NUMBER 118 JUNE 2009

QN

Quaternary Newsletter

A publication of the
Quaternary Research Association

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 £20 with reduced rates (£10) for students and unwaged members and an Institutional rate of £35.

The main meetings of the Association are the Field Meetings, usually lasting 3–4 days, in April, May and/or September, a 2-3 day Discussion Meeting at the beginning of January and 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 J.D. Scourse***, School of Ocean Sciences, University of Wales (Bangor), Menai Bridge, Anglesey, LL59 5AB. (e-mail: j.scourse@bangor.ac.uk)

Vice-President: ***Professor B.A. Maher***, Lancaster Environment Centre, University of Lancaster, Lancaster, LA1 4YQ. (e-mail: b.maher@lancaster.ac.uk)

Secretary: ***Dr S. Lewis,*** Department of Geography, Queen Mary, University of London, Mile End Road, London, E1 4NS (e-mail: s.lewis@qmul.ac.uk)

Publications Secretary: ***Dr P. Langdon***, Department of Geography, University of Southampton, Highfield, Southampton, SO17 1JB. (e-mail: P.G.Langdon@soton.ac.uk)

Treasurer: ***Dr P. Allen***, 13 Churchgate, Cheshunt, Herts, EN8 9NB (e-mail: Peter.allen@virgin.net)

Editor, Quaternary Newsletter: ***Dr M.D. Bateman***, Department of Geography, University of Sheffield, Winter Street, Sheffield, S10 2TN (e-mail: M.D. Bateman@sheffield.ac.uk)

Editor, Journal of Quaternary Science: ***Professor C. Caseldine***, Department of Geography, University of Exeter , Amory Building, Rennes Drive, Exeter, EX4 4RJ (e-mail: C.J.Caseldine@exeter.ac.uk)

Publicity Officer: ***Dr F. Marret,*** Department of Geography, University of Liverpool, Liverpool L69 3BX (e-mail: f.marret@liverpool.ac.uk)

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

QRA home page on the world wide web at: http://www.qra.org.uk

Registered Charity: 262124

ARTICLES

THE QRA 2008 FIELD GUIDE TO THE QUATERNARY OF GLEN ROY AND VICINITY: A DISCUSSION

J.D. Peacock

The new 2008 field guide is a 'must' for all who are interested in the Quaternary of this key area, which includes the well-known ancient lake shorelines, the Parallel Roads. Among the many subjects covered, the sections on a varve chronology for the lakes with possible links to tephrochronology, and the extensive slope failure in Glen Roy and Glen Gloy are of great significance for the glacial history of the region. The editors, Adrian Palmer, John Lowe and Jim Rose must be congratulated on a fine production. However, the 2008 Guide needs be read alongside that of 1989, in which there is much greater detail concerning Glen Spean, Glen Gloy and Glen Turret. The geomorphology of the last two valleys and that of uppermost Glen Roy is germaine to the age of most of the glacial landforms, whether of Loch Lomond Stadial age (LLS) or earlier. However the ice-flow indicators show that most of the LLS ice in Glen Spean was derived from west of the Great Glen rather than from the Ben Nevis massif.

The following comments, which should be read in conjunction with OS 1:50,000 Sheet 34, are based on the 1989 and 2008 Guides, on other fieldwork carried out prior to the publication of the 1995 BGS 1:50,000 Glen Roy (63W) Sheet), and on the brief Quaternary account in the BGS Memoir (Key *et al*., 1997).

North slope of the Creag Meaghaidh Massif to upper Glen Roy.

The corrie containing Lochan Uaine [NN 420 880] (914 m OD), with its debris-free backwall, is a classic example of LLS glaciation (Sissons, 1979). The low, blocky terminal moraine is fronted by till-covered ground with stone lobes and stone polygons. Below the polygons, northwards from Loch Roy (700 m OD) and Corrie Bhanain [NN 435 900], there are widespread moundy moraines that extend northwards and eastwards from the mouth of the Burn of Agie across the col into the upper Spey valley, almost to the end moraines at the Spey - Yairick confluence [NN 462 955] near Drummin (BGS 63W Sheet; 2008 Guide Fig. 39C). There is no clear distinction between the hummocky moraines of the Roy/Spey valley glacier and those on the slopes to the south, though a low, patchy lateral moraine extends from [NN 422 906] to [415 916] on the slope between the uppermost reaches of the River Roy and Creag a Bhanain.

The moraines of the Roy/Spey valley glacier are cut by the 350 m lake shoreline, and its westward retreat is supported by the presence of Rogen Moraine between the col and Loch Spey. As such it must date from either an early advance and retreat of a glacier during the LLS, which is highly unlikely, or from the Dimlington Stadial. However, it is possible that the hummocky moraines on the north slope of the Creag Meagaidh massif are partly of LLS age (Finlayson and Golledge, 2008).

Glen Gloy.

There is a doubtful trimline at c.490 m on the slope NE of Upper Glenfintaig, but the well-defined 426 m Parallel Road to the east, which is cut into bedrock, indicates a stable lake level with an ice barrier at that height for a significant time, probably that of the maximum extent of the LLS glacier (Figure 1; below). It is noteworthy that there is no evidence for the expected deltaic deposits associated with the maximum of the ice either here or in Glen Gloy itself, perhaps because of the lack of debris in or on the glacier.

Striated bedrock is widespread in lower Glen Gloy, but is confined to the valley bottom and eventually disappears a little north of Glen Fintaig (Figure 1). Farther up the Glen, the bedrock slopes on the west side have failed to depths

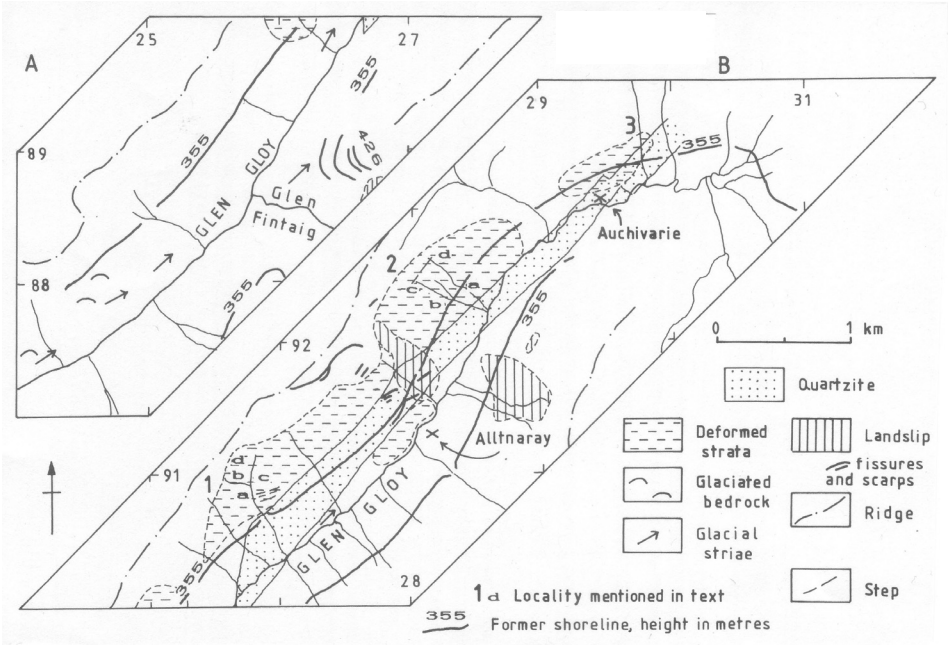

Figure 1. Glen Gloy: selected geological features (From Peacock and May 1993, Fig. 2).

of at least 50 m (Peacock and May, 1993) but, critically, were stabilised prior to the formation of at least the upper of the two widespread Parallel Roads (355 m and 294 m). The 355 m shoreline is up to 8 m wide and is cut into the overturned, but largely intact bedrock. As the Roads are undeformed by slope movement, the failure had clearly taken place before the damming of the 355 m lake. The probability that this part of the valley was glaciated during the LLS is therefore doubtful. Indeed, It is possible that the LLS Gloy glacier did not extend even as far up the valley as the small glaciofluvial delta at Alltnaray, a previously recognised limit (Peacock, 1970; Figure 1). In upper Glen Gloy, about 1 km west of the col into the valley of the Allt a Chomlain, there are exposures of glacially moulded, but unstriated quartzite, and at the 355 m col itself, moundy moraine extends up to 430 m OD. North and east of this, the rock knobs are glacially moulded, but broken.

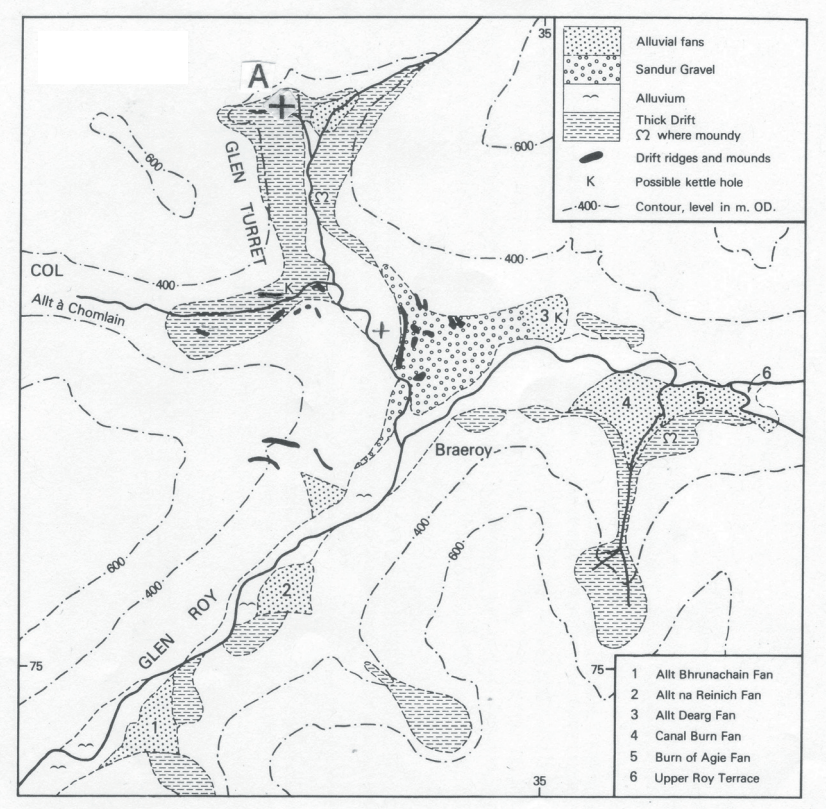

Figure 2. Sketch map of superficial deposits in upper Glen Roy (modified from Peacock 1986, Fig. 2).

Glen Turret and Turret Bank

The subaerial Turret outwash fan and terminal moraines were formed by a glacier occupying Glen Turret (Figure 2). The fan gravels, which are overlain by lake sediments, descend to well below 260 m,. As such, they must have been laid down before the formation of the Parallel Road at this level, and Peacock (1986) suggested that they were constructed prior to the LLS. An objection to this view is that there is no evidence for the preservation of organic sediments of Windermere Interstadial age in a kettlehole immediately upstream of the moraines (Lowe and Cairns, 1991; below). To reconcile the apparent contradictions, Benn and Evans have suggested that that the moraines are those of the outlet glacier of an early-formed LLS ice-cap which occupied the plateau north and east of Glen Roy (2008 Guide). They propose that the outlet glacier had started to retreat well before before LLS ice had reached its maximum extent in Glen Roy, but that it was still contributing sediment into upper Glen Turret at the time of the 350 m Parallel Road lake.

Unfortunately there is little or no support for the last proposition, either from field mapping (Peacock, 1986) or from a study of NEXTMAP imagery (Chen and Rose, 2008). The disposition of the Turret moraines suggests they were formed by a glacier that extended into Glen Turret from Glen Gloy from the west, and not from the proposed plateau glacier. In this connection, gravel ridges (lateral moraines?) on both banks of the Allt a' Chomlain, a little upstream of its confluence with the Turret, may mark the position of a minor ice front associated with the westward retreat of such a glacier. Roches moutonnées and striae at the head of the V-shaped Allt Eachach valley (the location of the outlet glacier) indicate ice-movement to the NE, which is the direction of movement of the former Dimlington Stadial ice-sheet, and not to the SW. Further, the sediments in the section [NN 3297 9430] on the right bank of the Turret (A on Figure 2), which Benn and Evans suggest are those associated with the 350 m lake, show post-depositional glacial disturbance. Details of the exposure are as follows:

	m
Diamicton (till), silty, sandy, with gravel and striated boulders to 0.5 m	4.0
Silt, laminated	0.3
Interbedded (1) very poorly sorted gravel, cobbly diamicton, and angular to subangular gravel in beds 1-3 m thick, and (2) hard, flat-bedded silty sand in beds 0.2-0.5 m thick, with scattered pebbles. Laminations in silt and sand deformed, impersistent.	13.0
Sand, hard, sheared, with pebbles	0.6
Sand, poorly sorted with pebbles, cobbles and boulders, poorly exposed	13.0
Bedrock, broken	

The deformation and compaction of the sediments underlying the till probably resulted from overriding by glacier ice, a suggestion supported by hydrofracturing in the deformed strata (Jon Merritt, pers. com. 2008).

There is no delta at or near the Turret fan associated with the 260 m lake, and the subaerial outwash was deposited at levels from 270 m to well below 240 m OD. The evidence thus indicates that the fan and moraines antedate the 260 m lake of the rising sequence, and thus the latter half of the LLS according to the Master Varve Chronology (Palmer, 2008). This being so, any organic material of Windermere InterstadIal age in the kettlehole behind the fan, if present, would have been overlain by sediment reworked from the Turret outwash and moraines or by deltaic deposits from farther up valley, and thus difficult to hand-auger (Peacock and Cornish, 1989; Lowe, 2008, option 3, p.165). Likewise, some modification of the fan surface would be expected, especially at the time of the 260 m lake.

There is no ready explanation for the fact that ice-dammed lakes were absent above 240 m during the deposition of the Turret outwash. However, this subsumes the view that the situation during the Dimlington Stadial deglaciation was similar to that at the close of the LLS. It is conceivable that the distribution of remnant ice masses in Glen Spean and the Great Glen differed from that of the LLS, allowing free drainage along at least the middle and lower reaches of Glen Roy and Glen Gloy, with the highest levels of any ice-dammed lakes (if such existed) being well below the lowest Parallel Road at 260 m OD. Were the draw-down of ice in the Great Glen to be rapid, perhaps consequent in part on high early Late-glacial sea-levels in Loch Linnhe, it is possible that parts of glaciers in some valleys would have become detached, including that in the upper part of the Glen Gloy. Expansion of the latter ice-mass during a short-lived climatic deterioration prior to the LLS would result in a readvance into Glen Turret to form the Turret moraines and outwash, and its disappearance would allow the stabilisation of the slopes in Glen Gloy, and the cutting of the 355 m Parallel Road during the LLS.

Conclusions

It is difficult or impossible to fit all the glacial events in Glen Spean, Glen Turret, and uppermost Glen Roy into the LLS, and other explanations must be sought. The above suggestion concerning the distribution of remnant ice-masses during the Dimlington Stadial deglaciation must be regarded as tentative, and it is possible that much better hypotheses will follow detailed geomorphological mapping, particularly in the Great Glen, and from more precise cosmogenic and single-grain luminescence dating.

Acknowledgments

I am grateful to Jim Rose for suggesting improvements to the text. Figures 1 and 2 are published with the permission of the editors, Scottish Journal of Geology.

References

Benn, D. and Evans, D. (2008). A Younger Dryas ice cap to the north of Glen Roy: a new perspective on the origin of the Turret Fan. In: Palmer, A.P., Lowe, J.J. and Rose, J. (eds.) *The Quaternary of Glen Roy and vicinity*, *Field Guide*, Quaternary Research Association, London, 158-161.

Finlayson, A. and Golledge, N. (2008). The northern Creag Meagaidh massif: geomorphology and glacier modelling. In: Palmer, A.P., Lowe,J.J. and Rose, J. (eds.) *The Quaternary of Glen Roy and vicinity*, *Field Guide*, Quaternary Research Association, London, 110-118.

Chen, C.Y. and Rose, J. (2008). A DSM perspective on the geomorphology of the region around Glen Turret and the adjacent part of Glen Roy. In: Palmer, A.P., Lowe, J.J. and Rose, J. (eds.) *The Quaternary of Glen Roy and vicinity*, *Field Guide*, Quaternary Research Association, London. 150-157.

Key, R.M., Clark, G.C., May, F., Phillips, E.R., Chackfield, B.C. and Peacock, J.D. (1997). *Geology of the Glen Roy District*: Memoir for the 1:50 000 Geological Sheet 63W. British Geological Survey. The Stationary Office, London.

Lowe, J.J. (2008). pollen stratigraphy of the Turret Bank pollen site (NN 337 927). In: Palmer, A.P., Lowe, J.J. and Rose, J. (eds.) *The Quaternary of Glen Roy and vicinity*, *Field Guide*, Quaternary Research Association, London, 162-165.

Lowe, J.J. and Cairns P. (1991). Pollen-stratigraphic evidence for the deglaciation and lake drainage chronology of the Glen Roy-Gen Spean area. *Scottish Journal of Geology*, 27, 41-56.

Palmer, A.P. (2008). Developing a varve chronology for the Spean-Roy lakes: the Lochaber Master Varve Chronology (LMVC). In: Palmer, A.P., Lowe, J.J. and Rose, J. (eds.) *The Quaternary of Glen Roy and vicinity*, *Field Guide*, Quaternary Research Association, London, 139-149.

Palmer, A.P., Lowe, J.J. and Rose, J. (2008). *The Quaternary of Glen Roy and vicinity*, *Field Guide*, Quaternary Research Association, London.

Peacock, J.D. (1970). Glacial geology of the Lochy-Spean area. *Bulletin of the Geological Survey of Great Britain*, 31, 185-198.

Peacock, J.D. (1986). Alluvial fans and an outwash fan in upper Glen Roy, Lochaber. *Scottish Journal of Geology*, 22, 347-386.

Peacock, J.D. and Cornish, R. (1989). *Glen Roy area*, *Field Guide*, Quaternary Research Association, Cambridge.

Peacock, J.D. and May, F. (1993). Pre-Flandrian slope deformation in the Scottish Highlands: examples from Glen Roy and Glen Gloy. *Scottish Journal of Geology*, 29, 183-189.

Sissons, J.B. (1979). The limits of the Loch Lomond Advance in Glen Roy and vicinity. *Scottish Journal of Geology*, 15, 31-42.

Dr. J.D. Peacock
18 McLaren Road
Edinburgh
EH9 2BN

OBITUARY

DEATH OF GEOFF BARTINGTON

Exciting research developments in environmental science often arise, in part at least, from technical innovations. The use of magnetic measurements to increase our understanding of environmental systems began in the early 1970's, at a time when appropriate instrumentation was not available. One sign of early progress in response to the need for new instrumentation was the development of the Bartington equipment for field and laboratory measurements of magnetic susceptibility. It opened up a wide range of applications, for example in Quaternary sediment stratigraphy, soil survey, archaeological prospecting, core scanning, sediment source ascription and particulate pollution studies. This equipment was designed and created by Geoff Bartingon who died on December 13, 2008. The revolutionary design, based on a meter to which a diverse range of sensors could be attached, was developed by Geoff in 1978, in his home, with minimal financial support and little prospect of any significant future payoff. By now, it is the longest serving item in an array of specialist equipment produced by the highly successful Bartington Instruments, established in 1985.

I was privileged to share in the development of the system with Geoff having met him at his workbench in Littlemore Scientific where I had gone to test and then purchase a classic susceptibility 'bridge' that he had made. After some excited discussions about needs and applications, he offered to carry the susceptibility meter to my car – an apparently unnecessary favour as it was small and light. Despite my protests, he insisted. Once we were outside, his motivation in accompanying me to the car became clear. He had envisaged the type of equipment I was keen to have and he was very keen to build a prototype. The problems were twofold. His boss, Prof. Teddy Hall, was against the idea as a waste of time and effort; moreover, Geoff did not have the money to buy the essential materials for the project as he was raising a family on a small salary with nothing to spare. I had just been given a small grant by the Institute of Hydrology for tracing stream gravel and decided there

and then to hand the lot over to him. We liaised over the next week about the broad requirements and performance specifications, after which I waited. In due course, the prototype meter (housed in a varnished marine ply box made by Geoff's twin brother) plus sensors arrived. There followed a good deal of collaborative work. Thanks to Geoff's creative genius and good humour, it felt like a cheerful conspiracy. The realization that there were interesting lessons to be learned from trying to characterize as economically as possible the frequency dependent component of the low field susceptibility led to the development of the MS2B dual frequency sensor. That in itself was a stroke of genius on Geoff's part and came to fruition only after many trials.

I can best illustrate the importance of Geoff Bartington's contribution to Quaternary Science by highlighting the key role of the dual frequency sensor in loess studies. By the mid 80's, Liu and Kukla had demonstrated the close correlation between the sequence of loess and palaeosol layers in the classic loess sections and the marine isotope stratigraphy that recorded orbital forcing of the Earth's climate during the Quaternary. The clearest demonstration of the correlation came from magnetic susceptibility measurements that showed higher values in the interglacial palaeosols than in the intervening loess layers. Early attempts to explain this postulated that the alternations were the result of a broadly constant flux of atmospherically deposited magnetic particles that became diluted during glacial periods by enhanced deposition of less magnetic dusts from the continental interior. In 1984, I was in Kashmir. Sitting alongside a small section in Pleistocene loess in the Himalayan foothills, I started to make the first dual frequency measurements of alternating palaeosol and loess layers using the first stable and sensitive dual frequency sensor. Within less than an hour it became clear that the main process modulating variations in susceptibility was pedogenesis.

Not until these measurements of frequency dependent susceptibility were made was it possible to show that the orbitally tuned signature in the loess was largely the result of soil formation during interglacials, leading to the secondary enhancement of fine grained magnetic minerals. (Zhou *et al.,* 1990). This opened up the way for a suite of highly significant papers using the magnetic susceptibility records from Loess profiles as a basis for reconstructing the palaeoclimate of successive interglacial stages. This is just one example of the key role played in Quaternary science by Geoff Bartington's pioneering innovation in instrumentation. The development of new instrumentation runs like a thread through so much of what has driven changes in environmental science over the last decades. It is rare for a key innovation to be linked exclusively to the inventive genius of a single person. By writing this brief note I want to record and honour the work of Geoff Bartington and the role it played in the development of environmental magnetism.

References

Zhou, L.P., Oldfield, F., Wintle, A.G., Robinson, S.G. and Wang, J.T. (1990). Partly pedogenic origin of magnetic variations in Chinese loess. *Nature,* 346, 737–39.

Prof Frank Oldfield
Geography Department
University of Liverpool
Liverpool
L69 7ZT

REPORTS

THE 7TH INTERNATIONAL QRA POSTGRADUATE SYMPOSIUM

Liverpool, U.K. 19th-22nd August, 2008

This year's symposium was held at the Department of Geography, University of Liverpool, and was organised by **Katherine Welsh**, **Ian Thrasher**, **Lee Bradley** and **Ningning Li.**

19th August: The conference opened with a wine reception in the Department of Geography, which provided an excellent opportunity for delegates to get to know each other and meet the conference organisers, as well to set up posters. The organisers then directed everybody to a restaurant nearer the centre of town, allowing everyone to see some cultural sights along the way.

20th August: The first day of oral presentations was divided into four sessions in addition to a keynote lecture by **Professor Richard Bradshaw**, who gave a fascinating talk focussing on geosciences meeting biology by putting a time-scale into biology. Particular attention was paid to the importance of climate and humans as driver's of Late Quaternary ecosystem change, threats posed to biodiversity as a result of these changes and the ability of biological systems to adapt.

The opening session covered a variety of stimulating talks that focussed on both human and climatic impacts on palaeoenvironments during the Quaternary. Talks were given by **Alice Milner** (University of Leeds), **Alistair Seddon** (Oxford University), **Emily Forster** (University of Southampton), **Joseph Williams** (The Open University), **Macarena Cardenas** (The Open University), **Rose Wilkinson** (University of Manchester) and **Sarah Callard** (University of Plymouth).

The second session consisted of a range of interesting talks that covered a variety of Quaternary dating methods including the use of cosmogenic analysis, microtephras, optical-stimulated-luminescence, radiocarbon dating, shell chronology and metal pollution dating. Talks were given by **Abi Stone** (Oxford University Centre for the Environment), **Christine Lane** (Research Laboratory for Archaeology, Oxford University), **Georgina King** (St Andrews University), **Ginette Warr** (University of Liverpool), **Jake Boex** (University of Exeter), **Paul Butler** (Bangor University), **Rachel Wood** (Research Laboratory for Archaeology, Oxford University), and **Hayley Mills** (University of Liverpool).

The final oral sessions of the day covered geoarchaeology from a range of sites found as locally as the British Isles, to as far a field as central Europe

and Morocco. In the first of these sessions talks were given by **Anna Oh** (Research Laboratory for Archaeology, Oxford University), **Caroline Juby** (Royal Holloway University of London), and **Eline van Asperen** University of York). The second session closed with talks from **Heather Adams** (University of Plymouth), **Michelle Farrell** (University of Hull), **Ruth Sowa** (Royal Holloway University of London) and **Tudur Davies** (University of Sheffield).

The day came to a close with a poster session and wine reception, which provided an ideal way to present posters in a relaxed environment as well as discuss the day's oral presentations and share experiences and advice both at a professional and social level. Posters were presented by **Emma Watcham** (Durham University), **Nick Felstead** (Liverpool John Moores University), **Abi Stone** (Oxford University Centre for the Environment), **Karolina Leszczynska** (Cambridge University), **Daniel Colton** (University of Liverpool), **Emma Shuttleworth** (University of Liverpool), **Lee Bradley** (University of Liverpool), **Ian Thrasher** (University of Liverpool) and **Katharine Welsh** (University of Liverpool). The evening again finished with much socialising both over dinner and a few drinks in the culturally diverse city centre of Liverpool.

21st August: Day two contained just three sessions and another absorbing keynote lecture, this time given by **Professor Frank Oldfield**. Professor Oldfield talked us through how the palaeo record, in its various forms, can inform and aid the answering of some of today's major global environmental issues. A particular focus was given to how both the past and present play vital roles in shaping the future of the earths' climate.

Two back to back sessions contained nine fascinating talks, which covered a range of proxy reconstruction methods, timescales and environments. Talks were given by: **Gina Moseley** (University of Bristol), **Gunnar Mallon** (University of Southampton), **Heidi Rea** (Queens University Belfast), **Jessie Woodbridge** (University of Plymouth), **Keziah Stott** (St Andrews University), **Ningning Lee** (University of Liverpool), **Tim Jones** (University of Leeds), **Guan Wang** (Lanzhou University), and **Shabnam Delfan Azari** (University of Plymouth).

Unusually for the QRA, only two presentations were given in the glacial environments session. **Deborah McCormack** (University of Manchester) and **Nanna Karlsson** (University of Hull) however, both gave interesting and beautifully illustrated talks.

The closing sessions provided a tour around the world, looking at the development of varied sedimentary landforms. The first three talks, from **Ann Rowan** (University of Manchester), **Greg Whitfield** and **Hywel Griffiths** (University of Aberystwyth), all focussed on Quaternary river development. Then the three last presentations took us to Antarctica (**Benedict Reinardy**, University of Swansea), to Italy (**Rajasmita Goswami**, University of Manchester) and

back to finish in the UK with **Stuart Glenday** (Queen Mary's University of London).

During the final day a meeting was held to discuss postgraduate business. **Christine Lane** stood down after two years as QRA Postgraduate Representative and **Gunnar Mallon** was elected to work alongside **Lorna Linch**. A vote was also held to select the venue for the 8th Postgraduate Symposium, in 2009, and the **University of Manchester** was chosen as the preferred venue.

In the evening the delegates headed to "60 Hope Street" for the conference dinner, which provided a rewarding close to two highly enjoyable days. Here, Katherine Welsh announced the two winners of the best presentation prizes. They went to: **Gina Moseley**, for her talk on the reconstruction of sea level high stands in Conch Bar Cave, Middle Caicos; and **Abigail Stone**, who outlined difficulties in OSL dating of linear dunes in the Kalahari Desert. A big thank you was given to the organising team at the University of Liverpool, in particular to **Katherine Welsh**, **Ian Thrasher**, **Lee Bradley, Ningning Li** and **Greg Whitfield**.

22nd August: Despite a full evening of socialising at the conference dinner followed by dancing at one of the numerous popular nightclubs in the city centre, there was good show of faces early the next day for the field trip to the Wirral Peninsula. Everyone took a coach down to Thurstaston Cliffs where we were met by **Dr Geoff Thomas** (University of Liverpool). From here, we took a gentle stroll along the beach, led by Geoff, who discussed the dynamic complex of glacial stratigraphy of the cliffs and the various arguments that had been put forward to explain such a diverse depositional environment. As a group we identified the major lithofacies that compose the contemporary cliff section, including lower and upper diamictons (both considered subglacial in origin), and occasional discontinuous zones of parallel laminated sands (considered to be deposited by subglacial meltwater channels). Sediment texture and structure were described and our own preliminary interpretations were discussed including, for example, the genesis of boulder pavement found near the lower boundary of the upper diamicton.

Lunch was provided in a quaint local ale house where everybody enjoyed a buffet and a sneak catch-up of the Beijing Olympic Games. Following lunch, the group travelled to the second site of the field day near Thurstaston Common. Everyone walked to the summit of Thurstaston Hill where four large, sandstone tor stumps that are believed to be glacially modified are located. "Tor stone", one of the largest sandstone bedrock outcrops incised with sinuous, undulating and smooth channels, was our focus of interest. Once again, Geoff enthusiastically talked us through his vast knowledge of these features and the various explanations that have been proposed over the years for their formation. While some believe that these features are Nye Channel incised by subglacial

waters, others believe they are simply Victorian artefacts, incised by years and years of children playing and running over the rock. The group inspected the channels and discussed their own ideas for potential methods of channel formation within the somewhat wonderfully surreal context of thousands of graffiti carvings that almost entirely cover the surface of the relatively soft sandstone tor today.

Ian Thrasher and Katharine Welsh expressed our great thanks to Dr Geoff Thomas for leading the day's field excursion with his incredible enthusiasm and in-depth knowledge of the history of the area. On behalf of the QRA, we'd like to thank all those involved in the symposium for such a great week.

Christine Lane
Research Laboratory for Archaeology
University of Oxford

Lorna Linch
Department of Geography
Queen Mary University of London

BRITISH PERMAFROST AND PERIGLACIAL ASSOCIATION FIELD MEETING BRECKLAND, EAST ANGLIA

27th – 29th March 2009

The inaugural field meeting of the British Permafrost and Periglacial Association to the Brecklands was heralded in with a blast of Arctic air to keep us suitably chilled for this two day fieldtrip. The evening session on 27th March was opened by Mark Bateman (Sheffield), who warmly welcomed the ten participants. The first talk of the evening was by Jon Lee (BGS), who summarised the recently-completed BGS mapping of the Thetford District. Stephen Hitchens (Sheffield) concluded the evening's proceedings by presenting an overview of his PhD research which applied OSL dating to develop a more detailed understanding of process and associated chronology of periglacial features in the Brecklands; the key sites would form the focus for this meeting.

Saturday 28th March

The first site visited was Wangford Warren, a relict, vegetated dune field abutting RAF Lakenheath. Stephen Hitchens described the results of a borehole through the sedimentary sequence which indicated two phases of dune mobilisation separated by a period of soil formation. OSL dating had indicated both phases corresponded to the Late Holocene. The site may have contributed sediment to the 'sand flood' of 1668, which overwhelmed the nearby village of Santon Downham.

With the morning's rain easing the group headed to Barnham Heath where Jon Lee described a valley infill sequence of sands and gravels interpreted as Anglian outwash. The main focus of the site though was the unpaired terrace sequence of the Little Ouse River, previously a westward flowing tributary of the Bytham River, but now a misfit stream flowing through the Fen Basin. Jon Lee assigned the highest of the three terraces to MIS 2, coincident with the initiation of coversand deposition within the region, with the remainder having formed during the Holocence.

After a brief lunch break in Thetford, the group re-convened at Brettenham Heath to examine the relict sorted polygons (Figure 1). Stephen Hitchens and Mark Bateman had dug a trial pit to expose a cross-section of one such feature, the sandy (coversand) infill of which Stephen had systematically sampled for OSL dating. The OSL ages spanned a large part of the Devensian, and Stephen suggested a phase of activity around the time of the Last Glacial Maximum (LGM). Julian Murton raised the possibility that coversand deposition may also have occurred during MIS 4, when eastern England would have been

underlain by permafrost yet sufficiently windy for aeolian activity to prevail, with reworking of sand during the LGM. Frank Nicholson suggested that the oldest coversand might be found in the chalky intertrough part of the patterned ground, which had probably been subject to soil circulation inward from the sides and upward in the centre. Interestingly, the coversand contained several flint pebbles, which may record frost heave. Additional debate ensued with respect to the processes responsible for eroding the chalk bedrock, in particular the effect of post-depositional solution in deepening the sand-filled troughs and whether infilled relict thermal contraction cracks were present beneath some of them.

Figure 1. Vertical section across two sand-filled troughs associated with polygonal patterned ground at Brettenham Heath.

The final stop was to view the sorted stripes at Grimes Graves, most of which had been systematically obliterated by agricultural management. But, as noted by Frank Nicholson, it was frost heave on the flint pebbles within the chalk that had encouraged Neolithic settlement here in the first place. The day culminated with a visit down the Neolithic flint mine, where it was collectively agreed that cleaning sections with nothing more than a sharp piece of flint would be hard work!

Sunday 29th March

The opening site was Beeches Pit at West Stowe, last visited by the QRA during the 2000 Annual Field Meeting but which had focused on the significant archaeological and macrofaunal assemblages. The sedimentary unit of interest though for the current meeting was the uppermost periglacially-disturbed gravel unit (Bed 9). Fortuitously the trenches dug for these earlier investigations still remained so the group were afforded several exposures of the unit. Stephen

Hitchens provided an overview of Quaternary geology: a tunnel valley incised into brecciated chalk, infilled with Lowestoft Till (MIS 12) and overlain by interglacial (Hoxnian) deposits. A key question raised by Mark Bateman concerned the age of this gravel bed: in the absence of evidence for a periglacial land surface, unlike at Hoxne, was it deposited during MIS 10, or MIS 2? Jon Lee considered that since there was no evidence for glaciotectonism it was unlikely to be MIS 10. However, Frank Nicholson countered that had the site been underlain by permafrost then sub-glacial deformation would be unlikely. At a second section, Julian Murton observed a sandier facies within involutions that, if coversand, could be dated by OSL and so constrain the period of deposition.

Onward to the Great Eastern Pingo Trail at Thompson Common, where Tim Holt-Wilson opened the discussion as to whether the rampart features clustered within this locality were actually former pingos, or palsas (Figure 2). Since these ramparts were not situated on an obvious valley floor Julian Murton considered a palsa interpretation to be more plausible; open-system pingos require a hydraulic gradient whilst palsas develop through the process of ice segregation. However Frank Nicholson argued that uni-directional freezing from the active layer would be sufficient to generate the cryosuction necessary to initiate pingo formation.

Figure 2. Low rampart surrounding a pond that may have formed by melting of a former pingo or palsa, Great Eastern Pingo Trail, Thompson Common.

After a hearty thee-course lunch at a local hostelry the final stop, near Croxton, was fittingly a doline, known as the Devil's Punchbowl. The BGS mapping had indicated a concentration of dolines in the Thetford district with a WNW– ESE alignment, normal to the strike of the chalk. It was uncertain whether this reflected former fault lines or fracture zones. These dolines were unusual in that they exhibited little seasonal variation in water level despite being groundwater-fed.

Julian Murton concluded the meeting by thanking the organisers for highlighting the exciting array of periglacial features in the Brecklands and for succinctly pinpointing the outstanding research problems.

Della Murton
School of Earth and Ocean Sciences
Cardiff University
Main Building
Park Place
Cardiff
CF10 3YE

QRA FIELD MEETING TO THE SOLENT BASIN AND WEST SUSSEX RAISED BEACHES

Southampton, 4TH – 8TH April 2009

Introduction

A group of more than fifty delegates took part in the 2009 QRA annual field meeting which was run jointly with the Prehistoric Society, and held at the University of Southampton. The meeting was designed to give an overview of the Quaternary development of the Solent Palaeo-basin and to address ongoing debates about differing stratigraphies and dating methods. Proceedings were started off by an evening of interesting introductory talks by **Becky Briant** (Birkbeck), **Ceri James** (BGS), **Martin Bates** (Lampeter), **Robert Hosfield** (Reading) and **Francis Wenban-Smith** (Southampton), which highlighted the importance of the recent work carried out in the region. The talks also raised a series of questions, which were to be addressed and considered over the next few days. Following the talks a selection of local ales were sampled in the various pubs around Southampton.

Day 1: Sunday, 5th April – Sussex Raised Beaches

The first stop of the field meeting took place at Warblington, Hampshire, a site of newly discovered last glacial lake deposits. **Martin Bates** gave an excellent introduction to the recent work carried out as part of the PASHCC project on depositional history of the area and the sources of proxy information. Using a series of posters, **Bates** explained how two OSL dates suggested that the present raised beach system belonged to Marine Isotope Stage 5e (MIS5e) rather than MIS7, whilst the characteristics of the microfossil material closely resembled that of the Brighton / Norton raised beach system. Furthermore evidence of three to four metres of chalky solifluction deposits in the adjacent graveyard was discussed. Issues over dating in conjunction with evidence of fresh water cold loving ostracod species, which supported the cold stage pollen based evidence, raised the important point that the palaeoenvironment may have been one of tundra pools found across a coastal plain. The faunal evidence found in the chalky deposits further suggested that there was a permanent deep body of water present surrounded predominantly by grassland. This led to a debate over how these large standing bodies of water could affect the archaeological potential of these deposits, which are very different to those seen within the Solent basin, and whether it is possible to have ponds in a soliflucting landscape. After a brief look at the beach and at cores that **Bates** had recently extracted the group headed towards Selsey, to look at interglacial deposits beneath a MIS5e beach.

At Selsey, **Bates** explained that there were two different sequences of sediment within the infill of the interglacial channel deposit (Figure 1). The northern part was filled with sands and rich in palaeontological remains whilst the southern section of the channel consisted of organic clay silts resting on gravels. Differences in marine and estuarine origins between the different sections highlighted that the area around Selsey shifted from a marine to an estuarine embayment during the last interglacial. In addition, all palaeoecological evidence showed that the Pleistocene channel structure at West Street was fully temperate and not cold, as seen at the other sites. **Bates** concluded that the section was formed in a warm wooded temperate environment on the edge of the channel. Filled with new insights and many more questions, the group settled down to have a relaxing lunch on the beach in the great southern English sunshine. Following lunch and a leisurely stroll through the quiet seaside town of Selsey, the group was back on the coach and heading off to the next destination.

In the afternoon, the group visited Slindon valley and Boxgrove, both very

Figure 1. Martin Bates leading discussions at Selsey (photo Pete Langdon)

important archaeological sites. At the National Trust reserve at Slindon Park, **Mark Roberts** (UCL) and **Matthew Pope** (UCL) explained that the sediments of the Slindon Formation extended along an east-west axis informally termed the Westbourne to Arundel raised beach. After a short walk through the forest the presence of the Boxgrove cliff and raised beach was clearly shown through a series of test pits. **Roberts** went on to show that a clear cliff-line existed with raised beaches on both sides. However, snowmelt from the last deglaciation

was responsible for cutting away sections of the cliff. Despite archaeological evidence being mixed with medieval material, the group was astonished when **Pope** produced a small hand-axe made from a beach pebble, which was passed around for the group to appreciate. Fuelled by the educational sections at Slindon, the group was eager to get to Boxgrove. The excitement, however, was temporarily halted by the coach-drivers spectacular parking lot manoeuvring, which prompted some delegates to put on their high-visibility jackets.

At Boxgrove, the group was treated to a rare hands-on display of artefacts and fossilised bone remains excavated from the site. **Roberts** explained how the site was unique as special restoration measures had been taken and only material from the adjacent pit was used to backfill the site, along with plans to plant trees, hedges and grasses on the bank surrounding the site, which also happened to be the location of the Boxgrove cliff. **Roberts** went on to explain how pond deposits were found at the site, containing excellent faunal micro-remains and archaeological finds. The group was then allowed to carefully explore the site and three open sections, which clearly showed lacustrine deposits. After a long and exciting day the group headed back to Southampton for some well-deserved drinks.

Day 2: Monday, 6th April – Isle of Wight

Following an early start to the day, the group enjoyed a hearty breakfast on board the ferry to the Isle of Wight which was to prepare them for another packed day of site visits and debates. The first site to be visited was Priory Bay, a site that has attracted much research attention in the past. During the 1987 QRA field meeting a section was cleared exposing a gravel deposit overlain by brick-earth. **Wenban-Smith** led the visit and showed the group two sections, which he had exposed in 2001 (Figure 2). A geological debate about whether the gravel deposits were of beach or fluvial origin ensued with good arguments for both interpretations. **Wenban-Smith** then passed around examples of artefacts found at the second section in the archaeologically rich gravel deposits. The gravel deposits produced two separate lithic assemblages, a very abraided and worn one on beach cobbles, and a fresh unabraided one on flint. A hand-axe, found at the site, showed this differing assemblage very clearly, since one face of it was worn and very abraided whilst the opposite face was not. **Wenban-Smith** put forward the interpretation that it was originally knapped at the time that the older assemblage was deposited and it was then reworked at a later stage. Numerous discussions followed surrounding the dating of the site and the provenance of the flint on which the fresh artefacts were knapped.

After lunch the group proceeded to Watcombe Bottom near Ventnor in the south of the Isle. **Richard Preece** (Cambridge) led the discussions and gave a very comprehensive and insightful introduction to current issues surrounding

the area followed by an overview of how the tripartite lithostratigraphy of the late glacial deposits formed within a sequence of chalky slope sediments. The site is very unique, since it is one of the very few sites in Britain where the Allerød soils on display can be observed in an open section. A lively discussion ensued regarding the possible palaeoenvironment and the affect an extraterrestrial impact would have had following Preece's account of Firestone *et al.*'s (2007) nano-diamonds paper. The presence of nano-diamonds has been confirmed at Watcombe Bottom alongside a series of Dutch sites, strengthening Firestone *et al.*'s theory, which attributes the Younger Dryas cooling event to an extraterrestrial impact, around 12900 years ago.

Figure 2. Richard Preece and Francis Wenban-Smith at Priory Bay (photo: Pete Langdon)

The final site visit on the Isle of Wight was to St. George's Down where **Peter Hopson** (BGS) and **Andrew Farrant** (BGS) spoke of the recent work by the BGS regarding the remapping of the Isle at a 1:10 000 scale. **Hopson** presented a number of complex issues surrounding the deposition of the Plateau Gravels leading to an interesting discussion. **Hopson** went on to highlight the importance of the presence of a series of north-south disturbances running through the divergent monocline as one of these may have resulted in the southern swing of the Solent River to the east of the Isle. It was also noted that within the quarry itself there are large clay deposits containing organic horizons. The provenance of these deposits, however, is still uncertain and sparked lively debate as to their origins on which **Tony Brown** (Southampton) offered a number of possible explanations. The general consensus following a long discussion was that further fieldwork into the provenance of the clay deposits was needed.

Day 3: Tuesday, 7th April – Solent River (New Forest)

Day three focussed on the western Solent Basin and was lead by field-meeting organiser **Becky Briant**. Still enjoying the splendid weather, the group arrived at Barton-on-Sea to look at a coastal section of middle Pleistocene river gravels referred to by Allen and Gibbard (1993) as the Old Milton Gravel and redefined in distribution by Westaway *et al*. (2006). **Briant** explained how some of the OSL dates from recent work, placing the fluvial gravels to around 330-410 ka BP, needed to be reassessed as samples might have been close to saturation. A relatively large number of 'twisted-ovates' had reportedly been found at the site, which led Rob Westaway (OU) to include this evidence in his dating model. **Francis Wenban-Smith** warned of the dangers of using archaeological evidence as part of a dating framework, as material may be reworked or early accounts of finds may not be entirely reliable. An informative discussion between **Westaway** and **Wenban-Smith** arose, weighing up the pros and cons of the differing approaches. This discussion was brought to an abrupt end by **Charles Turner's** (Cambridge) recital of a dating related poem. The group then carefully made their way to the cliff section, where **Richard Preece** drew attention to the presence of the Barton Sands and their tropical palaeoclimate connotations. Most delegates consequently spent some time searching the cliff face for hand-axes, especially 'twisted-ovates', without any luck, before making their way back to the coach to move on to the next gravel section, this time at Lepe Country Park (Figure 3).

Figure 3. Participants looking for artefacts at Barton-on-Sea

Lepe Country Park is used by many schools for day trips and it is worth mentioning that an inspirational and highly informative outreach package, including a handout and worksheets suggesting activities, was produced by **Becky Briant** on behalf of the QRA and is available at the Park Office. When the group arrived at the SSSI site, Stone Point at Lepe Country Park, they found a section, opened by **Martin Bates**, showing the upper part of the Lepe sequence. A series of OSL dates from the site placed the upper gravel at around 65 ka and the lower to between 120 and 200 ka. **Westaway** added to **Briant's** discussion by explaining the complexities relating to the Solent River terraces and how uplift and back-tilting of the local region can explain the terrace system found downstream. Further illustration came from **Frank Green** (New Forest National Park Authority) about the site's historical relationship to Portsmouth. The site is a very important one, as interglacial deposits are relatively rare in the Solent area. Evidence from pollen, macrofossils, ostracods, diatoms and foraminifera showed a distinct change from the base of the sequence at -8.5 m O.D. from grassland to birch to temperate mixed oak with hazel communities. The salinity signature was harder to read, with most proxies indicating a brackish- estuarine environment with sporadic evidence of freshwater. This led to the conclusion that The Needles on the Isle of Wight were a recent development, as discussed by **Ceri James** during the introductory lectures. The group used the opportunity to have lunch on the beach again while a second section was being dug, which clearly showed the previous PASHCC trench as well as the interglacial deposits discussed by **Briant** relating to the lower Lepe sequence.

The group finally had to gear up in full combat montage due to health and safety reasons, consisting of a hard-hat, high-visibility jacket and safety specs at the final site of the day, Badminston Farm Quarry. The gravels at the site formed part of the Allen and Gibbard's (1993) and Westaway *et al.*'s (2006) Tom's Down Gravel. Since these studies place the gravels at differing times, **Briant** explained the methods behind recent OSL work on the site, which dates the gravels to around MIS8 – MIS9. **Westaway** helped to clarify some of the confusion surrounding the different age predictions of the two conflicting stratigraphic models by explaining the differences in projected angle regarding the terraces. **Briant** further expanded on the problems regarding OSL dating and sample saturation and the fact that the gravels were hard to distinguish on lithological grounds as they came from the same catchment. This led **Dave Bridgland** (Durham) to harshly conclude that all Solent gravels were "relatively dull". None-the-less the group did not pass up the change to rummage around the 'reject pile' for artefacts, only to emerge empty handed, before heading back to Southampton.

Day 4: Wednesday, 8th April – Holocene human activity in the New Forest

Despite the reduced numbers, the final day of the fieldtrip proved to be highly enjoyable and provided a welcome change from inert objects to living matter in the capable hands of **Michael Grant** (Wessex Archaeology) and **Keith Barber** (Southampton). With the weather still holding up the group enjoyed a leisurely walk between locations through the New Forest. The day was made even more entertaining by **Barber's** many anecdotal tales of natural weed killers, TV appearances, illegal peat cutting and Schulze's Gunpowder Factory. On a ridge overlooking the main Cranes moor mire system, **Michael Grant** gave a very insightful introduction to the New Forest and its shallow mires, which is the largest mire system in southern Britain. **Barber** went on to explain that the small hills seen near the location were by no means glacial dunes but were in fact gravel deposits from the river Avon. A brief description of the recent archaeology told of a number of hill forts that were located on the ridge overlooking the Avon valley, which serves as an Iron Age clan boundary and marks the boundary of Barton sand with Pleistocene gravels. The walk to Cranes Moor offered many unforeseen yet exciting sights, such as a well exposed and nicely developed podsol section, which was promptly cleaned up and interpreted by **Jim Rose (**Royal Holloway). Other rare sights were two common adders (*Vipera berus*) in the manage-burned heath surrounding Cranes Moor. To perfectly link the archaeological evidence from previous three days with the sites of the day, **Rob Hosfield** found a well preserved Neolithic flake within reach of the bog.

Standing on a human-made causeway, which was testament to past peat cutting, **Grant** and **Barber** introduced the site, which is very rare as it contains an undisturbed climatically sensitive early to mid Holocene peat sequence. The site is currently dominated by *Molinia* grasses, but sections of the peat profile shows high abundance of hydrophilic *Sphagnum* section *Subsecunda*, indicating wet phases during the early and mid Holocene punctuated by a cold and dry 8.2 ka event. Using pollen diagrams from his Ph.D. thesis **Grant** discussed a phase of pine extinction. Current pine occurances around the site are a result of planting on the nearby Beaulieu estate in the 18th century. A group of participants then ventured out onto the bog, under the guidance of **Keith Barber**, to inspect a pool area and to discuss how the bog may have looked in the past. At the same time, **Grant** set out to find the illusive 'Nivea layer' (made up of proto-imogolite allophone), named after it's similarities in texture to a well known face cream, by taking a peat core from the base of the bog, helped by **Charles Turner** and the author. After several failed attempts during the previous evening an entire core of white peat was extracted from the base of Cranes Moor to the astonishment of all participants (including Michael Grant) on the first attempt. In conclusion, **Grant** and **Barber** propose a series of future research themes for the site.

Before leaving Cranes Moor **Richard Preece** warmly thanked the organisers on behalf of all participants for an inspiring, informative and thought-provoking field meeting. He especially mentioned the well prepared documents, **Briant's** outreach efforts and the overall impeccable organisation. A special mention was also made of **Keith Barber**, who is retiring at the end of this year and led the 1987 QRA trip to the region.

Following a relaxed lunch break in Lyndhurst, the picturesque capital of the New Forest, the group proceeded to Church Moor in Mark Ash Wood. Contrary to the previously held theory that Church Moor represented a complete Holocene profile, **Barber** explained how **Grant** had, through painstaking pollen analysis, identified that the site had been cut in the past and that there was "stuff missing" from the base. The stratigraphy of Church Moor shows a sequence of late Devensian interglacial and Holocene deposits. A section of black clay at the base with a 76% birch pollen concentration underlies a section of Holocene deposits. Discussions over the black clay at base quickly prompted a resurgence of the nano-diamond theory, previously discussed during the Isle of Wight trip. Using high-resolution pollen diagrams, **Grant** explained how a mid-Holocene woodland would have looked like at Church Moor. The site saw a rise in alder at the base due to bog hydrology and the arrival of ash, lime and beech species to around 6000-7000 years ago with relative "openness" in the mid-Holocene. Debates about what forest management techniques could be employed to stop the unnatural canopy-collapse, which is due to abandonment of woodland management, ensued and it was concluded the prevention of grazing would have a positive effect on forest regeneration.

Stories about Schulze's Gunpowder Factory kept the group entertained on their way to Barrow Moor, an infilled valley mire, which was formed by impeded drainage as a result of late Holocene land management. Using evidence from a series of control experiments, **Grant** illustrated how coppicing activities can influence pollen productivity of different tree species. As a result of this work, phases of low abundance of specific tree species in pollen diagrams from Barrow Moor were interpreted in relation to evidence of uncoordinated mid to late Holocene tree coppicing practices. **Grant** went on to explain how beech responded to changes in land management, how willow was harvested for the ship-building and furniture manufacturing trades and how alder was coppiced at the site, yet again by Schulze's Gunpowder Factory.

Concluding comments

This year's annual QRA field meeting was accompanied by some of Hampshire's finest spring weather and was much enjoyed by all participants. The wide range of topics covered and hands-on approach made it an excellent meeting, which has led to many informative discussions in the field and many more friendly debates over a drink or two in the evenings. It furthermore opened the door

to much needed future research in the region. The organisers of the trip have to be congratulated on a very well executed and brilliantly choreographed field meeting along side a highly informative colour field guide (Briant *et al*., 2009). Particular thanks go to **Becky Briant**, **Martin Bates**, **Rob Hosfield**, **Francis Wenban-Smith**, **Michael Grant** and everyone else who made this trip one to remember.

References sites

Allen, L.G. and Gibbard, P.L. (1993). Pleistocene evolution of the Solent River of southern England. *Quaternary Science Reviews*, 12, 503-528.

Briant, R.M., Bates, M.R., Hosfield, R.T. and Wenban-Smith, F.F. (eds). (2009). *The Quaternary of the Solent Basin and West Sussex Raised Beaches: Field Guide*. Quaternary Research Association, London.

Firestone, R.B., West, A., *et al*., (2007. Evidence for an extraterrestrial impact 12,900 years ago that contributed to the megafaunal extinctions and the Younger Dryas cooling. *Proceedings of the National Academy of Sciences*, 104, 16016-16021.

Westaway, R.W.C., Bridgland, D.R., and White, M. (2006). The Quaternary uplift history of central southern England: evidence from the terraces of the Solent River system and nearby raised beaches. *Quaternary Science Reviews*, 25, 2212 – 2250.

Gunnar Mallon
Palaeoecology Laboratory (PLUS)
School of Geography
University of Southampton
Southampton
SO17 1BJ
Email: g.mallon@soton.ac.uk

James Cole
British Academy Centenary Research Project Lucy to Language: The Archaeology of the Social Brain &
Centre for the Archaeology of Human Origins
Archaeology
University of Southampton
Southampton
SO17 1BJ
Email: jnc201@soton.ac.uk

QUATERNARY RESEARCH FUND

A BRIEF REPORT ON RECENT CHANGE IN SMALL GLACIERS IN BRITISH COLUMBIA, CANADA.

As planned, the period 30th July to 24th August 2008 was spent in the Bridge R. District, on the relatively dry side of the southern Coast Mountains, British Columbia. 25th August and 28-29th August were spent at the B.C. Forest Service in Merritt studying air photos of the District. This was the wettest of my thirteen summer field seasons in British Columbia, but I was nevertheless able to visit and photograph numerous glaciers in both the Bendor and Shulaps Ranges (51°N). I was accompanied by Dr. Pavel Mentlík of the University of West Bohemia, Pizeñ (Pilsen), Czech Republic, who is a mountaineer and a Vice-President of the Czech Association of Geomorphologists. Pavel studied lichens on moraines; he was impressed by the degree of fresh geomorphic activity and is planning further work on paraglacial activity in these mountains.

We were able to work on small glaciers around Mount Truax and to observe those at the heads of Fergusson, Bobb, Hawthorn and Piebiter Creeks in the Bendor Range. An attempt to reach the Whitecap Glaciers failed, as in 2003, due to extremely slow progress in the forest, combined with bad weather. There had been a forest fire later in 2003 and I hoped that access would have been improved (for fire-fighting), but the burnt-over area was even more difficult than it had been. In the Shulaps Range, glaciers in Peridotite Basin and at the sources of Liza, La Rochelle and Blue Creeks were visited.

I had feared that the exceptionally warm summer of 2003 (with many forest fires in B.C.), and the generally negative glacier mass balances of the 21st century (http://www.wgms.ch/mbb/mbb10/sum07.html), which certainly apply within coastal B.C. and Washington state to the Place, Helm and South Cascade Glaciers, might have greatly wasted small mountain glaciers and negated my conclusions from 2003 fieldwork (Evans, 2004). However, this was far from the case. Small glaciers are surviving remarkably well given the warmth of recent years – but they are high up and on steep, shady north-facing slopes. They are thinner and dirtier, but not much smaller than in 1993. There were several snowfalls in August and early September, and it is likely that mass balance for 2007-8 throughout these mountains has been less negative than previous years; perhaps even positive.

In the Bendor Range, cirque glaciers around Mounts Truax and McGillivray had changed very little since my 2003 visit, and were close to their 1993 extents although considerably smaller than in 1947 and the 1960s. Those at

the head of Hawthorn Creek had continued to recede, but bergschrunds and crevasses show that they remain active. Various small ice patches retain their 1960s or even 1947 extent.

In the Shulaps Range, two glaciers on the headwall of Peridotite Basin, which were hanging a few years ago, are unchanged in area but their snouts are mainly bevelled and they are calving fewer blocks of ice. Small glaciers near Big Dog Mountain are close to their Little Ice Age moraines (Figures 1 and 2). The cirque glacier at the head of LaRochelle Creek has changed little since 1997.

Figure 1. "Blue Dog Glacier" in the northern Shulaps Range faces north-northeast and extends from 2630 to 2490 m altitude. Its open bergschrund is visible, and there is annual banding in the ice around the bottom left debris patch. Immediately below that is the Little Ice Age moraine. (Both photos: Pavel Mentlík, 21 August 2008).

Statistical analysis of Bendor Range glaciers shows considerable differences

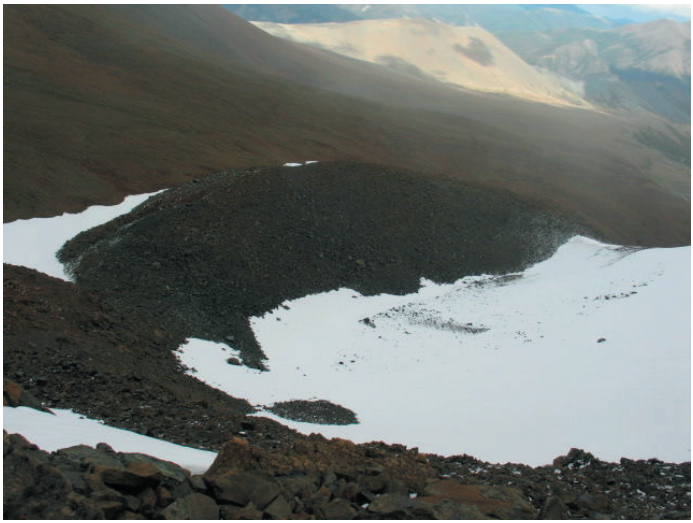

Figure 2. Western edge of "Blue Dog Glacier" showing its close proximity to its Little Ice Age moraine, bounded outside by a snowpatch. This glacier has downwasted at least 30 m in the twentieth century, but not greatly reduced in area.

in the pattern of change since 1947, compared with that from the nineteenth-century Little Ice Age moraines to 1947. Before 1947, small glaciers suffered the greatest (although highly varied) percentage losses of area. Since 1947, variation in small glaciers (<0.16 km^2) has been even greater: 18 of these 92 smallest glaciers have disappeared, but 22 have lost less than 20% of their 1947 area. The 25 glaciers between 0.16 and 2.8 km^2 in 1947 area lost 21-80% of that.

Studies elsewhere by others have variously suggested that small glaciers waste faster, or slower, than larger ones. The limited post-1993 changes in the smallest Bridge River District glaciers show that they have not shared in the recent acceleration of wastage reported for example in the Alps. This shows the need to sample glaciers in many different climatic regions (Braithwaite, 2002). However, these glaciers have shared in the generally observed dramatic twentieth-century wastage, and they are continuing to waste away.

Paul and Haeberli (2008) show that the 1985-99 surface lowering of Swiss glaciers affected especially the larger (and lower) glaciers. Their Figure 4 portrays average lowering of 12 m for glaciers 10 km^2 in area, but only 1.8 m for those around 0.1 km^2. Morover, although potential global radiation of 400 W m^{-2} gave an average of 11 m surface lowering, 230 W m^{-2} gave zero

lowering. Most glaciers for which mass balance is monitored are between 1 and 48 km^2, so the smallest glaciers are excluded – because of remoteness, gradient and avalanche risk.

My results are clear in indicating special processes operating to conserve cirque glaciers on shady slopes. Initial glacier downwasting unveils unstable cirque headwalls that produce copious rockfalls: these cover much of the ablation area, while the accumulation area is steep enough to receive minimal solar energy. We may expect that glacier remnants with low mass inputs and outputs will outlive exposed glacier tongues by decades or centuries. Given the high frequency of climate change now shown by high-resolution records for the Quaternary, it is likely that many cirque glaciers have survived short interstadials when conditions were unfavourable to glacier formation. Survival is a function of not just size, but also altitude, debris cover and exposure to solar radiation.

Coverage on 'Google Earth' was of low-resolution satellite images, but currently and helpfully these are being replaced by 2004 B.C. Forest Service colour air photos. The Quaternary Research Fund Award provided a most welcome contribution toward the cost of hiring a 4-wheel drive vehicle for 4 weeks: this was necessary for access along old logging roads. A journal paper is being prepared and preliminary presentations were made at the 13th Alpine Glaciology Meeting in February 2009, in Innsbruck, as well as at the University of West Bohemia and several Romanian Universities.

References

Braithwaite, R.J. (2002). Glacier mass balance: the first 50 years of international monitoring. *Progress in Physical Geography,* 26, 76-95.

Evans, I. S. (2004). Twentieth-Century Change in Glaciers of the Bendor and Shulaps Ranges, British Columbia Coast Mountains. *Quaternary Newsletter,* 104, 70-72.

Paul, F. and Haeberli, W. (2008). Spatial variability of glacier elevation changes in the Swiss Alps obtained from two digital elevation models. *Geophysical Research Letters,* 35, L21502, doi:10.1029/2008GL034718.

Ian S. Evans
Department of Geography
Durham University
South Road
Durham City
DH1 3LE
United Kingdom
E-mail: i.s.evans@durham.ac.uk

MAPPING OF GLACIAL DEPOSITS IN THE HIGH DRAKENSBERG, LESOTHO

Background and Rationale

The high Drakensberg is one of the few remaining places where uncertainty prevails regarding the occurrence of Quaternary glaciation. There have been several claims for Quaternary glaciation over the last four decades (Harper, 1969; Grab, 1996; Lewis and Illgner, 2001), however alternative explanations have often prevailed (Boelhouwers and Meiklejohn, 2002). Recent research (Mills and Grab, 2005; Mills *et al*., in press) has developed robust criteria to permit the identification and interpretation of deposits and landforms of glacial origin in the Lesotho highlands, southern Africa and several moraines have been dated to the last glacial cycle (Mills and Grab, 2005; Mills *et al*., in press).

Much of the work undertaken in Lesotho has been restricted to very few locations within close proximity to the Great Escarpment. This is mainly due to logistical issues, such as difficult access to many sites. (e.g. The main access road leads to Sani Top and the Leqooa Site is 2 days walk or 1 day on horse back; Figure 1). It has been suggested that the high Drakensberg region of Lesotho was

Figure 1. Location map of the high Drakensberg, Lesotho.

largely periglacial during the LGM, with only isolated niche glaciation (Mills, 2006). These glaciers were restricted to sites where local topographic (e.g. slope gradient and aspect) and microclimatic factors (e.g. enhanced snow-blow and sheltered from solar insolation) permitted their development. Mills (2006) and Grab *et al.,* (submitted) have identified that glacial deposits appear to occur in areas of contemporary late-lying snow; therefore these are locations that should first be considered when trying to identify further sites hosting potential glacial deposits in the high Drakensberg. The lack of high-resolution satellite imagery for the area means that aerial photographs are vital in order to identify moraines, and further sites of potential glaciation. A grant from the Quaternary Research Fund allowed a set of aerial photographs to be purchased from areas which experience contemporary late-lying snow, in order to identify further deposits and field-site locations.

Preliminary results and discussion

The aerial photographs were imported into ArcGIS and georeferenced. Identified landforms resembling potential moraines were then mapped (e.g. Figure 2). Several landforms along the Leqooa Valley were identified through the analysis of the aerial photographs and this area has been selected as a location for fieldwork in May 2009. This is the only area identified so far that hosts numerous deposits, as in general only one or two are identified along a particular mountain range (Mills and Grab, 2005; Mills, 2006). Of the mapped deposits along the Leqooa Valley, all occur on southerly-facing slopes (Mean = 198°) at altitudes exceeding 3000m a.s.l. (Mean = 3060m a.s.l.). They also tend to occur in upper-mid slope positions, where the gradients exceed 20°. Mulder and Grab (2002) have suggested that the alignment of the Leqooa valley acts as a localised airflow trap for the passage of contemporary snow-bearing westerly fronts and ridging high pressure systems. Thus, the high altitude (>3400 m a.s.l.) topographic context of the Leqooa site potentially provided a local topoclimatic setting conducive to enhanced snow accumulation during the last glacial cycle. This is supported by the observed contemporary snow accumulation patterns in eastern Lesotho, where late-lying snow is typically located on south and south-east facing slopes (Mulder and Grab, 2002; Grab *et al*., submitted), such as is the case for the Leqooa Valley (Figure 2).

Debris deposits in the southern Drakensberg region have a strong spatial association with the outer perimeters of longer-lasting contemporary snow banks (Grab *et al*., submitted), which confirms suggestions by Mulder and Grab (2002) that such deposits should occur at sites of prolonged contemporary snow cover. No debris deposits have thus far been identified on north-facing slopes in the high Drakensberg, most likely due to reduced snow longevity on these slopes. The isolated examples of probable Late Quaternary moraines

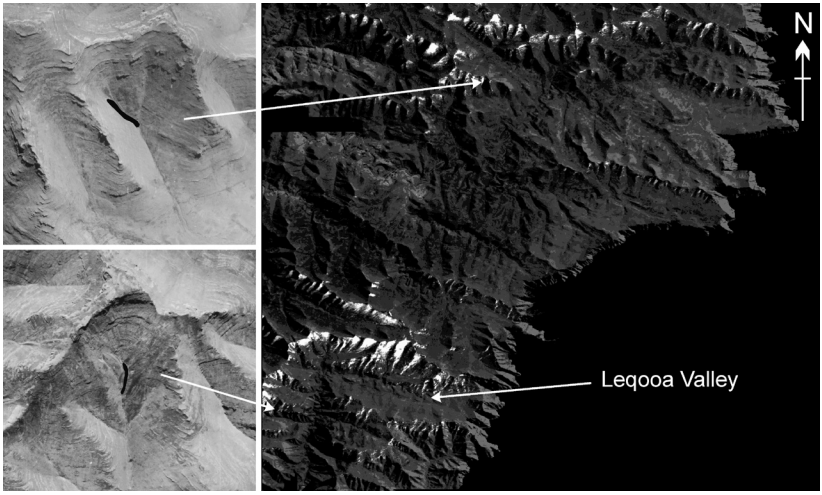

Figure 2. Areas of contemporary late-lying snow in south-eastern Lesotho and aerial photographs of mapped deposits.

on south-facing slopes in the Drakensberg attest to environmental conditions being marginal for glaciation.

References

Boelhouwers, J.C, Meiklejohn, K.I. (2002). Quaternary periglacial and glacial geomorphology of southern Africa: review and synthesis. *South African Journal of Science,* 98, 47-55.

Harper, G. (1969). Periglacial evidence in southern Africa during the Pleistocene Epoch. *Palaeoecology of Africa and the Surrounding Islands,* 4, 71-101.

Grab, S.W. (1996). Debris deposits in the high Drakensberg, South Africa: Possible indicators for plateau, niche and cirque glaciation. *Zeitschrift für Geomorphologie. Supplement Band,* 103, 389-403.

Grab, S.W, Mulder, N. and Mills, S. C. (Submitted). Spatial associations between late winter snow cover and cold region landforms in the high Drakensberg, southern Africa. *Geografiska Annaler.*

Lewis, C.A, Illgner, P.M. (2001). Late Quaternary glaciation in Southern Africa: Moraine ridges and glacial deposits at Mount Enterprise in the Drakensberg of the Eastern Cape Province, South Africa. *Journal of Quaternary Science,* 16, 365-374.

Mills, S. C. (2006). *The Origin of Slope Deposits in the Southern Drakensberg, Eastern Lesotho*. Unpublished PhD Thesis. University of the Witwatersrand; South Africa.

Mills, S.C, Grab, S.W. (2005). Debris ridges along the southern Drakensberg escarpment as evidence for Quaternary glaciation in southern Africa. *Quaternary International,* 129, 61-73.

Mills, S.C, Grab, S.W and Carr, S.J. (In press). Recognition and palaeoclimatic implications of Late Quaternary niche glaciation in eastern Lesotho. *Journal of Quaternary Science*.

Mulder N, Grab SW. (2002). Remote sensing for snow cover analysis along the Drakensberg escarpment. *South African Journal of Science* 98, 213-217.

Stephanie C. Mills
Department of
Geography
Queen Mary,
University of London
London
E1 4NS

DETERMINING THE AGE OF THE ANCIENT BEACH SUCCESSION AT MORSTON, NORTH NORFOLK, U.K., BY THE OPTICALLY STIMULATED LUMINESCENCE (OSL) PROCEDURE

With very few exceptions (Gale *et al*., 1988, Gale and Hoare, 2007 and, perhaps, Mitchell, 1960, 322), the ancient beach at Morston (TF 98714406; 52°57' 25" N, 0°57' 24" E) on the north Norfolk coast in eastern England has been consistently regarded as of last interglacial age (e.g., Solomon, 1932, plate 13; Pawley *et al*., 2008, 1369). Three samples for OSL analysis were collected in vertical succession from the freshly excavated face of the sandy part of the beach succession (units 2–6 of Gale *et al*., 1988) (Figures 1 and 2). OSL measurements were carried out at the University of St Andrews on quartz grains (180–212 μm) using the single-aliquot regenerative-dose protocol.

Figure 1. The sand body (units 2–6 of Gale *et al*., 1988) that forms the lower part of the ancient beach at Morston (and that is not visible under normal circumstances) may be seen at the bottom of the excavation. The OSL samples were collected from this material. The sand is overlain by rounded pebbles and cobbles of flint with a gravelly sand matrix (units 7–9 of Gale *et al*., 1988) (N.R. Larkin for scale).

Figure 2. The middle part of the Morston succession photographed by Hallam Ashley F.R.P.S. in 1953 or 1954 (Norwich Castle Museum Accession Number NWHCM : 2004.3.3927). The ~2 km-long section is at present (2008) largely overgrown and the position of the image could not be located. Beach gravels (believed to be equivalent to units 7–9 of Gale *et al*., 1988) lie partially within a narrow, steep-sided channel cut into sands (units 2–6). The erosional form may be compared to that of scour or rip channels but, as yet, a detailed explanation of its origin has remained elusive.

The OSL age estimates for the Morston beach indicate a Marine Isotope Stage (MIS) 7–6 transition date and lie within the Wolstonian Stage 'complex' of the British terrestrial sequence (Bowen, 1999, table 3). The extant beach sediments lie up to ~5 m O.D., yet global models suggest that contemporaneous eustatic sea-levels were typically below modern datum (Thompson and Goldstein, 2006, figure 4). The explanation may lie with poorly understood regional tectonic movements.

The MIS 7–6 date for the beach helps to constrain the ages of the subjacent and overlying glacial deposits described from Morston (Gale *et al*., 1988; Gale and Hoare, 2007), aids our understanding of regional stratigraphy, provides an opportunity to reconcile some of the contrasting stratigraphic models recently put forward, and may hold clues to questions of relative sea-level and of neotectonics. These aspects of the work are discussed in Hoare *et al*. (2009).

Acknowledgements

I am most grateful to the Quaternary Research Association for a grant from the Quaternary Research Fund to help defray the cost of the OSL age estimates.

References

Bowen, D.Q. (1999). On the correlation and classification of Quaternary deposits and land–sea correlations. In *A Revised Correlation of Quaternary Deposits in the British Isles*, Bowen D.Q. (ed.). Geological Society of London Special Report, 23, 1–9.

Gale, S.J. and Hoare, P.G. (2007). The glacial stratigraphy of lowland southern and eastern Britain: temperate-stage deposits at Morston and Kirmington. *Proceedings of the Yorkshire Geological Society,* 56, 245–251.

Gale, S.J., Hoare, P.G., Hunt, C.O. and Pye, K. (1988). The Middle and Upper Quaternary deposits at Morston, north Norfolk, U.K. *Geological Magazine*, 125, 521–533.

Hoare, P.G., Gale, S.J., Robinson, R.A.J., Connell, E.R. and Larkin, N.R. (2009). Marine Isotope Stage 7–6 transition age for beach sediments at Morston, north Norfolk, UK: implications for Pleistocene chronology, stratigraphy and tectonics. *Journal of Quaternary Science*, 24. DOI: 10.1002/jqs.1267

Mitchell, G.F. (1960). The Pleistocene history of the Irish Sea. *The Advancement of Science*, 17, 313–325.

Pawley, S.M., Bailey, R.M., Rose, J., Moorlock, B.S.P., Hamblin, R.J.O., Booth, S.J. and Lee, J.R. (2008). Age limits on Middle Pleistocene glacial sediments from OSL dating, north Norfolk, UK. *Quaternary Science Reviews,* 27, 1363–1377.

Solomon J.D. (1932). The glacial succession on the north Norfolk coast. *Proceedings of the Geologists' Association*, 43, 241–271.

Thompson, W.G. and Goldstein, S.L. (2006). A radiometric calibration of the SPECMAP timescale. *Quaternary Science Reviews*, 25, 3207–3215.

Peter G. Hoare
Honorary Associate
School of Geosciences
The University of Sydney
Sydney
New South Wales 2006
Australia
pgh@ventifact.co.uk

TESTATE AMOEBAE-BASED PALAEOCLIMATE RECORDS FROM GEORGIAN PEATLANDS.

Introduction

There are few Holocene palaeoclimate records from the eastern Black Sea littoral; this study aims to investigate the potential for palaeoclimate reconstruction from two peatlands in western Georgia. Peatlands have been shown to archive a reliable, replicable and high-resolution record of Holocene climatic change. Numerous records have been produced from sites in northern and central Europe, recently a number of studies have investigated the potential for climate reconstruction in other types of mire and in other locations around the world. This study investigates two sites; the Imnati mire near the city of Poti in northwest Georgia (Figure 1) and the Ispani-2 mire near the town of Kobuleti in western Georgia. Vegetation of both sites is *Sphagnum*-dominated; the Kolkheti lowlands are believed to be the only warm-temperate area of the world with *Sphagnum*-dominated mires (Kaffke 2008). In both sites sediments reach a depth of over 10m with more than 5m of continuous *Sphagnum* peat (Haberl *et al.*, 2006; de Klerk *et al.*, 2009). Peat-accumulation is extremely rapid with rates of around 3-4 mm yr^{-1} (Joosten *et al.*, 2003), potentially allowing an exceptionally high-resolution record to be obtained. Both sites have been the subject of previous palynological research and initial radiocarbon dating.

Figure 1. Imnati Mire with Lesser Caucasus in the background (photo courtesy of Andreas Haberl).

Methodology

The primary palaeoecological method in this study will be testate amoebae analysis. Testate amoebae are unicellular microorganisms (protists) which are highly abundant in wetland environments. Testate amoebae are very sensitive to water table changes and the solid shells ('tests') of the amoebae are well-preserved in peat sediments, making testate amoebae particularly well-suited to palaeoclimatic research. These sites provide an interesting object for testate amoebae-based palaeoecological research as such percolation bogs are theorised to be maintained by an excess of precipitation and have limited annual hydrological variability. It may therefore be that temperature, or other secondary environmental controls are more than usually important in forcing testate amoebae change.

A small grant from the Quaternary Research Fund allowed travel to Greifswald, Germany, where cores from both sites are stored. The Ispani-2 core was found to be in a degraded condition with the sediments dry and some fungal growth. The Imnati core however was found to be in a much better condition and seems more likely to produce a good record. The Ispani-2 core was sampled at low resolution (every 8-12 cm) and the Imnati core at high resolution (every 1 cm through the *Sphagnum*-dominated portion).

Preliminary results and discussion

The testate amoebae communities of the cores have yet to be studied in detail but a sequence of surface samples from the Ispani-2 site has been investigated. Fifteen samples were extracted in July 2007 by Matthias Krebs (University of Greifswald), prepared by standard methods and examined microscopically at 400X magnification. 150 amoebae per sample were counted. Apparent test concentrations were very high and the community was dominated by *Assulina muscorum, Assulina seminulum, Centropyxis ecornis* type and *Heleopera* spp. Most taxa identified are comparatively frequently found in *Sphagnum* peatlands, although the very high abundance of *C.ecornis* type is unusual. The samples had a very low diversity with as few as four taxa in some samples. This is an interesting counterpart to the very low plant diversity of the site. The palaeoecological research aims to use a transfer function to produce a quantitative record of past hydrological change. The closest applicable testate amoebae-hydrology transfer function is that of Payne et al. (2008) from the mountains of north eastern Turkey. However, when applied to these samples there is no relationship between transfer function inferences and measured values (R^2=0.04). It may therefore be necessary to develop a new regional transfer function before palaeohydrological reconstruction can be satisfactorily carried out in these sites.

Acknowledgments

Thanks to the Quaternary Research Association and the British Institute at Ankara for funding and to Hans Joosten, Pim de Klerk, Andreas Haberl and Matthias Krebs for discussion of the sites and cores, and for practical assistance.

References

De Klerk, P., Haberl, A., Kaffke, A., Krebs, M., Matchutadze, I., Minke, M., Schulz, J. and Joosten, H.(2009). Vegetation history and environmental development since ca. 6000 cal yr BP in and around Ispani 2 (Kolkheti lowlands, Georgia). *Quaternary Science Reviews,* 28, 890-910.

Haberl, A., Kahrmann, M., Krebs, M., Matchutadze, I. and Joosten, H. (2006). The Imnati Mire in the Kolkheti Lowland in Georgia. *Peatlands International*, 1/2006, 35-38.

Joosten, H., Kaffke, A. and Matchutadze, I. (2003). The mires of the Kolkheti lowlands (Georgia). *IMCG Newsletter,* 2003/3, 19-23.

Payne, R., Charman, D., Matthews, S. and Eastwood, W. (2008). Testate amoebae as palaehydrological proxies in Sürmene Agaçbasi Yaylasi peatland (Northeast Turkey). *Wetlands,* 28, 311-323.

Kaffke, A. (2008). Vegetation and site conditions of a *Sphagnum* percolation bog in the Kolkheti Lowlands (Georgia, Transcaucasia). *Phytocoenologia,* 38, 161–176.

Richard J. Payne
Geography
School of Environment and Development
University of Manchester
Manchester
M13 9PL

PLEISTOCENE GEOLOGY OF LUNDY ISLAND, SOUTH-WEST ENGLAND

Background and rationale

Very little detailed Quaternary research has taken place on Lundy Island, North Devon, although there have been several notable reports of glacial sediments and landforms (e.g. Mitchell, 1968; Taylor, 1974). The precise age of these Pleistocene sediments and landforms has been the subject of considerable speculation. Mitchell (1968) suggested that Lundy Island may have been glaciated during both the Anglian/Elsterian and 'Wolstonian'/Saalian cold stages based on his studies on the island.

Lundy Island is situated in an important strategic position in the British Isles, close to the southernmost limit of glaciation and potentially influenced by ice streams from both the Irish Sea and Wales (Figure 1). Understanding the timing of glaciation on this island will therefore be key in the interpretation of the Pleistocene history of southwest British Isles.

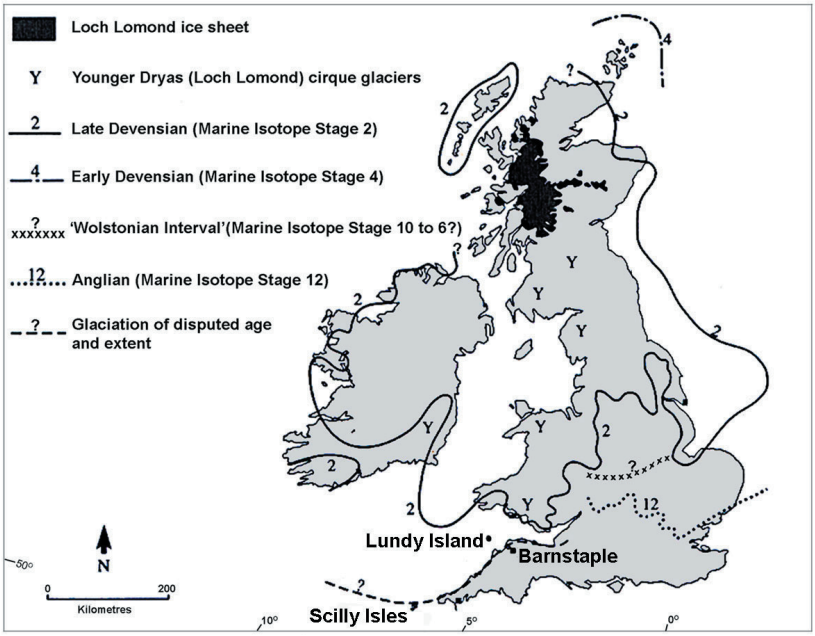

Figure 1. Reconstructed Pleistocene glacial limits after Campbell *et al.*

Lundy Island, approximately 4.5 x 0.8 km in size, is an exhumed Tertiary granite pluton. The granitic bedrock covers most of the island with an area of Devonian Morte Slate in the southeastern corner (Stone, 1990). The presence of glacial erosional features, such as such as grooved stream-lined whalebacks, suggest that Lundy Island was shaped in part due to glacial ice and supports suggestions that Pleistocene ice was present in Barnstaple Bay (Taylor, 1974). In addition, Mitchell (1968) has interpreted deep dry valleys in northeast Lundy as glacial meltwater channels. However, the age of the Pleistocene glacial landforms remains unknown.

Methodology

The glacial geomorphology of Lundy was mapped in detail on to 1:10,000 base maps in September 2008. Rock samples were collected from 20 different locations from ice-moulded bedrock for terrestrial *in situ* cosmogenic nuclide analyses (^{26}Al and ^{10}Be). The fieldwork supported by the QRA New Researchers Award Scheme and the Lundy Field Society was crucial in securing NERC support for cosmogenic isotope analyses (Cosmogenic Isotope Analysis Allocation No.9055.1008, in collaboration with Professor Tony Brown, University of Southampton and Dr. Phil Hughes, University of Manchester). These samples are currently being processed at NERC Cosmogenic Isotope Analysis Facility at the time of writing.

Figure 2. North End, Lundy Island showing exposed bedrock surfaces. (Photograph by C.J.Rolfe).

The majority of glacial evidence comprises of erosional landforms, which are clear and very well-preserved. Striations are not always clear because of the coarse grained nature of the granite. However, larger grooves are very clear and are superimposed onto roche moutonées, whalebacks and very clear bedrock lineations are visible – and especially striking when viewed on aerial photographs (Figure 2). Erratics are present too on the northern part of the island (Mitchell, 1968). However, from the sampling strategy the glacial erosional landforms (Figure 3) were considered best suited for cosmogenic nuclide analyses.

Figure 3. View to the North End of Lundy Island showing exposed bedrock surfaces. For scale Dr Soren Brage has been highlighted. (Photograph by C.J.Rolfe).

Discussion

The presence of moraine limits on the Gower Peninsula to the north of Lundy Island in South Wales, dated to the Devensian cold stage (Phillips *et al.*, 1994), suggests that Welsh ice did not reach Lundy during this cold stage. However, this does not exclude the possibility of the Irish Sea ice reaching and over-running the island from the northwest during the Devensian. However, the glaciation of Lundy Island may be much older – possibly of Middle Pleistocene age. The cosmogenic isotope analyses will help test these various scenarios.

Pleistocene deposits along the north Devon coast, including the so-called "Fremington Till" and the "Lundy Till", provide fragmentary evidence that an ice sheet reached the current north coast of the SW Peninsula — extending from the Isles of Scilly to north Devon at some point during the Pleistocene (Scourse, 1991; Mitchell, 1968). This evidence is largely based on giant erratics which have been found located on wave-cut platforms e.g. Saunton, glacigenic gravels e.g. Lundy Island (Mitchell, 1968) and Isles of Scilly (Scourse, 1991), and glacial deposits at Fremington near Barnstaple (Stephens, 1966). Glacial

deposits are extremely difficult to date. Therefore, understanding the exposure history of the clear glacial erosional landforms on Lundy Island will be crucial towards establishing the age of the glacial deposits on the Scilly Isles and the north Devon coast.

Acknowledgements

The author gratefully acknowledges the QRA New Research Workers' Award and the Lundy Field Society for funds that contributed towards the costs of fieldwork on Lundy Island. I would like to thank the Church of England, English Heritage, Natural England, and The National Trust for permission to work on Lundy Island. Many thanks to my supervisors Professor Tony Brown and Dr. Steve Boreham for their support of the project which is being carried out on a part-time basis. Further thanks to Dr. Soren Brage for field assistance. Special thanks to Dr. Philip Hughes, University of Manchester, for continued advice and support.

References

Campbell, S., Scourse, J.D., Hunt, C.O., Keen, D.H. and Stephens, N. (1998). *Quaternary of South-West England*, Geological Conservation Review Series, No. 14, Kluwer, London, 23.

Phillips, F.M., Bowen, D.Q., Elmore. D. (1994). Surface exposure dating of glacial features in Great Britain using cosmogenic chlorine-36: preliminary results. *Mineralogical Magazine,* 58A, 722-723.

Mitchell, G.F. (1968). Glacial Gravel on Lundy Island, *Transactions of the Royal Geological Society of Cornwall,* 20, 65-69.

Scourse, J.D. (1991). Late Pleistocene stratigraphy and palaeobotany of the Isles of Scilly. *Philosophical Transactions of the Royal Society of London,* B334, 405 - 448.

Stephens, N. (1966). Some Pleistocene deposits in north Devon. *Biuletyn Periglacjalny,* 8, 103-114.

Taylor, C.S. (1974). Some Notes on the Pleistocene Geomorphology of Lundy. *Lundy Field Society, 25th Annual Report*, 66-68.

Chris J. Rolfe
School of Geography
University of Southampton
Highfield
Southampton
SO17 1BJ
cjr1e06@soton.ac.uk

IN SEARCH OF A SEA-LEVEL CHRONOLOGY FROM DOGGER BANK

Background and rationale

The precise inundation history of Dogger Bank in the southern North Sea remains speculative. Radiocarbon data are consistent with models of relative sea-level change back to about 10 ka but beyond this, there is little published data (see Ward *et al*., 2006). This study proposes to extend the absolute dating of sedimentary sequences for the southern North Sea by dating an archived core (BH89/03) drilled to 274 m below seabed surface on the southeast side of Dogger Bank.

The core has been archived at Hanover at the Landesamt für Bergbau, Energie und Geologie for well over 10 years. Funding was sought to travel to Hanover to sample the core, which contained at least 5 intercalated peat and sand layers thought to date from the Cromerian (< 700 ka) to the Holocene (< 10 ka). It was intended that samples from the uppermost intercalated sand and peat layers would be taken for optical-stimulated luminescence (OSL) and radiocarbon dating respectively.

Results

Upon inspection the core was unfortunately revealed to be completely dried out, with little or no organic material left. Ten samples were taken overall but after also obtaining translation of the original core report, it was decided that only the topmost of these were young enough (i.e. < 150 ka) to warrant any OSL analysis. Three samples were treated to obtain pure quartz, a surface sample, one at *c*.17.0 cm and one a *c*.17.7 cm depth. These samples were then sent on to Aberystwyth Luminescence Research Laboratory for analysis. The report on the preliminary OSL analyses indicates that the surface sample (Aber147/1) is as expected very young (Duller, 2009). The De values show considerable scatter and either due to partial-bleaching at deposition or more likely that it was exposed to daylight during coring or sampling. However, if one takes a simple average of the D_e values shown in the preheat test then this gives a value of 2.2 Gy (Duller, 2009). For typical dose rate on land this would imply an age of ~ 1ka. For these marine sediments the dose rate may be considerably lower. The two deeper samples (samples Aber147/2 and 147/3) are much older than was envisaged based on other dates obtained at these depths (see Ward *et al*., 2006). Even without any dosimetry data, it seems likely that these samples are ~100 ka or older (Duller, 2009). However, the general behaviour of the quartz OSL is excellent.

Significance

The general conclusion from this initial pilot study is that no further analysis or dating of this core is warranted. However, the excellent OSL signal obtained from the quartz does indicate that the sands are well-bleached and that reliable OSL age estimates may be possible from fresh submarine sediments from Dogger Bank. This is further supported from the successful dating of marine sediments elsewhere (Stokes *et al*., 2002) and funding is now sought for obtaining new cores from the southern North Sea.

Acknowledgements

Sincere thanks the QRA for providing this research grant, Carsten Schwarz and his colleagues at LBEG for all the help in finding and sampling the core, Simon Armitage at Royal Holloway for providing facilities for preparation of the luminescence samples and finally Geoff Duller and Hollie Wynne who freely provided OSL analyses of the selected samples.

References

Duller, G. (2009). Interim Report: Project Aber147/BH8903-1, -2 and -3. Aberystwyth Luminescence Research Laboratory. Unpublished report.

Stokes, S., Ingrama, S., Aitken, M.J., Sirocko, F., Anderson, R. and Leuschnere, D. (2003). Alternative chronologies for Late Quaternary (last interglacial – Holocene) deep sea sediments via optical dating of silt-sized quartz. *Quaternary Science Reviews (Quaternary Geochronology)*, 22, 925-941.

Ward, I., Larcombe, P. and Lillie, M. (2006). The Dating of Doggerland – Post-glacial geochronology of the southern North Sea. *Environmental Archaeology*, 11(2), 207-218.

Ingrid Ward
17 Brickfield Cottages
Somerleyton
Suffolk
NR325QW

REVIEW

CADAIR IDRIS: GEOMORPHOLOGICAL MAP. SCALE 1: 10,000.

E.A.U. Sahlin (2008)

Published by Journal of Maps 2008
Map price: £6
Flat Size: 1045 x 944mm
Finished Folded Size: 234 x 152mm (approx)
Paper: Stock 90gsm matt

Available for purchase at: http://www.journalofmaps.com/

This is an excellent geomorphological map that details a range of glacial, periglacial and slope features on one of the most popular Welsh mountains. The map is very clear and utilises colour very effectively. In fact this map was awarded the "Best Map" award by the Journal of Maps, which is presented to the single best contribution to the journal in the year it was published.

Many of the symbols are adaptations of those used elsewhere. Some of these may be considered 'established' symbols (after Demek, 1972), such as the symbols for roche moutonee and striae, although no 'established' unified symbol notation really exists for glacial geomorphology — as a glance at a range of recent journal papers on glacial geomorphology will testify.

A majority of the landforms depicted are correct and accurate. However, the main controversy with this map is the interpretation of a lobate mass of ridged boulder debris to the north of Cyfrwy. Sahlin maps this as 'end-, lateral and recessional moraine crests, with ridge crest'. Stephen Lowe, who did his PhD in this area (Lowe, 1993), recognised this feature was a 'rock glacier', as did Ballantyne (2001) in a later study of this area. The feature certainly looks like a rock glacier – a lobate mass of boulder debris complete with very clear transverse ridges. Similar features have been interpreted as rock glaciers elsewhere in Wales (Harrison *et al*., 2008). However, Lowe (1993) identified the Cyfrwy feature as a former glacier-cored rock glacier. Advocates of a periglacial rock glacier model, *sensu* Barsch (1996), would argue that if Lowe's interpretations are correct then this was not a true periglacial rock glacier in any case, but a debris-covered glacier.

Rock glaciers always seem to cause controversy which has been exemplified by the decades of furore over the identification of true periglacial rock glaciers and debris covered glaciers. To compound the problem, the Cyfrwy feature could equally be confused with a rock slope failure deposit or the result of a combination of process: slope, glacial and periglacial (cf. Wilson 2004).

Whatever its origin, the position of the feature does not fit the interpretation depicted on the map of Sahlin and it is difficult to see the configuration of a former glacier that could form 'end-, lateral and recessional moraine crests' in this area. This rather controversial element in the map could have been avoided with a more judicious choice of wording when defining the symbols used on the map. For example, rather than use the words 'end-, lateral and recessional moraine crests, with ridge crest' it may have been better to use non-genetic terms such as simply 'boulder ridges, with ridge crest' and 'bouldery hummocks, mounds, and ridges' instead of 'moraine hummocks and ridges'. However, the problem of interpretation is inherent in glacial geomorphological mapping and, for that reason, this map really does need some justifying text on the reverse (see comments below).

One ambiguity with this publication is the link with the associated article in Journal of Maps. This article is referenced as on the Journal of Maps website: Sahlin, E.A.U. and Glasser, N.F. (2008) Geomorphological map of Cadair Idris, Wales, Journal of Maps, v. 2008, 299-314. However, there is no mention of this article or the co-author on the map. I would recommend printing articles associated with the sheet maps published by Journal of Maps on the reverse of any printed maps. This would add to their academic value. Nevertheless, there is no doubt that this is very fine piece of cartography and is a valuable contribution to geomorphology and Quaternary study in Wales.

References

Ballantyne, C.K. (2001). Cadair Idris: A Late Devensian Nunatak. In: Walker, M.J.C., and McCarroll, D. The Quaternary of West Wales: Field Guide. Quaternary Research Association, 126-131.

Barsch, D. (1996). Rockglaciers: indicators for the present and former geoecology in high mountain environments, Springer, New York, 331 pp.

Demek, J., Embleton, J. F., Andgellert, C. and Verstappen, H. T. (1972). Manual of Detailed Geomorphological Mapping., International Geographical Union Commission on Geomorphological Survey and Mapping, Academia, Prague, 320 pp.

Harrison, S. Whalley, B. and Anderson, E. (2008). Relict rock glaciers and protalus lobes in the British Isles: implications for Late Pleistocene mountain geomorphology and palaeoclimate. *Journal of Quaternary Science,* 23, 287-304.

Lowe, S. (1993). The Devensian Lateglacial and Early Flandrian stratigraphy of southern Snowdonia, North Wales. Unpublished PhD thesis, University of London.

Wilson, P. (2004) Relict rock glaciers, slope failure deposits, or polygenetic features? A re-assessment of some Donegal debris landforms. *Irish Geography,* 37, 77-87.

Philip D. Hughes
Geography
School of Environment and Development
The University of Manchester
Manchester
M13 9PL

ABSTRACTS

QRA AND RGS-IBG UNDERGRADUATE DISSERTATION PRIZE WINNER 2009

CLIMATE OF THE LOCH LOMOND STADIAL IN PERTHSHIRE AND THE CAIRNGORMS

Hannah Milne (BSc)
University of Aberdeen

Mapping of moraines in western Perthshire and the central Cairngorms, Scotland, provides evidence of a c.663km^2 icefield extension to the main Loch Lomond Stadial (Younger Dryas) ice cap over Loch Tay (Perthshire) and a *c*.26.6km^2 area of plateau-valley ice over Loch Avon (Cairngorms). Using inverse iterative models based on Schilling and Hollin (1981) it was estimated that the warm-based Tay ice reached a maximum surface elevation of *c*.850m and extended to the eastern ends of Loch Tay and Loch Earn. In contrast the Cairngorms glaciers were predominantly cold-based and extended from *c*.1300m on the plateau down to a large terminal moraine in lower Glen Derry. Both landscapes appear to be palimpsest, preserving some areas of thick Late Devensian sediments. Nevertheless whilst there is good geomorphic and model support for a Loch Lomond Stadial glaciation which was much more extensive than previously supposed, it is emphasized that dated constraints are needed to confirm these proposed limits. The icefield equilibrium line altitude (ELA) of 511 ± 51m (using a balance ratio of 1.8) is consistent with regional trends while the Cairngorms ELA of 842 ± 59m accords well with the Dee and Geusachan Glaciers also in this region which were previously supposed to be 'anomalously large'. Palaeo-temperature and precipitation estimates derived from an independent chironomid temperature proxy indicates a mean July temperature at the ELAs of 4.9 ± 0.55°C for the Tay region and 2.7 ± 0.4°C in the Cairngorms. Annual precipitation was 2348 ± 205mm and 1551 ± 133mm respectively. Consequently precipitation gradients across Scotland of 27-30% from West to East and 32% South-North are less extreme but significantly more realistic than previously predicted, though still reflecting the influence of more dominant southerly air streams which is probably due to the southerly position of the oceanic polar front.

AN EXAMINATION OF THE GEOCHEMICAL PROPERTIES OF LATE DEVENSIAN GLACIGENIC SEDIMENTS IN EASTERN ENGLAND

Clare Boston (MSc by research)
Department of Geography, Durham University

Onshore advance of the North Sea lobe of the Late Devensian British Ice Sheet during the last glaciation resulted in the deposition of thick multiple till sequences along the coasts of east Yorkshire and north Lincolnshire. Despite an abundance of sedimentological and stratigraphical data, the origin of these tills remains controversial, and their correlation along the coast is poorly understood. These multiple till sequences provide an excellent opportunity to test models of large-scale subglacial sediment transport and deposition beneath soft-bed ice sheets using geochemistry. Such geochemical analysis has been used extensively in other formerly glaciated areas, notably Canada, to identify till characteristics and dispersal patterns. However, to date it has not been applied in any detail to glacial sediments in the UK and its potential as a tool for till correlation and understanding till genesis remains relatively undeveloped.

A detailed sampling method was employed at seven sites in eastern England; Filey, Skipsea, Dimlington, South Ferriby, Kirmington, Welton-Le-Wold and Morston; to investigate vertical and lateral changes in till geochemistry in this region. Section logging and particle size analysis of the till matrix were used as additional tools to provide a sedimentological context. Complete linkage and Ward's method cluster analysis were used to establish groups of geochemically similar diamicton samples.

Geochemical results suggest that there are vertical changes in till geochemistry, which are likely to be related to a change in provenance from local to more distal sources. Geochemistry and particle size results were also unable to precisely differentiate between the Basement, Skipsea and Withernsea till types. Instead, the repeated nature of the geochemical signature at larger sites, such as Dimlington, and the lateral discontinuity of some geochemical groups suggests that the till sequences at Filey, Dimlington and Skipsea are comprised of a number of lithologically distinct rafts which have been tectonically stacked or elevated to higher levels in the sediment pile. At Dimlington the production of a glacitectonically folded and stacked moraine is proposed as a mechanism to explain the remarkably thick sequence of Withernsea Till and the repeated nature of the geochemical signature at this site. In addition, the changes in till matrix geochemistry are suggested to relate to changes in the dominance

of ice lobes of potentially different provenance, which re-worked pre-existing Quaternary sediments, excavated local bedrock and progressively mixed these sediments with more far travelled material from further north. This research therefore provides new evidence for our understanding of glacial stratigraphy and former ice dynamics in eastern England, suggesting that till composition and the mechanics behind its production are more complex than the traditional stratigraphic division allows.

THE LAST BRITISH ICE SHEET: A RECONSTRUCTION BASED ON GLACIAL LANDFORMS

Anna L. C. Hughes (Doctor of Philosophy)
Department of Geography, University of Sheffield

The last British Ice Sheet has been a focus of research for over a century, and yet we have only a generalised picture of its extent and internal geometry. This is a remarkable situation compared to knowledge of the larger former ice sheets of North America and Fennoscandia. The central tenet of this thesis is that the glacial landform record has been neglected as a source of spatial information, hindering our attempts to reconstruct the characteristics of the ice sheet. This motivated systematic mapping of glacial landforms (subglacial bedforms, moraines, eskers, and meltwater channels) for the whole of Britain, yielding the first consistent and countrywide glacial maps. Mapping was achieved primarily using a high resolution (5 m horizontal) digital elevation model to visualise the landscape. Over 60,000 features were identified and mapped, greatly expanding the known distribution and pattern of glacial landforms. Analysis of the landform data permitted a country-wide reconstruction of the pattern of ice sheet retreat. A database of just over 400 dates, compiled from the literature, was used to arrange the pattern of retreat in time. This exercise highlighted various incompatibilities between the presently available dates. Examination of landform patterns enabled the elucidation of some pre-deglacial configurations of ice divides and flow geometry, including ice streams. This revealed the existence of both transient (migrating) and persistent ice divides. In contrast to other and larger palaeo-ice sheets, the majority of flow evidence in Britain exhibits a particularly close association with topography, indicative of an ice sheet thickness comparable with the amplitude of subglacial relief. The retreat pattern, flow geometries and divide configurations that have been identified from this research provide a set of evidence-based constraints at ice sheet scale for future numerical ice sheet modelling experiments.

LATE QUATERNARY VEGETATION HISTORY OF THE ACIDIC LITHOLOGIES OF SOUTH EAST ENGLAND

Jonathon Alexander Groves (PhD)
School of Geography, Geology and the Environment, Kingston University

There have been few Late Quaternary vegetation records from the acidic lithologies of south east England. This study reports on investigations from three new valley mire sites (Bagshot, Conford and Hurston Warren), using pollen and charcoal analyses with chronologies provided by radiocarbon dating.

The Bagshot sequence begins at *c*. 12750 cal. BP with high *Betula* and *Pinus sylvestris* pollen values recorded during the late-glacial and early Holocene respectively. After a hiatus from *c*. 9800 to *c*. 7550 cal. BP, the dominant taxa are *Quercus*, *Tilia* and *Corylus avellana*-type. Tree pollen values decline from *c*. 3750 cal. BP, with *Calluna vulgaris* recorded from *c*. 3450 cal. BP. At Conford, high *Pinus sylvestris* values persist for *c*. 4700 cal. years from *c*. 10750 cal. BP. Increases in *Quercus*, *Tilia* and *Alnus glutinosa* occur at *c*. 6050 cal. BP. Here, tree pollen values decline from *c*. 2900 cal. BP with *Calluna vulgaris* then consistently recorded, along with other indicators of anthropogenic activity. The Hurston Warren sequence begins at *c*. 4400 cal. BP with high *Quercus*, *Tilia* and *Corylus avellana*-type pollen values. A fall in *Tilia* percentages from *c*. 3050 cal. BP is again followed by higher *Calluna vulgaris* values and the appearance of anthropogenic indicators.

Discussion focuses on the vegetation history of *Pinus sylvestris* in lowland England, anthropogenic activity associated with declines in *Tilia* pollen values and the development and persistence of heathland. In the early Holocene, while *Pinus sylvestris* was rapidly excluded from the more fertile soils of lowland England, in areas of poor sandy soils *Pinus sylvestris* often achieved dominance, which locally persisted into the mid-Holocene. Examination of palaeoecological trends associated with declines in *Tilia* abundance across lowland England has led to the identification of a number of processes that are responsible, though the majority of the declines are associated with clearance activity. The latter primarily occur during the Late Neolithic to Mid-Bronze Age. Their number is substantially reduced from the Late Bronze Age; however, this may in part reflect the scarcity of remaining *Tilia* woodland. The earliest of these declines appear to have occurred in areas of fertile soil; though by the Mid-Bronze Age they are focussed on the acidic geologies of south east of England. Extensive heathland development did not occur in these areas until the Bronze Age when expansion is associated with either an increase in pastoral activity or the frequency of burning. Once established, heathland areas appear to have been maintained into the historic period by these traditional management practices. At Hurston Warren and Conford, heathland areas appear to have expanded during the Anglo-Saxon and early Medieval period respectively.

TITEL LOESS PLATEAU – PALAEOENVIRONMENTAL AND PALAEOCLIMATIC RECONSTRUCTION OF THE LAST GLACIAL

Tivadar Gaudenyi (PhD)
University of Novi Sad (Serbia)

Titel Loess Plateau is located at the south-eastern part of the Carpathian Basin (Vojvodina, Serbia). The examined loess sequences at the open sections (Titel-old brickyard and Roguli_ Gully) of this nearly 80 km^2 loess plateau are situated on the right bank of Tisza river. Malacological analysis was the main method used in this study as an independent tool to reconstruct palaeoenvironments and palaeoclimates at the local/regional level. This was supported by grain size and magnetic susceptibility proxies and numeric age dating (using optically stimulated luminescence). Collection of 10 litres volume samples was conducted at 10 cm intervals in continuous columns at two sections (14.8 m and 11.4 m in height) for high-resolution quantitative malacological analysis.

The basal part of the analysed section was the MIS 5 (V-S1) chernozem palaeo-pedocomplex which had been affected by decalcification and was without molluscan shells. Above this was the MIS 4 (V-L1L2) sandy loess layer with a poor *Striata-* and *Pupilla* faunal assemblage which is confined to the rather temperate climatic and a sparse grassland, steppe-like environment. Based on the coarser sand distribution and sand laminations, the dominant influence was the local south-eastern Kosava wind. The MIS 3 (V-L1S1) unit showed that the initial paleopedocomplex of the ruling *Pupilla-* and *Striata* faunal assemblage was much more similar to the recent Central European steppe-like grassland climatic and environmental conditions. The MIS 2 (V-L1L1) loess horizon, with the dominance of *Pupilla* fauna in the assemblage, represents the coldest parts the last cold stage. LGM is clearly manifested with a *Granaria frumentum* minimum and at the northern profile (Roguli_ Gully) the only abundance of *Collumella collumella* species in traces (less than 1%) are evident. The steppe-like palaeoenvironment was not too extreme and more similar to the MIS 3 interstadial in some places of Bohemia and Moravia.

The results suggest that Titel Loess Plateau during the last cold stage (MIS 4-2; V-L1) was outside of the periglacial zone of the Carpathian Basin and that the palaeoclimate corresponds to rather moderate cold to temperate continental climate which belongs to the pseudoperiglacial zone. The climatic zonality based on Central European molluscan assemblages is associated to the dry loess steppe-like landscape.

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 £20 with reduced rates (£10) for students and unwaged members and an Institutional rate of £35.

The main meetings of the Association are the Field Meetings, usually lasting 3–4 days, in April, May and/or September, a 2-3 day Discussion Meeting at the beginning of January and 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 J.D. Scourse***, School of Ocean Sciences, University of Wales (Bangor), Menai Bridge, Anglesey, LL59 5AB. (e-mail: j.scourse@bangor.ac.uk)

Vice-President: ***Professor B.A. Maher***, Lancaster Environment Centre, University of Lancaster, Lancaster, LA1 4YQ. (e-mail: b.maher@lancaster.ac.uk)

Secretary: ***Dr S. Lewis,*** Department of Geography, Queen Mary, University of London, Mile End Road, London, E1 4NS (e-mail: s.lewis@qmul.ac.uk)

Publications Secretary: ***Dr P. Langdon***, Department of Geography, University of Southampton, Highfield, Southampton, SO17 1JB. (e-mail: P.G.Langdon@soton.ac.uk)

Treasurer: ***Dr P. Allen***, 13 Churchgate, Cheshunt, Herts, EN8 9NB (e-mail: Peter.allen@virgin.net)

Editor, Quaternary Newsletter: ***Dr M.D. Bateman***, Department of Geography, University of Sheffield, Winter Street, Sheffield, S10 2TN (e-mail: M.D. Bateman@sheffield.ac.uk)

Editor, Journal of Quaternary Science: ***Professor C. Caseldine***, Department of Geography, University of Exeter , Amory Building, Rennes Drive, Exeter, EX4 4RJ (e-mail: C.J.Caseldine@exeter.ac.uk)

Publicity Officer: ***Dr F. Marret,*** Department of Geography, University of Liverpool, Liverpool L69 3BX (e-mail: f.marret@liverpool.ac.uk)

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

QRA home page on the world wide web at: http://www.qra.org.uk

Registered Charity: 262124

QN

JUNE 2009 No. 118

Contents

ISSN 0 143-2826