QUATERNARY NEWSLETTER

No. 33 February 1981

Quaternary Newsletters are issued in February, June and November. Closing dates for submission of copy for the relevant numbers are 1st January, 1st May and 1st October. Contributions, comprising articles, reviews, notices of forthcoming meetings, news of personal and joint research projects, etc. are invited. They should be sent to the Secretary of the Quaternary Research Association, Mr. J. Rose, Geography Department, Birkbeck College, London University, 7-15 Gresse Street, London W1P 1PA.

PROGRESS REPORT ON EXCAVATIONS IN MINCHIN HOLE, GOWER

By A.J. Sutcliffe

Although one further field season (provisionally late September-early October, 1981) is still necessary for the completion of the present phase of excavation in Minchin Hole, after which it should be possible to proceed to detailed publication, some urgency already attends the publication of a general account of the stratigraphy of this site, to which reference can be made now by others working in related fields of Quaternary studies. Among other projects for which such information is relevant are the results of excavations at nearby Bacon Hole carried out by Dr. C.B. Stringer and Mr. A.P. Currant, and the studies of amino acid ratios in the Bristol Channel area by Dr. D.Q. Bowen and his colleagues. It is for the use of those working on such problems that this interim report and discussion have been prepared. All the above mentioned are also intimately involved in the excavation of Minchin Hole and their collaboration is here gratefully acknowledged; also that of the National Trust, on whose property the cave is situated and who have kindly granted permission for the excavation to be undertaken.

In this note special emphasis is given to the raised beach deposits in the cave and their potential significance in Upper Pleistocene sea level studies; with only brief mention of the fossil mammalian fauna at this stage. A fuller account, jointly with Mr. A.P. Currant, will appear in the final publication.

Introduction and history of earlier excavations

The importance of Minchin Hole in Quaternary studies has long been recognised. Dean Buckland visited the cave in July 1831, with L. W. Dillwyn, although there is no record of any excavation at that time. The first major investigation of the cave was undertaken in the 1850's by Lieut-Colonel E.R. Wood, as part of a series of excavations in diverse caves along the Gower coastline. Wood established a partnership with Hugh Falconer, who examined the mammalian remains which he found, two brief accounts of which appeared shortly afterwards - Falconer 1860 and, posthumously, in Murchison, 1868. Falconer made some important observations. He noted that, in both Minchin Hole and the nearby Bacon Hole, marine sands containing common existing shells lay at the bottom of the ossiferous deposits with remains of narrow-nosed rhinoceros, Dicerorhinus hemitoechus, and straight tusked elephant, Palaeoloxodon antiquus, suggesting a relatively date for a mammalian fauna at that time thought to be not far removed from Pliocene in age. He further noted that there were apparently two distinct faunal assemblages in the Gower caves: one (which we now know to be of interglacial age) with the mammalian species mentioned above; the other (which we now know to belong to the Last Glaciation) with woolly mammoth, Mammuthus primigenius and woolly rhinoceros, Coelodonta antiquitatis.

Although Hippopotamus was not recorded from the interglacial deposits of either of the above caves, Falconer did list it as part of a similar hemitoechus-antiquus fauna in nearby Ravenscliff Cave. He also discussed the glacial deposits and breccias of the area, concluding that the Gower caves had probably been filled with their mammalian remains after the deposition of the local Boulder Clay.

The next important excavation in Minchin Hole was conducted by Professor N. T. George in 1931. George (1932) described, at the mouth of the cave, in ascending order, the following sequence of deposits:

1. "Patella Beach", (a beach deposit) resting on the limestone floor of the cave.
2. Cave-breccia with narrow-nosed rhinoceros, lion and other mammals (a terrestrial deposit).
3. The "Neritoides Beach" (regarded by George as another beach).
4. Wind blown reddish-yellow sand.

He concluded that there had been a time interval of not inconsiderable dimensions between the "Patella" and "Neritoides" beaches and observed that the mammalian fauna of the breccia lying between them marked the occurrence of a genial episode. He further concluded that the local drift was younger than the "Neritoides Beach".

George's two supposed beaches have been widely quoted by subsequent writers, sometimes as evidence of two distinct climatic events. Bowen (1966) suggested that the "Patella Beach" might be of Hoxnian age, the "Neritoides Beach" (which he suggested was apparently wind blown and not a beach) Eemian. Following more extensive field studies along the entire Gower coastline he revised this view (1970) and assigned all three basal units of Minchin Hole ("Patella Beach", "Breccia" and "Neritoides Beach") to the Last Ipswichian/ Eemian Interglacial; a series of breccias forming the highest strata in the cave then being of Last Glaciation age.

Meanwhile, from 1946-1959 a further extensive excavation had been conducted in Minchin Hole by Mr. J.G. Rutter (co-author of Gower Caves, Allen and Rutter, 1948) and E.J. Mason, on behalf of the Royal Institution of S. Wales, the results of which have not yet been published in any detail. This excavation was concentrated in the area behind that investigated by George, i.e. further inside the cave. It exposed for the first time another, earlier, raised beach deposit (subsequently to be called the "Inner Beach") which had not been encountered by George at the cave mouth, where the "Patella Beach" rests directly on the limestone floor of the cave.

The present phase of excavations, coordinated by the Palaeontology Department of the British Museum (Natural History) in conjunction with members of the Geography Department of Aberystwyth University was begun in 1972 - the first time that Bowen had seen the Inner Beach which, since it had been covered up when the 1946-59 trenches had been refilled, is not mentioned in his earlier writings. A first report, in which the "Inner" and "Patella" beaches are distinguished from one another, appeared the following year (Sutcliffe and Bowen 1973). Rutter, who (while Curator of Scarborough Museum) had been away from Gower for some years, returned to live at Oxwich, only a short distance from Minchin Hole, on his retirement in 1975; and has since been involved with all further work at the site.

The present interpretation of the stratigraphy of the Pleistocene deposits in Minchin Hole

Since the sediments in Minchin Hole have been introduced by a variety of processes, from different directions, the sequence of deposits there is far from simple. There are three main groups of deposits - the fossil beaches at the bottom; an inner talus, which appears to be derived from the back of the cave; and the various parts of an outer talus cone, most of which had apparently spilled down the cliff slope above the entrance into the front part of the cave and gully outside (though part of it may be wind blown). There is some evidence of occupation by hyaenas and by birds of prey. The upper parts of the two talus cones interfinger.

As the result of the very extensive sectioning which has been carried out in the cave (generated initially by studies of the mammal bearing deposits) it has now been possible to construct a three dimensional picture of the relationship of the fossil beaches and terrestrial deposits. This sort of picture is unusual in raised beach studies where more commonly the observer must base his studies on only a two dimensional section along the back of the present dry shore, showing a rock platform of uncertain age overlain by an unknown part of a fossil beach, which in turn is overlain by non-marine deposits.

Figure 1 is a schematic section of the deposits in Minchin Hole, based on excavations up to 1980. The sequence of events, in order of decreasing age, was apparently as follows:

1. Deposition of the "Inner Beach" on the wave-smoothed floor of the cave. This deposit consists of a sand, with marine shells, laid down when the sea was relatively higher than at the present day. Its eroded surface is at about 11.6 metres O.D. and it probably had a head of water above it at high tide. The significance of this will be discussed later.

2. "Lower Red Cave Earth", resting disconformably on the "Inner Beach". A thick deposit of angular fragments of limestone of varied sizes set at all angles in a red clayey matrix with remains of a large form of northern vole, *Microtus oeconomus* (det. Dr. A. Stuart and Mr. A.P. Currant). No stratification is evident and the deposit is reminiscent of some "Head" deposits above ground. A relative fall of sea level is inferred (since otherwise this terrestrial deposit would have been washed away).

3. George's "Patella Beach". Following the deposition of the "Lower Red Cave Earth" the sea rose once more, cutting a cliff in the above mentioned deposits. The "Patella Beach" was laid down at the foot of this cliff, resting on the limestone floor of the cave at its mouth; upon the eroded surface of the "Inner Beach" beyond; and upon the eroded surface of the "Lower Red Cave Earth" at the back of the excavation area. This deposit represents the back of a storm beach. It is best developed at the cave mouth where it is made up of a mixture of boulders, shingle and shell fragments (especially of the limpet, *Patella*, after which the beach was named by George), but it thins out rapidly inside the cave and peters out entirely against a cliff in the earlier sediments about ten metres beyond the entrance. At its seaward end the "Patella Beach" is truncated by present day wave erosion. It rises gradually inside the cave, reaching 11.8 metres O.D. at its innermost limit.

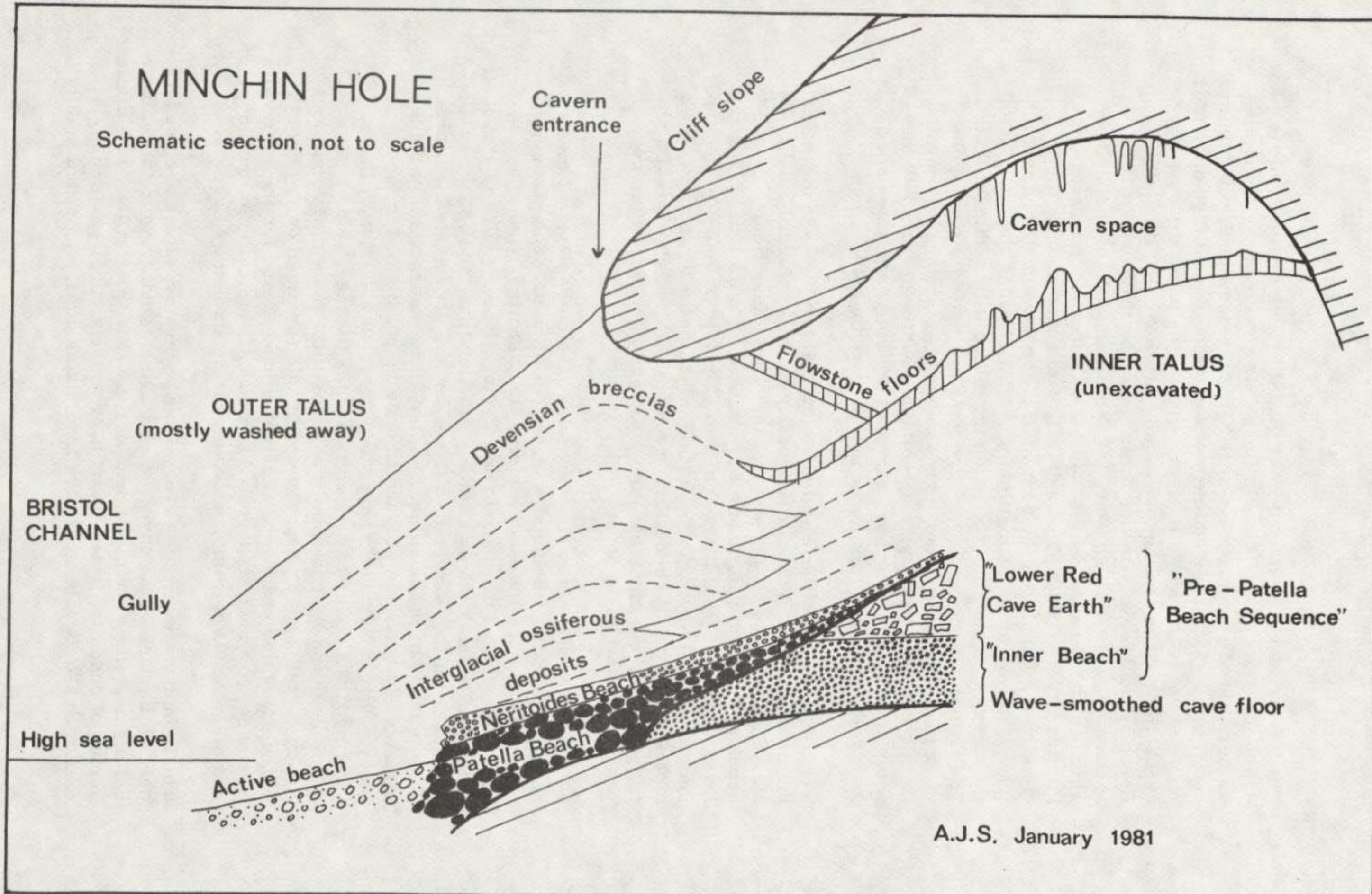


Figure 1. Schematic section of Minchin Holé, not to scale. The actual dimensions are a) length of gully 50 metres b) length of cave 42 metres c) height of summit of inner talus above level of present beach 22 metres.

4. The "Neritoides Beach" and interglacial "Earthy Breccia Series". At the cave mouth the "Patella Beach" is directly overlain on the western side by George's so called "Neritoides Beach" containing many small gastropods and remains of rodents and other mammals. We have not been able to confirm, during the present phase of excavation that on the eastern side of the cave the "Neritoides Beach" overlies the "Breccia", as indicated in George's 1932 section. Instead it appears that it merges with this deposit, which is an inner part of the outer talus cone; here sloping back into the cave. The high concentration of gastropods in the "Neritoides Beach" on the west side of the cave probably results from this part of the deposit being situated beyond the margins of the outer talus and thus not becoming mixed with sediment from it. The "Neritoides Beach" and "Breccia" are overlain by a series of further earthy breccias, sands and cave-earths (jointly named the "Earthy Breccia Series") containing sediment from both the outer and inner talus cones, abundant mollusca and also bones of mammals and birds and occasional sea urchin spines.

   The molluscs from these and other deposits in the cave are being studied by Dr. J. Evans of University College, Cardiff, and Mr. C. French, who suggest that the "Neritoides Beach" is not a beach per se, but represents a transition, at a time of falling sea level, from the "Patella Beach" (which is fully marine) to the upper part of the "Earthy Breccia Series" which has a terrestrial molluscan fauna. This is in agreement with the view previously expressed by Bowen (1966) that the "Neritoides Beach" is not a beach in the strictest sense.

   The "Earthy Breccia Series" contains relatively abundant mammalian and bird remains, including narrow-nosed rhinoceros, horse, elephant, red and fallow deer, pig, lion, spotted hyaena, red fox, bank vole, field vole, and northern vole, The remains of this last mentioned animal are appreciably smaller than those of the same species from the "Lower Red Cave Earth", previously mentioned. This fauna is of predeominantly interglacial character. Further stratigraphic division will undoubtedly be possible after further study. Pig is currently recorded only from a section of the "Earthy Breccia Series" which is part of the inner talus cone; fallow deer and hyaena from this deposit and from the "Neritoides Beach"; and horse is represented by one specimen only. Most of the excavated sediment, after being hand sorted for the removal of stones, has been transported to London for sieving for rodent and other small remains, which are being studied by Currant.

5. The later deposits in the cave. The uppermost strata are preserved only at the back of the cave and as fragments adhering to the walls and ceiling near the cave mouth and on the walls of the gully. Two distinct series of deposits, which interfinger in their upper parts, may be distinguished. These are the inner talus cone, composed mainly

of red cave earths and limestone breccias overlain by a thick stalagmite floor; and the outer talus, mostly sand rock and open breccias.

Since the stalagmite floor which forms the surface of the inner talus is interbedded with the later part of the outer talus (which rests unconformably upon it) it follows that the latest deposits at the cave mouth and in the gully outside are later than any inside the cave,

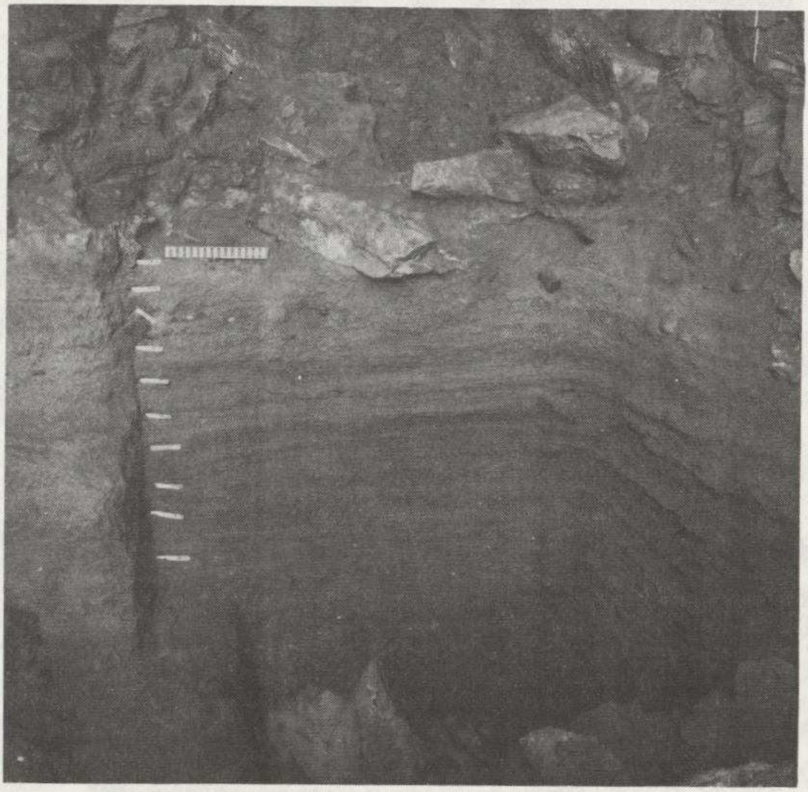


Figure 2. The "Inner Beach" and "Lower Red Cave Earth" of Minchin Hole, October 1979. Horizontal scale in centimetres. Pegs mark sediment samples. Photo: P. Richens.

except the stalagmite floor which is still growing there. At a late stage the outer talus completely filled the gully, mainly with thermoclastic screes, and blocked the cave entrance. A (Devensian) low sea level is inferred for this part of the sequence, since the gully could not have been so filled at a time of high sea level. These most recent deposits have not yet been examined for fossil remains, a task to be undertaken later this year. Lastly (presumably during the Holocene) the sea reinvaded the gully, washing away most of the deposits there. At times of exceptional present day storms waves wash over the eroded outer edge of the "Patella Beach" and deposit shingle and shell fragments upon it.

Discussion of the relationship between the two fossil beaches in Minchin Hole

The recognition of two apparently distinct fossil beaches (the "Inner" and "Patella" Beaches) in Minchin Hole is of such potential chronological importance, that it would be inappropriate to proceed further here without some discussion of the likely time interval between them. The stratigraphical relationship of these two beaches, the period of time between which is represented only by the "Lower Red Cave Earth", was clearly observable in the excavated section. There is agreement among everyone who was continuously involved with the excavation (for example Bowen, Currant, A. Henry, Rutter and Stringer, the writer and those visitors who came to the cave when suitable sections were exposed) about this relationship. The only outstanding problem is the length of time between the deposition of the two beaches. Does the "Lower Red Cave Earth" represent a minor event within a single marine transgression, of which both beaches are part, or are two distinct transgressions involved?

All the evidence favours the latter alternative. The "Inner Beach" was apparently already consolidated in part before being eroded by the "Patella Beach" sea, as evidenced by a fracture in it. The "Lower Red Cave Earth" is a deposit of massive volume, hardly to be interpreted as a minor event. The northern vole remains in it, as previously observed, are of very large size, larger than those in the deposits overlying the "Patella Beach". Is this an instance of Bergmann's rule and evidence of cold conditions? Most important of all is the amino acid ratio evidence recently obtained by D.Q. Bowen and colleagues from shells of Patella from the two beaches (Andrews, Bowen & Kidson, 1980; Bowen 1981, in press). Figures of 0.099 for those from the "Patella Beach" (Andrews, Bowen and Kidson's group 1) and 0.133 and 0.146 for those from the "Inner Beach" (group 2) also suggest a considerable time separation for these two beaches.

All the evidence suggests therefore that the "Inner" and "Patella" beaches of Minchin Hole represent two distinct marine transgressions. These are nevertheless not the same two marine events proposed by George. George had not seen the "Inner Beach"; and his "Neritoides Beach" is now regarded as part of the same marine event as the "Patella Beach". The "Patella Beach" and at least the lower part of the "Earthy Breccia Series" were apparently fully interglacial. There is evidence of a subsequent deterioration of climate.

Classification of the principal sedimentary units in Minchin Hole

For consistency in future publications where other authors wish to make reference to the sequence of deposits in Minchin Hole, some further definition of terms which might be used would be appropriate here. Authors are invited to employ the following:

The "Patella Beach". This is the name which was given by George to the Outer Beach of Minchin Hole in 1932. Although he describes the "Patella Beach" as occurring all along the Gower coast, his section of Minchin Hole on p. 299 shows a part of this deposit which can still be readily identified today and it is suggested here that this cave should be accepted as the type site. Since deposits of the "Patella Beach" transgression can, with caution, be recognised elsewhere along the Gower coastline, they have good potential as a marker horizon and as a means of correlating the deposits of individual unconnected sites.

The "Pre-Patella Beach Sequence". All the deposits ante-dating the "Patella Beach" (i.e. in Minchin Hole, the "Inner Beach" and "Lower Red Cave Earth").

The "Post-Patella Beach Sequence". Everything post-dating the "Patella Beach"; with the "Neritoides Beach" a transitional deposit (but nevertheless here regarded as an early part of the "Post-Patella Beach Sequence").

"Inner Beach" transgression and "Patella Beach" transgression: local terms for the two high sea levels represented by the deposits in Minchin Hole.

Discussion of the heights of the "Inner Beach" and "Patella Beach" sea levels

On first consideration both the "Inner Beach" with its present upper crust at about 11.6 metres O.D., and the "Patella Beach" (height at its innermost edge, where the highest wave petered out, about 11.8 metres) appear to represent former high sea levels of approximately the same altitude. If seen by itself, in two dimensional section on the open coastline, the "Inner Beach" would be indistinguishable, on altitudinal grounds, from the "Patella Beach" (Figure 2). It is only the observed stratigraphic relationship in Minchin Hole which leaves no doubt that the two beaches represent separate events. Can we be more precise about the heights of the two transgressions in question, which would in turn be of value to those making comparative studies of old shore lines elsewhere? Certainly this should be possible, since the period of time concerned is relatively late, with less blurring of the evidence to be expected than for similar studies of Lower Pleistocene transgressions.

It is widely recognised that in previous studies of former sea levels not all writers have used the same criteria for measuring heights, which has sometimes led to problems. Unless the basis for any calculation is explained, altitudinal comparisons with an accuracy closer than about five metres are impossible. Sometimes different heights have been established by different workers for the same shore line feature. Gilbertson and Hawkins (1977), by making accurate comparison of the shore line features at Swallow Cliff (Middle Hope) and North Bay, near Weston super Mare, were able to equate the so-called "3 metre" and 15 metre" stages of these two localities, previously established by other writers using different criteria, as apparently the same event. There are important discussions about methods of measuring the heights of former sea levels by various writers, for example Zeuner, 1952, and Kidson, 1977.

Even along stable coastlines, where there has been no isostatic or tectonic displacement, the measurement of the relative heights of former high sea levels can be made difficult by a series of complications, of which the following are some of the most important:

1. In a region of large tidal amplitude (for example in the Bristol Channel, including Minchin Hole) old shore line deposits will be at a higher latitude than deposits of the same age in a region of small tidal amplitude. Whenever O.D. or mean sea level is used as a datum for relating the height of fossil beaches, a correction must be introduced for the local tidal range.

2. Surge may carry deposits higher into a gully or sea cave than on the open coast.

3. As Professor Kidson pointed out to us, during an early visit to Minchin Hole, a present day beach complex is made up of a number of parts, the total vertical range of which may be quite considerable. The lower part of a sandy beach is commonly covered by a considerable head of water at high tide, whereas the storm beach boulders along the shore of the same beach may be reached by the sea only at times of storm and high water; or may even be thrown above high water mark. In any altitudinal study of a fossil beach, the beach element must be identified.

4. Rock platforms, old cliffs and the notches at their intersections cannot, without caution, be used as evidence of the level of the sea at the time when fossil beach deposits banked against them were

laid down, since old platforms have commonly been reoccupied during later transgressions and the marine deposits resting on them need not necessarily be contemporary with their formation.

With such problems, how can altitudinal comparison reliably be made from one fossil beach locality to another? Surely there is only one significant parameter with which comparison can be made; and this is "how much higher was the sea level then than it is now?" In any publication where the heights of former sea levels are discussed, the writer can be expected to know the locality concerned and local tide conditions better than the reader, and the inclusion of a description of his method of working and of his considered interpretation of how much the sea level seems to have changed since the deposits described were laid down would greatly add to the value of his report. Descriptions such as "height of beach deposits above present day sea level" or even "above mean sea level" are insufficiently precise for present day studies. May I appeal to any Editor who receives such an ambiguous description to return the paper in question to its author for elaboration?

Kidson et al's paper on the Burtle Beds, Somerset (1978), which provides considered figures for both past mean sea level above present mean sea level and past minimum mean high tide level above O.D., is a model of clear presentation.

An additional advantage of refining raised beach altitude measurements to actual change of sea level is that, in places far from any surveyed bench mark, this can still be done without reference to O.D. provided the study continues long enough for the investigator to get a clear picture of the maximum effect of waves during present day storms. Changes of sea level established in this way are local measurements and are relative only; but if sufficiently numerous and widespread can provide not only a precise record of actual changes of sea level but also a means of recognising tilted shore lines resulting from isostatic or tectonic or other causes.

To return once more to Minchin Hole: at least twice and probably more often during the last seven years (1974, 1979) waves have swept over the eroded front of the "Patella Beach", depositing shingle on it before finally losing momentum at about 10.2 metres O.D. The equivalent figure for the attenuated back of the "Patella Beach" is about 11.8 metres, a difference of only a metre and a half. While such accuracy cannot of course be claimed for the measurement of any fossil beach it is difficult to attribute a relative altitude of more than a few metres to the "Patella Beach" transgression; and the amount could have been appreciably less than this. Kidson, during a visit to the cave in 1980, pointed out that we have been observing the effect of storms in the cave for only nine years. An exceptional storm could carry the waves into the cave higher still, reducing the observed difference even to zero.

We need not necessarily assume that the wave cut limestone platform on which the "Patella Beach" rests at the front of the cave was eroded by the "Patella Beach" sea. Other raised beach workers have commonly found instances where late Pleistocene beaches deposits are separated from the underlying platform by terrestrial material; for example in the Isles of Scilly (Mitchell & Orme, 1967), Swallow Cliff (Gilbertson and Hawkins, 1977) and in Jersey (Keen, 1978). From the evidence currently available it seems more likely that the "Patella Beach" transgression reoccupied an initially sediment-covered shore platform of earlier age (the "Inner Beach" and "Lower Red Cave Earth" were part of this sediment) rather than that it cut a new one of its own. This event could have been of quite short duration.

The "Inner Beach", which has a surface at 11.6 metres, is a beach sand which must have had a head of water over it at high tide, though the depth of this water is at present unknown. It seems unlikely that, during "Inner Beach" times, sea level was less than about three metres higher than at the present day and this figure could have been considerably greater, perhaps five metres or more.

The ages of the "Inner" and "Patella" Beaches

Although it is not yet possible to reach any firm conclusions concerning the age of the beaches in Minchin Hole, some evidence can be presented here of the time range within which the results will probably lie.

Firstly there is the palaeontological evidence. Apart from the absence, so far, of hippopotamus itself from the interglacial deposits overlying the "Patella Beach", this interglacial horizon (characterised by narrow-nosed rhinoceros and 'straight-tusked' elephant) has all the other characteristics of the hippopotamus fauna which is so abundantly represented at other sites throughout England and Wales (for example in the Upper Floodplain Terrace of the Thames at Trafalgar Square, which also apparently dates from a time when sea level was marginally higher than at the present day) and which are usually referred to the Eemian/Ipswichian (Sutcliffe 1960). Stringer and Currant's excavations in Bacon Hole (Stringer, 1975, 1977) have produced a similar hemitoechus-antiquus fauna, so far also without hippo, overlying a beach deposit (their "Sandy Breccio-Conglomerate") which they believe may correspond to the Patella Beach. Hippo is nevertheless recorded by Falconer from the hemitoechus-antiquus assemblage at Ravenscliff Cave, although unfortunately these remains were found more than a century ago, their whereabouts is now unknown, and so is the exact level at which they were found. In 1976 we re-opened Wood's old excavation and re-established Falconer's published stratigraphy, but without finding any more remains of hippopotamus, which is very tantalizing! Either Falconer's hippopotamus horizon in Ravenscliff Cave must be identified (for which purpose a further examination of the site is planned for September) or, hopefully, this animal might yet turn up in Minchin Hole or Bacon Hole.

The relationship of the beaches in Minchin Hole to the deep sea oxygen isotope sequence was discussed by Bowen (1973), who suggested a number of possible correlations ranging from stage 5c for the "Patella Beach" and 5e for the "Inner Beach"; to stage 5e for the "Patella Beach" and 7 or 9 for the "Inner Beach" (my conversion here of the absolute dates quoted by Bowen). He drew special attention to the likelihood that the "Inner Beach" represented a distinct interglacial of pre-Ipswichian age, but left the solution to this problem open, pending further studies.

More recent studies related to this topic include Bowen's amino acid determinations, quoted above; and there is a single uranium series date of 101,000 $\pm$ 16,000 years from Dr. H. Schwarcz for a fallen block of stalagmite (travertine) found resting on the surface of the "Patella Beach" and buried in the base of the overlying "Earthy Breccia" deposits. Since this block is a fallen one, then it must be of either greater age than or about the same age as the "Patella Beach". It begins to seem unlikely that the "Patella Beach" is earlier than stage 5 (any other date would certainly be surprising), but the above figure is based on a single determination only and no firm conclusions can be drawn from it. Additional samples are in course of being processed now and the results are awaited with much interest.

But it may be in Bacon Hole and not in Minchin Hole that these problems can most readily be solved. Although the beach sequence in Minchin Hole is more straightforward (probably because the lowest part of Minchin Hole is altitudinally lower than the lowest part of Bacon Hole), Stringer and Currant's 1980 excavation in Bacon Hole revealed an interstratified stalagmite floor at the interglacial horizon, a date for which is expected imminently from Schwarcz; and Currant's study of the mammalian fauna has developed further the initial work conducted by Stuart which demonstrated that the warm phase which carried on from the "Sandy Breccio-Conglomerate" was in fact divided by a cool phase, possibly one of the two believed to have occurred between the three warm peaks of oxygen isotope stage 5. In addition the "Sandy Breccio-Conglomerate" is underlain by an earlier deposit with horse and large northern vole (the "Basal Sands") which may possibly be contemporary with the "Lower Red Cave Earth" of Minchin Hole. The situation at Bacon Hole is further complicated by the presence of a storm beach at the base of the basal sands resting directly on the rock platform (personal communication S. Colcutt, Stringer & Currant).

Only when the findings from Minchin Hole, Bacon Hole and Ravenscliff Cave have been dovetailed together is it likely that a reasonably full picture of Last Interglacial events in Gower can be established. This operation is already in hand.

Comparison of the sea level evidence from Minchin Hole with that at some other localities in the Bristol Channel and elsewhere

It would be out of place to embark here on any but the briefest comparison of the Minchin Hole sea level evidence with that elsewhere. A full analysis could provide several lengthy papers in their own right; and let us hope that these will come from other QRA members. There are nevertheless two problems which, for completeness of the present discussion, cannot be entirely omitted here. Firstly it has been shown that, at the time of the "Patella Beach" transgression, sea level at Minchin Hole was most probably only marginally higher than at the present day. The question then arises as to whether this is a true record of the general level of the sea during the period of time concerned, or whether the Gower coastline is somehow displaced so that the figure can be accepted as of local significance only. Secondly, of special interest to those of us concerned with fossil mammals, where do the marine Burtle Beds (just across the water from Minchin Hole and famous for their fallow deer remains) fit into the picture?

My general impression is that the Minchin Hole "Patella Beach" sea level is also widely represented by low altitude fossil shore line deposits at many other places along the coast of S. W. England. Around the Isle of Scilly, for example, those many sea stacks with aprons of "Head" around their flanks suggest a marginally higher sea level, followed by a period of solifluction, in the not very distant past. Zeuner applied the name Epimonastirian to this latest Pleistocene high sea level, which he regarded as dating from an interstadial within the Last Glaciation, although the Gower evidence suggests that it is more likely to have been fully interglacial.

Do the Burtle Beds, so frequently also referred to the Ipswichian, represent the same or a different event? It has often been suggested by previous writers that more than one high sea level is represented by the beach and other marine deposits along the southern shore of the Bristol Channel. Zeuner, for example (1945), attributed the Burtle Beds to his Main Monastirian (18 m.) stage. Apsimon and Donovan (1956), following the principles of Zeuner, equated the marine sands at their site in the Vale of Gordano with the Burtle Beds, both of which they considered on altitudinal grounds to be earlier than the Middle Hope (i.e. Swallow Cliff) raised beach, which they attributed to the Late or Epimonastirian (1 - 2 m.).

More recently Kidson et al's new study of the Burtle Beds (1978) in which a sea level difference of 9-12 metres is suggested (mean sea level above mean sea level) further suggests a sea level greater than that of the Minchin Hole "Patella Beach" transgression; and Andrews, Bowen & Kidson's study of the amino acid ratios of the Patella shells from the Burtle Beds and from the raised beach at Middle Hope (Andrews et al; 1979) point to a similar separation.

With the "Patella Beach" of Minchin Hole and the Middle Hope raised beach placed by the above authors in their amino acid group 1, and both the Burtle Beds, and the Inner Beach of Minchin Hole placed in their group 2 it begins to look as though the rich mammalian fauna of the deposits immediately overlying the "Patella Beach" in Minchin Hole does not represent the same interglacial event as the Burtle Beds, which are also rich in mammalian remains. The question then arises, do the Burtle Beds and the "Inner Beach" of Minchin Hole represent the same marine transgression? Mammalian species listed by Bulleid and Jackson (1938, 1941) from the Burtle Beds include very abundant fallow deer, elephant sp., rhinoceros sp., horse, giant ox, red deer, roe deer, spotted hyaena and wolf. Assuming that these remains really do come from the Burtle Beds, and not from later marine deposits of "Patella Beach" age around their flanks, there would seem to be evidence that some of these mammals, notably the fallow deer and spotted hyaena, were present in the neighbourhood of the Bristol Channel during the two separate interglacial stages near the end of the Pleistocene. In the light of recent deep sea oxygen isotope studies it now becomes increasingly difficult to continue regarding both of these events as "Last" interglacial and consideration needs to be given to the designation which should be applied to the older of these two warm stages, and to the period of time between them. Further work in Gower and a more reliable chronological framework should allow us to provide some solutions to these problems.

References

Allen, E.E. and Rutter, J.G., 1948. Gower Caves. Thomas, Swansea (previously published in Proc. Swansea Sci. Field Nats. Soc. 1943, 2, 6-7 and 1947, 2, 8-9.

Andrews, J.T., Bowen, D.Q. and Kidson, C., 1979. Amino acid ratios and the correlation of raised beach deposits in south-west England and Wales. Nature, 281, 556-558.

Apsimon, A.M. and Donovan, D.T., 1956. Middle Pleistocene deposits in the Vale of Gordano, Somerset. Proc. speleol. Soc., 7, 130-136.

Bowen, D.Q., 1966. Dating Pleistocene events in South-West Wales. Nature, 211, 475-476.

Bowen, D.Q., 1970. In Lewis, C.A. (Ed), Glaciations of Wales, London, Longmans.

Bowen, D.Q., 1973. The excavation in Minchin Hole. Gower, 24, 12-18.

Bowen, D.Q., (in press). The South Wales end moraine fifty years after. In Neale, J. and Flenley, J.R., Quaternary of Britain, Oxford, Pergamon.

Bulleid, A. and Jackson, W., 1937. The Burtle Sand Beds of Somerset. Proc. Somerset. archaeol. nat. Hist. Soc., 83, 171-195.

Bulleid, A. and Jackson, W., 1941. Further notes on the Burtle Sand Beds of Somerset. Proc. Somerset archaeol. nat. Hist. Soc., 87, 111-116.

Falconer, H., 1860. On the ossiferous caves of the Peninsula of Gower, Glamorganshire, South Wales. Quart. J. geol. Soc. Lond., 16, 487-491.

George, T.N., 1932. The Quaternary beaches of Gower. Proc. Geol. Ass., 43, 291-324.

Gilbertson, D.D. and Hawkins, A.B., 1977. The Quaternary deposits at Swallow Cliff, Middle Hope, County of Avon. Proc. geol. Ass., 88, 254-266.

Keen, D.H., 1977. The Pleistocene deposits of the Channel Islands. Rep. Inst. geol. Sci., 78/26, 14 pp.

Kidson, C., 1977. Some problems of the Quaternary of the Irish Sea: In Kidson, C. and Tooley, M.J. (Eds), The Quaternary of the Irish Sea. Geol. J. Special Issue 7, pp 1-12.

Kidson, C., Gilbertson, D.D., Haynes, J.R., Heyworth, A., Hughes, C.E. and Whatley, R.C., 1978. Interglacial marine deposits of the Somerset levels, South West England. Boreas, 7, 215-228.

Mitchell, G.F. and Orme, A.R., 1967. The Pleistocene deposits of the Isles of Scilly. Quart. J. geol. Soc. Lond., 123, 59-92.

Murchison, C., 1868. Palaeontological Memoirs and Notes of the Late Hugh Falconer, 2, Hardwicke, London.

Stringer, C.B., 1975. A preliminary report on new cave excavation at Bacon Hole Cave. Gower, 26, 32-37.

Stringer, C.B., 1977. Evidence of climatic change and human occupation during the Last Interglacial at Bacon Hole Cave, Gower. Gower, 28, 36-44.

Sutcliffe, A.J., 1960. Joint Mitnor Cave, Buckfastleigh. Trans. Proc. Torquay nat. Hist. Soc., 13, 1-26.

Sutcliffe, A.J. and Bowen, D.Q., 1973. Preliminary report on excavations in Minchin Hole, April-May 1973. Newsl. William Pengelly Cave Studies Trust, 21, 12-25.

Zeuner, F.E., 1945. The Pleistocene Period, London, Ray Society, 322 pp.

Zeuner, F.E., 1952. Pleistocene shore-lines. Geol. Rdsch., 40, 39-50.

A.J. Sutcliffe
Dept. of Palaeontology
British Museum (Natural History)
Cromwell Road
London SW7 5BD

IPSWICHIAN MAMMAL FAUNAS, CAVE DEPOSITS AND HYAENA ACTIVITY

By A. Turner

Introduction

There is some controversy in Britain about the number and nature of the warm stages immediately preceding the Devensian. In this debate little emphasis has been placed upon the oxygen-isotope evidence (Hays, 1978), and instead discussion has centred on the number of warm stages to be discerned, within the period assigned to the Ipswichian, on the basis of terrestrial mammalian assemblages. Attempts to place mammalian assemblages in chronological order, and to estimate the number of distinct stages, must take account of assemblage formation.

Previous arguments

Sutcliffe (1975, 1976; Sutcliffe and Kowalski, 1976) has argued that assemblages assumed to be Ipswichian actually come from two or more warm stages between the last two glacial periods of Mitchel et al, 1973. Much of the argument for his view is based on apparent anomalies in Thames terrace deposits at Ilford and Trafalgar Square, which are claimed to form part of separate and therefore non-contemporaneous terraces. Both sites have pollen assigned to Ipswichian Zone II but a markedly different mammalian fauna, in particular presence of hippopotamus and absence of horse at Trafalgar Square contrasting with lack of hippopotamus and abundant horse at Ilford. Differences in the rhinoceros and mammoth species at the two sites have led Sutcliffe to suggest that Ilford predates Trafalgar Square, and that both represent Zone II of different temperate stages separated by an as yet unrecognised cold stage.

Stuart (1976) has argued against this interpretation on several grounds. Firstly, he suggests that the two sites may not lie on separate terraces, and points to the difficulties of terrace interpretation in the Ilford area. Secondly, he disputes Sutcliffe's identifications of rhinoceros and mammoth to species, and claims that these animals do not support the sequence in deposition between the two sites put forward by Sutcliffe. And thirdly, he points to a good overall correspondence between Ipswichian pollen zones and fauna, and suggests that the horse-less hippopotamus stratum may be a general Ipswichian Zone II phenomenon. In his view, absence of hippopotamus at Ilford may be no more than an artefact of recovery, since the Zone II deposits there were rather localised, and the abundant horse remains actually seem to come from higher levels, within Zone III. Stuart thus agrees that Ilford and Trafalgar Square are faunally distinct, but argues that this stems at least in part from deposition during different zones of a single interglacial. West (1976) argues that Sutcliffe's scheme may represent a premature attempt at reinterpretation in the absence of secure stratigraphic information.

Cave deposits

However, both Sutcliffe and Stuart seem to agree that the horse-less hippopotamus stratum at Trafalgar Square is a chronological phenomenon. As Sutcliffe (1976) has pointed out, the assemblage occurs commonly in a number of British caves. He lists Tornewton, Joint Mitnor and Eastern Torrs Caves, Devon; Milton Hill and Durdham Down Caves, Somerset; Victoria Cave, Raygill Fissure and Kirkdale Cave, Yorkshire, and Ravenscliffe and probably Bacon Hole, Gower. To this list may be added Robin Hood's Cave, Mother Grundy's Parlour and Hoe Grange, Derbyshire, although the latter site produced no remains of hippopotamus (Table 1) but is some distance from any likely large source of water at the time. In fact virtually every cave in the country which has deposits assignable to the Ipswichian has only the horse-less hippopotamus assemblage. If presence of hippopotamus and absence of horse is confined to Ip II, as argued by Stuart, then it is likely that these cave deposits date to Zone II also (Table 1). The only exceptions to caves with Ipswichian

	Wo-Ia	Ib-early IIb			IIb							Caves ? II											III		III-IV		probably III - IV			? IV		
	Selsey	Selsey	Mundesley	Beetley	Beetley	Barrington	Trafalgar Square	Stone	Wortwell	Swanton Morley	Aveley	Joint Mitnor	Hoe Grange	Tornewton Hyaena Stratum	Mother Grundy's Parlour	Robin Hood	Kirkdale	Milton Hill	Eastern Torrs Quarry	Durdham Down	Victoria Cave	Raygill Fissure	Swanton Morley	Aveley	Histon Road	Stutton	Harkstead	Brundon	Ilford	Lexden	Crayford	
Primates																																
1. Homo sapiens (artefacts)	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	?	-	-	-	-	-	-	-	-	-	+	-	-	-	-	+	1.
Carnivora																																
2. Canis lupus	-	-	-	-	-	+	-	-	-	-	-	+	+	+	-	+	+	-	-	+	-	-	-	-	-	-	-	+	-	-	+	2.
3. Ursus sp.	-	-	-	-	-	+	-	-	-	-	-	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	+	+	-	+	3.
4. Meles meles	-	-	-	-	-	+	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.
5. Crocuta crocuta spelaea	-	-	-	-	-	+	-	-	-	+	-	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-	5.
6. Panthera leo	-	-	-	-	-	+	+	-	-	-	-	+	+	+	-	-	+	-	-	-	-	+	-	-	-	+	-	+	+	-	+	6.
7. Lynx lynx	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.
Proboscidea																																
8. Palaeoloxodon antiquus	-	+	+	+	-	+	+	+	+	+	+	+	+	-	-	-	+	+	+	+	+	+	-	-	-	+	+	+	+	-	-	8.
9. Mammuthus primigenius	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+	+	+	9.
Perissodactyla																																
10. Equus sp.	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-	+	+	-	+	10.
11. Dicerorhinus hemitoechus	-	+	-	-	-	+	+	-	-	-	-	+	+	+	+	+	+	-	+	-	+	+	-	-	-	-	-	+	+	+	+	11.
12. Coelodonta antiquitatis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	12.
Artiodactyla																																
13. Hippopotamus amphibius	-	-	-	-	+	+	+	-	-	-	-	+	-	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-	13.
14. Megaceros giganteous	-	-	-	+	-	+	-	-	-	-	-	+	+	-	-	-	+	-	-	-	-	-	-	-	-	+	-	+	+	-	+	14.
15. Dama dama	-	-	-	-	-	+	+	-	-	-	-	+	+	+	-	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	15.
16. Cervus elaphus	-	-	-	+	-	+	+	-	-	-	-	+	+	+	-	+	+	-	-	-	-	+	-	+	+	+	+	+	+	-	+	16.
17. Bos primigenius	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	+	+	-	+	17.
18. Bison priscus	-	-	-	-	-	+	-	-	-	+	-	+	+	+	+	+	+	+	+	-	-	+	-	-	-	-	-	(+)	+	-	+	18.
19. Bos sp. or Bison sp.	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	-	19.
20. Ovibos moschatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	20.

Table 1. Ipswichian sites: fauna and pollen zones. Only large mammals are shown. Information from Stuart (1976), Sutcliffe (1960), Sutcliffe and Zeuner (1962) and direct observation.

deposits which are solely of Zone II date would appear to be Bacon Hole and Minchin Hole (Sutcliffe, 1976; Sutcliffe and Bowen, 1973; Stringer, 1975) where other parts of the interglacial sequence do have horse, and perhaps Bleadon Cave in the Mendips. This latter cave was excavated in the early part of last century by William Beard (Barrington and Stanton, 1976, p. 42; Turner, 1980) and, unfortunately, is devoid of stratigraphic data. Work is still in progress at the first two of these sites, and should eventually clarify many problems of Ipswichian chronology and sequence. Bleadon appears to have been a trap deposit, and to have accumulated remains of Ipswichian Zones III and IV (Turner, 1980).

Hyaena activities

A further marked feature of the horse-less hippopotamus cave deposits is the inclusion, often in great numbers, of hyaena remains. The bone-gathering activities of modern hyaenas, together with the evidence of hyaena bone destruction in the Pleistocene deposits, leaves little doubt that in most cases this animal was the agent of accumulation. Both Sutcliffe (1976) and Stuart (1976) have remarked on the general absence of Ilford-type faunas (horse and no hippopotamus) in caves, with Sutcliffe attributing this to the greater age of Ilford assemblages and Stuart suggesting that lack of careful excavation is indicated. Both authors may, however, be mistaken. Although known in numbers only from one Zone II open air site, Barrington, hyaenas appear to have been totally absent from other sites datable to Zones III and IV (Table 1). If hyaenas were only present during Ipswichian Zone II, then only during that period would cave deposits containing bones be likely to have formed, tending to reduce the force of Sutcliffe's argument. Against Stuart's suggestion of oversight to explain the lack of horse one can raise the criticism of special pleading. Devensian sites excavated at the same time by the same people under the same conditions are often marked by the abundance of horse specimens, and their absence from the Ipswichian caves would seem to be a genuine feature.

Of course, if hyaena activity explains the formation of Ipswichian Zone II deposits in a number of caves occupied by this animal, it may still seem odd that trap deposits such as Joint Mitnor, Hoe Grange and Milton Hill had only Zone II material. It may be argued that if they were natural traps, then specimens of Zone III and IV would be expected, including perhaps horse and wooly rhinoceros. Milton Hill provides little answer to this, being reported in scant detail (Balch, 1948, p.142-3), but both Joint Mitnor and Hoe Grange appear from published details to have been full deposits, so that no material of Zone III age onwards could have been included. Lest this appear to be special pleading in favour of hyaena activity as an explanation for other deposit formation, it should be borne in mind that Bleadon Cave may afford an example of trap deposits which formed during Zones III or IV, as pointed out above.

Conclusion

The formation, preservation and recovery of vertebrate fossil assemblages depends upon the interaction of numerous factors, as is clearly shown in recent discussion (Behrensmeyer and Hill, 1980). Among these factors, the agency of initial accumulation is clearly of great importance. The apparent confinement of hyaenas to Zone II of the Ipswichian and the evident involvement of these animals in the formation of many Ipswichian cave deposits must have a major bearing on interpretations of Upper Pleistocene events which use such material. The absence of Ilford-type faunas (horse and no hippopotamus) in cave deposits of an interglacial character is related to the absence of an accumulating agent, the hyaena, rather than to the age of the deposits *per se*. It would therefore seem inappropriate to use the absence of Ilford-type cave deposits to support an argument for more interglacial stages.

References

Balch, H.E., 1948. *Mendip - its Swallet Caves and Rock Shelters.* 2nd edition. Bristol.

Barrington, N. and Stanton, W., 1976. *Mendip. The Complete Caves and a View of the Hills.* Cheddar.

Behrensmeyer, A.K. and Hill, A.P., 1980. *Fossils in the Making.* Chicago.

Hays, J.D., Imbrie, J. and Shackleton, N.J., 1976. Variations in the Earth's orbit; pacemaker of the Ice Ages. *Science*, 194 1121-32.

Mitchell, G.F., Penny, L.F., Shotton, F.W. and West, R.G., 1973. A correlation of Quaternary deposits in the British Isles. *Geol. Soc. Lond.* Special Report, No. 4, 99pp.

Stringer, C.B., 1975. A preliminary report on the new excavations at Bacon Hole Cave. *Gower*, 26, 32-7.

Stuart, A.J., 1976. The history of the mammal fauna during the Ipswichian/last interglacial in England. *Phil. Trans. Roy. Soc. Lond.*, B, 276, 221-50.

Sutcliffe, A.J., 1960. Joint Mitnor Cave, Buckfastleigh. *Trans. Torquay nat. Hist. Soc.*, 13, 1-28.

Sutcliffe, A.J., 1975. A hazard in the interpretation of glacial-interglacial sequences. *Quat. Newsl.*, 17, 1-3.

Sutcliffe, A.J., 1976. Reply from Anthony J. Sutcliffe. *Quat. Newsl.* 18, 1-7.

Sutcliffe, A.J. and Bowen, D.Q., 1973. Preliminary report on excavations in Minchin Hole. Newsl. of the William Pengelly Cave Studies Trust, 21, 12-25.

Sutcliffe, A.J. and Kowalski, K., 1976. Pleistocene rodents of the British Isles. Bull. Br. Mus. nat. Hist. (Geol.), 27, 33-147.

Sutcliffe, A.J. and Zeuner, F.E., 1962. Excavations in the Torbryan Caves, Devonshire. 1. Tornewton Cave. Proc. Devon Arch. Explor. Soc., 5, 127-45.

Turner, A., 1980. The Palaeoecology of British Upper Pleistocene Large Predators and their Prey. Unpublished Ph.D. Thesis, Sheffield University.

West, R.G., 1976. The British glacial-interglacial sequence. Quat. Newsl., 18, 1.

A. Turner
Environmental Archaeology Unit
Physics Block
University of York
Heslington
York YO1 5DD.

INTERGLACIAL AND INTERSTADIAL SITES IN NORTH-EAST SCOTLAND

By K.J. Edwards and E.R. Connell

In a recent issue of the Quaternary Newsletter, Peacock (1980) drew attention to an apparently overlooked record of interglacial or interstadial sites in north-east Scotland (Bremner, 1943). This paper has in fact been long known to many of us working in the area. It is useful to see it resurrected and placed before the Association, but it should be mentioned that Bremner's two sites, Tipperty Brickworks and Balmedie Village, were briefly described and located on a sketch map five years earlier in a paper published in The Deeside Field (Bremner, 1938). In this note we reconsider the status of these biogenic deposits and their relevance to the identification of older glacial deposits in north-east

Scotland. The opportunity is also taken to report new finds and to comment on Scottish pre-Late Devensian sites in general.

Bremner's paper (1943) drew attention to the Burn of Benholm peat (NO 795 692) in Kincardineshire. Campbell first described the site and it seems likely that Dr. I.M. Robertson, of the Macaulay Institute, Aberdeen, was responsible for the pollen identifications (Campbell, 1934, p. 180), although he seems never to have published his results independently. Bremner reports that the peat "yielded pollen grains of oak, pine, alder, elm, etc." (1943, p. 18). An apparently similar peat was sampled at the site on three subsequent occasions and pollen analyses were carried out by Donner (1960, 1979). These revealed spectra dominated by non-tree pollen, particularly Gramineae and Cyperaceae, with birch as the only major arboreal pollen contributor (an average 16.6 per cent of total land pollen, and even this might have been derived from the dwarf birch, Betula nana). Of the pollen types mentioned by Bremner, only pine was found by Donner (2.1 per cent average) and there is no trace of the more thermophilous taxa - oak, alder and elm. This either casts doubt on the earlier palaeobotanical determinations reported by Bremner or suggests that peats of widely different age and/or environment may be present at the site.

A further point must also be made. A ^{14}C assay of a sample of Burn of Benholm peat gave a date of 42,000 years bp (Hel - 1098) (Donner, 1979), confirming the pre-Late Devensian age of the material. The peat and masses of the lower grey shelly till occur as erratics within the red till, which is generally regarded as Late Devensian in age (Jardine and Peacock, 1973). This simply shows that both peat and shelly till pre-date deposition of the red till: the shelly till is not necessarily pre-Late Devensian.

Other possible pre-Late Devensian shelly tills have recently been reported from Caithness (Omand, 1978) and Orkney (Rae, 1976), the main evidence for age being the infinite ^{14}C date of derived shell material and the advanced periglacial modification of the drift deposits in Caithness (Omand, 1973). Both lines of argument must be considered cautiously, since infinite ^{14}C ages have been obtained from shelly glacial deposits in Banffshire which are regarded as Late Devensian (Peacock, 1971). As yet, no shelly till in northern or eastern Scotland can be confidently assigned to a pre-Late Devensian glaciation.

In spite of extensive investigations by Murdoch (1975, 1977) and McLean (1977), no trace can be found of the Tipperty Brickworks organic deposit, with its "pollen grains of oak, pine, birch, etc. - a temperate flora" (Bremner, 1943, p. 18). From Bremner's brief description, at least three interpretations of the site can be advanced: 1) the "interglacial" peat occupied a similar stratigraphic position to that of the Burn of Benholm deposit; on this interpretation the peat represents a deposit of pre-red till age; 2) the peat is Flandrian and incorporated within a recent slope deposit; 3) the palaeobotanical identifications were incorrect. None of the wood or peat samples collected from the site appear to have survived, but perhaps in support of hypothesis 1) it can be noted that wood remains have been found in red-brown till of probably similar age at Boddam Generating Station, Peterhead (NK 130 429) (unpublished borehole record, North of Scotland Hydro-Electric Board), and from glacilacustrine sediments at Hatton (NK 053 370) near Cruden Bay. However, at present no evidence is available to either confirm or reject any of the possible options.

As at Tipperty, our recent fieldwork (November 1980) revealed no signs of the Balmedie Village peat (NJ 96 17) (Bremner 1943, p. 18). It is unfortunate that Bremner did not precisely locate the site, though he did mention that the peat was found at a depth of six feet (Bremner, 1938, p. 65; 1943, p. 18 and map C4). As Bremner's section cannot be re-located it is unwise to comment on its significance, but other buried peats have been recently recorded nearby. At Milton of Potterton (NJ 945 162), 2 km south-west of Balmedie, a peat body 0.5 m in thickness was found buried beneath 0.43 m of "topsoil and stiff grey boulder clay" (unpublished trial pit report, Grampian Regional Council Water Services Department). The site occurs near the base of a steep drift slope and the peat is considered to be Flandrian and covered by a recent slope deposit. A similar site is known at Kinmundy (NJ 891 177), and other buried Late- and Post-glacial peats have been recorded from the Aberdeen area by Durno (1970). Over a wider area peats buried by 1.0 - 2.7 m of "head" deposits and dated by either radiocarbon or pollen analysis to the Late-glacial or early Post-glacial are known from sites near Tarves (NJ 833 318) (Clapperton and Sugden, 1977, p. 11) and near Fyvie and Turriff (Connell, Edwards and Hall, unpublished). Although the Balmedie peat recorded by Bremner may be an interglacial deposit, it is evident from the preceding remarks that this is not the only interpretation which can be placed on the limited evidence available.

Two sites in Buchan have recently provided "old" ^{14}C dates, namely Mintlaw (NK 000 482) and Cruden Bay (NK 088 370). The full significance of the organic deposits at these sites cannot be realised without further study, but "it could be proposed that they have been derived by meltwater from Middle Devensian organic material incorporated by an ice sheet of Late Devensian age" (Clapperton and Sugden, p. 12).

FitzPatrick (1975) suggested that a buried and periglacially disturbed interglacial podzol was visible in a sand pit at Denhead (NJ 998 521) north of Mintlaw. Since the site was first described the section has been destroyed by further sand extraction. Recent work, however, suggests that the glacifluvial deposits in the Denhead area are perhaps Late Devensian in age, thus relegating the "interglacial" podzol to either the Late- or the Post-glacial. Unfortunately the buried podzol was devoid of pollen (Edwards, unpublished) and could not be dated in this way.

Synge stated (1956, p. 140) that "no convincing interglacial deposits have yet been recorded", but was aware of the sites mentioned by Bremner (1938). He suggested that such deposits might be found in undrained hollows at suitable locations within the "moraineless" area, and mentioned Whiterashes (NJ 85 23) as a possible site. Subsequent investigations by Durno (1957) and Glentworth and Muir (1963) at Burreldale Moss (NJ 825 238), 3 km west of Whiterashes, demonstrated that the 4.9 m of peat at this site are Flandrian.

Peacock (1980) is quite correct in his initial statement that interglacial and interstadial sites are scarce in Scotland. If the Burn of Benholm peat is restored to a pre-Late Devensian phase, it augments the evidence from other early published sites such as Teindland in Morayshire (FitzPatrick, 1965; Edwards, Caseldine and Chester, 1976; Romans, 1977), Tolsta Head on Lewis (von Weymarn and Edwards, 1973; Edwards, 1979) and the Shetland sites of Fugla Ness (Birks and Ransom, 1969) and Sel Ayre (Birks and Peglar, 1979). In view of the paper by Warren (1979) which cogently argues on stratigraphic and palynological grounds that deposits assigned to the Gortian (= Hoxnian) interglacial are probably of last interglacial age, the Hoxnian age of the Fulga Ness site based on similarities with the Irish Gortian sites may have to be reconsidered. A further interglacial site may be present on Shetland at Channer Wick (HU 405 233), Mainland (J.S. Smith pers. comm.).

The above discussion serves to emphasise the fact that the sites recorded by Bremner (1938, 1943) and others that have been claimed to be interglacial or interstadial are open to alternative interpretations. Further, there are few sites in the north and north-east of Scotland where it is possible to convincingly demonstrate pre-Late Devensian glaciation. Whilst we agree with Peacock (1980) that "moraineless Buchan" and the possibility of pre-Late Devensian glacial sediments in the north-east merit re-evaluation, we submit that our limited knowledge of Scottish interglacial and interstadial phases makes such reconsideration extremely hazardous at present. The search for undoubted evidence of pre-Late Devensian glaciation in many areas is frustrated by the present confusion over the placing of the Late Devensian glacial limits! It is premature to base a revised Quaternary stratigraphy for the north-east on sites of such dubious significance as those described so briefly by Bremner (1938, 1943), especially as it is impossible to relocate the organic materials.

On a more optimistic note a new site has been discovered at Kirkhill Quarry (NK 012 528), Aberdeenshire, which has considerable potential for establishing a sequence of glacial and interglacial events for the north-east. Preliminary investigations suggest that for the first time in Scotland it may be possible to demonstrate the existence of two distinct interglacial phases within a complex sequence of till and glacifluvial sediments. Stratigraphic and palynological work at the site is currently being prepared for publication by Rodger Connell (Aberdeen), Kevin Edwards (Birmingham) and Adrian Hall (St. Andrews).

References

Bremner, A., 1938. The glacial epoch in north-east Scotland. The Deeside Field, 8, 64-8.

Bremner, A., 1943. The glacial epoch in the north-east. In Tocher, J.F. (Ed.) The Book of Buchan (Jubilee Volume), Aberdeen, 10-30.

Birks, H.J.B. and Peglar, S.M., 1979. Interglacial pollen spectra from Sel Ayre, Shetland. New Phytol., 83, 559-75.

Birks, H.J.B. and Ransom, M.E., 1969. An interglacial peat at Fugla Ness, Shetland. New Phytol., 68, 777-96.

Campbell, R., 1934. On the occurrence of shelly boulder clay and interglacial deposits in Kincardineshire. Trans. Edinb. geol. Soc., 13, 176-82.

Clapperton, C.M. and Sugden, D.E., 1977. The Late Devensian glaciation of north-east Scotland. In Gray, J.M. and Lowe, J.J. (Eds.) The Scottish Lateglacial Environment. Pergamon, 1-13.

Donner, J.J., 1960. Pollen analysis of the Burn of Benholm peat bed, Kincardineshire. Soc. Sci. Fenn. Comm. Biol., 22, 1-13.

Donner, J.J., 1979. The Early or Middle Devensian peat at Burn of Benholm, Kincardineshire. Scott. J. Geol., 15, 247-50.

Durno, S.E., 1957. Certain aspects of vegetational history in north-east Scotland. Scott. geogr. Mag., 73, 176-84.

Durno, S.E., 1970. Pollen diagrams from three buried peats in the Aberdeen area. Trans. bot. Soc. Edinb., 41, 43-50.

Edwards, K.J., 1979. Earliest fossil evidence for Koenigia islandica - middle-Devensian interstadial pollen from Lewis, Scotland. J. Biogeog., 6, 375-7.

Edwards, K.J., Caseldine, C.J. and Chester, D.K., 1976. Possible interstadial and interglacial pollen floras from Teindland, Scotland. Nature, 264, 742-4.

FitzPatrick, E.A., 1965. An interglacial soil at Teindland, Morayshire. Nature, 207, 621-2.

FitzPatrick, E.A., 1975. Denhead; In: Quaternary Research Association Field Excursion Guide, April 1975. Aberdeen, 21 pp.

Glentworth, R. and Muir, J.W., 1963. The soils of the country round Aberdeen, Inverurie and Fraserburgh. (Sheets 77, 76 and 87/97). Mem. Soil Surv. Scot. Edinburgh. 371 pp.

Jardine, W.G. and Peacock, J.D., 1973. Scotland, in Mitchell, G.F. et al. A correlation of Quaternary deposits in the British Isles. Geol. Soc. Lond., Special Report, No. 4, 53-59.

McLean, F., 1977. The glacial sediments of a part of east Aberdeenshire. Unpublished Ph.D. Thesis, University of Aberdeen. 152 pp.

Murcoch, W., 1975. The geomorphology and glacial deposits of the area around Aberdeen. In Gemmell, A.M.D. (Ed.) Quaternary Studies in North East Scotland. Aberdeen University, Dept. of Geography, 14-18.

Murdoch, W., 1977. The glaciation and deglaciation of south east Aberdeenshire. Unpublished Ph.D. Thesis, University of Aberdeen. 238 pp.

Omand, D., 1973. The Glaciation of Caithness. Unpublished M.Sc. Thesis, University of Strathclyde. 78 pp.

Omand, D., 1978. The glacial tills of Caithness. Bull. Caithness Fld. Club. 101-7.

Peacock, J.D., 1971. A re-interpretation of the Coastal Deposits of Banffshire and their place in the Late-Glacial history of N.E. Scotland. Bull. Geol. Surv. Gt. Br., 37, 81-9.

Peacock, J.D., 1980. An overlooked record of interglacial or interstadial sites in north-east Scotland. Quat. Newsl. 32, 14-15.

Rae, D.A., 1976. Aspects of glaciation in Orkney. Unpublished Ph.D. Thesis, University of Liverpool. 466 pp.

Romans, J.C.C., 1977. Stratigraphy of buried soil at Teindland Forest, Scotland. Nature, 268, 622-2.

Synge, F.M., 1956. The glaciation of north-east Scotland. Scott. geogr. Mag., 72, 128-43.

Warren, W.P., 1979. The stratigraphic position and age of the Gortian interglacial deposits. Geol. Surv. Ireland Bull., 2, 315-32.

von Weymarn, J. and Edwards, K.J., 1973. Interstadial site on the Island of Lewis, Scotland. Nature, 246, 473-4.

K.J. Edwards.
Department of Geography,
University of Birmingham,
P.O. Box 363,
Birmingham, B15 2TT

E.R. Connell,
Lark Hill, Carlton Avenue,
Hornsea,
North Humberside, HU18 1JG.
formerly of
Department of Geography
University of Aberdeen.

PLEISTOCENE FORAMINIFERA FROM SOUTH-EAST IRELAND - SOME PROBLEMS OF INTERPRETATION

By D. Huddart

1. Introduction

The stratigraphy and chronology of the eastern Irish glacigenic succession have been much debated recently (Mitchell 1972, Bowen 1973, Huddard 1977 and Synge 1977, 1979), but the results have been inconclusive with a variety of stratigraphic and chronological interpretations. In an attempt to elucidate some of the problems, parts of Wexford and South Wicklow have been mapped. Part of the succession has yielded a microfauna, which is outlined below. This paper also illustrates some of the difficulties involved in establishing a regional chronology without good radiometric or palynological control.

The sites are located in Figure 1. Clastic sediments overlie Irish Sea till and are in turn overlain either by further clastic/till sequences or by a till of inland derivation. Preliminary field examination suggested that some of the intermediary clastic sediments of Clogga Strand and the Knocknasilloge area are marine, in which case they could provide a valuable stratigraphic marker within the glacigenic sequence.

Foraminifera were collected from the intermediate units by sieving, followed by air drying and flotation in carbon tetrachloride.

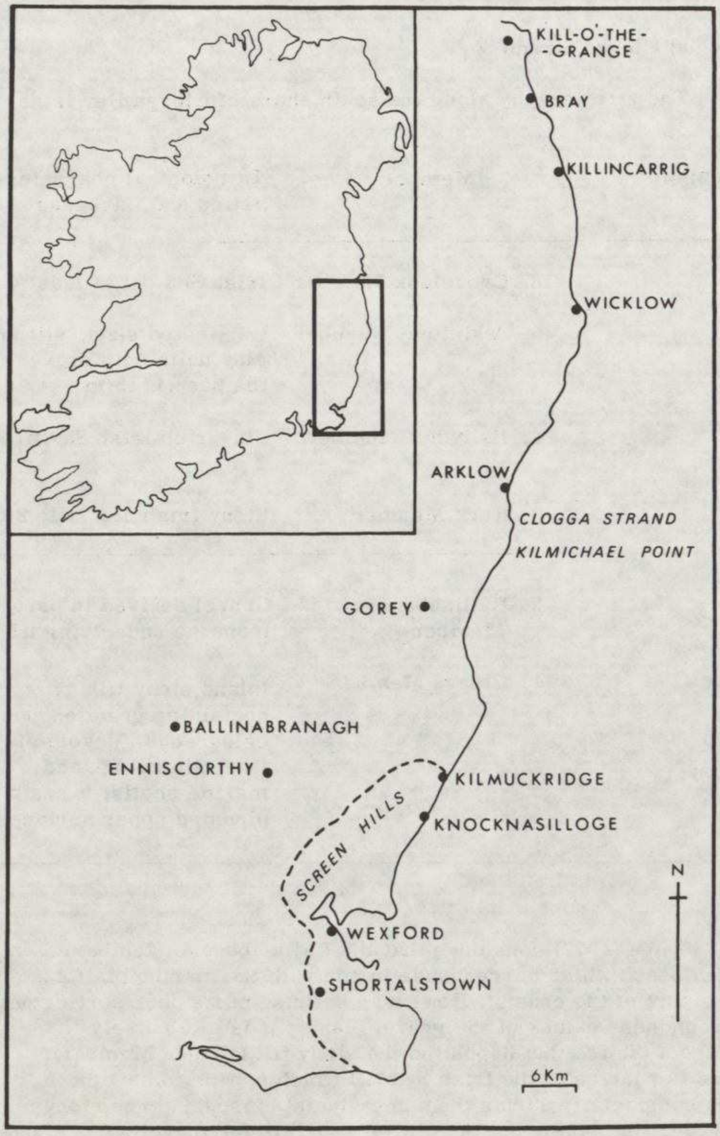


Figure 1. Location of sites mentioned in the text.

2. Results

a) Clogga Strand

The stratigraphy along the south shore of Clogga Bay is as follows:

Formation	Member	Lithological characteristics and thickness
Arklow Head Formation	6. Cronelusk Member	Irish Sea till, at least 4 m
	5. Askintinny Member	Laminated sand, silt and clay units with gravel at the base: 1.13 m
	4. Ballyduff Member	Clay-rich Irish Sea till: 2 m
	3. Rock Member	Stony Irish Sea till: 2 m
Clogga Strand Formation	2. Ballinabanoge Member	Gravel derived in part from the underlying till
	1. Clogga Member	Inland stony till, containing granite; non-calcareous; devoid of flint, limestone and marine shells. It has a planated upper surface.

Synge (1977) considers that the Ballinabanoge Member is an Ipswichian beach which corresponds in age with the marine platform along this part of the coast. However, because of its poor sorting and the low roundness values of the gravel clasts, it is more likely to be outwash from the ice that deposited the stony till (Clogga Member). Above are two facies of the Irish Sea till which appear to have been deposited subglacially during the same glacial episode. The stony facies is local in origin, but the clay-rich till is far travelled. Above is the foraminiferal-rich Askintinny Member which could represent either a break in the glacigenic sequence as a marine phase with *in situ* foraminifera, or a part of the glacigenic sequence, reflecting local glacifluvial conditions with foraminifera derived from underlying Irish Sea tills, whose matrix contained interglacial marine sediment. This clastic unit is succeeded by a further Irish Sea till.

The two chronological possibilities are therefore either:

a)
4. Midlandian Irish Sea till
3. Ipswichian marine sediments
2. Munsterian Irish Sea tills
1. Musterian local outwash and till

or

b)
2. Midlandian Irish Sea till/clastics underlain by:
1. Midlandian or Munsterian local till

The Clogga foraminiferal assemblage is shown in Table 1. In all four samples A-D the domínant species are Elphidium excavatum, E. clavatum, Protelphidium anglicum, Cibicides lobatulus and Cassidulina obtusa. The faunal diversity (Walton 1964) varies between 18 - 34 and the faunal dominance between 16.4 and 34.5. The total number of species varies from 24 to 41. There is a predominance of benthic forms although planktonic foraminifera do also occur. The latter are dominated by Globigerina quinaueloba but Globigerinita glutinata are left coiling Globigerina pachyderma are also found. Arenaceous foraminifera are rare, except for one Textularia sagittula in A and two in B, so there is no intertidal marsh facies present. Most of the species occur in the present day Irish Sea and are temperate foraminifera.

There seems to be a mixture of species indicating a shallow shelf environment (E. excavatum, E. clavatum, E. macellum and E. gerthi) of under 20 m water depth and estuarine conditions (A. beccarii, P. anglicum and E. articulatum). Other species, such as C. lobatulus, C. refulgens and P. mediterrensis, required a sea floor environment where they clung to weeds and rocks. Some species, such as C. obtusa and C. carinata have been current transported to the depositional site as they indicate greater shelf depths, while other small species, such as the Fissurina, Lagena, Bolivina, Bulimina and Oolina species also could have been transported. This applies as well to the largely juvenile planktonic Globigerina species. The presence of E. hannai in relative high numbers will be discussed later.

Some species are cosmopolitan in distribution, such as C. lobatulus. Others are cosmopolitan with preference for higher latitude waters (B. marginata, O. hexagagona, O. squamosa) or cool temperate (B. gibba); yet others are southern species close to their northern limits (Q. lata, Q. seminulum, P. anglicum, E. macellum and E. excavatum). Some appear to be close to their southern limit, such as B. frigida.

FORAMINIFERAL SPECIES LIST, CLOGGA

	A	B	C	D
N.	702	256	641	195
Elphidium excavatum	30.3	13.7	34.5	26.2
Elphidium clavatum	17.9	11.3	16.8	14.9
Elphidium macellum	1.1	2.7	°	1.0
Elphidium earlandi	-	-	°	°
Elphidium gerthi	1.0	-	-	-
Elphidium asklundi	-	1.2	-	-
Elphidium articulatum	°	1.2	°	°
Elphidium albiumbilicatum	°	1.2	°	1.0
Elphidiella hannai	°	3.5	1.9	3.6
Protelphidium anglicum	6.4	16.4	15.8	24.1
Cassidulina obtusa	14.4	2.0	3.7	4.1
Cassidulina carinata	°	-	°	°
Buccella frigida	3.8	1.6	°	°
Cibicides lobatulus	5.3	8.6	8.9	13.3
Cibicides refulgens	°	-	-	-
Bulimina gibba	1.0	°	°	°
Ammonia beccarii	-	1.2	°	°
Gyroidina spp.	°	1.2	°	-
Oolina williamsoni	-	2.7	°	1.0
Quinqiloculina seminulum	-	1.2	-	-
Quinqiloculina lata	-	1.2	°	°
Bolivina pseudoplicata	2.0	°	°	
B. variabilis	1.4	°	°	
Globulina gibba	°	-	-	-
Fissurina sp. A. (Haynes)	°	-	-	-
F. marginata	°	-	°	-
F. orbinyana	°	°	°	-
Nonionella spp.	°	°	-	-
Trifarina angulosa	°	-	°	-
Bulimina elongata	°	°	°	°
Miliolinella subrotunda	°	-	°	-
Reussella spp.	°	-	-	-
Dentalina spp.	°	-	-	-
Ammonia limnetes	°	-	-	-
Galevenopsis praegri	°	-	°	-
Lagena semilineata	°	-	-	-
Lagena doveyensis (Haynes)	°	-	-	-
Oolina globosa	°	°	°	-
O. caudigera	-	°	°	-
O. lineata	-	°	-	°
O. squamosa	°	-	°	-
O. acuticosta	-	°	°	-
O. hexagona	-	°	°	-
Globocassidulina subglobosa	°	-	-	-
Spiroloculina spp.	°	-	-	-
Lenticulina spp.	°	-	-	-
Textularia sagittulia	°	-	-	-
Bolivina subaenariesis	-	-	-	°
Bolivina pseudoplicata	°		-	°
Bolivina spathulata	°	-	-	-
Nonion depressulus	°	-	-	-
Fissurina cf. fasciata	-	°	°	-
F. lucida	-	°	°	-
F. Castanea	-	°	-	-
F. elliptica	-	°	-	-
Lagena substriata	-	°	°	-
Bulimina marginata	-	°	°	-
Lagena perlucida	-	°	°	-
Globigerinita glutinata	-	6.6	5.5	3.1
Globiqerina quinqueloba	-	-	°	-
G. pachyderma	-	°	-	°
Planorbulina mediterrensis	-			
Lagena laevis	-	°	-	-
Lagena striata	-	1	-	-
Trifarina bradyi	-	-	°	-
Elphidium crispum	-	-	°	-
Lagena sulcata	-	-	°	-
Pyrgowilliamsoni	-	-	°	-
Fursenkoina fusiformis	-	-	°	-
Nodosariacae spp.	-	-	°	-
Pararotalia spp.	-	-	-	1.0

° Species under 1% of the total

	A	B	C	D
FAUNAL DIVERSITY	19	34	18	18
FAUNAL DOMINANCE	30.3	16.4	34.5	26.2
TOTAL NUMBER OF SPECIES	41	39	39	24

Table 1. Foraminiferal species list, Clogga.

To compare the Clogga samples, similarity indices were worked out. For each species common to two samples, the lowest percentage occurring is taken and totalled to give a similarity index. This ranges from 47 to 76. Values higher than 80 indicate that the samples are nearly identical and lower values indicate increasing differences. However, it is reasonable to suggest that the samples from the Askintinny Member were deposited in similar environmental conditions.

b) Knocknasilloge

The Screen Hills form part of a complex terminal moraine which extends from Wexford to Kilmuckridge and is bounded to the west by the Oulart ridge and to the east by the sea (Huddard 1977). The sedimentary units of which it is composed consist of at least four basal till units and associated sand and gravel sandur sediments. At the base of the coastal sections between Wexford and Kilmuckridge and incorporated into the morainic landforms is an Irish Sea till (the Castleannesley Member) and the Knocknasilloge Member, which is composed of silts and sands. The two units form the Cush Gap Formation, and the overlying tills and outwash sediments form the Screen Formation. The complex stratigraphic succession is simplified in Figure 2a. The Knocknasilloge Member is composed of up to 13.8 m of predominantly grey and olive silts, fine sands and clays, which are deformed into overfolds at Knocknasilloge Gap. The sedimentary features include a structureless, homogeneous grey silt; type 'a' and 'b' ripple drift in fine sand; infrequent bi-polar ripples; parallel laminated grey, brown and olive silt. There are also isolated granule gravel and pebble gravel, with small scale faults and flame structures. Throughout the unit there are thin clay units and irregular clay laminae and lenses. Associated with this fine grained sediment in the basal part of the sequence are seven grey diamicton units, between 6 and 32 cm thick. These thin laterally to the south, have strong microfabric peaks and have been interpreted as flow tills by Huddard (1977). The Knocknasilloge Member merges with the underlying Castleannesley till Member. It is a typical shelly, calcareous, grey Irish Sea till with a fine grained matrix and is relatively stone free.

The microfossils in the silts and fine sands of the Knocknasilloge Member are mainly foraminifera (Table 2) but there are also some ostracoda, including Leptocythere cf. macallana and Callistocythere spp. (Harris pers. comm.). The dominant foraminifera are Elphidium macellum, E. excavatum, Elphidiella hannai, E. articulatum, Protelphidium anglicum, E. clavatum, Civicides lobatulus and Miliolinella subrotunda. The total number of foraminifera species was between 36 and 45, and the similarity index between samples 8S8 and 11S8 was 60. However, the similarity index between 8S8 and Askintinny A was only 28 (Table 3). This value indicates that, although there are many species

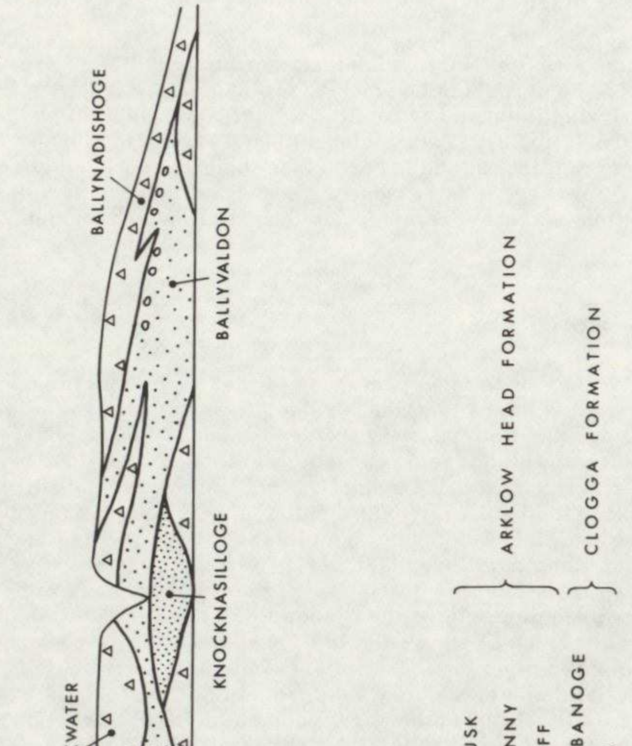


Figure 2. Stratigraphy at Knocknasilloge and Clogga Strand.

common to both, environmental conditions could have been rather different. The dominance of the Elphidae and the presence of M. subrotunda indicate a shallow shelf environment. E. clavatum indicates a water depth of under 20 m, and E. albiumilicatum occurs today in the Baltic and Oslofjord at depths down to 10 m, but is most common between 4 - 6 m. Estuarine indicators include Ammonia beccarii, P. anglicum and E. articulatum. The last today lives in Kiel and Jade Bays in the intertidal zone on sandy flats which are subject to little water movement, and has optimum temperature conditions of between 10 and 15°C and optimum salinity of 29 - 35/mille. A. beccarii has optimum temperature conditions of 15 - 20°C and optimum salinity probably over 10/mille, whilst P. anglicum is ubiquitous in brackish water habitats around the British Isles. As at Clogga there are many small foraminifera which could have been current transported to the depositional site. The high percentage of E. hannai is interesting, as today it is restricted to the west coast of the United States from California to the Canadian arctic islands.

3. Discussion of the foraminiferal assemblages

Although the assemblages from Clogga Strand and Knocknasilloge are slightly different, suggesting rather different original environmental conditions, they do have many species in common. Both are shallow water, slightly brackish, inner shelf, interglacial assemblages. There are no truly arctic species present. From the stratigraphy, the likeliest interglacial would be the Ipswichian. Mixing of adjacent ecological zones in the marine environment seems inevitable (Konradi 1976), and an inner shelf environment close to an estuary mouth seems the likeliest depositional site for both assemblages.

However, we must consider the problem of whether the foraminifera could have been reworked from older Quaternary deposits. Of crucial importance in this is the finding of Elphidiella hannai in significant numbers. This species has been correctly identified (Funnell pers. comm.), but raises several problems. It has not been observed in post-Anglian deposits of the North Sea and South-East England, and it has been assumed that it had disappeared from the North Sea and English Channel as a result of the Anglian glaciation (Funnel pers. comm.). However, reworked samples have been found in intra-Anglian outwash from the Corton Beds of East Anglia and in the Hoxnian deposits of Clacton-on-Sea, and these are the last records of the species in the Atlantic area. It is possible that it persisted into later interglacials nearer the Atlantic proper, though it was not noted in the last interglacial deposits at Selsey (Whatley and Kaye, 1971), the supposed Ipswichian deposits of the Somerset Levels (Kidson and Haynes, 1972; 1974) or the Shortalstown sediments (Colhoun and Mitchell, 1971). It is especially abundant in some pre-Anglian marine deposits, such as the Early Pleistocene of Easton Bavents (Funnell and West 1962), and the question arises could this species have been reworked from Early Pleistocene marine deposits in the Irish Sea area. The faunal list in Table 2 contains many species typical of the early Pleistocene of the North Sea, for example other Elphidae, Ammonia beccarii, P. mediterrensis, C. carinata, Lenticulina spp., Nodosaria spp., Pararotalia serrata, Quinqueloculina spp. and T. sagittula.

FORAMINIFERAL SPECIES LIST, KNOCKNASILLOGE SECTION 8

SPECIES	8S8 N - 1176 in%	11S8 N - 462 in%
Elphidium macellum	33.1	19.5
Elphidiella hannai	18.2	5.6
Elphidium excavatum	11.9	16.5
Elphidium articulatum	9.6	10.2
Protelphidium anglicum	7.6	6.3
Elphidium clavatum	2.8	5.0
Cibicides lobatulus	2.6	2.8
Miliolinella subrotunda	3.8	1.9
Elphidium albiumbilicatum	1.45	*
Ammonia beccarii	1.3	*
Quinqiloculina lata	1.02	*
Elphidium gerthi	*	1.3
Bolivina pseudoplicata juveniles	1.0	1.9
Cassidulina obtusa	*	2.2
Buccella friqida	*	6.7
Fissurina lucida	-	3.7
Globigerina spp. juveniles	*	2.4

	K8 S8
Oolina borealis	*
O. hexagona	*
O. caudigera	*
O. williamsoni	*
O. acuticosta	*
Quinqueloculina seminulum	*
Lagena striata	*
L. substriata	*
Planorbulina mediterranenis	*
Rosalina globularis	*
Lenticulina spp.	*
Ammonia limnetes	*
Triculina trihedra	*
Miliolinella circularis Var elongata	*
Pyrgo williamsoni juveniles	*
Lagena perlucida	*
L. sulcata	*
Oolina melo	*
O. Squamosa	*
O. Lineata	*
Q. bicornis	*
Q. cliarensis	
Spiroluculina juvenile	*
S. cf. S. subrotunda	*
Fissurina marginata	*
Globulina gibba	*
Bulimina marginata	*
Bolivina pseudoplicata	*

	K11 S8
Bolivina inflata	*
B. variabilis	*
Nodosariacae juveniles	*
Oolina glovosa juveniles	*
O. melo	*
O. borealis	*
O. hexagona	*
O. acuticosta	*
O. williamsoni	*
Fissurina trigono-marginata	*
Lagena clavata	*
Guttulina glacialis	*
Lagena perlucida	*
Lagena striata	*
Lagena semistriata	*
Trifarina angulosa juvenile	*
Lenticulina spp. juvenile	*
Elphidium earlandi	*
Nonionella sp. A (Haynes)	*
Rosalina globularis	*

* species under 1% of the total

Faunal diversity 8S8 = 16 11S8=25
Faunal dominance 8S8 = 33.1 11S8=19.5

TOTAL NUMBER OF SPECIES
8S8 = 36 11S8=45

Table 2. Foraminiferal species list, Knocknasilloge section 8.

Clogga		Knocknasilloge
A and C	- 70%	8S8 and 11S8 - 60%
C and B	- 61%	
C and D	- 76%	
A and D	- 61%	Between Clogga A and Knocknasilloge
A and B	- 47%	8S8 - 28%
B and D	- 50%	

Table 3. Similarity indices: Clogga Strand and Knocknasilloge, south-east Ireland.

A further problem is the fact that none of the samples of E. hannai observed here were significantly larger than 250 μm in diameter whereas in the Crag this species regularly approaches 500 μm (Funnell pers. comm.) The small size is not what would be expected of a breeding population, leads one to suspect transportation, reworking and sorting. Today the species grows to larger than 250 μm throughout its range on the North American west coast, but maximum size is reached in least favourable breeding conditions, and it could be argued that small maximum size indicates favourable conditions. A further point is that the pore openings along the radial sutures are biserial in the mature form (Funnell pers. comm.), but in these samples they are uniserial, although this could be a consequence of their small size.

In the Late Pliocene/Early Pleistocene St. Erth deposits Elphidiella hannai forms 2% of the assemblage (Funnell, in Mitchell, 1965). Margarel (1973) did not note the species in newly excavated sediment from St. Erth but twenty-six species out of one hundred quoted by him are found in the Knocknasilloge and Clogga sediments.

It would appear therefore that reworking from early Pleistocene or even older sediments seems a real possibility, especially as reworked Crag type molluscs are known from various sites in eastern Ireland. The Wexford Gravels have long been known to contain a suite of mollusca including some Crag species (Griffith 1835), and Bell (1888, 1891, 1915, 1919) recorded about 100 species of mollusca, including eleven 'Pliocene' species, and maintained that the gravels were pre-glacial. Cole and Hallissy (1914) showed that the gravels are glacial and suggested that the Crag shells were derived from the Irish Sea till. McMillan (1964) made a further study of the molluscs, finding 133 species, but suggested that of Bell's eleven supposed Crag species only five are really Crag. She considered that as a whole the mollusca of the Wexford Gravels have a strongly northern aspect, and the real Crag species form a minute proportion. However, the sand and gravels in which the molluscs are found are sandur sediments (Huddard 1977), so the shells must be derived. Other localities in eastern Ireland, such as Killincarrig, near Delgany, Co. Wicklow (McMillan 1938), Ballinabranagh, Co. Carlow (Cole 1912) and Kill-o'-the-Grange, Co. Dublin (Sollas and Praeger 1895) have yielded characteristic Crag species. Certainly there seems sufficient evidence to postulate a Crag basin in the Irish Sea during the Early Pleistocene, from which later ice advances could rework sediments and included fauna.

The possibility of later ice advances reworking not Crag sediments but later marine interglacial sediments must also be discussed. These sediments are rare around the margins of the Irish Sea, but at Shortalstown, Co. Wexford, Colhoun and Mitchell (1971) described a block of beach gravel and estuarine sand, disturbed by ice thrusting. This lay between two shelly calcareous tills. The fossils clearly indicate interglacial conditions, but record only the opening of the warm stage; the relatively high values of *Ulmus* suggested an Ipswichian age, but this was doubted by Synge (1977). The foraminifera were not described in detail, but an inner shelf environment offshore from an estuary was postulated. The short list has the following species in common with Knocknasilloge: *Ammonia* spp., *P. anglicum*, *E. macellum*, *E. excavatum*, *Q. seminulum*, *B. variabilis*, *Fissurina*, spp. and *O. williamsoni*. Ostracoda supported the environmental interpretation. Clearly the pollen was derived, but if the foraminifera were *in situ* then it is possible that this unit at Shortalstown is the equivalent of the Knocknasilloge member.

Over an extensive area of St. George's Channel Garrard (1977) described two Irish Sea tills separated by last interglacial marine sediments. Preliminary results from microfaunal analysis have shown a rich, dominantly marine boreal assemblage of both ostracods and foraminifera. Brackish water species are rare and make up $< 2\%$ of the total population. It seems possible that this is the offshore equivalent of the Knocknasilloge Member. The glacio-marine unit and its associated cold-water foraminifera and other fauna from Tullyallen, Co. Louth (McCabe and Colhoun 1973) seem to be from completely different environments from the sediments discussed in this paper, though the lower part of the succession with flow till units at Knocknasilloge was interpreted as marine sedimentation in association with ice (Huddard 1977).

4. Conclusions

There are several possible origins of the foraminiferal assemblages recorded from Wexford and South Wicklow:

(a) they were all derived from Early Pleistocene Irish Sea sediments, which were incorporated in Munsterian and Midlandian ice and then reworked into later marine interglacial sediments, glacial and glacifluvial sediments. The mollusca could have a similar history.

(b) Most of the foraminifera could be of Ipswichian age, but Elphidiella hannai and possibly some of the other species recorded from both Early Pleistocene and Eastern Irish contexts were reworked and derived into the interglacial marine sediments. Most of the mollusc species could be interglacial in age with incorporation of the Crag species from older sediment by ice. These were later incorporated into the glacifluvial sediments of the Midlandian phase.

(c) All the species are of Ipswichian age with Elphidiella hannai surviving much later in the Irish Sea and so that it was not until the last glacial phase that this species died out in Europe.

The high percentage of the species (18 - 20%) at some of the sites casts doubt on E. hannai being a reworked species. Hence alternative c) seems the most likely but as was noted earlier the marine Pleistocene of the Irish Sea basin is poorly known and documented and when further deposits are found, particularly under the Irish Sea, further evidence may support one of the other alternatives outlined above. A further approach to the problem is being attempted, that of looking at the foraminiferal content of the Irish Sea tills in eastern Ireland (Huddard in prep.). Macfadyen (1940) has already tried, with little success, to differentiate the foraminiferal assemblages from two Irish Sea tills south of Kilmichael point in north Wexford because Farrington (1939) thought that there was a considerable age difference between the two tills. Nevertheless, this approach has had some success in Denmark (Konradi 1973).

Acknowledgements

I should like to thank Professor John Murray for his help in identifications and for the use of his departmental facilities and research collections at the Department of Geology, Exeter University; Professor B.M. Funnell for discussions on Elphidiella hannai, and the Royal Irish Academy for an award of a Senior Visiting Research Fellowship.

References

Bell, A., 1888. First Report of the Committee upon the 'Manure' Gravels of Wexford. Rep. Brit. Ass. for 1887, 207-11.

Bell, A., 1891. Fourth and final Report of the Committee upon the 'Manure' Gravels of Wexford. Rep. Brit. Assoc. for 1890, 92-3.

Bell, A., 1915. The fossiliferous Molluscan deposits of Wexford and North Manxland. Geol. Mag., 6, 164-9.

Bell, A., 1919. Fossil shells from Wexford and Manxland. Ir. Nat., 28, 109-14.

Cole, G.A.J., 1912. The problem of the Liffey valley, Proc. R. Ir. Acad., 30B, 8-19.

Cole, G.A.J. and Hallissy, T., 1914. The Wexford Gravels and their bearing on interglacial geology. Geol. Mag., 6, 498-509

Colhoun, E.A. and Mitchell, G.F., 1971. Interglacial marine formation and Late-glacial freshwater formation in Shortalstown townland, Co. Wexford. Proc. R. Ir. Acad., 71B, 211-45.

Colhoun, E.A. and McCabe, A.M., 1973. Pleistocene glacial, glaciomarine and associated deposits of Mell and Tullyallen townlands, near Drogheda, Eastern Ireland Proc. R. Ir. Acad., 73B, 165-206.

Farrington, A., 1939. Glacial geology of south-eastern Ireland. Proc. geol. Assoc., 50, 337-44.

Funnell, B.M., 1961. The Palaeogene and Early Pleistocene of Norfolk. Trans. Norfolk. Norwich Nat. Soc., 19, 340-64.

Funnell, B.M. and West, R.G., 1962. The Early Pleistocene of Eastern Bavents. Q.J. geol. Soc. London., 117, 125-41.

Funnell, B.M. and West, R.G., 1977. Preglacial Pleistocene deposits of East Anglia. In Shotton, F.W. ed. British Quaternary Studies, Clarendon Press, Oxford, 247-65.

Garrard, R.A., 1977. The sediments of the South Irish Sea and Nymphe Bank area of the Celtic Sea. In Tooley and Kidson eds. Quaternary History of the Irish Sea, Geol. J. Spec. Publ. no. 7, Seel House Press, Liverpool, 69-92.

Griffith, R. 1835. On the geological map of Ireland. Rep. Brit. Assoc., Dublin 1835, p. 58.

Huddart, D., 1977. South-East Ireland, Guidebook for Excursion A14,X INQUA Congress, 56 pp.

Kidson, C. and Heyworth, A., 1972. Glaciation in the Somerset Levels: the evidence of the Burtle Beds. Nature, 239, 390-92.

Kidson, C., Haynes, J.R. and Heyworth, A., 1974. The Burtle Beds of Somerset - glacial or marine? Nature, 251, 211-3.

Konradi, P.B., 1973. Foraminiferas in some Danish glacial deposits. Bull. geol. Inst. Upps., 5, 173-5.

Konradi, P.B., 1976. Foraminifera in Elmian deposits at Stensigmose, Southern Ireland. Dan. geol. Undesøg. 11, No. 105, 57 pp.

MacFadyen, W.A., 1940. Foraminifera in boulder clays from the Wexford coast of Ireland Geol. Mag., 77, 276-82.

Margarel, J.P., 1973. In G.F. Mitchell and others. The Late Pliocene Marine Formation at St. Erth, Cornwall. Phil. Trans. R. Soc. B., 266, 25-29.

McMillan, N.F., 1938. On an occurrence of Pliocene shells in Co. Wicklow. Proc. Liverpool geol. Soc., 17, 255-66.

McMillan, N.F., 1964. The Mollusca of the Wexford Gravels (Pleistocene), South East Ireland. Proc. R. Ir. Acad., 63B, 265-90.

Mitchell, G.F., 1965. The St. Erth Beds - an alternative explanation. Proc. Geol. Assoc., 76, 345-66.

Mitchell, G.F., 1972. The Pleistocene history of the Irish Sea : second approximation. Sci. Ant. proc. R. Dubl. Soc., 4A, 181-99.

Sollas, W.J. and Praeger, R. Ll., 1895. Notes on glacial deposits in Ireland 11 Kill-o'-the-Grange. Ir. Nat., 4, 321-9.

Synge, F.M., 1977. The coasts of Leinster. In Tooley, M.J. and Kidson, C. eds. Quaternary History of the Irish Sea, Geol. J. Spec. Publ. No. 7, 199-220 Seel House, Press, Liverpool.

Synge, F.M., 1979. Quaternary glaciation in Ireland. Quat. Newsl., 28, 1-18.

Walton, W.R., 1964. Recent foraminiferal ecology and paleoecology. In Imbrie, J. and Newall, N.D. Approaches to paleoecology, Wiley, New York, 151-237.

Whatley, R.C. and Kaye, P., 1971. In Oertli, H. ed. Colloque sur la Paleoecologie des Ostracodes. Bull. Centre RECH Pau-SNAA-5-SUPPL., 311-30.

D. Huddart
I.M. Marsh College of Physical Education
Barkhill Road
Liverpool, L17 6BD.

QUATERNARY STUDIES AT LEICESTER

By R.J. Rice

The best known name among early Quaternary specialists in the Leicester area is probably W. Jerome Harrison who leapt to prominence in the 1950s when Shotton named the East Midland Pleistocene lake in his honour. Harrison was Curator of the Town Museum at Leicester from 1873 until 1879, during which time he published an oft-quoted account of Leicestershire geology that incorporated much information about local drift deposits. He was succeeded at the Museum by Montagu Browne, a zoologist and geologist, who, for the next quarter of a century, maintained the tradition of recording and publishing details of sections in Pleistocene deposits. All modern researchers are greatly indebted to these pioneers, and such of their associates as J.D. Paul and C. Fox-Strangways, for providing a wealth of factual detail about long vanished sections in the Leicester area.

The first half of the present century did not see these early traditions and interests maintained, although it is worth recording that the Bennett Building, which now houses both the geology and geography departments at the University, is named after a local amateur who, in the 1920s, discussed the evolution of the drainage pattern in Charnwood Forest, a topic that can still spark controversy among Quaternary geomorphologists. The foundation of the University College in 1921 did not provide any immediate stimulus to Quaternary studies and it was only with the expansion in higher education after World War II that the modern phase of development began. By the time the University obtained its charter in 1957 the staff already numbered among its members Ann Conolly and Winifred Tutin in the Botany department, Trevor Ford in the Geology department, and Stanley Thomas as Lecturer in British Archaeology in the History department. They were joined in the course of the next two or three years by Frank Oldfield and the present writer who were both appointed to the Geography department. Thus, largely by accident, a group of workers with strong Quaternary interests had congregated at Leicester in the early 1960s. After the departure of Frank Oldfield, the appointment of Francis Synge as a Research Fellow in the Geography department maintained this staffing pattern in the mid-1960s.

In the early 1960s there were no major undergraduate courses specifically concerned with the Quaternary, but the fact that Doug Bridger, Alan Morgan and the present QRA Secretary all graduated from Leicester at this time suggests that Pleistocene topics were not entirely absent from the syllabus. The first step towards formalising the teaching of Quaternary studies came in 1964 when a third-year course of that name was offered by the Geology department to students reading for the Combined Studies Science degree. Since 1964 was also the year in which the QRA was founded, it is of interest to note the range of topics that was included in that initial course: "Glaciology, climatology and palaeontology of the Pleistocene period. Quaternary deposits of the Mediterranean region and Africa. Physical anthropology and the evolution of man; human artifacts". In 1968 the Geography department, as the result of a major syllabus revision, for the first time offered its own version of Quaternary studies as a third-year optional course for single-subject students; it was followed a year later by the Geology department which then made the Combined Studies course available to its single subject students. Throughout the 1970s there were thus two largely independent courses, one offered in the Geography department and the other in the Geology department. The former was taught mainly by the Geography staff, most of the lecturing on physical topics being undertaken by the writer and on biological topics by Nigel Pears. By contrast the Geology course, organized by Trevor Ford, recruited its teaching personnel from a much wider spectrum. It called not only on local University staff drawn from the departments of Geology (John Hudson and the late Peter Sylvester-Bradley), Geography (the present writer), Botany (Winifred Tutin) and Archaeology (the late Stanley Thomas, and more recently Myra Shackley), but also on such outside guest contributors as Russell Coope, Fred Shotton, Theya Molleson and Chris Stringer. Adding together the numbers in the two courses, an average of 15 - 20 students took Quaternary studies each year; of those who later proceeded to a Ph.D. degree and active membership of the QRA, mention may be made of Cynthia Burek, Terry Douglas, Nick Eyles and Brian Whalley. During the last few years more and more of the two Quaternary options have been taught in a single joint lecture course, a trend that may well be accelerated as the Thatcher staffing cuts begin to bite.

On the research side, although the writer can reasonably lay claim to have made the most consistent attack on the problems presented by the Pleistocene deposits of the Leicester area, a task in which he has been greatly helped over the years by Doug Bridger, Terry Douglas and Gill Wood, the outstanding contribution to the general field of Quaternary studies has undoubtedly come from Winifred Tutin. Ably assisted for a number of years by Anne Bonny, in 1979 she received due recognition for her palynological work by election to a Fellowship of the Royal Society and appointment at Leicester to an honorary Professorship. Finally, it is pleasant to be able to return to the starting point of this brief survey by noting that once again Leicester City Museum has a Quaternary specialist at its head in the person of Patrick Boylan.

R.J. Rice
Department of Geography
The University
Leicester, LE1 7RH.

BOOK REVIEWS

Quaternary Palaeoecology. By H.J.B. Birks and H.H. Birks, 1980. Edward Arnold, London. 289 pp. Price: £28.00.

Palaeoecology is the reconstruction of past biota, communities and environments and because of the many problems of deposition and preservation and the fragmentary nature of fossil assemblages such reconstruction is often difficult. Consequently this book should be widely welcomed since it covers the broad spectrum of subjects and disciplines needed in palaeoecological work. It highlights the problems encountered in the interpretation of fossil assemblages and gives a clear picture of the progress that has been made in recent years, especially in the use of numerical methods. The problems and the progress are illustrated by reference to individual studies which are often described and discussed in considerable detail. This sometimes results in a rather jerky episodic style but on the other hand it gives an excellent insight into the various techniques and methods and an invaluable lead into the literature.

There are twelve chapters beginning with the philosophy and principles of palaeoecology, sampling methods and discussion of the sediments that are used. A chapter on plant macrofossils considers, amongst other things, the reconstruction of past communities of the mire succession, both by visual means and by numerical classification. It seems that numerical methods such as cluster analysis are of considerable use for the analysis of macrofossils from peat deposits but of much more limited use in lake sediments. Palaeolimnology is given a brief but by no means superficial introduction. The literature here is vast and this is reflected in the extensive bibliography covering such topics as diatoms, cladocera, fish, chironomids, ostracods, sedimentary structures, palaeomagnetism, organic chemistry and eutrophication. Molluscs and beetles are dealt with in some detail because studies of them have made such important and stimulating contributions to the reconstruction of palaeoenvironments. There is also a brief section on vertebrates.

Because pollen analysis is "the principal technique used to reconstruct Quaternary environments" this is dealt with in considerable detail. There is a section on the construction and zonation of pollen diagrams and an introduction to the use of numerical methods of zonation and of comparison between diagrams. The chapter on pollen production, dispersal, deposition and preservation serves to bring out many of the problems of pollen analysis and the following chapter on the reconstruction of past floras and past plant populations considers the ingenious and often sophisticated techniques that have been developed to overcome these problems. Since the early work of Iversen workers have attempted to quantify the relationship between the number of pollen grains in a sediment sample and the number of parent plants in the vegetation surrounding the site of deposition. This has led to the use of correction factors which can only be determined after extensive study of the relationship between modern vegetation and modern pollen rain. This rapidly developing aspect of the subject is dealt with in detail as is the use of pollen concentration and pollen influx diagrams, which have proved to be of more use than correction factors when interpreting data from large lakes or bogs. Pollen influx diagrams are useful for solving specific problems but the method can be expensive and there is therefore an emphasis on the need for carefully designed investigations. As in the reconstruction of past plant populations, the reconstruction of past plant communities can be approached in a number of ways but the most widely used is, again, the comparison between modern and fossil pollen spectra. Here also numerical methods such as principal components analysis and cluster analysis have proved to be useful tools. The final, rather brief chapter, considers the reconstruction of past environments using all the data available and culminating in the development of transfer functions and the climap project.

Throughout this book emphasis is placed on the advantages derived from the use of numerical methods while at the same time stressing the necessity for sound knowledge of present day ecology. The authors conclude by writing "Although its substance is fossils and sediments laid down long ago, Quaternary palaeoecology, as we have tried to show in this book, is very much an active, living science". They have certainly succeeded and this highly stimulating book can be recommended to all those with an interest in the subject, from undergraduates to research workers.

D.D. Bartley
Department of Plant Sciences
The University
Leeds, LS2 9JT.

The Natural History of Fossils. By Chris Paul, 1980. Weidenfeld and Nicolson, 292 pp. Price: £6.95.

The stated aim of this book is "to discuss the uses of fossils, their shortcomings and strengths and their application to wider aspects of the history of the earth". The nine chapters cover preservation history, evidence from sediments, fossil communities and associations, faunal provinces and continental drift, growth studies, time in geology, faunal succession and evolution, the origin of life and early evolution, and life on land. The later chapters include discussions of the adequacy of the fossil record as presently known, with the conclusion that we can no longer hide behind "the incompleteness of the record every time an awkward fact comes to light", and that sound interpretations of the history of life can be achieved so long as we understand the natural history of fossils, and unravel their preservation history to get back to the original organism.

Books on fossils usually start with a few chapters on general aspects such as what constitutes a fossil, modes of preservation, and the uses of fossils, before launching into detailed accounts of the morphology, classification, relationships and geological history of the various groups. Readers will search this book in vain for such detailed group by group analysis. Although the author does admit that his book will be far more comprehensible to those with some familiarity with different types of fossils and recent forms of life, his only concession to these aspects is a series of 16 black and white plates, illustrating a range of fossils, in the centre of the book. Omission of an introductory chapter on the major fossil groups would be quite acceptable if the book was clearly aimed at a readership already well acquainted with these details. However, such a readership is also surely likely to be acquainted with the rudiments of rock dating (28 pp), sedimentary rocks (34 pp) and plate tectonics (8 pp). Hence I am led to conclude that the book hopes to attract a general readership, with little prior knowledge of geology, as well as those with a sound geological background. So why no general introduction to the pageant of life preserved in the rocks? The only references which would help the general reader to learn about fossil groupings come at the very end of the nine pages of references and further reading. Two of these references are to American books entitled "The History of Life" and the final reference is to David Attenborough's "Life on Earth".

Perhaps this was intentional and references to general texts on fossils, as opposed to the history of life, are excluded because Dr. Paul wishes to stress that fossils were once alive, and thus had just as much "natural history" as trees or whales (other titles in the series). Certainly he has succeeded for me in bringing these chunks of stone back to life, and to this end he devotes half of his first chapter to a discussion of the wide variety of activities which can be deduced from the study of trace fossils. However, the general lack of sub-headings is a little annoying. For instance, "trace fossils" is given in the index nine times, including pp. 26, 30 and 41, though pp.26-41 form a reasonably self-contained sub-section solely concerned with this subject. Chapter 6 does use sub-headings, but then mis-uses them by continuing straight from a 4-page section on "Way-Up Criteria" to a 10-page discussion of "Absolute Dating Methods" with no sub-heading for the latter. Thus the book is not designed for quick reference to particular topics, and so is not really suitable as a standard student textbook.

Unfortunately, neither is it a scholarly discourse on the origin of life, evolution, faunal provinces or palaeoecology. Rather it seems to be aimed at the interested amateur who wishes to progress beyond fossil collecting to complementary reading to those already familiar with the morphological descriptions and stratigraphic palaeontology which still make up the bulk of many palaeontology courses.

In an "Epilogue" the author exhorts us to learn from the archaeologists and "copy the methods pioneered by the late Sir Mortimer Wheeler, of removing all material carefully, collecting everything, recording its location and orientation and leaving only the walls of the pits to record the stratigraphy of the site". This is grand advice - so long as we don't all take it too literally! Imagine the reactions of the residents of Walton-on-Naze if a party of students took this advice on a field trip to study the Red Crag! With antagonism between local residents and hammer-happy geologists only just beginning to be calmed by the relatively new attitudes towards geological conservation, surely the advice should have been to study the fossils and sediments in situ, as far as practicable, and only to resort to total extraction of the evidence if this is vital to a research project? Since this book aims at a general audience, it should be made clear that archaeologists only undertake such excavations under carefully controlled conditions, in propertly organized teams, and with the full cooperation of the land-owners. There is thus a strong case for the inclusion of the Geologists' Association's "Code of Conduct" with every copy of the book.

P.A. Madgett
27 Mardle Road
Linslade
Leighton Buzzard
Beds., LU7 7UR.

FORTHCOMING PUBLICATION

QUATERNARY STUDIES:
Occasional Paper Series, Vol. 1, 1981

This volume of papers is intended to be the forerunner of a series which will present a suitable vehicle for publication of a selection of the thesis work undertaken by members of the M.Sc. course in Quaternary Studies, run jointly by the City of London Polytechnic and Polytechnic of North London. It is anticipated that volumes will be published every two years to coincide with the biennial course structure. The first volume has been edited by R.H. Bryant and J.J. Lowe, and each paper has been fully refereed.

Contents:

Copies, priced £2.50, are obtainable from either the Geography Section of the City of London Polytechnic, Calcutta House, Old Castle Street, London, E1 7NT; or the Department of Geography and Geology of the Polytechnic of North London, The Marlborough Building, 383 Holloway Road, London, N.7. In either case, cheques should be made payable to City of London Polytechnic.

NOTICES

FOSSIL ICE-WEDGE CASTS AND SIMILAR FEATURES

I have recently begun a research project to study the nature and occurrence of casts of ice-wedges, sand-wedges and other thermal contraction features. In order to do this I need to study a large number of these features at sites in the U.K. and I would therefore be very grateful if any member could give me information regarding sections where any features of these types are currently exposed.

Mary B. Seddon
Department of Geography
Univeristy of Reading
2 Earley Gate,
Whiteknights Road,
Reading RG6 2AU.

DETAILS OF FORTHCOMING MEETINGS

CLIMATIC CHANGE IN LATER PREHISTORY

To be held at the University of Durham on March 19th-21st 1981

Speakers will include Professor H. H. Lamb (University of East Anglia), Professor H.-J. Beug (University of Göttingen), Dr. Jan Bouzek (Charles University, Prague), Dr. J.F. van Regteren Altena (State Archaeological Service, Amersfoort), Dr. J.R. Pilcher (Queen's University, Belfast), Dr. M. Bell (University of Bristol), Dr. P.J. Osborne (University of Birmingham), Dr. Helen Keeley (Ancient Monuments Laboratory, DoE), Dr. K.E. Barber (University of Southampton), Dr. M.J. Tooley (University of Durham), Dr. M. Joos (University of Basel).

The Conference will start with dinner on the evening of Thursday 19th March, and finish in the afternoon of Saturday 21st March. Accommodation will be in Hatfield College, Durham. The Conference fee will be £10 including tea and coffee. Accommodation and meals will be £13 per day, with an inclusive residential cost of £36. For further information and bookings please contact Dr. A.F. Harding, Department of Archaeology, 46 Saddler Street, Durham, DH1 3NU.

PROBLEMS OF LARGE SCALE GEOMORPHOLOGY

March 26th - 30th 1981

This is the second London Conference arranged by the British Geomorphological Research Group to bring together distinguished research workers from all parts of the world to consider a theme of geomorphological significance. The meeting is to be held at King's College in the Strand and King's College Hall, Denmark Hill, with accommodation provided at King's College Hall. The registration fee for the meeting is £10 and the cost of accommodation is £10 per night.

The tentative programme of titles and lectures confirmed to date include:
Thursday, 26th March: J.B. Thornes and D. Brunsden (Fundamental Problems in Modelling Large Scale Geomorphological Systems)

Friday, 27th March: A.L. Bloom (Plate Tectonics and Geomorphology) J. Chappell (Neotectonics, Sea Levels and Geomorphology) N.A. Mörner (Sea Levels) A.S. Goudie (The Arid Earth?) K. Butzer (Climatic Change)
Saturday, 28th March: J. Coleman (The Geomorphology of Large Fluvial and Deltaic Environments) D.B. Prior (Large Submarine Landslides) P.D. Komar (Rhythmic Shoreline Forms: The Large and the Small) D. Stoddart (Coral Reefs on the Large Scale) C. Embleton, R.U. Cooke and D.K.C. Jones (Twenty-one Years of British Geomorphology) H. Hagedorn and D. Busche (Twenty-one Years of German Geomorphology)
Sunday, 29th March: D. Coates (Large Scale Subsidence and Geomorphology) U.S. Corps of Engineers (The Management of Big Rivers) U.S. Corps of Engineers (The Management of Permafrost) K. Hare (The Management of Deserts)
Monday, 30th March: M. Sweeting (Karstlands of the World) M. Mainguet (The Sahara) G. Boulton (The Geomorphology of Large Ice Sheets) Dr. Drewry (Antarctica: The Evolution of an Ice Sheet) J. Walker (The Arctic)

Those requiring further details should contact Dr. John B. Thornes, Department of Geography, London School of Economics, Houghton Street, London, WC2A 2AE.

VARVES IN THE SPECTRUM OF TIME

A two-day Workshop on Varves, Ice-cores and Tree-rings will be held at Bedford College, University of London in the near future. A preliminary one-day seminar will be held at the Warburg Institute, University of London on May 1, 1981, in which the current work can be reviewed and plans for the Workshop confirmed. Participation at the Workshop will be restricted to about 50 people and preference will be given to speakers who have analysed replicated or cross-dated series extending over a thousand years. Charts will be available for discussion and comparison from Canada, U.S.A., Greenland Ice Cap, Sweden, Finland, U.S.S.R., Turkey, Central Europe, Ireland, Germany, S. America, Australia and New Zealand. Anyone interested in attending the Seminar on 1st May should contact Dr. D.J. Schove, St. David's College, Beckenham, Kent, England, giving name, address and details, including abstract, of any contribution they may wish to offer on varves/ice cores/tree rings, stating the period in years B.P. that they cover.

BRITISH GEOMORPHOLOGICAL RESEARCH GROUP
3rd POSTGRADUATE SYMPOSIUM

To be held at University of Reading, May 12th 1981

This meeting is being arranged to provide a forum for postgraduates to communicate the results of their research, whether as interim or final reports, and to discuss the many problems associated with postgraduate work. The meeting will consist of a paper session in the morning; a workshop session in the afternoon, which will provide the chance for discussion with Professor J.R.L. Allen, I.M. Fenwick, Dr. J.R.S. Townshend, Dr. J.B. Whittow and Dr. P. Worsley, who will act as advisors; and a Guest Lecture by Professor G.H. Dury. The meeting will be concluded with an informal cheese and wine reception.

Those wishing to present papers should contact Mike Fullen, Department of Geography, University of Hull, Hull, HU6 7RX; and further details about the meeting or problems of accommodation can be obtained from Mervyn Jones, Department of Geography, University of Reading, No. 2 Earley Gate, Whiteknights Road, Reading, RG6 2AU.

SYMPOSIUM ON PALEOHYDROLOGY OF THE TEMPERATE ZONE

Poznań, Poland: 22nd-28th September 1981

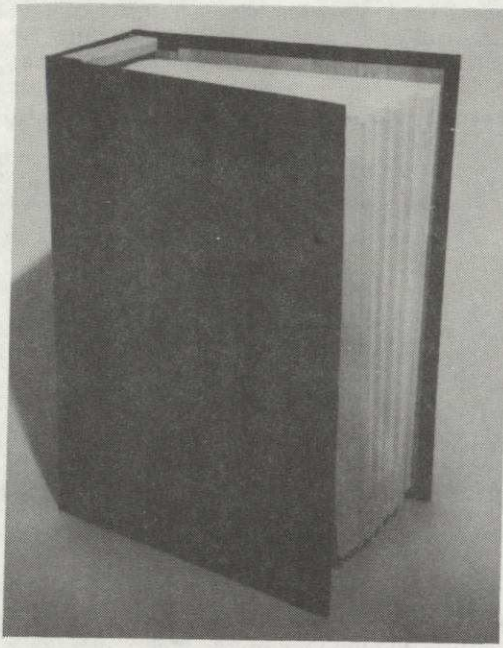
The Eurosiberian Subcommission of INQUA for the study of the Holocene is holding a symposium at Poznań, Poland from 22nd-28th September 1981 with the title "Paleohydrological changes in the temperate zone in the last 15,000 years". Reports and papers summarising the results of work conducted under the direction of IGCP Project 158 (including subprojects on fluvial environments and lake environments) will be published in a special issue of Quaternary Studies in Poland in 1982. These will be presented on 22nd-24th September, and on 25th-28th September there will be excursions to either the basin of the River Warta or to Pomerania and the Baltic coast.

The registration fee for the meeting will be 70 US$, and accommodation at 43 US$ per day will be provided in hotels. Those wishing to attend should write for further details and a preliminary booking form to Professor Dr. S. Kozarski, Adam Mickiewicz University, Institute of Geography, Fredry 10, 61-701 Poznań, Poland, before 28th February 1981.

ADVERTISEMENTS

BINDERS FOR QUATERNARY NEWSLETTER

Several members have mentioned that a binder would provide a most useful way of storing the Quaternary Newsletter. After making a number of enquiries, the most satisfactory product appears to be a very attractive dark-blue hard-backed Easibinder, with Quaternary Newsletter printed on the spine in silver. A single binder which will hold approximately 18 copies of the Newsletter can be obtained at a special price of £3.95 each including VAT, postage and packing.



Anyone wishing to purchase a binder should complete the slip that is attached to the Circular and send it along with a cheque made payable to the 'Quaternary Research Association' to J. Rose, Honorary Secretary of the QRA, Department of Geography, Birkbeck College, University of London, 7-15 Gresse Street, London, W1P 1PA.

CALENDAR OF MEETINGS

February 27th 1981	Annual General Meeting of Irish Association for Quaternary Studies (IQUA) followed by a Seminar on the topic: 'Dating the Irish Quaternary'. These will be held at the Department of Geography, Queen's University, Elmwood Ave., Belfast, from 11.00 a.m. Further details can be obtained from Dr. W.P. Warren, Geological Survey of Ireland, 14 Hume Street, Dublin.
March 19th-21st 1981	International Conference on Climatic Change in Later Prehistory, to be held at the University of Durham. Further details are given in this Newsletter.
March 25th-26th 1981	Geological Society of London/British Geomorphological Research Group. Residual Sediments. To be held at the Geological Society. Anyone wishing to attend the meeting may obtain abstracts and further details by sending an A4 stamped addressed envelope to Miss M. Lewis, Geological Society, Burlington House, Piccadilly, London.
March 27th-30th 1981	British Geomorphological Research Group 21st Anniversary Conference on Problems of Large Scale Geomorphology. To be held at King's College, London. Further details are given in this Newsletter.
April 12th-15th 1981	Quaternary Research Association Annual Field Meeting and Annual General Meeting to the East Midlands, based on Leicester. This is being organized by Dr. R.J. Rice. Further details are given in the Circular issued with this Newsletter.
May 1st 1981	Varves in the Spectrum of Time. A one-day seminar will be held on this topic at the Warburg Institute, University of London. Further details are given in this Newsletter.
May 1st-4th 1981	Quaternary Research Association Short Field Meeting to study glacial and periglacial features in North Wales under the leadership of Dr. J.M. Gray, J. Ince, Dr. J.J. Lowe and S. Lowe. Further details and a Registration Form are given in the Circular issued with this Newsletter.
May 2nd 1981	IQUA, one-day field meeting to Enniskerry Glen, Co. Wicklow. Leader F.M. Synge.
May 12th 1981	British Geomorphological Research Group Postgraduate Symposium to be held in the Palmer Building, White-knights Park, University of Reading. Further details are given in this Newsletter.
May 15th-18th 1981	Quaternary Research Association Short Field Meeting to East Cumbria, under the leadership of J. Boardman, Dr. D. Huddart, J.M. Letzer and J. Rose. Further

	details and a Registration Form are given in the Circular with this Newsletter.
May 27th-29th 1981	South African Society for Quaternary Research. The annual conference will be held at the Transvaal Museum, Pretoria. The main themes will be palaeosol concretions, caves, geomorphology of arid environments. It will be followed by an excursion to the Kimberley district and then by a conference of the South African Association of Archaeologists. Further details can be obtained from the Conference Secretary, Department of Archaeozoology, Transvaal Museum, P.O. Box 413, Pretoria 0001, South Africa.
June 1st-6th 1981	Quaternary Research Association Short Field Meeting to Harris and Lewis, Outer Hebrides, under the leadership of Dr. J.D. Peacock and D. Balfour. Further details and a Registration Form are given in the Circular issued with this Newsletter.
August 17th-21st 1981	Sub-Commission of the International Society of Soil Science. International Working Meeting on Soil Micromorphology. University College, London. Further details can be obtained from Dr. P. Bullock, Soil Survey of England and Wales, Rothamsted Experimental Station, Harpenden, Herts., AL5 2JQ.
August 21st-28th 1981	13th International Botanical Congress, Sydney, Australia. Details of a source of funding for members to attend this Congress are given on page 43 of Newsletter 32. Further details of the Congress can be obtained from Dr. H.J.B. Birks, Botany School, University of Cambridge, Downing Street, Cambridge, CB2 3EA.
September 18th-19th 1981	Quaternary Research Association Study Course to examine: i) basic principles of Soil Mechanics, and ii) Geotechnical problems relevant to Quaternary Studies. Organizer: Dr. M. Paul. Further details are given in the Circular issued with this Newsletter.
September 22nd-24th 1981	Quaternary Research Association Short Field Meeting to Central and South-eastern Grampians and Lowland Perthshire based on Crieff. Leaders: Dr. J.J. Lowe and Dr. M.J.C. Walker. Further details are given in the Circular issued with this Newsletter.
September 22nd-28th 1981	A Symposium on Palaeohydrology of the Temperate Zone, to bring together the results of I.G.C.P. 158, will be held at the Institute of Geography, Adam Mickiewicz University, Poznań, Poland. Further details are given in this Newsletter.
September 26th 1981	Geologists' Association Field Meeting to examine the Thames terrace sequence north and west of London. Leader: C.P. Green. Further details can be obtained from Dr. K.L. Duff, Nature Conservancy Council, Foxhold House, Thornford Road, Crookham Common, Newbury, Berkshire, RG15 8EL.

QUATERNARY NEWSLETTER

No. 33 February 1981

Contents

Compiled and printed for circulation to Quaternary Research Association Members and others by the Honorary Secretary to the Quaternary Research Association, Mr. J. Rose, Department of Geography, Birkbeck College, University of London, 7-15 Gresse St., London, W1P 1PA, England.

ISSN 0143-2826