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EDITOR:

Dr A. Stone

Geography, School of Environment,

Education and Development, The University of Manchester,
Arthur Lewis Building, Oxford Road, M13 9PL

(e-mail: abi.stone@manchester.ac.uk)

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

Edge of raised peat at Flanders Moss, Glensaugh, Scotland (see Davies, QRF report inside this issue) (photo credit Althea Davies).

SPOTLIGHT ON A SITE

QRA50: TOP 50(80) QUATERNARY SITES – SPOTLIGHT ON A SITE:

WEST RUNTON TO SHERINGHAM, COASTAL CLIFF SECTIONS, NORTH NORFOLK, ENGLAND.

Happy New Year to all! At the start of 2019 we wish congratulations to Phil Gibbard for his honorary membership of the QRA and also have a write up of his retirement symposium. For this reason, let's visit the site for which some of Phil's work is cited in the QRA TOP 50(80) sites collection. This is the cliff sections in North Norfolk from West Runton to Sheringham, nominated by Emrys Phillips and Jane Hart.

Here is a summary of the entry from Silva and Phillip (2015, p103-105-77):

- West Runton is the stratotype for the early Middle Pleistocene 'Cromerian' interglacial stage (containing the West Runton elephant and the West Runton Freshwater Bed).
- It also contains a spectacular array of highly-deformed preglacial and glacial sediments, and there are controversies surrounding the mechanism of its deformation (subaqueous slide and debris flows, or subglacial deformation).
- The section between West Runton and Sherringham contains for key lithological units: (i) a grey, massive to moderately foliated Happisburgh Till Member variably exposed at the base of the cliff; (ii) this is overlain by the highly folded and foliated, brown, Bacton Green Till; (iii) at the top of the succession are the outwash sands and gravels; and (iv) a glacitectonic mélange derived from both the Bacton Green Till and outwash sands and gravels.
- Below the glacitectonised sequence, in a structural sense, are the essentially undeformed, preglacial shallow marine sediments of the Wroxham Crag Formation, exposed towards the eastern end of the section, and underlying chalk bedrock that crops out along the foreshore.

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OBITUARY

CHALMERS MOYES CLAPPERTON (1938-2018)

Chalmers Clapperton, Professor of Geography at the University of Aberdeen, died on 23rd October, 2018. Chalmers was a researcher and university teacher known internationally for his insights into Quaternary glacier fluctuations and their relationship to past environmental and climate changes.

In 1951-1957 Chalmers was a top scholar at Hawick High School and he captained the Scottish Schools rugby team. His undergraduate years in the Department of Geography, University of Edinburgh, saw him win prizes in every year in both geology and geography and culminated in a First Class Degree in 1961. He started his research career with a PhD supervised by Brian Sissons at the University of Edinburgh on 'The Deglaciation of the East Cheviot Hills'. Moving to the Department of Geography in Aberdeen, his research continued within Scotland but extended to include study of glacier changes in Iceland, Svalbard, the Falkland Islands, the Antarctic Peninsula and the sub-Antarctic islands of South Georgia and South Shetland Islands. Further outstanding contributions came from his work in South America where he studied high-elevation glaciers in Peru, Bolivia and Ecuador and how these have changed in extent in response to climate change and volcanic eruptions, a topic of keen interest to surrounding populations dependent on the glaciers for water. Chalmers was also well known for his work in Patagonia, where he sought to understand how glacier histories at different latitudes could be linked to latitudinal migration of the Southern Westerlies. Chalmers was promoted to Professor in 1992. He was elected a Fellow of the Royal Society of Edinburgh in 1992 and was awarded the Royal Scottish Geographical Society's President's award in 1992, the Mungo Park Medal in 1997 and the Centenary Medal in 1999.

Chalmers was renowned for his skill as a fieldworker who made new discoveries and also for his ability to place them in their wider context. This is borne out in the large number of publications producing the first geomorphological maps of new areas, whether they are in Scotland, Iceland, Svalbard, South Georgia, the Antarctic Peninsula or in many locations in South America. Invariably, the maps are detailed, perceptive, integrated with sedimentary evidence and have proved to be the building blocks for further research. The second major feature of Chalmers' work was his ability to synthesise and link glacier changes to wider environmental changes in vegetation and climate. He brought an adventurous mind to bear on a wealth of empirical knowledge and developed it into far-reaching hypotheses. He wrote several significant review papers but the jewel in the crown is the *Quaternary Geology and Geomorphology of South America*, published in 1993. This involved bringing together ideas from the literature in Portuguese, Spanish

and English for the whole continent in a substantial blue-bound volume. In South America it still remains the first port of call for a new Quaternary researcher in South America, where the volume is affectionately known as *The Blue Bible*.

Another outstanding quality was his inspirational teaching ability, which drew generations of students to the study of the Quaternary. He loved to teach in the field and was renowned for his cheerful optimism whilst enthusing students in inclement weather in Iceland or the Scottish Mountains.

In September 1998, Chalmers was cut down by a stroke and forced into an early retirement at the very height of his career. This tragic loss was marked by a special volume of the *Journal of Quaternary Science* in 2000 entitled: 'Quaternary climate change and South America', put together by international colleagues. He will be sorely missed as a friend, colleague and researcher.

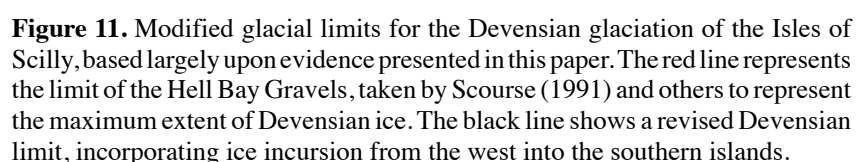
Please also see these tributes from the Royal Society of Edinburgh and the IAG/AIG websites.

<https://www.rse.org.uk/fellow/chalmers-clapperton/>

<http://www.geomorph.org/2018/11/tribute-chalmers-clapperton-south-america/>

Prof. Neil Glasser
Department of Geography and Earth Sciences
Aberystwyth University
Wales
SY23 3DB
nfg@aber.ac.uk

David Sugden
School of Geosciences
University of Edinburgh
David.Sugden@ed.ac.uk



COMMENT ON “EVIDENCE FOR EXTENSIVE ICE COVER ON THE ISLES OF SCILLY” BY BRIAN JOHN

James Scourse

Brian John's (2018) article in *Quaternary Newsletter* 146 (pp. 3-27) describes the results of some observations of the Pleistocene exposures of the Isles of Scilly during a visit to the islands in 2016. The Scillies are important since they host the southernmost limit of glacial deposits in the British Isles, deposited by the Irish Sea Ice Stream during the Late Devensian. The outcrops have been the recent focus of renewed investigation under the aegis of the BRITICE-CHRONO project (Smedley *et al.*, 2017), the results contributing to the overall effort of reconstructing the retreat pattern and establishing the deglacial chronology for the entire ice sheet. Any new observations from the islands, including newly exposed sections, especially any that might suggest a revision to the well-established ice limit described by Mitchell and Orme (1967) and Scourse (1991), are therefore noteworthy. The essence of John's paper is to present some observations that: (i) challenge the ice limit and (ii) suggest that at some stage the whole of Scilly has been glaciated. These observations and their interpretation are contentious and require a response.

The essence of John's arguments is 1) that erratics associated with the basal raised beach indicate complete glaciation of Scilly prior to the Late Devensian; and 2) that the Late Devensian limit is more extensive than previously described. I deal with these issues in turn, though they are to some extent conflated in John's article.

Pre-Late Devensian glaciation

John observes that the basal raised beach in places contains far-travelled erratic pebbles, as noted by Mitchell and Orme (1967) and myself (Scourse 1991), and interprets this as indicating a pre-Devensian glacial event to have “overwhelmed” (p. 21) the whole of the archipelago. However, erratics are extremely common in the raised beaches elsewhere in southwest England, and indeed along the Channel coast (Bates, 2000; Scourse and Furze, 2001) in situations where there is no supporting evidence for adjacent inland glaciation. The likely explanation for these erratics is that they were ice-rafted rather than transported by an ice sheet during high relative sea levels coinciding with cold stage conditions. John entertains this explanation but rejects it as “complex” (p. 21). Recent geochronological evidence from the Coutmacsherry Raised Beach in southern Ireland interestingly provides evidence for such conditions in Marine Isotope Stages (MIS) 3 or 4 (O'Cofaigh *et al.*, 2012). In my view, the presence of erratics in the Watermill Sands and Gravel does not provide conclusive evidence for terrestrial glaciation of the whole of Scilly at some point prior to the Late Devensian since it is clear that the majority of the Scilly landmass does not host glacigenic sediments (Scourse, 1991).

John goes on to possibly attribute this extensive glacial event to the “Greatest British Glaciation”, the “GBG” represented by the Anglian glacial episode (MIS 12). There is no evidence to support this contention, nor for the notion of an Anglian (or a Wolstonian) glaciation of the northern coast of southwest England, an *idée fixe* of the Quaternary community for several decades.

Of the basal raised beach John notes that “in some sections the gravels and pebble bands are mixed with faceted erratics in a silt and clay matrix and are sealed beneath brecciated slope deposits” (p. 6). This description resembles the Hell Bay Gravel, not the raised beach; the Hell Bay Gravel is a soliflucted admixture of till, outwash gravel with a very well sorted silty sand matrix derived from the aeolian Old Man Sandloess. Its distribution marks the maximum ice limit on Scilly (Scourse, 1991) and one of the problems I see with John’s interpretations is that he conflates the Hell Bay Gravel with the Scilly Till.

Revision of the Late Devensian ice limit

John describes “some exposures” at the northern end of St Agnes that also appear to be Hell Bay Gravel: “thin clay-rich diamictos containing faceted non-local cobbles lie directly on the raised beach or on a capping layer of sandy loess and colluvium” (p. 8). If this material is indeed Hell Bay Gravel it would be an important observation since St Agnes has hitherto been considered to lie well outside the ice limit. Unfortunately, no photograph or description of this section is provided, nor a grid reference, so it is difficult for the independent reader to assess the veracity of this potentially important observation.

The “diamictos” that John observes north of Cromwell’s Castle on Tresco “with highly variable clast sizes, shapes and lithologies” (p. 9) also resembles the Hell Bay Gravel. John reports “Erratics and patches of similar material occur in cliff exposures even further to the south in the strait between Bryher and Tresco. Exposures of related diamictos have now been exposed in many other locations within the accepted ice limit, generally at the coast in low cliffs with granite breccia and other deposits” (p. 10). These locations are unfortunately not described, illustrated or geo-referenced.

John reports that the key site of Bread and Cheese Cove on St Martin’s was “not easy to examine in 2016”. This is the type section for the Scilly Till which John illustrates in his Figure 6 (p. 11). This photograph is not of the Scilly Till stratotype. The section illustrated (with no scale) is clearly a granitic soliflual breccia containing erratics, hence it is the Bread and Cheese Breccia that lies stratigraphically above *in situ* Scilly Till. The reason why John interprets that “not all of the Devensian tills appear to have been glacitectonized” (p. 23), as interpreted by Hiemstra *et al.* (2006) for the Scilly Till at Bread and Cheese Cove, is because the diamictos he describes are not actually the Scilly Till.

John argues that at Chad Girt on White Island, St Martin's, recent erosion along the cleft has "revealed a c 2 m thick layer of massive clay-rich diamicton...the matrix appears to contain a higher percentage of clay and a lower percentage of gravel than the deposit at Bread and Cheese Cove" (p. 10) illustrated (again without scale) as his Figure 7 (p. 12). Elsewhere John refers to the freshness of new sections that were not available to me when I conducted my fieldwork on the islands in 1981-85, and since the "QRS" (*sic*) field meeting of 2006. I have visited the sections on Scilly on numerous occasions since 2006, and since 2013 annually. These annual visits now coincide with teaching field classes; I have taken students to Chad Girt in 2017 and 2018. I have therefore had the opportunity to examine the evolving sections recently and on no occasion have I observed *in situ* Scilly Till at Chad Girt. The diamicton described here by John is, again, the Hell Bay Gravel. The reason for the difference in the matrix in comparison with the deposit at Bread and Cheese Cove is that John has misidentified the Bread and Cheese Breccia at that site as Scilly Till. The matrix of the Hell Bay Gravel is indeed much finer than that of the Bread and Cheese Breccia.

John describes exposures containing erratics well south of the published ice limit close to the site of Carn Morval on St Mary's where "there has been substantial recent coastal erosion. The deposit is less than 1 m thick, and was seen in 2016 in close association with a cemented raised beach and granite breccia" (p. 12). Unfortunately no detailed description is provided nor is the exposure illustrated. This is a section I have visited annually over recent years. I have observed soliflucted raised beach, containing erratics, here but no exposure containing glacial sediments. John reports similar diamictons on the north and west coasts of St Agnes, admitting that these consist "largely of reworked raised beach materials" (p. 13). The photograph of the exposure at Carnew Point (his Figure 8; again without scale) shows not a glacial diamicton, but rather, soliflucted raised beach containing erratics. It is important that these sections are independently assessed, but from the descriptions provided they would appear to consist not of the Hell Bay Gravel or Scilly Till, but rather soliflucted facies of the basal Watermill Sands and Gravel.

Other problematic issues

John identifies two sites where granitic breccia can be found stratigraphically beneath the raised beach. This is effectively the same sequence reported for Porth Seal, and given chronostratigraphic significance, by Mitchell and Orme (1967). In this stratigraphic context it is crucial to examine the nature of the overlying raised beach since, in most cases, it is clear that the beach itself has been soliflucted and is therefore a part of the slope deposit. The key evidence is the matrix and structure of the raised beach. If it is matrix-supported by poorly sorted granitic debris ("grus") then it is likely soliflucted; if clast-supported with a matrix of sand, then it is likely *in situ*. No observations of the overlying raised beaches are provided by John in this regard. The photograph of the Peninnis Head site (his

Figure 2, without scale) shows a section of granitic head that could come from any one of several hundred sections on Scilly and crucially does not show the contact with the raised beach, or the raised beach itself.

Strangely, John argues that there “is no good reason for use of the term “periglacial” in connection with the bulk of these deposits [the granitic breccias]” (p. 18) yet contradicts this by referring to rapid mass movement in a mobile active layer associated with cryoturbation in solidly frozen ground, and later, the likelihood of periglacial conditions prevailing for “thousands of years” prior to the last interglacial (p. 21) and the prevalence of “periglacial conditions...some signs of cryoturbation, suggesting the intermittent presence of permafrost” (p. 22). The breccias (“head”) contain many of the key diagnostic criteria recognised as indicative of periglacial conditions, including slope-oriented clasts with upslope dips, pseudo-stratified fabrics indicative of ground ice and association with pollen assemblages from intra-bedded organic deposits consistent with tundra so it seems special pleading to argue that they did not accumulate in a periglacial context.

John concludes, on the basis of the evidence presented in the paper that “it is now possible to suggest a revised Late Quaternary relative chronology for the Isles of Scilly” (p. 20) yet admits “there was no time for sample collection or meticulous stratigraphic recording or sediment analysis, and no attempt has been made to fit the author’s stratigraphy into the lithostratigraphic units of Scourse (1991...) or to define till exposures into categories related to mechanisms of formation (cf. Evans, 2017)” (p.5). The proposition of a revised Late Quaternary stratigraphy for the islands must depend on the professional reporting of field evidence. In John’s paper the new observations are inadequately described throughout, they are not keyed into the lithostratigraphic sequence previously published for the islands, there are some erroneous statements, and the interpretations are unsupported by evidence, in particular with respect to the use of the genetic term *till*.

John did not visit the islands of Annet and Samson but argues that future investigations of these islands “may suggest that a lobe of ice pushed in from the west”. Recent observations from the west coast of Samson (D. Mawer, pers. comm., 2017), supported by photographic evidence, are convincing to me in indicating an exposure of Hell Bay Gravel here. If this is correct it would indeed represent a change in the ice limit on Scilly. This locality, and the sections described by John, require independent assessment and thorough description. It is likely that some details of the Late Devensian ice limit on Scilly will be redrawn as new sections and new observations come to light.

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James Scourse
Centre for Geography and Environmental Science, University of Exeter
Penryn, Cornwall TR10 9EX
[**J.Scourse@exeter.ac.uk**](mailto:J.Scourse@exeter.ac.uk)

REPLY TO SCOURSE “COMMENT ON ‘EVIDENCE FOR EXTENSIVE ICE COVER ON THE ISLES OF SCILLY’ BY BRIAN JOHN.”

Brian John

I am grateful to Professor Scourse for his comments on my short paper. In stressing its perceived inadequacies, he does not seem to have appreciated that it was not written at the conclusion of a long and detailed research programme. Instead, it was essentially a report on simple field observations conducted during one short

visit to the islands, interpreted in the light of my own experience of ice margin situations and other areas affected by Irish Sea / Celtic Sea glaciations. There is really very little difference between the interpretations of the Pleistocene history of the archipelago by Scourse and myself, as I acknowledge at many points in my text. However, Scourse raises a few points which deserve some further consideration.

1. On the matter of erratics in Scilly raised beaches, I see no reason to modify my view that they are unlikely to have been introduced by ice-rafting processes in a geographical location such as this, given what we know about glacio-isostatic adjustments and given that these processes are unlikely to have occurred here at a time of high or “interglacial” sea-level (Lambeck, 1997; Massey *et al.*, 2008; Shennan *et al.*, 2018). I agree that, as far as we can tell, “the majority of the Scilly landmass does not host glacial sediments”, but that does not mean that such sediments have never existed. Scourse also says that “there is no evidence” to support the contention that glacier ice has at some stage affected the coasts of southwest England. This is a matter of opinion, well documented (Harrison and Keen, 2005; Praeg *et al.*, 2015), and I disagree with him.

2. This is not the place to get involved in a debate about the extent or characteristics of the Hell Bay Gravel, the Scilly Till, or indeed any of the other lithostratigraphic units defined by Scourse during his research. He criticises me over and again for using the “wrong” labels for the deposits recorded in a number of different localities. However, I discovered as soon as I arrived in the islands that it was difficult and indeed unhelpful to seek to “force” the glacially-derived deposits into predetermined categories, as it became clear that those deposits had been laid down, redistributed and modified in a multitude of different combinations, exactly as happens in current ice-marginal environments. The Irish Sea till in Pembrokeshire, for example, displays widely differing characteristics from place to place (McCarroll, 2001), but it is always in the same stratigraphic position. It would be inappropriate to label the till at one site as “authentic” and at all the others as something else. Let us agree that some researchers like to categorize and label things, and others do not.

3. I am not sure why it should be problematic either to identify (in rare instances) slope deposits beneath raised beach cobbles, or to contemplate whether all of the Scilly slope breccias seen were really produced under periglacial / permafrost conditions. We ask exactly the same question at many of the Devensian coastal exposures of Wales. And neither am I sure why it should be problematic for an old codger like me to visit the Isles of Scilly, to record field observations, to suggest fresh interpretations, and to invite others with greater resources to visit those same sites with a view to either falsifying or confirming my working hypotheses. Eventually, truth will out.

Finally, I am gratified to learn that there are signs of a glacial incursion onto the west coast of Samson, and pleased that Scourse now accepts that the late Devensian ice limit on Scilly needs to be redrawn.

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Brian John
Trefelin, Cilgwyn,
Newport,
Pembrokeshire SA42 0QN
brianjohn4@me.com

RE-INVESTIGATION OF THE HIPPO SITE, EAST MERSIA, ESSEX

Hannah Wynton and Steve Boreham

Introduction

Many Ipswichian sites have been identified in Britain, but the majority are fragmented and thus only represent a short snap-shot in time (Lewis *et al.*, 2010). There is also bias in the record towards the earlier sub-stages of this interglacial as deposits formed at this time are more likely to be preserved (Gibbard and Lewin 2002). This paper describes the lithology and stratigraphy of the Hippo Site, East Mersea, Essex. Despite being discovered in 1976 and excavated to find bones of Hippopotamus amphibius, Bison priscus, Palaeoloxodon antiquus (straight-tusked elephant) and Megaloceros giganteus (giant deer), this study is the first to use the Hippo Site for palaeoenvironmental reconstruction. It is clear that the stratigraphy is more complex than previously thought, and pollen analysis has been used to reconstruct the surrounding vegetation and climate at the time of deposition.

Methods

A survey of the site, borehole investigations and subsequent laboratory techniques were used to understand the lithology and stratigraphy of the Hippo Site. Outcrops of London Clay bedrock, brown silty clay and organic muds were traced on the surface to determine the course of the palaeochannel across the foreshore. A subsequent north-south borehole transect was configured to intersect with these outcrops as well as the Hippo Site. Sediment from eight boreholes was described and a core was taken from the Hippo Site (BH1) for laboratory analysis. Ground penetrating radar (GPR) also provided a further means of investigating this transect. Using a 200 MHz antennae the results helped extrapolate the stratigraphy between borehole sites.

The lithology and colour of the sediment core were described in detail, and sub-samples were analysed for loss-on-ignition and laser particle size. The magnetic susceptibility of the core was analysed using a Bartington Magnetic Susceptibility Meter. Sediment sub-samples throughout the sequence were also prepared for pollen analysis. Eight pollen sub-samples from the basal silty clay unit were barren, but contained abundant micro-charcoal. This was likely due to a sparse pollen rain at the time of deposition and/or the in situ oxidation of the sediments (Pierre, 2002).

However, three sub-samples from within the distinct band of organic mud at the top of the core contained abundant palynomorphs, including a large proportion of Chenopodiaceae. Using the dichotomous key of Moore *et al.* (1991), 300 pollen and spores were counted and identified by HW for each of the sub-samples, excluding the Chenopodiaceae.

Geological setting

The Hippo Site is located on intertidal mudflats on the north-eastern coast of Mersea Island in Essex. The site is approximately 500m southwest of the famous Middle Pleistocene Cudmore Grove Channel (Figure 1). Palaeochannel deposits found at Cudmore Grove have been assigned to MIS9 based on a wide range of lithological and biostratigraphical evidence (Roe *et al.*, 2009). However, the discovery of *Hippopotamus amphibius* at the Hippo Site in a separate palaeochannel provides strong evidence to suggest that these deposits were laid down during the Ipswichian interglacial (MIS 5e) (Schreve, 1997). Indeed, *Hippopotamus amphibius* is a species exclusive to MIS 5e and absent from any other interglacial after MIS 12 in Britain. With both Cudmore Grove and the Hippo Site, Mersea Island is a very important area for understanding palaeoenvironmental changes during the Pleistocene.

The palaeochannel that contains the Hippo Site was likely a tributary of the River Blackwater (Bridgland, 1994). It is believed to have run roughly parallel to the present coastline, turning eastwards at the Hippo Site. The palaeochannel is associated with two other Late Pleistocene sites in the area: the Bison Site and the Restaurant Site. The Restaurant Site has yielded a very similar Ipswichian fauna to the Hippo Site with the addition of *Dicerorhinus bemiteochus* (narrow-nosed rhinoceros) and *Crocota crocuta* (spotted hyena) (Bridgland, 1994). The Bison Site was only discovered recently (Urquhart, 2011), and it is located further offshore partly overlain by Holocene muds (see Figure 1).

Between the Hippo Site and Cudmore Grove sits an outcrop of bedrock London Clay, which forms a barrier between the two palaeochannels. The geology of Mersea Island is dominated by Thames-Medway gravels deposited some 300,000 years ago (Bridgland, 1994). However, the cliffs above the beach near the Hippo Site are cut into Brickearth; periglacial loess formed during the Devensian (Bridgland, 1994). Coastal erosion continues today adding urgency to this investigation as the waves continue to remove the palaeochannel deposits that are exposed on the foreshore.

Survey and Borehole investigations

An initial survey of the sediments exposed on the foreshore surface mapped the outcrop of the London Clay close to the beach, followed by a zone of brown silty clay, a zone of organic muds, and finally grey silty clay extending out beneath soft Holocene muds into the intertidal zone (Figure 1). Tracing these outcrops helped to outline a suspected meander bend in the palaeochannel at the Hippo Site. Figure 2 shows the Hippo Site cross-section constructed from borehole investigations. Interbedded layers of organic mud, silty clay, sand and gravel are present, which dip towards the south. However, there is a sudden break in stratigraphy to the south, which appears to represent the incision by a younger channel-form in-filled by grey silty clay.

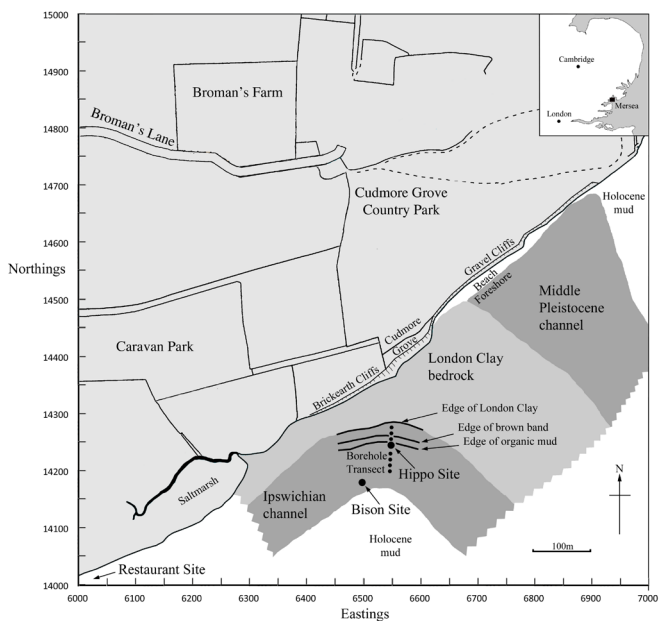


Figure 1. Map of East Mersea showing the Hippo Site and Ipswichian palaeochannel investigated in this study. The separate Middle Pleistocene palaeochannel to the north is also shown (Map reproduced with the kind permission of the Ordnance Survey. © Crown copyright Ordnance Survey. All rights reserved.).

Ground Penetrating Radar investigations

Figure 2 also displays the GPR transect conducted across the Hippo Site transect. The radar stratigraphy illustrated is based on the recognition of radar surfaces and radar facies (Neal et al. 2002). Three different reflector horizons are evident: a basal high-amplitude horizon, a moderate amplitude horizon and an upper low-amplitude horizon. The basal horizon can be interpreted as the London Clay bedrock, and the middle horizon as sand bands and silty clays. The upper horizon likely represents the upper organic muds. The GPR plot also shows a discontinuity in the reflector horizons around BH8 (60m), which corresponds with the break in stratigraphy shown in the cross-section.

Lithology and sediment description

At BH1 it was possible to identify seven different stratigraphic units including the organic mud (unit 1) at the top of the core, from which the original Hippopotamus amphibius skeleton was found (Figure 3). Lithological differences between these layers were confirmed using laser particle size and loss-on-ignition data.

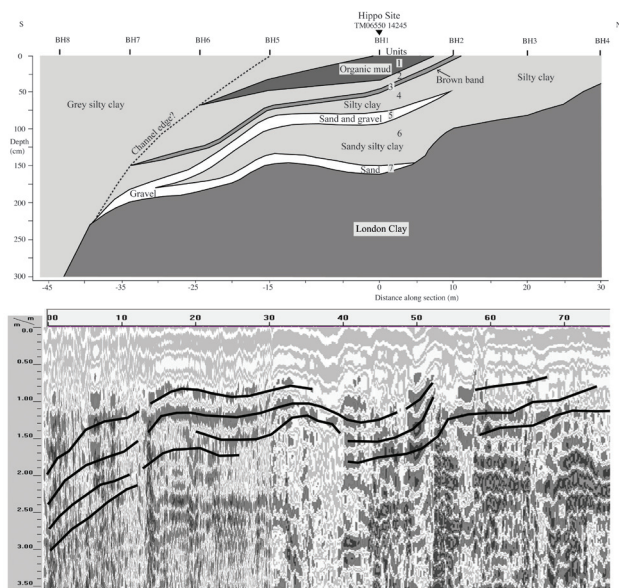


Figure 2. Geological cross-section S-N through the Hippo Site and palaeochannel across the foreshore at East Mersea constructed from boreholes, and a 200 MHz ground penetrating radar (GPR) plot of the same transect.

The upper organic mud had a higher % organic and calcium carbonate content compared the rest of the sequence. For example, organic content reached 16% at a depth of 15cm compared to values <3% for the basal part of the core. These results broadly agree with the volume susceptibility of the core. The presence of diamagnetic materials in the organic mud, such as calcium carbonate and organic matter, effectively reduced the ferromagnetic mineral concentration (Nowaczyk 2001) giving lower readings (4-6 SI units).

Although little organic material was found within layers 2-7, the lower layers of silty-clay (units 4 and 6) contained some rootlets traces. The mottled brown/grey colour of the sediment suggested that iron compounds had become oxidised (Collinson 1996). In this case most organic material preserved in the core would have been destroyed through microbial decomposition. The upper layer of grey silty clay (unit 2) did not contain any rootlet traces. The thin layer of mottled brown silty clay (unit 3) could have been mistaken for organic mud without the loss-on-ignition and magnetic susceptibility data. It was concluded that the appearance of this unit is likely due to oxidation of iron and manganese from incipient soil development.

Pollen Analyses

The fact that only the organic mud (unit 1) yielded pollen is not surprising on closer

examination of the low % organic values from the loss-on-ignition analyses. The results for the pollen analysis conducted on the three sub-samples from unit 1 are shown in Table 1. These pollen percentages express the Chenopodiaceae outside the main sum because it was very abundant. The Chenopodiaceae (Goosefoot family) includes species that commonly occupy halophytic and xerophytic areas like coastal environments and saltmarshes (Phillips 1974). Therefore the palaeochannel responsible for the deposition at the Hippo Site was likely very close to the coast and may have been part of an estuary.

The species with the highest abundances include *Betula* (birch), *Quercus* (oak), *Alnus* (alder), *Corylus* (hazel), *Poaceae* (grass), *Asteraceae* (daisy family), *Filipendula* (meadowsweet), *Plantago lanceolata* (ribwort plantain), *Pteropsida* (ferns) and *Sparganium* (bur-reed). Herbs dominate the pollen assemblage, and the abundance of grass pollen (*Poaceae*) stands out in particular. Pollen assemblage biozones have been identified for the Ipswichian based on other fluvial deposits across the British Isles (Table 2). When comparing these biozones with the assemblage of the Ipswichian site, it is possible to assign it to substage IpIIb of the Ipswichian, the climatic optimum.

Vertebrate remains

The left femur of a *Bison* (*Bison priscus* Bojanus) from a young adult was found in the palaeochannel within the silty clay unit c. 100m southwest of the Hippo Site. This unit appears to be younger than the organic muds at the Hippo Site. The bone had some degree of damage to the proximal end and to the patellar surface at the distal end. There was also evidence of mild abrasion to the surface. Despite this, the bone is considered well preserved with no signs of gnawing (Schreve, 2018, pers. comm.).

Discussion and Conclusions

This paper has provided the first detailed investigation into the lithology and stratigraphy of the Hippo Site, East Mersea, Essex. A variety of techniques have been used to understand the lithology and stratigraphy of palaeochannel deposits at the site. Pollen analysis and vertebrate remains have provided biostratigraphic evidence and aided the palaeoenvironmental reconstruction of the Ipswichian climate for the area. The findings suggest the stratigraphy of the Hippo Site is more complex than previously thought, with progressive layers of organic mud, silty-clays and sand/gravel. Some of these layers can be traced on the foreshore as outcrops on what would have been the outside bank of the meandering palaeochannel. As the river channel migrated over the course of the Ipswichian, deposition would have taken place in areas of reduced river velocity (Pierre, 2002). Layers of sand and gravel represent former positions of the riverbed, recording changes in the position of the river channel. A break in the stratigraphy at BH8 and in the GPR plot suggests incision by a younger channel-form, which was

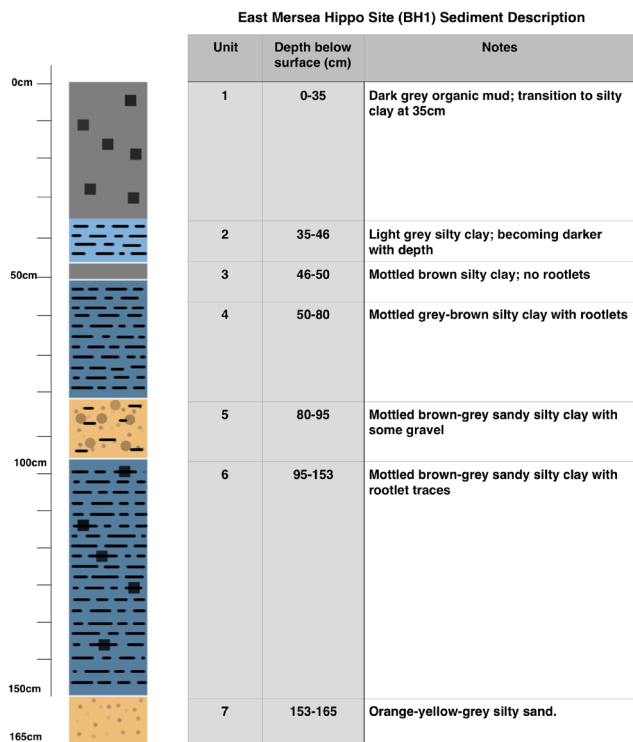


Figure 3. Description of sediment lithology at BH1 at the Hippo Site, East Mersea investigated in this study

subsequently in-filled when the palaeochannel became inactive (Gibbard and Lewin, 2002). It is possible however, that the stratigraphy identified at the Hippo Site continues further south, and that the palaeochannel deposits comprised a series of nested channels.

The stratigraphy of the Hippo Site in particular is interesting, with an upper layer of organic mud (unit 1) containing well-preserved rootlets, detrital remains (wood) and pollen. The pollen assemblage from this unit suggests that the sediment was deposited during the climatic optimum; substage Ip IIB of the Ipswichian. The dominance of *Chenopodiaceae* suggests the palaeochannel sat within or in close proximity to a coastal salt marsh environment. The abundant *Poaceae* (grass) pollen suggests that the river passed through an open grassland environment (perhaps reedswamp), with mixed oak woodland on drier land nearby.

Large herbivores such as the Hippo (*Hippopotamus amphibius*) would have affected the vegetation of river valleys during the Ipswichian, and acted as

Table 1. Percentage pollen data for the three sub-samples analysed from the organic mud (unit 1) at the Hippo Site, East Mersea (BH1)

Pollen sub-sample	5cm	15cm	25cm
Trees & Shrubs			
<i>Betula</i>	2.0	1.1	0.6
<i>Pinus</i>	0.7	0.3	0.3
<i>Quercus</i>	4.1	3.7	4.4
<i>Tilia</i>	1.4	0.5	0.9
<i>Alnus</i>	3.4	1.6	1.2
<i>Fagus</i>		0.3	
<i>Fraxinus</i>	0.7	1.1	0.3
<i>Corylus</i>	6.1	4.8	5.0
<i>Juniperus</i>	0.7	0.5	
<i>Hedera</i>	0.7		
Herbs			
Poaceae	14.3	9.9	7.0
Cyperaceae		0.8	
Asteraceae			
(Asteroidea/Cardueae) undif.		1.1	0.9
Asteraceae (Lactuceae) undif.		0.8	0.9
<i>Artemisia</i> type		0.5	0.6
<i>Cirsium</i> type		0.5	
Chenopodiaceae	59.9	64.8	72.6
Brassicaceae		0.3	0.3
<i>Filipendula</i>		1.3	0.9
Lamiaceae			0.3
<i>Plantago</i> undif.		0.8	0.3
<i>Plantago lanceolata</i>	0.7	1.1	0.6
<i>Ranunculus</i> type	0.7	0.5	0.3
<i>Rumex</i>		0.8	
<i>Thalictrum</i>	0.7	0.3	
Apiaceae		0.3	
<i>Limonium vulgare</i>			0.3
<i>Malva</i> type		0.5	
Lower plants			
<i>Polypodium</i>		0.5	0.9
Pteropsida (monolete) undif.	2.7	1.1	1.5
Pteropsida (trilete) undif.	1.4	0.3	0.3
Aquatics			
<i>Sparganium</i> type	0.7	0.5	0.6
<i>Typha latifolia</i>		0.3	
Summary			
Sum trees	12.2	8.5	7.6
Sum shrubs	7.5	5.3	5.0
Sum herbs	76.2	84.3	84.8
Sum spores	4.1	1.9	2.6

Table 2. A summary of the Ipswichian pollen assemblage bio-zones, first put together by Turner and West (1968) based on the Bobbit's Hole type-site in Ipswich.

Ipswichian Sub-stage	Pollen Biozone	Ecology
Ip IV	Post-temperate sub-stage	Herb-dominated vegetation with the re-establishment of boreal forests and steppe-tundra as the climate deteriorates.
Ip III	Late temperate sub-stage	A marked increase in herbaceous vegetation, with abundances of <i>Quercus</i> , <i>Corylus</i> and <i>Pinus</i> falling significantly.
Ip IIb	Early temperate sub-stage	Mixed-oak woodland becomes dominant with <i>Quercus</i> , <i>Pinus</i> and <i>Corylus</i> the most prevalent. In river sediments an increase in herbaceous vegetation is noted. Sea level rises above present day levels as the climatic optimum is reached.
Ip IIa	Early temperate sub-stage	<i>Pinus</i> dominates as opposed to <i>Betula</i> , which is still present but in a lower abundance. <i>Ulmus</i> is still present but <i>Quercus</i> colonises beginning the replacement of boreal forest with mixed-oak woodland.
Ip Ib	Pre-temperate sub-stage	The <i>Betula</i> , <i>Pinus</i> and <i>Ulmus</i> boreal forests prevail. Towards the end of the substage <i>Betula</i> begins to decline, becoming less dominant.
Ip Ia	Pre-temperate sub-stage	Grassland dominated with the establishment of boreal forests dominated by <i>Betula</i> and <i>Pinus</i> . <i>Ulmus</i> also colonises establishing a pine-elm zone.

‘ecological engineers’ (Waldram *et al.*, 2008) creating ‘Hippo lawns’ through repetitive grazing around water bodies. The existence of *Plantago lanceolata* within the pollen assemblage supports this finding, since it is a common indication of grazed, disturbed and trampled land (Stuart, 1976).

Few organic remains were evident in the basal silty clays (unit 4) deposited beneath the Hippo Site organic muds. However, the abundance of charcoal in these deposits perhaps hints that they were laid down in a somewhat arid climate, with dry grassland to fuel wildfires (Burjachs and Expósito, 2015). Some detrital remains were also present within this layer including rootlets, which suggests that vegetation was not absent, but that organic matter was not as easily preserved compared to during the climatic optimum. The sediments also show evidence of oxidation, which could have destroyed much of the organic material that had been preserved. The vertebrate remains of *Bison priscus* found within the upper silty clay unit are demonstrably of younger age than the organic muds of the Hippo Site. This suggests that deposition took place after the climatic optimum. *Bison priscus* was particularly abundant towards the end of the Ipswichian as forests

began to open up and climate deteriorated (Stuart, 1976). The original Bison Site was also located within the younger silty clay unit, to the south of the Hippo Site.

Like many British Ipswichian sites, the Hippo Site at East Mersea may represent a snapshot in time. However, vertebrate remains, detrital material and the preservation of charcoal suggest that the palaeochannel in which the Hippo Site is located may preserve deposits from before, during and after the Ipswichian climatic optimum.

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Hannah Wynton
Department of Geography, University of Cambridge
Downing Place, Cambridge CB2 3EN
[@hlouisew on Twitter](#)

Steve Boreham
Department of Geography, University of Cambridge
Downing Place, Cambridge CB2 3EN
steve.boreham@geog.cam.ac.uk

JAMES CROLL AWARD

JAMES CROLL MEDAL – ANN WINTLE

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.

This year, the QRA is delighted to make the Award to Ann Wintle. Ann is one of the world's leading Quaternary scientists. In a long and productive research career she has pioneered the use of luminescence dating in Quaternary Science. Ann has been a long-time member of the QRA, and has attended many field and discussion meetings.

Ann's career path makes interesting reading. It has not been in the straight line usual for academics. Having chosen to read Physics at Sussex University, she realised that carrying out experiments in a small laboratory was what she wanted to do for the rest of her life; and indeed this is what she has done. Her first thoughts were to explore applications of physics to geology; it was in the early days of palaeomagnetic research related to continental drift. Instead of pursuing this in a geophysics department, she was offered a grant for doctoral research at the Research Laboratory for Archaeology and the History of Art in Oxford; the research topic was not the interpretation of the magnetic data recorded in lava flows, but the development of a dating technique based on thermoluminescence (TL) signals from transparent crystals in lava flows. Until that time, TL dating had been applied to ceramic materials from archaeological sites. However, the failure of feldspar grains to retain their signal over time, a phenomenon that became known as anomalous fading, prevented successful dating of lava. This discovery gave rise to a widely cited paper in *Nature* (Wintle, 1973).

There followed a post-doctoral diversion into the TL dating of speleothem, dating the age of formation of the calcite crystals at ambient temperature; this

was inherently difficult because of the disequilibrium of the uranium decay chain that was the major source of the radiation giving rise to the TL signal. However, the success of this study led to a two-year post-doctoral position in the Physics Department at Simon Fraser University in Vancouver. Here, Ann developed a project to develop TL for dating deep-sea cores by determining the age of the calcitic remains of foraminifera. However, once again the project did not turn out as might have been expected. Realising that only dirty foraminifera gave TL signals, Ann realised that she was onto a significant discovery. Being able to determine the depositional age of the transparent mineral grains would enable not just the dating of deep-sea sediments, but also terrestrial deposits. This led to another Nature paper (Wintle and Huntley, 1976).

On returning to the UK, Ann set up her own TL laboratory in Cambridge, in the Godwin Laboratory which was part of the Sub-Department of Quaternary Research. Here, although still employed as post-doctoral research assistant, she was able to supervise PhD students, employ a technician and apply for research grants to employ research assistants from continental Europe, particularly from those countries with loess deposits. The method was ideally suited for loess deposited since the last interglacial. Many loess sites in Germany and Austria were located in wine-growing areas, and her first PhD student thought that WINE and TL went very well with her surname.

Her move to take up lectureships, first at Royal Holloway College and then at Aberystwyth University, enabled her to establish her own laboratories using the latest technology. Continuing her collaboration with scientists in the Danish laboratory that constructed the TL instruments enabled her to take advantage of the optically stimulated luminescence (OSL) measurement technique that had been developed by her former colleague in Vancouver. First with infrared stimulated luminescence (IRSL) of feldspars and then OSL of quartz, because the latter were not affected by anomalous fading.

This led to many projects involving aeolian sediments. During the next couple of decades, Ann was joined by a number of graduate students and post docs who were inspired to develop laboratory procedures that provided more accurate and more precise ages. In particular, the accuracy was helped by the ability to measure OSL signals from individual grains, and thus permit rejection of contaminating grains, whether older or younger than those that made up the main deposit. Ann's publications exceed 120, and as well as method development and application papers (e.g. Murray and Wintle, 2000; 2003 have almost 4,000 citations between them), her masterful review papers are also points of reference for all in the field (e.g. Wintle, 2008; Wintle and Adamiec, 2017).

OSL dating is now widely accepted, alongside radiocarbon dating, as a fundamental of Quaternary Science and it is for her pioneering achievements in this area that Ann has been presented with the James Croll Medal.



Ann Wintle receiving the medal from QRA President Prof. Neil Glasser (photo Adrian Palmer).

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Prof. Neil Glasser (QRA President)
Department of Geography and Earth Sciences
Aberystwyth University
Wales SY23 3DB
nfg@aber.ac.uk

LEWIS PENNY AWARD

LEWIS PENNY MEDAL – CLARE BOSTON (PORTSMOUTH)

The Lewis Penny Medal is aimed at a young (normally less than 35 years old) or new research worker who has made a significant contribution to the Quaternary stratigraphy of the British Isles and its maritime environment.

We are delighted to make the 2019 award to Clare Boston. Clare is a glacial geologist specialising in the glaciation of temperate and polar regions. Her research interests focus on former ice mass reconstruction and glacier response to changes in climate. She has expertise in glacial geomorphology and sedimentology, and she has developed this expertise through a combined approach of remote sensing and fieldwork.

Clare has made substantial contributions to the Quaternary palaeoglaciology of the British Isles, specifically in the tills of eastern England and their use in the reconstruction of the former ice sheet. She has also advanced our palaeoglaciological knowledge through the reconstruction of a previously unrecognised plateau icefield in the Monadhliath Mountains, significantly adding to the record of Younger Dryas ice in the Scottish Highlands. Her publication record is not only impressive but it also clearly demonstrates that she has already made a wide-ranging, conceptual impact on the discipline. She contributes not only to former ice-mass reconstructions but also to contemporary topical issues such as improving our understanding of glacier and ice-sheet dynamics.

Clare has also found time to make a major contribution to the QRA. In April 2013 she was the Field Meeting Leader for The Quaternary of the Monadhliath Mountains and the Great Glen, from 2015 to 2018 she served the QRA on the Executive as its Meetings Officer and she will organise a future QRA Annual Discussion Meeting in 2021. For all these reasons, Clare is a worthy recipient of the Lewis Penny Medal.

Clare says "I am deeply honoured to have been awarded the Lewis Penny Medal from the QRA. The QRA has formed an integral part of my academic career through field meetings, ADMs, my role on the Executive Committee, and the wide range of colleagues that I have met along the way. To be awarded the Lewis Penny Medal marks a significant highlight of my career so far and I am grateful to the many colleagues who have been involved in the research for which it was awarded. My interest in Quaternary glaciation was sparked during my BSc in Geography at Durham University and, rather appropriately, I then completed an MSc (by research) on the tills of east Yorkshire, an area well-known to Lewis Penny. This research laid the foundations for PhD study and a subsequent academic career in which I have been fortunate to work in a number of areas in Britain and also further afield."



Clare Boston receiving the medal from QRA President Prof. Neil Glasser (photo Adrian Palmer).

Please see forthcoming June QN for a full acceptance citation from Clare.

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Prof. Neil Glasser (QRA President)
Department of Geography and Earth Sciences
Aberystwyth University
Wales
SY23 3DB
nfg@aber.ac.uk

HONORARY MEMBER

One long-standing member of the QRA was awarded an Honorary Membership at the 2019 AGM in Chester. Honorary Members are in recognition of significant, long-standing contributions to the QRA and to Quaternary science more widely.

PHIL GIBBARD

Phil Gibbard's achievements in research lie in the field of Quaternary geology and environmental history, both in Britain and beyond. He has successfully integrated specialisms in glacial, fluvial, periglacial and shallow marine geology. Together with rigorous stratigraphical practice, aided by his expertise in pollen analysis and sedimentation, he has used these to reconstruct palaeoenvironments. He has worked extensively throughout the UK and northern Europe, the Mediterranean region, Russia and southeast Asia.

His research contribution has focused on four specific areas of interest.



1. Fluvial and terrestrial non-glacial history, where he has been instrumental in developing an understanding of European drainage systems during the Cenozoic. His work on the Quaternary stratigraphy of the Thames terraces will be familiar to many of you.

2. Shelf environments, where his research into the shallow marine environment and the shelf areas repeatedly exposed at low eustatic sea levels during cold periods demonstrated for example that the Dover Strait was formed by damming of the rivers as a result of glaciation in the Middle and Late Pleistocene.

3. Glaciation, where he has undertaken numerous studies of glacial sedimentation and stratigraphy in the Arctic, Finland, Russia, Germany, The Netherlands, Canada, USA, England and in Mediterranean mountains.

4. Stratigraphical division, where he has advanced our understanding of the correlation of high-resolution Quaternary sequences. He has become a leading authority on the application of stratigraphical principles, chairing the International

Commission on Stratigraphy's Subcommittee on Quaternary Stratigraphy and compiling the Geological Time Scale chronology.

Phil has also willingly given up his time to support the QRA. He has served the QRA in the following capacities: QRA Vice President (1997-2000); Chair, Joint Association Quaternary Research (2001-); QRA Hon Secretary (1982-1986); Editor JQS (1990-1995); Chair, QRALithostratigraphy Subcommittee (1980) and Ordinary Member Executive Committee (1979-1982). He has also participated in many QRA Discussion Meetings; he was a Keynote Speaker at the QRA at 50 Meeting and he has been a contributor to many of our field meetings.

In January 2015 he was awarded the 2014 James Croll Medal by the QRA in recognition of his outstanding contributions to the field of Quaternary Science. The award reflected Phil's "broad-ranging and cutting edge research across glacial, periglacial and interglacial stratigraphy, and his outstanding contributions to national and international committees including both the QRA and the Subcommittee on Quaternary Stratigraphy".

More broadly, Phil has also made major contributions to INQUA, the International Union of Geological Sciences (IUGS) and the Geological Society. In September 2016 he was appointed Secretary General of the International Commission on Stratigraphy of the International Union of Geological Sciences, in July 2011 he was elected President of the INQUA Commission of Stratigraphy and Geochronology (SACCOM) at the INQUA Congress in Bern, and he has served as the Chair of the International Commission on Stratigraphy, Subcommittee on Quaternary Stratigraphy (2002-) and was elected Secretary of the INQUA Commission on Stratigraphy (1999-2003). Phil was an invited member of the INQUA Subcommittee on European Quaternary Stratigraphy (SEQS) and the Joint Chairman of the INQUA Commission on Glaciation Committee (1996-) and Anglo-French Groupe Manche. He was an elected member of the Geological Society Stratigraphy Commission and is the corresponding member of the INQUA Commission on the Genesis of Quaternary Deposits. In April 1999 he was awarded the Geological Society's Lyell Fund prize 'for excellence in Quaternary geology'.

We are delighted to make Phil Gibbard an Honorary Member of the QRA.

Prof. Neil Glasser (QRA President)
Department of Geography and Earth Sciences
Aberystwyth University
Wales SY23 3DB
nfg@aber.ac.uk

QUATERNARY RESEARCH FUND

TEPHRA TRANSFORMATIONS: WHAT FACTORS INFLUENCE TEPHRA LAYER PRESERVATION

Context

Terrestrial tephra layers are often used in reconstructions of Quaternary volcanic eruptions. But how reliable are they? Inferences made from tephra layers rely on the assumption that the preserved tephra is representative of the initial deposit. However, the ways in which tephra layers are preserved (or not) are poorly understood, not least because the formation of tephra layers is a slow process and difficult to study in real time. Our project set out to address this knowledge gap with a field survey.

The Survey

Our strategy was to survey the tephra layer produced by a recent, well-studied eruption, and to compare our data with measurements of the fresh tephra deposit, thereby calibrating any losses and transformations that have occurred. We focussed on the tephra layer produced during the 1980 eruption of Mount St Helens (MSH1980) as there are detailed, contemporaneous records of the initial deposit. We focused on areas within the fallout zone that have been set aside for wildlife conservation, to minimise the likelihood of disturbance. We further narrowed our search to areas that had received > 5 mm of tephra in 1980. In each sampling location, we opened shallow soil sections and recorded tephra thickness and stratigraphy.

Results

We sampled 44 different locations ranging from 17 to 375 km from Mount St Helens (Figure 1). Preservation of the layer was generally good, and we found the tephra layer on all the sites we investigated. The extant layer closely approximated the thickness of the original deposit and the original stratigraphy was retained in proximal locations (<50 km from the vent: Figure 2). Both of the key features of the original deposit – a decay in thickness with distance, and a secondary thickening starting around 300 km from the vent – were captured by our measurements. We also observed thinning to the north and south of the main axis.

Discussion

The extant MSH1980 tephra layer retains a clear and consistent signal of the original deposit. Despite numerous sources of potential disruption, the preserved thicknesses closely approximated the values measured in 1980. Whilst it is

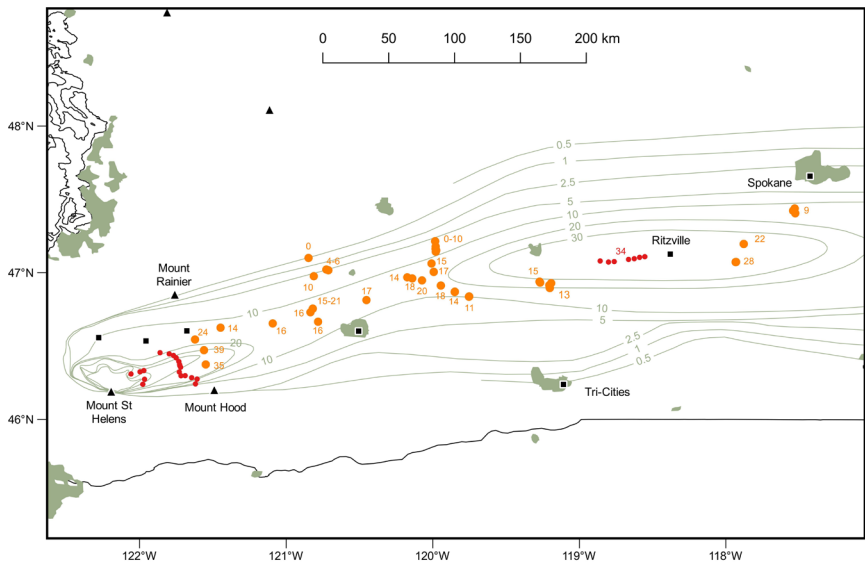


Figure 1. MSH1980 thickness measurements from the 2018 survey (orange dots, with mean thickness in mm also in orange). Red dots indicate thickness measurements made during a pilot study 2015 (Cutler *et al.* 2018). The grey isopach lines (with thickness in mm), shown for comparison, are based on measurements made shortly after the 1980 eruption (Sarna-Wojcicki *et al.* 1981).

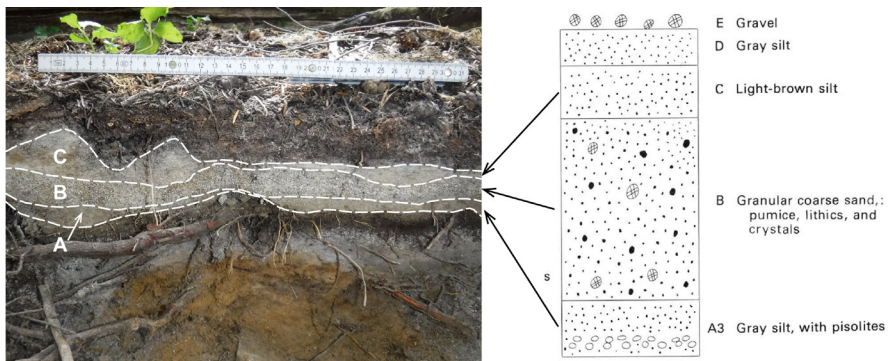


Figure 2. A typical soil section in forest ~40 km from Mount St Helens. The MSH1980 tephra is the off-white layer a few centimetres below the soil surface. Three of the units (labelled A-C in the sketch to the right of the figure) identified by Waitt & Dzurisin (1981) are clearly visible in the extant tephra layer.

often assumed that tephra layers underestimate the original deposit, our results demonstrate that terrestrial tephra deposits can be a reliable basis for the inference of past eruption parameters. The factors that facilitated preservation appeared to be a) limited anthropogenic disturbance; b) conditions that limit bioturbation by large herbivores and burrowing animals (e.g., mature vegetation, thin soils) and c) biogenic surface cover (dense vegetation, litter or biocrust) that acts to stabilize tephra shortly after deposition. The next stage of our analysis will be to construct and compare isopach (thickness) maps from both the original (1980) measurements, and the extant layers, using an objective, statistical model (Engwell *et al.*, 2015).

Acknowledgements

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Nick Cutler
School of Geography, Politics and Sociology, Newcastle University
Newcastle NE1 7RU
nick.cutler@ncl.ac.uk

DUNG FUNGI AS A PEATLAND GRAZING INDICATOR

Background and Rationale

In 1999, Richard Bradshaw and Fraser Mitchell commented on the need for better information on herbivore abundance to understand long-term interactions between grazing and vegetation structure, composition and dynamics. Although palynology remains the most widely used approach for understanding grazing over long timescales, using pollen to reconstruct both herbivory and vegetation dynamics introduces circularity which weakens arguments about cause and effect. Coprophilous fungal spores (CFS), that is, spores from fungi that grow on dung, have emerged as an important independent proxy for assessing changes in herbivore abundance (Baker *et al.*, 2013). They are part of a growing range of non-pollen palynomorphs that can be analysed in the same samples as pollen to help understand palaeo-habitat and conditions (van Geel and Aptroot, 2006). The sensitivity of the method has yet to be tested on peat- and moorlands though, with most existing literature focusing on lake sediments. Peatlands provide a significant source of palaeoenvironmental data, but pollen may be a relatively insensitive to local grazing impacts since the mineral soils required by disturbance indicators are scarce. With assistance from the Quaternary Research Fund, a pilot study was conducted on two sites to compare the grazing signal from pollen and CFS.

Approach

The study sites are located in Scotland (Figure 1). Glensauigh is a dry heathland located in upland Aberdeenshire, NE Scotland. Grazed and enclosed plots (each 20 x 100 m) were established in 2005 as part of a wider experiment to assess the role of herbivores in driving changes during succession from moorland to woodland. The area is grazed by red deer stags from mid-November to mid-September, with an estimated herbivore biomass of 53 kg/ha. Deer herbivory is restricting growth and recruitment of *Betula* (birch) and *Pinus sylvestris* (Scots pine) trees in planted sections of the grazed plots, indicating that deer numbers are above tree regeneration limits. Flanders Moss is a lowland raised bog located near Stirling in central Scotland. Using Shetland cattle, a relatively small breed, the conservation grazing regime aims to restrict tree regeneration on the peat. The grazing compartments comprise rush pasture on drained peat which is grazed by cows and calves from May to September (approx. 879 kg/ha), and peatland grazed by young cattle between June and August (approx. 175 kg/ha). An adjacent peatland area with no livestock grazing was also sampled. Despite cattle grazing over the last 20 years, scrub regeneration is an ongoing issue, which is managed by grazing and manual removal of tree seedlings/saplings. An unknown number of wild deer have access to Flanders Moss; their impacts have been assessed as limited and localised (Laird, 2014).

The experimental plots and grazing compartments provide differentiated areas of grazing which were used to assess whether spatial variability in the pollen and fungal spore signals could be linked with the grazing regime. Surface moss and litter samples were taken from each of the four pairs of open (grazed) and fenced (enclosed) plots at Glensaugh, giving a total of 24 samples. In each plot, three handfuls of moss/litter were combined from a c.1 m² area in the middle of each plot. Dominant vegetation cover and any herbivore indicators (dung, browsing on heaths, tracks) were recorded. Since the grazing compartments are larger at Flanders Moss, two perpendicular transects were laid out spanning the rush pasture, cattle-grazed and livestock-free areas of raised peat (Figure 2). Using the same collection technique as Glensaugh, thirty samples collected along these transects, spaced 15 or 30 m apart.

Samples were processed using standard pollen analytical techniques, including acetolysis but no hydrofluoric acid treatment was needed (Moore *et al.*, 1991). A minimum of 500 total land pollen grains (TLP, excluding aquatic taxa and spores) was counted for each sample. Pollen identification was based on standard pollen keys (Moore *et al.*, 1991). Spores of the three most common obligate dung-feeding fungi (*Sporormiella* HdV-113, *Sordaria*-type HdV-55A, *Podospora*-type HdV-368) were identified using published descriptions (van Geel *et al.*, 2003, van Geel and Aptroot, 2006).

Results

Disturbance indicator pollen (*Plantago lanceolata*, *Rumex* and *Urtica*) and CFS (mainly *Sordaria* and *Sporormiella*) were present in all samples. At both sites, the relative abundance of CFS was, on average, higher than pollen disturbance indicator values (Figure 2), suggesting that they provide an important additional source of evidence for herbivory.

At Glensaugh, median CFS abundance is higher in grazed than enclosed plots (Figure 2), but the relationship between indicator (pollen disturbance indicators, CFS) and treatment (grazed vs. ungrazed) was statistically significant only for the CFS concentration data. CFS concentrations were significantly higher in grazed than enclosed plots (Kruskal-Wallis chi-squared = 3.4133, df = 1, p-value = 0.06467). This indicates the importance of using absolute rather than relative values to interpret CFS data (Baker *et al.*, 2013). It also suggests a spore dispersal distance of <10 m (the midpoint of plot width), which is similar to previous estimates of dispersal distance from pond shorelines (Baker *et al.* 2016). At a landscape scale, CFS abundance at Flanders Moss was significantly higher in grazed than ungrazed compartments for CFS percentages (pasture vs. ungrazed bog: chi-squared = 4.8348, df = 1, p-value = 0.02789, and grazed vs. ungrazed bog: chi-squared = 4.8238, df = 1, p-value = 0.0280). The percentage abundance of pollen indicators was only significantly higher in grazed than ungrazed bog at



Figure 1. (a) View from open heathland plot at Glensaugh, showing stunted growth above tree guards across to ungrazed (fenced) plot with healthy tree growth. (b) View from the current edge of the raised peat at Flanders Moss over rush pasture to improved grassland in wider landscape (photos: A. Davies).

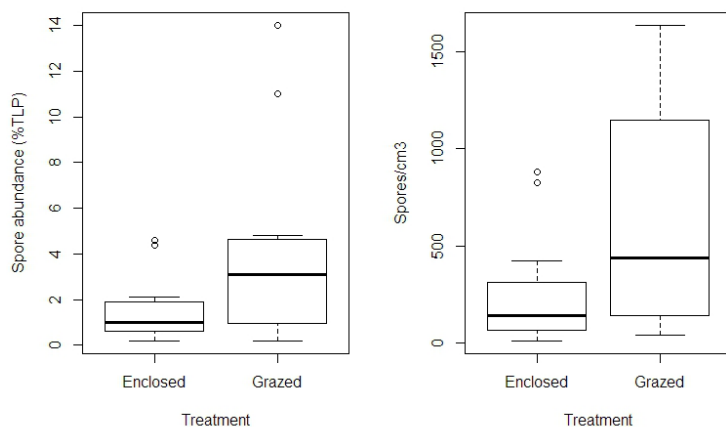


Figure 2. Boxplots of coprophilous fungal spore abundance in each treatment at Glensnaugh. The data consist of 12 samples from each treatment. Each boxplot represents the median value (solid line), upper (75%) and lower (25%) quartiles, two standard deviations (whiskers) and outliers (dots), which are defined as values greater than $Q3 + 1.5 \times IQR$, where $Q3$ is the upper quartile and the interquartile range ($IQR = Q3 - Q1$).

Flanders Moss (chi-squared = 3.0293, $df = 1$, p -value = 0.08177). These findings suggest that there is no strong ‘background’ signal from deer or sheep, which are present in the wider landscape. This is comparable with previous findings in bison-grazed dry grassland, with estimated dispersal distances of 25-100 m from Tauber traps (Gill *et al.* 2013). On a finer spatial scale, CFS abundance peaks near ‘hotspots’ of frequent use, like animal paths (Fig. 3). Both sites therefore suggest that CFS provide insight into herbivore activity on a predominantly local scale.

Significance

The present results provide the first quantitative evidence that CFS dispersal distances in peatlands range from around 10 m to tens of metres. While mycological studies indicate a correspondence between herbivory and CFS, this study shows that there is no simple quantitative relationship between CFS abundance and herbivore abundance in peat- and moorland samples. The findings demonstrate the importance of testing inferences from relatively new proxies to provide a more rigorous, empirical basis for palaeoecological analyses. Further work, using ecological and ‘natural’ grazing experiments, are needed across a wider range of grazing regimes and wetland environments to better understand what level of quantitative interpretation is possible.

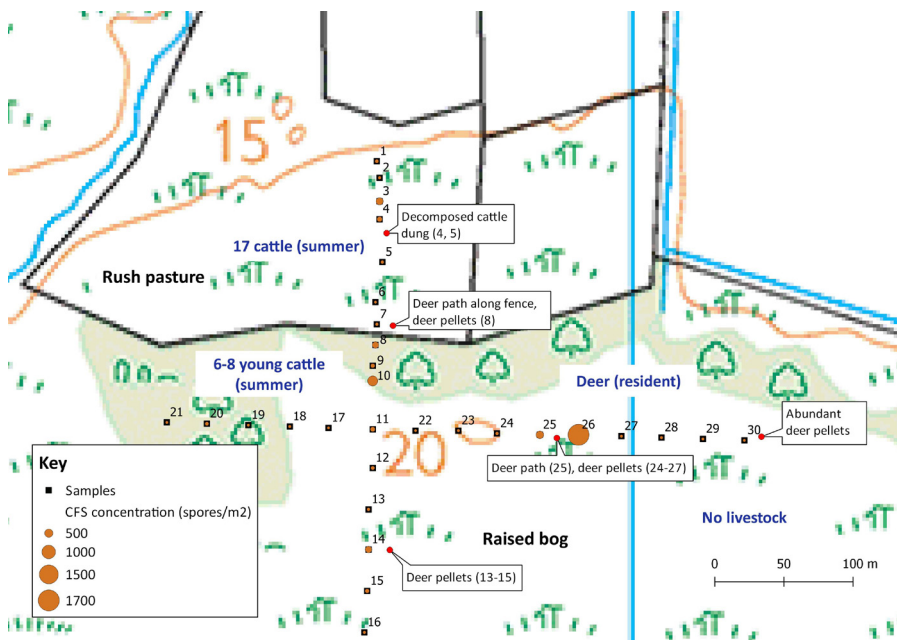


Figure 3. Spatial variability in CFS concentrations across Flanders Moss transects, relative to habitat type and grazing regime. Visible grazing evidence around each plot is also indicated.

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Althea L. Davies
School of Geography and Sustainable Development
University of St Andrews
Fife KY16 9AL
Scotland, UK
ald7@st-andrews.ac.uk

PALAEOGEOGRAPHIC AND CHRONOSTRATIGRAPHIC RECONSTRUCTION OF THE EARLY HUMAN PRESENCE IN ITALY

Background and Rationale

The Latium region returned one of the highest numbers of Palaeolithic sites in the Italian Peninsula, some of which are of great relevance to understand the past of the country. In particular, eight sites located on the Tyrrhenian Sea margin in the surrounding Rome (i.e., Polledrara di Cecanibbio, Torre in Pietra, Castel di Guido, Malagrotta, Collina Barbattini, Via Aurelia km 19.3, Via Aurelia km 18.9, Via Aurelia 4), presumably dating to MIS 9, returned about 4,200 archaeological finds (i.e. lithic and bone industry) and over 32,000 faunal remains, and were considered among the most representative sites of the Acheulean-Mousterian transition in Italy. We provided a chronostratigraphic review of these sites, whose surprising results are of significant importance for a better understanding of Italian prehistory.

Methods

Aiming to provide a solid geochronological constraint of the sites, we employed a multidisciplinary approach based on combining various dating methods and stratigraphic investigations with a recently developed method of correlation between sedimentary deposits and glacio-eustatic cycles (i.e. aggradational successions, Marra, 2008, Luberti, 2017), allowing for direct correlation with the MIS chronology. The aggradational successions in the coastal area of Latium are constituted by ten major sedimentary units deposited in response to sea-level rise during the glacial terminations of the glacial cycles spanning MIS 21 thorough MIS 1, plus several minor successions associated with the sea-level oscillations corresponding to sub-stages. These sedimentary successions occur at different elevation in consequence of the interplay between glacio-eustasy and a discontinuous regional uplift that affected the Tyrrhenian Sea margin of central Italy in the last 800 ka, offering further, geometric criteria for its identification.

Results

Our revision revealed only one site (i.e. Polledrara di Cecanibbio) maintained its previous chronology, albeit now better constrained, whilst the remaining seven have been substantially re-dated (Table 1; Marra, 2018). Results allow reconsidering the early human presence in central Italy, since previous studies

were based on imprecise dating of these sites and incorrect understanding of the depositional contexts. As a matter of fact, due to the new chronological framework, the bone artifacts discovered at Malagrotta, Castel di Guido and Via Aurelia, are now among the earliest occurrence of this typology of industry in Latium region (Ceruleo *et al.*, submitted). Moreover, our study demonstrated that all sites analysed, with the exception of Polledrara di Cecanibbio, are actually secondary deposition resulting from water transport, therefore not representing straightforward human activities.

Within a broader perspective, this study highlights the importance to integrate archaeological investigations with modern geological studies. The A revision of previous chrono-cultural attribution is recommended for sites, especially Palaeolithic ones, investigated before modern dating methods were available.

Table 1. New chronological framework of the sites investigated.

SITE	PREVIOUS ATTRIBUTION	REVISED AGE AND ATTRIBUTION	
		MIS	AGE (ka)
Malagrotta	MIS 9	11	~410
Collina Barbattini	MIS 9	11	~410
3 sites along Via Aurelia	MIS 9	11	~410
Castel di Guido	MIS 9	11	412±2
Torre in Pietra lower level	MIS 9	10	354±5-337±6

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Maurizio Gatta
University of York
Department of Archaeology
The King's Manor
York
YO1 7EP
maurizio.gatta@york.ac.uk

Fabrizio Marra
Istituto Nazionale di Geofisica e Vulcanologia
Via di Vigna Murata 605
00143 Rome - Italy
fabrizio.marra@ingv.it

INVESTIGATING THE SEDIMENTARY ARCHITECTURE OF THE BRAMPTON KAME BELT USING GROUND- PENETRATING RADAR (GPR)

Introduction

The Brampton kame belt is a large ($>40 \text{ km}^2$) glacio-depositional complex located at the centre of one of the most dynamic sectors of the former British-Irish Ice Sheet (Livingstone *et al.*, 2015). It is composed of an array of ridges (both continuous and fragmentary), flat-topped hills, channels and depressions, and has been associated with the development of a complex glacier karst formed by ice stagnation in the lee of the Pennines (Livingstone *et al.*, 2010). Previous work in this area has focused on geomorphological mapping from high-resolution digital elevation models (DEMs) and detailed sedimentological logging from a handful of boreholes and exposures within aggregate quarries (e.g. Huddart, 1970, 1981; Livingstone *et al.*, 2010). In this fieldwork we used Ground-Penetrating Radar (GPR) to undertake a systematic, large-scale study of the subsurface sedimentary architecture of the kame belt in order to (i) test the application of GPR in investigating complex glaciofluvial landform-sediment assemblages; and (ii) better understand the formation of the kame belt within the wider context of the deglaciation of the last British-Irish Ice Sheet

Methods

In total, over 20 km of survey lines were collected using the University of Portsmouth's Mala GPR system 100 Mhz and 50 MHz rough terrain antennas (Figure 1). The survey targeted the full range of geomorphic features present



Figure 1. Collection of a survey line across a flat-topped hill using the GPR 100 MHz antenna.

within the kame belt, including ridges, flat-topped hills, channels and depressions, and, where possible, survey lines were collected both along and across features in order to provide an insight into their 3D architecture. At two locations we were able to collect survey lines above man-made sediment exposures, which were logged in order to tie the radar data to the sedimentary facies.

Results

Figure 2 shows a 60 m survey line collected transverse to the crestline of a ridge, starting at the ridge crest and descending along its flank. The radargram shows a largely consistent pattern of reflectors, which we identify as a single radar facies with horizontal to sub-horizontal bedding to a depth of approximately 6 m. This suggests an aggradational depositional environment that has built-up over time. The depth of penetration and the uniformity of this facies possibly indicates a sand-dominated environment. Occasional high-angled, thin reflectors away from the central core of the ridge may represent faulting within the unit. This is consistent with fluvial sedimentation within a subglacial environment (e.g. Brennand, 1994), followed by post-depositional collapse after removal of supporting ice.

Summary

Initial analysis of GPR data collected from a variety of sites across the Brampton kame belt demonstrates it is possible to identify large-scale sedimentary architecture, including bedding, changes in sediment type, and deformation

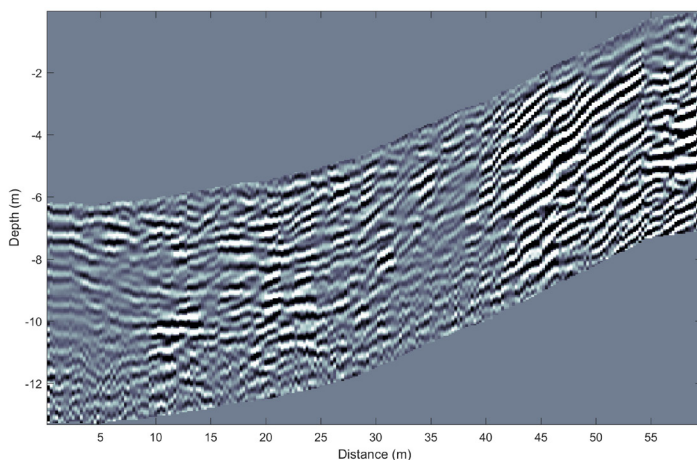


Figure 2. Radargram of a survey line collected across a ridge within the Brampton kame belt. The line was collected transverse to the crestline of the ridge, starting at the ridge crest and descending along the NW flank.

structures (e.g. faulting and folding). It is also possible to tie radar facies to sediment facies exposed in section. Further analysis of the data derived from this approach will help to improve existing models of kame formation through better understanding of individual landform-sediment assemblages, transitions between them and spatial variations in the pattern, style and volume of kame sediments in the region.

Acknowledgements

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Harold Lovell
Department of Geography, University of Portsmouth
Portsmouth PO1 3HE
harold.lovell@port.ac.uk

Clare Boston
Department of Geography, University of Portsmouth
Portsmouth PO1 3HE
clare.boston@port.ac.uk

Stephen Livingstone
Department of Geography, The University of Sheffield,
Sheffield S10 2TN
S.J.Livingstone@Sheffield.ac.uk

UNDERSTANDING THE GENESIS OF A SMALL ALPINE DRUMLIN, HORNKEES, AUSTRIA

Background and rationale

Mountain glaciers are amongst the most responsive ice masses to climate change (Vaughan *et al.*, 2013). Glaciologically, geomorphologically and sedimentologically, they are amongst the most well-studied ice masses, largely due to their accessibility in many areas. However, despite the wealth of data available for many Alpine glaciers, the rates and processes of subglacial erosion and deposition are still poorly constrained (Benn and Evans, 2010). This is frustrating, since such data are required by several disciplines, such as Quaternary geochronology, landscape evolution and glacial geology (e.g. Harbor *et al.*, 2006; Koppes and Montgomery, 2009; Benn and Evans, 2010).

This project, which sprang from observations made in the summers of 2014-2016 aims to address some of our gaps in understanding by quantifying subglacial erosion rates, or the lack thereof, in the foreland of Hornkees in the Eastern Alps, Austria. This foreland was reconnoitred during a field trip in July 2014 and contained several unexpected phenomena that were hoped could shed unprecedented light on the question of the (in)efficacy of subglacial erosion within a time frame that could itself be relatively tightly constrained. These exciting possibilities prompted the present project to be designed. The preliminary findings are briefly summarised below.

Results - description

The centre of the foreland contains a flat-topped sediment accumulation that stands about 5-10 m above present floodplain level and has a general oval planform shape, enhanced by a meltwater channel running along its western side (Figure 1). An exposure, ca. 50 m wide and up to 9 m high, at its downstream end bounded by a c. 5-7 m-high bedrock obstacle, had only been partly cleaned in July 2014 and was subsequently fully cleaned in 2015 and 2016 (Figure 1). The sediments thus revealed comprise lower units of largely well-sorted massive to trough cross-bedded sands and gravels, which are locally folded. Separated by a sharp, planar contact, these sediments are overlain by a massive, matrix-supported diamicton that displays clear fissility and contains a small number of larger clasts, the majority of which are bullet-shaped. The diamicton is very difficult to expose, particularly in the lower two thirds, and stringers of the underlying sorted units extend into the bottom parts of the diamicton, in a zone of c. 0.5 m above the contact of the sorted sediments with the diamicton. Samples of the sorted units were taken for optically-stimulated luminescence dating, but the quartz did not yield any measureable signal, unfortunately.



Figure 1. Oblique photograph of the landform studied and the extent of the exposure created between 2014 and 2016,

Results - interpretation

The initial working hypothesis based on the geomorphological context and initial cleaning of part of the exposure in 2014 had been compatible with an older sandur terrace or part of a preserved paraglacial valley-infill composed of a suite of glacially-overridden lake sediments. However, this initial interpretation required subsequent revision in 2015 and 2016 after the exposure through the entire landform had been cleaned. The sorted sediments are interpreted as proglacial outwash deposited during the advance of Hornkees towards its ‘Little Ice Age’ maximum (with the grain size differences reflecting differences in flow velocity; Evans, 2000). This succession of outwash was subsequently overridden and glaciotectionised (as evident by the shearing and folding of these units) before a subglacial traction till (sensu Evans *et al.*, 2006; Evans, 2018) was emplaced. Together, the geomorphological evidence, notably the oval planform and location near the valley axis, upstream of a large bedrock obstacle, and sedimentological evidence enable this landform to be interpreted as a small drumlin. This was most likely formed to enable the bedrock obstacle to be overcome (cf. Stokes *et al.*, 2011), thus leading to ‘smoothing’ of the glacier bed during the ‘Little Ice Age’ advance. The chronology of glacier retreat could independently be established by detailed photographic and glacier-length change records obtained in the archive of the Austrian Alpine Club in 2015, and this evidence is currently in preparation for publication.

Significance

Even though the original aim of better constraining subglacial erosion rates could not be achieved, the evidence in the valley occupied by the small glacier Hornkees is nonetheless significant for a number of reasons: (a) it gives an unprecedented insight into the transition from proglacial to subglacial processes during an advance/retreat cycle; it is the first of its kind and is chronologically well constrained by archival evidence, (b) this is also – as far as the author is aware – the first time an alpine drumlin has been described and studied in detail, especially sedimentologically (cf. Stokes, 2011 for context), allowing more light to be shed on the genesis of larger subglacial bedforms in contexts other than lowland ice sheet settings.

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Sven Lukas
Geologiska institutionen
Lunds universitet
Sölvegatan 12
22362 Lund
Sweden
Sven.Lukas@geol.lu.se

TRACING THE DRIVER OF THE 8.2 KA CLIMATE EVENT: FAR-FIELD INVESTIGATIONS FROM THE FALKLAND ISLANDS.

Background and Rationale

The '8.2 ka event' is recognised as the largest magnitude Holocene cooling event in the North Atlantic region (Daley *et al.*, 2011). Freshwater input from the retreating Laurentide Ice Sheet drove a slowdown of the Atlantic Ocean Meridional Overturning Circulation which caused the observed climatic shift (Alley *et al.*, 1997; Barber *et al.*, 1999). Three relative sea-level reconstructions have been utilised to quantify the magnitude and timing of the meltwater ice-ocean flux(s) (Hijma and Cohen 2010; Li *et al.*, 2012; Lawrence *et al.*, 2016). However, all three are Northern Hemisphere sites and require upscaling due to the uneven nature of global sea-level rise, the fingerprint, shown in Figure 1. Swan Inlet,

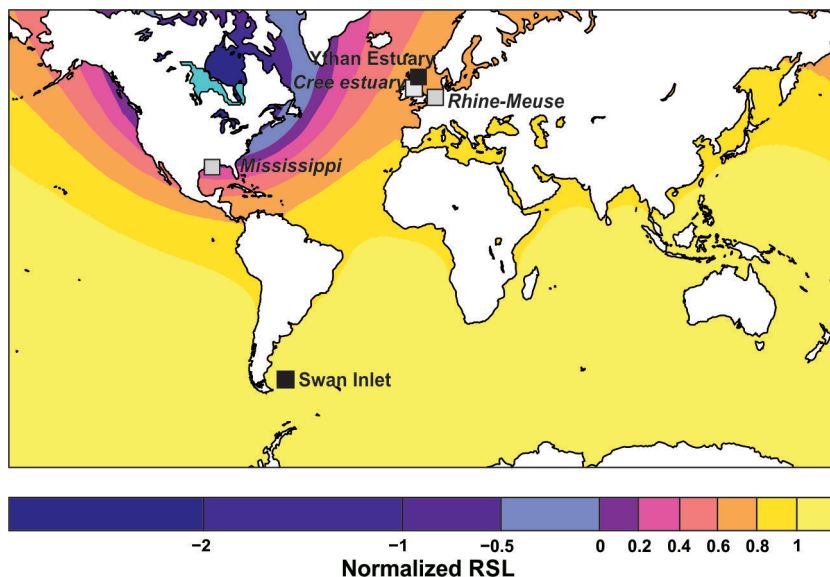


Figure 1. Numerically predicted sea-level fingerprint due to the drainage of Laurentide Ice Sheet at 8.4 ka. The blue colours show the zone of predicted sea-level fall; the remaining ocean areas, from pink to yellow, are regions of progressively higher sea-level rise. In the light yellow regions the sea-level rise exceeds the ice-melt equivalent (eustatic) rise. The grey squares represent sites of previous sea-level studies and the white squares are the Falkland Islands (Swan Inlet) and a second site studied as part of the wider research in Scotland (Ythan Estuary). (Adapted from Kendall *et al.*, 2008).

a salt marsh in the Falkland Islands offers a first opportunity to reconstruct sea level at high resolution over the critical time period in the Southern Hemisphere and hence forego any errors associated with upscaling.

Previous work at the site in 2005 and 2013 (Bentley *et al.*, 2005; Newton, 2017) demonstrated an apparent rapid salt marsh drowning that was preliminarily dated at c. 8500 ka BP as seen in Figure 2. The support of the Quaternary New Researchers Award enabled six weeks of fieldwork to survey and map the stratigraphy of this site and collect cores to return to the UK for further analysis. This will help resolve the question of the location, number and size of the drainage event(s) that drove the dramatic climate shift.

Results

At Swan Inlet 50 cores were collected, shown in Figure 2, and nine from other smaller patches of marsh around the coast of East Falkland. At Swan Inlet, the stratigraphy suggests that a palaeo salt marsh, peaty clays, was flooded and transitioned rapidly to a tidal flat/marine environment, sands. The transgressive contact was traced to its lowest and highest elevations at -1.22 and 1.16 m SD respectively, with the maximum sand deposit in a single core being 2.1 m in depth. The sands gradually transition into brown peaty clays across the upper contact. A similar marine deposit at corresponding heights was observed elsewhere on East Falkland that directly overlies pre-Holocene shales and bedrock. The sand unit is hypothesised to represent either a) one or more flooding phases in its entirety, or alternatively b) both the flooding phase(s) and a longer, subsequent millennial scale sea-level rise. Subsequent microfossil and chronological analysis on retained cores following the field work will test these hypotheses. It is anticipated that this work will produce a gradient of sea-level index points that will allow a quantification of the magnitude of the sea-level rise and its possible phasing in multiple jumps to be generated.

Significance

This work will assist wider research to better constrain the magnitude, length and source of the meltwater flux(s). The results are important in order to understand the effects of freshwater forcing on circulation patterns in the North Atlantic and the climatic impacts. The climate conditions of the 8.2 ka event are well understood and therefore provide an almost unique opportunity to test the forecasting skill of models under freshwater inputs into the North Atlantic.

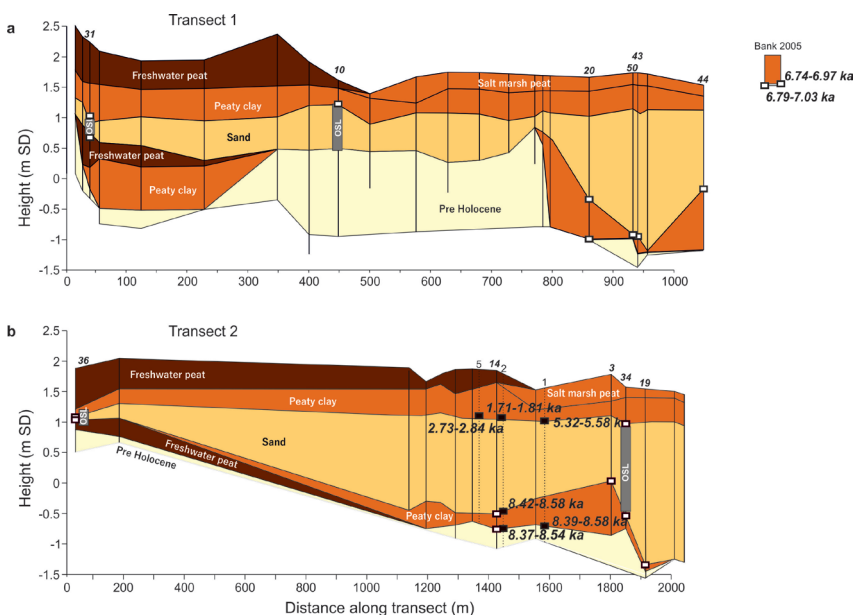


Figure 2. Stratigraphy at Swan Inlet. White squares show where radiocarbon dates have been requested in a recent application following this work, all of which have corresponding diatom counts. Cores to be subjected to OSL are in grey. Existing chronology is marked with solid black squares from cores marked with dashed lines (from Newton, 2017; Newton I. in prep). SD = Stanley Datum.

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Graham Rush
Department of Environment and Geography
University of York
Gpr504@york.ac.uk

Roland Gehrels
Department of Environment and Geography
University of York
roland.gehrels@york.ac.uk

Mark Bateman
Department of Geography
University of Sheffield
m.d.bateman@sheffield.ac.uk

ESTABLISHING A REFINED DEGLACIAL CHRONOLOGY FOR THE CAIRNGORM MOUNTAINS USING SCHMIDT HAMMER EXPOSURE-AGE DATING

Background and rationale

Recent work by Tomkins *et al.* (2018a) provides a revised Schmidt Hammer age-calibration curve for the British Isles based on 54 granite surfaces. Schmidt Hammer Exposure Dating (SHED) presents an opportunity to elucidate the dynamics of former glaciers during the Lateglacial and Younger Dryas Stadial by providing preliminary ages for glacial landforms. A logical application of this technique is in the Cairngorm Mountains – an area where published cosmogenic dates are in part used to construct this age-calibration curve. Although the Cairngorms has been subject to significant cosmogenic exposure dating (see Everest and Kubik, 2006; Philips *et al.*, 2006; Ballantyne *et al.*, 2009; Kirkbride *et al.*, 2014; Standell, 2014; Hall *et al.*, 2016), uncertainty regarding the areas deglacial history still exists. Therefore, the principal aim of this project is to enhance understanding of the deglacial chronology of the Cairngorms using the SHED age-calibration curve established by Tomkins *et al.* (2018a) to derive preliminary ages for glacial landforms. Funding sought from the Quaternary Research Association was used to support initial fieldwork (transport and accommodation) to collect preliminary measurements.

Results

In this pilot study sampling was concentrated in the Glen More, Northern Corries and Loch Avon areas of the Cairngorms (Figures 1 and 2). Ages were obtained following the procedures recommended by Tomkins *et al.* (2018a) using a new N-type Schmidt hammer. Values presented here were linearly adjusted for drift ('instrument calibration') over the period of operation via the SHED Earth Online Calculator using a local calibration boulder. The functioning of the hammer and operator was checked and corrected ('age calibration') using two surfaces in Coire An Lochain (see Dortch *et al.*, 2016; Tomkins *et al.*, 2018a). Following adjustment, the preliminary findings provide age constraint on 96 previously undated granite surfaces. The arithmetic means of Schmidt Hammer ages obtained from these sites span the last glacial to interglacial transition ranging from 16.18 ± 1.10 ka to 11.08 ± 0.97 ka (\pm mean absolute deviation). For example, in the Glen Avon area surfaces provide preliminary mean ages indicating: (i) the initial down-wastage of ice to within Strath Nethy prior to 16.18 ± 1.10 ka; (ii) the deglaciation of plateau areas by 15.21 ± 1.15 ka; (iii) a phase of valley-style glaciation prior to 15.01 ± 0.64 ka (see Standell, 2014); and (iv) the subsequent readvance of ice during the Loch Lomond (Younger Dryas) Stadial (Sissons, 1979), with deglaciation occurring before $11.66 \text{ ka} \pm 0.97$ ka. The preliminary

ages presented here are however, subject to further refinement following the application of additional statistical techniques used elsewhere to analyse SHED derived ages (e.g., Tomkins *et al.*, 2018b).

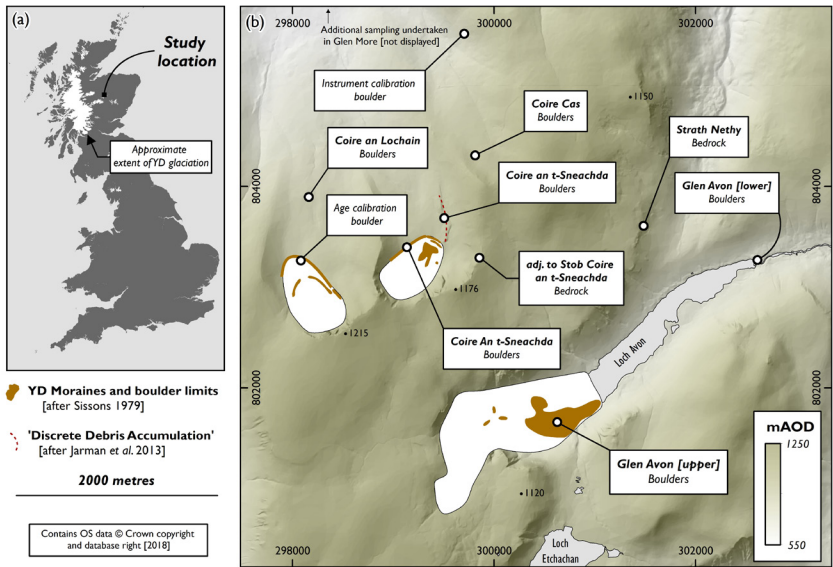


Figure 1. Sample locations and selected glacial geomorphology in the Glen Avon and North Corries area. Younger Dryas landform mapping and glacier extent is based on the work of Sissons (1979) as digitised by Bickerdike *et al.* (2016; 2018).

Significance

The data presented in this preliminary SHED study not only complements existing published chronological data, broadly according with the established view of deglaciation in the area (Standell, 2014; Kirkbride *et al.*, 2014; Hall *et al.*, 2016), but also enriches understanding of the deglacial chronology of the Cairngorms by presenting ages from previously undated bedrock and boulder surfaces. Encouragingly, these initial results highlight the potential of SHED for ongoing work investigating various sites in the Cairngorm Mountains where age constraints on glacial landforms are limited or absent.

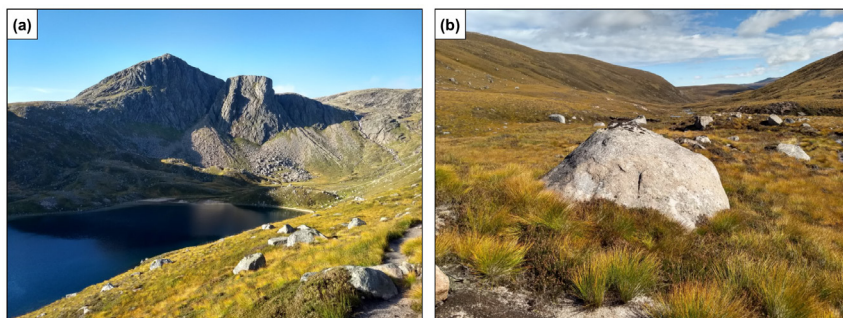


Figure 2. Example sample locations. (a) Upper Glen Avon. (b) Lower Glen Avon

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Toby N. Tonkin
School of Environmental Sciences
University of Derby
Kedleston Road
DE22 1GB
t.tonkin@derby.ac.uk

NEW RESEARCH WROKERS AWARD

DEVELOPING AN ANNUALLY RESOLVED CHRONOLOGY OF PATAGONIAN ICE SHEET DEGLACIATION USING VARVD LAKE SEDIMENT

Background and rationale

Recent developments in understanding the dynamics of the former Patagonian Ice Sheet, southern South America (Figure 1) have been achieved through detailed geomorphological mapping (Lovell *et al.*, 2012; Darvill *et al.*, 2014; 2017; Bendle *et al.*, 2017a) and improved dating of glacial events. Dating efforts have largely utilised cosmogenic nuclide exposure dating of moraine boulders and outwash cobbles (e.g. Kaplan *et al.*, 2004, 2011; Douglass *et al.*, 2006; Hein *et al.*, 2010; Boex *et al.*, 2013; Darvill *et al.*, 2015), or luminescence dating of outwash sands (Smedley *et al.*, 2016) and palaeo-lacustrine terraces (Glasser *et al.*, 2016). These approaches have yielded important constraints on the millennial scale behaviour of Patagonian Ice Sheet outlet glaciers, which includes the identification of ice sheet advance during Marine Isotope Stage 3 (Darvill *et al.*, 2015; Smedley *et al.*, 2016); glacier response to the Antarctic Cold Reversal (Sagredo *et al.*, 2018); and the timing of deglacial meltwater release to the Pacific Ocean (Glasser *et al.*, 2016).

However, these techniques are limited by (1) a general inability to constrain the sub-millennial timing of past ice sheet change; and (2) the often fragmentary nature of the geomorphological (e.g. moraine) record that underpins dating programmes. The lack of continuous, high-resolution glacial chronologies is a limiting factor on understanding ice sheet-climate interactions during periods of major ocean-atmosphere reorganisation (e.g. Last Glacial to Interglacial Transition) in the Southern Hemisphere, and the mid-latitude cryospheric response to short-term (decadal to annual) climate variability. Such records could enable critical comparisons to palaeoclimate records from Antarctic ice cores (e.g. WAIS Members, 2015) and a test of models of past climate activity.

Developing an annually resolved chronology

Annually laminated (varved) glaciolacustrine sediments provide an opportunity to formulate a continuous, annual-scale chronology of Patagonian Ice Sheet behaviour through the Last Glacial to Interglacial Transition (~18.0–8.0 ka). Glaciolacustrine varves exhibit a two-part sedimentary structure driven by the annual cycle of ice sheet ablation (Figure 2): (1) a coarse-grained (silt/sand) layer is deposited in the melt season (spring/summer) when sediment-laden meltwater plumes enter the lake; and (2) a clay layer settles from suspension in the non-melt

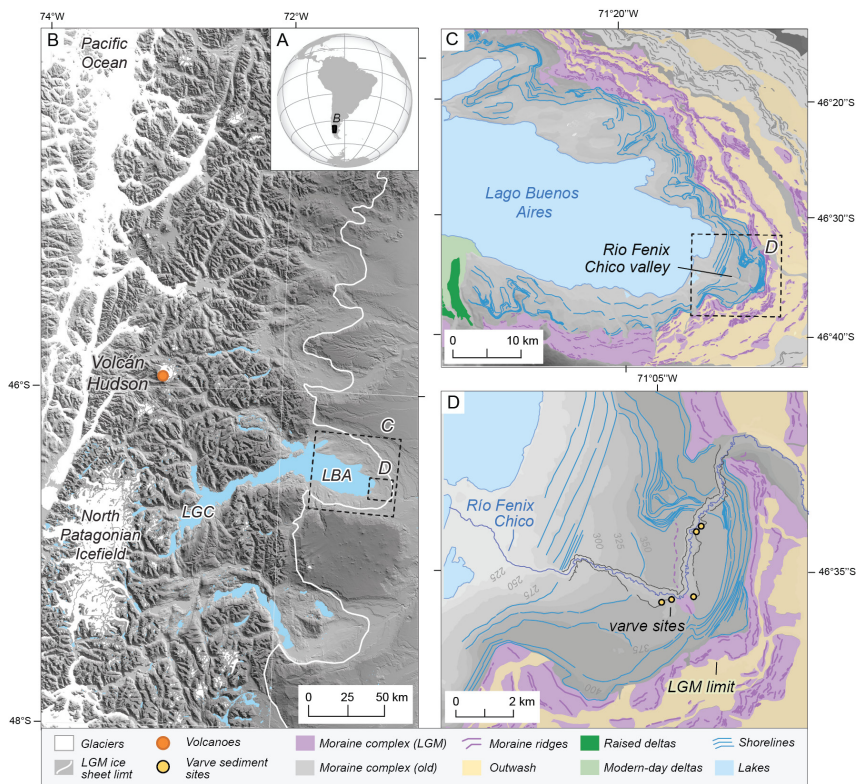


Figure. 1 (A) Location of Patagonia in southern South America. (B) Regional setting with extent of former Patagonian Ice Sheet (white line) and location of study sites. (C) Geomorphology of the LGC–BA outlet glacier (cf. Bendle et al., 2017a). (D) Map of the Río Fenix Chico valley showing location of varve sites in relation to ice limits.

season (autumn/winter) when lake currents lessen and ice-cover builds up at the lake surface. As well as providing environmental proxy data through changes in varve thickness, such sediments form the basis of precise chronologies for past glacier dynamics through annual layer (varve) counting.

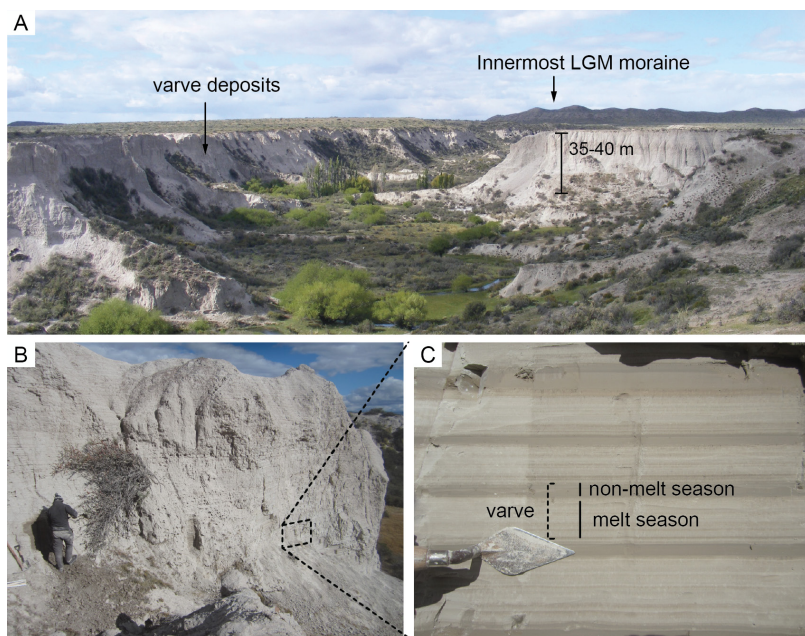


Figure. 2 (A) View of the Río Fenix Chico valley with varved lake sediments inset behind a Last Glacial Maximum (LGM) moraine limit. (B) Example of sediment section used for varve counting. (C) Structure of glaciolacustrine varves.

Varved sediment records were identified in Patagonia in the early 20th century (Caldenius, 1932) and linked to the formation of proglacial lakes during ice sheet retreat after the Last Glacial Maximum (21.0–19.0 ka). However, the potential of these records has been largely unexploited since their early discovery. This New Researchers Award provided funds to conduct fieldwork (Figure 2) at proposed varve sites bordering Lago General Carrera (Chile)–Buenos Aires (Argentina; LGC–BA) in central Patagonia (Figure 1), and represented an important step in the development of the first, and currently only, annually-resolved and independently dated chronology of Patagonian Ice Sheet deglaciation (Bendle *et al.*, 2017b).

Summary of findings

Field varve counting and thickness measurements at five sites in the Río Fenix Chico valley enabled the construction of a composite 994 ± 36 varve year chronology spanning the early stages of glacier retreat at LGC–BA (Figure 3; Bendle *et al.*, 2017b). The floating chronology has been anchored to the calendar-year timescale by the Ho tephra layer from Volcán Hudson (Weller *et al.*, 2014), which occurs within the varve sequences and has enabled the precise timing of glacier dynamics

to be determined. In summary, the new chronology suggests that deglaciation was underway at 46.5°S by 18.01 ± 0.21 cal ka BP. The rate of glacier retreat remained moderate (5.5–10.3 m yr⁻¹) until 17.32 ± 0.12 cal ka BP, before subsequently accelerating (15.4–18.0 m yr⁻¹) as the LGC–BA outlet glacier retreated westwards towards the Patagonian Andes. This acceleration coincides with an increase in the volume of ice-rafted debris with varved sequences, suggesting that calving processes enhanced the rate of ice loss following retreat into deeper lake waters (Bendle *et al.*, 2017b).

Acknowledgements

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Jacob Bendle
Centre for Quaternary Research
Royal Holloway
University of London
Egham
Surrey
TW20 0RG
Jacob.Bendle.2011@live.rhul.ac.uk

HOLOCENE PALAEOTEMPESTOLOGY AND ENVIRONMENTAL CHANGE IN THE GULF COAST OF THE U.S.A.

Background and Rationale

Hurricanes are one of the world's most destructive and deadly natural disasters. In recent years (amidst global warming fears), it has been suggested that the frequency and intensity of hurricanes are increasing (Liu and Fearn, 1993; Diaz and Pulwarty, 1997; Elsner, 2003; Elsner and Jagger, 2009, Landsea *et al.*, 2010). Palaeotempestology is a uniformitarian approach that analyses hurricanes (from the Holocene) by a multitude of geological proxy techniques (Liu and Fearn, 2000; Fan and Liu, 2008; Horton and Sawai, 2010). It is vital to examine palaeo records as instrumental data of hurricanes only extend back to around 170 years ago (Liu and Fearn, 2000; Kiage *et al.*, 2011; McCloskey and Liu, 2012; Toomey *et al.*, 2013). As this is a relatively new field of research, there is great demand for detailed records of palaeo-hurricanes and the environmental change as a result (Fan and Liu, 2008). Hurricane records are identified and examined in sediment cores by sand layers. Sand layers indicate hurricane presence as when a hurricane makes landfall a large storm surge is created which moves beach sand and debris inland and deposits it into lake and marsh environments (Oliva *et al.*, 2017). This has a significant effect on the local environment in combination of destruction caused by the hurricane itself.

Methodology and Preliminary results

The QRA New Research Worker Award enabled the field expedition in May 2018 to Gulf Shores, Alabama, U.S.A., where my supervisor and I met Professor Kam-biu Liu and his team. Two 6 m lake cores (BRIT 2 and 5) and one 3 m (LLM2) marsh core were extracted from Middle Lake and Little Lake Marsh using a Vibra corer and aluminium tubing (Figure 1). The cores were sliced in the field into 1m sections for easy transportation back to the U.K.

From initial visual inspection of the cores, BRIT 2 (6 m lake core) contains the most sand layers with three specific larger layers suggesting major hurricanes, therefore, laboratory analysis has begun with this core. Preliminary results of organic matter content (LOI) with a resolution of 1 cm, show reductions in LOI in correlation with the sand layers. Future analyses include; particle size, XRF, pollen and diatom records.

Significance

This data aids in the extension of the palaeotempestological database and analysis of aquatic and terrestrial environmental change. Furthermore, once complete these records will provide a detailed diatom assemblage for this area which has not been analysed before. There is potential for this data to be used in future climatic change predictions.

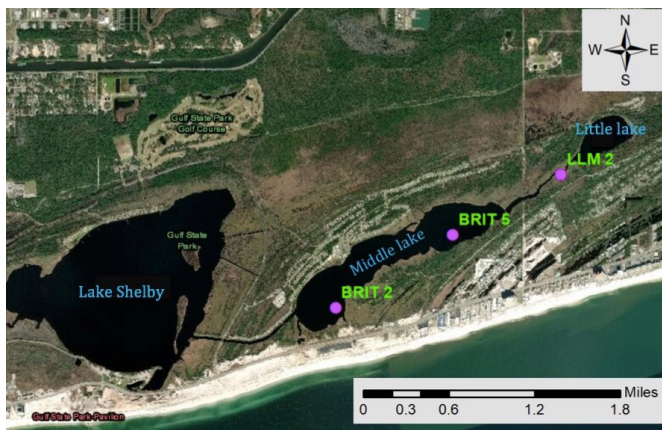


Figure 1. Locational map showing core extraction point from Gulf Shore, Alabama, U.S.A.

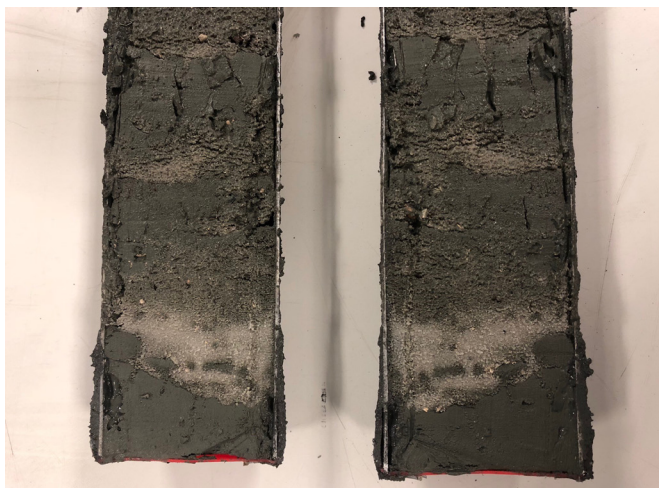


Figure 2: Large sand layer identified from BRIT 2.

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Emma V. A. Readitt
Department of Geography,
Edge Hill University,, St. Helens Road,
Ormskirk, Lancashire L39 4QP
readitte@edgehill.ac.uk

REPORTS

FOURTH SEA-LEVEL AND COASTAL CHANGE MEETING – SLACC 2018

3rd – 7th September 2018, Fort William, Scotland

The Sea-Level and Coastal Change (SLaCC) meetings have run since 2015, after they won QRA Research Group status for the years 2015 to 2017. In 2018, due to the long running success of the meetings, SLaCC enjoyed continued support from the QRA thanks to a Meeting Co-sponsorship Award. This year, the Fourth SLaCC meeting was held in Fort William, Scotland, where participants (Figure 1) attended a day of presentations and discussion sessions (Tuesday 4th Sept.) before visiting a range of sea level and coastal research sites across northwest Scotland (Wednesday 5th – Thursday 6th Sept.). The meeting was organised by SLaCC co-ordinators **Sarah Woodroffe** (Durham) and **Rob Barnett** (Exeter), with significant contributions from **Ian Shennan** (Durham) and **Jon Hill** (York). Alongside the QRA, SLaCC 2018 was generously supported by the INNUNDATION project (*“Improving coastal community hazard assessment using novel experiments”*), awarded to **Jon Hill** (York) by the White Rose University Consortium.



Figure 1. Sea Level and Coastal Change 2018 participants. *From left to right: Sarah Woodroffe, Jim Innes, Dorothy Weston, Caitlin Nagle, Luis-Rees Hughes (front), Trevor Faulkner (back), Sarah Bradley, Emma Hocking, Juliet Sefton, Tasha Barlow, Rob Barnett, Graham Rush, Emmanuel Bustamante-Fernandez, Helene Burningham, Salma Sabour, Thaisa Bergamo, (missing: Nick Everett, Guillaume Goodwin, Maryam Hanan, Jon Hill). Photo credit: Salma Sabour (Southampton).*

The aims of the meeting aligned closely with principles long held by the QRA; attendance of early career researchers (ECRs) was encouraged and supported thanks to the grants from the QRA and White Rose University Consortium. SLaCC 2018 welcomed 20 participants to Scotland, over half of which were ECRs and all of which presented research contributions. The meeting also established a comfortable and inclusive platform for contributions from all career stages and from a diverse spread of subject areas. Engagement across disciplines was stimulated further through open discussion sessions that focussed on how modern- and palaeo-facing studies could be used to better inform one another. Subject diversity was also reflected in the two invited keynote speakers, **Helene Burningham** (UCL) and **Sarah Bradley** (TUDelft). Helene is an Associate Professor in Physical Geography and has published over 40 articles on topics that include climate and wave climate forcing of coastal landforms, shoreline evolution and coastal sediment (morpho-) dynamics. Sarah is a Postdoctoral Researcher in geophysical modelling and also has over 40 research contributions within themes spanning palaeo sea- and land-level changes, ice-sheet dynamics and palaeogeographies. Improving integration between researchers from different fields in sea level and coastal research is an objective that is growing in value at SLaCC meetings. Past successes will be built upon at SLaCC 2019 (**1st – 4th Sept. 2019**) by the merging of existing themes on modern- and palaeo-facing research with resilience to coastal change when the meeting comes to the South West.

SLaCC 2018 started with an evening ice-breaker at the conference venue in the Gallery of the Lime Tree An Ealdhain (Fort William), who were hosting an auspicious coastal- and sea-scape exhibition entitled “*A View To The Sea*”. Poster presentations were erected amidst the relevantly themed artwork and local flavours were enjoyed in a relaxed setting where participants founded new relationships and enriched existing ones. The following day (Tuesday 4th Sept.), presentations started after a welcome note from **Sarah Woodroffe** (Durham) with a keynote contribution from **Helene Burningham** (UCL) on the drivers of and controls on sedimentary coastal systems. Helene used a suite of coastal examples from the UK and Ireland to demonstrate spatial and temporal variability in coastal response to important drivers such as sea-level and climate variability. This insight was informed by over a decade of research into multi-scalar coastal geomorphology and response and highlighted the complexities of coastal systems when distinguishing between local, regional and global driving processes. The second presentation of the meeting was given by former SLaCC coordinator **Natasha Barlow** (Leeds), who talked on the value of new offshore geophysical and borehole data in the North Sea, which was resulting from increased energy-related exploration of the basin. **Graham Rush** (York) continued the session by presenting high-resolution sea-level reconstructions of the 8.2 ka event using data from both northern (Ythan Estuary, Scotland) and southern (Falkland Islands, South Atlantic) hemispheres, which are vital for identifying melt-water sources that relate to the event.

After a short refreshments break, when participants could step outside and enjoy sun-filled views across Loch Linnhe, the morning session continued with a presentation on methodological improvements for automating the interpretation of ground-penetrating radar (GPR) data by **Luis Rees-Hughes** (Leeds). Luis' work in applied geophysics is bringing new insight to classic sea-level research sites and will contribute to larger-scale understandings of (palaeo-)coastal systems. **Rob Barnett** (Exeter) concluded the presentations of the morning by using examples from Quebec, Canada, to emphasise the importance of using robust understandings of modern coastal geographies for informing palaeo sea-level research.

Following the morning presentations, the first of two discussion sessions was held using a focus panel comprising **Helene Burningham** (UCL), **Sarah Bradley** (TUDelft), **Guillaume Goodwin** (Edinburgh) and **Rob Barnett** (Exeter). **Sarah Woodroffe** (Durham) chaired the discussion session and posed the question "*How can studies of modern coastal processes and geomorphology better inform our understanding of past sea level, land level and coastal changes?*" to the panel and the participants. A broad range of perspectives and experiences were shared throughout the group and the complexities of coastal environmental interactions were made abundantly apparent. A recurring theme within the discussion was the need to better understand, from both process and modelling perspectives, coastal and shallow offshore sediment transport and associated landforms across a range of temporal and spatial scales. The openness (and wit) of the panel prompted broad inclusivity throughout the discussion and valuable contributions were made from all career stages. Thus, the morning session of presentations for SLaCC 2018 came to a close on a happy and contemplative note.

A delectable lunch was provided by the attentive hosts at The Lime Tree, during which conference attendees enjoyed a wide range of poster presentations. **Emma Hocking** (Northumbria) presented stratigraphic evidence of tsunamis deposits in Chile and a discussion on the evidence of the Storegga Slide along the Northumberland coastline. **Natasha Barlow** (Leeds) presented sedimentary records of recent storm surges from the North Sea on behalf of **Graeme Swindles** (Leeds). SLaCC's furthest travelled participant of 2018, **Thaisa Bergamo** (Estonia), contributed a poster concerning the impacts of sea level and salinity changes on coastal wetland plant communities. On the topic of Holocene relative sea-level changes, **Maryam Hanan** (York) presented ongoing palaeoenvironmental reconstruction work from the Cumbrian coastline and **Trevor Faulkner** (Birmingham) contributed two posters on the deglaciation of Scandinavia. Finally, **Guillaume Goodwin** (Edinburgh) and **Salma Sabour** (Southampton) both presented on the role of different controls (e.g., sea-level, tidal range, lithology) on determining shoreline changes.

The afternoon presentation session was chaired by **Natasha Barlow** (Leeds) and started with the second keynote of the day from **Sarah Bradley** (TUDelft). Sarah presented new 20 ka simulations of the British and Scandinavian Ice Sheets that

were constrained by the state-of-the-art geodatabase produced by the BRITICE-CHRONO consortium and the recently updated sea-level database for the British Isles. These simulations demonstrated spatial and temporal variabilities in the two ice sheets, which will provide new insight into deglacial melt-water sources from all the major ice sheets during this time period. Sarah's presentation was followed by a talk on methodological improvements for a range of sedimentological, biological and geochemical sea-level proxies from mangrove sediments by **Juliet Sefton** (Durham). Following Juliet, **Trevor Faulkner** (Birmingham) introduced a new topic to many of the group in the form of raised littoral caves in Norway that helped to define deglacial marine limits. **Caitlin Nagle** (Sheffield) followed with a presentation of initial results on Holocene coastal and estuarine deposits from the Dysynni Valley, Wales, for interpreting relative sea-level changes. The afternoon presentations were closed with a talk by **Sarah Woodroffe** (Durham) on high-resolution sea-level reconstructions from Greenland salt marshes for constraining ice sheet mass balance during the Little Ice Age.

Prior to closing, the day ended with the second discussion session, this time chaired by **Natasha Barlow** (Leeds) and with a panel comprising **Sarah Bradley** (TUDelft), **Helene Burningham** (UCL), **Sarah Woodroffe** (Durham) and **Jon Hill** (York). The theme of the meeting was reintroduced and Tasha reversed the question of the first discussion session and asked "*How can studies of palaeo sea- and land-level changes better inform our understanding of ongoing coastal evolution?*". The ensuing discussion emphasised the importance of communicating the relevance of palaeo research and how communication pathways were key in reaching stakeholders and decision makers on topics of coastal environmental change. At this point, after a short summary note by the organisers, the participants were granted a few hours respite prior to a three course evening conference dinner of local flavours provided by the awarded winning restaurant at The Lime Tree.

Two days of field excursions followed the day of presentations, posters and discussion sessions. The excursions were informed by a comprehensive 20 page, full colour field guide prepared by **Ian Shennan** (Durham) that contained a tour of 15 stops around northwest Scotland. Excursion day 1 (Wednesday 5th September) included informative visits to Corran (Loch Lomand Stadial maximum ice extent); Loch Sunart (recent sea-level rise recorded by intertidal salt-marsh environments); Kentra Bay and Kentra Moss (widely studied SSSI and SAC environments comprising intertidal mud flats, tidal marshes, coastal blanket bogs and oak woodlands), this stop featured a welcomed note from invited guest **Nick Everett**, coastal geomorphology policy advisor to Scottish National Heritage; and finally Loch Shiel (Loch Lomand Advance limits and debated lacustrine versus marine deposits). The second excursion day (Thursday 6th September) contained a more hands on approach when the group headed to Arisaig, Morar, which contained a staircase of isolation basins that have been used to document the longest (>16,000 yrs) record of past relative sea-level changes in Great Britain. Participants were shown a number of sites and were quickly put to work coring



Figure 2. Coring isolation basin transition contacts at Arisaig. *Photo credit:* Salma Sabour (Southampton).

through many metres of peat bog, lacustrine muds and minerogenic grey clays (Figure 2). Naturally, competition ensued between the two coring groups but all were victorious when an impromptu education on Troels-Smith was introduced to the day. Sunny spells were interspersed with heavy showers, which contributed to an idyllic setting as conference activities came to a close amidst some outstanding scenery via Keppoch and Glenancross on the journey back to Fort William.

The conference organisers are pleased to acknowledge a wide variety of support that ensured the success of this meeting. The QRA and White Rose University Consortium are once again thanked for grant contributions. The hosts at The Lime Tree An Ealdhain were exceptional and we hope to revisit them again soon. Thanks to: the keynote speakers, **Sarah Burningham** (UCL) and **Sarah Bradley** (TUDelft); **Ian Shennan** (Durham) for a stupendous field guide; **Jon Hill** (York) and **Natasha Barlow** (Leeds) for contributions before and during the meeting; **Salma Sabour** (Southampton) for becoming the unofficial (turned official) conference photographer; the meeting coordinators **Sarah Woodroffe** (Durham) and **Rob Barnett** (Exeter); and of course all the presenters and participants of SLACC 2018.

Salma Sabour
Climate change and Energy Group
Faculty of Engineering and Physical sciences
University of Southampton
s.sabour@soton.ac.uk

Robert L. Barnett
Geography, College of Life and Environmental Sciences
University of Exeter
r.barnett@exeter.ac.uk

PHIL GIBBARD – RETIREMENT SYMPOSIUM

Monday 10th September, Department of Zoology, University of Cambridge

On a beautifully sunny Monday in early September, ninety participants gathered in the Department of Zoology, University of Cambridge to celebrate the many areas of research to which Phil Gibbard has contributed over the course of his career. This career started from 1968 to 1971 in the University of Sheffield, where Phil studied Geology. This was followed by a move to ‘the dark side’ to study the Quaternary of the Thames under the supervision of Professor Richard West at the Subdepartment of Quaternary Research in the Botany Department at Cambridge. During his PhD, Phil established the sequence of events that occurred in Hertfordshire during the diversion of the Thames in the Anglian. After this, Phil undertook postdoctoral research in Finland (University of Oulu, 1975-1976) and in Canada (University of Western Ontario, 1976-1977), in both cases studying the glacial deposits of these countries. Phil then held two NERC Fellowships and a Leverhulme Fellowship back in Cambridge, during which time he produced his seminal book on the Middle Thames (Gibbard, 1985), before securing a permanent post as Assistant Director of Research in 1984. Following closure of the Subdepartment of Quaternary Research in 1995, Phil moved from Botany to Geography, where in 2005 he was promoted to Professor. He retired in 2017 and is currently an Emeritus Professor of Quaternary Palaeoenvironments at The Scott Polar Research Institute (SPRI), Cambridge. The symposium was planned originally to be held in SPRI, but due to the large number of people signed up to attend, was switched to Zoology. An advance party who had travelled on Sunday had already started to develop the atmosphere of celebration and enjoying the company of old friends the night before over food and drinks in central Cambridge.

The symposium was arranged into four broad themes — marine, glacial, stratigraphy and terrestrial — that reflected Phil’s wide research interests. Speakers were selected by the organisers (**Della Murton** and **Sebastian Gibson**) to provide overviews of these research topics and, on the lighter side, personal reminiscence and stories of Phil’s career. The first session was on marine sediments. **Sanjeev Gupta** (Imperial) opened proceedings, wearing a shirt that exactly matched Phil’s own — clearly he is not just a scientific but also a sartorial influence! Sanjeev shared how coming across Phil’s paper in the *Island Britain* volume (by coincidence, that meeting was held 25 years earlier in the same Zoology lecture hall that now hosted Phil’s retirement symposium) had shaped his own well-known work on the bathymetry of the English Channel and the evidence for catastrophic flooding events, which Phil later reviewed for *Nature* (Gibbard, 2007). Following this, **Maria Fernanda Sánchez Goñi** (PSL University, Paris) outlined the progress that has been made in understanding key Quaternary palaeoclimatic questions in her research from the Iberian margin, in which Phil has always had a keen interest due to his

palynological training. Staying on the Iberian margin, **David Hodell** (Cambridge) then described geochemical (Ti/Ca ratios) and sedimentary (IRD peaks) evidence for meltwater discharges from the European and British-Irish Ice Sheets during MISs 12, 10, 8 and 6. These freshwater discharges occurred during the middle of these glacial stages and may have disrupted the Atlantic Meridional Overturning Circulation to such an extent thereby enabling North American ice sheets to survive the mid-glacial insolation maxima. Phil has also had longstanding warm relationships with many German colleagues, and the next to speak was **Thomas Litt** (Bonn, Germany) who described a pollen sequence encompassing the past 600 ka from Lake Van in Turkey. The final talk before coffee again stayed with the theme of long continental palaeoclimate records. **Chronis Tzedakis** (UCL) discussed how orbital forcing could influence the observed duration between interglacials. He described how over 1Ma ago, interglacials occurred every 41 ka, when the energy related to summer insolation exceeded a simple threshold. For the past 1Ma, however, the energy threshold needed for deglaciation had risen, and this consequently increased the duration of glaciations.

The talks after morning coffee focused on glaciations and glacial sediments. **Juha Pekka Lunkka** (Oulu, Finland), discussed the complexity of the Finnish stratigraphy and Phil's contributions to understanding it. **Markus Fiebig** (University of Natural Resources and Life Sciences, Austria) switched locations to the Alps. He summarised how OSL dating of terrace deposits has indicated difficulties when applied to the traditional stratigraphies and assignation of all terrace deposits to 'Gunz, Mindel, Riss, Würm'. For those of us in the audience to whom Phil had taught fluvial systems we knew exactly his opinion on this approach! Moving onto glacial deposits, **Jürgen Ehlers** (now a crime novelist), gave a talk on clast lithological provenancing. Jürgen is most readily associated as a co-author with Phil on several substantial books synthesising global glacial deposits (e.g. Ehlers and Gibbard, 2004a,b,c). Jürgen concluded his talk with a superb slide of Phil 'meeting' a woolly mammoth (Figure 1). This is the creature that Phil chose to represent the Quaternary Palaeoenvironments Group that he founded and designed all the branding for in the late 1990s following his move to the Department of Geography (Figure 2). We then heard from **Phil Hughes** (Manchester) about his twenty years of research on the glaciation of the Atlas Mountains in Morocco, all sparked by Phil G asking him as a PhD student to write the North Africa chapter in Ehlers and Gibbard (2004c), to which Phil H readily agreed, before realising quite how little was known...

Lunch was held outside in the sunshine, with the opportunity for a group photograph (Figure 3). Afterwards we reconvened to hear of Phil's considerable achievements and contributions to Quaternary stratigraphy. **Martin Head** (Brock University, Canada,) opened the afternoon's proceedings with a humorous presentation of how global boundary stratotype section and points (GSSPs) are decided upon and designated, and in particular how Phil played a leading role in redefining the base of the Quaternary. **Andrew Gale** (Portsmouth, Stratigraphy Commission of the



Figure 1. Phil comes face to face with an old friend in Jürgen Ehler's talk!



Figure 2. Phil's design and branding for his newly-formed Quaternary Palaeoenvironments Group in the Department of Geography in the late 1990s.

Geological Society of London) then outlined the stratigraphical achievement for which Phil is probably best known: ensuring the retention of the Quaternary as a formal geological period following its attempted assassination, by the International Stratigraphic Commission (e.g. Gibbard *et al.*, 2005). Phil has been Chair of this Commission since 2016. There followed some discussion about whether Phil had been born (in 1949) within the Anthropocene or the Holocene, with the conclusion that he predated the Anthropocene, neatly encapsulating the difficulties Phil has with the formal definition of this stage (Gibbard and Walker, 2014). Phil has also had a great interest in mapping, from his earliest publications on the northwest European rivers (Gibbard, 1988) to the present day, and the next two talks addressed this topic. **Kristine Asch** (BGR Germany) introduced us to the International Quaternary map of Europe, and outlined the difficulties associated with standardising and harmonising data across political and geographical boundaries. **Christine Batchelor** (Cambridge) presented seventeen time-slice maps of pre-LGM Northern Hemisphere ice sheet extents derived from synthesising published empirical and numerical modelling data. She then compared their ice volumes—calculated using a simple area-volume scaling power law—against global sea level (ice volume equivalent) curves and concluded that sea levels were 30–40 m higher during MIS 3. This was most probably because the Laurentide Ice Sheet was significantly smaller than had previously been reconstructed. The final speaker in the stratigraphy session was **Manfred Frechen** (Leibniz, Germany) presenting on recent OSL dating of the Rhine.



Figure 3. Symposium participants gather in the sunshine at lunchtime on the steps of the newly-refurbished Zoology Museum. At the front are (right to left) Phil Gibbard, with Symposium organisers Della Murton and Sebastian Gibson.

Our final session focused on terrestrial deposits. **Jamie Woodward** (Manchester) described how variations in neodymium and strontium isotopes in Holocene deposits of the river Nile indicated dramatic shifts in sediment supply from its two main tributaries – the Blue Nile and the White Nile. He attributed these isotopic variations to rapid shifts in climatic regimes, from humid to arid. **Julian Murton** (Sussex) then described how key periglacial processes of ice segregation, frost heave and thaw consolidation have shaped the landscape of southern England. In particular, how periglacial weathering and fluvial incision acted to impose significant relief onto the former low-relief land surfaces formed by Palaeogene and Neogene erosion. Our next topic was palaeogeography, this time in the Rhine delta and southern North Sea. Here **Kim Cohen** (Utrecht), who worked with Phil as a postdoctoral researcher on fluvial mapping of Europe in the 2000s, showed the importance of the southern North Sea basin for linking regional stratigraphies and understanding the evolution of northwest Europe. The next talk was a highlight for many attendees, as **Bettie Higgs** (Cork) let us all into the secrets of ‘Undergraduate Phil’ and his close-knit group of friends from his time in Sheffield. There were superb pictures of Phil looking like a rock musician, interwoven with tales of field trips, walking through snow drifts reminiscent of 2018’s ‘Beast from the East’ just to reach an icy phone box from which to call family back home, and of his single record played on a loop in his student room. But Bettie also recalled memories of the excitement and confusion of studying geology during the emergence of plate tectonic theory and of the serious misgivings that their favourite Professor had about Phil going off to study the Quaternary. The final talk, giving a light-hearted end to the day, was presented by **Thijs van Kolfschoten** (Leiden, Netherlands). He evaluated the evidence for a stratigraphical term mooted first at a QRA meeting in Cambridge in January 1999, of ‘the Gibbardian’.

I am sure that I speak for many in saying that excellent though the talks were, a real highlight was also the opportunity to reconnect with other former students and research associates, to reminisce and catch up with each other’s current successes. The coffee and lunch breaks were not long enough for all the conversations that I would have chosen to have. That sense of community speaks volumes about how open and welcoming Phil has always been, by hosting collaborators from other institutions and personally supporting the importance of regular coffee times. Former PhD students, post-docs, close colleagues, collaborators, family and friends of Phil’s gathered again in the evening for a formal dinner at Clare College. Here, we heard speeches, with **Veli-Pekka Salonen** speaking warmly on behalf of Phil’s many Finnish friends and colleagues, stating that Phil is, at some level, actually Finnish. The highlight of the speeches was **Mike Walker’s** poetic tribute to ‘The Saviour of the Quaternary’. Space forbids inclusion of all 37 verses here, but this verse gives a flavour:

‘So well done Phil, and Martin too,
For saving us from what might have been.
The Quaternary banished forever to the Dark Side,
In the evil empire of the Neogene.’

The event was a fitting tribute to the way in which Phil has advanced our understanding in many areas of Quaternary Science and trained more than one generation of current researchers, and our thanks are extended to two of Phil’s most recent PhD students, Della Murton and Seb Gibson, for all their hard work in organising this event.

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Rebecca M Briant
Department of Geography
Birkbeck, University of London
Malet Street, London WC1E 7HX
b.briant@bbk.ac.uk

IQUA ANNUAL SYMPOSIUM 2018: IRISH OFFSHORE QUATERNARY RECORDS

23rd November, Geological Survey Ireland, Dublin.

The 2018 Irish Quaternary Association (IQUA) symposium was recently held at the Geological Survey Ireland, organised and convened by Dr. Stephen McCarron (Maynooth University), Dr. Kieran Craven (Geological Survey Ireland) and Dr. Mark Coughlan (Irish Centre for Research in Applied Geoscience). This year's theme was "Irish Offshore Quaternary Records", focusing on advances in our understanding of the Quaternary history of Irish shelves and comparing existing work to ongoing research in neighbouring regions.

More than 60 researchers, consultants and interested parties gathered to hear nine presentations delivered by some of the foremost and up-and-coming researchers in the field at present. In his opening address, Dr. Stephen McCarron welcomed all the attendees and highlighted the pertinent and timely nature of the Symposium given recent and on-going research in the field and upcoming events such as the Quaternary Research Association Annual Discussion Meeting and the INQUA Congress in Dublin, 2019. He extended an especially warm welcome and thanks to those who travelled from the UK to present at the event or attend it, strengthening ties and collaborations between Irish and UK based researchers.



Figure 1. Dr Stephen McCarron delivering the opening address (Photo courtesy of IQUA).

The morning session engaged the attendees by setting the context for broad Quaternary stratigraphic frameworks and how they are established. Mr. Dayton Dove of the British Geological Survey detailed the extensive work undertaken in the UK since the 70s to rationalise Quaternary stratigraphy and nomenclature based on extensive datasets, and how best to present and deliver updated information on Quaternary geology (e.g. engineering properties) to ensure science advances are made useful and relevant to the many users of the UK offshore. Dr. Kara English of the Department of Communications, Climate Action and Environment (DCCAE), followed this by presenting the latest efforts by DCCAE and their consultants to

establish a Quaternary stratigraphic framework for Irish offshore deposits. Both talks highlighted the difficulties in developing a catch-all framework and the need for constant iteration based on the latest research.

After the morning break, attention switched to the Atlantic margin. Dr. Audrey Morley of the National University of Ireland in Galway discussed recent findings of an investigation, using a multi-proxy approach, into an abrupt high magnitude climate event in the North Atlantic and the implications for our understanding of glacial/interglacial condition drivers. Dr. Kieran Craven of Geological Survey Ireland presented a seismic stratigraphy, constrained by borehole data, for sediments found on the outer Malin Shelf and how we can infer several phases of phases of cross-shelf grounded ice extension from Scottish sources from it. Dr. Louise Callard of Durham University developed on some of the concepts presented by Kieran in her following presentation discussing the glacial and deglacial history of the Malin Shelf, based on new data gathered as part of the BRITICE-CHRONO Project. Mr. Xavier Monteys of the Geological Survey of Ireland then brought us further offshore to the Porcupine Seabight where he discussed some of the previous work carried out on IODP and INFOMAR data to constrain palaeoenvironmental change over the last c. 340,000 years, and how that data is now being collated to offer new insights into, what is, a poorly understood region.

After lunch, the final session moved south and east geographically to the Irish Sea and its approaches. Prof Andy. Wheeler of University College Cork discussed new ideas regarding ice dynamics and ice-sheet interactions off the south coast of Ireland, and how offshore data can be linked to onshore data for a more holistic approach. Andy was followed by his former PhD student, and current lecturer at Bangor University, Dr. Katrien Van Landeghem who presented some fascinating geophysical, sedimentological and geotechnical data used to define the spatial and temporal patterns of ice stream advance, retreat and reactivation in the Irish Sea. In a lovely continuum of research lineage, Katrien's own PhD student, Mr. Edward Lockhart of Bangor University, presented his latest work reconstructing ice sheet dynamics in the Celtic Sea during the last glaciation.

All the speaker presentations were well received and generated a significant amount of informed discourse throughout the day, which was enthusiastically carried through to the post-Symposium reception kindly sponsored by Arup. Here, the results of the 14C Chrono (Queen's University Belfast) sponsored awards were announced. Other sponsors on the day included the Institute of Geologists of Ireland, the Quaternary Research Association (QRA) and Geological Survey Ireland (GSI).

The organisers would like to thank the sponsors for their support and the speakers for providing such stimulating and engaging presentations.



Figure 2. Dr Kieran Craven (GSI) discussing the seismo-stratigraphy of the Malin Shelf.



Figure 3. IQUA Symposium 2018 at GSI, Beggars Bush (Photo courtesy of IQUA).

Mark Coughlan
iCRAG (Irish Centre for Research in Applied Geosciences)
O'Brien Centre for Science (East)
University College Dublin
Belfield
Dublin 4
Ireland
mark.coughlan@icrag-centre.org

ABSTRACTS

RECONSTRUCTING AMOC OVER THE PAST 7,000 YEARS: IS THE INDUSTRIAL ERA WEAKENING AN UNPRECEDENTED EVENT?

The Atlantic meridional overturning circulation (AMOC), which is responsible for the redistribution of heat from low to high latitudes in the North Atlantic, is a key component of the Earth's climate system. The AMOC is associated with northwest Atlantic climate, sea ice extent, and ice-sheet balance, global phenomena such as the mean position of the Intertropical Convergence Zone (ITCZ), and it is also a major oceanic carbon sink. Therefore, changes in AMOC strength have a significant impact on global climate and human societies. Recent studies suggest that AMOC has weakened throughout the Industrial Era. What is unclear, since existing reconstructions are limited either in duration or by methodological caveats, is whether the current trend is an unprecedented event or part of natural multidecadal to centennial scale variability. In order to place the recent Industrial Era AMOC weakening in context of the mid-late Holocene (~7,000 years), this study reconstructs AMOC variability using the characteristic sub-surface temperature (T_{sub}) AMOC fingerprint of Zhang (2008), which is based on temperature reconstructions from two relevant sites in the northwest Atlantic. Temperature reconstructions in this study are generated using the relative abundance of the planktic foraminifera *Neogloboquadrina pachyderma*, which is an established paleoproxy for T_{sub} . Additional proxy reconstructions are also used to confirm that the inferred changes in northwest Atlantic T_{sub} are indicative of AMOC. Results indicate that the recent Industrial Era AMOC weakening is unprecedented in the context of the mid-late Holocene, and it is

hypothesized that a reduction in North Atlantic Deep Water (NADW) formation due to an increase in freshwater flux into the Labrador and Nordic seas from melting Arctic sea-ice and ice-caps is the most likely cause.

Jack Wharton
UCL Department of Geography
University College London
Gower Street
London
WC1E 6BT

QRA UNDERGRADUATE DISSERTATION PRIZE 2018

We are pleased to announce that the winner of the 2018 QRA Dissertation Prize is **Jack Wharton** from University College London, for his thesis “*Reconstructing AMOC over the past 7,000 years: Is the Industrial Era weakening an unprecedented event?*”

The judges were deeply impressed by the clarity of the research objectives, the initiative displayed in micropalaeontological data collection, rigorous analysis and interpretation, and the quality of written and graphical presentation. Jack can be justifiably proud of this outstanding piece of undergraduate research. The dissertation as a whole was near to flawless in its construction and presentation, and demonstrated considerable originality in its insightful discussion. This led to clearly-stated conclusions which should be of interest to scientists working in other disciplines beyond palaeoceanography.

The judges wish to highly commend two other students who conducted substantial field and laboratory based studies. Tamara Brian (University of Cambridge) produced a meticulous and beautifully presented dendrochronological study of the Lötschental valley in Switzerland. Annabel Everard (University of St Andrews) conducted a fine palaeoecological study of evidence of changing burning and grazing regimes preserved in blanket bogs in the eastern Scottish Highlands. These two dissertations were close behind.

Judges:

Martin Kirkbride
Geography and Environmental Sciences
University of Dundee
Nethergate
Dundee
Scotland, UK
DD1 4HN
[**m.p.kirkbride@dundee.ac.uk**](mailto:m.p.kirkbride@dundee.ac.uk)

Will Fletcher
Department of Geography
University of Manchester
Arthur Lewis Building
Oxford Road
Manchester
M13 9PL
[**will.fletcher@manchester.ac.uk**](mailto:will.fletcher@manchester.ac.uk)

QUATERNARY RESEARCH ASSOCIATION

The Quaternary Research Association is an organisation comprising archaeologists, botanists, civil engineers, geographers, geologists, soil scientists, zoologists and others interested in research into the problems of the Quaternary. The majority of members reside in Great Britain, but membership also extends to most European countries, North America, Africa, Asia and Australasia. Membership (currently c. 1,200) 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.

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

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

President: *Professor Neil F. Glasser*, Professor Neil F. Glasser
Institute of Geography, Aberystwyth University, Aberystwyth, SY23
3DB, Wales (email: president@qra.org.uk)

Vice-President: *Professor Jane Hart, Department of Geography and*
Environmental Science, University of Southampton, University
Road, Southampton, SO17 1BJ.
(email: vice_president@qra.org.uk)

Secretary: *Dr Helen Roe*, School of Natural and Built Environment, Queen's
University Belfast, University Road, Belfast, BT7 1NN, Northern
Ireland. (e-mail: secretary@qra.org.uk)

Publications Secretary:
Dr Katherine Selby, Environment Department, Wentworth Way,
University of York, Heslington, York, YO10 5NG
(email: publications@qra.org.uk)

Treasurer: *Dr T. White*, 59 Beechwood Avenue, Melbourn, Cambridgeshire,
SG8 6BW.
(e-mail: tsw29@cam.ac.uk)

Editor, Quaternary Newsletter:
Dr Abi Stone, Geography, School of Environment, Education
and Development, The University of Manchester, Oxford Road,
Manchester, M13 9PL. (e-mail: newsletter@qra.org.uk)

Editor, Journal of Quaternary Science:
Professor Geoff Duller, Institute of Geography and Earth Sciences,
Aberystwyth University, Aberystwyth SW23 3DB (e-mail: editor@
qra.org.uk)

Publicity Officer: *Dr T. Roland*, Department of Geography, University of Exeter,
Amory Building, Rennes Drive, Exeter, EX4 4RJ.
(e-mail: publicity@qra.org.uk)

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

The QRA home age on the world wide web can be found at: <http://www.qra.org.uk>

1 SPOTLIGHT ON A SITE

1 West Runton to Sheringham, coastal cliff sections, North Norfolk, England

3 OBITUARY

3 Chalmers Moyes Clapperton *Neil Glasser and David Sugden*

5 ARTICLE

5 Erratum “Evidence for extensive ice cover on the Isles of Scilly” (Brian John (2018) QN 146, 3-27)

6 Comment on “Evidence for extensive ice cover on the Isles of Scilly” by Brian John. *James Scourse*

10 Reply to Scourse “Comment on ‘Evidence for extensive ice cover on the Isles of Scilly’ by Brian John.” *Brian John*

13 Re-investigation of the Hippo site, East Mersia, Essex. *Hannah Wynton, Steve Boreham*

23 JAMES CROLL AWARD - The James Croll Medal – Ann Wintle

26 LEWIS PENNY AWARD - The Lewis Penny Medal – Clare Boston

28 HONORARY MEMBERS

28 Honorary Members Awarded at the 2019 AGM.

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30 Tephra transformations: what factors influence tephra layer preservation. *Nick Culter*

33 Dung fungi as a peatland grazing indicator. *Althea Davies*

39 Palaeogeographic and chronostratigraphic reconstruction of the early human presence in Italy. *Maurizio Gatta, Vabrizio Marra*

42 Investigating the sedimentary architecture of the Brompton Kame Belt using ground-penetrating radar (GPR) *Harold Lovell, Clare Boston, Stephen Livingstone*

45 Understanding the genesis of a small alpine drumlin, Hornkees, Austria. *Sven Lukas*

49 Tracing the driver of the 8.2 ka climate event: far-field investigations from the Falkland Islands. *Graham Rush, Roland Gehrels, Mark Bateman*

53 Establishing a refined deglacial chronology for the Cairngorm Mountains using Schmidt hammer exposure age dating. *Toby Tonkin*

57 NEW RESEARCH WORKERS AWARD

57 Developing an annually resolved chronology of Patagonian Ice Sheet deglaciations using varved lake sediments. *Jacob Bendle*

62 Holocene palaeotempestology and environmental change in the Gulf Coast of the U.S.A. *Emma Readitt*

65 REPORTS

65 Fourth sea-level and coastal change meeting – SLACC 2018, 3rd – 7th September, 2018, Fort William, Scotland.

70 Phil Gibbard Retirement Symposium, 10th September 2018, Department of Zoology, University of Cambridge.

76 IQUA Symposium 2018: Ireland’s Offshore Quaternary Records. 23rd November, 2018. Geological Survey Ireland, Dublin.

79 QRA UNDERGRADUATE DISSERTATION PRIZE

79 Reconstructing AMOC over the past 7,000 years: is the Industrial Era weakening an unprecedented event? *Jack Wharton*