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Instructions to authors

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

Suggested word limits are as follows: obituaries (2000 words); articles (3000 words); reports on meetings (2000 words); reports on QRA grants (500 words); reviews (1000 words); letters to the Editor (500 words); abstracts (500 words). Authors submitting work as Word documents that include figures must send separate copies of the figures in .eps or .jpg format. In case of the latter, a 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.

New: Detailed guidelines on the formatting of contributions are now available via the QRA webpage and from the editor, including an EndNote style file to help with the formatting of bibliographies for submissions to *QN*

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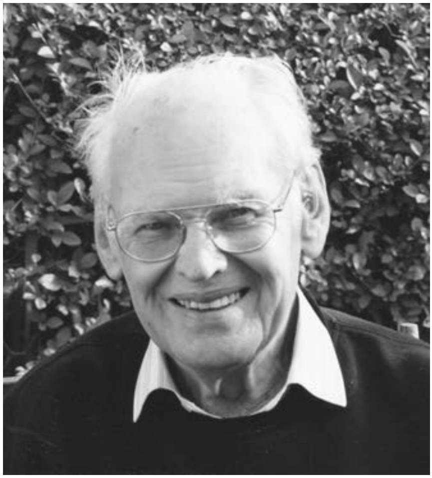
COVER PHOTOGRAPH
Moraine ridges and mounds in Winter Hope valley, Tweedsmuir Hills (photograph: Benedict Reinardy; see report on GLWG Meeting by Linch in this issue).

OBITUARIES

RICHARD HUGH 'CHUFF' JOHNSON (1926 -2012)



During my final undergraduate year at Keele 1961-62 the resident geomorphologist had a sabbatical year and as a consequence Chuff came down from Manchester each week to take the advanced geomorphology option. Although we spent a lot of time discussing British erosion surfaces, it was obvious to the class that we were being taught by an enthusiastic real practitioner of the subject, furthermore one who was actively publishing and supervising research students. He suggested to me that I might undertake a higher degree but I was not over confident about this and had plans to work for British Railways. Accordingly he invited me over to Manchester one day to privately meet David Hopley who was doing raised shoreline research. I have always been grateful for his understanding at that time and his insight into the needs of a student who might potentially be moving to another university. The rest is history and I subsequently joined David as a graduate student of Chuff's at Manchester.

Chuff was born in Newbury, Berkshire, and reputedly when very young and playing in the garden he used to like simulating steam locomotive sounds and the name stuck. Surprisingly to most, he was not a railway enthusiast! After having attended the local state grammar school St Bartholomew's, he did his national service in the Army, serving in India and Burma. He then read for a degree in geography at the University of Reading. There he was a member of Wantage Hall and the university rugby team; an associate recalls his aptitude for high jinks especially on field classes. An Austin Miller was the professor and he was an active denudational chronologist, as were most academic geomorphologists in Britain at that time. Chuff graduated in 1951 and moved to Sheffield as a junior demonstrator and commenced work on his MA under the guidance of David Linton. Unsurprisingly, the combined influences of Linton and Miller led him to a thesis topic related to denudation chronology in part of the Peak District (Johnson 1954). His subsequent PhD (Johnson 1966) was partly related to the same theme but also embraced glaciation, reflecting his increasing interest in Quaternary climatic change.

In 1954 he was appointed an assistant lecturer in the School of Geography in the University of Manchester and subsequently was promoted to lecturer and senior lecturer. His entire lecturing career was at Manchester and he chose the Manchester region as his field research area and only rarely ventured outside it. Inevitably, he worked on aspects of the glaciation of the southwest Pennine margin, river development and slope instabilities. He was keen to promote applied geomorphology and was always happy to collaborate in his research with specialists from allied disciplines. In the early 1980s, when universities were being severely squeezed by the Thatcher government, an attractive national early retirement scheme was on offer. Chuff realised that, by retiring, he would enable a younger geomorphologist a career opportunity, so in 1983 he took the hard decision to retire at the early age of 55. Freed from an increasingly underfunded university system he continued with his research interests from his home in Marple Bridge in the Pennines. He was able to make a major contribution to the Department of the Environment's national landslide study. In the mid 1990s he was invited to contribute his glacial landform expertise to the multidisciplinary Alderley Edge Landscape Project, a joint venture of the Manchester Museum and the National Trust. The resultant volume, including Chuff's work, is in press. His last geomorphological initiative was to support the 2008 Mellor (southeast greater Stockport area) Project , a venture with a similar objective to the one on Alderley Edge. Significantly his account of the physical landscape showed that Chuff was at ease with a wholly web-based publication. Indeed he spent much of his final years scanning-in his large slide collection.

Just after Chuff retired, we were looking for a replacement external examiner for physical geography at the University of Nottingham. Chuff was suggested as a candidate and to be frank the idea was not warmly received at first, since a professorial figure was expected by some. Nevertheless, in the event he was appointed and proved to be an excellent choice with the doubters were won over by the breadth of his knowledge, his diligence, industry, tact and humanity. He acted as external examiner for a number of universities where candidates had chosen topics related to the broad field of north of England Quaternary geomorphology.

Undoubtedly the highlight of his career came as a result of the decision by the British Geomorphological Research Group to base the 'First International Conference on Geomorphology' in Manchester in 1985, an event which attracted 675 delegates from 51 countries. The chief conference organiser was Professor Ian Douglas of the Manchester School of Geography. A decision was made to give all the delegates a book detailing the geomorphology of the northwest. In the selection of an editor for the proposed volume there was no contest since all recognised that Chuff was the regional expert. As editor he selected 18 workers to contribute to the book, half of whom were current or past members of the University. The resultant volume was judged to be a huge success and even now almost 30 years on it has not been superseded. Last May, the School of Geography celebrated its 120th anniversary and, although wheelchair-bound, with the help of his devoted wife Margaret, Chuff was able to attend and reflect with pride on his 30 years of service to the students of the university.

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R.J. (ROB) PRICE

On November 29th 2012 the Quaternary community was saddened to hear of the passing of Rob Price, one of the most influential of British glacial geomorphologists. Glacial researchers of my generation will be very familiar with Rob's seminal textbook "Glacial and Fluvioglacial Landforms" published in 1973, through which we were inspired by the process-form approach to glacial depositional environments, delivered through numerous case studies in modern glaciated catchments. It was this modern analogue approach that set Rob's work out as contemporary and agenda-driving, but his rigorous contributions to our science have tended to quietly inform rather than strongly manipulate the progress of glacial geomorphology. For this reason I have always had the impression that his work was under-rated relative to its many merits. For me, so important is Rob's work that every year I instruct my glacial geomorphology students to read Price (1969) – "if you read nothing else on this course, you must read Price (1969)". It is this paper that encapsulates everything that is valuable about Rob's work. It provides process-form linkages for a variety of landforms on the Breiðamerkurjökull foreland in Iceland based on mapping of aerial photograph series and yearly ground surveys, and thus forms the first example of a modern glacial landsystems analogue.

Figure 1: The participants of the Quaternary Field Study Group (latterly QRA) at the Breida Hut during the 1968 field meeting. Back row standing on benches, from left to right: L. Penny, W. Thorns, R.J. Rice, R. Johnson, A. Orchard, E. Brooks, E.H. Brown. Middle row from left to right: K. Clayton, M. Hodgson, G.F. Mitchell, R.J. Price, (seated), D. Mottershead, P. Howarth, P. Triccas and G. Saunders (standing). Front row from left to right: C. Embleton, E.A. Francis, J.G. Smart, J.D. Peacock, J. Thornes.

Rob was awarded his PhD from Edinburgh University in 1961. He was appointed as the first glacial geomorphologist in the Department of Geography at the University of Glasgow in 1963, after appointments as Assistant Professor at the University of Oklahoma (1961–2) and the University of Oregon (1962–63). He developed an early understanding of the processes and forms at modern glacier snouts when R.P. Goldthwait appointed him as Research Director for the Ohio State Institute of Polar Studies 1962 field season in Glacier Bay, Alaska. Rob's work focused on charting the changes in proglacial landforms, specifically on the foreland of the Casement Glacier (Price, 1964, 1965, 1966), and formed the foundation for his Icelandic research once at Glasgow. Glacial geomorphological research in Britain was approaching the cusp of a very productive period at that time but was not renowned for its modern analogue studies, an area of expertise that Rob was to pioneer with the help of his new topographic survey colleagues at Glasgow (see Evans 2009 for a review). This new alliance of professional surveyors and a glacial geomorphologist with a penchant for plane tabling on active glacier forelands, culminated in the Breiðamerkurjökull Project 1964-67 (Price 1968) and the production of the Breiðamerkurjökull maps based on existing (1945) and newly acquired (1965), ground survey-controlled aerial photographs (Howarth and Welch 1969a, b). The map series and ground survey control network set up by this project are in invaluable legacy for us, forming the foundation of an ongoing long term monitoring project of glacial landscape development. Rob also used the project as a catalyst for quantification of landform change (Price, 1980, 1982) and intensive study of glacial landforms in their pristine state (Price, 1970); and of course the seminal Price (1969)!

Stemming from the Icelandic survey work, Rob took on a further challenge in 1968 when he organized the first QRA overseas field meeting based at the Breiðamerkurjökull hut, an event attended by a host of eminent geomorphologists and Quaternary scientists (Fig. 1). The typed and ring-bound field guide for this meeting epitomizes Rob's attention to detail, from the expedition style meal menus to the rigorous documentation of the scientific content. Rob's commitments to the QRA were rewarded in 1993 when the association bestowed upon him an honorary membership.

Although Rob continued to chart glacier change at Breiðamerkurjökull (Price 1982), he entered into collaboration with Quaternary scientists Graham Jardine in the Geology Department and Jim Dickson in the Botany Department at Glasgow with the aim of reconstructing the glacial history of the Scottish landscape. This led ultimately to Rob's second textbook in 1983, entitled "Scotland's Environment During the Last 30,000 Years". During his career at Glasgow, Rob was a great upholder of traditional values as far as curriculum content and academic and educational standards were concerned and he was utterly devoted to the Department of Geography, to his colleagues, and to postgraduate and undergraduate students alike. His colleagues regarded him as extremely loyal and very generous. Upon his retirement in 1990, I was appointed as Rob's replacement and recall being somewhat nervous at having to attempt to fill some very big shoes! I need not have worried, as Rob occasionally dropped by my office to offer supportive advice and to chat about developments in the glacial research arena, and was always apologetic about taking up too much of my time – but for me it was fascinating to hear stories about Breiðamerkurjökull, especially as we moved towards the final compilation of the 1998 map in a style that matched the 1945 and 1965 versions produced by Rob and his contemporaries. As I presented him with the fruits of our progress I always detected a smile of recollection on his face that communicated to me that he would do it all over again if he could.

Rob's other passions were golf (he was a former captain of his local Kirkintilloch Golf Club) and sailing his own yacht on the west coast of Scotland. His passion for golf led to the publication of his third and very different textbook in 1989, entitled "Scotland's Golf Courses". This book was indeed a mix of academic and leisure activities for Rob, as anyone can appreciate when leafing through chapters on the locations of golf courses with relation to glacifluvial landforms. He also acted as a technical advisor on golf course design. Rob is survived by his wife Mary, a son and a daughter to whom he was absolutely devoted.

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ARTICLES

DARTMOOR GLACIATION – FACT OR FICTION? – A COMMENT ON ALLAN STRAW'S ARTICLE

David J. A. Evans, Stephan Harrison, Andreas Vieli and Ed Anderson

Reasoned and objective critical assessment of one's work should always be welcomed, especially when provided by fellow researchers with significant local knowledge pertaining to the area of study. Even the input of a "devil's advocate" ensures that we can be confident that all the potential pitfalls have been negotiated. There is however a very fine line between a devil's advocate and a hypothesis guardian angel! In his QN 129 article, "Dartmoor glaciation – fact or fiction?", Allan Straw (2013) has effectively embarked upon a crusade to defend the Dartmoor landscape against those (Evans *et al.*, 2012) who have the temerity to propose that it may once have hosted glacier ice. It is surprising that Straw did not submit this objection to our work to the journal in which our paper (Evans *et al.*, 2012) appeared, as this would have been a more conventional approach to initiating scientific debate. This is not an insignificant point, because the broader implications of our work relate to a concept of global importance, specifically the extent of glaciations in ice sheet marginal upland terrains.

For those who know very little about the Dartmoor landscape, the details of Straw's arguments will be difficult to reconcile with the content of our paper. We therefore provide responses to Straw's eight points below using some localized detail but more appropriately some wider conceptual issues relevant to palaeoglaciological reconstruction and appropriate scientific methodologies.

1. This opens with a review of the geology and structural control of the Dartmoor landscape, with which we have no dispute and indeed we acknowledge in our paper. We are then provided with a list of local landform characteristics and potential process-form relationships specifically centred on periglacial environments, which again we have no problem in acknowledging as periglacial processes have indeed been predominant over at least much of the late Quaternary. However, we are then asked "What criteria reveal that some of them might be moraines?" (Straw, 2013: 47), which is an impossible question to answer considering that Straw has provided no locational information. All we can do here is direct the reader to our paper and the details contained therein, where we identify specific landforms as having characteristics that can be interpreted as glacial in origin using the Occam's Razor principle of the least assumptions (i.e. a glacial origin is the simplest explanation). Contrary to Straw's charge that

we have used "generic terms" (we presume he means "genetic"?) for "features with no or minimal presentation of field evidence" (Straw, 2013: 46), we have presented copious detail, through description and illustration, of features that are anomalous in the periglacial/slope failure hypothesis.

2. The bedrock channels and potential esker ridge below Quinton's Man are described by Straw as indenting the frontal edge of a regolith sheet lying along the foot of the slope. This is simply inaccurate, as the channels cut down through bedrock and not a regolith sheet, and the ridge (esker), which Straw ignores after introducing it at the start of his paragraph, drapes the bedrock slope and extends onto the valley floor. We also do not understand what his phrase "a one-off inferred event" (Straw, 2013: 47) relates to. Our further questions to Straw would be: 1) how would sapping produce inset, arcuate bedrock channels located in an en echelon pattern on a valley side bluff, and if these are an example of sapping as a more widespread process across the moor where are the numerous other examples? 2) what is the origin of the sinuous bouldery ridge? We propose that it is an esker and we test that hypothesis by running detailed numerical glacier modelling to see if an icefield developing over this terrain would produce flow units that would feed meltwater to a suture zone during deglaciation. Although Straw clearly finds this conceptual model of supraglacial drainage evolution implausible, we feel obliged to be guided by the modern literature on this subject; but our "esker" is not "fact" and therefore we are willing to entertain alternative interpretations if they are made available.

3. In referring to our "boulder hummocks", Straw implies that we have provided no evidence of a glacial origin and that what we are describing are erosional residuals of regolith that become high points between anastomosing streams during periods of heavy rainfall. This description reveals clearly that Straw is not referring to our boulder hummocks, which have local relief of ≤ 10 m, are organized in broad arcs on valley floors, and link to linear drift ridges that ascend the valley slopes at low angles. Periglacial features such as icings and laccoliths are indeed entirely feasible in this landscape during glacial stages, but the density, size and pattern of our boulder hummocks and their association with valley-side linear drift ridges (most simply explained as lateral moraines) cannot be explained by such periglacial processes. Moreover, it is difficult to explain isolated boulders on the crests and shear structures in the internal sediments of hummocks in the centre of the valley floors by anything other than glaciation. It is therefore the simplest interpretation of the evidence but nonetheless it is an hypothesis and like all hypotheses needs testing, not dismissal based upon pre-determined interpretations of landscape evolution.

4. In this paragraph Straw again questions the details we have provided for glacial landforms. We have provided simple descriptions and clearly annotated photographs of all landforms followed by our preferred interpretations.

The latter are based as much on landform assemblages as on the individual landforms themselves, following the landsystems concept that we have been involved in developing over the last twenty years. Answers to Straw's specific questions are as follows: 1) lateral and frontal moraines are distinguished by their characteristics as discrete, relatively high relief depositional features that can be traced on aerial photographs to demarcate lobate, valley-parallel assemblages in valley bottoms; 2) a roche moutonnée is a partially streamlined bedrock outcrop with a plucked lee face, and a valley-side tor is a remnant bedrock stack with no evidence of glacial erosion. We have assumed in our paper that the QSR audience would appreciate this distinction and would see that Figure 6 is not a valley-side tor; 3) the "well developed terminal moraine" is not a terrace fragment because it is a constructional ridge with boulders on its surface, although it does contain glacitectonically disturbed fan gravels at its core, indicative of ice-contact fan progradation and overriding; 4) drumlins can be produced in any location where a glacier streamlines subglacial materials. We are not really sure what Straw means by "unpromising slopes" (Straw, 2013: 48); other than being an unfortunate example of animating the inanimate, this description is presumably intended to communicate disbelief in our drumlin interpretation? We acknowledge that the scale of reproduction in QSR is not the best for illustrating these subtle landforms so we have reproduced them here as Figure 1 as an example of our willingness to participate in open debate about these features. Their occurrence certainly surprised us and we offer our subglacial bedform interpretation as a hypothesis that appears to be the most plausible given the occurrence of other glacial landforms in the area. Obviously if one has a pre-determined notion that glaciation has never impacted on Dartmoor then drumlins in isolation would indeed appear bizarre; 5) facets are glacially abraded surfaces and hence are usually associated with striae. Because of the highly granular nature of the Dartmoor granite, striae have low preservation potential but are visible on some clasts nonetheless, as we have illustrated in our paper. Similarly, the weathering of granite clasts tends to produce rounded edges so that the joint planes that form that boundaries of an individual clast would be similarly rounded; a facet is manifest as a single surface that is less rounded at the clast edges compared to the edges of its other surfaces. This clast form characteristic is widely utilized in glacial sedimentology as indicative of subglacial wear.

5. An overdeepened valley does not need to be characterized by reversed thalweg gradients or lakes. Even though we are not dealing with an alpine landscape, the relatively steep U-shaped cross-profiles of some Dartmoor valleys indicate significant incision. We acknowledge that the transition from the granite dome to the metamorphic aureole will result in focussed erosion and we have no doubt that structure has inevitably guided all erosional processes in this landscape but none of this argues against a glacial origin for at least some of

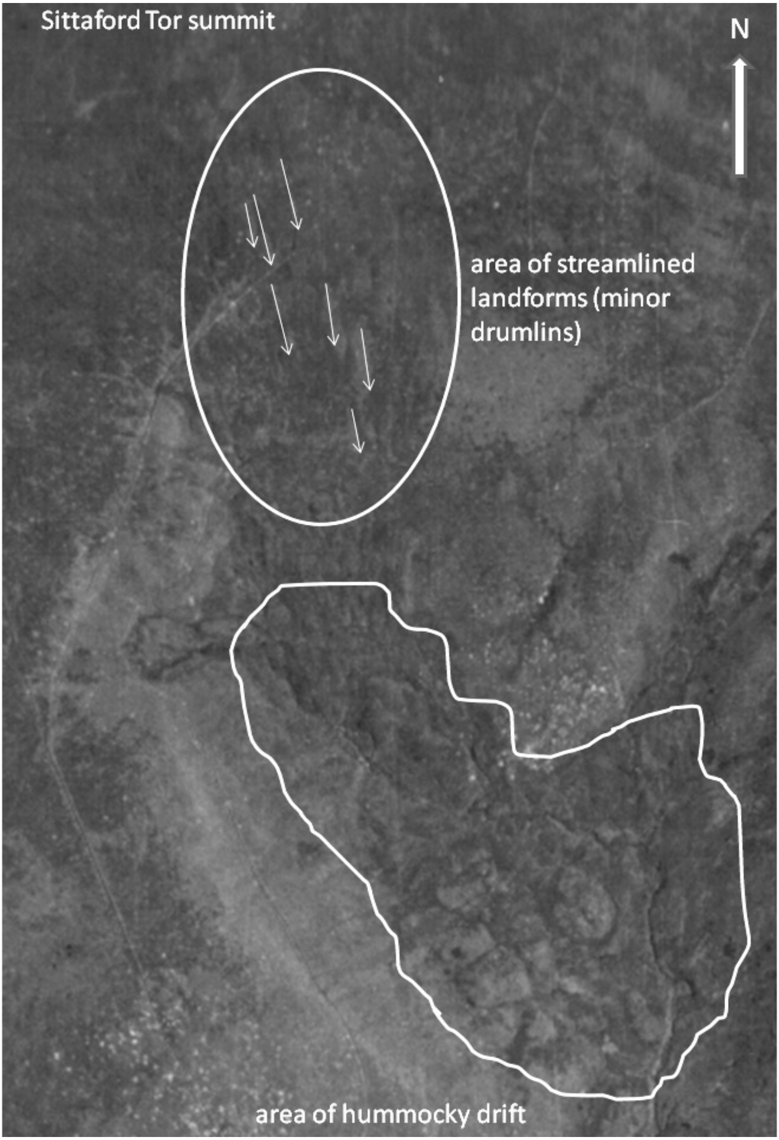

Figure 1: Aerial photograph extract of the southern slopes of Sittaford Tor, showing elongate or streamlined landforms and hummocky drift interpreted as drumlins and hummocky moraine respectively by Evans *et al*. (2012). Arrows identify only some of the streamlined forms.

the erosion. Again we erect this interpretation as a hypothesis to be tested and hence our comment that "evidence for such an extensive glaciation has yet to be identified" (Evans *et al*., 2012: 49). Clearly Straw feels that his preference for no glaciation is sufficient to reject any entertainment of it. He may feel that Dartmoor valleys are "unlikely ever to have been glaciated" (Straw, 2013: 48) but we would prefer to approach this question more scientifically or at least entertain the less emotive approach of a critical rationalist.

6. At the outset here we need to reiterate that one does not need a cirque to form a glacier, as an extensive literature on modern glacier systems clearly demonstrates; we need only to view the Younger Dryas glacial landforms of the Brecon Beacons, located a short distance north of Dartmoor, as good examples of this. Straw implies that we have proposed a glacial erosional origin for the cliff/niche at the Slipper Stones but we have merely identified glacial abrasion of the niche floor and have no particular objection to an original slope failure origin for the initiation of the feature. All we argue is that this was the site of a small glacier following the ice cap glaciation. Also rearing its ugly head in this paragraph is the thorny issue of the "nivation hollow", which is often a term used by those who prefer to deny the existence of glacier ice in a landscape (see Straw's (2002) arguments against a glacial origin for The Punchbowl on Exmoor as an example of this). His lengthy alternative description of the Slipper Stones represents a perfect case study of such denials. Some simple glacier physics when applied to such landform assemblages (cf. Ballantyne and Benn, 1994) clearly indicates that glacier ice must have occupied the location, and any imaginative alternative interpretations of the backwall-parallel depositional ridges as rock slope failures or "nivation"-related forms merely become red-herrings. The outer ridge at the Slipper Stones is located 100 m away from the 50 m-high backwall, making Straw's estimate of a 20 m-thick snow patch with a 20° slope difficult to entertain; simple conservative calculations of snow bed size suggest that the surface slope would have been in the order of 25° and thereby indicative of a surface ice velocity in the region of 7.5 m yr^{-1} using Ballantyne and Benn's (1994) numerical constraints on snowbed/glacier development. Additionally, why is the northeast orientation of the valley side more supportive of a mass movement origin for the Slipper Stones than a glacial origin – surely this is a prime reason for glacier ice development?

7. This section on tor types contains some further mis-representations of our work. First, the conflation of roches moutonnées and valley-side tors is another red herring, as we clearly have not classified any tors as roches moutonnées; our roches moutonnées are abraded bedrock outcrops, not bedrock stacks. Second, we have employed no "special pleading" (Straw, 2013: 50) in the explanation of the Yes Tor upland but have instead related tor development/ protection to the narrow and detached nature of the upland upon which a satellite glacier cover develops in our numerical model but never reaches a

critical thickness to initiate warm-based thermal conditions. This is a case of applying glacier physics to the interpretations of plateau icefield landsystems, an area of research that we have been developing over a number of years based upon extensive work on modern plateau icefields. It is a pity that Straw has not viewed our interpretations in the context of this work (cf. Rea *et al*., 1998; Evans *et al*., 2002; Rea and Evans, 2003, 2007). Third, we are entirely "aware" of the implications of our so called "sweeping statement" (Straw, 2013: 50), the first part of which (tors have never formed on some plateau surfaces) is entirely compatible with Straw's own opinion. Again we need to point out that our assessment of tor development and distribution takes into account previous work on this subject and above all is a hypothesis that requires testing; indeed since the publication of our paper, Gunnell *et al*. (2012) have demonstrated that the tors are in fact very recent features and therefore may have no significant implications for long term landscape evolution.

8. Here, Straw discusses The Punchbowl on Exmoor, described by Harrison *et al*. (1998, 2001) as a glacial cirque and the likely site of a small plateau icefield. Straw (2013: 50) argues that the Punchbowl

"is a fine example of a nivation hollow that took advantage of particular geological conditions and may have just reached a size and form to support a cirque glacier in the next cold phase, the so-called tills are within the range of Exmoor periglacial deposits, and an ice cap on Winsford Hill is pure speculation for which no evidence was presented".

A number of points need to be made in response. First, it is pleasing to see that Straw now supports the original interpretation of The Punchbowl as having been the site of a small glacier. Indeed in the 15 years since publication of the original paper no alternative hypothesis has been published. Second, Straw is wrong to say that the tills are similar to Exmoor periglacial deposits and Harrison *et al*. (1998, 2001) demonstrate this. The final point about the small Exmoor ice cap was not based upon "pure speculation". It was based upon a detailed assessment of sediments at the site and the likely subglacial shear stresses that could be generated by an ice mass confined to The Punchbowl, compared with those generated by a more significant ice mass. Given that Straw now appears to accept the former presence of glacier ice on Exmoor, at least down to around 300 m asl, it is intriguing that he cannot entertain the idea of glacier ice on the much higher plateau surfaces of Dartmoor, even though the concept of plateau icefield generation as originally demonstrated by Manley (1955, 1959) has been verified by modern analogues (Rea and Evans, 2003, 2007) and successfully applied and numerically tested in the British uplands (cf. Rea *et al*., 1998; McDougall, 2001; Golledge, 2007; Golledge *et al*., 2008; Lukas and Bradwell, 2010; Brown *et al*., 2011).

Point 8 communicates Straw's wider ulterior motive to question any evidence for, and reject any interpretation of, glaciation in upland settings beyond the British-Irish Ice Sheet. The inherent flaw in his argument lies in the referral once again to the "nivation hollow", with The Punchbowl on Exmoor being cited as a "fine example" (Straw, 2013: 50). The concept of a nivation hollow is fundamentally flawed for the simple reason that any feature comparable in size to The Punchbowl or the Slipper Stones backwall will contain enough snow to constitute a glacier – this is simply a case of applying Glen's flow law, as demonstrated by Ballantyne and Benn (1994). Any numerical modelling exercise, such as that reported in our paper for Dartmoor, is bound by such laws of glacier physics. Confidence in the accuracy of such numerical modelling exercises stems from applications to modern glaciers, and more appropriately in terms of this region, plateau icefield systems (Rea and Evans, 2007).

Straw's final comments regarding the possibility of our glacial landforms being mis-identified human landscape legacies are a fine example of the type of unqualified and unquantified generalizations that he accuses us of perpetrating. Where are these human legacies, what are their characteristics, and to what extent can they be regarded as similar in appearance to glacial features? Moreover, if they are so significant in this landscape could they not also be potentially mis-interpreted as periglacial or mass movement features, especially as Straw is convinced that the glacial features are indeed periglacial or slope related? On this matter, we are disappointed that Straw assumes we have not investigated the potential for human landscape disturbance, especially as we clearly refer to mining activity in the opening sections of our paper.

The very title of Straw's article signposts precisely the trajectory of his scientific methodology; it would appear that published research in his eyes can be categorized as either fact or fiction, not a hypothesis that needs to be tested. Throughout his article Straw maintains this very subjective approach, repeatedly charging us with scientific malpractice merely because we have entertained the notion of a Dartmoor glaciation, which, regardless of any evidence presented, he apparently rejects as an absurd notion due to the "fact" that Dartmoor is a periglacial landscape. It appears from this line of argument that British geomorphologists got the answer correct in the 1960s - in fact they got it so correct that it is beyond hypothesis testing. The view put forward in our paper that an extensive upland area in the British Isles was formerly glaciated seems to us to be entirely uncontroversial, and would have been so to a number of nineteenth and early twentieth century geologists, but appears to be beyond even cursory entertainment for Straw. It is only the rather narrow thinking of a number of scientists from the 1940s up to the present day that has perpetuated the uncritical idea that Dartmoor's landscape can only be described in purely periglacial terms. This failure to test alternative hypotheses is profoundly unscientific and needs to be challenged. Straw's final paragraph clearly demonstrates this subjective nature of his critical reasoning when addressing the potential for glaciation of the uplands of southwest England. Particularly enlightening in this respect is his statement “that individual slope and valley features really should, in the first instance be shown not to be the product of periglacial processes or of the influences of bedrock structure and composition before claiming a glacial cause” (Straw, 2013: 51) - this should be committed to the memory of all earth science students as a clear example of flagrant abuse of the well-founded scientific principle of adopting multiple working hypotheses.

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DARTMOOR GLACIATION – RESPONSE TO COMMENTS BY DAVID EVANS *ET AL.*

Allan Straw

The response by Evans *et al*. (2013) to my article in Quaternary Newsletter No.129 seeks, obviously, to justify their stance but questions remain, and misleading statements call for further comment.

Nowhere in my article (Straw, 2013) have I claimed that Dartmoor was never glaciated. My scepticism pertains to the veracity of the evidence that Evans *et al*. have collected, and my criticism to the way it was presented. There was no ulterior motive, no crusade; merely a reaction to a paper that unwisely adopted 'a priori' reasoning whereby generic terms were applied to landforms (i.e. as a class of glaciogenetic features) almost from the outset, before presentation of field evidence or any discussion of alternative origins. In spite of the tenor of both their paper (Evans *et al*., 2012) and their comment, I do not regard myself as either devil's advocate or hypothesis guardian angel. My concern was that an inductive approach, describing the various landforms in detail and discussing thoroughly alternative origins before claiming a glacial origin, would have been preferable.

Turning to specifics, the question about moraines sought further information, such as description of those features which distinguish the moraines identified on their map (Evans *et al*., 2012: Figure 4) from the variety of ridges produced in non-glacial ways. It is not sufficient to retreat behind Occam's Razor principle of least assumptions, when glaciation implies circumstances different from and in some respects more extreme than periglaciation.

Evans *et al*. claim not to understand my phrase 'one-off situation' with regard to the 'esker'. It is however the only one claimed on the Moor but, with no description of dimensions, gradient or materials, it was accounted for by a set of inferred glacial conditions. The landform lies on steepish slopes below a higher bluff, not along the valley floor, is flanked by spring-fed gullies, and may have been sapped by water emerging from its constituent materials, probably older head. My comments on hummocky ground have elicited some further description; the authors refer to relief of the order of 10 m, and to hummocks with particular dispositions and internal structures, but still do not demonstrate why they must be considered glacial. Large boulders for example frequently were rafted on or near the surfaces of mobile head sheets.

With reference to Figure 6 in Evans *et al*. (2012) readers will be hard-pressed to recognize a glacial imprint on the granite outcrop claimed to be a roche moutonée, and on Figure 7, if lee-side plucking of the granite on the back-slope of the Slipper Stones is evident, ice should have been moving uphill, an impossible circumstance which clearly militates against the slope being glacially abraded at all. Map references and orientations would have enhanced these and other photograph figures. Drumlins too are streamlined forms, and when highly elongate require fast-moving ice. In terms of distance of ice travel and availability of malleable material alone, the slopes below Sittaford Tor remain unpromising but, much more significantly, it should be noted that the 'drumlin field' lies in and above the headward part of a short, broadish valley which has extended north-north-west from the East Dart valley along a structural line that also influences the steeper eastern slopes of Quinton's Man ridge. Exploitation of a zone of closely-spaced joints along this line, etched by surface drainage into a pattern of sub-parallel runnels and slight ridges, adequately accounts for these features. The statement on clast morphology is interesting, but unconvincing, because facets are not exclusively glacial.

It is difficult to accept that 'over-deepened' does not mean what it describes, and it is surprising that experienced researchers, claiming to approach the question more scientifically, can refer to valleys as documenting the passage of glacier ice and then, in the very same sentence, admit that no evidence for an extensive glaciation has yet been found.

For the Slipper Stones, only the niche floor (i.e. the backslope of c. 25°) was regarded by the authors as suffering glacial abrasion, and they seem to accept that an element of slope failure in formation of the hollow is feasible. The question remains, what processes brought the niche to dimensions sufficient to nurture the postulated niche glacier 'following the ice cap glaciation'? Over a period of time debris would have had to have been transported downslope from the recess until its contained snow/ice mass reached a critical size and, in accordance with the laws of glacial physics, began to move. I prefer to regard such a formative phase as one characterized mainly by the operation of nivation processes.

There is clearly a difference of opinion regarding identification of valley-side tors and roches moutonées. Valley-side tors must apparently be bedrock stacks, whereas I confess to having applied the term loosely to any isolated bedrock outcrop below the summits. The bedrock outcrop in Figure 6 (Evans *et al.*, 2012) still looks remarkably free of glacial modification.

Although they state otherwise, the authors have again missed the point concerning my observation that they seem unaware of the implications of sweeping statements. In my example I should have italicized '*or have been removed by repeated glaciation during the Quaternary*'. Regardless of the age of the extant tors, the authors seem unaware that they are implying that Dartmoor has been glaciated on numerous occasions before the Devensian, and that, to my mind, raises a number of issues, for example environmental and climatic conditions during earlier glaciations; dating deposits and extents of any ice-caps; their effects on valley form and adjustment to structures; sea-level positions (affecting regional relative relief) and valley terraces. None of these were, of course, addressed in the original paper, so why make the statement?

Regarding the Exmoor Punchbowl I do not see how my view, as clearly set out by Evans *et al*. in the passage quoted from my article that the Punchbowl *might be occupied* by a cirque glacier *in the next cold phase,* reveals that I support the 'original' interpretation of the Punchbowl as *having been* the site of a small glacier. For the record, the original comment on the origin of the Punchbowl was in Straw (1995). The head of the Punchbowl valley has been extended and gradually enlarged along a fault zone for almost a kilometre from the Winn Brook valley to reach its present location and dimensions. Because there is no field evidence for an ice-cap above the hollow, no signs of flow over the rim or for any movement of snow/ice beyond a low bounding ridge within it, I do not believe the Punchbowl to be glacially-eroded. To argue that detailed assessment of the sediment below the Punchbowl confirms the presence of an icefield above it, is not provision of proof.

The authors have confirmed again in their comment their willingness to interpret features as glaciogenetic without providing crucial field evidence to support the hypothesis of glaciation. Periglaciation has had a profound effect on Dartmoor's landscape, and their paper and comment fail to take it sufficiently into account. My article was partly to show that alternative explanations for relevant landforms do exist and should have been carefully examined, not to prove the inviolability of the periglacial model. Periglacial features abound on Dartmoor and Exmoor, glacial features do not, so, if any do exist, there is particular necessity to demonstrate convincingly their non-periglacial character and to work toward a sound empirical model.

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PALAEOENVIRONMENTAL RECONSTRUCTION FROM A DECALCIFIED INTERGLACIAL SEQUENCE IN THE FORMER SOLENT RIVER SYSTEM AT ST LEONARD'S FARM, HAMPSHIRE, ENGLAND

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Abstract

The former Solent river system lacks known interglacial deposits, except for at two sites on the Isle of Wight whose relationship to the terrace sequence is unclear and three sites associated with the lower terraces in the New Forest, between Christchurch and Southampton Water. This paper describes palaeoenvironmental data from a borehole taken from the most centrally placed of these latter, at St Leonard's Farm in Hampshire. This is the first palaeoenvironmental study of this sequence. Fossil preservation was poor, but it showed evidence of deposition during an interglacial, in a freshwater setting with occasional brackish or tidal inputs. The age of these deposits is unclear, but not inconsistent with deposition during the last interglacial, as at Pennington Marshes and Stone Point SSSI. The altitudinal relationships between these three interglacial sequences are complex, as is estuarine deposition at the present day. There seems to be a downstream salinity gradient from west to east recorded in these three sequences.

Introduction

Interglacial deposits are rare in the terrace sequence of the former Solent river system. On the Isle of Wight, occasional exposures on the foreshore at Newtown have yielded fossils, including those of Hippotamus (Reid and Strahan, 1889), and two interglacial sites of different ages occur near Bembridge (Holyoak and Preece, 1983; Preece *et al*., 1990). None of these deposits can be clearly linked to the main Solent river terrace sequence, which is only preserved on the mainland. On the mainland, only three interglacial sequences are known, all from the sequences to the west of Southampton Water (Figure 1) – from Pennington Marshes (Allen *et al*., 1996), St Leonard's Farm (Mathers, 1982) and at Stone Point SSSI (West and Sparks, 1960; Brown *et al*., 1975; Bates *et al.,* 2004, 2007; Briant *et al.,* submitted). This paper reports the results of palaeoenvironmental analyses from a borehole drilled at St Leonard's Farm in Hampshire in April 2005 as part of the English Heritage-funded Palaeolithic

Archaeology of the Sussex / Hampshire Coastal Corridor (PASHCC) project. The site was investigated because it was the only one of the three sequences that had never had palaeoenvironmental investigations undertaken. Given the rarity of interglacial deposits within the Solent sequence, it was hoped that this study would shed further light on the sea level history of the region.

The St Leonard's Farm site also has local stratigraphic significance. The interglacial deposits occur within the Lepe Gravel mapped by Allen and Gibbard (1993). This is the same gravel body that overlies the altitudinally lower Stone Point interglacial deposits further east (Figure 1). In the Allen and Gibbard (1993) scheme, it is stratigraphically higher than the Pennington Gravel within which the Pennington Marshes interglacial deposit is found. The separation of these two gravel deposits seems unlikely since recent re-investigation of the Stone Point deposits suggests that they date from the same period as the Pennington Marshes deposits (Table 1; Briant *et al*., 2006, submitted). This mapping has also been queried by Westaway *et al*. (2006) who propose instead a gravel body with a different distribution called the St Leonards Farm Gravel, whose stratotype was designated as the MAR borehole described below (Table 1). The stratigraphy of these lower terraces was not, however, fully reorganised in the Westaway *et al*. (2006) scheme. The relationship between these three interglacial deposits remains unclear.

Description

The site is located to the west of the Beaulieu River, approximately 4 km south-east of the village of Beaulieu in the New Forest, Hampshire. Interglacial deposits were originally reported from this site in a British Geological Survey (BGS) Mineral Assessment Report (MAR). Borehole 49NW3 at SZ 4074 9783 had a surface elevation of 3.5 m O.D. and comprised 2.4 m of gravel underlain by 0.3 m of bluish-grey clay, 0.3 m of peat, 1.1 m of grey silt, then 0.7 m more of gravel before clay belonging to the Headon Formation was reached at -0.6 m O.D. The borehole reported here was located using a 1:10,000 map and GPS and drilled as close as possible to the grid reference of the borehole reported by Mathers (1982), given the constraint provided by the 8 figure grid reference originally cited.

The sequence encountered during the 2005 drilling (Table 2) lacked the thick layer of overlying gravel reported by Mathers (1982). Instead, c. 0.9 m of silty clay containing angular gravel and with a topsoil developed in it rested directly on top of 2.4 m of silty clay with varying organic content, followed by 0.6 m of fine sand with gravel and 1 m of gravel, reaching bedrock at -1.2 m O.D. (Figure 1, Table 2). The silty clay was sampled for multiple fossil analyses, some of which are reported below. All the samples processed for molluscan and diatom analysis however, were barren.

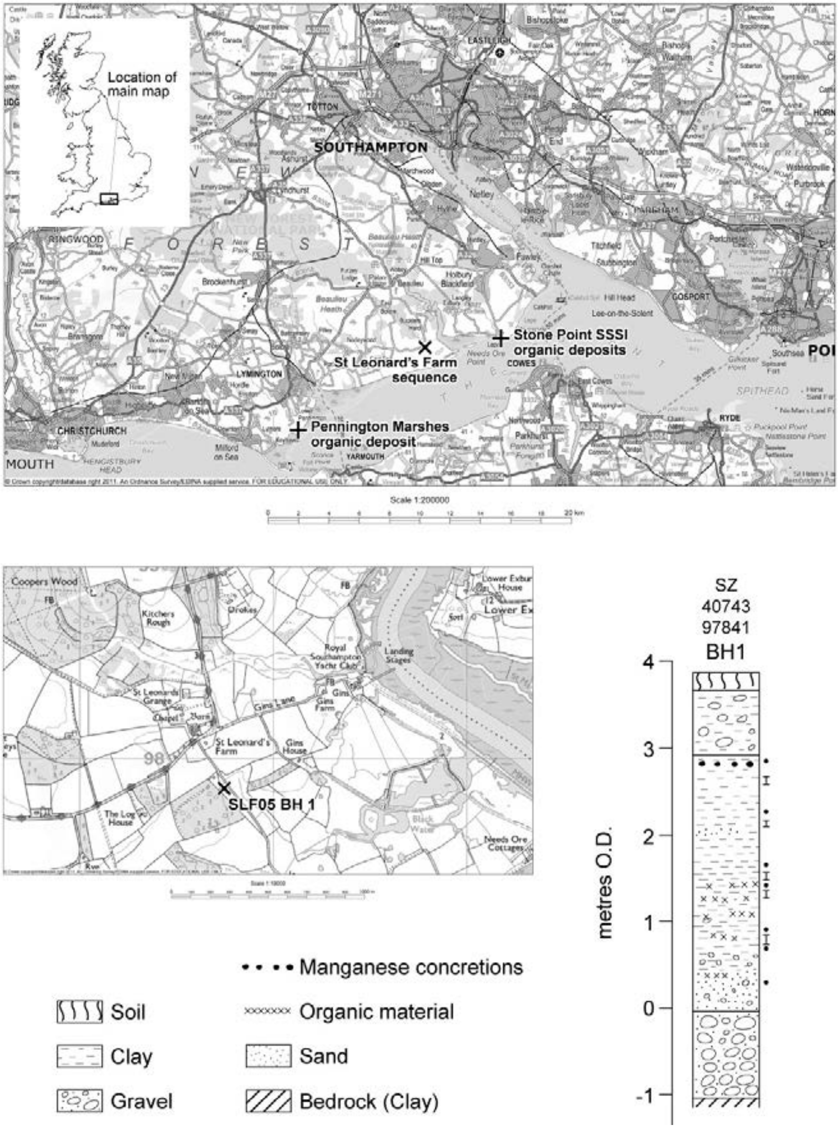

Figure 1. Stratigraphy and location of the St Leonard's Farm borehole in the context of other interglacial sites in the New Forest.

Table 1. Regional stratigraphic context of the three interglacial sequences preserved within the former Solent river system between Christchurch and Southampton Water.

	Pennington Marshes	**St Leonard's Farm**	**Stone Point SSSI**
Name of overlying gravel (Allen and Gibbard, 1993)	Pennington Gravel	Lepe Gravel	Lepe Gravel
Name of overlying gravel (Westaway *et al.*, 2006)	Pennington Gravel	St Leonard's Farm Gravel	Lepe Gravel
Altitudinal range of interglacial deposit	*c*. –3.9 to –5.3 m O.D.	*c*. 0.1 to 1.8 m O.D.	*c*.1 to -8 m O.D.
Salinity suggested by fossils within interglacial deposit	Freshwater (Allen *et al*., 1996)	Freshwater with brackish / tidal elements (see below)	Brackish / marine with freshwater elements (West and Sparks, 1960; Brown *et al*., 1975; Briant *et al*., submitted)
Suggested age of interglacial deposits	Last interglacial / MIS 5e (Allen *et al*., 1996)	Last interglacial / MIS 5e (Westaway *et al*., 2006)	Last interglacial / MIS 5e (West and Sparks, 1960; Brown *et al*., 1975; Briant *et al*., 2006; 2009; submitted) Penultimate interglacial (Allen *et al*., 1996) Not stated (Westaway *et al*., 2006)

Palaeoenvironmental analysis

Pollen analysis

Pollen samples were prepared using the standard hydrofluoric acid technique and counted for pollen using a high-power stereo microscope. Pollen preservation was relatively good, although some samples towards the top of the sequence showed evidence of post-depositional oxidation. Main sums varied between 35 and 422. It should be noted that for statistically reliable data, pollen sums of at least 300 are generally recommended. These counts rarely reach these levels, hence the presentations of the data in a table rather than a diagram. Care must therefore be taken during interpretation.

Table 2. Description of STL05 BH1. Grid reference SZ 40743 97841. Elevation at top of borehole 3.73 m O.D.

	Depths (cm)	Description
10	0-20	Topsoil
11	20-*c*.90	Medium grey massive silty clay with dispersed angular to subangular flint gravel. The gravel is up to 7-8 cm long. Gradational upper and lower contacts
12	*c*.90-140	Very cohesive light grey massive clay. Gradational upper and lower contacts
13	*c*.140-210	Very cohesive grey-blue massive clay with dispersed fine organic material. Gradational upper and lower contacts
14	*c*.210	Grey-blue massive clay containing some sand and fine flint gravel. The gravel is c. 1-4 cm in size. Gradational upper and lower contacts
15	*c*.210-270	Soft dark grey massive organic-rich clay with plant fragments. Gradational upper and lower contacts
16	*c*.270-330	Soft dark grey massive organic-rich silt with fewer plant fragments. Gradational upper contact, sharp lower contact
17	*c*.330-390	Fine sand with fine flint gravel (c. 1-4 cm) and some clay inclusions. Upper and lower contacts both sharp
18	*c*.390-490	Massive flint gravel. Clasts angular to subangular, fine to coarse in size. Medium to coarse sand matrix. Upper and lower contacts both sharp
19	*c*.490 and below	Stiff grey-blue clay of the Headon Formation

Tree pollen percentages are high throughout the sequence (between 38% and 56%), and the species represented – birch (*Betula*), pine (*Pinus*), oak (*Quercus*) and alder (*Alnus*) – all suggest temperate conditions. Also present in smaller percentages are elm (*Ulmus*), hornbeam (*Carpinus*), spruce (*Picea*) and yew (*Taxus*). There appears to be a transition from oak-dominated assemblages near the base of the sequence (233 cm and lower) to birch-pine-alder above 233 cm depth. However, pollen concentration preservation also decreases in the upper part of the sequence, so this transition can only be tentatively identified. Aquatic vegetation appears to be present only in the lower part of the sequence. The traditional interpretation of an interglacial fragment such as this would probably be that it is part of the Ipswichian (Eemian – MIS 5e). However, on the basis of pollen data alone, there is no strong biostratigraphic evidence that this is the case.

Plant macrofossil analysis

Diverse plant macrofossil assemblages were recovered with 30 taxa recorded of which 15 were identified to species level. Waterside and damp ground taxa

Table 3. Pollen recovered from St Leonard's Farm BH 1.

Sample depth	137 cm	161 cm	177 cm	193 cm	233 cm	249 cm	278 cm	296 cm	312 cm
	%	%	%	%	%	%	%	%	%
Tree pollen									
Betula	2.9	17.0	7.2	4.9	0.7	0.3	0.9	0.3	0.0
Pinus	17.1	12.8	15.2	7.8	6.6	3.0	4.5	7.9	11.4
Ulmus	0	2.1	0.0	0.6	0.0	0.7	0.0	0.3	0.0
Quercus	5.7	0.0	6.8	8.4	25.6	34.5	30.3	28.0	44.4
Alnus	25.7	8.5	17.9	20.0	5.0	1.3	0.9	0.7	0.3
Carpinus	0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
Picea	0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0
Taxus	0	4.3	1.5	0.3	0.0	0.0	0.0	0.0	0.0
Total tree	**51.4**	**44.7**	**48.7**	**42.0**	**38.2**	**39.8**	**37.3**	**37.2**	**56.2**
Shrub pollen									
Corylus avellana type	17.1	14.9	10.6	10.7	16.4	22.0	21.5	11.8	11.8
Hedera helix	0	0.0	0.4	0.6	0.0	0.0	0.9	1.0	0.7
Ilex	0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0
Total shrub	**17.1**	**14.9**	**12.2**	**11.3**	**16.4**	**22.0**	**22.4**	**12.8**	**12.5**
Herb Pollen									
Poaceae (Gramineae)	0	4.3	3.8	7.0	1.7	7.2	6.1	5.3	3.7
Cyperaceae	14.3	8.5	16.3	13.6	10.7	14.8	22.4	40.5	25.6
Calluna	0	0.0	1.9	1.2	0.9	0.0	0.0	0.0	0.3
Artemisia type (Asteroideae)	0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Cirsium type (Cardueae)	0	2.1	3.8	4.9	0.0	0.7	2.4	0.3	0.3
Caryophyllaceae	0	2.1	4.6	6.4	1.9	0.7	0.3	2.3	0.3
Potentilla type	0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Rumex	0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
Apiaceae (Umbelliferae) undif.	0	0.0	0.4	0.6	0.2	0.7	0.0	0.0	0.3
Myrica	0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.3
Total herb	**14.3**	**17.0**	**31.2**	**34.2**	**15.4**	**24.0**	**31.2**	**48.7**	**31.0**
Total spores	**17.1**	**23.4**	**8.0**	**12.5**	**30.1**	**14.1**	**9.1**	**1.3**	**0.3**
Total count: land pollen and spores	35	47	263	345	422	304	330	304	297
Slides counted	1	1	2	2	1	1	1	1	1
Total aquatic (as % of TLP + aquatics)	0	0	0.38	0	1.9	11.4	16.9	1.6	2.0

dominate, with aquatic taxa also important. This suggests that at the time of sediment deposition a reedswamp was located at the margins of the waterbody. Taller plants inhabiting the water's edge included colonies of *Scirpus lacustris* along with *Typha* and *Sparganium erectum*. Amongst these taxa were probably found herbs such as *Lycopus europaeus* and *Mentha* cf. *aquatica*. In places gaps may have existed in the reedswamp where muddy areas or short vegetation allowed *Cyperus fuscus* to flourish. These areas may have been produced by the activity of grazing animals or waterfowl.

Although *Najas marina* and *Potamogeton pectinatus* can tolerate brackish conditions, the assemblage as a whole suggests that the waterbody was freshwater. The presence of a Foraminifera test may indicate that the coast was not that distant. Floating aquatic species such as *Hydrocharis morsus-ranae* and *Trapa natans* show that the water was still or slow moving. A number of the aquatic taxa recorded point to nutrient-rich water.

Najas minor is not present in the British flora today (Stace, 1997; Preston and Croft, 1997). Its present distribution is mainland Europe, northwards to Belgium and central Russia (Tutin *et al.,* 1980). Therefore, its occurrence may indicate that when the sediments were being deposited warmer climatic conditions prevailed than are currently experienced in southern England. This conclusion is supported by the presence of *Trapa natans* which today occurs in southern, central and eastern Europe (Hultén and Fries, 1986).

Coleopteran analysis

Samples from levels 300-305 cm, 245-250 cm, 230-235 cm, 170-175 cm and 120-125 cm were analysed for insect remains. Only the lowermost three of these yielded insect fossils. The insect remains were recovered using the standard paraffin (kerosine) flotation technique (Coope, 1986). Most of the fossils were very fragmentary, suggesting that this assemblage may have been brought together as flood debris. Table 4 lists the numbers of coleopteran species in the taxonomic order and according to the nomenclature of Lucht (1997). The numbers opposite each species indicate the minimum numbers of individuals in each sample. Altogether twenty beetle taxa were recognised of which eleven could be named to species. All the taxa can be found living today in the British Isles. Other orders of insect were also present.

Local environment indicated by the Coleoptera

In spite of the likelihood that the species in this fauna were brought together more or less adventitiously, the assemblage presents a consistent picture of an environment that was probably widespread locally. Almost all the beetle species indicate a reedy freshwater fen. This is shown by various phytophagous

Table 4. Plant macrofossils present in (+) samples from St Leonard's Farm BH 1.

Sample depth		**300-305 cm**	**245-250 cm**
Waterside and damp ground taxa			
Alisma sp(p).	fruit	-	+
Cyperus fuscus	nutlet	-	+
Eupatorium cannabinum	achene	+	-
Lycopus europaeus	nutlet	+	+
Lythrum salicaria	seed	-	+
Mentha cf. *aquatica*	nutlet	+	+
Ranunculus scleratus	achene	+	+
Scirpus lacustris	nutlet	-	+
Sparganium erectum	fruitstone	-	+
Typha sp(p).	seed	-	+
Aquatic taxa			
Characeae sp(p).	oospore	+	-
Hydrocharis morsus-ranae	seed	-	+
Najas marina	seed	-	+
Najas minor	seed	-	+
Potamogeton acutifolius	fruit	-	+
Potemogeton pectinatus	fruit	-	+
Potamogeton sp(p).	fruit fragment	-	+
Sagittaria sagittifolia	embryo	-	+
Sparganium subgenus *Xanthosparganium* sp(p).	fruitstone	-	+
Trapa natans	fruit fragment	-	+
Unclassified			
Carex sp(p).	biconvex nutlet and utricle	-	+
	trigonous nutlet	+	+
Chenopodiacese sp(p).	seed fragment	-	+
Compositae sp(p).	achene	+	-
Hypericum sp(p).	seed	-	+
Juncus sp(p).	seed	+	-
Musci sp(p).	leaf	+	-
Rosa/*Rubus* sp(p).	thorn	-	+
Sphagnum sp(p).	leaf	+	-
Urtica dioica	achene	-	+
Viola sp(p).	seed fragment	+	-
Undetermined	bud	+	-

species (Koch, 1992). For example, *Donacia marginata* is monophagous feeding on *Sparganium ramosum*. *Donacia cinerea* is an oligophage preferring to feed on *Typha,* but it will also attack *Phragmites, Sparganium* and *Carex*. *Plateumaris braccata* feeds exclusively on *Phragmites*. *Plateumaris affinis* is an oligophage on many species of *Carex*. The sub-aquatic weevil *Bagous* feeds on a wide variety of pond weeds. The larvae of the Hydrophylidae are voracious predators but the adult beetles feed on decomposing plant remains (Hansen, 1987). *Cercyon sternalis* inhabits the margins of fresh, mainly eutrophic, water where it lives under plant debris. Species of *Anacaena* and *Laccobius* are often found in similar situations. *Hydrous* (*Hydrophilus*) *piceus*, the Great Silver Water-beetle, is one of the largest beetle species in Europe reaching 50mm in length. It is found chiefly in stagnant, rather eutrophic, sunny ponds where the water is clear and the bottom muddy. Its larvae feed predominantly on snails (mainly Lymnaeidae) but the adults feed on a variety of aquatic plants just below the surface, often in rather shallow water (Hansen, 1987). The staphylinid species *Paederus riparius* is a predator living in damp plant detritus, most frequently in heaps of rotting *Phragmites*. Similarly the minute species *Corylophus cassioides* is a predator that lives in wet plant debris particularly amongst decomposing remains of *Phragmites* and *Carex*. *Agabus bipustulatus* is an actively swimming predator found commonly in all sorts of stationary water. The carabid species *Agonum nigrum* is a scavenger living amongst sedges and grasses in marshy places where the soil is soft (Lindroth, 1974).

Two species in this assemblage do not fit the overall picture outlined above. *Pterostichus versicolor* is rather eurytopic but inhabits open country in either moist or dry habitats where it is markedly heliophilous (Lindroth, 1992). The larvae of the weevil *Pissodes* are xylophagous, excavating meandering burrows between the bark and sapwood of various coniferous trees. The adult beetles eat the leaves of similar trees. This species usually attacks trees that have already been debilitated either by disease or by previous insect attack.

In contrast to that from Stone Point (Briant *et al.,* submitted) the fauna provides no evidence of any saline influence in the environment.

Climatic conditions indicated by the Coleoptera

Although this assemblage is small, it indicates that palaeotemperatures were at least as warm as those at the present day in southern Britain. Several species have relatively southern geographical ranges at the present day, being absent from northern Britain and also much of north Fennoscandia. *Agonum nigrum* is a western European species that reaches its most northern limit in the British Isles. *Hydrous piceus* ranges as far north as Yorkshire and only the most southerly localities of Fennoscandia. *Donacia marginata, Donacia cinerea,* *Plateumaris braccata* and *Plateumaris affinis* also have geographical ranges that only reach as far north as southern Scandinavia.

The predominance of the marsh community of beetles in this assemblage indicates that precipitation levels must have also been sufficient to maintain the reed swamp with open water during the summer months, since these species are active only during the warmer half of the year and hibernate during the winters.

Foraminifera

Samples from levels 305-307 cm (110 g), 235-237 cm (125 g), 220-222 cm (130 g), 168-170 cm (130 g) and 125-127 cm (210 g) were analysed for ostracods and foraminifera, by repeated drying, wetting and washing through a 75 μm-sieve with hot water. Because of the high clay and/or organic content of the samples, all had to be processed twice to achieve a total breakdown. Each sample was then dry-sieved into various fractions and the residue sprinkled onto a metal picking tray, a representative number of each species being picked out under a binocular microscope and placed in a 3x1" faunal slide.

Only the lowest sample yielded any remains, and then only of foraminifera (Table 6). This comprised charophyte oogonia (organic linings only) and collapsed agglutinating foraminiferal tests and inner linings. In terms of the environmental conditions, the charophyte evidence is equivocal as stoneworts can live in both fresh and brackish water. However, the foraminiferal remains in the same sample are undoubtedly those of brackish, high saltmarsh species (especially *Jadammina macrescens*) and therefore the initial part of the sequence had tidal access.

Dinoflagellate cysts

Samples were processed from levels at 160 cm, 190 cm, 230 cm, 250 cm, 290 cm and 310 cm. They were oven-dried at *c*. 50°C and weighed. One *Lycopodium clavatum* spike was added (batch 938934, n=10,679, s=±426) to each sample prior to acid digestion. The palynological laboratory technique started with an overnight HCl (10%) treatment to decalcify the sample. Since no reaction was noted at this time, the samples were free of calcareous material. Next was a neutralisation step with KOH (10%) before HF (40%) was added to remove the silica. The samples were shaken for 2 h and left in HF for four days. Neutralising with KOH followed, before sieving on a 20 μm-nylon mesh to concentrate the dinoflagellate cysts. Residues were strew-mounted in glycerol gelatine on microscope slides. Slides were analysed with a light microscope at 200x magnification.

Table 5. Coleoptera recovered from St Leonard's Farm BH 1.

Borehole 1 sample depths	**300-305 cm**	**245-250 cm**	**230- 235 cm**
Carabidae			
Poecilus versicolor	1		
Agonum nigrum	1		
Dytiscidae			
Agabus bipustulatus	1		
Hydraenidae			
Ochthebius sp.	1		
Hydrophilidae			
Cercyon sternalis			1
Anacaena sp.		1	
Laccobius sp	1		
Hydrous (=*Hydrophilus*) *piceus*		1	
Orthoperidae			
Corylophus cassidoides	1	1	
Orthoperus sp.	1		
Staphylinidae			
Trogophloeus sp.	1		
Paederus riparius	1		
Helodidae			
Gen. et sp. indet.	1	2	
Chrysomelidae			
Donacia marginata	1	1	
Donacia cinerea		1	
Plateumaris braccata	2	1	
Plateumaris affinis	1	?	
Curculionidae			
Apion sp	1		
Bagous sp.		1	
Pissodes sp		1	

Table 6. Dinoflagellate cysts and freshwater palynomorphs present (x) in the samples from St Leonard's Farm BH 1.

Species/**Sample**	**160 cm**	**190 cm**	**230 cm**	**250 cm**	**290 cm**	**310 cm**
Lingulodinium machaerophorum	x					
Operculodnium centrocarpum sensu Wall and Dale (1966)	x	x	x			
Spiniferites/ Achomosphaera spp.	x	x	x			
Spiniferites membranaceus		x				
Reworked dinoflagellate cysts undetermined	x	x				
Pediastrum spp.	x	x	x			
Tasmanites spp.		x	x			

Marine palynomorphs were absent from samples at levels 310 cm, 280 cm and 250 cm, where only degraded organic plant debris was observed. Only the upper three samples at levels 230 cm, 190 cm and 160 cm contained dinoflagellate cysts and freshwater algae and will be discussed further. These upper three samples remain to show a strong terrestrial signal because of the dominance of fresh and degraded plant debris, pollen and spores and the presence of freshwater algae *Pediastrum* and *Botryococcus*. Only 10–20 dinoflagellate cysts specimens were identified in each sample, but these were well preserved and did not show signs of reworking. A dinoflagellate cyst concentration of 39 ±14 cysts per gram dry sediment was calculated for the sample at level 190 cm. Notwithstanding the low abundance, the dinoflagellate cyst presence confirms a marine influence in the upper three samples. The dinoflagellate cyst taxa recorded were *Spiniferites/Achomosphaera* spp., *Operculodinium centrocarpum* sensu Wall and Dale (1966) and *Lingulodinium machaerophorum*. *Spiniferites/Achomosphaera* spp. is a neritic species that commonly occurs on the shelf. *Operculodinium centrocarpum* sensu Wall and Dale (1966) is a cosmopolitan species found from the open ocean to the neritic environments (e.g. Marret and Zonneveld, 2003, and references therein). The presence of the *Lingulodinium machaerophorum* morphotype with long processes at level 160 cm indicates relatively warm and saline waters, most likely in proximity to the coast (Mertens *et al.*, 2009).

Together, the dominant terrestrial signal, the fresh water algae and the small but persistent marine influence recorded in the upper three samples could reflect a tidally influenced river (mouth) or estuarine environment in which marine waters masses entered, or alternatively a shallow, near-shore environment with strong influence from a nearby river.

Discussion and Conclusion

The palaeoenvironmental information available from the St Leonard's Farm sequence is limited by the lack of preservation of key fossil groups such as molluscs, diatoms and ostracods and poor preservation of foraminifera. However, such information as is available suggests that it was laid down during an interglacial period. For example tree pollen is dominant in all the pollen samples and thermophiles such as *Trapa natans* and *Najas minor* are present in the plant macrofossil assemblages. The salinity of the water body in which this deposit was laid down is less clear, partly because of the lack of key salinity indicators, but seems to have been mostly freshwater with some brackish or marine inputs. It is therefore possible that it accumulated in a tidal river, near to the tidal limit, so that freshwater influences were dominant but brackish elements entered the system occasionally, for example at particularly high tides. Dinoflagellate cysts are not studied routinely from interglacial sites, but were analysed from this site because of the poor preservation of other salinity indicators. This work suggests that they could form a useful component of such studies in the future.

There is no evidence of the age of this sequence. The lack of preserved mollusca means that the amino-acid racemisation technique (e.g. Penkman *et al*., 2011) cannot be applied, and similarly there was no suitable sandy material for optically-stimulated luminescence (OSL) dating. It is possible to OSL-date material from boreholes (e.g. Bates *et al*., 2010) but in this case, the 60 cm-thick sand bed recorded contained too high a proportion of gravel and clay to be suitable and the underlying gravel had too little sand for either dating or sampling. The poor preservation of the fossils and small size of the samples available (c. 500 g of sediment or less) also precludes an age estimate on biostratigraphic grounds, since the likelihood of a distinctive species occurring is less.

This sequence is found only 5 km west of the longer and better preserved estuarine sequence at Stone Point SSSI (Figure 1). The top of the St Leonard's Farm sequence is altitudinally slightly higher than the highest parts of the Stone Point sequence (1.8 m O.D. compared with 1 m O.D.). If these were both laid down during the last interglacial period, this might suggest a downstream height gradient within the estuary. The stratigraphic relationship between the St Leonard's Farm and Pennington Marshes sites is less clear, since the Pennington Marshes sequence is altitudinally considerably lower even though it is further upstream (Table 1). It records only the start of an interglacial and is entirely freshwater (Allen *et al*., 1996). This difference in altitudes conflicts with traditional ideas about correlation of sediment bodies along river systems using projected long profile gradients and might suggest that these sites were deposited during different interglacial periods. However such altitudinal differences are not unusual in the complex depositional environment of an estuary. For example, thick estuarine sequences at noticeably different altitudes at Rochford and Shoeburyness within the former Medway estuary in eastern Essex both yield AAR values on *in situ* material that correlate with the same interglacial period (Roe *et al*., 2011; Briant *et al*., 2012). Thus, the altitudinal differences do not rule out deposition of all three Solent interglacial sequences during the last interglacial (Ipswichian, MIS 5e).

The altitudinal correlations between deposits in this region still need to be addressed, ideally with a full borehole analysis. However, one clear pattern can be seen. Notwithstanding the preservation problems, there seems to be greater freshwater input into these three interglacial sequences as you travel further upstream (Table 1). The Wight-Purbeck ridge was probably still in place at this time (Velegrakis *et al*., 1999). The nature of the confluence between the Solent and the Test at the end of Southampton Water as sea level rose was therefore different from at the present day. The detailed configuration is not known. However, it is possible that the Solent could have been a narrow, enclosed estuary, with limited upstream tidal influence.

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REPORTS

GLACIATION OF THE SCOTTISH BORDERS THE 13TH GLACIAL LANDSYSTEMS WORKING GROUP (GLWG)

26th-28th October 2012

Introduction

This year's GLWG trip was held in the Tweedsmuir Hills in the Scottish Borders, discussing the largely overlooked abundance of glacial geomorphology. Led by **Danni Pearce** (University of Worcester) as the basis for her PhD research, and co-convened by **Brice Rea** (University of Aberdeen) and **Dave Evans** (Durham University) the trip comprised 2.5 days in the field with stimulating lively discussion between the 40 participants on upland and valley geomorphology from the late glacial through to the Holocene.

The Tweedsmuir Hills form an upland region situated on the border between Peeblesshire and Dumfries and Galloway in southern Scotland, covering an area of approximately 370 km^2. The area forms an extensive, undulating and interconnected highland (most summits >600 m a.s.l.) dissected by valleys in an approximately radial pattern. The valleys within this area exhibit a suite of glacial landforms thought to be associated with a distinct episode of glaciation subsequent to the Last Glacial Maximum ((LGM: *c*. 26-21 ka BP) Geikie, 1863, 1864; Young, 1864; May, 1981). Although plateau ice field, transection and valley glacier reconstructions have been proposed, previous investigations lack geomorphic mapping and no attempts have been made to derive quantitative palaeoclimatic information (Price, 1963, 1983; Sissons, 1967; May, 1981). Numerical modelling experiments for the period 38-10.4 ka BP predict a significant body of ice for the Tweedsmuir Hills at the onset of, and throughout, the Younger Dryas (YD) (Hubbard *et al*., 2009). With only a single ^{14}C date (*c*. 10.3 cal ka BP) from the far southwest of the present study area (Tipping, 1999) constraining and correlating the geomorphology, and reconstructing ice limits remains problematic. The purpose therefore of the GLWG meeting was to discuss the style, extent and timing of glaciation in the Tweedsmuir Hills.

Thursday 25th October

Upon arrival at the Tweedside Caravan Park (Innerleithen) the trip opened with a short yet informative welcome and introduction by Danni providing delegates with an opportunity to familiarise themselves with the site locations, geology and geomorphology.

Friday 26th October

Site 1: Late glacial glaciation of the Tweedsmuir Hills, Chaplehope valley

Awaking to a chilly but bright morning, the first site visit was Chaplehope valley. After a short stroll from the car into the mouth of the valley, accompanied by Lenny the shepherdess, Danni began talking us through the geomorphological evidence for a presently unrecognised glacial limit, SSE of the Tweedsmuir Hills. A suite of large valley-floor mounds and ridges (near Chaplehope Farm), nested lateral moraines on both sides of the river, and surface boulders, which are similar to geomorphic features described from adjacent valleys and elsewhere in Scotland, are thought to be associated with the last (YD) glaciation. The moraines are likely to indicate controlled or punctuated retreat of an outlet glacier sourced from the summits of Kerrcleuch and Muckle Knees, which formed part of a larger plateau icefield system. Lively discussions circulated around the source of moraine material (whether it was eroded *in-situ* or pre-existing), the reasons why hummocky moraine in Scotland and the Alps vary in morphology, the potential to examine clast rounding along a down-valley profile, and the present-day micro-climate contrasts (namely precipitation) between this and adjacent valleys.

Site 2: Geology of the Tweedsmuir Hills

After a short drive to the Grey Mare's Tail/Dobbs Linn, **Emrys Phillips** presented an informative overview of the geology of the Tweedsmuir Hills, including a description of a series of fault-defined tracts (NE-SW) dominated by approximately 90% greywacke (mud-rich sandstone) that appear to have exerted structural control on the preferential erosion of the valleys (Tipping, 1999). For further information Emrys referred us to the Regional Guide of Scotland (Stone *et al*., 2012), which provides a basic text on the geology of the Southern Uplands. From subsequent discussion it was suggested that information on glacial flow could be derived from correlating the geochemistry of the overlying tills with that of the underlying geology.

Site 3: Late glacial geomorphology of Loch Skeen

Following a steep, but welcomed, climb to the southern tip of Loch Skeen the group lunched with magnificent views into the valley overlooking the outlet flowing south, which feeds the 60 m high Grey Mare's Tail waterfall (the 5th highest in Scotland). After lunch Danni explained that the landforms in and around Loch Skeen, comprising mounds and ridge fragments including terminal, lateral and hummocky moraine, have attracted considerable interest since the mid 1800s. It is thought that the complex landsystem is likely to represent a number of stillstands and re-advances associated with an actively retreating (YD) valley glacier. Previously unmapped mounds and ridges identified south of a latero-frontal moraine (often termed 'The Causey'), instigated discussion around new southerly limits for the valley glacier, suggesting that The Causey represents a stillstand during overall glacier retreat and not the YD maximum. After a second climb up on to Mid Craig, overlooking Loch Skeen to the east, the group came to its final stop of the day. Here discussions circulated around a number of topics including the potential for overriding and streamlining of moraines to the SW of the crag during ice re-advance, evidence for deglaciation chronology, lateral meltwater channels, hummocky moraine, and why there seem to be few small glaciers associated with the YD glaciation. The site also provided the ideal opportunity for **David Jarman** to indicate a fantastic sunlit Rock Slope Failure (RSF) penetrating deep into valley walls at Bell Craig on the far side of Moffatdale. This glacial trough is lined with extensive slope deformations, attesting to significant erosion and postglacial stress release. The RSF cluster is substantially widening the trough, and is clearly important in Quaternary landscape evolution.

Saturday 27th October

Site 1: Late glacial geomorphology of the Megget, Winter Hope valley (Fig. 1.)

The second, now frosty, day began with a stop to the north of the Winter Hope valley. Here Danni presented previously undocumented geomorphological evidence for a substantial late glacial outlet glacier in the valley and explained the chronological implications this has for the landsystem at Loch Skeen. After a long stroll south into the depths of the valley, clearly sculpted glacial mounds and ridges were observed. On the basis of the relative positioning of lateral moraines in Winter Hope and Loch Skeen, discussion focused around the unlikelihood that both landsystems at the sites existed at the same time. Instead, multiple moraine systems suggest the late glacial plateau icefield system may have been much larger than previously thought, with the Winter Hope landsystem forming by the earlier, larger icefield and the second landsystem at Loch Skeen representing the final remnants of ice before complete YD deglaciation. In addition, it was suggested that until accurate chronology can be obtained, moraines in Winter Hope might pre-date the YD and the controversy will persist.

Figure 1. Ridges and mounds to the NE, Winter Hope valley, the Tweedsmuir Hills (photo: Benedict Reinardy).

Site 2: Late glacial to Holocene geomorphic development of Talla valley

i) The British Geological Survey (BGS) Talla Earth Observatory Site

After lunch discussion diverted briefly from glacial geomorphology with a talk by **Clive Auton** (BGS) in the Talla valley, who introduced an ongoing project run since April 2010 by the BGS using a combination of conventional surveying and non-invasive techniques to characterise the geomorphology, soils and shallow substrates of a typical small catchment in Scotland. The principal aims of the investigation at Talla are to i) develop a combination of techniques for mapping the landscape in three dimensions, and ii) establish a baseline from which palaeoenvironmental evolution of the area can be assessed and against which monitoring of impacts of future environmental changes can be undertaken. At the catchment outlet **Andrew Black** (University of Dundee) went on to explain methods for measuring and monitoring river water levels in mountain rivers and later presented a sophisticated ground-level rain gauge. This was followed by a short talk by **Jeremy Everest** (BGS) at a nearby weather station, and a second talk from Clive on bore-holes, coring and augering techniques used for pollen and radiocarbon analysis, and to establish

Figure 2. GLWG participants, Winter Hope valley (photo: Dave Roberts). Image looks East.

the conditions and thickness of peat and Quaternary sequences. Discussion largely revolved around the accuracy of the methods employed, as well as how the data will be used in the future.

ii) Late glacial geomorphology Talla valley

Moving back to glacial geomorphology, and after a short but extremely boggy march north of the BGS Earth Observatory Site, Danni pointed out a set of previously unreported ridges and mounds, north of the Talla valley. The interpretation of these features has consequences for the style and extent of glaciation in the area. Discussions centered around the origin and timing of the inner (up-valley) and outer (down-valley) features. It was suggested that the inner and outer moraines might represent separate deglacial events during the LGM and the YD. Following this, the group climbed up on to the mounds where **Jeremy Everest** presented cosmogenic dates, with the inner moraines mostly showing older dates than the outer moraines. A discussion on the methods and accuracy of cosmogenic dating followed.

Sunday 28th October

Site 1: Valley erosion and Rock Slope Failure

Awaking to a somewhat milder but wet morning, the group's final ascent of the weekend was led by **David Jarman** up to the head of The Glen valley (Tweedsmuir Hills) where the group assembled on top of a RSF displaying typical slippage from an 8-metre headscarp, with 500 m-long antiscarps. Unlike the paraglacial Moffatdale cluster, this 'freak' outlying RSF has developed above a 150 m deep overflow channel incising the Yarrow-Tweed drainage divide. From the far side of this steep incision, the group discussed whether the valley was cut in one or repeated meltwater outbursts, and whether ice could have played any part in enlarging it.

Acknowledgements

Thanks are due to the Quaternary Research Association and Van Walt for co-sponsorship, without which the 13th GLWG would not have been able to take place. Thanks also to Emrys Phillips (BGS), Jeremy Everest (BGS), Tom Bradwell (BGS), Clive Auton (BGS) and David Jarman (Mountain Landform Research) for contributions, and to Brian and Linda Graham, owners of the Tweedside Caravan Park, for their hospitality. Special thanks are due to Danni Pearce for excellent organisation, presentation and explanation.

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17TH QRA ANNUAL INTERNATIONAL POSTGRADUATE SYMPOSIUM

29th August to 31st August 2012, University of Aberdeen

From the 29th to 31st August 2012 the Department of Geography and Environment at the University of Aberdeen hosted the 17th QRA Postgraduate Symposium. The meeting was organised by Anke Küttner, Paul Ledger, Ilse Kamerling, David Ashmore and James Lea and was attended by more than 30 delegates from 20 Universities across the UK. During two and a half exciting days delegates enjoyed talks, posters and discussions covering a wide variety of methodological approaches and research questions in the Quaternary. Topics covered included geomorphological changes of landscapes, glaciology, dating techniques, sedimentology, palaeoecology and ancient DNA. While running on a tight schedule, there was still plenty of time left to socialise and deepen discussions over food and drink and to forge contacts for the future.

Many delegates arrived on Tuesday for the evening registration and an informal welcome drink to meet and greet the other participants, and to attend the field trip on the following day. The fieldtrip on the first day (29th August) was led by Prof. Alastair Dawson and Dr. Tim Mighall and took us to the Forvie National Nature Reserve and the Kippet Hills north of Aberdeen. we spent the morning at the Sands of Forvie located at the Ythan estuary. Here the magnificent coastal dune system developed over the past 5000 years and represents one of the biggest and least disturbed in Britain. It comprises various types of immobile and mobile dunes. Moreover, the vegetation covering the immobile dunes is an exquisite example of the development from pioneer species to climax vegetation, and how these influence each other. The dunes also offer a glimpse into the history of human activity in the area. Earliest occupation can be dated into the Mesolithic period through excavation of numerous stone tools and a lithic processing site (Warren, 2005, Finlayson & Warren, 2010). In fact, we were able to find remnants of tools ourselves which are steadily exposed due to the ongoing movement of the dunes. Additionally, the estuary is an excellent area to observe and discuss sea-level change since the last glaciation. Furthermore, we discussed the value to preserve such natural environments as objects of scientific interest and ecologic niches for flora and fauna in contrast with financial and economic driven decisions. After lunch we drove to the Kippet Hills located north of Meikle Loch. The extensive sand and gravel deposits form a striking assemblage of ice-contact glaciofluvial landforms formed during the melting of the Late Devensian ice-sheet (Gemmell, 1975). Here we discussed ice sheet locations and movements by observing a large esker and its orientation, as well as searching a quarry to identify possible sources

of the accumulated material. To wind down and to give all participants a truly Scottish experience we ended the day with a tour of Glen Garioch distillery. Apart from the educational aspects on peat and hydrology in regards to the making of whisky we also were able to taste a wee dram. To break the ice, and to give the late arrivals the chance to meet everyone, a Whisky reception was held later that evening at the St Machar Bar, a mere 30 seconds stroll from the Department of Geography.

The second day (30th August) started with a keynote lecture from Dr Dmitri Mauquoy on the developments in radiocarbon dating and age-depth modelling from his days as a PhD at Southampton University up the present day. Kicking off the four oral sessions was Palaeoecology, chaired by Robert Barnett (University of Plymouth), with six excellent and widespread talks from classic vegetation reconstructions using pollen to questions of wetland conservation and the role of arctic lakes in the carbon cycles. All of which inspired animated discussions which were carried on during the following coffee break. Two more sessions on Sea-level and Sedimentology followed in the afternoon. They proved to be just as varied and interesting as well as geographically dispersed with projects on sea-level change in Arctic Norway, dating dunes in the United Arab Emirates and sedimentary processes in the West Bengal Sundarbans. The subsequent poster session gave further opportunity for delegates to present their research and to engage in critical discussions.

The conference dinner that evening took place at Cafe 52, giving everyone the chance to relax and socialise around superb food in a warm and private atmosphere provided by the small restaurant.

The last day (31st August) started early with the final session on Glaciology. It was split into two groups with the first talks being on glaciers and the second on past glacial geomorphology and the reconstruction of the location, orientation and movement of ice sheets.

The meeting closed with the Annual General Meeting (AGM) where important decisions for the next year and regarding this meeting were made. During the AGM prizes were awarded to Peter Heintzman (Royal Holloway) for his talk '*An assessment of DNA preservation in two species of Ice Age beetle*' and Christopher Darvill (University of Durham) for his poster on '*Quaternary glacial and environmental change in Tierra del Fuego, southern South America*'. Southampton won the bid for hosting the 18th QRA Annual International Postgraduate Symposium with the Universities of Cambridge and Stirling as runners-up. The new junior postgraduate representative is Julia McCarroll from the (University of Gloucestershire) while Danni Pearce (University Of Worcester) is now the senior representative with Marcus Hatch (Queen Mary) stepping down after two years.

On behalf of all postgraduate members we thank Marcus for his work in his role with the QRA. Furthermore, we thank all delegates for making this a successful meeting and hope that many of you as well as new members will enjoy the next in Southampton.

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QRA ANNUAL DISCUSSION MEETING
LEADS AND LAGS: CORRELATION, COMPARISON AND CAUSATION

Newcastle University, 2- 4 January 2013

The 2013 QRA ADM was organised by **Steve Juggins**, **Emma Pearson**, **Takeshi Nakagawa** (Newcastle University) and Emma Watcham (Northumbria University) and held in the Research Beehive at Newcastle University on 2-4 January, ten years after the last ADM was held in Newcastle back in 2003. The meeting attracted sixty delegates from more than twenty institutions who contributed oral and poster presentations to three sessions relating to the meeting theme (*Advances in dating and correlation methods*, *Leads and lags between regions*, *Leads and lags between proxies and archives*) as well as a session on *General advances in Quaternary research*.

After lunch on the first day the meeting opened with the session on *General Advances in Quaternary Research* and talks by **James Lea** (University of Aberdeen) on rapid climate-driven retreat of a Greenland tidewater glacier during the 19th century using numerical modelling, geomorphology and historical accounts, **Julie Durcan (**Aberystwyth University) on optically stimulated luminescence dating and the role of changing fluvial activity in the 'collapse' of the Indus Valley civilisation, and **Kathryn Adamson (**Queen Mary, University of London) who discussed river system response to Pleistocene glaciation: a landscape scale correlation of morpho-sedimentary archives. Emma Watcham (Northumbria) discussed scale considerations in using diatoms as indicators of sea-level change, and the final talk of this session was from **Steve Juggins** (Newcastle) who highlighted issues when using palaeoecological transfer functions: a reality check.

After the first oral session the poster presenters were given a two minute slot each to summarise and advertise their posters. Two dedicated poster sessions were held in addition to further discussion during coffee and lunch breaks. The poster presentations covered a wide range of topics within the meeting theme and broader Quaternary context. These included the use of tephra to synchronise palaeoclimatic records using Greenland ice cores (**Peter Abbott**, Swansea University), to constrain rapid climatic events in the North Atlantic (**Adam Griggs**, Swansea University), and to examine spatial and temporal patterns of deglaciation in Scotland (**Ian Matthews**, Royal Holloway University of London).

The Holocene was a key period of interest with posters illustrating a range of proxies used to examine the late glacial Holocene vegetation history of Tierra del Fuego (**Claudia Mansilla**, University of Stirling), Holocene landscape and ecosystem dynamics in central Southern Africa (**Sallie Burrough**, Oxford University), Holocene climate and lake ontogeny in south-western Greenland (**Antonia Law**, Keele University), diatom based reconstruction of Holocene changes in the southern Balkans (**Xiaosen Zhang**, University of Hull), testing the terrestrial response to late Holocene climate change in eastern North America (**Helen Mackay,** Southampton University), deciphering timings and rates of abrupt climate changes over the Late-glacial-Holocene using biomarkers in Lake Suigetsu (**Emma Pearson**, Newcastle University), and reconstructing Holocene climate in Antarctica (**Louise Taylor**, Newcastle University and the British Antarctic Survey).

This session also included posters from members of Durham University on the last glacial maximum extent and controls of the Uummannaq ice stream system, West Greenland on deglaciation (**Tim Lane**), tipping points and rapid neo-glacial transitions in the North Atlantic (**Helen Ranner)**, assessing modes of interglacial sea-level change (**Natasha Barlow**) and Late-glacial sea-level change in the western British Isles (**Louise Callard**).

New advances in Quaternary techniques included testing the upper age limit of OSL dating (**Melissa Chapot**, Aberystwyth University) and the construction of a novel GDGT-temperature calibration for use in lakes (**Emma Pearson**, Newcastle University) while **Steve Juggins** (Newcastle University) highlighted problems with transfer fucntions.

The first day concluded with the QRA Lecture given by **Paula Reimer** (Queen's University Belfast) who updated everyone on the recent advances and the current status of dating and IntCal13 in her plenary "Towards a 50ka bona fide terrestrial radiocarbon calibration curve".

The second day started with the session on *Advances in dating and correlation methods* with a keynote talk from **Siwan Davies** (Swansea University) who spoke about "Tephra constraints on Rapid Climate Events (TRACE): a new initiative to precisely correlate marine and ice-core records in the North Atlantic region". Tephra and luminescence featured highly in this session, with a talk from **Anna Bourne** (Swansea University; also working on TRACE) examining new results from the Greenland ice cores between 25-45 ka BP. Continuing with the Welsh Institution theme, Aberystwyth University members talked about recent developments in reconciling the luminescence- and tephro-chronologies of the Palouse Loess in Washington State, USA (**Georgina King**), testing a new luminescence dating method for feldspars against the Kawakawa tephra, New Zealand (**Rachel Smedley**) extending the limits of luminescence dating applied to Quaternary sediments (**Geoff Duller**) and **Rosemary Stirling** then highlighted some exciting recent work on establishing a new luminescence method to date the entire Quaternary (2.6 Ma). **Chris Ramsey** (Oxford University) closed the session with a talk on the integration of long-term timescales using terrestrial radiocarbon: an example from Lake Suigetsu, Japan.

In the afternoon the *Leads and lags between regions* session was opened with the Wiley Lecture given by **Thomas Blunier** (Niels Bohr Institute, University of Copenhagen) who enlightened us on "Leads and lags from an ice core perspective". **Alison MacLeod** (RHUL) talked about Late-glacial tephrostratigraphy of Gropviken, Sweden and the move towards improved accuracy and precision of the Swedish varve chronology, **Gina Moseley** (University of Innsbruuk) talked about NALPS: A precisely dated European climate record. Next we heard from **Richard Staff** (Oxford University) about long distance identification of leads and lags in climatic change by way of direct terrestrial radiocarbon comparison and from **Takeshi Nakagawa** (Newcastle University) who highlighted the robust correlation among Lake Suigetsu, NGRIP, EDC and Hulu archives and the spatio-temporal structure of abrupt warming events.

The final session of the meeting was on *Leads and lags between proxies and archives* where we heard about multi-proxy studies highlighting abrupt climate changes in the tropical Pacific during Termination 1 (**Erin McClymont**, Durham) and evidence for early warming, variable interglacial intensities, and implications for ice-sheet growth and retreat through the last 1.5 Ma using marine sediments from the southeast Atlantic (**Ben Petrick**, Newcastle). On a shorter timescale **Eleanor Maddison** talked about her multi-proxy study of neoglacial cooling, **Gareth Tye** talked about quantifying rates of proxy response to rapid climate events during the closest analogue to the Holocene, and last but by no means least, the final presentation of the meeting was given by **Ian Candy** (RHUL) on tracking abrupt climate shifts with stable isotopes and using geochemical evidence to examine temperature, precipitation and seasonality regimes during the last deglaciation.

The oral and poster presentations and discussions throughout the three days provided a vibrant and stimulating start to 2013 and much positive feedback was received. Everyone who submitted an abstract was allocated a slot in the timetable, and we included two dedicated poster sessions and refreshment breaks for additional discussion. The meeting location in the Research Beehive meant the rooms we used for oral, poster and refreshment breaks were all interconnected, with other rooms available for more private discussion and meetings where required.

Following the meeting Steve Juggins ran a workshop on *Analysing Quaternary Science data with R* which ran from Friday after lunch until Saturday afternoon and which catered for a range of abilities. The workshop provided a chance for people to learn about the intricacies of this versatile statistical package and get hands-on practice in analysing different types of Quaternary data, as well as discuss their requirements relating to their own data and research questions.

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RIVERS THROUGH GEOLOGICAL TIME
THE GEOLOGISTS' ASSOCIATION TWO-DAY MEETING

13th-14th October 2012

Co-organised by the Devonshire Association

This was our first time attending a meeting of the Geologist's Association and we first have to say how grateful we are for being sponsored to attend such a lively and interesting conference and field trip. Thanks especially go to the organising committee – **Jenny Bennett** (DA and Open University), **David Bridgland** (GA and University of Durham), **Sarah Stafford** (GA), **Rosemary Stewart** (DA) and **Richard Scrivener** (DA and local consultant) for such a well organised event with such an interesting and diverse programme of speakers.

This 2012 Elsevier meeting of the GA in Exeter was jointly organised with the Devonshire Association (celebrating their 150 yr anniversary). As the theme of the meeting was 'Rivers over geological time', a wide range of material was covered ('deep time' as well as Quaternary), and comparisons made between present rivers and those in the geological record. The Sunday field trip looked at Permo-Trias in the local area followed by a visit to the Holocene deposits of the Exe Valley.

The Royal Albert Memorial Museum has been newly refurbished and designated 'Museum of the Year' for 2012. The spacious conference room was packed with 140 delegates, certainly a testament to the interest in the event. Facilities were excellent facilities and museum staff made us very welcome for the day.

Introductions and welcome to the event were given by **Dr Mike Barr**, Chair of the Devonshire Association Geology Section, and Professor Rory Mortimore, the Geologists' Association President.

Day 1, lectures

The first session on *Rivers in the harder rocks* began with the keynote speaker, **Professor Martin Gibling** from Dalhousie University, Halifax, Nova Scotia, painted a vivid picture of the early Earth, introducing us to the very first rivers 3800 Mya and emphasizing the importance of vegetation as an influence on fluvial activity (from the Palaeozoic onwards). **Geraint Owen** (Swansea) introduced us to the 1000 Mya coarse pebbly sandstone beds of the wide channelled river systems that formed the Applecross Formations in Scotland. **Susan Marriott** (Bristol) talked about the Old Red Sandstone rivers of the southwest of Wales, and **Chris Cornford** (IGI Ltd consultancy) looked at the geology around Bideford Bay comparing features of both the present-day

Taw and Torridge with those preserved at Westward Ho!. **Richard Scrivener** (Geological consultant) introduced the Permian and Triassic New Red Sandstone of Devon – to be visited on the field trip. **Malcolm Hart's** (Plymouth) talk on the Otter Sandstone River of the Mid-Triassic provided a good case study to fill in the detail of the types of organisms inhabiting the area at the time,

After Malcolm's talk we all then broke for lunch and the first poster session. Everyone enjoyed the spread that was prepared by the catering team and the break also gave people a chance to explore the fantastic museum and to see some of the impressive collections and exhibits.

Of greater interest to the Quaternary scientists amongst us was the next session *Rivers in the Cenozoic-Recent that* was kicked off by **Andrew Newell** (BGS), who looked at the Palaeogene coastal plain rivers of southern Britain. Andrew's talk illustrated much more than southern Britain, and showed just how susceptible fluvial systems are to other environmental and geological factors, such as climate change, tectonics and sea level changes.

Moving further forward in time, **David Bridgland** (Durham) spoke on the Pleistocene fluvial archives and landscape evolution, looking at the River Thames and analogues throughout Europe and Africa to investigate the development of the terrace sequences and how these can be used to document changes in landscape character through time, possibly linked to long-term changes in climate.

This was followed by perhaps the most technical talk of the conference, **Rob Westaway's** (Glasgow) 'Fluvial sequences, vertical crustal motions and crustal properties', where he outlined advances in the detailed modelling of patterns of vertical crustal motion to constrain crustal properties at depth, illustrating how the thickness of the mobile lower crustal layer affects observed uplift responses; a possible explanation for alternations of uplift and subsidence, and relationships with climate-induced stress-triggering in intra-plate continental regions. **Tony Brown** (Southampton) gave the QRA lecture on changing river geomorphology, from the Holocene to the Anthropocene. His talk highlighted just how 'genetically modified' British river systems have become and the problems that this has led to. His talk was particularly pertinent considering the flooding that has occurred since the meeting.

Moving back in time, the Palaeolithic Rivers of SW Britain: Hominin Occupation and River valleys were the next talk by **Laura Basell** (Bournemouth). Her data, coming from an English Heritage project that used resource from the Aggregates Levy Sustainability Fund, revealed the considerable overlap between archaeology and geoscience. The last talk before the second tea break and poster session was the BSG Lecture by **Gerald Nanson** (Wollongong, Australia) on 'Fluvial deposits as archives of geomorphology'. Perhaps the furthest-travelled speaker at the conference, Gerald used data and examples

Figure 1. Tony Brown giving his QRA talk. (Photo: Tom Elliot).

from his considerable research experience on the inwardly draining rivers of the Lake Eyre Basin, south-central Australia.

Tea and Poster Session

Session 3 in the afternoon was on the *'Added value of fluvial archives'* started by **Eric Buffetaut** (CNRS) on Fluvial deposits as repositories of vertebrate fossils, describing some of the more unusual fossils from fluvial contexts. **Richard Selley** (Imperial) then followed, on fluvial deposits as oil reservoirs, with amusing asides on interpreting seismographs. The final talk of the conference was by **Jenny Bennett** (OU) on Exeter and its River, describing how the underlying geology determined the shape of the river valleys and the development of the terraces through time, incorporating archaeological data. Jenny also showed how tracing of palaeochannels can aid the prediction of routes of future flooding.

Day 2 Field trip

The extremely well supported field trip (two coaches were needed) was fortunate in the weather and visited Budleigh Salterton to see the stratigraphy of the Permo-Trias exposed in the cliffs. We then moved round through Exmouth to Lympstone to look again at cliff exposures, this time of Exe Breccia Formation (close to the Permian–Triassic boundary). We then moved back into the village to have lunch in the cafes and a pint in the sunshine at the Swan Inn.

After lunch we travelled through Exeter along and up the Exe to our final site – Brampford Speke, where Jenny Bennett showed us the palaeochannels of the flood plain, the importance of culverts for flood drainage, and an overview of the Exe terrace system.

Thanks go to the organisers; the Royal Albert Memorial Museum; and sponsors, Elsevier, Quaternary Research Association, British Society for Geomorphology and FLAG (Fluvial Archives Group)

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NEW RESEARCHERS AWARD SCHEME

PATAGONIAN ICE SHEET ELEVATION AND THICKNESS CONSTRAINTS FROM COSMOGENIC SURFACE EXPOSURE DATING

Background

Changes in ice surface elevation of the Patagonian Ice Sheet (PIS) during the last glacial cycle (110-10 ka) are a major unknown in current glacial reconstructions based on chronologies of ice margin fluctuation (Kaplan *et al.,* 2007, 2011; Glasser *et al.,* 2011; Figure 1A) and ice sheet models (Hulton *et al.,* 1994, 2002). Empirical data on ice surface elevation and lowering is critical because (1) ice thinning may occur before marginal retreat thus recording the commencement of large scale climate shifts earlier than evident from glacial extent studies, (2) the 3-D ice topography (thick/thin ice) is an important component of, and has strong effects on, local and global circulation patterns, and (3) relating ice volume fluctuations to eustatic sea level requires accurate chronological data on lateral and *vertical* ice limits.

The numerically simulated central palaeo-PIS thickness at the last glacial maximum (LGM) ranges between 2000-2500 m. In addition a maximum volume of 500,000 km^3 equating to 1.2 m of eustatic sea level has been modeled (Hulton *et al.,* 2002). Under the modelled conditions the core area of the PIS (located between 52-43˚S) requires several thousand years of mass loss to attain its present form as the Southern Patagonian Ice Field (SPIF; Figure 1A and B). Empirical data on *vertical* ice extent and *thinning* rates are required to validate and refine the numerical model.

Methodology

Research was conducted on and adjacent to the central eastern margin of the SPIF, which constitutes the largest mass of ice in the southern hemisphere outside of Antarctica (Figure 1). The site was selected because it was at the former latitudinal centre of the PIS, it is currently at the core of the SPIF, and ice thickness measurements and subglacial trough profiles are available making it suitable for palaeo-ice thickness studies (Rivera and Casassa, 2002).

The *in-situ* produced cosmogenic nuclides beryllium-10 (^{10}Be), aluminium-26 (^{26}Al) and chlorine-36 (^{36}Cl) are used to date the surface exposure of bedrock and erratic boulders providing a chronology of vertical ice downwasting. The technique relies on rare nuclides being produced at known rates in the Earth's surface by secondary cosmic ray bombardment. The nuclides are extracted from

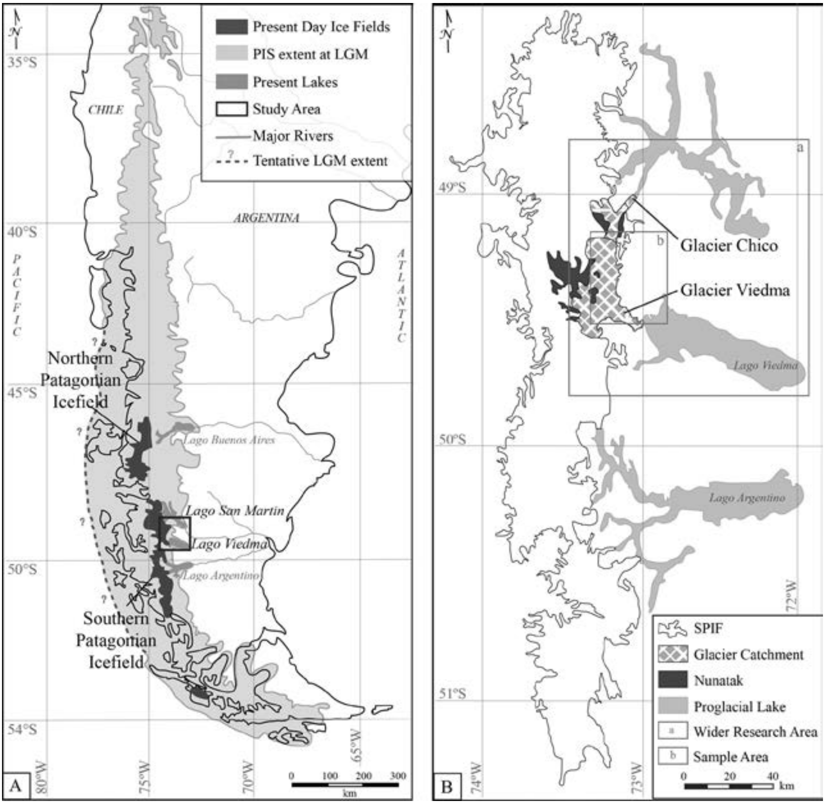

Figure 1. A) Maximum extent of the Patagonian Ice Sheet (PIS) at the LGM (26-16 ka; adapted from Rabassa, 2008), location map of the Southern Patagonian Ice Field (SPIF) and the study area. B) SPIF extent, Viedma & Chico Glacier catchment area. a) wider research area (~12,000 km^2) b) area where samples for surface exposure dating were collected (~1,500 km^2).

the mineral lattice of rock samples, and their concentration is measured using accelerator mass spectrometry (AMS). The resulting nuclide concentration is converted to a surface exposure age (see Gosse and Phillips, 2001, for an extensive review).

The field campaign was conducted over a period of 60 days. A total of 70 erratic/bedrock samples for surface exposure dating (SED) were collected along vertical transects of 7 ridges/summits between 500-1750 m.a.s.l. (Table 1). Samples were obtained from three distinct zones: Nunataks, peaks that are completely surrounded by the SPIF; ice proximal sites which are adjacent to Glacier Viedma (Figure 2); distal localities occupied by cirque glaciers located in the mountain range to the east of Glacier Viedma (Figure 1, Table 1).

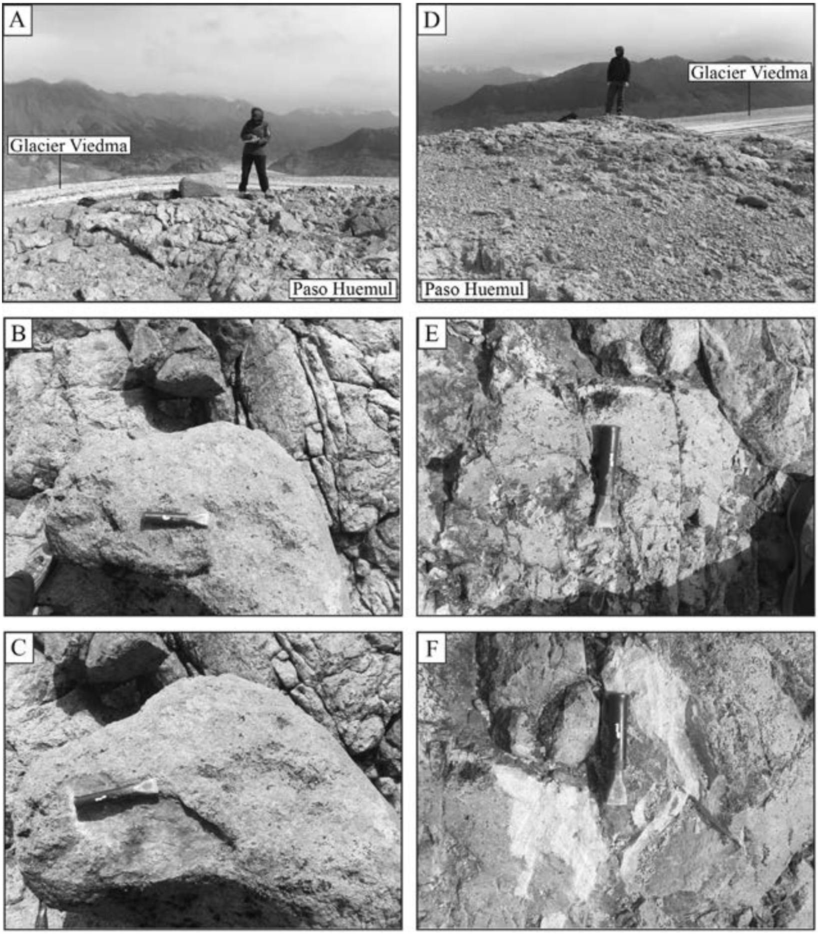

Figure 2 A) Erratic on bedrock at Paso Huemul. Picture taken towards south. B-C) Rock before and after sampling for SED. D) Bedrock at Paso Huemul. Picture taken towards south-west. E-F) Bedrock before and after sampling for SED.

Samples have been separated mineralogically at the University of Glasgow and are currently being processed to AMS targets at the NERC-Cosmogenic Isotope Analysis Facility, Scottish Universities Environmental Research Centre, East Kilbride.

Table 1. 57 rock samples selected for SED including the vertical range from current ice surface to highest sample at 7 mountain transects.

Sample Site	Sample Amount	Vertical Range (m)
Soto Nunatak, Chile	1 erratic, 3x erratic-bedrock pairs	400
Witte Nunatak, Argentina	5 bedrock, 2x erratic-bedrock pairs	500
Paso del Viento (ice-proximal)	10 erratics, 1x erratic-bedrock pair	850
Paso Huemul (ice-proximal)	1 bedrock, 3x erratic-bedrock pairs	900
Tunnel Valley (distal to SPIF)	1 bedrock, 2 erratics	300
Pizarras Ridge (distal to SPIF)	10 erratics	900
Chalten Valley (distal to SPIF)	3 erratics, 1x erratic-bedrock pair	300

Preliminary Results

The first AMS results were reported back in mid-November 2012. Minimum exposure ages have been calculated as corrections for snow shielding and erosion are still to be performed. Ages range between the late Holocene (0.55 ka) on Nunataks 200 m above the current ice surface to the late Pleistocene (45 ka) 700 m above the current ice surface in ice-proximal localities (Table 1). Further AMS results are expected for the beginning of February 2013.

Acknowledgments

The QRA New Researchers Workers' Award contributed to the rock shipment costs from Argentina to Glasgow (~80 kg). In addition the following funding bodies are acknowledged for their financial contributions towards fieldwork costs: British Society for Geomorphology, The Royal Geographical Society with IBG, The McCorkell family for a Travel Scholarship and the Carnegie Trust for the Universities of Scotland who also provide the PhD Scholarship. Sample processing was funded by NERC-CIAF grant 9117/0412. Lastly I would like to thank: my supervisors Dr. Fabel and Prof. Glasser for continuous guidance and project support; Dr. Hein, Lic. Ruiz, Robin, Luco, Iñaki and Jesus for field-assisting and discussion; my family and friends for endless encouragement.

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RECONSTRUCTION OF HOLOCENE CLIMATE AND DEFINING THE PRECIPITATION RECORD FOR THE NORTH ATLANTIC REGION

Background and rationale

Current research into Holocene climate indicates a highly variable record of global climate change (Mayewski *et al.*, 2004), however, there is also evidence of strong regional shifts (Charman, 2010). In order to better understand the variable nature of Holocene climate of the North Atlantic region and potential forcing mechanisms, we need to reconstruct the palaeoclimate in terms of single climatic variables, that is, temperature and precipitation (SAGES, 2010). Reconstruction of past climate relies on the interpretation of a proxy record; the aim of this research is to reconstruct a highly resolved precipitation record using changes in lake level as a proxy for precipitation. The study will focus on sediment stratigraphy, in conjunction with sub fossil larvae head capsules of chironomidae (Insecta; Diptera), as a biological proxy to quantify changes in lake level. Chironomid taxa have been shown to respond to changes in water depth, are abundant and species rich and therefore in a good sedimentary record provide a high temporal resolution and greater accuracy of results, making them good indicators of past lake level change (Luoto, 2009; Engels and Cwynar, 2011). This is a new and innovate application of chironomids and one which is still under development (Engels and Cwynar, 2011).

Careful site selection criteria can ensure that the lakes studied are sensitive to hydrological changes driven by fluctuations in the amount of precipitation (Tisdall, 2000), with the aim of defining changes in water depth, enabling the water depth to be quantified, and applying this value to model changes in precipitation. This will potentially enable a climate record to be produced, not only for the transect of sites used in this study, but also interpolated across Scotland and the North Atlantic Region.

A QRA New Researchers Award enabled the author to undertake a site survey and sediment coring at Loch of Sabiston, Orkney Isles in May 2012. The funding contributed to vehicle hire, travel and accommodation costs on Orkney. The aims of this fieldwork were:

- To retrieve sediment cores from across the lake and lake margins, ensuring the samples represent littoral and deep water environs and
- To obtain surface sediment samples in order to compile an intra-lake training set for this site.

Fieldwork locations

The Orkney Isles situated on the Eastern margins of the North Atlantic is an ideal location to study precipitation because the islands are dominated by North Atlantic weather systems and this proximity will potentially facilitate a better understanding of the link between climate fluctuations and ocean-atmospheric circulation patterns.

Loch of Sabiston (Lat. 59° 04'N, Long. 3° 14' W) is located in the north-west of Orkney's main island, about 1.5 km north of Dounby. Loch of Sabiston is a shallow marl lake lying on a bedrock of Devonian sandstone flags. Fen vegetation is present around approximately two thirds of the margin from the north eastern shore, westward to the south eastern margin. The lake is about 880 m long by about 580 m by 2 m deep and is situated at about 15 m asl. There are two small outflowing streams situated at the south west and south eastern edges of the lake. The sediment cores for this study were collected from the north east section of the lake well away from the outflowing streams.

Methodology

A sequence of cores were taken across the lake basin at Loch of Sabiston, with sampling sites taken at intervals from near shore and littoral environments out to deeper water environments. The sites were cored using a standard Russian corer being 1.0 metre long with an internal diameter of 6.0 cm (Jowsey, 1966). A raft was constructed and anchored down on three sides and utilised as a coring platform in the deeper water with sites LS5 and LS6 representing deep water sedimentation and samples LS1 – LS4 inclusive, representing sedimentation at the basin margin (Figure 1). Therefore changes in lake level which are identified within the stratigraphy can be traced along the core transect from the lake margin out to the deeper areas of the lake.

Preliminary Results

A detailed stratigraphic analysis was carried out in the field and in the laboratory on the sediment cores (Figure 1) using the Troels-Smith notation method to identify changes in the stratigraphy that could be distinguished as potential changes in lake level. The nearest shore sediments (LS1 and LS2) show terrestrial sediments of fen peat, capped by colluvium (slope wash) across the top as we move up the core. LS2 shows an abrupt transition from lacustrine sediment to fibrous fen peat; fen type vegetation is associated with lacustrine margins.

Between cores LS2 and LS3, the basin becomes over deepened and the stratigraphy shows a more gradual transition with lacustrine marls accumulating. Moving across the core transect to the centre of the lake, these marls change

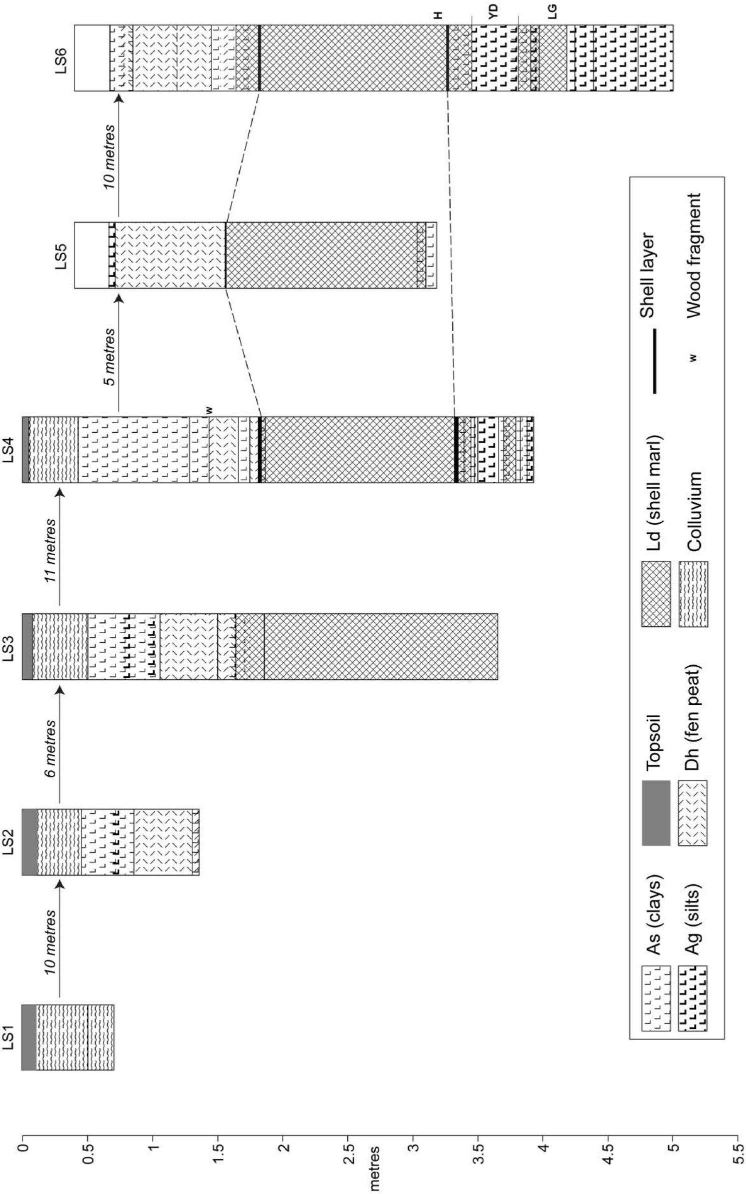

Figure 1. sediment stratigraphy across the Loch of Sabiston core transect (Cores LS1-LS6)

from fine creamy marl up into darker silty marls with organic rich lenses. There is also a fine, but well defined, shell fragment layer which is present in cores LS4, LS5 and LS6 and is perhaps indicative of previous shoreline. The lacustrine marls are topped by a sequence of fen peat and thinning colluvium and as the core sequence moves out towards the middle of the lake, the core transect suggests that the lake basin begins to flatten out at cores LS4, LS5 and LS6 as the sequence reaches the deepest parts of the lake.

The deeper water cores LS4 and LS6 show clear evidence of a 'tripartite' sediment sequence; this is most evident in LS6 (see Figure 2). The basal sequence is absent from core LS5 which could be due to incomplete coring at this core site. The stratigraphy in cores LS4 and LS6 indicates basal dark grey silty clays indicative of the Last Glacial Maximum (LGM), transitioning up into Late Glacial layers of brown silts and marls, and continuing up to a layer of dark grey banded clay; indicative of the Younger Dryas and followed by an abrupt transition to the grey brown silty marls of the Holocene. Above these silts there is a shell layer which transitions to creamy marl as warming continues, and above these shelly marls is a transition to fen peat. There is no tripartite LGM sediment present in cores LS1-LS3. During late glacial it is suggested that the lake is relatively small, with sediment accumulation showing in LS4 and LS6, indicating early stage development as sediment accumulates and the lake fills.

The presence of shell layers throughout the sediment sequence indicates that there have been changes in the water levels of the lake and that the lake basin is hydrologically sensitive, with the potential shorelines more obvious at the littoral edge (core LS4).

Significance

Stratigraphic analysis has confirmed that Loch of Sabiston over time has been sensitive to changes in hydrology and that lake levels may have been driven by fluctuations in the amount of precipitation. The next step in the analytical process will be to sample the core sediment at defined intervals using core LS6, as this core has the most complete and comprehensive sediment sequence, with particular attention being paid to those areas of the core which have shown evidence of lake- level change. Chironomid analysis will be used to ascertain if there are changes in the chironomidae assemblages which are indicative of changes in water depth, thus aiming to establish a proven methodology in terms of defining change in the chironomidae assemblages being a response to changes in water depth.

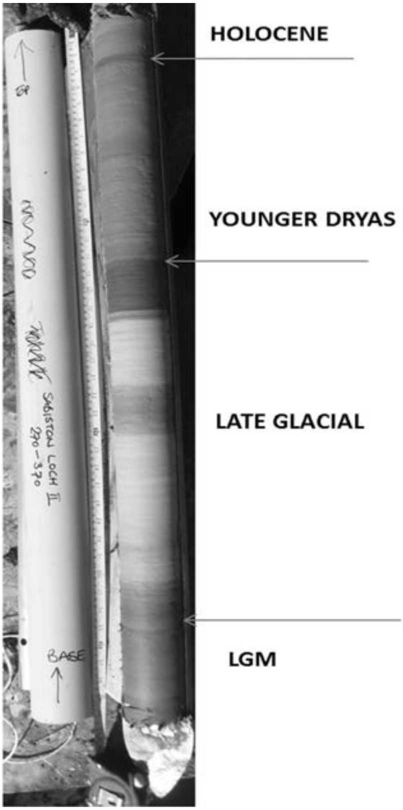

Figure 2. Sediment core (LS1) from Loch of Sabiston, Orkney Isles with visible tripartite sequence

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REVIEWS

PRESTON (SHEET 75) [1], GLOSSOP (SHEET 86) [2], SHEFFIELD (SHEET 100) [3], CHESTERFIELD (SHEET 112) [4], DINAS MAWDDWY (SHEET 150) [5], DUDLEY (SHEET 167) [6], ANDOVER (SHEET 283) [7], TIVERTON (SHEET 310) [8], NEWQUAY (SHEET 346) [9] : BEDROCK AND SUPERFICIAL DEPOSITS EDITIONS (ENGLAND AND WALES).

GEOLOGY OF THE GLOSSOP DISTRICT : SHEET EXPLANATION (86) 46 PP [10]
C.N. WATERS, J.I. CHISHOLM, E. HOUGH AND D.J. EVANS

GEOLOGY OF THE DUDLEY DISTRICT : SHEET EXPLANATION (167) 46 PP [11]
C.N. WATERS, D.M. BRIDGE, A.J. HUMPAGE, W.J. BARCLAY AND N.J.P. SMITH

PUBLISHED BY : BRITISH GEOLOGICAL SURVEY 2011 [3] 2012 [1, 2, 4, 5, 6, 7, 8, 9, 10] 2013 [11]

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1:50,000 sheets £12 each, sheet explanations £9 each and £18 with accompanying map; 25 % discount for academic institutions when ordered from : **Sales Desk, British Geological Survey, Keyworth, Nottingham NG12 5GG . Tel : 0115 - 936 3241 - Fax : 0115 - 936 3488 sales @bgs.ac.uk** (prices exclude post and packing - in the UK a minimum of £1.50 and 10% of the original value of the goods up to maximum of £7).

These 1:50,000 geological maps will be some of the last to be published as the product of ongoing surveys since the foundation of the BGS in 1835. This is not to say that this mapping, including inshore waters, is nearly complete, even before considering future developments in how stratigraphic units can be delineated. This is not to reject the digital age, but paper records are known to be durable for centuries, and printed geological maps can include otherwise confidential material and accommodate uncertainty, rather than interpolating mathematically exact data that can be flawed by simple lateral variations.

The Preston sheet (75) covers an area from the flanks of the Pennines to the low plains on the banks of the River Ribble before its estuary joins the Irish Sea. Compared to the separate bedrock edition this underlying linework is simplified to make it easier to absorb the complex patterns formed by the superficial surface deposits covering almost all the sheet. Much of the area is covered by till and associated morainic and glacialfluvial deposits, though peat cover sands, alluvium, tidal flat and salt marsh deposits also cover extensive areas. An insert map shows the rockhead contours and pre-Devensian drainage pattern, alongside a clearly annotated colour radar image of the district with a welcome overlap. In comparison the adjacent 1989 Southport sheet (74) is already in need of revision and could have been included by extending this map westwards by an extra couple of folds.

The Glossop sheet (86) covers a portion of the southern Pennines to the east of Manchester which is beautifully illustrated by the radar image. Along with former opencast mines and active quarries the map shows extensive landslips on the flanks of the upland moors mantled with peat, while there are highly complex areas around Glossop and along the River Tame with spreads of till and related deposits supplemented by worked ground. This district is covered by one of the last sheet explanations, designed to be sold alongside the folded and cased map in a plastic wallet. Though dominated by Carboniferous geology, it does have four pages on the Quaternary even if this gets off to a poor start by using "before present" outside its radiocarbon context and mistiming the Flandrian climatic amelioration to 10,000 rather than 11,700 years ago. Following this is a good overview and interesting account of the superficial structures associated with the local bedrock including valley bulges and landslides. This subject material also features in the applied geology section, which covers ground conditions, including mining subsidence and potential pollution problems.

Though the extent of superficial deposits on the Sheffield sheet (100) is very limited, the margins contain two radar images of the district, one with a simplified bedrock overlay which shows how many topographic features clearly reflect the underlying Pennines geology. Directly to its south the Chesterfield sheet (112) is very similar with Permo-Trias sediments to the east resting on a Carboniferous sequence of coal measures and underlying Millstone grits and often highly mineralised limestones west of Matlock. These veins and mining information are shown on a 1:25,000 insert spoiled by not using a base map at the same scale.

The Dinas Mawddwy sheet (150) in Wales covers a portion of the Cambrian Mountains underlain by a highly varied series of Ordovician and Silurian sediments. Often faulting has a very strong influence on the location of valleys and associated tributaries. In the margins there is a very well captioned radar image and a schematic cross section showing the superficial deposits. Given the intense glaciations this district experienced, patches of till and related deposits are scattered throughout the area. However, blue lines and symbols for glacial striae, roches moutonnées and other glacial features are completely omitted.

To the east the Dudley sheet (167) covers the district just west of Birmingham and includes the Severn Valley south of the Ironbridge gorge formed by late glacial melt-water capturing its current headwaters. Though the superficial deposits are often lightly scattered, they are a complex mix of units which thankfully benefit from a sheet explanation with over six pages devoted to them, plus further information about ground conditions, mining subsidence, slope stability, pollution potential, and water resources. This includes an excellent figure showing the superficial deposits and ice limit across the district, providing a clear overview and new references to update the publications covering neighbouring sheets. Furthermore, extensive urban areas are completely covered by artificially modified ground, including disturbed ground and former opencast coal sites. Around Dudley this means the Wrens Nest and Castle forming the classic industrialised landscapes associated with this Silurian inlier are lost, and so would have benefited from an insert map at an enlarged scale. Still at least a new edition has been published, as overlaps with the simplified geological map of the National Forest (Ambrose *et al*. 2012) have subdivided the glacial till on the Burton upon Trent sheet (140), and confirmed the pressing need to replace the historic Lichfield sheet (154) with a map based on its recently completed survey.

Further south the Andover sheet (283) covers a large swath of the Wiltshire and Hampshire chalk downs. South of the main escarpment these dissected dip slopes, often mantled with different types of head and clay-with-flints residual deposits, can be clearly seen on the lightly coloured radar image in the margins. This mapping shows these superficial deposits are far more extensive than the late Victorian surveying suggested. In addition, this work shows how en echelon faulting has influenced the form of the Swift Valley such that it cuts obliquely across the fall of the downland, along with picking out a number of other interesting landscape forming faults.

The transformation of the Tiverton sheet (310), mostly within Devon, is even more significant, with a complete overhaul of both the bedrock and superficial deposits beyond alluvium and river terraces by focusing on mass movement and wasting deposits. These are now seen to cover extensive spreads of ground with an impermeable regolith when it formed from the weathering of underlying Carboniferous mudstone, so that both elements of the geological map must be read in unison. This is brought home in a series of three schematic cross-sections illustrating the processes leading to the formation of these deposits in relation to the water table and springs associated with landslips often partly covered by later colluvial material. Due to the nature of this innovative reconnaissance mapping precluding protracted fieldwork, these landslips are suspected to be more extensive. To the north the Dulverton sheet (294) is completely outdated and covers a large portion of the headwaters of the River Exe which flooded several times during December 2012 blocking the London to Exeter mainline railway. Given the increased probability of heavy rainfall with global warming, it would make sense to continue this reconnaissance mapping to enhance the modelling of such runoff from such upland areas.

Finally the Newquay sheet (346) in Cornwall covers part of the north coast and has also been completely rejuvenated. Fresh mapping has refined the bedrock geology and overhauled the superficial deposits to include notable areas of head (another type of regolith), in addition to extensive blown sand, beach and intertidal deposits plus alluvium and artificially modified ground. Offshore there is very little data beyond the distribution of sea-bed sediments shown on an insert map. However, a few offshore bathymetric contours would have helped put this highstand coastline into context, and the airborne radar image of the district could have been pushed eastwards towards Bodmin, rather than showing large areas of blank sea. The enigmatic St Agnes formation is included in an excellent schematic cross-section of the cliffed coastline showing otherwise mainly Quaternary features in a 200 m high profile relative to Ordnance Datum neatly showing the usual mean range of spring tides between high and low water. Another shows the beaches and raised beaches where often varied material deposited above wave-cut platforms is blanketed by blown sand.

Reference

Ambrose, K., McGrath, A., Weightman, G., Strange, P., Lattaway, S., Lott, G., Barrett, D., Dean, S. and Liddle, P. 2012. Exploring the landscape of The National Forest – A walkers' guide to the landscape and natural environment of The National Forest. British Geological Survey, Keyworth, Nottingham. 106 pp + 1:50,000 walkers geological map

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QUATERNARY GEOLOGY OF THE SUMMER ISLES REGION – A BRIEF EXPLANATION OF THE GEOLOGICAL MAP SUMMER ISLES SPECIAL SHEET 33 PP [1]

M.S. Stoker and T. Bradwell

INVERMORISTON (SHEET 73W) [2] : SUPERFICIAL DEPOSITS (SCOTLAND)

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1:50,000 sheets £12 each, sheet explanations £9 each and £18 with accompanying map; 25 % discount for academic institutions when ordered from : **Sales Desk, British Geological Survey, Keyworth, Nottingham NG12 5GG Tel : 0115 - 936 3241 Fax : 0115 - 936 3488 sales @bgs.ac.uk** (prices exclude post and packing - in the UK a minimum of £1.50 and 10% of the original value of the goods up to maximum of £7).

The sheet explanation for the Summer Isles, off the northwest coast of Scotland, has appeared ahead of the intended 1:50,000 special sheet including offshore geology and surrounding mainland which, judging by the pharse "**under review**" in the 2012 BGS catalogue for the Kirkby Longsdale map (sheet 49, England and Wales) due to replace the 1892 edition, has been hanging in the balance. Along with three pending adjacent sheets (Ullapool 101E, Loch Fannich 92E and Loch Maree 92W) with which it overlaps, this truly innovative map was clearly designed to equal the Assynt (2007) bedrock geology special sheet detailing a classic portion of the Moine Thrust (Geology Today, 2010, v 26, p. 200). Assuming it is published, NEXTMap airborne radar imaging merged with GeoSwath bathymetry (for much of the offshore area) is used to generate a stunning shaded relief base map showing a great deal of geomorphological features and grain of the ice-scoured bedrock - like the Anglesey glacial landforms posters (Quaternary Newsletter, No. 127, pp. 50-51). This image also saves the expense of using Ordnance Survey mapping, though the km national grid could have been added, since crown copyright only last fifty years after publication.

Without its map, which usually appears first, this small (21 by 15 cm) colour booklet is a little lost even with its excellent spin-off papers, though it provides a highly informative (and correctly dated) account of late and post-glacial events reflected in the integrated descriptions of the varied units both on and offshore, including sensible use of colour codings. Naturally this account is transformed by including the seismic character of the offshore superficial deposits and really fine photographs of key cores alongside conventional ones of onshore outcrops. This is underpinned by a very clear series of graphic logs and a beautifully detailed annotated image of the Little Loch Broom slide complex greatly enlarged from the general colour bathymetry image in the introduction. This is followed by nearly four pages on geohazards focusing on slope instability and mass failure (since it was written this has come to the fore during 2012 an exceptionally wet year in Britain), along with sea-bed conditions, though the remote possibility of a more significant landslip into a loch or submarine slide triggering a mini-tsunami is not considered.

Further south the Invermoriston sheet (73W) with a conventional base map includes the southern end of Loch Ness along the Great Glen Fault which divides the Highlands physically in two. While bedrock geology is not shown, beyond a simplified insert map, a great variety of landform features is depicted by blue lines in these purple coloured areas, along with many in patches covered by superficial deposits spanning 19 different units. These lines and symbols for glacial striae, roche moutonnée and kettleholes show a wealth of detail, including the estimated late glacial limits of the Loch Lomond readvance also neatly picked out on the annotated 1:175,000 NEXTMap elevation model with informative notes as to how this image reflects the district's Quaternary history. Landslides are tentively divided into two age groups by colouring in older ones and where they are concealed by younger deposits showing their down-slope limits using pecked red lines, also used for esker crestlines and open tension cracks. To complete the marginalia there are correctly timed diagrams based on work first published in Quaternary Newsletter (No. 48, pp1-9) by C.R. Firth 1986 explaining raised shorelines and deltaic deposits around Loch Ness in relation to when it was dammed by former ice limits and a jökulhlaup event when one of them failed resulting in rapid lowering of this lake.

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QUATERNARY RESEARCH ASSOCIATION

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

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

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

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**.

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