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COVER PHOTOGRAPH:
The spectacular raised 'boulder' beach at Porth Nanven in west Cornwall - one of the sites to be visited during the QRA Short Field Meeting in May, 1999, and also described in *Quaternary of South-West England* (see review by Peter Banham in this issue). Photograph by David Keen.

ARTICLES

RADIOCARBON DATES FROM THE ERROL BEDS (PRE-WINDERMERE INTERSTADIAL RAISED MARINE DEPOSITS) IN EASTERN SCOTLAND

J.D. Peacock and M.A.E. Browne

Introduction

Scottish Late Devensian raised marine strata can be classified into two informal categories - the well-dated Clyde Beds (Windermere Interstadial and Loch Lomond Stadial), found principally in western Scotland and the innermost Forth Estuary, and the pre-Windermere Interstadial glaciomarine or marine sediments of the east coast for which there are few radiocarbon dates. The latter include the Errol Beds, which are found on the shores of the firths of Tay and Forth, and the St Fergus Silts near St Fergus at the tip of north-east Scotland (Figure 1). A shell bed in the latter has recently yielded adjusted

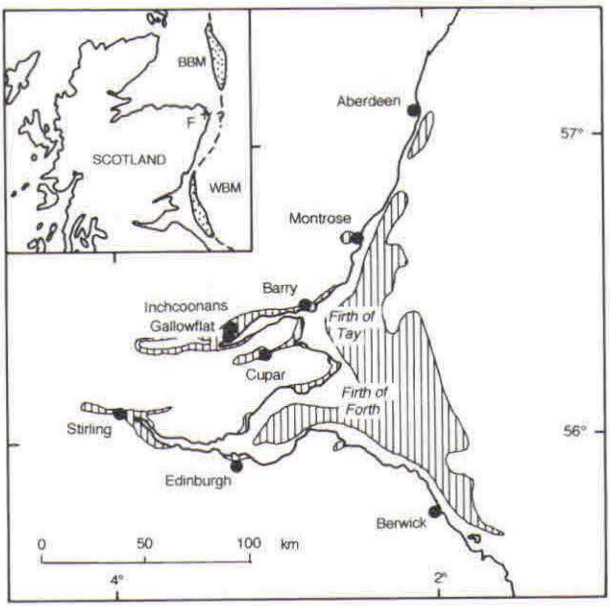

Figure 1. Localities referred to in the text, and distribution of the Errol Beds (onshore) and the St Abbs Formation (offshore) (both vertical shading). Offshore data from Andrews *et al.* (1990) and Gatliff *et al.* (1994). BBM - Bosies Bank Moraine, F - St Fergus, WBM - Wee Bankie Moraine.

radiocarbon ages of about 14.9 and 14.3 ka BP (Hall and Jarvis, 1989; Hall, pers. comm., 1998). The offshore representative of the Errol Beds is the seismostratigraphical St Abbs Formation (Figure 1), which was laid down following the retreat of Late Devensian ice from the Wee Bankie terminal moraine (Gatliff *et al.*, 1994). Here we report newly obtained radiocarbon ages from Inchcoonans and nearby Gallowflat (Table 1; Figure 1), the former being the type site for the Errol Beds (Paterson *et al.*, 1981), and briefly discuss the significance of these and other published and unpublished dates for the deglaciation chronology of eastern Scotland.

Inchcoonans Claypit

Three radiocarbon dates are available for the high-arctic Errol Beds from the type locality at the former Inchcoonans Claypit. During a recent investigation (Browne *et al.*, 1995), the threefold succession established by Paterson *et al.* (1981) was penetrated by three boreholes. An abstract of the data from one of these (SNH Borehole No. 3) is presented on Figure 2. Though most of the macrofaunal remains seen in the claypit are decayed to a greater or lesser extent (Davidson, 1932; Paterson *et al.*, 1981), the periostraca of the bivalve *Portlandia arctica* from SNH Borehole No. 3 were intact, allowing enough material to be

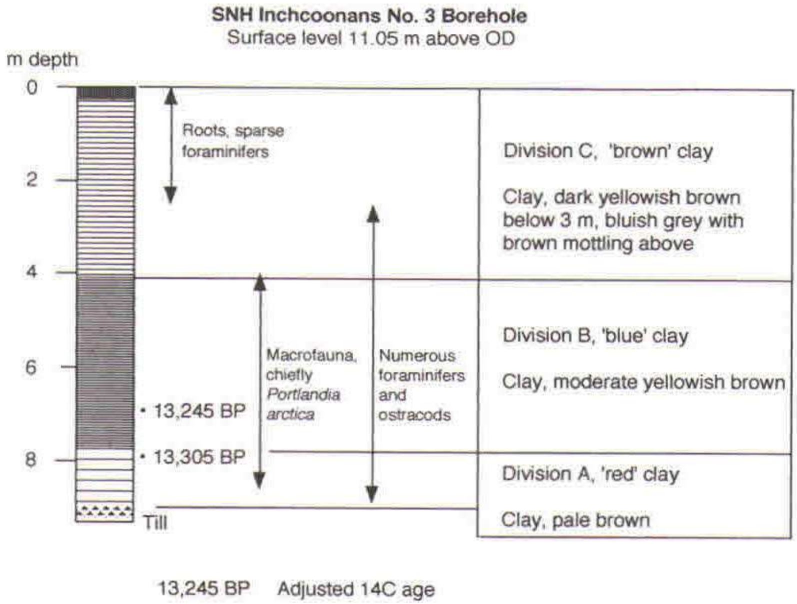

Figure 2. SNH Inchcoonans Borehole No. 3: lithology, fauna, and radiocarbon-dated horizons.

Table 1. Radiocarbon dates from the Errol Beds

Locality	Species	Laboratory No.	∂13C PDB ($^0/_{00}$)	Reported Age (years BP ± 1 sigma)	Adjusted Age (years BP ± 1 sigma)
Barry [NO 547 347]	*Balanus* sp.	OxA-1704	*	14,350 ± 170	13,950 ± 175
Inchcoonans Claypit [NO 241 234]	*Cyclopecten greenlandicus*	OxA-1703	*	13,090 ± 140	12,690 ± 145
Inchcoonans No. 3 Borehole [NO 242 334] 7.3-7.4 m depth	Seaweed	Beta-111507	-23.9	13,650 ± 70	13,245 ± 80
Inchcoonans No. 3 Borehole 7.9 - 8.0 m depth	*Portlandia arctica* (periostraca)	Beta-111508	-19.1	13,710 ± 80	13,305 ± 90
Gallowflat [NO 212 209]	*Balanus balanus*	Beta-111509	+0.9	13,340 ± 60	12,935 ± 70
Montrose (Puggieston) [NO 692 598]	*Somateria mollissima*	Birm-660	n/a	10,610 ± 220	
- do -	*Melanitta* sp.	Birm-661	n/a	11,110 ± 210	
Cupar: Springfield Claypit Stratheden [NO 363 131]	*Phoca hispida*	AA-18512	-22.0	12,510 ± 80	12,105 ± 90
Cupar: Easter Kilwhiss, Stratheden, [NO 2795 1018]	Plant material (unidentified)	SRR-391	n/a	13,636 ± 130	

*∂13C = zero (assumed). Adjusted ages based on an apparent age of 405 + 40 years for seawater (Harkness, 1983) which applies to marine algae and shell periostraca as well as shell carbonate (Dr D.D. Harkness, personal communication, 1998). Data from Williams and Johnson (1976), Harkness and Wilson (1979), Hedges *et al.* (1989), and A.C. Kitchener and J.C. Bonsall (personal communication, 1997).

collected for AMS dating from one horizon. Remains of seaweed were also encountered, enabling another nearby level to be dated in the probably rapidly deposited succession. The two adjusted dates of about 13,300 BP (Beta-111507 and 8) overlap at the 1 sigma confidence level, and are therefore regarded as reliable. A third adjusted radiocarbon age of 12,690 BP (OxA-1703) was obtained on an undecayed shell of *Cyclopecten* (formerly *Delectopecten*) *greenlandicus* which was collected from some 2 to 3m below the surface, in the north-west part of the pit (Prof. J. Rose, pers. comm., 1998), and thus probably from Division C of the stratigraphical succession (Figure 2). We regard this as a minimum age because, though the date is within the range to be expected for molluscs living in polar water at the transition from the Dimlington Stadial into the Windermere Interstadial (Peacock and Harkness, 1990), contamination by 'young' carbon cannot be excluded because the shell of *C. greenlandicus* is very thin.

Gallowflat Claypit

An undecayed plate of *Balanus balanus* from the Gallowflat claypit has yielded an adjusted age of 12,935 BP (Beta-111509). It was collected from the floor of the pit, probably from the Division B/C boundary in a succession similar to that at Inchcoonans. The figure is close to, and supports, the two non-carbonate ages of about 13.3 ka BP obtained from a little lower in the succession at Inchcoonans.

Other sites

The macrofauna from the former Barry Claypit (Figure 1), including the dated *Balanus* plate, is unusually well-preserved for the Errol Beds (Graham, 1983), and the adjusted age of 13,950 ka BP (OxA-1704) is therefore considered reliable (Table 1). However, the stratigraphical level in the pit from which the shell was collected is unknown.

Dates on duck bones said to have been collected from Errol Beds at Montrose (10.6 and 11.1 ka BP, Birm-660 and 661) conform to a Late Devensian age for the surrounding sediment (Williams and Johnson, 1976), but are 'unexpectedly young' (Cullingford and Smith, 1980). Apart from the possibility of contamination, the stratigraphical level from which the bones were collected is uncertain. They are thus believed to provide merely a minimum age.

Both the normalized (12.5 ka BP) and adjusted dates (12.1 ka BP) from recently analyzed bones of the ringed seal (*Phoca hispida*) from the former Springfield Claypit, near Cupar, Fife (AA-18512) (Figure 1; A. Kitchener and J.C. Bonsall, pers. comm., 1997) are also believed to be too young, given that an age pre-dating the Windermere Interstadial (*c*.13 ka BP) would be expected both from the relationship of the pit to the raised beach succession (Browne *et al*., 1981), and the fauna in the sediments (high-arctic rather than boreal). For these reasons, and because of possible contamination by 'young' carbon during a storage period of nearly 140 years, the dates are taken to be a minimum for the Errol Beds at this locality.

Plant debris dated to about 13.6 ka BP from the Cupar area (SRR-391) was collected from a bed of silt at about 38 m above OD. The silt underlies the sediments of a glaciofluvial delta (surface level about 42m OD) which were deposited while a glacier still occupied the adjacent Tay Estuary (Browne *et al.*, 1981). Though the date apparently adds to the evidence for deglaciation of the Tay Estuary about 13.5 ka BP, it should be treated with caution because the nature of the plant material is not known (Harkness and Wilson, 1979).

Discussion and conclusions

The radiocarbon analyses obtained from the vertebrate remains (Montrose and Cupar) are believed to provide only minimum ages for deposition of the Errol Beds. However, the dates from St Fergus, Barry, Inchcoonans and Gallowflat imply that the deglaciation of eastern Scotland and the inner Tay Estuary near Inchcoonans began respectively about 15 ka and a little before 13.3 ka BP. This is a significant result, because these figures are low compared with those based on the Andrews and Dugdale (1970) model of the raised beach sequence in the Tay area, which provided (revised) values of 17.6 ka BP for the oldest raised beaches on the outer coast, and 14.75 ka BP for beach formation (and therefore deglaciation) of the inner estuary (Sissons, 1976). They support Cullingford and Smith's (1980) impression that the raised beaches between Barry and Montrose were formed in the later part of the 17-13 ka BP period, and accord with the concept that much of Scotland, and part of England, may still have been ice-covered at 14-15 ka BP (Peacock, 1997).

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We are grateful to Drs A.M. Hall, A.C. Kitchener and J.C. Bonsall for access to unpublished radiocarbon dates from St Fergus and the Springfield Claypit, Stratheden, and for the comments of the referees, Drs W.E.N. Austin and D. Kroon. The paper is published with the permission of the Director of the British Geological Survey (NERC).

References

Andrews, I.J., Long, D., Richards, P.C., Thomson, A.R., Brown, S., Chesher, J.A. and McCormac, M. (1990). *The geology of the Moray Firth.* British Geological Survey: United Kingdom Offshore Regional Report, HMSO, London.

Andrews, J.T. and Dugdale, R.E. (1970). Age prediction of glacio-isostatic strandlines based on their gradients. *Geological Society of America Bulletin*, 81, 3769-3771.

Browne, M.A.E., Armstrong, M., Paterson, I.B. and Aitken, A.M. (1981). New evidence for late-Devensian marine limits in east-central Scotland. *Quaternary Newsletter*, 34, 8-15.

Browne, M.A.E., Paterson, I.B. and Wilkinson, I.P. (1995). Report on the geological survey of the SSSI at Inchcoonans Claypit, Errol. *British Geological Survey Technical Report* WA/95/67.

Cullingford, R.A. and Smith, D.E. (1980). Late-Devensian raised shorelines in Angus and Kincardineshire, Scotland. *Boreas*, 9, 21-38.

Davidson, C.F. (1932). The Arctic Clay of Errol, Perthshire. *Transactions and Proceedings of the Perthshire Society of Natural Science*, 9, 35-68.

Gatliff, R.W., Richards, P.C., Smith, K., Graham, C.C., McCormac, M., Smith, N.J.P., Long, D., Cameron, T.D.J., Evans, D., Stevenson, A.G., Bulat, J. and Ritchie, J.D. (1994). *The geology of the central North Sea*. British Geological Survey: United Kingdom offshore regional report, HMSO, London.

Graham, D.K. (1983). On the occurrence of the arctic marine bivalve *Macoma torelli* (Steenstrup) Jensen in the Errol Beds, east Scotland. *Scottish Journal of Geology*, 19, 355-357.

Hall, A.M. and Jarvis, J. (1989). A preliminary report on the Late Devensian glaciomarine deposits around St Fergus, Grampian Region. *Quaternary Newsletter*, 59, 5-7.

Harkness, D.D. (1983). The extent of natural ^{14}C deficiency in the coastal environment of the United Kingdom. *Proceedings of the First International Symposium on C-14 and Archaeology*, PACT 8, 351-364.

Harkness, D.D. and Wilson, H.W. (1979). Scottish Universities Research and Reactor Centre Radiocarbon Measurements III. *Radiocarbon*, 21, 203-256.

Hedges, R.E.M., Housley, R.A., Law, I.A. and Bronk, C.R. (1989). Radiocarbon dates from the Oxford AMS system: Archaeometry datelist 9. *Archaeometry*, 31, 207-234.

Paterson, I.B., Armstrong, M. and Browne, M.A.E. (1981). Quaternary estuarine deposits in the Tay-Earn area, Scotland. *Report of the Institute of Geological Sciences*, 81/7.

Peacock, J.D. (1997). Was there a readvance of the British ice sheet into the North Sea between 15 ka and 14 ka BP? *Quaternary Newsletter*, 81, 1-8.

Peacock, J.D. and Harkness, D.D. (1990). Radiocarbon ages and the full-glacial to Holocene transition in seas adjacent to Scotland and southern Scandinavia: a review. *Transactions of the Royal Society of Edinburgh: Earth Sciences*, 81, 385-390.

Sissons, J.B. (1976). *The Geomorphology of the British Isles: Scotland.* Methuen and Co., Ltd., London.

Williams, R.E.G. and Johnson, A.S. (1976). Birmingham University Radiocarbon Dates X. *Radiocarbon*, 18, 249-267.

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BURIED CHANNEL DEPOSITS AT MARCH, CAMBRIDGESHIRE, EASTERN ENGLAND

Harry Langford and Steve Boreham

Introduction

Buried channels are not uncommon features associated with Anglian glacial deposits, and some examples for the area are shown in Figure 1. In fact, Gallois (1988) notes an anomalous thickness (27 m) of 'chalky Jurassic till' at Wimblingdon Road, Town End, March (TL 4179 9482), about 4 km to the south of the site described here. He suggests that this could mark the course of a pre-glacial tributary of the River Great Ouse.

Although borehole data exist that provide sedimentological and lithological information on buried channels within the area (e.g. Horton, 1970; Gallois, 1979), little information is available from sections exposed within them. The sections exposed in what is believed to be a buried channel at March therefore offered a rare opportunity to examine the facies architecture of sediments infilling such a feature. As such opportunities are so rare, a brief report is presented here of observations made during a preliminary site visit.

The term buried channel is used here to describe linear depressions that have no relationship to the present topography and which have been infilled by relict depositional systems that have no relationship with systems operating to form the present landscape. No genetic interpretation of these features is intended by this description.

Physical setting

During 1996, East Waste Ltd excavated a rectilinear pit over 200 m long, about 20 m wide and up to 23 m deep at March, Cambridgeshire (TL 990 405), as a site investigation exercise prior to preparatory work for a landfill cell. Two-dimensional sequence reconstruction from site investigation borehole data (made available by East Waste Ltd) revealed that this excavation was located on the eastern side of a channel form, trending north–south, which the borehole data indicate is infilled by gravels, sands, clast-poor diamictons and chalk-rich diamictons.

The geology at the March Landfill site is described by the British Geological Survey (BGS, 1980) as March Gravel overlying Anglian (Lowestoft) Till, which in turn overlies Ampthill Clay (Jurassic), and the height of the land surface is about 5 m OD. Much of the Anglian Till and March Gravel had been removed prior to excavation of the trench, especially at the western end, where up to 3 m of the upper part of the sequence is estimated to be missing.

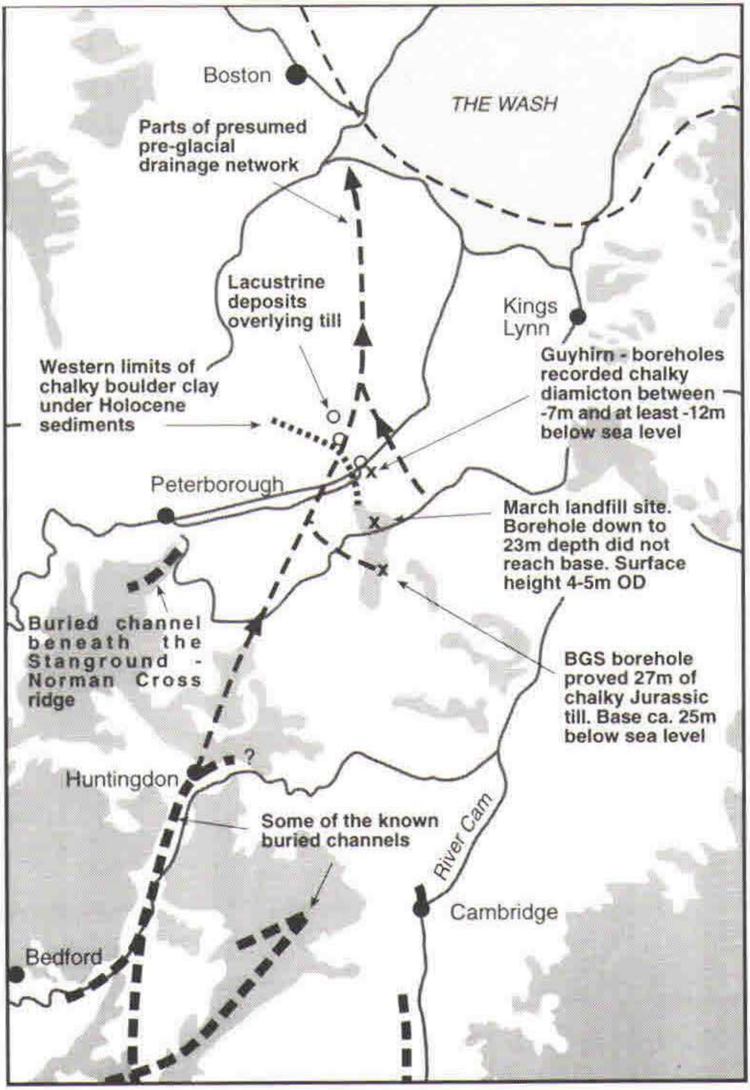

Figure 1. Distribution of glacial deposits (shaded) in the Fen Basin and on its margins (based on the Quaternary Map of the United Kingdom: South, 1st edition, 1977, HMSO), and the approximate positions of some of the known buried channels (based on Edmonds and Dinham, 1965; Horton, 1970) and parts of the presumed pre-glacial drainage network of Gallois (1979). Details of the British Geological Survey (BGS) borehole are given in Gallois (1988). Other data are from Horton (1989) and the site investigation boreholes for the Guyhirn bypass (courtesy of Cambridge County Council).

The excavated rectilinear pit was wedge-shaped, with the deepest part (up to 23 m deep) in the west lying at about −18 m OD, shallowing to about 1–2 m OD in the east. Several sections were available for study, but none had the full sequence exposed. The description provided here therefore is a composite of the sections exposed.

Sedimentology and stratigraphy

Figure 2 is a schematic representation of our preliminary observations at the March Landfill site. The western (deepest) part of the east to west-trending excavation revealed an overall upward-fining sequence (units 1 and 2), overlain by extensively deformed, fine- to coarse-grained sands (unit 3; Figure 3). Although five units are described, either poor exposure or inaccessibility has limited the amount of information available for some of the units.

Unit 1

Unit 1 consists of stratified, clast-supported gravels interbedded with structureless (massive) diamictons comprising clasts up to pebble size floating in a muddy matrix, and occasional sandy beds, at the base (unit 1a), and stratified sands and stratified gravels at the top (unit 1b).

All exposed sections of unit 1a were in a deep pit forming the deepest part of the excavation, which was used as a sump for pumping water from the

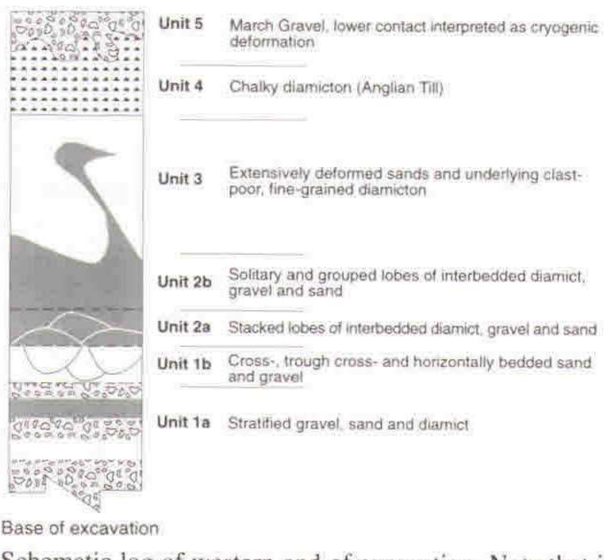

Figure 2. Schematic log of western end of excavation. Note that it is not to scale, but the upper, deformed, part (units 2b and 3) is about 10 m thick.

excavation. None of the sections, therefore, was available for close examination. The following description is based on a north to south-trending wall of this pit, where details of lithology and bounding surfaces could be observed. As this section lay normal to the probable direction of transport (see following description of unit 1b), it was not possible to determine which way the bounding surfaces of the bedsets dipped. There is, however, some indication of transport direction provided by the low-relief, upward-convex morphology of the contacts between individual beds, which suggest a cross-section through a large-scale, stratified lobate feature, with a source direction from the east or west. An easterly source, however, is suggested by apparent westward-dipping contacts in the very degraded east to west-trending walls of the pit.

Unit 1b comprises bedsets of stratified sands and gravels interbedded with a variety of fine-grained (predominantly silt but grading to mud locally) facies. The bounding surfaces of the bedsets have an apparent dip to the west, thus indicating a transport direction from the east. Individual lenses of trough cross-stratified gravel and sand at the western (deepest) ends of the bedsets indicate local reworking by north to south-flowing currents. Samples for clast-lithology analysis were collected from gravel lenses at the base and top of this unit.

Unit 2

There is a conformable transition from the well-stratified unit 1 to the poorly stratified unit 2. Muddy diamictons dominate unit 2, particularly in the upper part (unit 2b).

Unit 2a comprises coalescing and vertically stacking sediment lobes up to 10 m wide, which are composed largely of muddy diamictons, with minor interbedded gravels and sands. The muddy diamicton units contain evidence of deformation, liberation and incorporation of substrate sediments. In the deeper part of the excavation, in the upper lobes of this unit, deformation was evident locally in the muddy diamicton facies in the form of isolated clasts (up to 10 cm in diameter) of reworked, previously deformed, laminated fines. North to south- and west to east-trending sections allowed the three-dimensional architecture of individual lobes to be observed, which again indicate a transport direction from the east.

In unit 2b, isolated, or grouped, lobes of interbedded muddy diamicton, with minor sand and gravel, are present. Where these occur immediately below unit 3 (see below), they are deformed extensively. At these locations the presence within individual lobes of material that had been deformed previously may be the reason why the smaller-scale deformation features in this unit indicate more complex deformational histories. Deformation of this unit might well have destroyed primary sedimentary structures, and much of this unit might formerly have comprised massive muds. In addition, the similarity in colour of the

Ampthill Clay (which is a 'soft' mudstone) and the diamicton matrix might have prevented recognition of cohesive flow units composed of resedimented Ampthill Clay (i.e. Ampthill Clay liberated at basin margins and mobilised by cohesive flows without the addition of, or with only minor addition of, autochthonous material).

Unit 3

The extensive deformation of the lower part of unit 3 (Figures 2 and 3) and the inaccessibilty of the upper part, preclude a meaningful sedimentological description, except to note that fine-, medium- and coarse-grained sands are present and that primary sedimentary structures have been destroyed or modified by the deformation process.

Unit 3 is laterally extensive, and displays a complex pattern of deformation, including steep-angled shear planes associated with the upward injection of unit 2b and sets of low-angle shear planes within individual sand lobes.

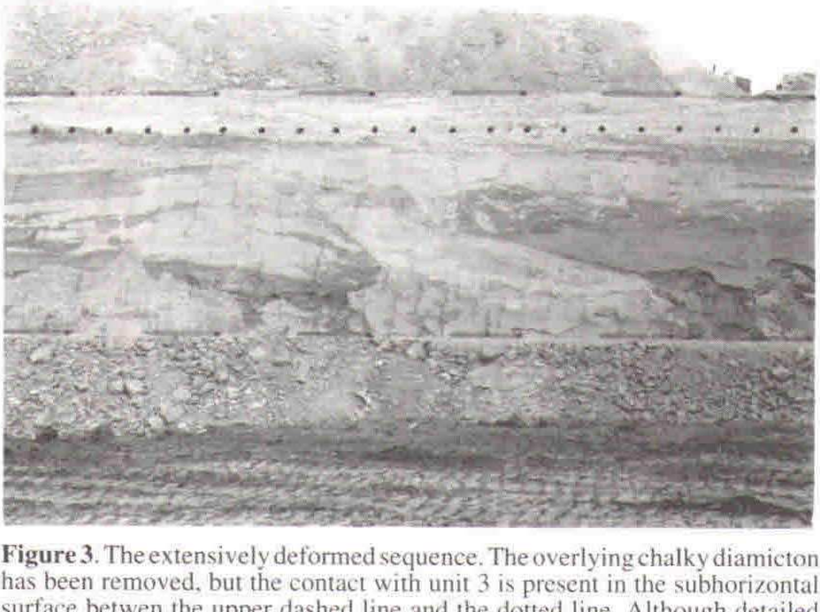

Figure 3. The extensively deformed sequence. The overlying chalky diamicton has been removed, but the contact with unit 3 is present in the subhorizontal surface betwen the upper dashed line and the dotted line. Although detailed examination along this contact was not possible, large-scale irregularities were not observed, suggesting lack of involvement of the chalky diamicton in the deformation of the underlying material. Above the upper dashed line, the material has been dumped. The material below the lower dashed line is back-fill. The distance between the dotted line and the lower dashed line is about 7 m (photographed by H. Langford, 10.10.96).

Preliminary observations suggest the same apparent sense of direction (east to west) for deformation structures in this unit, but more detailed consideration needs to be given to this aspect.

The lower contact is sharp and, because of the extensive deformation, highly irregular. The upper contact was observed only in a very degraded section, and although it was not possible to make a detailed study, the contact did not appear be highly irregular. In addition, the overlying unit 4 does not appear to have been involved in the deformation of units 3 and 2b, and sediments of the latter do not appear to be incorporated in unit 4.

Units 4 and 5

Chalky diamicton (hereafter unit 4) overlain by fossiliferous gravel (hereafter unit 5) cropped out at the (shallow) eastern end of the excavation, but the sections were too degraded to allow any form of study. Units 4 and 5, therefore, are not described here, but are inferred to represent Anglian Till and March Gravel, respectively, as described by BGS (1980). The contact between these units, however, is distinctly irregular, with large-scale diapiric injection of chalky diamicton and large-scale involutions of fossiliferous gravels (type 2a involutions of Vandenberghe, 1988; cited in Ballantyne and Harris, 1994).

Clast lithology

Samples from unit 1b indicate that local Jurassic and Cretaceous material forms about 90% or more of the clast lithology assemblage (Table 1). In the 8 mm to 11.2 mm fraction of the lower part of unit 1b, flint and chalk form 1.7% and 2.4% of the material, respectively. The corresponding percentages in the sample from the upper part of unit 1b are 3.2% and 8.0%. In the 11.2 mm to 16 mm fraction of the sample from the upper part of unit 1b the percentages increase to 7.5 and 11.2%, respectively, but in the lower part there is no corresponding increase. Igneous and quartz clasts make up 1.8% of the 8 mm to 11.2 mm fraction of the sample from the upper part of unit 1b, whereas in the lower part it is 5.4%. In unit 1b there is therefore a pattern of an upward increase in the near-travelled (easterly) erratic component and a decrease in far-travelled erratics, accompanied by a decrease in limestone in the coarser fraction.

Red Chalk, Carstone and Greensand clasts are present in the near-travelled (easterly) erratic component. The former two lithologies thin southwards from Hunstanton, which suggests that the provenance for unit 1 is restricted to the north to north-east. The decrease in limestone in the coarser fraction suggests a decreasing contribution from the west.

Local (Jurassic and Cretaceous) material also appears to dominate the clast lithology of unit 2, but samples were not collected from these sediments because suitably sized clasts were too few in number and analysis would have required an unmanageably large sample.

Table 1. Percentage clast lithology of samples from unit 1b.

Lithology[a]	Lower (%)		Upper (%)	
	11.2–16 mm	8–11.2 mm	11.2–16 mm	8–11.2 mm
Flint	1.2	1.7	7.5	3.2
Chalk	2.4	2.4	11.2	8.0
Limestone	47.6	53.1	37.2	55.2
Sand/gritstone	14.6	8.2	26.5	14.2
Silt/mudstone	15.9	20.4	10.7	10.3
Quartz + quartzite + igneous/metamorphic	7.3	5.4	0.9	1.8
Other[b]	11.0	8.8	6.0	7.3
Number of clasts	82	294	215	1137

[a]Limestone is predominantly Jurassic; sand/gritstone is predominantly Cretaceous; silt/mudstone is predominantly Jurassic.
[b]Largely Mesozoic fossils and fossil fragments.

Discussion

Initial observations indicate a sediment transport direction from the east for units 1 and 2. The presence of Cretaceous material in the clast lithology assemblages, including Red Chalk and Carstone, suggests a sediment supply source from the east, or north of east. The steep contact in the east, however, between the buried channel deposits and bedrock, and the lack of evidence for unit 1 sediments wedging out upwards towards the surface of the channel feature, may suggest a sediment transport direction from north of east; with perhaps the west-dipping bedsets forming the western limb of a north to south-trending delta lobe (Selley, 1976). The geometry of the upward-convex upper contacts of lobate sediment bodies, however, indicates that any departure from an easterly direction would not be too great.

One of several mechanisms could be responsible for the upward fining of units 1 and 2, including: an increase in water depth, a decrease in energy, increased distance from the sediment source, or channel infilling and abandonment (Selley, 1976; Allen and Allen, 1990; Reading, 1996). Whichever the explanation, it needs to be reconciled with the clast lithology pattern evident in unit 1b. The sedimentary structures and facies architecture indicate that deposition took place, initially at least, in a standing body of relatively deep water.

Deposition of sands (unit 3) on top of the fine sediments (unit 2b) within this water body could indicate channel infilling and abandonment elsewhere in the depositional system, or the reversal of conditions responsible for the upward fining apparent in units 1 and 2. Continued supply of sediment from the east would produce the deformation observed, and explain the nature of the contact between units 2 and 3 There is also a lack of evidence for incorporation of unit 4 in the deformation process, and a lack of evidence for incorporation of sediments of units 2b and 3 in unit 4, which suggests that the deformation of units 3 and 2b was syndepositional. However, evidence of well-consolidated diamictons found locally in unit 2, and the smaller-scale deformation evidence present locally in diamictons of unit 2b also have to be reconciled with any conclusion regarding the style of deformation.

Post-depositional cryogenic deformation of unit 5 (March Gravel) is evident locally, and may be restricted only to those areas where unit 5 overlies unit 4.

A more complete report of studies at this site is planned. It will be based on subsequent and possible future visits, but the latter will be confined to deposits cropping out at the surface because the lower levels of the pit have been back-filled. It is not possible at this stage to determine the genesis of the channel feature, neither is it possible to discuss its relationship with other buried channels of the area. Preliminary observations, however, suggest deposition in a relatively deep-water body, with synformational deformation of sediments. There appears to be no support for post-depositional, glaciotectonic deformation associated with deposition of unit 4 (i.e. Anglian Till).

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References

Allen, P.A. and Allen, J.R. (1990). *Basin Analysis: Principles and Applications.* Blackwell Scientific Publications, Oxford, 451pp.

Ballantyne, C.K. and Harris, C. (1994). *The Periglaciation of Great Britain.* Cambridge University Press, Cambridge, 330pp.

BGS (1980). *British Geological Survey (England and Wales): Ely Sheet 173, Solid and Drift Edition, 1:50,000 Series.* British Geological Survey, Keyworth, Nottingham.

Edmonds, E.A. and Dinham, C.H. (1965). Geology of the country around Huntingdon and Biggleswade. *Memoir of the Geological Survey of Great Britain: England and Wales.* Institute of Geological Sciences, HMSO, London.

Gallois, R.W. (1979). Geological investigations for the Wash water storage scheme. *Institute of Geological Sciences Report,* 78/19. HMSO, London.

Gallois, R.W. (1988). Geology of the country around Ely. *Memoir of the British Geological Survey, Sheet 173 (England and Wales).* HMSO, London.

Gallois, R.W. (1994). Geology of the country around King's Lynn and the Wash. *Memoir of the British Geological Survey, Sheet 145 and part of 129 (England and Wales).* HMSO, London.

Horton, A. (1970). The drift sequence and subglacial topography in parts of the Ouse and Nene basin. *Institute of Geological Sciences Report,* 70/9. HMSO, London.

Horton, A. (1989). Geology of the Peterborough district. *Memoir of the British Geological Survey, Sheet 158 (England and Wales).* HMSO, London, 44pp.

Reading, H.G. (ed.) (1996). *Sedimentary Environments: Processes, Facies and Stratigraphy,* 3rd edn. Blackwell Science, Oxford, 688pp.

Selley, R.C. (1976). *An Introduction to Sedimentology.* Academic Press, London, 408pp.

Vandenberghe, J. (1988). Cryoturbations. In: Clark, M.J. (ed.), *Advances in Periglacial Geomorphology.* Wiley, Chichester, 179-198.

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RHYTHMITES FROM BARMSTON, EAST YORKSHIRE

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Introduction

The glacial deposits of the Holderness coast of east Yorkshire have received considerable attention in recent years (e.g. Catt, 1977; Madgett and Catt, 1978; Catt and Madgett, 1981; Evans *et al.*, 1995). At Barmston South (TA 172593), laminated sand/silt/clay rhythmites lie in a basin overlying the major glacial units which in this area are subglacial and flow tills of the Dimlington Stadial (Evans *et al.*, 1995). The rhythmites were described as varved by Varley (1968) and Bridger (1977). They were later described in more detail by Evans *et al.* (1995) as their Lithofacies 2 and assigned to a proglacial lacustrine depositional environment. In this report, measurements of the thickness of the rhythmite laminae are described, using a novel sampling method. Periodicities of the environmental variations which led to variation in the thickness of rhythmite laminae are then calculated.

Methods

A new variant on the peel technique was evolved to measure the rhythmites, after attempts to remove long monoliths and acetate peels failed due to the friability of the deposits. After experiments with a small monolith in the laboratory, the following protocol was evolved. A section was carefully scraped smooth with trowels and then scalpels, with the strokes kept parallel to the bedding to minimise deformation of the laminae. The cleaned surface was allowed to air dry for a few minutes and then sprayed with aerosol clear acrylic lacquer from a distance of 0.25 m. The lacquer was allowed to dry and a further three coats were applied. After the final coat had dried, heavy-duty waterproof adhesive tape was applied to the lacquered section. The back of the tape was marked for way-up and depth using a felt-tip permanent marker. The tape was then pulled from the section, bringing with it the lacquer-impregnated sediment. The peels were transported flat to the laboratory, where the thicknesses of the rhythmite laminae were measured using a travelling microscope and a metre rule graduated in millimetres.

In order to test for periodicity, a spectral analysis was carried out. This analyses the variation of the series as a whole into periodic components of different frequency (SPSS,1993) but does not make other assumptions. The data on thickness of the laminae were loaded into the spectral density package in SPSS for Windows and a chart of periodicity was made with smoothing using a Tukey-Hamming Window (5).

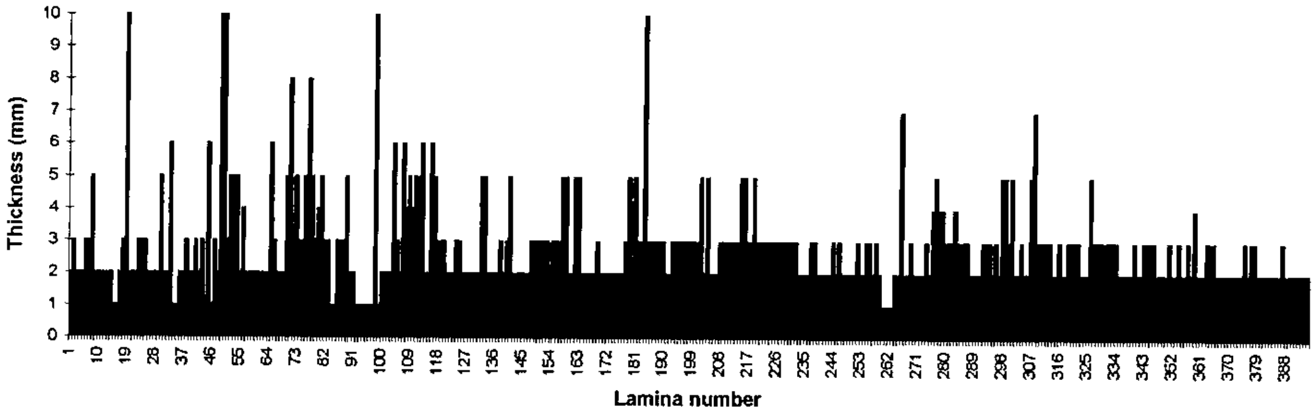

Figure 1. Plot of lamina thickness.

Results

A total of 395 laminae was counted. The plot of lamina thicknesses is shown in Figure 1. This shows that the laminae generally become thicker and more variable upward. The spectral density plot (Figure 2) shows periodicities of lamina thickness variation per number of laminae. This shows minor peaks at 2, 3, 5, 11 and a very strong peak in the 22-40 lamina area. There is no clear signal at longer periodicities, probably because the run of data is so short.

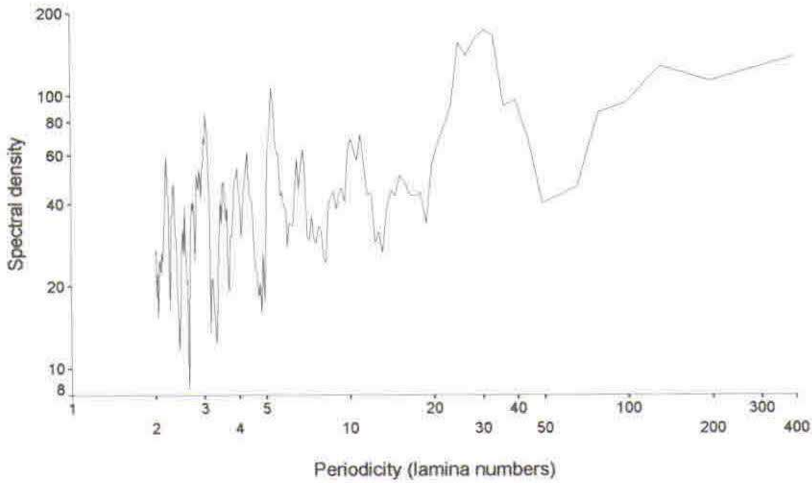

Figure 2. Plot of spectral density showing periodicity of lamina thickness variation.

Discussion

The strong periodicity peaks suggest that lamina thickness variations are responding to some regularly occurring combination of environmental factors. The peak in the 22-40 laminae area invites comparison with 22-year periodicities of solar output which occur with the double 11-year sunspot cycle (Bell and Walker, 1992; Rind and Overpeck, 1993). If this is the case, then there is a strong possibility that many of the laminae at Barmston South are annual laminae - in other words, true varves - and that thickness variations in the laminae reflect changing solar radiation inputs and thus volume of sediment liberated by melting in any particular annual melt-out event. The vagaries of climate make it entirely probable that in some years, melting at the glacial margin will have followed a complex pattern and that two or more laminae will have formed, thus 'spreading' the major periodicity peak beyond 22. In fact, even the solar cycle is not completely uniform. Extreme cases of sunspot activity observed over the last two centuries have ranged from just under nine to fourteen years (Lamb, 1985) although the impact of solar variation on climate usually follows a 22-year pattern.

If the laminae are mostly annual, the lamina count can be used to suggest that the proglacial lake at Barmston persisted for more than 350 years. This figure can be used to constrain models of glacial melting in the Holderness area during the Late Devensian.

Acknowledgements

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References

Bell, M. and Walker, M.J.C. (1992). *Late Quaternary Environmental Change*. Longman Scientific and Technical, Harlow, 74.

Bridger, J.F.D. (1977). Barmston. In: Catt, J.A. (ed.) *Yorkshire and Lincolnshire Guidebook for Excursion C7*. INQUA X Congress, Excursion C7, GeoAbstracts, Norwich, 32-36.

Catt, J.A. (1977). *Yorkshire and Lincolnshire Field Guide for Excursion C7*. INQUA X Congress, GeoAbstracts, Norwich.

Catt, J.A. and Madgett, P.A. (1981). The work of W.S. Bisat FRS. In: Neal, J. and Flenley, J. (eds) *The Quaternary in Britain*. Permagon, Oxford, 108-118.

Evans, D.J.A., Owen, L.A. and Roberts, D. (1995). Stratigraphy and sedimentology of Devensian (Dimlington Stadial) glacial deposits, East Yorkshire, England. *Journal of Quaternary Science*, 10 (3), 241-265.

Lamb, H.H. (1985). *Climate History and the Modern World*. Routledge, London, 321.

Madgett, P.A. and Catt, J.A. (1978). Petrography, stratigraphy and weathering of Late Pleistocene tills in East Yorkshire, Lincolnshire and North Norfolk. *Proceedings of the Yorkshire Geological Society*, 42, 55-108.

Rind, D. and Overpeck, J. (1993). Hypothesized causes of Decade to Century Scale Climate Variability: Climate model results. *Quaternary Science Reviews*, 12, 357-374.

SPSS (1993). SPSS for Windows release 6.0. SPSS Inc.

Varley, W.J. (1968). Barmston and the Holderness crannogs. *East Riding Archaeologist*, 1, 11-26.

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REPORTS

DISCUSSION AND FIELD MEETING IN THE FAROE ISLANDS — "ENVIRONMENTAL CHANGE IN NORTH ATLANTIC ISLANDS"

17th - 20th May, 1998

The Faroe Islands were the ideal location for this meeting since they lie in a uniquely sensitive part of the North Atlantic and are well placed to register the timing and severity of late Quaternary climatic changes. Much of the original data presented had been collected on the Islands, so this was a good opportunity to draw together multi-disciplinary evidence for local environmental change and to make comparisons with surrounding areas of the North Atlantic. In the varied programme the recurring themes were climatic change and tephra analysis - indeed it seemed that it was impossible to present a paper at the meeting without mentioning tephra.

On the whole, this was a well organised meeting (despite some confusion about the dates) which more than compensated for the arduous journeys experienced by some participants. The venue was Nordic House, a superb modern building whose picture windows afforded spectacular views across Tórshavn to the sea. The participants included many nationalities, with a wide range of interests, which provided the ingredients for a stimulating and enjoyable discussion of the subject.

Day 1

On the first morning, presentations on the theme of biostratigraphical change set the scene. There were contributions from Ole Bennike (describing environmental change in Greenland during the Holocene), Ole Humlum, Mats Rundgren and Anne Jennings. Mats Rundgren argued that plants may have survived the Younger Dryas in Iceland in glacial refugia. More than 100 years after the start of the controversy, this assertion still sparked lively debate. Anne Jennings presented two excellent papers describing ice-core data, from the south-west Iceland shelf, dating back to the late Weichselian. Detailed analysis of a core spanning the last 500 years indicated increased soil erosion and decreased marine productivity during the most severe sea-ice interval.

On a geomorphological theme, Andy Dugmore enthused about Icelandic landslides and explained how they might be used to estimate the rate of glacial erosion. Ole Humlum reviewed the palaeoclimatic significance of glacial and periglacial landforms and evidence for reglaciation in the Faroes. Chris

Caseldine discussed the evidence for Holocene temperature fluctuations in Iceland using radiocarbon dating and tephrachronology. The influence of ocean currents and the role of the Atlantic as a buffer for carbon dioxide and heat was examined by Bogi Hansen. Jeff Blackford described palaeoclimatic evidence from peat bogs and indicated that peat deposits might provide a record of solar radiation cycles. The day's presentations were rounded off by brief summaries of the posters by Steve Roberts, reporting on tephra deposits in Scotland and Heather Pardoe, describing patterns of surface pollen deposition in Western Svalbard.

That evening we were given a warm welcome at a reception hosted by Dorete Bloch (with Government support). Guests were greeted with a tumbler of Schnapps, creating a convivial atmosphere. The whole meeting had been threatened by the strike in Denmark which had disrupted air links and caused a depletion in stocks of imported goods. Dorete had decided, in the circumstances, to prepare a wide range of traditional Faroese dishes including horse mussels, nettle tart and dried fish which was much appreciated by her guests.

Figure 1. Frequent storms and high winds are responsible for active wind abrasion, evident at this site at the entrance to the Saksun Valley, Streymoy, Faroe Islands. Photograph by Heather Pardoe.

Day 2

On the second day, Ole Humlum and Hanne Christiansen led an excursion to several significant Quaternary sites. This provided those unfamiliar with the islands a good opportunity to see the dramatic landscapes and to imagine the difficulties of struggling to survive in such remote and isolated communities. Of particular interest was a visit to Saksunarvatn where Jóhannes Jóhansen had collected a 37 m long core, dating back more than 9,000 years, from which he first identified the Saksunarvatn ash layer. With endless patience and good humour the two leaders struggled to make themselves heard above the howling winds. At Eiði we were shown the site where the British author Chalmers first recognised the striae and roches moutonée as glacial phenomena. Gjógv provided the geomorphologists with fine lateral moraines, the botanists with many interesting plants and everyone with superb views of the coastline.

Day 3

The main theme of the third day was human impact, with three impressive papers from Kevin Edwards. Particularly fascinating was his account of the excavation of the Viking farmstead at Toftanes where there was evidence that seaweed may have been used for fodder. Gina Hannon's paper, based on high-resolution pollen and macrofossil data, provided evidence for colonisation of the Faroes and Iceland much earlier than previously recognised, research which had involved collecting cores from part-way down a vertiginous cliff.

Two more contemporary papers from the Faroes followed. Dorete Bloch described in graphic (and rather gruesome) detail the tradition of hunting pilot whales, on which the Faroese have depended throughout much of their history. With an unsurpassed 150 year record, she showed how the catch and sex-ratio of the whales has varied according to environmental conditions. Bergur Olsen outlined recent changes in the Faroese populations of gannets, puffins, guillemots and fulmars, using historical records and field evidence - work which had involved abseiling down cliffs to ring birds. Andy Dugmore and Stefan Wastegård described how the resolution of tephra analysis could be improved using microtephra analysis and geochemistry, with reference to deposits from the Faroes and Sweden respectively. Tom Bradwell showed, using lichenometry, a strong correlation between the recession of Virkisjökull-Falljökull and variations in mean annual air temperature.

Two archaeology papers in the afternoon gave quite a different perspective on the subject. A philosophical paper by Przemyslaw Urbanczyk discussed how cultural attitudes have conditioned human response to environmental change - for example how people who had traditionally been farmers might starve, even when fish was readily available, because they were unwilling to adapt. On a similar theme, Paul Buckland described how fleas and lice from humans and domestic animals could be used to piece together details of the lifestyle of European settlers in Greenland. Jeff Blackford proposed a vote of thanks to the meeting organisers which was warmly endorsed by all the participants.

Day 4

Our excursion on the fourth day began with a visit to Kirkjubøur, the Bishops' Farm where, traditionally, the Bishops and important farmers met. The farm, dating from 930 AD, was originally towed to the Faroes from Norway. It has passed down through 16 generations of the same family. Our hostess also explained the current controversy over plans to restore the nearby ruined medieval Magnus Cathedral.

The meeting culminated with visits to the Historical Museum and the Natural History Museum. Perhaps the most enlightening exhibits were the early photographs of the Faroese people going about their everyday lives, particularly when one realised that for these people environmental change was not simply a subject for academic debate but a question of survival.

The proceedings of the meeting will be published as a special issue of Fróðskaparrit which will be available in November 1998.

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QRA YORKSHIRE DALES SHORT FIELD EXCURSION

19th-21st June, 1998

A small select party of members, drawn mainly from the University of Leeds, gathered in Littondale for a short field meeting organised by **Andy Howard** and **Mark Macklin** (Leeds) devoted primarily to the Holocene fluvial development of the eastern dales. Following a substantial meal of excellent home-cooked food at Halton Gill Bunk Barn, Mark Macklin gave a brief talk about the current research being carried out in the area, after which we adjourned to the pub which was a pleasant two mile stroll down the dale (well halfway, thanks to a passing Nottingham High School minibus). One notable feature of this trip was the fine weather - something of a rarity in what was generally a very wet June.

Day 1

Having picked up three more members in Kettlewell, the first sites visited were in Coverdale. The first stop overlooking Hazel Bank Gill (SD 994772) allowed

Figure 1. Inspecting late Holocene boulder berm flood deposits on an incised alluvial fan, Lock Gill, Coverdale, Yorkshire Dales. Photograph by Andy Howard.

Steve Merrett (Leeds) to introduce the topic and explain his research programme on dating of the flood sequences in this part of the Yorkshire Dales, an area where there has been no mining disruption to complicate the sedimentological signal. Steve showed that the establishment of a lichen curve on boulder berms has been successful in identifying a series of major historical floods. At Lock Gill (SE 000778), the party viewed the landforms and sediments from the opposite hillslope, then descended to examine a complex section which indicated different periods of fan aggradation and incision (Figure 1). Lichen growth on the boulder berms indicates an increase in flood frequency in the late eighteenth century, with a major event in 1771 which continued through the nineteenth century when there was reworking and incision of the older deposits particularly by the October 1892 flood. Much discussion was generated by the general evolution of these fans and the problems of earlier Holocene activity in contrast to the impressive high-resolution record which has been replicated at many locations in the dales for the last 350 years.

Attention was then focussed on another aspect of the current research being carried out in this area when **Tom Coulthard** (Leeds) introduced the party to the modelling work he has been doing in the neighbouring valley of Cam Gill Beck which drains to the Wharfe at Starbotton (SD 954749). The first stop was on the return to Wharfedale to allow an overview of the catchment. The party then drove to the village of Starbotton and walked up into the catchment to observe geomorphological evidence which is attributed to the 'tempest' of February 1686. Using the field evidence, attempts have been made to model such flood events and Tom demonstrated his computer simulations and how they can be related to the field evidence.

A return was then made to Kettlewell for the enormous packed lunch provided by the bunk house and to meet **Roger Martlew** (Leeds) who introduced the archaeological theme for the first part of the afternoon with a visit to one of the numerous settlement sites which have been found in Wharfedale and on the adjacent interfluves. The first site visited was on the opposite side of the Wharfe near Kilnsey to examine the evidence for late Prehistoric field patterns and settlements which have survived in close proximity to the later Medieval field pattern. The extent of such ancient features and human population levels, and how they would have affected local vegetation and land use, was discussed particularly with respect to its influence on the fluvial system over this period.

The final part of the afternoon was directed towards the long-term fluvial development of Wharfedale with **Andy Howard** (Leeds) explaining the work that is being done on the terrace sequences of this dale. Little geomorphic research has been done on the glaciation of this part of the Yorkshire Dales since the work of Raistrick over sixty years ago. A general picture of a series of valley glaciers occupying the valleys can be taken as a starting point for the development of the river system, with the earliest terraces associated with deglaciation. A possible terminal moraine feature was seen near the confluence of the rivers Skirfare and Wharfe (SD 976693) before driving south to examine the terrace sequence at Grasswood (SD 982651) between Conistone and Grassington. A further terminal moraine is thought to occur just up river at Chapel House Barn (SD 980664) and four major terraces have been identified at heights of up to 20 m above the present river. Although no dates are available for the early terraces, a Uranium-series date on the calcareous sediments which 'lithify' the upper gravels gives an early Holocene age. Much discussion focussed on the nature of the fluvial system at this time and the reworking of glacially influenced sediments. The lower terraces are all of late Holocene age and are reasonably constrained by a series of dates from a number of sites within Wharfedale. **Karen Hudson-Edwards** (NHM, but ex-Leeds) showed that metal values on the lower terrace suggest formation after lead mining commenced in the catchment.

The day finished with a quick stop in Grassington to replenish liquid supplies for the evening meal and an ice cream. A further impressive meal awaited our return to the bunkhouse followed by the traditional evening site visit to the local hostelry.

Day 2

Sunday dawned fair but by breakfast time - yet another substantial meal - there was thick fog enveloping Littondale. However, our first site was in Swaledale and by the time we had driven over to Reeth, the cloud had been replaced by warm sunshine. The aim of this day was to examine the evidence of lead mining on the landscape and its interrelationship with the fluvial system. **Roger White** (Yorkshire Dales National Park and nothing to do with Leeds) took us into Arkengarthdale and outlined the extent of mining activity in this area with a stop at the abandoned smelt mill at Surrender Gill before visiting a hush - a large dry gully formed by the release of water from temporary dams to flush sediment off hillslopes to expose the mineral veins. The particular feature at Turf Moor Hush (NY 994022) is quite equivocal, having been eroded along a fault. Discussion ensued as to whether this was a partly natural feature based on its size, since in other parts of the country a meltwater origin would have been proposed.

The final site that morning was to Shaw Beck Gill (NZ 0005) to examine the effect of 'Hurricane Charley' in 1986 on these upland catchments. This particular storm event was responsible for the wettest day on record in England and resulted in widespread floods in the dales. Steve Merrett and Mark Macklin (Leeds) described the effects of the flood event within this catchment, which can still be seen clearly in terms of flushing out of sediment to expose bedrock with aggradation in less confined, lower gradient reaches.

After a brief lunch stop in Reeth, the party drove to the edge of the dales at Catterick to a section on the River Swale where Mark Macklin outlined the research which had been carried out by Mark Taylor and himself on Holocene fluvial changes with a series of detailed studies as part of the LOIS project.

This was a fieldtrip in the usual QRA tradition - although the turnout of members was low, this was a highly successful field meeting which was well organised by Andy Howard and Mark Macklin, with much new Quaternary material coupled with good accommodation, food and company.

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REVIEWS

QUATERNARY OF SOUTH AMERICA AND ANTARCTIC PENINSULA VOLUME 9 (1991)

Edited by J. Rabassa and M. Salemme
Published by A.A. Balkema, Rotterdam
ISBN 90-5410-615-8 ISSN 0168-6340, 1995
Hardback £42.00

The size of this publication (just slightly larger than A5) and its hardback cover give the impression that this is a book rather than a collection of scientific papers published as a journal; the last journal in this series was printed in 1993. The date given with volume details for this edition suggests that work was accepted for publication in 1991 but that printing was delayed until 1995. This may indicate a considerable time lag between completion of the scientific research and publication. This does not detract from the work, but substantial progress may since have been made in some topics.

There are no statements to indicate what selection criteria or reviewing procedures were adopted for the journal. Its editorial board is international but the majority of members are from Argentina (7) and the USA (5), with limited input from Brazil (1), Venezuela (1), Chile (1), Canada (1) and France (1). The authors are also predominantly from Argentina with the exception of contributions from Scotland (Warren, C.R. *et al.*), Canada (Helmens, K.F. and Kuhry, P.) and Germany (Heine, K.). Each paper is presented in English with the abstract reproduced in either Spanish or Portuguese.

This particular volume contains 12 papers covering a variety of disciplines, but with an emphasis on studies with a glacial theme. Topics in this category include: Glacial advances in the Ecuadorian Andes; Extra-Andean glaciation in Lago Buenos Aires Basin; A synchronous response of Patagonian glaciers to historic climate changes; The relationships between the oldest extra-Andean glaciations in the Rio Santa Cruz area; Glacier fluctuations and vegetation change associated with late Quaternary climatic oscillations in the Andes; The last Pleistocene glaciation in tributary valleys of the Beagle Channel; and Submerged moraines offshore northern Tierra del Fuego.

The remaining five papers are more diverse and cover unrelated subjects such as: Submarine outcrops underneath shoreface-connected sand rides, outer Bahia Blanca Estuary, Argentina; Upper Quaternary palaeoenvironments in the Northern Coastal Plain of Brazil; Palaeomagnetic results, the Campo Cerda Rockshelter, Province of Chubut, Argentina; Late Holocene forest-steppe interaction at Cab San Pablo, Isla Grande de Tierra del Fuego, Argentina; and Subfossil and living *Hiatella solida* from the Beagle Channel, South America.

Although the journal title would suggest a wide geographical cover of fieldwork locations, in this particular edition the majority of work (8 papers) took place in Argentina with research concentrating around the southern part of Argentina and particularly Tierra del Fuego. The only other countries included are Columbia, Chile (Patagonia), Brazil and Ecuador, with one paper from each country.

The majority of the papers present scientific work which is good but the quality of the work does vary and sometimes poor documentation of methods and databases detract from potentially interesting results and interpretations. Critical assessment of previous work is sometimes minimal and the limitations, assumptions and sources of error associated with the work are rarely explained. Papers founded on assertions and foregone conclusions which are stated emphatically at the beginning of the text leave little room for open scientific discussion on the results presented.

Typographical errors are few but the unconventional use of words and phrases such as 'conforming' instead of 'forming', 'associated to' instead of 'associated with', 'related with' instead of 'related to', and 'consisting in' instead of 'consisting of' disrupt the flow of the text. These are minor points but are relatively common throughout the volume. Stricter editing could have prevented this, making some of the papers less stilted and easier to read.

Generally the quality of presentation is excellent but the page size does limit the size of figures and tables that can be included. This is detrimental in some instances where fine detail is lost or difficult to see due to the small print. The presentation of some illustrations could be much improved if diagrams could be enlarged; a comment particularly relevant to detailed sedimentary logs and location maps (e.g. Heine, Figures 5 and 7 - both detailed chronostratigraphic logs and, Neves and Lorscheitter, Figure 1 - location and topographic map).

This edition is to be highly recommended for those with a specialist interest in the Quaternary of South America and for those involved with glacial research. It would also be a useful reference for a student library, as these often do not include material on Quaternary research outside Europe. The cost of the journal, the limited geographic coverage and the emphasis on glacial work in this particular volume may deter the more casual reader from purchasing the journal. For it to appeal to a wider audience it may be necessary to include features such as a general introduction to South American work (including a brief review of previous work and potential future work in South America), a map showing the relative locations of all the sites discussed and a general bibliography. This would obviously make it more like a reference book than a journal and it would increase the work and costs involved in producing the volume.

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QUATERNARY OF SOUTH-WEST ENGLAND

S. Campbell, C.O. Hunt, J.D. Scourse, D.H. Keen and N. Stephens
Published by Chapman & Hall, London
ISBN 0-412-83220-8, 1998
439pp, Hardback £135.00

This massive volume, the latest in the Geological Conservation Review (GCR) series from the Joint Nature Conservation Committee (JNCC), finally emerges as a triumph over diversity. First, we need to agree that South-West England is different. Other areas of southern England are also just beyond the glacial maximum and preserve subaerial 'head' from the early Tertiary onwards, but they lack two extensive coastlines and the great variety of bedrock found in the south-west. The boundaries of the region have been drawn far enough east to include more familiar Mesozoic rocks, but to the west occur older, harder rocks, including large outcrops of granite and other igneous rocks. Mainly chemical weathering in the (sub-)tropical Tertiary produced a thick residual cover which active, physical processes of Quaternary periglacial conditions have in places spectacularly quarried through to bedrock. Ice has reached the northern shore two or is it three times? A Devensian advance we expect somewhere in the general area, but the extent of Devensian glacial deposits on the Isles of Scilly might surprise. Another surprise is that evidence for an Anglian ice advance, the big boy from the Midlands east, is generally agreed to be weak. More, much the biggest glacial revelation of recent years is the decreasingly controversial *pre-Cromerian* (OIS 16?) till in Somerset. During warmer Quaternary stages, the sea has repeatedly risen to bite in around the region's edges to produce cliffs from which yet more head has slid to interdigitate with raised beaches. Dating, especially aminostratigraphy based on molluscs from these beaches, from the incredibly time-extensive cave sequences and from fluvial and estuarine material, has enabled the regional correlation of many of the scattered, local stratigraphies.

All this sort of thing is introduced in the excellent and essential synthesis (Campbell; Chapter 2). Chapter 1 (Campbell and Gordon) is a very readable 'thumbnail' update on the Quaternary in general, which ends by highlighting 'The Challenge to Quaternary Science'. Here, among other things, the fragmentary nature of the land-based evidence is stressed, together with the perceived need for the 'combined efforts of geologists, geographers, geomorphologists, botanists, zoologists and archaeologists ... to achieve the maximum resolution of the available evidence'. So, how have they done?

There has been the usual problem with the way fragmentary, multi-process Quaternary material is organised. The synthesis in Chapter 2 is primarily stratigraphical, as is the table of site details (Figure B), somewhat misplaced in the Preface and tabulated by county rather than by the sub-regions into which many sites are eventually decanted (see below). By contrast, the essay on the principles of site selection as applied to the Quaternary of this region, also in Chapter 2, recognises seven distinct *themes* ('site networks' in GCR speak) across the relevant subject areas (or 'blocks'): long-term landscape evolution, granite landforms, Pleistocene cave sequences, Pleistocene sea-level changes, periglacial landforms and deposits, key sequences for interpreting the distinctive Quaternary history of the region, Holocene vegetation history. The first three of these themes have each been allocated separate chapters (3-5), although I believe the declared objective of their integration into the broad perspective would have been better served if they had been introduced and described together with sites from the remaining four themes which have been re-distributed into five morphological sub-regions within Chapters 6-10.

This looks like an admission of defeat on the classification front, however. Philosophically that may be so, but this is fundamentally a conservation document in which it is essential to maintain the integrity of the sites. Here, then, is ample justification for some of the discursive text: that is, to provide a time and process framework for themes from the 63 selected sites, each of which has necessarily been treated primarily as a spatial entity. Despite the usual official disclaimer, an obvious side benefit is that descriptions of unfragmented sites also make the book much more useful for field visits.

To mention all of these sites is well beyond the scope of a review. Although picking jewels is difficult, especially for an outsider, here is a sample with superlatives deleted:
Kennpier and Yew Tree Farm (Ch 10), where temperate silts etc., AMS dated to OIS 15 ('Cromerian'), overlie a(?) glacial diamicton presumed as OIS 16.
Brannam's Clay Pit and Fremington Quay (Ch 7) take the prize for controversy on both what is it? and when was it? - glacial, glaciomarine, glacifluvial, soliflucted, glacitectonised and possibly OISs 16, 12 or 2, but definitely not 'Wolstonian'!
Broom Gravel Pits (CH 9), where temperate floodplain deposits (?OIS 7) are overlain by Axe Valley terrace gravels (?OIS 6) containing abundant Lower Palaeolithic artefacts.
Kent's Cavern (Ch 5), with material from seven OIS stages between 13+ and 1.
Portland Bill (Ch 6), with raised beaches from OISs 7 and 5e (etc.).
Tornewton Cave (Ch 5), where fossiliferous, interglacial sediments preserve extensive records of both OISs 7 and 5e.
Greylake (No. 2 Quarry (Ch 9), where the fossiliferous Burtle Formation and a palaeosol (OIS 5e) overlie estuarine deposits (OIS 7).
Westward Ho! (Ch 7), where a submerged forest with Mesolithic/Neolithic site rests upon a still undated raised beach and shore platform.
Bread and Cheese Cove and Old Man, Gugh, St Agnes, Isles of Scilly (Ch 8),

glacial till with blown-out sandloess of the same mineralogy and date (OIS 2).
Doniford (CH 7), artefact- and mammal-bearing periglacial river gravels and solifluction deposits (OIS 2).
Merrivale (Ch 4), for tors, clitter and cryoplanation (pre-Pleistocene and OIS 2).
Peninnis Head (Ch 8) for castellated tors (OIS 2, only ?)
Dozmary Pool (Ch 4) radiocarbon-dated, pollen-bearing, peat sequence spanning most of OIS 1.
One could go on and on, but you will have the idea by now. The whole is topped-off with a comprehensive (48 pages!) list of references and an excellent index.

There are criticisms additional to those already made. Is the book too long at 440-odd pages? Certainly there are not too many sites, but perhaps the numerous contributors have been given too much rope, because there is considerably more discursive text than is usual in a GCR volume and a greater variation in style. Some authors give accounts in which their own recent research figures very prominently; somewhat paradoxically, these sections of the book tend to be written in the established, concise, GCR style. By contrast, other authors have relaxed into more lyrical accounts of sometimes long-familiar material. A bit like Haydn spliced with Elgar: potentially disconcerting at changeovers. Again, many of the photographs are excellent in every sense, but a few show little more than contributors in thoughtful poses or excursions obscuring important outgrops. Only the cover picture is in colour and the volume has a distinctly 1980s feel, best exemplified by those multi-tone grey regional maps. The crucial, site-based line drawings are of the usual, very high GCR standard, however.

Nevertheless, this volume is clearly successful in its primary objective to provide an official justification for the conservation of the 63 most significant Quaternary sites in South-West England. More than this, for all its weight and length and perhaps partly because of its variation in pace, this book also conveys a good deal of the excitement of working on the Quaternary in that region at this time. In that sense it is an ideal aperient for those temporarily sated with a narrow time-slice of thick layer cake. Like all its fellows, this volume is expensive (£135), so you probably won't buy it yourself, but you should do your best to ensure that your library does. It can be argued that this large, multi-disciplinary volume is very good value for money, especially as the site descriptions which are absolutely necessary for research are accompanied by good introductory essays useful to students and general readers from a wide range of subject areas.

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ABSTRACTS

ROBUSTNESS AND PRECISION OF HOLOCENE PALAEOCLIMATIC RECORDS FROM PEATLANDS USING TESTATE AMOEBAE

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This thesis represents the first attempt to use quantitative testate amoebae (Protozoa: Rhizopoda) analysis to measure hydrological fluctuations in British peat bogs over the Holocene. Changes in the fossil species assemblage are used to reconstruct the mean annual water table records at different locations on mire surfaces using a transfer function designed for application on oligotrophic peatlands. The transfer function was found to provide more precise reconstructions for depth-to-water table than percentage soil moisture. Multiple cores were extracted from three of the Border mires; Coom Rigg Moss and Butterburn Flow (both intermediate ombrotophic bogs) and The Wou (a minerogenic valley mire). Testate amoebae analysis of these cores was used to assess the variability of hydrological change at three spatial scales, in an attempt to separate autogenic and allogenic influences on site hydrology. The morphology of each mire ensured a strong link between water and prevailing climate (precipitation-evaporation balance).

At the micro-scale (1-10 m), within the centre of a mire, microtopography explains differences between the hydrological record for two cores. This in inferred because one of the cores appears to have been the location of an insensitive hummock over much of the period of accumulation. At the meso-scale (100-1,000 m), between the central mire expanse and the mire margins, synchronous changes can be identified, but the edges generally have lower water tables than the central portions of the mires. However, this may be attributable to autogenic factors acting over the whole site, as well as to climate. Between sites, at the macro-scale (1-10 km), climatic influences can be identified clearly. The climatic signal is strongest in the centre of the mire and is more consistent between locations in the upper peats. If a hydrological shift is replicated in at least three cores from at least two sites, a climatic signal can be inferred.

The testate amoebae preparation technique was also modified as part of this research to provide cleaner slides for more efficient counting. Testate amoebae analysis provides a new quantitative technique for reconstructing the palaeohydrology and from this, inferred palaeoclimatic conditions of ombrotrophic peatlands.

TESTING THE SENSITIVITY OF THE PALAEOCLIMATIC SIGNAL FROM OMBROTROPHIC PEAT STRATIGRAPHY

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The aim of this thesis is to test the sensitivity of the palaeoclimatic proxy-record from the peat stratigraphy of six paired, ombrotrophic raised mires (Bolton Fell Moss and Walton Moss, Raeburn Flow and Bell's Flow, and Coom Rigg Moss and Felecia Moss), and one ombrotrophic blanket mire (Shaft Hill, Moor House), located along a rainfall gradient in northern England and the Scottish Borders.

Three techniques to reconstruct proxy-climate *via* mire surface wetness have been used - colorimetric humification, quantitative plant macrofossil, and testate amoebae analyses. Weighted averages ordination (Dupont index) and Detrended Correspondence Analysis (DCA), were used to transform the raw floral and faunal data into indices of mire surface wetness. The chronology of each peat profile was determined by radiocarbon assay, supported by spheroidal carbonaceous particle (SCP) analyses and pollen/landuse correlations. Palaeoclimate reconstructions have been made by linking known documentary/historical changes in climate, and other proxy-climate records, to those inferred from the sites investigated in the study region.

The adoption of multiple proxies to reconstruct mire surface wetness has led to improved palaeoclimate reconstructions, whilst the pollen and SCP chronologies have served to highlight deficiencies in the radiocarbon chronology and the existence of a possible hiatus in the stratigraphy of the blanket mire investigated.

The latter stage of the Little Ice Age (LIA), is the only climatic deterioration registered in all of the study sites. The largest inferred changes in mire surface wetness in Bell's Flow and Coom Rigg Moss occur coevally with the LIA, and suggest it was a severe climatic departure. Conflicting dates between the pollen and calibrated radiocarbon chronology for these two sites suggest the LIA may have occurred between 1420-1800 AD. The other main wet shifts detected in the aggregate peat stratigraphy occur at 3110-2950 BC, 2880-2810 BC, 2670-2390 BC, 1690-1340 BC, 1290-920 BC, 790-440 BC, 440-130 BC, 160 BC-100 AD, 210-380 AD, 550-810 AD, 790-1060 AD, 1010-1210 AD and 1290-1530 AD. Dry episodes occur at 2390-2180 BC, 2110-1880 BC, 1550-1240 BC, 830-580 BC, 580-400 BC, 130-40 BC, 20-170 AD, 230-370 AD, 360-530 AD, 640-890 AD, 930-1090 AD, 1110-1290 AD (the High Middle Ages), 1370-1480 AD and 1500-1690 AD.

The water balance, size, shape and hydrology of each site have been investigated in an attempt to explain the differences between their palaeoclimatic records. Evidence for differential site sensitivity is presented, which shows that Coom Rigg and Felecia Moss are the most sensitive in recording climatic deteriorations. The absence of potential summer water deficits and a mean annual effective precipitation of 677 mm, may explain the greater sensitivity of these mires, as the *Sphagnum* mosses experience optimal growth conditions here. Extreme effective precipitation within the Moor House Reserve (1,373 mm), may be routed away by throughflow and overland flow, which may possibly account for the lack of wet shifts registered by the flora and fauna. Alternatively, the presence of a fire-induced hiatus may explain the climatically insensitive blanket peat stratigraphy. Site-specific differences in mire hydrology may be responsible for the divergent plant macrofossil and testate amoebae stratigraphies of Raeburn Flow and Bell's Flow.

The extinction of *Sphagnum imbricatum* in the six raised peat bogs investigated, occurred between 1010-1520 AD, and is associated with climatic deteriorations.

Time-series analysis of the humification and DCA data from Bolton Fell Moss and Walton Moss has demonstrated the existence of a periodicity of *c.* 260-280 years. This periodicity matches results obtained from Denmark and The Netherlands, possibly suggesting the existence of a common climatic forcing mechanism affecting these North-West European sites.

THE STRUCTURE AND EVOLUTION OF RELICT TALUS ACCUMULATIONS IN THE SCOTTISH HIGHLANDS

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The aim of this research is to establish the evolutionary history of relict talus accumulations at five sites in the Scottish Highlands through study of their distribution, morphology, structure and sedimentology, and through dating and pollen analysis of buried soil horizons. Analyses of talus morphology demonstrate that though the investigated slopes comprise a basal concavity and upper straight slope, features hitherto interpreted as characteristic of unmodified rockfall accumulations, there is considerable variability in upper slope gradient. Surface relief indicates widespread reworking by slope failure, gullying and debris flows. Sections through gully-side exposures exhibit up to 3.5 m of stacked debris flow deposits, wash layers and buried soils overlying rockfall deposits, indicating a complex history of sediment reworking. Sedimentological analyses indicate that 27-30% of the talus sediments at one site (Trotternish) comprise fine (< 2 mm) particles representing granular weathering of the rockwall and thus syndepositional accumulation of both fine and coarse debris. The volume of talus accumulations in Trotternish implies an average rockwall retreat of 5.6 m since deglaciation at *c*. 17.5 cal ka BP, and thus an average retreat rate of *c*. 32 mm yr^{-1}, of which *c*. 0.10 mm yr^{-1} reflects granular disaggregation rather than rockfall. Failure and reworking of talus is inferred to reflect reduced infiltration rates (and high porewater pressures during rainstorms) caused by progressive accumulation of fines. Radiocarbon dating of buried soils indicates that reworking commenced prior to *c*. 6 cal ka BP, and has been intermittently active during the Holocene. Pollen analyses and charcoal concentration counts provide no evidence for accelerated reworking as a result of anthropogenic interference with vegetation cover, but the timing of reworking events provides support for enhanced activity associated with climatic deterioration after *c*. 2.7-2.3 cal ka BP. The characteristics of the investigated slopes show that models that treat talus as a free-draining accumulation of rockfall debris have limited applicability. An alternative model is proposed that incorporates progressive reworking by other processes.

QUATERNARY HERPETOFAUNAS OF THE BRITISH ISLES: TAXONOMIC DESCRIPTIONS, PALAEOENVIRONMENTAL RECONSTRUCTIONS, AND BIOSTRATIGRAPHIC IMPLICATIONS

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Fossil herpetofaunal (amphibian and reptile) assemblages can be used as accurate palaeoclimatic and palaeoenvironmental indicators. Though they collectively occupy a wide range of terrestrial and aquatic environments. Individual species often have specific tolerances for temperature, vegetation cover, water quality and other factors which control their distribution. Despite this, the study of herpetofaunal remains from the British Quaternary has received much less attention than virtually all other groups of biotic evidence. These remains are undoubtedly recovered from virtually all sites which produce other small vertebrate remains but, due largely to a lack of expertise, are infrequently identified. Furthermore, the data gathered so far have not been used to their full potential as a proxy from which inferences can be drawn. This thesis aimed to develop and apply palaeoherpetology as a technique in the British Quaternary.

The biology and ecology of thirty-seven species are discussed in order to facilitate their use in Quaternary palaeoenvironmental reconstruction (Chapter 2), and an account of previous work on fossil herpetofaunas is presented (Chapter 3). Due to a lack of published identification keys for fossil herpetofaunal remains, the preparation of a modern osteological collection of north-west European species (Chapter 4) has been a large and essential part of this project. Detailed study of this collection has enabled the production of an identification manual, appropriately illustrated with SEMs and hand-drawn figures (Chapter 5). The characters required for the diagnosis of individual taxa from isolated fossil remains are often very difficult to discern, and points of caution are stressed where necessary.

The acquired proficiency has been applied to over forty sites from which herpetofaunal assemblages are systematically described (Chapter 6). The existing stratigraphic, biotic and archaeological evidence from these sites is considered alongside the new findings, which include the AMS radiocarbon dating of herpetofaunal remains for the first time. Most of the new assemblages are of Devensian late-glacial and Holocene age, and this exercise has approximately doubled the volume of herpetofaunal material described from the British Isles. These assemblages collectively provide an almost continuous record of herpetofaunal history throughout the late-glacial and Holocene.

Palaeoenvironmental, biostratigraphic, zoogeographic and other inferences are discussed, and their relevance to the existing Quaternary framework for the British Isles is considered (Chapters 7-9). Specific topics relating to the interpretation of fossil herpetofaunas are discussed (Chapter 7).

A synthesised account of Pleistocene and Holocene herpetofaunal assemblages is presented (Chapter 8). From the existing work on Pleistocene faunas, new palaeoclimatic and biostratigraphic inferences are drawn and tentative correlations are suggested (Chapter 8.1-8.3). In the early Middle Pleistocene, thermophilous taxa distinguish Westbury-sub-Mendip lower units and Little Oakley from West Runton and Sugworth, and from the faunally distinct Boxgrove and upper Westbury herpetofaunas. Thermophilous herpetofaunas from Barnham, West Stow and Cudmore Grove include the southern European aesculapian snake *Elaphe longissima*, and three out of the seven exotic taxa at Cudmore Grove indicate a summer temperature at least 2-3°C warmer than today. Stage 9 appears to have experienced a reasonably continental climate, more so than Stage 11. The Stage 7 interglacial had pond terrapin *Emys orbicularis* and tree frog *Hyla*. The Ipswichian (Substage 5e) had *E. orbicularis* and a south European natricine snake *Natrix maura* or *Natrix tessellata*. Interstadial faunas from later parts of Stage 5 and from Stage 3 include relatively thermophilous elements such as natterjack toad *Bufo calamita* and grass snake *Natrix natrix* which are consistent with summer temperatures as warm as today's.

There are sufficient data to begin building a picture of colonisation and zoogeographic changes throughout the late-glacial and Holocene (Chapter 8.4). AMS-dated remains show that at least seven species colonised south-west Britain during the 'Late-glacial Interstadial', including *B. calamita* which indicates a mean July temperature of at least 15°C. during the first half of the Younger Dryas all of these species became extinct, but during the latter half the thermophilous *B. calamita* made an early return. Most amphibian and reptile species present today recolonised southern Britain very early in the Holocene. From the synthesis of early Holocene assemblages, some suggestions can be made regarding colonisation routes from the continent. In addition to today's herpetofauna, at least one reptile (*Emys orbicularis*) and two frogs (*Rana arvalis/dalmatina* and *Rana lessonae*) were present during the middle or late Holocene in East Anglia, and have since become extinct.

The natterjack toad, *Bufo calamita*, has proved especially useful in palaeoenvironmental reconstruction. Particular space is devoted to fossil records of this species, palaeoclimatic implications and zoogeographic considerations (Chapter 9). Suggestions for future work are set out in the final section (Chapter 10).

FLANDRIAN COASTAL ENVIRONMENTAL CHANGES: EVIDENCE FROM THREE SITES IN MAINLAND ORKNEY, SCOTLAND

Anne Cristina De La Vega (Doctor of Philosophy)
Centre for Quaternary Science, Coventry University

The Orcadian coastline is characterised by a high-energy paraglacial environment, where remobilisation of abundant glacigenic sediment has favoured the development of numerous barriers. To date, there has been little work on either Flandrian (Holocene) patterns or relative sea-level change or coastal processes affecting Orkney. In the present research, detailed morphological, lithostratigraphical and biostratigraphical work was undertaken in three areas of Mainland Orkney, and has revealed distinctive back-barrier sequences which illustrate the diversity of coastal responses to complex interactions between relative sea-level trends, sediment supply and coastal configuration.

Scapa Bay provides direct evidence of relative sea-level rise and coastal retreat during the early Flandrian. There, the sea flooded a freshwater marsh *c.* 8.5 ka BP at *c.* 5.4 m OD (Newlyn). Wave refraction remobilised abundant sediment supply from nearby cliffs before *c.* 7 ka BP, and a series of swash-aligned barriers (SAB) accumulated across the valley mouth. By *c.* 6.6 ka BP, direct marine influence had declined in the back-barrier area, although saltmarshes persisted until *c.* 5 ka BP. The enclosed lagoon was then infilled with terrestrial sediments and a freshwater marsh developed. The multiple-barrier complex in this sheltered embayment demonstrates land progradation against a backdrop of long-term rising relative sea level, facilitated by continuous sediment supply.

At Carness, a single SAB was built during the early Flandrian. Between *c.* 6.5 and 5.4 ka BP, marine influence was at its highest and a saltmarsh formed between *c.* -3.2 and -2.57 m OD. No direct marine flooding was, however, recorded. Later, as the water table rose, a brackish lagoon was ponded. Soil erosion occurred in the catchment and terrestrial sediments gradually infilled the lagoon. Slow inland migration of the SAB during the late Flandrian is related to complex barrier and lagoon interactions exacerbated by sediment starvation. The sheltered setting of the site enabled the barrier to keep cohesiveness throughout its inland translocation, although its present morphology shows signs of instability.

The Bay of Skaill is the most exposed and dynamic coastal environment of the sites investigated. During the middle Flandrian, a dune ridge was built as sand supply was abundant, and a freshwater loch was ponded in the back-dune area. From *c.* 6.1 ka BP, aeolian processes became dominant and the dune ridge slowly migrated landward, while machair developed inland. After *c.* 4.4 ka BP, the bay formed gradually as the dune ridge retreated to its present position. Moreover, a SAB developed and eroded the seaward dune edge. At present, the SAB is migrating rapidly inland due to sediment starvation and exposure to storm activity.

The Flandrian vegetational history around the three sites was investigated and accorded with that already established for Orkney. Herbaceous vegetation was initially dominant. A *Betula-Corylus* woodland, including *Salix* and possibly *Quercus*, developed during the early Flandrian and reached its maximum extent *c.* 5 ka BP. Anthropogenic impact (*i.e.* woodland clearance and mixed farming practices) from the Neolithic onwards affected significantly the landscape studied. Between *c.* 4 and 2.5 ka BP, a combination of natural and anthropogenic factors led to the spreading of heathland and a possible decline of anthropogenic activities.

NOTICES

1. GLACIAL-INTERGLACIAL SEA-LEVEL CHANGES IN FOUR DIMENSIONS

Quaternary Sea Levels, Climate Change and Crustal Dynamics

Albufeira (Algarve), Portugal, 13-18 February 1999

Chairman: A. Dawson (Coventry, UK)
Vice-Chairman: C. Andrade (Lisboa, P)

Scope of the Conference

The conference will focus on recent developments in our understanding of Quaternary sea-level changes and relationships to past changes in climate. The most up-to-date records of Quaternary sea-level change will be described while the influence of crustal dynamics on patterns and processes of coastal change will also be considered. The contribution of recent earth rheological models to our understanding of former sea-level and ocean-volume changes will also be addressed. Attention will also be given to links between former ocean circulation, climate change and sea level.

The conference is open to researchers world-wide, whether from industry or academia. Participation will be limited to 100. The emphasis will be on discussion about new developments. There will be a poster session. The Registration Fee covers full board and lodging. Grants will be available for younger scientists, in particular those from less favoured regions in Europe.

Deadline for applications: 2 November 1998

For information and application forms, contact:

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2. LOESSFEST '99

Loess: Characterisation, Stratigraphy, Climate and Societal Significance

Bonn and Heidelberg, Germany, 26 March - 1 April 1999

Scope of the Conference

An international conference in celebration of the 175th Anniversary of the first recognition of the origins of the loess by von Leonhard.

Held under the aegis of the Loess Commission of the International Union for Quaternary Research (INQUA) and the International Geological Correlation Programme (IGCP - UNESCO/IUGS), and involving an initiative to establish a terrestrial aeolian sediment database for the Last Glacial Maximum.

The initiative for the meeting comes jointly from the Loess Commission of INQUA and IGCP Project 413 on 'Understanding Future Dryland Changes from Past Dynamics'. The conference is open for the discussion of all aspects of loess research.

A number of distinguished researchers in the fields of loess and atmospheric dusts have already agreed to present keynote review papers in Bonn. At the time of printing of this First Circular, they include R. Arimoto (USA), Z.S. An (China), G. Bergametti (France), M.E. Evans (Canada), S.P. Harrison (Germany), F. Heller (Switzerland), K. Kohfeld (Sweden), G. Kukla (USA), E.A. Oches (USA), V.I. Osipov (Russia), S.C. Porter (USA), G. Richter (Germany), D.-D. Rousseau (France), A.K. Singhvi (India), I.J. Smalley (UK) and A.G. Wintle (UK).

For information and application forms, contact:

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Information and reply forms also on our www sites
http://www.gg.rhbnc.ac.uk/loessfest
http://inqua.nlh.no/commpl/loessm.html

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. The majority of members reside in Great Britain, but membership also extends to most European countries, North America, Africa, Asia and Australasia. Membership (currently *c.* 1,000) is open to all interested in the objectives of the Association. The annual subscription is £15 with reduced rates (£5) for students and unwaged members and an Institutional rate of £25.

The main meetings of the Association are the Annual Field Meeting, usually lasting 3-4 days, in April, and a 1 or 2 day Discussion Meeting at the beginning of January. Additionally, there are Short Field Meetings in May and/or September, while Short Study Courses on 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 October; the *Journal of Quaternary Science* published in association with Wiley, with six issues a year; the monograph series *Quaternary Proceedings* also in association with Wiley, 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 April Field Meeting. The current officers of the Association are:

President: ***Professor B.M. Funnell***, School of Environmental Sciences, University of East Anglia, Norwich, NR4 7TJ (e-mail: b.funnell@uea.ac.uk)

Vice-President: ***Dr P.L. Gibbard***, Quaternary Stratigraphy Group, Department of Geography, Downing Place, Cambridge, CB2 3EN (e-mail: PLG1@cus.cam.ac.uk)

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

QRA home page on the world wide web at: http://www2.tcd.ie/QRA

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