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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 5th 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 (800 words); reviews (1000 words); letters to the Editor (500 words); abstracts (500 words). Authors submitting work as Word documents that include figures must send separate copies of the figures in .eps, .tif or .jpg format (minimum resolution of 300 dpi is required for accurate reproduction). Quaternary Research Fund and New Researchers 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

NB: Updated guidelines on the formatting of contributions are now available via the QRA webpage and from the editor.

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COVER PHOTOGRAPH

Trails of Mesolithic human footprints through the Holocene mudflats and Formby Point, Sefton Coast, Lancashire, England (see report by Burns in this issue).

EDITORIAL

Happy New Year. I hope you have all had a good start to 2017. This marks the first of our predominantly electronic-distribution model for the *Quaternary Newsletter*, so please enjoy the colour photos and figures and I hope any included hyperlinks are all working smoothly. As editor, I hope that this move marks the start of some opportunities to develop an online format that will complement the ongoing production of the print version, beyond simply providing you with a pdf. If you have ideas about how you would like to see this develop, please get in touch.

With warmest wishes for 2017,

Abi Stone

OBITUARY

VALERIE ANNE HALL (*NÉE* CAIRNS) (1946-2016)

Professor Emerita Valerie Hall, Honorary Fellow of the Quaternary Research Association, passed away on 28th July, 2016, after a long and courageous battle with cancer. Valerie was a distinguished and greatly respected palaeobotanist and tephrochronologist whose research interests ranged from Irish landscape evolution to Greenland ice core chronologies. She was an eminent figure in Irish, UK and international Quaternary circles, known as much for her breadth of knowledge and enthusiasm for her discipline as she was for her open and warm nature.



Valerie's passion for palaeoecology began during her time as an undergraduate Botany student at Queen's University Belfast, when she embarked upon a final year dissertation with Prof. Alan Smith. The research introduced Valerie to the use of fossil pollen as a means of reconstructing past landscapes, and instilled in her a thirst for understanding human-environment interactions that was to stay with her for the rest of her days. After graduating with a BSc in 1968, Valerie discovered another of her passions, that of teaching, as she took on the position of Senior Biology Teacher at Bloomfield Collegiate Girls Grammar School in Belfast. From 1973, Valerie took a career break to support her husband, George,

in raising their two daughters, Fiona and Roisin. Never one for idleness, Valerie made use of her spare time to work with various charitable organizations, aiding the homeless and those affected by Northern Ireland's Troubles.

In 1981, Valerie was diagnosed for the first time with breast cancer. Treatment proved successful, Valerie remained resilient, and following her recovery, her thoughts returned to academia. In 1985, Valerie began a PhD under the supervision of Jonathan Pilcher in the Department of Botany at Queen's University that examined landscape history of the north of Ireland since Medieval times. For this work, she adopted what was at the time a novel, interdisciplinary approach, combining historical, palynological and experimental evidence to critique the received understanding of landscape development in the region (Hall 1988; 1989a; 1989b; 1989c; 1990; 1994; Bowler and Hall 1989). It was this very research that directly inspired one of us (GP) to leave the folds of archaeology and to venture into the world of palaeoecology.

On completion of her PhD in 1989, Valerie obtained a NERC-funded fellowship in the Institute of Irish Studies at Queen's University and, with Jonathan Pilcher, embarked upon an endeavour that brought her international renown. Together they cored countless bogs in Ireland and Britain in the search for cryptotephra and they established the first mid- to Late Holocene tephrochronological framework for Ireland (Pilcher and Hall 1992; 1996; Pilcher *et al.*, 1995; 1996; Hall and Pilcher 2002). The tephtras they found and geochemically characterised enabled them not only to date and correlate palaeoecological sequences (e.g. Hall 1998; 2003b; Hall and Bunting 2000), but also to examine the long-distance environmental impacts of volcanic eruptions (Hall *et al.*, 1994a; 1994b, 1996; Hall 2003a). The methodology they developed continues to be applied in cryptotephrochronological research around the world.

Following a period as Lecturer in Past Environmental Studies in the Institute of Irish Studies at Queen's, Valerie was promoted to Senior Lecturer in the School of Archaeology and Palaeoecology (now part of the School of Natural and Built Environment). There she continued to pursue tephrochronological and palynological research (e.g. Plunkett *et al.*, 2004a; 2004b; 2009; Hall 2005; Hall and Mauquoy 2005; Wastegård *et al.*, 2003), and expanded the reach of her tephrochronological expertise to Norway, the Falkland Islands, Greenland and China (Holmes *et al.*, 1999; Hall *et al.*, 2001; Coulter *et al.*, 2012; Zhao and Hall 2015; Zhao *et al.*, in press). At the same time, Valerie contributed to the work of the Irish Quaternary Research Association (IQUA), International Quaternary Research Association (INQUA) and PAGES, and served on a number of committees, not least INQUA's Commission for Tephrochronology and Volcanology (INTAV) on which she proudly served as Secretary (1995-1999) and then Executive Vice-President (1999-2003). Her prolific research outputs, her commitment to teaching and public engagement, and her leadership skills earned her promotion to a Personal Chair in Palaeoecology in 1999, a mere decade following the completion of her PhD.

The next decade was to bring Valerie a range of achievements and personal challenges leading up to her official retirement in 2010. In 2001, Valerie was proud to see the publication of her co-authored volume *Flora Hibernica* (Pilcher and Hall 2001). She continued the search for tephra in Greenland ice cores in order to improve the dating precision of prehistoric tephra, as much as to establish linkages between the ice core acid signals and their suspected sources. The ice core work led to some interesting connections with Valerie's research in Irish bogs and Chinese lakes. One of the first tephra that she and Jonathan had recognised in Irish bogs (Pilcher *et al.*, 1995; 1996), the "AD860B" tephra, was present in the ice. This tephra was subsequently found to have derived from the eruption of Mount Churchill, Alaska (Jensen *et al.* 2014) and correlated with the extensive White River Ash east lobe tephra bed (WRAe) in the Yukon and Northwest Territories. As a result of the tephra's discovery in the ice cores, the eruption could now be assigned a considerably more precise date of AD 854±1 based on a revised ice core chronology (Sigl *et al.* 2015). Their original age estimate of AD 860±20, based on a ¹⁴C wiggle-match dating of the peat, surrounding the tephra was not so very far off (Pilcher *et al.* 1996)! Also in the ice was tephra from the "Millennium Eruption" of Changbaishan on the China/North Korea border, a tephra whose glass chemistry had been characterised by Valerie's PhD student, Hongli Zhao (Sun *et al.* 2014; Zhao and Hall 2015; Zhao *et al.* in press) and which could now too be assigned a precise age of 946/947 based on the same revised ice core chronology.

Appointed Director of Research in what was now the School of Geography, Archaeology and Palaeoecology, Valerie's reputation as a pillar of wisdom was cemented: her door was always open to those in need of advice, and her counsel was guaranteed to be considerate, measured and sensible. She managed to juggle the administrative demands of this position with her teaching and her research, rarely if ever, showing signs of stress, while maintaining a wide variety of personal interests – gardening, plant dye production, spinning, weaving and knitting, playing the harp, bee keeping – and all the time grappling with ongoing health issues and the care of her ailing mother. Sadly, in 2007, George, her husband, passed away suddenly. This was a huge blow to Valerie, but her spiritual and philosophical outlook gave her the strength to remain positive and forward-looking.

As Valerie neared retirement, she worked towards the completion of her second volume, *The Making of Ireland's Landscapes since the Ice Age* (Hall 2011). With great pride, she spent a period as Parnell Fellow at Magdalene College, Cambridge, in 2009–10. Following her retirement in 2010, she continued her research as Professor Emerita at Queen's, aiming to tackle some of her "pet" projects, unshackled from the need to play to top-down research agendas. In recognition of her substantial contributions to tephrochronology as well as to teaching and mentoring, INTAV bestowed upon Valerie the title of Honorary Life Member, and the Quaternary Research Organisation awarded her Honorary

Membership in 2011 in honour of her distinguished and career-long service to Quaternary Science. These accolades meant a great deal to Valerie.

Valerie welcomed numerous colleagues and postgraduate students to visit and work with her at Queen's. Equally, she loved to travel, to experience other environments, other cultures, and she always returned from conferences and research visits animated, having built more friendships and learnt more about something! Her generosity, wit and breadth of knowledge became legendary amongst those who knew her. Her outlook on life served her well to the end; in her final months, aware that her diagnosis was terminal, Valerie continued to be stoic, to be positive, to be witty, and when her health permitted, to work on her final project, an environmental history of her home town, Belfast. The two key themes to emerge from the tributes that poured in following her death were that she was an inspiration to so many palaeoecologists (new and established generation alike!), and that she was a truly kind and lovely lady who was a joy to be with. She would be content indeed to be remembered in this way.

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JAMES CROLL AWARD

JAMES CROLL MEDAL 2017- IAN SHENNAN

The James Croll Medal is the highest award of the QRA 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 any 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 normally 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.

Ian Shennan is the pre-eminent Quaternary sea-level scientist of his generation. He is internationally recognised for his outstanding contributions to sea-level research over a range of temporal and spatial scales in the UK and abroad, for his rigour and innovation in developing new approaches to observing, reconstructing and modelling sea-level and coastal change, and as an inspirational educator and communicator. His work is widely cited and addresses topics as diverse as coastal evolution, ice-sheet history, glacio-isostasy, coastal archaeology, storms and tsunamis, land uplift and subsidence and meltwater spikes. Ian's involvement in various IGCP and INQUA projects have been critical in the advancement of sea-level studies in the UK and internationally. They helped transform it from a largely inductive science, marred by inconsistent methods and approaches that restricted national and international comparisons and synthesis, to a modern discipline founded on a commonly accepted language that now speaks to a diverse range of earth science communities.

Based on his seminal PhD research, Ian led the development of new methods of data collection and analysis, a role that he has continued in his career with the AGU/ Wiley publication in 2015 of the benchmark "*Handbook of Sea-Level Science*". Ian embraced numerical methods from his career outset, introducing rigour to the analysis of sea-level data and by his leadership in the rapidly developing field of



glacio-isostatic adjustment (GIA) modelling. In the latter capacity, Ian established himself at a critical interface between the GIA community, initially Professor Dick Peltier and Professor Kurt Lambeck, and the wider community of field-based scientists (e.g. glaciologists, glacial geomorphologists, sea-level researchers). Several publications from these collaborations have had wide-reaching influence by, for example, establishing key earth model parameters that are used in a range of current GIA-related applications. They include his widely-cited UK map of crustal motions that continues to directly influence coastal management decisions by national and regional authorities, whilst internationally the outputs from this work are central to the GIA-corrections that studies of ice-sheet mass balance are required to make. In these ways Ian was able to exploit the huge potential of the British and Irish database of sea-level data, whilst also developing a series of models of the British and Irish Ice Sheet that have provided a foundation for studies that concern the palaeogeographic evolution of the North Sea region, palaeotidal range changes, ice-sheet thickness and extent, and predictions of future sea-level rise made by the UK Climate Impacts Programme (UKCP09). His central role in UK sea-level science, and in the impact of his work on related disciplines, was reflected by his invited keynote on “Revolutions in Quaternary Science” given at the QRA 50th celebrations in 2014.

Beyond the British Isles, Ian has pioneered the use of sea-level data to improve understanding of earthquake hazards. His work in the Pacific Northwest (US) had a profound impact on a large cohort of coastal scientists who now routinely adopt the methods of quantitative microfossil analysis to reconstruct the nature and magnitude of land and sea-level movements caused by the earthquake deformation cycle. Close collaboration with US Geological Survey and a string of USGS grants led to new models of earthquake magnitude and recurrence developed

for Washington and Oregon (e.g. Shennan *et al.*, 1996 (cited 96 times); Nelson *et al.*, 1996 (cited 126 times)). Ian subsequently extended this work by applying the use of these methods to the palaeoseismicity of the Alaska/Aleutian system to develop models of earthquake history and GIA in this region (e.g. Shennan *et al.*, 2009). This work was show-cased in a highly successful IGCP Project 588 meeting led by Ian and held in south-central Alaska in 2014 that coincided with the 50th anniversary year of the 1964 Mw9.2 great Alaska earthquake.

Finally, Ian's influence and legacy are reflected by the many PhD students and postdocs that he has mentored and who have subsequently embarked on their own academic careers, including Antony Long, Ben Horton, Roland Gehrels, Jason Kirby, Jerry Lloyd, Jim Innes, Sarah Woodroffe, Andy Plater, Simon Haslett, Yongqiang Zong, Natasha Barlow, Glenn Milne, Sarah Bradley, Emma Watcham and Ed Garrett.

HONORARY MEMBERS

Three long-standing members of the QRA were awarded Honorary Membership at the QRA AGM in Durham (January 2017).

Tim Atkinson

Tim's life as a Quaternarist has had four themes – development of quantitative reconstruction methods for palaeoclimates, uranium-series dating, speleothem palaeoclimatology and studies of landscape evolution. Tim has been a member of the QRA since the early 1980s and for many years has served on the Editorial Board of the *Journal of Quaternary Science*.



In Tim's own words:

"I first started to think about the Quaternary after reading Zeuner's book of that title when I was about 17 or 18. I had made a study of the geomorphology of Longwood Swallet, one of the Mendip caves, and Zeuner was my guide to Quaternary time. My passion for caving led me into geology and then into research on karst aquifers and hydrogeology, as well as into geomorphology and landscape development. It was through hydrogeology that I found an indirect route into Quaternary science. During the 1970s the age of groundwaters in the deeper parts of British aquifers was being explored using radiocarbon analyses of dissolved inorganic carbon. Many waters appeared to have been recharged during the Last

Glacial, a time in which Britain was thought to have experienced severe permafrost conditions that might have precluded infiltration into aquifers. Clearly either the radiocarbon results were misleading or the climatic history was more complex than was then understood. In 1978 the Climatic Research Unit at UEA (University of East Anglia) was awarded a contract by the UK Water Data Unit, a ‘quango’ funded by the Department of the Environment, to prepare an outline of the British climate over the past 50,000 years. This was intended to be a background piece to the radiocarbon dating effort. I took up the role of researcher on this project for two years, but only a few months after I had begun the new Prime Minister Margaret Thatcher made good her election promise to declare war on quangos, and abolished the Water Data Unit. This gave me a very free hand as to how to pursue the research. I soon became dissatisfied with the rather vague statements in the literature about climate becoming variously cooler, colder, Arctic, temperate and so on. I felt it ought to be possible to develop a more quantitative approach that would reveal the thermal climate in more detail. Inspired by the early papers of Russell Coope I approached him with a suggestion that beetles could be made to reveal quantitative temperature information if their individual species ranges could be calibrated in climatic space rather than geographical space. It turned out that he was thinking along somewhat similar lines and from this the Mutual Climatic Range method was born. Russell and I published just two papers on it together, and one of them became both his and my most cited work. Later on a research student, Katy Sinka, extended the technique from beetles to herptiles and then to plant remains, allowing reconstruction of rainfall amounts as well as seasonal temperatures. The approach has since been developed also by David Horne and applied to ostracods (the MOTR method). Under Russell’s leadership the library of beetle climatic envelopes was greatly expanded and applied to estimate palaeotemperatures in many Quaternary sites in Britain and abroad. The Birmingham library of species climatic ranges is now available on the website BUGS [<http://www.bugscep.com/>], along with a Mutual Climatic Range program, both curated by Phil Buckland of the University of Lund. The paper I wrote with Russell for *Nature* has probably been my most influential Quaternary publication.

A few years before my sojourn in the Climatic Research Unit, I had collaborated with an American, Russ Harmon, on applying uranium-series dating to speleothems mainly to provide a timescale for cave development and for the geomorphic evolution of the landscapes of which the caves formed a part. In 1978 I, Russ and others, published a paper in *Nature* setting out the potential of speleothem dating for palaeoclimatology and geomorphology. This paper was one of the foundations for what much later became a very fast-growing area of Quaternary science. In 1980 I decided to start a uranium-series laboratory at UEA, at the same time as the late Miro Ivanovich was founding a similar (and much better equipped) lab at AERE (Atomic Energy Research Establishment) Harwell. I was joined in this by a research student, Peter Rowe, who has been a close collaborator ever since. With no budget we had to build our own equipment and it was thanks

to a superb electronics technician, the late Terry Manning, that we were able to do so at all. After a year, and with the benefit of several months spent at Derek Ford's and Henry Schwarcz's lab at Macmaster University in Canada, we were producing U-Th dates by alpha spectrometry. At first we concentrated on cave studies and landscape development, but Peter's first research area was in the Palaeolithic cave sites at Creswell Crags and this led us quickly into questioning the ages of the recognised stages of the British Middle Pleistocene. Over many years we plugged away at dating interglacial sites and were eventually able to show in a series of papers that the Hoxnian in Britain corresponds to Marine Isotope Stage 11 while some sites that had been assigned to the Hoxnian on pollen grounds actually belonged to a later interglacial episode corresponding to MIS 9. These developments helped to fix the chronology of the British Middle Pleistocene, and were followed by dates from other sites that have established them as corresponding to the glacial-interglacial cycles

Uranium-series dating was revolutionised by technical developments in mass spectrometry pioneered in the USA during the late 1980s. The new methods were much more precise and needed much smaller samples than the alpha-spectrometry techniques we had been using, so our pioneering efforts drew gracefully to a close. Instead, we opened up new fields in stable isotope measurements on speleothems and their interpretation in palaeo-climatic terms. Once again we chose a difficult pathway. Stable isotope ratios from cave calcite are easy to measure but ambiguous to interpret, so we decided to concentrate on direct isotopic measurement of the minute amounts of drip water that are trapped as fluid inclusions within stalagmites and flowstones. The enclosing calcite can be dated and so this approach has great potential for mapping out continental-scale patterns of stable isotopes in palaeo-rainfall through time. It took many years to develop reliable techniques, building on early work by Henry Schwarcz and co-workers, and in collaboration with Paul Dennis at UEA and later on Hubert Vonhof in VU (Vrije Universiteit) Amsterdam. Fluid inclusion measurements remain laborious and difficult to make, but they are proving the key to unravelling the climatic signals in speleothems.

My current research is mostly in geomorphic history, neotectonics and speleothem palaeoclimatology. With Dave Mattey of RHUL (Royal Holloway, University of London) I have collaborated with cavers in Gibraltar (the Gibraltar Cave Science Unit) in monitoring cave microclimate and establishing the exact pathways by which climate signals are recorded in speleothem chemistry. With Dirk Hoffmann of Max Planck Institute, Leipzig providing the dating we are now building a long composite record of palaeoclimate and the isotopic composition of palaeo-rainfall in the western Mediterranean. It is our intention that this record will stretch back half a million years and form a yard-stick against which other speleothem studies with shorter records can be correlated, bringing our long-term aim of continental-scale mapping of isotopes in palaeo-rainfall a few steps closer. Such patterns can be directly simulated using GCM climate models, so have great potential for modelling experiments. The aim of mapping continental-scale

patterns has already been realised for speleothem calcites, in a pioneering study led by Frank McDermott and published in 2011. This was the first-ever attempt at integration of speleothem records across the whole of Europe and it revealed extremely interesting changes in the isotopic gradient of cave calcites from east to west, through the Holocene. These seem to follow the summer insolation through most of the period, but to depart from the declining insolation trend at about 3 ka. In future, we hope that fluid inclusions and the direct measurement of cave temperatures using clumped isotopes will remove some of the ambiguities in the oxygen isotope ratios of cave calcite and make speleothems a more direct indicator of past climates and atmospheric circulation patterns.”

Mike Hambrey

Michael Hambrey’s interest in Quaternary environments was initiated when he took up fell-walking in the Lake District and Snowdonia at the age of 15. An awakening desire to understand glacial environments better led him to undertake a joint degree in Geography and Geology at Manchester University (1967-1970). Having been inspired as an undergraduate by his future supervisor, Wilfred Theakstone, in glacial matters, he stayed on at Manchester to undertake a PhD on the structure of a small glacier in Okstindan, northern Norway, the thesis (awarded in 1974) being achieved through four long seasons of fieldwork. Fortuitously, a post-doctoral opportunity arose immediately afterwards at the Swiss Federal Institute of Technology in Zürich, to develop the structural geological approach to understanding glacier dynamics under the tutelage of Geoffrey Milnes and Fritz



Müller (1974-1977). This gave Mike the opportunity to clamber over numerous glaciers in the Alps, and also provided his first opportunity to visit the high-Arctic (Axel Heiberg Island).

There were few academic opportunities in the UK in the late 1970s, a time of severe economic austerity, but a chance encounter with Brian Harland at Cambridge University led to a part-time appointment to co-ordinate and edit a major volume for the International Geological Correlation Programme (IGCP Project 38), entitled *Earth's Pre-Pleistocene Glacial Record*. This huge volume, in which papers were organised to a standard template, covered all known occurrences of pre-Pleistocene glacial deposits globally. Containing 212 papers by 165 authors, the book was published by Cambridge University Press in 1981, and became the standard reference work on this topic. It was reissued in paperback form in 2010. Concurrently, Mike became heavily involved in the Cambridge Spitsbergen Expeditions to work on Late Precambrian glaciations, and the Cambridge Arctic Shelf Programme to write Quaternary reports on the Arctic; both organisations were directed by Harland. Mike stayed in Cambridge for 14 years (1977-1991), initially as a Fellow of St Edmund's College and then as Senior Research Associate in the Department of Earth Sciences and the Scott Polar Research Institute. Funding was erratic, however, sometimes with a full salary thanks to NERC projects in Svalbard and Greenland, often part-time, and for the last three years lacking salary altogether. However, Mike established fruitful Antarctic contacts, starting with Peter Barrett (Wellington, New Zealand), the result being participation in New Zealand and German programmes, and the Ocean Drilling Program).

In 1991 the prospects of a permanent academic job remained bleak, but then a Principal Lectureship in Quaternary geology came up at Liverpool John Moores University (then a Polytechnic). Mike was appointed to this position (which was immediately turned into a Chair) and he became head of the newly constituted Earth Science department, developing new full degree schemes in Earth Science and Physical Geography. With a sudden heavy teaching and administrative load in both geography and geology, the learning curve was steep, but in this he was supported by a highly committed and loyal earth science staff.

In 1997, the opportunity came to apply for a Lectureship in Glaciology at the University of Wales, Aberystwyth (now Aberystwyth University). The Centre of Glaciology there had been set up a few years earlier by Julian Dowdeswell, and had already gained an impressive international reputation, so the opportunity to join them was too good an opportunity to miss. Many of Mike's colleagues thought it odd to move down-scale from a chair to a lectureship, but as it turned out Mike was back to a Professorship within two years and heading the Centre for Glaciology. Teaching duties were once again heavy, but with somewhat more time for research Mike was able to develop an Arctic research programme, as well as collaborative Antarctic research with colleagues in Australia, America, New Zealand and Britain.

Mike has held various external positions connected to his research including visiting fellowships at the Victoria University of Wellington, the University of Otago and the Alfred Wegener Institute in Bremerhaven, as well as a Visiting Professorship at the University of British Columbia.

Mike stepped down as Director of the Centre for Glaciology in 2009, to lead the development of the Climate Change Consortium of Wales (C3W), a £4m enterprise involving Aberystwyth, Bangor, Cardiff and Swansea Universities, covering many aspects of the science and social science of climate change. Mike was its Founding Director, until retiring (sort of) in 2010. Now fully retired, Mike lives in the northern Lake District, but remains fully involved in several research projects.

In terms of research, the underlying thread throughout Mike's career has been to understand the processes of deformation in glaciers from a structural geological perspective, and in so doing define how debris is entrained, transported and deposited. This has led to more rigorous interpretation of contemporary and Quaternary landforms. Furthermore, this has facilitated in-depth analysis of ancient glacial sequences, including Antarctic Cenozoic and late Precambrian (Greenland, Svalbard) examples. Full understanding of these processes requires detailed knowledge of glacial processes in a wide range of tectonic and climatic settings – this has been achieved through many seasons' fieldwork in the Antarctic (the Peninsula, western Ross Sea, Transantarctic Mountains and Prince Charles Mountains) Arctic (Svalbard, eastern Greenland, Axel Heiberg and Bylot islands in the Canadian Arctic), sub-Arctic regions (northern Norway, Yukon, Southern Alaska), alpine regions (Switzerland and New Zealand), the Himalaya (Mt Everest region, Nepal) and the Andes (Cordillera Blanca and Patagonia). Parts of the UK have got a look in, too.

Particularly significant and highly cited contributions that Mike has made to the literature have been the afore-mentioned IGCP volume, a textbook entitled *Glacial Environments*, and papers exploring the relationship between glacier structures and strain, the manner in which debris is transported by glaciers and the impact this has on glacier hazards, the links between structural glaciology and glacial depositional landforms, the long-term glacial record of Antarctica, and the sedimentology of well-preserved late Precambrian (Neoproterozoic) sequences in the Arctic that have a bearing on the "Snowball Earth Theory. This wide variety of research has resulted in a large research output, including 140 peer-reviewed papers, 2 peer-reviewed monographs, 11 authored/co-authored books, 6 edited volumes, and multiple chapters in 24 books. His most recent contribution, a *Colour Atlas of Glacial Phenomena*, due to be published by CRC Press in late 2016, is a unique collection of images from modern, Quaternary and ancient glacial environments, and is the culmination of over 45 years of field research.

Mike has been a member of QRA for many years, and has contributed to its profile by organising a couple of international meetings: a conference "Glacial

debris transport and deposition: processes and products” at the University of Leeds in 1998, and on Glacial Processes and Products at Aberystwyth University (co-sponsored with the International Association of Sedimentologists). He has also organised many other conferences, sessions and field excursions on behalf of other bodies, including the International Geological Correlation Programme (IGCP), the Geological Society of London and the Scientific Committee on Antarctic Research (SCAR).

Mike has served on many national and international committees over the years. In the UK these include NERC’s Peer Review College and Earth Science Committee, National Committee on Antarctic Research, the British Geological Survey’s Regional Advisory Panel for Wales and the Awards Committee of the Geological Society, the British Branch of the International Glaciological Society as President. Internationally, he has been Secretary of SCAR’s Geoscience Standing Scientific Group, Chair of the Working Group on ‘Debris entrainment and transfer in glaciers’ for the IUGG Commission for the Cryospheric Sciences, the nominations/medals committees of the International Glaciological Society and SCAR, and Working Group member for three IGCP projects, and a Member of the Stratigraphic Commission for Svalbard.

Arising from these international connections, Mike has undertaken a considerable amount of editorial work as subject/scientific editor of the *Journal of Glaciology*, the *Journal of the Geological Society of London*, GeoReach (the house journal of SCAR), and *Palaeogeography, Palaeoclimatology and Palaeoecology*. He has also been chief editor for several conference publications including *Antarctic Palaeoenvironments and Earth-Surface Environments* (Geological Society 2014), *Glacial sedimentary processes and products* (International Association of Sedimentologists, 2007), as well as for the International Cape Roberts Drilling Project, Antarctica (*Terra Antarctica*, 1998).

Mike has been an enthusiastic promoter of research to the wider public. This has been achieved through numerous talks, notably on climate change, to local societies, parish groups, etc., through the media (several interviews on radio and TV), and through the written word and images. Highlights include books for a wider readership: *Gletscher der Welt* by J. Alean and M.J. Hambrey (Haupt AG 2013), *Islands of the Arctic* by J.A. Dowdeswell and M.J. Hambrey (CUP, 2002) and two editions of *Glaciers* by M.J. Hambrey and J. Alean (CUP, 2004, 1996). He shares in the development of a website with J. Alean, www.glaciers-online.net that is considered by many to be the world’s best website on glaciers.

Mike’s achievements have led to recognition in various ways. He has received the Polar Medal from HM The Queen twice (1989, 2012), and has a topographic feature, Hambrey Cliffs on James Ross Island, named after him by the UK Antarctic Place-names Committee (2006). His book *Glaciers* earned the Outstanding Publication Award of the Earth Science Editors’ Association (USA) in 1996. Most recently

he was elected a Fellow of the Learned Society of Wales (2016) in recognition of his contributions to research, science, education and public outreach in Wales.

Mike Tooley

Michael Tooley was brought up near the North Devon coast where the beaches and dunes of Saunton Sands and Croyde Bay provided not only recreation every weekend but also initiated an abiding interest in sand dune history and vegetation. He was educated in Hereford and Lytham on the Lancashire coast where his school was set down amongst sand dunes and its motto was appropriately '*Sublimis ab unda*'. Many years later deep borings in a dune slack between the school and the frontal dunes proved the existence of a Mesolithic-age peat beneath a shingle stanner and an overburden of blown sand written up by Mike in *Sea-Level Changes in North West England*.



Mike went on to study at the universities of Birmingham and Lancaster in the UK and at Columbia in the USA. During the mid-sixties New York he was influenced by the work of Rhodes Fairbridge in the Geology Department, David Smith in the Geography Department and Pierre Dansereau in New York Botanic Garden. All were accomplished field scientists and introduced him to coastal landforms in

New England and New Jersey and memorably, in David Smith's MG Midget, to a traverse of the Californian coast with its potential for sea-level investigations.

Whilst being supervised by Frank Oldfield at Lancaster University on an NERC studentship (1966-1969), he was awarded a place on the British Council Young Scientific Workers Exchange Scheme and spent time working at the Geological Survey of the Netherlands in Haarlem under the supervision of Saskia Jelgersma.

In 1969 he was appointed to a temporary post in the Department of Geography at the University of Durham (this was later made permanent in 1971) and was promoted successively to a chair in 1993. He established an optional class in Quaternary Studies which he led for 26 years, and a sea-level research unit within the Quaternary Change Research Group in the department. Whilst there, he also built up a group of staff, post-doctoral research assistants, technicians and research students, including Ian Shennan, Stephen Ireland, David Bedlington, Antony Long, Cheng Zong and Edward Twiddy.

In 1973 he attended courses with Bob Devoy on unconsolidated sediments on the raised bog of Aamosen and marine sediments at Gammelholm, Samsø, Denmark given by Dr. Jorgen Troels-Smith. Later he returned to undertake research on Gammelholm and take Thermoluminescence measurements on the clastic sediments there with the collaboration of Ian Bailiff and Nigel Poolton of the Archaeology Department, Durham.

Mike's fundamental and strategic research has been on environmental changes in general and on coastal and sea-level changes in particular, employing and refining a methodology first used by Professor Sir Harry Godwin. He has carried out research throughout Great Britain and coastal Europe and in India, Bangladesh, China, Brazil and The Maldives. The fruits of this research have been published in >100 refereed journal articles and 12 single author or edited books, including *Sea-level Changes in North West England* for the Clarendon Press, *The Environment in British Prehistory* edited with Ian Simmons for Duckworths, *The Climatic Scene* edited with Gillian Sheail for Allen and Unwin, *Sea-level Changes* edited with Ian Shennan, *The Impacts of Sea-level Rise on European Lowlands* edited with Saskia Jelgersma for Blackwells, and *The Wetlands of Southwest Lancashire* edited with R Middleton and Jim Innes for Oxford Archaeology North. Scientific articles have been published in *Nature*, the *Geographical Journal*, the *Geological Journal*, *Philosophical Transactions of the Royal Society B*, *Journal of Coastal Research*, *Journal of Environmental Radiology*, *Journal of Quaternary Science*, *Proceedings of the Institution of Civil Engineers*.

For the QRA, Mike was involved with several field meetings to North West and North East England (in 1972, 1999 and 2004) and he has contributed to both *Quaternary Newsletter* and to Technical Guide 7 (Quaternary Stratigraphic Field Sections). He attended many of the earlier field meetings, of which the 1971 meeting in the Isle of Man was memorable for the contributions of Fred Shotton

and Frank Mitchell, the latter demonstrating the marine, freshwater and brackish water changes at Lough Cranstal and employing a hand lens to identify seeds and fruits extracted from the core. He was also successively Secretary, Vice President and then President of the INQUA Shorelines Commission from 1991 to 1999. Mike is currently a Professor in the University of St. Andrews and Professor Emeritus at Kingston University, London.

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CLEMENT REID (FRS FLS FGS) – REMEMBERING A 19TH CENTURY PIONEER IN BRITISH QUATERNARY SCIENCE AT THE CENTENARY OF HIS DEATH

The 10th December 1916 marked the centenary of the death of Clement Reid, one of the key pioneers in the study of the Quaternary interglacial deposits of the British Isles. Clement was born on the 6th July 1853 and joined the Geological Survey in 1874, working as an assistant geologist in south west England, later transferring to Norfolk in 1876. Up until his retirement in 1913, he produced fifteen memoirs and collaborated on a further five for the Geological Society, covering the length and breadth of England, along with many books and papers, several in conjunction with his wife Eleanor Mary Reid née Edwards, whom he married in 1897.

It was within this role with the Geological Survey of Great Britain that Clement developed a keen interest in Quaternary and Pliocene deposits of the areas that he studied. Through this work, his detailed synthesis of geology, stratigraphy, vegetation and faunal history have presented a firm foundation on which much subsequent research could be built. His work on the Cromer Forest Bed Series, published within the extensive geological memoir on Cromer (1882), provided the first detailed palaeoecological study of these deposits, demonstrating clear palaeoclimatic signals from the assemblage. This stratigraphic interpretation of the sequence remained largely unchanged until Richard West's work in the 1960s. His map of the palaeo-Rhine Estuary (Reid 1882) during the formation of the Cromer "Forest Bed" probably represents one of the first attempts to produce a palaeogeographic reconstruction of a sizable part of North West Europe for a Pleistocene interglacial.

The work of Clement and Eleanor was instrumental in the advance of plant macrofossils analysis as a technique and the important role of biostratigraphy in understanding the Quaternary deposits they encountered. Quite early in his career, Clement made botany a special study. In his studies around Cromer, he realised that certain seeds found in the "Forest Bed" needed determination, and he began, for comparison, to collect the seeds of wild plants, with the result that he became perhaps the first authority on the subject, and showed how much information regarding the climate of former times was to be obtained from fossil seeds. Clement's interest in palaeobotany is best demonstrated by his book '*The Origin of the British Flora*' (1899), where he detailed sites with Quaternary floras which he divided into chronostratigraphical units; this work later formed the basis for Harry Godwin's compilations of sites within his '*History of the British Flora*' (1956). Within his book, Clement observed the contrast between the potential limitations on the rate of range expansion in trees (through diffusion) and the rates

spread indicated within the palaeoecological data; this has been termed ‘Reid’s paradox of rapid plant migration’ and is still a topic of important research today, especially in relation to rapid climate change.

Clement’s approach to any site was to engage many leading specialists in different fields in order to better understand a site; a concept that we today term a multi-disciplinary approach. His close work with Alfred Gabriel Nathorst of the Geological Survey of Sweden is an early example, possibly the first, of a relationship with Scandinavian geologists in relation of Quaternary palaeobotany. Clement’s detailed studies extended beyond British shores, such as his work with Eleanor (1907) on fossiliferous interglacial deposits in the province of Limburg in the Netherlands, or his visits to Italy to study the Calabria Beds in order to establish a biostratigraphical correlation for the British Red Crag based upon shell fauna (Reid, 1890). His studies also extended to the interpretation of the stratigraphy of archaeological sites, most notably the Hoxnian stage stratotype at Hoxne, Norfolk (Evans *et al.*, 1896).

While his many palaeobotanical and geological achievements are remembered within the Quaternary and Palaeobotanical communities, it is perhaps his work on submerged landscapes that has been best remembered in the wider public. His book ‘Submerged Forests’, published in 1913, details his extensive work around the British coastline where he studied the submerged forest deposits that are often encountered within the intertidal zone, cliff exposures or derived from within the sea. This represented the first comprehensive survey of the prehistoric landscape preserved along the British coastline, and most notably highlighted how important submerged prehistoric landscapes are, along with grappling with key concepts on past sea-level change and the idea of a submerged landscape within the North Sea, which ultimately became popularly known as ‘Doggerland’. He and Eleanor (1909), along with members of the Essex Field Club, were some of the first to systematically investigate deposits dredged from the North Sea from a Quaternary perspective (notably the organic deposits recovered by fishermen called *moorlog*) and, from a British perspective, is seen as the founding father in the concept of submerged landscapes, inspiring the work of subsequent key researchers such as Gunnar Erdtman, Harry and Margaret Godwin, Graeme Clarke, Bryony Coles and, over the last two decades, major maritime investigations including the North Sea Mega Survey led by Vince Gaffney.

While many aspects of Clement’s work have undergone revision, most notably through improved chronostratigraphic correlations and applied dating techniques, the work of Clement and Eleanor Reid still remains engrained in the Quaternary literature and provides a major contribution to biostratigraphic interpretation and British vegetation history.

In one of the many obituaries written about Clement at the time of his death, Shepherd (1921) described him as being “*of a quiet and unassuming nature, a conscientious worker, but rarely entered into discussion or dispute; consequently*

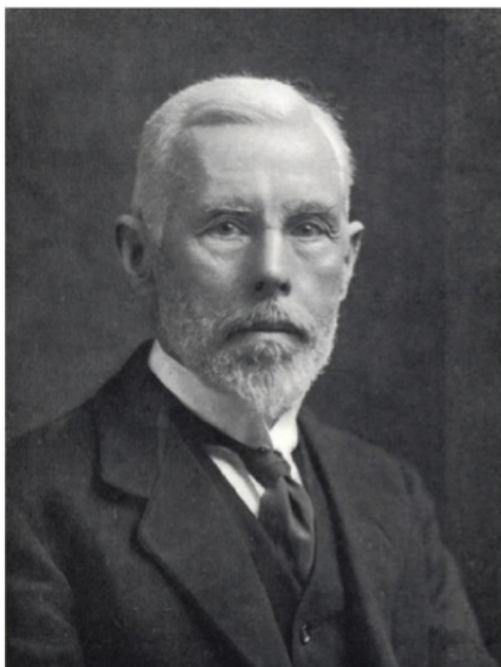


Figure 1. Portrait of Clement Reid (British Geological Survey P585022 <http://geoscenic.bgs.ac.uk/asset-bank/action/viewHome>).

he did not come before the geological world quite so prominently as many others whose work in originality and importance cannot be compared with his". While the centenary of his death may have also failed to be celebrated prominently, there is little doubt that even after 100 years, twice the length of time that the QRA has been in existence, the relevance of much of his work is still visible today with many researchers revisiting the key sites, theories and observations that he identified over a century ago. Such longevity is rare within science and is a testament to the quality and pioneering nature of the work undertaken by both Clement and Eleanor Reid (who herself continued to work extensively until her death in 1953) in the late 19th and early 20th century.

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BILL BISHOP AWARD

DYNAMICS AND TIMINGS OF GLACIATION IN THE WICKLOW MOUNTAINS, IRELAND

Lauren K. Knight

Background and rationale

Existing knowledge on the extent and timings of Midlandian Glaciation (MIS 2; ~29-10 ka BP) in Ireland remains limited (Clark *et al.*, 2012; Ó Cofaigh *et al.*, 2012). Whilst it is acknowledged that the Wicklow Mountains (Figure 1) hosted a local ice cap at the Last Glacial Maximum (LGM; ~27 ka BP; Ballantyne

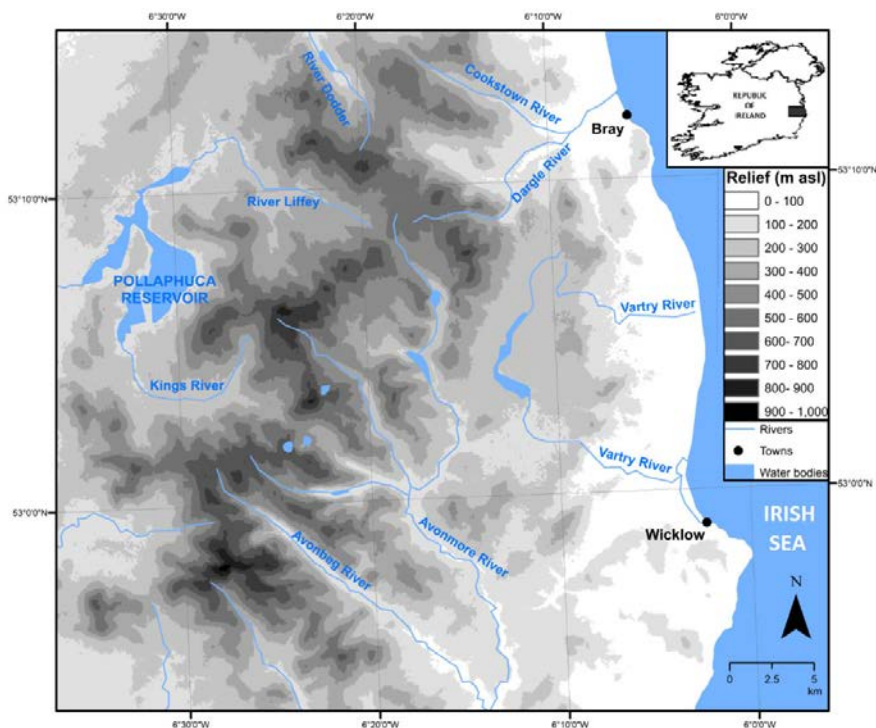


Figure 1. Location and relief of the Wicklow Mountains, Ireland (52°53'N-53°15'N; 06°11'W-06°36'W).

et al., 2006; Ó Cofaigh *et al.*, 2012), there has been little consideration of ice cap disintegration into a topographically constrained ice mass during the Last Glacial-Interglacial Transition (LGIT; ~15-10 ka BP). This study represents the first comprehensive investigation of LGIT glaciation in the area and seeks to constrain ice mass extent, dynamics and retreat patterns, in addition to establishing a relative chronology of glacial events. Better understanding of the evolution from ice cap to valley-style glaciation during the LGIT will help to build a coherent reconstruction of ice cap recessional dynamics during deglaciation, which in turn could provide insights for understanding contemporary small ice mass behavior (e.g. in Iceland and Norway) in a warming climate.

Key findings

To date, work has focused on systematic glacial geomorphological mapping in order to establish the geomorphological context for future detailed sedimentological and geochronological analyses. Mapping from remote sensing data (aerial photography, digital elevation models), in combination with field mapping, is being used to compile the first regional glacial geomorphological map at a 1:10,000 scale. Mapping conducted in 2015 saw the detailed and systematic field assessment of 29 sites. Two further field campaigns will complete the field mapping element of the project by the end of 2016. Figure 2 highlights some of the interesting features mapped in the field which will form an important part of future analysis and interpretation. From the fieldwork to date, several findings are apparent:

- The geomorphological and sedimentological record preserved in the Wicklow Mountains is significantly more extensive than previously recognised.
- The landform record archives complex patterns of ice mass growth, decay and readvance. Cross-cutting of features, in particular moraines, emphasise this clearly in selected areas.
- Several morphological signatures feature within the study area, highlighting varying landform characteristics (i.e. moraine size, shape and composition, meltwater channel incidence, drift extent). These are influenced, in part, by topographic controls (slope, aspect), geology, sediment availability and material transport distances.
- Small icefields and associated outlet valley glaciers may have existed during the LGIT following disintegration of the main ice cap, as evidenced by the presence of isolated moraines and meltwater channels at the plateau edge.

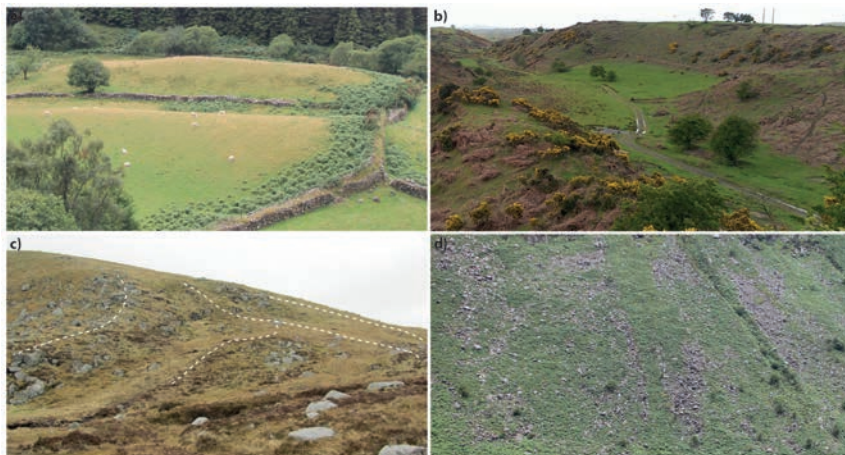


Figure 2. (A) Isolated linear features on valley floor of Glenmacnass, which may indicate streamlining due to fast ice flow; (B) meltwater channels at Hollywood Glen related to the drainage of Glacial Lake Blessington; (C) recessional moraines at Lough Mullaghcleevaun. Note bifurcation of ridge crests indicating differential retreat along the ice margin; (D) talus slopes in Glenmalur with thick drift cover highlighted by gullying.

Significance

The landscape of the Wicklow Mountains is dominated by glacial landforms recording ice mass oscillation (both sustained retreat and minor re-advance) that most likely occurred during the LGIT. It is evident from geomorphological mapping that clear spatial and temporal variability is archived in the Wicklow Mountains. The work to date has highlighted that the record of glacial activity in the area is significantly more complex than previously recognised. This geomorphological mapping will provide an important foundation for the next phase of research, which will employ sedimentological and geochronological analyses to determine glaciation patterns, assess ice-marginal dynamics and establish a relative glacial chronology.

Acknowledgements

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DATING THE HOLOCENE FOOTPRINTS AT FORMBY POINT, NW ENGLAND

Background and Rationale

Formby Point lies to the north of Liverpool on the Sefton Coast in northwest England. Footprints created by humans (adults and children) and a wide range of animals are found in multiple beds of silty Holocene salt marsh sediments along the foreshore. Academic interest in these footprints dates back to the 1980s when their antiquity and importance as a rare form of archaeological preservation was first recognised (Roberts *et al.*, 1996). We do not yet have a precise chronology for the formation of the footprints – although Roberts *et al.* (1996) did obtain a radiocarbon date (3573 ± 45 years BP; 2040-1760 years cal BC) from *Alnus* roots growing through the bed containing them. This only gives a *terminus post quem* for these footprints, but not the date of the footprints themselves. In an attempt to date the host beds directly, two OSL dates (6.65 ± 0.7 ka and 5.75 ± 0.6 ka) were obtained from sediment lying at a depth of 30 and 10 cm below the top of one outcrop (Roberts, 2009). However, no accurate record was kept of the height of the bed from which these samples derived and the errors associated with these OSL ages do not allow us to definitively assign this particular set of footprints to either the Mesolithic or Neolithic periods.

In order to clarify the archaeological context of the period (or periods) when humans were active within the Formby salt-marshes, it is important to obtain dates with greater precision. One strategy to improve the chronological resolution is to radiocarbon date plant macrofossils (such as seeds and leaf remains) extracted from the host sediment beds as close as possible to the footprints themselves. When the footprints were formed, the foot was pressed through the silt into the sediment and any organic remains beneath. In this early salt marsh environment, the silts formed dense consolidated layers separated by narrow lenses of sand. The plant macrofossils from each layer that have been dated provide maximum ages for the formation of the footprints in that bed (Figure 1).

Results and wider significance

The two new radiocarbon dates have established that the footprints in one of the outcrops fall within the Mesolithic Period. There are over 900 human and animal footprints within this particular bed (Figure 1). The stratigraphy of the cores from which these dates were obtained indicates the presence of a former saltmarsh

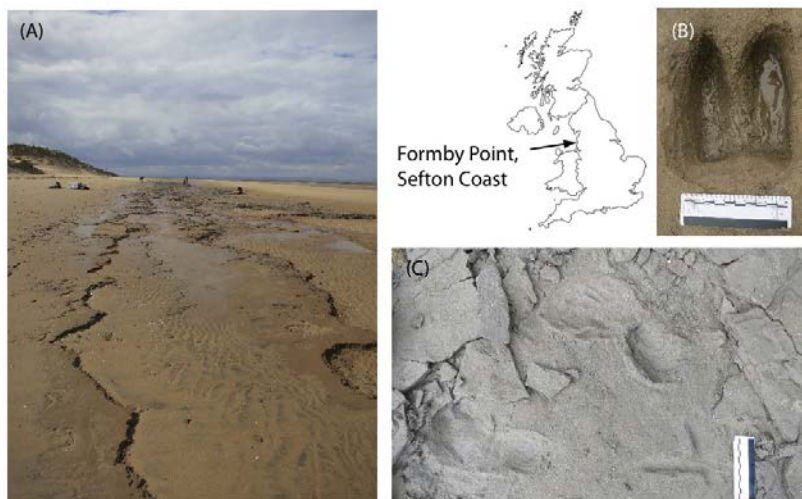


Figure 1. The location of Formby Point, the bed from which the cores were taken, and human and animal footprints found within them (Photo credit Alison Burns).

environment that was periodically inundated by the sea. More generally at this time, the level of the Irish Sea was rising, submerging the lower lying land to the west of the present coastline. This process created an extensive area of intertidal salt-marsh within a peri-marine zone which stretched from Anglesey to Morecombe Bay (Tooley, 1978; Fitch and Gaffney, 2011). The associated habitats attracted a wide variety of mammals, birds and marine life. The two radiocarbon dates and the sedimentology of the core indicate that the human footprints were created by a community of people who lived as hunter-gatherers within a fluctuating and dynamic coastal environment. Further cores have been collected and ongoing work is establishing the time period(s) of the other outcrops to establish the age and archaeological context of their footprints.

Acknowledgements

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RECONSTRUCTING SOUTHERN SIBERIAN ENVIRONMENTS: RESPONSES TO ABRUPT LATE QUATERNARY CLIMATIC FORCING

Background and Rationale

Understanding ecosystem responses to abrupt climatic forcing during the Late Quaternary is essential for examining past variability in regional climate and environment (Rasmussen *et al.*, 2014). The Late Quaternary provides a ‘natural laboratory’ for such studies, being characterised by a range of long-term and abrupt climate forcing mechanisms, which include insolation cycles, ocean circulation, solar activity and volcanic eruptions (Wanner *et al.*, 2008). Evidence of their impacts comes from Greenland ice cores, complemented by terrestrial and marine archives, detailing abrupt changes, superimposed on long term climate trends (Bond *et al.*, 1997; Wang *et al.*, 2001). While the general pattern of changes has been discerned in key archives (Wang *et al.*, 2001; Southon *et al.*, 2012) their expression and ecosystem impacts in some critical regions require further study, due to the paucity of well dated records, with suitable proxies.

Siberia is one of these critical regions, where recent observations have demonstrated warming occurring at twice the global average rate between 1938-2009 (Törnqvist *et al.*, 2014), with significant increases anticipated over coming years. This warming has multiple consequences including permafrost degradation, a shift northwards of the forest-steppe ecotone, and warming of one of the world’s most important freshwater ecosystems, Lake Baikal. Permafrost reduction is exacerbated by snow-cover decline, limiting albedo, while degraded landscapes are more susceptible to wildfires. Understanding palaeoenvironmental change is essential to inform models

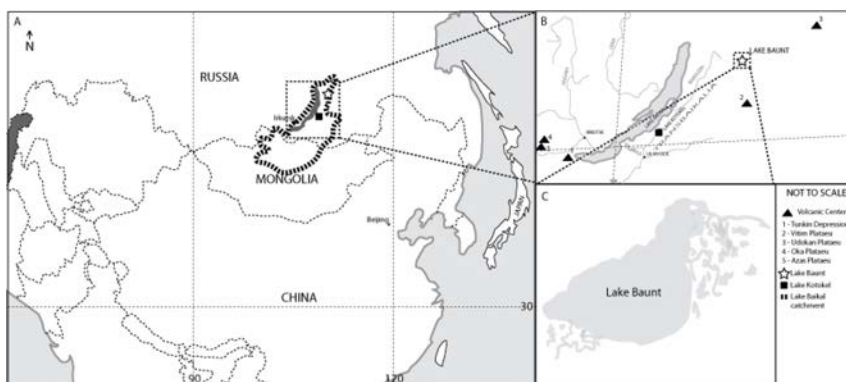


Figure 1. Map of Siberia highlighting the sites location to the north east of Lake Baikal in the Transbaikal Mountains.

of future responses to warming, with Siberia's continentality providing a unique opportunity to understand change away from oceanic influences. Additionally, Siberia is critical for examining Quaternary hominin distribution (Krause *et al.*, 2010). Despite Siberia's importance, well dated, high-resolution reconstructions are in limited supply, with most focusing on Lake Baikal, skewing the regional record of environmental change.

Results and Significance

Lake Baunt (55°10'59.52" N, 112°59'49.24"E; Figure 1) provides a key site to explore Siberian palaeoenvironmental change, due to its high sedimentation rate and excellent preservation of biogenic proxies, particularly diatoms. These have demonstrated several periods of abrupt change, which occur broadly in phase with transitions documented in key Quaternary archives, including Greenland. The additional radiocarbon dates (Table 1) have allowed significant chronological improvements, through constraining the 7 range-finder dates already available for Lake Baunt. This is essential, as accurate high-resolution chronologies are required to reliably compare climatic and ecosystem records. Radiocarbon dates were calibrated using IntCal13 (Reimer *et al.*, 2013) and will be modelled using OxCal 4.2 Bayesian deposition models (Bronk Ramsey, 2008) to generate high precision age estimates. The dates have improved the record of Lake Baunt's sediment deposition, demonstrating increased sedimentation rates since 6000 years BP, and additionally in constraining the Last-Interglacial-Glacial-Transition (LGIT), where sedimentation rate alterations result from landscape changes.

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Lake Baunt Depth (cm)	¹⁴ C Date	Error (±)	Calibrated Date (IntCal13) (Reimer <i>et al.</i> , 2013)
97.5	5049	40	5908-5664
497.5	11489	60	13457-13205

Table 1. Radiocarbon dates from Lake Baunt measured by Queens University Belfast, ¹⁴Chrono Centre.

with sample collection. I am grateful to my supervisors Professor A.W. Mackay and Professor J. Holmes for their support and advice. I also thank NERC for funding this PhD through the London NERC DTP.

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NEW RESEARCHERS AWARD SCHEME

LATE HOLOCENE RELATIVE SEA-LEVEL CHANGES IN SOUTH HINNØYA, ARCTIC NORWAY

Background and rationale

Since deglaciation, the Norwegian coastline has experienced net relative sea-level (RSL) fall as a result of isostatic land uplift following the retreat of the Fennoscandian Ice Sheet (Svendsen and Mangerud, 1987). Despite this history, with the slowing down of crustal rebound through the Holocene and the onset of rapid global sea-level rise during the past century, many locations along this coastline are expected to experience decimetre level RSL rise during the 21st century (Simpson *et al.*, 2014). Knowledge of past and ongoing regional sea-level changes and an understanding of the relevant mechanisms is paramount for the accurate prediction of future events and trends.

Geophysical models, such as the glacio-isostatic adjustment (GIA) model of Lambeck *et al.* (1998a) for Fennoscandia, are used to develop local and regional RSL histories that can be incorporated into ocean-atmosphere models useful for predicting future sea-level trends. Such GIA models rely on field evidence for validation (e.g., Lambeck *et al.*, 1998b). Despite the significance of recent changes in RSL trends in Norway, there remains a lack of field data useful for constraining the late Holocene sea-level history.

Funding from the QRA's New Research Workers Award facilitated a field expedition to the Vesterålen Islands off the northwest coast of Norway in 2011 to study coastal sediment deposits at Svinøyosen, South Hinnøya. An extensive programme of coring was undertaken to describe the sub-surface lithology. Several sediment cores were recovered for palaeoenvironmental investigations and surface transects were sampled for microfaunal assemblages along environmental gradients to provide modern analogues for their microfossil counterparts.

Results

The stratigraphy at Svinøyosen contains a basal marine clay at ~2 m below the surface, dated to 6469-6732 cal yrs BP (Figure 1). Above this is an unconformable and unlaminated, poorly sorted shell-sand unit which contains several age reversals suggesting that this unit may have been reworked immediately prior to c. 4000 cal yrs BP. Above the unconformable sands are a sequence of marine silts and sands that depict gradual shallowing from c. 4000 cal yrs BP to present. Intertidal silts and a modern salt-marsh deposit cap the sequence.

Microfossil foraminifera grade from offshore subtidal assemblages at the bottom of the stratigraphy, through shallow subtidal assemblages until c. 3000 cal yrs BP, into intertidal assemblages from c. 3000 to 500 cal yrs BP. From c. 150 cal yrs BP assemblages of intertidal salt-marsh foraminifera and testate amoebae are present.

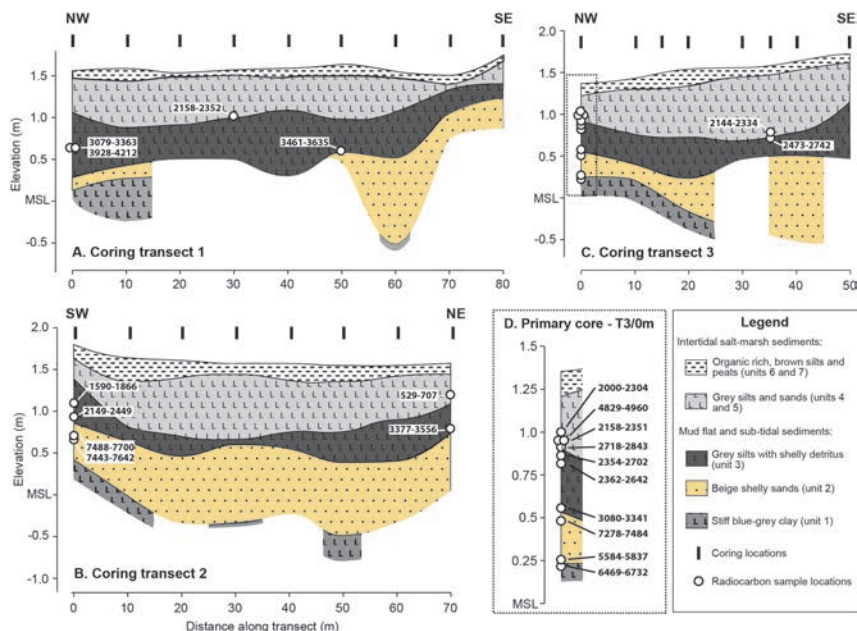


Figure 1. Sub-surface lithology at Svinøyosen, South Hinnøya, Norway. Shown are three coring transect profiles with associated calibrated radiocarbon dates in cal yrs BP.

Significance

Constrained within a chronological framework, the results describe gradual RSL fall (c. -0.7 mm.yr^{-1}) over the past c. 3000 years (Barnett *et al.*, 2015). However, sea-level outputs from geophysical models over-predict the rate of RSL fall for the region by at least -1.0 mm.yr^{-1} when compared against the new field data, possibly implying that the rate of residual land uplift may be overestimated by GIA models. Improving model prediction abilities for Norway will be necessary for developing accurate estimates of future sea-level changes in a region that may be more at risk of 21st century sea-level rise than previously thought.

Acknowledgements

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TEPHROSTRATIGRAPHIC DATABASE OF LATE PLEISTOCENE LANDSCAPES OF CENTRAL ITALY

Background and Rationale

Cava Muracci is a quarry site located on a superficial formation of Quaternary travertine in the lowlands of the Pontine Plain (Lazio, Italy) (Gatta *et al.*, 2016). A well preserved archaeological context containing faunal remains, coprolites and rare lithic industry, has been discovered here in 2012, allowing a series of interdisciplinary investigations which are still ongoing (Gatta and Rolfo, 2015).

Beneath the main archaeological layer (SU11), dating 35–44 cal ka ^{14}C , a sterile volcanic tephra layer (SU13), belonging to the Volcano Albano eruption, has been found (Figure 1). It has been analysed for trace-element composition and dated through $^{40}\text{Ar}/^{39}\text{Ar}$ method, along with a reference set of ten samples from the eruptive units of the Albano activity, for the purpose to create a new tephrostratigraphic database.

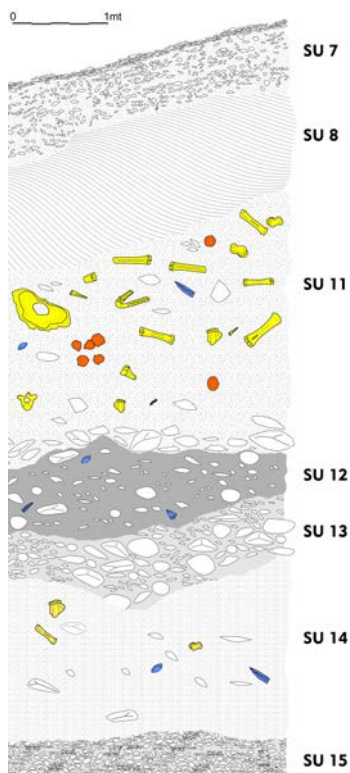


Figure 1. Stratigraphy of the Cava Muracci quarry site section, showing the location of the SU13 volcanic tephra layer.

Method

Ten samples, representative of the whole Albano crater eruptive activity, and one sample of the Cava Muracci tephra layer were analysed for major and trace element composition at Activation Laboratories (Canada) by Lithium Metaborate/Tetraborate Fusion ICP-MS. The fused samples were diluted and analysed by Perkin Elmer Sciex ELAN 6000, 6100 or 9000 ICP/MS. Wet chemical techniques were used to measure the loss on ignition (LOI) at 900°C. International rock standards have been used for calibration and the precision is better than 5% for Rb and Sr, 10% for Ni, Zr, Nb, Ba, Ce, and La, and 15% for the other elements.

Age determination was performed on sanidine grains extracted from Cava Muracci sample. Sanidine phenocrysts were isolated from the deposits using standard magnetic and density separation techniques and were co-irradiated with the 1.186 Alder Creek sanidine standard (Jicha *et al.*, 2016) at Oregon State University.

Results

The combined $^{40}\text{Ar}/^{39}\text{Ar}$ dating and trace-element composition of the tephra layer highlight the potential of this method. It has proved reliable thanks to the robust database, which made it possible an accurate comparison of the layers compositions. Cava Muracci's sample yielded a very well constrained $^{40}\text{Ar}/^{39}\text{Ar}$ age of 70 ± 2 ka which correlates it with Units 1 to 3 of the Albano activity at 69 ± 1 ka (Freda *et al.*, 2006; Giaccio *et al.*, 2009). Trace element composition provided even more accuracy demonstrating a confident correlation with Unit 3. The results show that this method provides a valid alternative to conventional dating methods, particularly to achieve *terminus ante/post quem*.

Significance

The research undertaken in this study provides an important step to further understanding and exploiting the volcanic products of the Albano Crater. The presence of these products it is attested in several Upper Pleistocene geo-archaeological contexts of central-southern Italy and eastern Europe, making this database a unique chrono-stratigraphical reference for many studies of this region whether archaeological, geological or stratigraphical. Moreover, the noteworthy benefit of this classification method, besides the ordinary and relatively inexpensive analyses, relies on its applicability to very small amounts (ca. 5 g) of even altered rocks. A remarkable feature which makes it suitable for most of the tephrostratigraphic and archaeological contexts, where other dating material may not be available or contaminated.

Acknowledgments

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MESOSCALE BARRIER ESTUARY BEHAVIOUR IN RESPONSE TO SEA-LEVEL RISE, STORMS AND SEDIMENT SUPPLY

Background and Rationale

Future vulnerability and resilience of coastal landscapes, and their associated communities, infrastructure and nature conservation interests, is of increasing concern due to the combined effects of climate change and sea-level rise. The Suffolk coast has high geomorphological (e.g. Orford Ness), archaeological and heritage conservation value (Special Area for Conservation protected under the EU Habitats Directive and an AONB) as well containing significant infrastructure (Sizewell B nuclear power station) but is both sediment supply limited and rapidly eroding (Pye and Blott, 2009; Haskoning, 2009). Holocene data for the Suffolk coast is spatially and temporally limited hindering an understanding of how the system behaves long term. Reconstructions of Suffolk's palaeogeography have been primarily based upon historical records (e.g. Pye and Blott, 2006), however

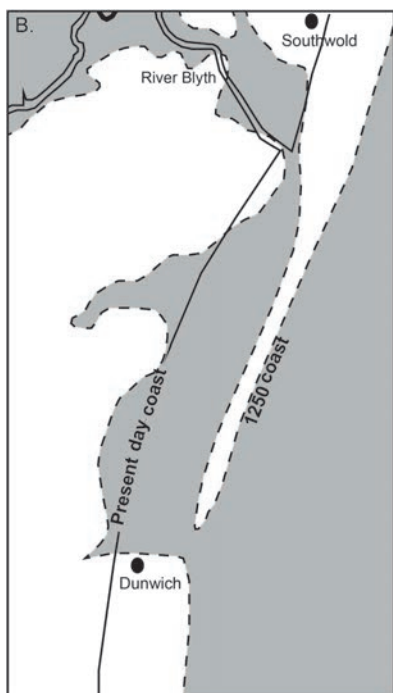


Figure 1. A. Location of Suffolk coast and the field work sites investigated within the Suffolk AONB (shaded dark grey) in April 2016. B. Conceptual model of Suffolk coastline in 13th century, compared to present day, based upon historical documents, charts and aerial photography (adapted from Pye and Blott 2006).

they have indicated that the coastline has changed dramatically in the last 1000 years (Figure 1). Producing robust baseline data on coastal evolution, relating to relative sea level, sediment supply and storm incidence, will improve this in addition to informing future management strategies for significantly unstable coastal areas.

A fundamental part of this research is to develop an extensive stratigraphic framework which will form the basis of the investigation into the long term influence of changes in sea level, sediment supply and storms on Holocene coastal system development. In April 2016, sediments from the enclosed wetlands of Oldtown Marsh and Great Dingle Hill were investigated and sampled. These sites are on the seawards end of the same system as Westwood Marsh (November 2015 fieldwork) and therefore more sensitive to coastline changes. Fieldwork costs were supported by the QRA New Research Workers Award.

Preliminary Results

Sediment cores from Oldtown Marsh and Great Dingle Hill were collected from a range of altitudes providing an opportunity to obtain mid-to-late Holocene compaction free sea-level index points. Preliminary diatom analysis across the main stratigraphic transitions has identified shifts from marine to freshwater conditions in the sampled cores. These periods of positive and negative sea-level tendencies could relate to changes in sea level or changes in the configuration of the coast, for example. Particle size, coupled with geochemistry, will shed light onto changes in the barrier and back-barrier and identify potential storm deposits. Radiocarbon dating will enable intra- and inter-site comparisons to be made.

Significance

Preliminary analysis of the sampled sediment record has shown that this section of the Suffolk coast has been subject to transitional and rapid changes during the late Holocene, supporting historical evidence. Future laboratory work will reveal additional information to support the diatom analysis initially undertaken. Future fieldwork will extend understanding of what has happened further north and south of this section of the coast to build a picture of the long-term processes which have shaped the coastline.

Acknowledgements

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THE SITE THAT SLIPPED THROUGH THE ‘LIME DECLINE’ NET A HOLOCENE HISTORY OF *TILIA* AT SHRAWLEY WOOD, WORCESTERSHIRE, UK

Background and Rationale

Through palynological analysis, this research examines the vegetation history of Shrawley Woods, an extant small-leaved lime (*Tilia cordata*) woodland on the banks of the River Severn, Worcestershire, UK, (SO814655). Given the widespread prehistoric *Tilia* declines across Britain, occurring primarily 4500–3000 cal BP or 2500–2000 cal BP (Grant *et al.*, 2011), and that fact that lime woodland is thought to have disappeared from Britain by 2000 cal B.P., this research provides a rare opportunity to explore the historic perseverance of *Tilia cordata*.

Results

A 1.35m core for pollen analysis was extracted using a Russian corer from a small filled-in basin on the edge of the current woodland. One range-finding radiocarbon measurement was obtained from 1.25–27m of 887 ± 31 BP (SUERC-63639) providing a calibrated date of cal AD 1030–1220 (95% probability).

Alnus pollen was excluded from the diagram (Figure 1) as it accounted for between 30–80% of total land pollen (TLP), potentially masking changes in other taxa. During SHA-1 *Quercus*, *Tilia*, Coryloid-type and Poaceae dominate, with *Ulmus*, *Plantago lanceolata*-type and *Rumex*-type pollen also being present. Small fluctuations in the *Quercus* and *Tilia* curves occur during the zone, but their concentrations change in tandem. The *Tilia* curve fades and does not recover in SHA-2, *Ulmus* also disappears. *Quercus*, *Corylus*, *Betula* and *Pinus* increase during the zone. The pollen of all tree species, including *Alnus*, decline during SHA-3, with herbaceous taxa rising alongside a large peak in microcharcoal.

Significance

The site represents one of the few dated lowland pollen sites where the presence of *Tilia* and *Ulmus*, alongside *Quercus* and *Corylus*, remain well into the historic period. Whilst further dating and analysis still remains necessary, the pollen evidence presented and the ancient tree evidence in the woodland suggest that whilst the area of *Tilia* trees has contracted, the *Tilia* woods did not completely disappear from this area. The presence of *Tilia* in other areas of the woodland suggests that the decline in *Tilia* pollen seen here is likely to have been a localised reduction, not a wholesale clearance. If this is the case, then the ‘declines’ and ‘disappearances’ seen palynologically in the earlier Holocene in other areas of the UK should be treated with caution as they could also be reflecting very localised changes in woodland structure and not necessarily total clearance.

Shrawley Woods, Worcestershire, UK

Pollen percentage diagram - selected taxa, *Alnus* excluded

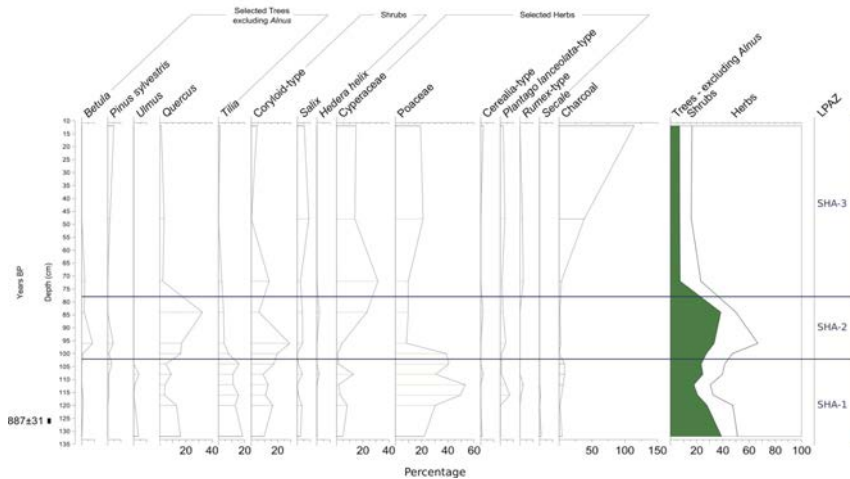


Figure 1. Shrawley Woods pollen percentage diagram of selected taxa, excluding *Alnus*.

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QUATERNARY RESEARCH FUND

GEOPHYSICAL IMAGING AND CHARACTERISATION OF CORS CARON, MID-WALES

Background and Rationale

Cors Caron (Tregaron Bog) is an important Quaternary site in mid-Wales. It is the location of a well-developed moraine of the Welsh Ice Cap, a Late Glacial moraine-dammed lake, a thick sequence of Holocene sediments, and is one of the best examples of raised bogs in Europe (Campbell and Bowen, 1989). Despite an important stratigraphic and geomorphological record, past work at Cors Caron has been limited in its spatial extent and depth of investigation. For example, the total volume of peat, and the thickness of glaciolacustrine sediments are unknown.

To address this knowledge gap, researchers from Newcastle and Cardiff Universities, collaborating with staff from Natural Resources Wales (NRW), have applied ground penetrating radar (GPR) and electrical resistivity tomography (ERT) to investigate the thickness and physical properties of the sequence of superficial sediments at Cors Caron.

Methodology and preliminary results

Funding support from the QRA allowed us to undertake an extensive ERT survey of the West Bog at Cors Caron, targeting the thickness and physical properties of the pre-Holocene sedimentary fill. The geophysical experiment consisted of three long ERT profiles, acquiring, in total, over 2 km of data. Due to a lack of access to equipment at the time of survey, a planned seismic refraction survey of the site was not undertaken.

ERT data were acquired using a 72-channel IRIS Instruments Syscal Pro resistivity system. Ground contact with the peat surface was achieved with metal electrodes, spaced at intervals of 5 m, connected to the resistivity takeout cable. Because of the high conductivity of the near-surface materials, data quality was excellent even with very low input currents. 40 MHz GPR data (Figure 1) were acquired coincident with the ERT profiles using an Utsi Groundvue 7.

Processing and analysis of geophysical data is ongoing, but initial results show that ERT imaging was possible to depths of 40-50 m. Data are consistent with known peat thicknesses of up to 10 m, derived from coincident GPR data and previous coring activities. In addition, however, the ERT data imaged the full thickness of pre-Holocene sediments and determined the sediment-bedrock boundary. Preliminary analysis suggests total sediment thicknesses (peat, glaciolacustrine and potentially other glacial sediments) in excess of 30 m.

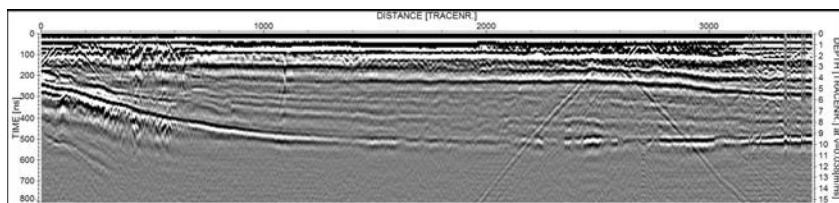


Figure 1. Example of 40 MHz ground penetrating radar data acquired across the West Bog, Cors Caron.

Significance

The next steps are to integrate our geophysical data, to develop an improved understanding of the post-LGM environmental history of Cors Caron. We will: (i) develop a 3D geophysical characterisation of an important raised bog peatland in Wales; (ii) provide key data for the optimisation of future coring activities at Cors Caron (e.g. informing site selection); and (iii) provide useful data and information to NRW for management and outreach purposes.

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REPORTS

SEA-LEVEL AND COASTAL CHANGE (SLACC) MEETING

5th – 6th July, Whitby

The second meeting of QRA's Sea Level and Coastal Change (SLaCC) research group was held at Whitby Museum in early July 2016. The conference was held in collaboration with Durham University's Coastal Behaviour and Rates of Activity (COBRA) research group, and organised by **Natasha Barlow** and **Sarah Woodroffe**, in association with **Nick Rosser** and **Matt Brain** (all Durham University). The setting of the conference at Whitby Museum made it an ideal place to discuss present coastal change along the North – East coast. The first day focussed on present research along this coastline and other coastal regions of the UK, whilst the second day focussed on past and present sea level and coastal processes research from all round the world.



Figure 1. Attendees of the second meeting QRA's Sea Level and Coastal Change (SLACC) at Whitby Museum.

Tuesday 5th July

The conference began with a keynote talk from **Nick Rosser** providing an overview of the wide-ranging research within the COBRA project. This long running research project began in 2002 with a focus on the rates, processes and

controls on coastal cliff erosion, in particular hard rock coastlines. The project has led the way in the development of erosion monitoring technology, such as terrestrial laser scanning for the monitoring of coastal cliff erosion. It currently monitors a 3.5km section of coastline on a monthly basis, with annual airborne LiDAR surveys to monitor a wider 23km section of the coastline. Throughout the day various researchers involved in the COBRA project presented their research. This ranged from using micro-seismic's to understand environmental controls on erosion (**Emma Vann Jones**, Durham), to high-resolution foreshore monitoring (**Zuzanna Swirad**, Phd Durham), to rockfall failure mechanisms (**Saskia de Vilder**, Phd Durham), and regional scale erosion monitoring using airborne LiDAR (**Jess Benjamin**, Phd Durham).

The North-East theme was continued with talks from **Alex Bellis** (CH2M) providing an overview of the different methods used to monitor coastal erosion by consultancy CH2M on behalf of the council, **Ken Pye** (Kenneth Pye Associates Ltd) outlining the importance of reliable tide gauge data in assessing sea-level rise, **Andy Barkwith** (BSG) discussing modelling of sediment movement along the Holderness coast, and **Andrew Colenutt** (Channel Coast Observatory) showcasing the data available as part of the National Network of Regional Coastal Monitoring Programmes.

Branching out from the North-East, invited speaker **Martin Hurst** (Glasgow) outlined the use of cosmogenic radio-nuclides to understand the evolution and retreat of coastal cliffs of East Sussex. Analysis of samples collected from foreshore platforms allowed long-term cliff retreat rates to be determined, revealing that Holocene cliff retreat rates were much slower than those derived from historical observations. Further along the south coast, **Steven Palmer** (Exeter) showcased a multi-faceted approach to monitor erosion along the South Devon and Dorset coastlines.

For a bit of fresh air and a chance to see erosion monitoring in action there was a short fieldtrip to the Whitby lighthouse. Currently installed at the top of the lighthouse is a terrestrial laser scanner which captures scans every 30 mins of the Whitby Cliffs below the famous Abbey. **Jack Williams** (PhD, Durham) talked through the benefits of this monitoring in allowing pre and post deformation of rockfall area to be recorded, as well as closer analysis between environmental controls and rockfall occurrence to be determined. There was also an opportunity to squeeze up into the lighthouse and see the logistics behind this technology and the scanning in action.

The first day of talks was topped off with some pre-dinner drinks at the Whitby Yacht Club, with a great view from the balcony overlooking a picturesque summer's evening scene of Whitby Harbour. The conference dinner was held at the famous Magpie Café, with some obligatory sampling of Whitby's famous fish and chips.

Wednesday 6th July

The conference took on a more global theme on Wednesday, with an opening talk by **Roland Gehrels** (York) on reconstructing records of late-Holocene sea levels, using salt marsh data, and showed some amusing examples of how this paper was received in the media. **Matthew Brain** (Durham) then presented work on the influence of sediment compaction on relative sea level change along the North American Atlantic coast. **Sara Woodroffe** (Durham) present work undertaken to reconstruct mass balance changes of the Greenland Ice Sheet in the 20th century using diatom analysis from saltmarsh records in Southeast Greenland, being the first time this technique has been used so close to the ice margin. The final talk of the first session was by **Louise Best** (a PhD student at the University of York) who presented her thesis work reconstructing late Holocene sea level change in the Humber Estuary, and the implications this has for the use of groundwater as a potable water resource in the area.

After coffee, invited speaker **Ivan Haigh** (Southampton) presented a compelling analysis of coastal flooding in the UK over the past 100 years, showing how extreme sea level events were mostly caused by moderate storm surges rather than extreme surges. Continuing the sea level theme of the day was **Aimee Slangen** (CSIRO, Australia and Utrecht University) present work on the impact of anthropogenic forcing on global mean sea level rise since 1970 using the CMIP5 model, finding anthropogenic impacts played a greater role in sea level rise after 1970. Moving away from sea level was **Andy Plater** (Liverpool) who showed the usefulness of marine radar on mapping intertidal areas, with impressive examples from the Dee Estuary, UK. The final talk of the morning session was by **Ed Garrett** (Geological Survey of Belgium) who took us to Japan to present work carried out with the *QuakeRecNankai* team reconstructing extreme wave events and tsunamis along the Japanese coast using low-lying saltmarshes and lakes.

After lunch, **Natasha Barlow** (Durham) took us to the Southern Hemisphere to test models of ice cap extents on South Georgia, showing that the island possessed extensive glaciation at the LGM. Moving back to the UK, **Christine Hamilton** (a PhD student at Liverpool John Moores University), presented her thesis plan on quantifying meso-scale barrier estuary behaviour in response to sea level rise, storms and sediment supply. The final talk of the meeting was by **Rob Barnett** (Université du Quebec, Canada), presented by **Roland Gehrels**, - which showed the potential of using salt-marsh testate amoebae as precise sea level indicators, with examples from the Quebecois and Norwegian coasts.

Throughout the conference poster presentations were on display from a wide range of topics. **Guillaume Goodwin**, a PhD student at the University of Edinburgh, presented his work on variability of wave induced erosion thresholds on tidal flats and salt marshes along the Venice coast. **Chloe Morris**, PhD student at Hull, presented her thesis developing a numerical model capable of simulation and

predicting morphodynamics of coasts and estuarine environments. **Noorzalinee Ghazali**, PhD student at the University of Edinburgh, presented her thesis work on wave attenuation rates of mangroves in peninsular Malaysia. **Greg Rushby**, PhD student at Sheffield, presented his work on using portable optically stimulated luminescence dating on coastlines in both Norfolk and North Wales. **Zuzanna Swirad**, PhD student at Durham, presented work on reconstruction of palaeo-cliff positions using cosmogenic dating with ^{10}Be . Finally, **John Preston**, PhD student at the University of Edinburgh, presented work in theoretical relationships between offshore slope and beach formation/stability and implications for understanding coastal archaeology on the island of Unst, Shetland.

The meeting once again proved a fantastic opportunity for members of the coastal research community to get together and enjoy the cutting edge research being undertaken all across the world.

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QRA SHORT DISCUSSION MEETING PALAEOECOLOGY: NEW APPROACHES, NEW INSIGHTS

6-7 September 2016

In September 2016 a meeting '*How developments over the last 30 years have changed our understanding of the paleoecology of the British Isles during the Holocene*' was held at the National Museum Wales, Cardiff with a broad remit to discuss ongoing research in palaeoecology, with a particular focus on new approaches and methodological advances. The meeting was organised by **Heather Pardoe**, **Elizabeth Walker** and **Trevor Bailey** (National Museum Wales), and was attended by 28 delegates from 15 institutions across the UK, including both academic and public organisations. 17 presentations were given over two days, typically followed by lively discussions, and delegates were also given the opportunity to visit some of the museum's natural history collections, including extensive insect and pollen collections.

The first day began with the keynote lecture, given by **Kevin Edwards** (University of Aberdeen), entitled 'Pollen, palynologists, people – glorious past, what of the future?' He provided a fascinating overview of the history of palynology and its pioneers, touching on the work of early scholars such as Lennart von Post, Gunnar Erdtman, Arthur Raistrick, Margaret Godwin and Sir Harry Godwin, amongst others. He discussed the incorporation of palynology into both archaeological and palaeoclimatological research, before considering the use of numerical modelling and potential future directions.

The first session began that afternoon, on 'Evidence for changes in plant distribution and diversity in the British Isles during the Holocene and the response of vegetation to environmental change', chaired by **Ralph Fyfe** (Plymouth University). The first talk was given by **Michael Grant** (COARS, University of Southampton) on the complexities of pollen data. He highlighted various sources of analytical bias and imprecision, but also how these can be accounted for, concluding that it is only by embracing and understanding such complexity that the science can move forward. Continuing this theme, **Helen Shaw** (UWTSO, Lampeter) spoke about the representation and interpretation of herbaceous taxa in palynology, using extensive modern analogue work to illustrate the potential problems of both under- and overrepresentation. Concluding this session, **Francis Rowney** (Plymouth University) presented a new pollen, beetle and fungal spore record from the West Runton Freshwater Bed, which he used to demonstrate the diversity of ecological disturbance processes occurring during Cromerian interglacials.

The next session, on 'Evidence for changes in animal distribution and diversity in the British Isles during the Holocene and the response of fauna to environmental change', was chaired by **Nicki Whitehouse** (Plymouth University). This began with **Eline van Asperen** (Liverpool John Moores University), who gave a talk on

reconstructing herbivore abundances using coprophilous fungal spores. Drawing on modern analogue and methodological research, she demonstrated that whilst these spores are a useful indicator herbivore presence, their relationship to abundance is more complex, highlighting a need to better understand their taphonomy. Moving to invertebrates, **Eva Panagiotakopulu** (University of Edinburgh) then spoke on the biogeography of synanthropic insects in the Palaearctic. She showed that whilst many expanded their ranges with the spread of farming during the Neolithic, others seem to have broadened their distributions in association with pathogens and more short-term movements of people. **Adrian Plant** (National Museum Wales) closed the first day with a talk on the post-Devensian biogeography of Empidoidea (Diptera) assemblages in Britain, demonstrating South-North gradients in assemblage composition, which suggest distinct phases of dispersal following the Last Glacial Maximum.



Figure 1.
Participants listening
to a presentation at the
QRA short discussion
meeting (Photo credit
Heather Pardoe).

The second day commenced with a short poster session. **Ashley Abrook** (Royal Holloway, University of London) outlined his recent research on vegetation responses to rapid climate change during the Lateglacial, with results suggesting increased disturbance during cooling episodes. **Heather Pardoe** (National Museum Wales) presented a poster introducing the Pollen Monitoring Programme, which has been operating for 20 years and aims to refine understanding of pollen-vegetation-climate relationships across Europe.

The third session of talks focused on ‘The range of botanical evidence for environmental change during the Holocene’, and was chaired by **Kevin Edwards** (University of Aberdeen). **Claire Jones** (Edge Hill University) gave the first talk, on the ‘big and small’ questions that palaeoecology can answer. A palynological case study on the history of Wistman’s Wood, Dartmoor was used to illustrate “the small”, and a broad-scale study of Holocene charcoal records across Britain and Ireland represented “the big”. **Heather Pardoe** (National Museum Wales) then presented findings from 20 years of modern analogue monitoring of variations in pollen productivity in one area, suggesting that intra-annual climate variability may influence the representation of different taxa.

Following this was a session on ‘Evidence for the impact of early people on the Holocene biota and environment of the British Isles’, chaired by **Elizabeth Walker** (National Museum Wales). This began with **Jane Bunting** (University of Hull) presenting on behalf of **Michelle Farrell** (University of Hull), whose recent collaborative work has utilised the multiple scenario approach to elegantly derive landscape-scale land cover reconstructions for the Somerset Levels, from the Late Mesolithic to the Early Bronze Age. This was followed by three talks on ‘crannogs’ (artificial lake islands), and their ecological and archaeological settings. **Kimberley Davies** (Plymouth University) gave the first of two talks which presented preliminary results from the ‘Celtic Connections and Crannogs’ project. Drawing on evidence from diatoms, chironomids and cladocera, she showed the impact on lacustrine ecology that human activity associated with crannogs may have had in some locations. **Katie Head** (Plymouth University) then presented the broader landscape setting for a crannog in County Fermanagh, Northern Ireland, using evidence from pollen analysis to infer the presence of pastoral and arable farming, and the cultivation of ‘high-status’ crops, in the region. Finally, **Mark Redknap** (National Museum Wales) spoke about the Llangorse Lake crannog: the only crannog known from Wales. Focussing on the archaeological evidence, he suggested cultural links to western Ireland and that this was another ‘high-status’ site.

The final session of the conference was chaired by **Heather Pardoe** (National Museum Wales), and was on ‘The development of multiproxy databases and computer models and their applications for reconstructing Holocene environmental change’. **Ralph Fyfe** (Plymouth University) presented an overview of the ‘Landscape Reconstruction Algorithm’ and its applications at different scales. He showed how it can be used to introduce spatiality to pollen records, which is often lacking from palaeoecological reconstructions, concluding that such models are getting us closer to ‘reality’. **Michael Grant** (COARS, University of Southampton) then concluded the meeting with a talk on the current development of the British Pollen Database (BPOL), which is making use of a broad range of data sources, including offline materials and ‘grey literature’, to produce a comprehensive database of pollen records.

Thanks are given to **Heather Pardoe**, **Elizabeth Walker** and **Trevor Bailey** (National Museum Wales) for organising the meeting, and to all delegates and presenters, whose contributions made it an engaging and productive two days. There was some fascinating research presented, which led to lively and interesting group discussions and suggested promising future directions for palaeoecological research.

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21ST QUATERNARY RESEARCH ASSOCIATION POSTGRADUATE SYMPOSIUM

14-16 September 2015

In September, the Centre for Environmental Geochemistry at the University of Nottingham hosted the 21st QRA Postgraduate Symposium. Overseeing the organisational efforts for the three-day conference were **Jack Lacey**, **Rowan Dejardin**, **Nick Primmer** and **Savannah Worne**. A strong attendance of 28 enthusiastic delegates from 17 institutions across the UK and Ireland ensured the meeting was a great success, with a broad range of Quaternary science themes being presented and discussed. The meeting also included a tour of the British Geological Survey, an ECR training workshop, and culinary excursions to England's oldest inn and one of the last Victorian music halls in the country.

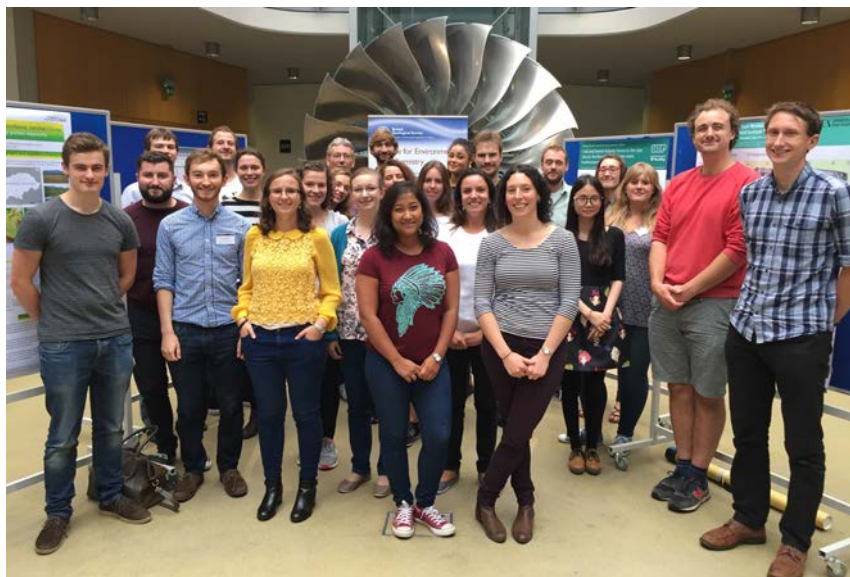


Figure 1. Delegates of the 21st QRA Postgraduate Symposium.

The first day of the symposium commenced with a keynote presentation and tour of the British Geological Survey. Delegates arrived at the BGS's De la Beche Conference Suite and, along with survey staff, were invited to a keynote given by **Professor Colin Waters** (BGS and secretary to the Anthropocene Working Group of the ICS Sub-commission on Quaternary Stratigraphy). The talk focussed on the question of the Anthropocene and providing evidence for a new epoch stratigraphically distinct from the Holocene. This presentation closely followed the Working Group's recent recommendation that the Anthropocene is geologically real and should be assigned Epoch status, which gained significant media attention. Following the keynote, delegates experienced a state-of-the-art 3D visualisation suite, explored the National Geological Repository core stores and biostratigraphy collections, and journeyed back through time on the Geological Walk during a tour of the BGS. Later that evening an ice breaker event was held in the University of Nottingham Museum of Archaeology, affording everyone the opportunity to meet one another and catch-up. Following the ice breaker, the group headed to the Malt Cross pub (one of Britain's oldest Victorian music halls) in Nottingham city centre for an informal dinner and then on to Ye Olde Trip to Jerusalem - the oldest inn in England built into the rocks beneath Nottingham Castle.

On Thursday morning we were back on the University of Nottingham campus in the Engineering and Science Learning Centre. This began by hosting **Dr Steve Hutchinson** (Hutchinson Training and Development) who ran an engaging workshop on strategic conference attendance and maximising your profile. Steve delivered information in a very accessible way and the course received excellent feedback. Although only a morning session, the workshop covered a lot of ground and assuredly will allow delegates to make the most of future conferences and networking events. An afternoon of presentations kicked-off with a keynote talk by **Professor Melanie Leng** (BGS/University of Nottingham) who introduced the science of stable isotope geochemistry in relation to palaeoclimate research. The talk provided fascinating examples of how isotopes are being utilised in global climate and environmental change research, with an emphasis on lake, ocean and speleothem deposits. This led into the first session of presentations from postgraduate students on *Marine Palaeorecords and Glacial Systems*, which took us from South Georgia in the Southern Ocean to North Mayo in Ireland. The talks were followed by a poster session, which generated further discussion and allowed an even wider range of research to be presented. The conference dinner was held at 4550 Miles from Delhi, one of Nottingham's liveliest Indian restaurants.

Friday morning started with a session on *Palaeoecology, Landscape Evolution and Management*, which comprised a range of outstanding talks on research covering peatland, estuarine, moorland, and coastal environments. The subsequent and final session of talks on *Palaeoclimate from the Terrestrial Realm* gave great insight into the use of chironomids, fossil rodent teeth and multi-proxy lake sediment records for reconstructing the past climates of Morocco, Turkey, Mexico and the

UK. symposium closed with the Annual General Meeting, where delegates voted for their choice of best presentation and poster. Prizes were awarded to **Stuart Umbo** from the University of East Anglia for his interesting and informative talk '*Reconstructing Quaternary North Atlantic temperatures using clumped isotopes*' and to **Dave Arnold** (Royal Holloway, University of London) for his poster on '*Assessing the extent of semi-arid environments in Late Quaternary Eurasia using mammalian evidence: implications for understanding ecological and human responses to abrupt climate change*'. Royal Holloway won the bid to host the 22nd QRA Postgraduate Symposium in 2017 and **Rachel Devine** (Royal Holloway, University of London) was elected as the new junior postgraduate representative on the QRA Executive Committee. **Laura Crossley** (University of Southampton) will take over the role of senior postgraduate representative from **Jack Lacey** (BGS/University of Nottingham), who will take on his new role as Treasurer of the QRA.

Thank you to the organisations who sponsored the event: Quaternary Research Association, Centre for Environmental Geochemistry, Wiley, University of Nottingham Life in Changing Environments Research Priority Area, The Micropalaeontological Society, University of Nottingham Department of Geography. Furthermore, thank you to all the delegates who attended and contributed to the symposium and made it such a constructive and enjoyable meeting.

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GLWG/QRA/IQUA JOINT FIELD MEETING: THE QUATERNARY OF THE MOURNE MOUNTAINS,

27-30th October 2016

In late October, lured by a packed itinerary and another high quality field guide, a throng of Quaternary scientists arrived at the Mourne Mountains to discuss the Quaternary glaciation of the area. The occasion was officially the 17th field meeting of the Glacial Landsystems Working Group (GLWG) and a joint meeting with both the Quaternary Research Association (QRA) and Irish Quaternary Association (IQUA). As usual, the GLWG meeting was popular drawing attendees from the UK, Republic of Ireland and South Africa. This field meeting was led by **Sam Roberson** (Geological Survey of Northern Ireland; GSNI), **Iestyn Barr** (Queen's University) and **Mark Cooper** (GSNI). Proceedings kicked off with a well-attended introductory talk and public lecture on Thursday evening at the Newcastle Community Cinema. After an excellent introduction to the Mournes and overview of the previous work in the region, the group retired to The Donard to prepare for the following busy days in the field.

Day 1

The group spent the first day exploring the Annalong Valley, a glacial trough preserving some of the best glacial sequences in the Mournes. Following an introduction to the geology of the Mourne Mountains from **Mark Cooper**, the group headed into the main valley. Discussions started soon after setting off, with **Sam Roberson** highlighting the presence of moraines extending from the lower Annalong valley onto the Mourne Plain. These features are attributed to the Annalong Glacier which is thought to have readvanced during the Killard Point Stadial (c. 17.2 – 16.6 ka) and cross-cut older moraines associated with sheet recession from the LGM. **Peter Wilson** provided an overview of granite tors in the Mourne Mountains with the limited work in the region focused on weathering pits, tor displacement and tor modification – epitomised by the presence of impressive granite plinths on the summit of nearby Slieve Lamagan.

The group continued upvalley towards a col overlooking the impressive Kilkeel Reservoir and Hare's Gap, a glacially breached watershed attributed to the incursion of regional ice, was just visible in the upper reaches of the Silent Valley. Here, **Iestyn Barr** talked about the extent of Younger Dryas glaciation in the Mourne Mountains. The region has been traditionally considered to be ice free during the Younger Dryas. However, geomorphological evidence and recent modelling suggests that cirque glaciers were present during this period. **Clare Boston**

queried how confidently the extent of Younger Dryas ice can be established using this approach in the absence of any chronological evidence (relative or numerical). The difficulties of establishing glacier extent in association with a limited geomorphological signature were discussed.



Figure 1. Group discussions overlooking Silent Valley and Hare's Gap (photo credit Clare Boston).

After lunch beside a small tarn, the group ascended to inspect Cove Lough where the group was able to further examine the discreet nature of the geomorphological evidence proposed by **Iestyn Barr** to potentially relate to the Younger Dryas. This vantage point also provided excellent views of moraines in the central Annalong Valley, attributed to deglaciation from the Killard Point readvance. The largest of these moraines has been sampled, using Schmidt-hammer exposure dating (SHED), as part of a larger relative dating campaign undertaken by **Sam Roberson** and **Iestyn Bar**. The sampling undertaken within the Annalong basin appears spatially coherent, supporting expected patterns of deglaciation, with summits initially exposed followed by cols, valleys and finally cirques. However, a different SHED campaign by **Peter Wilson** on the aforementioned Annalong moraine yielded markedly different results highlighting a significant limitation of SHED. A thought-provoking discussion resumed amongst the group regarding the potential dependence upon consistent sampling strategies for comparable results.

Finally, before leaving the valley, the group had the opportunity to inspect a large (10m high) section of diamicton exposed by stream incision. Those who were

sedimentologically-inclined climbed up to the section for a closer inspection of the sediments, after much discussion it was generally agreed that the sediments showed evidence of subglacial shearing and had been overridden by advancing ice. On the return journey to Newcastle, the day culminated with a final treat from **Jon Merritt**, a section hidden by public toilets. Although discreet, the importance of the site was immediately apparent upon explanation that the sediments were associated with the glaciation of the Irish Sea by ice flowing south from Scottish ice centres.



Figure 2. The group descends from Cove Lough along the largest of the Annalong moraines associated with the Killard Point Stadial (Photo credit Lauren Knight).

Day 2

The second day of the field meeting focused its attention upon the Mourne Plain. At Derryoge Bay, **Jon Merrit** led the group (via a muddy scramble) to an impressive coastal exposure comprised of Irish Sea till and overridden and deformed marine mud drapes. The sequence features a large swale incised into the till and infilled by glaciomarine sediments dated to c. 20 ka. This swale is just one of six between Derryoge and Kilkeel. Overlying the flanks and base of the swale

a boulder pavement is present, suggesting a subsequent phase of ice advance. Although it is unclear exactly how the pavement formed, it is particularly well preserved along the sequence and may reflect a tidewater glacier margin lifting off ploughed boulders. **Maarten Krabbendam** was particularly efficacious in discussing potential formation mechanisms for both the channels and the boulder pavement.

A short stop at Ballnahatten Pit introduced the group to a section composed of sand and gravels from underlying outwash. The sequence, situated in a working gravel quarry complete with horses, shows signs of overconsolidation as well as hydrofracturing through conduit fills. A similar section at the neighbouring Sandpiper Pit has been interpreted as rapidly deposited, ice-proximal subaqueous (glaciomarine) outwash. However, the general consensus of the group was that, at Ballnahatten, the presence of vertically orientated clasts reflect periglacial reorganisation rather than dropstones as previously suggested by Mashall McCabe. Over-consolidation coupled with an extensive planar basal contact, pronounced horizontal fissility and inclusion of ice-scratched clasts lodged at the base suggests subglacial deposition associated with a minor glacial readvance from the west.



Figure 3. Inquisitive locals joined the group at Ballnahatten Pit (Photo credit Lauren Knight).

The final site of the day was Kilkeel, a significant locality where a radiocarbon dated sequence of muds suggests relatively early deglaciation of the northern Irish Sea Basin. The sequence consists of several units including the Ballymartin Member, a subglacial traction till. The aforementioned swales continue at Kilkeel, with the Derryoge Member forming the channel fills. Work on this member suggests that the mud-filled swales were filled during several hundred years of shallow-water glaciomarine conditions with extensive winter ice. **Jasper Knight** highlighted some excellent ‘honeycomb’ till (brecciated till infilled by sand and gravel), providing evidence of large volumes of meltwater at high pressure (dykes running upwards through sequence). Sand and gravel layer on top of glacial sequences are very well sorted and may be ice-distal. Ice-wedge pseudomorphs identified by **Richard Waller**, providing evidence of periglacial conditions following the retreat of ice in Irish Sea basin around 17 ka. Finally, the group walked along the bay to look at an excellent example of a tectonised interglacial beach with marine gravels, sands and shells (dated to c. 40 ka). There was also significant evidence of proglacial slumping of marine sediment laden with gravels, though discussion emphasised that these are not necessarily glaciomarine but may constitute ice-proximal meltout till.

Day 3

The group started the final day winding its way through the County Down drumlin field and were joined by a local guide at Killard Point – an inquisitive dog. The group were escorted by the dog all the way to Bendarg Bay, which features a sequence dominated by couplets of angular gravel and winnowed red clay drapes. It is topped by a well-sorted sand unit with cross stratification, rip-up clasts, flame structures, waterscape structures and channel margin slumps. The sequence has been suggested as a possible grounding zone wedge featuring evidence of density driven deformation. Discussions centred upon the source of the large volume of sediment and a meltwater channel identified in Strangford Lough was suggested as the possible passage for significant meltwater volumes from Scottish ice courses. The sandstone lithologies are consistent with this suggested mechanism, although models of grounding zone wedge formation are problematic given the difficulty of accessing modern analogues.

The final stop of the field meeting was at Ballynahinch Recycling Centre, situated in the heart of the south Down drumlin field. Here the group were treated to the “best drumlin section ever” (S. Roberson, pers. comm., 2016), once everyone had scaled the recycling centre wall via ladder (Figure 4). The section exposed a sequence of tectonised silt containing deformed and laminated clay (with slickensides) overlain by well-sorted sand and angular gravels. Angular diamicton overlying the whole sequence supports the interpretation that the silt-clay sediments are lacustrine, deposited prior to drumlinisation. Sand and gravel deposits appear



Figure 4. The excellent drumlin section at Ballynahinch Recycling Centre (Photo credit Lauren Knight).

consistent with material derived through mass-flow, forming in a subglacial conduit or cavity. **Sam Roberson** highlighted the presence of carbonate nodules within the sequence, proposing that the sequence could be dated if working on the principal that carbonate-rich meltwater was injected through the sequence during drumlinisation. However, this leaves the question of whether this would happen at the LGM, during ice-drawdown, or the Late Glacial during the Killard Point Stadial. The latter is the currently accepted model.

Following a final group photo outside the aptly named Drumlin Primary School, it was time to say goodbye until the next meeting. The Mourne Field Meeting was a great success, full of stimulating and thoughtful discussion. Thank you to **Sam Roberson**, **Iestyn Barr** and **Mark Cooper** for organising a thoroughly enjoyable trip.



Figure 5. Attendees of the Mourne Mountains field meeting (Photo credit Lauren Knight).

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REVIEWS

EVOLUTION OF A BRECKLAND LANDSCAPE: CHALKLAND UNDER A COLD CLIMATE IN THE AREA OF BEACHAMWELL, NORFOLK

R. G. West

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The Suffolk Naturalists' Society, Ipswich, 110pp (softback): List Price £10.00. There is a special 'buy one, get one half price' offer of £15 (£18 inc p&p) if purchased with the companion volume 'From Brandon to Bungay' (2009). www.sns.org.uk

Following review of R. G. West's excellent book by **Julian Merton** in the October 2016 edition of *QN*, here **Tim Holt-Wilson** provides his take on the book in the following review.

The glacially-eroded chalk scarp south-west of Swaffham presents an open landscape of gently undulating arable terrain, where big geometrical fields are interspersed with occasional hedges, shelter belts and forestry blocks. It is drained by shallow, marshy valleys with damp meadows and tracts of carr woodland watered by seeps and springs arising from the bedrock; all draining south-westwards towards the Fenland basin as part of the northern Wissey catchment. This is the area investigated by Prof. Richard West in his latest book about the East Anglia's Pleistocene heritage. He confesses to have always found this corner of Norfolk "rather featureless". What he has done here is show how an enquiring mind can reveal a range of hitherto unnoticed geological features and contribute new insights into the evolution of a landscape.

The author covers three main topics: 1) the formation of dry valleys and associated spreads of sand and gravel in the Beachamwell area; 2) evidence for proglacial lake sediments of pre-Devensian age in the Shingham Stream valley; and 3) the evolution of local periglacial patterned ground and other landform features developed on the Chalk. "All these features combine to make the area of chalkland between Swaffham and Shouldham an area of great potential interest".

In keeping with the spirit of the times, the book is published at A4 size in 'austerity' format. With a total of 110 pages, it has a resistant, laminated card cover, but there is no title on the spine, no ISBN and – frustratingly – no index. (I presume the comprehensive contents page is a stand-in; I have had to start pencilling my own index inside the back cover in default of a flyleaf to write on). The typeface

is Times New Roman, only 10 point, which becomes a strain on the eyesight after a while. The diagrams are line-drawn by hand and uncoloured, including the maps, most of which are ingeniously detailed. Reading the book requires sustained concentration. I spent two nights in hospital in 2015, so I was able to give the book my uninterrupted attention then, but as I am not familiar with the terrain I needed a copy of OS Explorer map 236 (King's Lynn, Downham Market and Swaffham) to help make sense of the geography. Lacking one, I had to make do with an intricate exercise in memory and imagination. There are three appendices containing lithostratigraphic details, and an impressive 39 pages of annotated terrestrial and aerial colour photographs. We owe the publication to funding from GeoSuffolk, the Geological Society of Norfolk and the author himself. Its format and funding represent a way of spanning the gap between publication of specialist geological literature and a manifest need to interpret East Anglia's geology for a wider public.

The book has prompted me to explore this corner of the Norfolk landscape for myself. In the process it has raised some questions about the author's interpretation of the geology and geomorphology. Firstly, the British Geological Survey (1999) has mapped an isolated spread of sand and gravel in a basinal area within the chalk landscape round Beachamwell. It is classified as a terrace deposit, although it is likely that a substantial proportion would have been marked as 'head' had the mapping been completed in the same way as the adjacent Thetford sheet 174 (BGS 2010). The author interprets the Beachamwell spread as a post-Anglian solifluction deposit, as exemplified by chalk and angular flint gravels seen near Furze Hill. He goes on to investigate two local sands pits at Caldecote and Gooderstone, on the flanks of the Shingham and Gadder river valleys at *c.* 12 m and *c.* 18 m OD, respectively. He interprets their sediments as evidence for the presence of a short-lived proglacial Shingham Lake of 'Wolstonian' (post-Hoxnian / pre-Ipswichian) age (*c.f.* Bowen (ed) 1999) in the northern River Wissey catchment, ponded up against interfluves and rising ground to the east. This lake is linked with evidence for an ice sheet of MIS 6 (Saalian) age (the Tottenhill ice sheet of Gibbard *et al.* 2011) in the Fenland basin, which gave rise to an ice-dammed Lake Paterson in the southern Fens, having an eastward-draining spillway into the North Sea basin via the Little Ouse / Waveney valley corridor (Gibbard *et al.*, 1992; Gibbard *et al.*, 2009; West, 2009; Gibbard *et al.*, 2011). He considers the lake to have reached a maximum height of *c.* 18-20 m OD in the Beachamwell area, with a possible temporary spillway northwards into the Nar valley at Shouldham. The geological evidence for the presence of lacustrine deposits at Caldecote (Monson's Pit) is convincing – horizontally bedded, laminated silts and fine sands; the presence of rhythmically-bedded couplets with graded layers; dropstones – which I have seen for myself. I note that these deposits are not indicated on the geological map; the site is represented as only Chalk bedrock. They indeed rest directly on a chalk surface pitted with many solution pipes (some over 90 cm deep). What evidence is there, apart from their relationship to the hypothesised Shingham

Lake, to attribute them to the 'Wolstonian'? Their landscape context, on the crest of a low shoulder of rising ground, does argue for a substantial period of erosion since their deposition; they are thus very likely to predate the Devensian. The author's second site is at Gooderstone (Knights' Pit), where fine-grained sediments interpreted as Shingham Lake deposits at c. 20 m OD rest upon chalky and flinty gravels and a diamicton interpreted as 'marly till' of Anglian type. The Shingham Lake hypothesis is persuasive on grounds of geomorphology and what we know about the post-Hoxnian / pre-Devensian geological history of the Fenland basin, but I think the author's account begs for further work on the mineralogy and geological context for these deposits, perhaps involving cored transects and OSL dating of the solution pipe contents. They may be erosionally-isolated Anglian lacustrine deposits, perhaps preserved in chalk solution hollows. There is said to be a gravel pit at Furze Hill on the opposite side of the Shingham valley from Monson's Pit at c.13 m OD; this calls for investigation. I note that the BGS map shows eroded remnants of Lowestoft Till in adjacent parishes lying at equivalent heights (10 to 20 m) above OD; they straddle the Shingham and Gadder valleys which are incised through them.

Secondly, the author carries out an in-depth investigation of periglacial landforms in his study area using aerial photography of crop marks backed up by on-foot reconnaissance and soil augering. He identifies and analyses in detail the distribution of a variety of landscape elements across a wide area of some 40 km². These include a range of ground-ice depressions and associated forms (from fresh-looking to eroded looking), linear features, complexes of frost stripes and polygons, dry valleys, solifluction spreads. He has identified palimpsest phenomena where landforms of one period are superimposed upon those of an older. "So what we see now is the landscape and its patterns present on thaw of permafrost and change at the end of the last cold stage (Devensian) compiled from periglacial processes over two cold stages". "Re-imposition of the periglacial climate could well lead to a resuscitation of periglacial processes, 'reusing', or over-printing patterns already developed" (p.55). This is a key conclusion of his survey. However, I note that recent work on periglacial phenomena (Bateman 1995; Hitchens 2009; Bateman *et al.*, 2014) has not found evidence for any patterned ground formation and aeolian coversand deposition in East Anglia pre-dating the early Devensian. Drawing on OSL dating evidence, patterned ground formation has gone through multiple phases of activity during stadial periods from 60,000 years B.P. onwards, but it does not yet appear to date from earlier cold periods. The author proposes he has evidence for patterned ground formation in the 'Wolstonian' as well as the Devensian. While accepting that similar periglacial processes are likely to have been operating in both periods, I am unclear why he does not attribute his palimpsest evidence to the succession of stadials in the Devensian, this seeming the most parsimonious explanation at present.

Readers must buy the book and evaluate Richard West's evidence for themselves, preferably via a series of field excursions in winter time, when standing crops are absent and vegetation is dormant. It is an admirable book of an unusual kind, drawing on the author's enormous experience of the East Anglian Pleistocene, and combining geological and geomorphological evidence in what we might call a 20th century geographical tradition (c.f. Sparks and West 1964, Straw, 1973) to present a landscape-scale synthesis. It presents testable hypotheses as a framework for future research, contributing to debate about the evolution of post-Hoxnian / pre-Ipswichian East Anglia and presenting further evidence for possible local impacts of the Tottenhill glaciation. Above all, like its sister volume dealing with the Little Ouse valley (West, 2009), it is an extraordinarily rich field trip '*vade mecum*' for geologists and landscape enthusiasts which will, hopefully, prompt exploration and investigation for many years to come, whether in this study area or elsewhere in the East Anglian chalklands.

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GEOSCIENCE ATLAS OF SVALBARD
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This relatively affordable atlas provides a wealth of information about the physical environment and geology of Svalbard, a Norwegian archipelago 60,667 km² in area between 74° to 81° N and 10° to 35° E, around three fifths of which is still covered in ice, half way between the Arctic Circle and the North Pole. These demilitarized islands have a special international administrative status established by the 1920 Svalbard treaty. Ratified in 1925, this grants a growing number of nations mineral and trading rights regulated by the Norwegians on an impartial basis: soon this may be the only other place in Europe where British citizens have automatic residency rights! Along with a number of coal-mining settlements on Spitsbergen which is almost 400 km long, there are research and weather stations, along with huts are more widely scattered, including on the isolated islands of Bjørnøya and Hopen. Much of the islands are already heavily protected by nature reserves and national parks.

This atlas is subdivided into twelve thematic subdivided chapters written by 31 experts within a generous three column 34 by 24 cm format incorporating numerous full colour illustrations, photographs, and synoptic maps, often on pages opposite the accompanying text. With numerous neat subheadings, this text aims to present these topics in as accessible a way as possible to a wide range of readers, and to awaken researchers to related fields of interest, so that it is an eclectic mix of basic information and more intense scientific study. A lot can be gained by simply looking at the illustrations. Richard Binns edited the English to produce a fluent and consistently high quality text with very few Americanisms and mistakes. Given the sheer diversity of the material, it is sometimes necessary to refer to other chapters for information on related topics. Naturally the first chapter deals with the early history of Viking exploration around these uninhabited islands, rediscovered by Willem Barentsz in 1596 during the hunt for the northwest passage. The jagged

mountains or spitz along the northwestern coast of Spitsbergen resulted in its name, though its 1,713 m highest point Newtontoppen is more centrally placed. We are then treated to accounts of the early 19th and 20th century pioneers with reduced reproductions of the first geological maps, along with later regional sheets and the current 1:750,000 map of the islands coupled with the scientific contributions of a number of different nations, including the Soviet Union, Poland, and the United Kingdom.

The physical geography chapter places this remote archipelago into the broader context of other arctic environments and their surrounding oceans, including Hudson Bay and the Bering Sea and Aleutian islands, with useful summaries of both the Eurasian and North American landscapes at latitudes mostly above 60°N and notes about similar islands and the extent of their glaciation. The bathymetry of Svalbard's environs and glaciated continental margins is illustrated with a neat conceptual model and sea bed images showing iceberg ploughmarks at considerable depths down to even ~1,000 m. Then the islands themselves are briefly outlined along with their current areas and ice cover: during the last 40 to 50 years over 600 km² has been lost overall, as a result of the withdrawal of maritime glacier fronts. Next the ocean and sea ice chapter provides some remarkable insights into the ocean currents around Svalbard as they flow at various levels including a clockwise one around the islands. However no information is provided about the usual tidal range at the administrative capital Longyearbyen 78°13'N 15°38' E of under 2 m and any notable variations along these coasts which could affect both the formation of sea ice and calving of glaciers directly into the sea. However, it does provide a remarkable overview complete with photographs of how sea ice forms and develops over time, in spite of most of the increasingly dense salt water sinking as it cools towards freezing at about -1.8°C. A couple of pages show the monthly extent of sea ice between Greenland and Novaya Zemlya, indicating how these fronts have retreated between 1980 and 2010. Given the exceptional warmth in the high Arctic towards the end of 2016, it is worth checking the extent of Arctic Ocean sea ice on the US National Snow and Ice Center website <http://www.nsidc.org> including <http://nsidc.org/arcticseaicenews/charctic-interactive-sea-ice-graph/> - its interactive sea ice graph.

Glaciers are described in a brief chapter describing their regional distribution and broad characteristics, including the mean slope and elevation of these valley glaciers, cirques, ice fields, and more extensive and thicker radial caps. Along with some stunning panoramic photographs, there is a wonderful insert map showing the bedrock topography below the over 100 km wide Austfonna ice cap on Nordaustlandet which could have been captioned to explain that the white contours for ice surface are at 50 m intervals, so it is possible to plot its thickness and thus calculate its volume. Then the question of how glacial mass balance is measured is explained, before the chapter concludes with unpredictable glacier-surfing events: some remain stable for centuries while other glaciers surge much more frequently.

A much longer chapter on the islands' Quaternary geology and geomorphology starts with brief summaries of the varied landscapes found in Svalbard. This continues with Arctic landforms, including braided river plains, raised beaches, pingos, patterned ground and debris flows, giving some idea of what these ice margins must have been like much further south during earlier glacial stages. More recent changes to the landscape are then documented showing the impact of glacier retreat by comparing historic and contemporary photographs of the same places along with some detailed insert maps. The varied nature of the permafrost - consisting of frozen ground between about 100 m and 400 m thick in the mountains in relation to a much thinner overlying active layer which thaws during the summer - is explained including how these processes control the development of certain landforms. Karst features have developed in areas of exposed soluble sedimentary rocks subject to dissolution, including a number of thermal springs. Then the main types of superficial deposits are briefly outlined before the glacial geology is discussed in some detail. This includes a 5M map showing the successively shrinking limits of the late glacial maximum ice sheet, local emergence diagrams, and postglacial uplift contours ranging from zero along the northwestern most margins to over 70 m. This is coupled with an account of the islands' postglacial history since the thermal maximum between 10 and 5 ka during which the extent of the remaining ice has twice waxed and waned, including currently accelerated melting following the little ice age. The rest of the chapter goes into some detail about the development of slow and fast flowing ice landforms, coupled with fjord bathymetry and bedrock geology: the illustrations include seismic profiles, maps and colour hydrographic depth maps complete with a series of enlargements showing areas within Kongsfjorden.

The historic geology chapter explains the geological evolution of the islands since the Archaean, starting with an excellent page on the different methods of age determination of rocks by relative and absolute methods alongside a reproduction of the 2012 international geologic time scale. This text continues overleaf alongside a table showing this time line next to a global sea level curve with notes about the main stratigraphic units found on Svalbard as it drifted northwards from south of the equator during the Cambrian. This is followed by a comprehensive overview ending up with the Quaternary including a glaciation curve spanning the last 150 ka. Even if this is not its primary focus, more information can be gained from the excellent Quaternary Geology of Norway (Olsen *et al.* 2013) which can be downloaded for free.

The bedrock geology chapter starts with a beautiful geological map of the surrounding waters including, the Barents Sea shelf and the North Atlantic ridge as it enters the Arctic Ocean. Following another couple of synoptic maps showing the main stratigraphic units and rock types, the text outlines the development of geological sheets covering Svalbard, including those areas yet to be mapped in detail, before presenting an index of the 250k geological maps extending over

the islands on the following 23 pages (including one page at 500k), omitting the largely ice covered southern half of Nordaustlandet. These excellently drafted and thoughtfully coloured maps (with topographic contours in brown for land and blue over ice-covered areas) contain no fewer than 256 clearly numbered units, including unconsolidated material and isolated Quaternary volcanic rocks alongside faults and thrusts often inferred under the ice, with neat symbols for other features. The only flaws are, that the pages complete with scale bars are a bit pinched down the middle, making these areas hard to read, while the maps have no simplified offshore bathymetry. These maps compare well with the slightly awkwardly folded 200k geological sheets for NW and NE Nordaustlander (DE23G and FG23G) published in 2014 with a UTM 10 km grid and cross sections which provided rather more information including some extra subdivisions and structural detail. The overall style is considerably better than those produced by the British Antarctic Survey (Nowell 2012). However most of this series is published at 100k, including the isolated sheet (G14G) for the 32 km long narrow island of Hopen (2013) some 100km southeast of Edgeøya, which makes up for its limited extent by including an impressive array of marginalia and comprehensive notes mainly in English - the Triassic sediments are well exposed, and Norsk Fina drilled two wells given their potential to form hydrocarbon reservoirs in the Barents Sea. These three sheets are priced at 80 NOK each.

The tectonics chapter with numerous maps, impressive cross-sections and annotated photographs shows how this landscape is influenced by these underlying structures, even if a series of glaciers have simply sliced through the main north-south faults and thrusts to produce fjords. Some of these fault zones date back to the time during the Eocene when Greenland separated from the Eurasian plate before by the Oligocene becoming attached to North America. Near the end there are six very interesting pages on Neogene-Quaternary volcanism and thermal springs up to 28°C with precipitated travertine deposits. The Sverrefjellet volcano grew concurrently with the surrounding glaciers, and eruptions would probably have interacted with the frozen cryosphere (Smellie and Edwards 2016), even if these authors do not mention volcanism on Spitsbergen. This is followed by a reasonably comprehensive and clearly written glossary of structural and tectonic terminology. The Geophysics chapter is well worth dipping into: it covers the regional pattern of recent seismicity, gravity and magnetic anomalies along with changes in magnetic declination which are influenced by the intense magnetisation of certain local granites and dolerites. Returning to the Quaternary, the brief chapter on the geochemistry of superficial deposits presents a tantalising series of a dozen major element maps derived from 650 samples of fluvial sediments from Spitsbergen, coupled with a tabulation of the range of maximum and minimum values found for 48 elements.

The chapter on georesources neatly explains the history of mineral exploration, including drilling for oil and gas without success. While ores and industrial

minerals and building stone have been exploited, coal mining has been the main industry, including some of the world's oldest early Carboniferous coal seams, in addition to much more productive Palaeogene coal measures which are still being mined. Finally there is a brief chapter on the management and infrastructure of the islands, including the extent of the exclusive economic zone out to 200 nautical miles which may be outside the remit of the original Svalbard treaty. This chapter also has notes on the settlements, research and service stations, transportation and navigation. Then there is a detailed bibliography and extensive index. Overall this magnificent publication merits a wide circulation, including for inspiring researchers who wish to broaden their horizons. Also, this format could prove a useful template both for the British Antarctic Survey and the French TAAF for the sub-Antarctic Kerguelen islands in the southern Indian Ocean which have a much more isolated ice cap.

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ABSTRACT

QRA UNDERGRADUATE DISSERTATION PRIZE, 2016

The environmental impact of European settlement in Australia: influences on a patterned fen ecosystem

The European colonisation of Australia is considered to have had significant environmental impacts across the continent, however the extent of these impacts on a regional scale varies considerably. The modification of the Aboriginal fire regime is a frequently debated and contentious issue within the scientific community. This study conducts pollen and charcoal analysis on a core from a patterned fen wetland on Fraser Island of the east coast of Queensland to assess the impact of European colonisation in terms of trends in burning and vegetation. Being the first palaeoenvironmental study conducted at a high temporal resolution spanning the period of European colonisation on Fraser Island, the results provide a detailed insight into the interaction between burning, vegetation and responses to further anthropogenic modification. Contrary to the majority of literature, the charcoal record in this study suggests that European colonisation did not extensively modify the existing fire regime on Fraser Island. However, the pollen record suggests a change in vegetation has occurred within the patterned fen, namely an increase in grasses and heath, with a reduction in *Melaleuca* and potentially the important peat forming *Empodisma minus*. In the absence of a clear relationship between burning and vegetation, historical records were examined for potential anthropogenic impacts to explain the modification to vegetation. Road construction adjacent to the wetland and subsequent usage was discussed in this context and provided potential explanations for the modifications to vegetation including: alteration of wetland hydrology from road construction; and elevated pollution and the introduction of exotic grasses from road usage. This study emphasises the need to investigate the relationship between road construction and road use to patterned fen vegetation change, particularly in light of recent increases in four-wheel-drive related tourism on Fraser Island, to ensure the preservation of this ecologically significant patterned fen into the future, before irreversible change takes place.

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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. 1,200) 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.

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