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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.

DRIFT SEQUENCES OF THE ARDDLEEN DISTRICT BETWEEN WELSHPOOL AND OSWESTRY

By T.R.E. Thompson

Little has been published on the superficial deposits of the area around Arddleen, between Welshpool and Oswestry (O.S. 10 x 10 km square SJ 21), but observations made during a recent soil survey have revealed several interesting features related to the glacial history of the region. The only previous work covers the northern quarter (Wedd et al., 1929) and identifies Lateglacial silts, and glacifluvial sands and gravels in the Llandysilio - Four Crosses area.

Arddleen (SJ 260160) lies in the axis of the Vyrnwy and Severn valleys, 7 km west of their confluence in England at the foot of the most easterly Welsh hills. The area includes the floodplains of the two rivers, glacifluvial terraces of the Vyrnwy, and a large outwash plain at Four Crosses (SJ 270185) formed of tills and glacifluvial deposits and overlying glacilacustrine silts (Fig. 1). Interest centres on this outwash plain and the extent of glacilacustrine silts because of their key positions in any explanation of the glacial history of the district.

The Four Crosses outwash plain has an undulating surface with some larger ridges marked by the outcrops of glacifluvial deposits in Fig. 1. It forms a low fan with its highest points at the mouths of the Sarnau and Vyrnwy valleys to the west and passes under Flandrian alluvium to north, east and south.

In autumn 1977, Wales Gas laid a pipeline across the outwash plain at 2 m depth (Fig. 1) which confirmed ideas developed during the soil survey. The pipeline crosses a gravel ridge at Llandrinio in which the section exposed 1 - 2 m of moderately stony clay loam (Hodgson, 1976) over bedded sands and gravels with a tendency for the gravels to coarsen along the axis of the ridge. Most stones are of Welsh origin. The lower deposit contains ice wedge casts filled with very stony loamy material presumably originating from the upper unsorted sediments. At SJ 286174 layered silty clay loam, with the appearance of varves, floored the trench for a short distance. However, its depth is not known and it may only have been a thin layer within the coarse deposits. Shallow depressions within the ridge contain slightly stony impermeable clay loam or silty clay loam similar to that exposed over wide areas of the outwash plain.

On lower ground north and south of Llandrinio, 1 - 2 m of till rests on either thin sandy gravels over layered silty clay loam and glacilacustrine silty clays, or directly on the glacilacustrine silts. The till is a slightly stony clay loam containing Welsh Lower Palaeozoic sedimentary rocks. Gleyed fissures are present in parts and the base is usually convoluted. The sandy gravels are seldom thicker than 0.5 m and although normally bedded are poorly sorted. Locally they vary from moderately to very stony loamy sand with stones up to 0.1 m.

The glacilacustrine sediments (Fig. 1) consist of bands of silty clay loam alternating with very fine sands with laminations of under 5 mm thickness at depth. The upper 1 m is often contorted and in parts bedding is no longer present. Beneath the outwash plain, the surface of the silts is irregular with sharp ridges and dips suggestive of erosion by water and subsequent slumping. Bodies of gravel occur occasionally within the silty deposits and may result from disturbance following sedimentation. Where it is at the surface, this deposit has a hummocky surface similar to material in the Vale of York (Bullock, P. priv. comm.). The only exposure is in the canal clay pit at SJ 252140 where secondary calcium carbonate is present at 1.5 m as diffuse areas of cemented material up to 30 mm across. The maximum proven thickness of glacilacustrine sediments is 7 m at Neath Brook (SJ 276163) where it floored a deep pipeline section.

To the south of the outwash plain the surface of the glacilacustrine deposits is marked by a zone of ferrimanganiferous coatings and nodules (Hodgson, 1976) where it is in direct contact with overlying Flandrian alluvium from the Severn. The presence of the glacilacustrine deposits to the south of the river at Buttington (SJ 262102) suggests that they may straddle the floor of the Severn valley.

All erratics in the drifts described are of Welsh origin, Triassic rocks only appearing in deposits towards Oswestry, north of the Vyrnwy. The district is well within the limits of the Little Welsh Readvance of Wills (1950),

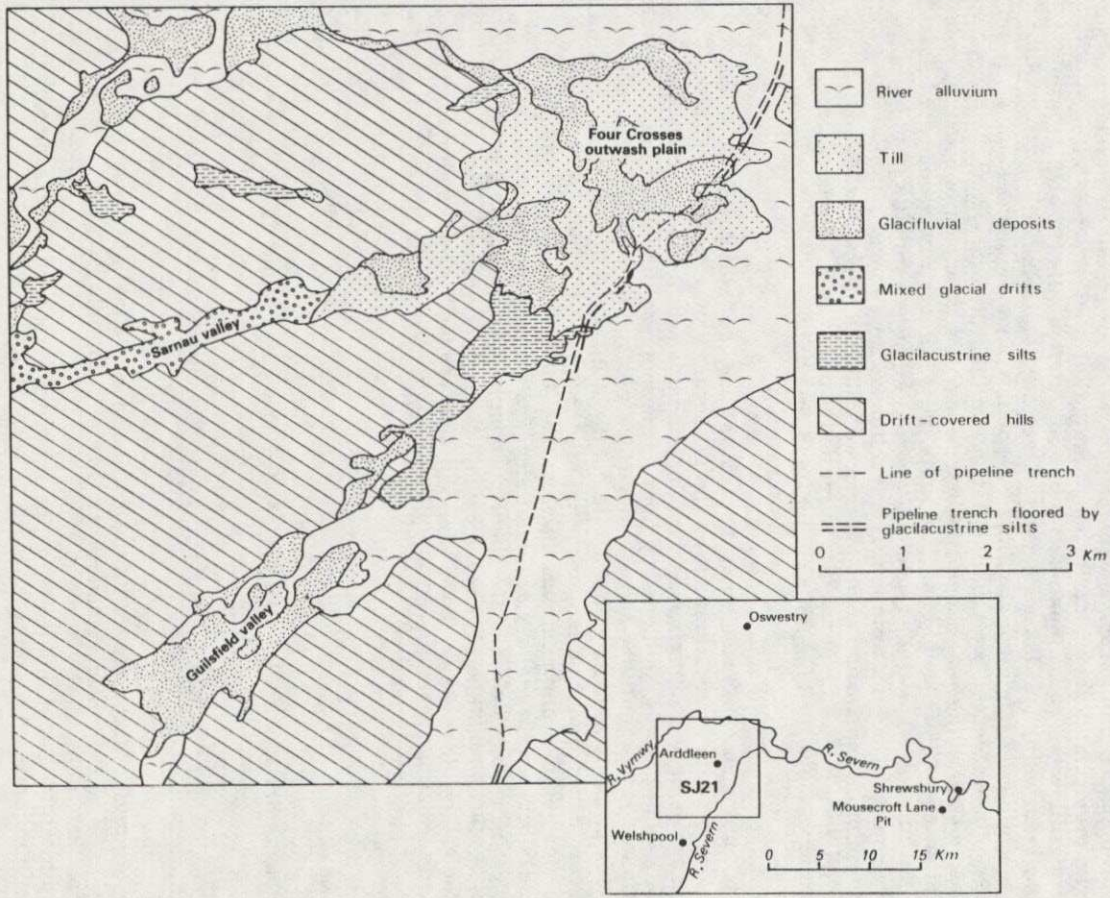

Figure 1. Superficial deposits in the region around Arddleen.

the products of which cover Irish Sea drifts at Mousecroft Lane, Shrewsbury (Shaw, 1971) where glacifluvial sands and gravels containing till lenses are overlain by several metres of uninterrupted till. The sequence there is interpreted as resulting from an advancing ice sheet progressively passing over its proglacial deposits, comprising basal braided glacifluvium followed by lake sediments. The till lenses are equated with flow tills (Boulton, 1968) and the main body of till is considered to have been released by top-melting of stagnant ice. While basal glacifluvial deposits are not proven at Four Crosses, the sequences bear similarities in that thin till covers soft unconsolidated sediments, and glacilacustrine deposits form part of both. The presence of glacifluvial materials above the glacilacustrine deposits is a major difference however, especially where it separates the silts from overlying till. The crests of the major glacifluvial ridges form a downward extension of the maximum heights of terraces within the Vyrnwy and Guilsfield valleys (Wedd et al., 1929) and it is suggested that they may have been deposited deposited in ice-walled meltwater channels (Shaw, 1972).

From the evidence available it is concluded that a large proglacial lake occupied the Four Crosses area and the Severn valley during the Late Devensian deglacierization. The outwash plain is thought to have formed after an ice lobe had moved on to the lake floor. It seems most likely that the major glacifluvial ridges mark the courses of surface meltwater channels while the thin tills probably constitute both in situ melt-out tills and flow tills. However, major questions remain unanswered, not least of which is the origin of the thin gravel and sand aprons that separate glacilacustrine silts and till in places between the major glacifluvial ridges of the outwash plain. The apparently braided surface of the glacilacustrine deposits suggests a subaerial phase. More crucial perhaps is the extent and duration of the proglacial lake and the nature of its eastern boundary. An understanding of this is vital to the interpretation of the Severn and Vyrnwy drainage pattern during part, at least, of the Late Devensian.

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SOME LITTLE KNOWN AND POTENTIALLY IMPORTANT MIDDLE AND UPPER PLEISTOCENE MAMMALIAN LOCALITIES IN ESSEX

By A.J. Sutcliffe, A.P. Currant and K.P. Oakley

In the last number of this Newsletter (28, p.36) attention was drawn by the subsidiary working group of I.G.C. Project 24 considering the problem of "interglacials after the Hoxnian" to the importance of the Ipswich area in Suffolk (which includes the Ipswichian type locality) in future studies on this topic; and to the need to reinvestigate such geographically closely situated Ipswichian and supposedly Ipswichian sites as Bobbitshole, Stoke Tunnel, Stutton, Harkstead and Brundon, in order to determine whether more than one interglacial might, in fact, be represented.

During the course of our routine curatorial work in the Department of Palaeontology of the British Museum (Natural History) we periodically handle collections of unpublished or scantily published Pleistocene mammalian remains, and the manuscript notes associated with them, some of which have been here for over a century; and also bequests of material from more recently deceased palaeontologists, among which are some very interesting items.

Among those which we have been examining recently are notes and specimens related to the apparently Cromerian site of Little Oakley near Harwich, the nearby apparently Hoxnian site of Dovercourt, and a (presumably Ipswichian) site with hippopotamus near Walton-on-the-Naze, all on the north Essex coast. All these sites are situated close to the "Ipswichian" localities mentioned above, from which they are geographically divided only by the River Stour which there divides Essex from Suffolk. It seems to us that these sites could be of quite considerable importance as a basis for resolving a number of problems related to the British Pleistocene sequence; and we would like to place on record here a summary of the information that has come to light in the hope that it may be of interest to

other Q.R.A. members already involved with Pleistocene studies in this neighbourhood, and will stimulate new research.

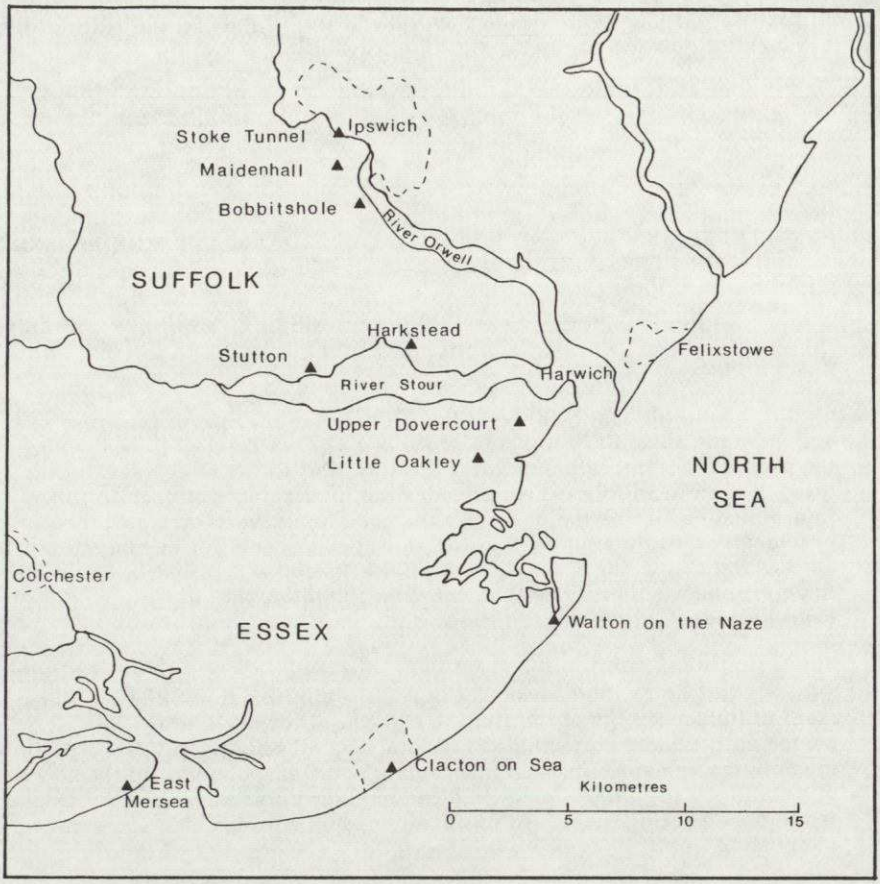

Figure 1. Location of Middle and Upper Pleistocene localities in the Ipswish area.

Little Oakley

Little Oakley is situated about four kilometres south west of Harwich, at about the highest point (23 metres) on the low ridge of land which there separates the River Stour from the North Sea. Fossiliferous deposits, which are of approximately Cromerian age, were first noticed in August 1939

by the late S. Hazzledine Warren who stopped (while motoring through the village) to examine some drainage trenches there. By the time of his visit the infilling of these trenches was unfortunately far advanced and what little remained open was close boarded on account of a treacherous "running sand" which formed the lower part of the deposit, so that he could only infer the general nature of the sequence from dumps of dug material. He nevertheless managed to recover a useful quantity of mollusca and a smaller quantity of mammalian remains. These, together with manuscript notes, are now preserved in the Mollusc and Mammal Sections and Library respectively of the Department of Palaeontology of the British Museum (Natural History). From these notes we can trace subsequent attempts to produce a preliminary report on the site (which it was hoped would lead to a grant for further work there) but, because of the war and Warren's increasing age, no further field work was ever carried out.

The earliest of the manuscripts is an annotated map signed by Warren and dated August 1939 which shows the exact location of the Little Oakley trenches, which are situated near Foulton Hall. Next there is a letter dated February 24th 1941 from A.S. Kennard to Warren, which includes a report on the mollusca. Kennard concluded that the Little Oakley deposit had been laid down by a quick flowing river and was close to West Runton in age. Kennard died in 1948. The next item is a manuscript note by one of us (K.P.O.) dated 1947 observing the occurrence of Kentish chert in the Little Oakley deposits, indicating a Cromerian river of the Thames-Medway system. Then follow four letters, dated 1955-56, from the late A.G. Davies to Warren, in which are discussed the possibility of further work and publication of the Little Oakley site. Lastly, there is the beginning of an unpublished report on the site, entitled "A Cromerian Channel deposit at Little Oakley, near Harwich, Essex" by Warren and Davies. This is mentioned in a Davies letter of January 1956 and was presumably written in 1955. In this paper only the introduction (by Warren) is complete. It includes a description of both the location and nature of the deposits and the important observation that the bottom of the Cromerian channel (which was not seen) was somewhat below 63 feet O.D. (the height of the bottom of the trench). The occurrence of remains of elk similar to the (Alces) latifrons type from the Forest Bed was also recorded. Also planned were reports on the mollusca (by Davies), pollen, erratics and (by Warren himself) a note on the relation of the channel to the proto-Thames drifts.

At about this time the site was visited by Davies and Michael Kerney, though no exposures or surviving spoil were then available for examination. They also visited Harmer's overgrown Red Crag site at Little Oakley, the famous molluscan fauna from which must not be confused with that from the Cromerian channel.

Davies died in 1957; Warren in 1958, so that the hoped for re-excavation of the site never materialized.

There are only a few other events to bring the history of the Little Oakley investigations to the present day. Both Kennard and Davies now having died, the mollusc collection was re-examined by Kerney as part of his Ph.D. studies and his report is included in his unpublished thesis (Kerney, 1959). His present view about the site (personal communication) is that is "definitely pre-Hoxnian". Very recently the deer remains have been re-examined by Adrian Lister, who (personal communication) confirms the occurrence of elk, which he regards as Libralces, a genus common in the Norfolk Forest Bed. The elk apparently then disappeared from the British Pleistocene, reappearing again as Alces in the Flandrian. The Little Oakley collection also includes remains of horse and one microtine tooth.

We know of only two published mentions of the Little Oakley Cromerian site. Both of these are very brief. The first is by Warren (1940). The second is by one of us (Oakley 1943) - "Incidentally, by Mr. Hazzledine Warren's discovery of a Cromerian fauna in deposits at 60 feet O.D. at Little Oakley in Essex is clearly one of the most promising subjects for research in the near future".

Upper Dovercourt

Since the Upper Dovercourt Acheulean gravels were comprehensively published over 60 years ago (Underwood, 1913) it is surprising that this site has attracted so little attention during more recent Pleistocene studies. Hazzledine Warren referred to it in several of his publications (the principal being Warren, 1932) and most of the points recorded here are derived from these two papers.

The site is of special interest here since it is situated very close to Little Oakley and, for purposes of altitudinal studies, can be compared with that site without there being any possibility of the study being distorted by differential land movements. The salient points are (1) the existence of about 4 metres of implementiferous gravel, resting on London Clay and extending up to 87 feet O.D. (2) many late Acheulean implements and (3) some mammalian and fish remains, described by M.A.C. Hinton in an appendix to Underwood's paper. The species listed are "Rhinoceros Megarhinus de Christol" (this would now be known as Dicerorhinus kirchbergensis, or Merck's rhinoceros), elephant, fallow deer and halibut. The implements suggest an approximately Hoxnian age and the sparse mammalian fauna is not out of keeping with such a date.

We have some unpublished information about this site at the British Museum (Natural History). Hazzledine Warren's map of the Little Oakley localities also shows Upper Dovercourt. On it he distinguishes two fields which were rich in late Acheulean implements and an adjacent field where there were no implements. In his 1932 paper Warren states that the gravel pits had long been closed. Examination of a recent map of the neighbourhood suggests that the locality is being increasingly built upon by the spread of nearby Harwich.

Also at this Museum we have three of the mammalian specimens from Dovercourt (parts of two fallow deer foot bones mentioned by Hinton and a cheek tooth of a horse) found among Hinton's collection, bequeathed to us in 1961. All are labelled "Dovercourt Palaeolithic floor 87 O.D.". Two are labelled "Underwood".

Walton-on-the-Naze

The occurrence of fossil bones at Walton has been recognised for a very long time, possibly as far back as the thirteenth century; and there are records that such finds were sometimes attributed to giants. Camden (1806, p.124) refers to an account by Ralph of Coggeshall written about 350 years previously "of the discovery on the sea shore at a place called Eadulfiness of two teeth of a giant so large that they would make 200 teeth of the present species of men"; and Owen (1846, p. 255-6) quotes from Lambard's Dictionary that "In Queen Elizabeth's time bones were found, at Walton, of a man whose skull would contain five pecks, and one of his teeth as big as a man's fist, and weighed ten ounces. These bones had sometimes bodies, not of beasts, but of men, for the difference is manifest".

But we must concern ourselves here only with those remains which still survive or of which there are good scientific descriptions or illustrations. The Walton area was apparently still producing a great quantity of remains during the first half of the nineteenth century. Parkinson (1811, Plate 21, Fig. 1) illustrates a molar of a hippopotamus which he had obtained during one of his visits to Walton. A further, more extensive, collection of mammalian remains was obtained, probably mainly during the 1840's, by John Brown of Stanway; and some of these were mentioned and illustrated by Owen (1846, p. 151 and Fig. 58 (hyaena); 255 (mammoth); 379 (Rhinoceros leptorhinus = hemitoechus); and 401 and Figs. 160-161 (hippopotamus)).

Owen (p. 401) states that Parkinson's specimens were in the Museum of the Royal College of Surgeons. This building was destroyed during the blitz, so that presumably this collection was also destroyed. A considerable part of Brown's collection of fossil mammalian remains, including his manuscript note books and finds from Walton, is preserved in the British Museum (Nat. Hist.). Animals represented include hippopotamus, giant and red deer, ox or bison, narrow-nosed rhinoceros (D. hemitoechus), straight-tusked elephant, mammoth, horse and hyaena (the specimen figured by Owen). Although this assemblage of mammals looks mixed and many come from more than one stratum or more than one locality, there can be no doubt that there is or was an interglacial deposit with hippopotamus, D. hemitoechus and straight-tusked elephant not very far from Walton.

As far as we can determine, this deposit has not produced any remains since the 1850's. Perhaps it has been obscured by sea defences? Perhaps it has all been washed away by coastal erosion? The re-discovery and re-examination of this deposit, if it still exists, could be of some importance. There are a few clues concerning its whereabouts. Owen

(1846, p. 255) states that the village of Walton near Harwich was famous for the remains of mammoth, "which lie along the base of the sea-cliffs, mixed with bones of species of horse, ox and deer". The hyaena jaw (p. 151), however, was "from the till which forms part of the beach at Walton Naze" and the R. leptorhinus (hemitoechus) was from "the till at Walton". It should be noted in this connection that Owen specifically cites "Walton Naze". At the present day Naze refers to the peninsular north of the town of Walton on the Naze. Phillips (1818, p. 7-8) mentions fossil shells found "mingled with sand and gravel, the whole forming a bed 20 or 30 feet thick, lying upon about 15 feet of blue clay" (i.e. London Clay) "in the cliff at Walton Naze", though he does not specifically say that the mammalian remains are from this deposit.

Perhaps some Q.R.A. members who know the Walton district could throw light on the whereabouts of the lost interglacial site at Walton?

Discussion

As part of a much broader study of the British Pleistocene sequence the above three localities seem to us to have been very much neglected and to merit greater attention than they have hitherto received. They are important in relation to the following lines of study.

a) As part of a general study of the British Pleistocene, they fill some of the gaps in the Suffolk-Essex sequence which now gives this region probably the most complete sequence of closely situated Pleistocene sites anywhere in the British Isles. These include, in ascending order, the Red Crag; the probably Cromerian site of Little Oakley; the probably Hoxnian site of Upper Dovercourt; and a whole series of "last" interglacial sites, representing one or two "Ipswichians" according to taste, including the type site of Bobbitshole. Even all this is to make no mention of the glacial deposits and palaeosols of the region (already the subject of intense study) and of the Flandrian deposits there. Three other localities worthy of brief mention are Bryant's and Turner's Hoxnian locality from the top of the cliffs at Walton Naze (Bryant and Turner, two separate notes, 1973); Mill Bay, near Harwich, from which Hazzeldine Warren obtained a mammoth tooth "from beneath Scrobicularia clay" (specimen in British Museum (Nat. Hist.) - someone has labelled it E. trogontherii); and Warren's prehistoric interment about three metres below the present day salting surface at Walton (Warren, 1911).

b) These Essex sites are geographically situated midway between the famous Pleistocene localities of Norfolk and the Thames Valley which have hitherto been studied largely by different people, living in different places, and it is only during relatively recent years that there has been any significant overlap of studies. Increased attention to the areas in between would advance this overlap of interests.

c) The Thames was apparently a London immigrant from East Anglia. Its past behaviour in Essex is of wide interest.

d) All three sites described above have bearing on East Anglian and Thames estuary sea level studies. It has been suggested from time to time that some E. Anglian sites, such as the Norfolk Forest Bed and Clacton, could have reached their present low altitudes by downwarping along the side of the North Sea graben, in which case the Little Oakley and Dovercourt sites at 63 and 87 feet O.D. respectively might both seem unexpectedly high. To what extent should such differences be attributed to land movements; and to what extent to a more complex glacial-interglacial sequence than is usually accepted?

We do not plan to embark on any work at Little Oakley or Dovercourt from this Museum, but we would like to draw the attention, of those who might be intere sted, to the existence of the specimens and records which we have here, in the hope that this may lead to further work at these localities. For a start we have sent Xerox copies of the Little Oakley notes to Phillip Gibbard, Jim Rose, Charles Turner and John Wymer, who are already working in this area.

As an extension of our work on the Thames terrace hippopotamus localities we are very interested in the between-the-tides site at East Mersea, west of Clacton, and we would welcome any available information about the last interglacial deposit at Walton. It has always been a cause of disappointment to those of us concerned with mammals that the mammalian fauna of Bobbitshole was so sparse. We do not know whether hippopotamus would have been represented at that site if a larger collection of remains had been obtained. All other records of hippopotamus in the Ipswich area are therefore of increased interest.

Incidentally, on Camden's 1806 map of Essex, the road bridge over the Belstead Brook near where this river joins the Stour is marked as "Bone Bridge". Is there an extension of the Ipswichian type site, which might produce some hippos, there?

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QUATERNARY GLACIATION IN IRELAND - A COMMENT

By C.A. Lewis

Synge's stimulating paper (1979) raises many interesting problems and reminds one of the Cromwellian saying: 'To Hell or to Connacht.' Some of the grosser misrepresentations in the paper suggest that the former fate may not be entirely inappropriate for its author!

In 1974 I showed that the glacial history of the Dingle peninsula was complex and paid particular attention to the use of erratic material as indicative of former directions of glacier flow (Fig. 1). One of the rock types in the area which form indicator erratics is the distinctive horizon of Devonian conglomerate, known as the Inch Formation. This outcrops from near Minard Castle to the vicinity of Inch, but also runs inland to outcrop at the head of the Derrymore Glen in the Slieve Mish (Fig. 2).

Synge refers to Inch Conglomerate erratics on the north side of the Dingle peninsula and states that they have been transported across the

peninsula. However, in noting the presence of a '.... large (5 m long) erratic of Inch Conglomerate that lies on the shore near Carrigaha,' I argued that it '.... could only have been introduced to its present position by ice from the south over-topping the peninsula or, flowing from the east, commingling with ice from such a valley as the Derrymore on the Slieve Mish (Fig. 1). The latter possibility seems the most likely.' Synge apparently ignores this possibility.

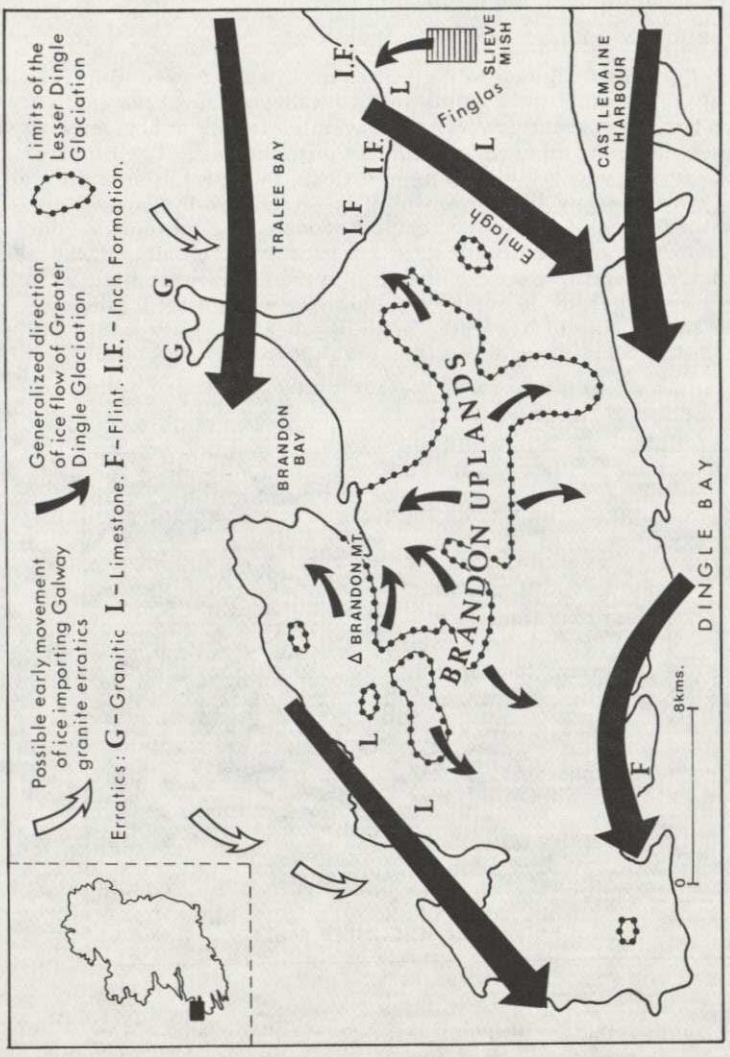

Figure 1. Generalized directions of ice flow in the Dingle Peninsula. The area shown in Figure 2 is shaded. The Inch Conglomerate Formation runs approximately from the headland north of the B of 'Dingle Bay' to the head of the Derrymore Glen (the shaded area).

The reasons for my conclusion are fully stated in the 1974 paper, and involved consideration of the existence of erratics of granite, apparently from the Galway area, and of limestone, on the northern side of the peninsula. Limestone erratics also occur in the Emlagh valley, to the south, and Parkin '.... has also discovered Silurian erratics, from Caherconree or the Derrymore Glen, at Caheracruttera, near Inch. This means that ice from the north..... flowed south towards Dingle Bay,' via the pass at the head of the Finglas valley, although other evidence shows that ice from the south also affected the southern side of the peninsula.

The Inch Conglomerate erratics are also referred to in relation to deposits at the mouth of the Finglas valley, where a gravel fan exists. 'The eastern portion of these gravels .... overlies lenses of boulder clay up to 3.5 m thick, that contain erratics of Inch Conglomerate. The Finglas gravels .... contain occasional granite erratics. Interpretation is difficult, but it appears that a westward movement of ice, transporting Inch Conglomerate erratics, was penecontemporaneous with a movement from the north, importing granite erratics.' I argued that the origin of the Inch Conglomerate erratics was the outcrop in the Derrymore Glen, whence they were transported northward, downslope, by a local glacier, which joined and became incorporated in an ice sheet that surrounded the Slieve Mish and in which there was a general east to west flow of ice.

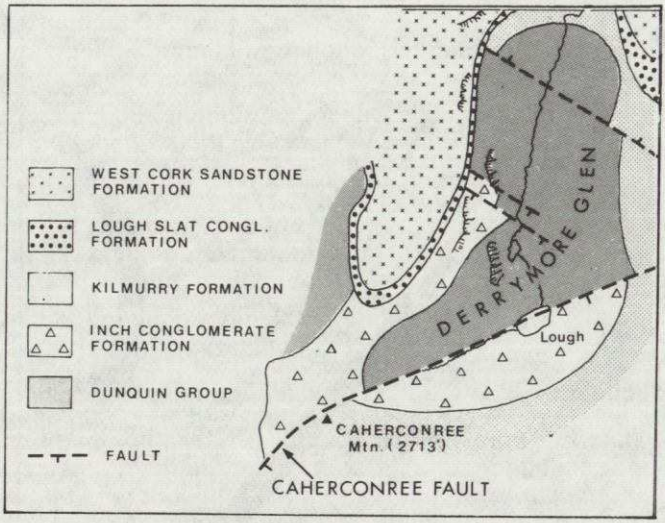

Figure 2. The distribution of Inch Conglomerate at the head of the Derrymore Glen. Source: R.R. Horne, 1976, Geological Guide to the Dingle Peninsula, Geological Survey, Dublin.

Synge writes that 'Boulders of Inch Conglomerate were transported across the peninsula and then deflected to the west by the presence of ice in Tralee Bay.' That statement ignores both Parkin's discovery of Silurian erratics at Caheracruttera and the existence of Inch Conglomerate at the head of Derrymore Glen, and should not, therefore, be uncritically accepted. Furthermore, building upon his previous statement, Synge writes that '.... this evidence contradicts the idea that local ice flowing NE out of the Brandon valley was deflected eastwards towards Tralee (Lewis, 1974).' However, I argued for an advance of local ice, subsequent to the deposition of the Inch Conglomerate erratics, as far east as Carrigaha, and I am of the opinion that the ice responsible for the deposition of the Inch Conglomerate erratics retreated from the area, and 'The Finglas valley became free of ice and a periglacial fan developed at its mouth. Local ice which had existed throughout the period of ice invasion subsequently advanced out of the Owencashla valley to form the .... Carrigaha deposits.' The ice flow to the east, in the Brandon Bay area, reaching the vicinity of Castlegregory, was an even more recent event. It would appear, therefore, that Synge's sentence is a misrepresentation of what I actually wrote, and Synge's verdict on this work is open to debate.

Synge also argues that beach deposits along the south coasts of Ireland, formerly thought to be pre-glacial, are of more recent age. He believes that the Munsterian drifts lying on top of the beach are in secondary position. Such arguments ignore the question of erratic composition in the beach. I have recorded a raised beach underlying drift in the Dingle peninsula, and called it the Dingle Beach. Occasional granite erratics have been noted on the north side of the Dingle peninsula and I have argued that 'Because the beach does not, apparently, contain granitic erratics, it probably predates the glaciation which introduced these erratics to the area. Since there is no evidence for any earlier glaciation it seems the beach is a pre-glacial deposit.' Neither Synge nor any other worker has, as yet, provided acceptable evidence that the beach is of more recent date. Obviously what is required is a detailed examination of the height and composition of the raised beach deposits of our coast, since we are presently caught in a circular argument that is self-defeating.

Finally, to Connacht, if not to Hell. In 1974 I raised the possibility that the Dingle peninsula might have experienced three, rather than two, glaciations. If one accepts Mitchell's (1970) interpretation of the organic deposits on the north side of Tralee Bay as correct, one could argue that 'It is not impossible that .... there was a pre-Gortian glaciation that introduced Galway granites to the area.' Nevertheless, '.... the stratigraphic position of this phase, represented by reworked deposits, is not clear.' Supporting evidence for such an early glaciation is afforded by granite erratics, presumably of Galway provenance, that I have discovered in situ in the lower till at Ballinskelligs Pier, in the Iveragh Peninsula (Lewis, 1977). They have clearly been reworked and incorporated in what is essentially a local deposit. Galway granite erratics occur widely in much of central southern Ireland: in morainic and outwash deposits at Roscrea, for example; even (according to older references) as far south as County Cork.

Although the evidence for an early ice advance from Galway is far from clear, it has traditionally been accepted as of Munsterian age. Synge's paper presents no evidence that contradicts such an interpretation. The Connachtian, if it existed at all, might thus be considered a stage within the Munsterian, rather than a post-Munsterian glaciation. Indeed, since the first really large erratic of Galway granite to be recorded in the province of Munster was that of Fahamore, on the north side of the Dingle peninsula, there is much to be said for calling this the Fahamorian. Or, since granite erratics also exist at Kilshannig, the Kilshannigian? After all, for some people it just seems to be the name of the game that counts! And is it really fair to compare 'the narrow rock-cut valley gorges' of the east and south, with the exposed rias of the south west, with their different sedimentary environment?

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QUATERNARY GLACIATION IN IRELAND
A REPLY TO C.A. LEWIS

By F.M. Synge

With regard to the comments made by Dr. Lewis, undoubtedly the succession of the earlier drifts in the Dingle peninsula is complex and difficult to interpret at this stage, although further work will certainly clarify the position. As far as the Inch Conglomerate indicator erratics are concerned, it would seem that the most likely source for the Inch Conglomerate boulder at Carrigaha is the outcrop at the glacially breached col at the head of the Finglas valley; this site is the nearest source point. If the limestone boulders in the Finglas basin and Emlagh valley are also of southern origin it would give added weight to this suggestion.

If we accept transportation of Galway granite by ice to Watergrasshill not far from Cork city, it is most likely that an early southward carriage also must have impinged on the north side of the Dingle peninsula. The subsequent E-W or W-E movement across north Kerry could belong to an entirely different glaciation. A movement from west to east along the north edge of the Slieve Mish would not produce limestone erratics and would be expected to be associated with kame terraces and lateral moraines pitching east - but as we do not know the direction in which these terraces pitch this theory cannot be confirmed or rejected. Further west, on the opposite side of the postulated ice divide, movement would be, of course, towards the west.

If carriage of Inch Conglomerate boulders occurred down Derrymore Glen by local glaciation while there was a general ice movement from the east we would expect to find clear evidence for similar movements in the southern glens; this, however, is not the case. Limestone derived from the early southerly movement has nowhere survived along the northern flanks of the Slieve Mish; only the silicified variety but not the fresh limestone occurs. This is another reason for regarding the limestone erratics of the Finglas valley and Emlagh valley as being derived from the later northerly carriage across Dingle Bay from Inveragh. Later, when the northern component of this ice sheet waned, the ice shed shifted further west so that local ice from the Brandon region was deflected east to the vicinity of Castlegregory. A similar movement out of the Owencashla reached Carrigaha, according to Lewis (1974), and Fenit according to Mitchell (1970).

Regarding the Dingle Beach, it should be noted that the absence of Galway granite in this formation is hardly surprising considering its rarity in the surrounding drifts. Far more significant is the uniform height and similar form of this beach in widely scattered sites. Because of its mode of origin great variations in composition are to be expected - in places it is derived from glacial drift, while in others the pebbles are eroded from the local bedrock. The very widespread occurrence of a beach similar in aspect and height that has been dated to the Last Interglacial on both sides of the English Channel seems too much of a coincidence to be dismissed lightly.

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A TOOTH OF EQUUS cf. SPELAEUS GALLICUS PRAT (1968) FROM THE COTSWOLDS.

By P.F. Whitehead

The tooth, a right M3 (Figure 1) was found in November, 1978 at SP 112343 by Mr. and Mrs. D. Hadden of Little Comberton, Worcestershire. It was picked up on the surface of a ploughed field . At this spot the soil is weakly developed over the Inferior Oolitic limestone of the Cotswold plateau and the tooth contains traces of reddish silty clay. The bivalve Pholodomya fidiula is an abundant fossil derived on the ground surface. The tooth is now in the possession of the finders. In due course it is envisaged that coloured prints will be lodged with the Department of Palaeontology in the British Museum (Nat. Hist.).

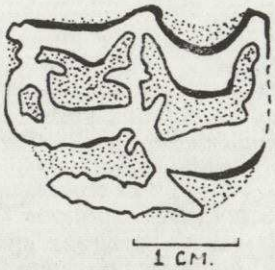

Figure 1. Occlusal view of a right M3. Cement is shown stippled, dentine white, and enamel black.

Description

Although slightly damaged, the roots were not closed at death. The biting surface is completely occluded suggesting an age at death of perhaps 6-10 years. The tooth is 69 mm long and the dimensions of the occlusal surface can be gained from the figure. Doubling of the styli is not very prominent with the exception of the metastyle, but the interstylar surfaces particularly between the meso- and parastyle are markedly concave. The enamel varies in thickness from 0.3 mm where it defines the cones, to about 1.3 mm between the styli.

My belief that the tooth may possibly be pinned down to species level hinges on the relatively long elongation of the protocone. It is 14.0 mm long and occupied 60% of the occlusal length, showing numerous minor convolutions. The enamel is creamy buff with some localised black stippling and rootlet impressions. Much of the buff coloured external cement has been lost. The tooth is highly calcified and I can see no objection to regarding it as fossil.

Discussion

What makes the find remarkable is that it should have been picked up on a modern land surface. Any attempt at dating is therefore fraught with

difficulties. In such a situation and position it seems unlikely that the tooth could have remained intact during prolonged cold climate weathering. Any horses bearing the name E. spelaeus cannot, as far as I know, be older than Lower Devensian, and on this basis a date for the tooth of between 70,000 and 10,000 years B.P. becomes a possibility. In my view, considering this evidence and the occurence on the modern land surfaces of some Late Upper Palaeolithic and many Mesolithic scatters, it is more probable that the tooth is from between 8,000 and 15,000 years old, but this cannot be proven.

It is not clear when wild horses became extinct in Britain. Mr. Don Bramwell has recorded horse in a Staffordshire cave layer dated to about 11,000 B.P. (Stuart, 1977). There certainly would be no ecological grounds for objection in supposing that the Cotswold plateau (and other upland areas in Britain) provided a refugium for wild horses during the closing stages of the Pleistocene and early Holocene. (A right M2 of Equus (cat no. 1, author's collection) found embedded in outcropping Lower Lias clay at Hampton (SP 018435 in July 1970 is clearly ancient but not from a demonstrably wild animal).

Nomenclature

There is a very low level of agreement on Eurasian members of the genus Equus. The problem revolves around the identity and relationship of E. ferus Boddaert (1785), E. przewalskii Poljakow (1881), and E. spelaeus Owen (1869). Some claim that E. ferus and E. przewalskii are synonymous, E. spelaeus on the basis of its very robust metapodials is evidently distinct from both; the subspecies of occidental Eurasia is the one with the elongated protocone.

I have previously (Whitehead, 1977) hung mid-Devensian horse teeth on the handle of E. ferus, but the opportunity for more detailed observation and description still eludes me. From gravels of Avon No. 2 terrace I currently recognise one species of horse, and robust metapodials from its Carrant Main terrace correlative have affinities lying with E. spelaeus. My earlier claim for Hydruntinus sp. (Whitehead, 1977) is no longer applicable. The slender and clepsydra-shaped metacarpal on which it was based (cat. no. 1310) I now regard as belonging to a juvenile horse.

Acknowledgements

I wish to thank the finders for bringing this tooth to my attention and Professor F.W. Shotton for some helpful suggestions.

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THE TYRRHENIAN OF TUNISIA

By R.W. Hey

During April, 1979, the INQUA Subcommission on Mediterranean and Black Sea Shorelines visited Tunisia, to examine the Tyrrhenian shorelines of the country and their associated sediments. These have recently been studied in detail by R. Paskoff, of Tunis, and P. Sanlaville, of Lyon, in close collaboration with a number of Tunisian specialists.

The term Tyrrhenian was first applied by Issel (1914) to marine Quaternary deposits in the Mediterranean region with a fauna which includes, in addition to normal Mediterranean species, a group of species no longer living locally but still surviving on the Atlantic coast of Africa, from Senegal southwards. This is the so-called Strombus fauna, named after its most conspicuous member, the large gastropod Strombus bubonius Lamarck. Its presence in the Mediterranean clearly denotes temperatures higher than those of today, and indeed it is commonly found in assocation with high-level shorelines, long recognised as marking interglacial or interstadial eustatic maxima.

Recent work suggests that the Strombus fauna is associated with three or four such maxima, the earliest dating from about 200,000 years ago, the latest from about 80,000 (Bigazzi et al., 1973; Butzer, 1975). Radiometric dates, however, are few, and neither the ages nor even the number of the Tyrrhenian transgressions can yet be regarded as certain.

Moreover, where no radiometric dates are available, it is still impossible to identify the deposits of any particular maximum, a matter of some importance to archaeologists as well as geologists, for the Tyrrhenian shorelines are often associated with palaeolithic remains. At one time, elevations above present sea-level were widely regarded as a reliable means of identification. Altimetric identifications, however, are now looked upon with suspicion, since it is becoming increasingly doubtful whether any part of the Mediterranean coastline is tectonically stable (Hey, 1978). Again, distinctions based on differences between "full" and "impoverished" Strombus faunas have often been proposed and are often locally valid, but none seems to be applicable throughout the entire region.

Tyrrhenian deposits and related geomorphological features are to be found on almost all parts of the Tunisian coastline. This coastline is more than 800 km long and is highly varied both geologically and topographically. It is therefore remarkable that the Tyrrhenian succession remains much the same throughout its length. Three distinct marine transgressions are recorded. The deposits of the latest, the Chebba Formation, contain an abundant and typical Strombus fauna and are further characterised by coarse and poorly sorted conglomerates, implying a plentiful supply of clastic debris. The deposits of the second transgression, the Rejiche Formation, also contain a Strombus fauna but differ from those of the Chebba in being finer grained and in containing abundant ooliths, presumably derived from some nearby area of warm shallow sea. Those of the first, the Douira Formation, consist largely of shell-fragments, and although they have not yet yielded a true Strombus fauna there is evidence that they are not much older than the Rejiche.

The visitors were shown slickensided fault-planes in the Rejiche Formation near Monastir, and an anticline and several thrust-planes in the same formation near Bizerta. They were told that evidence for very recent tectonics was in fact widespread along the Tunisian coast, which was therefore unlikely to provide any exact information about Quaternary eustatic sea-levels. They were also told that no reliable dates were yet available for any of the three formations, and that their climatic implications were still imperfectly understood.

Nevertheless, the fact remained that the three were clearly distinguishable from one another by their lithological features alone, and it was generally agreed that these features must in some way be related to climatic conditions. This raised the possibility that the various Tyrrhenian transgressions might be similarly identifiable elsewhere in the Mediterranean, even in the absence of radiometric dates or diagnostic fossils. Dr. Sanlaville pointed out that the Tyrrhenian succession of the Lebanese coast had indeed some features in common with that of Tunisia, and other members of the party suspected that the same could be said of the successions on parts of the Italian and Spanish coasts.

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QUATERNARY RESEARCH ASSOCIATION STUDY TOUR TO MALLORCA December 1978

By N. Rose and J.K. Maizels

In anticipation of warmer weather and a selection of new Quaternary environments, 20 members and friends attended the Q.R.A. Study Tour to Mallorca in December 1978. Although the weather failed to live up to expectations the party benefitted greatly from the efforts of Dr. H.A. Osmaston, Dr. K. Crabtree and Mr. J. Rose in directing us through the Quaternary maze present on the island. Special thanks must go to Dr. Juan Cuerda Barcelo whose long established interest and intimate knowledge of the Quaternary history of Mallorca not only amplified the site descriptions presented in the guide book, but stimulated wide ranging discussions throughout the tour.

Attention was focussed on the variety of marine and terrestrial deposits associated with a complex series of sea level changes throughout the Quaternary, exposed around the coastline. In addition, visits were made to study the Karst limestone landforms of the western Sierras, archaeological excavations at Deya and Valldemosa, channel infill in the Sierra de Norte and, by an adventurous few, the relict periglacial phenomena on Puig Mayor.

Background

The main body of work on the shoreline stratigraphy of Mallorca has been carried out by K.W. Butzer and J. Cuerda

(Butzer and Cuerda, 1962; Butzer, 1975). At present the stratigraphy has been resolved into a series of 6 littoral and 6 terrestrial hemicycles which have been dated from their biostratigraphy and with the aid of a number of thorium/uranium series radiometric determinations. Multiple sea level oscillations characterise each stage so that the altitudinal correlation of beach and platform remnants is unreliable. Furthermore, molluscan assemblages must also be treated carefully as Strombus extends over 100,000 years, whilst Patella ferruginea probably extends over a longer period. In addition, tectonic activity has caused tilting and warping to occur on lower Pleistocene beaches, and upper Pleistocene beaches appear to have been displaced in common with similar shorelines elsewhere in the Mediterranean (Hey, 1978).

Shorelines above present sea level are generally found as benches cut into older deposits or bedrock with raised beach deposits resting upon them, whilst sea levels below present are inferred from a regression sequence of sediments and palaeosols. Aeolianites in particular are considered to represent periods of sparse vegetation cover with large volumes of material available for redistribution from the adjacent sea bed. The inference therefore is for periods of relative coldness, with a low eustatic sea level. Warmer, moister conditions subsequently permitted more effective pedogenesis and accelerated geomorphic activity with a diminution in the supply of sediments. The major depositional sediments are colluvial silts derived from landward sources and laid down in dune slacks and on dune surfaces. This environment suggests that the glacioeustatically controlled sea level was less depressed than during aeolianite formation.

Site Visits

A number of sites were visited, mainly on the southern coast of the island, which together demonstrated the range of depositional environments present in the Quaternary. The southwestern sector of the island, with the main sites between Paguera and Magaluf, has a number of coastal sections in which colluvial silts occur up to 2.5m above present sea level, and are then overlain by beach deposits. At Paguera a shell-rich beach conglomerate overlies colluvial silts resting on a wave trimmed platform in Oligocene limestone bedrock. The faunal assemblage within the beach, which grades to sea level from +2.5m indicates an Eutyrrhenian date. The beach is then overlain by cemented dune sandstone regarded as last glaciation in age. The junction between the raised beach and basal red colluvial silts is very marked, this feature being common in many sections and representing a radical change between terrestrial and marine depositional environments.

At Penyes Rotjas, beach deposits and aeolianites are banked against a 30m high sequence of continental deposits. Rhodenburg and Sabelberg (1973) have conducted an intensive study of this succession and have identified 6 cycles of deposition in a sediment trap which has been continually downwarping throughout the period of deposition.

Each cycle of sedimentation commences with a soil horizon above which rest a number of beds of well-rounded gravels with interbedded silts and poorly developed soil horizons. The topmost deposits in each cycle are weakly bedded dune sands. The whole succession rests on tectonically warped conglomerates, clearly much older than the overlying sediments. The section is truncated at the southernmost point by a relict marine cliff against which later screes are banked and subsequently covered by Wurm dunes. This part of the exposure appears to have been significantly altered since the work of Rhodenburg and Sabelberg, being removed or disturbed during further marina development. An interesting junction between well-rounded well bedded gravels and the surface of an older scree slope defied placing in the literature model, despite the wealth of experience gathered below it!

The Penyes Rotjas site is possibly the most significant exposure of terrestrial deposits of Quaternary age on the island. Cycle B, with its base at 55m can be related to the classic transgression/regression cycle of interglacial/glacial sea level alteration. The relict marine cliff at the southern end is considered at least Eutyrrhenian in age (T II in older nomenclature) with the topmost cycle F not later than the last interglacial. The whole succession therefore predates this time.

The most important shoreline succession on the island is found at the Coll d'en Rabassa, at the centre of the Bay of Palma. Unfortunately, discussion here is limited to two or three minute periods between aircraft taking off from the adjacent Palma Airport!

The base of the succession is a cemented dune sandstone of Riss age, at least 20m thick, and which continues below sea level. This has obviously formed when sea level was considerably below the present day level. Landform evolution continued with infill between dune forms of fine grained red colluvial silts with abundant calcareous nodules indicating a warmer drier climate. The land snail Mastus pupa is the key stratigraphic indicator of this formation, when sea level was probably slightly lower than at present, during the Wurm II period. Beach deposits related to a sea level 3 - 4m above present level contain the important Strombus bubonius in a complete Senegalese faunal assemblage, typical of the Eutyrrhenian period. In many exposures at Coll d'en Rabassa the faunal list indicates a littoral environment, usually on a rocky foreshore. This raised beach grades inland into an impressive aeolianite formation. Continual wave activity related to past and present sea levels has produced a number of small notches and platforms with displaced blocks of older sediments and collapsed cave roofs. subsequently becoming surrounded or infilled with deposits of a later age, such as cemented beach deposits or aeolianites. The youngest beach of cemented marine sands and fine gravels lies at a maximum elevation of 2m at San Masson, at the easternmost limit of the area. Although a few scattered fragments of an early Neotyrrhenian beach, with Mytilus senegalensis and Tritonidea viverrata remain, the major formation is of a slightly later age, extending from present sea level to a maxumum height of 2m, and is considered to have formed about 70,000 years B.P.

The sections visible on this length of coastline, together with the impressive exposures of aeolianite seen in a series of quarries some 300m inland are probably the best on the island for use as teaching sites. Also of great interest are the erosional coastal landforms displayed on the coastal edge, with undercut faces and a presently evolving shore platform.

The rocky coastline to the south east of Arenal, includes several sections with raised beach deposits resting on platform fragments which are presumably wave cut. Some observers, however, were doubtful about this explanation for all of the surfaces, as many may possibly be explained by lithological changes. The westernmost sections have old pale pink cemented dune formations, possibly Mindel in age at and below present sea level. A wave cut platform between 5 and 5.5m in altitude is cut in a strongly cemented red sandy marl resting on the old Mindel dunes. Further dunes, possibly Riss in age overlie the marl formation. A further bench cut in the Mindel dunes between 1 and 2m above sea level supports raised beach deposits with Strombus of Eutyrrhenian date above which a brown steeply bedded dune sandstone has Mastus pupa shells in an upper soil formation and is dated as early Wurm. A more strongly red coloured dune, 0.5m thick, then follows, believed Wurm II in age, whilst a Neotyrrhenian beach of fine sands and small well-rounded pebbles, containing Arca plicata is banked against this dune, with the base between 2 and 2.2m.

Bench features cut in marine Miocene limestone and in aeolianites have been identified at a number of altitudes along the southeast coast of the Bahia de Palma. Most extensive is a 6.5m platform, but Eutyrrhenian raised beach deposits have been found at 3m, 7m and 10m, considerably higher than at Arenal. A higher beach of the same age is at 12m at Cap Arenal.

South of Lluchmayor, at Cala Pi, beaches also occur at relatively high altitudes. The Miocene bedrock is wave cut at 15m to form a wide platform on which are found beach remnants of Palaeotyrrhenian and Eutyrrhenian age, together with aeolianites and pink sandy marls. Most significant at this location is a fragment of raised beach resting on gently sloping limestone at 22m which was discovered by Dr. Cuerda during the field meeting. This was identified as the first Eutyrrhenian beach at this altitude in Mallorca.

Also noteworthy at the adjacent Els Bancals site is evidence for a major drainage realignment of the torrent which now flows into Cala Pi. Cemented rounded gravels on a coastal bench at 14m are found in two minor channels now overlain by aeolianite. These are believed to be the former courses of the torrente, the course of which has been subsequently realigned through tectonic activity, or due to dune formation blocking its original seawards exit.

A number of platforms have been identified on this stretch of coastline, many of which seem to have a marked gradient along their length.

In particular, the 12m and 15m benches appear to grade into one another, and may possibly represent a lithological surface rather than two discrete platforms. Without doubt, a 4m platform supports a Eutyrrhenian raised beach, and a constant altitude 1.5m bench exists lower down. Pliocene shells rest on a surface at 18m, and are overlain by early Pleistocene sediments, whilst a Patella ferruginea rich fauna in beach deposits at 13m is considered as Plio/Pleistocene in age. The complexity of this area, with a multitude of small beach fragments at a number of differing altitudes is very evident, and presents a great problem in interpreting the sequence of evolution.

Shorter visits to other coastal sites, including a Roman quarry in thick Pliocene shell beds at Vallgornera, were also carried out. At Puerto de Estellenchs, red Triassic crossbedded sandstones have been truncated by a wide, deep valley which was subsequently infilled with torrent gravels, which interdigitated with slope deposits at the valley sides.

Dr. Osmaston ably demonstrated solution processes around Lluch, aided by the heaviest rainfall of the week ! Despite the number of opinions expressed, the problem of step formation within the larger karren remained unsolved. They do, however, provide a convenient route to the top of the outcrops !

Dr. W. Waldrens' archaeological work around Deya and Valldemosa provided a "down the hole" opportunity for certain members to examine some 80,000 years of sedimentation, and in so doing to emulate the activities of some 2,000 Myotragus balaericus (Fig. 1), who perished in a natural trap at Sa Muleta !

An attempt was made to examine some of the relict 'periglacial phenomena' described by Butzer (1964) on the side of Mallorca's highest mountain, the Puig Mayor (1445m). The southeast slope of the Puig Mayor is bounded by the Torrellas valley, tending SW-NE at an altitude of about 900m; it is divided into two longitudinal sections by a marked 'saddle' comprising bedrock outcrop and weathered boulders. The floor of the valley to the southwest of the saddle is broader and lies at a higher altitude than the valley extending to the northeast of the saddle. Butzer described a number of 'true periglacial phenomena' from the Torrellas valley, including semicemented and partly sorted talus fans and block streams, a solifluction lobe 50m long forming a terrace feature and comprising alternating beds of cemented silts and coarser subangular debris northeast of the saddle, and a cryoplanation terrace across a Lias-Burdigalian subhorizontal junction southeast of the saddle.

Southwest of the saddle there appeared to be a conspicuous talus fan which, towards the foot of the southeast-facing valley side slope, truncated a series of intersecting lobe-like features. The poorly drained 'cryoplanation terrace' was identified as a conspicuous and wide valley side

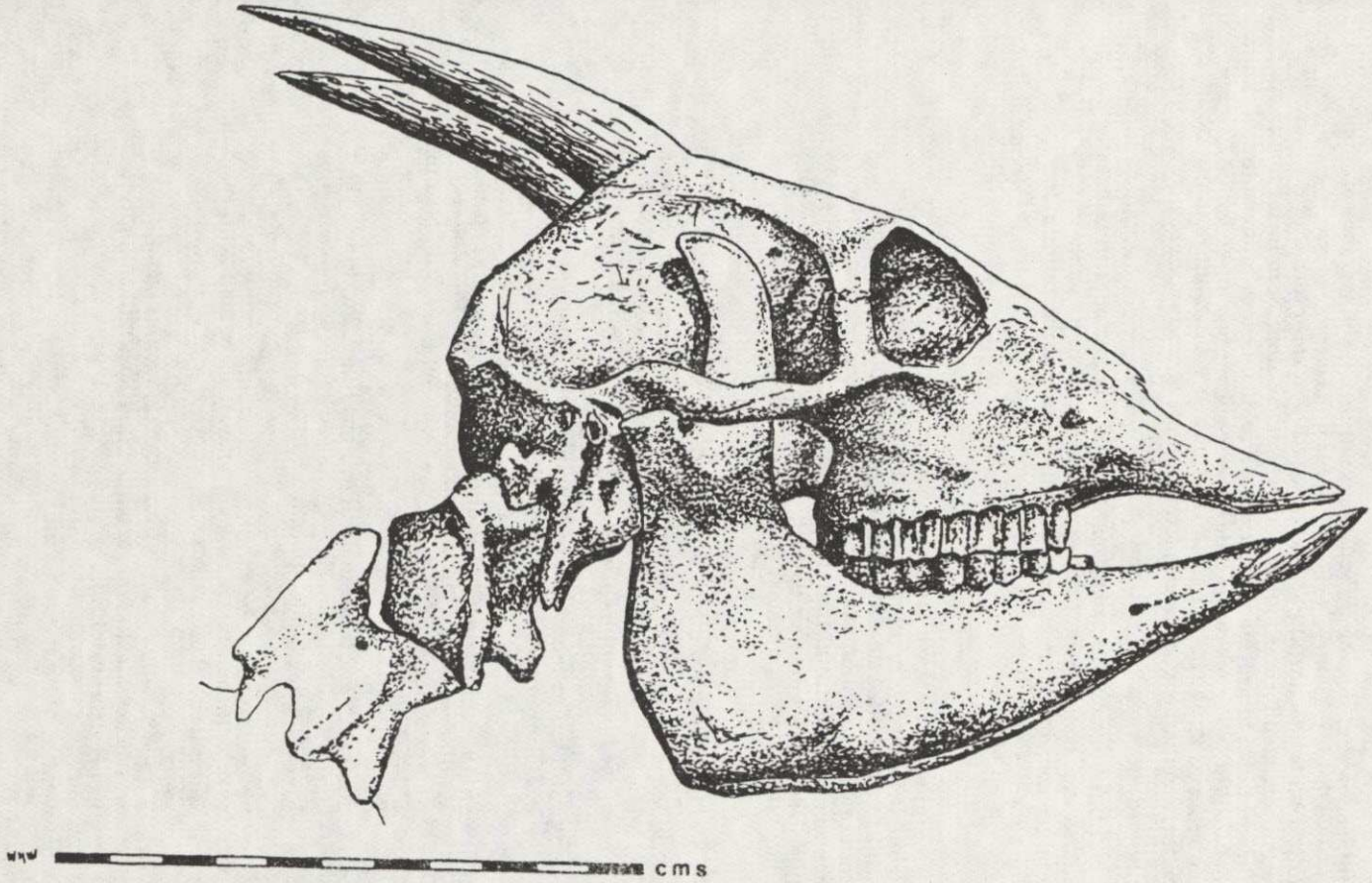

Figure 1. An articulated example of the cranium, mandible and 7 cervical vertebrae of Myotragus balearicus.

rock cut bench feature, dipping towards the southeast. The terrace appeared to be a clear structural feature, probably eroded by rivers, but not necessarily under a periglacial regime; it appears to represent a structurally controlled former valley floor which has since been incised on its northwestern side to provide the narrow gorge-like course followed by the present torrent. The northeast side of the saddle was marked by a distinctive break of slope, the origin of which was attributed either to the end of the 'solifluction lobe' or perhaps to the limit of headward erosion.

Unfortunately, no sections of 'solifluctoidal congelifracturbates' were available for examination. The consensus of the party on the 'periglacial phenomena' of the Torrellas valley was that the valley side slopes did exhibit some signs of mass movement activity, but the party was not convinced of its periglacial origin.

The wealth of the island's geomorphology is certainly very impressive. It is surely one of the most convenient locations for British universities to carry out student field-work. Although the shoreline sequences are very complex, they provide a necessary contrast to the usual environments studied in Britain. The limestone scenery presents a variety of landforms within a relatively small but easily accessible area, and the tourists need be no problem if dates are chosen carefully.

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IGCP PROJECT 24
QUATERNARY GLACIATIONS IN THE NORTHERN HEMISPHERE
WORKING GROUP 24.4
OFFSHORE DEPOSITS

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Introduction

Working Group 24.4 (Offshore Deposits) of IGCP Project 24, composed of the authors of this summary, has been recently formed with the aims of stimulating offshore Quaternary research. The working party sees its role in recognising and recommending particular lines of study, in encouraging multidisciplinary research, defining areas where more research effort is required and acting as an informal link between research groups, particularly where efforts may be duplicated. The group does not see any requirement to produce a publication of its own, but rather that it should encourage the presentation of results at national and international meetings. The formation of the group has come at a particularly suitable time. The whole of the Quaternary record is under review and many believe that the unravelling of the land records can only be done with a proper understanding of the more complete offshore succession. The studies on the shelf therefore form a natural stepping stone between the virtually complete oceanic records and the patchy history established on land.

The report below is a brief summary of the current state of the art offshore. Two things in particular emerge from this report. Firstly there is a vast and largely untapped data set available for those interested in the offshore Quaternary. This is largely the result of the Institute of Geological Sciences (IGS) regional reconnaissance offshore mapping programme. Under this programme IGS have run over 190,000 km of multi-instrument seismic track, collected samples at more than 15,000 sample stations and drilled over 400 boreholes, some of which exceed 200 m in depth. Most of these data contain information relevant to Quaternary studies and most of it is available for further detailed work. In addition IGS holds in its confidential archives much of the information which has been collected by commercial offshore operators. Where appropriate these data are being assimilated into the IGS Quaternary mapping programme and some of this information is potentially available to other workers. Several university departments also hold considerable data sets and much of this material is suitable for further study. The offshore Quaternary is not therefore short of data, but rather of people to study the data and interpret the results.

A primary objective of the Working Group is thus to encourage those interested in the Quaternary to expand their interests beyond the coastline and make full use of the information already available. A second

point is that most of the British shelf area has been already covered with the notable exception of the areas west of the Hebrides and the central part of the North Sea between 53° and 56° N. This cover is however thin and much more field work is required before we can begin to unravel the complexities of the offshore successions.

The present summary is necessarily short and much has been left out. We hope, however, that we are aware of most of the offshore Quaternary work in progress, although perhaps the gaps in this report will stimulate those not mentioned to ensure that their work is published. The Q.R.A. January meeting in Edinburgh entitled "Onshore and Offshore Quaternary of NW Europe - the scope for correlation", should provide an invaluable opportunity to air the needs and problems of offshore Quaternary and will, we hope, provide us with some feedback on how the Working Group can best contribute to the offshore research effort. The report below summarises the work that has and is being done around the British Shelf. Some references are quoted but no attempt is made to produce a complete reference list. A most complete bibliography is under preparation and it is hoped that a directory can be compiled which will list the addresses and interests of offshore Quaternary workers.

1. Northern North Sea

Most of the work in the northern North Sea (north of 56° N) has been carried out by the Institute of Geological Sciences as part of their regional mapping programme. The IGS efforts have concentrated in the area between 56° and 58° N, the Moray Firth and from 60° to 62°N. Additional work has been done by the Netherlands Institute for Sea Research (NIOZ) and Milling (1975). On the Norwegian side of the North Sea the Institute for Continental Shelf Research (IKU) are co-operating with IGS in mapping the area between 60°N and 62°N. Quaternary work in the Norwegian sector is also being carried out by groups at Bergen and Oslo Universities and at the Norwegian Geotechnical Institute (NGI).

Considerable controversy still surrounds the Quaternary history of the northern North Sea and many basic questions remain unanswered. In the central trough the Quaternary is known to be up to a kilometre in thickness with significant breaks within the sequence. Jansen (1976) and Holmes (1977) have published differing stratigraphies for the southern part of the area, their interpretation to some extent reflecting the different data types available to each author. North of 60°N Milling (1975), Skinner (in preparation) and Owens (in preparation) see a different sequence while on the Mesozoic and Palaeozoic platforms to the west of the central trough, where the Quaternary wedge thins towards the land, a yet different Quaternary succession is recorded both in the Moray Firth (Chesher and Lawson in preparation) and east of Shetland (Chesher in preparation). The work to date has therefore largely served to illustrate the magnitude and complexity

of the problems. However some of the significant points to date are the thickness of the sequence in the central trough where net subsidence has continued since Tertiary times. The dominantly clay nature and probable glacial marine origin of the succession and the evidence of major erosion surfaces within the sequence. Also significant is the relative absence of Holocene sediments (usually less than 0.5 m thick) with patches of late glacial and Holocene clays (rarely more than 20 m thick) occupying hollows on the old Weichselian surface.

2. Southern North Sea ($51^{o}N$ - $53^{o}N$)

This area covers coastal waters of France, Belgium, Holland and England. The Dutch have carried out the bulk of the studies of the area starting with Van Veen (1935) and continuing up to the present day. The Belgians with much the smallest offshore area under their jurisdiction have carried out only a little work which mostly concerns seabed sediment sampling. The French in mapping the eastern section of the English Channel have carried out studies in their coastal waters mostly of a sedimentological and morphological nature. The English have been represented by University College London (originally lead by Dr. A.J. Smith) in the south and King's College/Sir John Cass College London (originally lead by Dr. J.E. Prentice) in the central and northern parts of the area. The latter group still operates under Dr. B. D'Olier, studying Quaternary sediments from the Wash to the Straits of Dover. Work has begun on the offshore extension of the East Anglian Pleistocene Crag basin (1977-1978) and recently IGS have begun their reconnaissance mapping in the area working from the coast out to the median line and several deep boreholes have been drilled as part of the programme. Apart from the East Anglian Pleistocene Crag Basin, undoubted Lower and Middle Pleistocene deposits are rare or completely absent, the area being an eroded bedrock platform with thin, very recently deposited sediments lying on top. No reliable offshore radio-carbon dates have been obtained as yet except off the Dutch coast and in the Dover Straits, the latter for the Channel tunnel project.

3. The Celtic Sea

The Quaternary history, with the exception of the North Celtic Sea Basin, has not been reported in detail. Delanty & Whittington (1977) re-assessed the 'Neogene' deposits recognised by Blundell et al (1971) and extended by Dobson et al (1973) and Dore (1976), by long line correlations using seismic profiles from established sequences in the Cardigan Bay boreholes. Delanty & Whittington showed that the 'Neogene' unit which underlies a boulder clay correlates with marine sands and gravels and an earlier boulder clay. The interpretation of basal Wolstonian overlain by Ipswichian was inescapable. From all the published and unpublished data fresh lines were drawn to show the extent

not only of the pre-Devensian deposits, but also of the Devensian material. The latter now appears to lobe south to virtually the 51st line of latitude. In addition a sub-glacial drainage pattern was mapped out for part of the Nymphe Bank Basin.

4. The Bristol Channel

Evans and Thompson (1979) describe tills of probably Wolstonian age (they might be Devensian Head deposits) from the central area. These clays contain derived Triassic and early Jurassic rock fragments and fauna. Holocene silts and peats occurring in the depressions on the Pleistocene sediments in mid-Channel contain estuarine microfaunas and freshwater microfloras. As with studies in Cardigan Bay, Quaternary sea level changes have been linked to those documented by Clarke (1970) for offshore S.E. Devon. Banner et al (1971) studying the geology offshore from Barry mapped the Breaksea valley system which is infilled by sediments which, although not sampled, are thought to be of Lateglacial age. Maximum channel depths are 25 m to 36 m below datum. No attempt was made to correlate the drainage system with those studies in South Wales. Hawkins (1971) using borehole data from the Avonmouth area and Llanwern has attempted to correlate radio-carbon dated organic horizons to produce a sea level curve linked with rates of sedimentation for the late glacial period. This investigation, although restricted to the Severn Estuary has allowed a link to be established with the Somerset levels at Bridgewater and the work of Kidson (1977). It is thought that this area was within ice presence during the Devensian. Gelifluction processes have produced a thick mantle of head now associated with loess. The central part of the Bristol Channel has been tidally scoured free of most glacial material such that today only the deposits along the embayed South Wales coast and in the Bridgewater area now remain.

5. The Southern Irish Sea

This area has received considerable attention over the last decade, the most important contributions coming from Garrard (1977) and Haynes et al (1977). Briefly the source of the data has been IGS offshore boreholes and vibrocores together with the coastal borehole at Mochras. To this corpus of information must be added the high resolution seismic study which was employed to link the principal units identified in the cores. It must be emphasised that the direct evidence is largely restricted to Cardigan Bay; the St. George's Channel interpretations are based on long-line correlations. It is well established that the south Irish Sea contains one of the thickest successions of Quaternary sediments outside the North Sea. In the east the glacial sediments appear restricted to those of Devensian age and they are covered by well developed estuarine and lagoonal sediments of Lateglacial to Flandrian age. Selective erosion of the soft Tertiary of the St. George's Channel basin has allowed the accumulation of at least two units of Irish Sea till separated by thick

sequences of temperate marine interglacial sediments of possible Ipswichian age. Thus the lowermost till which may be Wolstonian in age remains the most controversial element in this sequence. Attempts have been made to map the southern limit of the Devensian ice sheet (Garrard and Dobson, 1974; Delanty and Whittington 1977) and identify and date, by the ^{14}C method, the sedimentary environments of the Lateglacial to Flandrian transgression phase (Haynes et al,1977). The work has shown that the history of the Flandrian transgression is largely the record of the infilling of meltwater channels cut during the Late Glacial. It supports the idea of the "climatic earliness" of the Welsh seaboard at all stages. The ideas expressed indicate that the Welsh ice withdrew before 14,000 years B.P.

Whilst Lateglacial events have been correlated with adjacent onland evidence e.g. the fossil forest at Borth, no systematic correlations have been tried for the glacial sequences which so dominate both the sea floor and the Welsh coastal areas. In the critical area between Carnsore Point and St. David's no boreholes have cored glacial sediments. Therefore the nature of the Devensian ice sheet at its most southerly point remains poorly understood.

6. The Central Irish Sea

Data for this area is restricted to Naylor (1965) and Whittington (1977) and two Ph.D. Theses by Al Shaikh and Efeotor, the details of which are listed in references. Naylor examined inner Dublin Bay using boreholes put down for the Dublin Port and Docks Board. Nine episodes were recognised, the lowest two of which are boulder clays. Above these is a periglacial gravel followed by 4 units of postglacial sediments and finally recent sediments. Although no dating was attempted, Naylor correlated the lowermost units with the Midland General (Devensian). Whittington recognised 3 distinct units above the rockhead in the adjacent Kish Bank Basin, a till sheet, thick well-bedded sediments which cover the till and infill the drainage pattern established on it. The unit appears entirely depositional for no erosional phases have been identified. The upper unit consists of sand banks, muds and silts, all of recent origin. Whittington favours a sub-aerial fluviatile origin for the drainage system established across Unit 1. Correlations are attempted, notably with Naylor's work and south into Cardigan Bay. Dating is by comparison and correlation with Bowen's (1973) discussion of the Irish Sea. Links are attempted, with boreholes put down in Caernarvon Bay, but not pursued.

7. The North Irish Sea

The published data is derived virtually exclusively from IGS (Pantin 1977, 1978). The general stratigraphy is rockhead - boulder clay - pro-glacial water laid sediments - marine sediments. West of the Isle of Man the proglacial sediments are commonly missing. The conditions of deposition and possible age of the sediments are discussed together with

gas entrapped acoustic turbidity problems commonly encountered on the pinger records. The core and borehole control is good east of the Isle of Man, adequate between the Island and Northern Ireland, but poor to absent S.W. of the Island. The proglacial waterlaid sediments are interpreted as proglacial lagoonal, and the name 'Vannin Sound' is proposed for the lagoon. Attention is also directed to the overlying marine sediments, principally in terms of the distribution of types and foraminifera, macro-fauna and microplankton from the area are reviewed by other authors. There has been no opportunity to obtain C^{14} dates from the cores collected and Pantin has not attempted to correlate the sequences with those of similar age found on the Isle of Man, the Lancashire coast or Northern Ireland.

8. The Malin Sea and Firth of Clyde

The submarine Quaternary sequence varies in detail from area to area but in broad terms comprises 3 units. Marine sediments, glacifluvial with glacimarine (subglacial ice shelf) sediments, and till (presumed to be the product of the Devensian glaciation). On the floor of the Firth of Clyde this sequence is largely incomplete, but there are indications that the glacial period was succeeded by the Flandrian transgression during which calcareous silty clays accumulated. The "Clyde Beds" of the Firth of Clyde were deposited in full marine conditions shortly after the ice of the main Devensian glaciation. Beach deposits of gravels and sands locally overlie the Clyde Beds.

The Malin Sea sequences (Evans et al, in press) have been broadly divided into 3 groups which in part relate to the scheme of Binns et al (1974). The first group are the poorly bedded or structureless deposits which occasionally show a hummocky upper surface, they are interpreted as tills. The distribution of these (Fm 1 of Binns et al, 1974) is extensive, occuring throughout the Malin Sea except in the Approaches to the North Channel where tidal scour has exposed the rockhead. The second group (? Fm II) is a complex, frequently thick, sequence of glacial marine sediments most particularly developed along the axis of the Malin Basin. The late glacial muds, probably (Fm III), occur noteably in the Sound of Jura (Evans & Ruckley, in press) and off Lough Foyle. Attempts were made (Dobson & Evans, 1975) to correlate these and the deposits of Donegal Bay with the sequences of Ireland, but without success. No dates are presently available. The concept of an ice shelf of Devensian age (Fm 1) occurring over the western Malin Sea area has been proposed, but not pursued (Dobson & Evans, 1975). The glacial deposits of the Firth of Lorne have been referred to by Barber et al (in press), but no detail beyond a broad seismic stratigraphy has been given. A resumé of the published data has been collected by Jardine (1977) who rightly observes that the detailed chronology of the submarine deposits requires to be soundly established before the history of Quaternary marine transgressions and regressions across the Shelf areas can be constructed.

9. The Hebrides Region North of 56°N

No sediments pre-dating the last glaciation have yet been cored. The boulder clay that has been cored and recognised on the seismic sections does not contribute significantly to the thickness of the Quaternary sediments. Locally some over-deepened rock basins may contain appreciable thicknesses. The late glacial (Fm II) sediments by contrast make a major contribution. They are not evenly distributed, however Binns et al (1973) have contoured the sediment thickness as recognised on seismic records and correlated and calibrated the evidence using the widely spaced boreholes. The 3 major formations referred to in the previous section, were first recognised here. Apart from some local unpublished work off Morar by Boulton there has been no attempt to link these shelf deposits with the sequences found on land in Scotland.

10. North Minch and the area West of Orkney and Shetland

Formations I to IV recognised by Binns can be traced in the North Minch but this sequence becomes increasingly difficult to apply further north towards Orkney where Formations I, II and III may appear as lateral equivalents with gradational contacts. Thus until the chronology and modes of deposition of these formations is better understood, no attempt has been made to extrapolate them into this area. In the North Minch, basal tills which may occupy over-deepened hollows, are overlain by glacial marine clays which can exceed 100 m in thickness (Bishop 1977, Chesher et al, in preparation). West of Orkney, tills and glacio-marine clays form a wedge which occupies a scoured depression deepening north-westward and terminated by large crag and tail-like faulted crystalline basement masses forming the island chain from Sule Skerry to Sula Sgeir (Fannin, in preparation). North and west of this, from preliminary evidence, the Quaternary cover appears relatively thin, deepening only to fill small depressions in the rockhead. Late glacial and Holocene sediments are largely restricted to a thin mobile sand cover with some areas of soft clay filling depressions on the old surface, particularly north-west of Foula and over the small Permo-Triassic basin in St. Magnus Bay.

Palaeontological Studies

In any palaeontological study of offshore Quaternary sediments in which the reconstruction of marine and continental palaeoenvironments, and palaeoclimatory is sought, a firm basis in modern ecological work is important. Such basic data, especially on a regional basis, is lacking although some work is available. There appear to be no published data on modern pollen distribution in sediments around the British Isles. Certainly there is much interest at University College London, Aberystwyth, Exeter and Hull in distribution studies of various groups in modern sediments but there is as yet no integrated regional study encompassing all the available data. Much of the published offshore Quaternary palaeontological studies have dealt with short cored sequences i.e. up to 10.0 m depth, in inshore areas because of, naturally enough, the limited resources available to university departments and the relative

facility of coring in inshore areas. Indeed, the IGS in its offshore exploration programme began in sheltered inshore areas. Some of the published work includes Clarke* (1970), Wall & Whatley (1971), Harland (1973, 1974), Binns et al (1974), Hughes (1974), Peacock (1974), Lees (1975), Gregory et al (1977), Haynes et al* (1977), Harland (1977), Culver and Banner (1978), Graham and Wilkinson (1978), Peacock et al (1978), Hughes (1978) and Harland (1978). The work has concentrated mainly on late- and post-glacial deposits, and with charting the nature and extent of the transgression related to the Flandrian climatic optimum, the transition from a glacial to non-glacial climate and younger events. It appears to be especially worthwhile to use an approach where many fossil groups are considered but in only a few cases (marked with an asterisk) has pollen work been done to attempt a link with the established pollen biostratigraphy. It would seem that more effort should be made in linking marine and non-marine environments within the Quaternary.

The study of deep cored sequences in the offshore area has largely been attempted to date by IGS through its offshore exploration programme. There is much interest in university departments and some projects linked with the oil industry are under way. Published work on deeper cored sequences of Quaternary sediments in the British sector include Hughes et al (1977), Harland (1977), Harland et al (1978) and Gregory and Harland (1978). Patterns of 'cold' and 'warmer' events have been recognised and elucidated and these can be used in correlation. The establishment of a correlation between the thick shelf sediments with both deep oceanic sediments and nearshore and onshore Quaternary, and their biostratigraphic, palaeomagnetic and palaeotemperature histories is of importance and should lead to a better understanding of the climatic events that characterise the Quaternary.

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X INQUA CONGRESS FUND

Thanks to a lot of hard work by everybody concerned (most of whom are members of the QRA), the 1977 INQUA Congress was not only a tremendous success, reflecting great credit on all who took part - but it also ended up with a handsome surplus. Discussions have been taking place during the past year to decide how this surplus might be used, and it has now been arranged that a Fund will be set up, under the auspices of the Royal Society, the interest from which will be used to further Quaternary studies by the award of grants to individuals.

The official announcement of the fund is given below. The closing date for the first batch of applications is 31st January 1980, but thereafter it will be 31st October in each year. The amount available will generally be in the order of £1,000 a year, and it is hoped the Quaternary workers will make good use of this additional source of finance for their research. Since the money came originally from an INQUA Congress, it would be appropriate if these awards led to greater British participation in INQUA Congresses and in activities (such as Sub-Commissions) connected with INQUA.

Lewis Penny,
Treasurer, X INQUA Congress.

Conspectus for X INQUA Congress Fund.

The Royal Society set up the X INQUA Congress Fund in 1978 from the surplus funds deriving from the organization in Birmingham in August 1977 of the X Congress of the International Union for Quaternary Research (INQUA). The interest from the invested surplus is utilized to enhance the advancement of the science of Quaternary studies, particularly in promoting participation by British scientists domiciled in the United Kingdom in the activities of INQUA and of kindred organizations (through the provision of grants to facilitate attendance at INQUA and related international meetings).

About £1000 per year is available for these awards which are made by the Council of the Royal Society on the advice of the Quaternary Research Subcommittee (of the British National Committee for Geology).

The following principles for administering and allocation grants from the Fund have been laid down:

(a) Applicants must be British subjects who are normally domiciled in the United Kingdom;

(b) Applicants should have a primary interest in Quaternary studies and be active in this field;

(c) Applicants will be expected to be capable of furthering the repute of British Quaternary studies in international circles.

Application forms are available from the Executive Secretary, the Royal Society, 6 Carlton House Terrace, London SW1Y 5AG, and should be returned not later than 31 January 1980. Results of applications will be made known as soon as possible. Telephone enquiries can be made at: 01 839 5561, ext. 249 / 203.

BOOK REVIEW

Ice Ages. Solving the mystery. By J. Imbrie and K.P. Imbrie, 1979. London: Macmillan. 224 pp, 49 figures. Price: £6.95 hard back.

This book is a curious mixture of style and content. The first third is devoted to a popular account of the history of the glacial theory, and the rest to the development of the Astronomical Theory of the origin of ice ages and to the history of investigation of the marine Pleistocene, with short concluding chapters on the coming ice age and the last million years of climate. There is a list of books for further reading and a bibliography which is complementary to sources mentioned in the text. The section on the history of the glacial theory is treated dramatically. For the serious student there are better documented accounts available. The sections on the Astronomical Theory and on the development of studies of the marine Pleistocene are far more rewarding and timely. Marine Pleistocene research has blossomed in the last 20 years and here both the flowering and fruiting are described in detail in what might be called a personal and blow-by-blow manner. The relation between the fruits, in the form of climatic curves for the Pleistocene, and the Astronomical Theory is discussed and the conclusion is drawn that orbital variations control the timing of the ice age succession.

The next stage in solving the mystery is determining the mechanisms through which orbital forcing operates. Meanwhile this book performs a valuable service in reviewing the origins and progress of the Astronomical Theory and the course of marine Pleistocene research in recent decades.

R.G. West

RECENT PUBLICATIONS AND CIRCULARS

Episodes. Geological Newsletter of the I.G.U. Edited by W.W. Hutchinson, Annual Subscription $12.00 (U.S.)

Episodes is the remodelled version of the old "Geological Newsletter" and is issued quarterly by the International Union of Geological Sciences. It communicates news of recent scientific activities of the Union and related organizations, and highlights news items, conference reports, publications and forthcoming events of interest to the international geological community.

Subscriptions can be established through Dr. V. Lafferty, International Union of Geological Sciences, Room 177, 601 Booth Street, Ottawa, Ontario, Canada K1A OE8. Cheques should be made payable to "EPISODES".

The World of Ice: The Natural History of the Frozen Regions.
By B.S. John, 1979. Orbis Publishing, London, 120 pp, Price: £5.95.

This is a full-colour large-format book about the "natural history of ice". All of the illustrations are in colour, with 97 colour photos and 15 text figures. The text, of about 40,000 words, is for the most part a layman's guide to glaciology and glacial geomorphology, although there are also sections on periglacial geomorphology and floating ice. The list of chapter headings is as follows: The Ice Planet; Ice Environments; Glaciers; Frozen Ground; Ice Afloat; Plants, Animals and Ice; Man in the World of Ice. There is also a Glossary, a short Bibliography, and a full index. Although it is intended for the non-expert, the book will no doubt find a place in a good many school and university libraries and on a good many academic bookshelves.

Flint Assemblages: Notes for the Guidance of Excavation Directors.
By Alan Saville, Lithic Study Group, Cheltenham Art Gallery and Museum Professional Publication.

This five page leaflet was prepared on behalf of the Lithic Study Group in order to provide certain basic information about excavation and processing of lithic material from archaeological sites. Its preparation has arisen from the dissatisfaction expressed by lithic specialists with the conditions and presentation of assemblages passed to them for analysis.

It includes an introduction and a review of the basic principles of collecting flint assemblages. This is followed by notes on recording, post-excavation procedures, the scope and scale of analysis and how to choose a lithic specialist. Two appendicies are included, giving the names and addresses of some lithic specialists and a brief review of the history and aims of the Lithic Study Group.

The leaflet can be obtained free by sending a stamped, self-addressed foolscap envelope to: Pat Konig, Art Gallery and Museum, Clarence Street, Cheltenham, Gloucestershire GL50 3JT.

CALENDER OF MEETINGS

October 4th 1979- March 27th,1980	A series of lectures by specialists in glacial geology and Quaternary studies will be given in the J.S. Fleet Lecture Theatre, The Geological Museum, Exhibition Road, London, SW 7. The lectures are held each Thursday at 6.30 p.m. and the fee for the course is £12.50, although the cost of attending just part of the course can be negotiated. Those interested should write to Mrs. J. Robins, Dept. of Extra Mural Stidies, Univ. of London, 26 Russell Sq., London WC1B 5DQ.
January 4th - 5th, 1980	Quaternary Research Association Discussion Meeting to be held at Murchison House, Edinburgh. 'Offshore and Onshore Quaternary of NW Europe - the scope for correlation'. Further details and a Registration Form are included in the Circular issued with this Newsletter.
March 28th- April 1st, 1980	Quaternary Research Association Annual Field Meeting and Annual General Meeting, Glasgow. Further details and a Registration Form are included in the Circular issued with this Newsletter.
May 22nd- 25th, 1980.	Quaternary Research Association Short Field Meeting in the Inverness Region under the leadership of Dr. J.S. Smith and F.M. Synge. Preliminary details are given in the Circular Issued with this Newsletter.
June 29th- July 6th, 1980.	V International Palynological Conference, Cambridge Information can be obtained from Mrs. G.E. Drewry, Geology Dept., Sedgwick Museum, Downing St., Cambridge, CB2 3EQ.
September 18th- 21st,1980	Quaternary Research Association Short Field Meeting to West Cornwall under the leadership of Prof. N. Stephens and P. Sims. Preliminary details are given in the Circular issued with this Newsletter.
August 26th- September 9th 1981.	Quaternary Research Association Overseas Study Course to Finland, organised by P.L. Gibbard. Full details are given on a separate form issued with this Newsletter.

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.

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