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QUATERNARY NEWSLETTER

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Instructions to authors

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**.

Suggested word limits are as follows: obituaries (2000 words); articles (3000 words); reports on meetings (2000 words); reports on QRA grants (500 words); reviews (1000 words); letters to the Editor (500 words); abstracts (500 words). Authors submitting work as Word documents that include figures must send separate copies of the figures in .eps format. Quaternary Research Fund and New Research Workers Award Scheme reports should limit themselves to describing the results and significance of the actual research funded by QRA grants. The suggested format for these reports is as follows: (1) background and rationale (including a summary of how the grant facilitated the research), (2) results, (3) significance, (4) acknowledgments (if applicable). The reports should not (1) detail the aims and objectives of affiliated and larger projects (e.g. PhD topics), (2) outline future research and (3) cite lengthy reference lists. No more than one figure per report is necessary. Recipients of awards who have written reports are encouraged to submit full-length articles on related or larger research projects.

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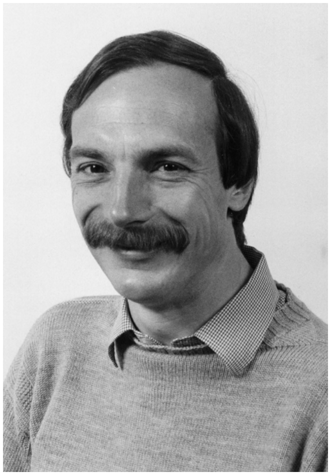
COVER PHOTOGRAPH
David Keen out in the field at Middleton Hall Quarry in the West Midlands.

TRIBUTES

PROFESSOR DAVID HENRY KEEN (1947-2006): FORMER QRA PRESIDENT, A GREAT SERVANT TO THE ASSOCIATION AND TO QUATERNARY SCIENCE

By Danielle Schreve, David Bridgland and Peter Allen



Although many others have contributed thoughts and information, it has fallen upon the three of us to prepare this appreciation of David Keen, whose premature death occurred on Easter Day, 26th April, 2006. We had been working closely with David in his final years, enjoying intensive writing sessions at his home preparing papers on Purfleet (published in *Quaternary Science Reviews*: Schreve *et al.*, 2002), the Lion Pit Tramway Cutting (*Proceedings of the Prehistoric Society*, Schreve *et al.*, 2006) and Aveley, the last of which will be one of many posthumous Keen publications to add to his legacy of over 100 already in print. Since they were located *chez* Keen, these sessions allowed us to get to know David's family, usually over a cup of tea after his wife Susan had returned home from work or when son Edmund or daughter Rosalind dropped in. They took place a few times a year and continued during his illness, about which he was completely sanguine. Before David's separation from the Geography Department at Coventry University such meetings would have taken place there. He had worked at this establishment, previously Lanchester Polytechnic, throughout has academic career, having secured a position there in 1976.

Peter Allen had known David the longest. David and he were contemporaries in that both graduated in 1969 and subsequently went on to teach in polytechnics. Having met as students they later developed a professional relationship, during which they frequently shared their common experiences. Peter's first impressions were that David was a quiet, perhaps even dour person, but he quickly learned that behind this exterior was a sharp wit; Peter particularly enjoyed and identified with David's sardonic, wry observations about their teaching and research situations. The two had in common their London upbringing – David was brought up in Catford (although he was born in Hitchin and attended Raine's Foundation Grammar School in Stepney - 1958-66) - and an interest in railways (in common with several luminaries of the QRA, to the despair of younger members like Danielle). Professionally Peter had experience of David as an incisive but practical external examiner at London Guildhall University and a thoroughly reliable co-author for the Quaternary of East Anglia and the Midlands volume of the Geological Conservation Review (GCR) series (this will be another posthumous Keen publication). During David's presidency of the QRA, he worked closely with Peter (then Treasurer) and Danielle (Awards Officer) to extend the Association's sphere of operation, by increasing the number of awards for delegates attending INQUA, helping postgraduates attend the increasingly expensive Annual Discussion and Field Meetings and by incorporating the Bill Bishop Award into the Association's portfolio.

David Bridgland is certain that he first met David Keen at a QRA meeting, although he is not sure which. David was always friendly towards those 'starting out' and was particularly helpful when DB, fresh from PhD research, was engaged by the then Nature Conservancy Council to oversee the GCR site selection for much of the English Quaternary. When the attention of both was directed towards the Midlands, another young researcher found David to be a great source of help and encouragement – Darrel Maddy, who was studying the Quaternary record of the Severn/Avon. This led to Bridgland, Keen and Maddy collaborating to reopen sections at a number of sites, particularly Cropthorne, where they showed that Mabel Tomlinson was wrong in her view that the terrace sequence there was chronologically inverted. Their attempts to demonstrate this to the QRA at the 1989 annual meeting, for which David edited the field guide, were somewhat thwarted by terrible weather, leading to Pete Coxon recalling this (repeatedly) as one of the worst QRA experiences ever - a source of gentle digs whenever Keen and Coxon came together. The banter did not stop the two of them from sharing a room on the last QRA Annual Field Meeting that David attended, in Ireland in 2005. However, Pete's antics upon returning to the room in the early hours when David was already asleep, provoked the dour comment: "Coxon, this isn't a bloody disco", as Pete succeeded in repeatedly turning the various lights in the room on and off in a vain attempt to locate the switch for the bathroom!

Danielle Schreve met David on the QRA annual field meeting in Jersey in 1993. It was her first AFM; she knew nobody and, as an archaeology undergraduate, was feeling rather nervous at encountering so many Quaternary scientists in one place. David's first words were "Aha, *Nucella*!" Somewhat bemused by this eccentric introduction and not *au fait* with molluscan taxonomy, she was ready to tell him that, actually, her name was Danielle but was spared further embarrassment when she realised he was peering intently at her ears, from which were dangling silver earrings in the shape of whelks. So *that's* what he's on about! She breathed a sigh of relief that she had not disgraced herself (needless to say, David roared with laughter when this story was recounted to him years later). Danielle's thorough enjoyment of her first QRA meeting, appreciating not just the science but also the friendliness that went along with it, was due in no small measure to David's knowledge and enthusiasm for the island and its past. As well as the QRA Executive, in recent years Danielle also served with David on the Palaeoecology and Human Evolution Commission of INQUA and, following his move to Birmingham University, on the National Ice Age Network project.

David was a firm friend and a constant source of advice and encouragement to all three of us. We undertook numerous field projects together, sampling late Middle Pleistocene sites in the Thames valley as roads and warehouses were built around us, laughing as we became stuck in knee-deep mud. Most recently, David and Danielle worked together in Norfolk at the Lynford Neanderthal site. When on fieldwork, David would sport a long green mackintosh that flapped wildly in the breeze and his lunch was always neatly packed in a small tin acquired from a well-digger that he had encountered years before when working on the Chinese loess plateau. He would talk as we worked about many things – his beloved Leicester Tigers, his knowledge of ornithology, his allotment, his son Edmund's sporting achievements and the latest postcard from daughter Ros, when on her world travels. He was a prolific writer, producing detailed reports almost as soon as we returned from the field and putting the rest of us to shame with our molluscan slowness in preparing manuscripts. Tim Mighall, a colleague at Coventry, recalls the first time he approached David with some samples from Enfield Lock in Essex: "David said that he would be more than happy to look at the samples as long as we intended to publish the results. I then, as a new and junior member of staff, received a 15 minute lecture on the importance of publishing the data with a clear message that 'if it is not published, the work has not been done', a lecture David later informed he got from Russell Coope when he first approached Russell about a project. I realized a week later his excitement and enthusiasm for all things Quaternary when David invited me into his office and presented me with the results, adding that he had identified at least another 20 or so species to an original list for the site, and about 2000 words of text for a paper!"

David's contributions to teaching and research at Lanchester Polytechnic and then Coventry were praised by many former colleagues and students. Few had known David for as long as Bob Jones, his co-author on the 1994 Chapman & Hall textbook *Pleistocene Environments in the British Isles*. Bob writes "We teamed up immediately following David's appointment to 'the Lanch' [David always referred to it thus] in 1976, I having become incarcerated in this venerable seat of learning two years previously. It was he who persuaded me to participate in new palaeoenvironmental studies, first in the Channel Islands, and then the neighbouring part of France, both of which continued until his untimely death. The culture of our institution in those days did not embrace research and was characterized by bureaucracy of which Joseph Stalin would have been proud. Our teaching duties included shared courses. Those in the field especially transferred David's boundless energy and enthusiasm, and breadth and depth of knowledge, to a generation of students. We published many papers together, often as members of multi-disciplinary teams assembled to enable as comprehensive an environmental reconstruction as possible to be achieved. *Pleistocene Environments in the British Isles* had its origins in one of our final year options, and was born of a desire to establish a more flexible framework for environmental changes over that time span."

David threw himself wholeheartedly into student fieldtrips, educating by day and entertaining in the bar of an evening. He was firm but fair with students and they loved him. Ian Foster, a colleague at Coventry, recalls "There was the time on a Geology field trip to Loch Assynt when Dave got the hotel barman to shut the bar on the last night and only serve students soft drinks because of previous rowdy behaviour. Dave had a line of orange squashes on the table - courtesy of the students - who could buy nothing else!! It was about 15 miles to the next pub!! Of course the ale ban did not extend to staff - luckily - so Dave just watched the line of orange squash grow throughout the evening - and happily carried on drinking beer".

The great kindness and patience that David showed (to younger colleagues and PhD students in particular) was a prominent aspect of his character. Chris Gleed-Owen writes "I will remember David Keen fondly as my lecturer, PhD supervisor, and friend. I was a geography undergraduate at Coventry Polytechnic from 1988-1992, and David Keen stands out as the best and most liked lecturer we had. He not only knew his subject (and many others) intimately, but he had that rare quality of being able to impart his knowledge skilfully and enthusiastically to students. We had a lot of good times on geography field trips too. David was always among the last to leave the hotel bar, from Arran to Slapton to Majorca, and he didn't miss a chance to get down on the dancefloor with the students. I remember the Eastenders Bar in Magaluf, where David danced until the early hours, drinking the awful cocktail the students had concocted, the 'Lanchester Lambada' I think we called it! But it was the fieldwork where David was most effective; he enthused countless students, and some certainly chose a career in earth sciences because of him. David was also my PhD supervisor from 1994-1998, and his unwavering support, both academic and pastoral, was second to none. His office door was always open to students, and many an erudite debate took place there, under the slightly dubious eye of his Chairman Mao portrait! I can see him eating his lunch there now, having just returned from his daily kilometre at the swimming baths, ready to listen to the woes of students. Those were amusing times, and we had to see the funny side of his constant battle with university bureaucracy. It is strange to think that David Keen is no longer imparting his wisdom to the world, and the world is a poorer place for it!"

Alastair Dawson, also a colleague at Coventry, writes "I have had the honour of David's company over the years, particularly during Easter geology field trips. Over the years we tramped across the mountains of Assynt, Raasay and later Arran. David had the ability to inspire students – both in the field and in the laboratory. He would spend long periods of time with individual students making sure that they understood a particular geological problem. Of all the staff that I knew, David was the only one who, having marked an essay, would spend a considerable amount of time with the student, carefully going through the marked essay and making sure that they understood all the areas where they had gone wrong or perhaps could have improved. In terms of teaching and inspiring students David was a shining example to us all. David was a gem, he cared about the students deeply but he also undertook his research for the sheer love of the subject".

Eleanor Brown, a former Coventry undergraduate (1991-1995) and now working for Natural England, echoes these sentiments: "I'll never forget him. I owe him so much, including my love of the Quaternary." Eleanor kept in touch with David after graduating and, when she heard of his illness, arranged to meet him last November in Birmingham. They had lunch and a chat following one of David's lectures and then he showed her around the geology museum at the University. A letter from Eleanor appeared in *The Guardian* on 10th June 2006 praising David as a university teacher, written as a follow-up to the obituary by David Bridgland on 26th May.

Many others wanted to contribute to this appreciation. Richard Preece (QRA Vice President during David's presidency) remembers friendly rivalry between himself and David as leading Quaternary malacologists. Mike Walker writes: "I knew Dave for almost 30 years, and over the last 15 or so of those, our careers seemed to be inextricably entwined. I succeeded him as Secretary of the QRA in 1990, and he succeeded me as President in 2002. I remember passing the baton (or the corer!) to him at the Annual General Meeting in Aberystwyth, and commenting that the time had come to hand over to a younger man - which caused him some amusement at the time. Dave also succeeded me as Chair of the NERC Radiocarbon Steering Committee in 2000, he and I having been colleagues on the Committee for the previous four years. I greatly valued Dave's assistance when I was Chair. He was an excellent reviewer of proposals, quick to spot the flaws, to which he drew attention in his own inimitable style, but equally he was ready to recognize good quality science and to praise it accordingly. Apart from seeing Dave at meetings, both at home and overseas, we kept in regular contact during the winter months through our shared love of rugby. Despite his illness, David's sense of humour remained intact - his email to me after England's (admittedly flattering) victory over Wales was entitled 'Normal service resumed...' !! The 2007 6-nations will not be the same, but I will think of Dave after each England game, and remember him as an outstanding scientist, a wonderful and congenial colleague, and a good friend".

Another contribution comes from Russell Coope, one of the QRA's senior figures and another past president. "One of the most exciting aspects of doing geological field work with David Keen was that there were so many frequent encounters with the totally unexpected: a peregrine falcon scything over the rooftops of Coventry or a green sandpiper making its unobtrusive getaway as we approached a gravel pit. His remarkable sensitivity to the landscape would lead him not only to see fascinating aspects of the geology there, but would suddenly trigger off accounts of battles long ago or others of the not so distant past. David wore coats of many colours. He was not only a fine geologist but a keen ornithologist and a first class military historian as well. But David was by no means a dilettante chameleon. He had an acute eye for those unexpected details that are such an essential part in the understanding of the broader picture. Let me illustrate this.

The organic deposits at Waverley Wood Farm Pit were first discovered by Fred Shotton on a local field excursion. A complex sequence of channel-fill sediments, were discovered underlying the classical Wolstonian (now equated with the Anglian) glacial sequence and cut into the surface of the Mercia Mudstone. David took a major part in mapping these deposits and in investigating their palaeontology. Also, in recent years, the site has become famous for its archaeology. In the early stages of gravel extraction, whenever these channel deposits were exposed, the quarry workers found occasional magnificent hand axes made of andesitic tuff as well as others crudely made by striking flakes off Triassic ("Bunter") quartzite pebbles. The problem was that none of these stone implements were found *in situ*; they had no secure stratigraphical context. Thus, in spite of the conviction that most of us had at the time that these superb stone tools were in fact of pre-Anglian age, there was no unequivocal scientific evidence to back this up. The inevitable controversy arose as to the real age of such technically refined artefacts.

Then, late one day after David and I had been sampling the Waverley Wood organic horizons, we were walking back along one of the deep drainage ditches that had been cut through the channel sequence. At this place the lowest of the channels was inorganic and made up of a metre or so of uniform fine sandy silt. David was wallowing in the bottom of the ditch and I was walking up above on firmer ground. Suddenly, in his usual style, he shouted up to me "… that's strange!". He was looking at a broken pebble about 5cm long interbedded within the fine deposits. What was strange about it was that it was sedimentologically out of place – it was unexpected to find a large stone in such fine sediments. After much scrambling he managed to recover the stone only to find that it was actually a flake that had evidently been deliberately struck off a larger pebble. It was in absolutely mint condition. It even retained a few tiny incipient flakes, still precariously attached to its sharp edges, resulting from its manufacture and these would certainly not have survived abrasion had it been transported any distance by a river. This was the first unimpeachable evidence for pre-Anglian human activity in the English Midlands. What was more, it indicated that the person who struck the flake from the pebble, must have actually lived and worked in the immediate vicinity. Suddenly this set the archaeological assemblage on a secure, if rather unexpected, stratigraphical foundation. On a point of personal irritation; I had already walked on past the spot without noticing anything special about it. It was Louis Pasteur who made the wise aphorism that "fortune favours the prepared mind" (what he actually said was " *Dans les champs de l'observation, l'hasard ne favorise que les esprits préparés*". The usual English version seems to have has lost something in transit). How well did David epitomise Pasteur's maxim.

As a postscript; it was not long before the media heard about David's find and a television crew descended on the gravel pit. He was made to "discover" the flake again and again, replacing and extracting the flake from the side of the ditch, as the cameras needed repeated retakes, until, I suspect, much of its finer detail was eroded away in the interest of establishing their sense of pseudo-realism. Muddy and tired, we all adjourned to the nearest pub where we had to go through discussions of its archaeological significance in front of the camera, again and again. To give the scene some semblance of reality, the continuity lady set glasses of whisky in front of us but every time she turned her back, one or the other of us would take a sip (or several sips). When she returned, she would instantly notice the difference in levels in the glasses and topped them up - again and again. Did she realise I wonder? However, it made a grand celebration of David's discovery of the 'flake in time'!"

David's funeral, at the Canley Crematorium in Coventry, was like a QRA meeting, although with numerous new faces from his latest stamping ground: the Department of Archaeology and Antiquity at Birmingham University where he had worked since 2003. How sad that they didn't have longer to enjoy and benefit from his presence there. The coffin was carried by Pete Coxon, David Bridgland, Mike Field (another of David's Coventry colleagues) and Andy Howard (a colleague from his Birmingham days), as well as David's brother Geoffrey and son, Edmund. Chris Green, who supervised David's PhD (at Bedford College, University of London) on the Quaternary of the English Channel, gave the opening address.

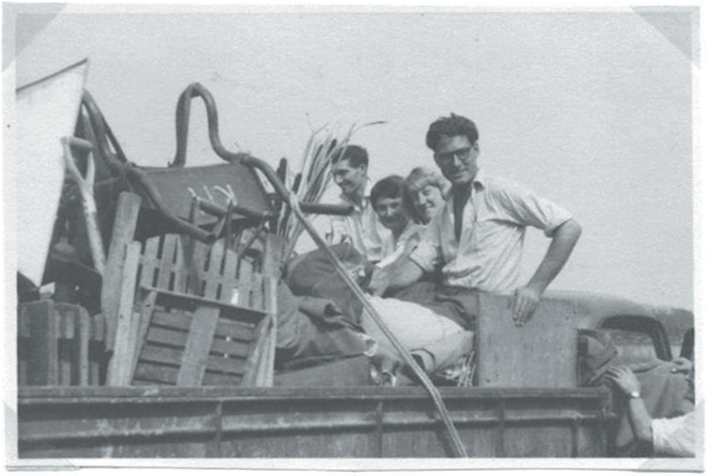
David seemed to have the balance right. He will be remembered by us all not only for his scientific achievements but also as a man who relished a good pint and a laugh with his family and many friends. Our hearts go out to Susan, Ros, Edmund, Geoffrey and father Kenneth. We shall all miss him; indeed, we do already.

A CELEBRATION OF THE LIFE AND TIMES OF JOHN WYMER (1928-2006)

Compiled by Nick Ashton

It might be thought that any tribute to John Wymer would be negligent in omitting his outstanding academic achievements, from the discovery of part of the Swanscombe skull (*Nature* 1955), the publication of several 'Bibles' of the Palaeolithic - gazetteers, site monographs and general syntheses, and not least to his involvement in the discovery of the earliest Palaeolithic site in northern Europe at Pakefield (*Nature* 2006). But this tribute is about the person behind this incredible record, one of the giants of the Palaeolithic world. John would have hated these plaudits, being the most self-effacing man I have known. But below are some personal memories from a few of his many colleagues and friends.

Andrew Lawson ... Like many others, I was introduced to the practices of archaeology by John Wymer, and I count myself privileged to have been taught by a master of his craft. I consider John to have been the finest of excavators and indeed many have commented that his fieldwork set the modern standard for British Palaeolithic archaeology. In hindsight it appears to me that he welcomed anyone, young or old, who had an interest in archaeology, and without hesitation actively encouraged them to participate in the subject. His supervision was a blend of careful instruction and encouragement but his style was never hostile or patronising, despite the inexperience of his new assistants. The ability to delegate was one of his strengths: once directed there was no interference in the discharging of the allotted tasks – unless, of course, things were going horribly wrong, when a firm hand soon 'steered the ship' back on course. John always maintained clear sight of his objectives and employed the most appropriate methods to attain them. These he had either learned from other successful excavators, or devised himself to fit the particular circumstances. His recording was meticulous, his reporting prompt and the quality of his illustrations second to none. Naturally, not everyone shared his interpretations but nobody could criticise him for not having observed the evidence at first hand.



Thatcham 1959 - leaving site.

I had the good fortune to encounter John in the early 1960s, when as an inquisitive schoolboy, I wondered how it was possible to know about the ancient past. By this time, John had seen service in the RAF, had worked for a printing company, had been an audit clerk for British Railways and had forsaken a career in teaching. However, none of these experiences were wasted on John because his systematic approach to recording, his ability to communicate and his wonderful drawings were in part forged in these temporary positions. Nonetheless, his position at Reading Museum was largely a consequence of his passion for collecting flint implements and his self-taught knowledge of quaternary sediments. From 1949 onwards, whilst maintaining the 'day job', he had also pursued in his spare time a relentless quest which took him to the gravel pits and open spaces of southern Britain and beyond in search of ancient artefacts. By the time I met John, his work at Swanscombe (amongst many other sites) was almost legendary.

John's wider archaeological interests took him far beyond the Palaeolithic and in my youth I benefited from working with him on Mesolithic sites and later barrows, both long and round. However, in 1965 he was recruited by Professor Ronald Singer to help with the investigation of early sites in South Africa. He had already tackled sites at Elandsfontein when I joined his small team for the second season of excavation at Klasies River Mouth. Here, all the qualities of leadership were apparent, and the published results of the excavation remain of crucial importance to the understanding of early humans in South Africa. In 1968, John and Ronald transferred their energies to important Palaeolithic sites in Britain. But by this time, digging with John had convinced me that archaeology was not only of the utmost interest and importance but was also hugely challenging and enjoyable. Thanks to John, I could really do little else than try and pursue a career in the subject. Like so many others, I found myself lured by John's combination of enthusiasm, erudition and natural ability to communicate into a worthwhile occupation. I enjoyed his company for forty five years and only wish it were longer.

Roy Shephard Thorn ... John and I were friends for over 30 years, extending back to 1974 when we were selected as joint editors for the 1977 INQUA excursion to 'South East England and the Thames Valley'. The task involved preparing itineraries, whipping in co-leaders, checking sites on the ground and writing and collating the guide book. In the course of this we discovered a common interest in the good things of life: good food and wine, real ale, fine women and jazz – which we shared over the succeeding years. On one occasion we tried to have a drink in all the Brakspear's pubs in Henley and only narrowly failed – time ran out.

John's reputation as an archaeologist needs no repetition by me. He had many other talents and interests. He was fine jazz musician – piano and guitar, a keen vegetable gardener, cabinet maker, photographer and author. He was also a gifted teacher. As a popular WEA lecturer in East Anglia, he led excursions to classic sites in France and Spain. I was lucky to attend a couple of these to Brittany and the Dordogne. Apart from the rich archaeological fare served up, I remember them as gastronomique, alcoholique and even spiritueuse occasions!

John's academic background was unconventional and he was to a large extent self-taught. He was surprised and delighted to receive an honorary Doctorate from the University of Reading, the town where he began his archaeological career at the museum – a time when he assembled his first major book on the Palaeolithic of the Thames Valley.

John was also a railway enthusiast and took great pleasure in planning long cross-country journeys from maps and timetables, sometimes managing to link between unexpected end points. He was especially fond of steam trains and preserved railways, not to mention the platform bars! One of our last outings together, in summer 2005, was to the North Norfolk Railway at Sheringham, where he was thrilled to be on a train pulled by the ex GWR 'City of Truro', 100 years old and one of the first steam locos to reach 100mph – although not on this occasion.

John enjoyed good company and entertaining. He and Mollie were wonderful hosts and party givers. Both are sadly missed by me and their many friends.

Phil Harding … My first contact with John occurred at the Institute of Archaeology when as a 'new boy' in the Lithic Studies Society we reconvened after lunchtime in the pub. John, courteous as ever, introduced himself and was somewhat relieved to find that as I had, at that time, never published any work of serious content he had no reason to know who I was. Inevitably that didn't stop him befriending me and making me feel at home amongst strangers. Eventually I was fortunate enough to spend six wonderful years working with him on the Southern and English Rivers Palaeolithic Survey, possibly some of the most memorable and rewarding of my life. In many respects we shared similar interests particularly blues music, real ale and most particularly Palaeolithic archaeology; but like early species of man ascending from the same stock and dividing, we enjoyed our own interests, for me sport, which John hated but was always prepared to tolerate by providing me with the relevant section of his newspaper. John had his own wide range of interests, including steam locomotives, gardening, fine food, astronomy and nature, subjects that he would share with anyone enthusiastically, to the extent that you couldn't help being absorbed by it. He introduced me to many works of literature that I might never have otherwise read.

John had an unquenchable appetite for archaeology, Palaeolithic archaeology in particular, and an enviable association with most of the significant sites in Britain, most of which he had visited, often remembered as working quarries, excavated and inevitably published. To visit them with him was an education. His quest for detail to establish the provenance of poorly recorded implements from old sources was absolute. Sometimes efforts resulted in failure but more often than not persistence paid off and artefacts were placed in their correct context, work that will never be repeated in such detail. His records, compiled on index cards, were his pride and joy and I felt privileged, once I had his confidence, to have been granted access to them and allowed to annotate them where necessary. He was an individual, instantly recognisable by his inspirational artefact drawings, accurate hand lettered plans and sections or his Christmas cards, which were beautiful, welcome on the doormat and immediately 'John's'.

In the field many times I witnessed the approach to the door of a prospective B&B, a courteous lift of the battered trilby, discussion on the doorstep and a thumbs-up or down denoting success or failure in obtaining accommodation for the night. Evenings were spent collating the results of the day's journey, compiling his journal and preparing for the next day's campaign before retiring to a suitable hostelry for a 'livener', normally two pints as an *hors d'oeuvre* to the evening meal.

John introduced me to a landscape without the trappings of administrative boundaries, divided more logically by geology, ice and drainage, elements of nature. His love of the countryside meant that he was an excellent navigator; only once did we err from a proposed route when the 'gravitational pull' of Bateman's beer drew us to Wainfleet. It was perhaps inevitable that the last time I saw him he was looking at a map annotating his note book. He loved life and sufficiently open-minded to embrace any new results that might add to knowledge of the past; however he held strong opinions on most things and steadfastly defended established thought, such as the independent status of the Clactonian, if he thought it was right. For those who knew him it was a privilege; for those who come after his legacy will live on.

John McNabb … I often used to marvel at how John could conjure up such dynamic mental pictures of vanished landscapes. It was uncanny how, when driving along the back roads of his beloved Norfolk, he would describe the terraces and river valleys of Pleistocene East Anglia in astonishing detail, almost as if he had been there himself. Later, I realised that part of John's secret was a very detailed understanding of the modern physical geography of Britain, the sort of geographical detail that simply isn't taught in schools any more. He had a 3D picture of the British landscape in his head and he could move effortlessly through it from the present to the past. Anyone who looks at his 1968 book on the Thames, or his 1985 book on East Anglia will readily appreciate that.

If John had the knack of seeing things clearly, he certainly had the ability to present that information in a simple and effective way. John was never one for the professional jargon or the clap-trap that attends much of academic science today. He was of the roll-up-your-sleeves-and-get-on-with-the-job school. His lectures and public speaking engagements were clear and to the point. He could simplify the most complicated subjects and then enthuse you with his no-nonsense delivery. I believe this to be a great gift, and one that is not as common as you would hope. His writings were equally as lucid, and he has a publication record that would make most professional academics green with envy.

Most people who knew John would recall his legendary conviviality. He and Mollie ran an open house and visitors, expected or otherwise, were welcomed with open arms. Whilst excavating at Barnham with Nick Ashton, we had an annual dig barbecue at their home in Great Cressingham. This was a high-spot of the season and very much looked forward to. One of our diggers refused to believe we were taking him to meet John Wymer, 'anyone that famous had to be dead' – this amused John no end. There would be the ritual tapping of the Abbot barrel, a small wooden keg of John's that he had filled some days before, followed by the ritual cutting of his carefully stashed biltong with a flint knife. Then the party would begin. John was a great conversationalist, and these evenings were filled with discussion and debate on every subject imaginable. Though John never went to university, he was a voracious reader and English literature was a great passion of his. One minute he would be discussing a gravel section, the next he would be holding forth on Tolstoy or some English poet you'd never heard of (he was fond of quoting Houseman, one of his favourite poets).

John also seemed to know just about everybody. Wherever you went he would have an acquaintance, or someone who owed him a pint. I well recall when Mike Field and I were digging for him at Clacton, we needed accommodation urgently, but didn't have a bean between us. We were standing on the front looking over the beach. With a great cry John pointed and loudly announced 'the deck chair man'. He strode off across the beach and collared the deck-chair attendant. He, it turned out, was an old friend who had dug for John at Clacton decades before, and he owed John a favour. By the end of the day Mike and I were comfortably ensconced in a garage belonging to the Bell at Thorpe-le-Soken, with a full English breakfast thrown in!

I will always be proud to be able to say John Wymer was a good friend of mine.

Nick Ashton … Many pages could be filled with similar accolades, each with individual anecdotes reflecting John's talents, interests, humour and zest for life. Something that I will always remember and for which I will be for ever grateful was his generosity of spirit. In early 1989, John McNabb, Simon Lewis, Simon Parfitt and myself approached John about the possibility of new work at East Farm, Barnham. As ever, John had been there first, having cut a section in the disused brick-pit ten years previously and had recovered a remarkable group of refitting flakes and a core, a real rarity in the Palaeolithic. Whereas others might have been reluctant to let comparative novices encroach on their territory, John was delighted that new work was being undertaken at the site and provided support and enthusiasm throughout the ten years of Barnham and the ensuing project at Elveden. To him it was the quest for knowledge that was important, not the individuals who sought it. Each season was centred on the unforgettable 'fixture'. Fuel for the barbecue would be gathered from the woods near East Farm and taken to John and Mollie's house at Great Cressingham, where John would gleefully misquote Macbeth and declare that 'Barnham wood do come to Cressingham'. The fire was often still burning at dawn, having witnessed the enjoyment of beef, beer and blues, and with a little encouragement ready for the cooking of Suffolk black bacon for breakfast.

Proposed new work at Hoxne was met with a similar enthusiasm. When told that we would be staying at the nearby village of Laxfield, John's response was:

'What Laxfield…? Really…? Marvellous. Laxfield has one of the finest hostelries

in Britain, and kippers are smoked there on a Tuesday. Molly and I nearly bought it in 1978, but I decided that life would be more enjoyable if I stayed this side of the bar'.

Quaternary scientists will be grateful that he did, although not necessarily the villagers of Laxfield. John was absolutely right. The 'Low House' is still one of the finest pubs in Britain, and John joined us there for more than the odd pint of Broadside during the work at Hoxne.

There were many things of which John disapproved – grated cheese, limp lettuce accompaniment to an honest sandwich, swan necks and Yorkshire roses on beer pumps, and of course canned music. In doing so, he taught several generations how to enjoy the good things in life, and always with a characteristic chuckle or a smile. Life without John is a poorer experience, but the spirit of the man lives on, in part through his publications, but above all through the wonderful memories that he left behind. Please raise your glass to John.

ARTICLES

STAGES IN THE PRE-ANGLIAN DEVELOPMENT OF THE RIVER SYSTEMS OF CENTRAL AND EASTERN ENGLAND

Roger Belshaw

The nature and distribution of the Milton and Courteenhall Formations in Northamptonshire (Belshaw *et al.,* 2004, 2005, 2006) imply four stages, detailed below, in the development of the landscape and drainage in the east Midlands before the arrival of post-Cromerian ice sheets in the Middle Pleistocene. The relationship of these stages to the development in central and eastern England is examined, allowing an approximate timescale to be proposed. This enables the testing of some of the current hypotheses for the development in the wider area. A new model of the development of the river systems of central and eastern England, underpinned by viable mechanisms of erosion and transportation, as well as deposition, is offered in the hope that testing and falsification will lead to the construction of a robust process-based model and the resolution of some of the difficulties in interpreting the vast fund of lithological data collected by researchers over the last 40 years, especially in determining the relative roles of the Thames, Trent and Bytham Rivers.

PRELIMINARY CONSIDERATIONS OF THE MILTON SAND AND ITS ENVIRONMENT

The significant features of the Milton Sand in Northamptonshire

The key features for the purpose of this model are that

1) Whilst the sand fraction is derived from the Triassic rocks in the Birmingham area, to the northwest of the later proto-Soar, the pebbles are derived solely from local Jurassic limestones and ironstones;
2) The Milton Sand occurs along the crest of the Jurassic Escarpment as well as along the valleys of the Milton River and the parallel Brigstock River;
3) There were at least 5 billion tonnes of sand in the Milton and Brigstock valleys when the supply was cut off by the development of the proto-Soar;
4) Massive bodies of the material were preserved as valley-side benches about 20m above the floodplain of the current rivers due to the disruption of the early drainage pattern by fault-related deep permafrost activity in the Lias

clays, creating the Upper Nene and Harper's Brook valleys;

5) Wherever the Milton and Courteenhall Formations are not exposed at the surface, they are immediately overlain by post-Cromerian glacigenic deposits which appear to have caused a very limited amount of erosion to the Formations beneath (Belshaw *et al.*, 2004, 2005, 2006).

The hydrology of the rivers that deposited the Milton Sand

Hjulström's diagram (1935) shows that to entrain sand the mean velocity for water one metre deep needs to reach about 0.3 ms^{-1}. Manning's equation relates mean velocity to the depth of flow, the slope of the water surface and channel roughness (Selby, 1985, 239-242). Substituting these values for mean velocity and depth and 0.03 for channel roughness for a sand-bed river produces a slope of about 0.0001 or 1 in 10000 - a very flat surface. To move medium gravel the slope would need to be 0.001 or 1 in 1000, while for large cobbles a slope of 0.01 or 1 in 100 is required. Although these values must be taken as approximations, they imply, for the whole of the time that the Milton Sand was being transported, that while valley sides were just steep enough to allow local fine and medium gravel to be moved down-slope to the river channel, the gradient of the channel itself was so gentle that only sand was moved downstream. To move significant quantities of gravel a river needs to have a gradient in excess of 0.001. During the whole of the time that the Milton Formation was being deposited, therefore, the gradient of the rivers did not vary much from 0.0001.

THE EARLY DEVELOPMENT OF LANDSCAPE AND DRAINAGE IN THE MIDLANDS

A profile (Figure 2) from a potential Tertiary sand source on Cannock Chase across the Jurassic Escarpment at the Watford Gap to the Nene valley at Northampton shows the separate stages in the development of the area.

Stage One: the initial drainage patterns

The thin deposits of sand spread along the top of the Jurassic Escarpment suggest that the initial surface between Cannock and Northampton was a very flat low-lying one. It is very probable that at this time there were no well-defined river systems in the area but an indeterminate drainage with shallow playa-style basins where thin sheets of Triassic sand and local pebbles were deposited.

Stage Two: the development of the early river systems

Over time the Milton and Brigstock Rivers developed south-eastwards as consequent streams on the gently dipping Jurassic strata, implying uplift in the northwest relative to the southeast, the slope not exceeding 0.0001 at any time. Incision into the less resistant Lias clays by subsequent streams saw the creation of the Watford Gap on the Milton River and the emergence of the ironstone Jurassic Escarpment, while lesser gaps were cut by the Brigstock River. These rivers are part of a trellised drainage pattern covering the Midlands, which is partly preserved under Middle Pleistocene till (Kellaway and Taylor, 1953).

The base of the Milton Sand in the Watford Gap is about 70m below the crest of the escarpment. The degree of incision into what was a low-lying surface and the considerable volume of preserved sand imply that this stage occupied a very long period of time when low energy conditions prevailed in the rivers of the area and tilting was subdued. For the Milton Sand to accumulate in such quantity the last part of the period must have been tectonically stable, at least along its northwest-southeast axis, maintaining a very low gradient. Downstream from the Gap the remains of the Milton River today have a gradient of about 0.0011 (1 in 900) compared to its original 0.0001, while the remains of the Brigstock River have one of 0.0037 (1 in 270). The differences between these gradients and that at the time of deposition imply that tectonic instability has been a significant factor in the changes in the behaviour of the rivers of the area during the Pleistocene.

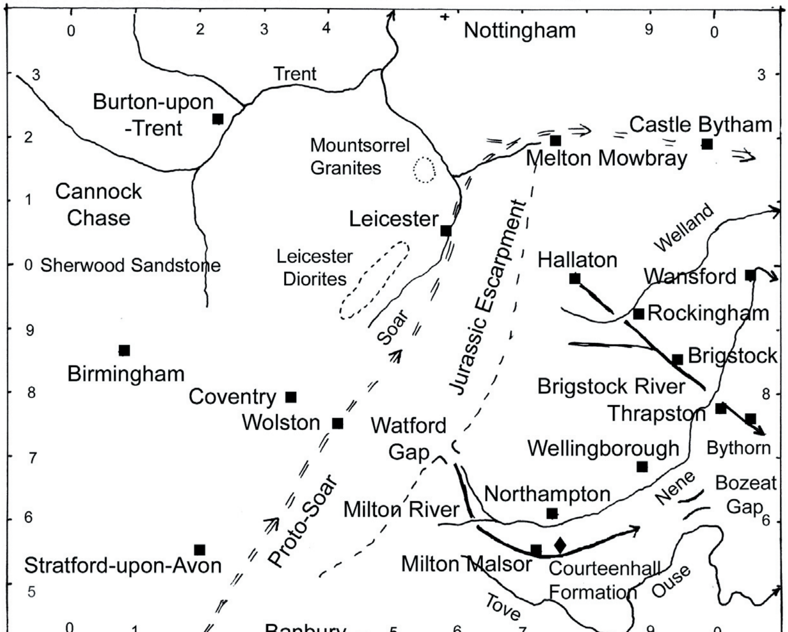


Figure 1: The Milton Sand and the present drainage of the Midlands

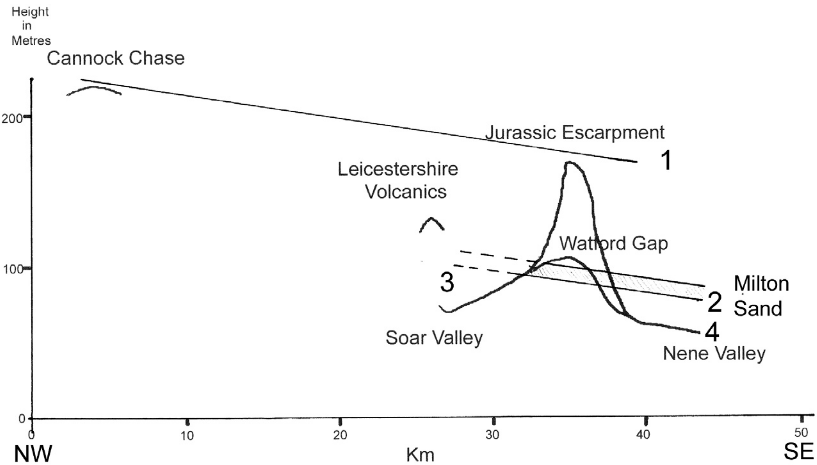


Figure 2: Stages in the development of the Midlands landscape

Stage Three: the beheading of the early rivers of the Midlands

The long second stage In Northamptonshire was terminated by the progressive capture by the proto-Soar of the headwaters of the Midland Rivers that crossed the Jurassic Escarpment, as it expanded its catchment towards the southwest (Belshaw *et al.*, 2004, 2005). The consistent composition of the Milton Sand up to the time of capture, with an absence of Triassic pebbles, indicates that the long-term low-energy environment of Stage Two was still operative. This makes climatic variability, which could affect hydraulic characteristics, an insufficient causative factor in this expansion. The development of the proto-Soar southwestwards probably implies the commencement of a region-wide tectonic movement giving an advantage to drainage towards the northeast. The continued deepening of the proto-Soar valley after the capture was probably contemporary with part of the last stage to affect the Milton Sand.

Stage Four: the diversion of the Milton River into the Nene "tunnel valley"

The present course of the Nene through Northampton lies over a linear "tunnel valley" filled with laminated calcareous lake clays (Belshaw *et al.*, 2006 for details and locations). These are the remains of the infill of a string of thaw lakes formed when massive ground ice developed along the lines of the Northampton Fault, where the highly productive aquifer, the Marlstone Rock, abutted against the highly frost-susceptible Lias clays. The lakes inhibited the movement of coarse material through the area. The removal of considerable quantities of suspended clay, associated with periglacial cambering and valley bulging, created a new valley with a lower base level a short distance to the north of the Milton River which diverted drainage through Northampton. At Courteenhall reworked Milton Sand (the Courteenhall Formation), deposited in a stream draining northwards towards this lower base level via the Wootton Brook, contains biogenic material with Cromerian affinities (Smith, 1999; Smith *et al*., 2000). Middle Pleistocene tills immediately overlie the Formation, indicating that the whole area was isolated from external sedimentary inputs up to the post-Cromerian ice advances.

The Cromerian biogenic material provides the only dependable chronology for the timing of the four stages within Northamptonshire. Use of the evidence from the surrounding area should allow the construction of a timescale for the history of the four stages and the testing of the current models of explanation.

THE FOUR STAGES IN THE CONTEXT OF CENTRAL ENGLAND AND EAST ANGLIA

Stage One

Gibbard and Lewin (2003) summarise the evidence from Tertiary sediments of southern Britain. They conclude that fluvial gravels are extremely rare in the alluvial record for the whole area, the period being dominantly one of deep weathering of flat low relief surfaces. Apart from the Brassington Formation in Derbyshire there are no sediments recorded for the Midlands for the whole period while the record for East Anglia is empty until the appearance of the fine-grained marine Coralline Crag of early Pliocene age. The very limited depositional activity suggests that erosion and transportation were similarly limited over a long period of time. There is nothing here to falsify the idea of a very flat landscape in the Midlands with negligible sedimentary activity, but equally nothing to help establish dates for this Stage - somewhere in the mid-Tertiary is probably all that can be surmised.

Stage Two

It is generally agreed that the "ancestral" systems of the Severn/Thames and Dee/Trent lay to the south and north of the Milton and Brigstock Rivers, stretching from Wales to the North Sea (Gibbard and Lewin, 2003). The Severn/Thames flowed from central and south Wales to the south-western extremity of the London Basin, while the Dee/Trent system drained northern Wales across the southern end of the Pennines and Lincolnshire through the Wash Gap to the North Sea (Straw, 1963, 1969). It is possible that the Milton River had an ancestral role between these two, but the lack of any distinctive material from Wales or the Welsh Borders in early fluvial deposits in the Midlands implies that the Thames and Trent systems separated to go south and north of a West Midlands watershed early in their history (Figure 3a).

If the uplift evidenced by the cutting of the Watford Gap affected the whole area as one block it would have enhanced the development of the ancestral drainage pattern. If, however, there were differential movements along the predominantly north-south faults (Gibbard and Lewin, 2003, Figure 1) the area would have been divided into incipient tilted blocks and basins, causing the diversion of the early Thames south towards the Bristol Channel and the Dee northwards into the Irish Sea, and the enhancement of the isolation of the Midlands by the rise of the West Midlands watershed.

In the area of the Thames the Reading Formation shows that in the late Palaeocene (*c*. 55 Ma ago) a substantial river carried exotic clasts from the west into the London Basin, while the Virginia Water - Bagshot Formation is evidence for a smaller river in the mid-Miocene (Gibbard and Lewin, 2003),

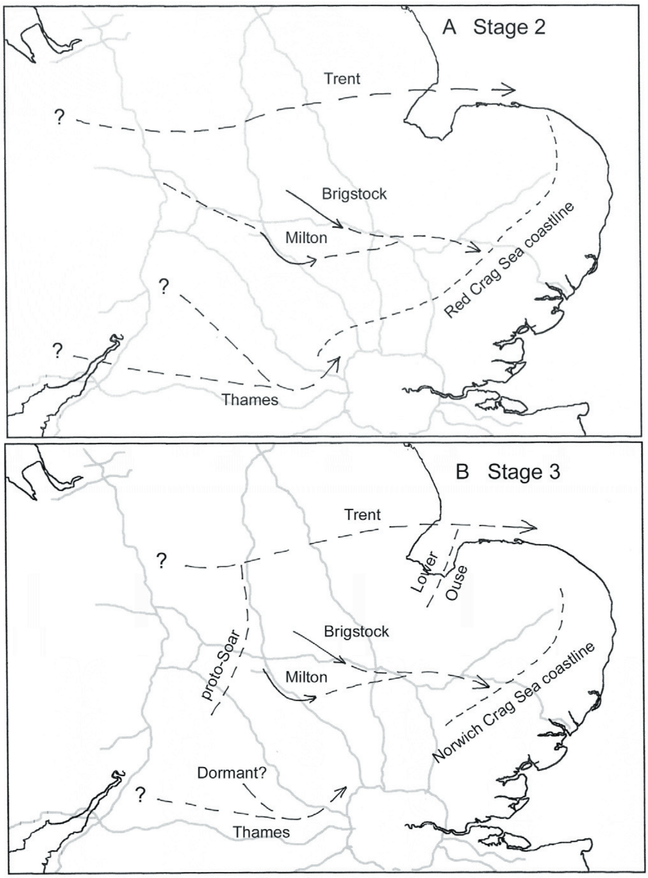


Figure 3: A) Early Red Crag time; B) Late Norwich Crag time. Major roads in grey.

suggesting that the system may have been in decline by then. There appears to be no sedimentary evidence for the state of the Trent over the same period.

The location of the coastline at Coralline Crag times is unknown but the later Red Crag coastline is probably marked by the Higher Pebble Gravel to the northwest of London which contains both Carboniferous and *Rhaxella* chert which are highly durable (Hey, 1976; Green and McGregor, 1999). Given that the *Rhaxella* chert originates from Yorkshire (Bridgland, 2000), it is most likely that marine processes have been involved in its distribution. In the present North Sea the interlocking cells of littoral sediment movement average only 30 to 40 Km in length, making long-range transport of the cherts by longshore drift alone improbable. Also, the estuary off the Wash Gap, although narrower than today, would have been a hindrance to long-distance coastal movement. One significant additional transport mechanism occurs offshore where sub-tidal sandbanks develop, as in the Red Crag at Buckanay Farm near Ipswich (Funnell, 1996). The channels between the banks would have been an important factor in the distribution of durable pebbles as ebb flows use different channels to flood flows, allowing a considerable cumulative movement of material. Oscillations in sea-level would provide a further means of moving sediment. Periods of higher relative sea-level would see sub-tidal currents moving material onto areas that were previously land while ones of lower relative sea-level would see the east coast rivers extending their courses to converge on the bed of the North Sea. In the associated cooler climate sands and, where the gradient was steep enough, gravels would be deposited in these lower reaches as far as the new coastline. Wave action would concentrate the clasts into swash-orientated barrier beaches (Orford *et al*., 1995), which would be swept back inland as sea-level rose in the succeeding warm period, distributing durable clasts along the retreating coastline. Boomer and Woodcock (1999) give an account of this happening on the north Norfolk coast in the Holocene. Due to the asymmetry in the energy levels of swash and backwash it is usual for only the finer material to be moved seaward in the long-term from barrier beaches, the coarse material being moved landward by storms that overtop the beach. The marine oxygen isotope record indicates that oscillations generally increased in magnitude but decreased in frequency from the late Tertiary to the Middle Pleistocene, while the record of transgression and regression of the coastline indicates that relative sea-level declined through the period (Gibbard and Lewin, 2003, Figure 2), allowing coarse material to be driven landward from progressively further offshore. The combination of these transport mechanisms with longshore drift accounts for the presence of far travelled durable lithologies along the coast. However, once distributed in this way the diagnostic value, for establishing provenance, process and routes of transport, is reduced as durable clasts are readily available for redistribution.

Stage Three

The regional uplift/tilting of the Midlands towards the northeast, which allowed the proto-Soar to expand its catchment, was probably caused by a combination of the uplift of the Wealden-Artois anticline in the south as part of the late Miocene/Pliocene Alpine orogeny (Gibbard and Lewin, 2003, p 838), tectonic activity in the Atlantic to the west causing a thickening of the crust under Wales (Westaway *et al*., 2002) and isostatic recovery from denudational unloading caused by the disaggregation of the highly frost-susceptible Liassic clays during the intense cold stages at the end of the Pliocene (taken as c.1.8 Ma ago) and in the Early Pleistocene (Hollingworth *et al*., 1944; Belshaw *et al*., 2006).

There are several lines of evidence that support the idea of a tilt towards the northeast at this time. The altitude of the coastline of the North Sea in Norwich Crag times relative to that in Red Crag times is lower in Hertfordshire but higher in north Norfolk where the Norwich Crag oversteps westwards the Red Crag (Funnell, 1961; Moffatt and Catt, 1986; Mathers and Zalasiewicz, 1988; Green and McGregor, 1999). Uplift in the middle reaches of the Thames would account for both the decrease in activity in the upper reaches of the Thames at this time, as the already gentle gradient across the Cotswolds would have decreased even further, and the increase in local activity in the Nettlebed area (Funnell, 1996). The record from the Crags in Suffolk confirm that most of the Thames was dormant and that transportation into the south-western part of the London Basin was limited to low levels of fine suspended sediment (Green, Hey and McGregor, 1980; Riding *et al*., 1997, 2000; Rose *et al*., 1999, 2002). The Midland Rivers flowing past Bury St Edmunds into the Sudbourne Basin carried detectable quantities of Jurassic fine sediment (Riding *et al*., 1997, 2000), but no pebbles. However the Norwich Crag, from the centre of Norwich (Chapelfield Gardens) to Whitlingham, 4 Km to the east, contains consistently 5% fine quartz and quartzite pebbles among the dominant chatter-marked flints and, exceptionally, medium quartzose pebbles at the base of the deposit as at Chapelfield (Funnell, 1961; Krinsley and Funnell, 1965). The immediate source of gravel supplied by the shoreward movement of swash-aligned barrier beaches would have been the bed of the North Sea off the northeast Norfolk coast because the low sea-level alignment of coastline would have been roughly northwest to southeast, and barriers retreat orthogonally to the coastline. In southeast Norfolk and northeast Suffolk the Westleton Beds are dispersed widely. They were deposited towards the end of Norwich Crag time (Funnell, 1961) and have consistently lower proportions of quartzose material (about 3%) than the Crag at Norwich. The immediate source of gravel would have been the bed of the North Sea off the Suffolk coast (Funnell, 1996; Sinclair, 1999). As each deposit represents the limit of a discrete barrier beach retreat in one phase of rising sea-level it is probable that the Beds were deposited over a number of sea-level oscillations. The decreasing percentages of quartzose material eastwards round the Norfolk coast suggest that throughout this time the Midlands quartzose material was transported down the Trent to the seabed off the Wash.

The strike valley of the lower Ouse on the Oxford Clay lying parallel to the proto-Soar probably also benefited from the regional tilting, allowing it to extended southwestwards into the Fens as a right-bank tributary of the Trent, but it probably did not get much further, leaving the Milton and Brigstock Rivers to flow eastwards past Bury St Edmunds (Boreham and Langford, 2006). It has been suggested by several researchers that the Wash Gap was created by an ice stream during the Middle Pleistocene Anglian glaciation (Perrin *et al.*, 1979; Clayton, 2000). However, the speed and erosive capability of ice in a lowland ice sheet, other things being equal, is very sensitive to ice depth. As ice sheets have rather level surfaces parallel to the ice front this is the obverse of height of ground. Thin ice over high ground moves too slowly to erode and so deposits lodgement till, as in the Northamptonshire Uplands, but thick ice over low ground that is orientated in the right direction flows in sharply defined ice streams causing selective linear erosion. There is an altitudinal zone between these two states where very little happens. For ice to stream across the area now occupied by the Fens in the Anglian period it would therefore appear necessary for there to have been a pre-existing routeway available to the ice. It may be argued that a gap could not have existed before the Anglian glaciation as otherwise the Bytham River would have used it, but this is an insufficient argument as gaps can be temporarily closed by ice, as occurred in the post-Anglian deposition of the kame terrace at Tottenhill on the east side of the Fens (Gibbard *et al.*, 1992). Large cobbles of tabular grey flint from Lincolnshire formed a delta in a lake impounded by ice against the Fen margin. These could have been transported to Tottenhill from the northwest across the Fens only by high-energy pipe flow within the ice. This problem is revisited in Stage Four.

Probably the development of the proto-Soar and the lower Ouse started in Red Crag and was complete by Norwich Crag times (Figure 3b).

Stage Four

There is no equivalent to the Stage Four of Northamptonshire in the surrounding areas. No glacial material was introduced into Northamptonshire until the Middle Pleistocene when the Lower Till capped the Milton and Courteenhall Formations at the end of the Cromerian period (Smith *et al.*, 2000), but in the adjacent Thames valley the Kesgrave Formation is composed of glacially-derived material.

In terms of the overall model being proposed, the processes involved in the deposition of the highest unit of the Northern Drift in Oxfordshire, the Waterman's Lodge Member, need to be highlighted. It is general agreed that the composition of the Northern Drift (quartzose, weathered flint and volcanic pebbles in a sand/clay matrix), size (up to 200 mm median diameter) and occasional striation of the clasts (Hey, 1986) indicate that glacial activity was involved at some stage in the transport into the area of material from North Wales, the north Midlands and the Pennines, but debate about the location of any ice front had yet to be resolved (Sumbler, 2001; Clark *et al*., 2004). However, the presence of a diamict containing large boulders on the Cotswolds Plateau, a flat area of low relief and altitude, that possibly last saw significant fluvial activity in the transport of the Virginia Water-Bagshot material in the mid-Miocene, while immediately to the north the Midland rivers had gradients too low to move anything coarser than sand, falsifies the idea that the Waterman's Lodge deposits were transported into the area by a river, however they were deposited. A brief field inspection in June 2006 of the Stour/Evenlode area, including some of the sites listed by Lucy (1872, 1880), shown as open circles by Hey across the Cotswold Plateau (1986, Figure 1), revealed that the former Thames routeway is covered with Northern Drift at least as far south as the Wychwood Forest ridge while the higher ground at either end, above Charlbury on the east and around Icomb Hill and Upper Rissington on the west, just south of Stow on the Wold, is bare. The area is immediately southeast of the Moreton Lobe of the Middle Pleistocene ice (Sumbler, 2001, Figure 1). The most probable explanation of this distribution is that a lobe of a Welsh/Midlands ice sheet reached as far as Shipton under Wychwood and left a broad terminal moraine/sandur complex across the Wychwood Forest ridge (Figure 4). Inspection should allow the determination of the rest of the boundaries of the ice sheet, which reached almost to Cheltenham, as the coloured quartzose and weathered flint pebbles are conspicuous in the field. The Shipton Lobe provided the material for the Sudbury Group of the Kesgrave Formation that progressively extended during the succeeding cold stages northeast through the Vale of St Albans as uplift of the Cotswolds continued, providing the necessary gradient (Westaway *et al*., 2002).

Krinsley and Funnell (1965) recorded in the highly quatzose gravels channelled into the Norwich Crag at Whitlingham (near Norwich) the presence of sand grains showing evidence, in electron-micrographs, of glacial modification. The authors showed that different modes of transport of sand leave distinctive signatures on the surfaces of the grains. Glacial (with stones), litoral and aeolian modes had major effects while glacial (without stones) and estuarine or deep-water modes had minor effects. Fluvial mode left no record. Chemical etching after deposition tended to erase the evidence. Incomplete modification of the evidence by succeeding modes or by etching left a history of the changes but high-energy littoral and aeolian modes tended to obliterate previous modes. The underlying deposits of Norwich Crag at Whitlingham showed evidence of only littoral, estuarine and deep-water modes. In the post-presentation discussion Funnell said that it was possible that the glacial sands in the highly quartzose gravels were transported a considerable distance into East Anglia by fluvial

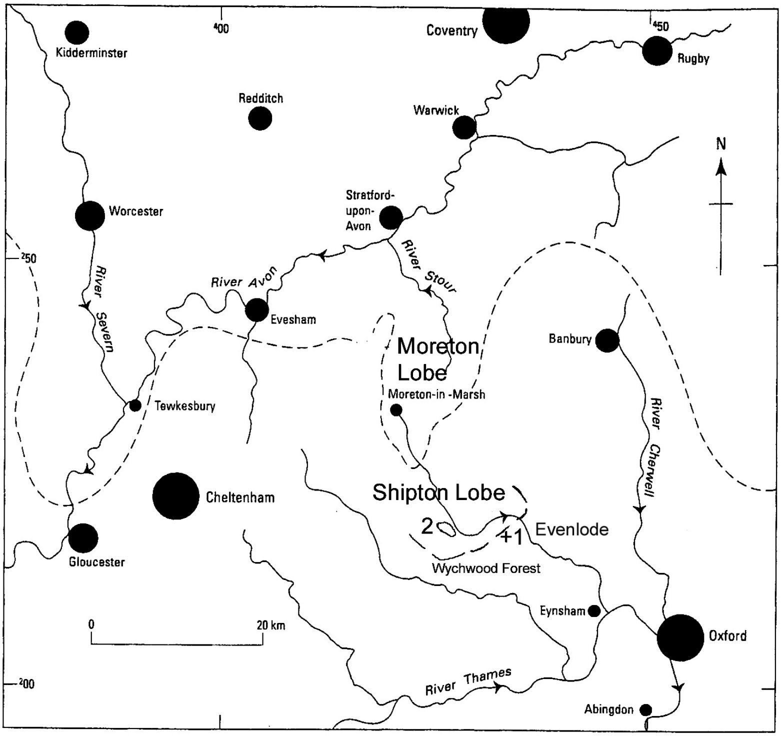


Figure 4: Early Pleistocene ice sheet limits in the Evenlode Valley from Sumbler, 2001, Figure 1. 1 Waterman's Lodge site on the Wychwood terminal moraine/sandur complex. 2 Bruerne Abbe diamict.

transport. Funnell (1961) had been keen to stress that the erosional relationships between the highly quartzose gravels and the underlying deposits were very important even before this evidence had come to light. Hey (1980) recorded that similar evidence for glacial modification had been recognised by Krinsley in equivalents of the Westland Green Gravels (Sudbury Group) at Peasenhall, Creeting Hill and Wortham in Suffolk, and Alphamstone and Lindsell in Essex, and considered that glacially-derived Thames material had passed Norwich to reach the north Norfolk coast. The highly quartzose gravels at Whitlingham marked the arrival of this material. As barrier beach movement in this area would be from the northeast towards the southwest, the presence of Wealden chert in the Wroxham Formation around Norwich confirms this (Rose *et al.*, 1996, 2001, 2002). Rose *et al.* (2002) establish that the Thames and a northern river were the sources of the material in the first two members of the Wroxham Formation, there being no evidence for a Bytham River input, although one was anticipated (Figure 5a).

On the floor of the Evenlode Valley at Bruerne Abbey, between the Wychwood Forest and the Moreton Lobe, the Combe Member contains coarse fluvial deposits and diamicts (Sumbler, 2001). These have been associated with the end of the deposition of Sudbury Group and the start of the Colchester Group (Westaway *et al.*, 2002). The latter contains a lower proportion of Welsh material, suggesting that derivation was more directly from the north Midlands and Pennines. The Moreton Lobe, which includes Chalky Till, is dominated by material from the north and northeast. It appears that over time the dynamics of the ice sheets reaching the Midlands has changed, with a progressive swing eastward in source areas. Westaway *et al.* (2002) equate the deposition of the Waterman's Lodge Member with the Beerse glaciation of northern Europe, which occurred about the end of the Pliocene.

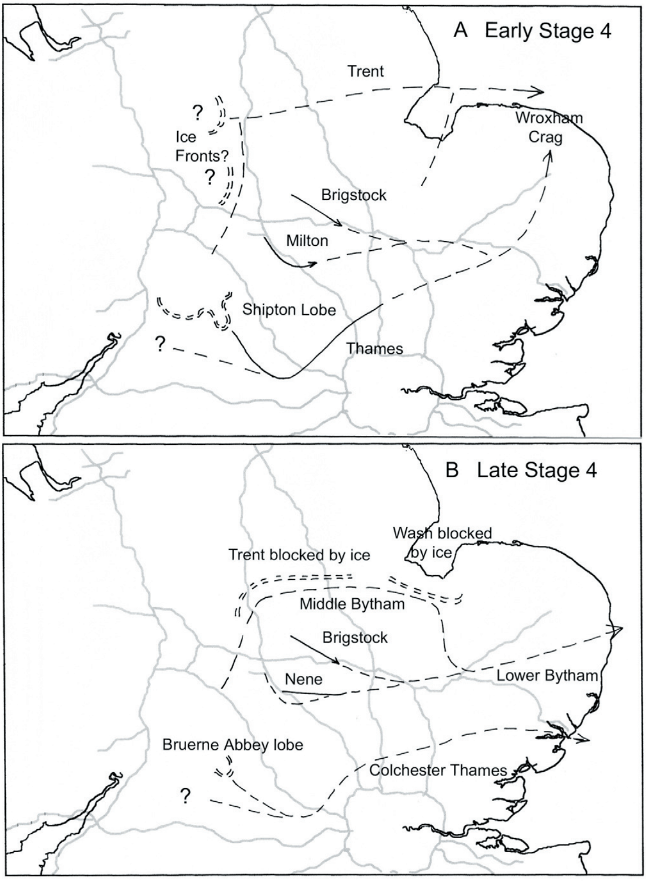


Figure 5. A) early Early Pleistocene, B) middle Middle Pleistocene

Understanding the changes in the development of the drainage system north of Northamptonshire poses great problems. It is usually stated that this is because so much of the evidence has been destroyed by later events. This would be true of valley floor evidence where the alignment allowed selective linear erosion, but on high ground deposition of lodgement till should preserve evidence well, as it did the Milton Sand.

In the belief that it is easier in the field to find something that one is looking for, rather than to hope that something significant will catch one's attention, it is important to have several models, some possibly contradictory, to ensure that as little as possible is missed. The model in current use, which gives a prominent place to the Bytham River in the Early Pleistocene (Rose *et al*., 2001; Lee *et al*., 2006), has two major problems. Firstly, there is no sedimentary evidence for the existence of the Bytham before the Middle Pleistocene, even in Suffolk where there is a complete history for the Thames preserved close by (Whiteman and Rose, 1992; Rose *et al*., 2002); is the lack of evidence because the Bytham did not exist until the Middle Pleistocene? Secondly, the assumption is made in the lithological analysis that underpins the model that all erosion and transportation of gravels was achieved by fluvial processes only. In the light of the evidence for the repeated advances of ice into the Evenlode Valley from probably as early as the late Pliocene it seems that an alternative model is needed for the north Midlands and south and east Pennines in spite of, or because of, the lack of evidence.

If, as Hey suggested (1986), west Pennine material reached the Evenlode valley by the start of the Early Pleistocene, it is very probable that some outwash from Pennine ice would have moved down the Trent to the North Sea off the north Norfolk coast, where it was progressively incorporated into the younger members Wroxham Formation. Initially the composition of the outwash would have been very similar to that expected of the Trent, making it difficult to discriminate, but andesite artifacts (Shotton *et al*., 1993) and a large andesite cobble (40 cm) (Keen *et al*., 2006) in the basal deposits of the Baginton Formation at Waverley Wood in Warwickshire indicate that reworking of glacial material probably occurred in the pre-Anglian. It is also interesting that Shotton identified the presence of weathered flint in the Formation (Shotton, 1953).

It is probable that, ultimately, an ice advance filled the Trent Valley and blocked the flow of the proto-Soar, causing an ice marginal channel to be cut across the high ground at Melton Mowbray. This deposited the Brooksby sand and gravel which lies buried below the Baginton Sand and Gravel in the valley of the Wreake. Very little seems to have been recorded about this deposit, but the gravels "show very little difference from the Baginton Gravel, where the latter is characterised by a substantial proportion of Carboniferous sandstone and chert" (Rice, 1991, 46) "that must presumably have come from the southern Pennines" (48). Organic deposits separate the Brooksby deposits from the Baginton Sand and Gravel, creating a stratigraphic sequence that contrasts with the inversion produced by the incised terraces of the Thames. Rice (1991), noting that the proportion of material of Pennine origin relative to that from the Sherwood Sandstone Group in the Baginton Sand and Gravel increased towards the east, suggested that "a possibility worthy of mention is an ice advance approximately contemporaneous with the Baginton Sand and Gravel that crossed the Trent Valley" and fed melt water into the northern tributaries of the then eastward-flowing Wreake (p53). Probably a similar event had led to the deposition of the earlier Brooksby material. Thus there is evidence for two events where river flow passed Melton Mowbray, but for six such events along the valley past Bury St Edmunds and Knettishall to the North Sea (Lewis *et al*., 1999; Lee *et al*., 2006). Probably North Sea ice advanced far enough to close the Wash Gap, activating the lower part of the river, before east Pennine ice closed the Trent. It is possible that the Bytham River did not become a significant feature in Suffolk drainage until the early Middle Pleistocene. By this time the Thames was further south depositing the Colchester Formation (Westaway *et al*., 2002). It is also possible that the sites in north Suffolk, where lithological analysis has shown the mixing of material sourced by both the Thames and the Bytham, are more likely to result from the reworking of Thames material by the Bytham than from the confluence of the two rivers (Figure 5b). This would account for the extreme local variability of the lithologies of sites in north Suffolk (Hey, 1980; Green and McGregor, 1999), and would avoid the problem of having to explain how the Thames and Bytham, having become confluent in the Early Pleistocene, achieved separation to follow different courses in the late Middle Pleistocene.

Once ice that blocked the Wash Gap melted, the Trent with the Proto-Soar and Ouse would be restored as the main drainage element in the north and the abandoned sections of the Bytham would be left as mis-fits. It seems possible that, unlike the Thames, the activity of the Bytham was not driven by the full pattern of climatic oscillations, but by only those cold episodes that saw the development of ice sheets that advanced far enough to inhibit river flow through the Wash Gap. This could account for the lack of a full record of terrace development on the Bytham through Bury St Edmunds to equal the nearby record contained in the Kesgraves.

Although the post-Cromerian glaciations may have obscured or reworked a large amount of low-lying evidence, as in the Fens, there should be enough left on higher ground to allow the testing of the model proposed here.

Conclusions

The Tertiary pattern of drainage in central and eastern England arose from gentle uplift in the west. It consisted of two major systems, the Severn/Thames in the south and the Dee/Trent in the north, that bordered a Midlands catchment

	Thames	Midland Rivers	Trent/Bytham
	--- post-Cromerian --	--- glaciations over ---	--almost all of the area --
cene		Courteenhall Formation	
Pleisto	Colchester Formation		Bytham outwash across Suffolk
Middle			Bytham ice-marginal channle
	Bruene Abbey glaciation	into Upper Nene	Brooksby ice-marginal channel
	reaches north Norfolk	Diversion of Milton River	
cene	through St Albans		Sea via Wash
Pleisto-	Sudbury Formation	Cambering and vallye bulging	Midland gavels to North
Early	Shipton glaciation	Deep permafrost	Trent glaciation
		and Brigstock Rivers	and Lower Ouse
Pliocene	Dormant	Beheading of Milton	proto-Soar
	Development of Proto-Soar	Trent gaining right bank	
	Possibly in decline	Trellised drainage	
		from west Midlands watershed	
	to London Basin	Midland rivers flow	
	mid and south Wales	sub-Miocene surface(?)	Wales to North Sea
Miocene	Severn/Thames from	Indeterminate drainage on	See/Trent from North

Table 1. Draft correlation of the development of the river systems of Central and Eastern England. Phrases read from the bottom

where very low gradient rivers slowly cut into the layers of hard and soft rocks, to develop a trellised drainage system.

Uplift in the south and west of Britain in the Pliocene caused the development of a southwest to northeast oriented pattern with the Proto-Soar and Ouse joining the Trent to drain the Midlands to the North Sea through the Wash Gap. The Thames ceased to be an active feature of the landscape, while the remnants of the Midland rivers continued to flow eastwards.

In the late Pliocene/Early Pleistocene a series of ice advances into the Cotswolds Plateau revitalised the Thames and supplying large quantities of erratic outwash material. Continued uplift led to the development of a suite of terraces, eventually allowing material to reach north Norfolk. The development of the terraces can be roughly correlated with the pattern of climate change. In the north Midlands the Trent moved glacially-derived material to the North Sea through the Wash Gap.

In the Middle Pleistocene the closure by ice of the Wash Gap diverted the Trent across East Anglia to form the lower course of the Bytham. Eventually ice fronts crossed the Trent valley and activated the middle Bytham as an ice-marginal channel. Melting of the ice restored the Trent as a major element in the interglacial drainage pattern and left the Bytham in East Anglia as a mis-fit river. The fluvial activity of the Bytham, therefore, tends to correlate with the periods of invasion by lowland ice sheets.

From the late Pliocene to the Middle Pleistocene the area covered by the Milton Formation remained isolated from external sediment inputs, although surrounded by widespread glacial and outwash activity.

As with all models, the devil is in the detail. It is hoped that this paper will encourage strenuous attempts to falsify both models and will lead to a more robust process-based explanation of the history of the area.

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References

Belshaw, R. K., Hackney, G.D. and Smith, K.A. (2004). Late Tertiary to Pleistocene drainage network evolution in the English Midlands: the significance of the Milton Formation. In: Langford, H.E. and Briant, R.M. (eds) *Nene Valley Field Guide*. Quaternary Research Association, Cambridge.

Belshaw, R. K., Hackney, G.D. and Smith, K.A. (2005). The evolution of the Drainage Pattern of the English Midlands from the Late Tertiary to the Early Pleistocene: the significance of the Milton Formation. *Quaternary Newsletter*, 105. 16-31.

Belshaw, R.K., Smith, K.A. and Hackney, G.D. (2006). The early Pleistocene modification of the remnants of the Tertiary drainage system in Northamptonshire, U.K. *Quaternary Newsletter*, 109, 11-20.

Boomer, I. and Woodcock, L. (1999). The nature and origin of the Stiffkey Meals, north Norfolk coast. *Bulletin of the Geological Society of Norfolk*, 49, 3-13.

Boreham, S. and Langford, H.E. (2006). The Milton Formation and late Cenozoic drainage development of the English Midlands: a comment on Belshaw, Hackney and Smith (2005). *Quaternary Newsletter*, 108, 14-23.

Bridgland, D.R. (2000). *Rhaxella* chert in East Anglia - Discussion. *Quaternary Newsletter*, 90, 24-26.

Clark, C.D., Gibbard, P.L. and Rose, J. (2004). Pleistocene glacial limits in England, Scotland and Wales. In: Ehlers, J. and Gibbard, P.L. (eds) *Glaciation of the World*, Vol. 1, Europe, 47-82.

Clayton, K.M. (2000). Glacial erosion of the Wash and Gen basin and the deposition of the chalky till of eastern England. *Quaternary Science Reviews*, 19, 811-822.

Funnell, B.M. (1961). The Paleogene and Early Pleistocene in Norfolk. *Transactions of the Norfolk and Norwich Naturalists Society*, 19, 340-364.

Funnell, B.M. (1996). Plio-Pleistocene Palaeogeography of the southern North Sea. *Quaternary Science Reviews*, 15,391-405.

Gibbard, P.L. and Lewin, J. (2003). The history of the major rivers of southern Britain during the Tertiary. *Journal of the Geological Society, London*, 160. 829-845.

Gibbard, P.L.; West, R.G.; Andrew, R. and Pettit, M. (1992). The margin of a Middle Pleistocene ice advance at Tottenhill, Norfolk, England. *Geological Magazine*, 129 59-76.

Green, C.P. and McGregor, D.F.M. (1999). Pre-Anglian gravel deposits of the River Thames and its tributaries between Goring and Cromer. *Proceedings of the Geologists' Association*, 110, 117-132.

Green, C.P., Hey, R.W. and McGregor, D.F.M. (1980). Volcanic pebbles in Pleistocene gravels of the Thames in Buckinghamshire and Hertfordshire. Geological magazine, 117, 59-64.

Hey, R.W. (1976). Provenance of far-travelled pebbles in the pre-Anglian Pleistocene of East Anglia. *Proceedings of the Geologists' Association*, 87, 69-82.

Hey, R.W. (1980). Equivalents of the Westland Green Gravels in Essex and East Anglia. *Proceedings of the Geologists' Association*, 91, 279-290.

Hey, R.W. (1986). A re-examination of the Northern Drift of Oxfordshire. *Proceedings of the Geologists' Association*, 97, 291-301.

Hjulström, F. (1935). Studies of the morphological activity of rivers as illustrated by the River Fyris. *Bulletin of the Geological Institute University of Uppsala*, 25,221-527.

Hollingworth, S.E., Taylor, J.H. and Kellaway, G.A. (1944). Large scale superficial structures in the Northamptonshire Ironstone Field. *Quarterly Journal of the Geological Society*, 100,1-44.

Keen, D.H., Hardaker, T. and Lang, A.T.O. (2006). A Lower Palaeolithic industry from the Cromerian (MIS 13) Baginton Formation of Waverley Wood and Wood Farm Pits, Bubbenhall, Warwickshire, UK. *Journal of Quaternary Science*, 21, 457-470.

Kellaway, G.A. and Taylor, J.H. (1953). Early stages in the physiographic evolution of a portion of the East Midlands. *Quarterly Journal of the Geological Society of London*, 108, 343-376.

Krinsley, D.H. and Funnell, B.M. (1965). Environmental history of quartz sand grains from the Lower and middle Pleistocene of Norfolk, England. *Quarterly Journal of the Geological Society of Society of London*, 121, 36-43.

Lee, J.R., Rose, J, Candy, I. and Barendregt. R.W. (2006). Sea-level changes, river activity, soil development and glaciation around the western margins of the Southern North Sea basin during the Early and early Middle Pleistocene: evidence from Pakefield, Suffolk, U.K. *Journal of Quaternary Science*, 21, 155-179.

Lewis, S.G., Rose, J. and Davies, H. (1999). Pre-Anglian fluvial and Anglian glaciogenic sediments, Knettishall, Suffolk, England. *Proceedings of the Geologists' Association*, 110, 17-32.

Lucy, W.C. (1872). The gravels of the Severn, Avon and Evenlode, and their extensions over the Cotteswolds Hills. *The Proceedings of the Cotteswolds Naturalists' Field Club*, 5, 71-125.

Lucy, W.C. (1880). Extension of the Northern Drift and Boulder Clay over the Cotteswolds. *The Proceedings of the Cotteswolds Naturalists' Field Club*, 7, 50-61.

Mathers, S.J. and Zalasiewicz, J.A. (1988). The Red Crag and Norwich Crag formations in southern East Anglia. *Proceedings of the Geologists' Association*, 99, 261-278.

Moffat, A.J. and Catt, J.A. (1986). A re-examination of the evidence for a Plio-Pleistocene marine transgression on the Chiltern Hills. III. Deposits. *Earth Surface Processes and Landforms*, 11 233-247.

Orford, J.D., Carter, R.W.G., McKenna, J. and Jennings, S.C. (1995). The relationship between mesoscale sea-level rise and rate of retreat of swash-aligned gravel-dominated barriers. *Marine Geology*, 124, 177-186.

Perrin, R.M.S., Rose, J. and Davies, H. (1979). The distribution, variations and origins of the pre-Devensian tills in eastern England. *Philosophical Transactions of the Royal Society of London*, B287, 535-570.

Rice, J. (1991). Distribution and provenance of the Baginton Sand and Gravel in the Wreake Valley, northern Leicestershire, England: implications for inter-regional correlation. *Journal of Quaternary Science*, 6, 39-54.

Riding, J.B., Moorlock, B.P.S., Jeffery, D.H. and Hamblin, R.J.O. (1997). Reworked and indigenous palynomorphs from the Norwich Crag Formation (Pleistocene) of eastern Suffolk: implications for provenance, palaeogeography and climate. *Proceedings of the Geologists' Association*, 108, 25-38.

Riding, J.B., Head, M.J. and Moorlock, B.S.P. (2000). Reworked palynomorphs from the Red Crag and Norwich Crag formations (Early Pleistocene) of the Ludham Borehole, Norfolk. *Proceedings of the Geologists' Association*, 111, 161-171.

Rose, J., Candy, I., Moorlock, B.S.P., Wilkins, H., Lee, T.A., Hamblin, R.J.O., Lee, J.R., Riding, J.B. and Morigi, A.N. 2002. Early and early Middle Pleistocene river, coastal and neotectonic processes, southeast Norfolk, England. *Proceedings of the Geologists' Association*, 113, 47-67.

Rose, J., Gulamali, N., Moorlock, B.S.P., Hamblin, R.J.O., Jeffery, D.H., Anderson, E., Lee, J.A. and Riding, J.B. (1996). Pre-glacial and glacial Quaternary sediments, How Hill, near Ludham, Norfolk, England. *Bulletin of the Geological Society of Norfolk*, 45, 3-28.

Rose, J. Moorlock, B.S.P. and Hamblin, R.J.O. (2001). Pre-Anglian fluvial and coastal deposits in Eastern England: lithostratigraphy and palaeoenvironments. *Quaternary International*, 79, 5-22.

Rose, J., Whiteman, C.A., Allen, P. and Kemp, R.A. (1999). The Kesgrave Sands and Gravels: 'pre-glacial Quaternary deposits of the River Thames in East Anglia and the Thames Valley. *Proceedings of the Geologists Association*, 110, 93-116.

Selby, M.J. (1985). *Earth's Changing Surface*. Oxford.

Shotton, F.W. (1953). The Pleistocene deposits of the area between Coventry, Rugby and Leamington and their bearing upon the topographic development of the Midlands. *Philosophical Transactions of the Royal Society, London*, B 237, 209-269.

Shotton, F.W., Keen, D.H., Coope, G.R., Currant, A.P., Gibbard, P.L., Aalto, M., Peglar, S.M. and Robinson, J.E. (1993). The Middle Pleistocene deposits of Waverley Wood Pit, Warwickshire, England. *Journal of Quaternary Science*, 8, 293-325.

Sinclair, J.M. (1999). Plio-Pleistocene relative sea-level changes in East Anglia: evidence from the Westleton Member and related deposits. *Proceedings of the Geologists Association*, 110, 149-162.

Smith K.A. (1999). *Quaternary environmental changes in the fluvial and faunal history of Central Northamptonshire*. PhD Thesis. University of Leicester.

Smith, K.A., Gillmore, G.K. and Sinclair, J.M. (2000). Sediments and ostracoda from Courteenhall, Northamptonshire, U.K., and their implications for the depositional environment of the Pleistocene Milton Formation. *Proceedings of the Geologists Association*, 111, 253-268.

Straw, A. (1963). The Quaternary evolution of the Lower and Middle Trent. *East Midland Geographer*, 3. 171-189.

Straw, A. (1969). Pleistocene events in Lincolnshire. *Transactions of the Lincolnshire Naturalists' Union*, 17, 85-98.

Sumbler, M.G. (2001). The Moreton Drift: a further clue to glacial chronology in central England. *Proceedings of the Geologists Association*, 112, 13-27.

Westaway, R., Maddy, D. and Bridgland, D.R. (2002). Flow in the lower continental crust as a mechanism for the Quaternary uplift of south-east England: constraints from the Thames terrace record. *Quaternary Science Reviews*, 21, 559-603.

Whiteman, C.A. and Rose, J. (1992). Thames river sediments of the British Early and middle Pleistocene. *Quaternary Science Reviews*, 11, 363-375.

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COMMENTS

PLEISTOCENE DRAINAGE DEVELOPMENT OF THE ENGLISH MIDLANDS: A COMMENT ON BELSHAW, SMITH AND HACKNEY (2005, 2006)

Harry Langford and Steve Boreham

Introduction

The article by Belshaw *et al*. (2005) was important because up to now emphasis has been placed on the development of the proto-Soar, Bytham and Kesgrave drainage systems. Belshaw *et al*. (2005) argued that the Milton Formation drainage system pre-dated the proto-Soar and Bytham systems, and they therefore favoured a pre-Pleistocene age for initiation of the Milton Formation system. Boreham and Langford (2006), in response to Belshaw *et al*. (2005), emphasised the importance of reconciling models of drainage development with: regional structural geology, lithological controls, prevailing tectonic regime and glacio-isostatic adjustment. In effect they favoured a 'bottom-up' approach for recognising potential drainage patterns and the conditions influencing accommodation and preservation potential for fluvial deposits; rather than the 'top-down' approach of attempting to reconstruct drainage patterns on the basis of litho- and biostratigraphical correlation of disparate fluvial deposits in the absence of reliable dating controls.

The latest article of Belshaw *et al*. (2006) focuses on the Early and early Middle Pleistocene drainage development within Northamptonshire. In both articles (Belshaw *et al*., 2005, 2006) a number of assumptions and generalisations are made, and undue credence is given to aspects of previous drainage reconstructions that support their case. Given the speculative nature of both articles perhaps this is inevitable. In this comment specific concerns relating to the age of the Milton Formation, the development of the proto-Soar, 'tunnel valleys' and fluvial terraces are addressed with the aim of engendering further discussion and research.

Age of the Milton Formation

An amino-acid racemisation (AAR) age estimate of marine oxygen isotope stage (MIS) 15 for the Waverley Wood Member of the Baginton Formation (Bowen, 1999) provides an upper age limit for the Milton Formation (or the cessation of the Milton Formation drainage system). Although the Courteenhall Formation is deemed to comprise reworked Milton Formation sediments, and therefore could post-date the Milton Formation, its (reworked) Cromerian faunal assemblage does indicate that the Milton Formation drainage system was operating during Cromerian times. As about 40 m of post-Milton-Formation downcutting had occurred prior to deposition of the Waverly Wood Member it seems reasonable to further constrain the upper age limit to the preceeding warm stage (MIS 17) at least, i.e. about 700 ka.

There is, however, no reliable age constraint for initiation of the Milton Formation drainage system. Belshaw *et al.* (2005, 2006) base their belief for initiation in Pliocene times on the interpretation of Rose and co-workers (Bateman and Rose, 1994; Rose *et al.*, 1999, 2002) that the Bytham river system was well-established by the Early Pleistocene, but chronostratigraphical data are lacking. Furthermore there is no clear evidence within the Milton Formation deposits that they aggraded over multiple glacial–interglacial cycles. Claims for a Pliocene age therefore need to be treated with caution, especially as initiation could have occurred at any time in the 1.9 Myr of the Pleistocene prior to MIS 17.

Proto-Soar

Development of the proto-Soar early in the drainage evolution of the English Midlands would appear counterintuitive if drainage initiation was controlled by the regional southeast dip of the bedrock, as envisaged in Boreham and Langford (2006). Under these conditions trunk streams would have a broadly NW–SE trend and left-bank tributaries with the same trend would develop preferentially. Strike-controlled drainage with a broadly NE–SW trend might evolve in response to differing bedrock lithologies as denudation proceeded. Again left-bank tributaries would develop preferentially and stream capture might lead to a pattern similar to that envisaged for the middle to lower stretches of the Bytham river. A right-bank tributary at the highest point in the region flowing to the northeast against the bedrock dip is difficult to reconcile with a drainage pattern controlled by regional geology.

Belshaw *et al.* (2005) overcome this difficulty by invoking regional Early Quaternary downwarping to the northeast (Moffat and Catt, 1986). On a denuded landscape with emergent strike-controlled drainage this would have led to preferential development of right-bank tributaries trending broadly SW–NE and stream capture would have produced a drainage pattern similar to that of the present-day Nene and Great Ouse. The effects on drainage of this downwarping would have occurred later in the west of the region, i.e. where the proto-Soar developed. It is difficult to reconcile the proposed course of the Bytham river with this scenario, particularly such a late-stage development of the proto-Soar, because the stretch on the eastern side of the Fen Basin would be flowing against the envisaged downwarping to the northeast.

An alternative, although highly speculative, scenario might be structural control through uplift of the London–Brabant Massif in response to subsidence in the North Sea basin, particularly if associated with ice-loading to the north (Pennines) and west (Wales). This could account for the proposed course of the proto-Soar and upper stretch of the Bytham river, and at the very earliest stage of development possibly the whole of the Bytham river. This, however, seems unlikely because when erosion is taken into account the Chalk scarp would lie further west and the proposed course for the Bytham river on the east of the Fen Basin would lie directly on the Chalk (Gallois, 1999). Such structural control would lead to a major W–E trending stream with an outlet at The Wash and major, broadly SW–NE trending, strike-controlled right-bank tributaries draining the East Midlands. This, however, would be superimposed on a pre-existing NW–SE dip-controlled network, which would produce a drainage pattern similar to that of the present-day Nene and Great Ouse.

'Tunnel valleys'

Belshaw *et al*. (2006) draw attention to the inconsistent terminology used for buried Pleistocene features, usually beneath (Anglian?) chalk-rich diamicton and often coincident with the present drainage network. These include the infilled depressions forming the pre-glacial drainage systems of Kellaway and Taylor (1953), Horton (1970) and Gallois (1979, 1988, 1994, 1999) and the buried tunnel valleys of Woodland (1970). The use of the term 'tunnel valley' by Belshaw *et al*. (2006) to describe the infilled depression at Northampton is misleading as both Early (1956) and Horton (1970) considered a number of causal processes, including the melting of buried ice. It is also confusing because the term tunnel valley is usually associated with a subglacial rather than a periglacial origin. Horton (1970) pointed out there was insufficient evidence available to enable positive genetic interpretation of these features, and that still remains the case. Where detailed sedimentological data are available (at March and Stanground in the Fen Basin; Langford and Boreham, 1998; Langford, 1999, 2004a,b) deltaic deposition preceded the first major influx of Cretaceous material into the area, but this does not explain the origin of the depressions. It does, however, rule out (at these locations) a subglacial origin by ice advancing from the northeast.

With regard to the infilled depression at Northampton, although genesis by periglacial processes is theoretically plausible it remains to be proven by detailed sedimentological study, and there is no clear evidence to suggest an Early Pleistocene age for its origin. It is feasible that separate elements of the systems identified by Horton (1970), Gallois (1979, 1988, 1994, 1999) and Woodland (1970) could have different ages and origins, as argued by Belshaw *et al*. (2004, 2005) for the pre-glacial drainage system of Kellaway and Taylor (1953), but the data available so far are not sufficient to rule out a common age and genesis. At March and at Stanground sedimentation appears relatively continuous from the base to the top, represented by chalk-rich diamictions. As it is widely believed that the first major influx of Cretaceous material into the area is associated with the advance of Anglian ice from the northeast (Bowen, 1999) a Middle Pleistocene age for these features would seem more appropriate.

Fluvial terraces

Belshaw *et al*. (2006) consider that the early Quaternary overdeepening of the valley floor in the Northampton area could account for the lack of a clearly defined Middle to Late Quaternary terrace system along the stretch between Northampton and Wellingborough. In the absence of other controls an absence of terraces would be the norm under a cyclic glacial–interglacial regime as deposits of the preceding cycle are removed and reworked in the subsequent cycle. The formation and preservation of fluvial terraces requires uplift (e.g. Maddy, 1997), but the presence of disparate fluvial sediment bodies along valley sides need not be related to terrace formation (Langford, 2002). Castleden (1980) also recognised the lack of River Nene 3rd Terraces upstream of Aldwincle, amongst other distribution characteristics of the terraces of the Nene and Welland. The presence of post-Anglian lacustrine deposits at Elton, downstream of Aldwincle, and interpretation of the Southorpe dry valley as a glacial meltwater channel (Kellaway and Taylor, 1953) indicated to Langford (1999, 2004c) that River Nene 3rd and 2nd Terraces upstream of Wansford formed as the river and tributaries aggraded to changing baselevels in response to fluctuating lake levels at Elton. Therefore it is the presence of 3rd and 2nd terraces between Wansford and Aldwincle that is unusual, not their absence between Northampton and Wellingborough.

References

Bateman, R. M. and Rose, J. (1994). Fine sand mineralogy of the early and middlePleistocene Bytham sands and gravels of Midland England and East Anglia. *Proceedings of the Geologists' Association*, 105, 33–9.

Belshaw, R.K., Hackney, G.D. and Smith, K.A. (2004). Late Tertiary to Middle Pleistocene drainage evolution of the eastern English Midlands. In: Langford, H. E. and Briant, R. M. (eds). *Nene Valley Field Guide*. Quaternary Research Association, Cambridge, 4–13.

Belshaw, R.K., Hackney, G.D. and Smith, K.A. (2005). The evolution of the drainage pattern of the English Midlands from the late Tertiary to the early Pleistocene: the significance of the Milton Formation. *Quaternary Newsletter*, 105, 16–31.

Belshaw, R.K., Hackney, G.D. and Smith, K.A. (2006). The Early Pleistocene modification of the remnants of the Tertiary drainage system in Northamptonshire. *Quaternary Newsletter*, 109, 11–20.

Boreham, S. and Langford, H. (2006). The Milton Formation and late Cenozoic drainage development of the English Midlands: a comment on Belshaw, Hackney and Smith (2005). *Quaternary Newsletter*, 108, 14–23.

Bowen, D.Q. (ed.) (1999). *A Revised Correlation of Quaternary Deposits in the British Isles*. Geological Society Publishing House: Bath.

Castleden, R. (1980). The Second and Third Terraces of the River Nene. *Mercian Geologist*, 8(1), 29–46.

Early, K.R. (1956). *Proceedings of the Geological Society of London*, 1532, 21–23.

Gallois, R.W. (1979). *Geological Investigations for the Wash Water Storage Scheme*. *Institute of Geological Sciences Report, 78/19*. Her Majesty's Stationery Office, London.

Gallois, R.W. (1988). *Geology of the Country around Ely. Memoir of the British Geological Survey, Sheet 173, England and Wales*. Her Majesty's Stationery Office, London.

Gallois, R.W. (1994). *Geology around King's Lynn and the Wash*. *Memoir of the British Geological Survey Sheet 145, (England and Wales)*. Her Majesty's Stationery Office, London.

Gallois, R.W. (1999). Pre-glacial drainage of Fenland. *Proceedings of the Geologists' Association*, 110, 257–258.

Horton, A. (1970). *The Drift Sequence and Sub-glacial Topography in parts of the Ouse and Nene Basins*. Report of the Institute of Geological Sciences, 70/9. Her Majesty's Stationery Office, London.

Kellaway, G.A. and Taylor, J.H. (1953). Early stages in the physiographic evolution of a portion of the East Midlands. *Quarterly Journal of the Geological Society of London*, 108, 343–376.

Langford, H.E. (1999). *Sedimentological, palaeogeographical and stratigraphical aspects of the Middle Pleistocene geology of the Peterborough area, eastern England*. Unpublished PhD thesis, Anglia Polytechnic University, Cambridge.

Langford, H.E. (2002). Time for a more open-minded approach to the study of British Middle Pleistocene deposits? *Quaternary Newsletter*, 96, 12–27.

Langford, H.E. (2004a). Middle Pleistocene deposits at Stanground (Peterborough) and March, eastern England: a discussion based on new evidence. *Proceedings of the Geologists' Association*, 115, 91–95.

Langford, H.E. (2004b). Comments on the Anglian glaciation of the Fen Basin. In: Langford, H. E. and Briant, R. M. (eds). *Nene Valley Field Guide*. Quaternary Research Association, Cambridge, 14–21.

Langford, H.E. (2004c). Post-Anglian drainage reorganisation affecting the Nene and Welland. In: Langford, H. E. and Briant, R. M. (eds). *Nene Valley Field Guide*. Quaternary Research Association, Cambridge, 36–43.

Langford, H.E. and Boreham, S. (1998). Buried channel deposits at March, Cambridgeshire, Eastern England. *Quaternary Newsletter*, 86, 8–16.

Maddy, D. (1999). English Midlands. In: Bowen, D.Q. (ed.) *A Revised Correlation of Quaternary Deposits in the British Isles*. Geological Society Publishing House: Bath.

Moffat, A.J. and Catt, J.A. (1986). A re-examination of the evidence for a Plio-Pleistocene marine transgression on the Chiltern Hills. III. Deposits. *Earth Surface Processes and Landforms*, 11, 233–247.

Rose, J., Smith, A., Lewis, S., Moorlock, B. and Hamblin, R. (1999). Reply. Pre-glacial drainage of Fenland. *Proceedings of the Geologists' Association*, 110, 258–62.

Rose, J., Candy, I., Moorlock, B.S.P., Wilkins, H., Lee, T.A., Hamblin, R.J.O., Lee, J.R., Riding, J.B and Morigi, A.N. (2002). Early and early Middle Pleistocene river, coastal and neotectonic processes, southeast Norfolk, England. *Proceedings of the Geologists Association*, 113, 47–67.

Woodland, A.W. (1970). The buried tunnel valleys of East Anglia. *Proceedings of the Yorkshire Geological Society*, 37, 521–578.

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REPLY PLEISTOCENE DRAINAGE DEVELOPMENT OF THE ENGLISH MIDLANDS: A COMMENT ON BELSHAW, SMITH AND HACKNEY (2005, 2006)

Roger Belshaw

Langford and Boreham (this issue) explore several issues that are very important in the search to find the most probable model for the development in the drainage of central and eastern England. This reply attempts to take this exploration further.

Methodology

A 'bottom-up' approach to recognising potential drainage patterns is important, as it may set broad limits for change over time, but fine detail is precluded by the difficulty of arriving independently at the 'prevailing tectonic regime' - the direction, magnitude and timing of sequences of movements along faults. As drainage development is extremely sensitive to changes in surface slope the 'bottom-up' approach has to give way at this point to a 'top-down' one, however inadequate the evidence may be. Where material is limited in origin to clearly defined locations and has been transported by fluvial processes only it is possible to speculate (construct hypotheses, falsify, etc) on the broad outlines of drainage patterns responsible for such movements. Clearly, disparate deposits do not allow one to get very far in this process, but if the fluvial deposits are massive and continuous over appreciable distances (as is the Milton Formation) it may be possible to have some confidence in the general pattern and its development over time, even in the absence of reliable dating controls. The great danger in this approach, however, is to assume that only fluvial processes have been involved in the transport of the material, and not to try to falsify such an assumption, for once glacial transport occurs it is impossible to justify any deductions made about the direction of the slope of the surface of the area.

The age of the Courteenhall Formation

The Courteenhall Formation comprises reworked Milton Formation sediments, a significant addition of reworked Jurassic silts and clays and *in situ* (not reworked) faunal assemblages. The narrow valley containing the sediments was incised at right angles across the Milton Formation. It declined from south to north to a base level several metres below that of the Milton Formation, to flow into a depression lying immediately to the north, suggesting that the Milton River had ceased to flow by this time. The faunal assemblages were broadly assigned to Cromerian times (Smith, 1999; Smith *et al.,* 2000). It would be difficult to correlate the Formation specifically with the portion of the Cromerian represented by the Waverley Wood Member of the Baginton Formation. The most relevant aspect in terms of dating controls of the Courteenhall Formation in that it is immediately overlain by a diamicton containing Bunter pebbles that is usually described as the 'Lower Till' and taken as evidence for the first glacial activity in the Northampton area.

The age of the Milton Formation and the development of the proto-Soar

Belshaw *et al*. (2004, 2005) base their belief in the initiation of the Milton Formation in Pliocene (or earlier) times on the presence of the Formation on the summit of the Jurassic Escarpment around the Watford Gap (Belshaw, 2007, this volume, for illustration). It is agreed that there is no evidence that the Formation aggraded over multiple glacial-interglacial cycles. The lack of silts and clays characteristic of Quaternary fluvial deposits and the sheer bulk of the material (several billion tonnes of soft clean sand) make it very unlikely that the Formation was deposited at any one stage in the Early or early Middle Pleistocene and support the belief that the Formation accumulated slowly over a long period of time before the multiple glacial-interglacial cycles of the Quaternary. In this scenario the proto-Soar is a very late modification to the dominantly structurally determined pattern. The significance to the Milton Formation is that the development of the proto-Soar assisted in its preservation by the isolation of the Northampton area from the pre-Anglian glacial activity that occurred to the proto-Soar valley (Keen *et al*, 2006).

Tunnel Valleys

The term 'tunnel valley' was used only in its morphological sense. Prior usage listed in the paper indicates that the use of the term in a genetic sense is unwise. It is agreed that a full sedimentological analysis of the infill would be very useful, but this may not indicate how and when the feature was formed. There is, however, already sufficient evidence to define parameters for the processes involved in the creation of this tunnel valley. It was already in existence before the first glacial ice or material entered the area (see above), so all glacially related processes are eliminated. Fluvial processes involve very strong feed-back loops that concentrate erosion on the valley floor, yet the tunnel valley was formed half way up the side of the valley of the Milton River. It is therefore unlikely that fluvial processes played a major part in the formation of the feature. The elimination of glacial and fluvial processes as the major formative factors leaves periglacial and tectonic processes as the only contenders. Evidence that periglacial activity caused widespread and severe modification of the Northamptonshire landscape in the Early Pleistocene has been available for a long time, but has not been accommodated in the current models of drainage development for the area.

Fluvial Terraces

The valleys of the Nene between Wellingborough and Wansford and of the

Ouse between Newport Pagnell and Bedford are incised in long wavelength meander form into the Jurassic strata. All deposits within them have proved to be post-Anglian in age. It is probable that both sections were initiated as part of an ice marginal channel when the Anglian ice sheet decayed. The valley of the Nene between Northampton and Wellingborough was graded to the Bozeat Gap. As this was filled with deposits from the Lower and Chalky Till times it is very probably that this part of the Nene Valley is considerably older than its next section downstream and had a lower baselevel.

Models

Central England, and much of eastern England has been exposed to sub-aerial denudation for several tens of millions of years. Any model of landscape development needs to address the whole of this period. The very limited nature of the evidence allows only a 'top-down' approach, but a focus on viable sedimentary processes should allow the modelling of the broad pattern of events.

References

Belshaw, R.K. (2007). Stages in the pre-Anglian development of the river systems of central and eastern England. *Quaternary Newsletter*, 111.

Belshaw, R.K., Hackney, G.D. and Smith, K.A. (2004). Late Tertiary to Middle Pleistocene drainage evolution of the eastern English Midlands. In: Langford, H. E. and Briant, R. M. (eds). *Nene Valley Field Guide*. Quaternary Research Association, Cambridge, 4–13.

Belshaw, R.K., Hackney, G.D. and Smith, K.A. (2005). The evolution of the drainage pattern of the English Midlands from the late Tertiary to the early Pleistocene: the significance of the Milton Formation. *Quaternary Newsletter*, 105, 16–31.

Keen, D.H., Hardaker, T. and Lang, A.T.O. (2006). A Lower Palaeolithic industry from the Cromerian (MIS 13) Baginton Formation of Waverley Wood and Wood Farm Pits, Bubbenhall, Warwickshire, UK. *Journal of Quaternary Science*, 21, 457-470.

Smith K.A. (1999). *Quaternary environmental changes in the fluvial and faunal history of Central Northamptonshire*. PhD Thesis. University of Leicester.

Smith, K.A., Gillmore, G.K. and Sinclair, J.M. (2000). Sediments and ostracoda from Courteenhall, Northamptonshire, U.K., and their implications for the depositional environment of the Pleistocene Milton Formation. *Proceedings of the Geologists Association*, 111, 253-268.

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A COMMENT ON THE QUATERNARY OF THE ROSSENDALE FOREST AND GREATER MANCHESTER FIELD GUIDE AND FIELD MEETING REPORT (QN 108)

The recognition of moraine features as described in the guide is of special interest because, although ice movement during the Last Glacial Maximum was primarily southwards, these moraines have ice contact slopes facing to the south and are orientated north-east to south-west. The leaders of the excursion rightly stress that they were formed during the 'retreat' of the Last Glacial Maximum ice sheets when ice melted away from the Pennine uplands to the east and north. Their studies suggest that during this phase, part of the ice sheet which had previously passed over the hills in the western part of the Rossendale Forest became obstructed by this upland. Ultimately it became slow moving and stagnated in the Roach, Irk and Irwell valleys. The release of meltwaters from the decaying ice on the upland slopes would account for the extensive fluvio-glacial and some glacio-lacustrine deposits in the areas north of the moraines as described in Crofts (2006).

At the same time ice streams from the west, not obstructed by the relief, were still sufficiently mobile to continue to cover the lowland in the Greater Manchester area and to create the moraines, as described in the guide. These fronto-lateral moraines have exposures displaying evidence of ice margin glacial tectonic features.

Comparable conditions appear to have affected the Alderley Edge area in East Cheshire where the landforms have a similar glacial morphology to those described in the guide. Here, a relatively low relief barrier extending from The Edge to Macclesfield obstructed ice movement southwards during a late phase of the Late Glacial Maximum ice sheet melting. In the east, this resulted in the diversion of the local River Bollin drainage, the erosion of meltwater channels and the formation of the Dane Moss lake depression (Johnson, 1985). A thick sequence of glacial and glacio-fluvial sediments cover the higher slopes in the areas west of Macclesfield and to the south of the Edge where several kettle holes have been recognised (Evans *et al*., 1968). On the southern flank of the Alderley Edge, there is a sequence of morainic ridges broadly similar to those described in Crofts (2006) and with the same approximate orientation. Temporary working faces in now defunct sand and gravel quarries have shown, in the past, deformed and contorted strata resulting from ice thrusting from the south.

These two areas provide a possible model for those situations where lateral ice movement is confined by upland hills at the margins and where smaller local relief features eventually become barriers to free ice flow during the general down wasting of the ice. When these conditions occur some ice streams, not hindered by the barriers, can move into those areas now no longer occupied by the impeded ice and, if sufficiently mobile, deform the glacial and fluvio-glacial sediments previously deposited.

References

Crofts, R.G (ed.) (2006) *Quaternary of the Rossendale Forest and Greater Manchester*. Cambridge: Quaternary Research Association.

Evans, W.B. Wilson, A.A., Taylor, B.J. and Price, D. (1968) *The geology of the country around Macclesfield*. Geological Survey of Great Britain.

Johnson, R.H. (1985) The imprint of glaciation on the west Pennine uplands. In Johnson, R.H. (ed.*) The geomorphology of north-west England*. Manchester: Manchester University Press, 237-262.

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REPORTS

REPORT ON THE INTERNATIONAL GEOLOGICAL CORRELATION PROGRAM (IGCP) PROJECT 495 UK WORKING GROUP CONFERENCE AND FIELDTRIP TO ROMNEY MARSH AND THE DUNGENESS FORELAND

"QUATERNARY LAND-OCEAN INTERACTIONS: DRIVING MECHANISMS AND COASTAL RESPONSES."

Wye College, Kent
9th-12th July 2006

Introduction

Nestled in the picturesque town of Wye, Kent, Wye College provided the backdrop to the second annual meeting of the UK IGCP Working Group for IGCP project 495 (Quaternary Land-Ocean Interactions: Driving Mechanisms and Coastal Responses). The meeting was jointly organised by Antony Long (Durham University), Andy Plater (University of Liverpool), Martyn Waller (Kingston University) and Jason Kirby (Liverpool John Moores University). The meeting consisted of a one-day scientific session (consisting of both academic papers and posters), which was followed by a two day field trip to the coastal lowlands and gravel forelands of Romney Marsh and Dungeness.

The registration evening was somewhat unusual as it coincided with the 2006 World Cup Final. After initial ideas by the organisers to move the event, it was decided that perhaps the millions of television viewing public would be a little put out, so the delegates were instead treated to a postponed 'welcome/poster' session after a thrilling three hours of football with the occasional head-butt thrown in. The evening welcome, given by Antony after the penalties, promised a very full programme over the coming days. A brief background was given to research in the Romney and Dungeness area so as to both prepare and 'wet the appetite' for the two day field excursion.

Monday 10th July

The first full day of the conference was given over to the scientific meeting which was arranged into three thematic sessions, each detailed below:

Session 1 – Methodologies for reconstructing and dating

The first paper of the day was given by **Robin Edwards** (Trinity) on 'Foraminiferal transfer functions and sea-level: Accuracy or precision?' A stimulating first talk introduced by Robin as being "statistics after breakfast". This didn't put people off though and the second talk of the day, given by **Wil Marshall** (Plymouth), entitled 'Dating recent salt-marsh sediments with radionuclides: a tentative look inside the 'Black Box'' caused a flurry of questions about the application of dating techniques in the coastal environment. This was followed by a presentation by **Sarah Woodroffe** (Durham) of her doctoral work, 'Foraminifera-based reconstructions of mid-late Holocene sea-level change from North Queensland, Australia'. This particular paper encouraged a lively debate to develop concerning the problems of the use of transfer functions in coastal studies, which integrated nicely with the first paper of the session given by Robin. **Joseph Kelley** (Maine) then gave a paper on the 'Investigations of lower-than-present sea-level positions: Methods and results from Northern Ireland and Maine, USA' which provided a fascinating insight into the use of vibro-cores, their relative positioning and absolute number considering the large costs involved. It served to highlight the growing need for high levels of pre-coring surveys where off-shore coring programmes are to be developed. The final paper of the session was given by **Matthew Brain** (Durham) who also presented work from his Doctoral work entitled 'Autocompaction behaviour of mineralogenic intertidal sediments'. As with the start of the session, statistics made a comeback. Matthew carefully guided the audience through the various models for Autocompaction of salt marsh sediments and the inherent problems that currently belie the methodology used by many to adjust for altitudinal correction. It provided a fitting end to a session that served to highlight that methodologies for reconstructing sea level data are far from resolved.

Session 2 – Coastal resilience

The first paper of the second session was given by **Roland Gehrels** (Plymouth), and was concerned with 'Coastal subsidence in southwest England'. Roland's paper was aimed at current policy makers and their reliance on specific documents that essentially can be misleading. This talk provided an excellent start to the second session as a lively debate followed about the use of data and what actually makes a good sea level index point. The second paper of the session presented by **Andrew Cooper** (Ulster), 'Beach morphological evolution during falling sea level: Millin Bay, Northern Ireland', presented new evidence for a coastal site that had many in the audience wanting to visit the area. So much so, Andrew has been charged with the organisation of a future meeting of the IGCP to Northern Ireland to see his fantastic sites. The third paper was given by **Simon Jennings** (London Metropolitan University) and concentrated on the 'Gravel transport along the East Sussex coast since the mid-Holocene'. The many different palaeogeographical maps that were presented were most fitting for this particular meeting as they provided further background to the coastal development of the area we were to visit on the two field days that were to follow. The fourth paper was given by **Sytze van Heteren** (TNO, Netherlands) and was a departure from the original advertisement due to a technical difficulty. The paper, entitled 'Detailed marine mapping: channel fills and other small-scale features' was an excellent stand by as it served to highlight the points made by Joseph in the first session about the need for detailed off-shore survey prior to expensive coring exercises. The next paper, given by **Sue Dawson** (St Andrews), was about 'Sedimentological and geomorphological coastal change: evidence from the Jan 11th 2005 storm in the Outer Hebrides, NW Scotland'. Again, as with Andrew's pictures of Northern Ireland, the Outer Hebrides stirred something in the audience and the Western Isles look like being yet another site for a future meeting. The final paper in this session was given by **Jason Kirby** (John Moores) and was entitled 'Coastal response to Holocene water level changes in the Humber Estuary'. This paper introduced the idea of coastal lagoons developing in the peri-tidal zone and provided the backdrop for a lively debate about lagoonal sedimentation that continued over the break for tea.

Session 3 –Human coastal interactions

The final session began with an extremely interesting paper given by **Vanessa Heyvaert** (Geological Survey of Belgium) on 'The impact of channel shifting of the river Karkheh on the late Holocene evolution of the northern part of the Lower Khuzestan plain (Persian Gulf, SW Iran): integrating geological and historical data'. The integration of geomorphology and archaeology/historical record was impressive in an area that essentially saw the birth of civilisation. The constant thought of working in the border country between Iran and Iraq was quite daunting. The second paper saw another of the Dutch contingent from TNO Built Environment and Geosciences, Geological Survey of the Netherlands, **Peter Vos**, present a paper on 'Geoarchaeology and palaeogeography of the northern Netherlands'. It should perhaps be pointed out at this stage that our IGCP European partners supported the Romney Marsh meeting extremely well and constantly provided excellent feedback and questioning of all the papers presented. Peter's paper was based around the 'geogenetic approach' which saw a high level of integration between geology, geomorphology and archaeology in order to reconstruct palaeoenvironments. The final paper of the session and indeed the day was given by **Henk Weerts** (TNO, Netherlands). Henk's paper, 'The engulfing of the Groote Waard (The Netherlands)', was thought provoking as it took historical reference and folklore of coastal flooding events in the Netherlands, and with the aid of high resolution geological work, aimed to prove and disprove certain theories with the production of a number of palaeogeographical maps.

The day was rounded off with a trip to Lympne Castle where the conference dinner was served in magnificent surroundings overlooking the coastal area of Romney Marsh (obscured slightly by the rain and low cloud). The castle setting was quite spectacular and was rounded off by a presentation by Andy Plater (aided by Jason Kirby) of the entire delegates alter egos via a very amusing set of web-based searches. It was amazing to learn of our exploits outside of our academic lives thanks to our namesakes, although some were worried what the web would associate with our names due to previous Google-search exploits.

Tuesday 11th July

With the scientific sessions over, the second day of the meeting was devoted to field visits in the Romney Marsh area. We were all provided with a large 'Field Guide and Abstracts' document that will no doubt provide many hours of light reading for the weeks that follow the trip. The provision of vast amounts of maps and diagrams to everybody was excellent though and helped no end with an understanding of the geomorphology of the area.

The first stop was Appledore (Mill Mount) where the four field trip leaders, Antony Long, Martyn Waller, Andy Plater and Jason Kirby, introduced the early Holocene history of the Romney Marsh depositional complex whilst overlooking Walland and Romney Marshes (see Plate 1).

Plate 1. The early Holocene history of the Romney Marsh depositional complex was introduced at Appledore (Mill Mount) (Photo courtesy of Roland Gehrels)

The second stop of the day was Pett Level (Wickham Manor). Here, Martyn Waller explained the destruction of the late Holocene wetlands and the first of a number of 'hands-on' coring exercises was undertaken (see Plate 2). The group coring exercise produced mixed results that were blamed on a number of different things, involving over enthusiastic coring technique, lack of coring technique or perhaps the wrong technique. All in all the English summer weather was perhaps too much for some coupled with the strain of penetrating the metre or so of hard clay.

Plate 2. Group coring exercise at Pett Level (Wickham Manor) (Photo courtesy of Roland Gehrels)

The lunch stop at Old Winchelsea provided another excellent opportunity to look out across Romney Marsh, further strengthening the understanding of the surroundings in relation to the extensive research that has been undertaken in the area. Although incredibly complex, the depositional history was starting to make sense.

The third main stop of the day, Moneypenney Farm and Walland Marsh, saw Martyn Waller and Antony Long introduce the history to the tidal inlets and tidal channels that underlie the area. A further coring exercise was undertaken with the supervision of Andy Plater in order to investigate fine laminations in the infilling of the Wainway Channel. Again, mixed results made sure that those with the incorrect technique were not allowed near the coring equipment again! Andy was quick to point out that the deposits were somewhat sporadic and perhaps not everybody should have found the same sedimentary, signal although it was felt that perhaps he was being somewhat accommodating.

The final stop of the day was at Jury's Gap where Andy Plater introduced the barrier/marshland interface. A short talk about SSSI designation was given by Brian Banks (English Nature) who pointed out that of the many SSSIs around the country, few are given over to geomorphological/geological areas.

Wednesday 12th July

The focus for the final day of the field trip was the coastal fringe of Dungeness. The first stop of the day was at the Dungeness Foreland (Muddymore Pit), where Andy Plater gave a complete depositional history of the area. We were all treated to a plethora of talks about the palaeoreconstruction of the Foreland area with a number of demonstrations of the sediments that can be found in-between the shingle ridges. One of the particular demonstrations that will stay with many, involved Anthony Long introducing us all to the 'leaping' technique of gouge coring, effective but perhaps far too energetic for some.

The next stop at the Dungeness Lighthouse allowed everybody to get a fantastic view of both the shingle deposition in the area and the imposing figure that is Dungeness nuclear power station. This was followed by an introduction to the coastal management of Dungeness by members of the shoreline management committee who also represented English Nature and the Power Company. The need for shingle dredging and beach nourishment was obvious in terms of protecting the nuclear power installation, but to hear how policy is constantly changing made many baulk at the prospects for the future of the area. As this was the last stop, it was decided that it would make a fitting place to take a group photo (see Plate 3). It was felt that this IGCP meeting was both productive and enjoyable and all involved thanked the organisers for such a marvellous effort.

Plate 3. The delegates of the 2006 IGCP 495 UK working group meeting

on the Dungeness Foreland, overlooking the Dungeness Lighthouse (Photo courtesy of Roland Gehrels)

For more information and/or free membership of IGCP Project 495, please contact Roland Gehrels (wrgehrels@plymouth.ac.uk). Further information regarding the IGCP is available on the Web (www.geography.dur.ac.uk/research/qec/igcp.html).

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SYMPOSIUM ON 'FLUVIAL SEQUENCES AS EVIDENCE FOR LANDSCAPE EVOLUTION AND CLIMATIC EVOLUTION IN THE LATE CENOZOIC' – IGCP 518. ŞANLIURFA, TURKEY

22nd to 29th September 2005

Introduction

The inaugural meeting of IGCP 518 - 'Fluvial sequences as evidence for landscape evolution and climatic evolution in the late Cenozoic' was hosted at Harran University in Şanlıurfa – Turkey, between the 22nd and 29th of September, 2005; and was organized locally by **Tuncer Demir** (Department of Geography, Harran University) and **Ali Seyrek** (Department of Soil Sciences, Harran University). It comprised: a 3-day field excursion to the Rivers Euphrates, Göksu and Tigris; a single day excursion to the East Anatolian Fault Zone; a 1-day meeting/conference at Harran University, with lectures, posters and the inaugural project business meeting; and a post-conference excursion to the source of the Tigris and the Mount Nemrut archaeological site. The field excursions were attended by a maximum of 18 delegates, the indoor meeting by around 30. Countries represented included Turkey, Britain, the Czech Republic, Bulgaria, Ukraine, USA, Lithuania, India and Italy, with posters additionally from Brazil, Romania and Spain (authors not present).

Scientific and business meeting (Harran University)

The conference was opened with a welcoming address from **Tuncer Demir** and **David Bridgland** (project leader IGCP449/518). **David Bridgland** (Durham University, UK) briefly introduced the project and highlighted its links to IGCP 449. The first paper was presented by **Metin Kartal** (Ankara University, Turkey) who provided an account about the 'last hunter-gathers of Anatolia'. After this presentation the conference was briefly halted, so that **Uğur Büyükburç** (Rector, Harran University), could formally welcome us to his university. His voice carried above the click of camera shutters and the whirling of film. **Uğur Büyükburç** welcomed us to the next speaker, **Tuncer Demir**, who offered an explanation for the 'late Cenozoic evolution of the Rivers Tigris and Euphrates', of SE Turkey. Continuing with this theme, **Rob Westaway** (Open University, UK) discussed the long-term 'evolution of the river Euphrates in Syria'; new Ar-Ar dates have allowed the terraces of the Euphrates to be constrained and mapped along its length. **Tim Kinnaird** (Edinburgh University, UK) presented new stratigraphical, sedimentological and structural data from southern Cyprus, to discuss ‘alternative models for the Late Cenozoic tectonostratigraphic evolution of Cyprus’. The final paper to be presented before lunch was by **Algirdas Gaigalas**, who gave an account of the climatic evolution of Lithuania, as evidenced by the interglacial and Holocene records contained in the oxbow sequences of Lithuania.

The lunch break provided an opportunity to study the posters. **İbrahim Atalay** (Dokuz Eylül University, Turkey) documented how the ‘fluvial terraces of the Banaz-Ulubey stream valley in Anatolia’ records extension and subsidence in this region. **Eva Břízova** (Czech Geological Survey, Czech Republic) has studied the Labe River, in central Bohemia, and recognised distinct evolutionary trends in the geomorphology of the river; the Labe River may be used as an analogue for the analysis of river sequences globally. **Zhongyuan Chen’s** (East China Normal University) poster identified key areas that require study along ‘China’s Yangtze River’; he chose to discuss one area in which he had preliminary data – a 400m thick sedimentary sequence at the river’s mouth that consists of 5 to 6 cycles of basal coarse gravely sands overlain by fine silt and mud. Sediment transported through the Yangtze system is typically composed of fine sands and silts. This coarse fraction may indicate a source in the ~500m mountain ranges located 300km away. **F. Gullentops’s** (Katholieke Universiteit Leuven) poster posed the intriguing question ‘did the Nile, at the end of the Pleistocene, temporarily cease to reach the sea?’. They present sedimentological, palaeontological and archaeological evidence for ephemeral damming, which led to temporary lakes that were exploited by humans. A poster by **Andrew Howard** (University of Birmingham, UK) documents the ‘Lower and Middle Palaeolithic occupation of the Middle and Lower Trent, UK. The work presented, as part of an English Heritage project funded through the Aggregates Levy Sustainability Fund (ALSF), aimed to elucidate the Palaeolithic archive of the present-day Trent valley and of areas formerly drained by the Trent prior to ‘ice-age’ diversions. Geological and palaeontological data discussed in **Edgardo Latrubesse’s** (Unversidade Federal de Goias, Brazil) poster shows that the existence of ‘an intracontinental seaway through southwestern Amazonia during the upper Miocene’, connecting the Caribbean Sea with the Parana basin is equivocal. **Andrei Matoshko** (National Academy of Sciences of Ukraine, Ukraine) provided two posters – ‘Late Cenozoic fluvial development within the coastal plains and shelf of the Sea of Azov and Black Sea basin’ and ‘Fluvial slope processes in the northern part of Ukraine (after the Dnieper Glaciation)’. **Marcel Mindrescu** (University of Suceava, Romania) has mapped the terraces of the Rivers Prut and Siret, to examine ‘the Late Cenozoic evolution of the River Prut’. **N. Roy** (Indian Institute of Technology Kanpur, India) has noted differences in ‘alluvial geomorphology and confluence dynamics in the Ganga valley, India’. **Juan Santisteban** (University of Complutense de Madrid, Spain) has complied a chronological database for the fluvial network that cuts across the Iberian Peninsula. The ‘Palaeolithic record for the Euphrates’ has been reviewed by **Andrew Shaw** (University of Durham, UK); this poster documents his recent findings and stresses the need to refine a dating framework for this region.

The afternoon session began with a presentation by **Petras Sinkunas** (Institute of Geology and Geography, Lithuania), who demonstrated that changes in the hydrographic palaeo-network, in areas of Pleistocene continental glaciations, can influence the advance and retreat of glaciers and force global environmental changes. Fluvial-lacustrine sediments buried beneath glacigenic deposits provide a clear record of such changes; as shown by Petras's case study in Lithuania. The evolution of fluvial systems on the Balkan Peninsula was shown by **Ivan Zagorchev** (Bulgarian Academy of Sciences, Bulgaria); to be largely controlled by tectonic events related to the Alpine orogensis and its subsequent extensional collapse, in his presentation 'Neogene tectonics, climate changes and fluvial system evolution in the Balkan Peninsula. **Rob Westaway**, never happy with giving one presentation at a meeting (or so I'm told), addressed the crowd with a presentation entitled 'Lateral variations in Late Cenozoic uplift across Turkey: the role of lower-crustal flow in landscape evolution'. IGCP 518 and its predecessor, IGCP 449, have included many studies of Late Cenozoic landscape evolution in different parts of Turkey. Rob Westaway concluded from this work that although Turkey is located close to the plate boundary between Africa, Arabian and Anatolian plates, the observed vertical crustal motions have not been caused, primarily, by plate motions but instead represent regional uplift as a result of isostatic response to erosion and lower-crustal flow. **Ökkes Kesici** (Gaziantep University, Turkey) presented field work and remotęly sensed data from Mount Süphan, eastern Turkey, which shows that mountain glaciers in this region have retreated at an alarming rate since the 19th Century. **Jaroslav Tyrácek** (Czech Geological Survey, Czech Republic) gave an exhaustive ac̆count of the 'Euphrates River terraces between Al-Qaim and Khan Al-Baghdadi (Iraq)', based on his work there two decades ago. **Hema Achyuthan** (Anna University, Chennai, India) outlined her ongoing research into collecting a 'Cenozoic fluvial sequence archive of the Chennai-Pondicherry Coast, Tamilnadu, India'; tectonic activity has altered the configuration of structural basins and influenced stream courses.

The final part of the day involved the business meeting for IGCP 518. Provisional timings and venues for future IGCP 518 meetings were discussed. Tentative arrangements were made for a scientific and business meeting on the Yangtze in 2006, but as **Zhongyuan Chen** was absent due to ill health, no definite arrangements could be made. On a more positive note **Hema Achtuthan** offered to host a project workshop on fluvial geomorphology. Several other key points arose from the business meeting; (1) it was suggested to seek funding outwith the normal IGCP sources, so that the success of future meetings could be ensured; (2) it was tabled that there is a need to expand the project internet data archive (IGCP 449/518 internet archive), as the redesign of the Durham

University host site has caused problems; and (3) it was suggested that the oral and poster contributions to the inaugural meeting be published in a journal special edition.

Field excursions

River terrace sequences of the Euphrates and its tributaries. The first stop of the field excursion, on the 23rd of September was at Birecik, to view the staircase terraces of the Euphrates River. This area was first mapped by Minzoni-Deroche and Sanlaville (1988); and has been subsequently reviewed by Sanlaville (2004) and Demir *et al*. (2004). Minzoni-Deroche and Sanlaville (1988) attempted to date the terraces using their archaeology. We arrived in Birecik in time for lunch; here we had our first view of the Euphrates, in the shade, enjoying for many of us our first Turkish kebab. After lunch **David Bridgland** instructed the group in a workshop on the art of artefact recognition. The remainder of the day was spent viewing each of the terraces of the Euphrates; we were encouraged to use our new-found ability to recognise Palaeolithic artefacts, to create a stratigraphic/chronological framework for the terraces. By dusk we had returned to Şanlıurfa, where those that were not stricken with the Turkish belly bug, ventured forth into the night. As I was one of the unfortunate few left in the hotel room, I cannot tell of the debauchery that followed!

The next day we travelled NW from Şanlıurfa, to examine the terrace deposits of the Euphrates below Atatürk Dam and also those of the Göksu, one of its tributaries. Our route was mainly in Cenozoic marine limestone, characteristic of sediments found on the Arabian platform, but after 35km we passed the small town of Bozova and encountered the Bozova anticline, one of many structures that accommodated convergence between Arabian and Eurasian plates (prior to the development of the modern plate-boundary strike-slip fault system at 4Ma). Near the Atatürk Dam, the Euphrates emerges from the Taurus Mountains and a different river geomorphology is observed to that viewed the previous day, when we saw it flowing across the Arabian platform. Here, the Euphrates and its tributaries are incised into the valley floor. **David Bridgland** gave workshops on the measurements of palaeocurrents and provenance analysis. By evening we had returned to Şanlıurfa; that night we wined and dined overlooking Şanlıurfa's ancient citadel, the Halil ar-Rahman Mosque and the Pool of Abraham, known as Balıhkgölö.

The East Anatolian Fault Zone. The next day, we again headed NW, passing the localities we had examined on the previous days, to reach the East Anatolian Fault Zone at Gölbaşi. As we approached Gölbaşi the landscape became more mountainous, as folding becomes more prevalent towards the Neotethys suture zone (which we did not reach). Drainage offsets in the region of Gölbaşi provide a means to quantify the tectonics of the East Anatolian Fault. We spent the day examining several of these drainage offsets for ourselves. **Rob Westaway** had prepared an extensive field itinerary for the day, so extensive that the group (separated into two mini-buses) found themselves on a small dirt track, high in the hills, in the dying light of day. **David Bridgland**,and his merry crew opted for the adventurous route home; which involved a failed attempt at fording a river, being rescued by a JCB, failed attempt to jump start a minibus with engine full of water behind said JCB, and numerous fast and furious phone calls in Turkish. There was a late arrival at home base but otherwise no serious damage done.

The Tigris River terrace sequence. On the morning of the 27th, we packed our bags and left the Euphrates system, travelling ~170km ENE to investigate the river Tigris, around the city of Diyarbakır. For the first ~55km to Hilvan, we traversed through Cenozoic marine limestones of the Arabian platform, with occasional outcrops of basalts to disrupt the monotony. However after Hilvan the landscape changed, as we entered a volcanic landscape. Quaternary volcanism is known to have influenced the course of the palaeo-Tigris, and to play a role in its present drainage. We visited several sites in which the interaction between volcanism and the evolution of the fluvial system could be clearly seen (Figure); at Yeşildere, a road cutting along the Diyarbakır-Mardin highway, alternation of the basalt and sedimentary fabrics within it, demonstrates that the basalt flowed into the contemporaneous river; at Bǎgivar, a large meander scar illustrates how the river preferentially incised into the bedrock of this region rather than cut through the basalt.

Post-conference excursion. The post-conference excursion began on the afternoon of the 27th. From Diyarbakır, we headed NW, following the course of the Tigris to its source, adjacent to Lake Hazar, a pull apart basin on the East Anatolian Fault Zone. The initial ~55km of our journey, was across the rather break landscape of the northern Arabian platform (yes you guessed correctly, Cenozoic limestones and late Cenozoic basalts). However, when we reached the town of Ergani the landscape changed; we had entered the mountainous folded northern margin of the Arabian Platform. After a further ~10km we crossed the Neotethys suture, and entered the former Anatolian continental fragment. We stayed overnight in a lakeside hotel beside scenic Lake Hazar. The next morning, **Rob Westaway** set the goal of reaching the summit of Nemrut Dagby lunch; thus began a long and windy journey along mountain passes and dirt tracks. But we had success and we dined beneath the summit, in spectacularly folded Cenozoic limestones, enjoying barbecued goat. After lunch we visited the summit mausoleum of King Antiochus 1 of Commagene.

Summary

The meeting was deemed to be a highly successful launch to the IGCP518 project. Participants from across Europe, Africa and India all attended. The Turkish hosts couldn't have been more friendly, and they organised a fantastic meeting. **Rob Westaway** designed a thought-provoking field excursion; combing aspects of sedimentology, geomorphology, archaeology and chronology. The field workshops run by **David Bridgland** led to many fruitful discussions.

Figure 1: Basalt, dated by Ar-Ar to to 1196±19ka (±2) (Bridgland *et al.*, in press), overlying high (70m) terrace gravel of the River Tigris, cemented by $CaCO_3$. Old quarry ~2km downstram of Diyarbakır city centre.

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THE 5TH INTERNATIONAL POSTGRADUATE SYMPOSIUM

Edinburgh, Scotland
29th August – 1st September 2006

Tuesday 29th August

The symposium commenced in the beautiful city of Edinburgh with a Wine and Ale reception, held in the old library of the Geography department on Drummond Road. Postgraduates from Europe and beyond gathered to share their research and experiences.

Wednesday 30th August

Following a welcome by the Organising Committee and the Postgraduate Representatives, the symposium commenced with a morning long session on Geochronologies. **Joseph Hägg** (Edinburgh) began by introducing us to cosmogenic dating and its application to landscape evolution and long-term erosion rates in SW England. **Jonathan Butler** (Edinburgh) continued this theme by demonstrating new erosion rate data and the quantification of the evolution of the Orange River basin, South Africa. **Maria J. Gehrels** (Plymouth) explained her use of crypto-tephrostratigraphy to enhance and extend the late Holocene tephra record for northern New Zealand while **Christine Lane** (Oxford) demonstrated the need to explore geochemical variability within Quaternary micro-tephra deposits in order to improve uncertainties in the technique. **Ian Matthews** (Royal Holloway) illustrated that the tephrostratigraphic investigations of archaeological profiles in the Daingean Bog, Co. Offaly, Ireland were yielding new data on anthropogenic disturbances. Then **Andrew Hein** (Edinburgh) focused on the possible outcomes of developing a cosmogenic nuclide chronology for the mid-late Pleistocene glacial history of the Patagonian Andes. **Gina E. Moseley** (Bristol) gave a fascinating insight into Quaternary sea levels and palaeoclimate from submerged speleothems. **Alison MacLeod** (Royal Holloway), only being 6 months into her research, introduced us to varve chronology and the possibilities it provides for dating the Last Glacial-Interglacial Transition in the UK while **Peter Abbott** (Swansea) provided an informative account on recent tephrochronological investigations of the Marine Isotope Stage 4 sections of the Greenland ice cores. **Ian Thrasher** (Liverpool) introduced us to the difficulties in obtaining Optically Stimulated Luminescence (OSL) dates for glaciofluvial sediments but highlighted new possibilities with the use of a lithofacies based approach. **Greg Whitfield** (Aberystwyth) concluded the morning's session with some preliminary results

Figure 1. The delegates assembled outside the Institute of Geography, University of Edinburgh

on controls and timing of high-frequency sediment supply cycles in the Rio Bergantes, northeast Spain.

The afternoon session began with the keynote lecture given by **Dr. Andy Dugmore** (Edinburgh), who took us on a fascinating journey with Erik the Red. We investigate the myth behind the legend that the early Greenland settlers perished due to climate change and Andy presented an argument that perhaps such a deterministic explanation is no longer valid.

Lynda Howard (Loughborough) began the late afternoon session on Palaeoecology and Environmental Archaeology with a fascinating account of the taphonomy of caddisfly larvae (*Trichoptera*) remains in the sediments of the River Soar, Leicestershire. **Ann Hendry** (Queen Mary) gave an overview of forest clearance at the Mesolithic-Neolithic Transition, based on extensive pollen investigations around the Irish Sea basin. **Bettina Stefanini** (TCD) presented a 5000 year record of landscape change and climate oscillation from her investigations of a small upland bog in Galicia, North West Spain. **Silvia Piovan** (Padova, Italy) presented her findings to date based on an intensive palaeoecological and stratigraphic study on a palaeo meander of the Adige river near Pettorazza Grimani, north-eastern Italy. **Elaine Treacy** (TCD) proved an insight into nutrient enrichment at Lough Currane Co. Kerry where she is using a multiproxy palaeolimnological approach to assess a *c*. 200 year record. **Barnaby Crocker** (Royal Holloway) gave a fascinating and informative account of diet preferences and masticatory processes in the Palaeoarctic woolly rhinoceros (*Coelodonta antiquitatis*). **Orpah Farrington** (Birkbeck) summarised her research on soil science techniques used to determine the composition and provenance of the soil components of a classic anthropogenic landscape. **Michelle Farrell** (Hull) concluded the day's presentations with an introduction to her research, which intends to reconstruct the palaeoecology and past human occupations of Orkney through pollen analysis.

Thursday 31st August

The morning began with a session on Glaciology and Sedimentology, commencing with an introduction to the ice pack by **Victoria Parry** (Edinburgh) who is focussing on meltwater refreezing and density variations in the snowpack and firn within the percolation zone of the Greenland Ice Sheet. **Valentin Burki** (Bergen, Norway) followed on, illustrating the formation of saw-tooth moraines in Bødalen, western Norway. A colourful presentation by **Benedict Reinardy** (Swansea) on the dynamics of palaeo-ice streams draining the Antarctic Peninsula Ice Sheet during the Late Quaternary linked to **Hannah Brown** (West of England). She is investigating the distribution and geotechnical properties of loess in southwest England and south Wales with reference to the significance of postdepositional weathering and reworking. **Piotr Hermanowski** (Silesia, Poland) illustrated the subglacial drainage through the Banie tunnel channel during the Weichselian glaciation, NW Poland. **Anna Hughes** (Sheffield) explained her novel use of GIS techniques for mapping the flow dynamics of the last British Ice Sheet. This was closely linked to the following presentation by **Sarah Greenwood** (Sheffield) who is working towards a geomorphological palaeo-glaciology of the last Irish Ice Sheet. **Lynda Yorke** (Hull) clearly demonstrated downstream variation in Late Devensian sediment-landform assemblages in the mid/lower Tyne Valley and showed the difficulties of dating non organic glacial sediments. Lastly in this session, **Kathryn Rose (**Southampton) showed us a novel use of instrumentation in her autonomous multi-sensor subglacial probe with exciting results from Norway.

After lunch, our second keynote speaker**, Professor Geoffrey Boulton**, (Edinburgh) focussed our thoughts on the changing concepts of ice sheet modelling. The traditional ideas of Quaternary ice sheets as slow flowing systems with radially symmetric patterns of velocity and temperature variation, have recently been superseded by detailed reconstruction of the orientations of parallel flow features. This has been achieved using satellite imagery and high resolution 3D thermo-mechanically coupled modelling. Crucial to this is predicting large-scale patterns of ice sheet erosion and deposition, which show a time-dependent mosaic-like distribution.

After a well earned tea break we continued in the realms of climate reconstruction and modelling. **Jop Brijker** (Amsterdam, The Netherlands) illustrated the pitfalls of basing scientific deductions on a single core sample as he explained environmental change over the last deglaciation in Indo-Australia using evidence from marine and terrestrial proxies. **Karen Logan**

(Queens, Belfast) gave a broad overview of her reconstruction of Holocene climate change from laminated diatomaceous marine sediments in British Columbia, Canada. **Ben Aston** (Aberystwyth) described his findings on the use of stable isotopes as archives of environmental change in the central Mexican freshwater lake Laguna Zirahuén, Michoacán. **Matthew Amesbury** (Southampton) examined the level of resolution possible in examining peat cores in fine-resolution Holocene palaeoclimate analyses. **Charlotte Dew** (Exeter) gave an introduction to palaeomonsoon variability during the Late Quaternary, using evidence from the lake sediment archives of Yunnan Province, China. **Katharine Welsh** (Liverpool) showed us how it is possible to model human-environment interactions in the catchment of the Petit Lac d'Annecy, in Pre-Alpine France. Finally **Iona Flett** (Canberra, Australia) vividly conducted a tour of the colourful Galapagos Islands, to demonstrate a new record of climate fluctuations in the Eastern Equatorial Pacific from peat humification and testate amoebae analysis.

Lynda Yorke and **Kathryn Rose** expressed thanks to **Huw Jones, Bronwen Whitney** and **Michael Burn** for organising the symposium, to all the participants who contributed to the high standard of the presentations over the two days, and especially to **Dr. Andy Dugmore** and **Prof. Geoffrey Boulton** for their stimulating keynote addresses. Participants voted to hold next year's symposium at the University of Copenhagen, Denmark. **Chris Lane** was successful in becoming the new postgraduate representative, taking over from Lynda Yorke who has served that role during the past two years.

The conference dinner was held in 'The Lot' on Edinburgh's Grassmarket, where **Bronwen Whitney** announced that **Barnaby Crocker** (Royal Holloway), who spoke so eloquently on the feeding habits of the Woolly Rhino (*Coelodonta antiquitatis*), was voted as winner of the best overall presentation prize. (This prize was sponsored by The Journal of Quaternary Science and a copy of his abstract can be found following this report). The evening continued into the early hours!

Friday 1st September

Despite our late night, we set off bright and early on a glorious sunny morning, to Blackford Hill located south of Edinburgh, with our leader **Professor Doug Benn** (St. Andrews/UNIS) to visit the Agassiz Rock. It was so named following Louis Agassiz's visit to Scotland in the 1840s, where he identified striations on a rock outcrop. Agassiz along with William Buckland clearly demonstrated that ice had once covered this great country.

A short walk to the top of Blackford Hill provided us with an opportunity to see a crag and tail landform, situated on top of Corbies' Crag. However, the location afforded us a great view over the city where Doug pointed out the impressive crag and tail landform on which Edinburgh Castle sits. The margins of the landform are characterised by glacially-deepened troughs; Princess Street Gardens and the Grassmarket now occupy these troughs. Doug talked about the story of the early workers during the mid 1800s who were instrumental in interpreting the Quaternary landscape and unravelling the glacial history of Scotland and an interesting discussion ensued concerning how although their religious beliefs had been the driving force in beginning their research it led them in a very different direction.

Next we travelled out along the Pentland Hills to Carlops to examine the extensive glaciofluvial deposits that crop out in the area. The site was investigated by Sissons in the 1950s who demonstrated that the formation of the channel and associated mounded deposits were the results of subglacial meltwater channel system and not evidence of extensive glacial lakes as was the previous interpretation based largely on ideas proposed by Kendall in the early 1900s.

Our final stop was to Arthur's Seat, situated in Holyrood Park. A short climb provided us with magnificent views over the city. Arthur's Seat and Salisbury Crags were key sites for Hutton (the father of modern Geology). It was here that he observed igneous and sedimentary rocks and understood that they had been formed at different times by different ways.

Bronwen Whitney expressed our thanks to **Professor Doug Benn** for leading Friday's field expedition. The day was concluded by a buffet lunch, held in The Sheep's Heid, followed by an impromptu game of skittles held in the pub's very own skittle alley.

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Journal of Quaternary Science Award for Best Presentation: Barnaby T. Crocker

This year at the 5th International Postgraduate Symposium held in Edinburgh, **John Wiley and Sons**, on behalf of the **Journal of Quaternary Science**, donated a prize of £50 for the postgraduate delegate deemed to have given the most outstanding presentation during the symposium. The standard of presentations this year was excellent. It was encouraging to see numerous contributions from new students, and a wide range of topics within the Quaternary were covered during the conference. The vote for best presentation was handed over to the delegates and **Barnaby Crocker** was nominated as the winner for his presentation on feeding preferences in the Pleistocene woolly rhinoceros. Notable runners up were **Anna Hughes** with her talk on producing a glacial map for Britain; and **Jop Brijker** for his presentation on glacial-interglacial changes in Indo-Australia.

The donation of this award was gratefully received as a means of recognising the high standard of work carried out by postgraduates in the QRA and the effort involved in presenting at the symposium. It is hoped that it will also encourage more students to present their work at future events! An abstract of Barnaby's talk is included below and the abstracts submitted by each delegate can be accessed via the QRA Postgraduate web pages.

Kathryn C. Rose
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Diet preferences and masticatory processes in the Palaearctic woolly rhinoceros (*Coelodonta antiquitatis*, Blumenbach, 1799)

As the last and most derived member of the Pleistocene rhinoceros lineage, the woolly rhino was supremely well adapted to its environment. Stocky limbs and thick woolly pelage made it well suited to the steppe-tundra environment prevalent across the Palaearctic during the Pleistocene glaciations. Its geographical range expanded and contracted with the alternating cold and warm cycles, forcing populations to migrate or perish as the glaciers receded. Like the vast majority of rhinoceroses both living and extinct, the body plan of the woolly rhino adhered to the conservative morphology displayed in the most primitive rhinoceroses, first seen in the Eocene.

Controversy has long surrounded the precise dietary preference of *Coelodonta* as past investigations have found both grazing and browsing modes of life to be plausible. Here the palaeodiet of the woolly rhinoceros has been reconstructed using several lines of evidence. Climatic reconstructions indicate the preferred environment to have been cold and arid steppe-tundra, with large herbivores forming an important part of the feedback cycle. Pollen analysis shows a prevalence of grasses and sedges within a more complicated vegetation mosaic.

A strain vector biomechanical investigation of the skull, mandible and teeth of a well-preserved last cold stage individual recovered from Whitemoor Haye, Staffordshire, revealed musculature and dental characteristics that support a grazing feeding preference. In particular, the enlargement of the *temporalis* and neck muscles is consistent with that required to resist the large tugging forces generated when taking large mouthfuls of fodder from the ground. The presence of a large diastema supports this theory.

Comparisons with extant perissodactyls confirm that *Coelodonta* was a hindgut fermentor with a single stomach, and as such would have grazed upon cellulose-rich protein-poor fodder. This method of digestion would have required a large throughput of food and thus links the large mouthful size to the low nutritive content of the chosen grasses and sedges.

This work forms part of the ongoing research into “The Evolution and Palaeoecology of the Palaearctic woolly rhinoceros, *Coelodonta antiquitatis* Blumenbach, 1799”, a NERC funded PhD studentship in the Department of Geography, Royal Holloway, University of London in association with the Natural History Museum, London (CASE partner). The project supervisors are Dr Danielle Schreve (Department of Geography, Royal Holloway, University of London) and Mr Andrew Currant (Department of Palaeontology, Natural History Museum, London).

Barnaby Crocker
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Figure 1. This image is of the right-hand profile of the skull and mandible recovered from the Lafarge Aggregates quarry site at Whitemoor Haye. Scale bar is in centimetres. (Photograph courtesy of P. Crabb, Natural History Museum, London).

QUATERNARY RESEARCH FUND

OSL DATING OF GLACIGENIC SEDIMENTS IN BUCHAN, NE SCOTLAND

Background and rationale

The Buchan area preserves an unrivalled archive of evidence for pre-Late Devensian glacial events and climate change in Scotland (See Merritt *et al*. 2003 for details of sites and the literature). The local record of glaciation during the Devensian cold stage is complex and controversial with ice from three main source areas each depositing distinctive suites of glacigenic sediments (Figure 1). Recently much attention has focused on the chronology and extent of the British/Irish Ice Sheet (BIIS) throughout the Devensian both from terrestrial evidence, and subsurface data from the North Sea Basin. Glaciation during both Marine Isotope Stages (MIS) 4 and 3 has been proposed for NE Scotland and during MIS 4 suggested for the North Sea. A complex two-stage glaciation model has been proposed for late MIS 3/MIS 2 both in NE Scotland and the North Sea (Bowen *et al*., 2002; Merritt *et al*., 2003; Carr *et al*., 2006).

To further test these proposed chronologies, and to directly date suitable glacigenic facies within the lithostratigraphic scheme of Merritt *et al*. (2003), Gemmell *et al*. (in press) have reported 17 optically stimulated luminescence (OSL) dates from seven sites in Buchan. At two sites (Nigg Bay and Oldmill. Figure 1) glaciofluvial and glaciodeltaic sediments low in the stratigraphic sequences have given ages of 63+/-7 and 74+/-6 ka respectively. These dates are significant and would support the glaciation of Scotland during MIS 4. They also report multiple dates from a new site at Toddlehills (Figure 1) where OSL ages date a sequence of fluvial or glaciofluvial sands, within a complex stratigraphy, to the Early Devensian (70+/-3 to 115+/-8 ka, ?MIS 5a-5d). Further “old” dates have been obtained from glaciofluvial/glaciodeltaic sediments at two sites west of Peterhead (Wester Rora and Woodside of Auchlee. Figure 1). It is unclear if these dates, in the range 76 – 108 ka, denote preservation of “old” sediments within the Ugie valley with no depositional record of later Devensian glacial events, or if the OSL ages are overestimates.

As part of an ongoing research programme into the chronology of Devensian glaciation in NE Scotland, and to help to confirm or extend some of the age interpretations noted above, fieldwork was undertaken at a number of sites to collect further material for OSL dating.

Preliminary results and work in progress

Fieldwork, over six days at seven sites, focused on the stratigraphic and sedimentological description of sections with collection of 11 OSL dating samples from suitable sediments. The sites comprised sand and gravel pits or coastal cliff sections. New sections revealed additional stratigraphic units at some sites thereby extending the number of depositional events recognised. Samples will be used to test the repeatability of dates from critical sites previously reported by Gemmell *et al*. (in press) (Oldmill, Toddlehills, Wester Rora and Cross-stones. Figure 1); others from Nigg Bay, Waulkmill and Sandford Bay (Figure 1) to date the youngest exposed glaciofluvial sediments in the sequences and to compare them with dates previously obtained at Toddlehills and Wester Rora.

Some of the samples may be archived for future analysis as sediment may not always be available from certain sites due to working out of pits or inaccessibility of coastal cliff sections. It is planned to publish detailed site descriptions, OSL dates and interpretations together with discussion of their wider significance when analyses are complete.

Acknowledgements

We would especially like to thank Dr Andrew Murray (The Nordic Laboratory for Luminescence Dating, Department of Earth Sciences, Aarhus University, Risø National Laboratory, Denmark) for his interest and continued support of OSL dating in NE Scotland. The landowners that allowed access are thanked for their help. Thanks to Mrs Alison Sandison for drawing the figure. ERC is most grateful to the QRA for a grant from the Research Fund that supported the fieldwork reported in this note. He would like to thank June and Al Gemmell, Colin Turner, and Sheila and Adrian Hall for their very generous hospitality. He would also like to thank Mrs B. Connell for much support and Derek Melling for helping to prepare sample tubes.

References

Bowen, D.Q., Phillips, F.M., McCabe, A.M., Knutz, P.C. and Sykes, G.A. (2002). New data for the Last Glacial Maximum in Great Britain and Ireland. *Quaternary Science Reviews*, 21, 89-101.

Carr, S.J., Holmes, R., Van Der Meer, J.J.M. and Rose, J. (2006). The Last Glacial Maximum in the North Sea Basin: micromorphological evidence of extensive glaciation. *Journal of Quaternary Science*, 21, 131-153.

Gemmell, A.M.D., Murray, A.S. and Connell, E.R. (in press). Devensian glacial events in Buchan (NE Scotland): a progress report on new OSL dates and their implications. *Quaternary Geochronology.*

Merritt, J.W., Auton, C.A., Connell, E.R., Hall, A.M. and Peacock, J.D. (2003). *Cainozoic geology and landscape evolution of north-east Scotland*. Memoir of the British Geological Survey (Scotland). 178pp.

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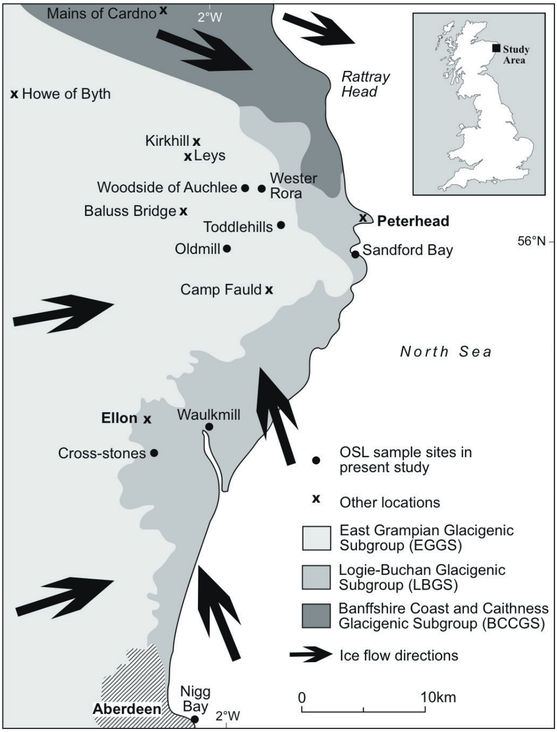

Figure 1. Location map of the Buchan area showing the surface distribution of major glacigenic lithostratigraphic subgroups and sites mentioned in the text (after Merritt *et al.*, 2003 and Gemmell *et al.,* in press).

NEWRESEARCHERSAWARDSCHEME

UNDERSTANDING CLIMATE PROXIES IN THE MARINE MOLLUSC *ARCTICA ISLANDICA*

Background and rationale

Arctica islandica is a long lived marine bivalve with a lifespan of over 300years (Schone *et al*., 2004). The organism produces annual growth line (during the winter months, when food supply is limited). These growth lines can be used in a method akin to dendrochronology to produce multi-shell chronologies. Thus the organism has the potential to produce high resolution (sub-annual) records.

The QRA new researchers award was utilised in understanding the trace element geochemistry of the shell, to determine its potential to reconstruct high resolution records of environmental conditions.

Methodology

Specimens were live- collected from Irvine Bay, NW coast of Scotland by University of Bangor, Wales in 2001. The nearby marine data station at Millport provides a long term instrumental dataset, as well as additional geochemical measurements.

Two specimens were prepared for analysis (using sections from both the umbo and from the prismatic layer). Two different techniques were used employed-SIMS and LA-ICPMS. The former was used in the umbo analysis, while the latter was used for analysis of the prismatic layer (Figure 1). SIMS provides

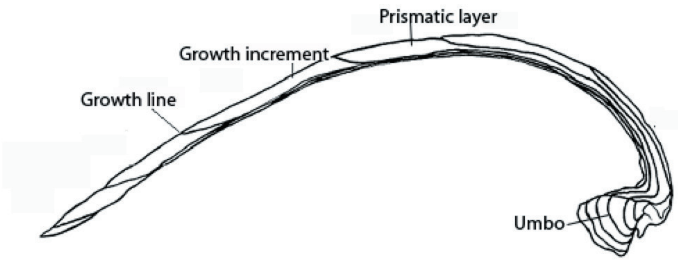

Figure 1. *Arctica islandica*: growth increments deposit in the prismatic layer synchronously with those deposited in the umbo. It is possible to follow a single annual growth line from the umbo to the prismic layer (Figure after (Witbaard, 1997).

better precision and a smaller spot size (~10microns), which is crucial in the umbo where the annual growth lines can be <50microns. LA-ICPMS however is more routine, and a larger spot size (~50microns) making it more suitable for analysis of the prismatic layer where the growth bands are >500microns. It was crucial to analyse two different sections of the shell to understand if the same year (a single growth check can be traced from the umbo to the prismatic layer) produce the same geochemical signal. This indicates whether the organism itself influences the trace element uptake and deposition, i.e. if the two parts during the same time period show a different concentration, it suggests biological mechanisms may play a crucial role.

Comparison between two specimens (live collected in the same year) provides information on whether fluctuations are reproduced in more than specimen and whether fluctuations are synchronous and are of the same amplitude in different specimens.

Results

Analysis shows significant fluctuations in trace elements occur during the lifespan of the shell in both the umbo and prismatic layer. Analysis of the Sr in the umbo of the first shell showed high concentrations at the annual growth check (Figure 2). This peak however is less defined during the more juvenile stages of growth (data not shown). Mg shows a more complex pattern with maxima occurring both intra-annually and during the growth check. Ba is generally low with high sporadic increases, a pattern that has been noted in other molluscs and other species but not understood (Sinclair, 2005). The umbo of the second shell also showed similar pattern of fluctuations in the trace elements, but the magnitude of these differed.

Results from the prismatic layer generally support these initial findings. There is an offset in the concentrations seen between the two regions, however work is ongoing on providing accurate calibration between the two instruments.

Conclusions

The two live collected specimens show a high degree of fluctuations in the trace elements, but the magnitude varying. Differences between the umbo and prismatic seem to be present. Initial interpretation being that incorporation is not wholly controlled by environmental conditions, with variations occurring both between specimens and between different parts of the shell. However further work is required on intercalibration between the two different techniques to determine whether if this is a true offset or is due to a calibration issue.

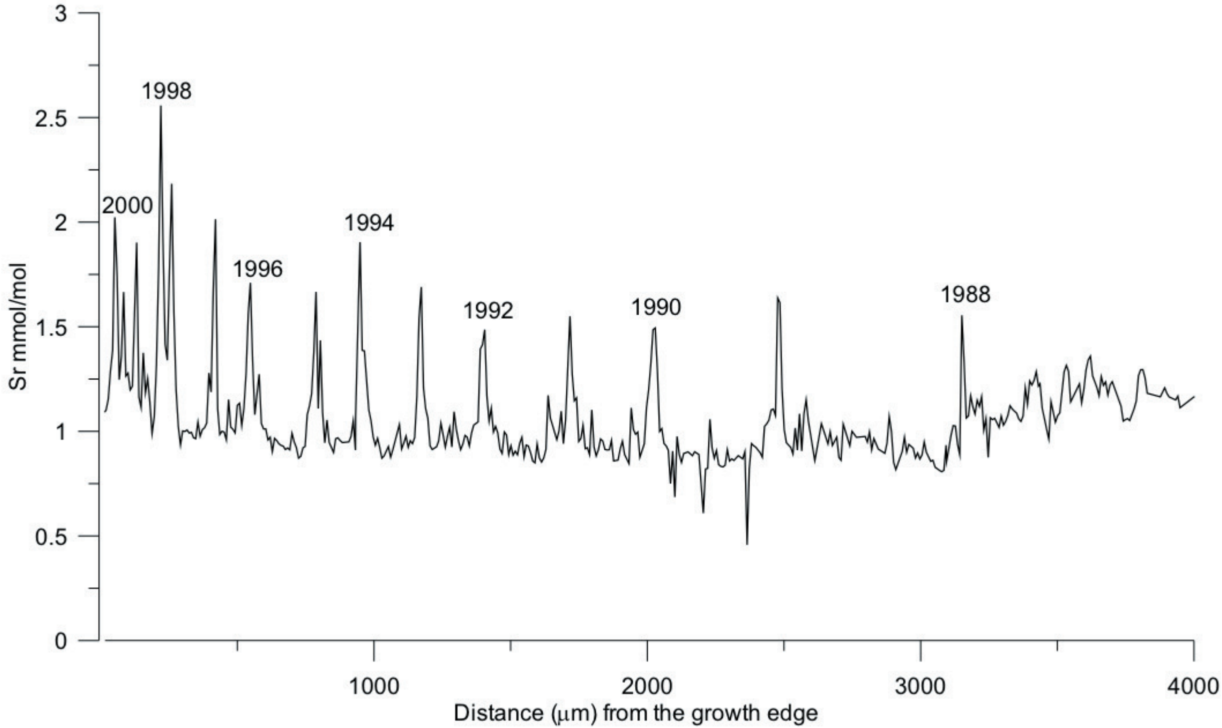

Figure 2. Variation of Sr in the umbo. Distance is from the growth edge (ie deposited 2001 when the shell was live-collected). The annual growth check is marked (and labelled together with the corresponding year). The annual growth check occurs during the winter months resulting from low food availability (Witbaard, pers. Comm.).

Acknowledgements

The QRA is gratefully acknowledged for contributing to supporting costs of laboratory work. I am indebted to technical assistance from Dr. R. Hinton and O. Tumyr as well as my supervisors Dr. N. Allison and Dr. A. Finch for invaluable insight into the data.

References:

Schone, B.R., Castro, A.D.F., Fiebig, J., Houk, S.D., Oschmann, W., and Kroncke, I. (2004). Sea surface water temperature over the period 1884-1983 reconstructeed from oxygen isotope ratios of a bivalve mullusk shell (Arctica islandica, southern North Sea). *Palaeogeography Palaeoclimatology Palaeoecology* 212(3-4), 215-232.

Sinclair, D.J. (2005). Non-river flood barium signals in the skeletons of corals from coastal Queensland, Australia. *Earth and Planetary Science Letters* 237(3-4), 354-369).

Witbaard, R. (1997). Tree of the Sea: the use of the internal growth line in the shell of "Arctica islandica" (Bivalvia, Mollusca) for the retrospective assessment of marine environmental change. PhD, University of Groningen http://www.ub.rug.nl/eldoc/dis/science/r.witbaard/ .

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THE EXTENT AND SIGNIFICANCE OF CORRIE GLACIATION IN THE ERRIFF VALLEY, COUNTY MAYO, IRELAND

Background and rationale

The Erriff valley hosts a series of corries with northerly/north-westerly aspects with bases at 217- 350m. Fluvioglacial/glaciolacustrine deposits characterise the valley floor. Recent work by Thomas and Chiverell (2005) raised the possibility of locally-sourced corrie ice interacting with valley ice flowing from the Midlands in this region.

Previous upland studies in Ireland have postulated a four stage chronology for corrie glaciation, with a final morainic stage often attributed to a post-late glacial period, sometimes specifically the Nahanagan Stadial (Colhoun and Synge, 1980). However, prevalence of periglacial deposits and structures indicates that many corries remained free of glacial ice during both Nahanagan and Midlandian stages.

Situated at the very margin of the western limit of the Midlandian glaciation, the Erriff corries represent an opportunity to study the interaction of corrie and lowland ice during the late Midlandian. Little high resolution mapping has been carried out in this region; with several of the corries seldom featured. Past authors allude to the moraines of Lough Glenawough and Loughanshee only briefly leaving unanswered questions about the synchronicity of corrie and inland glaciation.

A New Research Workers Award was employed to assist with transport costs to, from and within the field area.

Aims and Methodology

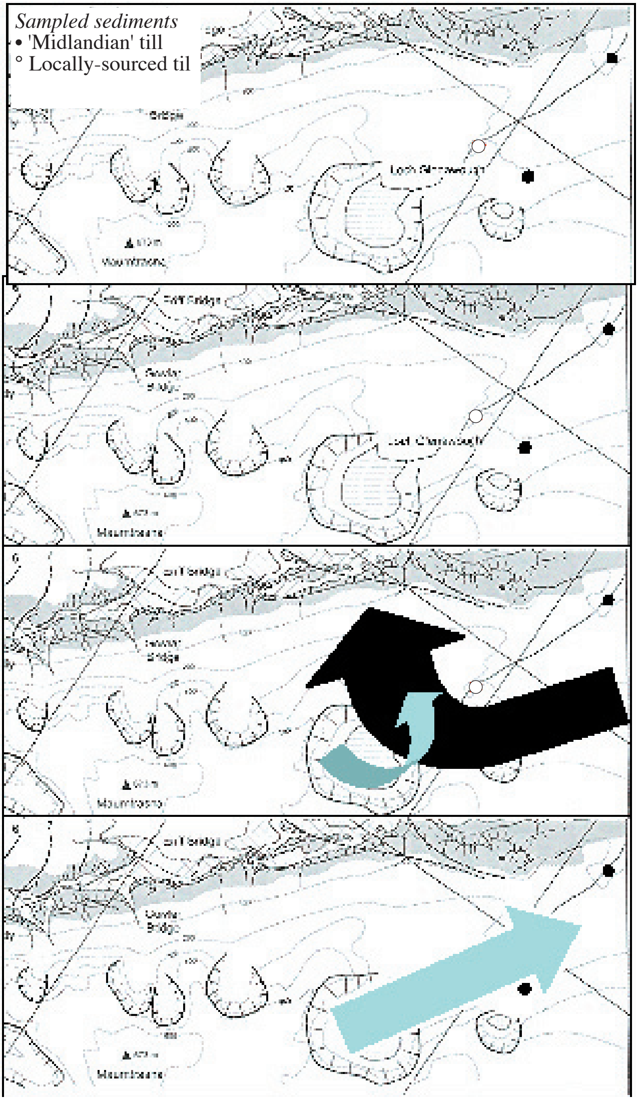
This study aimed to:

1. Investigate the extent of corrie glaciation and its relationship to Midlands-sourced valley glaciation through geomorphic mapping and sedimentary analyses

2. Establish a chronology for corrie glaciation in the Erriff valley

3. Ascertain the relative age of corrie glaciation with respect to valley glaciation using Schmidt hammer analysis

4. To assign a position to the corrie glaciation(s) within the Quaternary of Ireland



1. Growth of local Glenawough corrie ice (light arrow) pushes down Cross River Valley

2. Incursion of Midlandian ice (black arrow) from East pushes up the Cross River Valley.

3. Midlandian ice merges with, and diverts, Glenawough corrie ice
Deposition of Midlandian till with subglacial lake signatues and interbed sequence

4. As Midlandian ice retreats eastward Glenawough ice readvances down Cross Valley

Results

A detailed map of the glacial geomorphology of an area 16km^2 was produced which facilitated recognition of ice limits and development of a local eight stage glacial chronology. From the ice limits identified, glacial stages were reconstructed and calculations of basal shear stresses and Equilibrium Line Altitudes (ELAs) made for the most geomorphically well-constrained ice masses. This glaciological data equate well with both small modern glaciers with relatively high bed strength, and with Carr's (2001) reconstructions for proposed Loch Lomond Stadial cirque glaciers in the Brecon Beacons. Erriff ELAs also show strong correlations with corrie glacier ELAs calculated for the Nephin Beg region (Kenyon, 1986), values anticipated to relate to the Loch Lomond Stadial activity.

Basic statistical analysis of the Schmidt hammer dataset (6540 impact readings) suggests that the exposure age of sites beyond the projected bounds of corrie ice is only slightly older than that of those within. Consequently regrowth, or advance of corrie glacier ice, is anticipated to have followed rapidly upon, or been concurrent with, the retreat of Midlandian ice from the Erriff valley.

Morphostratigraphic relations indicate a period of conjoined valley- and corrie ice beneath at least the largest corries in the valley, an interpretation initially suggested by Charlesworth (1929). Sedimentary evidence of cannibalisation of Midlandian till by corrie-sourced ice in this location indicates that, latterly, corrie-sourced ice expanded into the territory of mainland ice, following retreat of this centrally-sourced ice mass.

Mature periglacial forms in two of the corries indicate an absence of glacial occupation during the last cold stage i.e. the Nahanagan Stadial, and raise the suggestion of the influence of snow-blow on corrie glacier formation during this period.

Significance

Reconstruction of ice limits suggest that corries with a high snow-blow potential would have supported independent glaciers extending to the main valley floor. At the eastern end of the group such corrie ice may have been diverted by and confluent with Midlandian ice for some time. Sedimentary evidence, in the form of cannibalised Midlands till, (Figure 1) indicates that following the retreat of Midlands-sourced ice, corrie ice expanded beyond the limits achieved at the valley ice Midlandian maximum.

Glaciological reconstructions for the Erriff corries show strong similarities with both regional values, (Nephin Beg; Kenyon, 1986) and other British Loch Lomond Stadial sites (Carr, 2001). Consequently it is reasonable to parallel the final corrie stage seen in the Erriff sites with the final corrie glacial stage in County Mayo, Achill IV (Synge, 1968), the Nahanagan Stadial in Ireland and, more broadly, a Younger Dryas event.

Geomorphic evidence and glaciological reconstructions indicate that snowblow potential was highly significant in dictating the formation of corrie glaciers during the Nahanagan Stadial in western County Mayo. The findings of this study also suggest that the degree of corrie glaciation at this western massif was much more extensive than previously postulated.

Acknowledgements

The author gratefully acknowledges the contribution made by the Quaternary Research Association towards fieldwork costs in Ireland, financial assistance from the Natural Environment Research Council, Professor Jim Rose for his guidance and support throughout the study, Professor John Lowe, Professor Pete Coxon and Aishling Farrell for useful discussion, Erriff landowners for access and terrain advice, Michael Sheehy and William Warren of the Geological Survey Ireland for use of aerial imagery, GIS software and mapping advice and Jaap van der Meer for facilitating contact with the Geological Survey Ireland.

References

Carr, S. (2001). A glaciological approach for the discrimination of Loch Lomond Stadial glacial landforms in the Brecon Beacons, South Wales. *Proceedings of the Geologists' Association*, 112, 253-262.

Charlesworth, J.K. (1929). The Glacial Retreat in Iar Connacht. *Proceedings of the Royal Irish Academy,* 39B (2), 95-106.

Colhoun, E.A. and Synge, F.M. (1980). The cirque moraines at Lough Nahanagan, County Wicklow, Ireland. *Proceedings of the Royal Irish Academy* 80B (2).

Kenyon, R.A. (1986). The glaciation of the Nephin Beg Range, County Mayo, Eire. *Quaternary Studies*, 2, 14-21.

Synge, F.M. (1968). The Glaciation of West Mayo. *Irish Geography*, 5(5), 372-386.

Thomas, G. and Chiverell, R. (2005). The Geomorphology of the Erriff Valley, Co. Mayo. In Coxon P (ed.). *The Quaternary of Central Western Ireland Field Guide*. Quaternary Research Association, 179-181.

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REVIEWS

GLACIAL AND PRE-GLACIAL DEPOSITS AT WELTON-LE-WOLD LINCOLNSHIRE

Allan Straw
Published by The Museum, Louth, Lincolnshire. £4.90

The aim of this booklet is to provide a factual statement of the author's field observations at Welton-le-Wold Site of Special Scientific Interest (SSSI) and Regionally Important Geological Site (RIGS). Fieldwork was undertaken during the 20-year period 1954–1974, and a description of the deposits has been published by Straw (1976).

The deposits at Welton-le-Wold are unique for the area because they comprise a sequence of gravels containing reworked palaeolithic artefacts and mammal fossils, which are overlain by three diamictons interpreted as tills. Only the latest of these diamictons (the Marsh Till) can be correlated with subglacial landforms, of Devensian age. Straw considers that the earlier diamictons and underlying gravels were deposited in marine oxygen isotope stage (MIS) 8. If this age is confirmed the sequence at Welton-le-Wold takes on national significance. A MIS 8 age suggests a considerable hiatus between the Calcethorpe Till and the Marsh Till, and implies a minimum age of MIS 9 for the palaeolithic artefacts and the mammal fossils. No temperate biogenic sediments have been found *in situ* though, and this precludes the possibility of correlating the bulk of the sequence with other pre-Devensian sites. Age-estimates for the sediments are also lacking, and neither the palaeolithic artefacts nor the mammal fossil assemblage are age diagnostic. Furthermore the earlier two diamictons (Welton and Calcethorpe Tills) are not related to any known subglacial landforms. Therefore a question mark must remain against both the age of the gravels and lower diamictons and the genesis of the lower dimictons.

The aim of providing a factual account undoubtedly has been met, but for those familiar with the Quaternary deposits of the area there is nothing new in this booklet. The intended readership, however, is somewhat unclear. In the title 'Glacial' and 'Pre-Glacial' appear to be formalised and used in the same way that 'Ice Age' is used to address a general audience. The lay person, however, would find the text daunting. The booklet would appeal to those with an interest in British Quaternary research and those wishing to gain insight into Quaternary deposits of Lincolnshire, although a separate map with place names would be an aid to understanding.

That there is a need for a booklet describing the Welton-le-Wold SSSI and RIGS I have no doubt. The text, however, needs to be substantially simplified with the addition of three-dimensional explanatory diagrams, and the quality of the photographs needs to be improved. Overall the booklet has been well produced, except for the annoying use of apostrophes in 1960s and 1970s on the back cover!

Copies are available from The Museum, 4 Broadbank, Louth, Lincolnshire, LN11 4AB. Price £4.90 (including p & p).

Reference

Straw, A. (1976). Sediments, fossils and geomorphology: a Lincolnshire situation. In: Davidson, D.A. and Shackley, M.L. (Eds), *Geoarchaeology: Earth Science and the Past*. Duckworth, London, 317–326.

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QUATERNARY RESEARCH ASSOCIATION

The Quaternary Research Association is an organisation comprising archaeologists, botanists, civil engineers, geographers, geologists, soil scientists, zoologists and others interested in research into the problems of the Quaternary. The majority of members reside in Great Britain, but membership also extends to most European countries, North America, Africa, Asia and Australasia. Membership (currently *c*. 1,000) is open to all interested in the objectives of the Association. The annual subscription is £20 with reduced rates (£10) for students and unwaged members and an Institutional rate of £35.

The main meetings of the Association are the 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.

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