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Quaternary Newsletters are issued in February, June and November. Closing dates for submission of copy for the relevant numbers are 1st January, 1st May and 1st October. Contributions, comprising articles, reviews, notices of forthcoming meetings, news of personal and joint research projects, etc. are invited. They should be sent to the Editor of the Quaternary Research Association, Dr. D.H. Keen, Department of Geography, Coventry (Lanchester) Polytechnic, Priory Street, Coventry CV1 5FB.

A NOTE ON THE QUATERNARY DEPOSITS AND LANDFORMS OF ST. KILDA.

By D.G. Sutherland, C.K. Ballantyne and M.J.C. Walker

The St. Kilda island group lies ca. 60 km to the west of the Outer Hebrides (inset, Figure 1) towards the edge of the continental shelf. No detailed descriptions of the Quaternary deposits have been published although Cockburn (1935), Wager (1953) and Macgregor (1960) have given brief, somewhat contradictory reports. Following these papers it has generally been assumed that St. Kilda has not been encroached upon by the Scottish ice sheet and this assumption has been used in delimiting the maximal westward extension of the Scottish ice (eg. Sissons, 1967). Furthermore, the position of St. Kilda close to the edge of the continental shelf offers the possibility of linking terrestrial palaeo-environmental evidence from an area that was dominated by the oceanic climate with similar information from the mainland, thereby providing a possible 'stepping stone' to the deep-sea core evidence.

Most Quaternary deposits on St. Kilda are located in the area around Village Bay on the main island of Hirta (Figure 1). Apart from Flandrian deposits (which are the subject of a separate pollen analysis investigation by M.J.C. Walker) the most recent evidence of environmental change is in the form of two protalus ramparts fringing the fossil screes below Conachair and Mullach Sgar. Weathering rind thicknesses on dolerite clasts in the fossil scree and the protalus rampart below Mullach Sgar are very similar indicating them to be nearly contemporaneous.

The protalus ramparts either cut across or occur within the limits of a small valley glacier. This glacier is defined by a drift limit extending from An Lag to the sea on the east and by large linear morainic mounds on the west. Cliff and stream sections within these limits reveal a glacial till (the Village Bay till) with two facies, the lower of which is interpreted as being a lodgement till, the upper being of supraglacial origin.

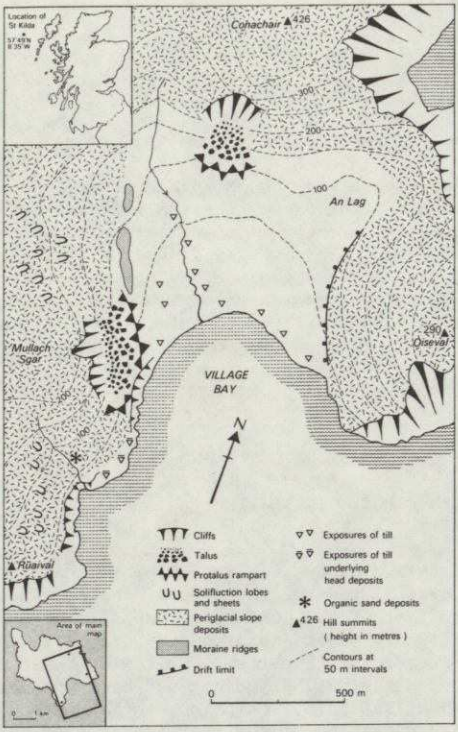

Figure 1. Map of the Village Bay area, St. Kilda, showing the features and localities mentioned in the text.

Beyond the limits of this glacier the hillslopes are mantled by periglacial deposits that locally take the form of solifluction lobes or sheets. These slope deposits are best developed (up to 3 m thick) on the flanks of Mullach Sgar towards Ruaival where they are clearly stratified. The absence of these periglacial deposits from the area of the above-mentioned valley glacier is most simply explained by the features being contemporaneous. This interpretation is supported by weathering rind thicknesses of dolerite clasts in the slope deposits on Mullach Sgar which are considerably thicker than those of the Mullach Sgar protalus rampart that is known on morphological and stratigraphical grounds to post-date the Village Bay till.

Below the stratified slope deposits an unbedded organic sand with occasional boulders and cobbles was discovered beside the Abhainn Ruaival (Figure 1). The organic sand is interpreted as having been formed by fluvial redeposition of an organic soil horizon, the cobbles and boulders having been introduced by contemporaneous slope instability. Pollen analysis of the included organic material indicated a species-poor vegetation dominated by grasses and sedges with few heaths or shrubs. Arboreal pollen was present throughout, being chiefly Pinus, but Betula, Betula/Corylus, Alnus and Fagus were also recorded. These tree pollen are attributed to long-distance transfer. The pollen grains were very sparse and poorly preserved and the conditions that gave rise to this may have selectively destroyed certain pollen types. The available evidence nonetheless contrasts strongly with the present vegetation of St. Kilda which has an appreciable heathland component as well as frequent Salix and a much greater diversity of plant types (McVean, 1961). An interstadial or end-interglacial climate is, therefore, suggested.

Two fractions of a large sample removed from the top of the organic sand were radiocarbon dated: an alkali soluble 'humic acid' fraction gave an age of 14,620 ± 180 yr BP (SRR-1809a) and after acid and alkali pretreatment the residual < 125 μm fraction gave an age of $24{,}710^{+1470}_{-1240}$ yr BP (SRR-1809b). The evidence of the humic acid contamination indicates that the residual fraction age is minimal but the date indicates that the organic sand is at least Middle Devensian in age.

In the cliff sections below the stratified slope deposits between the Mullach Sgar protalus rampart and Ruaival is a massive deposit up to 20 m thick consisting of cobbles and boulders embedded in a predominantly sandy matrix. Analyses of the aggregate clast shape characteristics and matrix granulometry reveal strong similarities with the Village Bay till, and this deposit is interpreted as a till emplaced by a valley glacier of rather greater dimensions than that which deposited the Village Bay till. Weathering rind thicknesses of dolerite clasts indicate that this deposit is much older than the overlying stratified slope deposits.

Samples from several of the above sedimentary units were found to contain trace quantities of red sandstone clasts, reddened feldspars and well-rounded quartz grains, all of which are foreign to St. Kilda. As these erratics occur in the oldest identified local deposit they must have been introduced to the island at an earlier period and it is considered that at some stage ice, presumably the Scottish ice sheet, encroached on St. Kilda and deposited erratics that have subsequently been reworked into the local sediments.

Table 1 summarizes the sequence and indicates the presumed ages of the various landforms and deposits. The relative chronology is rather well established being based on stratigraphic relations, relative positions of landforms and weathering rind thickness variations. The radiocarbon and pollen evidence support this chronology and help place it in an 'absolute' framework.

The evidence suggests that during the Late Devensian glacial maximum only a very small valley glacier existed on St. Kilda. This is in accord with the recent evidence indicating that at this time the Outer Hebrides supported an independent ice cap (Coward, 1977; Peacock and Ross, 1978; Flinn, 1978; von Weymarn, 1979) and were not overridden by the Scottish ice sheet, the margin of which may have been located to the east of the Outer Hebrides. Such evidence, which contrasts markedly with ice-sheet expansion into the Midlands of England, suggests lack of precipitation along the northwestern margin of the

Scottish ice sheet (cf Boulton, 1979). This is in general agreement with the deep-sea core studies that indicate extensive sea-ice cover for most of the year in the North Atlantic at this time (McIntyre et al., 1976). The earlier pre-Devensian period when ice from the east transported foreign erratics onto St. Kilda must have been characterised by a different climatic regime that allowed a considerably greater expansion of the northwestern margin of the Scottish ice. It may be argued that this condition would be the result of a more northerly position of the oceanic Polar Front than during the Late Devensian (cf. Sissons, 1979). If this was the case, the former expansion of the Scottish ice westwards to St. Kilda need not necessarily imply a corresponding southward ice-sheet advance of similar magnitude.

Table 1. The sequence of Quaternary events on St. Kilda.

Landforms/deposits	Presumed age
Protalus ramparts, frost-shattered debris	Loch Lomond Stadial
Village Bay till, moraines and drift limit, solifluction lobes and sheets, frost shattered debris, stratified slope deposits	Late Devensian
Abhainn Ruaival organic sand	Middle (?) Devensian
Ruaival till	Early or pre-Devensian
Exotic erratics	pre-Devensian

Acknowledgements

We should like to acknowledge the help of the Nature Conservancy Council and the Army for logistical support in travelling to and working on St. Kilda. A grant towards field expenses was provided by the Carnegie Trust for the Universities of Scotland and NERC provided facilities for the radiocarbon dates. Margie McMillan and Clare Swindells acted as field assistants. Thanks are also due to Dr. J. Catt and Dr. P. Wilson for examining samples for the Abhainn Ruaival organic sand and to Drs. R.J. Merriman, R.R. Harding and P.H. Nancarrow of the IGS Petrology Unit for the petrological analysis of the sediment samples.

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References

Boulton, G.S. 1979. A model of Weichselian glacier variation in the North Atlantic region. Boreas 8, 375-395.

Cockburn, A.M. 1935. The geology of St. Kilda. Trans. R. Soc. Edinburgh 58, 511-547.

Coward, M.P. 1977. Anomalous glacial erratics in the southern part of the Outer Hebrides. Scott. J. Geol. 13, 185-188.

Flinn, D. 1978. The glaciation of the Outer Hebrides. Geol. J. 13, 195-199.

MacGregor, D.R. 1960. The island of St. Kilda. A survey of its character and occupance. Scott. Stud. 4, 1-48.

McIntyre, A., Kipp N.G., Be A.W.H., Crowley T., Kellogg T., Gardner J.V., Prell W. and Ruddiman W.F., 1976. Glacial North Atlantic 18,000 years ago: a CLIMAP reconstruction. Mem. Geol. Soc. Amer. 145, 43-76.

McVean D.N. 1961. Flora and vegetation of the islands of St. Kilda and North Rona in 1958. J. Ecol. 49, 39-54.

Peacock, J.D. and Ross D.L. 1978. Anomalous glacial erratics in the southern part of the Outer Hebrides. Scott. J. Geol. 14, 262.

Sissons, J.B. 1967. The evolution of Scotland's scenery. Oliver and Boyd, Edinburgh.

Sissons, J.B. 1979. Palaeoclimatic inferences from former glaciers in Scotland and the Lake District. Nature 278, 518-521.

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

Wager, L.R. 1953. The extent of glaciation in the island of St. Kilda. Geol. Mag. 90, 177-181.

SUB-SURFACE FORMATION OF CHARCOAL AND ITS POSSIBLE RELEVANCE TO THE INTERPRETATION OF CHARCOAL REMAINS IN PEAT.

By W. E. Boyd

In this note a process for the formation of charcoal _within_ a peat profile is tentatively proposed. As far as the writer is aware, the process has not previously been suggested, and comments concerning it would, therefore, be welcome.

In part of a pollen diagram from Shewalton Moss (Ayrshire), the _Corylus_-rise, following a period in which the vegetation is becoming increasingly more open, appears to occur at a time when _Cenococcum geophilum_, _Gelasinospora_ spp., charcoal and other indications of local dry soil conditions are present (Fig. 1).

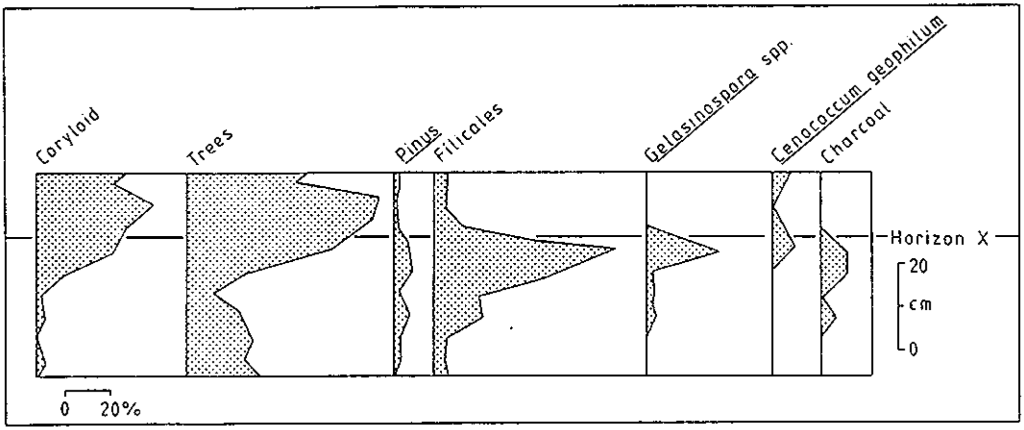

Figure 1. Partial pollen diagram, peat core, Shewalton Moss, Ayrshire (Nat. Grid. Ref. NS 352 360). The Coryloid and _Pinus_ values are % AP, Trees are % of total pollen, Filicales and _Gelasinospora_ spp. are % of total pollen plus pteridophyte spores, and the _C. geophilum_ and charcoal values are points on a nominal 5-point scale (absent to abundant). Soil dryness is indicated by the _Pinus_ and Filicales curves, which show the preferential preservation of these taxa; pollen corrosion of other taxa increases up to Horizon X. _Gelasinospora_ spp. are indicative of dry soil conditions, and _C. geophilum_ is often associated with other evidence for burning. Horizon X represents a probable dry soil surface, although in the core profile it is not a recognisable horizon.

Possible Mesolithic management of _Corylus_ has been discussed by Smith (1970, pp. 82-86) and Simmons _et al_. (1981, pp. 102-106). At Shewalton Moss, in an area with evidence of extensive Later Mesolithic activity, the presence of charcoal and _C. geophilum_ peaks during the _Corylus_-rise (Fig. 1, below Horizon X) is suggestive of possible human management of local vegetation. Strictly, however, the presence of charcoal indicates that organic matter, frequently wood, has been burnt, not necessarily that a fire has been started by human agency.

There is an alternative process which may explain the presence of sub-surface charcoal within peat.

In 1976, the writer assisted in the extinguishing of moor fires in the Kilpatrick Hills near Glasgow. The fires had been caused by solar heating of the peat levels below the surface. Surface fires were relatively limited in extent, but large areas of peat were burnt within the profile. During the summer of 1976 there also were reports from parts of Wales of considerable areas of soil being destroyed by sub-surface burning.

It is suggested that the heating of peat by the sun during a period of unusually warm weather is a process by which charcoal may be formed within the peat profile by natural agency. If this claim is valid, certain important implications follow:-

(1) After as little as one month of unusually warm weather, large areas of peat can be burnt within the peat profile.

(2) It is possible for large areas of peat to be affected without the presence of widespread or large-scale fires, and even without the appearance of surface fires.

(3) Charcoal need not, and probably will not, be produced at the surface at the time of charcoal formation. The stratigraphical position of charcoal produced by this process, therefore, will have little chronological significance, other than providing a minimum age for its formation.

(4) The stratigraphical position of the charcoal may be determined by factors such as the presence of a sub-surface layer or layers of woody peat. Charcoal at various stratigraphical positions may have been formed during the same event.

(5) In explaining the presence of sub-surface charcoal in peat it is not necessary to invoke large-scale forest fires, frequent burning events, abnormally high incidence of lightning (the commonly invoked natural ignition source), large scale climatic fluctuations or human interference, deliberate or otherwise.

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References.

Simmons, I.G., Dimbleby, G.W. & Grigson G., (1981), "The Mesolithic", in Simmons, I.G. & Tooley, M.J. (eds) (1981), The environment in British prehistory, Duckworth, 334 pp., pp. 82-124.

Smith, A. G. (1970), "The influence of Mesolithic and Neolithic Man on British vegetation: A discussion", in Walker, D. & West, R. G. (eds) (1970). Studies in the vegetational history of the British Isles. Cambridge, 266 pp., pp.81-96.

COMMENT UPON THE ARTICLE 'THE SPEETON SHELL BED' BY C A EDWARDS

By J D Peacock and J E Robinson

We should first congratulate Dr Edwards on his field observations on the Speeton Shell Bed, published in Quaternary Newsletter 36. His distinction of two shell beds is interesting, but more particularly, his recognition of the disturbed nature of the bed units adds an important consideration to the arguments as to the nature of the deposit, whether or not it is *in situ* or transported. This is a matter which still needs to be worked upon from several angles. Turning to the faunal and palaeoecological inferences drawn from the fauna which he records from the shell bed, however, we must have strong reservations, particularly over the judged arctic or sub-arctic character.

Dr Edward's account includes the statement that the macrofossils indicate a cool temperate estuarine environment and the microfossils a cold, sub-arctic euryhaline-brackish, shallow environment. Such apparent contradictions, which are unfortunately all too common in Quaternary studies, are likely to be a function of lack of knowledge and misinterpretation of the ecology of modern fauna. In this connexion, the molluscan fauna from Speeton (Lamplugh, 1881a) is a classic present-day British intertidal brackish water assemblage, which would not be found north of south west Norway. Dr Edwards himself mentions an environment similar to the Skagerak, which is hardly sub-arctic. As much is true for the ostracods (J.E.R.) none of which demand ecological conditions other than those typical for the North Sea basin. In fact if you were seeking modern analogues, Scarborough Harbour rather than Russian Harbour would suffice.

As for the Speeton Shell Bed and the Bridlington Crag being coeval, this seems unlikely from the evidence of either molluscs or ostracods; both point to the Crag being of decidedly colder aspect and derived from a variety of environments, including glaciomarine and littoral (Lamplugh 1881 b Appendix D; Neale 1966 and 1975). It is highly unlikely that the Speeton Shell Bed fauna could be an inshore equivalent for the same time period, if indeed the Bridlington Crag represents any one period.

Following from this, we would urge Quaternary workers who depend upon the distribution of present-day organisms for the interpretation of the past to join the various groups which concern themselves with the gathering of information on modern ecologies. In this work, although the marine mollusca have been comparatively well served for over a century ("everyone collects shells!"), the forthcoming 'Atlas of British Marine Mollusca' (Conchological Society of Britain and Ireland) will show that even in this relatively well known phylum, though there have been significant advances in knowledge over the last few years, much remains to be done. For the ostracods, one of us (J.E.R.) has been engaged upon the compilation of records from grab samples taken by the Continental Shelf Units of IGS, in order to establish the distribution of live carapaces (as opposed to dead valves) as a first step towards Pleistocene interpretations. For the benthonic foraminifera, which are (potentially) an important tool from their numerical abundance in samples, we suspect that more is known about their distribution in Quaternary deposits than their present geographical distribution along the coasts of western Europe.

In conclusion we should mention that marine recording is now reaching a critical and exciting stage with the immense data handling capacities of cheap computers. The possibilities thus offered for the correlation of occurrence with ecological parameters are unsurpassed.

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References

Lamplugh, G.W. 1881a. On a shell bed at the base of the drift at Speeton, near Filey. Geol. Mag. 8, 174-180.

Lamplugh, G.W. 1881b. On the Bridlington and Dimlington glacial shell beds. Geol. Mag. 8, 535-546.

Neale, J.W. in. Catt, J.A. and Penny, L.F. 1966. The Pleistocene deposits of Holderness, East Yorkshire, Proc. Yorks. Geol. Soc. 35, 375-420.

Neale, J.W. and Howe, H.V. 1975. The marine ostracoda of Russian Harbour, Novaya Zemlya and other high latitude faunas. In. Swain, F.M. Biology and Paleobiology of Ostracoda, Ithaca pp. 381-431.

A reply to J.D. Peacock and J.E. Robinson

by C.A. Edwards

The attention of Drs. Peacock and Robinson to the Speeton Shell Bed is to be welcomed. It has been a bone of contention amongst Quaternary geologists for the best part of a century and has sadly lacked the quantitative analysis needed to help solve its origin. Such an analysis was outside the scope of my geomorphological studies in the Vale of Pickering; my qualitative presence/absence analysis was intended more to advertise the microfaunal content rather than explain its origin. With reference to the stratigraphy and disturbance of the Speeton Shell Bed, I must stress that I consider the entire sequence to be one, I do not distinguish two shell beds.

A POSSIBLE INTERGLACIAL OR INTERSTADIAL DEPOSIT NEAR OUNDLE, NORTHAMPTONSHIRE

by J.W. Merritt

A recently published report on the sand and gravel resources of the country immediately south-west of Peterborough (Harrisson, 1981) includes summary logs of 117 shallow boreholes. This communication draws attention to a printing error in that report: part of the succession in one borehole record (TL 08 NW 179) was transposed, thereby obscuring the possible stratigraphical significance of part of the succession. The correct sequence is shown in a detailed log below.

Borehole TL 08 NW 179 Park Wood, Biggin Grange, Oundle

TL 0210 8907

Surface level 63.1m (207 ft) above Ordnance Datum
Water struck at 55.9m above Ordnance Datum
Completed 5 July 1974

	Thickness/m	Depth/m
Soil Brown pebbly clayey loam	0.3	0.3
Boulder Clay Sandy silty clay, firm to stiff, medium brown becoming dark grey with depth, clasts up to cobble-size mainly of chalk with some grey limestone	4.3	4.6
Glacial Sand and Gravel Pebbly sand, loamy, orange-brown, with a 5cm-thick seam of dark grey, very soft silty clay at 5.3m. Gravel mainly fine (4-16mm) but becoming more coarse with depth. Subangular to rounded ironstone and limestone, the former clasts being platy in shape and probably vein-ironstone of the type common in the Northampton Sand. The sand is mainly medium-grained (1/4-1mm) comprising sub-angular to rounded quartz with some limestone and ironstone	2.6	7.2
Lacustrine Deposits Clay, very silty, firm, tenacious, mainly finely laminated, dark bluish grey and pale brownish grey. Some siltier laminae quite micaceous. Thin leaves (2-5mm) of dark grey to black organic silt with scattered brown, peaty debris	0.8	8.0
?Boulder Clay Clay, silty, sandy, stiff, dark brownish grey. Rounded clasts of white-coated sandstone, ironstone and green/maroon friable sandstone. Increasing proportion downwards of pale greenish grey mudstone containing race and compressed ammonite remains	1.1	9.1
Oxford Clay Mudstone, pale olive grey, firm, fissile, containing race and white, compressed ammonites and serpulids	0.9+	10.0

The borehole, sited on a part of the Chalky Boulder Clay plateau of the east Midlands and some 2 km north-west of Oundle, was drilled by a conventional shell and auger site investigation rig: water was added from 4.6m to allow material to be recovered by shelling. Both the Chalky Boulder Clay and the Glacial Sand and Gravel proved in the upper part of the borehole were found to be compatible with deposits at similar stratigraphical positions in neighbouring boreholes. However, the discovery of laminated lacustrine deposits above a lower ?Boulder Clay (cf Figure 1 with Harrisson, 1982, p.66) is noteworthy, especially as the material includes thin leaves (2 to 5mm thick) of dark grey to black organic silt and scattered peaty debris. Where 'Lacustrine clays' (Horton, 1970) and 'Glacial Lake Deposits' (Horton and others, 1974) underlying Chalky Boulder Clay have been recorded elsewhere in the south-east Midlands, they generally contain little organic debris. The lithology of the basal till-like deposit at this site compares favourably with the 'Lower Boulder Clay' recognised elsewhere in the district (Horton, 1970, p. 1-2).

The lacustrine deposits described by Horton and others are thought to have formed in a pro-glacial environment as the ice-sheet responsible for depositing the Chalky Boulder Clay advanced into the area. However, the origin of the lacustrine deposit found here is less clear. The organic material possibly originated from a reworking of the local Oxford Clay, parts of which are usually bituminous, but more probably, as an *in situ* deposit laid down during an interglacial or interstadial. Unfortunately, the relevant specimens are not available and, therefore, another borehole would have to be sunk in order to determine the origin, composition and possible age of the organic material.

Acknowledgement

This note is published with the approval of the Director, Institute of Geological Sciences (NERC).

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References

Harrisson, A.M. 1981. The sand and gravel resources of the country south-west of Peterborough, in Cambridgeshire and east Northamptonshire. Description of 1:25 000 resource sheets TL 09, TL 19 and SP 98. TL 08. *Miner. Assess. Rep. Inst. Geol. Sci.*, No. 60. 98pp

Horton, A. 1970. The drift sequence and sub-glacial topography in parts of the Ouse and Nene basin. *Rep No. 70/9, Inst. Geol. Sci.*, 30pp

Horton, A., Lake, R.D., Bisson, G. and Coppack, B.C. 1974. The geology of Peterborough. *Rep. Inst. Geol. Sci. No. 73/12*, 86 pp.

A PRELIMINARY INTERPRETATION OF COASTAL DEPOSITS FROM EAST SUSSEX

By S. Jennings and C. Smyth

The low lying areas of the East Sussex coastline contain Flandrian deposits consisting of intercalated clays, silts, sands and peat which were laid down under varying marine and freshwater conditions. Similar deposits found in other coastal areas have been used as evidence for either oscillating sea-levels superimposed upon the general Flandrian transgression or have been explained by barriers that had formed seaward of these deposits being breached at intervals during the Flandrian. We believe that the sediments analysed from East Sussex can be better explained by the breaching model than by the assumption of oscillating sea-levels.

By identifying and analysing a sequence of intercalated minerogenic and biogenic deposits which were then dated and levelled, an oscillating picture of sea-levels was drawn by Tooley (1974, 1978) in north west England, Devoy (1977, 1979) from the Thames Estuary and Ters (1973) from the north coast of France. The minerogenic layers were interpreted as being deposited by a marine episode indicative of a transgression, i.e. a eustatic rise of sea-level; while the biogenic layers were laid down in response to a marine regression, i.e. a fall of sea-level allowing fresh water deposits to extend seaward over the transgressive minerogenic layers. However, more recently Tooley (1982) and Devoy (1982) have modified this view by interpreting some of the minerogenic and biogenic layers as responses to changing local conditions while maintaining that other sequences do reflect changing sea-levels. This is because dated correlations exist from different areas of Britain on sediments that have been interpreted as indicating actual eustatic changes. Therefore Tooley has suggested that the terms transgressive overlap and regressive overlap should be used to describe the situation where sediments show a transition to more marine conditions and to more freshwater conditions respectively rather than the terms transgression and regression.

Other workers, notably Kidson and Heyworth (1973, 1978) have interpreted changes in sediment types in coastal areas as being a response to changing local conditions and not to an oscillating sea-level. The build up and breaching of barriers, variations in tidal regimes, rare events such as storm surges, changing sediment supply and changes in the response of vegetation to coastal processes can all determine the types of sediment deposited and there is no need to invoke oscillating sea-levels as the cause. We believe that the deposits which we have studied in East Sussex can be explained as a response to changing local conditions superimposed upon the Flandrian rise of sea-level.

Three sites are discussed here (figure 1): Langney Point (TQ 642011) Lottbridge Drove (TQ 6101) and the Combe Haven (TQ 7709). The lithostratigraphies of these three sites are shown in figure 2 where they are compared with that from the Vale of the Brooks (Jones 1971, 1981). It is clear that the lithostratigraphies show considerable differences. Such differences are thought to be the result of local factors with the clay, silt, sand and peat sequences attributed to the formation and breaching of barriers which in turn have been influenced by variations in the supply of sediment to the coast. Both of these factors have been affected by man from at least Neolithic times through forest clearance and more recently, coastal defence schemes. The formation of these

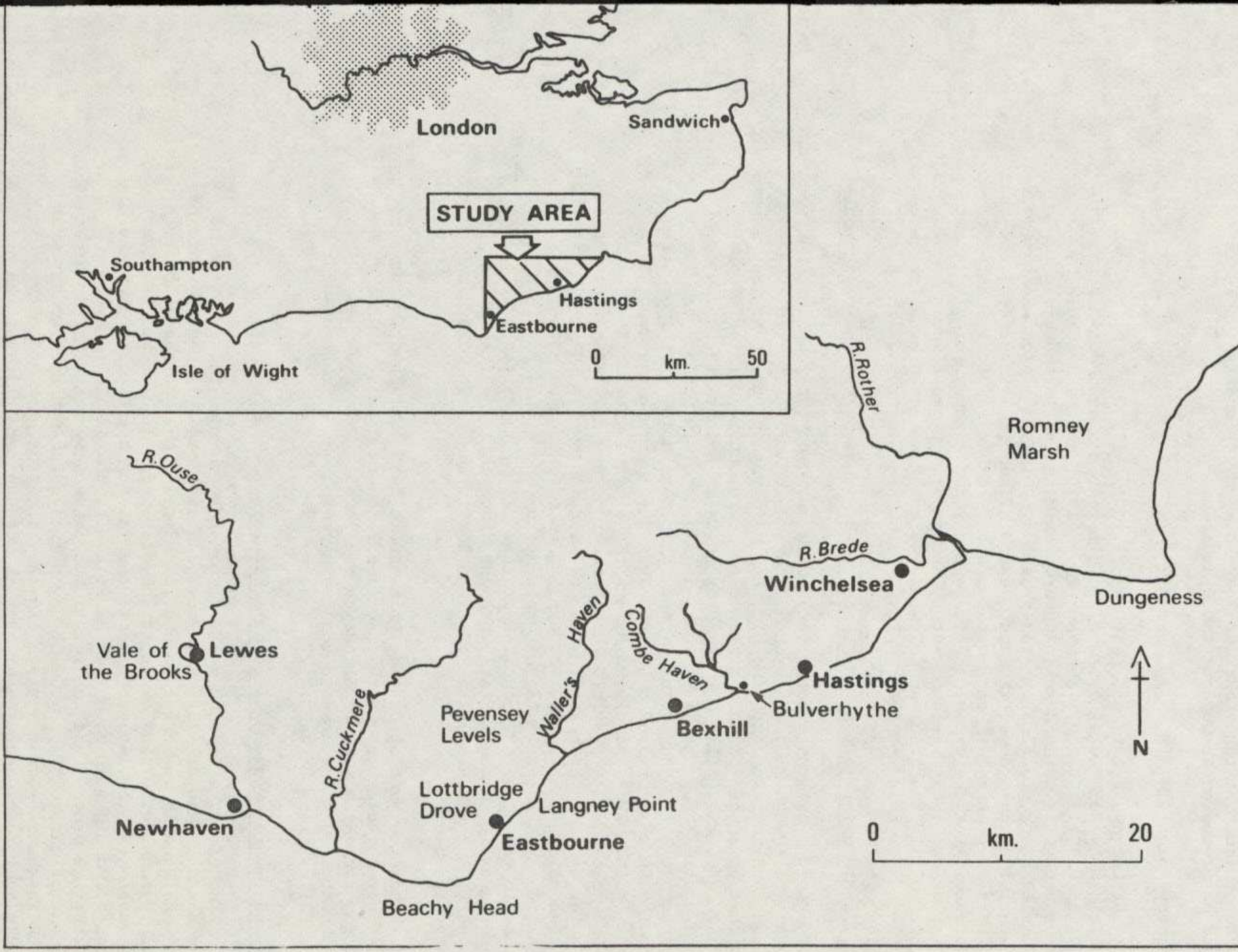

Figure 1 Location of the sections described.
Inset : South-east England.

barriers along the south coast of England has been well documented (Lewis and Balchin 1941, Robinson 1955, Kidson 1961, Carr 1978, Eddison 1982) and from our analysis of the lithostratigraphies at each site it is suggested that these barriers have played an important role in coastal processes throughout the Flandrian.

Langney Point

At Langney Point, the peat at -27.10 to -27.00 m O.D. can be explained by such local factors. This peat has been dated from 9,510 ± 75 to 8,760 ± 75 B.P. (Shephard-Thorn 1975) and is overlain by marine clays and silts which coarsen upwards culminating in the present Crumbles Spit (figure 2). Today Langney Point is a high energy environment of shingle deposition but several lines of evidence suggest that this is a relatively recent development. Cartographic evidence indicates that the Crumbles Spit (which forms Langney Point) did not exist before the sixteenth century and fossil evidence seems to show that prior to this the area was a low energy zone protected by offshore bars. Evidence for this are the remains of estuarine gastropods in the silts which overlay the peat e.g. Scrobicularia sp., Cerastoderma sp., Ostrea sp., and Hydrobia ulvae and H. ventrosa. The two species of Hydrobia are particularly indicative of quiet water conditions as found in estuaries. All these shells are believed to be local and not derived because although many are broken, the breaks are still angular and not rounded as would be expected had they been transported over long distances. Further evidence for the existence of a protective barrier is the presence of the pollen of Juniperus in large amounts in the sediment. This species today grows on coastal sand dunes in Holland and its occurrence at Langney Point is interpreted as being a Juniper scrub growing on coastal sand dunes that had developed in the area in the early Flandrian. It may have been these dunes and their associated offshore bars that provided the protection needed for the creation of a quiet water environment. Also of significance in these deposits is pollen of Chenopodiaceae. The presence of this type of pollen is usually taken to indicate that salt marsh conditions prevailed at or close to the site. The pollen of this family is not thought to be derived as it is consistently present (except in the freshwater peat deposit) and reaches values of circa 20% in the marine clays and silts above the peat.

Thus the peat at Langney Point seems best explained in terms of freshwater conditions which prevailed landward of a sand dune or bar during the early rise of Flandrian sea-level. The area was ultimately innundated by the sea which created a protected environment behind coastal barriers of sand.

The sediments landward of coastal barriers.

The clays, silts and peats found at Lottbridge Drove, at Combe Haven and in the Vale of the Brooks can also be explained as sediments that have built up behind coastal barriers. An important factor in this conclusion is the size of the freshwater input (i.e. from the river). The site with the largest river - the Vale of the Brooks - has the greatest depth of peat while the site with the smallest stream - Lottbridge Drove - has the least, but conversely contains the greatest amount of marine clay. Combe Haven lies between these two extremes both in the size of its river and the extent of peat and clay. It would seem then, that the greater the freshwater influence the greater the extent of peat formed while the smaller the freshwater influence the greater the extent of marine sediments. There could be two reasons

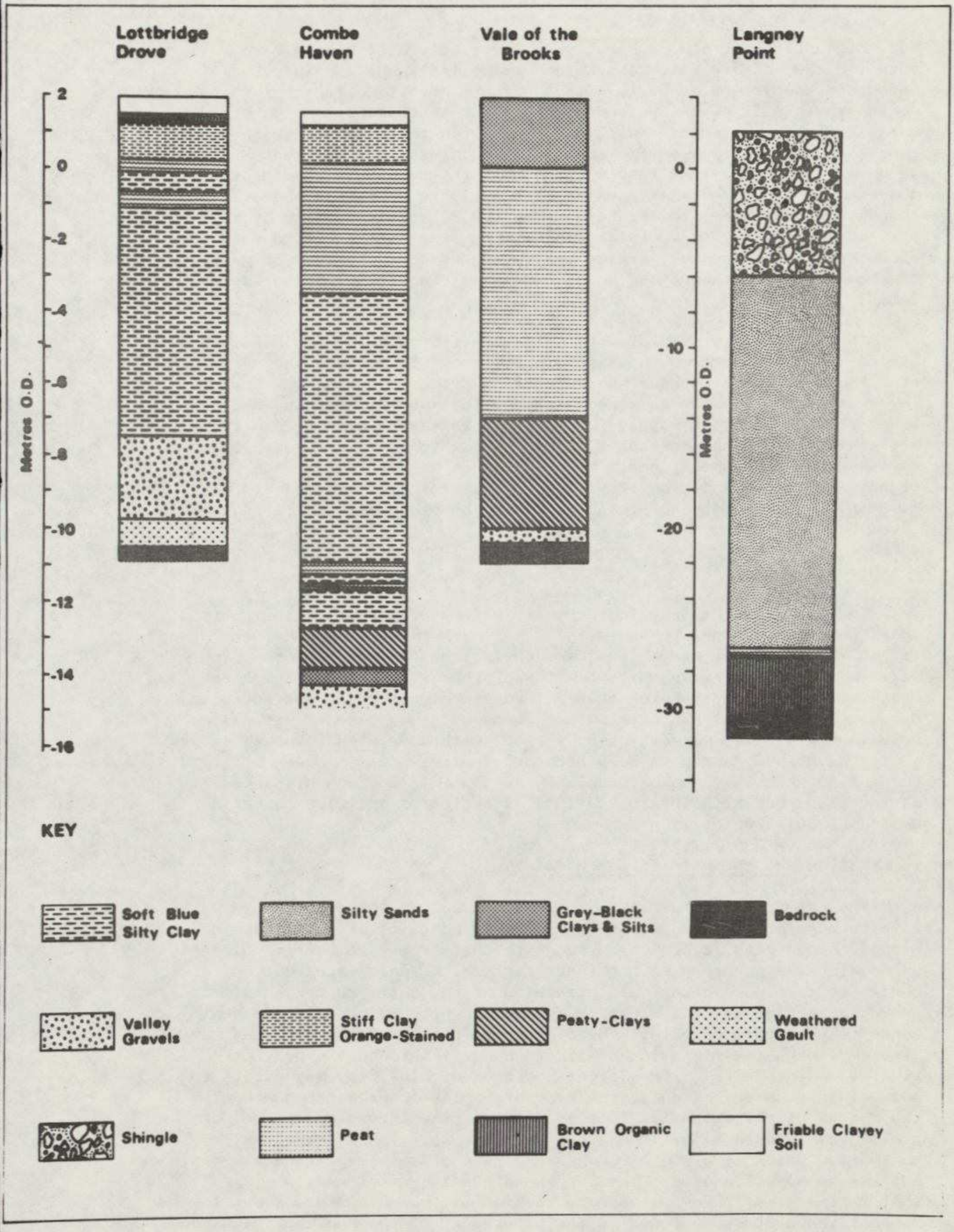

Figure 2 Lithostratigraphy of Coastal Flandrian deposits in East Sussex.

for this apparent trend. Firstly, a large volume of land water entering the estuary will lessen the marine influence and thereby encourage the growth of peat, although the controlling factor in biogenic growth will be the height of the water-table. Secondly, with large rivers more sediment will be transported to the mouth where it can be reworked into a barrier behind which freshwater sediments could accumulate. This might result in an apparent regressive sedimentary sequence. The size relationships of the rivers mentioned above are thought to have been similar throughout the Flandrian judging by map evidence over the last 400 years, and by the size of the buried channels offshore which we suggest are an indication as to the volume of water discharged during the Late-glacial and early Flandrian (D'Olier pers. comm).

Thus the supply of sediment to the coast from which the barriers are formed may come from the land via rivers. It may also be derived from the bed of the Channel where deposits produced during the low sea-levels of the Devensian have been transported landwards during sea-level rise. Sediment supply from the rivers may have increased from Neolithic times with increasing forest clearance so that since 5,000 B.P. barrier development could have been more active than in the early Flandrian. Also the rate of rise of sea-level has decreased since 5,000 B.P. so the tendency for barriers to be over-run by a rising sea-level has diminished.

Lottbridge Drove.

The extensive marine clay deposits at Lottbridge Drove indicates that the site was open to the sea for a longer period than the other two sites. However, it was a protected environment as shown by the fine grained nature of the deposits. It was probably the spits and bars that formed at Langney Point that afforded the protection for Lottbridge Drove. Pollen analysis carried out on these clastic sediments has revealed an assemblage dominated by Pinus with some Picea, but these grains have sacci and have been recorded in fine grained ocean sediments suggesting that they are particularly susceptible to long distance marine transportation (Dyakowska 1947, a series of articles in Marine Geology 1966, Stanley 1966).

Combe Haven and the Vale of the Brooks

The deposits in the Vale of the Brooks and at Combe Haven are very complex when studied in detail. The peats contain very thin blue or organic brown clay layers which suggests that from time to time biogenic deposition was interrupted for short periods. These interruptions could be due to small scale periodic breaching of the barriers during storms and at Mean High Water Springs (H.W.M.S.T.) which allowed marine sediments to be deposited briefly before the barriers reformed. They may also represent the migration of river channels through the peat or river flood deposits. The larger horizons of blue clay may relate to more widespread breaching of the barriers which altered the shape of the mouths of the estuaries thus enabling marine incursions to be more prolonged. These major incursions would be more likely to occur in the period prior to 5,000 B.P. when the rate of sea-level rise was rapid and the supply of sediment less. Therefore it was after 5,000 B.P. that barriers may have become more substantial which could account for most of the peat being found in the upper part of the sediment sequences of the Vale of the Brooks, the Combe Haven and Lottbridge Drove. As yet no C14 dates are available for the peats at the latter two sites, but the peat at the Vale of the Brooks has been dated from 6,290 ± 180 to 3,190 ± 125 B.P. It may be significant that a peat on the Pevensey

Levels which overlies a blue clay has been dated from 3,715 ± 80 to 480 ± 50 B.P. (Moffat unpub. Ph.D.)

Discussion

The three sites discussed above all show that the upper peat layer is overlain either by a silt and sand (at the Vale of the Brooks) or by a stiff orange stained silty clay (at Combe Haven and Lottbridge Drove). The silt and sand at the Vale of the Brooks has been interpreted by Jones (1981) as being marine and the clay at Lottbridge Drove and Combe Haven is also probably marine, as ostracods and foraminifers have been found. The date of this transgressive overlap is difficult to ascertain due to the paucity of radio-carbon dates, but the assay of 3,190 ± 125 B.P. from the peat at the Vale of the Brooks provides the earliest date for this event here. However, it is not clear whether this event is synchronous at the three sites. As well as a lack of dating, it is also not known how much peat was eroded at the sites.

The upper deposit of silt and sand at the Vale of the Brooks has been interpreted by Jones (1981) as representing a period of marine incursion - a transgressive overlap. This was preceded by a removal of the marine influence - a regressive overlap - which was responsible for a period of erosion that removed the upper surface of the peat layer. However, these deposits may better be explained by local factors. It seems incongruous that, in the Vale of the Brooks, at the time when sea-level was rising most rapidly (i.e. pre 5,000 B.P.) an organic clay or peat was deposited, but when the rate of sea-level rise decreased (i.e. post 5,000 B.P.) an inorganic silt and sand was deposited. We suggest that this upper deposit, whether of clay, silt or sand is a response to a breaching of coastal barriers. The resulting sediments were then affected by man. All three sites lie below H.W.M.S.T. and but for coastal protection schemes would be periodically flooded at H.W.M.S.T. and during storms as they have been in the past. Due to artificial drainage the water table at these sites has fluctuated which has probably produced (at Lottbridge Drove and Combe Haven) the orange staining in the clay. It is also this artificial drainage that may have prevented the formation of very recent peats. The result is that the clays, silts and sands laid down by the most recent breaching have been modified by farming practices to produce a deposit that owes much of its character to anthropogenic factors.

Conclusions

It is therefore suggested that interbedded sequences of clays, silts, sands and peats from East Sussex can best be explained by the study of local processes, especially the build-up and breaching of barriers. Important factors that have influenced these barriers and the sediments that have been deposited are:-

1. The rate of rise of sea-level
2. Variations in the supply of sediment to the coast
3. The volume of the freshwater input
4. Extent of barrier breaching
5. The effect of man

None of these five factors should be treated in isolation as it is probably a combination of factors that results in the deposition of a particular sediment type. Flemming (1982) has also suggested that the coast of Sussex and Kent may be subject to uplift. However, this conclusion may largely be statistical rather than real due to the small number of data points used and it is more likely that the area has been affected by subsidence throughout the Flandrian (Akeroyd 1972). Unless the rate of subsidence has been rapid it is thought that it would not affect barrier development.

The lithostratigraphic relationships between the sites in East Sussex are very complex and although the transgressive and regressive overlaps can be interpreted satisfactorily without invoking fluctuating sea-levels, this is not to deny the possibility that fluctuation did occur but on such a minor scale that the evidence is overwhelmed by local factors.

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East Sussex County Council Site Investigation Unit for providing information on deposits and the use of a drilling rig. Also, our thanks to David Snushall and Robin Skinner of North London Polytechnic for advice and assistance in producing the figures, to Dr. K. Thomas of the Institute of Archaeology for identifying the gastropods and to Dr. R.H. Bryant for supervising the work.

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References

Akeroyd, A. 1972. Archaeological and historical evidence for the subsidence of Southern Britain. Phil. Trans. R. Soc., London, A272, 151-69.

Carr, A.P. 1978. The long Chesil Shingle. Geogr. Mag. Vol L. No. 10, 677-81.

Devoy, R.J.N. 1977. Flandrian sea-level changes in the Thames Estuary and the implications for land subsidence in England and Wales. Nature 270, 712-715.

Devoy, R.J.N. 1979. Flandrian sea-level changes and vegetational history of the Lower Thames. Phil. Trans. R. Soc. London, B.285, 357-404.

Devoy, R.J.N. 1982. Analysis of the geological evidence for Holocene sea-level movements in South East England. Proc. Geol. Ass. London, 93, 65-91.

Dyakowska, J. 1947. The pollen rain on the sea and the coasts of Greenland. Bull. Int. Acad. Polonaise B., 25-33.

Eddison, J. In Press. The evolution of the barrier beaches between Fairlight and Hythe. Geogr. J.

Flemming, N.C. 1982. Multiple regression analysis of earth movements and eustatic sea-level change in the United Kingdom in the past 9,000 years. Proc. Geol. Ass. London, 93, 113-125.

Jones, D.K.C. 1971. The Vale of the Brooks. In Williams, R.B.G. (Ed.) Guide to Sussex Excursions 43-46 Inst. Br. Geogr.

Jones, D.K.C. 1981. Southeast and Southern England. London. Methuen.

Kidson, C. 1963: The growth of sand and shingle spits across estuaries Z. Geomorph., 7, 1-22.

Kidson, C. and Heyworth, A. 1973. The Flandrian sea-level rise in the Bristol Channel. Proc. Ussher Soc., 2, 565-584.

Kidson, C. and Heyworth, A. 1978. Holocene eustatic sea-level change. Nature 273, 748-50.

Lewis, W.V. and Balchin, W.G.V. 1941. Past sea-levels at Dungeness. Geogr. J., 96, 258-85.

Moffat, B. In press. History of vegetation and land use in Pevensey Levels, Sussex in the Post-glacial period. Unpub. Ph.D. Thesis. Polytechnic of North London.

Marine Geology 1966. Vol.4.

Robinson, A.H.W. 1955. The harbour entrances of Poole, Christchurch and Pagham. Geogr. J., 121, 33-50.

Shephard-Thorn 1975. The Quaternary of the Weald - a review. Proc. Geol. Ass. London, 86, 537-547.

Stanley, E.A. 1969. Marine Palynology. Oceanogr. Mar. Biol. Ann Rev., 7, 277-292.

Ters, M. 1973. Les variations du niveau marin depuis 10,000 ans le long du littoral Atlantique Francais. 9th INQUA Congress - The Quaternary, 114-35.

Tooley, M.J. 1974. Sea-level changes during the last 9,000 years in Northwest England. Geogr. J., 140, 18-42.

Tooley, M.J. 1978. Sea-level changes: Northwest England during the Flandrian Stage. Oxford. Clarendon Press.

Tooley, M.J. 1982. Sea-level changes in Northern England. Proc. Geol. Ass. London, 93, 43-53.

COMMENT ON RECENT PAPERS IN THE NEWSLETTER ON THE SUBJECT OF THE SOUTH LONDON GRAVELS

(1) By D.S. Peake

From recent communications by Macklin (1981) and Nunn (1982) it is good to know that at long last the high level Pleistocene river terraces in South London are again receiving attention. Small though the deposits are, their relative locations, heights and contents are of great significance in unravelling the lower Pleistocene history of this part of the Lower Thames valley. In particular Macklin's detailed sedimentological analysis, authentically confirming the opinion of early writers that the main gravel strip on the southern end of the Norwood ridge was fluviatile in origin, is an important corroboration.

Although the map included by Nunn showed the three areas of Pleistocene sand and gravel mapped by Dewey and Bromehead (1921) in the Norwood vicinity, his text omitted the important findings of these authors in the accompanying South London memoir: in all three deposits 10% of Lower Greensand material was recorded, similar to that found by Prestwich (1890) in the highest deposit at a site on Westow Hill (335707). The chalky nature of the gravels, which contain a very high proportion of subangular flint from the chalk and pebbles from the Blackheath Beds, also suggests a southern provenance for these fluviatile deposits (Roberts 1904). Nunn's claim that 'the topography of the North Downs in the area rules out a direct link with the Weald' ignores the collective views of many authors, among them Spurrell (1886), Prestwich (1890), Dewey and Bromehead (1921) and Wooldridge (1927), that the Merstham valley, now a wind gap, carried an early Wandle from the Weald.

A reappraisal of the Pleistocene history of the River Wandle and its basin, currently in the press,[1] links a Wealden Wandle, comparable to such rivers as the Mole, with the early Thames system of the Pebble Gravels period. It traces the river's repetitive history of diversions, beheadings, downcutting and aggradation throughout the Pleistocene until, bereft of its Wealden headwaters and its downstream extension across the central London area, it now occupies merely a corridor in the Tertiary tract south of the modern Thames. The suggestion is made that it was the valley of the proto-Wandle, superimposed from the Pebble Gravels level onto bedrock, which breached diagonally the Hampstead Heath - Epping Forest axial ridge in a northerly direction, prior to the reversal of the local drainage in the Anglian Glaciation.

Macklin refers tentatively to Spurrell's suggestion (1866) that the narrow crest of the Norwood ridge may mark the course of an ancient Wandle from Croydon through Norwood to Deptford; a presumed original north north eastward extension of the southern gravel capping was thought to have protected the underlying London Clay from denudation. Unconsolidated sands and gravels, if present, were unlikely to have thus preserved the long high hogsback ridge; residual gravel cappings persist more usually on interfluves, by-passed by fluviatile erosion.

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1 The ground upon which Croydon was built. D.S. Peake. Proc. Croydon Nat. Hist. Sci. Soc. 1982, 17(4), 28 pp. available from Croydon Natural History Society, 96A, Brighton Road, South Croydon, Surrey CR2 6AD. (price £1.50 inc. p + p.)

On the other hand the wide deep valley along the south east flank of the Norwood ridge, drained by the misfit Pool River, was obviously a Wandle outlet of a much later date than the drainage of the Norwood gravels period. Nunn's recording of 35% Lower Greensand chert in gravels at Deptford is supporting evidence of Pool River drainage (the Anglian Wandle) through the Merstham gap, for the percentage is much too high for this derived Wealden chert to have been supplied by the local downland river, the Ravensbourne, from the Clay-with-flints, or directly from the Weald by the Mole and Wey through their river gaps some distance to the west.

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References

Dewey, H. and Bromehead, C.E.N. 1921. The geology of South London. Mem. geol. Surv. G.B.

Macklin, M.G. 1981. Prestwich's "Southern Drift" in S.E. London: a re-evaluation. Quaternary Newsletter 34, 19-26.

Nunn, P.D. 1982. High level river terraces in South London. Quaternary Newsletter 36, 9-15.

Prestwich, J. 1890. On the relation of the Westleton shingle to other pre-glacial drifts in the Thames basin, and on a Southern Drift, with observations on the final elevation and initial subaerial denudation of the Weald; and on the genesis of the Thames. Q. Jl. geol. Soc. London 46, 155-81.

Robarts, N.F. 1904. The Plateau Gravel, Upper Norwood and associated Eolithic implements. Proc. Croydon nat. Hist. Scient. Soc. 6 (2), 14-18.

Spurrell, F.C.J. 1886. A sketch of the history of the rivers and denudation of west Kent. Rept. W. Kent. Nat. Hist. Soc.

Wooldridge, S.W. 1927. The Pliocene Period in the London basin. Proc. Geol. Assoc. London 38, 49-132.

COMMENT ON "THE PLEISTOCENE TERRACES OF THE WANDLE IN SOUTH LONDON."

(2) By P.D. Nunn

Peake is misleading in her claim that Dewey and Bromehead (1921) recorded 10% Lower Greensand material from the drifts shown in my Figure 1 (Nunn 1982). Following Prestwich (1890), they report this proportion from the Crystal Palace deposit, but with reference to the others - "in neither of these two patches is there any satisfactory section to be seen" (1921 p 45). Field mapping of these deposits was probably completed in the nineteenth century. My point was that, in the absence of Lower Greensand material in the sections I examined (in common with Hinde (1897), Robarts (1904) and Hogg (1904)), there was no proof of a primary southern provenance for these deposits. I suggested the very small numbers of Wealden constituents found in other sections were insufficient to demolish this view. Perhaps it is timely to recall Wooldridge's words - "Whatever this pit west of Brentford (say) may seem to show, someone else has seen a now invisible trench east of Brentford where his own eyes, as he solemnly assures you, have perceived something entirely different" (1960 p 113).

Peake's claim that the topography of the North Downs in the area does not rule out a direct link with the Weald ignores the collective view of many authors, including Hinde (1897) and Dines (1934), that the Merstham Gap was formed by the intersection of the dry valley head with the receding chalk scarp. Many similar dry valleys approach the scarp to the east around Caterham and Woldingham and just east of Merstham around Kingswood and Chipstead. On the published evidence to date, I am unconvinced the Wandle ever extended into the Weald. Whether it did or not is not critical to the formation of the Crystal Palace gravel.

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References

Dines, H.G. 1934. In discussion of Bull, A.J. et. al. (1934). The River Mole: its physiography and superficial deposits. Proc. Geol. Assoc. London 45, 35-69.

Hinde, G.J. 1897. Notes on the Gravels of Croydon and its Neighbourhood. Trans. Croydon Micro. Nat. Hist. Club. (1897), 219-233.

Hogg, A.J. 1904. The Gravels of the South Norwood Hills. Proc. Croydon Nat. Hist. Soc. 6(2), 18-19.

Wooldridge, S.W. 1960. The Pleistocene Succession in the London Basin. Proc. Geol. Assoc. London 71, 113-129.

THE CHRONOSTRATIGRAPHY OF PLEISTOCENE DEPOSITS IN SOUTH EAST LONDON: A METHODOLOGICAL ASSESSMENT.

(3) By M.G. Macklin

Recent work (Nunn, 1982) has proposed a denudation chronology at variance with the sedimentologically based framework outlined by Macklin (1981) for high level Pleistocene deposits of south east London. For such studies it is important to evaluate the merits of these respective methodologies from which Pleistocene events are formalised.

Bedrock Benches

Nunn's (1982) pre-"Boyn Hill" denudation chronology for south London relies on the identification of a staircase of benches leading down from the Crystal Palace-Upper Norwood ridge to the present valley of the Thames. Some, but by no means all, are overlain by sand and gravel deposits of presumed Pleistocene age. The mode and environment of deposition of most is unknown except for those of Wimbledon Common and Crystal Palace, described by Gibbard (1979) and Macklin (1981) respectively.

The depiction of a bench surface, be it a geomorphic terrace or terrace alluvium, by a single altitudinal measure and the projection of unlinked bench fragments, separated in some instances by tens of km., onto an arbitary north-south line is at best an over generalisation and at worst misleading. The resulting height-distance diagram (Nunn, 1982 fig. 2) displays a staircase of benches, although in reality it represents a cartographic artifact and as such would be impossible to demonstrate along a single transect, even allowing for differential preservation of particular bench surfaces.

Undoubtedly many of these erosional surfaces are polygenetic in origin and their form may not be solely the product of fluvial processes. Even if one envisages bedrock bench creation by means of "fluvioperiglacial pedimentation" (Castleden, 1980), only in a few cases (Castleden, 1976, 1977) has the formation of benches with contemporaneous deposition of sediment been shown. Pleistocene sediments are themselves the product of a variety of complex erosional and depositional processes; unidentified equifinality, inherent in many morphometric analyses, is minimised by the detailed examination of sedimentary properties and structures.

Borehole records from 13 sites (TQ 332 696 to TQ 341 714) were used to evaluate the bedrock surface underlying the Crystal Palace deposit for 2 km. at the southern part of the ridge. A best fit two-dimensional surface describing the form of the underlying bedrock was constructed using the reduced major axis line (Kermack and Haldane, 1950). This was used in preference to classical regression as the requirements of assigning dependency to either of the variables, height and distance, or knowing one variable without error, could not be met (Till, 1973). The unique line of best fit, the reduced major axis line, described a bedrock surface with a gradient of 3.87m/km. descending in a N.N.E. direction, having a correlation coefficient of $r = -0.925$, significant at the 0.001 level of probability. Both militate against the bedrock bench being a geomorphic terrace residual of an eastward flowing river.

Correlation

Macklin (1981) provided a thorough description of the Crystal Palace deposits. Gravel lithology was just one of the sedimentary properties evaluated and provides only a partial definition of lithostratigraphy. The lithostratigraphic unit proposed included both a physical and petrographic assessment, as well as the delineation and classification of the deposit as a three dimensional, lithologically unified body. Correlations between lithostratigraphic units using only the similarity of gravel lithology, or of morphostratigraphic units constructed on the basis of bedrock bench attitude, are dubious. This results from the inability to demonstrate time equivalence by standard stratigraphic procedures (Hedberg, 1976). Lithostratigraphy provides the basis of all other stratigraphy and hence is particularly important that its units are carefully and adequately defined (Bowen, 1978).

Nunn's (1982) altitudinal correlation of the highest bedrock benches in south London with gravels of the Westland Green Thames (Hey, 1980) illustrates this problem. Unfortunately, altitudinal correlation was used with chronostratigraphic implications but morphostratigraphic units are of informal stratigraphic status. There is little justification for the view that widely separated bench residuals at similar altitudes are isochronous, because of warping, differential erosion and post-depositional modification.

A denudation chronology for these erosional remnants cannot be more than a hypothetical model without supportive geochronological data, since morphological correlation alone is open to debate (Richards, 1981). It is preferable to rely on detailed sedimentological analyses rather than altitudinally based "correlation" of erosional features.

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References

Bowen, D.Q. 1978. Quaternary Geology. Pergamon Press, Oxford.

Castleden, R. 1976. The flood plain gravels of the River Nene. Mercian Geologist., 6, 33-47.

Castleden, R. 1977. Periglacial pediments in central and southern England. Catena., 4, 111-121.

Castleden, R. 1980. Fluvioperiglacial pedimentation: A general theory of fluvial valley development in cool temperate lands, illustrated from western and central Europe. Catena., 7, 135-152.

Gibbard, P.L. 1979. Middle Pleistocene drainage in the Thames valley. Geol. Mag., 116, 35-44.

Hedberg, H.D. 1976. International Stratigraphic Guide. New York.

Hey, R.W. 1980. Equivalents of the Westland Green gravel in Essex and East Anglia. Proc. Geol. Assoc. London, 91(4), 279-290.

Kermack, K.A. and Haldane, J.B.S. 1950 Organic correlation and allometry. Biometrika., 37, 30-41.

Macklin, M.G. 1981. Prestwich's "Southern Drift" in S.E. London: A re-evaluation. Quaternary Newsletter., 34, 19-26.

Nunn, P.D. 1982. High level river terraces in south London. Quaternary Newsletter., 36, 9-15.

Richards, K.S. 1981 in Geomorphological Techniques. ed. Goudie A.S. Allen and Unwin, London.

Till, R. 1973. The use of linear regression in geomorphology. Area., 5, 303-308.

ABSTRACTS OF PAPERS TO BE PRESENTED DURING THE QRA CONTRIBUTION TO THE FIFTH MEETING OF THE GEOLOGICAL SOCIETIES OF THE BRITISH ISLES, GLASGOW 23RD - 26TH SEPTEMBER 1982

THE GLACIATION OF SCOTLAND

INTRODUCTION: ASPECTS OF THE QUATERNARY GEOMORPHOLOGY OF SCOTLAND.

By J.B. Sissons (University of Edinburgh)

Present knowledge of late Quaternary events in Scotland is summarised under the following main headings: the last ice-sheet, the Loch Lomond Advance, periglacial landforms, relative changes of sea-level. Current problems that are raised include the maximal extent of the last ice-sheet in Scotland and surrounding seas, the duration of this ice-sheet, ice-sheet re-advances, the glaciation of the Outer Hebrides, and the relative ages and formative processes of coastal rock platforms and associated cliffs.

FOSSIL DIATOM ASSEMBLAGES RELATED TO FORMER SEA LEVELS IN THE FORTH AREA.

By M. Robinson (Cupar, Fife)

Diatom analyses of organic and minerogenic Flandrian sediments from three radiocarbon-dated sites confirmed the former presence of the sea in the Forth valley and in a coastal basin in East Lothian. The analyses involved detailed examination of the transgression/regression sequences across lithostratigraphical boundaries, the halobian status of the species counted being of primary importance. The sediments associated with marine episodes typically contain fossil diatom assemblages that indicate brackish, littoral conditions, while the organic sediments accumulated above mean sea-level can contain a very wide range of species indicating saltmarsh conditions and continued periodic marine inundation.

LATEGLACIAL AND EARLY FLANDRIAN VEGETATIONAL DEVELOPMENT IN MULL AND THE CHRONOLOGY OF ASSOCIATED EVENTS.

By M.J.C. Walker and J.J. Lowe (St. David's University College and City of London Polytechnic)

Pollen-stratigraphic evidence supported by fifteen radiocarbon dates is described from five sites on the Isle of Mull, Scotland. Two sites lie beyond the mapped limits of Loch Lomond (Younger Dryas) Advance ice and contain a full suite of Lateglacial sediments, while the three sites within the former ice limits contain only deposits of Flandrian age. These records provide the basis for a reconstruction of vegetation patterns of the Isle of Mull from the period immediately following the wastage of the Scottish ice sheet (around 13,000 B.P.) to the expension of birch and hazel woodland some 4000 years later. Environmental changes on Mull are discussed in the context of Lateglacial and early Flandrian vegetational developments on other islands of the Inner Hebrides, and adjacent areas of the Scottish mainland.

ICE MOVEMENT IN THE VICINITY OF A FORMER ICE DIVIDE IN SOUTHWEST SCOTLAND

By R. Cornish (University of Edinburgh)

Ice-sheet movement in the western Southern Uplands of Scotland is elucidated by tracing the distribution of erratics from four different bedrock sources (Loch Doon granite, Cairnsmore of Carsphairn granite, Craig of Knockgray microgranite and Upper Ordovician conglomerates) and from the mapping of glacial striae and ice-moulded landforms. The results show an almost radial movement of ice from the Loch Doon basin and adjacent areas away from an ice-divide zone. The control of relief over ice flow is emphasised. Abundant deposits of lodgement till occur in the Carsphairn valley, east of the

Loch Doon basin, in the vicinity of the former ice-divide zone. However, it is generally considered that glacial erosion, and therefore deposition, are insignificant at the centre of ice-sheets. This study suggests that this view is questionable, and that tills and erratice may be emplaced during ice-sheet build-up when conditions for erosion obtained, these deposits being protected from subsequent removal by the establishment of an ice-divide across the area.

LATEGLACIAL AND HOLOCENE PERIGLACIAL ACTIVITY ON SCOTTISH MOUNTAINS

By C.K. Ballantyne (University of St. Andrews)

Twenty-eight genetically-distinct types of periglacial landform or deposit have been identified on Scottish mountains. Relict periglacial features of Lateglacial age include various forms of weathered regolith, relict talus slopes, boulder sheets and lobes, certain solifluction sheets and lobes, protalus ramparts, rock glaciers, large-scale sorted circles, debris islands and stone stripes, and certain forms of nonsorted patterned ground. Features forming under present conditions include talus slopes, debris flows, solifluction sheets and lobes, turf-banked terraces, small-scale patterned ground, wind stripes and niveo-aeolian deposits. Criteria for distinguishing Lateglacial from active features are considered, and the Lateglacial and present-day periglacial environments of upland Scotland are discussed in terms of (i) climatic characteristics, (ii) comparative rates of periglacial activity and (iii) distribution of landforms and deposits. Some speculations are made regarding the environmental significance of certain landforms and deposits.

QUANTITATIVE PALAEOCLIMATIC RECONSTRUCTIONS FROM LOCH LOMOND STADIAL GLACIERS

By D.G. Sutherland, (University of Edinburgh)

A method has been devised that allows the quantitative assessment of former climate based on the extent and disposition of glaciers within a given mountain area. The method allows estimation of mean summer temperature and dominant wind directions for each mountain group as well as the calculation of mean annual accumulation (and hence precipitation) for each glacier. The basis of the method is outlined and certain assumptions are discussed. Preliminary results from various mountain groups in Scotland and the Lake District are presented.

LATE DEVENSIAN SHORELINE DISPLACEMENT AND ICE LIMITS IN EASTERN SCOTLAND

By R.A. Cullingford and D.E. Smith,(University of Exeter and Coventry (Lanchester) Polytechnic)

Landform and stratigraphic evidence concerning the nature of the deglaciation that accompanied the formation of Late Devensian raised shorelines in eastern Scotland are presented. Detailed attention is given to deglaciation/shoreline displacement relationships in north-eastern Fife and in Angus, and conclusions reached for these areas are considered in the context of conflicting views regarding these relationships in east-central Scotland as a whole.

THE DISLOCATED SHORELINES OF GLEN ROY AND VICINITY

By J.B. Sissons and R. Cornish (University of Edinburgh)

Detailed altitudinal measurements of the shorelines of former ice-dammed lakes in Glen Roy and vicinity demonstrate differential uplift of crustal blocks. Some blocks have no detectable tilt but others have gradients up to at least 4.6 m/km and are tilted in different directions. Some dislocations correspond exactly with the limit of the Loch Lomond Advance. In three areas 0.7-2.0 km long shorelines are distorted by crustal movements, all these areas having fossil land-slides attributed to earthquakes that accompanied crustal disruption. In one of these areas all three principal Glen Roy shorelines rise c. 3 m above their average altitudes in the immediately surrounding area and a fault scarp was produced. Analogy with crustal movements associated with man-made lakes raises the possibility that the local distortions accompanied catastrophic ice-dammed lake drainage by jokulhlaup.

Review

Godwin, H. 1981: The archives of the peat bogs. Cambridge University Press. £25.00. 229 pp.

Sir Harry Godwin, leading Quaternary botanist for half a century, has explored the British peat bogs more than anyone else. He has been engaged in the development of this research field since the 1930's - from a rather primitive, descriptive method to an elaborate, palaeo-ecological research branch, widely applied in order to describe environmental changes in the past. He has now published a synthesis of this research development in a book written in a fascinating way. On the basis of his field note-book drawings and photographs he takes the reader to the bogs where, around 1935, he himself first discovered the importance of the bog vegetation and the bog stratigraphy. Accompanying British and Scandinavian colleagues are presented and their discussions on bog stratigraphical problems are reviewed. In this way he describes different peat bogs and their palaeobotanical and archaeological information. This makes the book readable also for the non-specialist. Special chapters are devoted to the characteristic plants of the bogs. A couple of chapters deal with archaeological findings in peat bogs. The research discovery of prehistoric deforestation and agriculture is treated in a fascinating chapter. Finally, the importance of the bogs for the dating of past environmental changes by pollen zones and radiocarbon analysis as well as for palaeoclimatic registrations is discussed.

The well-printed book can be recommended to professional Quaternary researchers as a good piece of scientific history as well as to amateurs who would like to have an introduction in palaeoecological methods and findings.

Bjorn E. Berglund
Department of Quaternary Geology
Lund.

Obituary

Edward Watson B.A., Ph.D. (1916-1982)

The passing of Eddie Watson on March 26th of this year has imparted a serious loss to both Quaternary geomorphology and to the Association. He, more than any other, pioneered the investigation of former periglacial processes in Britain and his influence will live for many years to come.

He was born and educated in Belfast and graduated with first class honours in Geography at the Queens University in 1939. His initial research interests were strongly influenced by the then serving Professor of Geography at Belfast - Estyn Evans - and concerned prehistoric settlement and its environmental context. In 1947 he secured a lectureship in Geography at Aberystwyth and it was there that he spent the remainder of his career. Hence over three decades of graduates from Aberystwyth were influenced by his teaching. Although he embarked on his lecturing at Aberystwyth primarily as a human geographer his contact with the local physical environment induced a progressive change in interest such that he became 'converted' to physical geography particularly geomorphology. So drastic was his switch that his Ph.D. registration changed from settlement studies to periglaciation!

His first published works related to his adopted homeland, were glacially orientated, being studies of glacial morphology. But soon his objectives changed in favour of investigations of the effects of periglaciation. This trend was given encouragement by the visit of the distinguished Belgian periglacialist Albert Pissart to Aberystwyth. From 1961 onwards a steady flow of papers emanated from his pen describing the effects of periglacial processes on the central Welsh region, emphasising both the nature of the morphology and the sediments derived from the bedrock breakdown. A wide range of features were recognised and analysed including active layer structures, nivation cirques, pingo remnants and slope deposits. His approach reflected the growing awareness by physical geographers of the necessity to understand the immediate geological past and their role in the reconstruction of palaeo-environmental conditions in the Quaternary.

Inevitably this led to considerations of regional stratigraphic relationships. He suggested that the evidence for periglacial modification of the landscape was so strong that there was difficulty in reconciling it with a total Late Devensian glaciation of central Wales. This topic remains a subject of lively debate. The fruits of his earlier periglacial research were incorporated into his 1967 University of Wales Ph.D.

His mastery of the French language was expressed by his translation of a revised version of Jean Tricart's 'Geomorphology of Cold Environments'. A generation of students have cause to be grateful for his making this important synthesis of French thought readily available. Internationally he served as secretary of the International Geographical Congress working group on periglacial research and this culminated in the 1975 Aberystwyth field meeting which effectively featured his two decades of periglacial research.

The most recent Association meeting, the visit to Normandy in late May, visited the Cotentin Peninsula and reminded those present of his work on the periglacial facies exposed in the coastal sections. This French study, like many of his later publications was done jointly with his wife Sybil. Indeed, many meetings of the Association have been graced by their joint presence. Alas the Watson and Watson combination can be no more, although it is sincerely hoped that Sybil will maintain the tradition. Following his retirement in 1980 from active teaching Eddie Watson did not hang up his research boots and on the day before his fateful illness he had once more scaled Cader Idris which appropriately was the topic of his first geomorphological paper.

P. Worsley

NOTICES

The Bill Bishop Memorial Trust

Applications are invited for small grants to aid postgraduate fieldwork in the following areas:

(i) Cenozoic stratigraphy, palaeoenvironments and chronology in relation to hominid evolution;

(ii) British Quaternary stratigraphy, palaeoenvironments and geomorphology.

Further details and application forms are obtainable from The Secretary, Bill Bishop Memorial Trust, c/o Department of Geology, Bedford College, Regent's Park, London, NW1 4NS on receipt of a 9" x 4" stamped addressed envelope. The closing dates for applications are 30 APRIL and 31 AUGUST 1982.

MSc in Quaternary Studies

This part-time evening course, run jointly by the City of London Polytechnic and the Polytechnic of North London, is still thriving, and is now recruiting its fourth intake. The entrance requirement is a Class II Honours degree in a relevant subject (Geology, Geography, Biology, Archaeology, for example), and the intake will be restricted to a maximum of 18 students. Further information and application forms may be obtained from Dr. J.J. Lowe, Geography Section, City of London Polytechnic, Calcutta House, Old Castle Street, London E1 7NT. The closing date for applications is 1st September, 1982.

Anglo-French Karst Symposium

An international symposium on 'New Directions in Karst' will be held in England between 19th and 26th September 1983. The meeting, sponsored by study groups in England and France, is being organised by Dr. M.M. Sweeting (Oxford), Prof. J. Nicod (Aix-en-Provence) and Dr. K. Paterson (Liverpool).

The provisional programme consists of paper sessions and field excursions in Oxford (19-21st September), Swansea (21st-23rd September), and Lancaster (23rd-26th September). Accommodation will be provided in University Halls of residence.

Papers are invited on any aspect of limestone geomorphology. Abstracts of these should reach the Secretary (Dr. K. Paterson) by 1st May 1983. They should be in either English or French and not exceeding 250 words. It is intended to publish the papers after the Symposium.

Interested participants should contact either Dr. M.M. Sweeting or Dr. K. Paterson for further details.

Dr. M.M. Sweeting,
St. Hugh's College
Oxford OX2 6LE.

Dr. K. Paterson
Christ's & Notre Dame College
(L.I.H.E.)
Liverpool L16 8ND.

Late Cainozoic Palaeoclimates of the Southern Hemisphere

In September 1983 there will be an international symposium on the theme of LATE CAINOZOIC CLIMATES OF THE SOUTHERN HEMISPHERE. This will be held in Swaziland under the auspices of SASQUA, the affiliated society of INQUA concerned with Quaternary studies in Southern Africa. The first circular will be available in May 1982 and enquiries may be made to Dr. David Price Williams, the local organizer at the following address:

Dr David Price Williams,
S.A.R.A.
Swaziland National Trust Commission,
PO Box 100,
LOBAMBA
Swaziland
Southern Africa

'Cave Hunting' a Special Exhibition on the Life and Work of
Sir William Boyd Dawkins & Dr. J. Wilfrid Jackson. Opens May 22nd.

Sir William Boyd Dawkins (1837-1929) and Dr. J. Wilfrid Jackson (1880-1978) were both attached to Manchester University in the University Museum and both devoted their lives to the study of animal remains from caves and other archaeological sites. During the course of these two mens' lives, and very much as a result of their work, the study of archaeological remains from caves became established as a specialist science.

Buxton Museum possesses the libraries, correspondence and scientific manuscripts of both Sir William Boyd Dawkins and Dr. J. Wilfrid Jackson, which include letters from a wide range of leading geologists and archaeologists of the day such as Lyell, Darwin, Breuil, Evans, Petrie etc. The extensive archive collections will feature in an exhibition devoted to the geological and archaeological achievements of Dawkins and Jackson, and additionally the 'Boyd Dawkins Room' will be on view, a period style room recreating Dawkins' study at the turn of the century and featuring many items from his own home.

The special 'Cave Hunting' exhibition runs from May 22nd until the end of the year, while the 'Boyd Dawkins Room' will become a permanent establishment of the Museum which can be seen during normal Museum opening hours (Tues. - Friday 9.30-5.30, Saturdays, 9.30-5.00).

As a part of the special opening of the exhibition, there will be a public evening lecture given on May 21st by Dr. D.A. Roe, entitled 'Studying the Old Stone Age: from Boyd Dawkins to the present day'. The Museum exhibition will remain open until 7 p.m. on that evening.

Request for information on Quaternary Tectonics.

Mr. Ian Main (IGS, Edinburgh) requests information on fault movement for a project on earthquake distribution and fault movement in the British area in the Quaternary. In particular, the information required is on (i) fault types; (ii) fault location, (iii) extent of any fault scarps and (iv) assessment of rate and direction of fault movement.

Any members having information of this kind are invited to contact Mr. Main at The Institute of Geological Sciences, Murchison House, West Mains Road, Edinburgh EH9 3LA (031-667-1000 X209).

CALENDAR OF MEETINGS

June 26th - July 2nd 1982	7th Biennial conference of AMQUA to be held at the University of Washington, Seattle. The central theme of the meeting is 'Character and timing of rapid environmental and climatic changes which will be followed during paper sessions 28th-30th June at Seattle. Details of this and the pre- and post-Conference excursions from: AMQUA Local Arrangements Committee, Quaternary Research Center AK-60, University of Washington, Seattle, Washington 98195.
August 1st-9th 1982	XIth INQUA, Moscow. Pre-Congress excursions take place from July 23rd-31st. Post-Congress excursions from August 10th-19th. Further details on organisation in Britain may be obtained from The Royal Society (see notices in Newsletter 35, November 1981). The Second Circular for the Congress may be obtained from Dr. I.P. Kartashov, Secretary-General XI INQUA Congress, Geological Institute, USSR Academy of Sciences, Pyzhevsky 7, Moscow 109017, USSR.
August 22nd-28th 1982	XIth International Congress on Sedimentology, McMaster University, Hamilton, Ontario, Canada. Full details and conference circular may be obtained from IAS Congress, 1982, Department of Geology, McMaster University, Hamilton, Ontario, L85 4M1 Canada.

September 1st-17th 1982	IGCP Project 24 Quaternary Glaciations in the Northern Hemisphere. Final Meeting 1982 France and Italy. 9-10th September Report Session at UNESCO Paris. Pre-meeting field trips 1-5th September Corsica; 6-8th September Normandy. Post-meeting field trips 12-14th September French Alps, Lyons area; 15-17th September Italian Alps (Ivrea, Torino, Como, Milano). Further details from Dr. A. Billard, CNRS Laboratoire de Geographie physique, 191 Rue St. Jacques F75005 Paris.
September 7-10th 1982	Annual Meeting of the British Association for the Advancement of Science, University of Liverpool. Section C Geology (President Professor J. Sutton) 7th September - Geology and Government 8th September - Fossil Record and Evolution 9th September - The role of the amateur in Geology 10th September - The geology of the seaways to Liverpool. Further details from Dr. L.B. Halstead, Department of Geology, The University, Reading RG6 2AB.
September 11-14th 1982	Quaternary Research Association short field meeting to Co. Kerry. Further details and a booking form may be found in the Circular issued with this Newsletter.
September 17 and 18th	Quaternary Research Association short field meeting to the Wheeler Valley, North Wales. Full details and a booking form for this meeting may be found in the Circular issued with this Newsletter.
September 23rd-25th 1982	Quaternary Research Association participation in the Geological Societies of The British Isles Meeting - Glasgow. Abstracts of papers to be given at this meeting are included in this Newsletter. Details of the programme and a booking form may be found in the separate notice issued with this Newsletter.
October 16th-21st	1st International Congress of Human Palaeontology - Nice, France. Details of sessions and registration may be obtained from Professor Henry de Lumley, 1st Congrès International de Paléontologie Humaine, Institut de Paléontologie Humaine, 1, Rue René Panhard, 75013 Paris, France.
December 1982	Conference on the Palaeoenvironment of East Asia from the Mid-Tertiary. To be held at the Centre of Asian Studies, University of Hong Kong. Details of the programme may be obtained from Dr. Edward K.Y. Chen, Director, Centre of Asian Studies, University of Hong Kong.

January 7th and 8th 1983	Quaternary Research Association Discussion meeting - Coventry (Lanchester) Polytechnic, organised by Dr. D.H. Keen. The theme will be the reconstruction of non-glacial cold environments. Full details and booking forms will be published in the Circular with Newsletter 38.
September 19th-26th 1983	Anglo-French Karst Symposium. Preliminary details may be found on page 31 of this Newsletter.
September 1983	Symposium on Late Cainozoic Palaeoclimates of the Southern Hemisphere. Preliminary details may be found on page 32 of this Newsletter.

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