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# QN

## Quaternary Newsletter

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# QUATERNARY NEWSLETTER

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

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*COVER PHOTOGRAPH*:
Life-size model of a woolly mammoth (Mammuthus primigenius) outside the Beringia Interpretative Center, Whitehorse, Yukon, Canada. (see report by Whiteman, pp. 10-12, and website: **http://www.beringia.com/**).

# *ARTICLES*

## BROOM PALAEOLITHIC SITES

**R.T. Hosfield and R. Terry**

### Introduction

The Lower Palaeolithic sites at Broom (Figure 1), in the valley of the River Axe (ST 328025 and ST 326020), Devon, were re-investigated during September 2000 by a team from the University of Southampton (Department of Archaeology) and King Alfred's College, Winchester (Department of Archaeology). Two old sections were re-located, and a series of new trenches dug, in the Railway Ballast Pit at Broom (also described as Hawkchurch). Despite the richness of the past discoveries at these sites (Reid Moir, 1936; Shakesby and Stephens, 1984; Green, 1988; Wymer, 1999: 182–3; Marshall, forthcoming), the site chronology remains only vaguely established and there appears to have been no attempt to link the deposits with the oxygen-isotope record (Shackleton, 1987).

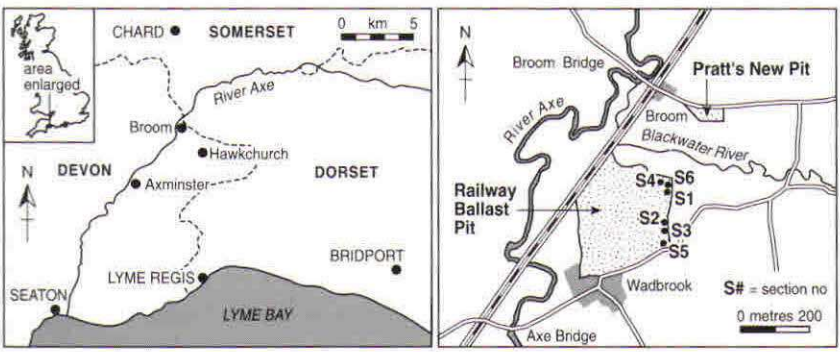


**Figure 1.** Location of the Broom sites and the Railway Ballast Pit sections (September 2000).

Preliminary work by Scourse suggested a temperate floodplain environment of possible Hoxnian age (Scourse: appendix in Shakesby and Stephens, 1984: 84). Pollen extracted from clays and silts in the Railway Ballast Pit suggested regional, boreal forest vegetation dominated by pine (*Pinus*), spruce (*Picea*) and birch (*Betula*), with silver fir (*Abies*). The tree types were probably limited to small patches in favoured localities, while open country dominated with ericaceous heath on the higher ground. Scourse concluded that the deposits were probably laid down at the end of a Middle Pleistocene interglacial (?Hoxnian) or during an interstadial (perhaps within the Wolstonian) (*ibid.* 86–87). In light of the increased current understanding of the Middle Pleistocene's glacial-interglacial cycles, the time seems ripe for a renewed examination of these deposits. Preliminary examinations by Dr. Rob Scaife (*pers. comm.*) of clay samples recovered in the 2000 excavations from section 3 have been unable to detect pollen of the type recorded by Scourse (*ibid.*), although further sampling and analysis is planned.

## The 2000 Excavations

The extensive gravel deposits in sections 1, 4 and 6 at the northern end of the pit (Figure 1) suggested that the polleniferous clays and silts were not continuously deposited throughout this area (Terry and Hosfield, in prep.). As suggested by Shakesby and Stephens (1984), excavations indicated gravel at least 8 m thick; due to the high water table in the area, it was impossible to locate the base of the gravel. These deposits presumably encompass the 'upper' cherty gravel and 'lower' flinty gravel described by Shakesby and Stephens (1984, fig. 2). Thick gravel deposits characterise the Axe Valley from Chard to Axminster (Figure 1), and the authors hope to expand their research to address the depositional history of the wider region during the Pleistocene.

Excavations in section 2 (Figure 2) indicated massively bedded upper gravel separated from the clay deposits by a possible unconformity. Although there were no sand lenses in the upper gravels of section 2, these features were present in section 1 at the north end of the pit, in keeping with Shakesby and Stephens (*ibid.* fig. 2). The clay in section 2 contained lenses of sand and fine gravel. Bedding in the clay was horizontal, with a number of sandy lenses and gravelly pockets. One of the sandy lenses was cross-laminated, and the northwards dip indicated localised flow and the complexity of the Pleistocene floodplain environment. The base of the clay showed evidence of post-depositional deformation. The clay was separated from the lower gravel by another possible unconformity, with the upper surface of the gravel marked by manganese staining (Terry and Hosfield, in prep.).

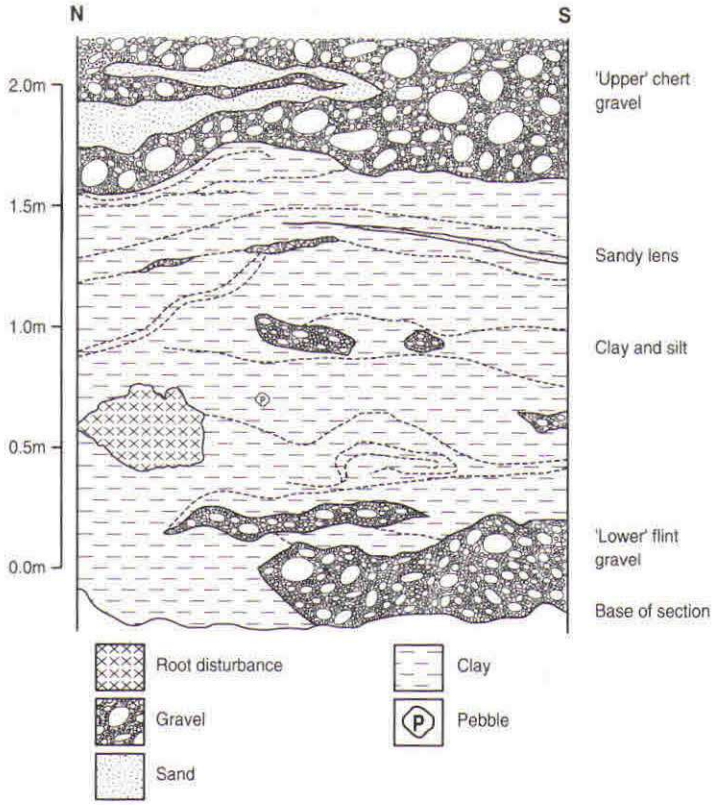


**Figure 2.** Depositional stratigraphy, section 2, Railway Ballast Pit, Broom (original section drawing by R. Terry and J.C. Chambers).

The excavations encountered the traditional difficulties associated with the re-assessment of gravel pit sites. Section 3 and section 5 revealed evidence of digger disturbance and in-filled deposits (Figure 3).

Over one hundred years of collection from these sites has produced more than 1800 handaxes, which made the paucity of artefactual material from the Railway Ballast Pit during 2000 somewhat surprising. Continuing work in 2001–2002 seeks to continue the work in the Railway Ballast Pit while also opening exploratory sections in Pratt's New Pit (currently heavily overgrown).

**Figure 3**. Digger disturbance, section 3, Railway Ballast Pit, Broom.

This pit was the source of two handaxes recovered by Green, Shakesby and Stephens in 1981 (Shakesby and Stephens, 1984, fig. 3) and, we hope, will provide a greater archaeological return. There also exists a substantial body of unpublished material from the 1978–1982 excavations (C.P. Green, *pers. comm.*) and the authors will be examining these data as part of their ongoing research.


## Acknowledgments

The authors would like to thank Mr and Mrs Lunt, who gave their very generous permission for these small-scale excavations to take place on their lands. RTH would also like to thank Dr John McNabb (for countless good advice) and Mr Tudor Bryn Jones — for far too many invaluable services to mention. Thanks are also extended to the field crew (Jenni Chambers, Yvette Bekker, Francesca Binyon, Nick Holland, Sian Lane and Shaun Moyler). The research was carried out and this paper prepared while RTH was undertaking a British Academy-funded Postdoctoral Research Fellowship.

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# *REPORTS*

## INAUGURAL MEETING OF IGCP PROJECT 449 'GLOBAL CORRELATION OF LATE CENOZOIC FLUVIAL DEPOSITS'

**Prague, Czech Republic, 21-24 April 2001**

The inaugural gathering of those involved with IGCP Project 449 was held in Prague during four days in April 2001. Approximately 45 delegates attended the conference, which was based in the headquarters building of the Czech Geological Survey (CGS). The scientific programme of events included two business meetings (one of them a workshop to determine the form of the data base, co-ordinated by **Darrel Maddy** [University of Newcastle, and International Secretary, IGCP 449]), six lecture sessions, a poster display and a day field excursion.

The lectures considered Late Cenozoic fluvial deposits in parts of Europe, north Africa, Asia, South America and the USA. The subject matter provided some indication of the task ahead for those who are attempting the worldwide correlation of these sediments.

### Sunday 22 April

After a warm welcome from **Miloš Růžička** (Director, CGS) and Jaroslav Tyráek (CGS, and President of the Czech Committee of INQUA), the first lecture session, chaired by Mike Blum, got underway. **Leszek Marks** (Polish Geological Institute, Warsaw, and Institute of Geology, Warsaw University) described 'Late and Middle Pleistocene fluvial systems in central Poland'. **A.V. Matoshko, P.F. Gozhik** and **A.S. Ivchenko** (National Academy of Sciences of Ukraine, Kiev) gave an account of 'The fluvial archive of the Dnieper River in the scope of the global correlation of Late Cenozoic fluvial sequences'. **Annamária Nádor, Miklós Lantos, Pál Müller, Edit Thamó-Bozsó, Zsolt Kercsmár, Ágnes Tóth-Makk** and **Judit Bulla-Farkas** (Geological Institute of Hungary, Budapest) discussed 'Climate and tectonics: competitive forces in Quaternary alluvial sedimentation, mid-latitude temperate zone rivers in the Pannonian Basin, Hungary'. Finally **Serge Occhietti** and **Najat Bhiry** (Geotop, Montréal, and Centre d'Etudes Nordiques and Université Laval Sainte-Foy, Québec) spoke on the 'Quaternary record in the semi-arid Souss middle valley, Morocco'.

The first afternoon session, chaired by Gyula Gábris, consisted of contributions from **Sampat Tandon** (University of Delhi, and Co-Leader, IGCP 449) on 'Late Cenozoic fluvial sequences of northern India: background and summary', **Rajiv Sinha** (Indian Institute of Technology, Kanpur) on 'Quaternary sedimentation in the Himalayan foreland basin: implications for interpretation of ancient sequences', **Aleksey Sidorchuk** (Moscow State University) on 'The Neogene-Quaternary evolution of the fluvial relief at the Russian Plain: a potamological review', and **Valentina Drouchits** (Russian Academy of Sciences [RAS], Moscow) described the 'Quaternary fluvial system of the Issyk-Kul lake depression'.

Serge Ochietti chaired the second session of the afternoon in which **Natalia Patyk-Kara** (RAS, Moscow) spoke on the 'Sequence of events in evolution of the Cenozoic fluvial channels at the East-Arctic shelf', **M.N. Alekseev** (RAS, Moscow) and **Valentina Drouchits** discussed the 'Correlation of regression-transgression offshore sequences with river alluvium on the coastal area of Russian Arctic', **Simon Lewis** (Queen Mary, University of London) gave an account of 'The Ingham Formation: pre-Anglian fluvial sediments in eastern England', and **Rob Westaway** (Durham), **David Bridgland** (Durham University, and Co-Leader, IGCP 449) and **Mark White** (Durham University) elaborated on the 'Physical modelling of the Quaternary uplift history of central-southern England, constrained by archaeological and biostratigraphical dating of river terraces and raised beaches'.

The already congenial atmosphere was enhanced by the early-evening ice-breaker party in the corridors of the Geological Survey.

### Monday 23 April

Leszek Marks chaired the first lecture session of the day, which consisted of contributions from **Rich Meyrick** and **Lutz Maul** (Forschungsinstitut und Naturmuseum Senckenberg, Weimar) on 'Recent biostratigraphic and sedimentological developments at Burgtonna, Thüringen, Germany', **Danielle Schreve** (Royal Holloway, University of London) on 'Correlation of British and German fluvial sequences using mammalian biostratigraphy', **David Keen** (Coventry University), **Christopher Green**, **Russell Coope** (Royal Holloway), **Michael Field** (Coventry University) and **James Wells** (English Heritage, Portsmouth) on 'Middle Pleistocene fluvial deposits from Hackney Downs, North London and their bearing on the environment of Oxygen Isotope Stage 9', and **Richard Fariña** (Facultad de Ciencias, Montevideo) on 'Large river ruled life and death of large south American Pleistocene mammals'.

During the second lecture session, chaired by Sampat Tandon, in which **Martín**

**Ubilla** (Facultad de Ciencias, Montevideo) spoke on 'Mammals as a biostratigraphic tool in correlation of Pleistocene fluvial deposits in mid-latitudes of south America: northern Uruguay as a case study, problems and criticism'; **Rob Westaway** described 'Physical modelling of the Quaternary uplift histories of classical river terrace sequences in the Czech Republic: the Ohre terraces in the Most Basin and the Red Hill section at Brno'; **Gyula Gábris, E. Félegyházi, B. Nagy** and **Zs Ruszkiczay** (Eötvös University of Budapest) reported on 'Climate and tectonic controlled river style changes in the Middle Tisza Plain'; and **Maijank Jain** (University of Delhi) and **Sampat Tandon** discussed 'Fluvial response to climate change: a case study from Quaternary alluvial sequences, western India'.

The afternoon lecture session and concluding discussion were chaired by David Bridgland and Darrel Maddy. **Mike Blum, Tammy Rittenour, Ronald Goble** and **Heidi Hoffower** (University of Nebraska) spoke on 'Luminescence dating of Late Quaternary fluvial deposits: progress and prospects', and **Tammy Rittenour, Mike Blum** and **Ronald Goble** discussed the 'Late Pleistocene to early Holocene evolution of the lower Mississippi valley'.

The evening's proceedings began with a pleasant stroll through the vast Prague Castle, with plenty of time to enjoy splendid views of the city.This was followed by a buffet meal in the wonderful surroundings of the Černín Palace, hosted by the Secretariat of the Czech Commission for UNESCO and Dr Miloš Růžička.

**Tuesday 24 April**

The weather had improved steadily throughout the meeting so that the field excursion to the terrace systems of the Vltava and Labe Rivers to the north of Prague, led by Jaroslav Tyráček, took place in the very best of conditions. A visit to the wine cellars of Mělník castle provided the perfect aperitif(s) to an excellent dinner in a restaurant in Mělník.

The programme of events was extremely well planned and executed. Our Czech hosts could not have been more hospitable or hardworking, and the vote of thanks to them was thoroughly deserved.

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# CANADIAN QUATERNARY ASSOCIATION (CANQUA) MEETING

## Whitehorse, Yukon Territory, 20-24 August 2001

If the Yukon (pop. c. 30,000) sounds a touch remote, even to Canadians, the classical distance-decay function was not obvious at the CANQUA biennial conference based at the High Country Inn, Whitehorse, capital of the Territory. Here some 120 members, including some from Australia, South Africa, Russia, and the UK, gathered to report their latest research, or review key issues, mostly concerned with the Canadian northwest. A series of technical lecture sessions, some run concurrently, was attractively interspersed with the opening reception, invited evening lectures, field trips and a poster session, the whole constituting one of the most stimulating, effective and efficient conferences that I can remember. The only hiatus the unavoidable absence of the recipient of the J. Ross Mackay Award, **Scott Lamoureux** (Queen's University), at the end of the first morning.

Most participants attended the convivial opening reception, held appropriately at the Yukon Beringia Interpretative Centre, a focus for Earth Science within the Heritage Branch (Department of Tourism) of the Yukon Government. Located on a Yukon River terrace formed in fine-grained sediments of the former Glacial Lake Champagne, the Centre contains a number of skeletons and models of extinct vertebrates that populated the landscape of Pleistocene Beringia, the now partially-submerged region centred on the Bering Strait between the Yukon and eastern Siberia, and a key theme of the conference. On this first evening, delegates were warmly welcomed by the Director of the Yukon Heritage Branch, **Jeff Hunston**, and by the Minister for Tourism, the Honourable **Sue Edelman**, both obviously intensely proud of the facility and keen to demonstrate the Yukon's interest in the scientific community. Besides the range of fascinating exhibits related to Beringia, the Centre possesses a fine auditorium where, on two subsequent evenings, members were both entertained and enlightened by Yukon Science Institute public lectures: the first, delivered by **Alan Cooper** of Oxford University, on "DNA Work on Ice Age Mammals", the second, by **Natalia Patyk-Kara** and **Irina Spasskaya** of the Russian Academy of Sciences, on "Beringia and its Mineral Resources: Cenozoic History and Placer Deposits.

The technical sessions began on Tuesday with a theme devoted to Palaeolimnology, Palaeohydrology and Permafrost. Amongst others, this provided the British contingent (**Julian Murton** and the author) with the

opportunity to report their work on buried Laurentide ice in the Tuktoyaktuk Coastlands, NWT. Concurrent afternoon sessions were devoted to long terrestrial records of Plio-Pleistocene climate change and economic Quaternary geology. Recent work in eastern Beringia is revolutionising ideas about the age and sequence of events in the region, and it is now necessary to begin to think in terms of much longer Pleistocene sedimentary records. **John Westgate** (University of Toronto) convincingly demonstrated the power of tephra in providing a secure framework for the late Cenozoic in eastern Beringia. The economic geology session was devoted largely to placer deposits, not unreasonably in view of the famous Klondike Gold Rush. In this context, **Grant Lowey's** (Yukon Geology Program) presentation on the role of forcing mechanisms, base-level change and accommodation space in the formation of the Klondike Goldfields was particularly interesting, and this subject formed a key element of the post-conference field excursion.

Wednesday was devoted to a series of mid-conference field trips following a 'Yukon Field Camp Pancake Breakfast. I have to express disappointment over the breakfast, not in terms of cuisine but the fact that it was held indoors. But the field excursions were well received. My choice involved rock glaciers. Those in the Kluane National Park seem to emerge from every suitable topographical orifice and there was little dissent from the view of the leader, **Peter Johnson** (University of Ottawa), that most were of the 'glacial' variety.

Thursday's technical sessions returned to the theme of long terrestrial records with, *inter alia*, reviews by **Charles Schweger** (University of Alberta) of warm and cold periods in the Yukon and a presentation on mutual climatic range analysis of fossil-beetle assemblages in the North American Arctic by **Scott Elias** (Colorado) and read, due to Scott's unavoidable absence, by **Nancy Bigelow** (University of Alaska, Fairbanks). The concurrent session was devoted to papers on geomorphology and Holocene palaeoecology. In the afternoon it was the turn of the archaeologists and palaeontologists, followed by the CANQUA annual meeting. In the evening the company relaxed over an excellent banquet, after which **Steve Porter** (University of Washington) presented a fascinating review of "Late Pleistocene Glaciation in the Pacific Northwest". For me, and I sensed for many, a highlight was his decision to support evidence of the scientific developments with numerous photographs of the key players in the story.

On Friday morning we were invited to review the poster displays and discuss them with the presenters. For the final afternoon session the theme reverted to Holocene palaeontology.

The host committee, **Jeff Hunston**, **Bruce Barrett** (Yukon Heritage Branch; YHB), **Jeff Bond** (Yukon Geology Program), **Greg Hare** (YHB), **Beth King** (YHB), **Bill Lebarge** (Yukon Geology Program), **Grant Lowey**, **Chris Marion** (Consultant) and **John Storer** (YHB), must be congratulated on the success of their enterprise and I would not hesitate to recommend future meetings of CANQUA if this is an indication of their general standard.

Copies of the abstracts and program of the conference are available as the first of a series of Occasional Papers in Earth Science published by Yukon Heritage Branch, and can be obtained from: Yukon Palaeontologist, Heritage Branch, Department of Tourism, Government of Yukon, Box 2703, Whitehorse, Yukon, Canada, Y1A 2C6 (Tel: (867) 667 8089; Fax: (867) 667 8007; e-mail: jstorer@gov.yk.ca; web page: http://www.yukonheritage.com).

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# PRE- AND POST-CONFERENCE CANQUA FIELDTRIPS, YUKON TERRITORY, CANADA

## Pre-conference Fieldtrip to the Fort Selkirk area, 18-19 August 2001

The Fort Selkirk area, near the confluence of the Yukon and Pelly rivers, south central Yukon, contains an important record of late Pliocene to middle Pleistocene glacial and volcanic history, and vertebrate stratigraphy. The fieldtrip involved a scenic boat journey along the Yukon River between Minto and Fort Selkirk, with riverside site visits, an overnight camp and guided tour of the historic former settlement of Fort Selkirk.

Incision by the Yukon River has exposed sections – tens of metres high – through volcanic rocks and interstratified sediments. Volcanic rocks near Fort Selkirk comprise basaltic lava flows, pillow basalts, pillow breccias and altered tuffs, collectively known as the 'Selkirk Volcanics'. In this area the lava flows have infilled much of the preglacial Yukon Valley and the preglacial landscape of the Wolverine Creek basin. The flows comprise stacked units of massive to columnar basalt with intervening flow breccias and, where they entered deep standing water – as seen at Cape Diamond – foreset-bedded pillows. Some of the volcanic rocks were erupted subglacially through the Ne Ch'e Ddhäwa volcanic edifice – a tuya. At least 5 eruptive periods between ~1.83 and 0.31 Ma BP have been inferred from dated volcanic rocks and a tephra within interbedded sediments in the Fort Selkirk area, as discussed by **Lionel Jackson** (Geological Survey of Canada), **Crystal Huscroft** (Simon Fraser University) and **René Barendregt** (University of Lethbridge). Significantly, the dates constrain the ages of glacial and interglacial sediments, for example, the older pre-Reid glaciation to between ~1.77 and 1.54 Ma BP, the younger pre-Reid glaciation to between 1.37 and 0.78 Ma BP, and the Reid glaciation itself to post-311 ka BP. Mammal bones obtained from loessic sediments with a probable age of between 1.8 and 1.5 Ma BP at the 'Fossil' locality are dominated by the vole *Allophaiomys deceitensis*. As **John Storer** (Yukon Heritage Branch) explained, analysis of molars suggests that the voles are slightly younger than the type sample of *A. deceitensis* from Cape Deceit, western Alaska, which is probably of latest Pliocene age.

## Post-conference Fieldtrip to the Klondike, 25-29 August 2001

The Klondike fieldtrip integrated a number of Quaternary themes, including the glacial and permafrost history of central and western Yukon, Beringian palaeoecology and palaeoenvironments, late Cenozoic evolution of the Yukon River, tephrochronology, palaeosols and gold placer deposits.

### Day 1: Whitehorse to Dawson City

Day 1 was spent driving northwest along the Klondike Highway from Whitehorse to Dawson City, a journey that crosses successively older Cordilleran glacial terrains. The youngest terrain dates from the McConnell glaciation (Marine Isotope Stage 2; <28 ka BP), the next youngest from the Reid glaciation (MIS 8; ~300-250 ka BP), and the oldest (pre-Reid) to one or more Pliocene to Mid-Pleistocene glaciation (~3 Ma to 780 ka BP). The decreasing extent of these glaciations has been attributed to uplift of the southwestern coastal mountains in Yukon-Alaska and the resultant drop in moisture supply to the interior plateaus. Land surfaces developed in the deposits from the three periods of glaciation have experienced differing degrees of soil formation, giving rise to three distinct palaeosols. Sections through these palaeosols were examined en route to Dawson, under the guidance of **Jeff Bond** (Yukon Geology Program).

The youngest palaeosol (Stewart neosol), formed on McConnell surfaces, is a shallow (30 cm), weakly-developed Brunisol that lacks clay illuviation and evidence of chemical weathering or disintegration of rock clasts. Intermediate in age (i.e. post-Reid glaciation) is the Diversion Creek palaeosol (≤130 cm thick), in which limited clay illuviation has taken place (Luvisol) and where numerous clasts have been frost shattered *in situ*. The oldest soil (pre-Reid) – the Wounded Moose palaeosol – is strongly weathered, rubified and contains thick clay skins in palaeoargillic Bt horizons. Sand-filled wedges penetrating the Wounded Moose palaeosol and examined during the fieldtrip showed evidence of both primary filling (mm-thick vertical laminae) and secondary filling (massive pebbly sand at depth within the wedges), suggesting an origin as composite-wedge casts.Also preserved on Reid glacial deposits, at the Ash Bend section of the Stewart River, is a sedimentary sequence attributed to the MIS 7/6 transition (~190 ka BP). As **John Westgate** (University of Toronto) explained, a channel-fill sequence incised into the Reid drift changes upwards from (1) an organic-rich silt with spruce logs and abundant spruce pollen through (2) a silt with sparse organic material to (3) inorganic silts and sands with little and poorly-preserved pollen mostly of sedges, grasses and sage. Unit (2) contains two tephra beds, the Sheep Creek tephra and the Ash Bend tephra.

A TL-age of 190 ± 20 ka BP from loess bracketing the Sheep Creek tephra near Fairbanks, Alaska, places the tephra at the MIS 7/6 transition, consistent with the change from boreal forest to tundra inferred in the channel fill at Ash Bend.

Near Dawson, we stopped at the Tintina Trench Lookout, where **Alejandra Duk-Rodkin** (Geological Survey of Canada) described the geological significance of the Tintina Trench – a major graben that formed during the late Miocene along a continental-size fault. Lateral displacements of hundreds of kilometres occur along the fault. The Trench fill in the vicinity of Dawson includes Miocene alluvial-fan deposits and Pliocene to middle Pleistocene glacial and fluvial sediments (see Day 4, below).

### Day 2: Klondike Valley and Northern Klondike Goldfields

Day 2 began with a view across the Klondike and Yukon river valleys from atop the Midnight Dome, which overlooks Dawson. From this vantage point, **Duane Froese** (University of Calgary) and Alejandra Duk-Rodkin introduced some of the region's physiographic features and history of the Yukon and Klondike rivers. The Yukon was diverted from its former southward course to its current northwest course by the first (late Pliocene) Cordilleran glaciation. The Klondike valley and its tributary creeks contain an impressive archive of fluvial, colluvial and aeolian sediments dating from the early Pliocene to the Holocene. The geomorphic location of the sediments comprise: (1) high-level terraces, underlain by the White Channel gravel and overlying Klondike gravel; (2) intermediate terraces, underlain, for example, by gravel and loessic sediments; and (3) valley bottoms, underlain by organic-rich silt ('muck') and gravel.

The White Channel gravel was examined, under the guidance of Duane Froese, at Jackson Hill and Paradise Hill. This quartz-rich gravel (40 m thick at Jackson Hill) derives from local lithologies and ranges in age from early Pliocene (~5 Ma BP) to late Pliocene, and has an upper unit containing ice-wedge casts. Significantly, the White Channel gravel has in places suffered alteration (e.g. leached matrix, decomposed schist pebbles) and, in the basal part, contains gold. As **Grant Lowey** (Yukon Geology Program) and Duane Froese explained, the cause of alteration (hydrothermal solutions, weathering, diagenesis?) and its significance to gold formation (detrital ± hydrothermal?) remain to be established. The Klondike gravel (55 m thick at Jackson Hill) contains erratic clasts transported into the Klondike valley by glacial meltwater, providing evidence for the first Cordilleran glaciation of the region. Both the Klondike and White Channel gravels were deposited in braided rivers.

Loessic sediments beneath an intermediate terrace ~100 m above the modern valley floor were examined at Midnight Dome. The sediments (10-14 m thick) overlie pre-Reid outwash and include pollen from three interglacial organic silts – as discussed by **Charles Schweger** (University of Alberta), palaeosols, ice-wedge casts and several tephras. The Mosquito Gulch tephra has provided a fission-track age of 1.45 ± 0.14 Ma BP for the lowest glacial-interglacial sequence, as discussed by John Westgate. The fission-track age of the Midnight Dome tephra, 8 m higher in the succession, is 1.09 ± 0.18 Ma BP.

### Day 3: Southern Klondike Goldfields

Day three began with a visit to King Soloman Dome to see the northern limit of the lodgepole pine in the Klondike and to examine quartz veins in the Mitchell deposit – a source of placer gold. At Quartz Creek, 35 km southeast of Dawson, Duane Froese and John Westgate showed the group an ice-wedge cast within the Upper White Channel gravel (Figure 1). The cast contained the white Quartz Creek tephra, which has a weighted mean fission-track age of 2.97 ± 0.24 Ma – evidence that permafrost first occurred in the Yukon during the late Pliocene.

One of the highlights of the trip was the valley-bottom muck examined at Quartz Creek (Figure 2). This organic-rich frozen silt contains a wealth of mammal bones (e.g. bison, horse, mammoth), the Dawson tephra (<22.3 and >11.6 ka BP) and a variety of ground ice (segregated, ice-wedge, pool). The muck formed largely by colluvial reworking of loessic sediment. As muck accumulated in valley bottoms, permafrost aggraded within it, facilitating growth of syngenetic ice wedges and preservation of mammal bones, carcasses and nest burrows (e.g. of ground squirrel). The bulk of the Klondike muck is thought to be of Wisconsinan (last glacial) age.

Additional site visits included ones to Sulphur Creek, to examine loessic sediments assigned to the mid-Wisconsinan, and to Ross Mine, Dominion Creek, to examine incised valley-fill gravel (Ross gravel; >780 ka BP) and overlying Dominion Creek gravel. Discussion focussed on the depositional processes of the Ross gravel (fluvial and/or debris flow?).

### Day 4: Tintina Trench Sites

On day 4 some of the party visited, by helicopter, stratigraphic sites in the Tintina Trench (described below), while others examined evidence for the glaciation of the Southern Ogilvie Mountains adjacent to the Dempster Highway.

The Tintina Trench sections at Fifteenmile River and Rock Creek reveal a remarkable stratigraphic sequence – middle Miocene to middle Pleistocene in age – of pre-glacial fluvial deposits, multiple tills, outwash, loess and palaeosols.

**Figure 1.** Ice-wedge cast within Upper White Channel gravel, Quartz Creek, ~35 km southeast of Dawson City. The white Quartz Creek tephra within the cast has a weighted mean fission-track age of 2.97 ± 0.24 Ma. From this, a late Pliocene age is inferred for the first occurrence of permafrost in the Yukon.

**Figure 2.** Perennially-frozen muck deposits containing the Dawson Creek tephra (white layer beside people), Quartz Creek, Klondike area. The age of the tephra is <22.3 and >11.6 ka BP.

As Alejandra Duk-Rodkin and René Barendregt explained, the stratigraphy records the drainage evolution and first glaciation in west-central Yukon, as well as six glacial/interglacial events, making it possibly the most complete terrestrial record of glaciations and interglaciations known in North America. Discussion at these sites considered, *inter alia*, interpretation of the palaeosols (clay illuviation in Luvisols), sub-till glaciotectonic deformation, palaeomagnetic dating, redeposited loess, Tertiary pollen and, most importantly, the preservation conditions for stacked tills and palaeosols. In addition, the helicopter flights provided fine views of the landscape, with its river terraces, open-system pingos and, in the Klondike Valley, the myriad ridges of gravel tailings left by the gold-placer dredges.

In all, the CANQUA fieldtrips were excellent, and the organisers should be congratulated. Quite apart from the stimulating Quaternary and Tertiary science what was particularly striking about these trips was the vitality and co-operation between a multi-disciplinary research team and their strong links with the Alaskan Quaternary community. Undoubtedly, this augurs well for the future of Quaternary and Tertiary research in eastern Beringia and adjacent glaciated Yukon.

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Yukon Palaeontologist, Heritage Branch, Department of Tourism, Government of Yukon, Box 2703, Whitehorse, Yukon, Canada Y1A 2C6

Web Page: http://www.Yukonheritage.com

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# THE SIXTH ANNUAL QRA POSTGRADUATE SYMPOSIUM:

## The University of St. Andrews

## 10th-12th September 2001

Postgraduate QRA members from across Britain and beyond met at the University of St. Andrews for two days of presentations and discussion followed by a one-day field excursion.

The first day began with a welcome by Professor Ed Stephens, head of the School of Geography and Geosciences at St Andrews. **Lindsay Wilson** (St Andrews) chaired the first session, which started with a discussion on glacier-climate interactions on the Tibetan Plateau by **Lindsey Nicholson** (St Andrews). The potential effects of varying thermal resistance, debris structure and moisture content on melt rates during diurnal and seasonal cycles were examined in the context of debris-covered glaciers. **Matt Jones** (Plymouth) described the use of high-resolution stable-isotope records from lake sediments of western Anatolia. Holocene climate change will be quantified from longer lake sequences which demonstrate significant inter-laminae isotopic variation. **Will Adam** (Keele) enthusiastically described his research on the debris bands in the basal ice of the Russell Glacier, western Greenland, demonstrating the important potential of this work to reconstructing the basal layer of former ice margins. **Kat Hands** (St Andrews) discussed the evolution and formation of supraglacial lakes upon the debris-covered Ngozumpa glacier, in the Nepal Himalayas. The presentation also covered the applied aspect of this research, for large supraglacial lakes have the potential to form hazardous glacial lake outburst floods.

**Eleanor Haresign** (St Andrews) introduced the final talk of the day, given by the invited guest speaker, **Professor Julian Dowdeswell** (Bristol), and entitled 'Arctic ice masses: past and present form and flow'. A comparison of trough-mouth fans with the contemporary fans of, for example, the Amazon and Mississippi allowed one to clearly appreciate the depositional capacity of the ice masses that created the former. The thinning of ice sheets was also cited, and how this could have the capacity to dilute and disrupt the salt density of North Atlantic Deep Water. The techniques that help to characterise present-day arctic glaciers were reviewed, with examples given from Severnaya Zemlya and the Canadian Arctic. This provided an array of information, perhaps the most striking being the consistent presence of 'fast ice' within larger ice

masses, and the tentative warning that one should include 'fast ice' when reconstructing or modelling past ice masses. The talk was followed by a wine reception and the annual conference dinner.

The second day started with **Siwan Davies** (Royal Holloway) in the chair. Siwan introduced **Dr. Steve Moreton**, (East Kilbride) an invited speaker from the NERC Radiocarbon Laboratory, who discussed the fundamentals of radiocarbon dating and the most 'street-wise' method (from a postgraduate perspective) for applying for radiocarbon dates. **Shirley Wynne** (Exeter) described her research in NW Scotland, where she is investigating the relationship between the two proxy records from blanket peat and speleothem. It is hoped that the speleothem record will improve understanding about the process of humification and its potential use as a paleoenvironmental proxy. Moving onto the topic of 'wild mammals', **Rhiannon Stevens** (Oxford) talked about the role of $\delta^{13}C$ and $\delta^{15}N$ in bone collagen as a climatic indicator. The problem of 'intra-site' variability was mentioned and isotopic data presented from the hair (a good modern substitute for bone) of two wild deer populations. **Stephen Thompson** (Glasgow) discussed the reconstruction of the Dimlington stadial glaciation of Holderness, East Yorkshire. His talk reviewed the various geomorphological, sedimentological, structural and glaciotectonic observations made both at the macro and micromorphological level, and considered the effective use of digital elevation models in strengthening the regional interpretation of deglaciation of this locality.

**Mark Lloyd Davies** (Amsterdam) chaired the following session. **Lindsay Wilson** (St Andrews) discussed a high-resolution study of amphi-Atlantic ice-rafted detritus correlations from the Barra Fan, NW Scotland. Initial results of the research demonstrate the highly dynamic nature of the British Ice Sheet during marine isotope stages 3 and 2, and it was tentatively suggested that the interstadial events might be the key to amphi-Atlantic correlations. **Stuart Wilson** (Glasgow) outlined the theories of hummocky moraine formation and how he was using digital photogrammetry and GIS to map the 'hummocky moraines' of Coire A'Cheud Chnoic, Scotland. The combination of this technique and some standard sedimentological analysis resulted in the emergence of a distinct spatial and morphological pattern in the distribution of 'hummocky moraine'. **Sarah Gilchrist** (Edinburgh) described shifts in the chironomid assemblages during the late glacial and Holocene in Patagonia. These shifts, in combination with contemporary sediment samples from 40 or more Patagonian lacustrine sites, may help to resolve the controversy over inter-hemispheric synchronicity during sub-Milankovitch events. **Zoë Hazell** (Plymouth) gave reasons why New Zealand peatbogs are of special interest as paleoclimatic proxies, and described how the multi-proxy palaeoecological approach is being adopted to help reconstruct Holocene paleoclimate in New Zealand.

**Matt Jones** (Plymouth) chaired the first afternoon session. **Alix Cage** (St Andrews) discussed the potential use of Scottish Sea Lochs as paleoenvironmental archives, especially in relation to using a circulation model to examine the relationship between inter-annual variability in sea-loch circulation, salinity and that of the North Atlantic Oscillation. He also considered the implications that this might have for interpreting marine carbonate $\delta^{18}O$ records. **Eleanor Haresign** (St Andrews ) spoke about the calving dynamics of a lake-terminating glacier (Leónes) in Patagonia. Data to be sought in the future include ablation rates, water temperatures and suspended sediment concentrations. **Chris Byrne** (Edinburgh) introduced the use of organic chemistry in tracing certain biomarkers (e.g. lignin phenols and specific lipids such as n-alkanes). It is hoped that biomarkers retrieved from a Barra Fan core, NW Scotland, will provide a high-resolution record, and might contribute to understanding whether the Scottish and Laurentide ice sheets fluctuated independently. **Mark Lloyd Davies** (Amsterdam) gave a presentation about contemporary and past environments of the Fox and Franz Josef Glaciers of Westland, New Zealand, where geomorphological and sedimentological evidence points towards a dynamic glacial history. This might serve as a modern analogue for the Oligocene of Victoria Land, Antarctica. **Erin McClymont** (Durham) introduced her PhD project, which considers, from a quantitative (biomarker) perspective, the role of the carbon cycle in both the development and regulation of the 100-kyr cycles.

With **Alix Cage** (St Andrews) chairing the final session of the day, **Clara Morri** (UHMI) discussed the use of deep-ocean current circulation as a millennial-scale record for climate variability. Issues addressed concerned the relationship between deep-water flow and glaciation, investigated by collating various geophysical and geological data. **Siwan Davies** (Royal Holloway) gave a clear presentation on new evidence from The Netherlands for the wider distribution of Termination 1-age tephras in NW Europe. Such tephras might provide sufficient resolution to determine the relative timing of late-glacial temperature changes. **Laura Park** (Durham) considered the mechanisms and details of deglaciation in Disko Bugt, central West Greenland. She discussed preliminary results of foraminiferal assemblages and oxygen-isotope data, and their relationship with the prevailing model of deglaciation. **Katharina Pahnke** (Cardiff) gave the final talk of the symposium, explaining the high-resolution connection between the Southern Ocean thermohaline circulation and the Antarctic climate. Evidence supporting this came from a marine sediment core spanning the last 340 kyr and the noted close connection in the variability of the elemental concentrations (e.g. calcium) and various Antarctic ice-core records (e.g. Vostok deuterium (temperature)).

Following the presentations, the inspired delegates returned to view the poster display and to hear the closing remarks. First, there were two nominations for the newly-formed position of QRA postgraduate member of the Executive Committee, to which **Matt Jones** (Plymouth) was elected to serve for the year ahead. Second, **Dr. William Austin (St. Andrews)** kindly donated £50 for the best presentation in this year's QRA postgraduate symposium, an award won by **Mark Lloyd Davies** (Amsterdam) for his talk on the Fox and Franz Josef Glaciers, New Zealand. Third, **Mark Lloyd Davies** proposed that the 7th QRA Postgraduate Symposium take place at the University of Amsterdam, a proposal that was unanimously accepted. Finally, a vote of thanks was given to the organisers of the symposium, **Eleanor Haresign** and **Lindsey Nicholson,** and especially to **Lindsay Wilson** and **Alix Cage** for their overall leadership and management.

On the following day **Dr Jack Jarvis** (St Andrews) and **Dr William Austin** led a local field excursion that examined aspects of Fife geomorphology and deglacial history. At Pilmour Spit the group examined coastal erosion and the beach-recharge scheme. The second stop was at Stathkinness, with a view of St. Andrews Bay, where we considered fluvioglacial deposits of the Wormit Gap and the Lateglacial and Holocene local shoreline developments. The Lomond Hills were the third visiting place, although low clouds and rain prevented a full appreciation of the Lateglacial and Holocene slopes. The final stop was Largo Bay, where there are raised rock platforms and a variety of postglacial raised-beach sequences. Returning to St Andrews provided the opportunity to say fond farewells and again thank the organisers for all their efforts. Finally, we all eagerly look forward to next year's symposium in Amsterdam; '*gezellig natuurlijk*' as the Dutch would say!

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# GLACIOTECTONISED SEDIMENTS AT MULLAGHMORE, COUNTY MEATH, IRELAND: EVIDENCE OF A LARGE SCALE RE-ADVANCE DURING ICE-SHEET DEGLACIATION?

Recent research (McCabe, 1996) has linked variation in the extent and dynamics of the British and Irish ice sheets with re-organisation of ocean-ice-atmosphere systems during 'Heinrich events'. Such a mechanism has been proposed as a contributing factor for the Drumlin Re-advance in Ireland and the Irish Sea Basin (McCabe, 1996; Knight and McCabe, 1997). This proposal has been controversial, with other evidence suggesting progressive deglaciation of central Ireland, with localised ice-marginal oscillations (Meehan, 1998, 1999), rather than a significant regional ice sheet re-advance event. The present report discusses initial findings of ongoing sedimentological and geomorphological analysis that may help to discriminate between large-scale re-advances or localised oscillation during deglaciation of central Ireland.

## Site Location and Study Methods

The study area is located at Mullaghmore, near Kingscourt, within the drumlin belt of north central Ireland. The drumlins in this region are aligned in a NW-SE orientation, and where drumlins are absent, rare exposed surfaces of bedrock, such as at nearby Barley Hill (Meehan *et al.*, 1997), preserve striations with similar orientations. However, in the NW-SE trending Ballyhoe basin, in the Mullaghmore area, drumlins are absent or have been obscured by alluvial, lacustrine and peat infill. At the southern end of the basin, as the land surface rises to altitudes greater than 40 m OD, a series of sediment exposures are preserved within an area formerly quarried for sand and gravel. The locality was mapped in September 2000 to place the main sediment sections within a local topographic context, and initial section descriptions carried out.

## Provisional Results

Research is ongoing to reconstruct the sedimentary and deformation history of the site, and to fit this into a regional context regarding deglaciation of the Irish ice sheet. Due to the Foot and Mouth outbreak, further fieldwork planned for March 2001 was postponed, and further detailed sedimentological analysis will take place in the near future. However, the following initial observations may be made.

- **Geomorphology:** A Digital Elevation Model (DEM) was constructed to examine the geomorphology of the locality around Mullaghmore (Figure 1). Ground-truthing of the DEM was carried out in the field, to confirm geomorphological interpretations. Initial observation suggests that the sediment sections at Mullaghmore reflected a longitudinal profile through a drumlin. However, mapping of the surrounding area, as well as investigation of archive records illustrating the pre-quarrying topography, suggests that in fact the exposure forms part of a WSW-ENE trending transverse ridge, interpreted as a thrust-block moraine. This moraine, although up to 15 m high, lies within and between the large drumlins in the area. This implies that the thrust-block moraine is younger than the drumlins, and reflects a post-drumlinisation 'oscillation' of ice.

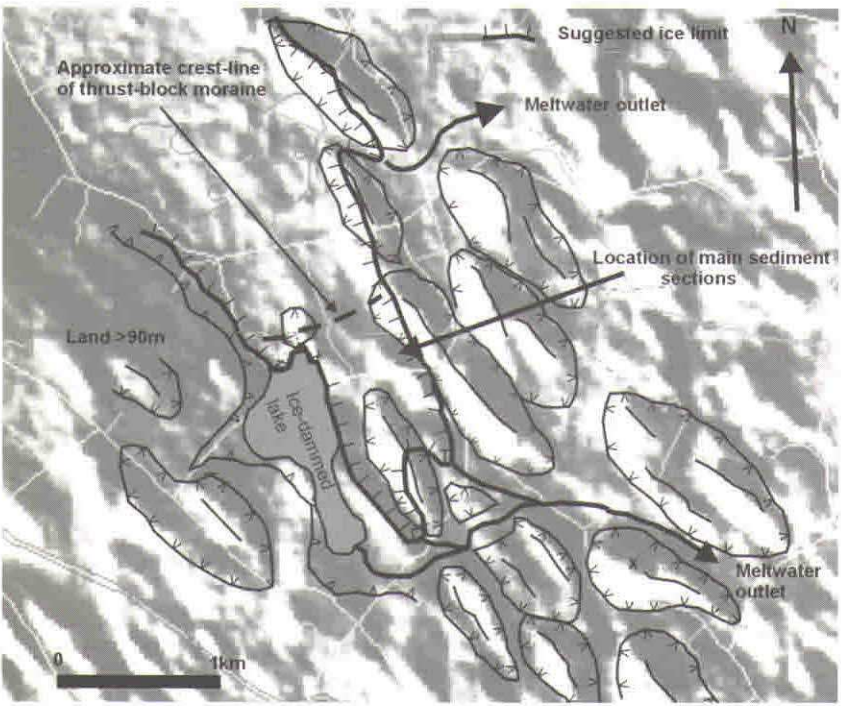


**Figure 1.** Geomorphological map of the area around Mullaghmore, central Ireland, with suggested margins of the small ice tongue extending up the Ballyhoe basin. Drumlins within this ice limit have undergone limited reworking, notably steepening of ice-proximal faces, concurrent with ice pushing up against pre-existing drumlins during a localised re-advance.

- **Sedimentology:** A section diagram from field observation and photographic evidence for the main sections at Mullaghmore has indentified the broad sediment facies and structural elements of this 'thrust-block' moraine. The next phase of work will involve the measurement of deformation structures to allow section balancing, restoration and development of a tectonostratigraphy for the site. However, it is apparent that the majority of the deformation sequence is compressional, supporting the idea of a small tongue of ice extending southwards, up the Ballyhoe basin, and terminating in a proglacial thrust-block moraine against the rise in underlying topography at the basin margin.

## Discussion

It is clear that the fluctuations of the Irish ice sheet, although locally significant, do not reflect regional ice-margin advances in the Mullaghmore area. The small ice-marginal fluctuation at this site probably reflects slight internal shifts of mass balance and ice-flow paths within a retreating and thinning ice sheet, rather than a climatically driven regional re-advance, such as that proposed for the Drumlin Re-advance. As with other sites in central Ireland (Meehan, 1998), Mullaghmore suggests the deglaciation of the Irish ice sheet was progressive, and the formation ice-marginal landforms within the region was time-transgressive, rather than relating to a single, large scale event. However, a significant amount of further research is ongoing for this site to develop these ideas.

## Acknowledgements

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# THE RECOVERY OF LATE GLACIAL/EARLY HOLOCENE DEPOSITS AT TILLING GREEN, RYE (EAST SUSSEX)

## Introduction

In June 2000, a grant was received from the QRA (and other organisations) to undertake fieldwork with the aim of sampling deeply buried organic deposits in the palaeovalley of the River Tillingham at Rye in East Sussex. The drilling was undertaken in late summer 2000, after crop harvesting. This short report outlines the scientific rationale for this work, presents the preliminary findings, and the proposed plan for further analyses.

## Background to study

In contrast to the wealth of information concerning mid to late Holocene environmental change in the Romney Marsh region, there is a paucity of data relating to the early Holocene period. Long *et al.* (1996) have analysed deep (>10m) stratigraphic data from the Rye area dating from *c.*7000 yrs BP but a precise chronology is lacking due to the absence of *in situ* organic material. In fact, the only dated organic sequence covering the early Holocene period in the area is from the adjacent Pannel valley (Waller, 1993).

Therefore, data are seriously lacking which can address issues such as the early Holocene sea-level record and the vegetational history of the Romney Marsh region. This is fundamental since it has been suggested that the expansion and migration of several major tree taxa from central European refugia occurred via the southeast (Birks, 1989). Furthermore, the influence of sea-level change on the pattern of landscape evolution in the early Holocene is poorly understood. Elsewhere in East Sussex, Jennings and Smyth (1987) have reported a deep peat deposit dated to *c.*8700 yrs BP in a borehole located at Langley Point, which pollen data suggest accumulated proximal to tidal channels and sand dunes. The deposits under proposed investigation at Tilling Green have the potential to shed light on these findings and answer at least some of the questions outlined above concerning sea-level and vegetational history of the region.

## Previous Investigations

In 1971, the BGS drilled a series of boreholes in the Tilling Green estate in Rye, one of which recorded more than 1 m of organic sediment overlying bedrock *c.*29 m below the surface. A date of *c.*9500 yrs BP was obtained from a peaty layer above the basal organic material (Welin *et al.*, 1974), although no further

samples were taken. This location is now a built-up area, which severely limits opportunities for reinvestigating the original site (now under a road). A previous attempt to recover the peat within 10 m of this location proved unsuccessful as bedrock was encountered at 24 m depth. This highlighted the unique nature of the deposit. Not only is the peat situated at inaccessible depths but it is also spatially very limited in extent, being contained within the deepest part of a very narrow palaeovalley.

In addition to these earlier investigations, a hand-cored borehole transect was completed across the Tillingham valley in fields to the west of the Tilling Green estate with the aim of defining the bedrock profile as closely as possible. This enabled the deepest part of the valley to be located to within 175 m. The next step was to employ a mechanical drilling rig to map the bedrock profile more closely and then to sample at the deepest point with the hope of recovering the deep peat. The grant from the QRA was used to assist this second phase of fieldwork, the results of which are presented below.

## Fieldwork Results

Using a dynamic penetrometer, a probe was drilled into the valley sediments at the mid-point of the gap in the bedrock profile as mapped by the earlier hand-core investigations. The first penetrometer assessment indicated a depth to bedrock of *c.*29 m immediately south of the present river Tillingham. A second, 30 m to the south encountered resistant sediment (weathered bedrock) at *c.*27 m below surface. A cased borehole was therefore sunk immediately to the south of the river (GR TQ 913297). The sediments recovered below 24 m are detailed in Table 1.

Although the fieldwork and recovery of organic sediments (between 27.64 and 28 m) was successful, the lack of correspondence with the BGS 1971 borehole was disappointing. The depths to bedrock and deepest unconsolidated sediments correspond well - with bedrock overlain in both cases by coarse inorganic material followed by organic material (silty peat). In both cases the organic sediment is overlain by further coarse clastic material and then by soft silty clays. However, in the new borehole, the thickness of peat is much less than the *c.*1.5 m reported by the BGS. Assuming the original information to be correct, this was very unfortunate, and highlights the perils of sampling material at such depths with an unavoidable 'hit or miss' tendency.

In addition to the deep organic material, a thin intercalated peat was also sampled at a depth of *c.*12 m which has also been mapped in the adjacent Brede valley (Waller, 1994). This will provide new information regarding sea-level change for a time when data are lacking.

| Unit | Depth (m below surface) | Depth (m OD) | Lithology |
|---|---|---|---|
| 7 | Above 25 | Above –22.01 | Soft, grey silty clay with organic fragments |
| 6 | 25 to 27.49 | -22.01 to –24.5 | Dark grey silty clay with organic fragments |
| 5 | 27.49 to 27.59 | -24.5 to -24.6 | Grey silt with abundant roots and some detrital organic material. |
| 4 | 27.59 to 27.64 | -24.6 to -24.65 | Yellowish grey, stiff silt with clay and sandstone fragments. |
| 3 | 27.64 to 28 | -24.65 to -25.01 | Light grey organic silt containing abundant plant macrofossils, wood, *Phragmites* rhizomes, leaf fragments and seeds (including a seed of *Cornus sanguinea* at 27.68 m and a fragment of a *Corylus avellana* nut at 27.64 m). |
| 2 | 28 to 28.80 | -25.01 to -25.81 | Very wet gravel in loose sandy matrix |
| 1 | Below 28.80 | Below -25.81 | Very stiff silt with sandstone concretions (Bedrock) |

**Table 1.** Lithology of the deep sediments recovered from the lower Tillingham valley 2000.

## Plans for future work

Palaeoenvironmental work is almost complete on the sediments recovered. A combination of pollen, plant macrofossil, diatom and radiocarbon dating is being undertaken in collaboration with Dr Martyn Waller (Kingston University). The early results are very promising and will certainly contribute to answering some of the questions regarding coastal evolution, sea-level change and vegetational history of the region. We anticipate submitting the results of this research for publication in an academic journal and also the forthcoming Romney Marsh Research Trust Monograph.

I would sincerely like to thank the QRA for awarding me this grant, which enabled the fieldwork to take place.

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# AMAZONIAN ECOSYSTEMS AND THEIR MODERN POLLEN SPECTRA: SAMPLES FROM NOEL KEMPFF MERCADO NATIONAL PARK, BOLIVIA

## Introduction

This New Research Workers Award has assisted in the funding of fieldwork to the Noel Kempff Mercado National Park (NKMNP) in Bolivia. Fieldwork in the Amazonian Lowlands involved assisting Dr Francis Mayle collect and replace the pollen traps which had been set up in NKMNP the previous year. The aim of this field trip was to collect material for my PhD project, entitled *"Characterization of Amazonian forest and savannah ecosystems by their modern pollen spectra"*, which commenced at the University of Leicester upon my return from the field.

The trip to South American comprised two stages. The first, based at the Museo Historia Natural in Santa Cruz, involved the construction of pollen traps, acquisition of permits and logistical support appropriate for the expedition, and the collection of pollen reference material from the herbarium. The second was the travel into, and back from, NKMNP with the samples.

## Rationale and aim

The relatively limited Quaternary investigations into the tropics (Flenley, 1997), coupled with diverse floral assemblages and widely varying pollen production between insect- and wind-pollinated plants creates difficulties when trying to interpret fossil assemblages (Salgado-Labouriau, 1997). The need for further understanding of Amazonian ecosystems has been recently highlighted in a number of papers. For example, changes in the composition of Amazonian ecosystems have been identified by Bush *et al.* (2000) in the Brazilian Amazon during the Holocene and by Mayle *et al.* (2000) in eastern Bolivia back to the Last Glacial Maximum. However, the degree of palaeoecological information gleaned from such pollen records remains rudimentary due to a lack of understanding of how differing tropical ecosystems are manifested in the pollen record. To resolve this problem, a clear understanding of the degree to which different modern-day tropical ecosystems can be differentiated palynologically must be achieved. This PhD project hopes to accomplish this goal for a number of Amazonian ecosystems.

## Research method

This research is centred upon analysis of surface pollen spectra of five distinct ecosystems within the NKMNP: (1) humid upland evergreen forest, (2) inundated evergreen forest, (3) deciduous and semi-deciduous forest, (4) upland Savannah, and (5) inundated savannah. Approximately 200 pollen traps, modified from a design by Bush (1992), have been set up and annually retrieved from NKMNP since 1999. An additional year of data will be collected during the summer of 2001 which will provide a baseline of three years of data to assess the effect of any inter-annual variations (Bush and Rivera, 1998). The pollen traps are located inside permanent vegetation plots which have been surveyed by the Missouri Botanical gardens; this data will provide the highly detailed botanical inventories required to conduct this study (Killeen and Schulenberg, 1999). The vegetation plots are typically 20 x 500 m in area, and each contains 10 traps distributed at 50-m intervals down a central line. Soil samples were also taken from the base of each trap during the 2000 field season.

## Pilot project

Four key questions were identified as fundamental to the scientific validity of the project and needed to be resolved:

1. What is the most effective strategy of sampling ecosystems for modern pollen: trap or soil samples?
2. How reliable is the method of extraction of pollen from samples?
3. Can a consistent pollen signal be extracted from a single plot?
4. Are different ecosystems identifiable from their pollen spectra?

A pilot study was set up to assess the practical extent to which these investigations could be carried out in the time available. The pilot study looked at trap and soil samples from four locations within a plot from each of the five ecosystems. From the subsequent analysis of these samples a number of preliminary findings can be drawn. The pollen captured and retained in the trap samples is better preserved than the pollen in the soil samples. It was also found that the soil samples, particularly in inundated areas, contained very high proportion of silicate material and were therefore difficult to process. Two methods were employed to extract pollen from the traps. The first, through chemical dissolution of the wool, using methods outlined by Bush (1992), was ineffective. The second method of preparation followed a washing method laid out by Behling (1997). Analysis of washed samples has raised questions regarding the

differential extraction of pollen grains dependant on their size; further work is required to identify if a statistically significant bias is occurring.

Pollen analysis has shown that there is a degree of intra-plot variation. This is thought to reflect the diverse make-up of the ecosystems, although there is some evidence of localised swamping of samples. Preliminary pollen data suggest that it will be possible to identify a consistent signal for each plot. It has also been shown that there is a discernable difference in the pollen assemblage produced by each of the five ecosystems.

## Conclusions

The analysis of the sampled pollen data is still in its early stages. However, issues regarding the feasibility of this study in NKMNP have been addressed and it has been shown that it is going to be possible to characterize ecosystems by their pollen spectra. The implications of the pilot project on the course of the research are: (1) a focus on trap material instead of soil samples, (2) further analysis of the effectiveness of the trap-preparation method, (3) the collection of further vegetation location data during the 2001 field season to help explain intra-plot variations in pollen distribution, and (4) the possible increase of pollen sums to 600/1000 grains allowing differences in ecosystems dominated by wind pollinated taxa to be drawn out. The project will go on to investigate further the problems already addressed and assess the effect of inter-annual variation and attempt to differentiate intra ecosystem signatures. It is hoped that these investigations will lead to the ability to distinguish a range of Amazonian ecosystems and sub-ecosystems by their modern pollen spectra.

Further details on this project can be seen on the web site below: http://www.geog.le.ac.uk/staff/wdg2.

## Acknowledgements

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# PRELIMINARY REPORT ON PARTICLE SIZE VARIATION IN A LATE HOLOCENE INTERTIDAL SEQUENCE, THE WAINWAY CHANNEL, ROMNEY MARSH, SOUTHEAST ENGLAND

## Introduction and Background

One approach to palaeoenvironmental reconstruction of former intertidal areas focuses on the direct, near-surface effects of reclamation through the study of spatial changes in sediments and topography (Green, 1968; Allen, 1992). An alternative method looks at long-term temporal development through the Holocene based on biostratigraphic and chronostratigraphic analysis of often isolated, or widely-spaced, and relatively deep cores (Long and Innes, 1995; Waller *et al.*, 1998). More generally, there is a poor understanding of the combined temporal (especially over $10^1$ - $10^2$ years) and spatial variation in marsh deposits, and the physical processes which lead to this variability (Allen, 2000).

The Wainway channel, part of the Romney Marsh complex, southeast England, was a blind tidal inlet with associated mud flats and salt marshes, which drained into the Rother estuary near Rye, until its reclamation from the 14th century onwards (Evans *et al.*, 2001). The final phase of deposition in the Wainway - Green's (1968) post-peat young alluvium - recorded the complex interaction of human activity and natural processes, but these sediments tend to be described simply as a variable mix of sand, silt and clay which is occasionally laminated (Long and Innes, 1995; Waller *et al.*, 1998). The author's PhD research aims to determine and interpret changes to depositional environments, through time and space, based on a detailed study of post-peat lithostratigraphy. A relict topography of creeks and reclamation embankments provides a temporal and spatial framework for the interpretation. Particle-size analysis, funded in part by the QRA, is an important part of this work and the preliminary results are reported here.

## Approach and Methods

Lithostratigraphy and topography have been recorded along transects constructed to intersect channels and embankments at a number of sites around the Wainway. Additional sample cores were recovered from selected sites for laboratory analysis. The latter included down-core magnetic susceptibility profiles, statistical analysis of cyclic variations in layer thickness within several laminated units, a $^{14}C$ date, and detailed particle-size analysis.

Preliminary lithostratigraphic and particle-size results from sample core TC2, located just north (seaward) of the 1649 wall (grid reference TQ964197), are shown in Figure 1. A Coulter LS230 laser particle-size analyser was used for grain size work, with the core sampled every 2 to 10 cm, and greatest resolution reserved for the undisturbed sediments below the root zone.

## Results and Discussion

The basic fourfold lithostratigraphy recorded in the field was supported by results of the laboratory analysis (Figure 1). Although the variability of these sediments, both within and between the four units identified, was clear from a visual inspection in the field, the extent of this variability, its trends and cycles, only became apparent after the detailed particle-size analysis.

The basal unit four (Figure 1) was composed of an impenetrable sand, with a very minor, possibly flaser-bedded, muddy component. This graded upwards, over just a few cm, into the finer grained and laminated sandy mud of unit three. Superimposed on the fining upwards trend is a clear cyclicity in mean particle size (Figure 1). This may be expected in laminated sediments, with clearly alternating muddy and sandy layers, but is perhaps a little more unexpected in the surrounding units.

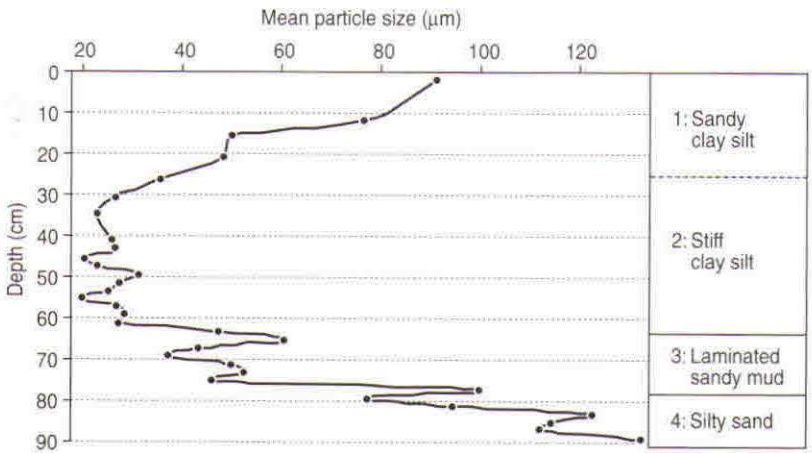


**Figure 1.** TC2: particle-size profile and lithostratigraphy.

Unit two, a sandy mud, is quite consistent in terms of mean particle size (Figure 1), and was relatively well sorted in comparison to the rest of the core. Poorly defined sand lenses were noted in the field description. Although the clear fining-upward trend is now absent the cyclic variability persists, but with reduced amplitude and slightly longer wavelength. Unit one, the structureless sandy clay silt, shows no evidence of cyclicity in particle size but has a coarsening-upward trend, accompanied by increasingly poor sorting.

Based in part on modern analogues (e.g. Reineck and Singh, 1980) three significant changes in depositional environment may be suggested from this evidence. A relatively high-energy channel or sand-flat phase led to the deposition of the basal sand. Units three and two were deposited in an increasingly quiet, though still variable, intertidal setting. This sequence could be related to the long-term silting up of the Wainway or its predecessor (Spencer *et al.*, 1998; Evans *et al.*, 2001). Finally, there was a return towards, perhaps very localised, higher-energy conditions. This was possibly driven by a change in hydrodynamics during piecemeal reclamation of the area through the 15$^{th}$-17$^{th}$ centuries, when wholesale changes to the location and extent of the channel network, tidal flats, and marshes occurred (Green, 1968).

## Conclusions

This brief report has aimed to show that study of the lithostratigraphy of post-peat sediments in the Wainway, previously described simply as complex and variable, can reveal in some detail palaeoenvironmental changes through that period. Ongoing work will attempt to link TC2 with other sites around the marsh, and to relate all to the existing topographical and historical evidence of environmental change.

## Acknowledgements

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# APPLICATION OF THE NEW RADIOLUMINESCENCE DATING METHOD TO SAMPLES OF UPPER PLEISTOCENE AND HOLOCENE AEOLIANITES FROM THE CARMEL COASTAL PLAIN IN ISRAEL

In the Mediterranean Coastal Plain of Israel relict barchanoid dunes now forming elongated ridges appear as morphological features running parallel to the current shoreline. These aeolianites are locally known as Kurkar ridges and are consolidated by calcareous cementation. They are intercalated with palaeosols. The mineral spectra of the relict dunes contain mainly quartz but also feldspar grains carried through the River Nile and northward along the coast by Mediterranean currents. Although there are several palaeolithic finds in the Hamra soils, the formation and age of each of the stratigraphical units are not yet clear. From the early 1960s to the 1980s two assumptions were generally held: (1) each ridge represents a single accumulation phase and (2) the age of the ridges steadily decreases from east to west. More recent research revealed that a sandstone ridge is a complex, multi-phase structure and that adjacent ridges could be contemporaneous. It was proposed that all ridges in the central coastal plain were deposited during the Last Glacial.

To achieve a reliable geochronological framework, luminescence dating is the best dating tool because of the lack of other datable material, the aeolian transport of the sediments and the expected time range. Samples from various sections along the northern part of the Israeli coast were collected for dating by infrared optically-stimulated luminescence and thermoluminescence. Initial results were published in Engelmann *et al.* (2001) and Frechen *et al.* (2001).

Some of the samples from the Israeli coastal plain had been chosen for a comparative dating study between radioluminescence dating and the results from the classical methods. Radioluminescence dating of these samples is the first extended radioluminescence dating study on a number of samples of fossil dune sands from a semi-arid to arid environment.

Radioluminescence dating is an entirely new luminescence dating method (Trautmann *et al.*, 1998, 1999; Krbetschek *et al.*, 2000). In conventional luminescence dating, two main activation energies have been used for stimulating the luminescence signal: heat (thermoluminescence dating) and light (optical stimulated dating). The new dating method uses radioactivity for stimulating the luminescence signal (radioluminescence dating).

The luminescence signal is detected during radioactive irradiation of the sample. The first signal measured is the natural radioluminescence signal; the irradiation and the measurement of the signals continues to the point where the

radioluminescence does not change; then the sample is bleached with artificial sunlight and the radioluminescence of the bleached sample is detected. The infrared emission at 1.42 eV can be used for infrared radioluminescence dating of potassium feldspars.

The new technique was applied to 14 samples from a section in a quarry at Habonim. The section consists of aeolianites intersected by a paleosol-complex. The measurements were made with the new automatic radioluminescence reader (Erfurt *et al.*, in press). From each sample measurements with two different optical filters were carried out. The samples were irradiated and the radioluminescence signal was measured simultanously. This resulted in about 650 dose points for each measurement. Through these dose points a simple exponential decreasing function could be fitted. The results of this comparative study will be published in Engelmann *et al.* (in prep).

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# A LATE HOLOCENE LAKE DIATOM AND ATMOSPHERIC POLLUTION RECORD FROM MASSIF CENTRAL, FRANCE

Late Holocene post-industrial lake acidification is well documented throughout the UK and Scandinavia. Various causes have been inferred, of which acid deposition is of particular interest due to its link to sulphur deposition from atmospheric pollution caused by fossil-fuel burning. Previous work has suggested good temporal and spatial correlations between reconstructed former lake pH and sulphur-dioxide and nitrous-oxide emissions.

As reliable indicators of lake-water pH, diatoms were used to investigate the acidity record of a lake in the Massif Central, France (Lac de la Godivelle d'en haut). The reconstructed record was then compared to an atmospheric pollution proxy: spheroidal carbonaceous particles (SCPs) (soot) produced from the incomplete combustion of oil/coal. These are extremely well preserved in lake sediments and are shown to match records of sulphur emissions.

The SCP concentration profile was successfully reconstructed, showing clearly the start of the record (*c.*1890AD, dated from other work in France), the sudden post-WWII rise (1950s-60s) and the 1970s peak, followed by a decline up to the present. These features were approximately dated using UN-published figures for fossil-fuel contributions to electricity production. Actual SCP concentrations at this site were found to be relatively low (only 1,000s per gram of dry weight sediment), suggesting that the site is relatively clean with respect to air pollution.

The diatom assemblages were used to reconstruct lake pH over time using the SWAP (Surface Waters Acidification Programme) transfer function (based on the UK and Scandinavian training set). Alkalinity (related to pH) was inferred from a local, previously-derived transfer function. Both reconstructions (Weighted Averaging with tolerance downweighting performed the best in both cases) showed very similar patterns, suggesting that at this site at least, the SWAP dataset is applicable. Rather than an acidifying trend, this lake has in fact become more alkaline over time, changing from pH 5.73 at 32 cm depth, to pH 6.35 in the surface sediment sample. However, low acidity values at the base of the core could have been driven by a high abundance of *Peronia fibula*, associated in the SWAP dataset with highly acidic conditions, but shown in other studies to be more epiphytic (living attached to plants).

This increase in alkalinity suggests either that acid deposition is not occurring in this region of France or, if it is, that levels are so small that the lake is capable of buffering it. The over-riding signal is that of increasing alkalinity, which could be due to a warmer climate encouraging within-lake productivity

(reinforced by increasing LOI values nearer the top of the core), causing more nutrient-rich, eutrophic conditions. However, changes in the catchment cannot be ruled out, since the natural forest vegetation has been cleared and replaced with grass some time in the past.

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# *REVIEWS*

## DEFORMATION OF GLACIAL MATERIALS

**Edited by A.J. Maltman, B. Hubbard and M.J. Hambrey**

**Geological Society Special Publication No. 176.**

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Until the early 1980s, subglacial and proglacial deformation received very little attention in the English-language literature. Concepts of subglacial geomorphic processes were dominated by the classic ideas of debris entrainment into, and deposition from, glacier ice, whereas large moraines exhibiting evidence of internal deformation were commonly interpreted in terms of a simple "push-from-behind" model. Since that time, there has been an explosion of interest in glacial deformation and its implications for glacier dynamics. Subglacial deformation, in particular, suddenly became the most fashionable of processes, and was invoked to explain a dazzlingly wide range of phenomena, from surges to Antarctic ice streams to the North Atlantic Heinrich events. Within the last few years, a more sober approach has prevailed, and a wide range of research strategies has been employed to assess the importance of glacial deformational processes in many environments. A consensus is emerging from a creative interaction between glaciology (studies of glacial structures, and data from instrumented boreholes and ice tunnels), laboratory experimentation, mathematical and numerical modelling, and sedimentology and geomorphology, in an impressively interdisciplinary research effort.

Many of these research themes are represented in the present volume, which is the outcome of a conference on the 'Deformation of Glacial Materials' held at Burlington House in September 1999. The volume contains 23 papers organised somewhat illogically into four sections; Ice Deformation; Glacier Flow and Structures; Subglacial Deformation; and Glaciotectonic Structures. The first section includes papers on the formation of basal-ice sequences in Greenland ice cores (Souchez *et al.*), ice crystallographic evolution in the Glacier de Tsanfleuron (Tison and Hubbard), laboratory experiments on the effects of solutes on ice rheology (Baker *et al.*), and comparative centrifuge experiments on the deformation of clean and debris-rich ice (Irving *et al.*). The Tison and Hubbard paper is an impressive study of ice crystallographic variation in a temperate glacier and its relationship to ice formation and deformation processes,

and is beautifully illustrated with two full-page colour photographs of ice in thin section. The centrifuge experiments reported by Irving, Rea and Harris are particularly interesting, and demonstrate the potential for using this technique to reproduce the stress conditions occurring beneath and within glaciers, allowing a wide range of new research questions to be addressed.

The following section, on glacier flow and structures, contains analyses of structures exposed on the surfaces of Variegated Glacier (Lawson *et al.*), Pasterze Glacier, Austria (Herbst and Neubauer), and the Central Framnes Ice Stream (Marmo and Wilson) and Johnsons Glacier (Ximenis *et al.*), both in Antarctica, together with the results of experimental studies (Wilson), high-resolution flow modelling (Hubbard and Hubbard), and an extended review of structural styles and deformation fields in glaciers (Hambrey and Lawson). The review by Mike Hambrey and Wendy Lawson is particularly useful, and should stand as a landmark paper on an important subject. An important point to emerge form this review and other papers in this section is the importance of rheological anisotropy and non-steady flow conditions (both in space and time) in generating ice structures. Other papers in this section demonstrate the impressive progress that has been made in high-resolution modelling of glacier flow fields.

The third section, subglacial deformation, also contains examples of theoretical modelling, field studies and laboratory experiments. Richard Alley offers a non-technical and thought-provoking essay on several aspects of subglacial deformation, providing an excellent guided tour through some of the recent literature, while Hindmarsh and Rijsdijk present a mathematical model of loading structures in effective-pressure-dependent viscous materials. Detailed observations of ice-deformation rates beneath the cold Suess Glacier, Antarctica, are reported by Fitzsimons *et al.* These valuable observations were made in a 25-m tunnel excavated into the glacier, although the business-like and objective style of the paper reveals nothing of the adventures that must have been involved in the construction and maintenance of such a working environment. Martin Siegert discusses airborne radar evidence for varying basal conditions beneath East Antarctica, including frozen-bed conditions, water-saturated sediments, and a subglacial lake. The ability to acquire such detailed information from airborne sensors is a very exciting development, which is sure to facilitate major improvements in models of glacier dynamics. Processes acting at much smaller scales are explored by Hubbard and Maltman, who report the results of laboratory experiments on the static and dynamic hydraulic conductivities of diamicton samples at a range of effective pressures. This section of the volume concludes with an interesting analysis by Fuller and Murray of the subglacial sediments exposed on the foreland of a surging glacier.

'Glaciotectonic structures' forms the theme of the final section of the book. John Menzies offers a typology of till microstructures, illustrated with several monochrome photomicrographs together with interpretive sketches. To my eye at least, many of the features identified in the sketches do not appear to correspond to anything in the photographs, although this could be due to the poor quality of reproduction. The following paper, by Van der Wateren *et al.*, is a useful review of the kinematic significance of deformation structures, at both micro and mesoscales, and makes good use of concepts from structural geology. Two case studies follow, illustrating the usefulness of structural studies at hugely differing scales. Philips and Auton focus on the microscopic structures in deformed glaciolacustrine sediments, illustrating their study with clearly drawn and well-observed detail, while Huuse and Lykke-Andersen use seismic profiling to reveal large-scale glaciotectonic thrust structures beneath the North Sea. The following paper, a weighty model of drumlin formation by Fowler, seems rather out of place in this section, but is likely to be a significant contribution to the literature. The model is a development of work by Richard Hindmarsh, and shows how till deposition can amplify small perturbations (such as topographic highs) in a deformable bed. Although very rigorous, it is unlikely to be the last word in the drumlin saga. Finally, Graham and Midgely take another look at the moraines in Cwm Idwal, applying concepts developed for polythermal glaciers in Svalbard.

Being a conference volume, *Deformation of Glacial Materials* does not offer a comprehensive overview of the subject, and some important recent research directions are not represented. It does, however, contain several very important papers in a significant and maturing discipline, and as such should be included in the library of any institution where glaciology and glacial geology are researched and taught.

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## MUNDESLEY AND NORTH WALSHAM (SHEETS 132 & 148)[1], FAKENHAM (SHEET 146)[2], SWAFFHAM (SHEET 160)[3] AND WOODBRIDGE AND FELIXSTOWE (SHEETS 208 & 225)[4] : SOLID AND DRIFT EDITIONS (ENGLAND AND WALES).

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After the publication of these maps there are few gaps left in the 1:50,000 coverage of East Anglia. Cromer (sheet 131) is being drafted, and the five remaining sheets should be surveyed within the next decade (see *Quaternary Newsletter*, 94, 48-9). Both the coastal maps were completely resurveyed, include marine geology and cover a larger area than normal. The Swaffham and Fakenham maps, however, are provisional editions compiled from the original 1880-83 survey, later publications and borehole records without any fieldwork. These maps are all Solid and Drift (S&D) editions that show in colour the Quaternary or drift surface outcrops along with older solid outcrops, which in East Anglia also include the lithified Plio-Pleistocene Crag Group (see *Quaternary Newsletter*, 93, 56-8). They also indicate under the symbols for the drift deposits the nature of the underlying solid subcrop. After a number of years, in addition to showing the Ordnance Survey kilometre grid, the BGS is once again marking longitude and latitude on the margins of 1:50,000 maps. As usual the publication date refers to the year it was issued as an Early Release electrostatic plot and not when the sheet was printed, sometimes after quite a time-lag, while folded copies normally appear six months later.

The Mundesley and North Walsham map covers the northeastern corner of Norfolk. Compared to the earlier BGS 1:250,000 Quaternary map of East Anglia (sheet 52N 00), the extensive Anglian Corton Formation is now mapped as either diamicton and glaciolacustrine silts or sand and gravels deposits. In addition to the Lowestoft Till and relatively small areas of intervening gravels

and head, the postglacial (Holocene) deposits and areas worked of peat in the Broads are meticulously delineated, while suffixes indicate the depositional environment of marine deposits that occur both along the coast and in patches offshore. Thus the offshore area is a fully-integrated part of the map, and the colours of the geological units below low water are subdued by white diagonal lines. A revised offshore boundary between the Chalk and Crag is also shown, and details of the local tidal range relative to Ordnance Datum are given. In addition to the standard cross section, insert maps and key, there are schematic cross sections relative to Ordnance Datum clearly showing the idealised relationships between the Quaternary deposits in five selected areas. These would have benefited from a vertical scale even if they are not true horizontal sections.

The Woodbridge and Felixstowe map covers the southeasternmost part of Suffolk, including tidal reaches on the rivers Deben and Ore, and extends up to 22 km offshore with detailed bathymetry at 5-m intervals. Inland of Orford, quite intricate boundaries between the different divisions of the Crag are shown, and this can be clearly seen even in areas mantled by younger drift deposits. These consist mainly of the pre-Anglian Kesgrave Formation, Lowestoft Till, glaciofluvial deposits and estuarine muds, while there are small areas of other drift deposits and narrow strips of beach gravels along most of the coast and widespread Eocene outcrops on the lower flanks of higher ground. The extensive made ground in the port of Felixstowe is indicated by ruled lines over the underlying geological colour, and this system is also used to show landslips, quarries and landfills.

The adjacent Swaffham and Fakenham sheets in western Norfolk are desktop compilations that provide otherwise hard-to-collate information on a modern base map, as a proper survey is unlikely before the present BGS mapping programme is completed. They tentatively show the distribution of the different units of the Anglian Lowestoft Till that mainly blanket the Upper Chalk and higher ground to the east, while towards the west Nordelph Peat and other Quaternary deposits that fringe the Fens are shown. Unfortunately, these provisional maps are printed on a smaller paper size than standard sheets and thus have no space in the margins for additional diagrams beyond one cross section and a key.

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# *LETTER TO THE EDITOR*

## THE OCCURRENCE OF RHOMB-PORPHYRY WITHIN DIAMICTONS IN NORTH-EAST NORFOLK

**B.S.P. Moorlock, R.J.O. Hamblin, J. Rose and J.R. Lee**

Many readers will be aware of our current work on the glaciogenic deposits of north-east Norfolk.

Following numerous field visits to the coastal sections of north-east Norfolk, and large pebble counts, we have found clasts of Scandinavian rhomb-porphyry only in the Briton's Lane Sand and Gravel that caps much of the Cromer Ridge. We have yet to find any evidence of Scandinavian rocks within the so-called 'North Sea Drift' diamictons generally attributed to deposition from Scandinavian ice. All the igneous and metamorphic clasts that we have seen in the diamictons, including various types of porphyry, can be correlated with rock-types currently found in northern Britain. Palynological analyses, by our colleague Jim Riding, confirm that the ice-sheets that deposited the diamictons incorporated Upper Palaeozoic and Mesozoic sediments from northern Britain.

Despite our lack of success in finding *in situ* rhomb-porphyry within the diamictons, there have been numerous published accounts that record its occurrence. However, we suspect that many of the findings refer to loose blocks found at the base of cliffs, and derived by erosion of the upslope Briton's Lane Sand and Gravel. In some instances, British porphyries with large phenocrysts may have been incorrectly identified as rhomb-porphyry. The very common and extensive slipped masses of diamicton along the cliffed-coastline could also have incorporated rhomb-porphyry derived from overlying sediments. It is even conceivable that during storms, pebbles of rhomb-porphyry from the beach could be thrown against the cliff and become embedded in the surface of the softer diamictons.

We would be most interested to hear whether or not QN readers' experiences reflect our own. If anyone has found incontrovertible *in situ* rhomb-porphyry within the diamictons, we would like to hear from them. If they could provide a grid reference and identify the diamicton (for example, First, Second or Third, or alternatively Happisburgh, Walcott or Hanworth) this would be much

appreciated. Would anyone with information please contact any of the undersigned either at the addresses below, or by e-mail.

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# *ABSTRACTS*

## RECENT HUMAN IMPACT AND LAND USE CHANGE IN BRITAIN AND IRELAND: A POLLEN ANALYTICAL AND GEOCHEMICAL STUDY

**Sarah H. Morriss (Doctor of Philosophy)**
**Department of Geography, University of Southampton**

With the exception of a few researchers, the study of the historic period to the present day has largely been neglected by palaeoecologists and existing studies often lack multiple methods of reconstruction, sufficient chronologies or detailed correlation with the documentary record. Consequently, this research seeks to investigate what effect human activity has had on the environment over the recent past by using a multi-proxy approach, trying to establish more rigorous chronological control over profiles and comparing sequences with local historical evidence.

A number of analytical techniques have been applied to four peat profiles from three ombrotrophic mires: Abbeyknockmoy (Co. Galway, Ireland), Shaw Moss (southwest Cumbria) and Tregaron (Southeast and West Bogs, Ceredigion, Wales); and three profiles from two lake deposits: Lake Gormire (Yorkshire) and Talkin Tarn (north Cumbria). Pollen analysis was used as the principal method of vegetation reconstruction at all sites, while Silicon and Titanium analyses were also undertaken at Abbeyknockmoy, Shaw Moss and Tregaron Southeast Bog. These geochemical profiles provide additional proxy records for the intensity and timing of anthropogenic activity. The chronology of each site is based on *Pinus* pollen data and AMS radiocarbon dates, with the exception of Lake Gormire where $^{210}Pb$ dating is used. The presence of an historic tephra isochrone at Abbeyknockmoy allows direct comparison with the documentary record and can be used to constrain the radiocarbon chronology of this profile.

The original aim of the project was to reconstruct the land-use history around each of the study sites for the last 1,000 years, with special reference to monastic influences. The results indicate, however, that some profiles date from either the prehistoric or Roman periods. While this was originally beyond the scope of this research, such profiles offer insights into the debates concerning the extent of Iron Age activity prior to the Roman invasion and the fate of agricultural activity after Roman withdrawal in *c.* 400 AD.

The results indicate varying degrees of Iron Age farming activity at Tregaron Southeast Bog, Shaw Moss and Talkin Tarn. Agriculture increased around the Southeast Bog during the period of Roman occupation, although the centuries immediately following Roman withdrawal are characterised by a phase of woodland regeneration and declining activity at the Southeast and West Bogs. Evidence from Talkin Tarn, however, suggests the continuation of farming after the end of Roman rule. The records from Abbeyknockmoy and the Southeast and West Bogs indicate that the establishment of local Cistercian monasteries in the 12$^{th}$ century AD had a significant impact on the landscape, while evidence from Abbeyknockmoy and Lake Gormire suggest that the Dissolution of the monasteries in the 16$^{th}$ century AD did not result in widespread land abandonment and woodland regeneration. The geochemical profiles correlate well with the pollen record for human impact and both proxies demonstrate a close relationship with the documentary evidence.

# HOLOCENE CLIMATE CHANGE IN GLEN AFFRIC, NORTHERN SCOTLAND: A MULTI-PROXY APPROACH.

**Eileen Wendy Tisdall (Doctor of Philosophy)**
**Department of Environmental Science, University of Stirling, Stirling**

A multi-proxy approach was used to generate a continuous, sensitive Holocene palaeoclimatic record for Glen Affric, northwest Scotland. Fluctuations in lake-level were used as a proxy for shifts in precipitation. Rigorous site selection criteria and a new methodology were developed to interpret the lacustrine sediment record in terms of climatically-driven changes in water depth by (a) separating allogenic from autogenic sediment inputs and (b) determining how the marginal fen-peat system responded to changes in lake-level. The sedimentary record from the lake site, Loch Coulavie, suggests that lake-level has fluctuated repeatedly throughout the Holocene. The comparative magnitude of changes in lake-level defined the relative intensity of shifts in precipitation.

Variations in mire-surface wetness, as determined through humification analysis, from a series of four hydrologically-isolated ombrotrophic blanket mire sites through the east-west trending glen, were used to generate a record of changes in effective precipitation. A reliable radiocarbon chronology obtained from both proxy records allowed the synthesis of these data sets and the definition of Holocene climate change in terms of relative shifts in temperature and precipitation. The data suggest that the early Holocene was more stable in terms of both temperature and precipitation, but that after *c.* 6200 yrs BP (7200 cal. BP) both temperature and precipitation became highly variable. Several short-lived, abrupt high-intensity shifts to increased precipitation occurred at *c.* 6200 yrs BP (7200 cal. BP), *c.* 5000 yrs BP (5700 cal. BP), *c.* 3000 yrs BP (3200 cal. BP) and *c.* 2400 yrs BP (2350 cal. BP).

Holocene climatic variability within Glen Affric corresponds to records of changes in North Atlantic oceanic circulation patterns. The predominance of atmospheric systems, such as Atlantic westerlies, may also have controlled spatial climatic variability within the glen, with the periodic establishment of very steep west-east climatic gradients, steeper than at the present day.

# *NOTICES*

## 1. THE XVI[TH] INQUA CONGRESS WILL BE HELD 23 - 31 JULY, 2003 AT THE RENO HILTON

**Resort & Conference Center, Reno, Nevada, USA**

Full details of the Congress can be found on the Congress Web site:

**http://www.dri.edu/DEES/INQUA2003/inqua_home.htm**

## 2. TEFRATRACE (TOWARDS A EUROPEAN FRAMEWORK FOR CORRELATING RECORDS OF ABRUPT ENVIRONMENTAL CHANGE)

**15-20 April 2002**

Department of Geography, Royal Holloway, University of London

CALL for participants and papers

An international workshop on applications of tephrochronology and laboratory training in the detection of microtephra horizons

**Invited Leaders**

| | | |
|---|---|---|
| Dr Valerie Hall | Dr David Lowe | Dr Stefan Wastegård |
| Queen's University | University of Waikato | Stockholm University |
| Belfast, UK | New Zealand | Sweden |

**Organisers**

| | |
|---|---|
| Dr Chris Turney | Prof John Lowe |
| INQUA Commission for | INQUA Palaeoclimate |
| Tephrochronology & Volcanism | Commission |
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**http://www.gg.rhul.ac.uk/inquatephra/tefratrace**

# 3. HISTORY OF THE NORTHWEST EUROPEAN RIVERS DURING THE PAST THREE MILLION YEARS.

A series of palaeogeographical maps illustrating the evolution of the northern European drainage system over the last 3 million years, compiled by Phil Gibbard, will shortly be available on the Quaternary Palaeoenvironments Group Web pages at:

**http://www-qpg.geog.cam.ac.uk/Phil%27s%20web%20page/NWEuroRivers/NWeuroindex.html**

The maps are based on a review of the histories of the major rivers of northwestern Europe. They include the rivers Elbe, Saale, Weser, Rhine, Meuse, Scheldt, Thames, Somme and Seine. Two further rivers that no longer exist, the Baltic and Channel rivers, are also included. The histories of these rivers illustrate how the interplay of tectonics and climate have influenced the northwest European drainage system through the late Cenozoic. Although they were originally published by Phil Gibbard in 1988, the maps were updated in spring 2001 for presentation at the final meeting of the Netherlands NEESDI project held in Amsterdam. They are presented here, in downloadable format, for use by anyone interested in the long-term development of river systems. They will be updated as evidence becomes available.

The drainage maps represent a contribution to International Geological Correlation Programme, IGCP 449: Global correlation of Late Cenozoic fluvial sequences.

## QUATERNARY RESEARCH ASSOCIATION

The Quaternary Research Association is an organisation comprising archaeologists, botanists, civil engineers, geographers, geologists, soil scientists, zoologists and others interested in research into the problems of the Quaternary. The majority of members reside in Great Britain, but membership also extends to most European countries, North America, Africa, Asia and Australasia. Membership (currently *c.* 1,000) is open to all interested in the objectives of the Association. The annual subscription is £15 with reduced rates (£5) for students and unwaged members and an Institutional rate of £25.

The main meetings of the Association are the Annual Field Meeting, usually lasting 3-4 days, in April, and a 1 or 2 day Discussion Meeting at the beginning of January. Additionally, there are Short Field Meetings in May and/or September, while Short Study Courses on techniques used in Quaternary work are also occasionally held. The publications of the Association are the *Quaternary Newsletter* issued with the Association's *Circular* in February, June and October; the *Journal of Quaternary Science* published in association with Wiley, incorporating *Quaternary Proceedings*, with eight issues per year, the Field Guide Series and the Technical Guide Series.

The Association is run by an Executive Committee elected at an Annual General Meeting held during the April Field Meeting. Current officers of the Association are:

**President:** *Professor M.J.C. Walker*, Department of Archaeology, University of Wales, Lampeter, Ceredigion, SA48 7ED, Wales, UK (e-mail: walker@lamp.ac.uk)

**Vice-President:** *Dr R.C. Preece*, Department of Zoology, University of Cambridge, Downing Street, Cambridge, CB2 3EJ. (e-mail: r.c.preece@zoo.cam.ac.uk

**Secretary:** *Dr C.A. Whiteman*, School of the Environment, University of Brighton, Cockroft Building, Lewes Road, Brighton, BN2 4GJ (e-mail: C.A.Whiteman@brighton.ac.uk)

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

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

# QN

October 2001 No. 95

## Contents

Page

1 **ARTICLE**

1 Broom Palaeolithic sites *Robert T. Hosfield and Rachael Terry*

6 **REPORTS**

6 Inaugural meeting of IGCP Project 449 'Global correlation of Late Cenozoic fluvial deposits'

9 Canadian Quaternary Association (CANQUA) Meeting

12 Pre- and post-conference CANQUA Fieldtrips, Yukon Territory, Canada

19 The sixth Annual QRA Postgraduate Symposium: The University of St Andrews

23 **Quaternary Research Fund**

23 Glaciotectonised sediments at Mullaghmore, County Meath, Ireland: evidence of a large scale re-advance during ice-sheet deglaciation?

27 The recovery of late glacial/early Holocene deposits at Tilling Green, Rye (East Sussex)

31 **New Research Workers Award Scheme**

31 Amazonian ecosystems and their modern pollen spectra: samples form Noel Kempff Mercado National Park, Bolivia

35 Preliminary report on particle-size variation in a late Holocene intertidal sequence, the Wainway Channel, Romney Marsh, southeast England

39 Application of the new radioluminescence dating method to samples of Upper Pleistocene and Holocene aeolianites from the Carmel Coastal Plain in Israel

42 A Late Holocene lake diatom and atmosphereic pollution record from Massif Central, France

44 **REVIEWS**

44 Deformation of glacial materials *Edited by A.J.Maltman, B. Hubbard and M.J. Hambrey*

47 Mundesley, North Walsham, Fakenham, Swaffham, Woodbridge and Felixstowe British Geological Survey Sheets (England and Wales)

49 **LETTER TO THE EDITOR**

49 The occurrence of rhomb-porphyry within diamictons in north-east *Norfolk B.S.P. Moorlock, R.J.O. Hamblin, J. Rose and J.R. Lee*

51 **ABSTRACTS**

51 Recent human impact and land-use change in Britain and Ireland: a pollen analytical and geochemical study *Sarah H. Morriss*

53 Holocene climate change in Glen Affric, northern Scotland: a multi-proxy approach Eileen W. Tisdall

54 **NOTICES**

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