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Quaternary Newsletter is issued in February, June and November. Contributions comprising articles, reviews, notices of forthcoming meetings, news of personal and joint research projects, etc. are invited. They should be sent to the Quaternary Research Association Newsletter Editor. Closing dates for submission of copy for the relevant numbers are 1 January, 1 May and 1 October.

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EDITORIAL

Dear Colleagues

May I wish you all a somewhat belated "Happy New Year" and apologise for the delay in publishing this issue - due to a bereavement and illness amongst colleagues at BGS, Keyworth, who help me (by working outside normal office hours) to produce the Newsletter.

For "Slimline" Research

After the Christmas holidays, I was half expecting another "slimline" issue of your Newsletter but I have been confounded by your many (and substantial) contributions which cover a wide range of topics - like, for example, a flint extraction site near Peterhead, the discovery of mammalian fossils near Peterborough, a sturzstrom or fossil rock glacier in North Wales and further discussions on periglacial fans or solifluction sheets in Central Wales. Thanks to David Gilbertson, Peter Smithson and Eileen Pounder, there are fulsome reports on two important meetings, the field meeting to the Western Pennines and the "Recent Themes" meeting at Sheffield City Polytechnic - where the last Executive Committee Meeting was held.

For "Wizen Old Men", read . . .

Thanks to new member Tessa Fenoughty of Warwick University, we also have an interesting insight into the image other people have of a typical Quaternary Research Member and how four days in the field with Wishart Mitchell and some 20 other QRA members disabused her of the idea that all members were wizen, grey-haired and roamed the moorland with furrowed brows.

Eddie Francis

I was saddened to hear of the death of Eddie Francis, a former colleague in the British Geological Survey. I met Eddie after he had left the Survey for academia but my impressions of him at QRA field trips concur precisely with those so eloquently expressed by Geoffrey Boulton. I was never prodded in the stomach but I well remember his "relentless questioning of received opinion" and field trips without him seemed to lack the piquancy which only he could instill.

Congratulations

Congratulations to all recent postgraduates - Lorraine Allen, John Aitken and Donald McLean and to Sue Creak who's thesis abstract will appear in the next issue.

A "treat" at last - a day out in the field in Hertfordshire

Last Autumn, between Newsletter No 65 and this, I enjoyed the rare "treat" of a day out in the field - with Roy Shephard-Thorn of the British Geological Survey's Eastern England Land Survey group.

The purpose of the outing was to see and sample for coleoptera (and other arthropods) a temporary section exposed during excavations for the Little Wymondley By-Pass at Todd's Green, near Hitchin, Hertfordshire, a chance discovery initially examined and sampled by Phil Gibbard and Steve Boreham, of the Sub-Department of Quaternary Research, University of Cambridge, for pollen and molluscan studies.

The deposit, which appears to occupy a kettle-hole approximately 60 m across, comprises up to 6 m of organic deposits thought to represent the Hoxnian interglacial - deduced from the occurrence of other datable organic sequences previously discovered in the vicinity and studied by Phil Gibbard. Time permitting, I hope to begin disaggregating the material in the next few weeks before conferring with Dr Russell Coope at Birmingham University/RHBNC and collaborating with the Sub-Department of Quaternary Research, University of Cambridge, in the compilation of a full report.

The area around Little Wymondley is currently being surveyed by the British Geological Survey as part of the Hitchin Sheet which will be published at 1:50,000 scale in 1993 or 94, together with a descriptive memoir and several additional papers and reports - including one for the Anglian Division of the National Rivers Authority on the results of investigations into the deep buried channel beneath Hitchin.

Prestigious Lecture on the Quaternary at BGS

On Tuesday, 28 January, Professor Brian Hoskins, FRS, of the Department of Meteorology, University of Reading, gave the inaugural lecture in a new series of Prestigious Lectures at two offices of the British Geological Survey, ie Murchison House, Edinburgh and the Kingsley Dunham Centre, Keyworth. His topic "Past Climates : the key to the future" was an appropriate one in view of all the discussion recently about global warming and the greenhouse effect but at Keyworth, Professor Hoskins was almost denied lecturing by one of his own elements, namely an all-enveloping dense fog (of the infamous pea-soup variety) that descended upon the English Midlands like a shroud. Nevertheless, spectre-like, nearly 200 (of an expectant audience of 270) braved the atrocious conditions to hear Professor Hoskins give a wonderfully articulated account (without notes) of past weather patterns from almost 150

million years ago through to the Ice Age Cycle and the Last Glacial maximum. Using models from the past.

Professor Hoskins demonstrated how these could be used to predict climatic regimes in the future and he discussed ways in which climate simulations can integrate and challenge geological investigations.

Some of those present at the lecture expressed the view that Professor Hoskins posed more problems than he attempted to solve but there is no doubt; I think, that his oration augured well for the future of this new annual series and he is to be congratulated on a stunning performance. So too are all those many visitors to Keyworth that night, some of whom ignored police warnings in order to participate in a momentous occasion.

Correspondents may wish to know that my telephone number at BGS Keyworth is 0602 363556

Brian J Taylor
Editor



The Editor in the field – please note his svelte-like figure!

ARTICLES



EXPLORATORY WORK AT DEN OF BODDAM, A FLINT EXTRACTION SITE ON THE BUCHAN GRAVELS NEAR PETERHEAD, NORTH-EAST SCOTLAND

Alan Saville and David Bridgland

Introduction

Flint is a rare commodity in Scotland. The only inland area with any appreciable quantity of flint is in the north-east of Grampian Region, some 40 km north of Aberdeen. Here a series of flinty 'gravel' deposits occur in a roughly east-west band, capping the higher ground between Whitestone Hill, north of Ellon, and Den of Boddam, south-west of Peterhead (Fig. 1A). These deposits form part of the so-called Buchan gravels, a generic term also applied to the quartzite-dominated deposits farther west and north (the Windy Hills gravels). The flint-rich deposits have been termed the Cruden Flint gravel (Kesel and Gemmell, 1981) or the Buchan Ridge gravel (McMillan and Merritt, 1980). Remnants of the Buchan Ridge gravel have been studied in temporary sections and boreholes, principally at Whitestone Hill, Hill of Aldie, Den of Boddam (Denhead), and Moss of Cruden (Kesel and Gemmell, 1981; McMillan and Aitken, 1981).

Various workers have described these flinty deposits, all noting that they do not resemble true water-lain gravels, but instead consist of well-rounded pebbles and cobbles of resistant rocks set in a matrix of stiff clay, silt, and sand. (The literature on the Buchan gravels is extensive: see Hall, 1984 and McMillan and Merritt, 1980 for earlier references). Incorporated in this matrix are ghost clasts of rotted, less durable rocks (Kesel and Gemmell, 1981). The highly rounded shape of the clasts in the Buchan Ridge gravel, coupled with the incidence of chatter-marks on their surfaces, has led some workers to conclude that this deposit is an ancient beach (McMillan and Merritt, 1980; Merritt and McMillan, 1982).

Analyses of the matrix of the Buchan Ridge gravel have shown that it contains a high proportion of kaolinite, a clay mineral that is formed by the decomposition of feldspar. Kaolinization of feldspar appears to be a likely process involved in the weathering that produced the ghost clasts in the Buchan Ridge gravel (Koppi and Fitzpatrick, 1980). It is also known to have affected the local Peterhead Granite, producing deep-weathered profiles reminiscent of those on Dartmoor (Hall, 1982; 1984). This process is considered to require very long periods of stable conditions (Hall, 1991), so that kaolinized profiles have frequently been attributed to Tertiary rather than (or in addition to) Quaternary weathering, thus supporting the suggestion that the Buchan Ridge gravel is of pre-Pleistocene age. Others have proposed that this gravel is the product of glacial deposition, the kaolinized debris perhaps having been transported by ice in an already weathered state (Kesel and Gemmell, 1981).

The considerable angularity of sand-sized quartz grains in the Buchan Ridge gravel has been cited in support of a glacial origin (Kesel and Gemmell, 1981), since this indicates minimal exposure to an aqueous environment. It appears difficult to reconcile the occurrence of ghost clasts with this view, however, since these would be expected to have been disrupted during glacial transport. Moreover, the angular quartz sand may have been liberated from former clasts that have rotted *in situ* (Merritt and McMillan, 1982). The degradation of non-durable rocks within the Gravel may indeed have provided the majority of the matrix in which the durable clasts are now set. (For summaries of the debate on these topics see: Gemmell and Kesel, 1982; Hall, 1982 and 1984; Merritt and McMillan, 1982.)

The origin of the flint in the Buchan Gravels has also been a subject of controversy, there being no Chalk onshore in north-east Scotland. Some workers have suggested that the flint might represent the resistant residue of a former Upper Cretaceous cover in this area (Hall, 1984 and 1991), whereas others have preferred to regard the flint as transported from the area of the Moray Firth, the North Sea, or even farther afield (Kesel and Gemmell, 1981). The mapping of outcropping Chalk on the floor of the Moray Firth and North Sea (e.g. Andrews *et al.*, 1990, Fig. 38) does not resolve the issue.

Archaeologically, it has long been realized that this enigmatic concentration of flint cobbles provided a potentially valuable resource for tool-making during prehistory (Jamieson, 1864–66, 240). Surface hollows at Den of Boddam were interpreted as flint-extraction pits by the end of the last century (Anderson, 1895–96, 351) and in 1918 Graham-Smith excavated two pits at Skelmuir Hill (NJ 987 415), finding evidence for “... a workshop for breaking up flint nodules ...” (Graham-Smith, 1918–19, 40). More recently, increased interest in prehistoric raw material exploitation in Scotland (Gemmell and Kesel, 1977; Wickham-Jones and Collins, 1977–78; Wickham-Jones, 1986) has made further knowledge of the Den of Boddam site a research priority.

Den of Boddam (NK 115 414) (Fig. 1)

The Den is probably a relict glacial meltwater channel, now covered in rough grass, heather, gorse, and bracken. At its narrowest and steepest-sided point, the floor of the Den was dammed in the 19th century to provide a small reservoir serving the former granite-polishing works downstream. Either side of the reservoir, but especially on the west, the slopes are interrupted by pronounced hollows, over 100 in total, varied in plan (though many are sub-circular) and about 1 m deep. These hollows, marking the presence of flint-extraction pits, have survived because the slopes are too steep and too agriculturally unattractive to have ever been cultivated (Fig. 1B). No other location on the Buchan Ridge gravel is known to have such pits surviving as surface features (though Skelmuir Hill did until the 19th century—see Graham-Smith, 1918–19), which makes the Den of Boddam an extremely important ancient industrial monument and an obvious focus for archaeological investigation.

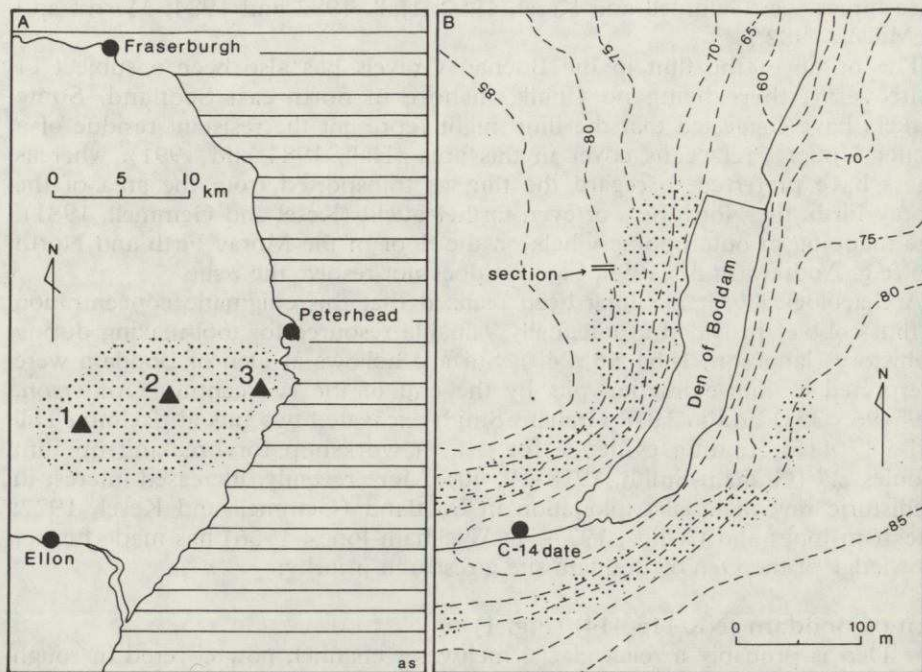


Fig. 1A Location in relation to the NE Grampian coast. Stipple indicates area of frequency of flint in surface deposits (after Kesel and Gemmell, 1981). 1 = Whitestone Hill, 2 = Moss of Cruden, 3 = Den of Boddam.

Fig. 1B Den of Boddam, showing the location of the section drawn in Fig. 2 and the area of the cores used to produced C-14 date GU-3056. Stipple indicates areas where pits are still visible on the surface. Contours are in metres above OD.

Exploratory excavations in 1991 looked at the upper infill of one of the sub-circular hollows high up on the west slope of the Den and also capitalized on the section provided by a former artificial water channel serving the reservoir. This section, beyond the main break in slope above the west side of the Den, showed that extraction pits continued beneath the near-level surface of formerly cultivated ground, and provided an opportunity for study of the Buchan Ridge gravel where blocks of it survived between the pits. The section was recorded in detail for some 30 m in an east-west direction and to depths up to 2.4 m below the modern surface. Fig. 2 shows a simplified schematic extract from the drawn section.

The natural stratigraphy can be summarized as follows, from the present surface downwards:

1. Soil—a peaty podzol, Skelmuir series, Skelmuir Association (see Glentworth and Muir, 1963, 162–4).
2. Till—a brownish-yellow to reddish-yellow and mottled stony loam, with flint and quartzite cobbles and fragments of fresh granite. Has preferred orientation (fabric) indicative of ENE–WSW ice movement.
3. Deformation till—similar to 4, with occasional clasts and narrow lenses from 2, and lacking any ghost clasts. Fabric identical to 2. On Fig. 2 this is not indicated separately but is subsumed within the Buchan Ridge gravel, of which it represents the upper 0.6+ m.
4. Buchan Ridge gravel—flint and quartzite cobbles in a variable matrix of white clay, silt, and sand. Ghost clasts of both igneous and sedimentary rocks are present. Clasts appear randomly orientated.

This sequence was intact in only a few places. Elsewhere it was replaced by the infill of pits dug from a previous surface down into the Buchan Ridge gravel, or disrupted by the collapse of the edges of the pits. Over much of the area the original surface level has been protected by spoil from the prehistoric pit-digging, as a consequence of which a buried soil is present above the till.

None of the pits sampled in 1991 were bottomed, but the recorded sections hint at their original depths. This hinges on the identification of substantial mounts of the observed stratigraphy as collapsed blocks of original sediments. These collapsed blocks are most readily recognized where they have resulted in the displacement of the junction between the remobilized Buchan Ridge gravel and the till. The original surface soil can also be recognized as a buried soil at the tops of some of the collapsed blocks. As well as experiencing downward displacement, the collapsed blocks have been somewhat rotated, to judge from the tilting of the displaced geological boundaries and from the curvature of the lines of failure. Simple extrapolation from the observed amount of vertical displacement suggests the bases of the pits lie at least 3 m below the modern surface in the area of this section.

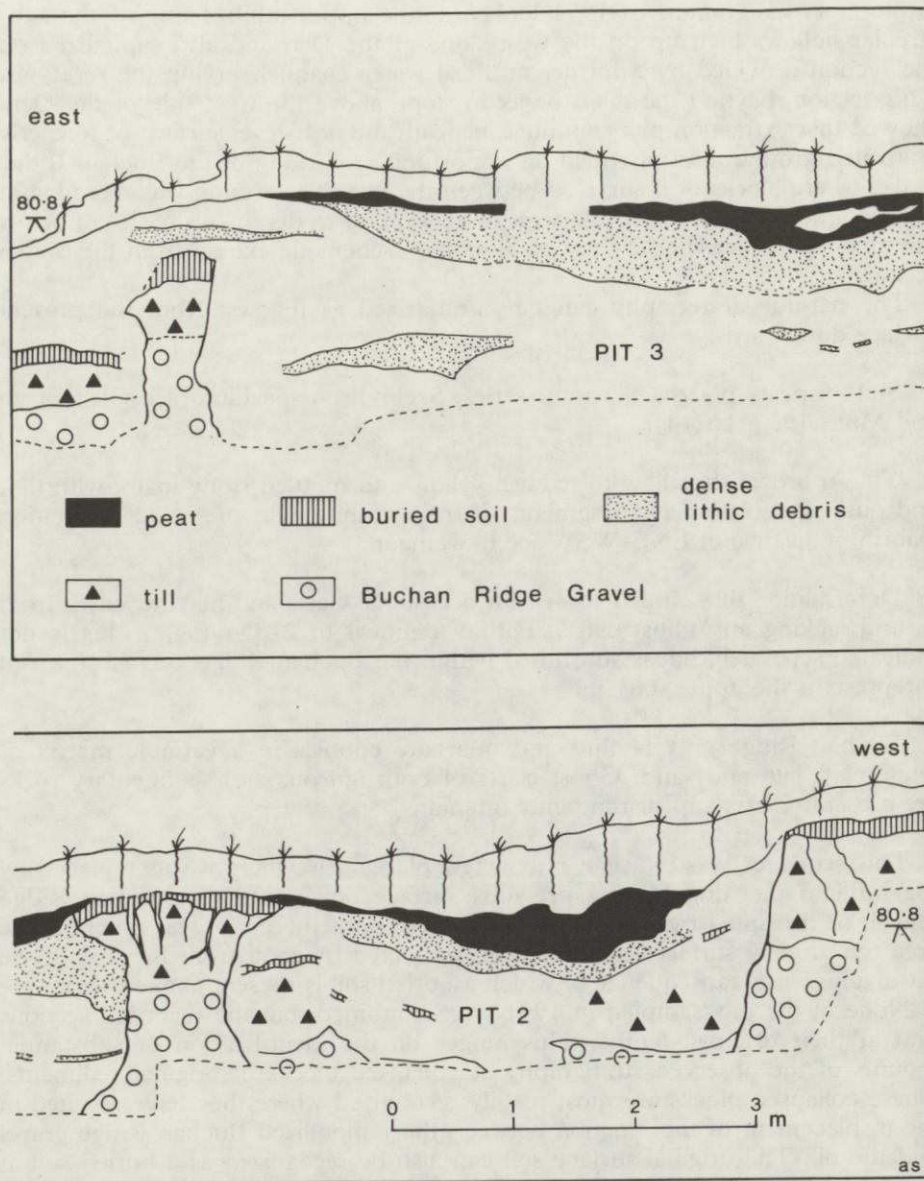


Fig. 2 Simplified schematic section through an area of prehistoric pit-digging into the Buchan Ridge Gravel at Den of Boddam. The dashed line at the base of the section indicates the limit of exposure in 1991. The datum point is given in metres above OD.

Apart from the collapsed blocks of till and Buchan Ridge gravel, the infill stratigraphy in areas of pit digging is comprised largely of mixed, redeposited till and gravel, with humanly produced lithic debris from the primary processing of the extracted flint cobbles. Flakes, cores, and smashed lumps and fragments are present in the section in thousands, sometimes in dense concentrations, apparently representing a process whereby cobbles were tested for quality and immediately discarded if not acceptable. The quartzite cobbles from the till and the Buchan Ridge gravel were used as anvil-stones on which the flint cobbles were broken with the aid of a hammerstone, and quartzites with the resulting characteristic indentations are common in the infills.

Until relatively recent times the pits in the area of the section had clearly survived as surface hollows, in the centres of which peat deposits up to 0.5 m thick had formed. Here the peat is capped by the modern soil (formerly a ploughsoil) and by spoil from periodic clearing of the water-channel, whereas on the slopes of the Den the hollows still have active peat infills.

Discussion

The occurrence of *in situ* Buchan Ridge gravel, with ghost clasts of rotted non-durable rocks, has now been confirmed at Den of Boddam and shown to underlie a flinty till. At the most westerly point where gravel was seen (not shown on Fig. 2), the surface of the gravel was more than 2.4 m below the present surface and beneath 2 m of till. The thickness of the Buchan Ridge gravel itself has as yet only been demonstrated in the present section to about 1 m (at Moss of Cruden the thickness is some 25 m: McMillan and Aitken, 1981).

Fabric studies have confirmed that the upper 0.6+ m of the Buchan Ridge gravel has been remobilized as a deformation till (cf. Clapperton and Sugden, 1975). The present work has shown that the previously published schematic section of this locality (Kesel and Gemmell, 1981, Fig. 3, D) is misleading, either because this earlier section encountered only the till and not the gravel itself or, perhaps more likely, because it was cut through stratigraphy disturbed in prehistory. Unless this can be clarified, the results of the previous granulometric sampling (Kesel and Gemmell, 1981, table 1) must be treated with caution.

Preliminary analysis of the clast contents has shown that there are marked differences between the composition of the Buchan Ridge gravel and the overlying till. The fact that unweathered igneous rocks occur in the latter but not the former is entirely expected (cf. Hall, 1984), but it has also been found that the till contains differently weathered flint pebbles. While the pebbles and cobbles from both deposits have the rounded, chatter-marked surfaces of beach material, the characteristic colour of the cobbles in the Buchan Ridge gravel at Den of Boddam is a bleached grey both internally and externally. This contrasts with the till, where, although grey flint is present, there are also numerous cobbles with red-brown/yellow-brown internal colouration and their external cortex stained dark brown or black.

This observation is of considerable archaeological interest, because knapped flints from many prehistoric sites in north-east Scotland are of the red-brown/yellow-brown type, including most of the material from Skelmuir Hill. Indeed, what is often referred to as 'Buchan flint' is the red-brown/ yellow-brown variety (Rankine, 1952, 146), while knapped grey flint has in the past been thought to have been imported from outside the region. It can now be suggested that the source of the red-brown/yellow-brown flint was the superficial till of north-east Scotland, while it is the Buchan Ridge gravel which provided the grey flint.

Whether the Boddam type of grey flint has a restricted distribution within the Buchan Ridge gravel remains to be tested, and is perhaps part of a broader question as to the homogeneity of the gravel. The general description in recent geological accounts (McMillan and Aitken, 1981; McMillan and Merritt, 1980) of the flint in the Buchan Ridge gravel as brown, without further qualification, adds to the potential confusion on this point.

It also remains an open question whether the flint in the till has been derived from the Buchan Ridge gravel itself, or from the same (or a similar) source as the flint in the gravel, which was perhaps in the form a beach deposit lying eastwards of the present coastline (unless the Buchan Ridge gravel is seen as an *in situ* beach, following McMillan and Merritt, 1980). Interestingly, the till contains no cobbles of igneous rocks of the types represented by the ghost clasts in the Buchan Ridge gravel. This implies that such material was absent from the source deposit, the supposed offshore beach. If such material was once present in the offshore beach deposit, but, prior to the glaciation which led to the formation of the flinty till, had been destroyed by kaolinization, the result would have been the production of a kaolin-rich matrix comparable to that of the Buchan Ridge gravel. It is unlikely that the brown and black colouration of the flints would have arisen or survived in such circumstances. This line of argument could support the view that the Buchan Ridge gravel is an *in situ* beach deposit, in which the flints, quartzites, and igneous rocks were rounded together at more or less their present location. It remains to be demonstrated, however, that the ghost igneous clasts are the remains of beach cobbles. Chatter-marks would probably not be preserved on the ghost clasts, even if it were possible to exume their surfaces from the matrix.

Possible avenues for further investigation in connection with these problems are: a) measurements of clast orientation in the Buchan Ridge gravel at greater depths, where original beach or fluvial imbrication may be preserved; and b) further analysis of flint shapes and sizes, to determine whether differences other than colour exist between the populations from the Buchan Ridge gravel and from the till. Other suggestions are welcomed.

It is now clear that prehistoric quarrying for flint at Den of Boddam occurred on a much larger scale and a more industrially organized basis than hitherto imagined. The most westerly pit yet discovered was dug through 1.4 m of till to reach the underlying Buchan Ridge gravel, and the pits are obviously densely clustered beyond the break in slope on the west side of the Den, despite the absence there of any surface indications.

Prior conceptions of the pits as shallow scoops into loose gravel have been revised with the realization that the Buchan Ridge gravel is a stiff clay-bound deposit capable of standing in vertical section and possibly capable of being undercut. Flint in the uppermost horizons on the Buchan Ridge gravel is thermally damaged and of relatively poor quality for knapping, whereas presumably lower horizons of less damaged cobbles were being sought by the prehistoric exploiters. The process of testing the flint cobbles for their quality has left what must be millions of pieces of debitage littering the surface of the site and incorporated into the infill of disused pits.

The period at or during which the pits were dug is not yet known. No pottery has been found, nor has any of the knapped flint yet been observed to have secondary retouch, let alone take the form of recognizable implement-types. The soil is acidic, so bone and antler will not normally survive, and the best hope for absolute dating is that well-stratified charcoal or burnt flints will occur. Otherwise palaeobotanical investigation of buried soils, peaty infills, and the peat succession on the floor of the Den will inject some chronological perspective. Dating of the quarrying activity is clearly vital for any wider investigation of the exploitation of the resource. However, the fact that the largest flint cobble yet noted at Boddam is 170 mm in maximum dimension makes it clear that this resource is very unlikely to have been capable of being used to manufacture such tools as axeheads; small implements like arrowheads, knives, and scrapers are more to be expected.

Further work is planned at Den of Boddam in June 1992, when it is hoped that at least one pit will be completely emptied and a deeper section for geological study will be opened. Palaeoenvironmental work by Dr Richard Tipping began in 1991 with the removal of exploratory peat cores from the floor of the Den to the south of the reservoir (Fig. 1B). The basal deposits from the meltwater channel now yielded a radiocarbon date of 9060 ± 80 years uncal. BP (GU-3056), so there is every chance that the accumulated deposits will contain a marker reflecting the period of industrial activity.

Acknowledgements

Work at Boddam in 1991 was jointly funded by The National Museums of Scotland and Grampian Regional Council, and is part of a research project initiated by the Department of Archaeology at the Royal Museum of Scotland, Edinburgh. We are particularly grateful for the co-operation and interest of the following individuals: Mr P Gordon (on behalf of the landowners); Mr I Shepherd (Grampian Regional Council); Dr D V Clarke (Royal Museum of Scotland); and Mr G Barclay (Historic Scotland). The use of facilities at the Department of Geography, City of London Polytechnic is gratefully acknowledged, as is the help of Dr G Cook and Dr R Tipping in expediting the radiocarbon date.

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MAMMALIAN FOSSILS RECOVERED FROM SUTTON CROSS, NEAR PETERBOROUGH, EASTERN ENGLAND: A PRELIMINARY REPORT OF RIVER NENE SECOND TERRACE DEPOSITS

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During construction of the Castor and Ailsworth bypass, a borrow pit was excavated at Sutton Cross (TF 108989) west of Peterborough (Figure 1), in a predominantly gravel deposit underlying the River Nene Second Terrace (Harrison, 1981; Horton, 1989). In July and August 1990 mammalian fossils were found in the deposit, which in this part of the pit comprised an upper unit (2–3 m thick) composed of gravel with subordinate sand and a lower unit (ca.1 m thick) of intercalated clay, clay-silt, sand and gravel.

Over much of the site the lower unit rests on Lower Lincolnshire Limestone (Jurassic), but at one location (B on Figure 2) it overlies a coarse, openwork pebbly gravel with abundant *Unio* sp. shells (D H Keen, pers. comm., 1991), and at another location (D on Figure 2) it overlies a cobble-pebbly gravel, which in turn overlies Jurassic Upper Estuarine Series deposits.

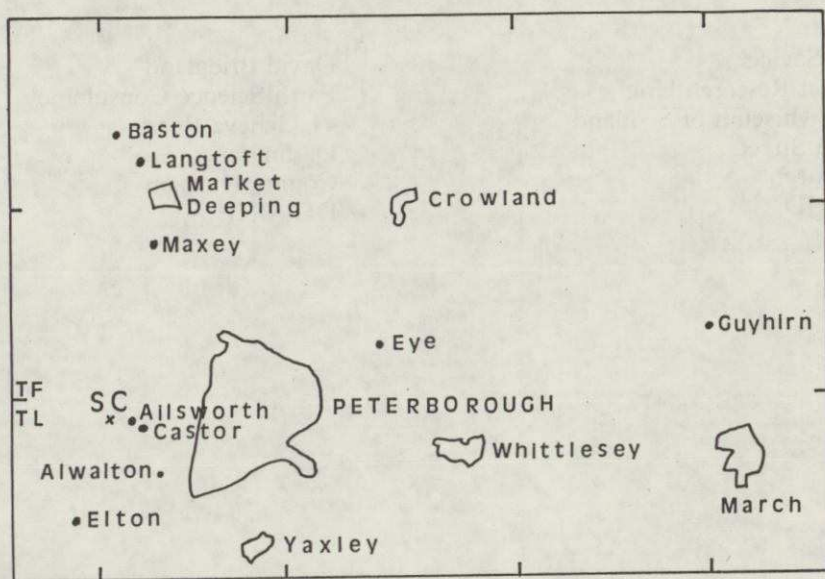


Figure 1 Location of the Sutton Cross (SC) site near Peterborough, eastern England, where recent *in situ* finds of mammalian fossil bones have been made. The tick marks on the border of the figure are 10 km apart. (Based on Ordnance Survey 1:250 000.)

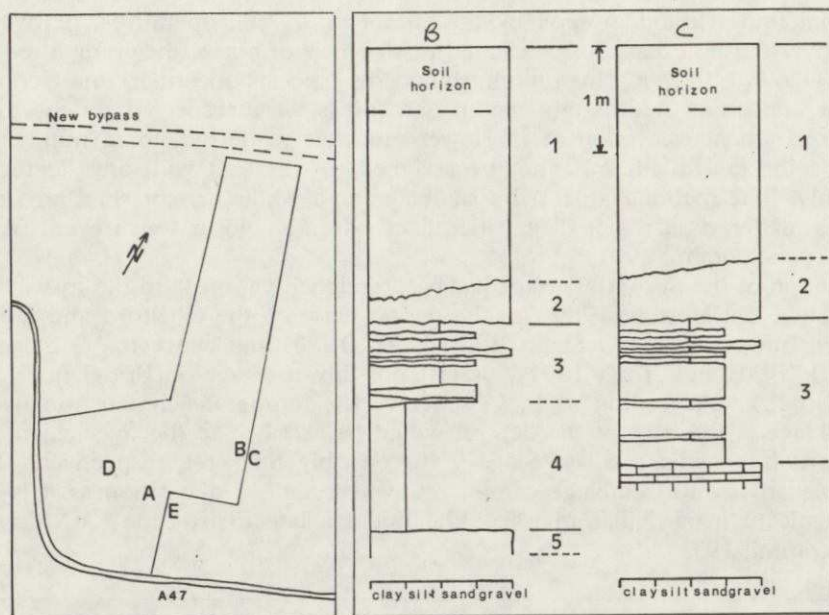


Figure 2 Site plan (not to scale) and simplified vertical graphic logs at B and C on the site plan. The section containing E is approximately 22 m. A-E refer to locations mentioned in the text. (1) and (2) comprise the upper unit, and (3) and (4) comprise the lower unit. (1) Massive, clast-supported pebbly gravel; (2) horizontally to subhorizontally bedded, clast-supported pebbly gravel; (3) intercalated clay, clay-silt, sand and gravel; (4) predominantly clay with scattered shells and organic fragments; (5) openwork, clast-supported pebbly gravel with abundant *Unio* sp. shells.

In situ finds included part of the skull and antler of giant deer (*Megaloceros giganteus* Blumenbach). This was found in the lower unit, in association with a temperate climate molluscan assemblage: e.g. high values were found of *Ancylus fluviatilis* Müller, *Pisidium henslowanum* (Sheppard) and *P. moitessierianum* Paladilhe (D H Keen, pers. comm., 1990). (Figure 3). Also in the lower unit, but at locality B in Figure 2, a metatarsal of red deer (*Cervus elaphus*) Linne was found. Three metres away (locality C in Figure 2), in the same unit, proximal radii of *Bos* or *Bison* were found. At locality E in Figure 2 a distal metatarsal of *C. elaphus* was found at the base of the overlying (upper) gravel unit.

Ex situ finds (found in spoil by the author or by site operatives, or by site operatives during excavation) included fossil bones of horse (including a tooth), *Bison* or *Bos*, *C. elaphus*, mammoth, rhinoceros (species uncertain) and elephant (species uncertain). Although mammalian fossils were recovered on the three occasions when excavation of the lower unit was witnessed, for a number of reasons the *ex situ* finds cannot be assigned to this unit with any degree of certainty. The mammalian fossil assemblage as a whole cannot shed any light on this matter, as it is not diagnostic of an extreme cold or warm event (A M Lister, pers. comm., 1991).

Deposition of the Second Terrace has been assigned variously to the Ipswichian (^{18}O Stage 5e; Horton, 1989), to the period between the Chelford and Upton Warren Interstadials (^{18}O Stage 3; Castleden, 1980) and between ^{18}O Stages 8 and 10 (Bridgland *et al.*, 1991), or just possibly to Stage 7 (Bridgland *et al.*, 1991, p.221). According to these schemes the temperate climate molluscan assemblage at the base of the deposit would be ascribed to the Ipswichian, the Chelford Interstadial, or ^{18}O Stage 9 (or possibly Stage 7), respectively. The mammalian fossil assemblage cannot resolve the age of deposition as it is not diagnostic of a particular phase of the mid- to late Pleistocene (A M Lister, pers. comm., 1991).

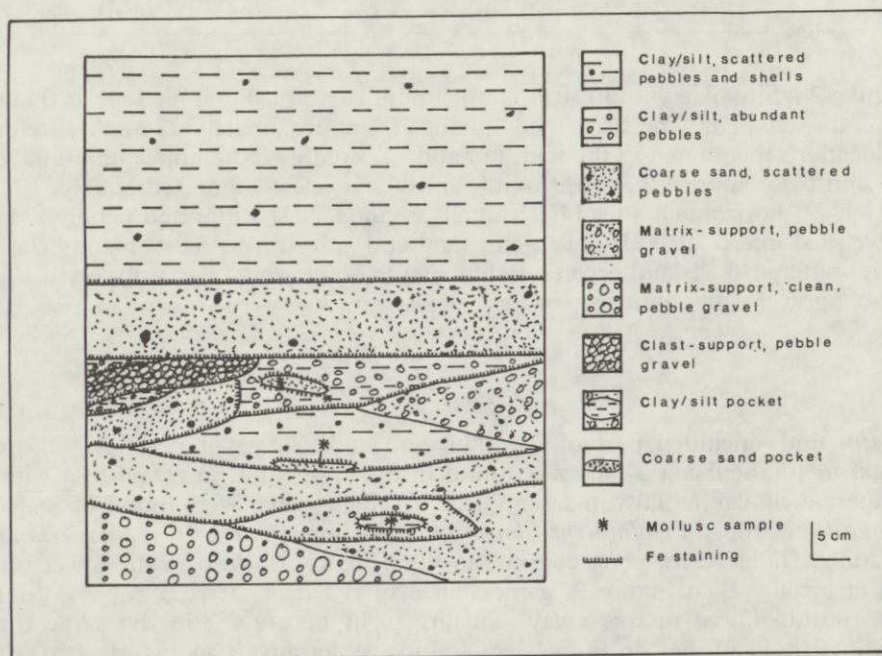


Figure 3 Detailed cross-section (approximately S-N) of the lower unit at A on Figure 2. The overlying sediments had been removed and the base was obscured.

A comprehensive study of the sedimentology, lithostratigraphy and biostratigraphy is in progress which may lead to a more definitive assessment of the age of deposition.

ACKNOWLEDGEMENTS

I am grateful to Phelan Group, Norwich, for permitting access to the site, and to Drs D H Keen and A M Lister for identifying the molluscan and mammalian assemblages; respectively, and for the ensuing discussions on the interpretation of the respective assemblages. Drs G F Dardis, D H Keen and A M Lister kindly read and commented upon an early draft.

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TWO *COELODONTA ANTIQUITATIS* SKULLS FOUND *IN SITU*: A PRELIMINARY REPORT ON RIVER NENE FIRST TERRACE DEPOSITS, PETERBOROUGH

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Abstract

Mammalian fossil bones have been found *in situ* at the base of deposits underlying the River Nene First Terrace. The site has yielded *Mammuthus primigenius*, *Equus ferus*, *Rangifer tarandus*, *Bos*, *Bison* and several other species of large mammals, most notable of which is *Coelodonta antiquitatis*. The last named species is represented by two skulls and a mandible.

Introduction

Davey (1991) has reviewed studies of Pleistocene deposits in the Peterborough area. He records the widespread occurrence of mammalian remains recovered in the past from several river terraces in the area. Thus far, however, few fossils have been excavated *in situ*.

This brief account serves to provide preliminary information, through a description of mammalian fossil finds *in situ*, on deposits underlying the River Nene First Terrace (Booth, 1982; Horton, 1989; Davey, 1991) at Tanholt Farm, east of Peterborough (TF 235 015). Such a preliminary account is deemed necessary because of the importance of finding the remains of two *Coelodonta antiquitatis* (woolly rhinoceros) skulls *in situ*, and because Tanholt Farm was included as an optional extra on day 4 of the QRA 1991 Annual Field Meeting and little information on the site has been recorded (Horton, 1989; Davey, 1991; Scourse, 1991).

A combined mineral extraction and landfill operation is located at the site (Figure 1), where in January 1991 a mammoth tusk was found *in situ* on the floor of a previously excavated cell. It was associated with organic-rich, laminated clay-silt-fine-sand and was lying in contact with the underlying Oxford Clay (Jurassic). This led to further finds of mammalian fossils in March–April 1991 as the cell floor was being stripped by bulldozer in preparation for landfill operations.

The research at Tanholt Farm forms part of a much wider research project to determine the sedimentology, lithostratigraphy, biostratigraphy and chronostratigraphy of Pleistocene deposits in the Peterborough area.

Brief description of fossils

The most notable *in situ* large mammal remains from Tanholt now in the Peterborough Museum collection are two *Coelodonta* skulls, one of which (M.496) was excavated during the QRA field visit; it is rather abraded and is

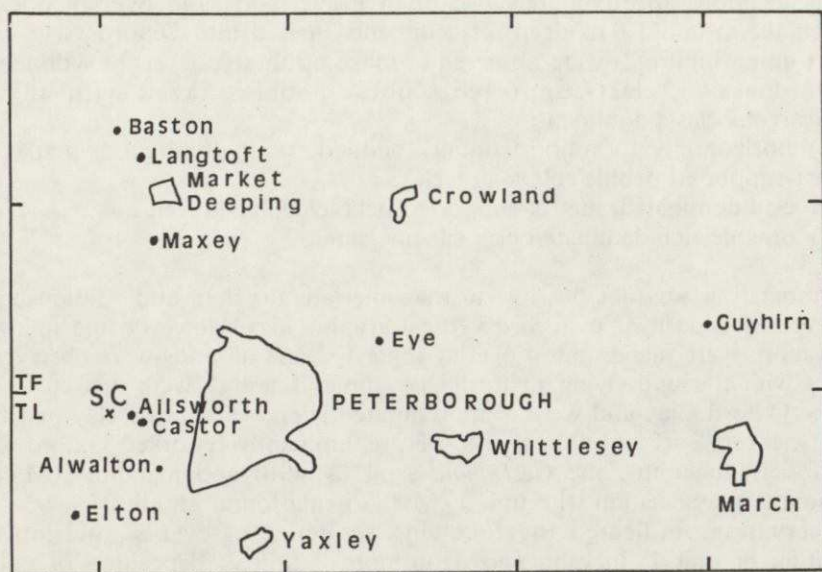


Figure 1 Location of the Tanholt (T) site near Peterborough, eastern England where recent *in situ* finds of mammalian fossil bones have been made. The tick marks on the border of the figure are 10 km apart. (Based on Ordnance Survey 1:250 000.)

missing part of the right side and has no teeth. The other skull (M.487) is better preserved but lacks the right cheek and the tip of the snout; it has two molars in place and may belong to the same individual as a fine mandible (M.488) found close by. The only other rhino skull known from the Peterborough area is a complex example (M.301) from Farcet (a village a few kilometres south of the River Nene), found in 1923 and now on display at the Museum.

Other notable *in situ* remains are a mandible (M.521) and femur (M.491) of *Equus*, several partial femora and other bones of *Coelodonta*, fragments of reindeer antler and several mammoth tusks, including the large specimen excavated in January 1991 and referred to above. There is an apparent paucity of material definitely assignable to *Bison*, a genus thought to characterise faunas of the earlier part of the Devensian (Stuart, 1982).

Associated sediments

At this location, approximately 4–5 m of gravel and sand overlay pockets, between 0.5 m and 1.0 m deep, of sediments incised into Oxford Clay. Four distinct units (Figure 2) were observed to make up these pockets of sediment:

- (1) massive, clast-supported, cobble-pebble gravel, with angular calcareous clasts dominant;
- (2) horizontally to subhorizontally bedded, sand dominated, matrix- to clast-supported pebble/cobble gravel;
- (3) clay dominated, matrix-supported pebble/cobble gravel;
- (4) organic-rich, laminated clay-silt-fine-sand.

Unfortunately it was not possible to map the lateral extent and relationship of each type of deposit or to record vertical graphic logs. However, the following observations were made: unit 4 overlay units 1–3 and all units were observed in contact with the underlying Oxford Clay; units 1 and 2 were incised deeper into the Oxford Clay and were of more limited lateral extent; the clay matrix of unit 3 was very stiff and appeared to be predominantly reworked Oxford Clay; most fossils, including one *Coelodonta* skull (M.490) and mandible (M.488), were found in association with unit 3 (M.487 being found in unit 2).

Observations indicated the following sequence of events: incision and deposition of unit 1; incision and deposition of unit 2; deposition of unit 4. Where unit 3 fits in this sequence is problematic. It was not observed to overlie units 1 or 2 and therefore it could have been deposited prior to unit 1, penecontemporaneously with unit 1, between units 1 and 2 or penecontemporaneously with unit 2.

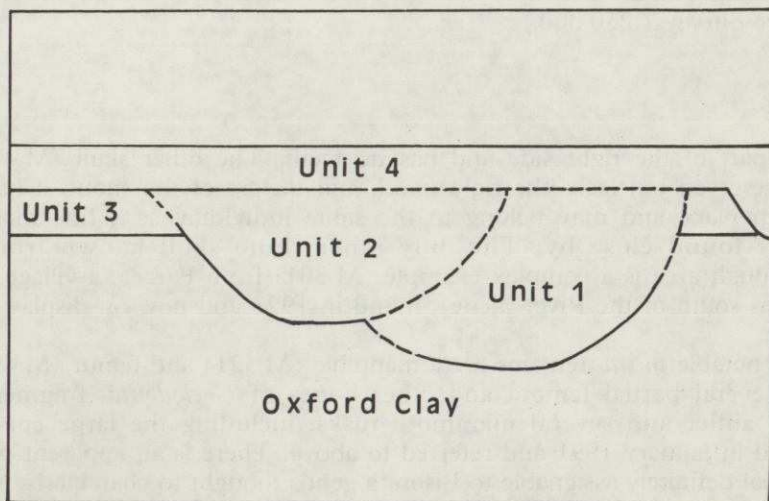


Figure 2 Schematic representation of units 1–4. The dashed lines indicate contacts not observed.

Conclusions

In March and April 1991, *in situ* mammalian fossils were recovered from the base of deposits underlying a River Nene First Terrace hitherto variously referred to as being deposited between the Upton Warren Interstadial and the Devensian ice maximum (^{18}O stages 2-3) (Castleden, 1980), during the Devensian (^{18}O stages 2-5) (Horton, 1989) and the late Saalian to late Devensian (^{18}O stages 2-6) (Bridgland et al., 1991). The mammalian assemblage is characteristic of a cold stage fauna and is comparable with that associated with middle to late Devensian assemblages found elsewhere (Stuart, 1982).

Acknowledgements

We are grateful to Drs G F Dardis and D H Keen for reading and commenting on an early draft, to Dr A J Stuart for help in fossil identification and to Mr Charlie Rayner of Butterley Aggregates for every assistance in the field.

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STURZSTROM OR FOSSIL ROCK GLACIER?: A REINTERPRETATION OF THE RELICT BOULDER DEPOSIT, CWM BOCHLWYD, NORTH WALES

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Cwm Bochlwyd, on the southern side of Ogwen Valley in North Wales (Figure 1), is considered to have been occupied by glacial ice of Loch Lomond Stadial age (Unwin, 1975, Gray, 1982). The cwm is north-facing and surrounded on its southern side by steep cliffs which rise to 914 m OD. The lip of the cwm is at approximately 550 m OD. A lake (Llyn Bochlwyd) occupies much of the cwm floor. The Loch Lomond Stadial ice limit is hard to define but is likely to have extended up to 100 m beyond the northern margin of Llyn Bochlwyd.

To the south of the lake, a mass of boulders has been mapped by Gray (1982) as "a large group of massive, steep-sided moraines with a dense cover of large boulders up to 5 m in diameter." More recently, Addison et al., 1990, p.99, have mapped this debris concentration as till.

The boulder mass forms a tongue-shaped feature some 240 m in length and elongated in a southwest to northeast direction (see Figure 1). The width ranges from 176 m to about 20 m. Of the well-developed lateral margins, the westernmost is the most obvious, extending in a near straight line along a bearing of 024°. This margin rises some 8 m above the surrounding grass-covered hillside. The eastern margin is not so well-defined but extends in a general northeasterly direction before veering towards the north at its downslope end. The feature is separated by a shallow depression from scree slopes that run down from cliffs encircling the southern end of the cwm, and is located some 480 m from those cliffs.

The surface of the boulder mass is highly irregular, with a local relief of up to 6 m or so, and is composed of a series of ridges and intervening hollows. Towards the rear of the feature are several conical peaks and small circular depressions.

Three main ridges are present which transverse the long axis of the feature and have fronts inclined at 30 degrees. They are separated by clearly-defined intervening hollows.

The greater part of the boulder mass is almost entirely free of vegetation and only on its eastern edge has there been any significant colonisation by plants. Clasts are mainly large, elongate and angular or subangular in shape. Many show evidence of edge-rounding although this may be a consequence of post-depositional weathering. None of the clasts show evidence of having undergone sub-glacial erosion. Splitting characterises many of the larger blocks, and the two pieces have moved relative to each other, although often only for a few centimetres. There is no evidence for a fine matrix within the deposit and in several places it is possible to trace spaces between large blocks for 6 or 7 m below the surface.

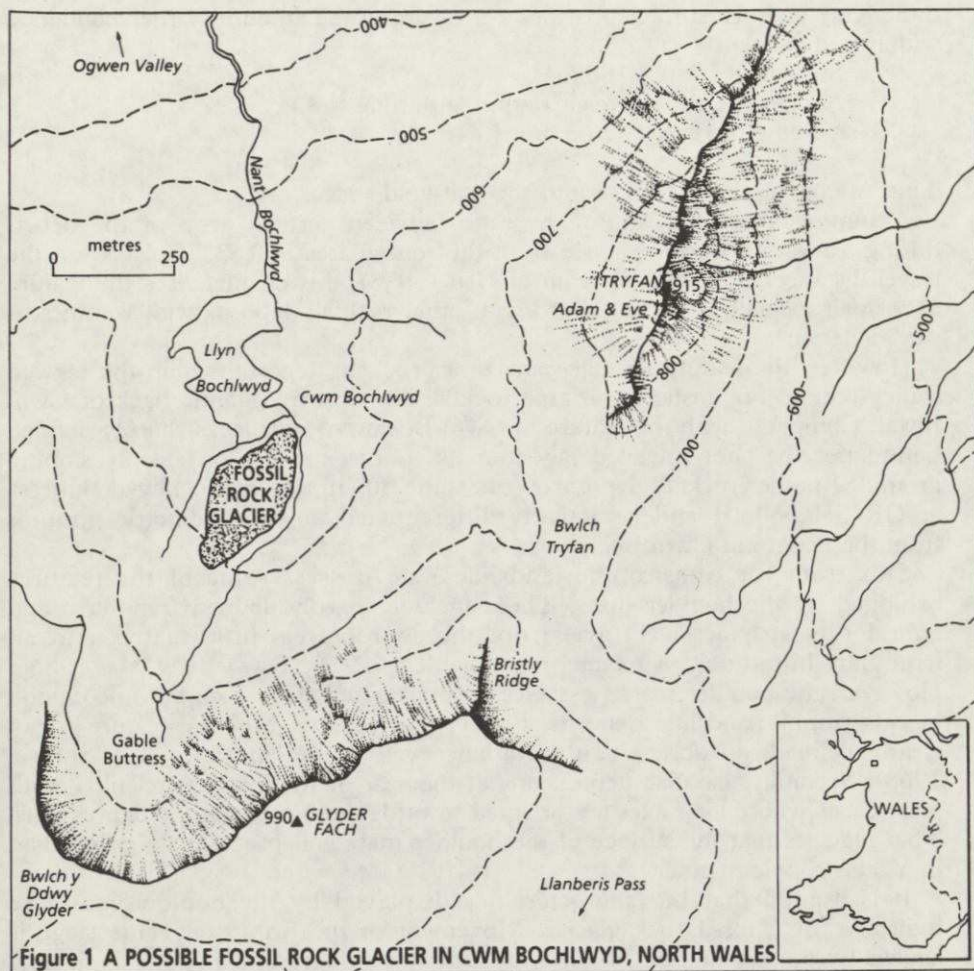


Figure 1 A POSSIBLE FOSSIL ROCK GLACIER IN CWM BOCHLWYD, NORTH WALES

The morphometry and location of this feature, the nature and arrangement of the clasts and the absence of fine matrix suggest that this is not a moraine. Although moraines are developed within the cwm, notably forming the constriction in the lake on its eastern shore, these form chaotic jumbles of clasts and do not possess sharply-defined bounding ridges. Instead, several of the characteristics suggest a rockfall or rockglacier origin for this landform.

This boulder mass could be a rockfall deposit. Set into the backwall of the cwm immediately above and behind the feature is a large wedge failure. Its volume (calculated to a line flush with the existing cliff) is 188 000 m³.

Preliminary survey of the boulder mass and estimation of the slope of the underlying bedrock surface provides a measure of the amount of rock contained within it, namely:

Surface area = 17 166 m²

Average height above surrounding hillside = 8 m

Volume of rock = 137 328 m³

This, of course, does not take into account void spaces.

Assuming a rockfall origin, the ratio between vertical drop of the debris during travel and travel distance from the source area is 0.53. If placed on the travel distance to rockfall diagram of Hsu (1975), this characterises the feature as a small rockfall and is in accord with other rockfall deposits with volumes of $<0.5 \times 10^6$ m³.

However, the feature is unlike any other rockfall deposits within the Ogwen Valley region. For instance, a large rockfall has occurred at the back of Cwm Idwal. Compared with the feature in Cwm Bochlwyd, this lacks sharply-defined boundaries, has not travelled far from its source and lies on steeply sloping ground. Another rockfall deposit occurs some 300 m east of Bochlwyd Buttress at GR SH 660601 and is similarly differentiated on morphometric grounds from the feature in Cwm Bochlwyd.

Sturztrom (or catastrophic landslides) do possess some of the features exhibited by the boulder mass. These include sharply defined transverse and lateral ridges, excessive travel from the source area, little matrix and an irregular, hummocky surface (e.g. Cruden, 1976, Dawson et al., 1986). However, the boulder mass possesses two characteristics which are uncommon in catastrophic landslide deposits. Firstly, the front edge of the feature is not clearly defined, an observation at variance with some landslides (e.g. Shreve, 1968). Secondly, circular depressions at the rear of the feature are 'tiled' with platy clasts whose long axes are oriented towards the bottom of the depressions. This suggests that the surface of the boulder mass collapsed slowly rather than in a catastrophic manner.

It is argued that the characteristics displayed by the boulder mass are indicative of a fossil rock glacier. Movement of the feature at some stage is shown by the orientation of clasts in transverse ridges and hollows indicating extending and compressive flow of the deposit and, this is especially well seen along its western side. Assuming a void coefficient of 0.4, the volume of this rock glacier is 54 931 m. Melting of ice within the rock glacier during decay may have resulted in the development of the circular depressions and these can therefore be interpreted as 'collapse pits'.

Although fossil rock glaciers have been described in the literature from other highland regions of the British Isles (e.g. Sissons, 1975, Dawson, 1977, Wilson, 1990), there have been no references to them in the mountains of Snowdonia (although the presence of a possible fossil rock glacier is mentioned on Moelwyn Mawr to the south of Snowdon (Gray et al., 1981). As indicators for permafrost at some stage, they are important for palaeoenvironmental reconstruction.

The sequence and timing of events which resulted in the formation of this rock glacier are not yet clear. However, it is likely that development of this feature was a multi-stage event, involving initial rockfall and subsequent slow flowage and deformation of the mass downslope. Owing to its position within the cwm (inside fresh moraine limits), a Loch Lomond age for the feature seems likely.

Further research is required to accurately assess the nature of this boulder mass and the probable timing of movement. To this end, analysis of clast form and macrofabrics and detailed surveying of the feature is currently being carried out.

Acknowledgements

I would like to thank Drs J M Gray and I S Evans for reviewing an earlier draft of this note. Dr D Cresswell and D Warren provided valuable discussions in the field.

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REPORTS

SHORT FIELD MEETING REPORT: THE WESTERN PENNINES, 17-20 SEPTEMBER 1991

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The Western Pennines, defined here as the north western part of the Yorkshire Dales including Wensleydale, Garsdale, Dentdale and the adjoining upland areas, is a critical region with respect to ice dispersal patterns in northern England during the Dimlington Stadial. It is also an area which contains evidence for the former presence of corrie glaciers during the Loch Lomond Stadial and of land-slipping on a massive scale, the age of which is difficult to establish.

These three themes formed the foci of the field meeting which was attended by 20 enthusiastic Quaternary scientists. The Black Bull in Kirby was the base, (apart from an outpost at the Croglin Castle Hotel) where members gathered on the first evening for the introductory talk by Wishart Mitchell. The field meeting represented the culmination of nine years of Wishart's detailed field mapping of 350 km² at 1:10 000 of this wild terrain, which included over 900 drumlins and slopes in excess of 35 degrees on the valley sides in Mallerstang. (A new classification for slope steepness could be, hard, very hard and Wishart!).

Wishart gave a splendid lecture, illustrated by aerial photographs which he took himself (courtesy of the Army Air Corps). He explained the importance of mapping the landforms in order to ascertain ice flow directions, the changing positions of the ice divide and the relationship of the inland areas to the ice margins in the light of recent research on ice sheet collapse. The mapping of the drumlins is particularly significant in ascertaining the regional pattern. It was shown that the drumlins exhibit a hierarchy of forms similar to those described by Rose (1987) and that where superimposed drumlins are present, two distinct stages of ice flow direction occurred. Maps and photographs of the landslides and terminal moraines also whetted the appetite for the following day in the field, when the complexities of their interpretation could be experienced first hand.

Day 1 Slips, slopes and drumlins

The theme for the morning was drift tails and drumlins. The former term was introduced by King (1935) and the features were demonstrated at our first stop en route to Widdale. Discussion ensued as to whether drift tails are composed entirely of till, if till forms only a thin veneer or whether the features are primarily streamlined interfluves.

Lively discussion followed on the problems of mapping drumlins, particularly where mass movements have occurred on the flanks. Wishart contrasted his earlier attempts at mapping and his later revisions (p.56 of the guide) and emphasised the importance of accurate reconstruction of the original drumlin shape for meaningful morphometric analysis. Accuracy in mapping is fundamental to all subsequent palaeoglaciological reconstruction. The altitude of the drumlins is significant in indicating the thickness of the ice sheet. On Widdale Fell their altitude varies between 562 m and 651 m OD and the mean orientation is 87° . This suggested that the ice was thick enough to have inundated the present topography and that the ice source for this valley was to the south with ice flowing north to join the main Wensleydale ice, contrary to previous explanations.

Exposures of sediments are not widespread in the area but, in places where streams erode the sides of drumlins, the till is available for investigation. The sediments had been analysed and interpreted by Professor Jim Rose, who unfortunately was indisposed and unable to be present. Discussions ranged from the hypothesis that we were seeing the results of deformation of a whole sediment body by the ice, that the different units represented various stages of deposition within the ice, to speculation as to whether the different units represented various stages within the ice. Theories ran riot and at least one group decided that unless the whole feature was systemically cored the question would remain unresolved!

The next stop was at the foot of Swarth Fell where we abandoned transport and set off for the heights. A remarkable series of flow lobes mantle the hillside. In places moraine ridges were shown to overlies the landslips, whereas other failures appear to be more recent and lie within the moraine ridge. It was demonstrated that the sequence of slope failure extended from the Late Glacial Period, through the Loch Lomond Stadial and into the Holocene. The moraine ridges form an extensive sequence which demarcate the limits of a small glacier although there is little evidence of a classic cirque form; therefore, it was suggested that the calculated mean ELA value of 567 m reflected a regional characteristic as the snowblow area is small. Calculations of basal shear stress and ice velocity show that the glacier was hardly moving. The problem of low velocities, calculated by assuming a resistant bed, may be explained by the bed being of low shear strength, enabling the glacier to move through the process of bed deformation. Within the moraine limits there lies a small tarn — awaiting a palaeobotanist's attention!

After lunch, taken by some hillslope enthusiasts on a windy slope, whilst the rest found a sun trap protected by the moraine, the party ascended Wild Boar fell. We were rewarded by magnificent views which ranged from Buckden Pike (or was it Great Whernside?) to Ingleborough, Penyghent, Whernside, the Howgills, the Lake District massif and the Vale of Eden, Cross Fell, the Alston and Askrigg Blocks. Cameras were busy recording the magnificent array of plateau, gully, glacial trough and all the major landscapes of Northern England. (Condolences to the pessimist who thought the early morning rain would persist).

The rest of the day was spent in first hand experience of the slopes which had been diligently mapped at approximately 1:3000 using air photographs as a base for the field mapping. The hundreds of lobes, ridges and rockfalls, present an intricate pattern, and whilst they awaited investigation of their geotechnical properties and ages, they afforded plenty of opportunity for discussion (see pp.72-73 of the field guide).

Day 2 Drumlins and ice flow directions

This was also a day of drumlins in the morning and slopes in the afternoon; however, the features discussed and their mode of presentation brought out different aspects and provided another stimulating day in the field.

The first walk in Grisedale (SD 7793) entailed crossing a suite of superimposed drumlins. The problems encountered in mapping complex features were ably demonstrated to the party. Viewed from different angles, it may be a case of "now you see it, now you don't", due to the changing perspectives. In order to establish form, the procedure was to ascertain the crest of the main drumlin, the crests of the superimposed drumlins and then establish breaks of slope. This is done by walking over the ground, mapping forms and rewalking, checking and amending the map. The different drumlin forms were shown to relate to two flow events, the earlier which came off the eastern side of Baugh Fell across Grisedale and the later which flowed down Grisedale.

The Moorcock Inn provided supplements to packed lunches, prior to the ascent of the slopes on the east side of Mallerstang. Here, spectacular mass movements have occurred beneath Loven Scars and Hanging Scars. These have been assiduously mapped by Wishart. The contrasts between the east and west sides of Mallerstang were demonstrated. On the former, faulting and lithological controls are more apparent. The main rock face is composed of sandstones interbedded with shales. Mudslides and fallen blocks of sandstone form a complex pattern of curved compression ridges and linear patterns of boulders. Deep-seated rotational failure of the back wall aided by the jointing pattern was shown to have been the source of the slide material. It was apparent from recent rockfalls that movement is still taking place, but the main movement appears to have been associated with the Late Glacial period and Loch Lomond Stadial. There is scope for further research on the age and on the regional pattern of slope failures. It is now evident from Wishart's work that these features are a consequence of slope failure and not a result of local glaciation in Mallerstang as previously interpreted (Rowell and Turner, 1952).

Day 3 Another fine one, both in terms of weather and the programme

The area of interest on the final day was the western fringes of the field mapping area. This included two of the lowest sites of the small ice masses during the Loch Lomond Stadial, Cautley Craggs and Combe Scar.

En route to visiting these sites, we were joined by Jocelyn Letzer whose work in the Upper Eden Valley is contiguous to the field area under discussion. The importance of erratics in establishing former patterns of ice movement was

discussed and illustrated by the erratic train which extends south west from Bluecaster, a hill which has limited outcrops of dolerite. The presence of these erratics to the northwest and north suggests a change in direction of ice flow as the position of the ice divide changed.

At Cautley Craggs, the presence of arcuate moraines was demonstrated and contrasts between slopes on the backwall, inside and outside the moraine were noted. The possibility that some of the rock debris was a pro-talus rampart was debated. Detailed mapping revealed that the features were more complex than had been realised hitherto. Much discussion related to the mass of drift which lies in the bottom of the valley and the view that it may have been a rock glacier was disputed. It appeared to have a drumlinoid form and on cursory investigation, a striated pebble was found among the subangular clasts in the exposures. It is evident that detailed fabric analysis would be useful in any further elucidation of the landform history here. It was suggested that if the deposits on the valley floor are composed of till, they are likely to be of Dimlington Stadial age.

The last site visited was Combe Scar which has the lowest altitude of any Loch Lomond Stadial glacier in the region. The arcuate moraine ridge is at 260 m OD and an ELA calculated to be 311 m. The suggestion that snow accumulated at this site is the occurrence of a very large potential snowblow area to the south west. Palaeoglacial reconstruction undertaken by Wishart showed that the glacier could have been active even at this low altitude. Further support for the presence of a glacier during the Loch Lomond Stadial comes from the work of Rod Gunson on the pollen stratigraphy of the hollow which lies behind the moraine ridge. There had evidently been a small lake, dammed by the moraine, which eventually became filled with Holocene sediments. Peter Worsley pointed out that stratigraphy alone, without a date, could not provide conclusive evidence that the cirque glacier was not of Dimlington age; however, the interpretation given is consistent with the regional pattern.

The meeting concluded at this point. Wishart was thanked for organising such a comprehensive programme which had stimulated lively discussion by providing so much new material. This had drawn together evidence for the regional pattern of glaciation with the detailed landforms which were placed in their spatial and temporal context from the Dimlington Stadial to the present. Participants will long remember this as a very enjoyable meeting where there was good humour and friendliness, characteristic of the QRA. Although the atmosphere of the meeting can't be conveyed in a text, the academic content is in the excellent Field Guide, edited by Wishart Mitchell with contributions from T P Buggie, A R Gunson and J Rose. The book provides, in addition to a guide to the area, the application of recent glacial theory to the late Pleistocene ice sheet reconstruction in Northern England and there are thirteen pages of references.

Wishart is to be congratulated, not only for the meeting, the book and all the organisation, but that this coincided with the successful submission of his PhD thesis.

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A WALK IN THE WESTERN PENNINES — BY A NEW MEMBER

Tessa Fenoughty

Department of Science Education, University of Warwick

It was with some trepidation that I arrived at The Black Bull Hotel on Kirby Stephens high street in mid September. As a recently appointed Geography Lecturer in the Department of Science Education at Warwick University, it was suggested by a colleague that I should join and attend the next QRA field trip.

Having come from teaching in a secondary school, I had rarely come into contact with academics and so my image of typical Quaternary Research members was wizened, grey-haired old men clad in tweeds, roaming over the moorland with furrowed brows, immersed in deep intellectual debates. Fortunately it could not have been further from the truth!

On the first evening the organiser, Wish Mitchell allocated sleeping partners as the group gradually assembled in the upstairs room of the pub. I have been on several courses and usually at this point unknown newcomers like myself, find themselves aimlessly wandering about or reading for the fourth time, the course programme! This was not to be the case on a QRA trip. Wish's introductory talk on the first night about "debris flow levees", "snow blow areas", "ELA" and "mega drumlins" had me fooled until Stephan, a fast talking geomorphologist in shining armour rescued me and unravelled the mysteries of drumlin formations and mass movement processes.

In the field it was the same. I had imagined that the group would scurry away and dig frantically into exposures mumbling about "clast size" and "orientation", leaving me in ignorance wondering what the feature was anyway!

In fact several group members were quite happy to translate Wish's pearls of wisdom in to English and I even began to understand and enjoy the heated debates, such as whether or not the ridges at the base of Swarth Fell were moraines or a protalus rampart. "... but I just can't get the glacier to move fast enough ..." "... surely the slope angle is not steep enough for boulders to cross the snow ..." "... what's the Canadian angle on this one Dave?"

With the sun shining as we assembled at the last site, Cautley Craggs I rather wished the field trip had not come to an end. It had been four days of fascinating geography, led professionally by Wish Mitchell and in the company of new found friends.

I am sure this will not be the last QRA field trip I attend. Thank you Wish and all the people on that trip for making it a memorable and enjoyable few days. I look forward to seeing you all at future meetings.

RECENT THEMES IN QUATERNARY RESEARCH: A REPORT

David Gilbertson and Peter Smithson
University of Sheffield

The QRA Winter Meeting was held on January 3rd and 4th 1992 at Marshall Hall, Sheffield City Polytechnic. It was attended by over 60 people and the accommodation and food were excellent. The design of the lecture room was unconventional but very successful, promoting a more informal atmosphere than is often the case. The following report is based upon the final abstracts provided by the speakers.

The Friday afternoon session began with *KE Barber*, *FM Chambers* and *D Maddy* who reported progress in the NERC Special Topic "Palaeoclimate of the Last Glacial/Interglacial". They paid particular attention to evidence of the spatial and temporal variability of *Late Holocene palaeoclimates derived from very detailed investigations of peat stratigraphy — most notably from studies of humification, plant macro- and microfossil studies*. They were able to demonstrate the important progress they had made towards building predictive models of palaeoclimate.

C D R Evans and *C James* presented a series of excellent slides in their lecture "*Some aspects of the Quaternary history of Hong Kong waters*" which illustrated the results of an extensive and integrated programme of drilling and seismic profiling in the territorial waters of Hong Kong. Their work has considerably amplified present understanding of the Quaternary stratigraphy of the region, and it was most interesting to learn of possible correlations with studies in nearby areas by Chinese Quaternary scientists. The Hong Kong offshore Quaternary sequence was divided into a lower and lithologically variable alluvial unit which overlay a dominantly marine unit up to 50 m thick. These two units were thought to be, respectively, the Holocene and a Late Pleistocene marine transgression.

By contrast, *K V Boyle* reported the results of very detailed investigations into the nature of the (macro) vertebrate faunas of very Late Devensian age from south west France and the Mendips in a paper entitled "*Zoogeography: spatial patterning in the faunal record*". Multi-variate analyses and investigations of distribution were combined with biogeographical theory to reveal the presence of distinct types of spatial patterns in the fossil record — patterns which when final chronological control is available for some sites — will lead to a much better understanding of what animal lived where, and the impacts of human activities upon these faunas.

Theoretical and computational advances in "*Correspondence Analysis*" were discussed by *NR J Fieller* and *JA Padmore*. This statistical technique, which produces graphical displays of a contingency table, has gained substantial popularity in recent years, not least amongst ecologists and palaeoecologists for whom it is a natural tool for the investigation of different species at various sites. This popularity was said to be a result of the ready availability of easy-to-use software packages with attractive and sophisticated graphics. This paper continued by addressing four fundamental problems which were too easily ignored by workers dazzled by seductive computer display namely: (1) how much of the available information in the raw data was captured in the correspondence plot? (2) what features of the data contributed to the display, and in what proportion? (3) how well were the individual points displayed in the display? (4) how could the effects of random variability in the data be assessed and allowed for in the data? Theory and methods were illustrated on data sets on abundances of different morphotypes of phytoliths in modern and archaeological deposits in the Hebrides and on faunal abundances in strata from excavations at pinhole Cave, Creswell Crags. "Detrending" is suspect; "bootstrapping" is advocated.

The Friday afternoon session closed with a well illustrated account of the nature and interpretation of a high resolution seismic survey (325 km line length) from offshore West Cumbria by *G D Williams* and *G P Eaton*. This was used to define the "*Seismic sequence stratigraphy of the Quaternary deposits and rock head of north east Irish Sea*". Several seismically distinct sequences were recognised, as were regional and local unconformities and their correlative conformities. The Quaternary sequence was shown to be dominated by aggradational sequences up to 30 m thick with a progradational sand sequence and correlative offshore bar in the top 10 m of the section. Vibrocore samples from the upper 5 m of sediment have yielded shelly marine faunas that have been dated by ^{14}C methods. Progradational sands (10 500–8300 years) were shown to be overlapped by a transgressive sequence (maximum 7500 years) which were believed to represent the Flandrian transgression. The study had also revealed the presence of major N–S trending channels +80 m deep and 1.5 km wide which were cut into the rock head and which displayed seismically-imaged gas plumes above them. The use of a seismic sequence approach was shown to have yielded significant new information on the Quaternary stratigraphic architecture of the north east Irish Sea.

The Saturday programme opened with the Invited Lecture "*In Search of Eurasia's Oldest Hominids*". This was delivered by Robin Dennell who used excellent slides of the spectacular and rapidly eroding landscapes of the Siwalik Hills and Pabbi Hills of Pakistan to describe the work of the British Archaeological Mission to Pakistan, of which Robin is the Director. He pointed out the extent to which the well known finds of early hominids in Africa were associated with particular types of depositional environment and taphonomic circumstances — e.g. lake basins, cave deposits — whereas open savanna, plains or fluvial environments might be situations in which hominid preservation is less frequent, and at best may consist of only a few of the more robust parts of the hominid skeleton. The paleogeography of the region for the period, one or two million years ago, was demonstrated to be significantly different from that seen today as a result of the rapid uplift of this part of the Himalayan mountain chain. Fluvial sedimentation from the rising mountain mass was seen to be dominated by tectonic influences rather than by climatic fluctuations, although the mountains have been subjected to repeated glaciation etc. The fluvial sequences were seen to contain rich and spectacular assemblages of vertebrate remains, some subject to significant re-working, others representing good *life assemblages*. As yet, remains of primates and hominids are proving elusive, but Dr Dennell was able to display casts of stone tools and chipped flakes recovered from deposits which were older than 1.5 million years. The question of whether these stone tools might be natural "accidents" of fluvial processes or "contaminants" was discussed at length in the lecture and in the subsequent enjoyable discussion.

After coffee, D Q Bowen reviewed the theoretical and empirical bases for *Amino-acid racemisation dating* of molluscan remains and described the various quality control and replication procedures that are in place to assure the reliability of the analyses. He proposed that the basic principles and procedures could be further tested by applying them to sequences of marine (raised beach and similar) deposits of south west Britain and to terrestrial sequences such as those of the west Midlands and in the Thames basin. In the case he described, where the lithostratigraphic sequences are (reasonably) securely known, the relative dating provided by the amino-acid racemisation studies of molluscs conformed with the sequences proposed by the lithostratigraphic studies and might therefore contribute towards a future chronostratigraphy.

Discussion of the Quaternary sequence in the English West Midlands continued in a paper by D Maddy, D Q Bowen, D H Keen, C P Green and S G Lewis who proposed "*The English West Midlands: a new type area for the British Upper Middle Pleistocene*". They showed that although the well known deposits at Wolston are older than previously thought, there is in the West Midlands a sequence of fluvial and glacial deposits which appear to have been accumulated during the time period conventionally referred to as the "Wolstonian" stage. This sequence was described in detail, and in the subsequent discussion when predictions were made about the lithostratigraphic relationships of other deposits in the area, predictions which in principle can be tested. The sequence proposed in the lecture was shown to be notably more

complex than previously believed and the authors outlined a case for the adoption of "ocean oxygen-isotope stage nomenclature" to aid further study of this sequence.

Attention switched from lowland southern Britain to valleys in the Grampian Mountains with the paper by *M J C Walker, J W Merritt, C A Auton, G R Coope, M Field, H Heinis and B J Taylor* who described the *Early Devensian site at Allt Odhar in northern Scotland* some 16 km south-east of Inverness. This site is notable for its evident survival of valley glaciation, as well as its northern and mountain location. Their slides showed the outcrop of a felted peat beneath two Devensian tills. The peat has been subject to rigorous palaeontological investigations (pollen, plant macrofossils and Coleoptera) which indicated the presence of an episode of birch expansion and its eventual replacement by open grassland at a period of time suggested by U-series disequilibrium dating to be "about" 106 ka BP. The lecture continued with a detailed analysis of the palaeobiogeographic situation of western Europe at this time and the possibility of its correlation with the Chelford Interstadial, the Brorup Interstadial of continental Europe and Isotope Substage 5e of the deep ocean record.

P L Gibbard and R G West delivered a paper on the "*Limit of the Wolstonian Glaciation*" in Norfolk. The research focussed upon long exposures in gravel pits at Tottenhill Quarry in west Norfolk. Detailed sediment logs, analyses of lateral sediment distributions and facies relationships were presented, together with information on palaeocurrent directions. The authors concluded that the sequence probably accumulated in a delta-like accumulation deposited by glacial meltwater at the eastern margin of "present Fenland". The ice was deduced to have entered the area from the west to north west. Some of the still-water deposits within the fan sequence present were shown to contain an arctic leaf flora. The pollen assemblages recovered from these deposits appeared to be derived largely by reworking from the underlying and *in situ* Hoxnian marine and freshwater sediments. The age of these glacial deposits was discussed and it was concluded that the glaciation must date from the early part of the Wolstonian Stage on the basis of previously established stratigraphical sequences in the area. Comparisons with continental Saalian Stage events were also presented together with a definition of the Wolstonian stage.

The final two papers reflected cave-oriented Quaternary research in Sheffield. *Peter Smithson* described the "*Microclimatology of modern and Quaternary caves*" with the aid of detailed studies of the thermal regimes and patterns of airflow in two Derbyshire Caves — Poole's Cavern at Buxton and Robin Hood's Cave at Creswell Crags. The patterns of air temperature distribution and its variation through the year in Poole's Cavern were shown to approach earlier theoretical predictions. In summer, the main chamber of the cave was shown to have an almost uniform temperature with a slight increase with height above the cave floor. Its value of 7°C was close to the mean annual temperature recorded at a standard microclimatological station nearby. When the outside temperature fell below about 7°C density currents were shown to flow into the cave. The aspect of the cave entrance with respect to changes in

climate of the cave in that in some synoptic situations a forcing of external air into the cave could be generated. These results were of considerable importance to archaeological studies which were seeking to explain the frequent and intensive use of the cave for lead smelting. Significant air pollution must have occurred in the relatively still-area parts of the cave where smelting was practiced. Similar studies were also reported for Robin Hood's Cave at Creswell Crags, but with the addition of experiments designed to explore both the impact on cave microclimate and habitability of lighting fires for the heat, light and protection in the cave entrance and interior. Major effects were noted.

G M Coles used the microclimatological models developed by Peter Smithson as one component in the presentation of a model of the *Taphonomy of airfall pollen in caves* at Creswell Crags. Pollen was trapped continuously for a one study year in various caves and compared with pollen recovered from lake surface sediments immediately outside the caves and with land use-biogeographic maps of the area within a 5 km radius of the caves. The analyses indicated that the composition of the airfall pollen within the caves reflected the biogeographic situation outside the cave, with two exceptions — namely that *Fraxinus* and *Ilex* could be considered to be under-represented in the trapped cave pollen, whereas various ferns in the cave entrance areas were over-represented as a result of the combination of enhanced spore production-liberation often being co-incident with low-level airflow into the cave. Water-borne transport of pollen from the exterior environment via fissures etc., into these particular caves was shown to be negligible in the study period.

The President thanked the organisers for their work — Paul Buckland, David Gilbertson, John Grattan and Peter Smithson — who in turn have written to Sheffield City Polytechnic thanking them for their excellent accommodation, food and organisation.

LAST INTERGLACIAL IN THE ARCTIC AND SUBARCTIC

by John Matthews Jr

[Although this article by John Matthews Jr has already been published in *Eos*, Transaction, American Geophysical Union, 72, No. 28, July 9, 1991 p.299, it was thought that its contents shall be given wider coverage by being reproduced in this Newsletter: Editor.]

An international group of 30 Quaternary scientists studying the last interglacial in the Arctic met recently to share regional information and to begin the compilation of paleoclimatic information on a hemispheric scale. The NATO Advanced Studies Workshop was held in Hanstholm, Denmark.

The last interglacial (s.s.) has been identified at sites across the Arctic, as have other discrete intervals later in stage 5. The development of hemispheric data sets requires international programs that foster the exchange of field-based paleoclimate data and increased communication between field researchers and the modeling community. Toward that goal, LIGA (The Working Group on the Last Interglacial in the Arctic and Subarctic) was formed to foster the development of a global-scale data base and to serve as an interface between field-based Quaternary scientists and ongoing regional programs addressing the field record of the last interglacial (for example, PONAM, CELIA, SOVPEC, PALE), and the climate-modeling community.

A better knowledge of Quaternary climates at high northern latitudes is essential to predict natural and anthropogenic-induced global climate change. The Arctic plays a crucial role in the global climate system. It includes some of the most dynamic boundary conditions of the planetary ocean-atmospheric system: the extent and duration of sea ice, the geography (area and elevation) of continental ice sheets, the position of tree line, the distribution and duration of seasonal snow cover, permafrost, the boundary between polar and subpolar ocean surface waters, and a locus of oceanic deepwater formation. How these parameters control energy exchanges and rates of climate change and whether anticipated changes in these parameters can be predicted are two of the major scientific challenges of the coming decade. The study of how these boundary conditions have differed in the recent geologic past and reconstructing the concomitant climate change as preserved in the proxy records is the role of the Quaternary science community. Paleoclimate data sets derived for specific intervals of the Late Quaternary define the rates and mechanisms of climate change and provide one of the only means of validating general circulation models.

Changes in solar radiation receipts caused by Earth-Sun orbital variations and amplified by as yet poorly described feedback processes within the Earth's climate system have lead to the growth and decay of the continental ice sheets, accompanied by significant environmental change at lower latitudes. The early phase of the last glacial cycle (marine oxygen isotope stage 5: circa 128–75 ka BP) is characterised by the shift of climate from the preceding glaciation (stage 6) into a brief interglacial (substage 5e: Eemian/Sangamonian), when summer

temperatures across high northern latitudes were above current values. The peak interglacial warmth in substage 5e, although not a direct analogue for the future because the forcing was different, offers the most recent example of the planetary response to Northern Hemisphere summer temperatures higher than at any time in the present interglacial. Although Northern Hemisphere summers were somewhat warmer than present in the early Holocene (c.9–5 ka ago), a time period that has been the focus of several studies (for example, COHMAP), general circulation models (GCMs) simulations suggest even warmer conditions by the end of the next century. It is necessary to look farther back in the geologic record to reconstruct conditions during such temperatures.

By the end of the peak warmth of the last interglacial (substage 5e) ice sheets were already growing in the Arctic, eventually attaining about half their maximum volume during stage 5, even though the North Atlantic Ocean remained essentially interglacial. A summer insolation maximum late in stage 5, that was similar in magnitude to that of substage 5e, produced a very different climatic response. The difference in the physical climate system's response may be related to difference in boundary conditions. Thus, the last interglacial (s.l.: stage 5) offers the potential to test the sensitivity of global circulation models to boundary conditions and forcing mechanisms.

The goal of LIGA is to define the primary physical boundary conditions and climatic parameters that characterise the planetary surface at high northern latitudes during the last interglacial (s.l.; isotope stage 5), and from these to develop a better understanding of the land/sea/atmosphere interactions that control the polar environment during "interglacials" and during major climate transitions (for example, 6/5e, and 5a/4 boundaries). Specific boundary conditions can serve as input to GCMs and the predicted climate output of the models tested against the proxy climate data from the inventory of last interglacial sites.

Specific tasks include:

Chronostratigraphy Providing an accurate and precise time frame for high-latitude sites, including deep-sea cores, deposited between 75 and 130 ka ago, is problematic for all but a few exceptional sites. LIGA members will develop a protocol for sampling strategies to maximise the chronological information obtained from the variety of terrestrial sites being studied under the auspices of the individual regional programs. The group will facilitate interaction between geochronologists and field geologists with the goal of an intensive dating effort of two to three key sites in each region to address questions of inter-comparability of the various techniques.

Data Sets A key role for LIGA is the compilation of known last interglacial sites of the high northern latitudes in a standardised format for archiving into a readily accessible format by the community. Development of a standardised format that is applicable to the wide range of sites that have been studied, and that will contain both primary and interpretive information, is essential. Primary information includes quantification of the flora and fauna and their isotopic ratios, sediment characteristics, and magnetic properties. The key interpretive parameters include such boundary conditions as annual and seasonal

temperatures, precipitation, snow cover, permafrost, salinity, sea and lake ice, and surface water currents. It is from these data sets that paleoclimate reconstructions can be deduced.

The next meeting of the working group is scheduled for fall 1992 in Montreal, Canada. For additional information, contact LIGA c/o John V Matthews, Jr, and/or Alice Telka, Geological Survey of Canada, 601 Booth St., Ottawa, Ontario, Canada K1A 0E8.

Members of the LIGA Task Group are Brian Huntley, John V Matthews, Jr, Gifford H Miller, Hans Petter Sejrup, Andrei Velichko, Anne de Vernal, and Alice Telka (secretary). — John Matthews, Jr.

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SOUTHERN RIVERS PALAEOLITHIC PROJECT

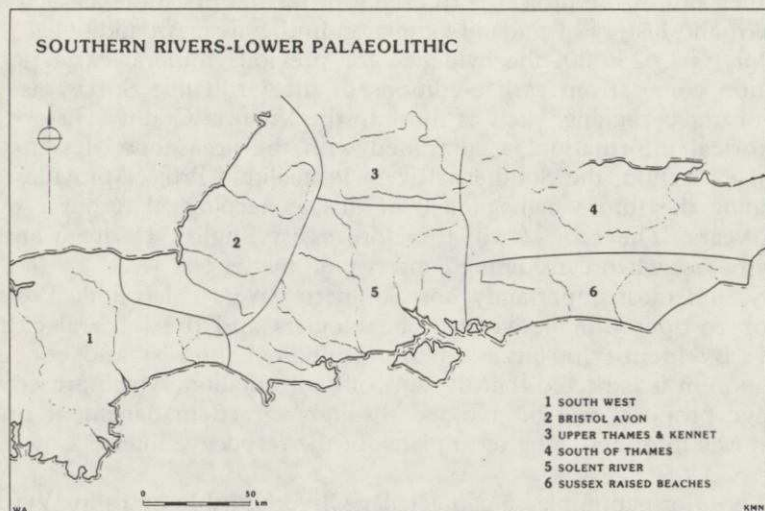
— a progress report from Clive Gamble
Dept. of Archaeology, University of Southampton

The archaeology of the earliest inhabitants of England and Wales is widely acknowledged as a world heritage resource. The sites of Swanscombe, Clacton and Hoxne are well known in both textbooks and general works dedicated to the colonisation of northern latitudes. Recent investigations at Boxgrove, Pontnewydd, La Cotte and High Lodge have confirmed the importance of this archaeological resource for understanding the evolution of human behaviour during the Middle Pleistocene, dated between 730 000 and 130 000 years ago.

However, for all the importance of these sites and the level of current research interest, the lower palaeolithic in southern England has remained, in management terms, a neglected resource. Statutory protection for these sites is almost non-existent. Conservation, as a routine aspect of the planning process, is rarely considered and presentation leaves much to be desired.

The focus for these issues came in 1988 with an application to extract sand and gravel from Kimbridge in the Test Valley, Hampshire. The pits at Kimbridge and Dunbridge had, in the days of hand digging, produced almost a thousand handaxes. Deciding on the correct planning decision led to the first evaluation of the palaeolithic potential of a proposed extraction area. A lively debate followed over the value and character of the archaeological material.

The Kimbridge investigations resulted in one very positive outcome for the general profile of the lower palaeolithic. In 1990 English Heritage commissioned Wessex Archaeology to produce a research design for a survey of the lower palaeolithic sites south of the Thames and Severn. The report, written by John Wymer, assisted by Karen Walker, and in consultation with Andrew Lawson (Wessex Archaeology) and Clive Gamble (University of Southampton), spelt out the threats to the archaeology from future proposals for mineral extraction as well as providing case studies of the type and quality of the data which could be recovered and ways of presenting the information to assist the planning process.



The Southern Rivers Palaeolithic Project was born. English Heritage announced in 1991 that they would be funding a full scale survey of the lower palaeolithic. This would last for three years and cost £250 000. John Wymer was appointed as the project leader with two assistants from Wessex Archaeology, Phil Harding and Karen Walker, and Clive Gamble as academic advisor. Work began in March 1991.

One decision in the research design had been to divide the area into six regions (Figure 1). Each year two regions are examined. In the first year these have been 3 and 5, The Upper Thames & Kennet and Solent river respectively. In 1992 regions 4 and 1 will be examined while in 1993 the project will conclude with regions 2 and 6.

In the first nine months all the palaeolithic findspots in regions 3 and 5 have been visited. Derek Roe's invaluable gazetteer, published by the CBA in 1968, has been updated and as accurate a record of palaeolithic materials as possible established. A full catalogue has been prepared of the finds and their contexts, where known. Since the primary aim of the Southern Rivers Palaeolithic Project is to assist management decisions in the planning process, the data have been

presented in map form. The scales range from town plans for areas of very high density such as Bournemouth and Southampton to 1:25 000 and 1:50 000 where appropriate. At all scales the findspots have been plotted against the maps of the British Geological Survey which identifies terrace units. Where appropriate other drift geology has been added.

The two regions so far completed are covered by 57 maps. These provide the most detailed assessment of lower palaeolithic resources carried out anywhere in Europe. While of obvious importance to County Archaeologists and County and District Planning Departments they also represent an invaluable resource for researchers and students.

A further aim of the project is to establish, for the first time at such a scale, the pattern and history of mineral extraction in the area. An additional series of maps plots, at 1:25 000, the evidence for previous mineral extraction. The information comes from earlier editions of the Ordnance Survey as well as records of gravel digging, such as those in the Victoria County History. When this historical information is combined with the areas now designated for proposed extraction, the Southern Rivers Palaeolithic Project provides a basis for planning the future management of this archaeological resource over the next 25 years. The project will therefore assist English Heritage and other statutory bodies when considering conservation matters.

Finally, and most importantly, the Southern Rivers Palaeolithic Project is a focus for co-operation between archaeologists and the mineral extraction industry. By identifying areas of archaeological interest and concern for conservation, it is expected that the sort of confrontation, which arose over the Kimbridge proposal will be avoided through agreed management practices, based on well informed, long-term plans for the respective interests.

For further information please contact: **Dr Clive Gamble or John Wymer**
at Wessex Archaeology (0722 326867).

THESIS ABSTRACTS



SEDIMENTOLOGY AND PALAEOENVIRONMENTAL SIGNIFICANCE OF LATE DEVENSIAN TO MID HOLOCENE DEPOSITS IN THE DON VALLEY, NORTH EAST SCOTLAND

A dissertation submitted for the degree of Doctor of Philosophy
at the University of Aberdeen

by
John F Aitken

The aim of this thesis was to produce models of the evolution of the Don Valley and its associated coastal lowland both during and following deglaciation, with the specific objective of identifying the pattern of deglaciation and to relate this to current theories of ice sheet and glacier decay in north-east Scotland, in particular the concept of "Moraineless Buchan".

The specific problems addressed by the research were the valley floor morphology and sedimentary stratigraphy. Valley floor morphology was determined by air photo analysis, field mapping and surveying of terrace fragments, whilst the drift geology and stratigraphy were established from British Geological Survey and other borehole and trial pit records, field sediment analyses and by palynology and radiocarbon analyses of organic horizons.

The models bring together the detailed stratigraphic, morphological, sedimentological and palaeoecological studies and rely heavily on a stratigraphy recognised in the principal exposures (predominantly gravel pits) together with data from BGS maps, pre-existing boreholes, morphological mapping and temporary exposures.

Detailed sedimentological investigations throughout the study area allowed the subdivision of the drift sequence into four broad groups, identified on the basis of their lithofacies associations:

- 1) Braided outwash deposits
- 2) Glaciolacustrine deposits
- 3) Deltaic deposits
- 4) Diamictons.

By correlating both temporally and spatially, palaeogeographic models were constructed for the lower Don Valley (downstream of Kemnay) and the coastal lowlands. Farther upstream, the scarcity of exposures and boreholes meant that correlation between widely dispersed sites proved difficult.

Although both the concept of "Moraineless Buchan" and the concept of an Early Devensian glaciation cannot be disproved, the evidence presented in this thesis provides further support for total glaciation of Buchan in the Late Devensian. Furthermore, it calls into question recently constructed ice limits in north-east Scotland.

John is currently a BP funded post-doctoral research assistant at the Department of Earth Sciences, University of Liverpool, where he is researching on reservoir characterisation within a sequence stratigraphic framework of Pennsylvanian (Upper Carboniferous) fluvio-deltaic deposits in eastern Kentucky.

THE EVOLUTION OF THE SOLENT RIVER SYSTEM DURING THE PLEISTOCENE

**A dissertation submitted for the degree of Doctor of Philosophy at the
University of Cambridge**

**by
Lorraine Gillian Allen**

Although the Solent River no longer exists, since most of its course has been drowned by eustatic sea level rise during the Flandrian, it previously flowed in an easterly direction across south-east Dorset and south Hampshire as an extension of the River Frome. As such, it formed the major drainage line of the Hampshire Basin syncline. A sequence of dissected and discontinuous fluvial aggradations, ranging in height from just over 125 m OD to below sea level, provide evidence of the former courses of the river and its tributaries. These deposits have been studied in detail in the field and from borehole data. Detailed clast lithological analysis of the gravel has been undertaken to determine provenance and for stratigraphical purposes. A series of litho-stratigraphical units have been defined and traced throughout the study area. The facies types and sedimentary structures indicate that the fluvial sand and gravel deposits generally accumulated in a braided river environment under a periglacial climate. Such conditions prevailed in southern England during the cold stages of the Pleistocene.

Fossiliferous organic sediments discovered during this work have been investigated. An interglacial (Ipswichian) and a Flandrian sequence have been studied and integrated with other evidence from the region.

The conclusions demonstrate that the Solent River was a large system, similar in size to the Thames, and formed a tributary to the extensive 'Channel River' during periods of low sea level. Its evolution reflects the influence of Pleistocene climatic change, local geological structure and long term tectonic activity. Although lack of datable deposits prevent determination of the age of the Solent River sequence, it is undoubtedly of considerable antiquity and potentially extends back to the Early Pleistocene.

MAGNETIC AND SEDIMENTOLOGICAL ANALYSES OF QUATERNARY LAKE SEDIMENTS FROM THE ENGLISH LAKE DISTRICT

D McLean
Luton College of Higher Education

Results of mineral magnetic, mobile element, and granulometric analyses of Holocene sediments from Buttermere and Crummock Water (two closely-linked lakes in the north-west of the English Lake District) are presented. These are used to: (1) identify the effects of internal (lacustrine) and external (catchment) controls on sedimentation; (2) establish catchment source-lake sediment linkages and assess the value of mineral magnetic techniques in palaeolimnological studies; (3) identify major catchment environmental changes.

Analyses of lake sediment fabrics (using sediment thin sections, SEM clay flake analysis, standard granulometric analysis, and mineral magnetic indicators of grain size change) indicate that river plume sedimentation is the normal sediment dispersal mechanism in these lakes. Thin (≤ 3.0 mm) chlorite-rich laminae, found at intervals in the otherwise homogeneous Holocene sediment sequence, are probably formed by trapping and concentration of fine, platy particles within lake waters. They are subsequently deposited during lake overturn. This represents an "internal" control on sedimentation. A model of sedimentation processes operating in these lakes is developed, incorporating river plume sedimentation, episodic density surges, and lake thermal structure.

Mineral magnetic measurements allow the objective subdivision of the lacustrine lithostratigraphy, identifying broad changes in lake sediment characteristics. Samples from both lake catchments are clustered into six magnetically distinct groups — despite the lithological complexity of the catchment. Comparison of these with the lake sediments has enabled identification of major sources during the Holocene. Following deposition of relatively unaltered bedrock-derived material during the Late-glacial ("primary" sources), secondary sources (which may include glacial diamicts, soils and stream sediments) dominate the lake sediments. Direct input of topsoil-derived sediment from *circa* 1000 AD onwards (during and following the main period of Norse settlement of the Lake District) is identified by its distinctive mineral magnetic characteristics, (high $X_{fd}\%$ values, $> \sim 4\%$). Industrially-derived magnetic spherules contribute significantly to the mineral magnetic characteristics of the more recent sediments, (mainly those post-dating *circa* 1900 AD. These are used to construct a proxy chronology for recent sediments.

Catchment environmental changes are mainly related to stabilisation of vegetation following deglaciation and, from *circa* 2000 BP, the anthropogenic effects of deforestation and land disturbance, thus increasing lake sediment accumulation rates. These findings are broadly consistent with the interpretation of the Lake District Post-glacial sediment sequence presented in studies by Mackereth (1966), and Pennington (1981), demonstrating a uniformity of lake and catchment development within the Lake District.

A prominent minerogenic layer present in the Buttermere and Crummock Water sediment sequence however, broadly correlates with similar horizons deposited in other Lake District lakes from *circa* 7400–5000 BP. These have been previously interpreted as composed of topsoil-derived material from human actions, (Pennington, 1973, 1981). In the Buttermere and Crummock Water sediments, this layer is best interpreted as derived from glaciogenic sediments reworked from within the lake basins, probably following lowered lake water levels during the period *circa* 7300–5300 BP. Thus it is suggested that re-interpretation of similar Lake District lacustrine sediments using the methods employed in this study would be appropriate.

Donald McLean gratefully acknowledges grants from the Bill Bishop Memorial Trust and the QRA Young Research Workers Award.

He is currently employed by the East Sussex County Council as an Assistant Pollution Control Officer, mainly concerned with monitoring landfill sites.

OBITUARY



Edward Francis 1930–1991

Edward Francis was a man of great vitality, who had a considerable influence on the Quaternary Science Community in Great Britain and beyond.

He was a native of Northampton and after graduating in Geology from Aberystwyth joined the Field Staff of the British Geological Survey at its Leeds office in 1954. While there he gained a broad experience in mapping, particularly in the Carboniferous, Permian and Quaternary, over wide areas in northern England.

I first met Eddie, as he was then known to most of us, thirty years ago, when I was a callow new recruit to the Survey. I well remember at coffee time on my first day, a tall, beaming and fresh-faced character who bounced up to me, prodded me on the chest (a characteristic mannerism) and bombarded me with questions and comments on current issues of the day, on science and on philosophy. He had an ebullient and often cutting humour, but he was a great source of energy, ideas and good company, and a perpetual irritant to what he regarded as the conformity and dullness of the Civil Service. His experience in mapping the area around Durham, in particular, a fascinating and puzzling series of tills and laminated clays, awakened his interest in the Quaternary. He was amongst the small group which met in Birmingham in 1964 to set up the Quaternary Field Studies Group and when, in 1968 it became the Quaternary Research Association, Eddie Francis was the obvious choice as first secretary. His wide-ranging interests, organising skills and energy were used to good effect in ensuring that the QRA maintained a multi-disciplinary character and rose to the challenges offered by the growing interest of many disciplines in the earth's recent past. These skills were later utilised by the International Association for Quaternary Research (INQUA) which made him its Secretary General in 1990.

He played a remarkable role within the Quaternary Science Community. Although the paucity of his publications was a poor reflection of the research which he undertook, his greatest scientific influence lay in his contributions during field trips and discussion meetings. His broad knowledge, his eye for detail, his relentless questioning of received opinion and his quizzing and debating with its protagonists produced a lively intellectual atmosphere on most occasions when he was present. Many young scientists owed much to his encouragement, banter and scrutiny.

It was clear to him that the Civil Service could not offer the scientific freedom for which he craved and in 1967 he took the brave decision to accept a temporary post in Geology at Newcastle University. In 1972 he moved to Keele University as a lecturer and warden of Barnes Hall.

It was at this time, however, that his multiple sclerosis was intensifying. He felt that in order to control the disease, he must control his life in a way which was difficult both for his family and his friends. As a scientist and a rationalist he set out first to understand the disease, to treat himself and of course, being Eddie, to leave his doctors in no doubt of the treatment he required. As a generous enthusiast he became a one-man help-line giving advice and support to many other sufferers.

His indomitable and restless character was reflected in a final move in 1983 to his beloved cottage and mountainside in Wales. It was incomprehensible to many of us that someone with his ailment could live on a high isolated moorland, but notwithstanding its problems, he was devoted to it.

Although it is sad that problems of health and circumstance prevented him from making the contribution to the published literature for which his skills fitted him, he was pleased in his last year that some of his contentious views of twenty years earlier on such issues as the palaeoenvironmental sequence at High Lodge and the origin of certain eskers have been borne out by recent work. Moreover his contributions to Quaternary Science were much greater than that, through the ideas and the stimulating intellectual environment which he helped engender. Warts and all, and there were several, Eddie Francis had a vitality and humanity which is missed not only in the scientific community but in the broad company of his many friends.

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BOOK REVIEWS



GLACIAL ISOSTASY, SEA-LEVEL AND MANTLE RHEOLOGY

Proceedings of the NATO Advanced Research
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There is general agreement on a global sea-level rise of 1.5 mm/year, when local data are corrected for the effects of isostatic compensation due to Pleistocene deglaciation. Large discrepancies are found between the viscosity profiles derived from the various rebound and geoid anomaly models. This is probably due to the effects of transient rheology, non-linearity in the constitutive equations, lateral viscosity variations in the mantle or inconsistencies in the different data sets employed by the various researchers. In this book one can find state-of-the-art discussions of the dynamic consequences of the equation of state, mantle mineralogy, chemical and phase-change stratification on key issues of global geodynamics. This book is ideal for graduate students and researchers in general, since it offers a very up-to-date vista of the exciting research being carried out in many important areas of the geosciences, all within a common framework.

The Quaternary of Colombia, Vol. 1-17

(Reprint series, editor T van der Hammen, Amsterdam)

When Professor Thomas van der Hammen went to Colombia in 1951, he began to undertake palynological and geological research with the Colombian Geological Survey on Cretaceous, Tertiary and Quaternary sediments. The unique possibilities for the study of the Quaternary in Colombia became progressively clear to him during his 8-year stay. Its place in northwest South America on the pathway of southward and northward migrations in the western hemisphere renders Colombia biogeographically extremely interesting. Ecologically, Colombia presents very diversified conditions: landscapes from tropical lowland to permanently snow-capped mountains and climate ranges from pluvial areas to deserts. Sediments from mountains, lakes and bogs provided good Late-Glacial and Holocene pollen records and possibilities of correlating the climatic changes in tropical latitudes with those of the northern temperate regions became clear. The first long continental pollen record came from a 300 m deep borehole in the sediments of the high plain of Bogota, a desiccated old lake in the intermontane basin at 2550 m altitude. A series of glacial and interglacial intervals was reflected in the pollen record. Based on a broad experience of Quaternary research carried out in the fifties, a multi-disciplinary research project was launched in cooperation with the geological, archaeological, and natural history institutes in Bogota. Palynological studies would form the backbone of the project and provide the necessary knowledge of the history of the flora, climate and environment, and the chronostratigraphical framework. To make the expected series of publications easily available, Van der Hammen initiated a reprint series under the title "The Quaternary of Colombia" ("El Cuaternario de Colombia"). Today, 18 volumes have appeared, being reprints of various international journals (Review of Palaeobotany and Palynology, Quaternary Research, and Palaeogeography, Palaeoclimatology, Palaeoecology), book series (Dissertationes Botanicae) and PhD theses of Dutch universities.

Volume 1 (1973) contains an introduction to the research project (Van der Hammen, T: The Quaternary of Colombia: introduction to a research project and a series of publications) and the palynological results of 2 cores derived from the Fuquene Lake (Van Geel, B & Van der Hammen, T: Upper Quaternary vegetational and climatic sequence of the Fuquene area, Eastern Cordillera, Colombia). The longest pollen record represents the last c.30 ka and shows the transition from cold-humid to cold-dry conditions in the period c.30 ka to 15 ka; during the glacial interglacial transition it also clearly demonstrated a first warming event followed by a marked climatic rebound (El Abra stadial) which apparently correlates with the Younger Dryas cooling event of the North Atlantic. Up to now, the records from the Fuquene cores are among the finest and most informative of their kind.

Volume 2 (1973) includes a classical study describing the stratigraphy and palynology of the Eastern Cordillera around Bogota, that concluding that the composite pollen record presented therein documents the upheaval of the northern Andes (Van der Hammen, T, Werner, J H, and Van Dommelen, H: Palynological record of the upheaval of the northern Andes: a study of the Pliocene and Lower Quaternary of the Colombian Eastern Cordillera and the early evolution of its high-Andean biota). It is remarkable that whereas the time frame proposed in this study was originally thought to be too young, it is still valid. This is an example of a good tentative but ambitious interpretation of the chronology called into question by detailed subsequent work. Finally, the time frame of the sediments of Bogota was reassessed on the basis of new evidence derived from one of the longest continental pollen records (*see*: Hooghiemstra, H and, Sarmiento, G: Long continental pollen record from a tropical intermontane basin: Late Pliocene and Pleistocene history from a 540-m core. Episodes, 14:107–115).

Volume 3 (1974) contains a study of the morphology of trilete spores of recent Colombian ferns (Murillo, M T, and Bless, J M: Spores of recent Colombian Pteridophyta. I. Trilete spores). The Andean vegetation belts are very rich in pteridophyta which is reflected in the fossil pollen record by the presence of numerous spore types. This study includes 12 plates in which 35 genera are photographically illustrated but a magnification of x500 is, in several instances, insufficient to show details. One plate shows scanning electron micrographs of 3 species of *Lindsaea*. Scientifically, there is no justification to include a SEM plate in this study but when the authors concluded their research, there was a generally exaggerated appreciation for SEM illustrations in morphological studies.

Volume 4 (1976) provides a study in which evidence of paleosols and slope deposits leads to a reconstruction of Quaternary landscape development (Jungerius, P D: Quaternary landscape development of the Rio Magdalena basin between Neiva and Bogota, Colombia. A reconstruction based on evidence derived from paleosols and slope deposits). Various stable and instable phases were recognised from Early to Middle Pleistocene age and a tectonic influence was identified.

Volume 5 (1978) includes a study based on the morphology of monolet spores of recent Colombian ferns (Murillo, M T, and Bless, J M: Spores of recent Colombian Pteridophyta. II. Monolet spores). This study includes 19 plates in which 29 genera are well illustrated photographically: a magnification of x1000 makes recognition of morphological characters easy. However, the layout is less attractive as the spores are variously orientated within the plates. In another paper (Van der Hammen, T, and Cleef, A M: Pollen morphology of *Lysopimia* HBK and *Rhizocephalum* Wedd. (Campanulaceae) and the revision of the pollen determination "*Valeriana stenophylla*" Killip), a misnomer, used in several earlier pollen records, is corrected but in an area which is palynologically so

diverse revisions, like this are inevitable. Thanks to the formation of an extensive reference collection of recent pollen and spores (in an early stage of the project), those kinds of revisions are rare. In this respect, it is difficult to understand why funding bodies seem reluctant to simulate the creation of pollen reference collections of newly investigated areas and why pleas are necessary to obtain the right tools to perform Quaternary studies in sites that are unanimously recognised as high priority areas in Quaternary research, such as the Amazon lowlands.

The particular expertise of the Van der Hammen group is the exploration of new palynomorphs that provide paleoecological information. The paper included in this volume (Van Geel, B, and Van der Hammen, T: Zygnemataceae in Quaternary Colombian sediments) shows that many types originally described from European sections are also present in sections from tropical areas. Finally, this volume presents a pollenmorphological study of the rosaceous genera *Polylepis* and *Acaena* from the Colombian Eastern Cordiller (Smit, A: Pollenmorphology of *Polylepis boyacensis* Cuatrecasas, *Acaena cylindristachya* Ruiz et Pavon and *Acaena elongata* L. (Rosaceae) and its application to fossil material). Possible identification in routine analysis is important as the ecology of the tree *Polylepis* is quite different from the ecological preference of the herb *Acaena*. *Polylepis* is important in the upper forest limit and temperature reconstructions in this area are mainly based on altitudinal shifts of this limit, rendering a reliable inference of the upper forest line very important. In this study, the application of scanning electron micrograph analysis is essential and Smit succeeds in providing morphological characteristics to differentiate between these genera. However, no keys are provided for routine light microscopy.

Volume 6 (1978) includes 4 papers dealing with prehistoric man in the area of Bogota. In the first paper, a sequence of warmer and colder intervals has been documented in 10 pollen records (Schreve-Brinkman, E J: A palynological study of the Upper Quaternary sequence in the El Abra corridor and rock shelters, Colombia). A general stratigraphy and paleoecological-paleoclimatological reconstruction was deduced for a sequence thought to range in age from (?) Eemian to Recent. The environmental history of the El Abra area is further documented in (Van der Hammen, T: Stratigraphy and environments of the Upper Quaternary of the El Abra corridor and rock shelters, Colombia). This paper provides evidence for 3 major episodes, each with their characteristic environmental conditions (100-50 ka, 50-37 ka and 37 ka to the present). The faunal remains recovered in the El Abra rock shelters belonged to deer, armadillo, rabbit, cavia, guinea pig, carnivores and birds (Ijzereef, G F: Faunal remains from the El Abra rock shelters, Columbia). It was concluded that these rock shelters probably served as temporary hunting camps. In an effort to integrate the multidisciplinary evidence from the high plain of Bogota (Van der Hammen, T, and Correal Urrego, G: Prehistoric man on the Sabana de Bogota: data for an ecological prehistory), an outline of the prehistoric environmental conditions is given. It is concluded that early man

possibly entered the area before the beginning of the Late Glacial, but certainly during the Guantiva interstadial (12.5–11 ka) when rock shelters in the area were used. The first signs of agricultural activities and ceramics are found shortly after 2500 yr BP.

Volume 7 (1980) deals with the calibration problem of palynological records (Grabandt, R A J: Pollen rain in relation to arboreal vegetation in the Colombian Cordillera Oriental). Arboreal vegetation types along 15 transects between 300 m and 4000 m altitude were used to compare vegetation relevés with the corresponding modern pollen rain. The phenomenon of colian supply of allochthonous pollen to vegetation types with a low pollen production (background effect) in the most upslope vegetation belt (superparamo) is also reviewed.

Volume 8 (1981) focusses on the Sierra Nevada del Cocuy where a combination of aerial photographic analysis, field studies on moraines and analysis of radiocarbon dated pollen sections led to a reconstruction of the environmental history (Van der Hammen, T, Barelds, J, De Jong, H, and De Veer, A A: Glacial sequence and environmental history in the Sierra Nevada del Cocuy, Colombia). The greatest extension of the glaciers probably took place in the period c.45–25 ka. During the dry climatic episode of 21–14 ka, ice extension was much less and the upper forest limit lower. The role of *Polylepis* dwarf forest at the upper forest limit became better understood and was evident during the interstadial intervals Saravita (22 ka), Susaca (13 ka) and Guantiva (11 ka) when the forest limit shifted to slightly higher positions.

Volume 9 (1981) is a PhD thesis from Utrecht University constituting a monumental work on the syntaxonomy of the Colombian paramo vegetation (Cleef, A M: The vegetation of the paramos of the Colombian Cordillera Oriental). This publication contributes substantially to an understanding of the altitudinal zonation of the paramo vegetation and describes 121 associations of zonal and azonal vegetation. This volume represents a considerable source of help for those palynologists who try to translate fossil pollen assemblages into modern vegetation types. A checklist of paramo species and 91 well-designed figures of vegetation transects and altitudinal ranges complete this publication.

Volume 10 (1984) is a PhD thesis from Amsterdam University that deals with a palynological study of the 357 m deep borehole Funza I in the lake sediments of the basin of Bogota (Hooghiemstra, H: Vegetational and climatic history of the high plain of Bogota, Colombia: a continuous record of the last 3.5 million years). After analysing 1230 samples and over 400 different taxa, this huge data matrix was graphed. According to dated volcanic ash horizons, this record represents over 3 Ma, but recent evidence from a second deep borehole has reassessed this time frame and the age of the base is now thought to be c.1.5 Ma. The present vegetation of the Bogota area is presented concisely and forms the basis for the interpretation of the pollen record. A detailed

environmental and climatological reconstruction of the 55 recognised pollen zones is provided that serves to identify a long series of glacial-interglacial cycles. Descriptions and photographs of 429 pollen, spores etc. are illustrated in 49 plates.

Volume 11 (1985) is a PhD thesis from Amsterdam University that deals with the relationship between the recent vegetation and modern pollen rain (Grabandt, R A J: Pollen rain in relation to vegetation in the Colombian Cordillera Oriental). Between 2900 m and 5000 m altitude, this relationship was studied in 353 sites. Results are listed as coefficients for the most important taxa. Subsequently these data have been applied to some pollen records in order to infer an "estimated vegetation diagram". Because it is not easy to infer stable factors, this study is clearly a good first step on the way to interpret, quantitatively, pollen percentages into vegetation cover.

Volume 12 (1985) is a PhD thesis from Amsterdam University that deals with 12 pollen records from peat and lake deposits of Upper Pleniglacial to Holocene age (Melief, A B M: Late Quaternary paleoecology of the Parque Nacional Natural los Nevados (Cordillera Central), and Sumapaz (Cordillera Oriental) areas, Colombia). The relationship between vegetation and recent pollen rain along transects is studied and the general vegetational and climatic development the reconstructed and compared with results from the principal previous studies of this area. This volume concludes with plates of rare and unknown palynomorphs.

Volume 13 (1986) is a PhD thesis from Amsterdam University that deals with 17 pollen records from volcanic soils and deposits (Salomons, J B: Paleoecology of volcanic soils in the Colombian Central Cordillera, Parque Nacional Natural de los Nevados). The vegetational and climatic history of the last 45 ka, including evidence of may interstadials and stadials originally reported from earlier publications, is referred to in some detail. Abstracts of the palynology of soils and sub-aerial sediments is a relatively little used technique, but its advantages and disadvantages are discussed in detail and a survey of the published literature given. Of special interest is an altitudinal record for the preservation of pollen, related to climatic conditions and its bacterial and fungal activity in the soil which increase with higher temperatures. It appears that ash and pumice deposits and fossil and buried soils contain well preserved pollen, above 3000 m.

Volume 14 (1988) is a PhD thesis from Amsterdam University that deals with 5 pollen records from 3 paramo areas near Bogota between 3250 m and 3625 m altitude (Kuhry, P: Palaeobotanical-palaeoecological studies of tropic high Andean peatbog sections, Cordillera Oriental, Colombia). Radiocarbon datings and indirect time control based on pollen concentration data provide a reliable chronological basis for these records. Correlation with previous environmental studies from this area support and improve an understanding of

a detailed regional vegetation and climate history of the last 22 ka. Ten stadials, interstadials, and other characteristic intervals are described. Macrofossil analysis provided valuable information concerning the local vegetational development. Finally, 27 plates with microfossils and macrofossils are provided with descriptions.

Volume 15 (1989) consists of 4 publications with palynological, petrographic and glacial morphological studies of the Central and Eastern Cordilleras. The first paper (Helmens, K F, and Kuhry, P: Middle and Late Quaternary vegetational and climatic history of the Paramo de Agua Blanca, Eastern Cordillera, Colombia) shows a pollen record of c.465 ka. Discrepancies with the published long records from the basin of Bogota are probably temporary as time control of both records can be improved. A study of the volcanic ashes of the sections of the Fuquene lake suggest that petrographic characteristics may be of use in correlation studies in the area around Bogota (Riezebos, P A: Petrographic aspects of a sequence of Quaternary volcanic ashes from the Laguna de Fuquene area, Colombia, and their stratigraphic significance). The 11 m long peat section El Bosque (3650 m alt.) shows a detailed environmental history of the last 5.8 ka (Kuhry, P: A paleobotanical and palynological study of Holocene peat from the El Bosque mire, located in a volcanic area of the Cordillera Central of Colombia). The repetitive destructive interference of lava flows gave rise to pioneer vegetations and the process of re-establishment of forest could be studied at several depths in this core. The last paper shows 4 distinct morainic levels near Bogota between 2750 m and 3750 m dated respectively 13–12.4 ka, 18–14 ka, 22.5–19.5 ka, and Middle Last Glacial or Penultimate Glacial age (Helmens, K F: Late Pleistocene glacial sequence in the area of the high plain of Bogota, Eastern Cordillera, Colombia). Illustrative photographs of landscapes and glacial morphological maps are included. A tentative correlation of the Late Pleistocene morainic sequences and biostratigraphic units of various areas in the northern Andes is provided; that assign this study to its appropriate place in the current regional environmental history of the region.

Volume 16 (1990) is a PhD thesis from Wageningen University that contains a geological-environmental study of an area that has been inadequately researched hitherto (Bakker, J: Tectonic and climatic controls on Late Quaternary sedimentary processes in a neotectonic intramontane basin: The Pitalito Basin, South Colombia). The influences of tectonics and climatic change on sedimentation patterns are studied. A gravity survey examines the basin geometry and subsidence is estimated from sedimentation rates. Two pollen records show the paleoecological history of the last 60 ka. A temperature depression of 6–8°C is inferred for this site at 1300 m altitude during the coldest part of the last glacial. The effects of climatic change are superimposed upon those of tectonic activity. A geomorphological map of the Pitalito Basin (scale 1:40.000) is included.

Volume 17 (1990) is a PhD thesis from Amsterdam University that provides an updated view on the geological history of the basin of Bogota (Helmens, K F: Neogene-Quaternary geology of the high plain of Bogota, Eastern Cordillera, Colombia. Stratigraphy, paleoenvironments and landscapes evolution). The many new field and mapping data on the Neogene-Quaternary lithostratigraphy, the sequence of depositional environments and the biostratigraphy are presented here. The sequence of formations described by Van der Hammen (1973: see Volume 2) is further delineated and extended, and several new formations are recognised along the main rivers, flood slopes and surrounding mountains of the high plain of Bogota. An absolute chronology based on tephra datings from outcrops and deep boreholes provides a revised time frame (compared to the ideas based on the Funza I pollen record) for the history of the Bogota basin. This important publication finally includes two Neogene-Quaternary geological maps (scale 1:80.000) of the upper drainage basin of the Rio Bogota.

Volume 18 (1991) is a PhD thesis from Wageningen University that deals with tectonics in the Colombian Andes (Van der Wiel, A M: Uplift and volcanism of the SE Colombian Andes in relation to Neogene sedimentation in the Upper Magdalena Valley). The geological histories of 3 different areas (Garzon Massif, southern part of the Neiva Basin, and the ignimbrite plateau near La Plata) are integrated in a single model. Uplift of the Garzon Massif is discussed in the light of the plate tectonic setting. This publication includes a geological map (scale 1:55.000) of the S. Neiva basin.

Several studies are still underway and will be included in subsequent volumes in this series of publications. Copies of volumes 5 (\$7.95), 6 (\$15.90), 8 (\$7.50), 10 (\$12.00), 11 (\$9.00), 12 (\$10.00), 13 (\$10.00), 14 (\$14.00), 15 (\$12.00), 16 (\$10.00), 17 (\$15.00), and 18 (\$ 15.00) are still available and can be ordered at the Hugo de Vries-laboratory of Amsterdam University. Please send a purchase order to Alice G dos Santos at the address below.

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GLACIAL DEPOSITS OF GREAT BRITAIN AND IRELAND

Edited by Juergen Ehlers, Philip L Gibbard and Jim Rose

A A Balkema
Postbus 1675
NL-3000 BR Rotterdam
Netherlands

580pp including a 35 page index plus 24 unnumbered pages of colour plates

£57.00 [£44.25 discounted price to QRA members]

This important book has been long awaited, having been 'in press' for around five years, but the superior quality of its production will lead most to conclude that the wait has been worthwhile. Here is a glossy hardback book of just below A4 size and over an inch thick with a plethora of illustrations, both photographs and drawings. Every aspect of the subject of its title is covered, as well as some that are peripheral to it, in a volume comprising some 44 separate articles. For a complete list of contents, the prospective purchaser should consult the sales literature from the publishers that accompanied earlier issues of Quaternary Newsletter, as it is not possible to mention them all here.

The subject of glacial deposits in the British Isles is in fact approached in three separate ways, giving rise to three divisions within the volume. First there are eleven contributions in a section entitled 'Glacial Events'. The topics in this section range from a synthesis of the punctuated glacial history of the British Isles by D Q Bowen, the opening paper, through the various known glaciations (in chronological sequence), to a review of the Loch Lomond Stadial glaciation by J M Gray and P Coxon.

This section includes a contribution by two of the editors, J Ehlers, and P Gibbard, on the Anglian glacial deposits in Britain and adjoining offshore regions that also includes some very interesting discussion of Wolstonian and Devensian events, particularly offshore. There are commendable syntheses of the evidence for pre-Midlandian glaciation in Ireland, by P G Hoare, of the late Devensian glaciation in Scotland and adjacent offshore areas, by D G Sutherland, and of glaciation of the same age in eastern England and the adjoining part of the North Sea, by J A Catt. Two separate and contrasting interpretations of last glacial deposits in Ireland are included, by P G Hoare and W P Warren, potentially adding the spice of controversy to a coverage that is otherwise systematic, although there is a disappointing lack of debate between the two.

R J Rice and T Douglas provide a balanced synthesis of the traditional view of the glacial sequence in the Midlands, in an article on the Wolstonian glaciation. They seem to find the evidence for the existence of Lake Harrison rather more convincing than that for dating the glaciation of the Wolstonian type area as equivalent to the continental Saalian. They emphasise

importance of the lacustrine deposits in the stratigraphical correlation, seemingly implying that if the Lake Harrison story founders, the case for a Wolstonian glaciation will collapse. Much work of pertinence to this topic has been completed in the 4–5 years that this book has been in press, leading to the feeling that this particular article is one of many in it that are inevitably a little dated. P Worsley's contribution, reviewing evidence for Early Devensian glaciation in the British Isles, suffers more than most from this delay in publication; it takes no account of the recent revelations about the ages of Chelford and Upton Warren interstadials, now widely believed to correlate with Oxygen Isotope substages 5c and 5a respectively (see Bowen, 1989) [This important new interpretation is also missing from Table 1, in the opening article, suggesting that the article was prepared by Bowen before the information included in his 1989 paper was available]. The Early Devensian has long been a source of frustration, being geologically recent and yet poorly documented within the sedimentary record. Now it seems that the search for a glaciation pre-dating the Upton Warren episode has been a wild goose chase — in terms of the oxygen isotope record, that period probably falls within the last interglacial complex (Oxygen Isotope Stage 5).

The second part of the volume, entitled 'Critical Regions', is easily the largest, comprising twenty-three articles. The editors have achieved a comprehensive coverage of the glaciated parts of the British Isles, coaxing contributions from some authors who work is well known but too seldom seen in print. The joint offering by P Allen, D A Cheshire and C A Whiteman on the tills of southern East Anglia is particularly welcome in this respect.

Even in so large a book, some of the contributions seem too brief to develop their subjects fully. Thus D G Sutherland (six pages on the glaciation of Orkney and Shetland) and A M Hall and E R Connell (seven and a half pages on the glacial deposits of Buchan) merely whet the appetite. Thorp, on the other hand, is allowed twelve pages to explain how the extent and form of the major Loch Lomond Stadial icefield in the western Grampians has been determined. This he does with the aid of some excellent diagrams.

Other highlights in this section include the description of the glacial deposits in north-west Norfolk by J Ehlers, P Gibbard and C A Whiteman. All too brief (only about four pages of text), this includes a discussion of the Marly Drift, on which the authors have published in more detail elsewhere (in Van der Meer, 1987). Four further pages of this article are devoted to Figure 143, which depicts the stratigraphy and structures visible in the cliff sections between Weybourne and Sheringham. Another example of contrasting approaches can be found in contributions on the Irish Sea area, firstly by N Eyles and A M McCabe, who strongly advocate glacio-marine deposition as the dominant process, and then by R V Dackombe and G S P Thomas, who put forward a more conventional view in an account of the glacial deposits of the Isle of Man.

There are few gaps in the regional coverage, although J Boardman's study of the glacial deposits in the Lake District is in fact a review only of the north-eastern corner of that area, where he has defined a detailed lithostratigraphical

sequence, aided by soil-stratigraphy, that extends back in time to the pre-Ipswichian. A glance at the map (Figure 368) on page 495 also shows that northern Scotland, the Southern Uplands and North Wales are all missing from the regional section of the volume, the last of these seeming to be the most significant omission.

In the last section of the volume, entitled 'Critical Topics', there are ten further papers, the last of which is a summary and overview by the three editors. That these three have managed to collaborate on a pithy discussion of such subjects as 'Wolstonian — the missing glaciation' and 'correlation with the deep-sea record', both touching on the thorny issue of 'extra stages', is no mean feat, knowing that they hold somewhat disparate views on these topics.

Earlier in the section there is a fascinating review of past, present and future mapping of glacial deposits by the British Geological Survey, provided by W P Warren and A Horton. Reading between the lines it seems that the Survey officers still see more of the Quaternary as glacial than the rest of us!. A M McCabe provides a comprehensive review of drumlin distribution and stratigraphy, with examples mostly from Northern Ireland. Also containing a full discussion of the likely genesis of these features, this article would have been an excellent choice of reading material prior to attending the recent QRA field meeting in the western Pennines. I D Bryant provides a brief but useful summary of glaciofluvial deposition and includes a table listing numerous case studies of such sediments. P Allen has compiled a review of deformation structures in British Quaternary sediments, a subject that was rather poorly documented at the time he was writing. His hope, that there would be "a greater interest in the examination and interpretation of disturbances in Pleistocene sediments", can now be seen as prophetic; three major volumes devoted to the topic have been published while this present work was in press, two of them by Balkema (Van der Meer, 1987; Croot, 1988; Aber, Croot and Fenton, 1989).

A strong feature of this volume is the quality of illustrations in virtually all the contributions. Articles are fully illustrated with well-drawn figures and a very generous number of black and white photographs, the quality and usefulness of which are exceptional. The 24 pages of colour plates are even better, setting new standards for the presentation of this type of subject. The clarity of illustration is not always matched by the style of the written text, but there are few typographical errors. So comprehensive is the coverage of the subject that this will surely be an essential reference volume for many years to come, although it is not quite a textbook, as claimed in the promotional literature. There is inevitably a mixture of fresh up to date work and rather stale reviews of older research. Time will tell whether the more modern opinions have the longevity of the older ones.

In conclusion, everyone seriously interested in the subject of Quaternary glaciation in Britain will want a copy of this book, which, given its size and quality, represents good value for money, especially with the QRA discount.

David Bridgland

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FURTHER CORRESPONDENCE



PARAGLACIAL FANS OR SOLIFLUCTION SHEETS IN CENTRAL WALES?

Stephan Harrison

Department of Geography and Planning, Middlesex Polytechnic

A reply to Mrs Watson

I am grateful to Mrs Watson for replying to my paper on the nature of "solifluction sheets" in upland areas in Britain (Harrison, 1991). Her observations on the sediments exposed at Morfa-Bychan on the Welsh coast near Aberystwyth are very informative and certainly suggest that a considerable amount of solifluction of angular, gelifRACTED material has occurred at this site.

However, my main argument concerns the nature of "solifluction sheets or terraces" in the upland valleys of central Wales. Several workers (e.g. Watson, 1977, Potts, 1971) have reported the presence of glacially-abraded clasts within the "solifluction terrace" deposits. The downslope orientation of these and other clasts suggests that the sediments have been reworked by slope processes. I wholeheartedly agree with Mrs Watson (1991) when she states that "the slow rate of deposition by solifluction make a Late Glacial age for the transportation of glacial deposits into solifluction sheets quite untenable". However, if central Wales was covered by a local "Welsh" ice cap then this period of reworking of the superficial deposits can only have occurred during the following deglaciation; hence a faster mass movement process than solifluction must be invoked.

Resolution of the controversy concerning the presence or absence of a local Welsh glaciation during the late Devensian is therefore crucial if we are to interpret correctly the nature of the upland drifts. Macklin and Lewin (1986) identified *in situ* glacial till in the Rheidol valley and used this to argue that the area was glaciated by a local glaciation. In the absence of a proper dating framework into which the drifts can be placed, our interpretation of the age of this event must remain speculative. However, I believe that the case for a widespread Late Devensian glaciation of central Wales and hence my ideas concerning a paraglacial origin for the upland drift sheets remains strong.

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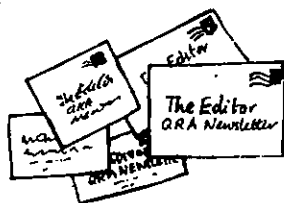
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POST BAG



Dear Dr Taylor

Members of the Quaternary community might be interested in a book, "Natural History of Hokkaido", just published "on the Quaternary of northern Japan". Although the subtitle of the book by Dr Yaeko Igarashi, — "travelling through Ice Age forests" — indicates the author's main interest which is palynology, the book includes chapters on geomorphology and volcanism as well as new, previously unavailable data on Quaternary vegetation/climatic change in the northern island of Japan. The book, which is published by Hokkaido University Press has 219 pp.

Having just returned from Hokkaido, I was dismayed by the amount of Quaternary information available of which many of us are unaware.

Perhaps you can fit in a brief notice of Igarashi's book in *The Quaternary Newsletter*.

Sincerely

Linda E Heusser

Lamont-Doherty Geological Observatory of Columbia University

Palisades

New York State

TWX 710-576 2653

Dear Sir

A major Pliocene warming

A few years ago I published a series of papers on the St Erth Beds, initially on my own and later with colleagues (Jenkins, 1982; Jenkins *et al.*, 1986; Jenkins and Houghton, 1987; Houghton and Jenkins, 1988). From the analysis of planktonic foraminifera and nannofossils, it was concluded that a major warming had occurred at c.1.9 Ma, when sub-tropical waters had bathed the

southern part of Cornwall, England, (Jenkins and Houghton, 1987; Houghton and Jenkins, 1988). This presented us with a problem; the warming in this area could have been due to a significant switch in the Gulf Stream gyre system, or there could have been a major North Atlantic warming.

Desperate to find confirmation we tried to pick out a warming in the oxygen isotope record and there are possible indications of minor warmings in core V28-179 (Shackleton, 1985). After these later publications of ours there was a deathly silence in this minor branch of science. A major Late Pliocene warming! So what? It could have been the first major warming after the 2.4 Ma North Atlantic glaciation.

The St Erth Beds stand 55 m above sea level, so the deposits could possibly record a high stand in sea level at 1.9 Ma. Further, I had examined some North Atlantic DSDP sites in the Basel Museum repository in 1987 and I was able to confirm the St Erth warming in the planktonic foraminiferal record.

Earlier in the Pliocene I had recorded an increase in the species diversity of planktonic foraminifera in the Lower Pliocene of New Zealand (Jenkins, 1968; 1972) and this could very well coincide with the postulated warming in Antarctica at this time (Webb and Harwood, in press) which has also been recorded in the Arctic region (Matthews, 1989; Matthews and Ovenden, 1990). In the North Atlantic, Cifelli and Glacon (1979) were of the opinion that in the Early Pliocene the western margin of the North Atlantic Gyre had been 10° latitude farther north than it is today.

So let me pose a few questions:

If there was a major Pliocene warming at c.1.9 Ma with a high stand in sea level (which resulted from a massive melt-down of Arctic and Antarctic ice), where is this recorded in the oxygen isotope record? Could it be that the oxygen record is not recording major cooling and warming episodes in the Pliocene? Perhaps someone could address these questions which also have a direct bearing on another major world warming in the Early Pliocene.

Yours sincerely

D Graham Jenkins

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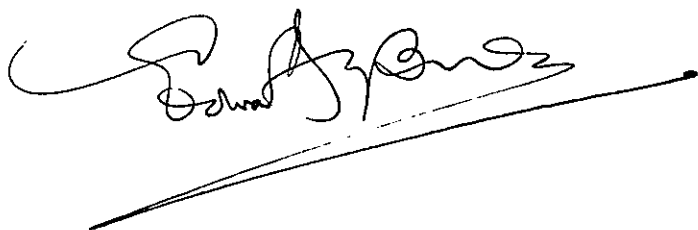
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Dear Dr Taylor

I am reluctant to complain about editorial inaccuracies two issues in succession, but the number of errors in the attached list of the new INQUA officers published in the October 1991 Newsletter (No. 65) forces my hand. The correct names of the officers are as shown on this letterhead. (*Shown on next page*)

Yours sincerely

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NOTICES & ANNOUNCEMENTS



NOTICE OF MEETING IGCP 274 UK NATIONAL COMMITTEE

The Final annual meeting of the UK IGCP 274 will be held at the University of Ulster in Coleraine between 17 and 21 September 1991. The meeting will include paper sessions, discussions and poster displays, plus two field trips, one full-day excursion to the Inishowen Peninsula, Co. Donegal and a short visit to the Giants Causeway cliffs and coast.

Accommodation available in Halls of Residence. Travel between Aldergrove Airport, Belfast City Airport or Larne and Coleraine can be arranged.

All enquiries to: Professor Bill Carter
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University of Ulster
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Co. Derry BT52 1SA
Northern Ireland

Tel: 0265 44141 Ext.4428
Fax: 0265 40911

MSc/PgD QUATERNARY ENVIRONMENTAL CHANGE

The next intake to this course will be in October 1992. The course is part-time, two evenings per week for two years, run jointly by the City of London, North London and Thames Polytechnics. The first year (to PgD) examines and gives practical experience of the geomorphological, sedimentological, biological and archaeological evidence used in reconstructing the environmental and climatic changes that occurred during the Quaternary. The second year (to MSc) concentrates on considering and evaluating models of atmospheric, sedimentological and biological change in the Quaternary and demonstrating the relevance of Quaternary science to environmental and resource management.

Applications are invited from graduates in archaeology, botany, environmental science, geography, geology, soil science or zoology and from non-graduates who have appropriate scholarship or experience. Further details can be obtained from:

Dr P Allen
Department of Geography
City of London Polytechnic
Calcutta House
Old Castle Street
London E1 7NT

Tel: 071 320 1019
Fax: 071 320 1117

A DATE FOR YOUR 1993 DIARIES !

1993, May 17-19. Geological Association of
Canada/Mineralogical Association of Canada joint Annual
Meeting, Edmonton, Alberta.

FOR INFORMATION;

J W Kramers, Alberta Geological Survey,
P.O. Box 8330,
Station F,
Edmonton,
Alberta, T6H 5X2
Telephone: (403) 438-7603,
Fax. (403) 438-3364

NOTES

THE SECOND ROMNEY MARSH CONFERENCE RUTHERFORD COLLEGE

Friday 25th–Sunday 27th September 1992

Romney Marsh and Dungeness form a major feature on the coastline of south-east England. The area has a fascinating and complex history, involving great changes in the coastline and river courses, silted harbours and lost ports, and great inundations by the sea. Historically, it occupied a position of prime importance facing the Continent.

This conference examines the dramatically changing geography, and how these changes affected human activities. It looks at the archaeological and historical evidence of Roman and medieval settlement, occupations, and the constant battle against flooding by the sea and by fresh water.

The papers reflect the work which has been supported and coordinated by the Romney Marsh Research Trust since 1987, and the final paper will review the problems of present-day sea defence and land drainage—without which the Marsh would not exist as we know it.

Fees: £98.00 Full residential
 £55.00 Non-residential, all meals except breakfast
 £30.00 Non-residential, without meals

On Sunday afternoon there will be a field excursion, an optional extra at £5.00 each. Numbers for this will be limited, allocated on a first come, first served basis.

APPLICATION FORM

Please complete and return this with your remittance to Mrs Sue Carrel, Mittell House, Church road, New Romney, Kent TN28 8TU **NOT LATER** than 15th June 1992.

I wish to book places for the Romney Marsh Conference at £..... each

I enclose a cheque for £ payable to Romney Marsh Research Trust

Name(s) _____ Dr/Mr/Mrs/Miss

Address: _____ Telephone number: _____

Field Trip I/We would like places, at £5.00 each, on the field trip, if available. Please do **NOT** send payment for this now.

Membership: I am not able to attend the Conference, but am interested in knowing more about the Research Trust, its lectures and field days. Please send me details.

NOTES

QUATERNARY RESEARCH ASSOCIATION

The Quaternary Research Association is an organisation comprising archaeologists, botanists, civil engineers, geographers, geologists, soil scientists, zoologists and others interested in research into the problems of the Quaternary. Most members reside in Great Britain, but membership also extends to most European countries, North America, Africa and Australasia. Current membership stands at c.1000. Membership is open to all interested in the objectives of the Association. The annual subscription for ordinary members is £10.00 and is due on January 1st for each calendar year. Reduced rates apply for students, unwaged and associated members.

The main meetings of the Association are the Annual Field Meeting, usually lasting 3 or 4 days, held in April, and a 1 or 2 day Discussion Meeting held at the beginning of January. Additionally, Short Field Meetings may be held in May or September and occasionally these visit overseas locations. Study Courses on the techniques used in Quaternary work are also occasionally held. The publications of the Association are the *Quaternary Newsletter* issued with the Association's *Circular* in February, June and November, the *Journal of Quaternary Science* published in association with Wileys, and with three issues a year, the Field Guides Series and the Technical Guide Series.

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

President: Professor G S Boulton, Department of Geology and Geophysics, University of Edinburgh, James Clerk Maxwell Building, Mayfield Road, Edinburgh EH9 3JZ

Vice President Professor W A Watts, Provost's House, Trinity College, Dublin 2, Ireland

Secretary Dr M J C Walker, St David's University College, Lampeter, Dyfed, Wales SA48 7ED

Assistant Secretary (Publications): Dr D R Bridgland, 41 Geneva Road, Darlington, Co Durham DL1 4NE

Treasurer: C A Whiteman, Botany School, University of Cambridge, Downing Street, Cambridge CB2 3EA

Editor (*Quaternary Newsletter*): Dr B J Taylor, British Geological Survey, Keyworth, Nottingham NG12 5GG

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

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