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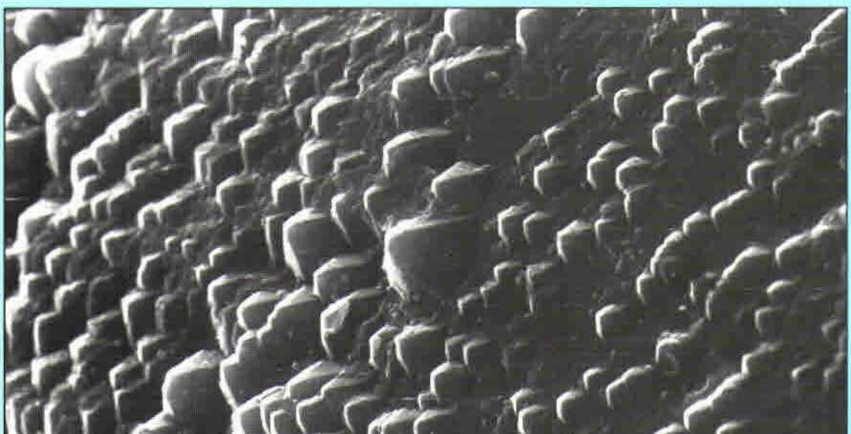

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QUATERNARY NEWSLETTER

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Quaternary Newsletter is issued in February, June and October. Contributions comprising articles, reviews, notices of forthcoming meetings, news of personal and joint research projects, etc. are invited. They should be sent to the Quaternary Research Association Newsletter Editor. Closing dates for submission of copy (news, notices, reports etc.) for the relevant numbers are 1st January, 1st May and 1st September. *Articles should be submitted well in advance of these dates.* The publication of articles is expedited if manuscripts are submitted both as hard copy and on floppy disc. The preferred type for the latter is 3.5" floppy disc in Apple Macintosh format, but IBM PC compatible formats are also acceptable.

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COVER PHOTOGRAPH:
Scanning Electron Micrograph of a quartz grain, from sands of the St Agnes Formation, showing swarms of euhedral quartz overgrowths. St Agnes was one of the highlights of the recent QRA field meeting to West Cornwall, arousing much discussion of Tertiary sediments and landscape evolution (see report by Julian Murton in this issue). Photograph by Stewart Campbell.

ARTICLES

AGE AND ENVIRONMENT OF THE RINGED SEAL (*PHOCA HISPIDA*) FROM SPRINGFIELD CLAYPIT, CUPAR, STRATHEDEN, FIFE

J.D. Peacock and M.A.E. Browne

While we welcome the second paper by Andrew Kitchener and Clive Bonsall on the dating of extinct Scottish mammals (1999), we believe that the authors are over-emphasising the significance of the single radiocarbon analysis of the Cupar ringed seal. The low age (12.5 ka BP normalized; 12.1 ka BP adjusted) contrasts with the higher value (>13.5 ka BP) that would be expected from the event stratigraphy. This we believe to be robust about 13 ka BP, which is the date for the transition from arctic to boreal conditions both on land and offshore (Peacock and Harkness, 1990; Coope *et al.*, 1998). Here we comment further both on the environment of the Cupar seal, and on the distribution of ringed seals generally in Scottish raised marine deposits.

1. In addition to investigating technical matters associated with the radiocarbon date, it would be useful, as discussed with Andrew Kitchener, to examine the matrix of the Cupar seal for marine microfauna. In this connection, our reference to a high arctic marine environment at Springfield and an expected age of >13.5 ka BP for the seal skeleton is not based on the presence of the seal itself but, firstly, on the relationship of the red clay in the claypit to the raised beach sequence and, secondly, on the presence of cold-water marine microfaunas in red clay (Errol Beds, now Errol Clay Formation (ECF)) at Ladybank, west of Cupar, and at the mouth of Stratheden. The remains of ringed seals and the arctic brittlestar *Ophiocten sericeum* have been recorded at the latter locality (Forsyth and Chisholm, 1977; Browne *et al.*, 1981; Peacock, in press).

2. We consider the 'lacustrine' solution for the environment and a Windermere Interstadial age for the Cupar seal to be unlikely. Firstly, none of the ECF in Stratheden is known to be lacustrine (see above), though a former kettlehole lake (Rossie Loch, now drained) floored by peat, and grey, white and brown sand, is situated upstream of, and at a higher level than, the top of the claypit. Secondly, the modern populations (subspecies) of ringed seal referred to by

Kitchener and Bonsall are adapted to fresh water, and have been genetically isolated for thousands of years in very large lakes (Lagoda and Saimaa), with no suggestion that they currently use the rivers to reach the sea (Ekman, 1967; Remmert, 1980; Smith, 1986). Moreover, to the best of our knowledge, no ringed seals have been recorded from strata of Windermere Interstadial age (post-13 ka BP) either in Scotland (e.g. Smith *et al.*, 1904) or Denmark (Jessen, 1936). They are thus unlikely to have been common in the North Sea between 13 and 12 ka BP (see next).

3. Remains of ringed seal are known from 12 localities in eastern Scotland, 10 specimens (including that from Cupar) being from the ECF with its high-arctic fauna, and two possibly from earlier glacial or glaciomarine deposits (Peacock, in press). In this connection, the ringed seal is well adapted to land-fast sea ice (Smith, 1986), and its southern limit of distribution (apart from strays into boreal regions) broadly reflects that of pack ice (National Geographic Society, 1983; Kitchener and Bonsall, 1999, fig. 2). Though the Baltic subspecies extends into the boreal waters of the western Baltic, the young are born only in the Gulf of Bothnia, on ice. Here the highly brackish sea is frozen over for five months of the year or more, and the marine climate is arctic (Ekman, 1967). The number of records of ringed seal in the ECF tentatively suggests that, in agreement with the high-arctic marine climate inferred from other evidence, there could have been a breeding population in the western North Sea in the period 15-13 ka BP. In contrast, during the Windermere Interstadial, although the firths and sea lochs around Scotland are also thought to have been ice-covered in winter (Peacock, 1981), the thickness and duration of such ice is unlikely to have been sufficient to support a breeding population of ringed seals. This may be the reason for the apparent rarity or absence of the species during the Winderemere Interstadial, and an additional reason for its likely non-occurrence post-13 ka BP in Stratheden.

In conclusion, while we believe that the weight of evidence is strongly in favour of a pre-Windermere Interstadial age for the Cupar ringed seal, we are also aware of the arguments in favour of the validity of the radiocarbon determination. The impasse cannot be resolved without further work both on the ground and in the laboratory.

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A POLLEN IMAGE DATABASE FOR EVALUATION OF AUTOMATED IDENTIFICTION SYSTEMS

Andrew Duller, Geoff Duller, Ian France and Henry Lamb

Introduction

The purpose of this note is to draw attention to a web-accessible database of pollen images that can be used to evaluate automated pollen identification systems. One such system, using a neural network approach, is now under development at Bangor and Aberystwyth. The image database described here is designed to allow comparison of our results with those of other groups working on automatic pollen identification.

Early attempts to use computers in palynology were based on computer-aided systems which were developed to automate the use of classification keys (e.g. Guppy *et al.*, 1973). However, these were simply an aid to visual identification by the palynologist. A more exciting prospect is to use computers to undertake the complex task of identifying pollen grains on a slide. The advantages of such an approach have been discussed (Stillman and Flenley, 1996; Green, 1997; France *et al.*, in press), but progress towards a practical system has been slow.

Our approach to automatic pollen identification is based upon neural networks. These have a wide range of applications in the classification of images. We aim to develop a system that could entirely automate the pollen counting process. The requirements of the system are that it should locate pollen grains on a slide placed on an optical microscope, and then classify them. Initial results of this work, using a computer-controlled microscope and a neural-network image analysis system, have been presented by France *et al.* (1997, in press).

An essential part of the development work is assessing the performance of the system in an objective way. In spite of the growth in the use of computers for imaging, we were unable to find a source of images of pollen grains against which we could objectively test our system. Most pollen image collections are meant as identification tools for human pollen counters, and provide one or two images of 'perfect' grains in order to show clearly the distinguishing features of a specific taxon (see list in Appendix I). For testing a computerised identification system a large number of 'real' images of pollen grains are needed, including the grains that are slightly deformed, or which may be orientated so that only some of the key distinguishing features are visible. This type of resource is essential if automated pollen counting systems are to be objectively evaluated and compared. Since we were unable to locate such a resource, we have started to construct a database that fulfils these criteria.

The pollen image database

The database consists of a large number of images of a few pollen taxa. We plan to increase the range of taxa covered in the future. The number of images so far available for each taxon in shown in Table 1. The images were made from reference pollen slides using the automated system described by France *et al.* (in press) at a magnification of 250. Raw images were collected using a charge coupled device (CCD) camera with a resolution of 768 by 576 pixels. These raw images were than processed to identify any pollen grains that were present. Smaller images, typically 80-100 pixels on each axis, were then produced which contain a single pollen grain. Once a grain was detected, the microscope was autofocussed on that grain using an algorithm that takes a series of images at different focal points. The optimal focusing was that which maximised the high frequency content of the image. It was necessary to undertake this procedure of focusing on each individual grain because on a typical pollen slide the grains are not found in a single plane.

The spatial resolution of the images appears low to palynologists, and the level of structural and sculptural detail discernible on the grains is also low (Figure 1). This is because with a computer-based, image-analytical system there is a trade-off between the definition of the image (defined by its size in pixels), and the time taken to undertake the numerical processing within the neural network used to classify the image. If we double the spatial resolution (say from 100 by 100 pixels to 200 by 200 pixels) then the number of pixels increases by a factor of four, as does the processing time. Similarly, the images have different levels

Table 1. List of images available.

Taxon	Number of Images
Plantago lanceolata	727
Quercus robor	382
Alnus glutinosa	1,778
Polypodium vulgare	196
Rumex acetosella	1,034
Conopodium majus	449
Dactylis glomerata	1,200
Polemonium caeruleum	60*
Nymphaea alba	60*
Crataegus monogyna	84*

* These images were collected without autofocussing (see France *et al.* (in press) for details).

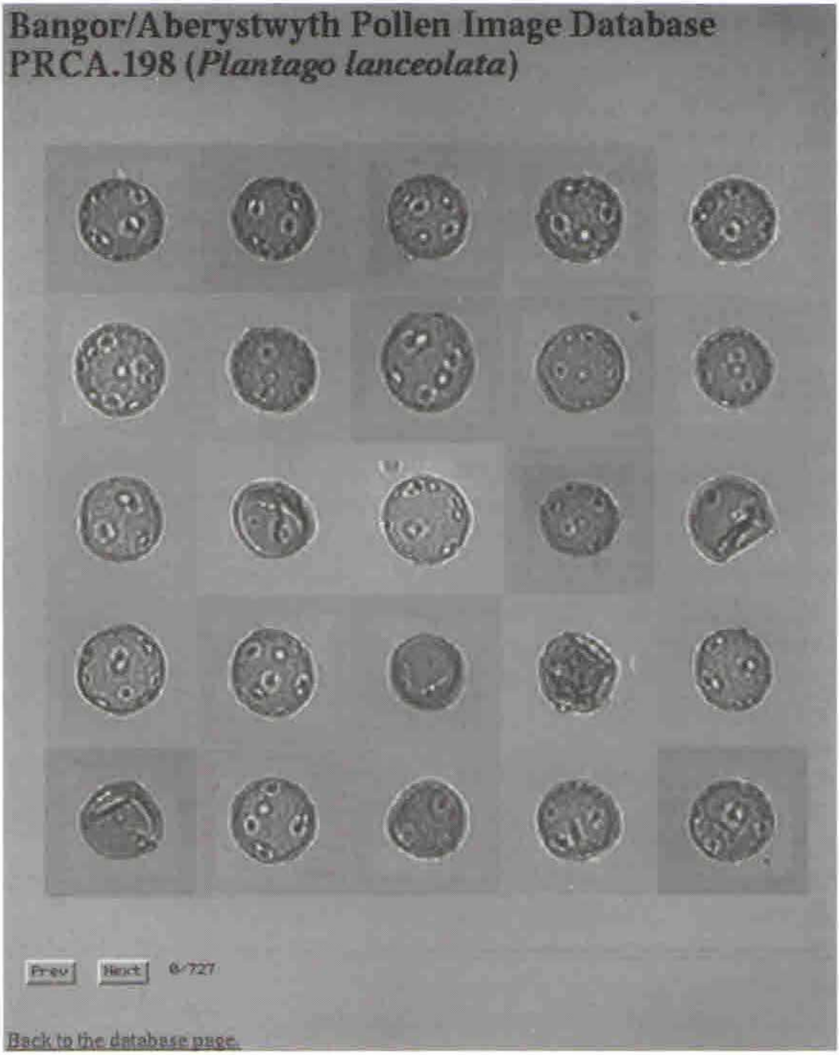

Figure 1. An example of 25 images taken from a reference slide of *Plantago lanceolata*. These were collected using the autofocussing procedure described in the text.

of contrast, some contain small pieces of debris, and others have small optical artefacts from the microscope. In effect, these are 'real' images such as an automated pollen counting system would have to cope with. They are not intended to aid human operators in pollen identification.

Accessing the database

The database can be found at the following location on the world wide web:

http://www.sees.bangor.ac.uk/~ian/pdbase/pollen_dbase.html

The images may be browsed on-line (Figure 1), or downloaded so that they can be used to evaluate a classification system. Instructions about the procedure for viewing and downloading the image files are given on this first page. Download times should be fast since a dedicated server is being used for the database.

We would welcome any comments from other groups interested in this type of work, and particularly those who can use these images on automated systems of their own.

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Appendix I: Annotated bibliography of WWW sites relevant to automated pollen identification and collections of pollen images

1. **Palynology at the University of Arizona**
   This comprehensive site at the University of Arizona is a good starting point for a wide range of pollen websites.
   http://www.geo.arizona.edu/palynology/

2. **Catalogue of pollen types**
   This extensive catalogue of British pollen types has been put together as a result of a NERC grant in 1995 to Keith Bennett. The site is now maintained from the Quaternary Geology Department at Uppsala University, Sweden. Images are available for a wide number of taxa. As discussed above, this database is intended as a key for human operators and contains, normally, a single excellent quality image of each taxon. However in spite of this it is an extremely valuable tool.
   http://www.kv.geo.uu.se/pc-intro.html

3. **Automatic Identification and Counting of Airborne Pollen Grains**
   This project runs from 1998-2001, and is a collaborative effort between the German Weather Service, the Swiss Meteorological Institute and the Institute for Computer Science at the University of Freiburg. The web pages give a brief outline of the project along with some examples of the images that have been obtained.
   http://www.informatik.uni-freiburg.de/~ronnerber/pollen.html

4. **Automated Diatom Identification and Classification (ADIAC)**
   This is an EU-funded project that has been running since 1998. Its overall aims are to study image processing and pattern recognition tools suitable for the automation of diatom identification by computer processing. Although the subject of study is diatoms rather than pollen, many problems are common. The project is run as a European Union network, and a large number of WWW pages exist located at various host institutions. Within the UK one of the most comprehensive pages is maintained at the Royal Botanical Garden, Edinburgh.
   http://www.rbge.org.ac.uk/ADIAC/index.html

5. **USDA Pollen Laboratory**
   An extensive collection of light micrographs and scanning electron microscopy images of pollen, housed by the USDA.
   http://scrl.usda.gov/scrl/apmru/imms/pollen.index.htm

6. **Swedish Museum of Natural History (CD-ROM)**
The Swedish Museum of Natural History is currently putting part of its photographic archive onto CD-ROM. The palynology laboratory is currently working on four CDs containing visible and scanning electron microscopy images of pollen from various collections: Scandinavian pollen, pollen from bee plants, pollen from the international collection, and allergenic pollen.
http://www.nrm.se/pl/cdrom.html.en

7. **African Pollen Database**
The African Pollen Database contains a large number of SEM images of pollen, as well as providing a range of other information.
http://medias.meteo.fr/www/anglais/activites/donnees/

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INTERNATIONAL UNION FOR QUATERNARY RESEARCH (INQUA) AND THE QUATERNARY RESEARCH ASSOCIATION

M.J.C. Walker and G.S. Boulton

Introduction

The International Union for Quaternary Research (INQUA) is the leading body that promotes Quaternary science at the global scale. The Congresses, which are held every four years, are the centrepiece for its activities and provide a forum for Quaternary scientists to discuss research progress over the preceding inter-Congress period, some of which will have been both promoted and supported by INQUA. The purpose of this short note is to provide an update on INQUA for members of the QRA, to explain the recent changes that have taken place in funding for INQUA within the UK, and to encourage colleagues in the British Isles to participate more fully in INQUA and its activities.

The structure of INQUA

INQUA is run by an Executive Committee which is elected at each Congress. The Committee therefore serves for four years and consists of a President, Secretary, Treasurer, four Vice Presidents and the Past President. The Committee for the period 1999-2003 is shown in Table 1. More than thirty countries are members of INQUA (Table 2). The majority of these are West European, and an important goal of the present Executive is to increase the number of members in Asia, South America and Africa. Each member country pays a fee which is based on the GDP of the country and the number of active Quaternary scientists within that country. Those countries with few Quaternary scientists may elect to become Associate Group members, in which case they are directly affiliated with INQUA, but pay only a very modest sum on an annual basis. Fee levels are fixed at each Congress, where bids are also received to host the next Congress. At the recent Durban Congress (INQUA XV), Reno, Nevada, was awarded the 2003 (INQUA XVI) Congress, and approval was given, in principle, to the bid by Japan for INQUA XVII in 2007.

Apart from the four-yearly Congresses, INQUA also supports a wide range of Quaternary research through its Scientific Commissions. The Commissions (Table 3) are run by small Committees which encourage international research collaboration in the form of Working Groups. These groups can apply *via* the

Commission to the INQUA Executive Committee for funding to run the scientific programmes. The awards are not large (typically $500.00/year or slightly less), but are sufficient to cover administrative and some travel costs. In 1996, for example, immediately following the INQUA Congress in Berlin, about $38,000 was provided directly to the 24 projects put forward by the Commissions and approved by the Executive Committee. At the recent Congress in Durban, South Africa, all of the Scientific Commissions produced a half-day symposium on research that had been carried out by their Working Groups during the preceding inter-Congress period.

Table 1.

INQUA Executive Committee, 1999-2003

President:	Prof. Sir Nicholas J. Shackleton	UK
Secretary:	Prof. Sylvi Haldorsen	Norway
Treasurer:	Prof. Allan Chivas	Australia
Vice Presidents:	Prof. Zhisheng An	China
	Dr John Clague	Canada
	Prof. Leszek Marks	Poland
	Prof. Timothy C. Partridge	South Africa
Past-President:	Prof. Stephen C. Porter	USA

The official newsletter of INQUA is *Quaternary Perspectives* which is published by Elsevier Science and is distributed free of charge to Quaternary scientists worldwide[1]. Other information is available either through Commission Newsletters or through the INQUA Home-Page (http://inqua.nlh.no/statutes.html).

INQUA and the QRA

In most countries that have full membership of INQUA, Quaternary scientists in those countries become members of INQUA through an existing scientific body, such as an Academy of Sciences, a National Research Council, or a combination of different institutions or societies. That body is then affiliated to INQUA, a person is appointed as the National Representative at the INQUA Congresses, and the Representative is entitled to vote on behalf of his/her country in the General Council sessions. In the United Kingdom, the affiliated body has, hitherto, been the Royal Society, and the National Representative has been one of us (GSB). The INQUA membership fee has been carried by the Royal Society and, QRA members have been eligible to apply to the Royal Society for grant aid to enable them to attend INQUA Congresses. Over the years, many members of the QRA have received financial support from the Royal Society, either through its Travel and Conference Fund, or through the INQUA Congress Fund which has been managed by the Royal Society, with the assistance of the QRA.

Table 2.

Member countries of INQUA

Argentina	Hungary	Poland
Australia	Ireland	Portugal
Austria	Israel	Russia
Belgium	Italy	South Africa
Brazil	Japan	Spain
Canada	Korea	Sweden
China	Latvia	Switzerland
Czech Republic	Lithuania	United Kingdom
Denmark	Mexico	United States
Finland	Moldova	
France	The Netherlands	
Germany	New Zealand	
Greece	Norway	

Over the last few years, however, the Royal Society has been encouraging learned societies to become the formal adhering bodies to international organisations. In line with this policy, it has now invited the QRA to act as the national organisation that is affiliated to INQUA. This means that the National Committee, which represents the UK in INQUA affairs will, in effect, be the QRA Executive Committee. However it also means that the QRA will be responsible for a proportion of the INQUA subscription fee. The proposal from the Royal Society, which has been accepted by the QRA Committee, is that the QRA, as the affiliated body, pays 51% of the fee and the Royal Society pays 49%. The inter-Congress fee for the period 1999-2003 for the UK is 13,125 Swiss francs (£5,380 at the current rate of exchange) per year, which means that the QRA should pay an annual subscription fee of approximately £2,700. However, the Royal Society has agreed to a transitional period of three years during which the QRA's contribution will rise in three stages (15%, 25% and 51%). Thereafter, the fee will settle at 51%. The Royal Society has agreed to subsidise the QRA (and British Quaternary science) by undertaking to pay 49% of whatever affiliation fee is agreed by the INQUA Congress in the future.

One important corollary of this change in affiliation will be that, from now on, the President of the QRA will be the UK National Representative, and will speak at the INQUA Congress on behalf of British Quaternary science. These changes will considerably strengthen the position of the QRA in INQUA affairs.

The QRA and INQUA

Membership of INQUA offers the opportunity for Quaternary scientists to participate in INQUA Commissions, Committee and Working Groups. In particular, it promotes research collaboration at the international level. One of our aims here is to raise the profile of INQUA with British Quaternary colleagues and, in particular, to encourage members of the QRA to become even more involved in the work of the INQUA Commissions. For the first time for many years, a British Quaternary scientist (Sir Nick Shackleton) has been elected as President of INQUA and, as can be seen on Table 3, several QRA members now hold offices in the Commissions. In addition, Professor Michael Tooley has been appointed as the new Editor of *Quaternary Perspectives*. We would therefore invite those with ideas for research projects at the national and, perhaps more importantly, the international level, to contact either the secretaries or Presidents of the appropriate INQUA Commissions (Table 3). Michael Tooley would also welcome material for *Quaternary Perspectives*. One of the most encouraging features of the recent Congress in Durban was the large number of QRA members at the meeting. Indeed, the British delegation was probably the largest at the Congress. The international profile of UK Quaternary science is already high, but it could be further raised by a greater involvement in INQUA Working Groups and Commissions. This should ensure an equally strong QRA presence at the next INQUA Congress in Reno, USA, in 2003.

By becoming the UK adhering body for INQUA, the QRA has an opportunity to develop new ways of promoting Quaternary science. The QRA Executive Committee will want to discuss how this might be done, but the advice of members, particularly those with experience of the INQUA Commissions, would be very helpful. The QRA could decide, for example, to set up groups to shadow the work of individual Commissions to maximise both the contributions by UK scientists to Commissions and the benefits from them. It could also decide to set up a National Committee for INQUA, as some other

Table 3.

Scientific Commissions of INQUA and officers, 1999-2003

Carbon

President:	Professor Hughes Faure Commission/IGCP 404 B.P. 106 La Poste F-13406 Marseille cedex 09 France email: faure@luminy.univ-mrs.fr	Secretary:	Dr Jonathan Adams Department of Geography University of Adelaide Adelaide, SA 5005 Australia email: jadams@arts.adelaide.edu

Glaciation

President:	Prof. Jan A. Piotrowski Institute of Geology University of Aarhus CF Møllers Alle 120 DK-800 Århus C Denmark email: jan piotrowski@geo.aau.dk	Secretary:	Dr Timothy G. Fisher Department of Geosciences Indiana University NW Marran Hall 238 3400 Broadway Gary, Ind 46408-1197, USA email: t.fisher@iumhaw1.iun.indiana.edu

Global Continental Palaeohydrology

President:	Prof. Kenneth J. Gregory University of Southampton Longmoor Road, Liphook Hants GU30 7PB, UK email: ken.gregory@btinternet.com	Secretary:	Dr Gerado Benito Environmental Sciences Centre, CSIC Serrano 115 bis 28006 Madrid, Spain email: ebvaa75@ccmaa.csic.es

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Table 3.

Scientific Commissions of INQUA and officers, 1999-2003 *(continued)*			
Palaeoclimate			
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countries do; alternatively, the QRA Executive Committee could continue to take on that role. Any suggestions are welcome and should be addressed to the President (MJCW).

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REPORTS

QRA SHORT FIELD MEETING TO WEST CORNWALL

20th - 23rd May, 1999

The meeting was based in Penzance and involved 41 participants, excursion leaders and contributors to the field guide. It began on the evening of 20th May, when the organisers, **James Scourse** and **Mark Furze** (Bangor), welcomed participants to the Cornwall Museum of Geology, home of the Royal Geological Society of Cornwall. A series of lucid introductory talks relating to west Cornwall were given on pre-Tertiary geology (by **R. Shail**, Camborne School of Mines), pre-Pleistocene geomorphological evolution (by **Peter Walsh**, London), Late Pleistocene stratigraphy and palaeoenvironments (by James Scourse) and Late Pleistocene sea-level change in the Celtic Sea (by **Mark Furze**).

Day 1: Penwith and the Hayle-Marazion lowland

Marazion Marsh was the first site visited. The marsh, separated from Mount's Bay by a sand-gravel barrier, is underlain by *c.* 9-10 m of Holocene sediments comprising a basal unit of organic-rich sediments, a middle unit of shelly sand and an upper unit of organic-rich sediment and minerogenic fines. Interpretation of pollen, diatoms and ^{14}C age estimates from the basal, organic-rich unit, **Mick Healy** (Limerick) explained, suggests that the influence on deposition of a probable rise in relative sea level between *c.* 5,500 and 4,500 BP was indirect, consistent with penetration of seawater through the barrier causing a rising water table and increased salinity. The overlying shelly sand records marine deposition sometime after *c.* 4,500 BP and before *c.* 1,600 BP, by which time organic-rich sedimentation has resumed inland from the coast.

Next the party visited some former sand and gravel quarries near St Erth, where **Adrian Marks** (Cornwall College) summarised the history of study and stratigraphy of the St Erth Formation. Analysis of planktonic foraminifera within marine clay, probably *in situ* within this formation, suggests a Late Pliocene age of *c.* 2 Ma BP and a water depth of *c.* 35-45 m above the present level. A Late Pliocene age is also inferred from the pollen assemblage of the St Erth Formation, which suggests a correlation with the Tiglian Stage of The Netherlands.

The third site examined, under the guidance of **Les James** (Reading), was at Godrevy, one of the key Pleistocene stratigraphic sections in south-west England. Overlying a shore platform (4-10 m OD), the main stratigraphic units comprise, in ascending order: (1) a pebbly raised beach; (2) a complex sandy unit, in places cemented to form 'sandrock'; (3) head deposits; and (4) silty (loessic) sand with a modern soil developed on it. The raised beach and overlying (coastal dune) sand constitute the stratotype for the Godrevy Formation, the age of which, regionally, is ascribed to Oxygen Isotope Stage 7 and Substage 5e, although estimates of the age of the raised beach at Godrevy itself range from 'Hoxnian' through OIS 7 to 5e. The overlying head deposits are attributed to solifluction and assigned to the Penwith Formation of Devensian and, possibly, OIS 6 age. Within the sandrock occur palaeokarstic features in the form of sand- or diamicton-filled pipes. As **Peter Walsh** explained, the $CaCO_3$ cement in the sandrock has been derived from the solution of shells. However, the site-specific factors determining the location of pipes remain inscrutable.

After an excellent buffet lunch, the party climbed atop Trencrom Hill, site of a hillfort on the eastern margin of the Land's End Peninsula. Trencrom Hill, as **Jeanette Ratcliffe** (Cornwall Archaeological Trust) discussed, may have been used first as a seasonal camp by Neolithic people. Much later, during the Early Iron Age, were built the ramparts of the hillfort and a number of small circular huts. The last occupation of the site may have been during the Dark Ages, based on sherds of 'grassmarked' pottery found on Trencrom Hill.

The fifth locality examined was beside the bay of Porth Nanven, a few kilometres north of Land's End. The stratigraphic sequence at Porth Nanven, superbly exposed, rests upon a shore platform (*c.* 8.5 m OD) and comprises a cobble-boulder raised beach overlain by head deposits and sand. **Les James** and **James Scourse** described this sequence, assigning the raised beach to the Godrevy Formation and the head to the Penwith Formation. The raised beach is particularly impressive, being the thickest (≤ 8 m) and coarsest in Cornwall, the coarseness probably reflecting the widely-jointed granite sediment source and the very exposed (Atlantic) coastal location. Deposition of the overlying head deposits was attributed by **Deryck Laming** (Exeter) to a débâcle.

The final site visit of the day was to St Loy, on the southern coast of the Land's End Peninsula. As **James Scourse** emphasised, St Loy has the distinction of being the only known Pleistocene site in mainland south-west England where a head deposit contains an organic unit, possibly a palaeosol or lacustrine deposit. The organic unit - fortunately, well exposed - contains a pollen assemblage consistent with either open temperate or arctic tundra grassland, as well as some aquatic species indicative of small pools. The unit has yielded a

^{14}C age estimate of *c.* 29 ka BP, suggesting that the organic material and head deposit (Penwith Formation) are of Devensian age. However, the reliability of this single age estimate is difficult to assess.

Day 2: The Fal Estuary and the Lizard

Day 2 began with a visit to Restronguet Creek in the Fal Estuary, where **Duncan Pirrie** (Camborne School of Mines) gave a lucid and fascinating account of the influence of mine waste discharge on late Holocene estuarine sedimentation in Cornwall. Large volumes of particulate mine waste (tailings) have been released into Cornish rivers as a result of: (1) tin placer mining, from the Bronze age onwards; (2) hard-rock mining, mainly during the last three centuries; and (3) china clay extraction. Geochemical and mineralogical analyses of estuarine sediments from the intertidal areas of the Fal and other estuaries reveal, in places, anomalously high metal concentrations, for example, at the mouth of Restronguet Creek (tin ≤ 1,800 ppm; copper ≤ 2,320 ppm) and a tin 'spike' at a depth of *c.* 40-50 cm in sediment cores from the Tresillian River near St Clement; the tin spike is attributed to a pulse in mine waste contamination during the 1880s and '90s. Further study of the coastal sediment sequences will undoubtedly provide an improved understanding of the early history of Cornish mining.

The second site visited was a coastal lagoon (5.5 ha area; ≤ 3 m depth) at Swanpool, 1 km south of Falmouth. Here, **Paddy O'Sullivan** (Plymouth) summarised the valuable palaeoenvironmental information inferred from microfossil, chemical and mineral magnetic analyses of a 4.5 m deep lake sediment core and interpreted in the light of documentary evidence for catchment landuse changes during the last few centuries. Such changes include the opening of Swanpool Mine in 1760, connection of Swanpool to the sea in 1826 and a peak in mining activity at *c.* 1850. The latter, for example, is thought to have led to high concentrations of copper in the lake, inferred from chemical analyses of biogenic and authigenic fractions of the lake sediments.

From Swanpool, the party moved to Lowland Point, on the Lizard, one of the best loess localities in west Cornwall. The loess (≤ 2.0 m thick) examined was crudely stratified (?reworked) and rested upon an apron of head deposits. The Cornish loess, James Scourse explained, is coarser and mineralogically distinct from the Late Devensian loess found between east Devon and Kent, and was probably derived from glacigenic deposits to the west and south-west of Cornwall, on the floor of the Celtic Sea. Detailed luminescence dating studies of the two loess provinces in southern England are now needed to test the hypothesis that loess accumulation in these areas took place at different times.

After lunch, the party, led by **Peter Ealey** (Lanarth), visited the Crousa Gravels on the Lizard Peninsula. The 'gravel' examined was texturally a diamicton (i.e. stones in a sand-clay matrix); the pebble-cobble-size stones comprise mainly vein quartz, in contrast to the underlying gabbroic bedrock; and the sand-clay matrix, **Peter Walsh** suggested, probably formed by Tertiary weathering of an original, true gravel, producing a saprolite. In support of a Tertiary rather than Pleistocene age for the Crousa Gravels, **James Scourse** noted the dominance of *Engelhardtia* sp. pollen, a Tertiary palynomorph, within a pebbly clay unit. The depositional environment of the Crousa Gravel remains to be established, suggestions including fluvial, shallow marine and, as recently as 1992, glacial settings.

The next locality visited was Loe Bar, a shingle barrier across a coastal lake, Loe Pool, 1 km south of Helston. **Paddy O'Sullivan** summarised the documented environmental history of the local area and the palaeolimnological investigations of the sediments within Loe Pool. The bar has been artificially breached on numerous occasions during the last few centuries, most recently in 1984, to prevent flooding in Helston. The shingle making up the bar, **Deryck Laming** determined by a rapid stone count, includes numerous pebbles of flint, vein quartz, slate and a certain "spotted rock". By contrast, the nearby raised beach at Gunwalloe, **James Scourse** pointed out, lacks flints pebbles; why? The lake sediments in Loe Pool include varves, with black laminae - rich in metallic sulphides derived from mine waste - deposited in anoxic conditions during summer, and grey or brown laminae deposited in oxidising conditions during winter. Currently the sediments are being re-examined to determine if they provide a record of the North Atlantic Oscillation.

The final site vist of the day, guided by **James Scourse**, was to Sydney Cove, Prah Sands, midway between Helston and Penzance. Significantly, the site has yielded the first description (1904-7) in the British Pleistocene of a palaeosol. The palaeosol, within a gravelly silt-clay unit, overlies a raised beach and underlies head deposits. Soil formation is thought to have occurred during two stages, and clearly pre-dates a major episode (?Devensian) of periglacial head deposition. In the centre of the Sydney Cove stratigraphic section, the head is overlain by late Holocene peat (which grades upslope into another buried palaeosol) and recent dune sand. The peat, **Mick Healy** explained, probably developed in a wetland carr-marsh behind a dune barrier.

Day 3: North Cornwall

The third day began with a visit to Trewirgie, in the Redruth Cricket Club Ground, site of a possible Tertiary outlier (*c.* 145 m OD). Here, **Simon Camm**

(Camborne School of Mines) and **Les James** described a sediment sequence, no longer exposed, comprising in ascending order: gravels, sand (?aeolian) and diamicton (head) overlying Devonian metasedimentary bedrock. The basal gravel, with chattermarked surfaces, they interpreted as marine in origin, overlying a shore platform backed by a degraded fossil cliff, although **Peter Walsh** questioned the marine interpretation (see below). The age of the basal gravel, inferred from pollen preserved in clay locally overlying the gravel, is thought to be Miocene.

Discussion of Tertiary sediments and landscape evolution continued at the next site, beside St Agnes Beacon. As Peter Walsh explained, there are two adjacent Tertiary outliers here overlying Devonian metasediments, the "St Agnes Outlier (*s.s.*)" and the "Beacon Cottage Farm Outlier". The former comprises two sand units, possibly of aeolian origin, separated by a clay unit containing lignitic material with a terrestrial pollen assemblage suggestive of a subtropical Mediterranean climate and a Miocene age. Peter suggested that the sub-Miocene unconformity, locally buried beneath the St Agnes Outlier, has been widely exhumed to form a prominent planation surface, the so-called "Reskajeage Surface", for example at St Agnes Head; alas, the Reskajeage Surface was today quite invisible, shrouded in mist. As to the origin of the planation surface Peter favoured pedimentation whereas **Bob Thomas** (Plymouth) favoured etchplanation. The nearby Beacon Cottage Farm Outlier was briefly examined in a pit exposing sand ("Basal Sands") beneath clayey silt ("Candle Clay"). Palynological analysis of samples thought to have been collected from lignitic clay, probably from the Candle Clay, suggests an Oligocene (?Chattian) age for the sediment. Since the lowest elevation of the sub-Oligocene unconformity at this site (116 m OD) is below the basal gravel of possible Miocene age at the previous site, Trewirgie (145 m OD), Peter Walsh questioned whether post-Oligocene sea level could have risen above 116 m OD in this region of Cornwall without completely eroding the weakly consolidated Beacon Cottage Farm Outlier and underlying rotten rock foundation – hence his skepticism about the putative marine origin for the basal gravel at Trewirgie.

Next, the party examined Pleistocene deposits at Fistral Bay, Newquay. As **James Scourse** outlined, the stratigraphic units, from base upwards, comprise: (1) gravel, (2) sand, (3) diamicton (head deposit) and (4) recent dune sand. Units 1 and 2 are interpreted as a raised beach, and unit 2 is in places cemented to form a magnificent exposure of 'sandrock'. Amino-acid analyses of marine shells from unit 2 have been ascribed to both OIS 7 and Substage 5e, and sand from the same unit has given a TL age estimate of *c.* 116,000 BP. The sandrock contains small cemented vertical tubes interpreted as the burrows of tälitrid sandhoppers, precluding a cold-stage origin for the raised beach, because the sandhoppers currently do not occur to the north of southern Norway. Also within the sandrock are palaeokarstic pipes similar to those previously observed by the party at Godrevy.

Following another excellent pub lunch, the party visited Goss Moor, *c*. 15 km east of Newquay, where **Colin Bristow** (St Austell) described the local geology and discussed the evolution of the Upper Fal catchment. Goss Moor is a shallow depression (*c*. 4 km long, east-west, and ≤ 2 km broad) located on the metamorophic aureole to the north of the St Austell Granite and previously mined for alluvial tin. The depression contains a thick (≤ 20 m) sequence of sand, clays and peats above a basal, tin-bearing gravel that overlies weathered Devonian slate. Unfortunately, the details of the sediments and stratigraphy are not clear, but, Colin suggested, would provide, along with nearby periglacial structures in the 'Retew Gorge', good "meat for Quaternary study". The cutting of the gorge itself, by a southward-flowing river occupying the valley of the Lower Fal and exploiting at Retew weaknesses associated with kaolinized granite and a fault zone, permitted river capture of the headwaters of the Fal, which therefore changed course from westward during the Palaeogene to southward, as at present. More fodder for Quaternary study was suggested by **James Scourse**: a peat layer of possible pre-Holocene interglacial age beneath tin ground near Bolventor on Bodmin Moor, described by Pattison in 1865 (see Fig. 8 in the current guide book).

The next locality visited, briefly, was Trewornan, beside the River Amble, adjacent to the Camel Estuary. The sediments at the site, summarised by **James Scourse**, comprise *c*. 13 m of fines and sand, the basal 0.6 m of which are organic-rich. Pollen from the organic-rich sediment suggests wet conditions (e.g. fen-carr) interrupted by a period when scrub woodland developed on or near the site. Diatoms from the same unit suggest an upward transition from freshwater to brackish conditions. A ^{14}C age estimate of *c*. 6,400 BP has been obtained from the basal organic-rich unit, suggesting that deposition of these estuarine sediments began during the mid-Holocene.

The field meeting ended with visits to two important Pleistocene sites beside the Camel Estuary, Tregunna and Trebetherick Point. At Tregunna, the stratigraphy comprises, in ascending order: (1) an involuted slate breccia, (2) the Trebetherick Boulder Gravel and, a little to the west, (3) a diamicton (head deposit). The boulder gravel, which also occurs at Trebetherick Point, has variously been interpreted as fluvial, periglacial (head), glacial, marine (raised beach) or composite (e.g. soliflucted glacial outwash) in origin and has been used to mark a maximum limit of 'Wolstonian' glaciation. Re-examination of the gravel by the site leader (**James Scourse**) suggests that all of the contained clasts are derived from within the catchment of the River Camel and that the decrease in elevation of the gravel with increasing distance up the Camel Estuary is inconsistent with both the fluvial and raised-beach interpretations. Instead, James favoured deposition from river ice, whereby rock clasts were imported into a matrix of mud and sand by river ice floes; however, this interpretation, too, is difficult to reconcile with the altitudinal variation of the gravel along the estuary. Penetrating the gravel and underlying breccia at Tregunna are some wedge structures attributed to thermal contraction cracking under former periglacial conditions.

At Trebetherick Point the party examined an exposure of sandrock interpreted as dune sand overlying a raised beach assigned, on the basis of a single amino-acid analysis, to Substage 5e. The aeolian interpretation of the sandrock was contested by **Deryck Laming**, who thought that some of the stratification could be attributed to "overspill" on a marine beach. Deryck also described the results of a study of the $CaCO_3$ content of beaches around the South-west.

On behalf of the QRA, **John Renouf** (St Brelade, Jersey) thanked the organisers, site leaders and guide contributors for producing an excellent field meeting and guidebook. The meeting proved to be highly successful, for it integrated diverse themes of Tertiary and Quaternary research, clearly summarising the main recent advances in our understanding of environmental change in west Cornwall and identifying promising avenues for future research. The results of the next chapter of this research will be presented, the current organisers promise, at the proposed QRA field meeting in west Cornwall in 2019. Meanwhile, who will rediscover and study the Bolventor peat and ...?

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QRA FIELD EXCURSION TO DUMFRIES AND GALLOWAY

4th - 6th September, 1999

Day 1

A party of around 25 to 30 Association members assembled at the Queen's Hotel on the outskirts of Lockerbie for the start of what proved to be a varied and stimulating three-day programme of site visits and discussions. After a fortifying breakfast the party clambered aboard two mini-buses and a car and set out in a south-westerly direction for the coast. The first site, on the upper estuary of the River Cree below Newton Stewart south of the Galloway Hills, very much established the focus for the rest of day 1 for the emphasis was to be on sea-level change. After a brief introduction by the excursion organiser, **Richard Tipping**, we ascended a hill to get a good view of the lower tidal course of the Cree at which point **James Wells** began explaining the relative sea-level changes of the area. From this vantage point we observed the nearby study areas of Carsewalloch Flow, Muirfad Flow and Palnure, where litho- and biostratigraphic analyses have been undertaken, and the more distant study localities of the Moss of Cree, Carsegowan Moss and the Carse of Clary. However the locality where we were able to get a close-up view of the fine-grained estuarine carse sediments and overlying peats was Blairs Croft on the valley margin. One feature that caused some discussion was the presence of a single-crested beach ridge, one of at least three that extend out across the carse. The effect such features would have on the sedimentary regime provoked comment and we were interested to hear of the presence of more than one mid-Holocene shoreline in the Cree Estuary.

Our next stop was Brighouse Bay, a narrow inlet at the south-eastern extremity of Wigtown Bay that forms the outlet for the River Cree. Again we had **James Wells** as our guide. This time however, in addition to learning of the Holocene evidence, we were also able to hear about late-glacial relative sea-level change. Analyses of foraminifera and ostracods from red/pink silty clays revealed in a gas pipeline in the intertidal zone, suggested that these silty clays were possibly equivalent to the Errol or Clyde Beds. Given late-glacial deposits are known from elsewhere in the south-west of Scotland, this provoked a good discussion as to why no equivalent deposits were known from Cree and the implications this had for isostatic uplift, ice-loading and ice-ablation patterns in the region. Brighouse Bay also provided the first opportunity to introduce Holocene vegetation history – a major theme of the excursion – and, in particular, whether there is a relationship between the rise of alder and increasing relative sea levels as demonstrated here by the simultaneous onset of brackish marl accumulation behind a barrier beach.

Next came lunch in Kirkcudbright and a drive towards Dumfries in order to visit the small valley of Crooks Pow where again we were to learn about early to mid-Holocene relative sea levels. Within the narrow former tidal inlet was an important multi-period archaeological site, Picts Knowe, which mostly belongs to the late Neolithic/early Bronze Age but has evidence for early Neolithic and late Iron Age activity. The result was a nice mix of subjects with **Andrew Haggart** covering the Holocene sea-level change, **Richard Tipping** taking us through early to mid-Holocene vegetation history and groundwater fluctuations, and later Holocene human impact on the vegetation, whilst **Julian Thomas** discussed the archaeology. Sitting in the hot sunshine we learnt that the Late Devensian sea level had fallen from 11 to 1 m OD; that peat began to accumulate in the early Holocene prior to the onset of the main mid-Holocene sea-level transgression; and that marine conditions had receded many centuries before humans arrived. The presence of a brief regressive oscillation around 7,200 ^{14}C BP (*c.* 8,200 Cal BP), also known from other localities in the same region, caused much interest in that several participants thought it might represent a local response to the *c.* 8,200 year-old climatic downturn recently reported from GISP/GRIP. Turning to the archaeology, various attempts were made to show that Picts Knowe was "special" because of its remoteness (communication only being possible from one direction due to the presence of waterlogged peat and clay in the valley floor, and a prominent water-filled gully to the north). Although an acceptable picture for the early Neolithic, there was some doubt whether this could be sustained into the late Neolithic/early Bronze Age when the main phase of "ritual" activity took place. Regarding the vegetational record of the area, one aspect of note was the importance of a climatically dry phase in the mid-Holocene that allowed significant numbers of pine trees to colonise the Late Devensian sands of the valley floor, whilst alder was colonising the wetter peat surfaces. This was ascribed to changes in the substrata that allowed both species to compete successfully with deciduous trees (oak and elm) which otherwise would have been the norm.

From Picts Knowe we moved eastwards to Priestside Flow, 8 km west of Annan, where **Jeremy Lloyd** explained how studies of paired localities north and south of the inner Solway Firth could reveal important information relating to differential isostatic uplift on either side of the estuary. He particularly related how age/altitude index points from the north Solway fitted with the geophysical models of Lambeck (1993, 1995) and Peltier (1998). From there we moved to our final site of the first day, west of Newbie Cottages, where **Alastair Dawson** began by paying special tribute to the pioneering work of Graham Jardine in the area. Ably assisted by **Sue Dawson**, and using data supplied by various co-workers, they explained a number of coastal cliff exposures with intercalated carse clays, peats, sands and soils. Particular attention was drawn to the evidence for two separate periods of carse deposition with an intervening phase of marine regression – dated to *c.* 6,000-6,600 ^{14}C BP in this locality. After this we returned to Lockerbie for a late dinner, our timetable having been overturned by the longer than anticipated periods of discussion.

Day 2

The weather was again warm and sunny but the programme suggested we were in for a very different time. The focus of day 2 was to be the hinterland of the Solway, primarily concentrating on the lowland river valleys. The first site was the magnificently preserved late Bronze Age/late Iron Age fortifications and Roman siege-works on Brunswark Hill above Lockerbie. Here our guide was **Stratford Halliday**. We started by walking to see the small Antonine fortlet on the southern slopes before looking across at the slightly later Roman siege-works and up towards the hilltop defences. Evidence as to why the siege-works are thought to be the result of Roman military training manoeuvres rather than the remains of a genuine siege were discussed and we learnt about the "punctuated" nature of the Roman-British period in Scotland. Next followed a "charge" to the top of the hill where further discussion ensued about the problems of inhabiting such localities where there is no easy access to water. The difficulty in recognising native settlement from the end of the 2nd century AD was also touched upon.

The rest of the morning was spent at Burnfoothill Moss in the parish of Kirkpatrick Flemming, south of Lockerbie. Here **Richard Tipping** explained a particularly rich and intensively studied Holocene palaeoenvironmental record. Much discussion ensued about the conflicting climate signals one can obtain from the different proxy measures he had used on this site, and the question of thresholds and possible human significance. A similar degree of lively discussion was generated when Richard presented the palynological record for human "interest" (*i.e.* disturbance/interference), from the moss and, in particular, the timing and nature of the late Iron Age/Romano-British clearance event so well represented here and elsewhere. At this point the discussion overflowed the allotted time so much so that the third locality we were intending to visit that morning – the Kirtle Water – had to be dropped from the programme. As it was we still arrived late for lunch.

From Burnfoothill Moss we turned north into the foothills of the Southern Uplands to the headwaters of the White Esk and the archaeological site of Over Rig. This extraordinary late Iron Age and Romano-British ceremonial site nestles at the base of a natural amphitheatre, and for this reason provided an ideal opportunity to study the small-scale vegetational changes associated with a well-defined pollen recruitment catchment. **Stratford Halliday** began by outlining the archaeological background to Over Rig, describing what was found during the excavations in the 1980s, and placing the site within the context of what is known of the local late prehistoric archaeological landscape. **Richard Tipping** then proceeded to explain the work he and William Boyd had undertaken whilst the site was under excavation. Palaeobotanical studies of wood and macrofossils from one of a number of waterlogged ditches had suggested the coppicing of 5-12 year-old hazel. Pollen from fine, rapidly deposited clay laminations in the base of the ditch seemed to confirm this with abrupt oscillations in the hazel curve suggesting blocks of similarly aged coppice had been harvested simultaneously. If the interpretation is correct then this example is of considerable importance representing one of the few clearcut records of woodland management.

The next stop was a rather more typical locality on the floor of the Annan Valley south of Moffat at Catharine Hill. This site provided **Richard Tipping** with an opportunity to start explaining the fluvial stratigraphy and chronology of the River Annan whilst continuing the theme of Holocene vegetational change. The site consisted of a small basin or kettlehole between fluvioglacial outwash structures. We heard how Paula Milburn's pollen record from the site exhibited a high degree of temporal resolution for the mid-Holocene with one (or two?) identifiable discernible periods of Mesolithic impact, but that the early post-glacial period is missing and the later Holocene sequence is poorly resolved. **Rupert Housley** reported that a broadly similar palynological picture could be observed in Susan Ramsay's diagram from Northholm Plantation, 12 km downstream in the Annan Valley.

The final visit on day two was to the Frenchland Burn, a tributary of the Annan upstream of Catharine Hill. Again our excursion organiser, **Richard Tipping** continued his elucidation of the fluvial history of the Annan by explaining the nature and timing of overbank accumulations against organic peat growth. This provoked discussion as to what caused such fluvial systems to switch from one sedimentary regime to another. A possible link with sea-level events nearer the coast was deemed unlikely.

Day 3

In contrast to the first two days the weather on day 3 began misty and overcast. This was awkward in that we had planned to visit the uplands; however the poor visibility meant the programme had to be changed. As it was the first stop, the exceptionally well-preserved prehistoric landscape of settlements, hut-circles, and cairns on Stanshiel Rig above Moffat, was possible and **Stratford Halliday** did his best to point out the different monuments despite a rather too luxurious cover of obscuring vegetation. The site provoked discussion as to whether such presumably typical sites (although atypical in terms of its exceptional preservation) represented continuous settlement over a long time period or represented a series of short intermittent habitation events separated by long periods of less-intensive use, for example as grazing.

Next stop was Grey Mare's Tail, a hanging valley leading to Loch Skene where there is some of the best evidence for the Loch Lomond Readvance in the Southern Uplands. Unfortunately the poor visibility prevented us visiting the moraine system up at Loch Skene and so **John Gordon** had to explain the evidence using a lower altitude valley. Despite this a good discussion was generated with the problems of dating such features being well aired. The limited nature of glacier development in the Southern Uplands during the Loch Lomond Readvance was focused on and the information this conveys about differences in climate between this stadial and earlier in the Late Devensian when the area formed a major centre of ice-sheet accumulation.

By preventing a visit to Loch Skene, the weather also precluded us from looking down to Rotten Bottom where our next guides, **Alison Sheridan** and **Richard Tipping**, were to have introduced the site of the oldest bow found in Britain. Instead we learnt about Rotten Bottom whilst looking up towards the escarpment beyond which the site lies at 660 m OD as the mist slowly thinned. We heard that a chance find by a local walker in 1990 revealed two thirds of yew flatbow (D-shaped in cross-section) that had broken in use, which when ^{14}C dated produced an age of 4,040-3,640 Cal BC. Tests on the bow and analogies to ethnographic accounts indicated it would have been suitable for hunting deer, although the shooting range would have been no more than 10-15 m. Palaeoenvironmental analyses were used to investigate whether woodland existed at this altitude in the mid-Holocene or whether blanket peat had already covered the area as it does today.

Lunch on the final day was in the sight of the magnificent waterfall at Grey Mare's Tail. We then headed off to our last, and most northerly, site in the Clyde Valley near Biggar where **John Rowan** brought us almost up to the present day when he presented a site where studies have charted the impact of historical metal mining on fluvial systems. Here we heard about "zircon slugs" (zircon-rich sediment accumulations travelling downstream) and "hushing" (water torrents used to assist mining). Geochemical analyses of the fine-sediment have allowed the elucidation of the various peaks of historical metal mining in the headwaters of the River Clyde. This led to some discussion of the various problems of differential sediment input and transport and the effect this would have on such studies. At this point **Kevin Edwards** gave a vote of thanks before we headed back to the vehicles.

The success of this field excursion is very much the direct result of all the hard work and effort of the contributors and the people who helped behind the scenes. However, the main organiser, Richard Tipping, deserves particular mention for instigating the field excursion, sorting out the itinerary, getting all the contributors together, and for looking after the logistics of the meeting. The varied programme and the amount of thought-provoking discussion must to a large extent reflect the breadth of research that has been undertaken in the region by many individuals over recent years.

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REVIEWS

A REVISED CORRELATION OF QUATERNARY DEPOSITS IN THE BRITISH ISLES

Edited by D.Q. Bowen
Geological Society Special Report No. 23
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Some still mistakenly believe that the British Isles are part of Eurasia - but not for the British. For them Britain is an independent continent and, for that matter, the primary one! This point is clearly demonstrated in the compendium of Pleistocene stratigraphic units of the British Isles (England, Ireland, Wales and Scotland and their continental shelves), edited by D.Q. Bowen, because nowhere in the 174 pages of this remarkable book can one find a mention of Riss or Würm - those terms of foggy meaning, sacred to every Quaternary geologist in France! Were it not for the misspelling on Table 28 we would not even learn about the North European glacial and interglacial stages, such as Weichselian and Holsteinian. Table 28 summarizes the stratigraphy of the continental shelf, a hated segment of the Earth's crust that deprived Britain of independence through much of the Pleistocene!

But D.Q. Bowen's team did what all Quaternary stratigraphers should be doing. They made their correlations with the continuous depositional sequences of the ocean floor because they understood it would be difficult to reconstruct a complete Pleistocene climate history from pitifully incomplete geologic evidence on land. The authors were careful not conceal in any way this substantial deficiency of the land-based stratigraphic systems. As closely as reasonably possible, they marked blanks where the evidence is missing. They did not use elaborate systems of boxes and separation lines in the correlation tables, giving a false impression that every single minute of the Earth's history is accounted for and every unit boundary clearly fixed. Instead they established the facts.

The book is a follow-up to the classification of British Quaternary deposits published by Mitchell and co-authors in 1973 as Geological Society Special Report No. 4. Edited by David Bowen of Cardiff University, it has 15 authors and many more contributors. It has 12 chapters followed by 34 densely packed pages of references. The introductory first chapter, written by Bowen, explains the philosophy of correlation and summarises the state of the art. The remaining chapters are based on regions. Each lists in stratigraphic order the lithologic formations and members of the area, their stratotypes and their geographic co-ordinates given in the British and Irish Ordnance Survey Grids. Also included are brief lithologic and biostratigraphic characteristics of the units, available age determinations and the relevant references. A map provided in each chapter shows the position and the name of the localities. Unfortunately it doesn't contain the grid so that a reader unfamiliar with local geography may have a hard time finding a particular stratotype. The material is arranged in a format similar to the classic work of Willman and Frye on the Pleistocene stratigraphy of Illinois (Illinois State Geological Survey Bulletin 94, 1970).

What is new are the tables showing correlations of the land-based units with marine oxygen isotope stratigraphy that is dated by palaeomagnetic horizons and fine-tuned to the Earth's orbit. The correlations are supported by available radiocarbon, amino-acid and thermoluminescence data. The aminostratigraphy is especially helpful for making correlations with Oxygen Isotope Stages. This is widely applicable to the type of deposits common in the British Isles and the resolution of the method is sufficient to differentiate between individual glacial cycles, a task crucial in linking the sediments from the last half million years with marine stratigraphy. Excessive reliance is sometimes attached to these because their accuracy is still hotly debated. But correlations with the deep-sea units appears to be generally reasonable.

From evidence elsewhere in the world, it appears that there were only three major cold episodes when glaciers reached far to the south. These correlate with Oxygen Isotope Stages 2, 6 and 12. The boundary between Stages 12 and 11 is the extremely pronounced Termination V that correlates with the Elsterian-Holsteinian boundary in Central and Western Europe. This is a major Middle Pleistocene climatostratigraphic horizon. Its British equivalent is the Anglian-Hoxnian boundary.

It is at the Hoxnian horizon where in my opinion the correlation scheme of Table 2 is open to discussion. Swanscombe and Hoxne, the two warm-climate units, are shown as being separated by a cold stage, Stage 10 in the newly revised scheme, which is marked by a reduced and relatively short-lived glaciation. It is highly unlikely that the Hoxne interglacial deposit which overlies the Lowestoft Till without an apparent gap would belong to Stage 9 as concluded from the amino-acid racemization and ESR results. It is much more probable that the Swanscombe and Hoxne interglacials correspond both to a single warm marine isotope Stage 11 as shown in Gibbard's view (Tables 3 and 12).

Another point where the reviewer differs from the authors of the continental shelf correlations (Chapter 12) is the placing of the Pliocene/Pleistocene boundary at the base of marine isotope Stage 95, way above the pronounced heavy isotope peak of Stage 100. The latter is considered by many stratigraphers to be the level of Pretiglian, the first major Pleistocene cooling. On the other hand, I applaud the complete disregard of the Pliocene/Pleistocene boundary at the Vrica level. This boundary, near the top of the Olduvai magnetozone, has no major climatostratigraphic significance whatsoever.

An issue to think about is the apparent lack of a major till corresponding with the Saalian in Germany - a major series correlated with marine isotope Stages 6 to 10. Advances of the Saalian ice into Germany and Holland are very probably restricted to Stage 6 only because Saalian tills overlie a complex series of warm and cool deposits apparently correlated to marine isotope Stage 7 through to 10. Apart from the Severn Valley and Birmingham (Table 8), was eastern England really saved from the huge glacier advance of Stage 6?

Is there anything which we would like to see improved in the update of this monumental work expected several years from now? Yes, it is the badly missing index of the hundreds of units described in the book. Some of them are relatively new and not widely known. But other than that there is only praise and admiration of the authors.

The authors have produced an admirable piece of work and have come a long way indeed since the times of James Croll and Robert Ball, their Scots and Irish great-grandfathers. I am sure they would be justly proud of the work which sets an example to Quaternarists the world over.

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LATE CENOZOIC ENVIRONMENTS AND HOMINID EVOLUTION: A TRIBUTE TO BILL BISHOP

Edited by Peter Andrews and Peter Banham
Published by the Geological Society of London
ISBN 1 86239 036 3 1999. 274pp, Hardback £69.00

Bill Bishop died in 1977 in the prime of his life and career. He will have been well known to many of our older members, from his publications, if not personally. Our Newsletter No. 23 for November 1977 included an appreciation of his life as an Earth scientist by Peter Banham. His enthusiasm and range of interests was astonishing. Somehow, with all his studies and commitments, he always seemed to find time to see for himself temporary exposures or excavations in Quaternary deposits that became available. He turned up at all the major sites that this reviewer was directing, in both England and Africa: Swanscombe, Hoxne, Clacton, Elandsfontein, Langebaanweg and Klasies River Mouth. Always, he had much to say and made suggestions or gave constructive criticism in a friendly manner. I think the last time I saw him was at Clacton in 1970, when after a lengthy tour of the sites and several lunchtime pints, he decided to go swimming! His energy was as great as his interests, ranging from the Miocene to the Holocene. Stratigraphy and anything that pertained to the elucidation of past environments, dating and especially human evolutions were his forte. Thus, not surprisingly, he spent much time in East Africa, mapping and investigating. Travelling so much prevented him from holding any office with this Association but, as far as the British Quaternary is concerned, his earlier work on the Midlands was a major contribution. In the couple of decades that have elapsed since his death, there have been great advances in many aspects of Quaternary studies, especially in dating methods. What better tribute to him than to have current specialists in the area of Bill's work, assess the present state of knowledge of the very things that concerned him so much. In the process of which they have produced a volume which gives up-to-date surveys that are essential reading for any student or researcher involved in the same subjects. For this alone, it is highly commended to members of the QRA.

The volume is, as one would expect from the prestigious editorship of the Geological Society (one of Bill's past positions), a finely produced, neatly assembled collection of papers presented in a clear, uniform manner, with numerous plates and figures. To conform with Bill's main interests, the papers are divided into three sections:

Part I Early Miocene of Uganda
Part II Middle Miocene to Pleistocene of the Tugen Hills, Kenya
Part III Quaternary environments

These are prefaced by a sympathetic, informative, retrospective appreciation and bibliography by **M.H. Day** and **P.H. Banham**. Each of the papers is composed as follows:

Short overview
Usually an uncaptioned photograph of Bill in a relevant setting of the area or site concerned
A summary of conclusions
References

There is an index covering all the papers at the end of the volume. This reviewer has not the competence or temerity to comment or criticise any of the contents of the individual papers, other than to stress their high standard and relevance to Quaternary research as a whole. It is hoped that a statement as to what each part contains will guide members to what may concern them most. Thus:

Part I Overview by Andrews

Cormack gives an assessment of Bill's work in Uganda, especially around Napak and Moroto, and emphasises Bill's admiration for, but reinterpretation of, the pluvial theories of Wayland.

MacLatchly and **Pilbeam** discuss the earlier Miocene hominoids found in Uganda, including one regarded as the earliest known with features akin to those found on the extant apes, named after Bill as *Morotopithecus bishopi.*

Pickford, **Senut** and **Gommery** assess this Miocene hominoid and enlarge upon its geological and biological contexts and date.

Part II Overview by Andrews

Renault, Ego, Tiercelin, Le Turdu and **Owen.** They discuss the variability through time of the palaeolakes in this region of the rift valley in Kenya: alkaline, saline or freshwater.

McCall emphasises the complexity of the sequence at Lake Kamasia in relation to volcanic activity.

Kingston outlines the effect on hominid habitats of changing environmental conditions.

Hill concentrates on the sediments and fossils of the Tugen Hills within the Baringo Basin. The earliest dated member of the genus *Homo* (2.43 Ma) was found in 1968 in the Chemeron Formation.

Bishop (L.C.), **Hill** and **Kingston** have studied the numerous remains of pigs in the Tugen Hills sediments and conclude that they indicate the presence of forest and woodland habitats throughout the Pliocene and Early Pleistocene.

Wood gives an invaluable summary of the hominins (his term as opposed to hominids as he puts *Homo*, *Pan*, *Australopithecus et al.*, all into the same family, which may please the 'lumpers' but not the 'splitters') from the Baringo Basin including those from the Chemeron and Kapthurin Formations. The latter has produced two mandibles of the most recently dated known examples of *Homo erectus*.

Gowlett covers the archaeology of the region, mainly based on his work at Chesowanja and Kilombe. With characteristic caution he gives the arguments for and against the evidence of fire from Chesowanja being a hearth or a natural fire. It is associated with a hand-axe industry. There is much of importance in this paper on archaeological sequences and hominid fossils.

McBrearty considers the archaeology of the Kapthurin Formation. There is evidence for a non-hand-axe industry that would be contemporary with Acheulian industries elsewhere in Africa, as in Europe during the Middle Pleistocene. Hand-axes made on Levallois flakes, and blades at 240 ka are the earliest evidence for MSA technology in Africa.

Part III Overview by Banham

Keen gives a masterly account of the problems in the British Midlands of the so-called Wolstonian Stage. Emphasis is made on not accepting without reservations several current interpretations of the glacial-interglacial sequence, even the attribution of the Anglian Stage to OIS 12.

Maddy questions previous assessments of the palaeogeography during the early Middle Pleistocene of the Baginton River and the ancestral Thames. He gives evidence to support his conclusions that the Thames never had its source in North Wales, and that the Baginton River's upper reaches went no farther west than the Birmingham area.

Hart proposes a new method of differentiating between deformed bed tills and lodgement tills. This could allow the recognition of specific events and hence contribute to identifying a stratified sequence within a glacial stage.

Gleed-Owen has a comprehensive paper on the herpetofauna of the British Middle Pleistocene - Holocene. It is concluded that there are distinct assemblages during different Pleistocene episodes. Thus, they can be used to relate sites to particular stages of the Oxygen Isotope scale, rather than just indicating habitats. His detailed table of material from 84 sites adds a new dating tool to equate with molluscs, mammals and flora.

Wells, Mighall, Smith and **Dawson** describe the impact of humans on the vegetational succession during the Holocene at a coastal site in south-west Scotland, from the Mesolithic to the Iron Age.

Anderson stresses the importance of peat sequences for recognising the regional patterns of climatic change. Sites in north-west Scotland are used as examples. More intensive study is recommended as very few such peatland sites have been adequately studied.

Stokes, Washington and **Preston** present the final paper, which takes us back to Africa. They have employed optical dating for what are now inactive dunes in the Kalahari, and related deposits. Such show environmental response to wet-dry climatic changes, with inactive dunes reflecting humid periods, which can be correlated with sea-surface temperatures in the adjacent Atlantic.

Thankfully, Bill received honours in his lifetime, such as the Prestwich Medal of the Geological Society. To his own publications there is now this fitting tribute: not just a eulogy but an authoritative account of so much that is relevant to current Quaternary research. I am sure that Bill would have highly approved of it.

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EXCAVATIONS AT THE LOWER PALAEOLITHIC SITE OF EAST FARM, BARNHAM, SUFFOLK 1989-1994

Edited by N.M. Ashton, S.G. Lewis and S. Parfitt
British Museum Occasional Paper No. 125
ISBN 0 86159 125 9 1998. 305pp, Softback £25.00

This volume, an "occasional paper", but in reality a substantial site report, describes the archaeological, palaeoenvironmental and geochronometric work done at East Farm, Barnham 1989-1994 by a team organised by the British Museum and headed by the editors of the volume. Although the primary reason for excavation was archaeological, the team working the site was a multi-disciplinary one. Archaeological topics by N.M. Ashton, F. Wenban-Smith and R.E. Donahue, make up about 70 pages of the total length of the book, with the remainder, 230 pages, devoted to the environmental context of the Palaeolithic occupation of this part of Suffolk. The palaeoenvironmental work is commendably thorough, with chapters on Quaternary geology (S.G. Lewis), Geophysical investigations (C. Roberts), Soil micromorphology (R.A. Kemp), Pollen (C.O. Hunt), Wood charcoal (C. Cartwright), Mollusca (M.B. Seddon), Mammalia (S. Parfitt), Avifauna (J.R. Stewart), Herpetofauna (J.A. Holman), and Ichthyofauna (B.G. Irving and S. Parfitt). In Middle Pleistocene sites such as Barnham, the age of events is often the most contentious problem to be addressed. In this volume a four-fold attack on dating by Amino-acid geochronology (D.Q. Bowen), Thermoluminescence on burned flint (N. Debenham) and Optically Stimulated Luminescence and ESR dating (E.J. Rhodes), was conducted.

Controlled archaeological excavation and publication in a site monograph has allowed the British Museum team to make the most of their work. Sites with a similar wealth of palaeoenvironmental detail, but without the archaeological content, tend to be more hurriedly examined in the field and written up in the much more condensed form which is all that journals will allow. The difference between this volume and a journal paper is particularly emphasised by the palaeontology chapters and the tables of vertebrate finds. In both cases the amount of detail and the depth of discussion is of a different order to that possible in any mainstream journal. This full coverage allows presentation of the environmental and dating evidence from the site, and brings out the differences in these which are inseparable from sites of Middle Pleistocene age.

The environmental evaluations all agree that the site is fully interglacial in character. The vast amount of sediment sieved has yielded 24 species of mammals, 10 species of amphibians, 7 species of reptiles, 13 species of fish and

3 species of birds. Preservation of molluscs was poor due to a chemically hostile post-depositional environment, but 14 taxa were recovered which fit with the environmental indications of the vertebrates. The pollen is also of interglacial character.

The age of the Barnham site is broadly Hoxnian, but exactly how that fits with generally applicable stratigraphic schemes is a constant point of discussion. Amino-acid results indicate an age in Oxygen Isotope Stage 11 and thus different to that of Hoxne which is of Stage 9 age by this method. The mean of five TL dates is 286 ± 18 ka, indicating a Stage 9 age. The results from OSL showed too irregular luminescence characteristics for an age estimate, but ESR gave maxima of 417 ± 17 and 432 ± 29 ka BP. E.J. Rhodes, the author of this chapter, however, considers that a "true" age is likely to be between *c.* 200 and 300 ka, therefore in Oxygen Isotope Stages 7 or 9. The age of the Barnham deposits determined from mammalian biostratigraphy fits best with the early part of the Hoxnian and compares with such sites as Clacton, the lower part of Swanscombe, Hitchen and Woodston. The pollen results appear not to fit very well with any previously published "Hoxnian" pollen diagram, and C.O. Hunt, the author of the pollen chapter, while noting that pollen biostratigraphy is now "becoming unfashionable" suggests that the Barnham site is palynologically distinct from both Hoxne and Clacton. He poses the possibility that Barnham may date from a hitherto unrecognised Middle Pleistocene interglacial, perhaps accounted for by the occurrence of more than one terrestrial interglacial occurring in a single oxygen isotope warm stage. If true, this would add further complication to the pattern of interglacials between the Anglian and Ipswichian beyond that yet supposed.

As Barnham is primarily an archaeological site, there are, largely descriptive chapters, on the technology, taphonomy and microwear of the flint artefacts. However, N.M. Ashton uses the space available in a monograph to amplify his 1994 conclusions (Ashton *et al.*, 1994a, 1994b) that the Clactonian and Acheulian industries (respectively flake and biface dominated) previously thought to be chronologically and culturally separated, were in fact contemporary. The concluding chapter by the three editors puts this archaeological debate into the context of Middle Pleistocene environment and landscape as controls over human behaviour.

The volume is well produced with very few typographic or other errors and a high standard of illustrations (many by P. Dean). The expansive treatment given to all aspects of this site can be used as a yardstick to judge how such studies should be written up whether they have an archaeological content or not. Many interglacial sites published rather briefly in the mainstream journals in recent years, would have benefited from the space available to Ashton, Lewis and Parfitt. The presentation of all the evidence for environmental reconstruction and geochronology, as is possible here, gives an added dimension to studies of the Middle Pleistocene. At £25.00 this volume is a "must buy" for anyone interested in the Middle Pleistocene.

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FORTROSE : SOLID AND DRIFT EDITION
(Scotland Sheet 84W)

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The Fortrose 1:50,000 geological map has now been printed by the British Geological Survey (BGS), after first publishing it as an electrostatic plot (review 1999: *Quaternary Newsletter*, 87, p. 52). This is the completely resurveyed western half of the original one-inch (1:63,630) sheet, Nairn (84), since the enlargement to metric scale and the welcome addition of increasing amounts of information around the margins of maps has, as with most sheets in the Scottish series, necessitated its division. The 1:50,000 sheet straddles the Inverness Firth and thus covers the south-eastern part of the Black Isle round Fortrose in addition to the main area east from Inverness to Cawdor and as far south as Moy, and contains many varied geomorphological features and Quaternary deposits. The north-eastwards-flowing river Nairn cuts the sheet diagonally and is aligned with the river Findhorn that cuts the south-eastern corner of the map. This drainage pattern is parallel to the Caledonoid trend of the bedrock and the Great Glen Fault zone that runs mainly offshore along the north-western side of the Inverness Firth. The Solid pre-Quaternary geology of the northern coastal half of the district consists mostly of Old Red Sandstone of Devonian age, while Precambrian metamorphic rocks with intrusions of Caledonian granite form the higher ground to the south. These extensive uplands rise to over 600 m in places and are divided by the glacially enhanced north-westward-trending Moy Gap through which the river Findhorn originally flowed. As the underlying bedrock is not too complex, it has been possible to publish this sheet as a single Solid and Drift (S&D) edition, with a slightly simplified 1:100,000 insert map showing this Solid geology added for extra clarity.

The Drift deposits that blanket most of the district are all younger than mid-Devensian in age at the surface, since the remaining pockets of older Quaternary sediments, some of which contain important research localities, have been buried by subsequent events. The Quaternary deposits on the map have mainly been classified on the basis of their depositional environment and associated lithologies. So on the key, next to each patch of colour and symbol, the type of deposit is printed in bold, followed by brief descriptive notes. In addition darker coloured lines have been used to delineate clearly the extent of eskers and other narrow ridges of material. Similar units have the same central symbol with different accessory initials or, in the case of fan deposits from different environments, a small triangle. The symbols used, on the face of the map, for this complex classification have been developed by building on the traditional shapes used to represent Drift deposits. Thus, once familiar with the logic of the system, it is still relatively easy quickly to understand the nature of the Quaternary deposits, on both new 1:50,000 maps and earlier one-inch editions, without having to consult the key too often. This is unlike the present labelling, by the BGS, of older (Solid) stratigraphic units with initials, which is completely incompatible with the previous system that was logical and straightforward to remember.

Different patterns and letters along the lines marking various features have been used to distinguish clearly between breaks in slope, abandoned cliffs, channel margins, buried valleys and the conjectured Late Devensian marine limit. In places the near-parallel pattern of smaller glacial meltwater channels, marked by a thicker line ending in an arrow, show how marginal channels formed at progressively lower altitudes as the last ice sheet shrank. Locations with striae, crag and tail and roches moutonées that indicate the former direction of ice flow across the area are also marked. Also six important sites including the interglacial deposits at Dalcharn are marked on the map by lettered black squares. In addition an insert map at 1:10,000 shows the distribution of the limited outcrops of the ice-rafted Clava Shelly Formation which is clearer than figure 31 in the sheet memoir. This formation, containing within it marine clay with arctic fauna, generated a great controversy about its origin towards the end of the 19th Century. Since many thought it to be *in situ* and since it is at a height of around 150 m, this implied that during the Pleistocene there had been a great submergence of the region. The addition of offshore bathymetry at 10 m intervals clearly shows the deep waters around the narrow mouth of the Inverness Firth, but unfortunately the key does not indicate which datum they relate to. To illustrate the general nature of the Drift deposits two additional cross-sections with a larger than normal (+10) vertical exaggeration have been drawn. They include the structure of an ice-pushed ridge near Ardersier and coastal deposition with the part burial of a former cliff on the eastern outskirts of Inverness.

For once the geological map appeared after the accompanying sheet memoir had been published. As usual with BGS maps this sheet is well drafted with good colour selection and a vast wealth of clearly labelled detail, so that it can be read quite easily. The only exception to this is the base map which is too faint, and while it can still be read in most places, some contours are indistinct and parts of the foreshore along the coast have as a result disappeared. However, this map shows what the result of comprehensive geological mapping can reveal about an area's Quaternary history and would be ideal material for teaching exercises.

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ABSTRACTS

LAST GLACIAL MAXIMUM IN THE NORTH SEA BASIN

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This thesis explores Late Weichselian/ Late Devensian events in the North Sea Basin, in terms of the extent and dynamics of the British and Scandinavian ice sheets. It addresses critical themes such as the timing and duration of glaciation, the stability of the respective ice sheets, and whether the ice sheets were confluent in the central North Sea.

The thesis describes previous research in the North Sea, to place the current work in a contextual framework, and the techniques of thin-section micromorphology. A series of parallel process studies, examining contemporary glacial and glaciomarine sediments in Svalbard, and studying the development of microfabrics in diamicts in Scotland are carried out. Critical microscale features are identified which allow discrimination of fundamental processes involved in the deposition and deformation of sediments as a function of applied stresses.

These studies underpin the techniques used for the analysis of sedimentary and seismic sequences in the North Sea. The study area is separated into the southern and northern North Sea sectors, although a single interpretation is synthesised for the whole region. Three distinct glaciodynamic episodes are identified, the Ferder, Cape Shore and Bolders Bank episodes. The former two episodes, tentatively correlated with OI Stage 4, and OI Stage 2, respectively reflect extensive glaciation of confluent British and Scandinavian ice sheets across the North Sea Basin. The final 'Bolders Bank' episode, relates to surging of an ice stream down the east coast of England, as a function of destabilisation of the British ice sheet subsequent to decoupling with the Scandinavian ice sheet. This event may be correlated with deposition of the Skipsea and Withernsea tills in Eastern Yorkshire.

The implications of the reconstructions are discussed, in terms of the dynamics and processes occurring within the ice sheets, and how these are reflected in the sedimentary and seismic records. Particular attention is given to the implications of rapid glaciation and deglaciation of the North Sea Basin, especially during the younger glacial episodes. A model relating sub-Milankovitch climatic forcing processes, glaciation, and isostasy is presented as a possible explanation for the identified glaciodynamic episodes.

THE HOLOCENE PALAEOENVIRONMENTS OF THE RIFT MARGIN IN SOUTHERN JORDAN (WADI FAYNAN)

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This thesis addresses the sequence and causes of Holocene environmental change in the rift margins of southern Jordan, with special reference to vegetation history, climate change and human impacts on the landscape. The study area is the Wadi Faynan and its tributaries, which drain into Wadi Araba from the rift-marginal mountain front. This area is undergoing geo-archaeological investigation by a multidisciplinary team co-ordinated by the British Institute for Archaeology, Amman, the Department of Antiquities, Amman and some British Universities. The climate and vegetation of the Wadi Araba is desertic. The summit of the mountain front is in the Mediterranean climate and vegetational zone. The vegetation of the Wadi Faynan and its tributaries is an extremely degraded steppe. The Wadi Faynan is an area of copper mineralisation and was in Bronze Age to Roman times one of the World's most important copper mining areas. It was also once a major agricultural area, with extensive flood-water farming systems, but these are now abandoned.

Comparatively little is known about the Holocene climate, the vegetational sequence and the history of human impact in the southern Levant. The Wadi Faynan research project was set up to investigate these issues, with especial references to the issue of desertification. This thesis explores these issues using stratigraphic and palynological, molluscs, plant macrofossils and sedimentological data from the sequence of Holocene deposits in the research area and radiocarbon dates on suitable materials.

The samples on which this thesis is based were obtained by members of the Wadi Faynan expedition in 1996 and by the author in early 1998. Samples from 18 sites have been analysed, 14 sites contained pollen, and 12 of these contained sufficient pollen for detailed analysis.

The Holocene sequence is described and attributed to one formation, the Faynan Formation, which is divided into five members. These are the Faynan Member - early Holocene fluvial deposits; the Dana Member - late Holocene fluvial deposits; the Khirbet Member - late Holocene lacustrine deposits and cistern fills; the Atlal Member - late Holocene anthropogenic deposits and the Tell Loam Member - late Holocene aeolian deposits.

A pollen biostratigraphy consisting of eight assemblage-biozones is erected. This, together with the lithostratigraphy described above and radiocarbon dates, enable correlation of the Holocene deposits of the Wadi Faynan, and the identification of a sequence of environmental change.

The Faynan Member consists mostly of epsilon cross-bedded fluvial deposits, with some palaeosols, though at one locality there is a transitional to multichannel deposition. This member contains pollen and plant macrofossil assemblages suggestive of a steppe environment close to the transition to a Mediterranean woodland and attributed to the PCP, PPA, PAP biozones. Molluscs which require perennial waters are present. Deposition of the Faynan Member ceased about 5,740 ± 35 BP (uncal.) (HD-12337).

There is a long hiatus in the fluvial sedimentary record, which recommences with the Dana Member in the late Holocene, dated to 390 ± 50 BP (uncal.) (Beta-115214). The Dana Member was laid down by multichannel streams, which rapidly aggraded substantial terrace gravel bodies and alluvial fans. The deposits contain pollen assemblages dominated by Chenopodiaceae and desertic species, comparable with the present vegetation in the Wadi Araba and attributed to the C biozone. Incision terraces following the deposition of alluvial fans of the Dana Member contain pollen very similar to that now accumulating in the research area, attributed to the CL Biozone, and dated to 100 ± 50 BP (uncal.) (Beta-119602).

The hiatus between the fluvial units was addressed by the analysis of lacustrine fill deposits attributed to the Khirbet Member, of anthropogenic deposits of the Atlal Member and aeolian deposits of the Tell Loam Member. The latter two units did not contain sufficient pollen for reliable analysis, but the Khirbet Member contained abundant pollen. Deposits from a chalcolithic cistern-fill contained assemblages consistent with a well-vegetated steppe environment and attributed to the PCPJ Biozone. The deposits of the lacustrine fill behind the Barrage at Khirbet Faynan show a sequence of pollen assemblages commencing around 2,630 ± 50 BP (uncal.) (Beta-110840). At the base of the sequence, pollen attributed to the CLP Biozone are consistent with a degraded steppe environment, with indications of probable arable agriculture. These assemblages are followed by assemblages consistent with a slightly more degraded steppe, without regular agriculture, attributed to the CPE Biozone. The following C Biozone is characterised by extremely high counts for Chenopodiaceae and thus enables correlation of this part of the sequence with the Dana Member. The top of the sequence contains pollen consistent with a degraded steppe and similar to that accumulating today. This is attributed to the CL Biozone.

The environmental sequence thus shows a slow change from the 'good steppe' environments of the early Holocene, with progressive degradation up to the Late Holocene, around 350 radiocarbon years before present. At this time there was a major desiccation episode which came to an end around 100 radiocarbon years ago. Resolution of the calendar age of this event is made difficult by the nature of the radiocarbon calibration curve in the late Holocene.

With regard to the vegetation sequences, it has been demonstrated that there is a clear division between the southern Levant sites in Saudi Arabia, Jordan, Sedom, the Hula Basin and Syria, and northern Levant sites in Turkey and Iran. In the southern Levant sites, as in North Africa, there was a major deterioration in the environment, with most of the area becoming drier around 6,000-5,000 BP, whereas in Turkey and Iran, at this time, the environment become wetter and forest spread and become more dense. Sites from Saudi Arabia, through Jordan, Palestine and Syria show higher rainfall than occurs at present, in the period between 10,000 and 6,000-5,000 BP. The Wadi Faynan results show the same pattern of a wet early Holocene. The critical evidence from the Wadi Faynan is the presence of *Corylus*, which requires summer rain. This implies a different pattern of climate at that time, with summer rains resulting from a monsoonal pattern of circulation.

The causes of the early Holocene alluviation are likely to be the result of a partial response to the soil erosion brought about by the introduction of herding and arable agriculture. There is no sign of alluviation in response to early mining activity. In the late Holocene, also, there is no sign of aggradation as a response to mining activity or agricultural development. Alluviation in the late Holocene appears to have taken place as a response to extreme aridity. Importantly, in recent times, desertic conditions appear to have retreated from the Wadi Faynan.

THE BIOSTRATIGRAPHY AND DATING OF HOLOCENE TUFA SUCCESSIONS IN NORTH-WEST EUROPE

Richard Andrew Meyrick (Doctor of Philosophy)
University Museum of Zoology, Cambridge

Land snails are common in calcareous sediments of Holocene age and are ideally suited for providing detailed palaeoenvironmental data. One of the best types of sediment for preserving land snail assemblages is a calcareous spring precipitate known as tufa. Where tufa accumulation was rapid, the temporal resolution of each sample can be on a centennial scale or less.

This study extends the coverage of well-dated molluscan successions from Britain onto the European continental mainland. In addition to one site in Britain, sequences have been examined from tufa deposits at two sites in Germany, one site in Luxembourg and three sites in Sweden. In most cases, radiocarbon chronologies have also been provided. Individually, these sequences provide the first quantitative Holocene molluscan records from their respective regions and collectively represent a 1,200 km south-north transect of faunal successions across north-west Europe.

Local mollusc assemblage zones have been defined for each of the sites. These have been combined with data from the limited number of other published sites to propose regional mollusc zones for Northamptonshire, the Rheinland (Luxembourg and western Germany), Skåne (southernmost Sweden) and south-central Sweden.

Broad scale similarities in the development of molluscan faunas during the Devensian late-glacial and Holocene across north-west and central Europe have been demonstrated. The timing of key biostratigraphical events has been used to evaluate the dispersal of terrestrial molluscs from glacial refugia. It has been established that the molluscan assemblages of the British Isles developed in parallel with those from the Rheinland. Significantly, however, although similar closed-forest faunas developed approximately synchronously in these two regions, they are characterised by the occurrence of different species, *Spermodea lamellata*, and *Acicula polita*, respectively. The establishment of such faunas, which become progressively more impoverished with increasing latitude, was delayed until at least 5,000 yr BP in Skåne, southernmost Sweden, and until historical times in Östergötland, south-central Sweden.

At least one of the new sites has evidence for tufa deposition continuing up until historical times. It is suggested that the apparent north-west European 'mid-Holocene tufa decline' actually reflects the widespread localised destruction of favourable conditions for tufa formation, primarily through anthropogenic deforestation.

NOTICES

1. GEOSCIENCE 2000
University of Manchester, 17-20 April 2000

At the Geoscience 2000 meeting in Manchester next April the following symposium is being sponsored by the QRA through the Joint Association for Quaternary Research:

Shelf sea palaeoceanography: the Quaternary record

The realisation that excellent palaeoceanographic records can be derived from north-west European shelf seas has largely been driven by the comprehensive offshore mapping and sampling programmes conducted since the 1970s. Renewed interest, particularly amongst the palaeoceanographic community, in the coupled land-ocean system makes the shelf seas and their palaeoceanographic records highly significant. This symposium aims to bridge the gap between oceanographic and biogeochemical process studies of shelf seas and the geological record, and to provide analogues for palaeoenvironmental interpretations of ancient shelf sequences. Another focus will be on numerical modelling of shelf sea processes over geological timescales (e.g. glacio-hydro-isostatic, palaeotidal, circulation).

This symposium will be convened jointly by Bill Austin and James Scourse. Keynote speakers will include Professor Kurt Lambeck (Australian National University), Dr Colin Jago (University of Wales, Bangor) and Dr Jon Eiriksson (University of Iceland). If you are interested in submitting an abstract for this symposium (oral or poster) please contact one of the convenors directly. More information about Geoscience 2000 is available at:

http://www.geolsoc.org.uk

Convenors details:

Dr Bill Austin
Department of Geography and Geology
University of St Andrew's
St Andrew's
Fife
KY16 9AL
e-mail: wena@st-andrews.ac.uk

Dr James Scourse
School of Ocean Sciences
University of Wales (Bangor)
Menai Bridge
Anglesey
LL59 5EY
e-mail: j.scourse@bangor.ac.uk

2. BIBLIOGRAPHY OF EUROPEAN PALAEOBOTANY AND PALYNOLOGY 1996-1997

The *Bibliography of European Palaeobotany and Palynology 1996-1997*, compiled by H.S. Pardoe, C.J. Cleal, H.E. Fraser and B.A. Thomas, is now available. The Bibliography consists of a list of publications produced by palaeobotanists and palynologists throughout Europe in 1996 and 1997, together with a list of publications in press and current research interests. The 168-page publication is divided into sections according to geological period.

If you would like to purchase a copy of the Bibliography please send a Sterling cheque for £5.00 to Miss H.E. Fraser at the address below, making your cheque payable to the National Museum of Wales. Europeans in countries outside the British Isles can obtain a copy from their regional representative. If you wish to pay by credit card then please write to the address below and a form will be sent to you. The cost of the Bibliography, if purchased using a credit card, is £6.75 (including p & p).

The following four titles are still available:

Report on British Palaeobotany and Palynology 1988-1989

Bibliography of European Palaeobotany and Palynology 1990-1991

Bibliography of European Palaeobotany and Palynology 1992-1993

Bibliography of European Palaeobotany and Palynology 1994-1995

Each can be purchased individually at the same price as the latest Bibliography or a complete set can be purchased for £30.

Work on the *Bibliography of European Palaeobotany and Palynology 1998-1999* will begin shortly. Any worker from the British Isles who would like to contribute to this publication should contact Heather Pardoe or Helen Fraser at the address below:

Department of Biodiversity and Systematic Biology
National Museums & Galleries of Wales
Cathays Park
Cardiff CF1 3NP
UK
Heather Pardoe:
Tel: 01222 573294
e-mail: Heather.Pardoe@nmgw.ac.uk
Helen Fraser:
Tel: 01222 573344

3. EARTH SCIENCE AND THE NATURAL HERITAGE: INTERACTIONS AND INTEGRATED MANAGEMENT

Scottish Natural Heritage's 7th Annual Conference will be held at the new Dynamic Earth visitor centre in Edinburgh on 4-5 November. Invited speakers will examine how geology and geomorphology underpin coastal, freshwater and montane environments, the implications for sustainable management and new developments in interpretation and raising awareness. In addition there will be workshops on sustainable minerals development, river management, coastal management, soil protection and Earth science education. These will lead to a general discussion of future directions for Earth science and the natural heritage in Scotland.

For further information and bookings, please contact:

e-mail: JOHN.GORDON@snh.gov.uk
www at: http://www.snh.org.uk

4. BCRA CAVE SCIENCE SYMPOSIUM
March 25, 2000

Call for papers

The next British Cave Research Association Cave Science Symposium will be held on Saturday, March 25, 2000 from 10.00 to 17.00, hosted by the Limestone Research Group, Division of Geographical Sciences, The University of Huddersfield, Huddersfield, HD1 3HD.

Papers and posters are requested on any aspect of cave science, including archaeology, biology, cave diving, cave history, cave location, cave photography, cave radio and electronics, cave surveying, chemistry, computing applied to caves, geochemistry, geology, geomorphology, hydrology, palaeoclimate, physics, speleogenesis, and technology applied to cave exploration. Details of previous symposia can be found at:

http://www.sat.dundee.ac.uk/~arb/bcra/detail/sci.html

Simultaneous OHP and 35 mm slide projection will be possible but there will not be a data projector. Space is available for poster displays. Setup time will be available from 09.30 on the day.

Domestic Organiser:

Prof. John Gunn
Division of Geographical Sciences
The University of Huddersfield
Huddersfield
HD1 3HD

Titles of papers and posters, together with an abstract, should be sent to the Lecture Secretary (see details below).

Please submit a short abstract (200 words maximum + title + author name and initials + affiliation) to the Lecture Secretary at the above address by e-mail or letter by the deadline of 17th January, 2000. Please state whether you would prefer to give a poster or oral presentation. It would be helpful if submissions could include note of length of the time requested for oral presentations (up to 30 minutes) and any special requirements. In the case of posters, the area required for display should be given.

Costs, payable on the day, will be around:

BCRA full members - £7; Students - £4; Others - £8.

These costs include tea/coffee in the morning and afternoon, but no lunch.

A range of venues to suit all tastes will be available in Huddersfield town centre for lunch.

The Lecture Secretary
Dr Andy Baker
Department of Geography
University of Newcastle
Newcastle
NE1 7RU
Tel: 0191 222 5344
Fax: 0191 222 5421
e-mail: andy.baker@ncl.ac.uk
http://www.ncl.ac.uk/ecam/

5. 'COOL PETERBOROUGH: PETERBOROUGH IN THE ICE AGES'

A booklet has been produced to accompany the 'Cool Peterborough: Peterborough in the Ice Ages' exhibition to be held at Peterborough Museum from 29 May to 27 November 1999. It is not, however, a programme and consequently will still be useful after the exhibition closes.

The booklet relates, in more detail than the exhibition, the history of the Peterborough area during the last 'Ice Age'. Evidence from sediments deposited in the area, and from the fossils contained within them, tell a fascinating story of the events that have occurred in and around Peterborough over the past 130,000 years. It has been written with the general public in mind, and provides an up-to-date introduction to the Quaternary Period as a whole (*i.e.* the past 2 million years), and will serve as a useful introduction to the Quaternary history of the Peterborough area.

New information from the Late Devensian glacial site at Eyebury and the Ipswichian interglacial site at Deeping St James has been included in the booklet.

The proceeds from the sale of the booklet will go towards making casts of the exhibits so that they can be on permanent display.

A copy can be obtained from:

Langford Editorial Services
16 Magnolia Avenue
Longthorpe
Peterborough
PE3 9QT

by sending a cheque for £3.00 made payable to H. E. Langford. The price of the booklet is £2.50 plus £0.50 postage and packing.

6. POSTGRADUATE PALAEOECOLOGY CONFERENCE 2000

17-19 April 2000, University of Plymouth

The Geography Department at Plymouth University invites postgraduates, of all years, to present and discuss their research in an informal setting. This conference will be run by postgraduates, for postgraduates in the field of Quaternary and recent environmental change, incorporating palaeoecology, micropalaeontology, archaeology and sedimentology. The conference will comprise presentations, poster presentations, laboratory techniques and a local field excursion, providing an ideal opportunity to network with postgraduates carrying out research in similar fields.

For further details contact:

Amy Burgess, Elizabeth Hunt or Tony Massey
Department of Geographical Sciences
University of Plymouth
Drake Circus
Plymouth
Devon PL4 8AA
Tel: 01752 233050 (AB & EH) or 01752 232974 (TM)
Fax: 01752 233054 (department)
e-mail: aburgess@plymouth.ac.uk,
ehunt@plymouth.ac.uk
or amassey@plymouth.ac.uk

Please also check the University of Plymouth web pages, where more information and a registration form will be posted shortly.

7. Miss ROBIN ANDREW (University of Cambridge) Dr ROBIN WINGFIELD (British Geological Survey)

Members of the QRA who knew Miss Robin Andrew and Dr Robin Wingfield will be very sorry to hear of their recent deaths. Obituaries, with an appreciation of their contribution to Quaternary research, will appear in the next issue of *Quaternary Newsletter*.

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 £15 with reduced rates (£5) for students and unwaged members and an Institutional rate of £25.

The main meetings of the Association are the Annual Field Meeting, usually lasting 3-4 days, in April, and a 1 or 2 day Discussion Meeting at the beginning of January. Additionally, there are Short Field Meetings in May and/or September, while Short Study Courses on techniques used in Quaternary work are also occasionally held. The publications of the Association are the *Quaternary Newsletter* issued with the Association's *Circular* in February, June and October; the *Journal of Quaternary Science* published in association with Wiley, incorporating *Quaternary Proceedings*, with seven issues per year, the Field Guide Series and the Technical Guide Series.

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

President: *Professor M.J.C. Walker*, Department of Geography, University of Wales, Lampeter, Dyfed, SA48 7ED (e-mail: walker@lamp.ac.uk)

Vice-President: *Dr P.L. Gibbard*, Quaternary Stratigraphy Group, Department of Geography, Downing Place, Cambridge, CB2 3EN (e-mail: PLG1@cus.cam.ac.uk)

Secretary: *Dr C.A. Whiteman*, School of the Environment, University of Brighton, Cockroft Building, Lewes Road, Brighton, BN2 4GJ (e-mail: C.A.Whiteman@brighton.ac.uk)

Publications Secretary:
Dr S.G. Lewis, Centre for Environmental Change and Quaternary Research, Department of Geography and Geology, Cheltenham and Gloucester College of Higher Education, Swindon Road, Cheltenham, GL50 4AZ (e-mail: slewis@chelt.ac.uk)

Treasurer: *Dr D. McCarroll*, Department of Geography, University College Swansea, Singleton Park, Swansea, SA2 8PP (e-mail: D.McCarroll@swansea.ac.uk)

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Professor M.J.C. Walker, Department of Geography, University of Wales, Lampeter, Dyfed, SA48 7ED (e-mail: walker@lamp.ac.uk)

Publicity Officer: *Dr D. Maddy*, Department of Geography, The University, Newcastle-upon-Tyne, NE1 7RU (e-mail: Darrel.Maddy@newcastle.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**.

QRA home page on the world wide web at: http://www.qra.org.uk

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