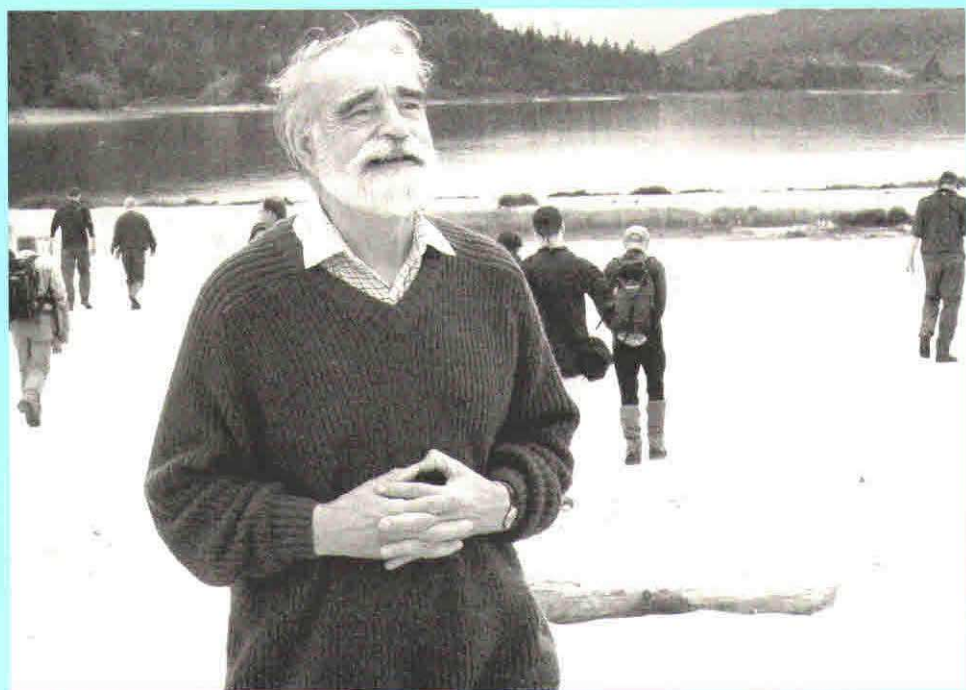

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QUATERNARY NEWSLETTER

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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 Jpeg 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

Prof. Russell Coope on the NE shore of Loch Laggan during the 2008 QRA field trip to Glen Roy & vicinity (photo by Steve McCarron)

EDITORIAL

My time as editor of *QN* has finished with the production of this current issue. It has been a privilege to serve as *QN* editor and one which I have found rewarding. However, *QN* would not be what it is today without the efforts of many others. I should therefore like to take this opportunity to say thank you to Val Siviter for typesetting *QN* and Gwasg Ffroncon for printing it. I should also like to thank the many QRA members who have contributed to *QN* with research articles, obituaries and other reports. Without this it would be impossible for *QN* to offer a mix of news, preliminary research results and a platform for new researchers to have their first work published. I would also like to thank all of you who kindly agreed to act as referees for the articles or graciously agreed to write items for *QN*.

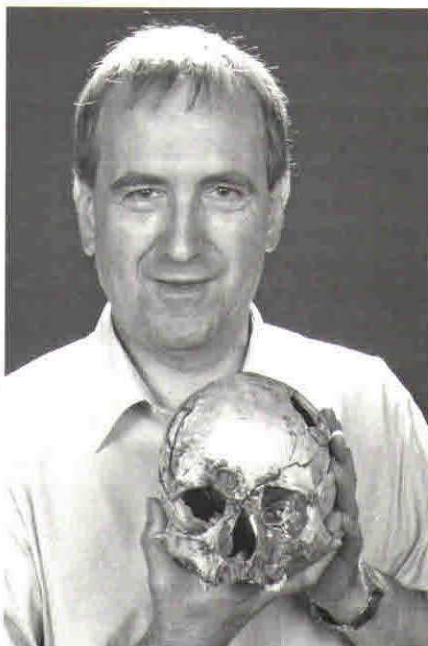
The new editor of *QN* is Sven Lukas. Sven grew up in northern Germany and completed an MSc in Geography at the Ruhr-University of Bochum in 2002 followed by a PhD at St Andrews University on Scottish hummocky moraines which was completed in 2005. After a Marie Curie postdoctoral position in Bern, Switzerland, he was appointed as a Lecturer at the School of Geography, Queen Mary, University of London in 2007 where he is now a Senior Lecturer. Sven's research interests are in modern and ancient glacial environments where he is interested in the link between climatic and glaciological controls on ice-marginal processes, and how these can be applied to Quaternary sites. Sven is also interested in the application of luminescence dating to glacial and associated sediments. He has published widely with over 40 articles and contributions to books. As a long standing QRA member (since 1999), Sven has contributed widely to the activities of the QRA helping to organize two field meetings, contributing to the associated guides as well as a QRA technical guide. He was awarded the 2011 QRA Lewis Penny Medal. I wish him well in his term as editor and hope that QRA members will continue to write articles for *QN* and support him in his task.

Professor Mark D. Bateman
***QN* Editor**

JAMES CROLL AWARD

The James Croll Medal was instituted by the QRA in 2010 as its senior award and is named in honour of James Croll (1821-1890). Croll is most closely associated with fundamental work on the astronomical theory of the ice ages, but he also made seminal contributions on the glacial geology of Scotland, on the mechanisms that drive ocean circulation and the impact of that circulation on recent climate, on tidal theory and the rotation of the Earth. These are all major issues that occupy Quaternary scientists to this day. Croll was effectively self-taught. His work and example demonstrate that individuals from all backgrounds can rise to national eminence and generate science of lasting and major international impact, that it is not who you are or where you come from but what you do that is important. These are the qualities that the QRA seeks to celebrate in the award of the James Croll Medal. The Medal is therefore awarded to a member of the QRA who has not only made an outstanding contribution to the field of Quaternary science, but whose work has also had a significant international impact. The 2010 James Croll Medal was awarded to Geoffrey Boulton at the 2011 ADM in Durham. This year the 2011 Croll Medal has been awarded to Professor Chris Stringer.

Chris Stringer is one of the world's leading authorities on human origins and evolution. His work combines traditional palaeontological methods with recent advances in genetics and has yielded fundamental insights into human origins, rates of evolutionary descent from earlier hominins, relationships between *Homo sapiens* and Neanderthals, the significance of Quaternary climatic and environmental change on patterns and rates of human evolution, and on the evolution of culture. He is most closely associated with the "Out of Africa" hypothesis for the origin, and rates and routes of dispersal, of anatomically modern humans (Stringer and Andrews, 1988; Stringer, 2002). He also has an outstanding record in the Public Understanding of Science. He is



author of several prize-winning books, including *African Exodus: The Origins of Modern Humanity* (Stringer and McKie, 1996), *In Search of the Neanderthals* (Stringer and Gamble, 1993), *The Complete World of Human Evolution* (Stringer and Andrews, 2005), *The Origin of Our Species* (Stringer, 2011) and perhaps most significantly in the context of the QRA, *Homo britannicus* (Stringer, 2006). This work and Chris' regular work with the media have promoted Quaternary science amongst a much wider scientific and public audience. He has an outstanding record in the broadcast media, and is one of the few members of the UK scientific research community well-known to the general public, such that in 2010 he was listed at number 53 in *The Times* 100 most influential people in UK science.

Following a first degree in Anthropology at University College London, and a PhD based in the Anatomy Department at Bristol University, his entire research career has been at the Natural History Museum in London where he is currently Merit Researcher and Research Leader in Human Origins. Though his research has necessarily been global in extent, he has a particularly distinguished record in developing our understanding of the richness, diversity and significance of the British and northern European hominin record. He was a central part of the team that identified the earliest known human remains in Britain, at Boxgrove in West Sussex, in the late 1980s (Roberts *et al.*, 1994; Stringer *et al.*, 1998), and has worked at many of the other key sites in the British Pleistocene containing human remains, Pontnewydd Cave in North Wales (Green and Stringer, 1981) and Gough's Cave in Cheddar (Stringer, 1985) to name but two. His recent role as the Director, Ancient Human Occupation of Britain projects 1, 2 and 3, funded by The Leverhulme Trust, has had a galvanising impact on the British Quaternary. He has marshalled a large team of specialists in this major collaboration aimed at reconstructing the first detailed history of how and when Britain was occupied by humans. This has injected momentum into the entire UK community concerned with Pleistocene stratigraphy, sedimentology, geochronology, and palaeoenvironmental reconstruction and has resulted in data that extends far beyond the immediate aim of understanding human origins. AHOB has resulted in major publications reporting the results of recent excavations that have yielded evidence for the earliest human occupation of northern Europe at Pakefield and Happisburgh on the East Anglian coast (Parfitt *et al.*, 2005, 2010; Ashton *et al.*, 2011). *Homo britannicus* (Stringer, 2006) is a stunning testament to the success of AHOB and has won prizes including the 'Best Archaeology Book Award 2008' and the Kistler Book Award 2008.

Chris Stringer is one of the most outstanding members of the QRA. He has made fundamental contributions to the study of human origins within the context of Quaternary science, and his work has had a hugely significant international impact. The QRA are delighted to award the 2011 James Croll Medal to Chris Stringer.

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Professor Dan Charman
QRA President

LEWIS PENNY AWARD

THE 2011 LEWIS PENNY MEDALS

We are delighted to announce that in its sixth year, there will be two Lewis Penny medals awarded in recognition of the work of two outstanding early career Quaternary scientists. The awards are made to Dr Ian Candy of Royal Holloway and Dr Sven Lukas of Queen Mary. The offering of this medal, in memory of Lewis and his contributions to Quaternary science and his support of the QRA, was made possible through the generosity of many of Lewis's former students, friends and colleagues. The prize is intended to recognize a young or new research worker who has made a significant contribution to the Quaternary stratigraphy of the British Isles and its maritime environment, including adjacent areas of continental Europe that have relevance to the British Isles.

Ian Candy

Ian is an exceptional early-career scholar, whose contribution to understanding and reinterpreting British Quaternary stratigraphy is founded on his expertise in sedimentology, micromorphology, palaeoenvironmental analysis (especially stable isotopes) and geochronology. His key contributions cover a range of key areas. Focusing principally on East Anglian Early and Early Middle Pleistocene sediments, Ian is currently engaged in exhaustive sedimentological and stratigraphical studies along the coast in order to differentiate and order these complex suites of deposits. The outcomes of the research notably include the elucidation of the poorly-known Early Pleistocene record through better characterization of discrete climatic episodes and the recognition of palaeomagnetic excursions, and the establishment of the age and nature of different short-lived episodes of temperate-climate conditions



during the early Middle Pleistocene (Candy *et al.*, 2010, 2011a). Candy *et al.* (2011a) further explores the contrasting nature of interglacial warming after the Mid-Brunhes Event in NW Europe compared to its expression in other long terrestrial records such as EPICA. Both strands are fundamental to our appreciation of the British Quaternary stratigraphic record on land. A corollary of Ian's research into the interglacial succession has been its significance for understanding the timing and nature of the earliest human occupation of Britain, exemplified by his contribution to Parfitt *et al.* (2005) and through his contributions to the *Ancient Human Occupation of Britain* project. Ian has also employed stable isotope analysis extensively in order to shed light on the different nature of climatic episodes during the British Pleistocene (Candy *et al.*, 2011b), in particular the identification of seasonally-dry climates in early Middle Pleistocene deposits at Pakefield (Candy *et al.*, 2006; Lee *et al.*, 2006; Parfitt *et al.*, 2005), the recognition of rhizogenic calcretes in glacial deposits (Candy, 2002) and the characterization of the Hoxnian interglacial (Candy, 2009; Preece *et al.*, 2007; Ashton *et al.*, 2005). Again, this research contributes significantly not only to British Quaternary stratigraphy through the recognition of palaeosols with distinctive palaeoclimatic attributes that are of stratigraphical significance, but also provides the palaeoenvironmental backdrop for hominin occupation and behaviour. Ian is also engaged in geochronological dating with a view to testing and underpinning key parts of the British Quaternary succession. For example, Candy and Schreve, (2007) used high-precision ICP-MS U-series dating to identify short-term episodes of temperate-climate conditions that appear to correspond with marine isotopic substages. This has been particularly important for improving the resolution of the British terrestrial record as well as for testing current models of mammalian biostratigraphy. Most recently, Ian has expanded his area of interest to Late Pleistocene cave deposits in Britain and to dating speleothem deposits contained within them as an aid to constraining the mammalian faunal record. Finally, Ian has repeatedly demonstrated his commitment to the broader goals of Quaternary research and to the promotion of public understanding of Quaternary science, serving on the QRA committee and contributing to various meetings including the Annual Field Meeting in Norfolk (Candy *et al.*, 2007). He is an editor for the *Proceedings of the Geologists' Association*, and has promoted Quaternary science to a wider audience through activities such as organisation of a public meeting for the Geologists' Association on *Warm Climates: Linking the Past and Present*, a forthcoming exhibition (joint between the Natural History Museum and British Museum), and the outreach work related to the AHOB project. In summary, Ian's research places him in the unusual position of contributing to the lithostratigraphy, chronostratigraphy and biostratigraphy of the British Isles, making him an excellent candidate for the award of the 2011 Lewis Penny medal.

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Sven Lukas

Sven Lukas has made an important contribution to our understanding of the glaciation of the British Isles, especially the landforms developed during the Younger Dryas (e.g. Lukas 2003; 2006). Throughout his work he shows an unparalleled ability for using landforms to understand glacial processes and ice mass dynamics (e.g. Lukas and Benn, 2006; Reinardy and Lukas, 2009). He completed his MSc in Bochum, Germany in 2002, but was already collaborating with British Quaternary researchers in research on Scottish glacial landforms. His PhD (2005) at St Andrews, working with Doug Benn, Colin Ballantyne and Tom Bradwell, saw the emergence of a new approach to classic but not yet truly understood landforms in Scotland. Although much work had been done on the glacier extent during the Younger Dryas, there were still rather few insights into the development of landforms and the processes that must have been active during that period. One of the most enigmatic glacial landforms is referred

to as ‘hummocky moraine’ and this particular landform or landform association is quite widespread in the British Isles during the Younger Dryas, much more so than in previous glacial phases. Thus it is obvious that special conditions must have reigned during the Younger Dryas in these



Figure 1. Sven Lukas standing on top of Midre Lovénbren, Spitsbergen, one of the type sites of the englacial thrusting model. In the background, ice-cored moraine mounds are visible. Photograph courtesy of Clare Boston (August 2009).

parts. Sven studied hummocky moraine intensively and contributed strongly to its understanding. For his PhD, he meticulously mapped hummocky moraine distribution, detailed patterns and sedimentology in a remote part of the northwest Scottish Highlands (Lukas and Lukas, 2006). Whereas so far most people would have been happy to delineate an area as just being 'hummocky' and mapping it as one coherent unit, Sven mapped the position, orientation and shape of individual hummocks, thereby revealing patterns that would not be otherwise discernable. Combining these patterns with the sedimentology and structural geology as observed in numerous outcrops led him to the realization that some current models (like englacial thrusting) could not explain his observations (Lukas, 2005; 2007). He then studied actively glaciated areas in the Arctic and Subarctic and came to the conclusion that there are no modern analogues for hummocky moraines (of YD age) as found in the Scottish Highlands and most likely, other parts of the British Isles. This in turn led him to reconstruct the particular climatic and glaciological conditions that typify the Younger Dryas in this part of the world (Benn and Lukas, 2006; Lukas and Bradwell, 2010a).

Sven has also made significant contributions to wider activities in British Quaternary science. He used his research as a basis for leading two QRA fieldtrips to the Grampian Highlands in 2004 and western Sutherland in 2010 demonstrating his findings and those of others in the field (Lukas *et al.*, 2004; Lukas and Bradwell, 2010b). Impressively, he led the former trip whilst still a PhD student and showed his willingness to defend his findings and ideas where it matters - in the field, and to his knowledgeable peers. He has also contributed to the updated edition of the best-selling QRA technical guide on *Clast lithological analysis*: (Demir *et al.*, 2011; Lukas, 2011; Lukas *et al.*, 2011) and edited one of the outputs from the 2008 QRA Annual Discussion Meeting (Smith *et al.*, 2008). The QRA is delighted to recognize his achievements with the award of the 2011 Lewis Penny medal.

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Professor Dan Charman
QRA President

INTERGLACIAL CLIMATES AND STRATIGRAPHY OF EASTERN ENGLAND

Dr Ian Candy

(Department of Geography, Royal Holloway, University of London)

Introduction

The Quaternary stratigraphy of the British Isles has been studied for over 150 years and, although it might be assumed that such a history of research would make new studies unprofitable, it is, in fact the sheer volume of work on this region that makes it such an exciting location to work in. From the pioneering work of West (e.g. West, 1956; 1957; 1980) and others which led to the identification of the main glacial and interglacial episodes that have effected Britain (Mitchell *et al.*, 1973) through to the re-interpretation of the terrestrial record and its correlation with the marine isotopic record, the British Isles has one of the best resolved Quaternary stratigraphies in the world (Bridgland, 2000; Keen, 2001; Preece, 2001; Schreve, 2001; Rose, 2009). The quality of this stratigraphy is down to the exceptional ability of the large number of scientists who have worked on this record from, with respect to eastern England, the pioneering work of Clement Reid onwards. The level of resolution available in the British Quaternary sequence, coupled, with our ability to directly correlate specific deposits with marine isotopic stages makes it an ideal location to investigate how climate events/episodes that are clearly identified in marine and ice-core archives are expressed in the terrestrial record of western Europe. This has been the main focus of my research.

Research

Although my doctoral studies focussed on the Quaternary of the Mediterranean region (an ongoing research interest) it developed my research interests in continental carbonates (soil carbonates, or *calcrete*, tufa, lacustrine and palustrine carbonates) particularly their petrography, geochemistry and stable and radiogenic isotopic characteristics. It is this theme that has linked my research interests in southern Europe/north Africa with those in Britain because despite the fact that British Quaternary sediments are rich in a wide variety of carbonate types very little work has actually been done on them (Candy *et al.*, 2011a). Crucial to my involvement in research into the British Quaternary record was my becoming a member of the Leverhulme funded "*Ancient Human Occupation of Britain*" (AHOB) project as a postdoctoral researcher in 2002, based at Royal Holloway, University of London with Prof. Jim Rose. The aim of this research was to investigate the potential of using the oxygen and carbon isotopic composition of carbonates as a means of reconstructing the environments of Palaeolithic occupation in Britain, whilst also investigating the potential of dating the age of formation of many of these carbonates by

$^{230}\text{Th}/\text{U}$ techniques. This work proved successful and I have remained a member of the AHOB project through its numerous phases (AHOB II and AHOB III).

I think it would be impossible for me to stress how important my involvement with the AHOB project has been for the development of my research interests. As well as the research support and funding that such a large project offers, involvement with the AHOB project has had three major advantages for me. Firstly, it meant that I came into regular contact with many of the key researchers in British Pleistocene studies. Secondly, it offered me an opportunity to become involved in individual projects, within the overall framework of the AHOB programme, which ranged from re-investigating the stratigraphy of the Early Pleistocene through to reconstructing Lateglacial climates. Finally, many of these projects have acted as the pilot studies on which my future research projects have been built.

The crucial theme that runs through much of my AHOB-related work has been that of "Interglacial climates". This has involved a number of different projects and themes. In collaboration with Prof Danielle Schreve (RHUL) I have applied high-precision $^{230}\text{Th}/\text{U}$ dating of tufa at the late Middle Pleistocene site of Marsworth in an attempt to resolve questions about the correlation of this site with the marine isotopic record (Candy and Schreve, 2007). This study, the first use of U-series Multi-collector ICP-MS in British Pleistocene studies, has not only shown that Marsworth can be definitively correlated with MIS 7 but also that the substage forcing observable in the marine isotopic record is also present in the British terrestrial sequence. The use of oxygen isotopes in investigating interglacial climates has focussed on two specific time periods; 1) the early Middle Pleistocene, "Cromerian Complex" interglacials, and 2) the Hoxnian interglacial (MIS 11). Work on the Cromerian complex has highlighted the diversity of climates during this period and, consequently, the diversity of environmental niches available to early Humans (Candy *et al.*, 2006; Candy *et al.*, 2011a & b). Stable isotopic studies have shown that during climatic peaks climates were more like those of southern Europe, "Mediterranean style climates", whilst many episodes occurred that were cooler than the present day (Candy *et al.*, 2011b).

The Hoxnian is an important interglacial as, being correlated with MIS 11, it is suggested to be the closest analogue to the Holocene. Oxygen isotopic studies have shown that, with respect to temperature, the Hoxnian interglacial is indeed comparable to the Holocene with no evidence for the extreme warmth that is seen in deposits of MIS 5e, 9 (?) and some of the Cromerian interglacials (Candy, 2009; Candy *et al.*, 2011a). Many of these ideas have been synthesised in a review that I undertook in collaboration with Dr Richard Preece (Cambridge), Simon Parfitt (NHM), Prof Jim Rose (RHUL), Dr Jonathan Lee (BGS) and Dr Danielle Schreve (RHUL) on the evidence for interglacial warmth in British interglacials of the past 800,000 yrs and their comparison with the diversity of interglacial climates as recorded in marine and ice core records (Candy *et al.*,

2010; Candy *et al.*, 2011b)). This review has shown that many key transitions that are observable in EPICA and SPECMAP (such as the mid-Brunhes Event) are not observable in the British Quaternary sequence, questioning the "Global" nature of such climatic transitions (Candy *et al.*, 2010).

My collaboration with Prof Jim Rose, since my time as a Royal Holloway undergraduate, has been critical to my development as a scientist and a fundamental step in my current research was Jim inviting Prof Rene Barendregt (University of Lethbridge, Canada) to carry out palaeomagnetic analysis on a diverse range of British Pleistocene sediments. During the third stage of the AHOB project (2009-2012) a major component of my research was based around remapping and re-investigating the Early and early Middle Pleistocene deposits of the Crag basin of East Anglia (Candy *et al.*, 2008; Candy *et al.*, 2011b). The detailed sedimentary logging carried out by my research assistants, Gareth Tye and Jenni Sherriff, was augmented by extensive palaeomagnetic dating by Rene. This research is currently in the process of being written up for publication but, through the identification of greater amounts of "reversed" sediments than had previously been acknowledged and the detailed facies analysis of the sediments, a clearer picture of the stratigraphy is emerging and the impact of major transitions, such as the Mid-Pleistocene Transition, is being investigated.

Although my doctoral research involved the investigation of landscape response to long-term Pleistocene change, until my involvement with AHOB I had very limited research interest in the Lateglacial. During the course of AHOB II (2005-2009) I supervised Ruth Waghorne's AHOB-funded PhD thesis entitled "Rapid climate change and human occupation during the Lateglacial; Sproughton, UK" which used a multi-proxy approach, but focussed strongly on stable isotopes, to understand climate and landscape dynamics in the UK during the Lateglacial (Candy *et al.*, 2011a). Ruth's research opened my eyes to the potential that oxygen isotopes have to understanding abrupt climate change, primarily because of the minimal lag time between temperature change and isotopic shifts in rainfall chemistry. Investigating the climate of the Lateglacial in Britain links in with research that I am currently engaged in, led by Danielle Schreve, on the cave records in southwest England of the Lateglacial, relating the timing of faunal turnover, and human occupation to these abrupt climate forcing events.

Future research

My current research into the Quaternary of Britain, beyond that of the AHOB project, is focussed on two main areas; 1) the climate of MIS 11, and 2) the isotopic record of the Lateglacial in the UK:

1. *Climates of MIS 11 in Britain* – Due to major glacial scour during the Anglian glaciation (MIS 12) the British Quaternary record has an exceptional record of MIS 11 within the lacustrine sediments that accumulated in

these basins after Anglian ice retreat. MIS 11 is the best analogue of the Holocene and the fact that several of these basins are varved and contain authigenic lake marls offers the opportunity for an annually resolved isotopic record of this interglacial. As part of my research into MIS 11, myself, Danielle Schreve and Dr Adrian Palmer (RHUL) are supervising two PhD students, Gareth Tye and Jenni Sherriff, who are investigating climate stability during MIS 11 in Britain during the climatic optimum and the end of the interglacial.

2. *Oxygen isotopic record of the Lateglacial in Britain* – Building on the work of Ruth Waghorne I am currently engaged in research on the isotopic record of Lateglacial sites in Britain. This is with Dr Ian Matthews, Dr Adrian Palmer and Dr Simon Blockley (RHUL) and is currently focussed on Star Carr as part of a research programme led by Dr Nicky Milner (York). Detailed work by two postgraduate students at Royal Holloway, Amanda Farry and Chris Darvill, has led to the generation of high-resolution oxygen isotopic curves from Star Carr which compare well to the record of abrupt climate forcing in the Greenland ice cores. Further work at Star Carr, and other Lateglacial sites, will be used to identify regional differences in response and increase our understanding gradients of climatic change in western Europe.

Acknowledgements

I hope that this article has highlighted that all of my research is collaborative and that none of it would be possible without the long history of Quaternary research that has been carried out in Britain. I am very pleased to be awarded the Lewis Penney medal and thank the QRA for this honour, but the award is mainly down to the excellence of my collaborators, consequently, I would like to thank them for their help over the years. In particular thanks to Chris Stringer and the rest of the AHOB group. At Royal Holloway my colleagues Danielle Schreve and Adrian Palmer have been critical in making research so exciting and enjoyable, whilst I am permanently indebted to Jim Rose for his help and support over the years. Finally, at Royal Holloway I am very fortunate to be involved in teaching on the MSc “Quaternary Science” which means that every year I have the pleasure of teaching British Quaternary Stratigraphy to a group of enthusiastic and exceptional young Earth Scientists. I would like to thank all of the cohorts that I have taught for the challenging debate and discussion that they have provided over the years.

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YOUNGER DRYAS MORAINES AND GLACIER DYNAMICS IN SCOTLAND

**Dr Sven Lukas (Department of Geography
Queen Mary, University of London)**

Introduction

First of all I would like to thank the QRA for honouring my work by awarding me the Lewis Penny Medal. My introduction to, and continued interest in, the British Quaternary owes much to an ERASMUS year at the University of Sheffield while on leave from my home university in Bochum, Germany. Unbeknown to Mark Bateman, Chris Clark and Andy Hodson, who taught me back then, that year inspired me to do research in the British Quaternary. The next, and probably most crucial catalyst for my future career was attending the QRA field meeting to Banffshire and Buchan, organised by Jon Merritt and others. At that meeting, the seeds for my MSc thesis work were sown, with Jon taking the lead in organising the whole logistical side of things. Thanks to food and mouth disease the summer prior to me starting the fieldwork, I did end up doing my MSc project in the Scottish Highlands instead of Cumbria. This introduction, which included the obligatory Drumochter Pass varieties of horizontal rain, sleet and heavy snowstorms, did not put me off applying for a PhD studentship jointly funded by the BGS and St Andrews University, which I was thankfully offered shortly before my MSc thesis was submitted. Needless to say, the weather theme continued throughout my PhD, but interspersed with dry and midge-ridden episodes. The research since the start of my PhD is summarised below.

Research

Because of a pronounced lack of research activity in NW Scotland since c. AD 1900, it became necessary to first of all inventorise what was there in terms of sediments and landforms. This inventory, via geomorphological mapping, was the initial focus of my PhD fieldwork, and there was initially no inclination towards focusing on any part of the area or on any time slice in particular. It quickly became apparent, however, that there were several in-depth problems out there to tackle that necessitated abandoning a focus solely on geomorphological mapping. The geomorphological map eventually provided the context for all other detailed work (Lukas and Lukas, 2006; Lukas and Bradwell, 2010a), however. Two key themes that I would follow for most of my PhD emerged relatively quickly, namely (a) how the moraines in my area, previously summarised under the umbrella term "hummocky moraine", had formed and what implications this had for former glacier dynamics in NW Scotland and (b) what kind of currently glaciated environments would be

similar to those. Superimposed on both topics was the question of how old these features were. I will briefly go into a little more detail on each of these areas.

Hummocky moraine: distribution, genesis and glaciodynamic implications

Previous models of how Scottish “hummocky moraine” had formed included: stagnation and thus passive meltout of material to form moraines with a chaotic appearance (Sissons, 1977); incremental retreat of active ice margins that formed the majority of moraines by a combination of pushing and dumping (e.g. Benn, 1992); and, according to observations by Hambrey *et al.* (1997) and Bennett *et al.* (1998) in Svalbard and Glen Torridon, Scotland, by englacial thrusting. The latter model has quite distinct glaciodynamic implications, because several moraines may form at once in an englacial and/or subglacial position. This differs markedly from the model of incremental retreat, where individual moraines can be used to reconstruct individual ice-marginal positions. Furthermore, this prediction was testable and necessitated a thorough sedimentological investigation of these moraines, which was made possible by several small exposures created for gravel extraction. These and other initial shallow surface exposures were enlarged using a trenching tool to create much bigger exposures, many of which extended the whole widths of moraines. In total, a database of 52 exposures across my PhD study area (Lukas, 2005a, b; Reinardy and Lukas, 2009) finally enabled me to piece together that: (a) these moraines formed at oscillating ice margins during overall retreat; (b) they were formed by ‘dumping’, in this case by stacking of sediment transported in supraglacial debris flows and deposited against the ice margin which acted as support; (c) the majority of these moraines resembled ice-marginal positions that had been occupied more than once, since the sediments contained plenty of evidence of postdepositional disturbance; and (d) there was no support for the englacial thrusting hypothesis. The last point in particular caused some discussion in the literature (Graham *et al.*, 2007; Lukas, 2007a), and I am pleased to report that work on this subject is still ongoing.

Modern analogues for Younger Dryas glaciers and glaciation in Upland Britain

Based on previous research, two conflicting interpretations of the glacier thermal regime and dynamics existed. Firstly, Benn (1992) had argued that the glaciers were most likely temperate and dynamic, while Hambrey *et al.* (1997) and Bennett *et al.* (1998) had argued for more polythermal conditions. After having abolished the applicability of the englacial thrusting model and having established the rapid nature of oscillations recorded in the moraine sequences, the question remained whether there was evidence from modern glacial environments to test which of these ‘modern analogues’ could best explain this record. Fieldwork in Norway (temperate end member) and Svalbard (polythermal to cold-based end member) was chosen as a good way to capture

this spectrum. Besides yielding a number of individual contributions to these environments and our understanding of moraine formation (Lukas, 2007b) and de-icing of ice-cored moraines (Lukas *et al.*, 2005), these studies also led us to conclude that there is no single modern analogue that can explain *all* the features summarised under the term of Scottish “hummocky” moraine (Benn and Lukas, 2006), once again demonstrating that the Scottish Younger Dryas is a very special and unique subject to work on!

Younger Dryas glacier extent, chronology and climate

Due to the lack of previous work in NW Scotland, it was necessary to constrain the timing of particularly clear glacier limits and establish to ensure that any palaeoclimatic information was not ‘floating’, but could be tied to palaeoclimatic records and events elsewhere. The mapping provided the template for this, and sample sites were selected based on a morphostratigraphic assessment of the evidence (Lukas, 2006; Lukas and Bradwell, 2010b). Luminescence dating sadly failed in this context (but provided a useful example of poor quartz sensitivity to the luminescence community! Lukas *et al.*, 2007), so radiocarbon dating and cosmogenic isotope dating of boulders on moraine crestlines were used to constrain the timing of events, with all ages agreeing that the prominent glacier limits in the study area were of Younger Dryas age (Lukas and Bradwell, 2010b). Linking glacier limits with the same morphostratigraphic signature yielded an ice cap of astonishing dimensions (when compared to reconstructions of the 1970s and 1980s), covering an area of 350 km². The discovery of this ice cap has removed an awkward gap in the Younger Dryas glacier coverage of Scotland (Golledge, 2010) and shown the potential for other areas in Scotland to be (re-) mapped.

Future research

In Scotland, I am currently involved in the first mapping project of the whole of the Monadhliath Mountains (central Scotland) through my PhD student Clare Boston, who is currently finishing off her thesis. In addition, an MSc student of mine (William Hughes) worked on an area around Lochnagar, and this is where future efforts, in collaboration with colleagues in Scotland, will be focused for the next few years. There are also several smaller projects in NW Scotland that I am involved with (mostly undergraduate dissertations). In my PhD study area, I am currently exploring ways in which the timing and climatic implications of hummocky moraine sequences can be linked to more high-resolution local records.

In addition, a big part of my current research interests has developed from what were initially very small parts of my PhD, namely modern analogues and luminescence dating. In the past six years I have been involved in investigating the geomorphic and sedimentary signature of (former) glaciers in parts of

Scotland, the Alps and Svalbard. The aims of this work are to better constrain the boundary conditions that existed during the time of moraine formation (and degradation in case of dead-ice incorporation), and to provide an interpretative framework for other sites (e.g. Lukas, 2012). In Svalbard, I have looked in more detail at the sedimentary signature of surging glaciers, partly through a PhD-student (Harold Lovell), who I am jointly supervising with Doug Benn. Some of this work has led me back to one of the type sites where the englacial thrusting model was developed, providing a nice link and reminder of my days as a PhD student.

At the same time, I also aim to enhance our understanding of the timing of glacier fluctuations during the LGIT using luminescence dating, partly to demonstrate that this can be done even in environments that are deemed to be too challenging by others. We have had some very promising successes with this recently (Lukas *et al.*, 2012), and I am hopeful that similar successes can be repeated elsewhere.

Acknowledgements

I am indebted to far too many people who have made a contribution to my work and career up to this point, so any acknowledgements have to remain incomplete. In particular, I would like to thank: Nick Golledge, Jon Merritt (BGS), Wish Mitchell (Durham) and Andreas Pflitsch (Bochum) for making my MSc research at Drumochter possible and for introducing me to the Scottish Quaternary with all its quirks; my PhD supervisors Doug Benn, Colin Ballantyne (St Andrews) and Tom Bradwell (BGS) for an extremely enjoyable and productive time (then and since); Benny Reinardy (Swansea), Jostein Bakke (Bergen) and David Jarman (Glasgow) for widening my perceptions of sediments, lakes (sorry: lochs!) and rock slopes; Joel Spencer, Ruth Robinson (St Andrews), Frank Preusser (Stockholm) and Andreas Lang (Liverpool) for their introductions to luminescence dating that have ultimately inspired me to build up my own laboratory. Equally, I could not have done without the interest, enthusiasm and probing questions of my colleagues at Bochum, St Andrews, Bern and Queen Mary which have certainly helped to keep me on my toes throughout the various stages of my career. Finally, I would like to thank the participants of the two QRA field meetings I was fortunate enough to organise for their enthusiasm and for providing an important part in tightening up some of my arguments. Last but not least, I would like to thank my wife Tina and our daughter Lara for making all of this possible.

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HONORARY MEMBERS 2012

Honorary Membership of the QRA is bestowed on individuals who have given distinguished and career-long service to Quaternary science and/or effective contributions to the activities and development of the QRA itself, and who are on the cusp of professional retirement or who have recently retired. I am delighted to announce that both proposed nominations for new Honorary Members of the Association were warmly and enthusiastically endorsed at the Annual General Meeting of the Association during the Annual Discussion Meeting held by the University of Southampton on 4th January 2012.

Dr Doug Harkness

Doug Harkness has a long and distinguished career as an isotope geochemist and is best known amongst the Quaternary community for his work on radiocarbon analysis and dating. His career began with good Dundee marmalade and chocolate when Doug worked in the laboratories of a food manufacturing company, leading to graduate membership of The Royal Institute of Chemistry in 1965. He then joined the Ministry of Defence as experimental officer in



a new team set up to maintain and refit Britain's first nuclear submarine, HMS Dreadnought. This work led to the development of a personal interest in the detection of low-level radioactivity in the environment, and in 1967 he took up a MRC funded research assistantship at Glasgow University investigating the environmental distribution and potential health hazard from artificial C-14 produced during nuclear weapons test programmes. He was awarded his PhD in 1970, which also involved collaboration in establishing the Glasgow University Radiocarbon Laboratory and led to a lectureship in the Scottish Research Reactor Centre in East Kilbride. This post carried responsibility for the design, commissioning and subsequent operation of a second Scottish based radiocarbon laboratory grant-funded by NERC. It also marked the beginning of his active involvement with Quaternary research interests *per se*.

A critical development for the UK Quaternary science community came in 1976, when the laboratory status changed from that of a grant-aided unit to being a NERC facility with a priority remit to support research in both the component bodies of Council and its grant aided institutes of higher education. The NERC Radiocarbon Facility has been a vital component of UK Quaternary science capacity for 35 years and there must be hundreds of postgraduates and academics (including me!) who would not be where they

are today without its support. Doug remembers the first postgraduate student Steve Ladyman (now MP for South Thanet) and Chris Turney amongst those that passed through his capable hands. As head of the new lab in the 1970s Doug was faced with a steep learning curve to meet the objective application, measurement and interpretation of low-level C-¹⁴ measurements in support of the Quaternary research community. This need was met by the appointment of a steering committee composed of eminent Quaternary scientists, and together they ensured the clear definition of scientific priorities and equally importantly encouraged the opportunity for mutually beneficial links between the laboratory and its users. Doug was highly influential in developing the idea that the user community should be regarded as collaborators rather than customers, an approach that continues today.

On reaching compulsory NERC retirement age in 1998 Doug continued academic involvement via a Senior Research Fellowship at the University of Glasgow, heading the re-launch of the Scottish Universities Research and Reactor Centre (SURRC) as the Scottish Universities Environmental Research Centre (SUERC), a major part of this effort was with the planning, procurement and installation of a new AMS facility. Doug finally retired in 2002 to enjoy the countryside of rural Perthshire and a ready abundance of top grade golf courses!

Doug has contributed enormously to Quaternary science, and directly or indirectly assisted the activities of a very large number of Quaternary researchers during his career. Besides setting up the internationally recognised NERC Radiocarbon Facility, he also published over 200 peer reviewed papers, served on editorial advisory boards to *Quaternary Science Reviews* and *Radiocarbon* and advised on the establishment of other isotope research facilities around the world. The QRA is delighted to be able to award honorary membership in recognition and gratitude for these contributions.

Brian Moorlock

Brian's first degree was a BSc in geology, specialising in mineralogy and petrology. He then worked on his PhD on the geology and geochemistry of the Angmagssalik district of Greenland. This involved spending about 6 months under canvas on the east coast of Greenland studying the high grade granulite facies metamorphic Precambrian rocks, but not looking at any of the glacial deposits or processes! He was soon exposed to the attractions of the Quaternary when he joined British Geological Survey (BGS) in 1975. BGS had a rather perverse



sense of humour of sending new recruits to work in areas of the stratigraphic column with which they were unfamiliar! Thus, soon after taking up his

post, he was sent out to the deepest depths of Essex to map on the Braintree and Epping 1:50,000 sheets, where he engaged fully with the intricacies of the Quaternary. At about this time, Jim Rose, Peter Allen and Richard Hey were publishing the results of their work on the Kesgrave sands and gravels in a high profile *Nature* paper. There was great opposition at BGS to their conclusions about these deposits being formed by the River Thames, and Brian recalls taking part in several field meetings with very heated discussions! With this fiery introduction to Quaternary science, Brian never looked back and became a QRA member and stalwart. In his BGS mapping work, he went on to cover the Bury St Edmunds sheet before leaving East Anglia to work on the Tewkesbury and Worcester sheets, becoming involved with the terraces of the Avon and Severn. From there he moved on to work on the Leighton Buzzard sheet, surveying large areas of glacial deposits and then south to map the Romford sheet where the main interest was in deciphering the terraces of the Thames. He returned to work in East Anglia in 1986 with a sequence of work on the Saxmundham, Lowestoft, North Walsham, Cromer and Wells-next-the-Sea sheets, finally working on the Aylsham sheet. He also worked extensively on desk compilations of the Fakenham, Swaffham, Saffron Walden and Biggleswade sheets.

The extensive mapping work that Brian completed in his career with BGS led to many new insights into British Quaternary stratigraphy, a few controversial debates and many satisfying collaborations to resolve these. For example, the Lowestoft and Saxmundham sheets and the conclusions drawn from them stimulated debate and a decade of subsequent collaboration with Jim Rose and colleagues at Royal Holloway to resolve some of the problems. Brian's career of mapping and the numerous maps, sheet descriptions, memoirs and other publications that have been produced from this are testament to the way in which detailed field information is vital in developing a full understanding of Quaternary stratigraphy. His work took him over East Anglia on a field by field basis so that not many exposures or quarries evaded him. The information collected during these activities will remain an essential underpinning for future work for years to come.

Brian became Principal Scientific Officer in BGS and District Geologist for Northern East Anglia, leading the survey team there. He was also Deputy Programme Manager for Southern England and Wales. His links with higher education establishments were formalised by becoming an Honorary Research Fellow at Royal Holloway, and he served as membership secretary on the QRA Executive Committee. Although Brian himself is at pains to stress that much of the mapping work is essentially a group activity, his individual contribution to this and wider work in Quaternary science and the QRA deserve full recognition as a QRA honorary member.

Professor Dan Charman
QRA President

THE IMPORTANCE OF QUATERNARY GEOCONSERVATION

Cynthia Burek

Introduction

Geoconservation is the youngest of the conservation sciences sitting alongside biological and archaeological conservation in the natural environment. The importance of conservation for Quaternary sites, specimens and features can be summed up by the 3 Vs:

- They are easily Visible so people can identify with them
- They are Valuable as cultural, teaching and research sites with more importance being given to them since the recognition of global warming and
- They are Vulnerable as they are on the surface, easily accessible in most cases and form part of our everyday lives

Geoconservation is defined as “Action taken with the intent of conserving and enhancing geological and geomorphological features, processes, sites and specimens” (Burek and Prosser, 2008) in other words - Taking an active role in safeguarding Geodiversity. The Quaternary community while recognising the vulnerability of its unique landscapes, landforms and processes has been slow to cooperate with other organisations actively pursuing this aim until relatively recently. Whether this is through ignorance of their existence or a lack of understanding of their role is unclear. Thus this article has been commissioned by the Executive committee of the Quaternary Research Association to raise awareness of Geoconservation amongst the Quaternary community and the opportunities that exist for cooperation taking on board the questions posed by the recent paper in Proceedings of the Geologists’ Association discussing challenges for geoconservation for science and society which are issues of concern to us all (Prosser *et al.*, 2011).

Geoconservation designations

Geoconservation is undertaken at many different levels and scales (both temporal and spatial) for many different reasons. When conserving a site or feature the reason for its conservation must be clear. Is it for its scientific uniqueness that it is being conserved such as with SSSIs or does the conservation have a broader remit such as with Local Geological or geodiversity Sites (LGS) or RIGS (Regionally Important Geodiversity Sites)? The latter are conserved not only for their research/scientific value but also for their educational potential,

their historical value or their aesthetic nature. This gives LGS/RIGS a much wider choice of sites. However while SSSIs are protected under legislation, RIGS are only safeguarded within planning policy statements (PPS9) soon to be updated or replaced (Office of the Deputy Prime Minister 2005). This needs a watching brief. The term RIGS is also under review and while it is still being used in Wales, is being replaced in England and Scotland with the term Local (Geology) Sites to sit alongside Local Sites (Biology) formerly known as Sites of Biological interest (SBIs).

On a much larger scale geoconservation designations include World Heritage Sites (WHS) of which we have 2 in the UK recognised specifically for their geodiversity, Giant's Causeway in Northern Ireland and the East Devon and Dorset Coast in England, but neither for their Quaternary interest. Scotland and Wales at present have no natural WHS. It is interesting to note, however, that at this current time the Republic of Ireland is preparing an application based on the unique landscape of the Burren, a Quaternary landscape if there ever was one.

Other designations such as the internationally important coastal Ramsar Sites (named for the Intergovernmental treaty The Convention on Wetlands of International Importance, called the Ramsar Convention). This provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. Special Areas of Conservation (SAC) and National Nature Reserves (NNR) while sometimes protecting the underlying habitats and therefore the Quaternary geodiversity are actually designated for their biodiversity and geoconservation is not the prime aim.

Marine Sites

The new Marine and Coastal Access Act 2009 with similar legislation passed in Scotland in 2010, gives additional opportunities to conserve geodiversity in the marine environment as it is specifically mentioned in the aforesaid legislation. There are four Marine Conservation Zone (MCZ) Projects concerned with the selection of MCZs sites in English inshore waters and offshore waters next to England, Wales, Scotland, Isle of Man and Northern Ireland. Recommended sites have been submitted to the Government for scrutiny before going to public consultation, for designation by the end of 2012. Measures are underway to protect Quaternary seabed landforms in the four designated areas in England: Irish Sea Conservation Zone (ISCZ), Finding Sanctuary (SW), Net Gain (North Sea) and Balanced Seas (SE). Wales, Scotland and Northern Ireland are pursuing their own designation areas within their national limits. I am happy to report that the ISCZ Stakeholder Group has recently recognised the importance of the drumlin field off the North west coast of Anglesey and is seeking to protect this landform specifically as well as St Bee's Head, the Sefton Coast with its peat

deposits and the upper and mid sections of St George's Channel (Whitfield, 2011). These MCZs will have statutory protection. There are also reference zones which will have much stronger protection. The questions of policing and monitoring the areas are yet to be decided. The importance of conserving the Quaternary geodiversity of the sea bed cannot be stressed enough.

Geoconservation Organisations

Similarly the organisations operating to conserve geological sites on land are many and diverse. They include both the voluntary (Burek, 2008a) and non voluntary sectors (Prosser, 2008,

National Level

At the national level there are two organisations, other than the statutory agencies, which have a watching brief on geoconservation are the Geoconservation Commission of the Geological Society of London and GeoConservationUK (formerly known as UKRIGS). Both these bodies can, if they choose, act as government consultees for geoconservation documentation. The former is mainly made up of professional organisations such as English Heritage, National Trust, BGS, Geologists' Association, and are represented around a table. The latter is the umbrella organisation for the voluntary geoconservation and RIGS movement. Both could take a greater recognition and lead on Quaternary geoconservation if awareness of issues were raised. The case of conservation issues on the East Anglian coast have been championed by them in the past.

SSSI

Geological SSSIs are safeguarded by the statutory agencies: Natural England, Countryside Council for Wales and Scottish Natural Heritage and in Northern Ireland the Area of Special Scientific Interest (ASSI) are designated by the Environment and Heritage Service of the Department of the Environment. It is their statutory duty to safeguard and maintain these sites for their geodiversity interest regardless of what it is. Several of the Geological Conservation Review books are specifically on the Quaternary (Ellis, 2011).

Local Geoconservation Sites

Local Geology Sites formerly RIGS in England and other terms used (SINCs, LGS) are recommended by geoconservation groups or similar for designation by Local Authorities. They are then embedded and protected in the planning system. RIGS groups or similar are normally under the guidance of the National Body, GeoConservationUK. In the main these organisations have a strong voluntary component (Burek 2011b) and may be hosted by Geological Societies such as Black Country Geological Society, in museums such as the Grosvenor

Museum, Chester, in Universities, within Wildlife Trust or Local Authorities and some are independent such as GeoLancashire. The Geology Trusts have been very successful in attracting funding in all aspects of geoconservation from clearance and monitoring to publicity and teaching. They tend to be concentrated in the southern part England.

At present there are over 3060 Local Geological Sites represented in Natural England's database (Larwood, 2010). They are divided into site type and by including static and active geomorphology along with cave and karst sites this adds up to roughly 15% Quaternary interest sites. However the nature of the site type data probably means that other classifications contain Quaternary exposures (e.g. river/stream sections or active quarries and pits) and the % is more likely to be around 25%. If that is the case then clearly RIGS groups are including some Quaternary designations. However soils are not in a category listed and I suspect that this is often ignored along with the wider Quaternary interest. The issue of protecting our soils is raised by Conway (2009).

In Wales the Association of Welsh RIGS Groups (AWRG) is supported by Countryside Council for Wales (CCW) and Welsh Assembly Government (WAG). It is the umbrella organisation for mainly voluntary action in Wales. A history of RIGS in Wales has been covered in detail by Burek (2008b). There are active groups mainly in the north although over the past 5/6 years RIGS groups have completed an audit throughout Wales for WAG. South Wales was the last group to complete their audit at the end of 2011. Therefore Wales has become the first country in the world to have been completely surveyed and notified all their local geological sites (RIGS). This is a fantastic achievement.. By September 2011 there were 761 RIGS registered from the NW, NE Central and SW RIGS groups and an additional 130 from South Wales. About 174 have a Quaternary interest. It is hoped that the complete hardcopy document of sites will eventually be available through the British Geological Survey in Cardiff, the National Library of Wales, CCW and on line. However the paucity of knowledge of soils and geomorphology including Quaternary landforms is recognised and will be addressed as one of the networks of sites. The presence of Stewart Campbell in CCW with his acknowledged expertise in Quaternary geomorphology means it will not be forgotten but further needs to be undertaken in certain areas. Perhaps there is room for cooperation here. Indeed this is probably true of all RIGS groups not just Welsh ones and many do not include soils at all in the assessments.

In Scotland 10 groups are members of the GeoConservationUK organisation covering all areas of Scotland and they have recently formed the Scotland Geodiversity Forum. The location of RIGS groups is available on the GeoConservationUK website www.geoconservationUK.org. The RIGS movement undertakes an enormous amount of geoconservation work from cleaning sites to raising public awareness through walks, talks, leaflets and

participation in local events of all kinds and is part of the so called Geovolunteer army (Burek, 2008a, 2011b). Raising awareness of Quaternary issues among these groups could prove fruitful. That notwithstanding, GeoSuffolk and Lincolnshire geoconservation groups have produced some very good leaflets on aspects of the Quaternary as have Warwickshire and Hereford and Worcester with their Ice Age leaflets. These are just a few examples of what can be achieved.

Partnership approach

Cooperation in raising awareness of the importance of Quaternary conservation can capture the public imagination and this is beneficial to all. Input from the latest research within the Quaternary puts this awareness at the cutting edge. Interest among the public is rife as can be seen at the interface of Quaternary science and Archaeology especially where bones are concerned. Mammoth tusks have tremendous pulling power.

Local Geodiversity Action Plans

Local Geodiversity Action Plans (LGAPs) are a recent phenomena based on the Biological Action Plans (BAPs) (Burek & Potter, 2002, 2006, 2008a). They are often county based (Cheshire being the first dedicated published one) or in some cases other easily recognised boundaries such as Area of Outstanding Natural Beauty (AONB) e.g. Clwydian Range. This partnership approach to action planning with an agreed aim and objectives sets SMART targets. At present there are over 40 throughout the UK London being one of the latest and Greater Manchester just about to go to press. Often sustainability is built into these partnership plans but all are at different stages and have different success rates. There is no driver from government as there is for BAPs. Alongside this initiative are the entirely English: Regional Geodiversity Partnerships such as the West Midlands, East Midlands or the North West. Wales and Scotland do not have these as AWRG and the Scottish Forum are considered equivalents in a UK context.

The partnership approach to conservation practise has recently been put forward in the Government Natural Environment White paper where Local Nature Partnerships are being encouraged to adopt a holistic approach to conservation by being given seed money. It remains to be seen if this approach is sustainable. This follows the ecosystem approach which was admirably described by Gordon and Brown in (2011). Here the key is to incorporate geodiversity and Quaternary geoconservation within that framework.

Everyone needs the Quaternary! This is acknowledged in the recently published *Norfolk's Earth Heritage – valuing our geodiversity* by the Norfolk Geodiversity Partnership (Holt-Wilson, 2010) which includes their LGAP. This document admirably describes the Quaternary geodiversity in Norfolk, but also evaluates

the threats to the resource as well as working in partnership. This publication was aimed at a lay audience and shows what can be achieved when cooperation is successful. But perhaps here we are talking to the converted as this area has long been a stronghold of Quaternary research and scholarship. This publication was reviewed by Burek (2011a) in Quaternary Newsletter.

The importance of the QRA's participation in these partnerships is obvious. Where Quaternary geology and geomorphology is widespread as in East Anglia there is no debate but in areas where the Quaternary is more subtle the links need to be made for professionals and the wider participants. So while the Quaternary geoconservation should still be built into the action plan in, for example Anglesey, it is often the solid geology which is more obvious to those partnerships. Again the presence of different soils or Quaternary landforms needs to be explicitly included. So perhaps Quaternary geoconservation should be an objective or target in Local Geodiversity Action Plans.

Discussion of successful cooperation

Methods for conserving Quaternary sections have been problematic for a long time and featured in the 1992 Crewe geoconservation conference fieldtrip to Borrass airfield a sand and gravel site owned at that time by McAlpine (Stevens, Gordon, Green and Macklin, 1992). This site is discussed in more detail later. There are numerous articles in Earth Heritage discussing these problems and methods of dealing with them (Johnson and Macfadyen, 2009; Owen 2011). Often recording of data (similar to rescue archaeology) is the only feasible option if commercial interests are deemed more important than the feature itself. This often happens with sand and gravel landforms such as eskers or kames which are important terrestrial sources of building materials. It is useful here to highlight one particular success story.

The so called 'Wrexham delta terrace' (Thomas, 1988) is and has been an important source of building material for the Northwest lying as it does close to the cities of Liverpool and Manchester. However Borrass airfield is the last remaining open, i.e. not built over, area showing the advance and interaction of the Welsh Ice with the Irish Sea Ice - during the last, Devensian, stage. It also contains important kettle holes which are designated RIGS and a SSSI, called Vicarage Moss, (Campbell and Bowen, 1989). This site is now under the ownership of Tarmac. When a planning extension was requested and then planning permission granted for 30 years, NEWRIGS (North East Wales RIGS) negotiated within that agreement the ability to log and photographically capture annually the retreat of faces and the ability to sample, analyse and evaluate but not stop the extraction. This is actually built into the planning requirements for the next 30 years and shows the cooperation which can be successful between a conservation group and a commercial company if it is tied into planning guidance and there is mutual respect between the partners.

It could be regarded as cynical that there is an economic driver and of course that is true but if geoconservation is to be successful this must be recognised and incorporated within any plans.

A optimistic note from Wales is the incorporation of geodiversity throughout the National Environment Framework (NEF) 'A living Wales - a new framework for our environment, our countryside and our seas' which is at the heart of the Welsh Assembly Government's approach to all environmental issues (Welsh Assembly Government, 2010). It was due to intense lobbying by all Welsh geodiversity groups during the consultation period (finishing in Dec 2010) that it was embedded. This shows the power of partnerships and lobbying.

Why is Quaternary Geoconservation important to Quaternary Scientists?

The Quaternary is our living landscape and heritage both in the terrestrial and marine environments. It produces features which are familiar to all and form the context for our own existence.

It is the lack of understanding of many people as to the uniqueness and vulnerability of these features that is important and this is a two way lack both by the scientists themselves and other Quaternary disciplines. An analogy to extinction in biodiversity conservation could be made. However in these cases as detailed above an early input into the conservation process is not only advantageous but essential (Prosser *et al.*, 2011) and can be a win-win situation. The problem of landfill is a real one to Quaternary sections and the demise of Four Ashes can be cited.

The QRA has tremendous expertise in the formation and preservation of Quaternary sediments and this expertise is lacking in many voluntary groups who perhaps have expertise in palaeontology and mineralogy. Traditionally geology teaching in schools and universities did not encompass geomorphology or other wider Quaternary aspects but these could now be included within geodiversity. Another problem is that today geoconservation is rarely taught to geology, geography or environmental science students in higher education with a few notable exceptions. It is important that the Geography, Earth and Environmental Sciences group of subjects are exposed to geoconservation and again cooperation from the QRA would seem to be a way forward.

Conclusions

The area of Geoconservation is new and cooperation is recommended to the QRA to embrace this aspect of our science to safeguard our unique features for tomorrow's generations of the Quaternary Community. The drivers are financial, climate change, new legislation at both EU and national levels and the breadth of the Quaternary. It is a challenge but the three Vs are in our

favour here, The Visibility of the Quaternary for all to see, The Vulnerability of our sites and processes which could act as an incentive for cooperation and last but not least the Value of the resource. It is hoped that the two case studies highlighted above show the importance of cooperation to successful Quaternary geoconservation.

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OBITUARY

PROFESSOR RUSSELL COOPE 1929-2011

Russell Coope died suddenly on 26th November, 2011, in the grounds of his home on the shores of Loch Tummel, near Pitlochry, Scotland. He suffered a heart attack while tending to the menagerie of domesticated and wild animals that he reared and cared for on his Scottish 'estate'. Given his life-long, passionate devotion to the animal kingdom in all its forms, there could hardly have been a more fitting finale. A regular performer (in more ways than one) on the Quaternary stage at home and abroad, Russell will be sorely missed by all who knew him – which must include a sizable proportion of the QRA membership.

Russell was an enthusiastic supporter and active member of the QRA from its inception in 1968. He was the Association's Vice-president from 1976 to 1978, its President from 1982 to 1985, and a co-organiser of the 10th International Congress of INQUA held in Birmingham, UK in 1977. For his contributions to Quaternary science, he was awarded Honorary Life Fellowship of INQUA in 1995 and Honorary Membership of the QRA in 2000. But he was much more than an exceptional and influential scientist: while his breadth of knowledge was immense, he was also a great advocate of his science; an inspirational, pragmatic humanist; and was invariably the life-and-soul of the party. He was certainly someone to whom the sobriquet 'larger-than-life' could be justly applied.

Russell openly acknowledged two major influences on his early academic development, that were to steer him away from an intended medical career (the family tradition) towards palaeontology and a life-long habit of questioning 'the consensus explanation'. The first was his evacuation to the Welsh countryside during WWII, which gave him unfettered access to the local natural world, and to where he could escape from the more fettered scholastic ministrations of the Jesuit priests responsible for his schooling. But it was those exacting tutors, Russell would sometimes recall over a glass of his favourite tippie, who sharpened his intellectual edge, for they were invariably well versed in, and acutely enquiring of, scientific as well as religious matters. Russell considered them exceptional teachers, who fostered in him a deeply quizzical and focused approach to all forms of intellectual enquiry.

The second great influence was his first university mentor, Professor Fred Shotton, whom Russell held in great esteem. An early encounter with Shotton was recalled by Russell in his acceptance speech to the Geological Society in 2005 following his award of the Prestwich Medal. *"I am reminded of my interview with him [Shotton] in 1954, for a Research Fellowship in the Department of Geology at Birmingham University. Having been given the post, I rather naively*

asked Fred what research programme I was expected to pursue. The reply was as typical as it was unexpected; 'You have just been given three years' funding, now it's up to you how you spend it'. That was the golden age and what idyllic days they were! Shortly afterwards I happened, entirely by accident, to visit a Quaternary gravel pit in which were exposed the spectacular bones of mammoth, woolly rhinoceros and bison. Looking at their sediment matrix I was amazed to find enormous numbers of equally spectacular, if somewhat smaller, insect remains. I was hooked instantly!" The rest, as they say, is history. This rather relaxed entrée into PhD study, so radically different from modern induction norms, was the start of a career of research into Quaternary insect remains that led to a number of highly original discoveries which heralded paradigm shifts in Quaternary evolutionary, stratigraphical and palaeoclimatic theory.



Left: Russell, whisky in hand, at his home in Foss near Pitlochry, Scotland (Photo by Mike Walker). Right: Russell with falcon. As a keen falconer, Russell looked after many birds of prey in need of care. His favorite, a goshawk named Ingrid, appeared in the film *'The Vikings'* starring Kirk Douglas and Tony Curtis, released by United Artists in 1958. (Photo by Allan Ashworth).

Russell's rise to eminence in the Quaternary community was not always a smooth progression, however, and a less robust spirit might easily have been disheartened by the criticism that he initially encountered. Indeed, Fred Shotton himself could easily have extinguished the freshly-lit palaeontological candle at the very outset, for when Russell excitedly delivered his first collections of fossil beetle carapaces into the Birmingham laboratory, Shotton's response was muted: "*don't be silly, Russell, they are modern ones that have just crawled in there to die!*". Russell was not to be deterred, however, and by meticulous analysis of the fossil remains, and through comparisons with contemporary insects, demonstrated that many of his fossils were of species not extant in the modern British fauna. As the palaeontological data-base began to expand, aided by the recruitment of other young scientists to the coleopteran cause, clear patterns began to emerge. One was the remarkable similarity, down to the

finest anatomical detail, of fossil beetle specimens from different parts of the Quaternary record. Russell reasoned that beetles, being highly mobile, did not need to evolve when placed under environmental stress, but could move to, or stay within, their environmental comfort zones during times of environmental reconfiguration, as for example when cold-adapted species found today in the high arctic and Siberia repeatedly migrated to the British Isles during successive cold episodes. This somewhat controversial view initially drew criticism from evolutionary biologists, until the weight of biostratigraphical evidence in support of the notion eventually became overwhelming.

The discovery that excited Russell the most, however, was the realisation of how extraordinarily rapidly the beetle records 'switched' between cold- and warm-adapted assemblages (and sometimes *vice versa*). From these observations, he concluded that climate must have changed abruptly, '*within a human life-time*' as he frequently put it, or '*on a Tuesday in Lent*' for added emphasis, but at any rate too rapidly to be quantified by the dating methods available at the time. Russell suggested that the beetle evidence for climate change frequently pre-dated the terrestrial plant response which, he assumed, must reflect the longer time needed for plants to disperse. These lines of thinking were first outlined at the INQUA Congress in Paris in 1968 and were received with general skepticism, particularly by the palaeobotanical community which was then the dominant element in Quaternary palaeoecology. Indeed, opposition from some quarters continued for a further twenty years, until Russell was vindicated by the emerging Greenland ice-core records, by other proxy records, and by developments in geochronology, all of which showed that marked temperature shifts could occur in a matter of decades and that the botanical responses did indeed often lag these abrupt changes in climate.

What was it that gave Russell the confidence to persevere in the face of such strong opposition? Almost certainly it was his conviction about the integrity of the material that he had personally collected, painstakingly analysed and carefully interpreted. Throughout his career, Russell did most, if not all, of his own fossil analyses, and backed up his interpretations through consultation with leading contemporary entomologists around the world, as well as by spending long hours checking identifications against modern beetle collections. For several decades he was a very familiar face to Dr. Peter Hammond and the staff of the entomological section at the Natural History Museum in London. Yet Russell was never a 'loner'. He warmly embraced collaborative work, was one of the first to recognise the importance of multi-disciplinary stratigraphical studies, and was equally at home when entering into debate with physical geographers, archaeologists, evolutionary scientists and others. He even found time to keep abreast of developments in medicine and to maintain contacts with his family members and friends allied to that profession, especially through his devoted wife Beryl, who spent her career as a practising family doctor while raising their four children, Robert, James, Fiona and Bernard.

Not only was Russell a brilliant scientist, he was also a great communicator. No-one who has been to a Russell Coope lecture will ever forget the experience, for he charmed, informed, amused and entertained in equal measure. And he was a wonderful raconteur. He loved nothing more than to spend an evening, often in the company of his favourite malt whisky, discoursing on subjects ranging from art, philosophy and the classics, to literature and antiques, of which he was an avid collector. It was probably this broad intellectual canvass that enabled Russell to paint the bigger picture. But he also had the statistician's instinct that 'outliers' can often provide more insight than the modal grouping. In his meticulous analysis of each fossil beetle assemblage, he left no carapace unturned, and was always intrigued and excited by the unusual occurrences – those fossils that were, as Russell frequently expressed it (with his usual lack of deference to political correctness), '*as rare as a pork chop in Jerusalem*'. These surprising discoveries were often the catalyst for a new perspective on, and often a rewriting of, the fossil beetle record.

Russell continued his beetle research and publication of the results long after his formal retirement, and particularly while holding Honorary Professorships at the University of Birmingham and at Royal Holloway University of London. As recently as 2010 he was co-author of a multi-disciplinary *Nature* paper that described the discovery and environmental context of the earliest human artifact to be found in Britain, which appears to be over three-quarters of a million years old. Shortly before his death, he had taken custody of a new set of samples from a Hoxnian site, and was describing, with his usual excitement and enthusiasm, the discovery of yet another highly unusual fossil beetle within the assemblage. This consummate passion for his subject comes as no surprise to those of us who have been fortunate enough to have worked closely with him, to have enjoyed his company, and to have been privileged to count him as a friend. While deeply mourning his passing, we salute a man of great wisdom and indomitable spirit, whose pioneering work on fossil coleopteran studies will ensure his place as one of the outstanding Quaternary scientists of our time.

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RICHARD WILLIAM HEY (1917-2011)

Richard William Hey, the co-founder of the Quaternary Field Studies Group – the forerunner of the Quaternary Research Association – died on 14th November 2011 aged 94. Richard brought up in Yorkshire, and it was here, where the rocks are an ever present, frequently commanding element of the landscape, he developed his passion for geology. Richard went up to Trinity College Cambridge in 1935 to read Natural Sciences and took his BA in 1939.



Figure 1. Richard Hey explains the Westleton Beds at Wangford, QRA Field Excursion on the Pliocene – Middle Pleistocene of East Anglia, April 1988. Photograph: James Scourse.

On the outbreak of war Richard volunteered and joined the RAF as a Flight Lieutenant. Always very short-sighted, Richard was employed as an aerial photograph reconnaissance officer. He spent much of the war in North Africa and was attached to the United States 7th Army during Operation Anvil, the invasion of southern France, reaching Germany in May 1945. At a presumably very late stage during the war he was stationed at Bletchley Park, interpreting the images of the Peenemünde V2 rocket site on the Baltic coast. Asked once what it was like to be at Bletchley, Richard commented “Oh, absolutely awful. Too many really rather odd people with far too many brains all cooped up together. Just like Cambridge really!”

Richard’s experience of aerial photography, geology and the Mediterranean coastal regions was to prove decisive for him after the war. First, however, he returned to Yorkshire as an exploration geologist investigating potential sites for open-cast exploitation in the South Yorkshire coalfield. He might have continued this work had he not received an invitation in early 1947 from Cambridge colleague Charles McBurney, who later became Professor of Palaeolithic Archaeology, to join an expedition to the coastal region of Libya. Like Richard, McBurney had served in the RAF as an aerial photograph

interpreter. Crossing the desert in Cyreniaca he had recognised sites scattered with Palaeolithic stone artefacts and was anxious to return to investigate them. Many of the finds were in geological contexts and therefore he needed a geologist to unravel the environmental evidence, as well as to suggest possible ages. Richard's local knowledge and general geological expertise were appropriate and so he was persuaded to join McBurney for an expedition in summer 1947, a successful season followed by a second in 1948. This work involved Richard studying the broader context of the shorelines and marine, alluvial, dune, tufa and slope deposits along the coastal plain, eventually published as *Prehistory and Pleistocene Geology in Cyrenaican Libya* (1955; Hey and McBurney), a notable early example of Quaternary inter-disciplinary collaboration.

Whilst he was in Libya, W.B.R. (Bill) King, who was the head of the Cambridge Geology Department ('the Sedgwick'), suggested that Richard register for a Ph.D on Cyrenaican Quaternary research and this he duly did on his return in 1947, supervised by King himself. Richard was awarded his doctorate in 1951 and shortly after was appointed to a University Demonstratorship. He was appointed to a University Lectureship in 1956, a post he held until his retirement in 1982.

Although Richard himself had no formal Quaternary training, the newly-established Subdepartment of Quaternary Research under Harry Godwin contributed significantly to encouraging Richard's developing interest in the British Pleistocene. Richard's first venture into the English Quaternary came in the mid - 1950's when, during walks close to his sister's home near Malvern, he realised that the work on the terrace deposits of the lower Severn by the Birmingham geologist Wills required revision. Richard's studies led to three publications in the late 1950s and early 1960s.

At about the same time, Richard became involved in the INQUA Subcommission on Mediterranean - Black Sea Shorelines and the Working Group on the Pliocene - Pleistocene Boundary (formerly the Neogene-Quaternary Boundary). The latter group was established to define the precise position and correlation of the boundary, work only finally published in 1997 (van Couvering 1997). In this volume Richard reviewed the evidence from Britain (the Craggs) and Iceland (the Tjörnes section), his interest in the latter area being the result of a visit to Iceland at the invitation of his friend Þorleifur Einarsson (University of Iceland).

Meanwhile, Richard maintained an interest in north Africa, returning to undertake further fieldwork in summer 1962. Coincidentally he had been appointed internal examiner for the Cambridge Geography research student Claudio Vita-Finzi who had been studying recent wadi sedimentation. This was Richard's first PhD examination appointment but he started as he meant to go on, by giving the candidate his oral examination at sites along the coast over several days, rather than in his University office. Others, including both Phil Gibbard and James Scourse, also benefited from this unconventional yet agreeable form of *viva voce* examination.

During the early 1960's, during his frequent weekend walking forays into Hertfordshire and western Essex, Richard started to notice exposures of the high-level Pebble Gravels. Richard was aware that Sir Joseph Prestwich (1890) had proposed a correlation of the Pebble Gravels with the Westleton Beds of the Suffolk coastal area, and had thus extended the Westleton Beds from the coast to the Goring Gap in Oxfordshire at a stroke - an idea that was ripe for reconsideration. His interest sparked, he resolved to investigate these enigmatic sediments and he began "wandering on foot a great deal in the Lea Valley" and "mostly satisfied his idle curiosity by wandering around Barnet and Elstree" examining sites that had been identified by the geologist H.J. Osborne White. He was rewarded by the discovery of a hitherto unnoticed quartz-rich unit in the lower Pebble Gravels which he named, after a site in western Essex, the Westland Green Gravels. The 1965 publication in which Richard described this unit extending from Berkshire to Essex was unquestionably a milestone that marked a new era in Thames drainage system research. This is because in this investigation we see the first systematic application of statistically-valid clast lithological counts to the sediment gravel fraction. Other workers have continued this approach ever since.

Building on this success, Richard set about tracing his quartz-rich gravels downstream which led to his sedimentological investigation of the Westleton Beds (Figure 1). This study represents a pioneering application of sedimentological principles, in particular the comparison with Dungeness as a modern analogue, to this part of the British Pleistocene succession. He recognised that the deposits represented a marine littoral and sublittoral accumulation that pre-dated his quartz-rich unit (1967). At the same time he followed quartz-bearing gravel as far as Norwich, where it occurred beneath the Norwich Brickearth (North Sea Drift Formation till), and into Essex. He was certain that the gravels, although representing multiple aggradational units, were preglacial accumulations of the Thames. At this time Jim Rose and Peter Allen (then of Birkbeck College, London) liaised closely with Richard. Following discussions in Cambridge, Rose and Allen received a letter from Richard, giving a list of sites in Hertfordshire, Essex and Suffolk that might be of interest. Rose and Allen then visited each with mounting excitement, finding that at almost every one there was a development of Thames river gravels capped by a palaeosol and overlain by glacial deposits. The work was quickly submitted to *Nature* where it was published in the same year (Rose, Allen and Hey, 1976). Rose and Allen named their gravels the Kesgrave Sands and Gravels (Formation) and the soil, the Valley Farm Palaeosol (Rose and Allen, 1977; Rose, Allen and Hey, 1976).

Richard then traced the Kesgraves into north Norfolk where his Cambridge colleague Richard West, of the Subdepartment of Quaternary Research, was investigating the Cromer Forest-bed Formation of the Norfolk coast and the

early Pleistocene crags further south. Richard was able to demonstrate that the quartz-rich gravels first arrived in the newly identified pre-Pastonian Stage. Richard's examination of clasts in the East Anglian Thames gravels indicated they contained bleached quartz pebbles from the Bunter pebble beds of the Midlands and erratic rhyolite pebbles from North Wales. Although Richard had already observed these phenomena in the 1960s, it was not until the 1970s that his ideas were published with Christopher Green and Duncan McGregor (then of Bedford College, London).

In the late 1960s to early 70s, Richard's interest in early Thames gravels led him and Richard West to ponder the evidence for the Thames' diversion from its former course through Hertfordshire to that through London. The diversion of the Thames seemed an appropriate research project and Phil Gibbard took up the challenge and was set to work under the supervision of West, but with regular advice from Richard. This application of the clast lithological technique served to emphasise further its suitability for both the subdivision and provenance study of Thames system alluvial deposits in general. Work continued through the 1980s, culminating in a complete re-investigation and evaluation of the Thames system Pleistocene by Gibbard and David Bridgland, then of the City of London Polytechnic, now at Durham University, working independently. Arguably the subsequent re-examination of the geological evolution of many other lowland English river systems can be attributed to the seminal burst of activity initiated by Richard's pioneering discoveries in the Pebble Gravels.

In the early 1960s, Richard was appointed to a Fellowship in the newly-established Churchill College. Richard became very involved in the life of the college, where he became resident, and was able to indulge his passions of art, collecting modern art and particularly abstract paintings, and music. Richard was a vigorous pianist and an enthusiastic cellist, and spent many chamber music sessions with like-minded Quaternarists, notably Nick Shackleton (clarinet) and James Scourse ('cello). Earlier in his career he had been an excellent rock-climber, organizing *ad hoc* trips with friends from Cambridge, notably to Snowdonia, and he retained a keen interest in architecture to the end.

During a Yorkshire Geological Society excursion one weekend in 1962, Allan Straw (then University of Nottingham) and Bill Watts (Trinity College Dublin) demonstrated the Quaternary of the Lincolnshire Wolds. These topics attracted an unusually large number of Quaternary workers and this prompted Richard to muse that an organisation to run Quaternary field excursions, modelled on the informality of the Yorkshire Geological Society, might be successful. After discussing the matter with colleagues, notably Richard West, in 1963 the two sent a letter to all potentially-interested colleagues suggesting that the Quaternary Field Study Group (QFSG) be established. The reaction was very positive, and at Easter 1964, the QFSG held its inaugural field meeting, based at the University of Birmingham and organised by local secretary Russell Coope,

another key founding member of the QRA who recently sadly died within days of Richard's own death. The QFSG quickly became established as the national forum for Quaternary Science and, was renamed the Quaternary Research Association (QRA) in 1968. Richard served the QRA in many ways; he was a QFSG committee member from 1964-66, President of the QRA 1981-3 and was appointed an Honorary Member in 1984.

On retirement Richard left Cambridge and settled in Herefordshire. He nevertheless continued his gravel-based research, demonstrating the existence of four terrace units in the Wye catchment and, as a by-product, creating a new gravel drive at his cottage. Later he was forced to give up both music and field geology after suffering a stroke. Reflecting on his research in England, Richard said his overriding impression was of "Sunday afternoons running across fields whilst carrying large bags of gravel being chased by large Alsations and farmers with double-barreled shotguns"!

Formally, Richard only supervised one research student, Nic Flemming (1960-1964), now at the Southampton Oceanography Centre. Nevertheless through Richard's encouragement of colleagues and also young research workers, he made an indelible mark on the subject that all will readily acknowledge. Everyone who knew Richard tells the same story. He was a charming gentleman, excellent company in both social and professional contexts and whose contribution to Mediterranean and British geology was, typically of the man, understated and yet substantial.

Acknowledgements

This obituary is an abridged and slightly adapted version of the biography published in the *Proceedings of the Geologists' Association* in 1999 (Gibbard and Vita-Finzi, 110, 83-92) and we would like to acknowledge all those who provided information for that earlier publication. Readers desirous of more detail, particularly concerning specific aspects of Richard Hey's geological research, and a full bibliography, are recommended to consult the earlier publication.

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REPORTS

“WHEN PUSH COMES TO SHOVE”: UNRAVELLING POLYPHASE GLACIOTECTONIC DEFORMATION HISTORIES

**QRA, GLWG and IPA Workshop and Fieldmeeting, North Norfolk,
11th-16th September 2011**

Yet again the Quaternary Research Association found themselves back in East Anglia! On this occasion – the 9th meeting to be staged in the region, a new workshop format was employed with two days of lectures, posters and classroom discussion, and two and half days of field visits focussing on Glaciotectonics. The meeting was co-sponsored by the Glacial Landsystems Working Group (GLWG) as their 12th annual meeting, and the International Permafrost Association (IPA). To provoke informal and productive discussion, numbers were restricted to just under 30. Participants were far travelled and included a good mix of and well established academics, research students and Quaternary enthusiasts (Figure 1).

Day 1

The week began on the evening of the 11th Sept at the Sheringham YHA where we were greeted by organisers **Emrys Phillips**, **Jonathan Lee** and **Hannah Evans** (British Geological Survey) together with impressive information packs that included the *Glaciotectonics Field Guide*. After a formal welcome and logistical overview from **Emrys Phillips**, the first session was kicked off by **Jonathan Lee** who led the introductory lecture which took us on a journey through time by documenting the origins and development of glacial theory and glaciotectonic theory, through to modern day and deformable beds and landystems. Jon commented on the steady stream of glaciotectonic PhD studies over the past 30 years as a tribute to the significance of the discipline. He closed with a summary of the Quaternary backdrop of East Anglia, its glacial history, various tills and resulting glaciotectonic melange.

Day 2

After a less than peaceful nights' sleep for the few adventurous campers who braved the tail-end of Hurricane Katia, the workshop proper began with a full day of presentations. The morning session, chaired by **Jaap van der Meer** (Queen Mary, University of London), was kicked off by talks from **Julian Murton** (University of Sussex) and **Dave Evans** (University of Durham) on the permafrost areas of Arctic Canada. Julian discussed the interactions of



Figure 1. Group photo of delegates who attended the meeting.

cold-based ice with the underlying permafrozen glactectonites and resultant ductile and brittle deformations, whilst Dave presented a magnetostratigraphic framework at Banks Island displaying evidence of disturbance through extensive folding, faulting and rafting. **Joseph Pomeroy** (University of Loughborough) followed with signs of deformation within the recently exposed fluted foreland of a poly-thermal glacier in northern Sweden.

The session continued with **Izabela Szuman** (Adam Mickiewicz University, Poland) who spoke about the highly variable conditions at the ice/bed interface based upon macro- and micro-scale observations from sites in Poland and artificial shearing experiments. **Mark Tarplee** (Queen Mary, University of London) followed with an enthusiastic insight into the 3D microscopic 'signature' of strain using X-ray computed microtomography, creating impressive 3D simulations featuring fractures, clasts and voids. The micro-scale theme and animated air was continued by **Amanda Ferguson** (Queen Mary, University of London), with attractive slides effectively illustrating the benefits of micromorphology in understanding polyphase deformation in glacial sediments.

Session 2, chaired by **Julian Murton**, was started by **Anne-Sophie Høyer** (Aarhus University / Geological Survey of Denmark) with observations of large-scale glactectonism from boreholes and Sky TEM geophysical data from western Denmark. **Derek Teasdale** brought us briefly back to the UK with detailed section diagrams and logs from the Whitburn Bay, Northumberland, illustrating complex patterns of glactectonic deformation relating to the flow

of ice down the northeast coast of England. **Harold Lovell** (Queen Mary, University of London) drew our attention to debris incorporation within High-Arctic tidewater surging glaciers in Svalbard, with striking photographs of large debris-rich structures. **Emrys Phillips** closed the session with an insight into hydrofracturing, looking at conditions and processes of hydrofracture formation and resultant characteristics. The day was formally closed with a poster session, chaired by **Jane Hart** (University of Southampton), with presentations on a range of themes from Neoproterozoic glaciectonites in northwest Scotland to chalk rafting in Ireland.

Day 3

The final presentation session was chaired by **Dave Evans**. **Richard Waller** (University of Keele) started proceedings with how the deformation of warm permafrost sediments at sub-freezing temperatures could explain part of the glaciectonic melange at West Runton. **Jane Hart** shared video footage of her subglacial probes in action, working to gain real-life observations of subglacial conditions and till formation. **Harry Langford** returned the focus to East Anglia presenting a sub-aqueous theory for the origin of chalk-rich diamictos within the western margins of The Fens, traditionally considered to be subglacial deposits. **David Vaughan-Hirsch** (University of Southampton / BGS) then presented an insight into the processes leading to glaciectonic rafting and their detachment, transport and emplacement during active ice retreat, using macro- and micro-scale evidence from Killana Bay, Ireland. Ívar Örn Benediktsson (University of Iceland) drew the presentation session to a close with an excellent talk on glaciectonic end moraines of Icelandic surge-type glaciers.

The group then took a short bus ride to a sunny yet breezy Overstrand for the first of the field sessions. Here, **David Vaughan-Hirsch** presented a new interpretation of the spectacular internationally-renowned Chalk rafts. David argued that these were locally derived due to the low level of deformation observed, and became detached near to the ice-margin, or proglacially under the onset of permafrost conditions. **Emrys Phillips** closed the day with an impressive sand-based "Art Attack"-like illustration in support of David's theories.

Day 4

Another sunny day in the field began at West Runton where **Emrys Phillips** led us through the numerous sections along the coastline between East Runton and Sheringham. The theory presented was one of proglacial to subglacial origin in a westward direction whereby:

- proglacial deformation was dominated by thrusting, and steep-sided moraines composed of deformed till

- stacking of up-ice material occurred at the ice-margin due to folding and thrusting
- and highly variable subglacial deformation occurs including folding and thrusting, homogenisation, ductile shearing and superimposition of a shear zone upon earlier deformation, which increases in complexity towards the west to create a distinctive glaciotectonic melange.

The party examined some of the impressive sand basins near East Runton which dominate the coastal geology, and **Emrys Phillips** presented a new model arguing that the sand basins were syn-tectonic extensional basins that opened at the tips of small thrust-block moraines. The traditional model, that these sand basins are massive load structures, was presented by **Jane Hart**. Opinions were sharply divided between both models with debate focussing principally on the nature of the basin margins – were they extensional faults or soft sediment deformation structures?

Heading westwards towards Sheringham, the next stop involved a healthy debate on the significance of a large sand-filled fracture partly exposed beneath the glacial succession – was it a hydrofracture or an ice wedge? Opposing arguments were presented by **Dave Evans** and **Julian Murton**, and an alternative model was also presented by **Emrys Phillips**, whereby the feature was an ice wedge that was later over-printed by hydrofracture development. However, the base of the feature was not visible and so the question was left open for future consideration and it was stressed that much more research is needed on this northern part of the Norfolk coastline. Continuing westwards, the party stopped at various points for **Emrys Phillips** to describe the glaciectonic structures associated with deformation at the margin (large scale folding and thrusting) and submarginal to subglacial deformation (polyphase folding, fabric development, liquefaction). Drawing proceedings to a close, **Richard Waller** spoke about the sand intraclasts which occur commonly within the till and argued that these were actually incorporated into the glaciectonic melange as partially frozen blocks remaining largely intact.

Day 5

On this again glorious day we met at The Esplanade in Sheringham for our final outing and, after waiting for late arrivals due to the previous night's conference dinner, we began our way to the less than imposing summit of Skelding Hill to the west of Sheringham. **Jonathan Lee** gave an introduction to the geomorphology of the area pointing-out the various landforms including the Cromer Ridge push moraine and the Kelling and Salthouse outwash plains. The party then continued westwards for about 3 kilometres before descending onto the beach.

Emrys Phillips introduced the first site, demonstrating evidence of subglacial channels within the sequence which had been over-ridden by ice and progressively deformed. **Jonathan Lee** described a second set of channels at the next site that intersected the cliffs west of Sheringham. Jon argued that these were filled by sediments deposited as hyper-concentrated flows that originated as mass-wastage of the scarp slope of the Cromer Ridge. Heading eastwards, **Emrys Phillips** described sections of thrust diamicton and outwash gravel that were produced by a final southwards-directed ice advance.

The final site of the day was a spectacular Chalk raft that formed part of Skelding Hill. **David Vaughan-Hirsch** and **Emrys Phillips** introduced the site, with delegates impressed by the stunning array of deformation structures within the diamicton adjacent to the raft margin. **Dave Evans** then called the meeting to the close, extending warm thanks to the organisers for a superb and thought-provoking meeting.

As a relative "newbie" back into the glacial world, I found this workshop a great forum for free discussion and networking in a friendly and encouraging environment, with impressive contributions from participants of all levels. The course content was well focused on the glaciotectionics theme and the location of north east Norfolk appropriately chosen with its complex displays of deformation structures, much of which can be revisited in the superbly prepared Glaciotectionics Field Guide.

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16TH QRA ANNUAL INTERNATIONAL POSTGRADUATE SYMPOSIUM

30TH August to 1ST September 2011, University of Durham

The 16th QRA Annual International Postgraduate Symposium was hosted by the Department of Geography at Durham University during 30th August to 1st September 2011 by postgraduate students **Vicky Brown** and **Ed Garrett**. Almost forty students from across Europe came together to participate in presenting their innovative research and to discover the wide array of Quaternary research being undertaken by the postgraduate community. During the two and a half days, we were transported along the Durham coastline to look at fascinating remnants of Quaternary environments; captivated by 21 student presentations and 14 posters from 4 themed sessions (palaeoglaciology, sea-level change, palaeoclimatology and geoarchaeology/landscape evolution) which were introduced by 4 keynote speakers; and indulged in good food, tasty beverages and social banter.



Figure 1. Symposium participants 2011, Durham University.

Many delegates met on the Monday (29th August 2011) evening to register and have a welcome drink in the college bar of Van Mildert College, where most of the participants were staying. The next morning (Tuesday 30th August) the symposium started in full swing with a day along the Durham Heritage Coastline visiting Quaternary deposits and landscapes, with experts from Durham Geography Department describing the environments in which they formed. First stop was at Whitburn Bay (about 20 miles north of Durham) where **Derek Teasdale**, a PhD researcher at Durham examining the Quaternary sedimentation history in this area, highlighted features in the exposed cliff for evidence of past glaciation from competing lobes of ice. During the LGM Whitburn Bay was an important location for the coalescence of ice lobes

originating from Scotland and the North Sea, and until recently, the lack of chronostratigraphic control has prevented the reconstruction of various flow phases and ice interaction. As a group we cleaned-up and examined a number of sedimentary features (pipe structures, hydrofractures and folding) in the cliff along the beach, whilst Derek discussed the history of the site.

Just before lunch we hopped back on to the coach and headed south along the coastline to Easington. A lovely walk across the headland and short scramble down towards Shippersea Bay brought us to Easington Raised Beach. **Dr Dave Bridgland** set the scene for the area by pointing out key topographic features and highlighting that the area has SSSI status as a result of the raised beach and the variety of surrounding flora and fauna. Easington Raised Beach is thought to be the most northerly remnant of raised beach in England from the Middle Pleistocene. It is suggested that its preservation is a result of the proximity of Beacon Hill to the west, which would have deflected subsequent ice from proceeding directly over the raised beach deposit allowing its preservation to this day. Amino acid dating of marine shells found in the deposit and supporting OSL dates indicated that the beach formed between 240 and 200 ka BP (MIS 7). A short walk further at Hawthorn Dene, where a traditional brick railway bridge spans the gap, evidence of rapid post-glacial incision was discussed along with various arguments for the gaps' formation.

Further south along the Durham coastline we found ourselves at Cowpen Marsh in Cleveland; a remnant of a much larger former tidal flat. **Dr Natasha Barlow** and **Dr Matthew Brain** led this part of the excursion by explaining the importance of this area for providing stratigraphic and microfossil evidence of relative sea level (RSL) changes since the LGM and the problems encountered with postglacial isostatic adjustments when reconstructing RSL histories around the UK. Set against the backdrop of heavy industry and with the rain setting in, we were soon distracted by the equipment brought by **Van Walt** (sponsoring body) to demonstrate sediment sampling. Various coring equipment was demonstrated and those who wanted to participate had an opportunity to have a go themselves. Using a percussion hammer, the stratigraphy at Cowpen Marsh down to about 2.5 meters was captured in a liner and window sampler. **Dr Natasha Barlow** briefly described the environment in which each stratigraphic unit would have formed in relation to what sea level was doing, whilst **Dr Matthew Brain** explained the issues of sediment autocompaction and its effect on reconstructing sea level change.

During the following two days (Wednesday 31st August and Thursday 1st September), the symposium was held in the Geography West Building at Durham University. Fascinating oral presentations kept us captivated through a diverse range of subject areas split into four-themed sessions, initiated by keynotes given by invited speakers. The first of these was given by **Dr Chris Stokes** to kick-start the session *Palaeoglaciology*, followed by a second session on

Palaeoenvironmental reconstruction. After lunch we were treated to a session on *Geoarchaeology/Landscape evolution* introduced by **Dr Dave Bridgland**. Subsequently a poster session and drinks reception ensued, where authors were required to display and defend their posters. It was also an opportunity to have informal discussions amongst members about the day's presentations and to discover shared research interests.

In the evening, the conference meal was held at Oldfields Restaurant in the centre of Durham, serving real British food from locally sourced produce. The three-course meal was delicious and the atmosphere superb; it was an opportunity to relax and get to know people beyond their research.

The first session of the final day was *Palaeoclimatology* and was introduced by a keynote by **Dr Erin McClymont** (Newcastle University), followed by three student presentations. After morning coffee **Professor Ian Shennan's** keynote opened the *Sea-level change* session, which included three more fascinating talks from postgraduate researchers but also indicated the end of this year's symposium.

There was just enough time to make some crucial decisions about the venue for next year's symposium and to present the awards for the best oral and poster presentations. Congratulations to **David Vaughan-Hirsch** from Southampton University for the Best Oral Presentation entitled *Large-scale thrusting and glaciectonic rafting of limestone bedrock during active ice-retreat; an example from Killala Bay, Co. Mayo, Republic of Ireland*, and to **Nicola Brocklehurst** from Keele University for the Best Poster Presentation on *Ecological and sedimentological characteristics of kettle-hole lakes in the proglacial environment, Skeidarársandur, south-east Iceland*. Members from the Department of Geography and Environment at the University of Aberdeen made a successful bid to host next year's symposium in August/September 2012. **Danni Pearce** (University of Worcester) was successfully elected as the new QRA Postgraduate Representative alongside existing representative **Marcus Hatch** (Queen Mary, University of London), whilst **Helen Cockerton** stepped down from the two year position.

On behalf of all the postgraduates and the QRA, we would like to thank **Vicky Brown** and **Ed Garrett** for their hard work in creating a fantastic postgraduate symposium at Durham University this year. We look forward to welcoming new and existing members to the 2012 symposium hosted by the Department of Geography and Environment at the University of Aberdeen.

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MARINE TEPHROCHRONOLOGY MEETING

October 26TH 2011, Geological Society of London

A one day meeting on the theme *Marine Tephrochronology*, co-sponsored by the QRA and the Marine Studies Group, was held at the Geological Society of London in October 2011. A diverse programme was organised by Bill Austin (University of St. Andrews), Peter Abbot, Siwan Davies (Swansea University), Nick Pearce (Aberystwyth University) and Stefan Wastegård (Stockholm University). There were over 50 attendees from across Europe, which included (amongst others) tephrochronologists, palaeoceanographers and volcanologists.

In total there were 12 oral presentations, including four invited speakers, and 18 poster presentations. The day opened with a paper on the transport of volcanic ash by Stephen Sparks (University of Bristol), which set the scene for a number of talks on mechanisms of transport and deposition of tephra in the marine realm. These included a discussion of tephra as airfall and ice rafted debris in the North Atlantic by Jo Brendryen (University of Bergen), and novel thin section investigations of tephra layers in Adriatic marine cores by Ian Matthews (Royal Holloway, University of London).

Christel van den Bogaard (Leibniz Institute of Marine Sciences, IFM-GEOMAR) moved the focus away from European records and gave an overview of the KALMAR project and the tephrochronology of the NW Pacific region. This was followed by two papers on Patagonian tephrochronological records: David Pyle (University of Oxford) discussed the timing and causes of southern Chilean volcanism and Giuseppe Siani (Université Paris Sud) demonstrated how South Chilean Margin tephra records are helping to understand ¹⁴C reservoir ages.

After a lively lunchtime poster session, Hafliði Hafliðason (University of Bergen) began the afternoon's session with an historical review of North Atlantic tephrochronology and a discussion of future possibilities. We stayed in the North Atlantic for the next two talks. Peter Abbott (Swansea University) provided an overview of the SMART project's investigation of MIS 4 to 6 tephra horizons and Esther Ruth Guðmundsdóttir (University of Iceland) presented an impressive and detailed tephrostratigraphical record from the North Iceland Shelf.

Two further talks provided examples of tephrostratigraphical applications. Samantha Engwell (University of Bristol) showed how distal tephra deposits can provide evidence of eruption characteristics, and then Anna Bourne (Royal Holloway, University of London) demonstrated the use of marine tephrostratigraphies in independently testing the chronologies of palaeoceanographic archives. The day was brought to a close by John Lowe (Royal Holloway, University of London) who talked about the "fruits and trials" of the painstaking study of cryptotephra layers in Quaternary marine deposits.

The posters, displayed throughout the day, picked up on the main themes of the meeting by presenting marine tephra records from around the world, exploring methods of tephra deposition and by demonstrating novel approaches to geochemical identification.

Discussions were, of course, continued enthusiastically in a nearby pub where delegates got to reflect on a fascinating meeting. Proceedings from the meeting are to be compiled in a Geological Society Special Publication, which promises to be an interesting read. Thanks are given all of the meeting organisers. As well as those responsible for the scientific content (listed above), help was given by Emma Martin and Helen Olaz (University of St. Andrews) and to Louise Dyer and her team at The Geological Society.

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‘ALL AT SEA’ CONFERENCE. ‘COASTAL ENVIRONMENTS: AN HOLISTIC APPRAISAL

September 8TH – 9TH 2011, University of York

The second ‘All at Sea’ meeting at the University of York was much anticipated and took place at King’s Manor, a building with a rich cultural heritage located at the heart of the walled city. It was within this historic setting that the international delegates assembled.

Katherine Selby (York), the principal organiser, welcomed everyone and introduced the first, thought-provoking keynote presentation by **Gustav Milne** (UCL). He discussed the daily threat posed to our coastal heritage by tidal erosion; highlighting the importance of long-term monitoring projects in the intertidal zone, such as the Thames Discovery Programme. These allow at least a sample of the available information to be retained, for use in multi-disciplinary research.

Following a coffee break and discussion, **Sarah Woodroffe** (Durham) chaired the first session of presentations on ‘Coastal environments in mid-latitudes.’ **Simon Fitch** (Birmingham) gave an holistic interpretation and discussion of the final results from the Humber Regional Environmental Characterisation Project. **Katie Szkornik** (Keele) then presented preliminary findings from research into the sedimentary record of Larnaca salt lake, Cyprus: testing the impact of environmental changes on the Late Bronze Age abandonment of the harbour town Hala Sultan Tekke. The interactions between land, sea and society were also the focus of **David Ryves**’ (Loughborough) talk on Holocene environmental change in coastal Denmark; a multi-proxy PhD project by **Jonathan Lewis** (Loughborough), encompassing the last ~9,000 years. **Patrick Kiden** (Geological Survey of The Netherlands) considered the regional and local factors influencing Holocene water-level evolution in the Netherlands over the last 50 years, highlighting the importance of palaeogeographical knowledge in its interpretation. **Wolfram Wartenburg** (Institute for Chemistry and Biology of the Marine environment) then transported us to northwest Germany relating the changing Holocene sedimentary record from terrestrial to marine influence, of a modern embayed tidal flat system at Jade Bay, Lower Saxony. The morning’s presentation session was concluded by **Katie Szkornik**, discussing **Kelly Ross**’ (Keele) PhD project on the Holocene salt-marsh stratigraphy and coastal evolution of the Dyfi Estuary, west Wales, UK.

A fine spread awaited us at lunch, which was enjoyed alfresco by some, as the courtyard was now bathed in the midday sun. With the lunch break, also came the opportunity to peruse and admire the diverse collection of research posters.



Figure 1: Delegates enjoy a sunny afternoon in the courtyard at King's Manor.

The second mid-latitude session was chaired by **Katie Szkornik**. **Roland Gehrels** (Plymouth) dealt with the constraints on late glacial relative sea level in western Ireland. **Tom Lawrence** (Plymouth) followed, constraining the amount of sea-level rise that triggered the 8.2 ka climate cooling; revealing the southernmost evidence of the Storegga Slide tsunami on the East coast. As part of a wider research programme of analysing spatial and temporal trends in sea-level change across the North Atlantic over the last 500 years, **Margot Saher** (Plymouth), examined relative sea level change in New England, USA disclosing preliminary results from Maine and Connecticut, whilst **Natasha Barlow** (Durham) followed with Late Holocene relative sea level change in northwest Scotland. **Barbara Mauz** (Liverpool) then discussed observational data for a mid-Holocene sea-level highstand in the Mediterranean; assessing the significance of south eastern Tunisia for recording an Antarctic meltwater fingerprint.

Roland Gehrels chaired the final mid-latitudes session of the day, which began with **Zhixiong Shen's** (Tulane) study into the rapid and widespread response of the Lower Mississippi River to eustatic forcing in the last glacial-interglacial cycle. A provocative presentation by **Matt Brain** (Durham) ensued, on compression of low energy intertidal sediments, considering the controls, effects and solutions. **Ruth Thurstan** (York) concluded the day's presentations with a reconstruction of 150 years of change in UK seabed habitats. This was undertaken through ecological surveys, sediment coring and analysing historical evidence of oyster abundance, to understand temporal changes in mollusc communities in response to human activities.

Delegates were then able to relax and reflect on the day with a drinks reception and dinner in the King's Manor refectory; inevitably heading to The Maltings afterwards, one of York's fabled 365 pubs, to sample a comprehensive range of real ales!

The following morning, **Dominic Hodgson** (British Antarctic Survey) began with a fascinating keynote presentation on improving estimates of ice mass loss from Antarctica using records of Holocene relative sea level change. He discussed the use of radio-echo sounding to map palaeocoastlines and highlighted the difficulty in reconstructing Holocene/ Pre-Holocene relative sea level change in Antarctica, especially as penguins are notorious for altering the coastal geomorphology!

Nigel Pontee (Halcrow) chaired the first session of the day on 'Coastal environments in high latitudes.' **Eva Panagiotakopulu** (Edinburgh) discussed palaeoenvironmental investigations into marginal environments and human impact in Greenland and the Norwegian Arctic, primarily through the use of insect fauna. **Antony Long** (Durham) concluded the session, by revealing a novel dating technique using the marine bivalve *Astarte borealis*, to develop high resolution chronologies of sea-level change and coastal evolution in the high arctic.

The second keynote presentation of the day was by **Sarah Woodroffe**, who related the inherent problems of dating mangrove sediments from the Seychelles, whilst searching for eustasy in mid-late Holocene sea-level records from the Indian Ocean. Chaired by **Andy Bicket** (Wessex Archaeology), presentations on 'Coastal environments in low latitudes' continued. **Paramita Punwong** (York) presented her research on Holocene mangrove and sea level changes on the northwest coast of Zanzibar, Tanzania and outlined similar problems in dating the sediments. **Matt Williams** (York) utilised archaeological and coastal geomorphological techniques in his multi-disciplinary approach to studying the mid-Holocene palaeocoastlines of the Red Sea.

After lunch, **Nigel Pontee** delivered the final keynote presentation, forecasting future coastal management approaches and challenges in the UK. The 'Future coastal management' session was chaired by **David Ryves**. **Andy Bicket** discussed recent work by Wessex Archaeology around the Solent and Isle of Wight, encompassing 500,000 years of Archaeology from England's South Coast and the implications for future management. **Katherine Selby** then presented results of a contemporary study into the multifaceted impacts of the Churchill Barriers, Scotland on the coastal environment, since their construction 70 years ago; also considering the implications for future management of such structures.

The theme of future coastal management continued in the final presentation session, chaired by **Antony Long**. Through his interdisciplinary study into sea-level rise and coastal vulnerability around the Southwest Main Line, **David**

Dawson (Plymouth) emphasised the socio-economic importance of coastal research in planning for a sustainable future. **Ken Pye** (Ken Pye Associates) echoed this theme with his concluding talk on research commissioned by The National Trust, into the past, present and future geomorphological development of the North Norfolk Coast, UK.

Thanks to all involved, especially to organisers **Katherine Selby**, **Antony Long** and **Sarah Woodroffe**, for a thoroughly enjoyable conference; a truly holistic appraisal of coastal environments, drawing on a wealth of expertise from the diverse spectrum of coastal research. We look forward to next year's meeting!

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QUATERNARY RESEARCH FUND

CAVE SEDIMENTS FROM THE ATTERMIRE-HORSESHOE COMPLEX, YORKSHIRE DALES

Background and rationale

The limestone caves of the Yorkshire Dales have yielded an impressive range of Quaternary faunal remains and archaeological artefacts (King, 1974; Taylor *et al.*, 2007, 2011; O'Connor, 2011; Taylor, 2011; Wilkins, 2011). Nevertheless, many sites have not received the attention they deserve, in part due to the complexity of their stratigraphy and the often byzantine histories of survey, excavation and exploration stretching back into the nineteenth century, conducted by antiquarians, archaeologists, speleologists, amateur cavers and others. The preservation of archives has often been partial and patchy and publication has often been significantly delayed or absent.

The Attermire-Horseshoe cave complex (SD 84145 64187; Altitude 420 m OD), located near Settle in the Yorkshire Dales, is typical in this regard, having been described as early as 1800 by Housman and excavated in 1930 by James Simpson and again by Walter Howarth in 1947 who recovered Romano-British brooches, iron wheel fittings, an iron lamp holder and stand, a sheet lead bowl, and a perforated whetstone from the narrow outer access ledge, and revealed a charcoal-rich deposit in limestone scree beneath the cave entrance where finds included Romano-British metalwork, and a quernstone (Lord Cave Archive; T.C. Lord pers. comm.; King, 1974; Branigan and Dearne, 1992; Henig and King, 2003).

The complex is currently unscheduled and protected only by its location within the Yorkshire Dales National Park and its SSSI and Countryside Stewardship management scheme designations (cf. White, 2006). The archaeological remains in Attermire and Horseshoe appear to be under immediate threat due to leisure activities and metal detecting, as at nearby Kinsey Cave (Taylor *et al.*, 2011). Following preliminary assessment in 2004 and 2005, with the support and encouragement of Tom Lord and the Yorkshire Dales National Park Senior Conservation Archaeologist, Robert White, limited archaeological and speleological resurvey and test excavation of the cave complex, took place in 2007, with analysis supported by a Quaternary Research Association grant. This was ahead of the (then unexpected) eventual publication by Alan King of Wilfrid Jackson's 1931 report on Simpson's findings (Jackson, 2007).

Horseshoe Cave is adjacent (and has a 'vocal connection') to Attermire Cave which is a key site that has produced significant Romano-British material of a reputed 'cultic' nature (Jackson, 2007), as well as a comb-decorated beaker; in

addition, iron slag and fragments of galena have been found, while secondary copper ores are known from a mine shaft system above the rear of the joint Attermire/Horseshoe cave system (J. Thorp, pers. comm.). The purpose of the 2007 intervention was threefold: (i) to resurvey the cave complex following the original Victorian survey (Cuttriss, 1897); (ii) characterize surviving deposits at strategic points within the cave system and (iii) investigate the potential of surviving spoil from historic (mainly early 20th century) excavations presumed to survive on the scree slope below the Attermire and Horseshoe cave entrances, following a strategy successfully employed at adjacent cave sites (Taylor *et al.*, 2007, 2011; Taylor, in prep.; see Last (2003) for background).

The initial cave floor consists of clay-based sediments which may turn out to be anthropogenic, perhaps caused by prehistoric deforestation. Beyond this the cave leads, via clasts and a cascade, to stalagmitic flooring beneath which many of Simpson's finds were made. Reassessment of deposits in the inner section in 2004 and 2005 indicated evidence of Dark Age/early Medieval activity; from this and other observations, it is conjectured that sediments from within this deep cave system may have washed down to cover in situ deposits in the lower-lying Horseshoe cave, which is currently completely blocked by them (Figure 1).

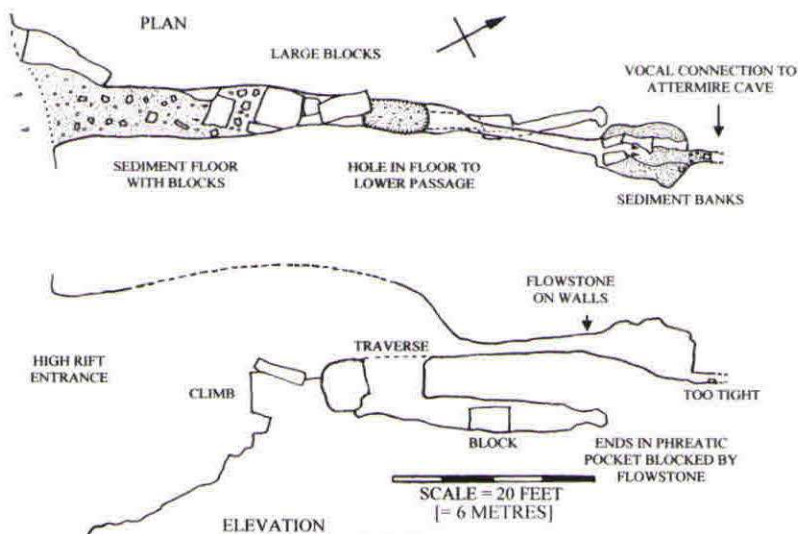


Figure 1. Schematic diagram of Horseshoe Cave, Attermire Scar. Drawing based on L.U.U.S.S. survey 1964. Floor detail J.A. Thorp (2007).

Pollen analysis of a mire immediately beside the cave indicates a largely open environment with little tree cover for most of the Holocene and phasic evidence of extensive burning (Rushworth, 2010). This finding is contrary to the traditional view of Holocene upland environments in the vicinity and even more perplexing as large mammal fauna such as lynx (which require ~40 % tree cover) and bear from adjacent caves have been AMS dated to AD 450-650 (Hetherington *et al.*, 2005; Lord *et al.*, 2007). A series of sediments, partially overlain by a stalagmite floor, were encountered at the lower end of the cave and were characterised by major colour variation between facies.

We extracted a monolith sample from the sediment sequence to i) see if archaeological artefacts were contained within and ii) to examine sediment provenance using pollen, sedimentological and mineralogical analyses. We attempted to test whether these sediments were in-situ, autochthonous cave sediments or washed in from the Attermire cave, or from above ground (allothronous). In addition, we attempted to elucidate the cause of the colour variation in the sediments, as a clear band of darker-coloured sediment may be due to decayed organic remains or in-wash of organic soil.

Results and significance

A sedimentological analysis showed that there is variation organic content and carbonate content in the profile, which explains the marked colour changes in the sediments (Figure 2a). X-ray diffraction (XRD) analyses of five sediment samples showed that the sediments are composed of Quartz and Calcite (Figure 2b). A semi-quantitative XRD analysis showed that there was variation in the relative contributions of Quartz and Calcite from a minimum of 3% (22-24cm) calcite to a maximum of 19% (1-3cm). Organic macrofossils were not encountered in the sediments. Despite these initial findings, further work is needed to fully understand the provenance of the sediments in the Attermire-Horseshoe cave complex including radiometric dating of the stalagmite floors that overlie the sediments in places. Pollen analysis may provide a landscape context to sediment formation. The cave complex is within the Craven Fault zone with its varied and rather complex mineralogy (already alluded to in relation to historic copper mining to the rear of the complex); thus, while the only excavation- recovered artefact was an undiagnostic fragment of probable Bronze Age pottery (ID = A. Gibson, pers. comm.), the presence of copper oxides in the examined sections suggests the possibility that the Horseshoe section of the Attermire-Horseshoe complex may have been substantially artificially created through the working out of a mineral seam in prehistory.

Acknowledgements

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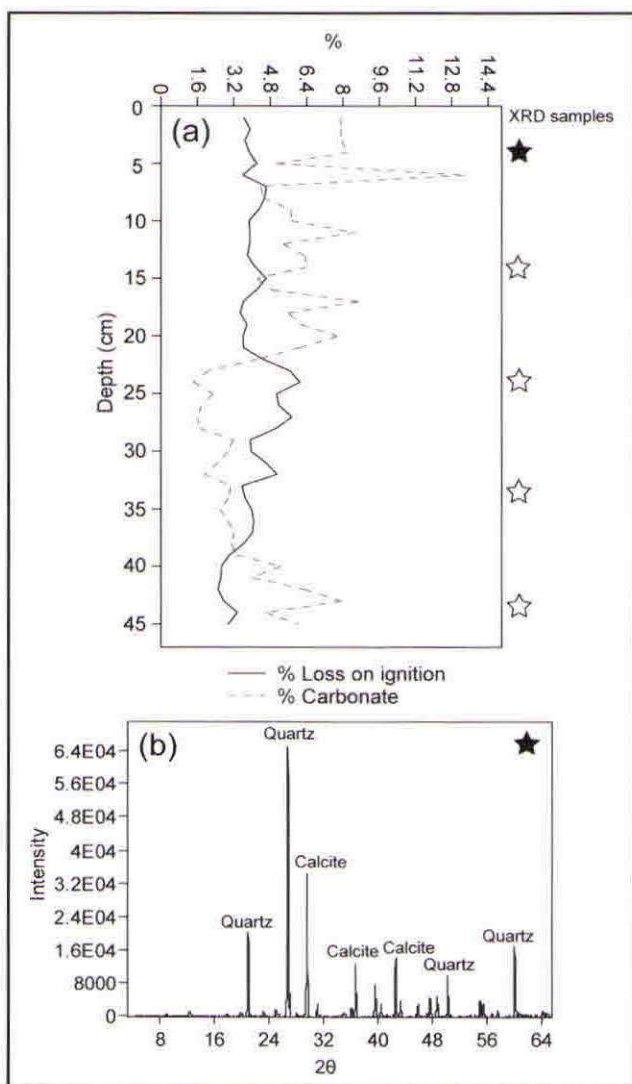


Figure 2(a). Sedimentological analysis **(b)** XRD analysis of sediments from Horseshoe cave.

the XRD analyses. Thanks also to Tom Lord for archival support, Robert White (YDNPA) for additional funding, and the Attermire-Horseshoe survey and excavation team, including Terry O'Connor, Garry Rushworth (palynology), John and Wendy Thorp (cave survey), John Howard and Sue Stallibrass. Christopher Boot is thanked for assistance with sample preparation.

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A REINVESTIGATION OF THE CHAPEL HILL SANDS, NORWICH, NORFOLK

Introduction

Read *et al.* (2007) drew attention to the Quaternary succession at Chapel Hill (TG 228046; ca. 30 m O.D.), ca 4 km south of Norwich. Their investigation of temporary exposures during the construction of the A47 Norwich Southern Bypass led them to recognise a new stratigraphic unit, the Chapel Hill sands, between tills of the Happisburgh and Lowestoft formations, which was interpreted as of marine origin, being deposited during an early Middle Pleistocene interglacial. In addition, the Chapel Hill sands were said to have been subjected to (post-depositional) tectonic uplift in excess of 30 m. Thus these sands occupy a crucial position in the current debate on the regional glacial stratigraphy and may also be important for our understanding of Quaternary crustal movements.

The reinvestigation

Given the potential significance of the Chapel Hill sands and, in particular, the micropalaeontology therein, a resampling exercise was undertaken to procure fresh material for further micropalaeontological analyses. A preliminary coring programme was carried out in January 2009. Three boreholes (BH 1–3, Figure 1) were drilled using a hand-held, petrol-driven Cobra percussion auger fitted with a window sampling chamber. However, it became evident that a more complete understanding of the site could be achieved only by opening fresh faces.

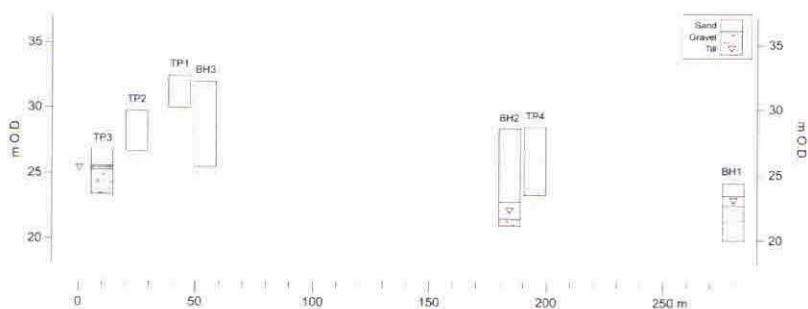


Figure 1. Summary of boreholes and test pits completed during the 2009–10 field investigations at Chapel Hill, Norfolk, positioned along a N–S transect.

The Quaternary Research Fund grant enabled four test pits to be dug with a mechanical excavator in May 2010 (Figures 1 and 2). These test pits exposed the Chapel Hill sands to a total thickness of ca. 6 m. Detailed section descriptions were recorded, palaeocurrent measurements were made on the sands and samples were collected for micropalaeontological and sedimentological work. In addition, four samples were taken for OSL dating using light-tight tubes, and field dosimetry measurements were made with a gamma spectrometer.



Figure 2. Exposure of Chapel Hill sands in TP 4 (Photo: Peter Hoare).

Preliminary findings

Preliminary analysis of samples from this reinvestigation indicates that the Chapel Hill sands are rich in very well preserved calcareous ostracods and foraminifera derived overwhelmingly from the local Upper Chalk bedrock. It has not been possible to identify the autochthonous foraminiferal and ostracod assemblages on which the interpretation of temperate marine conditions was based; a return to the view that they represent glacial outwash (Nickless, 1971) may be more appropriate. The Chapel Hills sands may represent an analogous situation to that suggested for units Pa D–I at Pakefield (Gibbard *et al.*, 2006). If the Chapel Hill sands can be shown to be the result of deposition by glaciofluvial processes, it would not be necessary to invoke tectonic uplift of the area to the south of Norwich following their deposition. Furthermore, the Happisburgh and Lowestoft glaciations may be accommodated within the ‘short (MIS 12) chronology’ (see discussion in Preece *et al.*, 2009).

Acknowledgements

Thanks are due to the Quaternary Research Fund for a grant (to SGL) to support the fieldwork at Chapel Hill; to the landowner, Mr Daniels, for permission to enter his property; to John Whittaker and Haydon Bailey for work on the ostracods and foraminifera of the Chapel Hill sands respectively; and to Rodger Connell and Rob Davis for assistance with field work and surveying respectively. Thanks also go to Nick Ashton, Beccy Scott and David Waterhouse who assisted with coring in January 2009.

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NEW RESEARCHERS AWARD SCHEME

ERUPTIVE HISTORY OF A PERALKALINE CALDERA VOLCANO: PANTELLERIA, ITALY

Background and rationale

Pantelleria is an active volcanic island in the Mediterranean with an eruptive history of at least 300 ka (Mahood and Hildreth, 1986; Figure 1). It has produced lavas, pumice fall deposits and ignimbrites (deposits of pumiceous pyroclastic density currents), some of which are caldera-forming. The eruptive products are of peralkaline trachytic to rhyolitic composition which makes Pantelleria unique in the Mediterranean (e.g. Villari, 1974).

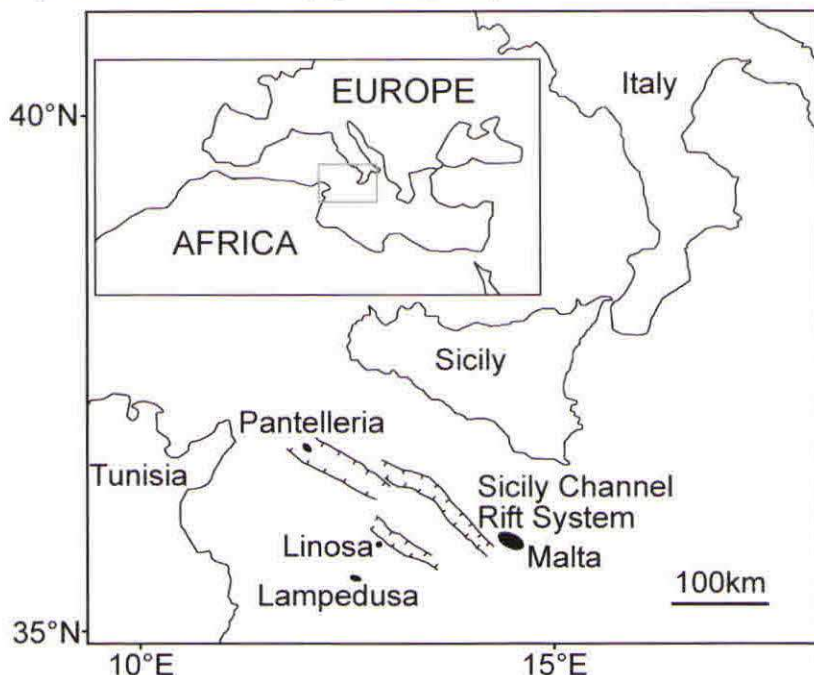


Figure 1. Map of southern Europe to show location of Pantelleria between Europe and Africa.

The ca. 50 ka 'Green Tuff', an intensely rheomorphic welded ignimbrite that drapes the entire island (Figure 2), acts as an important stratigraphy marker (Williams, 2010). It has been correlated to the Y-6 ash layer that has been

found in the Mediterranean as far as about 1000 km to the east of Pantelleria (Keller *et al.*, 1978; Narcisi and Vezzoli, 1999), proving that Pantelleria is capable of producing large eruptions including caldera collapse. Much work has been done to characterize the younger eruption-units, but little is known about eruption-units older than the 'Green Tuff'.

Figure 2. An outcrop of welded ignimbrite with lithic breccia near the top.



The aim of the present research is to determine the older eruptive history of the Pantelleria volcano, particularly the larger, ignimbrite-forming eruptions. In particular what is the size of these eruptions? How often do they occur? Does the volcano go through recurring cycles?

Methods

During a 5-week field campaign on the island eruption-units previously established on the north coast toward the south coast were traced. Thirty-three rock samples were collected, mainly of ignimbrites and pumice fall units, for whole-rock XRF analysis, microprobe analysis and thin section petrography to

characterize eruption-units chemically and to possibly be able to differentiate them from each other.

Results

The tracing of eruption-units along coastal sections toward the south of the island proved harder than expected due to large lateral variations in the rocks (e.g. presence/absence of bedding, lithic concentrations, types of lithics; changes in colour etc). Also, access to outcrops along the south shore was much more limited due to up to 300 m high vertical cliff sections. Preliminary results suggest that, like in the post-‘Green Tuff’ period, the eruptive history of the island comprises large-scale ignimbrite-forming eruptions, lava effusion and local pumice falls (field observations). Lithic breccias in many of these ignimbrites suggest more than two caldera-forming events (as had been proposed by Mahood and Hildreth, 1986; Civetta *et al.*, 1984). Lateral tracing and detailed lithostratigraphic logging has led to a reduction in the number of eruption-units compared to previous studies (e.g. Mahood and Hildreth, 1986). Chemical fingerprinting of eruption-units merely by whole-rock XRF is difficult due to large areas of overlap between individual eruption-units.

Significance and further research

Some correlations for Pantelleria with distal ash layers have been attempted on the basis of major element analyses on glass shards (e.g. Wulf *et al.*, 2004; Caron *et al.*, 2010). These tephra layers generated during explosive eruptions can be found in marine or lacustrine drill cores as well as archaeological sites and provide good marker horizons across the Mediterranean provided they can be dated with sufficient accuracy. However, major element results may not always allow for unambiguous correlation. This project will, for the first time, provide accurate chemical data that allows for confident correlation. We plan to conduct LA-ICP-MS analyses to obtain trace element results of glass shards (rather than whole-rock). We will also date major eruption-units via Ar-Ar radiometric dating.

The welded ignimbrites of Pantelleria have previously been described as welded pumice fall deposits (Wright, 1980). Lateral changes in an eruption-unit are inconsistent with this concept and have led to a very large number of eruption-units being proposed. Advances in physical volcanology enable reinterpretation of the rocks and simplification of the stratigraphy of the island by recognising the lateral changes in an ignimbrite and thus reducing the number of eruption-units.

Furthermore, characterizing the eruptive history of a volcano advances our understanding of this volcano and permits better predictions of future hazards. This includes the magnitude, style and frequency of eruptions. Further fieldwork aims to establishing the stratigraphy and eruptive history of the entire island.

Acknowledgements

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LATE QUATERNARY SEDIMENTATION ASSOCIATED WITH THE BRITISH-IRISH ICE SHEET ON THE NORTHWEST IRISH CONTINENTAL MARGIN

Background and Rationale

During glacial periods, the entire NW European continental shelf was extensively dominated by glaciers. The northwest Irish continental margin is considered the boundary between the “glaciated” and the “glacially-influenced” margins of the Northeast Atlantic Ocean (Weaver *et al.*, 2000) and is an area of transition in the style of sediment deposition beyond the shelf break (Sacchetti *et al.*, 2011). Downslope mass transport of glaciomarine sediment, pelagic settling and along slope processes are known to have been important in the shaping this margin (cf. Weaver *et al.*, 2000).

The Donegal-Barra Fan, across UK and Irish waters, is the most southerly prograding sediment wedge on this margin and appears to have been fed by ice streams that periodically crossed the shelf, draining western Scotland and northwest Ireland, resulting in the accumulation of large mass flows on the slope (Bradwell *et al.*, 2007). Further south, downslope transport of glaciomarine sediments seems to have exploited the older canyon system formed in the Paleogene, without forming distinct sediment depocentres in deep water (Elliott *et al.*, 2006). It is thought that these canyons were primarily active during sea level low stand when sediment supply at the shelf break was much larger, while they were largely inactive during interglacial periods when pelagic and hemipelagic sedimentation prevailed (Cronin *et al.*, 2005; Weaver *et al.*, 2000).

Although both glacial and glaciomarine processes strongly influenced the development of the NW Irish continental margin, the character and timing of sediment distribution beyond the shelf break remains largely unknown. The focus of my PhD project is to evaluate the influence that Pleistocene glacial processes had on the geomorphological and sedimentary processes on the Irish continental margin. For this project, in 2008 and 2010 using the Irish R.V. Celtic Explorer, twenty-eight sediment cores were collected by piston and vibro-coring from three main canyon systems along the NW Irish margin, in transects from the upper continental slope onto the Rockall Trough basin. The analytical phase on the sediment cores started in March 2011 with the acquisition of a number of physical properties. In June 2011, with the assistance of the QRA New Researchers Award Scheme, all the sediment cores were scanned using the new X-Ray facility available at the School of Health Science, of the University of Ulster, Jordanstown.

Methodology

The recognition of the core depositional facies, such as turbidites, nepheloid layers, Heinrich layers, etc., is a crucial step towards the identification of

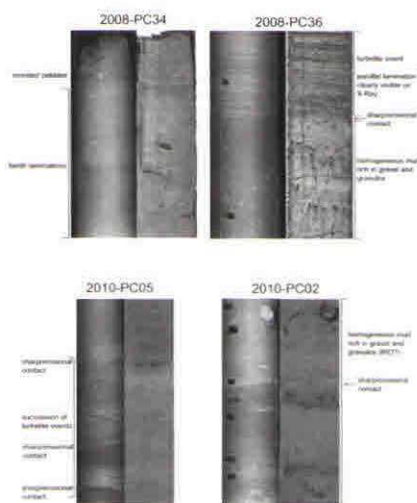


Figure 1. Examples of X-Ray results from four different core sites. PC34 and P36 from 500 and 1900 m of water depth respectively and PC02 and PC05 and 5 from 1000 ad 3000 m water depth respectively.

glaciomarine and deglacial sedimentary processes that occurred on this margin. The initial classification of facies was based on the initial core descriptions of what is directly visible on the core face, including sediment grain size, sorting, presence or absence of laminations and fossils. However, most of the sediment appeared fairly homogeneous and featureless. In order to maximize the potential of the sediment record, a DRX-Ascend X-Ray system recently installed the School of Health Science (UJ), was used to obtain scan radiography of the internal sedimentary structure for each core section. Photo-mosaics of the X-ray scans were then created and will be used to refine the interpretation of depositional facies.

Preliminary Results

Figure 1 includes few examples of X-Ray results from four different core sites. Cores PC34 and PC36 were collected during the 2008 cruise by a piston corer, in respectively 500 and 1900 m of water depth. Cores PC02 and PC05 were collected during the 2010 cruise in 1000 and 3000 m water depth. The dark grey mud observed on top of core 34 appears fairly homogeneous and lacks any evident sedimentary structures but X-ray scans show faint laminations throughout. The top of this section appears reworked and contains sparse rounded pebbles. The section of core 36 showed in Figure 1 is a clear example of a turbidite with a sharp bottom contact and parallel laminations. The lower part of the section presents homogeneous sediment, rich in small granules and gravel (possibly ice rafted debris, IRD, deposited by icebergs) of upward decreasing grain size. Similarly, X-ray scans of sections of cores 2 and 5 show a series of

turbidite deposits with erosional bottom contacts and internal laminations, as well as IRD-rich intervals, that would be otherwise not visible.

Significance

X-Ray scans of the sediment cores not only provide us with an invaluable amount of additional information for the interpretation of sedimentary facies, but will allow to sample precisely undisturbed layers (i.e. hemipelagic intervals) for radiocarbon dating.

Acknowledgement

The author would like to take this opportunity to thank QRA for its financial support. The X-ray analysis was undertaken with QRA's New Research Worker's Award. Acknowledgements should also be given to Dr Sonyia Mc Fadden and Dr John Cathcart for the technical support and advise on the use of the DRX-Ascend X-Ray, and to the School of Health Science at the University of Ulster for running the analysis within budget.

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ABSTRACT

THE CLASSIFICATION AND MANAGEMENT OF LIMESTONE PAVEMENTS – AN ENDANGERED HABITAT

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This thesis describes an in-depth study of limestone pavements across North West England and North Wales. The aim was to combine elements of geodiversity and biodiversity in order to create a holistic limestone pavement classification to inform future management. A field-based research protocol was used to assess a stratified random sample (46 pavements), accounting for approximately 10% of the limestone pavements in the geographical area. Detailed analyses of key elements are presented, along with important issues that continue to pose threats to this Annex One Priority Habitat. This research resulted in a comprehensive classification, using TWINSpan analysis and Nonmetric Multidimensional Scaling, identifying six distinct holistic functional groups. The prime factors driving limestone pavement morphology, and hence the classification, were established to be lithology, proximity to structural fault, altitude and human intervention, particularly in terms of grazing intensity. Three upland, open limestone pavement classes were formed. Of these, the richest in terms of geodiversity and biodiversity was the group with the thickest bedding planes and hence the deepest grikes, typically greater than 1m. The class that was most species-poor was at the highest altitude (above 450 m), formed on the thin limestones of the Yoredales. These were characterised by shallow, wide grikes. The third upland limestone pavement group had mid-range grikes, generally 0.5-1 m in depth, and small clints. Two wooded classes were identified. One was a lowland 'classic' wooded limestone pavement group with deep, narrow grikes and shallow soils. Indicator species included *Juniperus communis* and *Taxus baccata*. The second wooded group was situated proximal to a major structural fault. In this group the pavement dip ranged between 10°-40° with well-runnelled clints that were heavily moss-covered. The sixth group was low altitude, proximal to the coast, characterised by low moss growth, un-vegetated clints and the presence of *Ulex europaeus*. Conservation management was identified as key to the quality of the limestone pavement habitat and this thesis identifies best management practises and links these to the holistic limestone pavement classification. Finally, as a sample case study, this thesis presents mollusc species and diversity from eleven of the Yorkshire limestone pavements. Analysis establishes significant links between geodiversity and mollusc populations, with key drivers for mollusc communities echoing those of plant species on limestone pavement.

REVIEW

ARID ZONE GEOMORPHOLOGY: PROCESS, FORM AND CHANGE IN DRYLANDS

Thomas DSG (editor)

Third Edition. 2011 Wiley-Blackwell, 624pp.

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Like the London buses of myth and legend, it seems that a long time passes without a major desert geomorphology text being published and then two come along at once. A second edition of *Geomorphology of Desert Environments* (Parsons and Abrahams, 2010) was published last year, and this year has seen the publication of a third edition of *Arid Zone Geomorphology* (Thomas, 2011).

Arid Zone Geomorphology represents an edited collection of 24 chapters organised into 5 sections: large scale controls and variability in drylands (5 chapters); surface processes and characteristics (5 chapters); the work of water (6 chapters); the work of the wind (5 chapters); living with desert geomorphology (3 chapters). As we might expect, the book is dominated by considerations of contemporary geomorphological processes and only one chapter (Chapter 3: Climatic frameworks: legacies from the past) is overtly concerned with Quaternary palaeoenvironments, although the final chapter considers the impact of future climate change on the deserts. Whereas in previous editions separate chapters on past environments have been hidden away at the end of the book, here the climatic legacies chapter is seen as important context for the process-based chapters that follow. David Thomas's claim in the preface is that in this edition the consideration of the Quaternary has been integrated into the process-based chapters. Interestingly, the decision has also been taken to omit the regional descriptions of deserts – which formed a substantive section in the second edition – from this third edition.

Some authors are more successful at considering the Quaternary impact on desert landscapes than others. Chapters, for instance, on runoff generation and on sediment mobilisation by the wind concentrate understandably on short-term, present-day time frames so Quaternary impacts are barely relevant. Elsewhere the Quaternary development of the landforms under consideration is often appended as a short section at the end of the chapter. David Nash, for instance, adds a couple of pages on palaeoenvironmental significance to his chapter on desert crusts. Adrian Harvey's chapter on alluvial fans which might have been an opportunity to discuss the Quaternary development of fans includes a few rather sketchy case studies towards the end of the chapter. Paul Shaw and

Rob Bryant provide a page or so on pans and playas as palaeoenvironmental indicators.

In fact, the contributor who pays greatest attention to the aspiration to integrate information about the Quaternary into the substantive chapters is David Thomas himself. As well as co-authoring chapter 3 on climatic frameworks which provides a summary of the Quaternary context for dryland studies, he also makes considerable reference to Quaternary palaeo records in aeolian sediments, in particular in Africa, in his chapter (17) on aeolian landscapes, as well as providing a lengthy box explaining luminescence dating. He has also co-authored a final chapter (24) on future climate change with Richard Washington.

If you are looking for a book about the Quaternary development of the world's deserts, this is not the book for you, but that was never the intention of the editor or the authors. What they have provided is a thorough, up-to-date coverage of the geomorphological processes operating in the world's arid zones. It is a shame that there is no colour in the illustrations but there has clearly been a decision to keep the cost well below half that of *Geomorphology of Desert Environments* and therefore within the reach of keen students. The new edition of *Arid Zone Geomorphology* ensures that this book will continue to be, as it has been for the past two decades, one of the major sources of information for those interested in the development of desert landforms.

Reference

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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 Field Meetings, usually lasting 3–4 days, in April, May and/or September, a 2–3 day Discussion Meeting at the beginning of January. Short Study Courses on techniques used in Quaternary work are also occasionally held. The publications of the Association are the *Quaternary Newsletter* issued in February, June and October; the *Journal of Quaternary Science* published in association with Wiley; and the QRA Field Guide and Technical Guide Series.

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