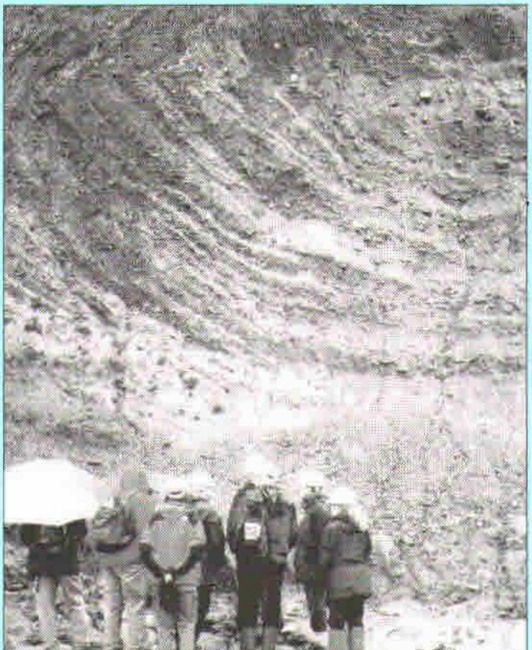
NUMBER 97 JUNE 2002

QN

Quaternary Newsletter



A publication of the
Quaternary Research Association

QUATERNARY NEWSLETTER

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Quaternary Newsletter is issued in February, June and October. Articles, reviews, notices of forthcoming meetings, news of personal and joint research projects, etc. are invited and should be sent to the Editor. Closing dates for submission of copy (news, notices, reports etc.) for the relevant numbers are 1st January, 1st May and 1st September. These dates will be strictly adhered to in order to expedite publication. **Articles must be submitted at least 6 weeks before these dates in order to be reviewed and revised in time for the next issue of QN, otherwise they may appear in a subsequent issue**. Authors are encouraged to submit material as e-mail attachments, with text in Word format and diagrams and black-and-white photographs in .eps format.

Argraff/Printed by:
Gwasg Ffrancon Press
BETHESDA
Gwynedd
North Wales
Tel: 01248 601669 Fax: 01248 602634.

COVER PHOTOGRAPH:
Spectacular deformation structures in Irish Sea diamicton and overlying sands and gravels at Traeth y Mwnt, West Wales. Photograph kindly supplied by Alastair Curry (see report on Annual Field Meeting).

ARTICLES

THE LATE DEVENSIAN ICE LIMIT IN THE HUMBERHEAD AREA – A REAPPRAISAL

Allan Straw

Introduction

The QRA field meeting in east Yorkshire and north Lincolnshire, based in Sheffield (September, 2001), provided an excellent opportunity to observe and reconsider deposits and landforms associated with limits claimed to have been reached by Devensian ice in Yorkshire, both east of the Wolds and in the Humberhead area. The highly informative Field Guide (Bateman *et al.*, 2001) includes descriptions and illustrations of many of them.

One circumstance which permeates the Guide, and has indeed been widely published (Gaunt, 1976a, 1981, 1994), is the claim that Late Devensian ice, which had traversed the Vale of York, extended south across the Humberhead area to a maximum limit at Wroot (SK 714030) in the latitude of Doncaster. Yet, compared with the wealth of Devensian deposits and landforms in areas east of the Wolds and at, and north of, the Escrick moraine, the Humberhead area is remarkably deficient in Devensian deposits and landforms.

Several positions for the southern limit of Devensian ice in the Vale of York have been proposed since the argument for a Lake Humber by Lewis (1894). Charlesworth (1957, 1190-1) presented without question what had become the traditional view that this limit was to be identified at the Escrick moraine, although Edwards *et al.* (1950, 50, 57) claimed that the Linton-Stutton gravels southwest of this moraine marked an earlier advance. In 1966, Palmer identified a 'Balby stage', regarding till south of Doncaster as Devensian. Gaunt (1976a, 1976b, 1981, 1994) has established the limit at Wroot that is reproduced on the Quaternary Map of the United Kingdom (South), First Edition (1977), Institute of Geological Sciences, and is included in the QRA Field Guide (Bateman *et al.*, 2001, Fig.4). Straw (1979, 1991, 1992) has maintained the view of Edwards *et al.* (1950), finding no evidence for Devensian glaciation south of the Trias hills of Hambleton Hough (SE 557299), Brayton Barff (SE 586304) and Holme-on-Spalding Moor (SE 822388) about the latitude of Selby.

In the light of the recent Field Meeting and publication of the Field Guide, it seems pertinent to reappraise the status of a Devensian advance toward Doncaster, initially along two lines of enquiry:

- what actual evidence has been adduced to date for such an advance?
- what evidence might reasonably be expected by comparison with east Yorkshire and the area north of Escrick?

Actual evidence

Palmer (1966) accepted tills at Balby (SE 555010) as Late Devensian. He recognised and sought to explain the paucity of till in the area immediately to the north by suggesting that the ice had crossed a partly-frozen land surface, and of 'dead-ice' features by claiming the replacement of decaying ice by the 100-foot (33m) Lake Humber. Gaunt (1981) demonstrated the Balby till to be pre-Devensian.

Gaunt (1976a) drew particular attention to the discontinuous line of sands and gravels (his Younger Glacial Sand and Gravel) from Wroot northnorthwest to Thorne (SE 690135) and possibly East Cowick (SE 663213). Concluding that they were Late Devensian ice-marginal materials, he proposed that ice had advanced some 30 miles beyond the Escrick moraine into a pre-existing, 33m, Lake Humber. This model was reiterated in Gaunt (1981) and in the relevant British Geological Survey Memoir (Gaunt, 1994), where the deposits were designated 'Glacial Sand and Gravel of Devensian age'. In this paper, purely for convenience, these Wroot-Thorne Gravels will be referred to as W-TG.

Prospective evidence

Four categories can be examined:

1. Tills
2. Ice-marginal deposits and landforms
3. Deglacial products within the postulated limit
4. River adjustments.

1. Tills

Within the Late Devensian limit defined by Gaunt (1976a) no tills have been identified at the surface nor, in borehole-logs, beneath lacustrine sediments (25-foot Drift) and Holocene alluvium. Gaunt (1976a, 635) fully acknowledged this, and suggested that the ice might have been partly lubricated or even floated by impounded water, which could also have sorted or swept away any glacial debris released. Such a circumstance, it was held, could explain both the lack of associated till and the water-laid nature of the W-TG (Gaunt, 1981, 92; 1994, 114). The ice, at least 35m thick, was considered to have surged into the waters of high-level (33m) Lake Humber, but it would have required much deeper water to have floated without grounding anywhere on the lake floor, and certainly could not have floated over the till-free Mercia Mudstone eminences of Crowle and the Isle of Axholme. By implication, the surging ice was considered relatively clean and its speedy flow and subsequent rapid melting contributed to the lack of glacigenic materials. Yet it was a surge of the east coast ice that reached south into Lincolnshire (Boulton *et al.*, 1977; Straw, 1979), and there is no dearth of such materials related to that. Granted, this ice was able to rework unconsolidated marine sediments, but the Vale of York ice would have crossed and entrained, at least in part, substantial spreads of fluvial, mass wastage, and probably aeolian deposits accumulated over tens of thousands of years over bedrock that also offered relatively little resistance. Yet vital evidence for an ice incursion, the presence of till, is missing from the whole of the 450 square miles claimed to have been occupied by Late Devensian ice.

2. Ice-marginal deposits and landforms

Gaunt (1976a, 634-635; 1994, 114) claimed the W-TG to be ice-marginal gravels located along some 7 miles (9%) of the extended ice perimeter, with possibly a concealed ridge toward East Cowick. He confessed to a complete absence of similar materials along the eastern edge of the ice, that is for some 36 miles from southwest of Scunthorpe to the Humber estuary and thence northward along the lower slopes of the Yorkshire Wolds scarp. It was suggested that such materials possibly collapsed into the valley (the Trent) and were re-worked or swept away. Certainly, a resurgent River Trent might have removed some material where it is relatively close to the Lower Lias scarp, but it should be noted that the combined efforts of Trent/Ouse waters and Humber tides have not fully removed similar deposits of Devensian ice which passed westwards through the Chalk gap of the Humber to Winteringham (SE 930222). If a small lobe of east coast ice could leave substantial deposits round its margin (Straw, 1957; Frederick *et al.*, 2001) why did a much larger Humberhead mass leave no sign of its presence only 4 miles to the west? Indeed, on any reasonable expectation, this short stretch of the Humber between the two ice fronts should have been clogged with sediment but, the fact remains, there is no material evidence for Late Devensian ice along any part of the postulated eastern margin.

3. Deglacial features

If the landscape north of the Escrick moraine is any indicator, there should be some evidence of deglacierization over the 450 square miles held to have been ice-covered south of the moraine, especially as the same ice-stream was involved. Even if it partly floated, it would have grounded when high-level Lake Humber drained away and, following a surge, it would have stagnated and ablated '*in situ*'. After travelling some 75 miles down the Vale of York, the ice could not have been free from debris and 'dead-ice' deposits and features including hummocky moraine and kettle depressions should exist. No such evidence occurs over the Crowle and Isle of Axholme eminences, though it could have been buried beneath the younger mantle of glacilacustrine sediments (25-foot Drift) of low-level (8m) Lake Humber.

However, Gaunt (1994, 110 and fig. 42) states

> " .... contours at and below OD on the base of the Devensian deposits, in effect mainly on the base of the 25-foot Drift, reveal the former landscape ....",

which is essentially one of fluvial valleys eroded into pre-Devensian fluvial and glacial materials and bedrock. Although some patches of sand and gravel have been proven between the 25-foot Drift and bedrock, Gaunt (1994, 113) regarded them as fluvial sediments of various ages.

4. River adjustments

From Ripon south-southeast to Tadcaster, a swarm of meltwater channels and river diversions is closely associated with the western edge of the Vale of York ice (Kendall and Wroot, 1924, 543-555) and similar features exist along the flank of the Howardian Hills on its northeastern side (Straw, 1979, 27-28). The Rivers Nidd, Wharfe and Derwent are the more obvious examples. The western margin of the extended ice would have crossed the valleys of the Aire, Went and Don, but none of these has suffered similar deflection, nor was the Wharfe forced into the Aire valley. In crossing the Humberhead area and advancing south up the Trent valley, the ice would have obstructed so effectively the drainage of much of the English Midlands that water would have backed up in the area west of Lincoln. High-level Lake Humber reached about 33m OD and, unless the Gainsborough gap was higher than this, such a water level must have prevailed many miles to the south. The Aire, Went and Don rivers could therefore have entered the peripheral lake rather than impinging directly on the ice front. Being submerged, the lower parts of their valleys could thereby have avoided disruption, but there are apparently no bodies of sediment in these valleys that should have accumulated in such flooded situations. Strand-line materials (Older Littoral Sand and Gravel) provided Gaunt's evidence (1976a) for the lake, but consisted of reworked local drifts

> " .... with no input of sediment from outside the immediate locality". (Gaunt, 1994, 116).

Between the Don and Idle rivers lies Older River Gravel (ORG), a large body of pre-Devensian fluvial sediment (Gaunt, 1976a, 1976b) over which Lake Humber would have been very shallow and beyond which on its northeast side are the W-TG, part of the postulated Late Devensian moraine. No river deflections occur in this area; rather the Don, Torne and Idle take courses directly through the so-called moraine toward the Humber.

Discussion – the Wroot-Thorne Gravels

The lack of glacigenic and geomorphological evidence for the existence of the ice lobe, apart from the W-TG, focuses particular attention on the nature and status of these deposits, under the following headings:

1. Geomorphological attitude
2. Lithology and sedimentary features
3. Stratigraphical position

1. Geomorphological attitude

The W-TG are found in several low eminences standing a few metres above surrounding surfaces of 25-foot Drift. Acknowledged as 'not typical of morainic sediments' the gravels were still regarded as having been derived from an ice front (Gaunt, 1976a, 635; 1994). As the meltwaters probably issued from canals draining from the ice into the peripheral lake, the deposits should display something of the form and constitution of subaqueous fans or of kames splayed out from the ice edge but, disposed in narrow elongate outcrops parallel to the postulated ice front they bear no resemblance, for instance, to the ice-marginal deposits so evident in Holderness between Gembling and Keyingham (Evans *et al.*, 2001, 9-10; Thomson and Evans, 2001). So, the question can be posed: are they indeed original discrete accumulations and landforms or, are they separated portions of an older once-continuous depositional feature?

The W-TG lie along the 'brow' of the west side of a deep valley eroded into Sherwood Sandstone to –10 to –15m OD, presumably by the River Idle (Gaunt, 1981, fig. 4; 1994, fig. 42), subsequently filled and concealed by 25-foot Drift. Excavated in earlier Devensian time before Lake Humber is considered to have reached its 33m level, the valley would have been utilised again by the Idle when the water level fell and before it recovered to 8m, the 25-foot Drift stage. The presence of such Drift around the W-TG mounds suggests that small valleys tributary to the Idle valley were available to receive it, having been produced by streams flowing between the mounds from the area of ORG to the west. The W-TG outcrops may well, therefore, have suffered erosion on all their margins.

Concealed ridges of sand and gravel exist north of Thorne and southeast of Burn (SE 600280) and may represent continuations of the W-TG feature (Gaunt, 1976a; 1994, fig. 43), but they lie athwart the lower parts of the Don-Went and Aire valleys and have a wholly different geomorphological attitude from the W-TG, which survive on elevations of Sherwood Standstone. The W-TG can, then, be regarded as residual deposits saved from complete removal by the base-level rise associated with low-level Lake Humber, which suppressed fluvial erosion and retarded mass movement.

2. Lithology and sedimentary features

The W-TG have a very large component of Carboniferous sandstones, some 20-40% of Permian limestones which are held to distinguish them from other sands and gravels in the region, and a meagre non-local component, including Carboniferous Limestone, chert and Lake District rocks, similar to erratic assemblages in the pre-Devensian glacial drifts (Gaunt, 1994, 114). This composition is anomalous given that the W-TG source is claimed to be the very same ice-stream that flowed down the Vale of York, later to retreat and stabilize at the Escrick moraine and there deposit a 'Teesdale' assemblage of erratics including Whin Sill dolerite and Cheviot and east Scottish igneous rocks as well as Lake District types (Kendall and Wroot, 1924, 527; Edwards *et al.*, 1950, 57).

The largest recorded thickness of exposed W-TG is 5.2m on the Tudworth ridge (SE 693100) below a ground surface at about 8m OD (Gaunt, 1976b) but, because all the W-TG except at Tudworth rest on Sherwood Sandstone at depths no greater than -5m OD and their upper surfaces between 6 and 9m OD are remarkably accordant over some 8 miles, the average thickness is of the order of 12m. If deposited in Lake Humber, about 25m of clear water could have stood above the W-TG even, presumably, adjacent to the ice edge. Wherever exposed, the W-TG have been observed to be sorted and, although with local cross-bedding (with dips mostly south and southeast) and ripple-bedding, to be generally level-bedded (Gaunt, 1976b, Chapter 16). These features of the W-TG do not seem consistent with deposition by discrete meltwater streams draining from ice into standing water.

3. Stratigraphical position

Two criteria, established to Tudworth (specifically, occurrence between Lower and Upper Periglacial Surfaces, and superimposition on ORG), have been used to place the W-TG relative to other deposits. Because the Older Littoral Sand and Gravel, which marks the shoreline of high-level Lake Humber, also satisfied these criteria, it was regarded as contemporary (Gaunt, 1976a, 633; 1994, 114).

Ventifacts found at the presumed base of the W-TG at Tudworth were allocated by Gaunt (1976a, 633; 1994, 116) to the Lower Periglacial Surface (LPS), a term used to identify a former landscape severely affected by periglacial conditions that existed previous to the contemporaneous events of high-level Lake Humber and glaciation. The Upper Periglacial Surface was identified above Late Devensian lacustrine and glacial deposits.

It has, perhaps, been unwise to adhere too rigidly to this concept (Gaunt, 1981, 90). Periglacial conditions affected Britain for many of the tens of thousands of years of the Early and Middle Devensian, interrupted by several warmer interstadials, and the LPS must be taken to represent that long time. Almost any deposit of this time could, however, rest on and lie beneath 'surfaces' betraying periglacial activity, and which of them would be *the* LPS? The so-called Upper Periglacial Surface may also represent more than one periglacial phase, the latest being of Loch Lomond Stadial age (Murton *et al.*, 2001, 124-5). The point here is that greater caution should be exercised in allocating evidence of periglacial activity to one or other of only two Periglacial Surfaces. The ventifacts discovered at Tudworth may indeed represent Gaunt's LPS, but could equally well have been formed and covered much earlier in the Middle or Early Devensian, or indeed before then.

Gaunt reports no traces of periglacial features beneath pre-Devensian deposits (1976a, 633) but the pre-Devensian glacial regime over south Yorkshire was one of scour and erosion, so this is not surprising. However, emplacement of pre-Devensian tills at Welton-le-Wold in Lincolnshire, only some 35 miles away, was immediately preceded by a prolonged periglacial period (Alabaster and Straw, 1976), and cambering and 'head' deposits have been reported from beneath pre-Devensian tills in southwest Lincolnshire (Wyatt *et al.*, 1971; Wyatt, 1971). Ventifacts and other periglacial features of pre-Devensian date could therefore also persist in south Yorkshire.

If the stratigraphic criterion of 'between Periglacial Surfaces' is less precise than has been thought, and the Tudworth ventifacts are unreliable as stratigraphic markers, then firm designation of the W-TG at Tudworth to the Late Devensian rests solely on identification of the underlying gravel, rich in Carboniferous sandstones, as ORG (Gaunt, 1976b; 1994, 114). The latter extends from the Hatfield Woodhouse area toward the Tudworth ridge, but is covered by 25-foot Drift before reaching it. Does the ORG really pass beneath the W-TG on the Tudworth ridge or is the underlying gravel an older glacifluvial deposit of very similar composition, such as survives on the Doncaster ridge only a few miles southwest? Because neither circumstance can be demonstrated unequivocally, this second criterion also becomes unreliable.

Conclusion

In rejecting origins other than a 'moraine' for the W-TG, Gaunt (1976a, 634-5) had to invoke the presence of glacier ice in spite of acknowledged difficulties, and utilise the concept of two Periglacial Surfaces (Gaunt *et al.*, 1972) to rationalise the stratigraphic relationships. However, certain characteristics of the W-TG, if taken together, suggest that the W-TG are remnants of pre-Devensian materials; if they are, the requirement for a Late Devensian ice lobe to explain them disappears.

The general level-bedding of the sediments on each of the eminences, the existence of south or southeast dips on some cross-bedded units, the close accordance of summit heights, and an erratic content akin to that of undoubted pre-Devensian deposits in the area, collectively point to deposition by running-water, probably glacifluvial. A geomorphological case has been offered above for post-depositional dissection and erosion of the W-TG. It is not unreasonable to suggest that the W-TG are vestiges of a former tract of outwash gravel aggraded by waters draining southsoutheast. Such a continuous tract would initially have been wider than the surviving fragments and, acknowledging the Permian limestone content, would probably have extended west of Thorne toward the Went valley (and the Permian cuesta) and possibly to the Snaith ridge.

Gaunt's difficulty with a glacifluvial origin was that the gravel tract was not valley-bound (1976a, 634), but a palaeogeographic scenario can be envisaged which confines it within an ice-walled valley during a late phase in the wastage of a pre-Devensian icesheet.

Straw (1963; 2002) has demonstrated how, during such a glaciation, the Trent was forced to incise a new course across the Mercia Mudstone between Nottingham and Newark, how its Hilton (Eagle Moor) terrace was guided to Lincoln, and how later as deglaciation proceeded, the Trent extended its incised valley to Gainsborough (and presumably thence to the Humber), all events controlled by stagnating ice masses in the Vale of Belvoir and west of Lincoln. By analogy, meltwaters moving round and perhaps over and through similar dwindling masses west of the emerging Mercia Mudstone cuesta, in the Idle basin, and north of Doncaster could well have been responsible for the large spreads of outwash on the Rossington and Doncaster ridges (Gaunt, 1994, 104-5). Later, drainage from the more northerly mass could have taken an ice-walled course, laying down the W-TG mostly on Sherwood Sandstone and finding escape through the Haxey 'gap' to the Trent.

After complete disappearance of the ice, the Don could have emplaced ORG to the west of the W-TG tract and the Idle likewise to the south and east, reworking and replacing some of the outwash gravel and at the same time achieving some erosion and reduction in areas of the slightly younger W-TG. Further erosion would have followed during the Early and Middle Devensian when the Don and Idle rivers and some of their tributaries excavated valleys through the ORG into bedrock prior to the formation of Lake Humber, leaving W-TG residuals only on higher parts of the Sherwood Sandstone and on older outwash at Tudworth.

This sketch scenario obviously needs further investigation, but it serves to show that a feasible alternative interpretation of the W-TG is available. The claim for a Late Devensian ice advance to Wroot rests only on the two stratigraphic criteria, here considered to be unreliable, pertaining to the W-TG at Tudworth. The claim must be evaluated against both a credible alternative and, as discussed above, the absence of any evidence for glaciation. This absence has, to date, been dismissed too lightly, and demonstration of an ice advance well to the south of the Escrick moraine should show unequivocally that it can be reasonably and comprehensively accounted for.

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THE 'AD 860' TEPHRA IN SCOTLAND: NEW DATA FROM LANGLANDS MOSS, EAST KILBRIDE, STRATHCLYDE

Pete Langdon and Keith Barber

Introduction

The Holocene tephra layers found in Scottish peats are from stratigraphically discrete horizons, not visible to the naked eye, and originate from volcanic sources in Iceland. Although at least seven Holocene tephras have been characterised from Scotland (Dugmore *et al.*, 1995; Table 1), there is evidence that more exist. Langdon and Barber (2001) have produced geochemical data for a historic tephra, dated by interpolation using a radiocarbon-dated age / depth model to AD 1080-1150, and for a new prehistoric tephra dated by interpolation to 420 BC. Holocene tephras have also been identified from Irish peats, notably Hekla-4 and the Lairg layers (Hall *et al.*, 1994; Pilcher *et al.*, 1995), although many more historic ash layers have been discovered in Ireland than in Scotland (e.g. Pilcher *et al.*, 1996). The presence or absence of these historic ash layers in Scotland is crucial to an understanding of patterns of tephra dispersal from individual eruptions, which often seems to have resulted in patchy fallout (Dugmore *et al.*, 1995). One of the tephras that has been located in Ireland but not yet characterised in Scottish peats is the 'AD 860' layer. This tephra was first identified geochemically by Pilcher *et al.* (1995) in Sluggan Bog, and has yet to be identified outside Ireland. An ash layer of this approximate age was discovered in a montane blanket bog, Moine Mhor, in the Cairngorms (Barber *et al.*, 1999), but because the shards were too few and too small geochemical analyses were not undertaken. Here we present new data suggesting that the 'AD 860' tephra was indeed deposited over Scotland.

Site and methods

As part of a wider study (Langdon, 1999) peat cores from twelve ombrotrophic mires in Scotland were examined for tephra content. Using the ashing technique of Pilcher and Hall (1992), distinct ash horizons were identified in seven sites, one of which, Langlands Moss, contained two tephra layers within the upper 100cm of peat. Langlands Moss is a nature reserve of the Scottish Wildlife Trust situated to the south of Glasgow near East Kilbride, only a mile or so from the NERC Radiocarbon Laboratory (Figure 1). The site is *c.* 25 hectares in size with a relatively large area of primary raised bog, which exhibits a marked domed appearance. The western half has been afforested, although the unafforested area still contains species typical of a raised bog.

The two ash layers identified at Langlands Moss both had low concentrations of tephra shards. The lower horizon (85-86cm: LAGT-2) contained concentrations

Table 1. Some of the mid to late-Holocene tephras which have been identified in northern Britain and Ireland and which have published geochemistries (see also Hall and Pilcher, 2002). Dates of tephras are as reported in original papers for historic tephras and wiggle matched dates (WMD). Tephras previously reported in ^{14}C ages have been calibrated using Calib 4.3 (*http://radiocarbon.pa.qub.ac.uk/calib/calib.html*) and the full 2 sigma range is presented.

Tephra	**Comments**	**Author**
Hekla AD 1510	Has currently been located in the Western Isles, Sutherland, and Northern Ireland. SiO_2 content between 64-57%.	Dugmore *et al.* (1995) Dugmore *et al.* (1996) Pilcher *et al.* (1996)
Loch Portain B tephra (AD 1510)	SiO_2 content > 70%. Some similarities in geochemistry to Oræfajökull 1362 AD. Scant occurrence so far leads to the non acceptance of a distinct isochrone	Dugmore *et al.* (1995)
Oræfajökull AD 1362	Characterised by high Na_2O and very low MgO (Larsen *et al.*, 1999). Located in Northern Ireland and reportedly found in Scotland (Pilcher *et al.*, 1996).	Pilcher *et al.* (1995)
Hekla 1 (AD 1104)	Found in small quantities in Irish peats. Characterised by FeO:MgO and K_2O:TiO_2 ratios (Larsen *et al.*, 1999).	Pilcher *et al.* (1995) Pilcher *et al.* (1996)
'AD 860 layer'	As yet unattributed to an Icelandic eruption. Forms two distinct geochemical populations on the basis of different CaO, MgO and K_2O proportions.	Pilcher *et al.* (1995) This paper
Glen Garry tephra (375-2 BC)	Found extensively in Scotland and also located in northern England, this tephra may be distinguished from other silicic tephras by K_2O, CaO, MgO, and FeO contents.	Dugmore *et al.* (1995) Pilcher and Hall (1996)

BGMT-3 tephra (*ca*. 390 BC[1])	Only current known locality is in the Isle of Skye. The geochemistry is highly silicic with alkali ratios (Na_2O:K_2O) close to one, compared with other silicic centres such as Hekla which have ratios around 1.5. Snæfellsjökull has been suggested as a possible source.	Langdon and Barber (2001)
Kebister tephra (2134-1775 BC)	Only found in Shetland, and appears to be absent from Orkney and the Scottish mainland. Differs from Glen Garry and older tephras on the basis of CaO/MgO ratios.	Dugmore *et al.* (1995)
Hekla-4 tephra (2310 ± 20 BC) WMD	By far the most studied tephra in Britain, it can be found in Scotland, Ireland, and northern England. A relatively large range of SiO_2 content has been found, ranging from 76%-59% in Scotland. The geochemistry can be clearly differentiated from most other tephras by differing ranges of variables, notably MgO/CaO ratios. Hekla-4 has been wiggle match dated to 2310 ± 20 BC (Pilcher *et al.*, 1995).	Dugmore (1989) Dugmore and Newton (1992) Dugmore *et al.* (1992) Hall *et al.* (1994) Hall *et al.* (1994) Pilcher *et al.* (1995) Pilcher *et al.* (1996) Pilcher and Hall (1996)
Hoy tephra (4535-4343 BC)	To date this has only been found on the Orkney Islands. It has a narrow range of SiO_2 and characteristically high alkali content.	Dugmore *et al.* (1995)
Lairg layers (A+B) (A: 4774-4677 BC) WMD (B: 4997-4902 BC) WMD	Stratigraphically distinct tephra zone composed of two distinct silicic populations of glass shards. All shards exhibit low FeO and TiO_2 and some similarities can be found with the Hekla-4 tephra. Additional dates for the two populations can be found in Pilcher *et al.* (1996).	Dugmore *et al.* (1995) Pilcher *et al.* (1996)

[1] Date interpolated from an age/depth model

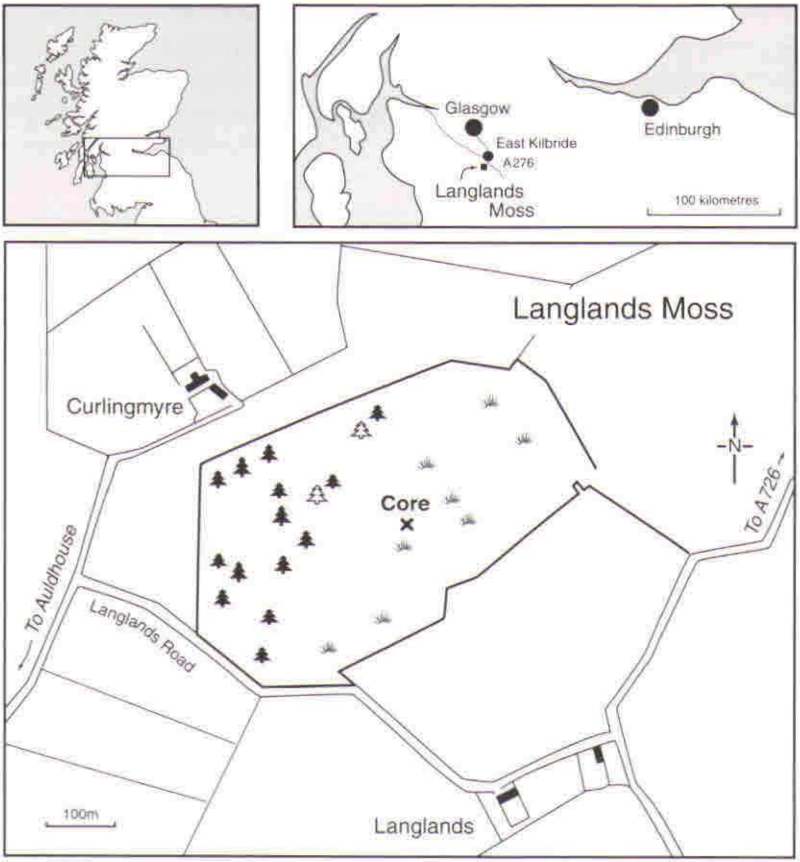

Figure 1. Map of Langlands Moss showing the coring position and the location of the moss with respect to Glasgow and Edinburgh.

of less than 200 shards/gram, whilst the upper layer (30-31cm: LAGT-1) had concentrations of less than 50 shards/gram. Identifying and geochemically typing discrete tephra layers is not always easy, especially when concentrations are low or the shards themselves are small. The shards from LAGT-1 were all small, on average less than 30 µm, which can make them unstable geochemically when subjected to analysis with an electron beam. Electron probe microanalysis (EPMA) was undertaken on the MK V Microscan at Edinburgh University and proved difficult with both ash horizons as only a few shards survived the preparation process and hence were available for fingerprinting by EPMA. Geochemical data were, however, obtained for both ash layers.

Results

Comparison with the geochemical data of LAGT-2 with Tephrabase (*http://www.geo.ed.ac.uk/TEPHRA/TBASEHOM.HTML*) suggested that the tephra belonged to the Glen Garry ash layer (Figure 2), whilst LAGT-1 clearly had a different geochemistry (Table 2). It is important to note that one of the shards from LAGT-1 (analysis no. 132) has very different values for MgO, CaO and K_2O, suggesting that two geochemical populations could be present within this ash horizon. The fact that this one analysis forms a separate geochemical population becomes significant when compared with other data. Pilcher *et al.* (1995) provide data which define an 'AD lower layer' at Sluggan Bog, containing a very similar geochemical signature to LAGT-1. More significantly, the data from Sluggan include two populations, which are outlined in Figure 2, and can be seen to enclose the data from LAGT-1. The layer from Sluggan was

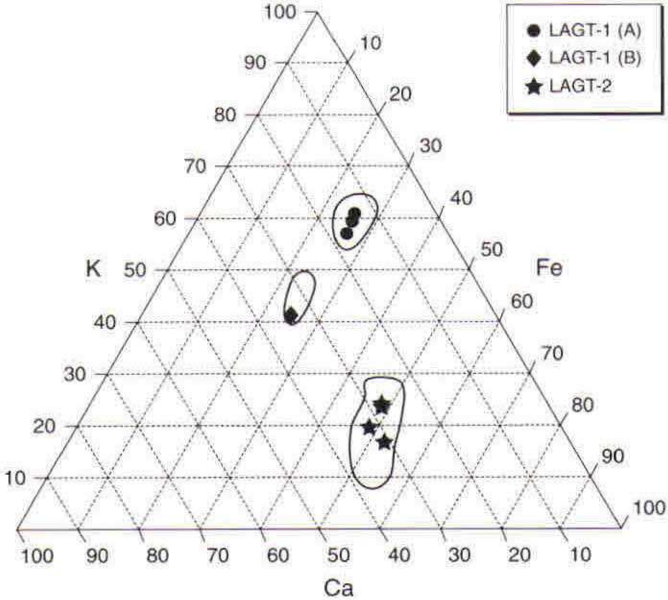

Figure 2. Ternary diagram showing the iron, calcium and potassium data from LAGT-1 and LAGT-2. LAGT-1 has two populations, A (circles) and B (diamond), which correlate with the data fields from the 'AD 860 layer' (Pilcher *et al.*, 1995). LAGT-2 (stars) are surrounded by the data field from the Glen Garry tephra as explained in the text.

Table 2. Langlands Moss LAGT-1: 'AD 860 Layer' around 30-31cm

Analysis No	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	Total
135	73.14	0.11	11.81	1.63	0.02	0.21	1.03	3.95	3.52	95.42
136	72.77	0.17	12.25	1.53	0.04	0.07	0.79	3.81	3.65	95.08
137	72.50	0.16	12.18	1.62	0.07	0.08	0.90	3.70	3.69	94.90
132	69.66	0.20	13.33	1.69	0.00	0.59	2.25	3.81	2.82	94.35

Total iron is expressed as FeO.

[1] Date interpolated from an age/depth model

wiggle-match dated to AD 860 ± 20 (Pilcher *et al.*, 1995) and this date has since been refined to AD 776-887 by reassessing the data in a more formal Bayesian approach using the Gibbs sampling option in Oxcal v2.0 (Pilcher *et al.*, 1996). The isochrone was designated as the 'AD 860 layer' and has not yet been attributed to an Icelandic eruption, or other source (Pilcher *et al.*, 1996).

The results from Langlands Moss have important implications for the analysis of tephra layers within British peats. The concentration of this historic tephra was very low and the tephra horizon could therefore be easily missed from other sites (it was not found in any of the other sites studied by Langdon, 1999). The shards themselves are very small (on average <30 μm) which can make EPMA problematic. Although it is difficult to be certain, due to the low number of analyses, that LAGT-1 is the 'AD 860' ash layer, it certainly represents an historic eruption that has not yet been documented from the Scottish peat archive.

Palaeoecological analyses were also undertaken on the Langlands Moss peats in order to develop a proxy-climate record (Langdon, 1999). The plant macrofossils show *Sphagnum imbricatum* to have been growing at the time of the LAGT-1 ashfall, subfossil testate amoebae show declining levels of *Difflugia pulex* and increasing levels in more hygrophilous taxa, whilst humification levels are low, indicative of a higher mire water table and a cooler / wetter climate at the time of the ash deposition. This probable occurrence of the 'AD 860' tephra at Langlands Moss and Moine Mhor lead us to suggest that it may be present at other sites in Scotland, and has possibly been missed in routine analyses due to low tephra concentration and small shard size. In order to correlate historic palaeoecological sequences more precisely, and to refine radiocarbon-based chronologies, it would be extremely useful if other occurrences of this tephra could be located.

Acknowledgements

NERC are acknowledged for their financial support, through the provision of a NERC studentship (GT4/96/274/E) to PGL; through the allocation of radiocarbon dates, and through the use of the Electron Microprobe facility at Edinburgh University. We thank Dr Pete Hill for assistance with the geochemical analyses. Professor Mike Walker and an anonymous referee are thanked for their helpful comments on an earlier version of the text.

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NUNATAKS AND THE SURFACE ALTITUDE OF THE LAST ICE SHEET IN SOUTHERN SNOWDONIA, WALES

P.D. Hughes

Introduction

It has long been suggested that the last ice sheet (*c.* 22 – 18,000 yrs BP) in Wales had its central axis southeast of the north Snowdonia mountains in the Arenig Region (Figure 1). Greenly (1919) noted that the Rhinog mountains were abraded by westward moving ice coming from the vicinity of the Arenigs. Moreover, Arenig erratics have been reported from the borderlands to the east (MacKintosh, 1873, 1874; Reade, 1885, 1897; Strahan, 1886; Kendall, 1892; Harrison, 1898). There is therefore clear evidence for an ice-shed in this region and it is still widely accepted (Rowlands, 1979; McCarroll and Ballantyne, 2000). However, there has been continued debate as to whether or not this ice sheet pushed through the north Snowdonia mountains (Whittow and Ball, 1970; Addison, 1978, 1983, 1990), or was diverted around an independent ice sheet in this area (Gemmell *et al.*, 1986; McCarroll and Ballantyne, 2000).

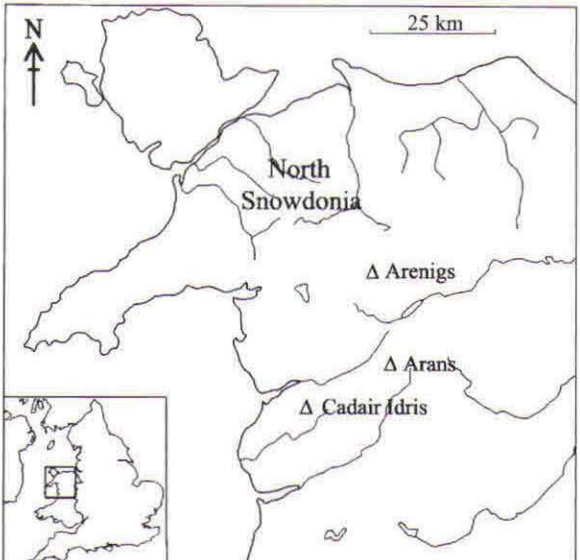

Figure 1. Location map showing the field areas in southern Snowdonia.

The work of McCarroll and Ballantyne (2000) would appear to close this debate since they have convincingly argued the case for an independent north Snowdonia ice sheet. They used periglacial trimline data and the presence of gibbsite, an end product of prolonged weathering (sub-aerial exposure since the pre-Devensian), at the base of soils to support the presence of nunataks above the last ice sheet in this area. Using this data, and evidence of flow directions close to the trimline, they were able to reconstruct the height of the last ice sheet and provide evidence of ice dispersal from an independent ice sheet.

In the study presented here, attention is paid to the evidence in southern Snowdonia and attempts are made to reconstruct the height of the last ice sheet in this area based on periglacial contrasts and evidence of nunataks. The work presents preliminary findings and discusses the implications for ice-sheet reconstruction in Wales.

Study area

Southern Snowdonia can be defined as the area to the southeast of Mount Snowdon in the southern part of the Snowdonia National Park (Figure 1). The region contains fewer and lower mountains than in the north and much of its area is an elevated tableland (>400m). The highest mountain peaks are composed of Ordovician volcanic rocks and the surrounding tablelands of Ordovician slates and shales.

The evidence

Evidence of periglacial-glacial contrasts and the presence of nunataks protruding above the south Snowdonia ice sheet is provided on the three highest mountains of the area: Aran Fawddwy (SH 863224), Arenig Fawr (SH 827369), and Cadair Idris (SH 712131).

The Arans

The south summit of Aran Fawddwy (905m) is capped by a small tor and the whole summit area displays evidence of frost shattering. The northern approaches of this peak also display clear boulder fields. Small tors are also evident to the south of Aran Benllyn and the whole ridge between this peak and Aran Fawddwy displays well-developed periglacial features, especially frost-shattered bedrock and blockfields. There is no evidence of glacial smoothing compared with the lower slopes where roche moutonnée and striated bedrock abound. The transition between glacial and periglacial terrain, based on field observations and aerial photographs lies between the 750 and 800m contour (Figure 2A).

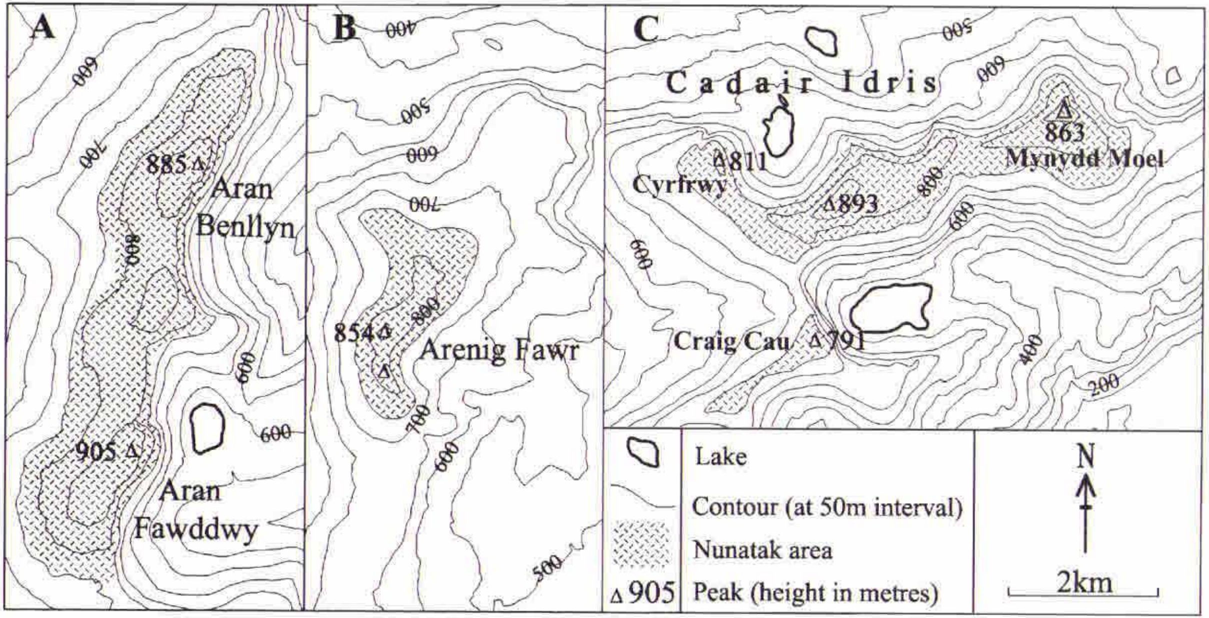

Figure 2. Maps showing the areas of the proposed nunataks.

Arenig Fawr

The summit ridge of Arenig Fawr (854m) displays classic frost-shattered features and in places small tors have developed, the most impressive of which occur on the southern peak. Blockfields are in evidence all around the main peak, especially on the eastern slopes, and also on the southern peak. The periglacial trimline roughly follows the 750m contour (Figure 2B).

Cadair Idris

The impressive summit tors and blockfields of Cadair Idris were noted by Watson (1960) and Ballantyne (2001). Tors are very well developed around the summit area especially to the south on the Pony Path approach. Blockfields are also well developed on the broad ridge between this peak and its eastern satellite Mynydd Moel (863m). The same is true to the west, towards Cyfrwy (811m). Evidence of ice-moulding exists on the col to the south of the Cadair Idris summit though the peak to the south, Craig Cau (791m) which, too, is intensely weathered with rocks displaying deep fractures and jointing. Overall, a periglacial trimline can be consistently traced roughly along the 750m contour (Figure 2C).

The age of the periglacial features

It is likely that the periglacial features are likely to have formed during the Last Glacial Maximum (*c.* 22 - 18,000 yrs BP). A Loch Lomond Stadial age (*c.* 11 - 10,000 yrs BP) for the summit periglacial features is unlikely since distinct weathering limits exist, implying summit exposure as nunataks above the last ice sheet. If the periglacial features had formed during the Loch Lomond Stadial then such weathering limits would not exist because glaciers were restricted to cirque heads (Hughes, 2002). This is not to say that periglacial weathering was not an active agent during the Loch Lomond Stadial, but that it was less active than during the Last Glacial Maximum. This is evidenced by the minor trimlines between smooth ice-moulded bedrock inside and frost-weathered rocks (though showing macro-scale evidence of past glacial action) outside of the former Loch Lomond Stadial glacier limits (Hughes, 2002).

It is possible that the periglacial features described here were covered by cold-based ice during the Last Glacial Maximum, therefore protecting them from erosive glacial action. This is especially likely on higher summits where thin ice would have resulted in low basal ice pressures. However, given that weathering limits are found at similar altitudes through south Snowdonia, it is likely that the features represent nunataks above a former ice sheet. Under cold-based ice there would be varying altitudes of the englacial thermal boundary depending on the land-surface position with respect to ice flow. As a result, one would expect local disparity in the altitude of preserved periglacial phenomena, especially between stoss and lee-side slopes. This is not the case in the areas studied here.

A further possibility is that the nunataks formed during the retreat of the Late Devensian icesheet. This is difficult to refute on the basis of the evidence presented here. However, given that there appears to be a good correlation with sites of intense mountain-top periglaciation and high soil gibbsite content in many parts of Britain (Ballantyne, 1997, 1999; Ballantyne and McCarroll, 1995, 1998; Ballantyne *et al.*, 1997, 1998; McCarroll and Ballantyne, 2000), it would seem reasonable to suggest that the sites in this study are indicative of a prolonged period of weathering and were ice free during the Late Devensian.

Discussion

It would appear that on the basis of periglacial contrasts the summits of the Arenig, Aran and Cadair Idris mountains stood above the last Devensian ice-sheet as nunataks. The altitude of the periglacial trimlines on these peaks suggests that the southern Snowdonia ice sheet did not reach over 750 - 800m above modern sea level compared to 850m for the north Snowdonia ice-sheet (McCarroll and Ballantyne, 2000). The slightly lower altitude of the southern Snowdonia ice-sheet is to be expected given the lower elevation of the mountains in this area. This difference has implications regarding the relative dominance of the two ice centres.

It is clear that the south Snowdonia ice sheet could not have breached the north Snowdonia mountains. Such a scenario would only have occurred had the ice centre in the Arenig region been higher than that in north Snowdonia. Instead, the two ice sheets would have coalesced, probably around the area of Blaenau Ffestiniog, forming ice streams that flowed westwards into Tremadoc Bay and north-east towards the Conwy valley. This is supported in field observations by Smith and George (1961) and Rowlands (1979).

The evidence presented here further supports the findings of Ballantyne and McCarroll (2000) and does not conform to ice-sheet models proposed by Lambeck (1993, 1995, 1996) which underestimate the altitude of ice in North Wales by 250 to 350m. The most suitable model, with regard to ice depth, appears to be that of Boulton *et al.* (1991) where ice-surface altitude was placed at 750m over both north and south Snowdonia. However this model, as well as that of Lambeck (1996), fails to incorporate radial flow from multiple Snowdonia ice sheets and therefore further adjustments are necessary. It may also be the case that independent ice sheets occurred on the mountains to the south of Snowdonia. This would have important implications with respect to the style and dynamics of glaciation in Wales during the Late Devensian.

In conclusion, periglacial evidence such as tors and blockfields, and the transition between these features and glaciated terrain in lower areas, is used to support the presence of nunataks above the Late Devensian ice sheet. This implies that the surface of the last ice sheet in southern Snowdonia was no higher than 750-800m. It is unlikely that the ice sheet in this area could have breached the mountains of north Snowdonia given that the icesheet there had a greater surface elevation. The evidence therefore supports a theory of multiple independent ice sheets over North Wales during the Late Devensian.

Acknowledgements

The author would like to thank Phil Gibbard for comments and discussion regarding this article.

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REPORTS

QUATERNARY RESEARCH ASSOCIATION NOMINATION OF HONORARY MEMBERS

University of Wales, Aberystwyth, 3rd April 2002

At the 38th Annual general Meeting of the Quaternary Research Association, the following were nominated as Honorary members of the QRA by the President, Professor Mike Walker.

Professor John Catt

John Catt has made a major contribution to British Quaternary science, principally through his work on glacial sediments, aeolian deposits and palaeosols. He also enjoys an international reputation in these fields and in soil science. He was born in Kent, and took his first degree in geology at the University of Hull, where he remained to work for his PhD on the tills of East Yorkshire under Lewis Penny. This was both ground-breaking (and back-breaking) research, for not only was John one of the first to apply a geological approach to the interpretation of British glacial deposits, but during the course of his field work he removed and carried across the cliffs some two tons of sediment from the Dimlington site in order to obtain sufficient organic material for radiocarbon dating! Dimlington proved to be a key find for it fixed the maximum of the Late Devensian glaciation in eastern England to around 20 ka BP. John's seminal paper with Lewis Penny in the *Proceedings of the Yorkshire Geological Society* (1966) remains a classic of its type. After leaving Hull, John worked for many years at the Rothamstead Experimental Station. It was there that he continued his research on tills and where he produced a series of key papers on aeolian sediments and palaeosols. Indeed he became the leading British figure in the field of palaeosol studies, and his 1986 book *Soils and Quaternary Geology* (Clarendon, Oxford) was one of the first texts specifically to integrate pedology in the interpretation of Quaternary sediment sequences. In 1988 after an initial appointment to a Visiting Professorship at Birkbeck College, London, he moved to a similar position at University College, London, where, although formally 'retired', he still teaches Quaternary science. Throughout his career, John has been a major figure on the international stage, has conducted fieldwork in many parts of the world, and has been particularly active in the Palaeopedology Commission of INQUA. His distinguished list of publications resulted in the award of a DSc from the University of Hull. He has been a life-time supporter of the QRA, and was an Executive Committee member from 1971-1975, Secretary from 1974-78, and Vice President from 1984-1987. It is also worth noting that the modern version of *Quaternary Newsletter* dates from John's time as Newsletter Editor (1974-78), a position which was then combined with that of QRA Secretary. It is a very great pleasure to be able to nominate him for Honorary Membership of the QRA.

Professor Chalmers Clapperton

Chalmers Clapperton is a Quaternary scientist of international distinction, and although trained as a glacial geomorphologist, his extensive list of publications includes numerous papers involving broader Quaternary issues. Chalmers was born in the Scottish Borders and studied for both his first degree and his PhD at the University of Edinburgh. The latter was on the 'Deglaciation of the East Cheviot Hills', under the supervision of Brian Sissons (he was, in fact, one of the earliest members of the Sissons research school). From Edinburgh, he moved to the University of Aberdeen where he remained throughout his career, eventually being appointed to a Personal Chair in 1992. Chalmers' contribution to Quaternary science has been considerable. In addition to his research in Scotland, he has conducted fieldwork in other areas of Europe, in the Americas and in Antarctica. He is perhaps best know for his work on South America, where his research into the glacial and environmental history of the Andes has been widely admired. There is no better barometer of his South American work than the seminal volume *Quaternary Geology and Geomorphology of South America* (Elsevier, Amsterdam, 1993), which stands as one of the most majestic compilations to be produced by a British Quaternary scientist in the last twenty years. The quality of Chalmers' international research has been reflected in his collaborations with numerous distinguished overseas scientists, and in his work with, *inter alia*, the International Geological Correlation Programme (IGCP). He has received numerous honours in his native land, being elected to a Fellowship of the Royal Society of Edinburgh in 1992, and being awarded the Royal Scottish Geographical Society's President's Medal in 1992, the Mungo Park Medal in 1997 and the Centenary Medal in 1999. His premature retirement after a serious illness in 1999 was followed by a Special Issue of *Journal of Quaternary Science* (2000, vol. 15, no 4), edited by his long-time friend and collaborator, David Sugden, the truly international nature of which is testament in itself to the esteem in which Chalmers Clapperton is held world-wide. Although never a QRA office-holder, Chalmers has been an active supporter of the Association, and has enlivened many a Field and Discussion Meeting with his warmth, good humour and stimulating contributions. In every way, he has earned the distinction of Honorary Membership of the QRA and it is a pleasure to be able to nominate him.

Professor Bill Watts

For many years now, Bill Watts has been at the forefront of research on Late Quaternary palaeoecology and, despite having formally retired, he continues to be a leading international figure in this field. He was born in Dublin and attended Trinity College where he obtained a First Class Honours Degree in Natural Sciences. His first academic appointment was as Assistant Lecturer in Botany at the University College, Hull (now the University of Hull), but in 1955 he returned to Trinity College, Dublin to take up a lectureship in Botany, and has remained there ever since, becoming, respectively, a Fellow of the College (1960), University Professor of Botany (1960), and Professor of Quaternary Ecology (1980: a Personal Chair). He was awarded a DSc in 1973, and from 1981 to 1991 was Provost of the College (a position equivalent to a Vice-Chancellor in Britain). He is an acknowledged authority on the Irish Quaternary, but he is also well known for his work on the Late Quaternary history of the eastern seaboard of the USA, conducted in association with leading North American scientists, and on the Late Quaternary of southern Italy, research that has been carried out with collaborators from the UK and from Europe. Bill's long list of publications also includes the results of work on Bermuda, in Mexico, and in the central USA. He has held a number of visiting positions in overseas universities, including the posts of Visiting Fellow and Adjunct Professor of Geology at the University of Minnesota, Distinguished Visiting Professor at the University of Washington, Field Associate of the Florida State Museum and Visiting Professor at the University of Cracow. Among his many honours are an Honorary Doctorate of Laws from Queens' University Belfast, an Honorary Doctorate of Science from the National University of Ireland, Membership of the Royal Irish Academy (he has, in addition, been President of the RIA on two occasions), Honorary Life Membership of INQUA and Honorary Membership of IQUA, the Irish Quaternary Association. He has a wide range of other interests, has held Chairmanships of a number of Health and Hospital Boards, and been Governor of the National Gallery, a Council Member of the Dublin Institute for Advanced Studies and Chairman of the National Trust for Ireland. He has also been an active member of the QRA, has spoken at numerous Discussion Meetings, and was Vice President of the Association from 1990-1993. He is eminently worthy of Honorary Membership of the QRA and I am delighted to be able to propose him.

Acknowledgements

I am grateful to numerous colleagues who have provided biographical information on these three distinguished Honorary Members

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THE SECOND MEETING OF IGCP PROJECT 449 "GLOBAL CORRELATION OF LATE CENOZOIC FLUVIAL SEQUENCES"

Kanpur, India: 20th to 22nd December 2001

Following the successful inaugural meeting in Prague in April 2001, the second International Meeting of IGCP Project 449 was hosted in December 2001 at the Indian Institute of Technology, Kanpur (IITK): organised by **Sampat Tandon** (University of Delhi, India; one of the co-leaders of IGCP Project 449) and **Rajiv Sinha** of IITK. About 30 delegates attended, representing 8 countries.

The conference was opened with a warm and traditional Indian welcome from Professors **S.G. Dhande** and **D. Kunzru**, the Director and Dean of IITK. The programme included oral and poster sessions, two business meetings to plan the future of IGCP Project 449, and a field excursion to examine Late Pleistocene and Holocene sediments of the Yamuna and Ganga (Ganges) rivers. Associated social events provided excellent opportunities to sample a wide range of superb Indian food, much of which is unavailable at Indian restaurants in Britain.

The technical sessions on 20th and 21st December concentrated on fluvial records from India, with international participants also describing sequences in Europe, the eastern Mediterranean region, and Australia. In addition, three talks covered research techniques. **A.K. Singhvi** (Physical Research Laboratory, Ahmedabad, Gujarat, India), **M. Jain** (Riso National Laboratory, Denmark), and **P. Srivastava** (IIT Roorkee, India) discussed techniques for luminescence dating. **Satish Sangode, Rohtash Kumar**, and **Sumit Ghosh** (Wadia Institute of Himalayan Geology, India) explained the development of improved magnetostratigraphic techniques for dating the Siwalik Group (Mio-Pliocene fluvial sediments from Himalayan rivers, uplifted by folding and reverse faulting along the southern front of the Himalaya). **Rob Westaway** (Open University, England) explained that the well-documented similarity and regularity of European river terrace sequences may result not directly from Milankovitch forcing but from Heinrich events. If correct, this explanation allows these terraces to be accurately dated, as they will correlate with geomagnetic excursions, because the Heinrich events involve rapid fluctuations in global ice volume that affect the Earth's rotation and so can destabilise its magnetic field.

The two business meetings discussed the 2001 progress report for IGCP 449, which **David Bridgland** (University of Newcastle and co-leader of IGCP 449) had submitted in November 2001. Provisional timings and venues for future IGCP 449 meetings were also discussed. It was decided to proceed with a plan to establish a web-based fluvial archive database, centred on illustrative material (summary diagrams) but supported by keywords so that it can be searched. This to be put on the IGCP 449 website in a piecemeal way to start with. In addition, Rajiv Sinha will lead a group – based in India – to establish a pilot database based initially on a single Indian river. This will determine the feasibility of this objective and will also aim to establish an appropriate standard data format for fluvial archives, which may enable the original aim of a global database to be resurrected at a future date.

The highlights of the presentations on long-term river terrace sequences were the talks by **Andrey Tchepalyga** (Russian Academy of Sciences) and **Andriy Ivchenko** (Ukrainian Academy of Sciences) on fluvial sequences from the Black Sea region, including the rivers Dniester and Bug. The record from the Dniester in Ukraine and Moldova is particularly impressive. This terrace staircase has 11 designated terraces, but recent work has increased the total of distinctly identifiable levels to 20. Terrace VI at up to +65 m contains the Matuyama-Brunhes boundary; the oldest terrace (XI) at +150 m contains a Ruscinian (Early Pliocene) mammal fauna. The Proceedings volumes from the Prague and Kanpur meetings of IGCP 449 will describe this work in more detail, and it is intended that summaries will also shortly be posted on the developing IGCP 449 website.

A poster by David Bridgland and **Darrel Maddy** (University of Newcastle) summarised their work to date on global correlation of fluvial archives. A second poster, by David Bridgland and **Danielle Schreve** (Royal Holloway) discussed evidence from fluvial deposits in south-east England that allows individual Middle and Late Pleistocene interglacials to be distinguished using mammal biostratigraphic evidence. **Tuncer Demir** (Harran University, Turkey) and Rob Westaway reported evidence from fluvial sequences for ~400 m of regional uplift of western Turkey since the Early Pliocene, of which ~200 m has occurred since ~1.2 Ma. In contrast, **Bob Wasson** (Australian National University) described the evolution of river systems in Australia since ~0.3 Ma. Although many rivers in this continent have not produced terrace staircases, palaeo-environments indicating alternations between moist and arid conditions are well-preserved in lake sediments.

Contributions on long-term fluvial sequences in India included two talks by Satish Sangode, Rohtash Kumar, and Sumit Ghosh on the Siwalik Group. The rhythmic alternations in grain size within these Mio-Pliocene sediments presumably reflect Milankovitch forcing, and their systematic upward coarsening presumably reflects long-term climate change. These talks discussed regional correlations, and changes to sediment provenance due to adjustment of river courses caused by changes in the geometry of reverse faulting along the front of the Himalaya. The detailed records now available raise the imminent possibility that the Siwalik Group will be the first Mio-Pliocene terrestrial sedimentary sequence to be correlated with the Milankovitch orbital-forcing chronology, as has already been done for some marine sequences. This will be a major achievement.

The final contribution on this topic, by **Sheila Mishra, S.N. Rajaguru, Sonali Naik, Sushama Deo,** and **Savita Ghate** (Deccan College, India) concerned the Neogene fluvial sequences of central India, deposited by rivers draining the Deccan region that in the latest Cretaceous experienced very large-scale basaltic volcanism associated with the break-up of the former Gondwana continent. Rivers in this region have incised up to ~1 km into this basalt, but this incision was evidently completed in the Early Tertiary. This can be deduced because, in some localities, fluvial gravel that is underlain by as much as ~7 m thickness of weathered basalt (and which may well thus be tens of millions of years old) crops out at the same level – just above modern river level – as Middle Pleistocene gravel yielding flint artefacts. There are thus no river terrace staircases in this region, like previously reported in Australia but unlike any of the localities described in Europe and the eastern Mediterranean region. This observation stimulated considerable discussion concerning possible explanations for these characteristic differences in geomorphic evolution in terms of the structure of the underlying crust. This suggestion of a link between crustal structure and geomorphic evolution was an exciting – and unexpected – outcome of this meeting.

The remaining talks and posters concerned river evolution on time scales ranging from the Holocene (some including the latest Pleistocene) to the past century, with examples spanning much of northern India including the western states of Rajasthan and Gujarat. These talks provided abundant evidence of very detailed, high-quality fieldwork. However, their time scale falls outside the intended scope of IGCP 449. A justification for including this material is that knowledge of the complexity of modern river systems in India may be necessary for understanding older fluvial sedimentary sequences such as the Siwaliks. However, the main conclusion to emerge from this series of talks was that every river system in India has a different story, presumably because each is located in a region with a different climate history. Of particular topical significance was the talk by **D.M. Maurya, L.S. Chamyal** (University of Baroda, India), and **M.G. Thakkar** (Lalan College, India) on river evolution in the Kachchh (Kutch) region of western Gujarat: on the Arabian Sea coast near the border with Pakistan, the epicentral area of the destructive Gujarat earthquake of 26 January 2001. The authors documented effects on river evolution in this region both of older large earthquakes and of regional uplift. Several apparent active normal faults were indeed described: in some localities, latest Pleistocene river terraces appear to be warped where rivers flow across these faults. However, their slip rates appear to be very low, in the range ~0.01-0.1 mm a^{-1}, suggesting that large earthquakes like in 2001 have long recurrence times on any individual fault.

The field excursion on 22nd December visited two localities: Kalpi on the river Yamuna, ~90 km SW of Kanpur, and Bithoor on the Ganga, ~20 km NW of Kanpur. The Yamuna and Ganga both rise in the Himalaya north of Delhi: they initially flow southward, then eastward across the plains of the Gangetic foredeep to the Bay of Bengal. At the time of our visit, both rivers were ~200 m wide and up to ~8 m deep: the current was ~2 m s^{-1} at the surface of the Ganga, less on the Yamuna. These dimensions indicate the scale of these rivers at localities ~1500 km from the coast in the middle of the *dry* season.

The ~20 m thick section exposed along the right bank of the Yamuna at Kalpi consists mostly of silt and fine sand, interpreted as a succession of overbank flood deposits. About ~5 m above the river level at the time of the visit is a calcreted gravel, up to ~1 m thick, formed of reworked clasts of older calcrete. This has yielded flint artefacts and is dated at ~30 ka. Although disrupted by gulley erosion, in the uppermost ~8 m of the section remains of many buildings are evident, indicating that the sediments at this level date from historical time. In the Middle East, such a deposit would thus be designated as a "tell". Along the right bank of the Ganga at Bithoor, the ~15 m thick section is interpreted as equivalent to the upper part of the section at Kalpi. Here, too, the uppermost ~8 m or so of the section exposes historical remains, presumably reflecting the long history of habitation of these riverside localities.

At both field localities the young fluvial sediments of the Gangetic foredeep are ~1 km or more thick. This region is regarded as a foreland basin, where sediment loading is depressing the underlying crust, creating the accommodation space for future sediment. The recent alternations of deposition and erosion evident at both localities are thus presumably "ripples" on the longer-term trend of overall subsidence, which has presumably led to the systematic burial of older channel systems over many millions of years. The scale of these channel systems would readily enable them to be identified at depth by seismic reflection profiling. Subsequent drilling thus offers the possibility of recovering superb long-term fluvial records. However, these types of study appear to have not yet been undertaken in this region.

Access difficulties meant that to view the section at Bithoor, participants were transported on the Ganga by rowing boat. This boat trip, in the soft light of the late afternoon to the sound of parakeets and music from riverside Hindu temples, was a memorable experience that provided a fitting end to an extremely interesting and informative meeting.

Rob Westaway
Tuncir Demir

QRA ANNUAL DISCUSSION MEETING 'CONSTRUCTING QUATERNARY CHRONOLOGIES'

University of Oxford, 3rd-5th January 2002

The QRA Annual Discussion Meeting 2002 was held at St. Anne's College, University of Oxford, from 3rd to 5th January 2002. It was organized and chaired by **Robert Hedges**, **Chris Ramsey** and **Eddie Rhodes** of the Research Laboratory for Archaeology, University of Oxford, and attended by around 140 delegates. Some 24 oral and 21 poster presentations were given over the two and a half days of the meeting. Visits were also organized to the AMS and Luminescence Dating laboratories in Keble Road on the afternoon of the 4th and these were followed by the conference dinner, in the dining hall of St Anne's College, later that evening.

Thursday 3rd January

Robert Hedges welcomed participants to Oxford and chaired the first of two sessions on the 'current state-of-the-art chronological methods'. The presentations provided an up-to-the minute overview of absolute dating methods.

Professor Mike Summerfield (University of Edinburgh) gave the first paper, on *Cosmogenic isotope exposure dating: potential and limitations.* He summarized the theory behind the technique before pointing out the most commonly used isotopes and their relative merits in exposure dating. He showed that, in many instances, multiple isotopic determinations are a pre-requisite for reliable age determinations and that commonly, the best use of cosmogenic isotope dating is to provide an orders of magnitude estimate for erosion rates in geomorphically simple areas. He then demonstrated some successful applications of the technique, most notably using ^{3}He and ^{26}Al in southern Africa and also mentioned that cosmogenic dating may be available from East Kilbride by the summer of 2002.

Geoff Duller (University of Wales, Aberystwyth) presented the results of new work using *Optically stimulated luminescence dating*. Recent advances in understanding the physics of the OSL process and technical innovations, including the use of blue light emitting diodes to produce single aliquot measurements, were enthusiastically explained. He stressed the benefits of OSL over thermoluminescence (TL) and showed how the single aliquot method could be used as a finely tuned dating tool with an age range of ~100 – 100ka. In exceptional circumstances, the limit of age determinations can now be taken back as far as 800 ka. **Chris Turney** (Queen's University, Belfast) flew the flag for *tephrochronology*. Over the last few years he has identified ash layers in several new British localities. Consequently there is even greater potential for using tephra layers and, in particular microtephra, to correlate various stratigraphic records with a high degree of precision.

After lunch, **Chris Ramsey** (University of Oxford) summarized *Current developments in ^{14}C dating*. His talk focused on research being carried out at the Oxford Radiocarbon Research Laboratory and highlighted the improvements in instrumentation, which now allow AMS dating of single (sub-microgram) samples, such as fragments of insects and pollen grains. The presentation by **Robert Hedges** (University of Oxford) on *Chemical specificity in radiocarbon dating* focused on difficulties in dating samples containing isotopically dissimilar carbon from multiple sources. He described a technique for isolating molecularly purified 'compound specific' lipids, which combats these multi-source problems. Its application to the dating of cooking-derived lipids from archaeological potsherds was shown. He also discussed advances in assigning chemical specifity for proteins, chitin and cellulose. **Alistair Pike's** (University of Oxford) talk on *Direct dating of bone by U-series: problems and solutions* covered the difficulties in determining the level of Uranium uptake by bone, when simplistic models are used. These models often take insufficient account of the chemical interaction between bone and U, or the complex geochemistry of the burial environment. These may result in errors of >50% in the age estimates obtained. He explained how such problems could be overcome by using a diffusion/adsorption model and by comparing the model with measured profiles of U uptake across sections of bone.

Martin Bates (University of Wales, Lampeter) *British Quaternary amino-stratigraphy at the start of the 21st century: a user's view* presented a review of the difficulties that he encountered in applying the current amino-stratigraphic framework to the correlation of sites on the Sussex coastal plain. This was followed by **Danny McCarroll** (University of Wales, Swansea), who gave an absorbing lecture on the problems of using *Amino acid geochronology in the British Pleistocene.* Danny made a cogent argument for the publication of full data sets for amino-acid ratios for shells from important (type) sites, to be included with interpretations of their ages and their chronostratigraphic significance. **Matthew Collins** (University of Newcastle) presented the last paper before the mid afternoon tea break. Entitled *Improving AAR,* it focused on improvements in amino acid measurements that can be made by concentrating on racemization of intracrystalline proteins, which reduces possible contamination from sediments surrounding the fossil being dated. The measurement of ratios from multiple rather than single amino acids was also seen to provide the ability to 'tie down' amino-acid dates more rigorously.

Immediately after the tea interval, authors of posters were encouraged to each make a two-minute presentation in the lecture theatre, providing a lead-in to their exhibits. Most of the 20 or so authors availed themselves of this opportunity and an informative (and often amusing) 40 minutes ensued. This was followed by the first of two scheduled viewing sessions for the posters, housed in a lecture room adjacent to the main conference venue. This concluded the formal part of the opening day. An informal drinks reception was held at the University Museum, some 5-10 minutes walk from St Anne's College. This was attended by the majority of the conference delegates and friendly and informed banter continued for several hours amongst the impressive Earth Science exhibits.

Friday 4th January

The first session of the second day was devoted to 'Deep time measurement'. In the first talk of the day, **Gideon Henderson** (University of Oxford) returned to the theme of Uranium series dating in a presentation entitled New U-series chronologies for marine and lacustrine climate change. This presentation showed that not only corals, but also aragonitic carbonate muds are amenable to U-Th dating. Isochrons plotted from dating these sediments suggest that Termination II occurred at 135 ka. Calcareous and organic units within lacustrine sequences, notably in lakes from the Dry Valleys of Antarctica have also been dated by U-Th and indicate that ^{14}C reservoir ages can be as high as 18ka in this particular environment.

Unfortunately Professor Nick Shackleton (University of Cambridge) was unable to give his talk on *Stratigraphy and chronology of the last glacial cycle in marine sediments.* His place in the programme was taken by **David Richards** (University of Bristol), who presented a paper on *The use of radiocarbon dating for sediments deposited prior to the last deglaciation*. Small-scale fluctuations in the amount of atmospheric ^{14}C, recorded in speleothems over the last 100ka, are in tune with climatic oscillations and may be the result of deep-ocean ventilation change. In particular, AMS ^{14}C data from stalagmite GB-89-24-1, from the Bahamas, indicates that millennial scale fluctuations in "^{14}C coincide with abrupt shifts in climate indicated in the "^{18}O record form Greenland ice cores. **Professor John Shaw** (University of Liverpool) showed in a highly entertaining presentation, how *Magnetic dating* could be used to ascertain the age of early hominid remains found in China and southern Africa. And how you should never ignore a call for scientific help no matter how crazy it might at first seem!

The second session was on 'Dating at high resolution'. **Gerry McCormac** (Queen's University, Belfast) used the ^{14}C record in tree rings to examine *Temporal variation in the Southern Hemisphere ^{14}C* offset over the last 1000 years. In a very interesting talk he showed how the offset between North and South varies with time from ~10 to 80 years and that the periodicity of these changes shifted markedly around 1400 AD. A driving mechanism is still elusive, although solar forcing and changes in the themohaline circulation are most likely. **James Scourse** (University of Wales, Bangor) examined the use of *Radiocarbon dating in the marine environment*, looking particularly at the significance of benthic boundary-layer processes. He demonstrated that reservoir ages in North Atlantic marine sediments vary in response to ocean currents around Iceland and Greenland. For example, during abrupt oceanographic disturbances – such as Heinrich Events – ^{14}C reservoir ages may be up to 2000 years too old. **Maarten Blaauw** (University of Amsterdam) discussed the advantages and limitations of *^{14}C wiggle-match dating*. This shows how a weakly dated sedimentary sequence can be fitted to the ^{14}C calibration curve to produce a much tighter chronology. However, the method, like all statistical approaches, is not without its limitations.

After lunch, **Professor Claus Hammer** presented the ***John Wiley Lecture*** on *Ice core dating: precision, time range and potentiality.* During a highly stimulating talk, Claus commented on various aspects of ice core dating, drawing on evidence from both hemispheres. Limitations centered on dating techniques. Currently ^{18}O isotopes, nitrate concentrations and dust concentrations are all used to date ice cores, making comparison between cores difficult. However, known marker horizons such as the massive volcanic event at 17 350 BP can be used to tie any two chronologies together. Consequently, dating precision is extremely high – with a precision of +/- 1 year over the last 10 000 years. According to the NGRIP ice core from Greenland the Younger Dryas ended 11 505 BP (AD 1950) and lasted exactly 1 194 years!

The keynote address was followed by a second opportunity to view the poster displays and by visits to the AMS and Luminescence Dating Laboratories in Keble Road. The visits provided a fascinating insight into the workings of both labs. Parties of 10-12 were able to gaze in awe at the brand new AMS machinery and peer through the gloom, to view the automated measurement of OSL signals from single quartz grains in Eddie Rhodes' Optical Dating Lab. The conference dinner, in St Anne's College, later that evening, was attended by some 30 or so delegates who enthusiastically endorsed the vote of thanks to the conference organizers, given by the QRA president **Professor Mike Walker.**

Saturday 5th January

The theme of the first session of the third day was 'Correlation and linkages'. **David Bridgland** (University of Durham) presented a wide-ranging talk on River terrace sequences as frameworks for Quaternary terrestrial chronologies. This showed how fluvial lithostratigraphic frameworks could provide important chronological constraints when examining Pleistocene climatic change, as well as faunal and human evolution. It also showed how submerged fluvial sequences also have considerable potential for correlation between the onshore and continental shelf successions. **Danielle Schreve** (Royal Holloway, University of London) presented a new mammalian biostratigraphical framework for the Middle and Late Pleistocene in her talk Mammal-based chronologies: a key to correlation in the Pleistocene. In the light of her results, the age of type-sites such as Boxgrove and Hoxne may need to be re-evaluated.

Adrian Lister (University College London) presented a paper which he co-authored with **Anthony Stuart** on *Reconstructing the chronology of Late Quaternary megafaunal extinctions.* They showed that extinctions of megafauna in Europe were staggered and geographically variable, with 'last stands' occurring in very different regions. For instance, woolly mammoth (*Mammuthus primigenius*) is found in northern Europe until c. 12 ka and in mainland Siberia until 10 ka. A population of mammoths is now known to have survived until 4 000 BP on Wrangel Island in the Arctic Ocean! **Professor John Lowe** (Royal Holloway, London) gave a presentation on *Improving the chronology and correlation of events during the Last Termination.* This focused on recommendations made by the IMTIMATE group of the INQUA Palaeoclimate Commission for improved procedures for development of a ^{14}C-based timescale for four British sites (Gransmoor, Llanilid, St Bees and Sluggan), which span most of the Last Termination. **Wim Hoek** (Universiteit Utrecht) compared *Ice-core and terrestrial records using oxygen isotopes as a common proxy.* He showed how sediments from periglacial features in the Netherlands could be used to construct a paleaoclimatic record of the last 15ka. **Bill Austin** (University of St.Andrews) explained how tephrochronology could be used to determine the timing and pattern of ocean-atmosphere change during the Late Glacial. Using the *^{14}C age of North Atlantic Ash Zone I* as a stratigraphic marker, various marine sediments were correlated. During the Younger Dryas the marine ^{14}C reservoir age is now known to have been almost twice its modern-day value (~700 cf. 400 yrs).

The final session was on 'Quaternary dating applications'. In the first presentation, **John Hunt** (University of Gloucestershire) elegantly described *Ten tephra isochrons from the NE Atlantic seaboard: Irish evidence for new Holocene eruptions.* This resulted from detailed geochemical analysis of ten identifiable cryptotephra 'layers' within a core through lacustrine sediments from An Loch Mór, Aran Islands, western Ireland. The final formal presentation of the meeting, by **Stephen Stokes** (University of Oxford) *Absolute chronologies for Quaternary sediments via luminescence dating strategies: A review of key developments and applications in applied luminescence research,* returned to the theme of luminescence dating, showing how the newly developed techniques could be applied to sediments from a variety of depositional settings (aeolian, fluvial, glaciofluvial and marine). He described an innovative method for testing the completeness of grain bleaching in subaqueous settings that has only become available with the ability to measure single aliquots.

The meeting was wrapped up with an open forum to discuss issues in Quaternary Chronology chaired by Eddie Rhodes. Several issues were raised, including the need to take a more integrated approach to constructing chronologies for Quaternary applications, with the application of multiple dating techniques and the provision of accessible, well-dated event stratigraphies.

Throughout the meeting and 'after hours' there was lively scientific debate and a good deal of constructive chat across all the disciplines. The conference was well attended by a diverse cross-section of the 'Quaternary dating community'. This was reflected in the oral and poster presentations. Over 20 original research posters were presented at the meeting covering the whole dating spectrum, from the very recent (Lichenometric dating in Iceland; Tom Bradwell) to the considerably older (Uranium-series dating of calcretes; Ian Candy). The presentations well represented the international flavour of the conference, with data collected from 6 continents and presented by scientists from several countries.

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QRA ANNUAL FIELD MEETING - WEST WALES

University of Aberystwyth 2nd – 5th April, 2002

Tuesday 2nd April

After welcoming the QRA members to west Wales **Mike Walker** (Lampeter), **Danny McCarroll** (Swansea) and **Mike Hambrey** (Aberystwyth) introduced the sites to be visited, and summarised their interpretations. Digestion of the evening's talk was aided by the thoughtful provision of wine and a selection of Welsh cheeses.

Wednesday 3rd April

Abermawr

A party of fifteen split off from the main group and travelled to Abermawr to view 'some mud' and speculate over its glacio-terrestrial / glacio-marine origins. Kenneth Rijsdijk (Utrecht) provided a brief context of the site and a summary of the stratigraphy, pointing out features such as macropores in the gravels and suggesting that the sequence was unlikely to have been deposited under submarine conditions. Debate focused on the fracturing and clastic dykes seen in the blue-grey Irish Sea till. Jane Hart (Southampton) questioned whether the fractures were indeed related to thrusting, and Emrys Phillips (BGS Edinburgh) pointed out that thrusting involves compressional forces. To create a hole, extensional forces would be needed, leaving lags that could be infilled with sand. The brittle deformation visible in the Irish Sea till was taken as further evidence that the sediments were laid down under glacioterrestrial conditions.

Carningli

Meanwhile the remainder of the party group viewed the tors and blockfield at Carningli, juxtaposed with the spectacular meltwater channels of the Gwaun Valley. **Danny McCarroll** initiated the debate on the relative and absolute ages of the landforms, and the potential offered by cosmogenic dating. He outlined the problem of blockfield created under periglacial conditions next to large, possibly subglacial meltwater channels. He proposed three hypotheses; i) cold-based ice on the tors and warm-based ice above the meltwater channels; ii) the Gwaun meltwater system owing its formation to a glaciation older than the Late Devensian with the Late Devensian ice limit close by; and iii) the area of the tors has never been glaciated and perhaps the meltwater channels were produced during the drainage of ice-dammed lakes to the north. This provoked a wide-ranging debate taken on initially by **Brian John** (Greencroft Books, Newport) who discussed the evidence for active ice in the area during the Devensian and agreed with the hypothesis that the large meltwater systems of the Gwaun are of some antiquity. **Mike Hambrey** compared the channels to those in the Cardigan area, which have a multiple history.

Banc-y-Warren

Mick McGee, the quarry manager, talked about the work undertaken at the site before **Geraint Owen** (Swansea), **Mike Hambrey** and **Danny Lear** (South Woodford, London) related a short history of Banc-y-Warren and the surrounding area, finishing with the recent work undertaken by the BGS and the University of Swansea in the nearby Aberteifi Valley. This work revealed the extent of glacio-lacustrine and sand and gravel deposits in the region.

Traeth y Mwnt

Kenneth Rijsdijk introduced this site and identified 4 main units: a basal grey diamicton, intercalated gravels, sandy diamicton and sub-horizontal diamicton and loess. He described the structures, which included faults, tear drop gravel structures, till rafts and a large-scale recumbent fold. He attributed the structures to soft sediment deformation under high pore-water pressure, although he also put forward an alternative hypothesis of deposition and deformation under glaciomarine conditions. **Mike Hambrey** proposed a third mechanism of glacioaquatic deposition, either in a lake or under marine conditions. Further debates continued in small groups and models of deposition and deformation were drawn on the beach sand to illustrate the points being made.

Thursday 4th April

Morfa Bychan

Charles Harris (Cardiff) discussed the visible cliff stratigraphy by detailing the SEM work on grain surface textures and micromorphology. The occurrence of silt cappings was suggested as indicating a cold, but non-glacial depositional environment. The overlying blue unit was characterised by more rounded and striated clasts, and occasional surface wash facies, whilst the micromorphology revealed oriented clays with evidence for rotation of grains and shearing processes. It was proposed that the unit had accumulated rapidly as a paraglacial deposit in an unstable environment, causing it to slump down onto the foreshore and bury the fossil cliff. The upper brown head unit was characterised by a more open texture and angular clasts produced by frost shattering under periglacial conditions then moved in by solifluction processes. Cryoturbation had further affected the upper parts of this unit. Many of the members were interested to find out how the micromorphology and surface texture SEM investigations had added to and strengthened the field evidence.

Llanon

Charles Harris once more introduced us to the sediments, which consisted of a cryoturbated basal till overlain by fan gravels and loess. The cryoturbation structures included several large sag structures at the contact between the till and the overlying gravels, with evidence of frost sorting. He speculated as to whether these structures would have a surface expression of patterned ground in a horizontal plane. The climatic and seasonal regime under which these structures formed was then debated, including postulated thicknesses for the active layer and the impact of permafrost decay.

Cledlyn Valley

Charles Harris reviewed the research history of the ground ice landforms in this valley before describing the results of a geophysical survey on one of the pingos. **Stewart Campbell** (Countryside Council for Wales) described the work in progress by the Council to identify the conservation status of pingos. **Mike Walker** concluded by discussing the possible age of the landforms, with the lack of Lateglacial Interstadial sediments within the pingo basins implying a Younger Dryas age. However, he reminded us that absence of evidence is not evidence of absence.

Tregaron Bog

Here **Keith Barber** (Southampton) gave us a detailed description of the research history of this site including the work of Sir Harry Godwin and others in the 1930's and the paradigm of the cyclic regeneration of bogs. **Paul Hughes** (Southampton) discussed the early initiation of the bog as a lake impounded by a moraine across the Teifi Valley, followed by the development of reed swamp and a change to acid peat at 7300 ^{14}C years BP. The bog then records drier conditions with the presence of charcoal and species such as cotton grass. After 4500 ^{14}C years BP Tregaron was a true Atlantic raised bog dominated by *Sphagnum imbricatum*. **Jenny Schulz** (Southampton) went on to complete the record by detailing the last 2000 years of vegetation changes such as the disappearance of *Sphagnum imbricatum* in Medieval times. She provided an insight into the application of recent bog stratigraphy to facilitate the conservation and management of these important sites.

Teifi Pools / Bryniau Pica

Mike Walker introduced the site of Bryniau Pica and discussed its relative proximity to the remains of the Cistercian Abbey at Strata Florida. **Shaun Buckley** (Reading) went on to give us more detailed information on this water shedding blanket mire, and his multiproxy reconstruction using plant macrofossils, pollen, fungal spores, charcoal, humification and tephra. He provided dates for the initiation of hazel (9135 ^{14}C years BP), the first indications of anthropogenic activity detected by the expansion of *Calluna vulgaris* (6135 ^{14}C years BP) and clearance events (3100 and 2000 ^{14}C years BP). One interesting find was a single tephra horizon at 5800 ^{14}C years BP, although geochemical fingerprinting to determine its origin was not successful. This provoked a debate on the possible source of the tephra and the evidence for human activity in terms of charred heather macrofossils.

Friday 5th April

Borth Bog

An attempt to view the submerged forest just offshore at Ynyslas was abandoned due to unfavourable tidal conditions. **Paul Hughes** introduced the Borth Bog site and described its development from marine/brackish clays to reed swamp and forest beds. He highlighted the potential for the site to provide information on the timing of sea level changes. Again, *Sphagnum imbricatum* turned out to be a key species from 3270 cal years BP to Medieval times. **Jenny Schulz** reviewed the information given by old maps on the drainage of the bog and described how the surface of the bog is different to 500 years ago, particularly regarding the extent of *Myrica*. Finally, **Keith Barber** summed up by returning to the importance of *Sphagnum imbricatum* and speculated that without human intervention it might well have fought back!

Craig Goch

John Hutchinson (Imperial) began by reviewing the research history of the Craig Goch landslide dam, which impounds Tal–y–Llyn, and considered its various former interpretations as moraine or a rock barrier. The slide is thought to consist of three main failures, firstly an upper shelf failure, which is cut by and is therefore older than the main landslide dam, and two large failures forming the dam itself. He outlined the reasoning behind the identification of two slides before suggesting that the slide may have taken place in as little as 30 seconds with a speed of 50 m/s, and it would have travelled for over 2km if not constrained by the opposite valley sides. Finally, there was a discussion of the age of the landslide dam and **John Hutchinson** appealed for a joint QRA effort to resolve this issue. The data collected so far indicates that the first lobe of the landslide dam dates to Lateglacial times as the periglacial reworking suggests it occurred before the Younger Dryas. The lack of periglacial reworking of the second slide indicates that it probably post-dates the Younger Dryas. Further discussion in the field focussed on the possible triggers for the landslide such as earthquake activity or postglacial isostatic readjustment.

Moelwyn Mawr

Half of the group followed **Jim Rose** (Royal Holloway) up to Moelwyn Mawr to view the fossil rock glacier and nearby protalus rampart and stone stripes. Enroute the group discussed the processes responsible for producing a ploughing boulder, strongly assisted by Jim Rose's 'eye-of-faith' as the ploughing of the boulder was not very discernible at the time. Further up-slope, vegetated stripes were visible, highlighted at the northern end of the slope by slate slabs in the furrows. It was reported that these are shown to be actively forming as they reform after being dug-out, but at present they are not well developed, again possibly reflect mild climate. The group continued on to view the impressive protalus rampart across the scree in the upper part of the basin containing the fossil rock glacier. **Jim Rose** explained the processes behind the formation of protalus ramparts, while **Rick Shakesby** (Swansea) pointed out that this landform should in fact be referred to as a pronival rampart as there is talus both above and below the feature. At Moelwyn Mawr **Jim Rose** outlined three possible hypotheses for the formation of this feature before **Jane Hart** (Southampton) suggested that the outermost ridge might represent lateral moraines with supraglacial material forming the 'rock glacier' between the moraines. Several members proposed that the feature may have been formed by one or more catastrophic rock falls or rock failures. However, everyone agreed that it was difficult to explain the large separation between the outer ridge and the inner ridges and the 'less blocky' nature of the outer ridge.

Llyn Gwernan

Mike Walker introduced the site in the absence of John Lowe, and discussed the work carried out by Stephen Lowe during his PhD research. The sequence consists of minerogenic clays deposited after deglaciation, organic sediments from the Lateglacial Interstadial, a return to minerogenic clays during the Younger Dryas and finally an accumulation of Holocene organic sediments. **Mike Walker** stated that the site is remarkable because the amount of Lateglacial Interstadial sediments (approximately 2m thick) are far greater than virtually every other site he is aware of in the UK. It is also significant that this site was initially dated using radiometric radiocarbon techniques and provided important new information including a basal date of 13 200 ^{14}C years BP. Since then, it has been realised that there are problems associated with the radiocarbon dating of lake-muds. The site was re-dated using AMS techniques, giving an even older basal date of 13 700 ^{14}C years BP. **Mike Walker** discussed the potential of the site for providing an even longer sequence if coring could be carried out from a boat in a deeper part of the basin, and he also touched on the potential of using further proxies such as beetles, chironomids and isotopes.

In summary, this was an extremely varied fieldtrip, covering a wide area of West Wales. The rich diet of glacial landscapes juxtaposed with bogs, periglacial landforms and sediments and mass movement landforms was more than enough to sustain everyone's interest regardless of individual specialisms. The debates were varied and there are still many unanswered questions offering the potential for future work and the application of new techniques. The field trip was managed flawlessly by the organisers, Mike Walker, Danny McCarroll and Mike Hambrey. The fact that they maintained their enthusiasm and commitment for another year following the postponement of the meeting is especially commendable.

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MIDDLE TO LATE PLEISTOCENE DEPOSITS AT WHITTLESEY, EASTERN ENGLAND

A Quaternary Research Fund grant has contributed to fieldwork costs involved in the investigation of Pleistocene deposits at Whittlesey, eastern England. Specifically this has enabled sedimentary successions to be mapped and logged following the clearance of Pleistocene deposits overlying Jurassic Oxford Clay to the northwest of King's Dyke brickworks (Figure 1). Several fossiliferous units are present (Figure 1, areas A-D) and there are sufficient sandy deposits with the potential to provide age-estimates by optically stimulated luminescence (OSL) methods.

The Pleistocene deposits at this location are mapped by the British Geological Survey (BGS, 1984) as River Nene 1st Terrace, i.e. post-Ipswichian (Horton, 1989) or compound fluvial terrace deposits ranging from marine oxygen isotope stage 7 to 2 (Bridgland *et al.*, 1991). Pleistocene deposits immediately to the south of the Fen Causeway and to the east of Funtham's Lane are mapped as March Gravel by the BGS (1984), and dated as Ipswichian (Horton, 1989; Keen *et al.*, 1990), although marine oxygen isotope stages 7 and 9 are suggested by Bridgland *et al.* (1991). As the investigation is at the preliminary stage, only brief details can be presented here, and these are confined to areas A–D shown on Figure 1. Where appropriate samples have been collected for clast lithological, pollen, plant macro fossil, molluscan, ostracod and small mammal analyses. In addition samples were collected for OSL and amino-acid racemisation dating purposes.

Area A

A1 is a narrow depression in Oxford Clay infilled by pebbly diamictic mud to pebbly matrix- and clast-supported gravel, with a solitary coarse-grained sand lens. Rafts of organic mud and silt are present as are wood fragments.

A2 is a broader depression in the Oxford Clay infilled by a muddy, pebbly gravel containing abundant shells of land and freshwater Mollusca, including *Potomida littoralis, Unio crassus, Corbicula fluminalis, Belgrandia marginata* and *Theodoxus danubialis*. Upwards there is a gradational change to a dark, muddy silt with pockets of shells dominated by *Bithynia tentaculata*.

A3 is a channel infilled by fossiliferous gravel and sand and is present on both sides of Funtham's Lane. Sedimentary structures indicate flow to the northeast.

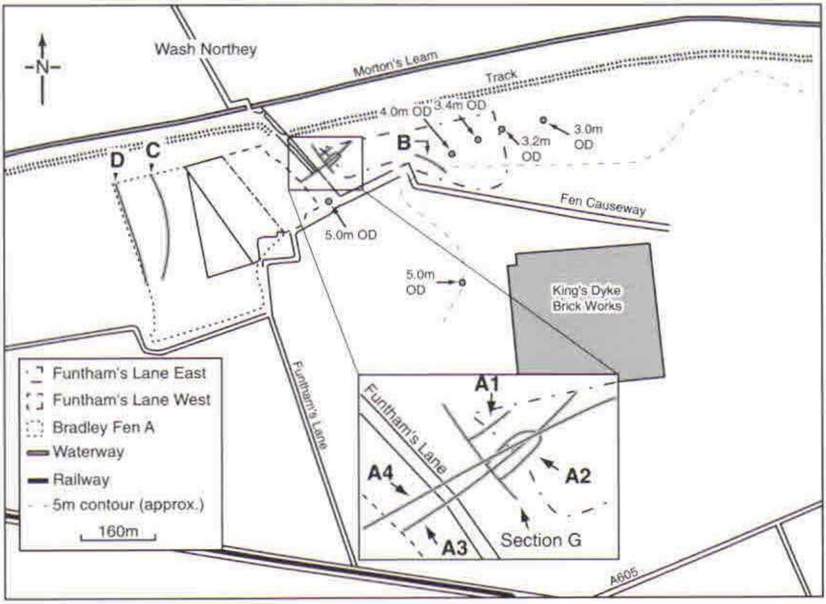

Figure 1. Location of recently removed Pleistocene deposits to the northwest of King's Dyke brickworks, Whittlesey, eastern England. Areas A–D are referred to in the text. In area A, A4 marks the southern boundary of this fossiliferous grey-green silt–sand.

It appears to contain the same molluscan assemblage as the underlying muddy gravel, but *Corbicula* are extremely abundant.

A4 occupies a much broader area. At section G, unit A4 has a gradational contact with the underlying dark muddy silt of unit A2, but in the southern part of section G it is truncated by unit A3. Less than 100 m to the northeast, the greenish grey fossiliferous silt–sand of unit A4 overlies A3 sediments. Therefore deposition of unit A4 was contemporaneous with unit A3. A *Bos/Bison* horn has been found in this unit and *ex-situ* finds of antler and elephant limb bone are probably associated with this unit.

Area B

Two complexes of channel cut-and-fills are present at area B. Both commonly, but not always, show channel cutting followed by deposition of clay–silt and then gravel. The most easterly complex is the older, with no evidence of reworking molluscs from area A. The most westerly, and nearest to area A, does appear to have reworked molluscs from area A.

Area C

Area C contains a shell-rich gravel and sand channel incised into gravel. At its northern end it overlies a muddy gravel incised into Oxford Clay. The molluscan fauna of A2 and A3 are not represented in the fauna of this channel, although large bivalves are present. The absence of *Corbicula* still has to be confirmed (J. Merry, *pers comm.*, 2001).

Area D

Area D denotes a fossiliferous muddy channel fill, the base of which penetrates Oxford Clay at its northern end. Mammal bones, probably elephant ribs (D. Schreve, *pers. comm.*, 2001) have been found *in-situ*. The molluscan fauna appears to be restricted, perhaps by local environmental rather than climatic conditions.

Comments

Several generations of channel incision and infill are evident at this site, with incision generally down to about +1 m to present sea level and aggradation up to about +3–4 m OD. The presence of *Corbicula* in A2 and A3 suggests a minimum age of marine oxygen isotope stage 7 (Meijer and Preece, 2000), and the presence of *T. danubialis* together with *P. littoralis* and *U. crassus* compares with the 'Rhenish' fauna of Swanscombe (Bridgland, 1994) and may indicate an age as great as marine oxygen isotope stage 11. At least one of the channel cut-and-fill episodes in area B post-dates A3. At Tanholt Farm (Chancellor and Langford, 1992; Bateman, 1999), 4 km northeast of Peterborough, a radiocarbon date suggests Devensian aggradation from about +1 m OD to 5 m OD. At Whittlesey, about 1.25 km to the east of Funtham's Lane, OSL dates suggest Ipswichian aggradation at about +3–4 m OD and marine oxygen isotope stage 6 aggradation at about 6 m OD (Langford, 1999). Although the age relationships of the channels at this site are not known at present, there is the possibility that fluvial activity at the western Fen Basin margin has remained at about the same altitude, in both cold and warm stages, since the Anglian Stage. This limited altitudinal range has implications for the age of the Woodston Beds and March Gravel (Horton *et al.*, 1992; Langford, 1999), both of which contain evidence for brackish conditions.

Acknowledgements

Many thanks to Jason Jordan of the Geography Department, Coventry University for producing the figure, and to David Keen, John Merry, Mike Field, Tim Mighall, Chris Green, Steve Boreham, Becky Briant and Mark Bateman for their collaboration on this multidisciplinary effort.

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NEW RESEARCH WORKER'S AWARD SCHEME

THE HOLOCENE STABLE ISOTOPE LIMNOLOGY OF WESTERN ANATOLIA. A PRELIMINARY REPORT.

Introduction and Background

Investigations carried out in the last decade on Mediterranean lake sediments have started to reveal regionally coherent trends in stable isotope variability (ISOMED, 2001). These records are important not only from a palaeoclimate perspective, but also may help answer some of the archaeological questions currently under investigation in the Near East (e.g. Eastwood *et al.*, 1998). There is a need to establish the isotopic sensitivity of individual lake systems, to understand how faithfully changes in water isotopic values respond to climatic variability and how these changes are incorporated into the sedimentary record.

This PhD project aims to:

1) establish statistically valid relationships between twentieth-century meteorological variations, notably in precipitation and evaporation, and the isotopic composition of authigenic carbonates in dated lake sediment profiles;
2) investigate the modern isotopic mass budgets from lakes with varying hydrology and salinity, and establish a modelling approach for the interpretation of lake isotopic records; and
3) quantify environmental change through the last 2000 years based on the information gained above.

This work is part of a three-year collaborative research project between the University of Plymouth, the University of Birmingham and the Turkish Geological Survey (MTA) looking at climatic and tectonic histories in Turkish lake basins.

Study sites

Three sites were cored in the summer of 2001. Nar Gölü, a 25 m-deep crater lake in Cappodocia, was known to have laminated surface sediments from a preliminary core taken by Neil Roberts and co-workers in July 1999. A preliminary isotopic study on this 1m core showed there to be significant (> 0.1 ‰) isotopic variation between adjacent laminae.

In the south west of Turkey Lake Burdur, a 60 m deep tectonically controlled basin, and Gölcük, a 25 m deep crater lake 20 km east of Burdur, were cored as they lay at different hydrological positions along the local evaporation line described by water samples taken in previous years. Previous work on these sites consisted of short Glew cores from the margins of the lakes.

Sediment traps were left in Nar Gölü to collect a year's sediment flux. This should increase understanding of the nature of the laminae, including their temporal resolution, and also of the isotopic relationship between waters and sediment. Water samples were taken from the lakes and surrounding springs to add to a database of lake water oxygen, carbon and hydrogen stable isotope values from across Turkey.

Preliminary Results

A 3.5m sequence was obtained from Nar Gölü using Glew and Livingstone coring systems. The sediments were laminated throughout (approximately 2000 laminations in total) but also include what appear to be turbidite events from an alluvial fan-delta at the edge of the lake. An initial study of these events suggests these "turbidites" become more frequent towards the top of the record. The laminae are composed of couplets of almost pure calcite and green algal layers, and are in the order of 2 mm thick. Analysis has begun of the stable isotope chemistry and also the mineralogy of this sequence.

Short Glew cores were obtained from the centre of Lake Burdur. It was discovered that these sediments are also laminated although the composition of these laminae is yet to be established. Stable isotope analysis of these cores is also underway.

The sediments in Gölcük were found to be highly clastic and unsuitable for stable isotope work as there was negligible carbonate present.

Future work

High-resolution stable isotope analysis of the recent sediments from Nar and Burdur will be compared to local meteorological records. This should establish the sensitivity and controls on the lake isotope system and allow robust interpretations of records obtained from longer core sequences to be obtained in July 2002. A new site from the north of Turkey, from a different climatic regime, will also be investigated to compare with these two records.

Acknowledgements

I would like to thank the QRA and the Dudley Stamp Memorial Fund for their support of this work. I would also like to thank my supervisors Neil Roberts and

Greg Price in Plymouth and Melanie Leng at the NERC Isotope Geosciences Laboratory, Keyworth. My thanks also to all those involved in fieldwork in Turkey this summer, Neil Roberts, Warren Eastwood, Damase Mouralis, Anne Mather, Catherine Kuzucuolu, Mustafa Karab1y1kolu and other colleagues from the MTA. I would also like to thank the British Institute of Archaeology in Ankara for their continued support of this work.

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QUATERNARY GLACIATION IN THE PINDUS MOUNTAINS OF EPIRUS, GREECE

The research aims to recognise the extent, dynamics and chronology of Quaternary glaciations in the Pindus Mountains of Epirus, Greece. The extent of former glaciation is deduced via detailed geomorphological mapping over a 200km^2 area which will establish the number, extent and sequence of glacial phases. In addition detailed sedimentological analysis of glacial and glaciofluvial sections aims to provide insight into the environments of deposition. Chronological control is provided by the U-series dating of calcretes and other calcite deposits which have formed within the glacial deposits following deposition. The dates therefore provide minimum ages for the glacial deposits, and these are used in conjunction with morphostratigraphy. In future work, the geomorphological and chronological data will be combined to allow the reconstruction of the Quaternary glaciers in this region. This will then enable palaeoclimatic inferences to be made based on modern glacier-climate relationships.

The research centres on the Timfi (2497m) and Smolikas (2637m) massifs in Epirus, northwest Greece (Figure 1). The former massif consists largely of limestone bedrock, with flysch prominent in lower areas whilst the latter massif consists largely of ophiolitic lithologies. Evidence of glaciation is remarkably well preserved on both massifs. Well-developed glacially-eroded features such as cirques, troughs and glaciokarst limestone pavements exist, as well as clearly-defined depositional features such as moraine ridges and kame terraces. Initial data have suggested that the largest glaciers extended to as low as 850m above sea level in places. Also, there is evidence of a possible ice cap on Mount Timfi which fed the lower valley glaciers.

The timing of the most extensive glaciation in the study area is unclear at present. Whilst it is tempting to assume that this phase corresponds to the last glacial maximum of Northern Europe (25 - 18,000 yrs BP), preliminary U-series dates suggest an earlier age. Current data suggest an age equivalent to the Early Weichselian, Saalian and earlier glacial stages of northern Europe (Woodward *et al.*, in press). Multiple phases are evident in the geomorphological record and work is in progress to provide further U-series dates from post-depositional calcites.

This research will provide valuable insights into the Quaternary environments of northwest Greece with wider significance for the palaeoclimate of the Mediterranean. The project has the potential to develop the most detailed chronologically-constrained glacial reconstruction in the mountains of the Mediterranean. It will also be useful to compare the dated glacial record with the long Pleistocene lacustrine sequences such as at nearby Ioannina (Tzedakis,

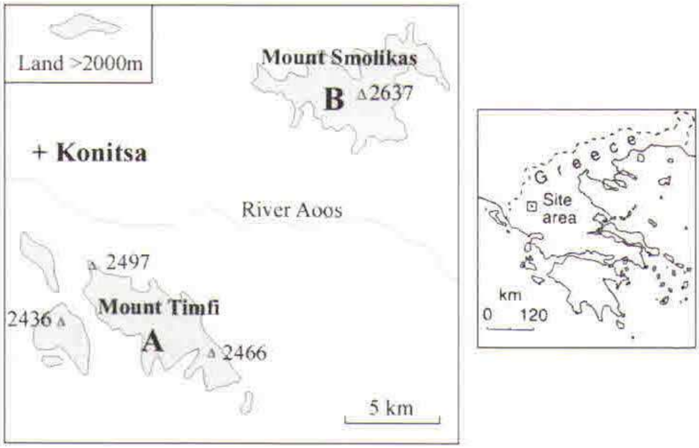

Figure 1. Location map of the research area.

1994) and Tenaghi Philippon (van der Wiel and Wjimstra, 1987a, 1987b), as well as the fluvial sequences of the Voidomatis, which drains the southern slopes of Mount Timfi (*cf.* Woodward *et al.*, 1995, Hamlin *et al.*, 2000). Also, glacier reconstruction and glacier-climate modelling will provide valuable palaeoclimatic data for southern Europe during glacial phases. The project is therefore of major importance in furthering our understanding of Mediterranean Quaternary environments.

Acknowledgements

The fieldwork was supported by travel grants from the following sources: the Quaternary Research Association; Darwin College, Cambridge and the Department of Geography, University of Cambridge. I would also like to thank Phil Gibbard (Cambridge) and Jamie Woodward (Leeds) for supervising this research.

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AMINO ACID RATIOS FROM ABINGTON HALL, CAMBRIDGESHIRE

Abington Hall is situated in the valley of the River Granta, a tributary of the River Cam, between the village of Great Abington and the A11 road, 12km south of Cambridge. The Granta valley (*c.*25-30m OD) drains to the northwest, and is flanked by higher land to the north and a plateau area to the south reaching *c.*100m OD. The bedrock geology comprises Middle and Upper Chalk broadly dipping towards the southeast, and the Quaternary geology comprises till on higher ground with patches of 'Glacial Gravel'. Remnants of 3rd Terrace Deposits are mapped along the Granta valley and Undifferentiated 2nd and 1st Terrace Deposits and alluvium are confined to the valley floor (BGS Sheet 205 Saffron Walden).

In summer 1998 the author was invited by the Cambridgeshire County Archaeologist to inspect the site of The Welding Institute's Science Park development at Abington Hall prior to major building works. Topsoil had been removed from the archaeological site to reveal a shallow meandering palaeochannel filled with pale marly silty clay, and cut into the surrounding gravel mapped as Undifferentiated 2nd and 1st Terrace Deposits by the BGS. Mesolithic artefacts recovered from the channel and subsequent pollen analyses by the author suggested that it was of early to mid-Holocene age. Adjacent to the archaeological site, an old gravel pit previously filled with refuse had been re-opened and deepened in preparation for an ornamental lake. This afforded excellent sections in the deposits including the Holocene channel deposits and the underlying gravel (3-4m thick). At one location (site twi/g) (TL 5242 4909) the author noted grey organic silts exposed on the newly deepened floor of the pit beneath the gravel unit. An augered borehole was put down through these deposits proving 3.5m of silty clay resting on gravel. Closer examination of the pit floor revealed that the silty clay unit could be traced for at least 100m to the east. The author arranged to have a trench (section twi/hi) (TL 5249 4905) dug at the eastern end of the pit. This excavation proved 4m of silty clay also overlying a basal gravel.

The floral, molluscan, and coleopteran assemblages from the silty clay unit at twi/g and twi/hi show a distinct change from cool to temperate conditions. Pollen analyses show a vegetational succession from an open grassland habitat with birch and pine scrub to closed canopy mixed oak woodland, within a fluvial environment. Such a change in the vegetation seems consistent with climatic warming at the beginning of an interglacial (Substage I to II). Coleopteran analyses show a faunal change from one broadly comparable to that from southern Sweden (c.61°N) to a beetle fauna indicating a temperate climate perhaps 3-4°C warmer than today.

Mollusc shells from the site were submitted to Charles P. Hart, at the Center for Geochronological Research, INSTAAR, University of Colorado, USA, for amino acid ratio analyses. The shells were prepared to produce total acid hydrolysates of the preserved amino acids. Cation exchange chemistry in a High Precision Liquid Chromatograph was then used to measure the ratio of D-alloisoleucine to L-Isoleucine following the method of Miller and Brigham-Grette (1989). Two analyses were made on each shell, and the resulting chromatograms were carefully examined to provide the mean ratio of D-alloIsoleucine to L-Isoleucine (D/L) and the standard deviation for each sample.

Amino-acid racemization analyses for two *Valvata piscinalis* shells from the upper part of the silty clay unit at twi/hi gave D/L ratios of 0.117 (0.013 s) and 0.133 (0.017 s). These ratios broadly equate to an early Ipswichian (MIS 5e) age. Optically stimulated luminescence (OSL) dating of quartz from the upper part of the silty clay at trench twi/hi gave an age of 137.74 ±41.65. This also appears to indicate a correlation with the Ipswichian (MIS 5e).

In the field, the sequences of silty clay at twi/g and twi/hi were clearly seen to be part of the same channel-fill sequence truncated by the overlying gravel. It appears that these sediments represent the silting up of a river channel during a phase of climatic warming, probably at the beginning of the Ipswichian (MIS 5e) interglacial. The gravels at Abington Hall are thought to have been deposited by a braided stream within a confined valley system. The Holocene silty clay overlying the gravel also appears to be a channel filling abandoned by the river.

Acknowledgements

This work was undertaken as part of an Open University PhD project entitled 'The Pleistocene Stratigraphy and Palaeoenvironments of the Cambridge District' supervised by Charles Turner and Colin L. Forbes. The author is grateful to the QRA for part-funding the amino acid ratios from this site, and to Colin L. Forbes who provided funding for amino acid ratios, radiocarbon and optical dating throughout the entire project. The author also gratefully acknowledges the field and analytical support given by R.G. West, P.L. Gibbard, R.C. Preece, G.R. Coope, R.M. Briant and A. Dixon. The author is also indebted to Tim Malim, Cambridgeshire County Archaeologist, for the original invitation to inspect the site.

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REVIEWS

ICE AGE

by John and Mary Gribbin, 2001,
The Penguin Press, ISBN 0713 996129

This book tells the story of the development of the Ice Age theory. Several years ago while teaching the History of Science to a group of students I looked for a book on this topic, but found nothing other than James Geikie's book (1877) 'The Great Ice Age' or his brother, Archibald Geikie's book, 'The Founders of Geology', the latter of which looked at 'Foundation of Glacial Geology – Agassiz'. There have been references in standard Ice Age and Quaternary texts such as 'Glacial Environments' by Michael Hambrey, but nothing that describes in detail the fascinating story that led up to the worldwide acceptance of multiple Ice Ages.

Therefore, I really enjoyed reading this book, which starts with The Victorians and moves forward through the 20th Century to end at an epilogue called "Ice Ages and Us". Here the last sentence states "We are the product of the latest Ice Epoch, in a way Agassiz, Croll and Milankovitch could never have guessed, and that realization is the ultimate triumph of the theory of Ice Ages."

The section on Croll's contribution, the account of Milankovitch during World War II, the work from Lamont-Doherty Geological Observatory on deep sea sediments and the oxygen isotopes work of Imbrie and Shackleton are all dealt with in detail. The book draws to a close with a discussion of thorium dating and Hays work with CLIMAP.

I have but two criticisms. One is the paucity of photos of our heros. We have Croll and Milankovitch but not Agassiz. The whole book, to my mind, is also lacking in diagrams. Many pages contain none at all. The other irksome thing is the use of mya for millions of years. As I teach palaeontology, mya is a bivalve and the use of Ma should be encouraged. Nevertheless there are three pages of references at the end, some in the original French and German, which is good to see.

As a book that is trying to popularize and join the other books on science and history, this book lacks the charismatic outer cover and the high quality of paper inside. However, the story it tells is fascinating and personally, I found it a difficult book to put down. To those of you wanting a short factual account of the development of the Ice Age theory this is your account!

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ROMNEY MARSH - SURVIVAL ON A FRONTIER

Jill Eddison

160 pp   ISBN 0 7524 1486 0

Published by Tempus Publishing Ltd, 2000

This book is mainly about the frontier between the sea and the land, though as Jill Eddison notes, Romney Marsh is at the frontier between Britain and mainland Europe - an avenue for trade and a tempting bridgehead for actual and aspiring invaders.

Jill Eddison was the moving spirit in the foundation of the Romney Marsh Research Trust in the mid 1980s, and for many years she was the Secretary. In the last fifteen years, understanding of the landscape history of Romney Marsh has been transformed, largely through the efforts of the Trust. This book is a summary of that history for the interested visitor to the Marsh or for a wider readership with a general interest in the landscape of Britain.

The meat of the book is in nine chapters that trace the development of the landscape chronologically from the Postglacial rise of sea level to the floods of the 1990s that threatened the Dungeness nuclear power stations. The account weaves together the recent findings of research supported by the Trust and earlier archaeological and archival investigations. The story that emerges is thoroughly readable, and a nice balance is maintained in terms of the attention devoted to each of the periods into which the history is divided. This is not however, and is not intended to be, the place to track down the primary source material. There are no references in the text and the recommended further reading, at the end of the account, is a modest selection of titles. Of course the list includes the three monographs in which much recent work on Romney Marsh has been published (Eddison and Green, 1988, Eddison, 1995, Eddison, Gardner and Long, 1998) and if you are familiar with those publications, you will recognise their influence on the text.

The recent developments in the understanding of Romney Marsh have arisen from three main fields of enquiry. Firstly, the sediments of the Marsh have been widely explored, so that we now have a much better idea how the pattern of salt marsh, river channel and coastal barrier has changed through time. This very detailed work based on the analysis of sediments and biological remains from a huge number of boreholes is outlined only briefly but its importance is constantly apparent in the accounts of land reclamation and natural disaster that define the history of the Marsh.

Secondly, archaeological investigations, often funded by the Trust, have uncovered the physical remains of settlement and occupation, particularly of the prehistoric and Roman period, for which, on the low ground of the Marsh itself, evidence was previously very limited. This work and the excavation of the medieval church at Broomhill are given due prominence in the text and complement the retelling of earlier archaeological investigations, of the Saxon Shore Fort at Stutfall Castle and of the Saxon occupation horizons at Sandtun.

Thirdly, and occupying the major part of the book, archival research has shed much new light on the medieval and post-medieval history of settlement, sea defences, and land reclamation, and on the development and decline of the ports of Romney, Winchelsea and Rye. This is the territory in which copious footnotes normally flourish, but there is no expectation here that the reader will want to unravel the documentary sources.

So, this is an informed popular account that brings the general reader up to date on the landscape history of Romney Marsh. Without weighing it down with scholarship, it could have been made more attractive to the specialist reader, but it is not intended for the specialist. You will have to buy the monographs. A fourth is in preparation.

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EARTH SCIENCE AND THE NATURAL HERITAGE: INTERACTIONS AND INTEGRATED MANAGEMENT

Edited by John E. Gordon and Katherine F. Leys, 2001

Scottish Natural Heritage *Natural Heritage of Scotland* series No. 9

ISBN 0-11-497283-4 £35.00.

Few would question the wealth, diversity and importance of Scotland's heritage of rocks, fossils, soils and landforms. It has contributed to the better understanding of the development of landscapes and life, is central to Scotland's natural environment and scenery, and has shaped many aspects of her economy and culture. Few then, would question the need to manage this earth heritage wisely. But how? In recent years, the importance of understanding the evolution and sensitivity of our natural heritage has been increasingly recognised as a prerequisite for sustainable landscape management. Centred on the role of Earth science in sustainable management of Scotland's natural heritage, this affordable volume gathers together work originally presented at the Scottish Natural Heritage (SNH) *Earth Science and the Natural Heritage* conference held at Our Dynamic Earth in November 1999. Throughout the book, three requirements for future natural heritage management emerge: (i) wider recognition of links between the Earth's physical and biological systems; (ii) integration of Earth science knowledge and understanding in sustainable management; and (iii) raising public awareness of Earth heritage and promoting greater involvement.

The volume contains 34 chapters organised into five parts: Earth science and the natural heritage: exploring the continuum (54 pp); Earth science and the natural heritage: foundation and interactions (68 pp); Earth science and the natural heritage: pressures and sustainable management (113 pp); Earth heritage awareness, involvement and education (43 pp); and Key issues for a sustainable future (41 pp). Although some of these headings are less than transparent, each part is prefaced with a helpful overview, and individual chapters contain summaries. Part One introduces the central, recurring themes by emphasising the links between geology, geomorphology, soils and ecology **(A. Manning)**, the role of geology in global change **(G.S. Boulton)**, and the need to help others to understand Earth science.

Part Two highlights the links between Earth science and the natural heritage. It sets out the geological and geomorphological framework of the present landscape **(N.H. Trewin)** and examines links between physical process, human impact and natural heritage in coastal, fluvial and upland environments. It is these links that are crucial to sustainable management of sensitive landscape components, be they machair plains (**J.D. Hansom** and **S. Angus**) or high summit plateaux (**V.M. Haynes** *et al.*). Similarly, physical processes underpin the biodiversity of freshwater ecosystems. As **C. Soulsby** and **P.J. Boon** argue though, sustainable management of those fluvial resources depends on an understanding of spatial linkages and temporal scale. **D.B.A. Thomson** *et al.* offer a thought-provoking paper on Scotland's varied mountain landscapes, reflecting a complex product of geological, glacial and postglacial histories and climates, geomorphological processes and human activities. Reflecting on the uncertainty of their 'natural' status, several research priorities are highlighted for work in the Scottish mountains.

In Part Three attention focuses on pressures facing the natural heritage resource (especially those arising from planning developments and land use changes), and sustainable management and conservation responses predicated on effective application of Earth science knowledge and skills. Several case studies provide examples of an holistic, integrated (*cf.* sectoral) management approach for coasts, rivers, soils, mineral and energy resources, emphasising the value of working with, rather than against, natural processes. For instance, **J.D. Hansom** *et al.* outline the pressures facing the Forth Estuary coastal zone, and the importance of sound process understanding for possible managed coastline realignment. As with the coast, the maintenance of natural processes and application of integrated management for natural heritage and wider interests are crucial in fluvial systems, as illustrated by **K.F. Leys** for the River Spey and **L.J. McEwen** and **W. McGhee** on the River Ettrick. Sustainability issues are particularly evident in the use of soil. By mapping soil erosion risk by overland flow across Scotland, **A. Lilly** *et al.* pave the way for targeting vulnerable areas for appropriate management. Other papers in this part discuss the earth heritage perspective within sustainable mineral and energy resource use, issues which **I. Lindley** *et al.* demonstrate are key to a strategic planning process seeking to balance the demand for mineral production with competing uses for land. On a broader level, **C. Mitchell** presents the SNH 'Natural Heritage Zone' framework for progressing sustainable development. Obviously, the importance of demonstrating the value of earth heritage and environmentally sensitive management to key stakeholders remains paramount.

The challenge to raise awareness of our earth heritage, both for interpretation aimed at the general public and education, forms the message of Part Four. Clearly, support for earth heritage management and conservation will only thrive if earth scientists can enthuse others in the subject with relevant, interesting and accessible themes and language - a challenge for us all. Work being undertaken in Scottish schools, museums, visitor attractions and in other countries is presented in several papers, and **E.J. Brown** discusses the potential for developing these initiatives through a co-ordinated approach to interpretation and geotourism. Finally, Part Five looks forward to the key future challenges facing all practitioners in natural heritage, not least that of communicating Earth science knowledge and understanding for the implementation of informed sustainable policy and for the benefit of society (**M.B. Usher**).

Sixty-six authors contributed to *Earth Science and the Natural Heritage*. Throughout, the standard of production is high; there are few typographic errors and only a small number of inconsistencies. The volume is attractively illustrated with 74 figures and tables, and a tempting spread of 36 colour plates. Being a conference volume, *Earth Science and the Natural Heritage* does not offer an exhaustive overview of the subject, though it complements work presented at the 'Landscape Sensitivity' conference held earlier in 1999 at the University of Stirling (Thomas and Simpson, 2001). In highlighting several important issues and approaches in a growing inter-disciplinary field, it should be included in the library of all interested in Scotland's natural heritage, as well as any institution where landscape sensitivity and environmental management are researched and taught.

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1:30,000 CARTOGRAPHIC MAPS OF THE BREIDAMERKURJÖKULL GLACIER IN 1945 [1], 1965 [1] AND 1998 [2] WITH TWO AERIAL PHOTOGRAPH STEREO-TRIPLICATES OF THE GLACIER FORELAND (6 PHOTOS) IN 1998

P.J. Howarth and R. Welch [1]

D.J.A. Evans and D.R. Twigg [2]

Published by University of Glasgow 1969 [1] 2000 [2]

£25 for the standard package, individual maps £5 per sheet (20% discount for orders of 10 or more and 30% for 20 or more) prices include postage with small supplement for flat maps. Available from **Department of Geography & Topographic Science (Breida map), University of Glasgow, Glasgow, G12 8QQ, Scotland.** Further details at http://www. geog.gla.ac.uk/Breida/ Breida.htm

The Breidamerkurjökull glacier is situated on the southeast coast of Iceland. It has been steadily retreating up to 4 km during the decades covered by this series of maps, revealing a series of fresh moraines and related fluvioglacial deposits. While symbols are not used to identify the different glacial deposits indicated on these maps, the colour tones are distinct enough to be easily distinguished without being too bold. They clearly document the progressive changes to the whole proglacial environment, including the alignment of the shoreline, the extent of the ice-marginal lakes and tarns, and the positions of the water courses draining these still-consolidating deposits or carrying material directly away from the decaying ice front, in addition to the changing morphology of the glacier itself. The three maps were compiled from aerial photographs covering the same area roughly 10km wide by 19km running parallel to the coast and trending northeastwards. The fairly generous scale allows for 10m contouring while keeping the sheets quite compact and easy to deal with when neatly folded into panels just under A4 in size.

While the first two maps were produced in 1969 the latest map in the series follows broadly the same colour and topographic conventions. However, it contains much more detailed annotation to show many of the complex geomorphological features yet does not overwhelm the reader with too much apparent detail. In effect these maps show only the Drift geology of these superficial deposits and the glacier itself, while ignoring areas of exposed bedrock apart from contouring mountainsides adjacent to the ice. Interestingly, the contours on the older maps seem to have more texture, while those compiled with the aid of digital cartography appear to be smoother. This is especially apparent on the glacier where the modern map distinguishes itself by showing the actual grain of the ice surface, seen on the accompanying aerial photographs, in a blue tone. For example, medial moraines appear as darkened strips on the glacier whereas previously lighter blue tone stippling indicated them.

By comparing the maps it is possible to pick up very subtle changes to the minor water courses that no longer drain the proglacial area, so that many of them are now marked on the most recent map as abandoned channels in the glacial-fluvial deposits. This is in addition to the eskers, flutings and drumlin crests, moraine ridges, lateral meltwater channels, kettle holes, terraces and crevasse-fill ridges that are carefully depicted amongst the glacial deposits. Considering the benefits to be gained from closely comparing the three maps it is a pity that the same grid intersections are not shown on the latest map, which carries a different grid. Also, as the surface levels for many of the larger lakes have changed significantly between the dates of these two surveys, it would have been a useful addition on the 1998 map and an aid to their interpretation. However, as this package is linked to its own web site, which already shows the locations of the aerial photographs, these lake levels could be provided along with information about the local tidal range relative to mean sea level, which is the datum used for these maps.

That said, these maps and the accompanying aerial photographs are excellent value for money and would not only be stimulating university teaching material but a useful addition to the curriculum in colleges, sixth forms and secondary schools. It is particularly amazing to see the blocks of ice that have calved from the glacier on the surface of lake Jokulsarlon standing out in three dimensions. This is in addition to the freshly eroded channels and glacial features that stand out when these high quality 228 mm (9") square aerial photographs are seen through a stereo viewer.

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ABSTRACTS

LATE PLEISTOCENE AND EARLY HOLOCENE SMALL MAMMALS IN SOUTH WEST BRITAIN: ENVIRONMENTAL AND TAPHONOMIC IMPLICATIONS, AND THEIR ROLE IN ARCHAEOLOGICAL RESEARCH

Cath Price (Doctor of Philosophy)

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This thesis examines small mammal faunas from cave sites in South-west England and South Wales. The aims are threefold:

1. to examine the rapid environmental changes taking place in the Late Pleistocene and early Holocene:
2. to understand the processes by which small mammal remains were deposited in the caves examined:
3. to demonstrate the value of small mammal studies as an archaeological tool.

All identifiable small mammal remains from twelve selected sites are listed. Of particular interest is the first British record of a grey-sided vole (*Clethrionomys rufocanus*) from the Lateglacial Interstadial deposit at King Arthur's Cave (Wye Valley). Ten of the sites are new material, including the first in-depth analyses of the small mammal faunas from the Torbryan Valley Caves Project and the Wye Valley Caves Project. As the species examined here are seldom exploited by humans, their biostratigraphy provides a record of the past environment unaffected by human selection of particular species, as might be the case in larger mammal assemblages. An examination of possible agents of accumulation is provided for each site to identify any bias introduced by prey selection. Reconstructions of the environments local to each cave at the time of deposition are offered.

The evidence provided by the small mammals is related to the archaeological findings from each cave, to demonstrate the effect of human habitation of cave sites on the depositional and post-depositional processes shown by the microfauna. The environmental evidence provided by the study reflects a wider landscape rather than merely the immediate surroundings of the cave, and so gives a basis for human exploitation patterns in the area accessible from the cave.

Reconstructions of the ecological mosaics formed by the rapidly changing climate of the period and the topographic variation around the cave sites are provided, demonstrating the potential complexity of the environment in which the humans and other fauna of the period existed. It is hoped that this will encourage archaeologists to look beyond the general division of environmental boundaries in this period, and to examine local variation in habitat availability and use.

VEGETATION SUCCESSION IN THE HUMBER WETLANDS

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Three sites located in different physiographic sub-regions of the Humber wetlands (Lambwath Mere in Holderness, Withern in the Lincolnshire Marsh, and Sutton Common in the Humberhead Levels) are chosen to investigate Postglacial successional pathways and forces driving vegetation change in wetlands formerly common to these regions. Successional changes at these sites are compared against successional trends in other mires and inland freshwater basins in the Humber wetlands and British Isles. Palaeoenvironmental evidence for dryland vegetation changes and prehistoric human activity at all three fieldsites is also considered. Techniques used in the reconstruction of past environments include lithostratigraphic survey, pollen and environmental magnetic analyses, and radiocarbon dating.

Throughout the majority of the Holocene, succession in the large Holderness meres (mean basin area > 0.5 km^2) occurred along progressive (autogenic) series. At Lambwath Mere, deep open water was succeeded by an aquatic macrophyte stage at *c.* 5150 yr BP. After *c.* 3700 yr BP divergent successional pathways within the basin led to the development of *Salix* swamp carr (via reedswamp) at the centre of the mere, and *Alnus* fen carr in drier littoral areas.

In floodplain and coastal wetlands allogenic forces, particularly relative sea-level (RSL) changes, appear to have exerted significant control over mid-Holocene succession, and reversals are common in the successional sequences investigated. At Shirley Wood, hydrological changes accompanying rising RSL appear to explain replacement of dry *Tilia* woodlands by fen woodlands at *c.* 5900 yr BP and may have played a role in a later reversal from *Betula* poor fen to *Alnus* fen carr dated *c.* 4400 yr BP. At Withern, RSL fluctuations between *c.* 4650-2450 yr BP resulted in transitions between *Alnus* fen carr and open coastal communities (saltmarsh, reedswamp).

From the Bronze Age-Iron Age transition onwards successional reversals from fen carr to open fen communities and the maintenance of open wetland habitats at Lambwath, Withern, and Shirley Wood coincided with widespread and intensive regional deforestation and the creation of cultural landscapes. This suggests the emergence of human agency as the dominant allogenic control over wetland succession throughout the region. Climatic deterioration may have contributed to the maintenance of the high groundwater tables necessary for the persistence of late Holocene reedswamp and fen communities.

NOTICES

1. TO ALL MEMBERS OF THE QUATERNARY RESEARCH ASSOCIATION

In recent years there has been a burgeoning of specialist journals catering to all aspects of the Geosciences. While the Quaternary science community is particularly well served by a series of high-quality international journals, it is important to ensure that all facets of Quaternary science reach the wider Earth Science readership on a regular basis – so that this user-community can appreciate the high resolution of Quaternary sequences and the significance of these data for the study of the pre-Quaternary record and *vice versa.* We are therefore writing to encourage Quaternary Research Association members to submit high quality and topical research papers to the *Journal of the Geological Society (JGS).* As new members of the Editorial Board and Editorial Advisory Board respectively, we are eager to see an increase in the number of Quaternary science papers in the journal. It is clear that many of the major advances in Quaternary science of recent years (such as wider appreciation of the importance of Milankovitch forcing mechanisms on global climate; changes in ocean and atmosphere circulation and abrupt climate change; rates of process change and response) have important implications for the study of the pre-Quaternary record.

An increase in the number of Quaternary science papers in the Journal of the Geological Society will inevitably lead to a more effective dialogue between Quaternary scientists and those concerned with earlier periods of Earth history. This will, in turn, lead to an improved understanding of the causes and impacts of global climate change.

The *JGS* covers all aspects of geology, has been published continuously since 1845 and has a current global circulation of 5000 copies in more than 100 countries. The Geological Society has long-standing links with the Quaternary Research Association and the Editorial Board would be happy to consider proposals for 'cutting-edge' special issues on Quaternary science and on themes that link the Quaternary and pre-Quaternary records.

We hope that you will consider contributing to the journal in the near future. More information about the journal and recent papers can be viewed on The Geological Society web pages at www.geolsoc.org.uk

Yours sincerely,

Dr Jamie Woodward and Dr Philip Gibbard
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2. JOURNAL OF QUATERNARY SCIENCE

Forthcoming Research Papers

Walden and Ballantyne. Use of environmental magnetic measurements to validate the vertical extent of ice masses at the last glacial maximum

Woodward *et al.* Formation and reorientation of structure at a surge-type glacier: Kongsvegen, Svalbard

Bennike and Björck. Chronology of the last recession of the Greenland Ice Sheet

Evans *et al.* The geomorphology and style of plateau icefield glaciation in a fjord terrain, Troms-Finnmark, North Norway

Raunholm *et al.* Weichselian sediments at Foss-Eikeland, Jæren (SW Norway): sea-level changes and glaciation history

McCuaig and Roberts. Topographically-independent ice flow in northwestern British Columbia: implications for Cordilleran Ice Sheet reconstruction

Richards. A multi-technique study of the glacial stratigraphy of Co.Clare and Co.Kerry, south-west Ireland

Seppä *et al.* Changes of tree-line and alpine vegetation in relation to post-glacial climate dynamics in northern Fennoscandia based on pollen and chironomid records

Solovieva and Jones. A multiproxy record of Holocene environmental changes in the central Kola Peninsula, north-west Russia

Onac *et al.* Isotope-climate record in a Holocene stalagmite from Ursilor Cave (Romania)

Jones *et al.* A high resolution, multi-proxy Late-glacial record of climate change and intra-system responses in NW England

Eynaud *et al.* Norwegian sea surface palaeoenvironments of Marine Isotopic Stage 3: the paradoxical response of dinoflagellate cysts

Alexanderson *et al.* The North Taymyr ice-marginal zone, Siberia - a landsystem approach

Harle *et al.* A chronology for the long pollen record from Lake Wangoom, western Victoria (Australia) as derived from uranium/thorium disequilibrium dating

Smith *et al.* Stable carbon and oxygen isotopic evidence for late Pleistocene to middle Holocene climatic fluctuations in the interior of southern Africa

Heusser *et al.* Late Wisconsin periglacial environments of the southern margin of the Laurentide Ice Sheet reconstructed from pollen analysis

ISSN 0 143-2826

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, incorporating *Quaternary Proceedings*, with eight issues per year, the Field Guide 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. Current officers of the Association are:

President: ***Professor D. H. Keen*** , Centre for Quaternary Science, Coventry University, Priory Street, Coventry CV1 5FB
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Vice-President: ***Dr R.C. Preece***, Department of Zoology, University of Cambridge, Downing Street, Cambridge, CB2 3EJ.
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June 2002 No. 97

Contents