery et al., 1982) and was also assumed for the buried reddish horizons of the Valley Farm Soil in southern East Anglia by Rose and Allen (1977). Kemp (1985) confirmed the presence of hematite in the Valley Farm Soil and has recently shown that its redness intensity and that of some non-buried paleo-argillic horizons in eastern England are highly correlated with hematite content (Kemp, in press).

In order to avoid confusion *rubification should be defined as the pedogenic formation of hematite resulting in production of reddish colours* (Schwertmann et al., 1982). In more detail this process is thought to consist of the internal dehydration of amorphous hydrated iron oxides, possibly derived from weathering, and subsequent crystallisation to hematite via an intermediate crypto-crystalline form termed ferrihydrite (Fischer and Schwertmann, 1975; Duchaufour, 1982). It is proposed that this definition be adhered to in the future and that the adjective 'rubified' be used to describe materials reddened by this and *only* this process.

Similarities between the red colours in buried interglacial soils or paleo-argillic horizons and those of fersiallitic soils presently forming under sub-tropical and mediterranean climates has led to reddish colours in soils of temperate regions to be ascribed to rubification during earlier temperate stages of the Pleistocene when the climate is assumed to have been warmer. Some justification for this interpretation is provided by laboratory experiments which confirm the fact that hematite formation is favoured by high temperatures, although good soil aeration, rapid organic matter decomposition and length of soil-forming interval are also important factors (Schwertmann, 1971; Schwertmann et al., 1974; Fischer and Schwertmann, 1975). However, the validity of using non-inherited reddish soil colours as an indicator of pre-Devensian temperate stage pedogenesis has been recently brought into question by Schwertmann et al. (1982) who showed that hematite has formed since the last glaciation under temperate environments in some well-drained, calcareous, coarse-textured soils in Germany which maintain a warm pedoclimate. Although hematite formation (rubification) has not yet been reported in soils formed solely during the Flandrian in Britain, there are a number of soils developed in Late Devensian deposits which have non-inherited reddish colours (Clayden, 1977; Boardman, 1984). Standard x-ray diffraction techniques failed to relate the red (10R) colours on ped surfaces in the Flandrian Laddray Wood Soil in Cumbria to the presence of hematite: the major iron oxide present was lepidocrocite (Boardman, 1984). Such reports have led Atkinson and Burrin (1984, p.26) to use the terms 'reddening' and 'rubification' synonymously to signify 'different processes involving hematite and lepidocrocite'.

Lepidcrocite is reported to impart 5YR to 7.5YR hues to soils (Schwertmann, 1977). Although the mineral sometimes forms in well-drained calcareous environments (Ross and Wang, 1982), it is normally associated with gleying in seasonally waterlogged conditions, where it forms from the oxidation of precipitated ferrous hydroxy compounds (Schwertmann and Taylor, 1977). Atkinson and Burrin (1984, p. 25) have discussed the formation of the mineral in terms of 'relatively warm periods', although there is no evidence to indicate any direct relationship between lepidocrocite production and temperature. The processes responsible for the formation of lepidocrocite and hematite respectively are, therefore, clearly different and reflect the influence of different environments. Consequently, it is suggested that the definition of rubification used by Atkinson and Burrin (1984) is an unnecessarily vague notion, which should be replaced by one restricted solely to the process of pedogenic hematite formation. Future work should concentrate on means of distinguishing between reddish colours formed by rubification (i.e. due to hematite) and those by gleying (i.e. due to lepidocrocite) or other processes (e.g. ferrihydrite formation). At present the satisfactory identification of hematite is dependent on highly specialised laboratory techniques, such as differential x-ray diffraction on Mossbauer spectroscopy, which few people have access to.

Summary and conclusions.

It is suggested that the continued use of the term 'paleosol' is unnecessary. Its meaning and significance has become blurred through time and it fulfills no function other than as a general non-specific term covering any one of a number of situations. Buried or exhumed (Quaternary) soils and non-buried soils containing relict (interglacial, early Flandrian, Devensian etc.) features are adequate to describe particular situations.

It is recommended that rubification should be defined as, and restricted to, the pedogenic formation of hematite resulting in the production of reddish colours in soils. Future research should attempt to measure the types and amounts of iron oxides in soils of all ages and colours. This should then allow soil colour/iron oxide relationships to be better evaluated, and also to determine whether the pedogenic formation of hematite (rubification) can be considered solely as a pre-Devensian process in Britain. These studies may also provide some clarification of the regional environmental significance presently attached to the rubification process in Britain.

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THE ORIGIN AND DEVELOPMENT OF LANGNEY POINT: A STUDY OF FLANDRIAN COASTAL AND SEA-LEVEL CHANGE

By S. Jennings and C. Smyth

The recent article by Gerrard, Adlam and Morris (1984) in the *Quaternary Newsletter* No.44 has drawn attention to the problems of separating, within coastal sequencies, evidence for local coastal changes from regional eustatic movements. In addition, Nicholls (1984) has provided a useful insight into the historical context that present spits and barrier beaches may be placed.

The aim of this article is to use Langney Point in East Sussex as an example of barrier development during the Flandrian and, in so doing, to illustrate some of the problems involved in the methodology of sea-level research and in the interpretation of coastal sequencies.

This forms part of a much wider research project into late-Quaternary environmental change in coastal areas of East Sussex, with the objective of examining sea-level, coastal and vegetational changes (see, for example, Smyth, 1985).

The location of Langney Point (TQ 642011).

Langney Point is a small promontory of the extensive Crumbles Shingle that stretches from Eastbourne eastwards to Pevensey along the East Sussex coastline (Fig.1). Behind the Crumbles lie Willingdon Levels (Fig.2) which is a flat area of lowland (approximately +3m. O.D.) consisting of unconsolidated clays and silts with a thin peat horizon at circa +1.5m. O.D. Below Langney Point there are extensive unconsolidated sediments to a depth of 33 metres. From radiocarbon dating of these sediments, they appear to be entirely of Flandrian age (Shephard-Thorn, 1975; Jennings, forthcoming), and therefore represent major sediment accumulation during the postglacial.

Very little detailed, previous work has been undertaken in this area. Redman (1851-2), Milner and Bull (1925) and Steers (1964) have suggested that the Crumbles developed as a spit that grew eastwards from Beachy Head, behind which fine grained sediments were deposited to form Willingdon Levels. Unfortunately, no supporting lithostratigraphic or biostratigraphic information was provided to substantiate this. The development of the Crumbles and Willingdon Levels is currently being examined (Jennings, forthcoming) following the commissioning of a bore-hole at Langney Point and at Lottbridge Drove (on Willingdon Levels) with the support of approximately 50 hand-auger investigations.

Methodology.

Three sea-level index points are presented which suggest tendencies of relative sea-level movements. Two of these index points have been recognised from a single, deep borehole, in which case indicative litho-stratigraphic changes are termed 'contacts', whilst a third index point can be traced laterally thereby forming an 'overlap' (Tooley, 1982).

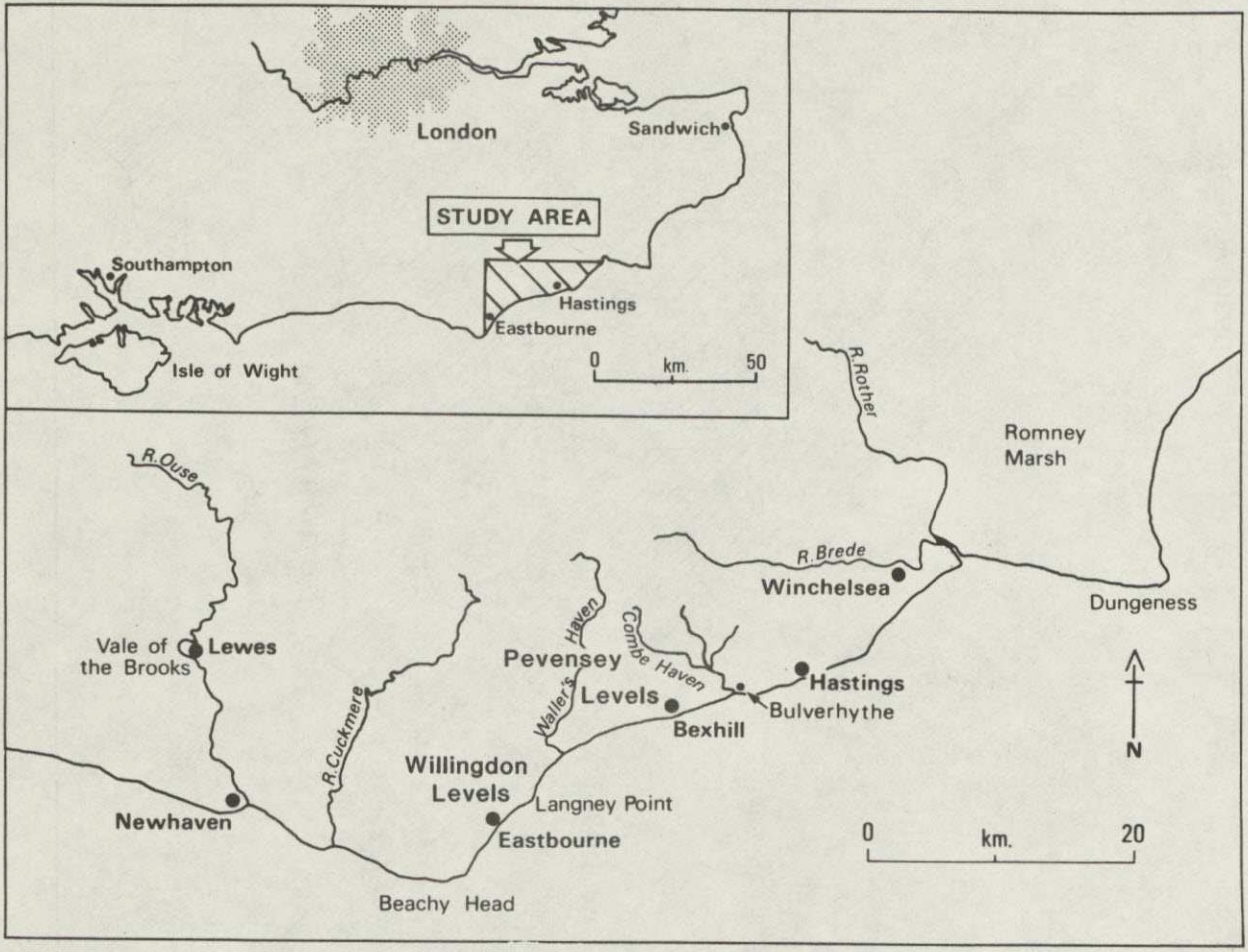

Figure 1. Location map - regional context.

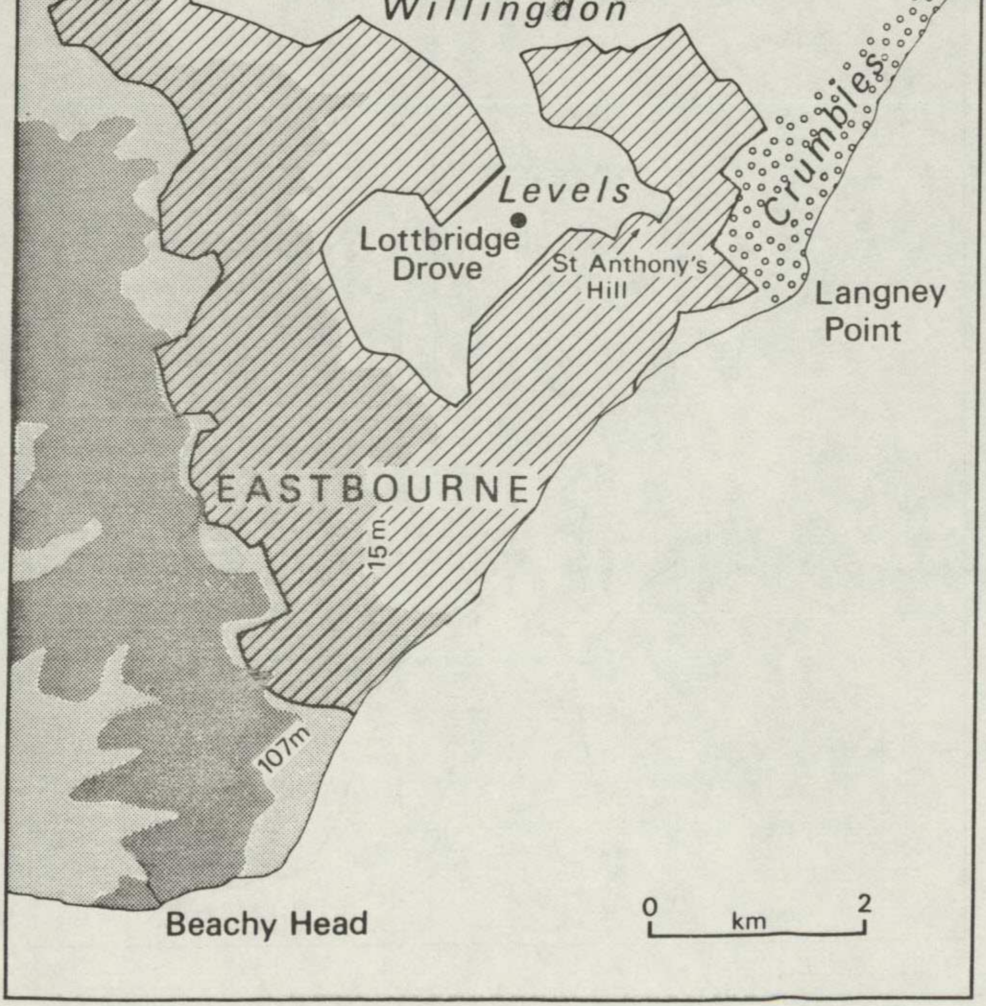

Figure 2. Location map - Eastbourne area.

The recognition of 'contacts' and 'overlaps' in a sedimentary sequence has become a central issue in the examination of sea-level change (Shennan, 1982, 1983; Tooley, 1982). These are 'lithostratigraphic descriptive terms' (Tooley, 1982) with no process(es) being implied as to their formation. A major consideration in the interpretation of overlaps is the possibility that their formation is independent of sea-level change because of accretion or erosion of the coastline. Thus, a 'transgressive' or 'regressive' episode recorded in a sedimentary sequence may owe nothing to eustatic movements. It is principally to overcome this interpretive problem that the terms 'contact' and 'overlap' are used descriptively and do not imply any particular process.

However, a further problem exists when significant environmental changes can be demonstrated to have occurred within an apparently uniform lithologic unit. This situation will be demonstrated in the Langney Point lithostratigraphy where an examination of the biostratigraphy has revealed environmental changes that are not made apparent by a description of the lithostratigraphy .

Thus, 'contacts' and 'overlaps' are identified principally through lithostratigraphic means (e.g. variations in organic content or particle size) often supported by changes to the contemporary fossil record. However, in addition, evidence for major palaeoenvironmental changes within coastal deposits may exist within a uniform lithostratigraphic unit and be revealed only by changes in the biostratigraphy, these changes showing no correspondence with lithostratigraphic boundaries. In this case the term 'tendency of sea-level movement' (either positive or negative) is adopted. These two situations can be demonstrated by the Langney Point stratigraphy. In the following discussion the term 'transgressive contact/overlap' is used to indicate a positive tendency of relative sea-level movement at a lithostratigraphic boundary, and 'regressive contact/overlap' a negative tendency (Shennan, 1983). These terms relate to a probable increase and decrease, respectively, of the marine influence. In neither case is any specific process implied (Shennan, 1983).

The Langney Point stratigraphy.

Figure 3 illustrates the lithostratigraphic units* (based upon field-observation and particle size analysis) that make up the Langney Point formation. Also shown are the positions of the sea-level index points.

Three sea-level index points are recognised.

1). At -25.94m. O.D.:- This is an indicator of a positive tendency of sea-level movement occurring within the Lower Minerogenic Sequence (clay). This index point is identified by the first appearance of the following biostratigraphic indicators of estuarine conditions:

Pollen - Chenopodiaceae.
Molluscs - *Ostrea edulis* Linné, *Scrobicularia plana* (da Costa)

*Note: The depths for the Crumbles Peat unit on Fig.3 replace the depths originally given in Jennings and Smyth (1982) which were based upon an unreliable levelling point.

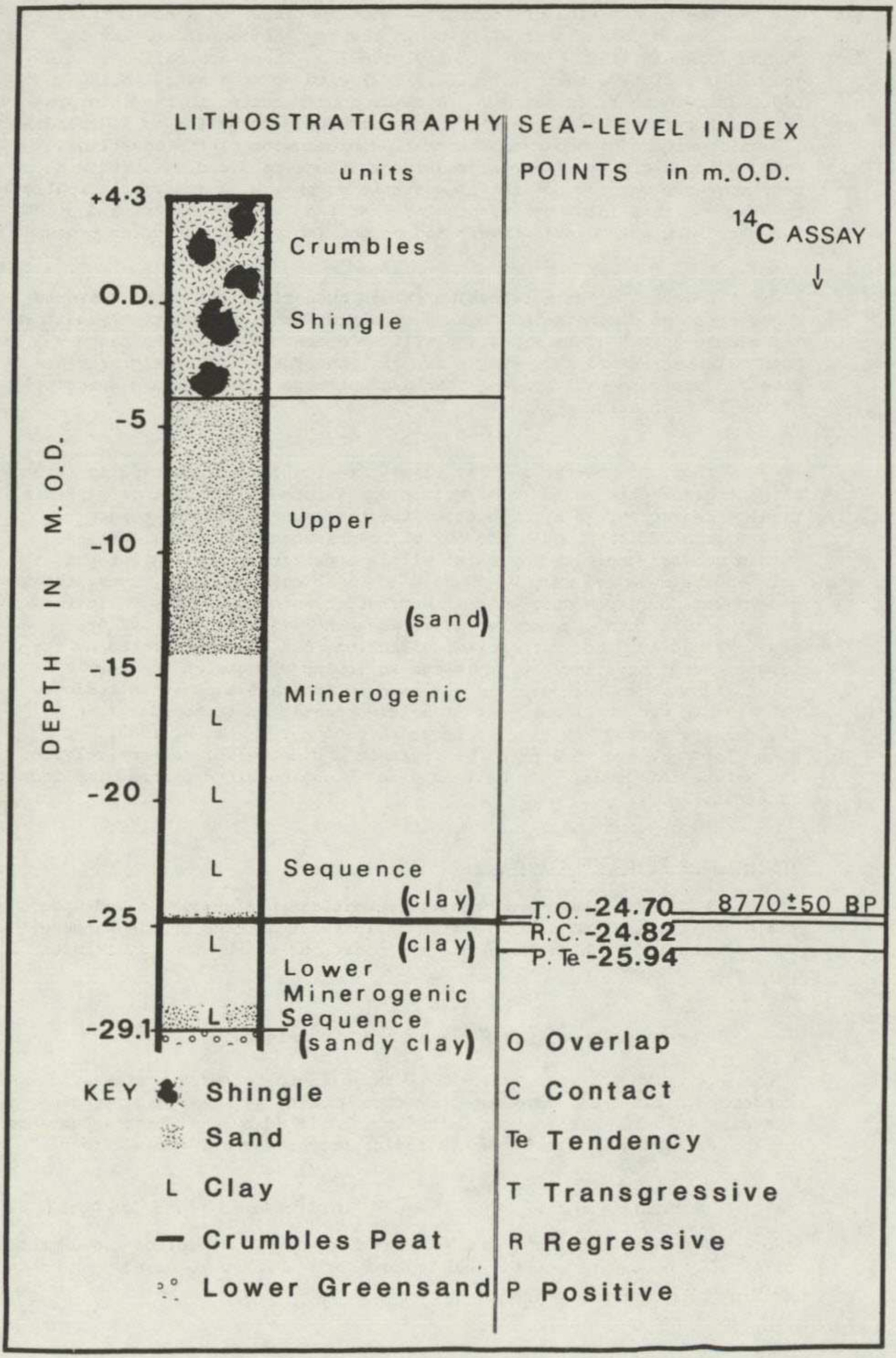

Figure 3. Langney Point - Stratigraphy.

These estuarine conditions replaced an earlier freshwater episode during which no estuarine molluscs are recorded. The pollen assemblage in this earlier phase is characterised by the dominance of freshwater taxa, for example, Cyperaceae, Filicales and *Sphagnum*. Chenopodiaceae pollen grains are absent.

2). At -24.82m. O.D.:- With the formation of the Crumbles Peat a regressive contact heralds the return of freshwater conditions. No estuarine molluscs are found in the peat and the pollen and plant macrofossil records are dominated by *Equisetum*. Chenopodiaceae pollen grains undergo a major reduction in relative frequency.

3). At -24.70m. O.D.:- A transgressive contact is marked by the deposition of the Upper Minerogenic Sequence (clay) (U.M.S. (clay)) and is dated to 8,770 ± 50 B.P. (SRR-2452). This contact can also be recognised in a borehole from Langney Point analysed by the I.G.S. (Shephard-Thorn, 1975), so that together they form an overlap recording a dominant positive tendency of relative sea-level movement in the area. With this event estuarine conditions returned which is well illustrated by the recognition of the following assemblages within the U.M.S. (clay):

Foraminifera - *Ammonia beccarii* (Linné), *Protelphidium germanicum* (Ehrenberg), *Elphidium* app.
Ostracoda - *Cyprideis torosa* (Jones), *Loxoconcha elliptica*, Brady *Leptocythere lacertosa* (Hirschmann), *L. castanea.* Sars.
Molluscs - *Hydrobia ventrosa* (Montagu), *H. ulvae* (Pennant), *Ostrea edulis* (Linné)
Scrobicularia plana (da Costa), *Cerastoderma edule* (Linné), *Mytilus* sp.
Pollen - Chenopodiaceae.

These lists represent a summary of the taxa identified. A full list will be given in Jennings (forthcoming).

Within the U.M.S. at -14.2m. O.D., sand-sized particles replace clay as the dominant texture type (Fig.3). At the same time, Foraminifera (e.g. *Quinqueloculina*) and Ostracoda (e.g. *Pontocythere elongata* (Brady)) indicative of more open-sea conditions replace the estuarine assemblages. In turn, this unit is replaced by the Crumbles Shingle at -3.7m. O.D., thereby establishing a coarsening-upwards in the lithostratigraphy from the U.M.S. to the Crumbles Shingle.

Interpretation.

The positive tendency of sea-level movement at -25.94m. O.D. is probably a response to the early Flandrian transgression which produced estuarine conditions at this site. However, the sediments from a nearby borehole (approximately 10m. away) analysed by the I.G.S. reveal freshwater conditions with peat formation (Shephard-Thorn, 1975). It seems likely that the establishment of this early episode of estuarine conditions may have been restricted to local channels. It is also possible that sand dunes were present in the area which allowed local stands of juniper (the pollen of which reaches a maximum of 49% total land pollen) at a time when pine and hazel had already become established (Jennings, forthcoming).

The regressive contact at -24.82m. O.D. marks an expansion of the Crumbles Peat. However, it is unclear whether this represents a eustatic fall, because this contact could also be explicable in terms of blocking of the tidal inlets referred to above by wind blown or marine transported sand.

At -24.70m. O.D. a transgressive overlap marks the return to estuarine conditions. This is dated to 8,770 ± 50 B.P., a date which shows a very close correspondence with the assay of 8,760 ± 75 B.P. obtained from the borehole analysed by the I.G.S., recorded at a depth of -24.9m. O.D., the lithostratigraphic contact occurring at -24.8m. O.D. (Shephard-Thorn, 1975). This suggests that the organic layer (the Crumbles Peat) recovered at both sites is a single unit.

The contact between the Crumbles Peat and the overlying U.M.S. (clay) is represented by a thin layer of coarse grained material (which has a predominantly sandy texture), above which the U.M.S. (clay) is then established. This thin, coarse layer is suggestive of the over-running of sand dunes and banks, and significantly it contains a badly fractured marine diatom assemblage (Battarbee, pers. comm.). Thus, the extensive episode of estuarine conditions which followed the establishment of the U.M.S. (clay) may be explained by the creation of sheltered conditions behind protective sand barriers. No evidence has been found of oscillations of relative sea-level within this lithostratigraphic unit, and it should be appreciated that this prolonged estuarine phase occurred during the rising sea-levels of the early Flandrian and on what is today a high energy coastline. Such considerations are suggestive of barrier protection during the early Flandrian at Langney Point. The absence of shingle in this unit indicates that early barriers were largely composed of sand and, with the creation of estuarine conditions at Langney Point, were located to seaward of this site.

At -14.2m. O.D. the U.M.S. (clay) is replaced by the U.M.S. (sand) with the attendant fully marine Foraminifera and Ostracoda. Such a pattern is explicable in terms of the over-running of a sand barrier and the shoreward migration of dunes and banks, thereby establishing high energy conditions at Langney Point. The lithostratigraphic investigations revealed sand textured sediments close to St. Anthony's Hill, suggesting that the sand banks probably migrated close to this area where they became the foundations upon which the later accumulation of shingle (the Crumbles) became established.

The growth of the Crumbles Shingle.

Steers (1964) suggests that Langney Point may be a recent (18th century) feature. However, a map of the area compiled in 1587 (reproduced in Bourdillon, 1885) records the position of 'Langney Pointe'. Additionally, documented evidence (Dulley, 1966) mentions the presence of shingle at Pevensey in 1207. Therefore, although no evidence has been found for shingle being in the area as early as 5,500 B.P., as Eddison suggests for Dungeness (Eddison, 1983a,b), there are indications that shingle has been present for at least 700 years.

The provenance of the Crumbles Shingle is problematic. Erosion of Langney Point today which, according to cartographic evidence began in the 18th century (Redman, 1851-2; Milner and Bull, 1925; Steers, 1964), suggests that present supplies of shingle are insufficient to maintain, let alone have created, this shingle complex. It is, therefore, suggested that offshore supplies have been important in the creation of the Crumbles and Langney Point. A system of sediment transfer from offshore, similar to that found today along the East Anglian coast (Robinson, 1966) and possibly at Hurst Castle in Hampshire (Jones, 1981), is proposed. The present erosion may, therefore, be the result of coastal adjustment to the termination of offshore shingle supplies. Of note, the sea-bed off Langney Point today is clear of any banks (Jones, 1981).

The development of the Crumbles has influenced the pattern of sedimentation on Willingdon Levels. This aspect is beyond the scope of this article, but is discussed in Jennings (forthcoming). In summary, it is suggested that the accumulation of sediment in the Langney Point and St. Anthony's Hill area may have initiated the formation of the thin peat on Willingdon Levels dated between 3,750 ± 40 B.P. (SRR-2455) to 3,390 ± 40 B.P. (SRR-2454), which was replaced by estuarine sediments of the Upper Clay (Jennings and Smyth, 1982). However, the relationship between the Crumbles Shingle and the peat is unclear. A negative tendency of sea-level movement recorded within the Upper Clay that overlies the peat, is considered to be the consequence of the complete establishment of the Crumbles Shingle, a process that deflected eastwards the drainage system of Willingdon Levels, and allowed agriculture to spread onto the Levels.

General discussion.

The coarsening-upwards sequence from the U.M.S. to the Crumbles Shingle, with its accompanying changes to the fauna, is probably related to an increase in the energy of the coastal system over time at Langney Point. Significantly, this occurred as the rate of Flandrian sea-level rise decreased. The estuarine conditions established after 8,770 ± 50 B.P. continued uninterrupted despite this being the period of the most rapid rate of eustatic rise. The transition to a high energy environment occurred during the period of slower sea-level rise.

Such a pattern suggests that the history of sedimentation at Langney Point has been influenced by the landward migration of barriers, initially composed of sand, but culminating in the establishment of the Crumbles Shingle. If the assertion is correct that important offshore sources of sediment have existed during the Flandrian, and their transfer to the shore is now complete, then the possibility exists that the coastline at Langney Point has been subjected to distinct phases of greater and lesser sediment influx. The establishment of the Crumbles between circa 700 B.P. to circa 300 B.P., a period during which many East Sussex harbours became silted-up behind drifting shingle, may therefore represent the most recent phase of major sediment influx, the termination of which has resulted in the present coastal erosion. It is interesting to note Nicholls' (1984) observation that Hurst Castle Spit may suffer a future "irreversible breach due to insufficient beach sediment" (Pg.18). Although the diminished sediment supply at Langney Point and at Hurst Castle may be due to the activities of man through dredging and sea-defence work, nonetheless, it is possible that natural sediment depletion is now occurring along parts of the south coast of England. If this is happening then it has important implications for planning in low-lying coastal areas.

Discussion on terminology.

The discussion above on methodology illustrates that a separation exists in the terminology between sea-level index points that include lithostratigraphic evidence (the 'contacts' and 'overlaps') and those which are based exclusively on fossil evidence (the 'tendencies of sea-level movement'). This separation arises because a contact and an overlap are lithostratigraphic descriptive terms (Shennan, 1983). Biostratigraphic indicators of sea-level tendencies, although capable of recording palaeoenvironmental changes as effectively as contacts and overlaps, may occur independent of lithostratigraphic changes and, in such circumstances, are not described as contacts or overlaps.

The important standardisation of terminology devised by Shennan and Tooley is necessary if ambiguities in sea-level research are to be avoided. However, the application of their terminology to the Eastbourne coastal sediments has resulted in a variety of descriptive terms being employed; one index point being a 'tendency' and another a 'contact' or 'overlap'. Whilst the retention of the terms 'contact' and 'overlap' is desirable, it is possible to standardise this variety of terms by adopting a small refinement to the existing terminology. Instead of separating 'contacts/overlaps' from 'tendencies' solely on the basis of whether a lithostratigraphic change occurs, two types of contact/overlap may be recognised:

> *'Lithostratigraphic contact/overlap'* - Revealed by a change in the sediment type (e.g. variations in organic content or particle size), often supported by changes in the contemporary fossil record.
>
> *'Biostratigraphic contact/overlap'* - Revealed only by changes in the biostratigraphy. There are no accompanying changes in the lithology.

Thus the sea-level index point at -25.94m. O.D. is an example of a biostratigraphic transgressive contact. This tendency of sea-level movement is revealed exclusively by the biostratigraphic record which shows a change from freshwater to saline conditions. Since this index point has only been found in this borehole it is termed a contact. Importantly, this fossil record is not transitional to a lithostratigraphic boundary - as, for example, changes in the pollen record within coastal peat beds usually are. Pollen of taxa of salt marsh affinities often appear in a coastal peat as a precursor to and subsequent to a lithostratigraphic boundary. This situation would be termed a 'lithostratigraphic overlap' as it is formed by a combination of bio- and lithostratigraphic evidence. With a lengthy transitional fossil record leading to a lithostratigraphic boundary, the overlap's position would probably be determined by the first appearance of fossils indicative of the new conditions. Although this might occur well before the corresponding change in the sediment type, it would still be termed a lithostratigraphic overlap because a palaeo-environmental change resulted in an alteration to both the bio- and lithostratigraphies, albeit diachronously. The precise position of an index point in a stratigraphy should, of course, be clearly defined if correlations between sites or regions are to be attempted. In this respect, a long transitional sequence of the type just described, poses a particular problem.

The remaining two index points in the Eastbourne sediments comprise a lithostratigraphic regressive contact and a lithostratigraphic transgressive overlap.

This refinement would further standardise the terminology when applied to sequencies such as those found at Eastbourne. It would also free the term 'tendency' from playing a confusing dual role of describing exclusively biostratigraphic index points as well as being used to describe whether the marine influence is increasing or decreasing at a given site irrespective of the type of index points used. At the same time it releases the terms 'contact' and 'overlap' from the confines of being applied only when lithostratigraphic changes occur.

Conclusion.

The coastal deposits at Langney Point are extensive and may have been influenced by variable amounts of sediment entering the area. Under such circumstances it is questionable whether low magnitude eustatic events would be recorded in the deposits.

That coastal barriers may have had an important influence upon the pattern of Flandrian coastal sedimentation along parts of the Channel coast has received much discussion in the *Quaternary Newsletter*. It is hoped that this article goes some way towards furthering our understanding of coastal barrier formation during the Flandrian, and adding supporting data to the ideas expressed by Jennings and Smyth (1982). It is also hoped that it contributes to the discussion on the methodology used in this type of research.

Acknowledgements.

We are very grateful to Dr. J.E. Robinson and to Dr. J.E. Whittaker for identifying the Foraminifera and Ostracoda, and to Dr. R. Battarbee for examining the diatoms. We would also like to thank Claire Wastie for drawing the two location maps, and Dr. R.H. Bryant for useful comments on an earlier draft.

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THE MERE SANDS OF SOUTH-WEST LANCASHIRE - A FORGOTTEN FLANDRIAN DEPOSIT

By Peter Wilson

Shortly after publication of 'Petrography, origin and environment of deposition of the Shirdley Hill Sand of south-west Lancashire' (Wilson et al., 1981) I received a letter from Dr. A.E. Mourant FRCP, FRS concerning the sediments and stratigraphy in the vicinity of Mere Sands Wood (SD 446159, Fig. 1). The Late Devensian and Flandrian succession in this locality, as observed by Tooley and Kear (1977) and Wilson et al. (1981) is shown in Figure 2. This is fairly typical for that part of south-west Lancashire covered by Shirdley Hill Sand although sediment thicknesses are very variable. The lowest intercalated peats, often displaying evidence of periglacial disturbance, are dated to the Loch Lomond Stadial of the Late Devensian (Tooley and Kear, 1977; J.A. Taylor, pers. comm. 1979). Stratigraphically younger (Flandrian) organic layers also occur within the sand and are believed to represent phases of landscape stability and biogenic accumulation followed by periods of instability that led to sand blowing, burial and preservation of some of these organic sediments. Pollen and 14C dating suggests that instability and reworking of the sand occurred in association with Mesolithic and Neolithic deforestation and agriculture (Tooley and Kear, 1977; Tooley, 1978).

At Mere Sands Wood (Fig. 1) Tooley and Kear (1977), Wilson et al. (1981) and Wilson (unpub.) recorded the presence of a surface sand unit up to 1 m thick and underlain by woody detrital peat (Fig. 2). Pollen values indicated a post-elm decline age for the peat and, therefore, for the surface sand, which was considered to be part (reworked?) of the Shirdley Hill Sand formation (Tooley and Kear, 1977).

However, Wilson et al. (1981), on the basis of detailed particle size analysis, heavy mineralogy and SEM study of quartz grain surface textures, showed that this 'upper' sand was most unlike the underlying Shirdley Hill Sand and had greater affinities with the modern beach and dune sands of the Lancashire coast. The suggestion that it was probably deposited by westerly winds blowing coastal sand inland was made, but there was no attempt to determine its full extent or to rename it.

It was with regard to this last point that Dr. Mourant wrote informing me that he had been the first to discover this sand unit during 1929-30 whilst working on the Preston sheet for the Geological Survey. He recognised that it was distinct from the Shirdley Hill Sand and, in conjunction with W.B. Wright, proposed the name Mere Sands. Unfortunately no mention of the sand appeared in the Preston memoir, possibly due to its small extent and relative thinness, although Dr. Mourant recalls reading a paper, jointly with L.H. Tonks, at a local society meeting in Manchester in either 1929 or 1930, in which the sand was discussed. This paper may subsequently have been published but neither Dr. Mourant nor myself know of its whereabouts. If any QRA member is familiar with it I would be grateful for details.

The only publication known to the present author in which this sand unit is recognised and mapped is Crompton (1966). Soil survey work

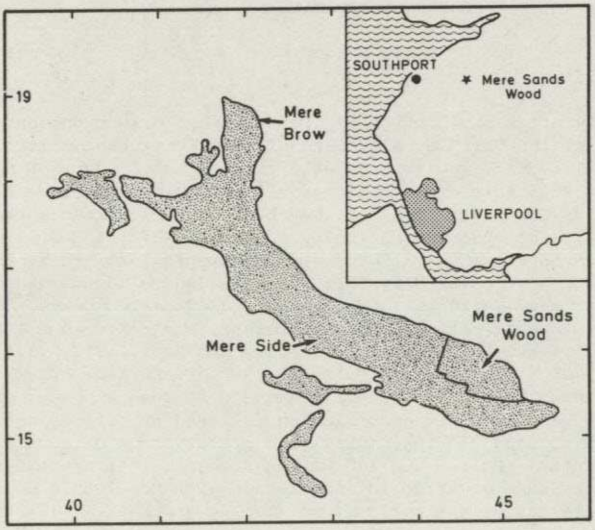

Figure 1. Extent and configuration of the Mere Sands (after Crompton, 1966).

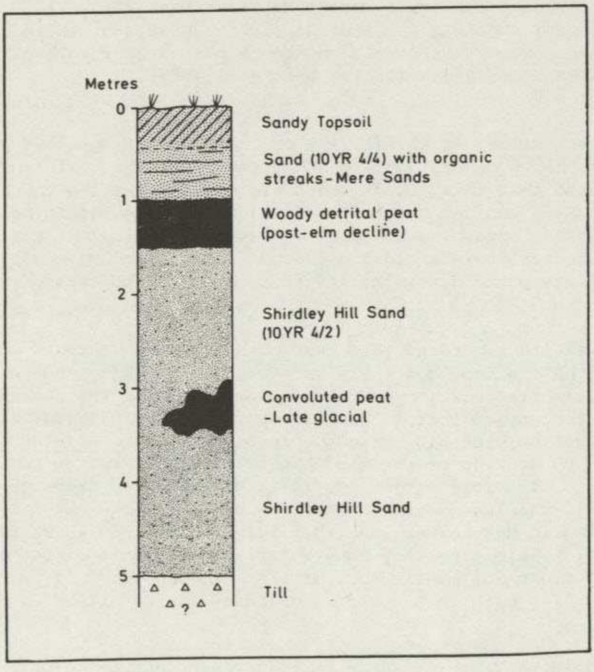

Figure 2. The Late Devensian and Flandrian succession in the vicinity of Mere Sands Wood (after Tooley and Kear, 1977: Wilson et al., 1981).

has shown the extent and configuration of the sand (Fig. 1). It forms an elongate body trending north-west - south-east from Mere Brow to Mere Sands Wood, a distance of 6 km. Maximum width of 1 km is reached towards each extreme of its outcrop. Three small patches of sand lie adjacent to the main body. Total area of the sand is c. 6 km^2.

Soils developed on the sand are mapped as part of the Mereside Complex, the characteristic soil type being a ground-water gley. The position of the water-table in these soils is related to the depth of peat but in some areas (e.g. south of Mere Brow) peat is absent and the sand rests on till. Crompton (1966) considers the sand to be lacustrine and associated with the old lake beach of Martin Mere - a lake that occupied the area until drained in the 18th century. Resorted Shirdley Hill Sand and material of glacial derivation are stated as being the major components of this sand.

Thus three different explanations exist for the sand's origin and mode of deposition viz:

1. Lacustrine sand comprised of Shirdley Hill Sand and glacial material (Crompton, 1966).

2. Wind blown sand, i.e. reworked Shirdley Hill Sand (Tooley and Kear, 1977).

3. Wind blown sand, i.e. coastal sand blown inland (Wilson et al., 1981).

It is not the intention of this short communication to argue the case for one or other explanation but it should be noted that only Wilson et al. (1981) have provided analytical data pertaining to various aspects of the sand. One anomaly that does exist, however, in the available data concerns particle size distribution (Table 1). Crompton (1966) states that the soils of the Mereside Complex "are very coarse-textured throughout" and presents data to show that generally more than 50% of the sand exceeds 200 μm in size. The corresponding value from the sample analysed by Wilson et al. (1981) would be 3.3%! Textural parameters derived by Wilson et al. (1981) show the sand to be of fine sand size (mean size +3.04 ϕ) and very well sorted (0.34 ϕ).

Table 1

Particle Size Data - Mere Sands

% 2000-200 μm	% 200-20 μm	Remarks
46-76	19-50	Ranges for 8 samples from 1 soil profile (Crompton, 1966)
3.3	96.7	1 sample (Wilson et al., 1981)

Finally, although the true origin of this sand unit still needs to be established, its undeniable distinctiveness from the Shirdley Hill Sand leads me to formally propose the name Mere Sands (following Mourant, pers. comm.) - a name first suggested over fifty years ago, but one which did not enter the literature.

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URANIUM-SERIES DATING OF CALCITE CEMENT FROM THE RAISED BEACH AT PORTLAND, DORSET

By Peter Rowe and Tim Atkinson

The antiquity of the raised beach deposits at Portland Bill, and also of many other similar deposits around the shores of the English Channel, is extremely uncertain (Mitchell 1977, Zeuner 1959). Andrews et al (1979) have established the similarity of amino acid ratios from Portland and the Burtle Beds (the latter being tentatively referred to the Ipswichian by Kidson et al (1978)), and these compare closely with ratios obtained by Keen et al (1981) from the raised beach deposits of Belle Hougue Cave, Jersey, uranium-series dated by them to around 121Ka.

The presence of secondary calcite cement within parts of the Portland deposits offered an opportunity of obtaining direct evidence of the minimum age of the beach by uranium-series dating. The cement transpired to be of Holocene age, and this note records the details of this rather disappointing result.

The succession at the western end of the raised beach was recorded by Arkell (1947 p.331) as,

	Ft
Head: angular rubble of Purbeck and Portland Beds, roughly stratified, especially in the lower part, where it is interstratified with the loam.	4 - 5
Loam, yellowish brown, with many calcareous pellets and layers of rubble, especially towards the top. Non-marine shells.	4
Shingle, well rounded, clean washed, obliquely bedded, becoming sandier towards the lighthouse, where marine shells are common; gastropods predominate. Locally cemented.	9

The shingle unit is weakly cemented by calcite throughout most of its thickness in the exposures on the cliff ledges at the extreme west of the beach, just outside the present fence surrounding Admiralty land (G.R.SY6753 6857,400 metres northwest of the lighthouse). Most beds in the shingle contain some sand and fine gravel which is included within the cement, making it potentially unsuitable for uranium-series dating. One lens of chert and flint pebble-gravel, approximately 1.5 metres (5 feet) above the base of the shingle, is almost completely free of such fine particles. It is cemented by clean, white calcite, forming rinds up to 5 mm thick around the pebbles and it proved possible to collect a 100 gramme sample of fragments of these rinds.

The sample was cleaned mechanically and also by dissolving the surface layers of the fragments in dilute acid. Two 230-Th/234-U age determinations were made by normal methods (Gascoyne et al 1978, Ivanovich and Harmon 1982). The results are presented in Table 1.

Lab. No.	U conc (ppm)	Chemical Yield(%) U	Chemical Yield(%) Th	234-U / 238-U	23 -Th / 234-U	23 -Th / 232-Th	Age (YrsB.P)
UEA 57	1.55	58	55	1.063±0.011	0.077±0.003	16.2±1.4	8,700±400
UEA 94	1.81	57	28	1.111±0.016	0.031 0.002	6.1 0.9	3,400 200

Table 1. Uranium-series Analytical Data for Portland Calcite Cement

(Errors quoted are 1 standard deviation based on counting statistics only)

The samples are slightly thorium contaminated and the calculated ages are consequently rather too high, especially in the case of sub-sample UEA94. Nevertheless, it is apparent that the calcite cement was precipitated during the mid-late Holocene, probably from water percolating through the overlying calcareous head and loam deposits that have subsequently been eroded back to expose the pebble beds.

The dates indicate that the secondary carbonate is of such recent origin as to place no realistic constraint upon estimates for the actual age of the beach itself, which must pre-date the calcite. However, this note may at least save others from repeating the same exercise unnecessarily.

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IGCP 24 QUATERNARY GLACIATIONS IN THE NORTHERN HEMISPHERE

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The basic objective of Project 24 was correlation of glaciations. This inevitably also involves consideration of interglacials and interstadials, as well as periods of cold climate (shown by biological indicators or by oxygen isotope ratios in deep sea cores) that were not cold enough to generate glaciers in this country. Before giving conclusions about correlation which have been reached during the last 8-9 years, it is important to summarise progress in absolute dating which, if reliable, is the best tool for correlation.

Correlation Methods

Radiocarbon The simultaneous use of multiple small counters at Harwell and more stringent 'cleansing' methods generally have reduced the standard error, but the ultimate dating limit without enrichment is still close to 50,000 years. The tandem accelerator at Oxford did not have time to contribute to the project.

Uranium/Thorium This technique faces a practical limit to age measurement of ∿ 350,000 years, but this range is nevertheless very useful. (Much of the British work has been done in collaboration with American laboratories.) Dates on speleothem formation in caves cluster around three maxima, 0-15 ka, 90-140 ka and (broadly) 170->350 ka. These measurements reflect the Flandrian and Ipswichian interglacials and, less closely, the pre-Wolstonian warm periods. More precisely, Ipswichian cave deposits and a raised beach in Jersey approximate to 125 ka, correlating the Ipswichian with sub-stage 5e of the deep sea oxygen-isotope record.

Thermoluminescence of sediments is a method of dating which seemed to be basically improbable, but is gaining in credibility. In Britain, this is due to work by Wintle (Cambridge) and Aitken (Oxford) who suggested improved working procedures and correction for the residual effect of undischarged thermoluminescence.

Amino-acid ratios. As yet this is only a method of relative dating but useful results have been obtained by Bowen, working initially with colleagues at the University of Colorado and subsequently at Aberystwyth.

Oxygen isotopes The major progress has been the development by Shackleton of the technique of measuring the $^{18}O/^{16}O$ ratio on a single foraminifer or comparably-sized calcareous test. Knowing the life habits of the species, conclusions drawn about the composition and temperature of the sea at any time can be closely related to depth conditions. Continued collaboration with the Lamont-Doherty Laboratory in the USA has established a very firm sequence of maxima and minima on the isotope curve which can be regarded as reliably reflecting the fluctuations of world climate.

Magnetostratigraphy. With virtually no deposits in Britain encouraging the use of this technique, no serious British contribution can be reported.

Biological correlation. The use of pollen, macro-plants, molluscs, ostracods, small vertebrates and large mammals has been refined continuously, but the major innovation (pre-1974 nevertheless) has been the use of Coleoptera and, to a lesser extent, other insects as indicators of ecology and climate. The leading proponent of the technique in the U.K. is Coope (Birmingham), but the technique is becoming widely practised in this country and has spread abroad.

Correlation in the U.K.

The Geological Society of London's Special Report on the Correlation of British Quaternary Deposits appeared in 1973, prior to the start of Project 24, so the British names for stadials, interstadials and interglacials are used. In the following summary, divisions are considered from modern to ancient.

Holocene. The Holocene Commission of INQUA has recommended that the commencement of the period should be at 10,000 radiocarbon years BP; British opinion largely agrees with this definition. If otherwise based, a change from Arctic to temperate conditions would result in diachronism from region to region. Various authors have shown that an Arctic insect fauna persisted until about 9850 BP and that, by 9500 BP, the fauna was fully temperate. Palaeobotanists agree that vegetation started to change radically about 10,000 years ago and, in such a continuous process, a logically convenient figure of 10,000 radiocarbon years is a practical division.

Devensian. The main Devensian glaciation reached its maximum extent in North Wales and South Yorkshire as recently as 18,000 years ago; possibly, a little earlier in the Midlands. Deglaciation seems to have been complete about 14,000 years ago. There was a brief recrudescence shown by a small ice cap centred near Loch Lomond (known as the Loch Lomond Readvance) between about 10,600 and 10,000 BP. There is no evidence in this country of physical glaciation in the Middle or Early Devensian, as there is in parts of eastern Europe and the USA.

Between the main glaciation and the Loch Lomond readvance, British opinion now accepts only one interstadial, the Windermere, in lieu of the Danish scheme of Allerød Interstadial above and Bølling Interstadial below, separated by the Older Dryas Stadial. Pennington and Coope differ slightly in their interpretation of the rate of climate change. The Middle and Early Devensian were cold, often very cold, apart from two or three interstadials. The earliest of these is claimed to be at Wretton in Norfolk, where West considers that the pollen, including arboreal pollen, denotes an interstadial, but Coope maintains that the beetle fauna is 'cold'. If accepted as an interstadial, it could be Britain's only example of the Amersfoort of Holland and Denmark.

On firmer ground is the interstadial named after Chelford in Cheshire. By 'enriched' dating, it has been given an age of 60,000 ± 1500 (GrN 1480) and this correlates it with the Brorup of Holland and Denmark. It has been recognised at perhaps three other sites in Britain including one in the English Channel (Shotton 1977).

The next interstadial is named after Upton Warren in Worcestershire. It was short-lived, from 43,000 to 40,000 BP, long enough for a thermophilous insect fauna to develop, but too short for trees to invade the area. It has been recognised at five other locations in Britain.

Western Europeans claim six interstadials during the Devensian, but only three, at best, have been found in the UK; Upton Warren does not coincide convincingly with the Hengelo of Holland. British work suggests a climate after about 40,000 BP as consistently cold, passing to Arctic desert for a short time prior to the Late Devensian main glaciation.

Ipswichian Interglacial. In the oversimplified classification of the 1973 *Correlation of British Quaternary Deposits*, there was only one interglacial between the Devensian and the Wolstonian. Now it seems probable that there are two separate warm periods, divided by an interval where cryoturbation without glaciation is evident. The British INQUA Subcommittee set up a working group to assess the evidence and reported its findings, in part based on work not yet published.

The stratotype Ipswichian of West, from Bobbitshole near Ipswich, is regarded as the later of two warm periods. It is to be correlated with deposits at Trafalgar Square (London), the uppermost beds of the

Summertown-Radley Terrace of the Thames at Oxford, 'Terrace 3' of the Warwickshire Avon, the *Hippopotamus* layer in Victoria Cave (Settle), the upper ossiferous layer of Joint Mitnor Cave (Devon), and with the raised beach associated with Belle Hougue Cave (Jersey). The vertebrate fauna includes *Hippopotamus* for the first time since the Cromerian. This period has been dated by U/Th on speleothem encrusting hippopotamus at around 125,000 BP and is, therefore, correlated with sub-stage 5e of the oxygen isotope curve.

There are a number of locations where older deposits with at least a temperate biota and demonstrably post-Hoxnian occur, viz., at Marsworth (Bucks), Stanton Harcourt (or Linch Hill) near Oxford, No.5 Terrace of the Warwickshire-Worcestershire Avon and a series of sites near Ipswich (Stoke Tunnel, Maidenhall, Stutton, Harkstead) and Brundon in Suffolk. In all of these, the vertebrate fauna includes *Equus* and if *Mammuthus* occurs, as it usually does, it is of the broad lamellae forest type. In none of the sites does *Hippopotamus* occur. Hence, there has developed a picture of two 'Ipswichian' periods, one *sensu stricto* with *Hippopotamus* and *Palaeoloxodon antiquus* and an earlier one with *Mammuthus* and *Equus*. At Marsworth, these two deposits are separated by a layer with strong cryoturbation; at Stanton Harcourt, the *Mammuthus-Equus* (and *Corbicula fluminalis)* deposits occur at the base of the Summertown-Radley Terrace, overlain by glacial gravels with *Mammuthus primigenius* and from above these Sandford recorded *Hippopotamus*. These earlier warmer climate deposits are thought to belong to oxygen isotope stage 7.

Bowen, working with INSTAAR of Colorado, has recently measured amino-acid ratios of *Patella vulgata* and *Nucella lapillus* from a number of raised beaches, some of which have been accurately dated by U/Th. They fall into two series, one corresponding to sub-stage 5e (i.e., Ipswichian s.s.) and this includes most of the raised beaches of Gower. A second group of ratios, about 1.65 times the others, comprises raised beaches at Hopes Nose, Swallowcliffe and Saunton in Devon and the inner beach at Minchin Hole (Gower). These have been equated with isotope stage 7, with an age of about 210,000 years.

Wolstonian. It would serve no useful purpose to disentangle here the confusion which has arisen over three conflicting views about the status of the Wolstonian. Briefly these are:

(i) That the stratified glacial succession worked out by Shotton south of Coventry is pre-Ipswichian but post-Hoxnian and is justifiably the national stratotype, with the name Wolstonian, for the penultimate British glaciation, broadly equivalent to the Saalian (the orthodox view).

(ii) That the Oadby Till, a calcareous boulder clay laid down towards the end of the Wolstonian, has a mineralogy similar to that of the Lowestoft Till, also a calcareous boulder clay, and that on this basis they should be correlated. This would make the Wolstonian equivalent to the Anglian and roughly equivalent to the Elsterian (Perrin and others, including some members of IGS).

(iii) That there is no glacial period between the Devensian and the Anglian, that the Hoxnian and Ipswichian are successive phases of a single interglacial and, therefore, that the Anglian stage is the penultimate British glaciation equivalent to the Saalian (not to the Elsterian) and, of necessity, the same as the Wolstonian (Cox and some other members of the IGS).

So leaving the Wolston area for future discussion but retaining the term Wolstonian for any situation where a post-Hoxnian, pre-Ipswichian or pre-Devensian glaciation can be demonstrated, we need only go 20-27 km from the westernmost occurrences of the chalky facies of the Wolstonian to encounter thick Hoxnian interglacial deposits separating two glacigenic series which must be Wolstonian and Anglian, respectively. In both cases the successions occur on hill tops left as erosional relics above the valleys invaded by the late Devensian glacier. They occur at Nechells in north Birmingham and Quinton, west Birmingham. The biota of the interglacial sediments of Nechells have been described by Kelly (1964) and by Shotton and Osborne (1965), but the botanical work of Margaret Herbert-Smith and the coleopteran work of Kenward at Quinton have not yet been published. In each case, undoubted Hoxnian occurs, filling a deep hollow or channel in glacial gravels at Nechells and in the Nurseries Till at Quinton. In each case also an overlying till (Ridgacre Till) or a series of tills and gravels cuts horizontally across the interglacial beds and earlier glacial deposits unconformably. So in the Birmingham area there is clearly a post-Hoxnian but pre-Devensian glaciation and a pre-Hoxnian glaciation. There seems no alternative to referring to these as Wolstonian and Anglian, respectively.

The southern limits of these two ice sheets are inadequately known. To the north of Birmingham each must have been present at its appropriate time but rarely, if at all, are both or even one manifest. In Lincolnshire, e.g. at Tattershall Castle, a till composed of Jurassic and Cretaceous material is overlain by undoubted Ipswichian peats which in turn are covered by Devensian gravels. The calcareous till, named (by Straw) the Wragby Till, is credited by him to the Wolstonian, with the Anglian unrepresented. By others, the Wolstonian is believed to be absent and the Wragby Till is credited to the Anglian because of its calcareous nature. One of the most important papers dealing with this area is by Alabaster and Straw (1976) who described a succession at Welton-le-Wold in Lincolnshire:

Calcethorpe Till (a Jurassic-Cretaceous calcareous till which Straw maintains runs laterally into the Wragby Till).

Welton Till (non-calcareous)

Welton Gravel

The great significance of this section is that the Welton Gravel has yielded a tooth of *Palaeoloxodon antiquus*, three Acheulean flint hand-axes and a worked flake. On all counts this makes the gravel post- or late-Hoxnian. Therefore, the Calcethorpe Till indicates that chalky tills could form later than the Anglian if suitable Chalk and Jurassic rocks lay in the path of the glaciers.

<u>Hoxnian.</u> For a long time, this has been a key horizon. The stratotype, at Hoxne in Suffolk, was described in terms of pollen zoning by West, but several other successions in the eastern counties, some more complete than Hoxne, have been discovered and described. In all cases, the Lowestoft Till is channelled and the organic silts of the Hoxnian fill the hollows. By definition, therefore, the Lowestoft Till forms at least part of the Anglian stage. The Hoxnian is a cooler interglacial than the Ipswichian, but its palynological zoning portrays the expected stages of development, acme and decline, that characterise all interglacials.

Recent re-excavation of the Hoxne section (Gladfelter 1975) has produced a few mint-condition Acheulean flint implements which are important in the chronology of the Lower Palaeolithic in Britain. They have also shown that the later stages of the Hoxne section were deposited and disturbed by contemporary frost action, presumably during the Wolstonian.

In the extraglacial terrace gravels of the Thames, the Boyn Hill Terrace is largely, but not entirely, of Hoxnian age (as shown by its fauna and flora). Its gravels yield a wealth of Lower Palaeolithic artefacts and the earliest British *Homo*, Swanscombe Man. In the Upper Thames, the Hanborough Terrace continues the profile of Boyn Hill and must also be in part Hoxnian, though Briggs and Gilbertson have claimed an early Wolstonian age for part of it.

Anglian. From the correlation point of view, after the references which have been made to it earlier, the Anglian needs little amplification. It has two glacial sub-stages, the upper very extensive Lowestoftian and a basal Guntonian represented by the much more restricted Cromer Till (or tills) and the Norwich Brick-earth. Between the two is the Cortonian, though the Corton Sands were deposited in a cold sea; consequently all three sub-stages are ascribed to the single Anglian glacial stage. As most British stratigraphers are happy to equate Hoxnian with Holsteinian and Cromerian with some part of the Voigstedtian, the intervening Anglian should be correlated with the Elsterian.

Across East Anglia, the Lowestoft Till is known to end in Essex along a roughly east-west line on the latitude of Hornchurch, but its continuation to the west becomes progressively more and more conjectural as it passes towards the Wolstonian and towards Wales where very little is known stratigraphically about the pre-Devensian.

Pre-Anglian Pleistocene. The classical area for studying the earliest part of the Quaternary is East Anglia, where sediments of shallow marine, littoral, estuarine, fresh water and marsh origin were deposited in the subsiding Anglo-Dutch basin of the North Sea. The basal deposit is the Red Crag of Walton on the Naze, correlated with the Calabrian of Italy. The upward succession has been studied in the Ludham and Stradbrooke boreholes, in coastal sections and in inland sections near Norwich. Pollen, Foraminifera and molluscs have been the major agents for palaeontological zoning and for climatic and ecological interpretation. West (1980a, 1980b) lists the temperate (t) and cold (c) stages of the East Anglian succession as below, introducing the new terms of Pre-Pastonian and Bramertonian:

Cromerian (t)
  Beestonian (c)

Pastonian (t)
  Pre-Pastonian (c)

Bramertonian (t)
  Baventian (c)

Antian (t)
  Thurnian (c)

Ludhamian (t)

None of the cold stages produces evidence of actual glaciation in East Anglia, though some of the gravels have foreign erratics which can only be explained as originating from glacial deposits elsewhere; the Baventian may have seen the worst deterioration of climate.

Correlation of East Anglian stages with Europe is very difficult, even with the nearest sequences in Holland. West (1980a) is not prepared to go closer than the scheme shown in the accompanying figure

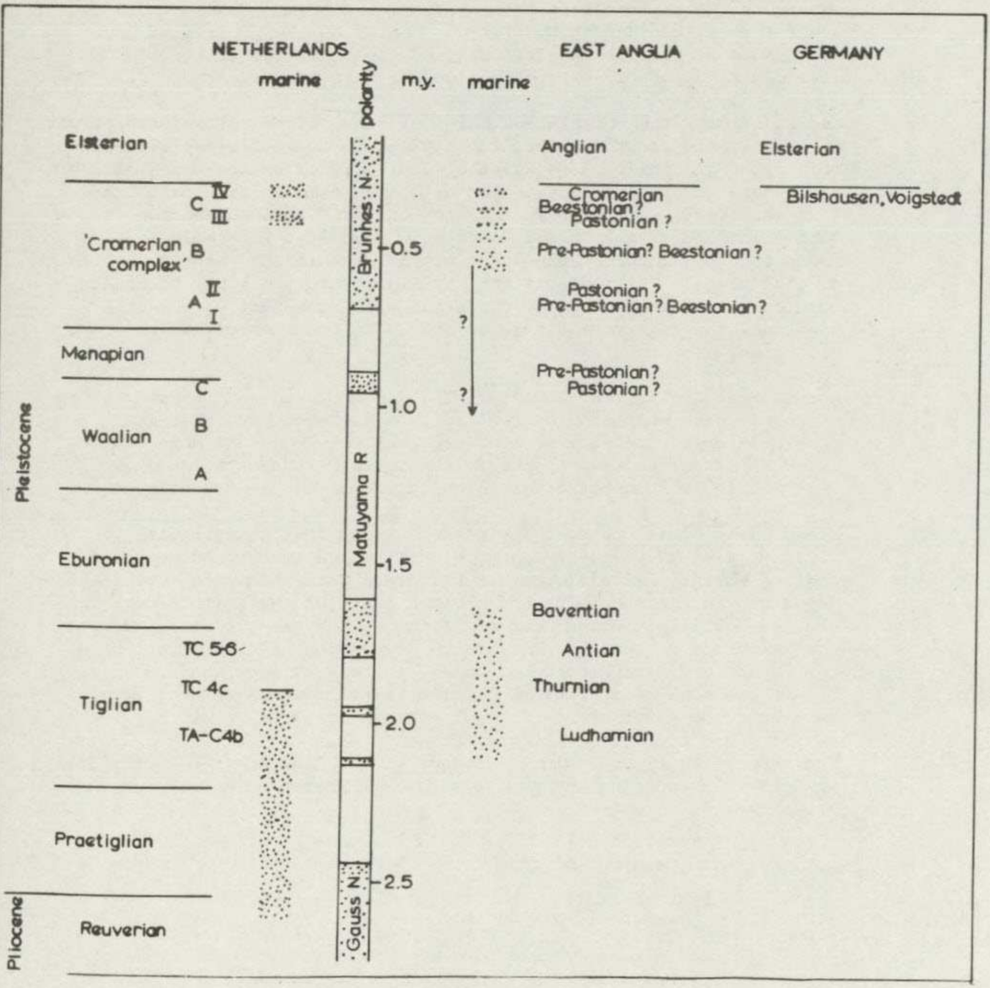

Figure 1. Correlation of The British and Continental successions (from West, 1980a *The pre-glacial Pleistocene of the Norfolk and Suffolk coasts, C.U.P.)*

It will be seen that West acknowledges many stratigraphical breaks and in particular much of the Waalian and Eburonian of the Netherlands may be unrepresented.

Older gravels of the Thames and a Lower Pleistocene glaciation

The Middle and Lower Thames lies south of the limit of any glacier and, therefore, carries the history of its behaviour in its terrace gravels. Only the lower deposits have been dated closely and reference has already been made to the Boyn Hill Terrace gravels as being dominantly Hoxnian. Above this level, a flight of terraces become less and less clearly defined until they terminate as spreads of pebbles on the highest land of the Chilterns - the 'Pebble Gravels'. The higher gravel spreads do not follow the present course of the river down to the sea, but run across Hertfordshire and Essex, indicating a progressive diversion of the estuary to the south. Much important work has been done on these older gravels (Hey 1976, 1980, Green & McGregor 1978), but dating in terms of the East Anglian climatic stages is still difficult and largely conjectural.

On the Upper Thames above the Goring Gap, there is a well known sequence of terraces, in ascending order: the Lower Floodplain, Upper Floodplain, Summertown-Radley, Wolvercote and Hanborough. The latter is consistently correlated with the Boyn Hill Terrace. Recently, a higher terrace has been located, named the Sugworth Terrace (Shotton et. al. 1980). Here a gravel deposit, regarded as solifluxion, covers sands with silty channels carrying Cromerian IIIb fauna and flora. Consequently, the terrace itself has been dated as Anglian.

On the Cotswold dip slipe small outcrops of 'Plateau Drift' have long been known. These sometimes take the form of pebbly clay, sometimes of normal sands and gravels. All are completely decalcified. Some lie on the upstream continuation of the long profile of the Sugworth Terrace, but most are considerably higher than this, and therefore older. The pebble content of all the varieties of 'Plateau Drift' is remarkably constant, often being about 94-96% quartz and quartzite pebbles of the Kidderminster Conglomerate (ex-Bunter Pebble Beds) of the West Midlands. There is a very small amount of brown flint and, very rarely, fragments of Ordovician volcanic rocks. The virtually indestructible pebbles of quartz and quartzite have been derived from one age of 'Plateau Drift' to a later one, and figure prominently in Cromerian IIIb channels under the Sugworth Terrace; so the pre-Cromerian age is established. With most of the clasts coming from the West Midland Trias, and a small proportion of volcanics from North Wales or the Lake District surviving weathering and decalcification, glacial transport on to the Cotswold Scarp is the only possible transport mechanism. There may have been more than one pre-Cromerian glaciation, but it is only necessary to postulate one. Its pebbles were redistributed in all the Thames terraces younger than the glaciation. Green, Hey and McGregor (1980) have found such 'foreigners' in all the old terraces of the Thames downstream of Goring Gap up to and including the Westland Green gravels, though not in the 'Pebble Drift'; the glaciation is thus judged to be the age of the Westland Green gravels. This must be well back into the Lower Pleistocene and might approximate to a Baventian age. The original 'Plateau Drift' may thus be regarded as the product of an authenticated Lower Pleistocene glacier. Whether this is the only example is uncertain, for a till-like deposit found on the Chilterns (the 'Chiltern Drift') has been claimed to be pre-Anglian, however, solid proof that it is a glacial deposit is lacking.

An isolated site rich in vertebrate remains, revealed by quarrying in Carboniferous Limestone at Westbury-sub-Mendip in Somerset, was described by Bishop (1974). It is a fissure-cave filling and dates to some part of the Cromerian. Highly weathered flints are claimed to be human artefacts.

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EISZEITALTER UND GEGENWART

Annals of the German Quaternary Association

By J. Rose

It is perhaps appropriate at a time when the Quaternary Research Association is about to launch a new journal to look at *Eiszeitalter und Gegenwart*, which has been produced by the German Quaternary Association (Deutsche Quartarvereinigung, or DEUQUA) since it was founded in 1948. This is a journal that, over the years, has included articles of significance to local, international and systemmatic Quaternary problems, and in many respects must provide a model that should be of relevance to the QRA.

Eiszeitalter und Gegenwart is issued to all members of the German Quaternary Association as part of the annual membership subscription of DM 50.00 (about £15.00 at current exchange rates). It is produced once a year with soft covers, and type-set print. It includes photographs and throw-out illustrations and is expected to contain about 300 pages. In addition to the main body of the journal which consists of research papers, there are sections which include reports and obituaries.

The most recent issue is No 32 for 1982. This has 221 pages of text, which includes 13 articles, a critical review, and an obituary for Julius Fink who died on April 2nd 1981. All except one of the articles are in German. The exception being in English, but all have English abstracts and two others have an additional abstract in another language. The range of topics covers almost the whole scope of Quaternary Science, and can perhaps be best summarised in figure 1. Of particular interest is the fact that of the 13 contributions only 7 are concerned with Germany and the adjacent North Sea region, while the remaining 6 cover areas as far afield as Spain, Italy, Greece, Israel, U.S.A. and Japan. This compares most impressively with recent issues of *Boreas* (Vol. 3, No.2, pages 89-260) of which 6 of the 8 articles are concerned with evidence from Scandinavian territory, or *Quaternary Research* (Vol. 21, No.3, pages 267-405), where 8 of the 11 articles are concerned with evidence from U.S. territorial regions; and both these Journals claim either in their title or implicitly in their editorial board a more international range of subject matter. On the other hand, the authors of the articles in *Eiszeitalter und Gegenwart* is far from international in range, with only 3 of the 23 contributors employed in countries other than West Germany. It seems safe to say that the international scope of the contents reflects more the global spread of Quaternary interests by German scientists, rather than the journal acting as a forum for international Quaternary research.

Be that as it may, the contents reflect many aspects of Quaternary research currently considered to be of significance. For instance, topics such as palaeomagnetism, offshore stratigraphies in the North Sea region, and neotectonics, are considered, and no less than 6 of the articles give attention to palaeosols. Subjects, such as sediment lithology, terrace stratigraphy, and loess stratigraphy, that are in many ways typical of German Quaternary research are also included, as is the more unusual topic of pack-ice processes and effects in Japan.

Figure 1. Contents of Volume 32, 1982, *Eiszeitalter und Gegenwart.*

Topic of article	Number of pages	Region	Workplace of authors
Pack-ice	12	Japan	Germany, Japan
Neotectonics	10	U.S.A.	U.S.A/Venezuela
Aeolian sediments, palaeosols, stratigraphy.	26	Israel	Germany (x 2), Israel.
Sea-levels.	7	Italy	Germany (x 3)
Palaeomagnetism	6	Greece	Germany (x 2) Greece.
Late Weichselian sediments and palaeosols.	18	Spain	Germany
Sedimentary petrology	11	Germany	Germany
Late Pleistocene sediments and palaeosols.	15	Germany	Germany (x 2)
River Terraces and loess	30	Germany	Germnay
Glacial stratigraphy and palaeosols.	25	Germany	Germany (x 2)
Late Pleistocene stratigraphy and palaeosols	13	Germany	Germany (x 2)
Offshore marine sediments and microfauna.	26	North Sea	Germany
Quaternary and pre-Quaternary palaeosols.	10	Germany	Germany

There are several points of interest with regard to some current thoughts by British Quaternary scientists. For instance, in view of the work on the Main Lateglacial Shoreline in Scotland (Sissons, 1974) it is interesting to see that the work in Japan suggests that pack-ice, frost action and the effects of ice-shove are not considered to be as effective erosive agents as waves (Ellenberg & Hirakawa, pp. 1-12). The interpretation of the stratigraphy of the southern coastal plain of Israel for the last 110 ka (Brunnacker et al., pp.23-48) suggests that summer temperatures in that region show a pattern of change that has greater similarity to that described for Midland England (Coope, 1977) than that typically attributed to the Netherlands (van der Hammern et al., 1967). Apparently there is no evidence for the interstadials known as Hengelo and Denekamp in the Netherlands, whereas a rise of temperature is shown for the period between about 50 ka and 40 ka. On a quite different topic, ESR and 230Th/234U dating of marine shorelines in central Italy (Radtke et al., pp.49-55) and the palaeomagnetic interpretation of sediments from Greece (Heye et al., pp.57-62) confirm the importance of tectonic instability in the Mediterranean region, and emphasise the futility of altitudinal correlation of displaced shorelines around the Mediterranean coasts (Hey, 1978).

From Germany, the analysis of sediments and fossil soils from an infilled kettle hole in Saalian glacial deposits (Lade & Hagedorn, pp. 93-108) cannot fail to make us wonder where all our Wolstonian (Saalian?) kettle holes may be if Wolstonian glacial deposits currently at the surface are as extensive, as suggested by Straw (1983) and Shotton (1983). It is possible, of course, that the Warthe is not part of the Saale (see Ehlers et al., 1984), or there is no equivalent to the Warthe yet known in Britain, but these are matters which would equally justify receiving attention.

Clearly, the existence of *Eiszeitalter und Gegenwart* as the journal of the German Quaternary Association demonstrates the viability of such a product. The fact that a proportion of the Association's annual subscription contributes to the production of this journal, in the fashion adopted by traditional geological societies in Britain, such as the Geological Society of London, the Geologist's Association and the Yorkshire Geological Society, does however provide a more secure financial basis than that intended to be adopted by the QRA. Also, the division of costs among the maximum number of members makes a significant reduction in the costs of production and hence the price of each issue. However, this approach has the counter-attraction that annual subscription to all members must be higher, and the Association may become beyond the financial reach of some members just wishing to attend meetings and receive informal publications such as the *Quaternary Newsletter*. Obviously there is no simple answer, but it is not unreasonable to think that lessons can be learnt from DEUQUA and the production of *Eiszeitalter und Gegenwart*.

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Membership of *Deutsche Quartarvereinigung* and copies of *Eiszeitalter und Gegenwart* can be obtained by sending DM 50.00 or the equivalent to Dr. K-D Meyer, 3000 Hannover, Stilleweg 2, Postfach 510 153, West Germany.

SYMPOSIUM ON "THE QUATERNARY STRATIGRAPHY OF THE NORTH SEA" HELD AT THE DEPARTMENT OF GEOLOGY, UNIVERSITY OF BERGEN, 3rd-5th DECEMBER 1984.

By J.D. Scourse

With the increased hydrocarbon interests in the North Sea over the last twenty years or so, there have been a number of site investigations of Quaternary strata to satisfy a demand for information on foundation problems, pipeline planning and hazard potential. These investigations have been largely independent of each other, and there has been little regional multidisciplinary work, or syntheses of data. For a number of years the Department of Geology at Bergen, which specialises in marine and Quaternary geology, had seen the need to hold an international meeting on the Quaternary stratigraphy of the North Sea to bring workers from the universities, national geological surveys and commercial organisations together to discuss new results, ideas and common problems. The final impetus to hold the meeting in 1984 was provided by the retirement of Professor Hans Holtedahl from the chair of marine geology at the University of Bergen, and the Symposium was accordingly held in his honour.

Though the meeting was truly international in flavour, with participants from Norway, Sweden, Denmark, West Germany, Belgium and Britain attending, the meeting had not been widely publicised in this country. This is to be regretted, as it is certain that had a body such as the Quaternary Research Association been informed in advance, many more British workers would have attended. In addition, the absence of Dutch participants was conspicuous.

What follows is inevitably a largely personal and subjective account of the Symposium. It is intended simply to provide a taste of the major themes arising out of the papers and discussions, rather than an exhaustive list of speakers and of topics covered. For QRA members particularly interested in specific papers, I have a copy of the abstract volume and would welcome any enquiries for further information.

Much of the first day was taken up with stratigraphical accounts of specific areas or boreholes. It quickly became apparent that different workers in different areas using different techniques were proposing vastly different environmental or chronological conclusions. Thus Read (N.G.I. Oslo), in his paper on the "Quaternary stratigraphy at Statfjord B", proposed a reconstruction involving twelve glaciations, eight interstadials and six interglacials, correlated with the deep sea oxygen isotope stages, whilst Carlsen (N.G.I. Oslo), in her paper on "Geotechnical, sedimentological and stratigraphical examinations of Late Quaternary sediments from the northern North Sea, Block 34/10 (61°10'N 2°15'E)", interpreted five glacial episodes, all occurring within the Weichselian. It is precisely the difficulties of trying to make sense of such widely differing interpretations resulting from the application of different techniques at different sites that has led to the establishment of the North Sea Project at the Department of Geology in Bergen, under the leadership of Hans-Petter Sejrup. A multidisciplinary study of one particularly fine core, BGS 81/26 (200m) from the Bosies Bank area, is being undertaken. Apart from seismostratigraphy, the sedimentology, micropalaeontology, amino-acid geochronology and palaeomagnetic stratigraphy of this core have so far been investigated and a number of papers were presented on different aspects of this project. Brigham-Grette and Sejrup presented information on amino-acid geochronology, Løvlie and Ellingsen on palaeomagnetic dating, and Sejrup presented a review of the current interpretations concerning depositional environments and dating. It is hoped that 81/26 will become a reference core for the area, other similar studies eventually being undertaken on neighbouring cores which can then be correlated with the reference core. This detailed multidisciplinary approach seems to provide the best potential for eventually understanding the complicated Quaternary sequences in the North Sea.

Whilst palaeontological studies of core 81/26 have been useful in identifying interglacial episodes, most dating evidence has so far come from amino acid geochronology and palaeomagnetic investigations. Much of the informal discussion at the meeting centred on the validity of these two methods in the context of the North Sea Basin. Brigham-Grette and Sejrup (University of Bergen) in their paper "Stratigraphic resolution of amino acid geochronology in North Sea Quaternary sediments" were able to conclude that the method can provide a good resolution up to 300 Ka, and that it is especially useful in the borehole context in the identification of hiatuses. A search for more speedy racemizers should be undertaken, however, as this will improve stratigraphic resolution. The paper on "Palaeomagnetic dating of Quaternary sediments. Interpretations of results Bosies Bank core 81/26, North Sea" by Løvlie and Ellingsen (University of Bergen) was the final paper to be presented, and was very much the sting in the tail, concluding the Symposium on a controversial note. The identification of the Brunhes-Matuyama boundary in a number of North Sea cores was reported by officers of the B.G.S. in a paper in *Nature* in 1983 (Stoker, Skinn er, Fyfe and Long, 1983). Further work by Løvlie and Ellingsen on the palaeomagnetism of core 81/26 suggests that though a lower reversed sequence is identifiable, the proposed correlation with the Brunhes-Matuyama boundary is conjectural because chemical in situ remagnetisation has taken place. In addition, the amino acid geochronology of the core indicates a hiatus at the point of reversal, suggesting that the boundary itself is missing. The Blake event cannot be identified because its precise palaeomagnetic signature is not present in the North Sea cores. A final concensus seemed to have been reached in discussion, with the existence of a lower, reversed and an upper normal sequence; neither the Blake event nor the Brunhes-Matuyama boundary can, however, be unequivocally identified.

There were a number of papers dealing with non-dating methodological problems. Paul and Jobson (Heriot-Watt University) presented "The acoustic structure of sediments from the Witch Ground, Central North Sea"; an alternative title for this paper could have been 'What is an acoustic reflector?'. The authors have found difficulty in correlating reflectors with lithostratigraphic boundaries in cores, and suggest that in some cases correlations between these parameters in the past have been rather uncritical. This is most important, for the vast majority of the existing unit subdivision in the North Sea is based on seismostratigraphy. Reflectors can be caused by moisture variations, zones of overconsolidation and other non-lithological parameters. The point is here that seismostratigraphy is a perfectly valid tool for the subdivision of rock-units, but the causes of reflectors must be more fully appreciated and adequately investigated; reflectors should not be assumed to be always indicators of lithological boundaries.

This problem was again touched on in two papers by Edge and Derbyshire (University of Keele) concerning the geotechnical properties of, and fabric character within sediments. Shear stress variations, they report, can also cause reflectors. These papers also could have been given an alternative title, 'What constitutes till?'. This problem, painfully familiar to many land-based Quaternary geologists, is greatly accentuated when dealing with borehole material in a marine environment where most tills constitute reworked clast-free marine sediments. Primary fabric structures and geotechnical properties are especially useful in this context, granulometry taking a back seat. Edge and Derbyshire argued that many genetic interpretations of North Sea sediments may well be incorrect. Their work is firmly couched within the school that argues that it is the physical characteristics of sediments that provide evidence on genesis rather than chemical characteristics, such as mineralogy or clast petrology.

Jansen (University of Bergen) provided a review of "Stable isotopes as a tool for palaeoenvironmental interpretations in the North Sea", and there were a number of papers dealing with Holocene or contemporary sedimentary environments and biogeographical patterns in the North Sea area. Thus Werner (Christian-Albrechts University, Kiel) spoke on bedforms in the North Sea, Wartel and De Mayer (Belgisch Instituut voor Naturweten-schappen) recent sediments off the west coast of Belgium and Wagner (Geol. Pal. Inst. Munster) distribution patterns of benthonic foraminifera from the Iceland-Faeroe Ridge. Qvale (University of Oslo), Stabell (University of Oslo) and Thiede (Christian-Albrechts University, Kiel) all presented papers concerning the Holocene history of the Norwegian coastal current and associated palaeontological studies of a core from the Skagerak.

Another important theme was the Quaternary stratigraphy of the shores of the North Sea Basin, and it was here that the British contribution was most noticeably lacking. Sarntheim (University of Kiel), Stremme and Mangini gave an account of Th/U and ESR dates on marine Mollusca from paratype Holsteinian sites, corroborated by a K/Ar date on an ash bed at the base of the Ariendorf palaeosol (Holsteinian), and concluded by correlating the Holsteinian with oxygen isotope stage 11, the overlying Wacken-Domnitz episode with stage 9. These authors make the important point that they regard the apparently 'high' Holsteinian/ Hoxnian transgression to be the result of extreme glacio-isostatic depression caused by extensive and prolonged glaciation during the preceding Elsterian/Anglian stage. In discussion, Mangerud (University of Bergen) was critical of the reliability of Th/U dates on Mollusca, and therefore cast doubt on the proposed correlations.

Mangerud himself gave an account of his project with Miller (INSTAAR, Colorado) on the amino-acid geochronology of the Eemian interglacial. With the advent of new techniques such as the amino-acid method, it is essential to calibrate the results with material of known age; this has been attempted by Mangerud and Miller by analysing marine Mollusca from the Eemian stratotype at Amersfoort and from other sites characterised by a typically Eemian pollen sequence. They confirm that the stratotype Eemian is indeed the last interglacial, which contradicts Kukla and Bowen who have both argued that the typical Eemian pollen sequence has characterised a number of interglacials, and that the type Eemian does not represent the last interglacial. This work is important in the North Sea context for it provides a calibration for the amino-acid studies of offshore cores. Mangerud concluded with the controversial question of the age of the Fjøsanger interglacial near Bergen. The amino-acid ratios indicate an age somewhat older than Eemian by comparison with the other sites studied, which they suggest might be the result of methodological problems.

Feyling-Hansen (University of Aarhus) gave an exceptionally clear account of the foram biostratigraphy of three cores from the northern North Sea, but concluded by correlating a curve of 'boreal species' with the oxygen isotope curve so as to provide absolute ages for his biozones. And this in an area of non-continuous sedimentation! Dale (University of Oslo) gave an entertaining and enlightening paper on the value of dinoflagellates as palaeoenvironmental indicators, and Griffin (University of Oslo) reported on the pollen and macrofossil analysis of cuttings taken from a tantalising freshwater organic deposit from the north-central North Sea.

Mörner (University of Stockholm) gave a paper entitled "The regionality of the Earth's climatic system and the ocean-continent interaction with special reference to the North Atlantic situation in Late Quaternary time". In its scale and scope this paper was in a class of its own, and gave a wider perspective to the meeting.

The Symposium was concluded by a few remarks from Thiede. He was surprised at the predominance of marine units and the concentration on the younger part of the record as reflected in the papers given. Both these tendencies were perhaps the result of an imbalance during the Symposium towards the northern, rather than the southern, North Sea. It was unfortunate, therefore, that Zagwijn was prevented from attending the meeting through illness,to deliver his invited lecture on the Quaternary stratigraphy of the southern North Sea. This would have gone some way to restoring the balance of the meeting. Thiede recommended caution concerning sampling methods, a more critical awareness of potential sample contamination, and indicated that so far sub-sampling intervals have been too large. He concluded by recommending that somebody should attempt a preliminary synthesis of the Quaternary stratigraphy of the North Sea. Given the problems outlined above, this would indeed be a formidable task!

The Department of Geology at the University of Bergen, especially Hans-Petter Sejrup and Inge Aarseth, should be congratulated for conceiving and organising such a useful, important and enjoyable meeting. Having witnessed the combined expertise, enthusiasm and superb facilities at the Department, Professor Hans Holtedahl has good reason to be proud of the institution he has helped to create. The mix of participants from universities, geological surveys and industry at the meeting was most stimulating. The contact between all three types of institution is of great mutual benefit and it is regrettable that, in Britain, Quaternary studies are all too often seen as being of solely academic interest.

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ABSTRACTS OF RECENT Ph.D. THESES

Postglacial sediments and Foraminifera at Dundalk, Ireland

D.N. Penney

Ph.D. Thesis, University of Dublin (Trinity College), 1983

The palaeogeography of the Postglacial succession at Dundalk is interpreted from the foraminiferal, ostracod and mollusc assemblages collected from cores and sections, and supported by grain size analysis. The sea first entered Dundalk Bay during the Lateglacial, probably before 12,000 BP and deposited silts at Finnabar. The microfossil assemblages found at this site indicate a brackish, turbid, shallow, cold water environment. Comparable faunas have been observed in Lateglacial and early interglacial deposits from North-West Europe and Canada. It is suggested that further evidence for a Lateglacial sea within Dundalk Bay may occur within the limits of Postglacial and modern day coastal processes. The shore platform at Blackrock, Co. Louth, is reinterpreted as being mainly formed during the Lateglacial and the *Roundstonia* horizon in Dublin Bay is also considered to be Lateglacial in age.

The sea again reached Dundalk during the early Postglacial and deposited a complicated sequence of intercalating mud flat, sand flat, channel fill and beach deposits within the confines of a buried valley. Two phases of marine inundation have been identified on the basis of the examination of 5 deep boreholes at Dundalk and the collation of evidence from commercial site investigations. A pre-7,500 BP age is

suggested for the earlier phase, for which there is stratigraphic evidence up to -2.0 m msl. The second phase cut deeply into the subjacent deposits and reached Balmer's Bog at around 7,500 BP (pollen evidence). This enclosed, brackish water depression was isolated again at about 7,000 BP, but marine conditions persisted in other parts of Dundalk up until at least 6,000 BP, when a beach ridge was thrown up on top of peats at Finnabar. The Castletown River may have been diverted northwards to its present course during phase 2, and the Seatown beach ridge prograded to its present position. A third phase, identified in short borings in the eastern part of the Marshes, corresponds to local channel migration within the present tidal range throughout the remainder of the Postglacial period, up until Historic times.

A detailed systematics section reviews the taxonomy and ecology of 130 foraminiferal species found in the Postglacial deposits at Dundalk.

THE GLACIAL GEOMORPHOLOGY OF PART OF THE WESTERN GRAMPIANS OF SCOTLAND WITH ESPECIAL REFERENCE TO THE LIMITS OF THE LOCH LOMOND ADVANCE

P.W. Thorp

Ph.D. Thesis, C.N.A.A. (City of London Polytechnic) 1984

The limits of a large icefield that built up in the western Grampians during the Loch Lomond Stadial were mapped using O.S. maps to scales of 1:10 000 and 1:25 000. The main forms of mapped glacial evidence comprised moraines, thick deposits of drift, fluvioglacial landforms, erratics, boulder spreads, ice-moulded bedforms, striae and friction cracks. Outside the inferred glacial limits the main types of mapped periglacial evidence included frost-riven bedrock, thick fossil screes, smooth debris-strewn slopes, tors, and solifluction lobes, terraces and sheets. 204 trimlines, based on various forms of contrasting glacial and periglacial evidence, were mapped on spurs and valley sides. The trimlines enabled the upper limits and form of the glaciers to be reconstructed, to varying degrees of accuracy, especially in the accumulation areas of the former glaciers. This information was supplemented by the evidence on 73 cols. The reconstructed form of the icefield indicates that it covered an area in excess of 2 000 km^2, that its total volume was ca 460 km^3, and that maximum ice-shed altitudes of ca 700-750m O.D. were attained in the Glen Nevis-Rannoch Moor-Glen Lyon areas. Eight major outlet glaciers flowed radially outwards from an ice-cap centred over Rannoch Moor. The outlet glaciers in the western part of the icefield descended to sea-level and flowed for considerable distances along major tidal water lochs.

Equilibrium firn lines calculated for the icefield and for 17 independent corrie, valley and plateau glaciers indicate that firn lines rose from ca 400m O.D. in the south-west to +900m O.D. in the north-east part of the study area. Trend surface analysis of corrie-floor altitudes, the spatial distribution of amounts of precipitation at the present time, and the equilibrium firn lines of the former Loch Lomond Advance glaciers, indicates a broad correspondence between these factors. Amounts of precipitation during the stadial on the mountains are estimated to have ranged from 3 000-4 000 yr^{-1} in the south-west to less than 1 000mm yr^{-1} in the north-east.

Glacial evidence outside the limits of the Loch Lomond Advance suggest that the pattern of build-up and directions of ice-flow in ice-sheet times were very similar to those that occurred in the stadial. This implies that the climatic parameters that operated during the stadial were broadly similar to those that operated in earlier glacial periods.

REVIEWS

The Geology of Offshore Ireland and West Britain. By D. Naylor and P.M. Shannon 1982. Graham and Trotman, London. 174pp., paperback edition £14.50/US$23.00 including surface mail or £16.50/US$26.00 including airmail. ISBN 0-86010-340-4 (hardback), ISBN 0-86010-247-5 (paperback).

Perhaps a more accurate title for this book would have been "The Petroleum Geology of Offshore Ireland and West Britain", with the main thrust of the book being unashamedly directed towards an examination of the present state of hydrocarbon potential and exploration in the increasingly important basins on the continental shelf to the west of Britain and Ireland. Both the overall structure of the book and the organisation of material within each chapter, demonstrates this fundamental purpose. After an introductory chapter dealing with the historical background to research in the area, the nature of the continental margin, the location of the major sedimentary basins and a brief account of opening of the North Atlantic, there follows twelve chapters, each of which examines specific basins, or groups of basins, in a systematic way. A useful synthetic chapter on palaeogeography follows, and the main part of the text is concluded with an account of the history of oil and gas exploration in the U.K., Ireland and France. There are two appendices, the first concerning basic geological concepts and exploration/production techniques, the other containing a glossary. If any further evidence is needed to convince the reader of the aims of the book, one has only to turn to this glossary; the 'c' entries include 'cap rock', 'casing', 'chalk', 'christmas tree', 'commercial field', 'condensate', 'conglomerate', 'continental shelf', 'core' and 'crude oil'.

Given that the book is geared towards providing a general review of petroleum geology in the area, then, the lack of information on the Quaternary sequences and sediments is lamentable. Surely an overview of exploration and potential should include information on sea bed conditions, topography and the strength characteristics of sediments? As the search for oil and gas in the more hostile environments towards the shelf edge in the west is promoted by the rising costs of energy, so site assessment and hazard evaluation will become critical. Quaternary scientists have much to offer in this area, and the contact will be mutual, for the solution of many of our problems is likely to be advanced by detailed studies of the offshore shelf sediments. This is especially true in the attempts to correlate the terrestrial with the marine record.

Instead, the Quaternary seems to be regarded as either irrelevant or a nuisance. There is no consideration of the Quaternary in the chapters on the Channel Basin, Goban Spur, Northwest Irish Offshore and Eastern Canada, and only very brief mention in the chapters on the Rockall Plateau and Trough and the Western Approaches Basin. In Chapter 11 (p.111) the authors state that 'there is a thick Quaternary cover over much of the Inner Hebrides Basin which has hampered shallow seismic and sampling investigations'. It is precisely this sort of problem that should be tackled head-on and discussed as part and parcel of the process of exploration and production, rather than perceived as an annoying irrelevance. Within petroleum geology, then, the book is mainly concerned with the evaluation of source, reservoir and cap rocks and trapping structures, rather than engineering problems.

There are a number of specific instances of inattention to Quaternary detail. In the stratigraphic classification table (Table 1.1, p.6), the Pleistocene is subdivided into the 'Calabrian' and 'Sicilian' Stages, with the base of the Calabrian being given as 1.8 My B.P. 'Recent' is used in place of Quaternary in Table 12.1 (p.119), and on the next page in Table 12.2 'Glacial Drift' is used in the same hierarchical context as Lias, Rhaetic and Keuper.

In what way, then, is this book useful to the Quaternary scientist interested in the western continental shelf? It provides a broad background to basin formation and sedimentary history essential to an understanding of the patterns of Quaternary sedimentation. The offshore Quaternary sediments must be seen in the context of the long-term processes related to basin formation and the opening of the North Atlantic as well as to smaller magnitude/higher frequency events. Quaternary sequences are often explained in terms of short to medium-term fluctuations which demand little recourse to large, slowly-operating processes, especially gradual tectonic evolution. This book is able to provide this essential perspective.

Despite the reservations outlined above, to the 'undergraduate geology student' and 'the professional geologist seeking background material', the authors' declared market, this book will prove to be an invaluable source of information. The style is very clear and straightforward, easily understandable by the non-specialist, and the 70 maps, figures and diagrams useful. It is a shame, then, that a few spelling mistakes should mar this otherwise excellent presentation; these include 'Cherburg' for 'Cherbourg' on p.11, 'Contentin' for 'Cotentin' on p.12 and again on p.14, 'Witch Farm' for 'Wytch Farm' on Figure 2.3, 'Marlaix' for 'Morlaix' on p.26 and 'concels' for 'conceals' on p.123. Given the large size of some of the diagrams, they could perhaps have included more information. Figure A1.1, which illustrates the various geological controls for hydrocarbon entrapment, could be more helpful; for instance, the 'fold trap' is apparently indistinguishable from the 'stratigraphic trap', and the 'fault trap' described in the text is not illustrated. The term 'drill string' is introduced on p.155 and readers are referred to Figure A1.2 for diagrammatic explanation, but the 'drill string' does not appear on the diagram. In addition, I would have found an index useful.

In places factual information gives way to speculation; on p.31 the authors state that 'the Lizzen-1 well 110 km northwest of Brest drilled in 1975 to more than 4,000 m is rumoured (sic) to have lacked good reservoirs...'. This lack of fact is, however, more than made up for in terms of 'Dallas'-style entertainment value.

The book may be obtained directly from Graham and Trotman Ltd., Sterling House, 66 Wilton Road, London, SW1V 1DE (Tel: 01-821 1123).

This book will not be directly relevant to many British Quaternary workers; to those interested in the offshore sequences in the west of Britain it provides a very useful synthesis of background information, and at £14.50 it represents good value for money.

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Glacial-Marine Sedimentation. Edited by B.F. Molnia, 1983. Plenum Press, New York. 844 pp. Price £61.75 (hard cover). ISBN 0 306 41497.

Glacial-marine sediments have in the past received much less attention than terrestrial glacigenic deposits, despite their relatively wide occurrence in the late Cenozoic stratigraphic record. The publication of this book emphasises the recent upsurge of interest in such sediments, and provides us with 18 papers which either synthesise or present new evidence on this important but hitherto neglected aspect of glacial sedimentation. The editor's stated aims are (1) to point out the differences which exist between glacial-marine environments in different geographic settings and (2) to characterise their glacial-marine deposits and facies. Use of the term 'glacial-marine', as opposed to glaciomarine or glacimarine, will undoubtedly not be to everyone's taste, and Molnia does not define at the outset which sediments are included within the term. A catholic definition is, however, implied by the range of topics discussed, including rafting by sea ice.

The volume opens with a review of the spatial and temporal distribution of ancient glacial-marine deposits, in which Anderson also summarises the different criteria which may be used to distinguish glacial-marine deposits from other glacial and non-glacial sediments. While one may not agree with all Anderson's ideas, his thorough review illustrates the wide range of criteria that can be applied to this problem and is an important contribution.

The bulk of the book contains studies of Quaternary glacial-marine sediments from Alaska, Antarctica, the Arctic Ocean, Kane Basin and Baffin Island, the Puget Lowlands and the north Atlantic Ocean. These varied locations presumably relate to Molnia's aim of characterising the variety of glacial-marine environments found. In general, the content of the papers fulfills this purpose, but it is a pity that none of the important studies by Elverhøi and co-workers from the fjords of Spitsbergen and the Barents Sea are included. A major point to emerge from these regional studies is the distinction between Antarctic glacial-marine sedimentation and that found at lower latitudes, for example the Gulf of Alaska. The Antarctic model (Anderson and others) is characterised by the presence of ice-rafted debris in a muddy matrix, and meltwater is unimportant as a sediment transport agent. Mass flow processes are also relatively widespread on the Antarctic shelf due to relatively high relief resulting from repeated episodes of glacial erosion. In contrast, Molnia proposes a 'sub-arctic' model of glacial-marine sedimentation where meltwater inputs are of major importance and a number of diverse facies are found. These include proximal well-sorted nearshore deposits and chaotic ice-contact sediments, through medial silty clay or clayey silt rock flour derived from meltwater, to a distal, poorly-sorted ice-rafted facies. Submarine landslides are described from the Alaskan shelf, but because of the generally low gradients such activity is more restricted than on the Antarctic shelf.

Three papers discuss sedimentation in the Arctic Basin, that of Clark and Hanson being of particular interest in its examination of sediment transport by sea ice. Each paper stresses the very low sedimentation rates in this basin. Core chronology is based largely on palaeomagnetic information, with the oldest sediment recovered dating back some 3.54 million years. A more recent study based on amino acid epimerization suggests, however, that cores from this area span no more than 200,000 years, implying that sedimentation rates are underestimated in the above studies and that sea ice may be a more important agent of sediment transport in this area than was previously thought (Sejrup and others, 1984).

Glacial-marine sedimentation at the scale of fjords is discussed by Powell, who deals with sedimentation from Alaskan Tidewater glaciers. This contribution is an important summary of Powell's research, containing a useful discussion of the factors (ice calving and retreat rates, position of transport of glacial debris, meltwater streams and oceanographic processes) controlling sedimentation from tidewater glaciers and a detailed description of the facies that result. The poor design of a number of diagrams in this paper is, however, unfortunate. Osterman and Andrews' model of glacial-marine facies changes over the last 11,000 years in Frobisher Bay, Baffin Island, is also of interest through its attempt to link evidence from the analysis of a marine core with the relatively thoroughly studied terrestrial record of glacier fluctuations around the bay. However, one hesitates to concur with their suggestion that glacial-marine sedimentation in shallow fjords approximates that described for the glaciolacustrine environment, because of the significantly different density structure and tidally-influenced circulation in the glacial-marine environment. Papers by Mode and others and Domack provide models which summarise clearly the facies associations resulting from cycles of glacier advance and retreat linked with sea level change in two coastal situations.

The volume concludes with three papers on ancient glacigenic sediments. Stratigraphy and facies associations are documented efficiently in each study, and a number of criteria are used to infer a glacial-marine origin. Despite the statement in the editor's preface to the volume, which implies that many studies of such ancient sediments have relied mainly on dropstones as <u>the</u> criterion indicative of a glacial origin, these papers are not the first examples of such a multi-parameter approach. Indeed, while the study of modern glacial-marine sediments is an important key to the interpretation of ancient deposits, the excellent exposures (as opposed to cores for modern sediments) of fjord sedimentary facies discussed and illustrated by Armentrout indicate that the study of ancient sequences can also aid the understanding of contemporary facies associations. A note of caution must, however, be sounded as a result of Visser's attempt to model the Permo-Carboniferous Southern African Ice Sheet from reconstructed subglacial topography and glacial facies information. The proposed models are considerably more sophisticated than the field evidence warrants. His reconstruction of a 'marine ice sheet' during the Early Permian (p. 696) is very similar to that of Denton and Hughes for the Laurentide Ice Sheet in the late Wisconsin. The Denton and Hughes model is itself highly controversial (Andrews, 1982), and if we cannot reach a consensus view on the morphology and dynamics of the Laurentide Ice Sheet 18,000 years ago it is difficult to see how we can hope, at present, to produce a model of similar sophistication for the Permo-Carboniferous.

The presentation of the book is in general good. Figures are for the most part clear, and the typeface is bold and easy to read. The exhaustive author, subject and geographical indices make it easy to dip into the volume and enhance its utility considerably. These features are a credit to the editor. One criticism is that a few papers are rather long, presenting large quantities of data but relatively little interpretation. This failing should not, however, detract from what is a useful and timely book, which will form a basic reference for the study of both unlithified and lithified glacial-marine sediments.

References

Andrews, J.T. 1982. Review of 'The Last Great Ice Sheets' edited by G.H. Denton and T.J. Hughes. *Quaternary Science Reviews*, 1, ii-v.

Sejrup, H.P., Miller, G.H., Brigham-Grette, J., Løvlie, R. and Hopkins, D. 1984. Amino acid epimerization implies rapid sedimentation rates in Arctic Ocean cores. *Nature*, 310, 772-775.

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Late-Quaternary Environments of the United States and the USSR. Volume 1. The Late Pleistocene of the United States. By S.C. Porter (ed.) 1984. Longmans, London. 407 pp., numerous illustrations price £45.00 (hard cover) ISBN 0582 301238.

This is the first of three important volumes on the Late-Quaternary of the USA and USSR, and covers the period 25,000 to 10,000 years ago in the USA. The last similar and comprehensive review of this kind was published on the occasion of the INQUA meeting in the USA nearly twenty years ago. It contains a series of authoritative reviews by specialists in five general areas: glaciation, nonglacial environments, coastal and marine environments, Pleistocene biota and climatology.

The first chapter (Mickelson et al.) covers the period 25,000 to 10,000 years ago, the time of the maximum extension of the ice in the later part of the last cold stage in North America, the Wisconsin, and the wasting of the Laurentide ice sheet. The descriptions and discussion centre on the regions south of Canada, as do the detailed and useful map reconstructions of the ice lobes, flow lines, ice margins and landforms associated with the ice sheet. The variation of the time of maximum extension of the ice is instructive for students of the margin of the Weichselian ice sheet(s) in northern Europe. In the section on glaciation there are also reviews of the Cordilleran ice sheet in Alaska (Hamilton & Thorson) and the northern Rockies (Wait & Thorson) and of mountain glaciation in the western United States (Porter et al.).

In the section on nonglacial environments there are accounts of fluvial systems (Baker), loess (Ruhe), soils (Follmer; Shroba & Birkeland), periglacial conditions (Péwé) and pluvial lakes (Smith & Street-Perrott). The review of loess includes valuable descriptions of the fossil flora and molluscs associated with loess deposition. The soil review includes a section on the classical Sangamon soils as well as dealing with soils of the Wisconsin cold stage. The chapter on periglacial matters is a very useful review of the evidence for and interpretation of periglacial structures, with a map of features thought to be indicative of past permafrost and of those not necessarily indicative of permafrost. In the section on coastal and marine environments there are contributions on sea level and coastal morphology (Bloom) and on the oceans around North America at the time of the last glacial maximum (Imtbrie et al.). The former includes discussion of sea level changes in the period 28,000 to 23,000 and of the time of minimum levels associated with the Late Wisconsin glacial maximum and the following rise, 23,000 to 10,000. There is also a discussion of the problem of high Middle Wisconsin sea level. The chapter on the surrounding oceans draws together the marine and continental sides of environmental history.

The chapters on Pleistocene biota include accounts of vegetational history in the major regions of the United States (Heusser; Spaulding et al.; Watts), vertebrate history (Lundelius et al.), beetle history (Morgan et al.) and the history of man (West). There are pollen diagrams from the major vegetation regions, an account of the major Late Pleistocene vertebrate faunas in the United States, and a consideration of the fewer sites with beetle remains which have been studied. In relation to the vexed question of the time of entry of early man in the Americas, it is concluded that all unequivocal evidence places this time at 13,000 to 12,000 years B.P. The last section, on climatology, deals with stable isotope evidence (Friedman) and Late-Pleistocene climatology (Barry), the latter with regional accounts of climatic history.

The volume as a whole provides a most useful and well-illustrated account of the important and extensive developments in Quaternary research which have taken place in the United States in the last twenty years, both in developments of techniques and discoveries of fact. Although the contributions are separate there is much synthesis in the volume as a whole. The result is a book which is indispensable to students of the Quaternary, whatever their field of specialised interest.

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Reconstructing Quaternary Environments. By J.J. Lowe and M.J.C. Walker 1984. Longman, London xviii + 389 pp., numerous figures and tables. Price £12.95 (soft cover only). ISBN 0-582-30070-3.

This attractive book "is designed for undergraduate and first-year postgraduate students who may have been introduced to certain aspects of Quaternary studies, but whose training has not focussed specifically on palaeoenvironmental reconstruction." The authors comment that relatively few texts have so far been concerned specifically with landscapes of the Quaternary, and with the way in which different forms of evidence can be integrated to provide an insight into both spatial and temporal changes in Quaternary environments. The book thus contains "a description and assessment of the principal methods and approaches that can be employed in reconstruction of Quaternary environments." The wide-ranging text reflects the multi-faceted nature of Quaternary research so that "although written by geographers, therefore, it is anticipated that students of archaeology, anthropology, botany, geology and zoology will find ... material that is of use to them."

The book has seven chapters. Following an introduction, the three main classes of evidence used in Quaternary palaeoenvironmental reconstruction are considered in separate chapters on the (geo) morphological evidence, lithological (i.e. stratigraphical and sedimentological) evidence and biological (i.e. palaeontological) evidence. These are followed by chapters considering dating methods and the main approaches used in Quaternary stratigraphy and correlation. Finally, in order to demonstrate application of techniques and methods the "Environmental changes in Britain during the last (Devensian) cold stage" are reconstructed. The book is rounded off by a good bibliography of 26 pages and a satisfactory index.

The range of subject matter covered is impressive and should provide enough of a background for the student to pursue the remainder elsewhere. In addition, the book is in general clearly written so that most sections are easy to read. These considerations, combined with the inherent interest of the subjects covered make this a good student text. The price of £12.95 also appears appropriate for a textbook of this size.

The book is illustrated by a large number of line drawings which (almost without exception) are clear and drawn to high standards. The numerous half-tone photographs, however, are of more variable quality. The worst of them are a waste of space (e.g. Fig. 3.14), although others are adequate. In a book aimed at a student market it is unfortunate that various photographs of geological sections lack clear scales.

Any general introduction to the reconstruction of Quaternary environments needs to consider material from a range of disciplines so wide that some parts will be beyond the research experience of individual authors or in this case pairs of authors (and of course of individual reviewers). Consequently, there is a risk that treatment of some topics may be less rigorous than that of areas familiar to authors. Nonetheless, this risk must be taken if any wide-ranging palaeoenvironmental synthesis is to be offered. Overall, the present book appears to be successful in combining a broad approach to reconstruction of Quaternary environments with generally high standards of scholarship. This shows the advantages of the authors' backgrounds in physical geography as well as their good sense in receiving comments on draft chapters of the book from a range of specialists.

There are however, a series of minor imperfections that may annoy specialist readers while not detracting much from the value of the book for students. Often these are matters of emphasis or judgement rather than clear matters of fact. For example, the value of non-marine molluscs in palaeoenvironmental reconstruction appears hedged with reservations and an air almost of condescension. It is suggested (p. 187) they "are manifestly unsuited" as palaeoclimatic indicators or as a means of dating geological events, but much recent literature (not least the parts selected for Table 4.6 and Fig. 6.10 of the present book) has them serving these purposes very well. In contrast, we are told that Coleoptera "combine both evolutionary and physiological stability with a sensitivity to climatic change that is seldom found in the plant or animal kingdoms". These and other differences of emphasis when making wide generalisations may, of course, have less to do with fundamental differences between groups of organisms than to the contrast between the cautious reticence of workers leading some fields compared to bold advocacy in others.

The coverage of many topics is confined to a few pages so that it is necessarily selective. In general the flavour of recent work is well demonstrated and the references provide a good starting point with the literature. In a few places however, the selection of examples does not do justice to recent work, as where pollen concentration and pollen influx studies are illustrated only by a concentration diagram with no radiocarbon dates (Fig. 4.4). Likewise, the treatment of plant macrofossils does not do justice to recent work. The examples used here are mainly from lacustrine and mire sediments and the much richer assemblages often obtained from fluvial sediments are not discussed. (There is indeed no section devoted to fluvial sediments in the chapter on lithological evidence, although more than 8 pages are given to discussion of river terrace landforms in the preceding chapter).

It is an unfortunate consequence of the plan of the book that the treatment of some related topics is to be found in several separate chapters. The ocean core evidence, for example, is treated separately under lithological and biological headings. But there is no ideal arrangement for such diverse subject matter and parts of some subjects are bound to be separated if repetition is to be avoided.

A few sections betray unfamiliarity with parts of the subject matter, as where ice wedges are stated to form "where thermal contraction of the active layer in winter opens vertical cracks" (p.104), when of course it is deeper cracking that is important because ice wedges do not form in the active layer. Another error occurs in the section on aminostratigraphy, where it is stated that only L-isomers of amino-acids occur in living proteins (D-isomers are known in bacteria and other organisms). Overall however, real errors are few and matters of emphasis and balance will be of more concern to a critical reader.

A large proportion of the examples chosen (and most of Chapter 7) are from the British Isles. Of the others, a substantial proportion are from North America with fewer from continental Europe. The Quaternary landforms of tropical and subtropical regions (especially lake levels and dune fields) are discussed at some length, but any other than oceanic biostratigraphy in the tropics and Southern Hemisphere is hardly considered.

The final chapter considering "Environmental changes in Britain during the last (Devensian) cold stage" demonstrates how a variety of techniques can be used to produce a synthesis of environmental change over a particular segment of Quaternary time. The authors admit that such a reconstruction contains a strong element of subjectivity, but the result is nonetheless stimulating. In particular, it shows how the combined discussion of oceanic and terrestrial evidence can allow a deeper understanding than was formerly possible.

As a whole this book is a welcome addition to the Quaternary literature. It should serve well as a student textbook and attract new recruits to Quaternary studies, while offering much that is of interest to experienced workers.

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Environmental Archaeology - a regional review. H.C.M. Keeley (ed.) 1984. Directorate of Ancient Monuments and Historic Buildings, Occasional Paper No.6. Department of the Environment, London. 181 pp., 20 figs., 15 tables 2 plates. Price £7.50 plus £2.50 postage and packing. ISSN 0141 6596.

This review details work done by DOE-funded environmental archaeology contracts in East Anglia (at UEA), in the south-west of England (at the University of Bristol), in northern England (at Durham) and in relation to the excavations of the urban centre of York (at York). The report is the first of a series in which the work of environmental archaeologists nationally will be presented to summarise work completed, to point out areas where further work is needed, and generally to enhance the use made of environmental archaeological work.

The first chapter on East Anglia by Peter Murphy gives a general introduction then reviews recent work and particular sites in the area, ranging from the coast at Caister-on-Sea and Great Yarmouth, to the Fen-edge in west Norfolk, and on to the plateaux of till and glacial deposits which form the core of the area. Although the concentration on individual sites is often on remains of crop plants due to their close association with human activity, a large number of other environmental lines of evidence have been followed including marine and non-marine Mollusca, bones of mammals and fish, insects and Foraminifera and at a few sites, pollen. The chapter concludes with a table of sites in the area on which environmental information is available and a bibliography of published work.

Chapter two (by Martin Bell, with contributions by Astrid Caseldine, Chris Caseldine, Keith Crabtree, David Maguire and Edward Maltby) follows the same general pattern as chapter one but tabulates the sites investigated (190 in total!) and sets out clearly the various techniques employed. Given the nature of the area with Dartmoor and the Somerset Levels prominent, pollen analysis has been widely used, but other lines of investigation are also important including again Mollusca and animal bones. The authors of this chapter rightly stress the importance of radiocarbon dates to their region and many dates are quoted in this section. As with Chapter one a very considerable bibliography to the archaeological context of south-west England and also to recent environmental work is provided.

Chapter three (by Alison Donaldson and James Rackham) is shorter than the earlier ones partly perhaps due to the amount of work still in progress. This chapter also provides a list of sites worked on (the many of which have yield pollen, but some also animal bone - especially urban sites - and others crop plant remains, Mollusca and occasional insects. The chapter concludes with a general bibliography and a list of Ancient Monument Laboratory reports on sites in the north of England.

Chapter four (by H.K. Kenward, A.R. Hall, A.K.G. Jones and T.P. O'Connor) covers the urban archaeology of York and is slightly different in character to the other chapters reflecting perhaps the different problems of urban sites and also possibly the popular attention the work at York has attracted. As with the other chapters this also contains a bibliography which, as well as containing a list of the work on York, confusingly also contains reference to other papers published by the York units' members on topics not associated with the city, such as Halls' work in east Anglia and Kenward's geographically wide ranging papers on insects.

As a whole this volume is a useful addition to the literature for Quaternary scientists, widely disseminating details of work of relevance in the areas under study which might otherwise be lost in the great tide of papers and reports which engulfs all of us. The other aspect which comes across strongly is the amount of work waiting to be done. Strategies suggested by the York unit suggest that "If all the worthwhile backlog material is to be examined, it is estimated that more than fifty man-years of (Research) Fellow's time and a similar amount of technician's time will be required". It is to be hoped that the publication of this report and the later ones in the series, highlight the detail of such environmental,work and show the vital part it has to play in environmental as well as archaeological investigation, and thus ensure that funds continue to be available for this work to be done.

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NOTICES

Xth INQUA Congress Fund

Income from the Xth INQUA Congress Fund for 1985 and 1986 is to be applied to assist potential UK participants in the XII INQUA Congress to be held in Ottawa, Canada, from 9 to 18 August 1987. Details of eligibility and procedure will be advised in later issues of the *Newsletter*. Enquiries may be made to the Royal Society, 6 Carlton House Terrace, London SW1Y 5AG (attn: C.R. Argent).

MSc in Quaternary Studies

This two-year, part-time evening course in Quaternary Studies, leading to a Master's degree awarded by the C.N.A.A. is taught jointly by the staff of the Geography and Geology departments of the City of London Polytechnic and the Polytechnic of North London. The colleges were due to enrol a fifth cohort for the course in October, 1984 (see *Quat. Newsletter*, No. 43), but due to a temporary staffing problem, enrolment had to be postponed for one year. It has been confirmed that the course will go ahead as usual in October, 1985. However, since the majority of places accepted by successful applicants in 1984 have been re-confirmed for 1985, only four new places can be offered for the next intake. Anyone who is interested in enrolling for this course should, therefore, apply as soon as possible. Application forms and further details of the course are available from:-

Dr. P. Allen
(Course Tutor: MSc Quaternary Studies)
Geography
City of London Polytechnic
Calcutta House
Old Castle Street
LONDON E1 7NT.

Official closing date for applications is 31st July.

The minimum entrance requirement is normally a Class II Honours degree in an appropriate subject (Geography, Geology, Biology, Archaeology, for example). Fees for the course will be approximately £80 per annum.

The course considers a wide spectrum of the field of Quaternary Studies, and offers practical instruction in a number of techniques, including field survey methods, sedimentary analyses, macrofossil identifications and various aspects of micropalaeontology. Several residential field courses, including a foreign field excursion, are essential elements of the course, and students undertake a detailed field and/or laboratory study which is examined by thesis as part of the formal assessment. The course was granted extended approval by the C.N.A.A. in 1984.

Sea-Level Changes on the West-Norwegian Coast. Excursion and Symposium in Norway 16 June-23 June 1985.

This joint meeting is being organised to demonstrate field-sites for the study of sea-level changes in Norway as well as to present and discuss results of IGCP-Project 200.

Provisional programme.

Sunday	16 June:	Arrival in Bergen.
Monday	17 June:	Excursion Bergen - Sotra - Austrheim.
Tuesday	18 June:	Excursion Austrheim - Masfjorden - Bergen. Late Weichselian and Flandrian shorelevel displacement curves based on sediments from lakebasins with rock thresholds - Radiocarbon-dating problems in lake sediments - Relation of Late Weichselian icefront oscillations to sea-level changes - Stone age dwelling places and their relation to sea-level - Eem deposits at Fjøsanger.
Wednesday	19 June:	Symposium in Bergen.
Thursday	20 June:	Departure by flight to Alesund. Excursion Vigra - Valderoy - Godoy.
Friday	21 June:	Excursion Alesund area. Marine formed caves - Middle Weichselian sedimentation and sea levels - Gravel shore lines - Tapes transgression beach ridge - Relative sea-level curve - Younger Dryas volcanic ash layers.
Saturday	22 June:	Departure by flight to Vernes (Trondheim). Excursion to Fosna.
Sunday	23 June:	Excursion Gauldal - Trondheim. High marine limits - Clay sedimentation - Quick clay landslides. Relation of glacial icefront-deposits to sea-level changes - Morphological shorelines.

The excursion.

The excursion will present methods and results of Late Weichselian and Flandrian sea-level investigations on the west coast of Norway between Bergen and Trondheim. Late Weichselian glacial oscillations and their relation to sea-level changes will be demonstrated and discussed. In some cases it is possible to demonstrate localities with prehistoric settlements in relation to shore level. In addition, the excursion will visit localities of great geological interest, such as the Pre-Weichselian sediments at Fjøsanger (Bergen) and Sjonghelleren (Alesund).

Because of the great distances in Norway the excursion will go by airplane from Bergen to Alesund and Alesund to Trondheim. The excursion in the Bergen, Alesund and Trondheim districts will be by bus and ferries. Accommodation will be in hotels.

Main organisers for the excursion are Professor Ulf Hafsten, Professor Peter Emil Kaland and Professor Jan Mangerud.

Papers.

A volume of abstracts of papers at the symposium will be published. Abstracts of papers will be required not later than 20 March 1985. In addition we will prepare a guidebook for the excursion.

Costs.

A registration fee of N.kr. 800, paid in advance will be required, but not before 20 March 1985. The excursion is sponsored by the Norwegian Council for Science and Humanities (NAVF). It is our hope that the total excursion costs will not exceed N.Kr. 3.500. Details will follow in the second circular.

Organisation.

Organiser of the excursion is:

Professor Peter Emil Kaland
Botanical Institute
P.O. Box 12
N-5014 BERGEN-UNIVERSITETET
Norway
Telephone: 47 5 213050

NB! Our excursion is immediately followed by "THE 12TH INTERNATIONAL RADIOCARBON CONFERENCE" in Trondheim, June 24 to 28, 1985. Information about the conference can be obtained from:

The 12th International Radiocarbon Conference
Att: Pat Ueland
Studies and Academic Administration
The Norwegian Institute of Technology
N-7034 Trondheim-NTH
Norway
Telephone: 47 7 59 52 46

Swanscombe NNR : 50th Anniversary Celebrations

To celebrate the 50th anniversary of A.T. Marston's discovery of the first piece of the Swanscombe skull, it is intended to hold an open weekend at Swanscombe on the 29th-30th June 1985. The sections dug for the visit of the INQUA trip in 1977 will be re-opened and there will be extensive displays of archaeological and geological material both from Swanscombe and related sites. A Nature Conservancy Council booklet is being produced on the archaeology and geology of Swanscombe and this will be available for the open weekend.

CALENDAR OF MEETINGS

12th-16th April 1985	Quaternary Research Association Annual Field meeting in the Isle of Man organised by R. Dackombe and G.S.P. Thomas. Further details may be found in the Circular accompanying this *Newsletter*.
4th-5th May 1985	Quaternary Research Association short field meeting in the Peak District and Hallamshire organised by D. Briggs, D.D. Gilbertson and R.D.S. Jenkinson. Further details and a booking form may be found in the Circular accompanying this *Newsletter*.
7th-10th May 1985	Quaternary Research Association/Birkbeck College short course on soil micromorphology and its applications to the Quaternary. Further details and a booking form may be found in the Circular accompanying this *Newsletter*.
16th-23rd June 1985	IGCP-200 Field meeting and Symposium - Sea level changes on the west Norwegian coast. Further details may be found on p.56 of this *Newsletter*.
19th-21st June 1985	Colloquium of AFEQ on Climatic Oscillations between 125,000 BP and the glacial maximum to be held at the University of Rennes. For further details see p.66 of *Newsletter 44*.
29th-30th June 1985	50th anniversary open-weekend at Swanscombe NNR. For further details see p.58 of this *Newsletter*.
21st-23rd August 1985	7th York Quaternary Symposium, University of Lethbridge, Alberta, Canada. For further details see p.63 of *Newsletter 44*.
15th-21st September 1985	First International Geomorphology Conference, Manchester. For further details and a Circular write to Professor I. Douglas, School of Geography, University of Manchester, Manchester, M13 9PL.
19th-21st September 1985	Joint meeting of the Geological Societies of the British Isles, with a QRA contribution on Quaternary Palaeontology. To be held in Birmingham. Further details may be found in the Circular with this *Newsletter*.
21st-23rd September 1985	Joint QRA - IGU Periglacial Commission meeting on Periglacial processes and landforms in the British Isles. To be held in Manchester. Further details may be found in the Circular with this *Newsletter*.

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Contents

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