QUATERNARY NEWSLETTER

EDITOR:
Dr Sven Lukas  School of Geography, Queen Mary, University of London,
Mile End Road, London, E1 4NS.
(e-mail: s.lukas@qmul.ac.uk)

Instructions to authors

Quaternary Newsletter is issued in February, June and October. Articles, reviews, notices of forthcoming meetings, news of personal and joint research projects etc. are invited and should be sent to the Editor. Closing dates for submission of copy (news, notices, reports etc.) for the relevant numbers are 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
View of Kruševice, a large karst polje within the glaciated limestone mountains of western Montenegro (photograph by Kathryn Adamson) (see Review Article by Adamson et al. in this issue).
I would like to use this editorial of QN to ask for ideas and proposals for future QRA meetings. As everyone knows, the lifeblood of the QRA is our range of meetings, which are run by QRA members for QRA members with support from the QRA Meetings Officer. QRA meetings bring our membership together, stimulate both discussion and new ideas, and showcase our collective work to the outside world. Therefore, meetings in various guises have always played a key role in the QRA’s activities.

However, in recent years, the Executive (and probably the membership as well) have noticed that proposals for meetings have declined in numbers. We attribute this to a large extent to an increased workload in other areas (e.g. teaching, administration), but also to a possible perception that the QRA is only interested in proposals for (multi-day) field meetings.

Whereas traditionally this may have been the case, as we approach our 50th Anniversary, we are keen to evolve and expand our range of activities to reflect the needs of QRA members. Our flagship meetings are the Annual Discussion Meeting (usually held over two or three days in early January) and the annual QRA Postgraduate Symposium. Otherwise, the format of QRA meetings is very flexible – they can take the form of a single or multi-day field meeting; a half, one or multi-day indoor workshop or conference; or a combined workshop and field meeting. QRA meetings can also help deliver outreach activities (including pathways to impact plans) or communicate new research related to the conclusion of RCUK grants. Meetings can also be convened to record a site that is due to be quarried away, which helps our geoconservation efforts at the same time. Field meetings are usually held in the UK or Europe, and indoor meetings can be on any Quaternary topic or area of the world. Organisers of QRA meetings can apply to the QRA for financial support. The QRA also co-sponsors meetings run by other associations where the content of the meeting is of interest to QRA members (see www.qra.org.uk for further details).

If you would like to discuss your ideas for meetings, please contact the QRA Meetings Officer, Dr Eleanor Brown (Eleanor.Brown@naturalengland.org.uk), and to discuss any outreach ideas, please contact the QRA Outreach Officer, Dr Barbara Silva (pollenbird@hotmail.com).

With best wishes,

Sven Lukas, on behalf of the Executive
Review Article

Pleistocene Glaciation of the Mediterranean Mountains

Kathryn R. Adamson, Philip D. Hughes and Jamie C. Woodward

Abstract

There is extensive evidence of Pleistocene glaciation across many mountainous regions in the Mediterranean. Research into the glacial record began over a century ago, but the application of radiometric dating techniques over the last few decades has allowed us to develop more robust geochronologies. It is now established that ice caps and valley glaciers developed on multiple occasions during the Quaternary during Marine Isotope Stages 14, 12, 10, 8, 6, 5d-2 and the Younger Dryas. This review synthesises the Mediterranean glacial record, using some of the most securely dated archives, to explore regional variations in the timing and extent of glacial activity. Understanding these records has important implications for our understanding of Pleistocene glacial dynamics both across the Mediterranean and elsewhere.

Introduction

The Mediterranean mountains have been glaciated on multiple occasions during the Quaternary. There is now considerable evidence for the development of cirque and valley glaciers as well as larger ice fields and ice caps as well as periglacial activity (Cowton et al., 2009; Hughes and Woodward, 2009; Hughes et al., 2010; Calvet et al., 2011; Figure 1). In comparison to the larger Eurasian ice sheets, these Mediterranean ice masses would have been highly sensitive to Quaternary climate change (Hughes and Woodward, 2009). This is not only because of their small size, but also because of their position in the mid-latitudes due east of the North Atlantic Ocean, where millennial-scale changes in sea surface temperatures would have exerted considerable influence on weather systems over the Mediterranean basin (Sanchez Goñi et al., 2002; Hughes et al., 2006a). What is more, the region was not overrun by the large continental ice sheets, and its Quaternary records are frequently well-preserved. These archives can therefore provide important detail to our understanding of Quaternary environmental change.
The glacial history of the Mediterranean has been studied for well over a century, since the pioneering work of Penck (1885) in the Pyrenees and Cvijić (1898) in the Balkans. In 1967 Bruno Messerli completed one of the most comprehensive reviews of the Pleistocene Mediterranean glacial record. This study largely relied on morpholithostratigraphy and was completed before the use of radiometric dating techniques became widespread in a glacial context.

It is only in the last few decades that dating methods such as optically stimulated luminescence (OSL), cosmogenic nuclide, and uranium series (U-series) dating have allowed more robust geochronological frameworks to be developed in the region. These have recently been reviewed in detail by Hughes et al. (2006b), Hughes and Woodward (2008; 2009) and Hughes (2011a). This brief review synthesises the Pleistocene Mediterranean glacial record using the most securely dated glacial archives from five key zones: the Iberian Peninsula; the Italian Peninsula; the Balkans; Anatolia; and North Africa (Figure 1).

![Map of the Mediterranean Pleistocene ice masses based on geomorphological observations.](image)

**Figure 1.** Map of the Mediterranean Pleistocene ice masses based on geomorphological observations. After: Messerli (1967) and Hughes *et al.* (2006b).

**Iberian Peninsula**

During the Pleistocene, glaciers developed on many of the high mountains of Iberia (Hughes *et al.*, 2006) including the Pyrenees, the Picos de Europa and the Sierra Nevada. In the Pyrenees, ice masses reached a maximum thickness of c. 900 m and extended for up to 65 km downvalley (Pallàs *et al.*, 2006). The glacial chronology of this region has been particularly well-resolved (e.g. García-Ruiz *et al.*, 2001; Lewis *et al.*, 2009) using OSL and cosmogenic exposure dating of glacial and glaciofluvial deposits.
In the south central Pyrenees, glacial phases have been correlated to MIS 7, MIS 5, MIS 4, MIS 3-2, and MIS 2 (Peña et al., 2004; Lewis et al., 2009; Pallàs et al., 2010; Calvet et al., 2011). Elsewhere in Iberia, evidence of glacial activity has been correlated to MIS 3 and MIS 2 (Delmas et al., 2008; Cowton et al., 2009; Palacios et al., 2010). During the last glacial cycle, a number of these records indicate a local glacial maximum several thousand years prior to the global LGM (Andrieu et al., 1988; García-Ruiz et al., 2003; Lewis et al., 2009; Domínguez-Villar et al., 2013), which suggests that these glaciers were out of phase with the larger continental ice sheets (Hughes and Woodward, 2008). This behaviour has been observed elsewhere in the Mediterranean, and forms a distinctive feature of the Mediterranean Pleistocene glacial record.

The oldest evidence of Pleistocene glaciation in Iberia has been identified in the Picos de Europa. Here, Villa et al. (2013) applied U-series dating to determine the age of cemented breccias that rest on top of glacially-abraded surfaces. They found that the breccias were cemented during MIS 11 or earlier and the glacial surfaces beneath therefore must be older, possibly forming in MIS 12. Middle Pleistocene glacial surfaces have also been found in the Serra de Queixa and the Serra de Xúres of northwest Iberia, although here they are correlated to MIS 8 based on $^{12}$Ne dating of moraines and glacially-polished surfaces (Fernandez Mosquera et al., 2000). During the early Holocene and Little Ice Age (LIA), isolated glaciers existed only in the highest cirques of the Pyrenees, the Picos de Europa and the summits of the Sierra Nevada (González Trueba et al., 2008). At present, glaciers exist in the central Pyrenees. It has been argued that they represent inherited forms from the LIA (Pallás et al., 2006; Grunewald and Sheithauer, 2010).

**Italian Peninsula, Sardinia and Corsica**

The Italian Peninsula was also extensively glaciated during the cold stages of the Pleistocene. Glaciers and large ice caps were present in the Alps and the Italian Apennines, and smaller glaciers developed in the mountains of Sardinia and Corsica (Carraro and Giardino, 2004).

The last maximum ice advance in the northern Italian Alps has been dated to 30 – 18 ka using $^{14}$C and $^{10}$Be cosmogenic methods (Bini and Zuccoli, 2004; Monegato et al., 2007). This is consistent with evidence from elsewhere in the Mediterranean, such as Greece and Spain (Lewin et al., 1991; Woodward et al., 2008; Lewis et al., 2009), which suggests an early local LGM.

The Italian Apennines contains some of the most securely dated Pleistocene glacial sequences of the Italian Peninsula. In the Campo Felice Basin, six glacial advances have been identified in the Quaternary geological record. A range of dating techniques including $^{14}$C, U-series, $^{39}$Ar-$^{40}$Ar and tephrochronology have been used to correlate these to MIS 14, 10, 6, 4, 3 and 2 (Giraudi, 1998;
The local LGM here has been radiocarbon dated to c. 30-18 cal ka BP (Girauldi, 2004; Giraudi et al., 2011). This chronology contrasts with the evidence from the Iberian Peninsula, where the oldest reported glacial evidence is correlated with MIS 8. In the Campo Imperatore region of the Gran Sasso massif, Central Apennines, the last glacial maximum is dated to 22,680 ± 630 ¹⁴C BP (28,930 – 25,725 cal BP), and preceded the global LGM. At this time, ice covered an area of 19 km².

Pelfini and Smiraglia (1992) reported 201 modern glaciers in the Italian Alps; many of which have shown a broad trend of retreat throughout the historical period. The Ghiacciaio del Calderone is the only glacier in the Italian Apennines, and is one of the southernmost glaciers in Europe (d’Orefice et al., 2000).

**Balkan Peninsula**

As one of the wettest parts of Europe (receiving > 5,000 mm/yr in some parts of Montenegro), the mountains of the Balkan Peninsula still support some small glaciers today (e.g. Hughes, 2007; Djurović, 2013). In the Pleistocene, the Balkans saw the development of some of the largest Pleistocene ice masses in the Mediterranean (Liedtke, 1963; Hughes et al., 2006c; Woodward et al., 2008; Hughes et al., 2010, 2011). Evidence of these glacial phases is preserved from the Julian Alps in Slovenia (Bavec et al., 2004), and in the Dinaric Alps of Croatia (Marjanac and Marjanac, 2004), Kosovo (Kuhlemann et al., 2009) and Montenegro (see references above), and as far south as the Peloponnese in Greece (Mastronuzzi et al., 1994). These glacial records were first studied by Cvijić (1898) and Sawicki (1911).

The mountains of Greece contain some of the best preserved records of Pleistocene glacial activity in the Mediterranean (Woodward et al., 2004; Woodward and Hughes, 2011). Sedimentological analysis of the glacial record of Mount Olympus has been carried out by Smith et al. (1997) though attempts to derive radiometric ages for these deposits have been problematic (Manz, 1998; Woodward et al., 2004). In the Pindus Mountains of northwest Greece there is evidence for three glacial phases, which have been correlated using U-series ages to: MIS 12, 6 and 5d-2 (Hughes et al., 2006b). The largest ice cap, correlated to MIS 12, covered an area of 72.6 km².

In Montenegro, there is evidence for at least four glacial phases (Telbisz, 2010a, b; Hughes et al., 2010, 2011a). Their ages have been constrained using U–series ages to: MIS 12; 6; 5d-2 and the Younger Dryas (Hughes et al., 2010, 2011b) and are in good agreement with the glacial stratigraphy of Greece. There is also evidence of glaciation during MIS 8 within the central massifs of Montenegro. As in Greece, the most extensive glaciation occurred during MIS 12. At this time, large ice caps developed along the Orjen massif (Figure 2) and the central massifs. A series of coalescing ice caps covered an
area of c. 1,483 km² over the Durmitor region (Fig. 3). This formed one of the largest Pleistocene ice masses of Southern Europe, and contrasts markedly with the much smaller MIS 12 ice caps that developed on Mount Tymphi in the Pindus Mountains of northwest Greece (72.6 km²).

**Figure 2.** Glaciated terrain across the upland plateau of Orjen, western Montenegro. Looking NE from near the summit of Subra (1,679 m). An ice cap covered this area radiating outwards from the central plateau of Orjen (Hughes et al., 2010).

Today, glaciers and snow patches exist on several of the highest peaks of the Balkan Peninsula, including the Triglav glacier, Slovenia (Gabrovec, 1998), the Prokletije Mountains of Albania (Hughes, 2009) and the Debeli Namet glacier of Durmitor, Montenegro which measures 0.05 km² (Hughes 2007)

**Anatolia**

In Turkey, Pleistocene glacial landforms have been identified within three key regions: The Taurus Mountains (southeast Turkey); The Pontic Mountain Range (eastern Black Sea coast); and independent mountain chains and volcanic centres across the Anatolian plateau (Çiner, 2004). Surface exposure dating has
Figure 3. Reconstruction of the maximum (MIS 12) ice limits in central Montenegro. The ice cap covered an area of almost 1,500 km². From: Hughes et al. (2011b). Reproduced with permission.
been widely employed to constrain the timing of Pleistocene glacial activity (e.g. Akçar et al., 2007; Sarikaya et al., 2008; 2009; Zahno et al., 2010). These records indicate that the local LGM in Anatolia was broadly in phase with the global LGM (see Sarikaya et al., 2009). This contrasts with other parts of the Mediterranean where the local LGM preceded that of the large continental ice sheets by several thousand years. This emerging pattern of regional contrasts in the timing of the maximum ice advance is an intriguing feature of the Mediterranean glacial record.

Today, glaciers occupy only the highest peaks of Turkey and are largely concentrated in the southern Taurus Mountains. A modern ice cap of c. 10 km², the largest in Anatolia, is present on Mount Ağri (Ararat) (Kurter, 1991).

North Africa

Quaternary glacial landforms are widespread throughout the Atlas Mountains of North Africa (Fig 4), though the timing and extent of Pleistocene glacial activity is not yet fully understood (Hughes et al., 2004). Preliminary results of an on-going ¹⁰Be dating programme from three moraines in the High Atlas have recently been published by Hughes et al. (2011c, d). The oldest advance is clearly pre-global LGM with ¹⁰Be exposure ages ranging from 31.1 ± 3.8 to 76.0 ± 9.4 ka (Hughes et al., 2011d) and may indicate a local glacier maximum in Morocco early in the last glacial cycle (Soltanian Stage). Moraines at higher elevations have yielded younger exposure ages that are close in time to the global LGM. The highest moraines yielded ages that overlap within error with the Younger Dryas (12.9 – 11.7 ka) (Hughes et al., 2011c). Further work is under way to expand the dataset using both ¹⁰Be analyses (on quartz veins) and ³⁶Cl analyses (on basalts and andesites). Today, snow patches exist on the highest peaks, such as Mount Toubkal (4,167 m a.s.l.) in the High Atlas (Messerli, 1980; Hughes et al., 2006b), but glaciers do not exist under the current climatic regime. The only truly permanent snow field is the ‘Névé permanent’ which is present in a gully below the cliffs of the Tazaghart plateau (3,980 m a.s.l.).

Discussion: A Mediterranean-wide framework

The records discussed above represent a selection of the most securely-dated glacial archives in the Mediterranean. These are broadly representative of the wider record, and reveal important details of the Pleistocene glacial history.

Evidence of Pleistocene glacial activity has been identified in Marine Isotope Stages 14, 12, 10, 8, 6, 5d-2 and the Younger Dryas. There is also evidence for several Holocene and present-day glaciers. The Campo Felice Basin, on the Italian Peninsula, is the only location where glacial activity as early as MIS 14 has been reported (Giraudi et al., 2011). This is based on indirect evidence
of glaciation within a long lacustrine sequence. The earliest direct evidence of Middle Pleistocene (MIS 12) glaciations, in the form of moraines, has been identified in catchments in Greece (Woodward et al., 2004, 2008) and Montenegro (Hughes et al., 2010, 2011b). Abraded glacial surfaces thought to have formed in MIS 12 have also been revealed in (Villa et al., 2103). In some catchments, such as in Turkey, at the time of writing there is no reported evidence of glaciation prior to the global or local LGM (Kuhlemann et al., 2009; Sarikaya et al., 2009).

While Mediterranean glacial advances track the large-scale glacial-interglacial cycles evident within other palaeoenvironmental archives, such as the long pollen record from Tenaghi Philippon, Greece (Tzedakis et al., 2003), the glacial records also reveal considerable spatial contrasts. In some catchments, ages suggest a local glacial maximum in phase with the global LGM. In other catchments, such as Northwest Greece (Woodward et al., 2004), Northern Spain (Lewis et al., 2009) and the Italian Apennines (Giraudi and Frezzotti, 1997; Kotarba et al., 2001), morphosedimentary evidence indicates a local

**Figure 4.** A large glacially-deposited boulder being sampled for cosmogenic nuclide dating in the High Atlas, Morocco. A moraine is also present in the distance behind this boulder. Both $^{10}$Be and $^{36}$Cl analyses have been applied to establish the age of moraines in this and neighbouring valleys.
LGM several millennia prior to the global LGM, during MIS 4-2. This is in accord with evidence from other mountain areas around the world where the glacial records of individual cold stages, such that of the last glacial cycle, are spatially and temporally complex (Hughes et al., 2013). What is more, in some mountain ranges, such as the Pyrenees, contrasting glacial histories (both throughout the Pleistocene, and within individual cold stages) have been reported for neighbouring basins. The patchy nature of the Mediterranean glacial record is a function of various factors including catchment-specific characteristics (topography, geology and local climatic regime) and their influence on glacier dynamics, localised variations in the development and preservation of the geomorphological record as well as inconsistencies in dating. The Mediterranean glacial records provide a valuable archive of long-term environmental change, and a valuable opportunity to develop our understanding of Quaternary glacial dynamics.

References


d'Orefice, M., Pecci, M., Smiraglia, C. and Ventura, R. (2000). Retreat of Mediterranean glaciers since the Little ice Age: Case Study of Ghiacciaio del Calderone, Central Apennines, Italy. Arctic, Antarctic, and Alpine Research, 32, 197-201.


Kathryn Adamson
School of Geography, Queen Mary, University of London
Mile End Road, London E1 4NS
k.adamson@qmul.ac.uk

Philip Hughes, Jamie Woodward
Geography
School of Environment, Education and Development
The University of Manchester
Oxford Road
Manchester M13 9PL
Philip.hughes@manchester.ac.uk
Jamie.woodward@manchester.ac.uk
ARTICLE

FINDING IRISH POLLEN DATA

Fraser Mitchell, Bettina Stefanini and Rob Marchant

Introduction

With 17% of the land surface covered by peatland as well as several thousand lakes, Ireland has been a key destination for Quaternary palynology for almost 100 years. Despite its relatively small size (84,422 km²), the island of Ireland can boast 475 pollen diagrams. A catalogue of the metadata associated with these pollen diagrams has been compiled and is available online (www.ipol.ie). The data within the catalogue have also been reviewed in Mitchell et al. (2013) which is available to be downloaded on the IPOL website.

Data in the catalogue

It was never the intention of this project to collate and store the pollen count data; the European and Global Pollen Databases have been established for this purpose. Instead, this catalogue is designed to facilitate researchers to find out where pollen work has already been done in Ireland, to gain some idea as to the temporal extent of the existing data and where to find the relevant publications. Consequently the catalogue contains the following fields:

- Site name
- Latitude (N)
- Longitude (W)
- County
- Altitude
- Site type
- Time span (calBP)
- Top Date (calBP)
- Base Date (calBP)
- No of ¹⁴C dates
- Tephra
- Other dates
- Analyst
- Publication
Figure 1. Map of Ireland depicting locations pollen diagrams within the IPOL database overlaid with site type (From: Mitchell et al., 2013).
Table 1. Number of pollen diagrams in the IPOL database per county listed by province, numbers in parentheses are the province totals.

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Brief review of the data

The pollen diagrams are reasonably well distributed throughout Ireland (Figure 1) but there is some clustering with, for example, sixty-three in Co. Kerry and none in Co. Carlow (Table 1). The vast majority of the sites (88%) are Holocene in age but there are 73 records of Late-glacial age and a further 19 interglacial or interstadial records. There are 221 diagrams with one or more radiocarbon dates and 50 records have used tephra dating.

Use of the catalogue

We have come a long way since Erdtman (1927) published the first Irish pollen diagram. It is anticipated that the catalogue will facilitate future research; not only in indentifying where palynological data already exist but also highlighting areas where data are absent. The catalogue will be maintained through the website www.ipol.ie so that anyone can report new data as well as reporting sites that have been overlooked.

References


The joint Quaternary Research Association (QRA) and British Cave Research Association (BCRA) field meeting on ‘Cave archaeology and karst geomorphology in North West England’ was hosted at the Dalesbridge Centre, North Yorkshire from the 21-24th June 2012. The field meeting was organised by Hannah O’Regan (Liverpool John Moores University) and Trevor Faulkner (University of Birmingham), and attended by 35 delegates including academics, undergraduate and postgraduate students and cavers. The fieldguide, Cave Archaeology and Karst Geomorphology of North West England, containing 19 papers including overviews of the region plus site specific chapters, was distributed to all participants.

The meeting was formally opened by Trevor Faulkner with a summary of the weekend’s upcoming excursions and evening talks. After a quick explanation of the weekend’s schedule we then proceeded onto a brief and amusing introduction on the two associations, the QRA by David Bridgland and the BCRA by David Checkley. These gave a summary of the development, history and purpose of each organisation. Both introductions however raised points about the increasing average age of members of both organisations and the need to encourage younger members to join. Hannah O’Regan then gave a brief introduction about cave archaeology as a discipline and practice and included examples of some of the difficulties archaeologists face when interpreting sites with complex or missing stratigraphic histories. The talk was followed by the first of three excellent meals at the Game Cock in Austwick and an evening of friendly discussions amongst the delegates.

Day 1: Quaternary landscapes, speleogenesis and cave archaeology

The day began at 8.45am outside the Dalesbridge centre with some people only just managing to make the coach. Due to the dreadful weather forecast predicted we were all prepared for the weather, or so we thought... Upon leaving the agreeably arid conditions of the coach, with great enthusiasm and zest we proceeded undeterred by the weather and began the first day’s session on the history of the Kingsdale valley, near Ingleton, led by Arthur Batty and Trevor Faulkner. The focus of this visit was to discuss the Quaternary development of Kingsdale and its many caves. General observations of the deglaciated landscape were somewhat hampered by the torrential rain (90 mm during 24 hours), low cloud and poor visibility, however, in spite of the
inclement weather the walking tour continued as planned (Figure 1). Further up the valley on the Sandymire lake flats the discussion turned to archaeology and the recent discoveries of Mesolithic flints, Bronze Age timbers and stone drains, indicating the long-term occupation of the valley during the Holocene. This was followed by a visit to Yordas Cave, an old Victorian show cave in the Kingsdale valley, which revealed to those unfamiliar with sport caving the full power of the underground rivers that intersect the Dales. During the 20 minutes that we were underground the water levels in the main chamber rose by as much as 40 cm, and so a swift retreat was made to the comfort and safety of the coach. Due to the high water levels we were unable to cross the main chamber to view the two high-level examples of stalagmite deposition on the sediments within the cave, the main reason for visiting Yordas!

Due to the inclement weather the planned tour of the Ribblehead drumlins was replaced by a much welcomed pit stop at the Station Inn and indoor talk by Wishart Mitchell on the surrounding geomorphology and Whernside glacier, as people enjoyed hot soup, hot drinks and the few cold ones on the side to keep the spirits up. This talk detailed the wealth of geomorphological evidence present at Ribblehead for the reconstruction of glacier movement, but emphasised the lack of adequately dated deposits within the immediate vicinity.

**Figure 1.** Bedraggled delegates view Thornton Force, Kingsdale, in the torrential rain. Photo by Lucy Greenwood.
to accurately constrain the date of the LGM and the onset of deglaciation. Due to the distinct lack of visibility, someone kindly drew “expert” diagrams in the condensation of the pub window for those who were unfamiliar with the landscape that should have been visible outside.

Shortly after this the group left the now steamed-up pub and began the final trip of the day – a trip to Jubilee and Victoria Caves above Settle, led by Tom Lord. The speleogenesis of Jubilee and Victoria caves, and the history of archaeological excavations at both sites was discussed, once we were able to hide in them! The first venue, a rather cramped and drippy Jubilee Cave, raised a number of questions as to what a relict phreatic cave passage (formed under a hydraulic surface) was doing ~400 masl in the Langcliffe Scar. The second site, Victoria Cave, was considerably larger in size and provided a more auspicious venue to discuss the history of the cave’s excavation by the Settle Cave Exploration Committee between 1873-78 by William Boyd Dawkins and Richard Tiddeman. Recent analysis of the sedimentary deposits in Victoria Cave have established the cave’s age as >600 ka, with active phases of sediment deposition between the Early Middle Pleistocene and MIS 1.

An further evening talk on Victoria Cave was given by Tom Lord, followed by a display of archaeological remains from The Cupcake, presented by John Thorpe and Andrew Hinde, while the trip organisers rustled up a bed for a delegate unable to get home because of flooding. If anyone doubts just how soggy it was you can view highlights of the day on Youtube: http://www.youtube.com/watch?v=EgnLOKyCBt8

When the talks had finished, we again headed to the Game Cock for our evening meal, just managing to fit round the tables and slowing drying out from the day!

Day 2: Cave archaeology, limestone pavements and erratics

Much to the relief of those in attendance on the second day the prevailing weather conditions had improved significantly, with only a few passing showers throughout the day. The first site, Kirkhead Cave near Grange-over Sands, provoked an interesting debate on the cave’s formation and whether or not the chamber was part of a larger undiscovered system or an abandoned sea cave. It is a spacious chamber, roughly oval in plan and easily managed to fit us all in to hear Ian Smith’s excellent talk on the archaeological finds from Kirkhead, and the history of its excavations during the 1960s and 70s.

A short distance from Kirkhead Cave lies Kent’s Bank Cavern, a relict cave comprised of two connected main passages with numerous cave spiders. Here, Ian’s talk on cave archaeology continued with reference to finds of animal bones and a human femur found at the site. The human remains have been dated to the early Mesolithic period, coinciding with similar mortuary activities at
Aveline’s Hole and Gough’s Cave in Somerset. **Andrew Hinde** from Natural England identified the spiders as *Meta menardi* – European spider of the year, an unexpected bonus on the fieldtrip.

The afternoon’s session began with a walk across the limestone pavement at Hale, led by **Peter Standing**, to discuss the work carried out in his BSc dissertation on the limestone pavements and their development. The work carried out by Peter included a detailed assessment of the lithology of grike erratics and density. **Peter York**, a Ph.D. student at the University of Chester, also spoke about the microclimate of limestone pavement grikes and their similarity to cave entrance habitats.

The limestone pavements at Gait Barrows provided the second venue for the afternoon. This site provided excellent examples of large, undissected areas of smooth clints in the massive, thick-bedded, Urswick Limestone. Prior to the site’s designation as a National Nature Reserve in 1977, large areas of the pavements were damaged by the quarrying of limestone for garden rockeries. **Helen Goldie**’s talk went on to discuss the evolution surface drainage features, including the bowl-like kamenitza, runnels and solutions holes present across the site.

The evening lecture, presented by **Trevor Faulkner**, covered the Devensian deglaciation of the Yorkshire Dales and possible formation of large ice-dammed lakes, which may have been responsible for the formation of high elevation phreatic caves and large surface notches present at Langcliffe Scar and other sites across the Dales. The talk emphasised the lack of recent comprehensive assessment of the way the Yorkshire Dales deglaciated after the LGM and the need to revisit existing literature, such as that by Arthur Raistrick and Ernest Tillotson. The group was then able to retire to the pub for the final time.

**Day 3: Erratics, loessic sediments and palaeoecological and archaeological studies**

The final day began with a visit to the Norber erratics near Austwick, led by **Peter Wilson, Helen Goldie** and **Tom Lord**, and dealt with cosmogenic isotope surface exposure dating of the erratics. Results from the paper by Vincent *et al.* (2010) in Proceedings of the Geologists’ Association demonstrated that the majority of dated surfaces were exposed between 18.86 ± 1.39 and 17.12 ± 2.03 ka (results at 1σ), providing a local constraint on the timings for deglaciation. A significantly younger age on one of the dated erratics was accounted for by the removal of the top ~24 cm of surface during the last 50 years, identified from archived and modern photographs, resulting in an exposure age of 14.35 ± 1.28 ka. A talk on the pedestals at Norber was given by **Helen Goldie**, in which she outlined the early study of these formations and the current theory of their emplacement.
Moving on from the Norber erratics, the delegates were taken to the day’s second site at New Close, near Malham Tarn, where Peter Wilson discussed loessic sediments, which were deposited across much of mainland Europe close to the margins of LGM ice sheets around ~26-21 ka. The talk included a demonstration of the coring techniques used to access the loessic sediments, as well as an explanation of the characteristics of loessic materials, and how these differed from other fine grained materials, such as lake/river alluvium. The 16.5 ± 1.7 ka age of the oldest loess at New Close, determined by the Optically Stimulated Luminescence (OSL) technique, indicates when this site became deglaciated. It should be noted that by Sunday there were fleeting glimpses of the sun, which made things much more congenial!

From New Close we drove down through Malham and to an alternative dropping off point for the Attermire-Horseshoe cave complex, which is around the escarpment from Victoria Cave. Here we were met by Tim Taylor and Graeme Swindles who guided us towards the site of the old Attermire Tarn. At the foot of the Attermire cave complex Tim gave a talk on the recent finds of Romano-British artefacts and settlements found in the vicinity, putting into context the occupation history of the Dales during the Holocene. This was followed by a talk from Graeme, based on the PhD studies of Garry Rushworth at Bradford University, on the palynological evidence that indicates significant changes in the types of vegetation present from the late glacial to the present.

The field meeting was concluded at the Dalesbridge Centre with light refreshments, a raffle, and special thanks from all the delegates to those responsible for organising the event.

Christopher J.M. Smith  
School of Geographical Sciences  
University of Bristol  
University Road  
BS8 1SS  
Chris.Smith@bristol.ac.uk

Tom Elliot  
Archaeology  
Institute of Science and Environment  
University of Worcester  
tom.elliot@outlook.com

Lucy Greenwood  
Department of Archaeology  
University of Exeter  
lucydgreenwood@gmail.com
The All at Sea 2013 meeting, 4-5th July, was hosted by the University of York Environment Department, and held in the historic King’s Manor. The meeting was organised by Katherine Selby (University of York) and was attended by over thirty delegates from more than fifteen institutions across the UK and Europe. During the two day meeting, delegates contributed to oral and poster presentations and discussions during four sessions under the meeting theme: ‘An integrated approach to research in the coastal zone’.

After the welcome in the morning of the first day, the meeting began with a session on ‘Nutrients and ecology of the coastal zone and how they improve our understanding of environmental change’, chaired by Katherine Selby (University of York). This session was opened with a keynote presentation given by Mike Elliott (University of Hull), on the nutrients and ecology of the coastal zone, and explored whether the science is sufficient for environmental understanding and management. This was followed by presentations from Jonathan Lewis (Loughborough University) on changing salinity and nutrient dynamics in the Limfjord, Jutland, Denmark, over long and short timescales, and by Nuno Cosme (Technical University of Denmark), who discussed a spatially-explicit LCIA endpoint model for marine eutrophication and the application to future climatic-driven pressures.
The second session, chaired by Jason Kirby (Liverpool John Moores University) and Roland Gehrels (University of York), questioned ‘What challenges remain in understanding past and future sea-level variability?’ and was opened by a keynote presentation delivered by Ivan Haigh (University of Southampton). He discussed the complexities involved with understanding sea-level and some of the challenges that are faced, providing a very thought provoking start to what was an engaging session. Following a break for lunch, this session continued with Louise Callard (University of Durham) giving a presentation on evidence of past glacial activity and relative sea-level change from the submerged landscape of Belfast Lough; Margot Saher (University of York) then discussed drivers of late Holocene relative sea-level changes in western Iceland using diatom and testate amoebae indicators; Katherine Selby (University of York) discussed Holocene sea level changes along the Tanzanian coast, East Africa, based on mangrove pollen, and David Smith (University of Oxford) discussed sea-level rise and submarine mass failures on open continental margins.

After a coffee break, this session resumed with a talk by Marc Hijma (Tulane University; Deltares) on the evolution of Louisiana’s Chenier Plain and the implications it poses for the Mid/Late-Holocene highstand debate. This was followed by Michael Tooley (University of St Andrews) giving a forty-five year critical retrospect of sea-level investigations in south-west Lancashire, and Ruggieri Gabriella (University of Urbino) discussing sea-level change during the Roman period along the coast of Central Italy. The day then concluded with an engaging discussion on the topics and issues raised during the day, followed by some well-earned drinks and a conference dinner.

The second day of the meeting began with a third session considering ‘New methods to observe and reconstruct coastal change’, and was chaired by Robyn Inglis (University of York). This was opened by a keynote presentation given by Gerd Masselink (University of Plymouth) discussing the importance of field research and numerical modelling in coastal morphodynamic research, and the benefits of adopting both approaches when investigating coastal processes. This was followed by Roland Gehrels (University of York) presenting Holocene sea-level reconstructions from freshwater backbarrier peat systems in southwest England, and the session concluded with Mark Bateman (University of Sheffield) considering if dunes contain an archive of storm events, focussing in particular on the dune systems of Spurn Point.

After a coffee break, the meeting moved onto its final session ‘Marine archaeology’, chaired by Margot Saher (University of York), and began with a keynote presentation given by Geoff Bailey (University of York) providing an archaeological perspective on submerged landscapes and marine geosciences, and how these aid understanding of past sea-level changes as well as the response
of past populations to coastal changes. This session continued following lunch with a talk by Andrew Bicket (Wessex Archaeology) on palaeogeography and prehistory, with reference to investigating the current state of knowledge of submerged prehistory and palaeolandsapes in the British Isles; Peter Murphy (English Heritage) followed with a discussion on the English Heritage Rapid Coastal Zone Assessment surveys and the management of coastal historic environments. Evan Hill (Queen’s University Belfast) then gave a talk on the exploitation of marine resources at the Ha‘u Fte‘ah, Libya, during OIS 2 and OIS 3, and Robyn Inglis (University of York) gave the final presentation on integrating submerged and dryland landscape archaeology in the Southern Red Sea. The meeting then concluded with further interesting discussion on the themes raised during the two days.

Throughout the meeting there were several posters on display that were viewed and discussed informally during the coffee and lunch breaks. These posters incorporated a number of themes covered during the meeting, and included topics such as the reconstruction of historical sea-level trends for the Croatian coast of the Adriatic using saltmarsh foraminifera (Jason Kirby, Liverpool John Moores University); the environmental geochemistry of sediments from Khai River Estuary of Nha Trang Bay, South China Sea (Sofia Koukina, Shirshov Institute of Oceanology of RAS); the effects of storms on coastal ecosystem services and wellbeing (Tom Holmes, University of York) and late Holocene sea-level change and saline intrusion on the Humber Estuary (Louise Best, University of York).

A massive thanks to all the delegates and presenters for making this a truly engaging and enjoyable meeting that encompassed a variety of coastal and sea-level topics, demonstrating the breadth of current research within coastal zones.

Louise Best
Environment Department
University of York
York
YO10 5DD
lab554@york.ac.uk
In June 2013, 40 scientists (Figure 1) met in the New Forest to attend the 12th International workshop on subfossil chironomids. This meeting, hosted by the University of Southampton, brought together researchers from Europe, North America, South America and Asia. This workshop setting fosters coherence and cooperation within the subfossil chironomid community and provides an invaluable opportunity for introducing new researchers to the field. The workshop series began in the mid-1990s, with the most recent meetings being held in Iceland (2007), Denmark (2009) and Norway (2011). The purpose of this workshop was to exchange ideas, discuss new developments in the field and to unify subfossil chironomid larval taxonomy and methods.

The meeting was organised by Pete Langdon (University of Southampton) and Steve Brooks (Natural History Museum, NHM). The QRA and PAGES sponsored the event, providing attendance bursaries for a number of workshop delegates.

The meeting was held over three days, and was split into seven sessions designed to cover all aspects of subfossil chironomid research, with additional practical sessions on taxonomy and statistics.

Day 1

The workshop commenced with a social ice-breaker pre-dinner walk, providing an opportunity to observe New Forest wetlands, heathlands and ponies. Due to the lack of sunshine, the anticipated dragonflies failed to make an appearance, much to the disappointment of Steve Brooks!
Day 2

Session one, "Temperature inferences", contained presentations on chironomid-inferred temperature records from around the world. Nelleke van Asch (Utrecht University) started this session with a talk entitled “Last Interglacial summer temperatures inferred from fossil midges”, and focussed on the differences in chironomid and vegetation based temperature reconstructions. Nelleke discussed the possibility that these differences may reflect responses to different seasonal temperature regimes, underlining the importance of using a multiproxy approach. The following talks in this session covered progressively younger time periods, with Julieta Massaferro (CONICET) presenting the first chironomid-inferred temperature reconstruction from Patagonia, which indicated that a cool period occurred between 14.5 and 11 cal kyrs BP, encompassing both the Atlantic Cold Reversal and the Younger Dryas. Next, both Angela Self (NHM) and Larisa Nazarova (Alfred Wegener Institute) individually presented Holocene and Late Holocene climate records, respectively, from various sites in Kamchatka, Russia. These records show the influence of global teleconnections driving cooling at 5.5, 3.5, 2.7 ka, but also the local influences of forest development and volcanic ash deposition. A high-resolution multi-proxy record from Sweden, covering the last millennium, was presented by Annika Berntsson (Stockholm University), which showed the strong influence of precipitation. The session concluded with a talk by Steve Brooks (NHM), who demonstrated the close similarity between a chironomid-inferred temperature record and meteorological records despite the lake being industrially impacted and eutrophicated.

The theme of the second session of the day was “Training sets and transfer functions”. This session began with a talk by Stefan Engels (University of Amsterdam) who illustrated, with a New England chironomid lake depth dataset, how training set selection, taxonomic resolution and taxa deletion can be critical in influencing model performance and reconstructions. Alberto Arenada (Universidad de Concepcion) presented his work on developing a chironomid-based temperature training set for Chile, and Frazer Bird (Open University) described preliminary results of similar work in the Bolivian and Peruvian Andes. Both studies suggest temperature is a driver of chironomid abundance and distribution in these regions, but further work is required to generate an inference model with adequate performance statistics. Eleanor Maddison (Durham University) spoke about her new Greenland chironomid training set, and demonstrated that it has potential for reconstructing air temperature with existing Greenland chironomid records.

The third session continued the “Training sets and transfer functions” theme. Steve Juggins (Newcastle University) presented his critical evaluation of the use of transfer functions in palaeolimnological quantitative reconstructions, which included more stringent ways in which the data should be tested to evaluate the performance of the inference model and the reliability of reconstructions.
by identifying the effects of confounding secondary variables. Next, Richard Telford (University of Bergen) spoke about his work “Identifying lakes with potential for good temperature reconstructions”. In the following talk Oliver Heiri (University of Bern) discussed recent criticisms of environmental reconstructions and transfer functions using chironomids and concluded that cross-validation of results from other sites or against other independent proxies is an appropriate way to validate chironomid-inferred reconstructions. This session culminated in a lively discussion on the use of chironomids in reconstructing past temperatures and ways to validate reconstructions in the future.

With the talks concluded for the day, two practical sessions ran simultaneously: an informal subfossil taxonomy session and an R-tutorial, run by Richard Telford (University of Bergen) and Steve Juggins (Newcastle University). The final task for the day was to look at a range of interesting research posters, accompanied with a glass of something from the bar.

**Day 3**

With a move away from training sets, transfer functions and temperature reconstructions, the theme of the fourth session was titled “Crossing environmental gradients”. The session opened with a talk by Andrew Medeiros (Wilfred Laurier University) which explored nutrient and productivity gradients in Arctic lakes using chironomids and geochemistry, and demonstrated responses of certain chironomid taxa to climate-driven changes in carbon and nitrogen, which lagged direct temperature responses by other chironomid taxa. Next, Guillermo de Mendoza (University of Barcelona) showed that temperature is the ultimate environmental driver of chironomid species distributions in the mountain lakes of the Pyrenees, although temperature may act indirectly through other environmental and physical variables. Petr Paril (Masaryk University) presented preliminary chironomid results from a palaeolake in the Vihorlat Mountains, the first study of its kind in Slovakia, covering the late-glacial to Holocene transition. Next, Christopher Luszczek (York University, Canada) presented a study of chironomid communities from south-western Hudson Bay, the southernmost treeline in the world, which showed trends towards species typical of warmer, more productive conditions over the last 30 years. To close this session Enlou Zhang (Chinese Academy of Sciences) spoke on his extensive work compiling a huge database of modern chironomid communities from northern China and central Mongolia.

The fifth session, “Trophic changes and human impacts”, began with a fascinating talk by Roberto Quinlan (York University, Canada) on the most polluted lake in America (Onondaga Lake, New York State), describing the widespread human disturbance of the lake’s watershed and related changes in the chironomid assemblages. Wing Wai Sung (NHM) spoke on differentiating
the effects of drought, temperature and nutrient enrichment on the biota of a Danish lake using a multiproxy approach and meteorological records, and **Pete Langdon** (University of Southampton) demonstrated how time-series analysis of palaeolimnological data from a nutrient-enriched lake in China could be used to test ecological theories on the mechanisms driving alternative stable states and provide early warnings of critical ecological transitions. This was followed by a talk by **Katherine Hesketh** (University of Southampton) who is using a multiproxy approach to assess sediment and nutrient accumulation in order to establish baseline conditions in sub-catchment lakes of the River Itchen, Hampshire. **Assia Fernane** (Université Bretagne Occidentale) spoke on how chironomids are being utilised to determine past positions of coastlines in Brittany, France, by their response to salinity changes in river estuaries. This session was concluded with a talk by **Subodh Sharma** (Kathmandu University) on the challenges of sampling high altitude Himalayan lakes in Nepal and their potential for chironomid studies to investigate environmental change in this poorly studied region.

A session on “**Stable isotopes**” started with a presentation by **Kimberley Davies** (University of Southampton) who discussed the potential of chironomids as indicators of lake methane production in Arctic thermokarst lakes through the analyses of stable carbon isotopes from chironomid head capsules. **Maarten van Hardenbroeck** (University of Bern) followed with a talk on taxon-specific stable carbon isotope values in chironomid larvae and head capsules, and showed that in general profundal chironomids were typically more depleted in $\delta^{13}C$ than littoral taxa. **Ladislav Hamerlik** (Matias Belius University) concluded the session by discussing microhabitat influence on chironomid community structure and $\delta^{13}C$ signatures in the low Arctic (West Greenland).

**Gaute Velle** (University of Bergen) opened the final themed session, “**Biodiversity and lake restoration**”, with a talk discussing biodiversity changes in European freshwaters over the last 30 years. The talk focussed on the recovery of lakes and rivers post-acidification from the 1980s onwards, with preliminary results indicating a general trend of increasing biodiversity. The last presentation of the meeting was given by **Isabelle Larocque-Tobler** (LAKES) on restoration of Lake Muzzano in Switzerland, which suffered significant fish kills in 1967 and 1994 due to Microcystis blooms. Isabelle discussed a holistic approach to the problem.

The last day of the conference concluded with a further taxonomy session and R-tutorial, and was swiftly followed by speciality drinks for all from China, Chile and Canada. The workshop finished in style with an impromptu ‘disco’, with a variety of music provided by members of the gathering.

On behalf of everyone that took part, I would like to thank Pete Langdon and Steve Brooks for arranging this invaluable workshop. The location and date of
the 13th international workshop on subfossil Chironomids is still to be decided upon, but may be linked to the next International Palaeolimnology Symposium to be held in China in 2015.

Eleanor Maddison  
Department of Geography  
University of Durham  
Science Laboratories, South Road  
Durham, DH1 3LE, UK  
E.J.Maddison@durham.ac.uk
Background and Rationale

The development of millennial-length palaeoclimate reconstructions from tree-ring stable isotopes requires the compilation of data from multiple sample series. In ring width- or density-based dendroclimatology, series are routinely detrended to remove growth trends and maximise environmental signals, prior to calibration and independent verification against instrumental climate data. (e.g. Cook and Kairiukstis, 1990; Helama et al., 2002; Esper et al., 2012; Wilson et al., 2012a; McCarroll et al., 2013). If tree-ring isotopes contain no long-term age-related trends, then where sufficient individuals can be sampled, isotope series may be combined and interpreted without the need for statistical detrending (Young et al., 2011). Isotopic variability from natural inter-tree variability will be reduced (through replication) to yield palaeoenvironmental data with quantifiable uncertainty. To maximise the potential of the tree-ring isotopic signal for palaeoclimate research it is essential to understand and characterise the natural variability between individual trees. A grant to NJL from the Quaternary Research Association enabled sampling of native Scots Pines from the Cairngorms, Scotland to explore the nature of inter-tree isotopic variability and evaluate the implications for developing robust palaeoclimate reconstructions.

Method

To explore the range of natural inter-tree variability, 100 mature (non-juvenile) Scots pine trees (Pinus sylvestris L.) were sampled from native pine woodland in the Cairngorm Mountains, Scotland. Trees were selected as randomly as possible and to simulate the recovery and selection of sample material from antiquity (Wilson et al., 2012b). This approach includes the caveats that trees exhibiting obvious significant signs of damage or disease or apparently very young trees (<50 years in age) were rejected as these would not normally be used in isotope dendroclimatology. Cores were collected using a 10mm diameter increment borer from trees growing across an area of c. 3.5km² and from a range of woodland micro-environments typical of the region. Tree-rings were precisely dated and wood from the year 2009 manually excised using a scalpel for cellulose preparation and isotopic analysis by pyrolysis at 1400°C (Loader et al., 2013a, b). Analytical precision of standard cellulose was 0.1 per mille (‰) (δ¹³C) and 0.3 per mille (δ¹⁸O) σ n=10.
The resulting carbon and oxygen isotope datasets were explored using a replicate resampling (bootstrap) method to determine how different levels of replication affected the uncertainty in the mean. By sampling at different levels of replication (with replacement), based upon sub-samples of single ring measurements from 1-20 trees it becomes possible to determine the relative confidence intervals associated with the natural variability within the data, to assign uncertainty estimates around the mean and to propose levels of sample replication to attain reasonable uncertainty estimates.

Results and Discussion

The isotopic range for the 100 trees is 2.93 per mille for carbon and 2.35 per mille for oxygen. This range is somewhat large when compared with natural climate-driven isotopic variability over time, but not unexpected considering previously reported intra-tree variability and the non-selective sampling protocol employed here. As the AD 2009 ring falls within the recent period of post-industrial increased atmospheric CO₂ concentration it is also possible that changes in tree response (intrinsic water-use efficiency) resulting from changing CO₂ concentrations will lead to a wider range of variability than observed in pre-industrial times. Therefore these values may be considered as providing a conservative estimate of inter-tree isotopic coherence (McCarroll et al., 2009; Waterhouse et al., 2004).

For a sample size of 10 we can expect 90% of mean values to fall within a range of 0.57‰ and 0.56‰ (carbon and oxygen isotopes respectively), and 95% of mean values to fall within a range of 0.68‰ and 0.67‰. Raising sample size to 20 (95%) gives ranges of 0.50‰ and 0.46‰. For a sample of 5 (95% and 90% confidence intervals) the values are 0.98 and 0.86 per mille for carbon and 0.92 and 0.79 per mille for oxygen.

Conclusion

The results described above suggest that a reliable mean value can be established when ≥10 trees are sampled, although depending upon the aims of the individual study a smaller number may also be acceptable. A potential solution to such resource limitations is the pooling of sample material to yield annualized chronologies at the expense of the individual series. Importantly, these findings confirm that it is highly unlikely that long-term palaeoclimatic changes could faithfully or confidently be reconstructed with only one or two trees.

Acknowledgements:

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**Bibliography:**


Neil J. Loader, Giles, H.F. Young, Danny McCarroll
Department of Geography
Swansea University
Swansea
SA2 8PP
n.j.loader@swansea.ac.uk

Robert J.S. Wilson
School of Geography & Geosciences
University of St Andrews
St Andrews
KY16 9AL
LONG-TERM VEGETATION DYNAMICS IN AN AMAZONIAN PEATLAND

Background and rationale

Researchers working in the floodplains of the Upper Amazon Basin have recently begun to describe the extensive peatlands which exist there. The peat deposits are up to 7.5 m thick and form beneath a range of vegetation types in a variety of hydrological settings (Lähteenoja et al., 2012). Probably covering at least 150,000 km² (Schulman et al., 2009), they make a significant contribution to landscape and biological diversity, and represent a globally important carbon sink (Lähteenoja et al., 2012). Rapid peat accumulation means that they preserve well-resolved palaeoecological records (Roucoux et al., 2013). Our aim in this project is to improve our understanding of the processes which lead to peat formation in Amazonia and to determine the sensitivity of these peat-forming habitats to disturbances and climatic changes by studying their long-term vegetation history (Roucoux et al., 2013). The contribution from the QRA Research Fund enabled me to travel to northern Peru with the project team to carry out vegetation censuses and collect cores for palynological study at three of the peatlands described by (Lähteenoja et al., 2009).

Results

Palynological analyses have so far been completed in core QT-2010-1 from Quistococha, a palm swamp 10 km from the city of Iquitos. The core site is situated in a largely infilled palaeochannel of the Amazon with vegetation dominated by Mauritia flexuosa and Mauritiella armata, typical of many Upper Amazon peat-forming systems (Lähteenoja et al., 2009). The swamp is underlain by up to 4.9 m of peat which lies conformably on lake sediments overlying Amazon channel sediments. Radiocarbon dating yielded an age of c. 2200 cal yr BP for peat initiation and peat accumulation rates of 1.43 to 3.30 mm yr⁻¹. Pollen analysis (Figure 1) has revealed pronounced and sometimes abrupt changes in vegetation composition, including reversals in the apparent trajectory of change (Roucoux et al., 2013). Four distinct phases of vegetation development are represented, with peat accumulation continuing throughout: 1) Cecropia-dominated lake margin vegetation, 2) floating mat and marginal fen vegetation of Poaceae and Cyperaceae coincident with peat initiation, 3) diverse seasonally-flooded forest with abundant Myrtaceae, 4) Mauritia/Mauritiella palm swamp vegetation representing establishment of the present day community c. 1000 years ago.

Significance

This pattern of vegetation change suggests decreasing fluvial influence over time. Given the highly dynamic nature of the Amazon and its floodplain in
Figure 1. Summary pollen percentage and loss-on-ignition data for core QT-2010-1 plotted against age in calendar years before present (AD 1950). Pollen assemblage zones are indicated on the right. Taxa were chosen to represent the key phases in vegetation development recorded at this site. Analysts: K. Roucoux, I. Lawson, T. Jones.
this region, this is likely to be due to migration of the Amazon channel away from the site rather than to the upward growth of peat deposits. Climatic changes may have contributed indirectly by altering the hydrological regime, but any direct climatic effects are probably masked by the impact of fluvial processes. Our census work suggests that there may be a relationship between vegetation community composition and peat presence/absence. However, there appears to be no straightforward relationship between vegetation community and peatland age since the vegetation can revert to an earlier state in response to a change in the hydrological regime. The sensitivity of these peatlands to external drivers means that any long-term autogenic successional trajectory is likely to be overwhelmed by local geomorphological dynamism.

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References


Background and Rationale

Age constraints on the timing of glaciations in southernmost Patagonia are weak and it is not possible to discern the pattern of glaciations without better age controls. The timing and pattern of change has profound implications for our understanding of past global climatic change in a region heavily influenced by important atmospheric and oceanic circulatory systems (e.g. the Southern Westerly Winds and the Antarctic Circumpolar Current; Figure 1), so improved temporal control is much needed.

It is likely that the southernmost ice-lobes of the former Patagonian ice sheet operated within one of two opposing modes – either a step-wise decrease over successive glaciations from the Greatest Patagonian Glaciation (ca. 1000 ka) to the Last Glacial Maximum (LGM, ca. 21 ka; Coronato et al., 2004) or a peak maximum extent during the LGM with no step-wise decrease. Meglioli (1992) advocated a step-wise retreat, giving rise to the classic nested geomorphology described by Caldenius (1932). However, this was predominantly based on relative weathering analyses and correlation with deposits further north. Cosmogenic exposure ages on erratic boulder trains sitting on glacial limits yielded ages far younger than their respective relative ages, leading Kaplan et al. (2007), and later Evenson et al. (2009), to propose that erosion and exhumation of the boulders had caused anomalously low ages. In short, the timing of glaciations in this region remains ambiguous.

Approach

Detailed geomorphological mapping of the study area was conducted using satellite and aerial imagery, combined with field-mapping, to help develop a glacial history for the region and provide context for the dating campaign. A study of the locations, physical characteristics and weathering of erratic boulder trains in Tierra del Fuego was also carried-out. Many of the previous, ‘ambiguous’ cosmogenic ages came from these boulders, so it is important to develop a model for their deposition.

A depth-profile approach to cosmogenic dating is being used to obtain robust ages for glacial limits. This technique provides an age for outwash surfaces and shows whether they have remained stable since deposition. Hein et al. (2011) demonstrated that this can overcome issues of erosion and exhumation that affect erratic boulder samples and produce robust ages for pre-LGM glacial limits.
Preliminary Results

Geomorphological mapping seems to support previous assertions of four major limits for the Bahía Inútil-San Sebastián ice-lobe, but the Magellan lobe may contain more limits and the Otway and Skyring lobes possess more than has been previously reported. The geomorphology of the Bahía Inútil-San Sebastian ice-lobe is particularly complex, and shows evidence of significant readvance(s) rather than simple deglaciation. However the landforms for this lobe suggest recurrently low-energy deposition. Indeed, the geomorphological sequences for all of the ice-lobes are largely dominated by meltwater features and there

Figure 1. (A) Map of the southernmost part of the southern hemisphere showing the location of the study area (black box) as well as the Antarctic Circumpolar Current (black, continuous arrows) and Southern Westerly Wind belt (grey, discontinuous arrows). (B) The locations of the southernmost Patagonian ice-lobes. (C) An example of an outwash depth-profile sampled for cosmogenic dating during the 2013 field-season. Amalgam gravel samples are taken at depths through glaciofluvial outwash to give both an age for the surface and demonstrate its stability since deposition.
is generally a mismatch between the apparent grand size of the ice-lobes and their resulting terminal moraines. Ultimately, development of a glacial history requires robust results from the cosmogenic dating, and these samples are currently being processed.

A public blog about our experiences in the field during the 2013 field-season can be found at:

www.durhampatagonia.wordpress.com

Acknowledgments

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References

Caldenius, C.C.z. (1932). Las Glaciaciones Cuaternarias en la Patagonia y Tierra del Fuego. Geografiska Annaler, 14, 1-164


Christopher Darvill
Department of Geography
Durham University
South Road
Durham
DH1 3LE
christopher.darvill@durham.ac.uk
PALAEOLIMNOLOGICAL RECONSTRUCTION OF ABRUPT CLIMATIC EVENTS DURING THE HOLOCENE IN SOUTH WESTERN GREENLAND

Background and Rationale

It is well documented that the Holocene was characterised by climatic variability (Bond et al., 1993; Alley et al., 1997; Dahl-Jensen et al., 1998; Broecker 2001). Greenland and the North Atlantic Ocean are critical locations for enhancing our understanding of hemispheric and global climate variability (Rasmussen et al., 2007). The Greenland ice-core records have provided a wealth of information about hemispheric climate change (e.g., Bond et al., 1993; Dahl-Jensen et al., 1998). Lake sediment records from south western Greenland provide high-resolution palaeoclimate information about regional Holocene climatic variability (Anderson et al., 2012; Perren et al., 2012).

In 2006, sediment cores spanning the Holocene were taken from two lakes (AT1 and AT4) close to the coastal settlement of Sisimiut (67N°00’008.0”51W°12’31”) in south western Greenland (Figure 1). The cores contain clay laminations throughout and have a distinct layer at the base comprising glacial clays, which may reflect climatic deterioration and sedimentary inwash events. Preliminary loss-on-ignition (LOI) profiles demonstrated a distinct period of low organic content at the base of the core, which may reflect a period of significantly reduced biological production and possible climatic deterioration associated with the 8.2 kyr event in the region (Alley et al., 1997). Furthermore, the LOI profiles are punctuated with pronounced peaks every ~1000 - 1500 years (Figure 2), which may correlate to climatic events comparable in nature, timing and magnitude to Bond Cycles (Bond et al., 1993).

By characterising the sediment accumulation rates and chemical composition of the inwash events, it may be possible to link the sedimentary characteristics to periods of climatic change during the Holocene. This is the first study from south western Greenland which aims to use the characteristics of lake sediment records to identify the timing and magnitude of Holocene climatic variability.

Methodology

The cores were sampled at 1 cm resolution and analysed for sedimentary parameters including LOI, minerogenic (MAR) and organic accumulation rate (OMAR). The cores were also analysed at 1 mm resolution using x-ray fluorescence spectrometry (XRF). Seven bulk AMS$^{14}$C dates (paired with plant macrofossils at one level at AT4 and two levels at AT1) were used to produce chronologies and age-depth models for the lake sediment records.
Preliminary Results

The early Holocene (~10,500 - 9500 cal. years BP) was characterised by high rates of minerogenic deposition in both lakes (Figure 2). At AT4, large increases MAR and Calcium (Ca) (both proxies for catchment erosion) occurred every ~1000 - 1500 years from ~8400 cal. years BP until ~ 4000 cal. years BP. OMAR was low until ~4700 cal. years BP when it demonstrated a rapid increase. The OMAR record from AT1 displays an inverse relationship to that of AT4; high rates during the early Holocene followed by a rapid decline at ~6000 cal. years BP. At AT1 the trends in MAR, Ca and Ti are comparable throughout the Holocene (Figure 2).

Conclusions

High MAR values in the early Holocene (10,500 - 9,500 cal. years BP) reflect the inwash of large quantities of minerogenic sediment that are readily available from recently deglaciated terrain. At AT4, an increase in MAR at ~8400 cal. years BP may indicate increased catchment erosion in response to climatic deterioration during the 8.2 kyr event. Individually, both lakes demonstrate periodic, simultaneous increases in MAR and Ca during the mid-Holocene (8000 - 4000 cal. years BP); indicating episodes of climatic deterioration and subsequent catchment erosion. The contrasting trends in OMAR between the two lakes reflect differences in catchment response to climatic deterioration during the colder, drier conditions of neoglacial (~ 4000 cal. years BP). At AT1, the onset of neoglacial cooling initiated catchment deterioration, vegetation dieback, a return to permafrost conditions, and a decrease in the hydrological transfer of nutrients and sediments into the lake resulting in a decline in organic matter sedimentation. Conversely, at AT4, because of the well-vegetated and
Figure 2. Sedimentary parameters from lakes AT1 and AT4; LOI (%), the organic matter accumulation rate (OMAR) in g cm\(^2\) yr\(^{-1}\), minerogenic accumulation rate (MAR) in g cm\(^2\) yr\(^{-1}\), and Calcium (Ca) and Titanium (Ti) from the XRF data presented as peak area.
steeper geomorphology of the catchment, neoglacial climatic deterioration caused the erosion of peat and soils, which were then washed into the lake. At AT4, these climate-catchment changes resulted in an increase in OMAR from ~4700 cal. years BP onwards.

Acknowledgements

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References


Antonia Law
School of Physical and Geographical Sciences
William Smith Building, Keele University, Keele ST5 5BG
a.c.law@keele.ac.uk
TESTING THE PEATLAND RESPONSE TO LATE HOLOCENE ENVIRONMENTAL CHANGE IN EASTERN NORTH AMERICA

Background and rational

Peatlands play a dominant role in the global carbon cycle by sequestering a third of the earth’s soil carbon. The amount of carbon storage is influenced by climatic conditions; a signal of which is also recorded in ombrotrophic peatlands since their inputs are of atmospheric origin and their accumulation is influenced by the prevailing available water balance (Barber, 1993). This study exploits these excellent archives of atmospheric moisture balance (Barber and Langdon, 2007) with the aim of further understanding the relationship between peatland carbon storage and climate. Late Holocene variations in the moisture balance and carbon dynamics are reconstructed from plateau peatlands across a climatic gradient in eastern North America. Emphasis is placed on investigating changes associated with the most prominent late Holocene Northern Hemisphere climatic alteration: the Medieval Climatic Anomaly-Little Ice Age transition. This change was associated with a ca. 7-10 ppmv decline in atmospheric CO₂ concentrations (Ahn et al., 2012); however the timing and spatial extent of the climatic manifestation is still poorly constrained in eastern North America.

Fieldwork and methods

Four peat cores were obtained during the summers of 2011 and 2012 from the eastern coast of Canada in Maine, Nova Scotia and Newfoundland. These cores have since been analysed for plant macrofossils, bulk density and carbon content throughout the top 2 m of the cores using standard methodologies (Barber et al. 1994; Heiri et al., 2001). Cryptotephra analysis was also completed (following Hall and Pilcher, 2002) to obtain robust chronologies.

Results from the analyses outlined above informed the sampling strategy of the 2013 field season, which aimed to investigate the origin of changes present in the peat stratigraphies; specifically whether environmentally-forced changes can be distinguished from internal peatland responses. A duplicate core was, therefore, obtained from the Newfoundland site along with a core from a proximal peatland. Whilst these two sites are the same peatland type and contain similar plant communities, the pool formations vary (Figure 1).

A further objective was to obtain surface samples for biomarker analysis. Information from the composition of the \( n \)-alkanes will be added to the identified plant macrofossil remains in an attempt to enhance the past vegetation reconstructions. Individual plant samples were collected and placed in tin foil
envelopes in an attempt to minimise contamination. These analyses will be conducted upon completion of the current testate amoebae identifications.

Figure 1. Differences in proximal peatland hydrology – Jeffrey’s Bog (upper) and Fischelle’s Bog (lower)

Preliminary results and conclusions

Eighteen tephra horizons have been identified from the four main study sites with ages spanning the last ca. 4000 years. Preliminary geochemical analysis suggest that all constrained eruptions originate from the Cascade Range and Alaska ca. 5000-6000 km to the west of the sites. The isochrons bracket the time period of the Medieval Climate Anomaly-Little Ice Age transitions, which will facilitate a more accurate comparison of environmental conditions. This work highlights the valuable role of crypto-tephrochronology in enhancing palaeoenvironmental reconstructions and the understanding of the environmental history of eastern North America.
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References


Helen Mackay
Geography and Environment
University of Southampton
Shackleton Building 44
Highfield
Southampton
SO17 1BJ
h.mackay@soton.ac.uk
THE GEOARCHAEOLOGY OF VIKING OVERWINTERING CAMPS IN ENGLAND: PRELIMINARY RESULTS OF A RADIOCARBON DATED PALYNOLOGICAL SEQUENCE AT BRAMPTON IN TORKSEY, LINCOLNSHIRE

Background and rationale
The abundance of Viking metalwork discovered by metal detectors on the site at Brampton in Torksey, Lincolnshire (SK 83460 80340), has received much attention from archaeologists. This attention has focused primarily on the typology of the metal artefacts in relation to the Viking winter camp at Torksey (Blackburn, 2011), as recorded in the Anglo-Saxon Chronicle in 873 AD (Whitelock, 1965: 47), and the excavation of the Torksey Anglo-Saxon pottery kilns (Barley, 1964). The importance of the site in understanding Viking overwintering camps has led to the development of the Torksey Project, a multidisciplinary research project between the Universities of Sheffield and York, the British Museum, and the Fitzwilliam Museum, University of Cambridge.

One aspect of the Torksey Project, and the main topic of my PhD research, is a geoarchaeological and landscape analysis of the site and surrounding environs as it would have existed during the Anglo-Saxon period (400-1066 AD). This research will also contribute to the understanding of why the Vikings chose specific locations to place their overwintering camps. The geoarchaeological and landscape project includes a Holocene timeline of the sediment movement on the site, including a study of the Lincolnshire coversands, a GIS analysis of landscape changes from the Roman period to the medieval period, and finally, a palynological study and radiocarbon dating from the peat sequence that is directly adjacent to the site of the Viking winter camp. The specific aim of this QRA-\(^{14}\)CHRONO Centre Radiocarbon Dating Award was to date the peat sequence in relation to major vegetation changes in the palynological record.

Methodology and results
The British Geological Survey had previously mapped dispersed peat deposits east of the overwintering camp site. A more detailed coring sequence was completed as part of my PhD research in 2011 (Stein, 2013), and this demonstrated that peat covered the whole area east of the site. A small test pit and subsequent coring with a Russian corer enabled the extraction of a sequence of 125 cm. The profile of the peat was recorded at the same time, revealing dry and disturbed peat in the top 45 cm, with increasing humification.
with depth, overlying grey, gleyed clayey-sand at 126 cm. A radiocarbon date of the peat at 125 cm depth indicated that the peat sequence build-up began around 3316±39 CalBP (BETA 317584).

The QRA-\(^{14}\)CHRONO Centre Radiocarbon Dating Award generously granted three additional radiocarbon dates from the Chrono Centre Lab at Queens University Belfast. The samples were derived from the depths of vegetation change, as based on preliminary pollen counts (Figure 1). At 96 cm depth, the peat was very humified, and dated to 2915±42 CalBP (UBA-21481). At this depth, there was a slight rise in some tree species, especially *Quercus*. At 68 cm depth, the peat was moderately humified, and dated to 2413±55 CalBP (UBA-21480), which corresponds to a small decline in Poaceae, a rise in *Corylus*, and resurgence of some tree species. Finally, at the top of the preserved profile at 48 cm depth, the peat was moderately humified to un-humified, and dated to 1749±46 CalBP (UBA-21479); at this time, there was a sharp rise of Poaceae, and dramatic decline in tree and shrub species, especially *Corylus*.

**Significance**

The dated sequence at Brampton in Torksey provides a 1500-year-long timeline for the development of peat and vegetation history of the previously waterlogged area east of the Viking overwintering camp. The peat development indicates that the landscape would have continuously been a waterlogged marshy area throughout prehistory, and that peat was still actively developing into the Roman period; this information may suggest that this area would have been waterlogged throughout the Anglo-Saxon period, though future environmental studies will continue to test this hypothesis. The evidence for clearance throughout the Roman period also provides a vegetation landscape for the outset of the Anglo-Saxon period.

This radiocarbon-dated sequence is one of very few pollen sequences from the Lincolnshire side of the Lower Trent Valley. When fully analysed, this palynological sequence will finally provide a contemporary comparison and allow cross-referencing with the numerous peat and pollen sequences in Nottinghamshire (i.e. Brayshay and Dinnin, 1999; Scaife, 1999; Knight, 2000; Howard, 2004).

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Figure 1. Preliminary pollen results (counts to 200 grains) of percentages of selected taxa, and radiocarbon dating results. Lithology represents increasing humification of peat deposit, overlying gleyed sand.
Finally, special thanks to the Torksey Project, the University of Sheffield, and all land owners who made sampling possible.

References


Samantha Stein
Department of Archaeology
University of Sheffield
Northgate House
West Street
Sheffield
S1 4ET
sstein1@sheffield.ac.uk
ABSTRACTS

A PALAEOENVIRONMENTAL RECONSTRUCTION OF CRAGIE GULLY, ST MICHAELS WOOD, FIFE

Craig R. Frew

Abstract from undergraduate dissertation - submitted as part of the final examination for the degree of MA Honours in Geography and Environmental Science, University of Dundee, 2012

Evidence for relative sea-level changes through the Holocene is examined at a site in St Michaels Wood, Fife using morphological mapping, stratigraphical investigation, grain size measurements, diatom analysis and radiocarbon dating. These methods have permitted a chronology of events to be developed for Craigie Gully which shows an early inundation of the site during the Late Devensian Period. It is suggested that the sediments deposited during this time relate to the High Buried Beach of the Forth Valley, studied by Sissons (1966). A second inundation of the gully is identified based on the presence of marine microfossils and is dated at 6710±110 14C BP. This inundation is related to the Main Postglacial Transgression where raised marine sediments are recorded up to an altitude of 10.45 m (OD). This altitude is considerably higher than previously studied raised marine deposits in the immediate area. Several reasons for the uncharacteristically high nature of the Main Postglacial deposits in Craigie Gully are given. It is most likely that tidal amplification in response to morphodynamic forcing acted to produce the variable altitudes of raised marine deposits seen around St Michaels Wood. Accordingly, it is likely that the high altitude of Main Postglacial deposits in Craigie Gully are a reflection of local tide variations at the time of deposition. The question of whether younger (Blairdrummond) raised marine sediments are preserved at the site is also investigated. It is possible that subtle changes in the raised marine deposits of Craigie Gully could relate to a separation between sediments associated with the MPG Transgression and sediments of Blairdrummond age, however a lack of dated evidence prevents a conclusion from being reached.

The presence of deposits relating to the Holocene Storegga Slide tsunami at the site is confirmed based on sedimentology and microfossil content. The height of tsunami run-up at the Craigie site (5.3 m) appears higher than neighbouring locations and can again be explained by the influence of topography in producing locally variable run-up.
The final event to take place at the site was the formation of a sandbar across the mouth of the gully, separating it from the influence of the tide. Review of temporary sections from farmland to the east (seaward) of the gully suggests that sand deposits also are found extensively over raised marine in this area. It seems possible that successive beach zones have developed seaward of Craigie Gully following Holocene relative sea level fall. By this reasoning the study of land progradation in the Tentsmuir area could provide information regarding rates of relative sea level change since the culmination of the MPG Transgression. Overall, this study has provided a new empirical data point for the understanding of relative sea level change on the Scottish east coast and provides a strong case for the collection of additional material for radiocarbon dating.

References:

THE ROLE OF CLIMATE IN DETERMINING THE ONTOGENY TRENDS OF LOW ARCTIC LAKES, SOUTH WESTERN GREENLAND

Antonia Liversidge (now Law) (PhD)
Loughborough University

This thesis uses palaeolimnological records to reconstruct Holocene ontogeny trends from four lakes in south western Greenland. The research addresses four hypotheses investigating how Holocene lake ontogeny trends vary under different climatic settings, how long-term changes in ontogeny relate to periods of established climatic change in the region, the similarities between proxies within the lakes and between the lakes, and the role of vegetation in lake ontogeny.

The study region occupies the widest ice-free area of south western Greenland and is characterised by a climatic gradient. The area inland and nearer to the ice-margin is arid, receives less precipitation and is warmer relative to the coastal areas. A paired lake approach, using lake records from two inland lakes and two coastal lakes, was adopted to examine the role of climatic setting upon lake development trajectories. Specifically, diatoms were used to reconstruct DI-alkalinity from the lakes using a DI-alkalinity model created from existing training sets in the region (WA_Cla model, $r^2_{\text{boot}} = 0.76$, RMSEP $= 0.28 \log$ alkalinity units), sedimentary pigments to investigate trends in production and sedimentary parameters to reconstruct organic and minerogenic accumulation rates.

All four lakes experienced comparable Holocene long-term ontogeny trajectories; maximum alkalinity in the first ~1000 cal. year BP of deglaciation followed by maximum production during the peak of Holocene Thermal Maximum (HTM) warming (~7000 -6000 cal. years BP). Following the HTM, all lakes demonstrated oligotrophication and a decline in pH. Vegetation development and catchment stabilisation at the end of the HTM may be important in determining the onset of oligotrophication in vegetated catchments. However, the impact of vegetation development on lake ontogeny cannot be isolated from the changes in the lakes associated with the colder and wetter climate which occurred at the end of the peak HTM warming. The timings of the large transitions in the ontogeny trajectories are comparable with established periods of Holocene climatic variability in the region; climate forcing drives ontogeny in these lakes. However, there are short-term differences between the lakes indicating that lakes have different thresholds of ecological change and may respond differently to the same climate forcing. It is concluded that ontogeny is driven by climate but lakes may respond differently to forcing depending on catchment specific characteristics (e.g., geomorphology, location, vegetation development) which can filter out the climate signal or cause climate to influence the lake in a more direct way (e.g., ice-cover, thermal stratification).
REVIEWS


The Yorkshire Dales are one of the best examples of limestone karst terrain in Britain. They contain the longest and some of the deepest cave networks, and the most extensive areas of glaciokarst in the UK. The Yorkshire Dales are comparable to the other great karst regions of the world, in the Mediterranean and North America, for example. This volume provides a comprehensive detailing of the Yorkshire Dales cave and karst system, covering a wide range of specialisms within 16 chapters, including: geology; geomorphology; Quaternary glaciation, travertine and tufa; speleothems; hydrogeology; biology; and archaeology. It is an effective successor of a previous (1974) BCRA volume Limestones and Caves of North-West England and incorporates the many developments in our scientific understanding. In many ways, this volume not only deals with the karst and cave networks of the Yorkshire Dales, but also highlights the value of this area as an earth science laboratory.

The book is expertly produced in full colour with excellent diagrams, maps and photographs throughout. These provide a clear understanding of site locations, landforms and karst processes. Whilst the book does not contain a glossary per se, many of the chapters are equipped with glossary boxes and text boxes which offer detailed specialist information (such as: isotope characteristics and ecological classifications).

Chapters 1 (The Yorkshire Dales) and 2 (Geology of the limestones) provide a very accessible introduction to the region and an overview of the geological significance of the karst landscape. Both chapters are accompanied by excellent geological and geomorphological maps. Chapter 3 (Glaciation and Quaternary evolution) provides a thorough detailing of the Quaternary history of the Yorkshire Dales. The author draws some very good links to the wider context of British Quaternary records and chronostratigraphy. Ice sheet landforms in the Yorkshire Dales are discussed in detail and exemplified by a number of photographs and geomorphological maps. The history of karst development presented in Chapters 4 (Karst geomorphology) and 5 (Limestone pavements) provide a very insightful discussion of karst processes and landforms. The cross sectional diagrams within chapter 4 are particularly suitable for specialists and non-specialists alike. The photographs within Chapter 5 exemplify the classic karst features of the Yorkshire Dales and really highlight the value of these striking landforms within a wider, global karst context.
Chapters 6-10 (Travertine and tufa; Cave geomorphology; Geological influences on the caves; Hydrogeology of the karst; Chronology of the caves; Speleothems and palaeoclimates) are dedicated to the subterranean karst networks and caves of the Yorkshire Dales. These chapters provide excellent detailing of recent advances in the studies of the cave environments. In particular, Chapter 10 presents a highly accessible and informative account of Quaternary dating techniques and their application in the Yorkshire Dales and within cave settings more generally.

Chapters 12-15 (Holocene environments; Subterranean biology; Bats in the caves; and Cave palaeontology) focus on cave and karst (palaeo)ecology and emphasise the broad appeal of this volume. These chapters would be particularly suitable not only for Quaternary scientists working in the UK, but also for cave biologists elsewhere. The final chapters 14 (Cave palaeontology) and 15 (Cave archaeology) further the scope of this publication, whilst providing excellent links to previous chapters. The photographs of bone and tool specimens provide important examples of the cultural uses of the sites. This effectively demonstrates the value of the Yorkshire Dales within the wider, British archaeological record, and provides a very fitting end to this volume.

Although the chapters function very well as stand-alone elements, common themes are developed throughout, and all components are effectively integrated into a single publication. The broad range of subjects means that this volume will be of interest not only to those researching the geological history of the British Isles, but also to those studying karst and cave environments more generally. The authors effectively draw together introductory level text, whilst developing this into more specialised discussion, meaning that this provides an important reference work for karst researchers and Quaternary scientists/geologists as well as wider karst and cave interest groups. This is a highly accessible volume that can be strongly recommended.

Kathryn Adamson
School of Geography
Queen Mary, University of London
Mile End Road
London E1 4NS
K.Adamson@qmul.ac.uk


For any Quaternary Scientist Suffolk is an earthly paradise. I’m quite happy to admit that, given my research and the field trips that I run, I am likely to be biased. In order to justify myself, however, consider the following: if you had to run a “Quaternary” field trip, i.e. a trip that visited sites spanning the entire Quaternary Period, took in sequences that represented a range of depositional environments and climatic settings and contained a good variety of important archaeological sites as well, where would you base it? I would argue that one of the only answers to this question is: Suffolk. Within a short distance you can access sediments the span the onset of the Quaternary through to sediments that offer annually laminated records of the Holocene. Suffolk offers the stratotypes of two of the major British interglacials; Bobbitshole, just outside of Ipswich (the Ipswichian, MIS 5e) and Hoxne in the Waveney valley (the Hoxnian, MIS 11), whilst also containing type sites of several major glaciogenic units; the Lowestoft Formation and the Corton Formation (both MIS 12). Furthermore, the Palaeolithic sites present in the county contain evidence for some of the earliest human occupation in all of northern Europe (Pakefield) and one of the most important hand axe sites to be found anywhere in the world (Hoxne). There is also a rich history of Quaternary study in this county with many of the key early researchers in the field, i.e. Reid, Blake and Woodward, undertaking groundbreaking work in the region during the 19th century.

The title of this volume, “A Celebration”, could not be more apt. It is a celebration, not just of the geology of Suffolk itself, but of the rich history of research that has been undertaken in the county, the ongoing work of professional and amateur geologists and the important work that GeoSuffolk is undertaking in raising the awareness of the public to the geology beneath their feet and the importance of geoconservation. The volume is divided into four main sections. The first of these, “A Foundation”, contains a range of contributions that provide the background to the volume; overviews of the geology (Geodiversity, Suffolk: an Introductory Excursion by Tim Holt-Wilson, Suffolk Geology: my first impressions by Ann Ainsworth and From Pipe Rock to the Pleistocene: a working journey through the geological record by Jeff Redgrave) and education and geoconservation (Suffolk Geology for Children by Susan Brown, The University of the third Age in Suffolk by Derek Barbanell and A history of geoconservation in Suffolk by Jonathan Larwood). This first section finishes with three chapters that are much more focussed on specific sites (Life, the universe and the Sutton Knoll by Barry Hall) or specific time
intervals (Remarks on Natural History in East Anglia and the Quaternary by Richard West) or themes (archaeology in Prehistoric Attitudes: A Suffolk Pedigree by Steven Plunkett). In many ways the contributions in this section are amongst the most interesting, they offer personal insights and reflections from people who have been engaged, for many years, with the study of the geology and the dissemination of the results to the general public. There is almost no other outlet for these kinds of contributions in academic journals and they make fascinating reading.

The second section, which forms the main bulk of the volume, is entitled “The Stratigraphy” and contains review articles, which provide either broad overviews of time intervals, depositional environments and fossil assemblages, or detailed summaries of individual sites. The contributions within this section are too numerous to discuss in any detail suffice to say that many of them are very impressive. Several of these chapters would make excellent review chapters in peer-reviewed journals. They are not, of course, all Quaternary focussed. The geology of Suffolk contains Mesozoic and Tertiary rocks, whilst deep boreholes have retrieved Silurian rocks. There are review chapters covering all of these. The chapter entitled The Chalk of Suffolk by Mark Woods, Rory Mortimore and Christopher Wood is particularly impressive. This wonderfully illustrated chapter provides a detailed overview of the stratigraphy of the chalk, which is a major part of the geology of this region but is, in general, poorly exposed. The chapters on the Pliocene and Pleistocene contain authoritative reviews on the major stratigraphic units; the shallow marine “Crag” units (Why look again at the Coralline Crag? By Peter Long and Jan Zalasiewicz, The Red, Norwich and Wroxham Crags of Northern Suffolk by Richard Hamblin and Jim Rose and The Norwich Crag Geology of the country around Westleton by Howard Mottram), fluvial stratigraphy (Preglacial rivers (Thames, Bytham), palaeosols and early humans in Suffolk by Jim Rose, Richard Hamblin and Peter Allen) and glacial sedimentology/stratigraphy (The genesis and significance of the Middle Pleistocene glacial meltwater and associated deposits in East Anglia by Philip Gibbard and P van der Vegt, Deducing Glacier Behaviour in Suffolk by Peter Allen and Scandinavian Indicators in East Anglia’s “pre-glacial” Succession by Peter Hoare).

There are also excellent, and, speaking as a sedimentologist, extremely accessible and useful review articles on many aspects of the biostratigraphy (Bryozoans from the Pliocene Coralline Crag of Suffolk by Paul Taylor and Anna Taylor, Biotic interaction in the Suffolk Crags by Elizabeth Harper, Burrowing into the past: history of research on the Norwich and Weybourne Crag voles by the late David Mayhew and Determining Macoma species from the Crag by Peter Norton) which conclude with an excellent review on the Palaeolithic archaeology (The Palaeolithic Archaeological Record in Suffolk by Simon Lewis). Throughout this section there are also excellent chapters
that provide reviews of historical or ongoing work on specific sites many of which, such as Harkstead on the banks of the River Stour (Field Guide to the Harwich Formation and Pleistocene Deposits of Harkstead, Suffolk by W.H. George), contain extensive fossil assemblages but have, in reality, received little attention elsewhere. Section three, entitled “Some Geomorphology”, is relatively short but contains some fascinating chapters on the landscape of the region including both fluvial (Gulls of East Suffolk by Caroline Markham) and coastal processes (The Orford Ness Shingle by Christopher Green and The Havergate Island hydrograph anomaly by S.J. Lindford-Wood). Section four, entitled “Florilegium” (a new word for me but apparently “a compilation of excerpts from other writings”, thank you Wikipedia), contains chapters on applied geology, the histories of local museums and biographies of early geologists in the region. Entertainingly, the volume finishes with the editor, Roger Dixon, suggesting a menu based on species found in the Red Crag or their nearest modern equivalent in the case of extinct species. Those readers who don’t have a taste for shellfish will be pleased to know that, considering the richness of the marine mollusc faunas that are found within the Red Crag, only one of the five courses is marine invertebrate based.

Roger Dixon has done an excellent job in collating the diverse array of chapters that are contained within this volume. A nice touch is that, throughout, there are one page summaries of key Sites of Special Scientific Interests (SSSI) in the region which describe and illustrate the key units that are present at each locality. It is great to be reminded about how impressive the Quaternary Geology of some of these sites is. It is easy to forget, for example, that at sites such as Great Blakenham the Red Crag (shallow marine, Pliocene), the Norwich Crag (shallow marine, Early Pleistocene), the Kesgrave sands and gravels (proto-Thames fluvial deposits, Early Pleistocene), the Valley Farm soil (an early Middle Pleistocene palaeosol) and the Lowestoft Till (Middle Pleistocene subglacial till) can be found superimposed at a single locality. The volume is well illustrated and colour is used throughout which makes it an attractive book to read and study. There are some issues. For example, there is not always a logical arrangement to the order of the chapters. Also, when reading the volume, it undoubtedly helps if you have a little background knowledge on the geology of Suffolk as there isn’t enough wider context to the overall regional geology for those readers who have limited background knowledge. These are minor points, however, because the chapters are well-written and accessible. The compilers sought sponsorship to keep the cost of this volume down and, despite the extensive use of colour, it is competitively priced at £20.00. Whether you are actively researching the Quaternary of East Anglia, lead field trips to the region or want to develop a better working knowledge of some of the key Quaternary sequences in the British Isles this is an accessible, informative and, importantly, entertaining volume which is thoroughly recommended.
Ian Candy
Department of Geography
Royal Holloway, University of London
Egham, Surrey
TW20 0EX
Ian.Candy@rhul.ac.uk
QUATERNARY RESEARCH ASSOCIATION

The Quaternary Research Association is an organisation comprising archaeologists, botanists, civil engineers, geographers, geologists, soil scientists, zoologists and others interested in research into the problems of the Quaternary. The majority of members reside in Great Britain, but membership also extends to most European countries, North America, Africa, Asia and Australasia. Membership (currently c. 1,000) 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 Annual Discussion Meeting in January. Current officers of the Association are:

President:  
**Professor D. J. Charman**, Department of Geography, University of Exeter, Rennes Drive, Exeter EX4 4RJ  
(email: d.j.charman@exeter.ac.uk)

Vice-President:  
**Professor D. Schreve**, Department of Geography, Royal Holloway, University of London, Egham, Surrey, TW20 0EX  
(email: Danielle.Schreve@rhul.ac.uk)

Secretary:  
**Dr P. Langdon**, Department of Geography, University of Southampton, Highfield, Southampton, SO17 1JB  
(email: p.g.langdon@soton.ac.uk)

Publications Secretary:  
**Dr I. Candy**, Department of Geography, Royal Holloway, University of London, Egham, Surrey, TW20 0EX  
(email: ian.candy@rhul.ac.uk)

Treasurer:  
**Dr T. White**, 59 Beechwood Avenue, Melbourn, Cambridgeshire SG8 6BW  
(email: t.white@zoo.cam.ac.uk)

Editor, Quaternary Newsletter:  
**Dr S. Lukas**, School of Geography, Queen Mary University of London, Mile End Road, London, E1 4NS  
(email: s.lukas@qmul.ac.uk)

Editor, Journal of Quaternary Science:  
**Professor A. J. Long**, Department of Geography, University of Durham, Durham, DH1 3LE (e-mail: a.j.long@durham.ac.uk)

Publicity Officer:  
**Dr R. I. Waller**, Geography, Geology and the Environment, Keele University, Keele ST5 5BG (email: r.i.waller@esci.keele.ac.uk)

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

The QRA home age on the world wide web can be found at: [http://www.qra.org.uk](http://www.qra.org.uk)

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