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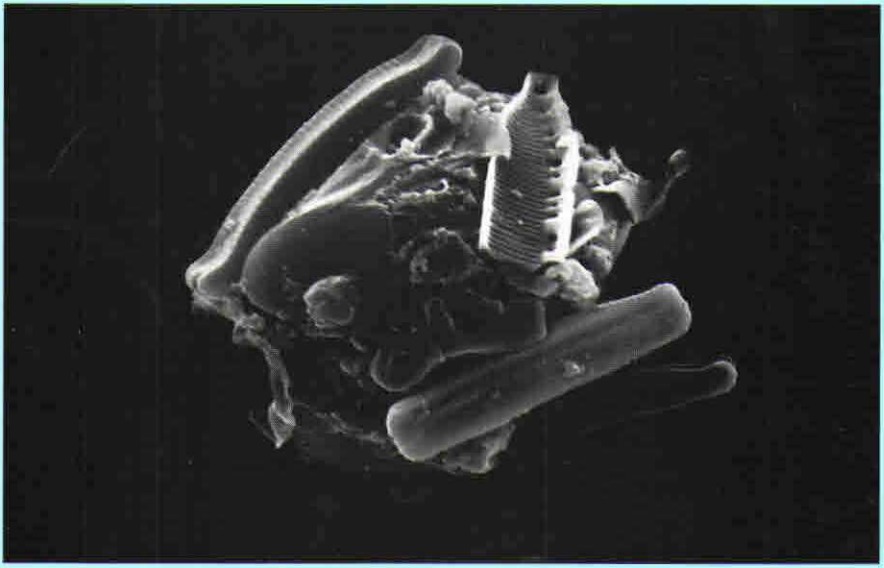
Quaternary Newsletter



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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 (x 2,000) of *Difflugia bacillariarum* Perty 1849, a testate amoebae taxon found in bog pool habitats which uses diatom frustules in the construction of its test. A guide to the identification of testate amoebae in peats is the subject of a forthcoming QRA Technical Guide to be published later this year (see report on First Workshop of PALPEAT by Keith Barber in this issue). Photograph by Dan Charman.

OBITUARIES

ROBIN ANDREW
1909 - 1999

Robin Andrew died in Cambridge in September 1999 at the age of 90. Many who started or were involved in pollen analysis and its development in the period 1950-1990 will remember with gratitude her willingness to advise on problems of pollen identification, and it is in recognition of this contribution that a short account of her life and achievements is given.

Robin came to Cambridge in 1947, having served in the War as an ambulance driver, based largely at Reading. Before the War she was an almoner at the American Hospital in Paris, having lived in France for some years. Here she met an assortment of patients, including Russian exiled nobility, from whom she treasured many gifts. When the Germans arrived in 1940, the hospital staff evidently took some time to recognise the problems, but on the 10th of June she left Paris in a large Buick, joining a stream of refugees moving southwards, though optimistically hoping to be back in Paris in a few weeks. Eventually she arrived in Bordeaux and left on one of the last evacuation ships, in the company of King Zog of Albania and his retinue. Robin wrote an entertaining and vivid account of this journey, which has been accepted into the archives of the Imperial War Museum.

On arrival in Cambridge in 1947 Robin answered an advertisement in the local evening paper for a part-time technical assistant for Dr Godwin in the Botany School of the University. She was successful in obtaining the place, the duties of which were to count pollen for Dr Godwin and to build up a pollen reference collection. This was rather small when she arrived, under ten type slides she once told me.

At that time two developing fields of research demanded much better expertise in pollen identification, Iversen's 'landnam' and late-glacial investigations. Though Robin had no formal training in botany, she had a remarkable eye for microscopic detail (which combination gave her an independence of judgement), and this enabled her, under the guidance of Harry Godwin, to improve greatly the standards of pollen identification in the '50s. This was acknowledged in the 1950 paper on late-glacial deposits in Cornwall - "Robin Andrew.... responsible for a good deal of the pollen counting, ... especially for the identification and recording of pollen of late-Glacial herbaceous plants" (Conolly *et al.*, 1950). This contribution is readily seen in the greatly improved detail of British pollen diagrams published in the '50s and later.

These developments were only possible because of the ready availability of well-identified herbarium sheets in the University's Herbarium in the Botany School, a use never envisaged when such herbaria were built up, so illustrating the point that developments in science are often based on knowledge accumulated for other purposes. The importance of the support of a well-documented herbarium is seen in Robin's account of the pollen of British species of *Tilia*, where observations were based on sheets from many named localities (Andrew, 1971).

The result of Robin's work over the years was the Cambridge pollen reference collection, described by her in the Godwin Festschrift (Andrew, 1970). In 1980 Robin produced a Practical Pollen File of the British Flora, which listed the characters of size and pattern of pollen grains of plants of the British Flora. The major classes in this account were based on aperture (furrows, pores). This was a facsimile reproduction of the file she had built up over many years. The introduction noted that "Facsimile reproduction has been adopted to in order to retain the informal nature of the original file and to the same end informal and often untechnical terms are used ...". Such terms as these weren't exactly what the protagonists of various classifications of pollen morphology and structure (e.g. Erdtman, Faegri and Iversen, etc.) had in mind when they put forward their systems. But their informal nature was certainly appreciated by those who used the file in conjunction with the type slides, even if it was subject to criticism by others. The file was revised and published by the Quaternary Research Association in 1984 (Andrew, 1984), and has been of help to many people. It is perhaps the most complete record of the pollen and spores of a national flora and is a remarkable achievement, resulting from a life-time's careful study.

Robin Andrew continued her work, still part-time, long past retirement age. Over many years she greatly assisted and encouraged many student and staff members of the Subdepartment of Quaternary Research and a much wider field of researchers. Such assistance was always given in a quiet and modest fashion, though it must be admitted that she may have appeared rather forbidding to younger enquirers. In no small way did she contribute in her own way an essential discipline to the development of Quaternary palaeoecology.

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R.G. West
Great Shelford
Cambridge

DR ROBIN WINGFIELD
1940 - 1999

The sudden and premature death of Robin Wingfield on Easter Monday 1999 robbed the UK Quaternary fraternity, and a much wider circle of marine geologists worldwide, of one of its most colourful characters. Robin was a bounding enthusiast whose energy, humour and polymathic knowledge will be sorely missed by many of us who respected him as a colleague and valued him as a friend.

Robin was born in Stamford during the war years and, after attending preparatory school, went to Stowe before going to Trinity College Dublin to read Natural Sciences in 1960. Here he came under the influence of Professor Hudson in the Department of Geology and, as an undergraduate, spent many enjoyable fieldtrips in the mountainous and remote west of Ireland, graduating with a First Class B.A. in Geology in 1964. He continued at TCD as a research student and was awarded his doctorate on the *Geology of Kenmare and Killarney* in 1968. Whilst in Dublin, Robin became deeply involved in sailing and, more particularly, ocean racing, developing a love for the sea and things nautical that never waned. So, when he joined the British Geological Survey in Leeds in 1967 straight from TCD, it was natural that he should combine his marine and geological interests by being appointed to the newly formed marine group. Apart from a secondment to Fiji between 1976 and 1979, Robin spent his entire career in the marine sections of BGS during what was an extremely exciting phase of the Survey's history. He was intimately involved in mapping the shelf around the UK, spending many months at sea for many years, and deserves to be recognised as a key member of an initiative which means that the UK now has one of the best-explored continental shelves in the world and which has spawned many ground-breaking research initiatives. In Fiji, Robin was responsible for establishing a marine geological survey but, in typical fashion, became involved in other multifarious activities as diverse as monitoring coral reef drilling, running a tsunami early warning centre, introducing satellite navigation in the South Pacific, establishing an *ad hoc* air-sea rescue service and searching for oil seeps. Robin returned to the marine group in Leeds but soon after moved with this group when it was relocated to Keyworth. During this later phase he became increasingly involved with international initiatives in marine geology and was responsible for establishing a series of conferences supported by the European Science Foundation on sea level during the last 20,000 years. The first of these meetings was held in Mannheim in 1994 and the fourth meeting in this series is now in its planning stage. Robin took early retirement from BGS during 1998, hoping to devote his time to writing novels, the first of which had already been accepted by a well-known publisher.

For many of us collaborating with the BGS on investigations into the Quaternary

sequence of the continental shelves of north-west Europe, Robin was often the first port of call for some information or advice. Indeed, recourse to the National Geological Database was redundant with Robin at the end of the 'phone. He had a phenomenal memory for cruises, cores, seabed features, bathymetry and was always more than willing to pass details of these on; he was always particularly helpful to young research students. To enter his office was to risk life and limb in a maelstrom of charts, data and diagrams of incredible complexity, penned in multiple coloured pencils and annotated with bizarre acronyms of vaguely nautical derivation. Many times I sought his advice on a specific point only to find myself emerging (staggering) after several hours having been subject to an intellectual bombardment of almost physical intensity on a latest theory. Robin was big on theories. These were often criticised by others, notably his efforts on the glacial origin of incisions, but always stimulating and progressive in the sense that the counter-reaction moved the science forwards. Indeed, I was myself openly critical of some of his ideas, but in my experience he never took such criticism personally and I always respected him for that. It is particularly sad that Robin only enjoyed a few months of retirement with his wife Anne and their sons James and Charles, and failed to live to see the publication of his first novel. He had completed this during the months leading up to his death, and had others in the pipeline; it is a measure of the man that when I cheekily commented that if this had half as much fiction in it as his scientific papers, then it was surely bound for the bestsellers list, he bellowed in self-mockery; lesser mortals would have been merely offended.

Robin had a bottomless pit of anecdotes and an extraordinarily wide general knowledge, particularly in British naval and military history. On one extensive fieldtrip involving long drives across England, Wales and Ireland, scarcely a hedge or barn was passed without some comment on its history, or indeed a longer narrative, often involving colourful scenes from the lives of his Wingfield ancestors. His skill as a raconteur derived much from his inability to recognise anything as merely average, normal or boring. As his old colleague from BGS Leeds days, Henry Pantin, says "the Tropical Revolving Storms (hurricanes or typhoons to the media) which he encountered were fiercer than anyone else had ever seen, and the size of the Fijian cockroaches was second only to Concorde".

Life was always eventful in Robin's presence. A few weeks after he retired from BGS, I was on the 'phone to one of his former colleagues. "What's it like without Robin around ?" I said. The response says it all: "Quiet".

I should like to acknowledge the help of Dr Chris Evans (BGS Keyworth) and Dr Henry Pantin in writing this obituary.

James Scourse
School of Ocean Sciences
University of Wales (Bangor)

ARTICLES

COMPLEX INTERACTION OF THE ANGLIAN ICE SHEET AND PERMAFROST, THORINGTON, SUFFOLK

A.E. Richards

Introduction

Recent work on the Middle Pleistocene deposits of East Anglia has centred on the dynamics and depositional environment of Anglian Stage glaciation (Eyles *et al.*, 1989; Hart *et al.*, 1990; Allen *et al.*, 1991; Hart and Boulton, 1991; Lunkka, 1994). Much of this work discusses the genesis of diamictons deposited by the Scandinavian and British ice sheets during the Anglian cold stage. Following initial interpretation as lodgement till (Rose *et al.*, 1976; Perrin *et al.*, 1979), some of these diamictons have since been reinterpreted as glaciomarine sediments (Eyles *et al.*, 1989) or, as has been widely accepted, the products of a subglacially deforming bed (Hart *et al.*, 1990; Hart and Boulton, 1991).

The gravel quarry complex at Thorington (TM 423728) is situated 8 km west of Southwold in northern Suffolk (Figure 1). Sections here expose an important sequence of Early and Middle Pleistocene sediments (Figure 2). This paper has two main objectives. Firstly, to present details of observations in the quarry from June 1994 to September 1997 which provide further evidence for phases of intensely cold conditions immediately before and during the incursion of the British, Anglian ice sheet. The paper also describes till facies associated with the Lowestoft Formation which exhibit a wide range of structural styles which appear to comply with established models of subglacial deformation. However, it will be argued that different structural styles may result from the persistence or otherwise of frozen-bed conditions throughout glaciation.

Deforming bed conditions associated with the East Anglian ice sheet

The concept of a subglacially deforming bed is largely based on observations of modern glaciers where glacial ice is coupled with an underlying bed of unconsolidated sedimentary rocks or till and most of the subglacial shear stress is transmitted through subglacial debris (Alley *et al.*, 1986; Boulton and Hindmarsh, 1987; Humphrey *et al.*, 1993). The deformation of subglacial material is thought to be responsible for the high velocities of Antarctic ice streams and the primary mechanism in the shift from low to high flow states in surging glaciers (Hamilton and Dowdeswell, 1996).

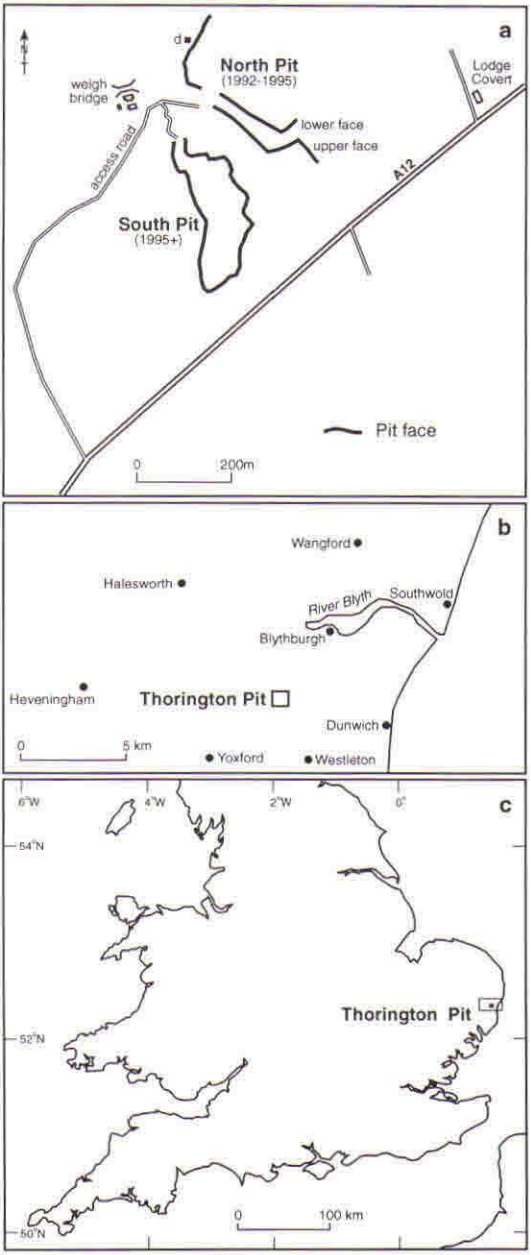

Figure 1. Location of study area.

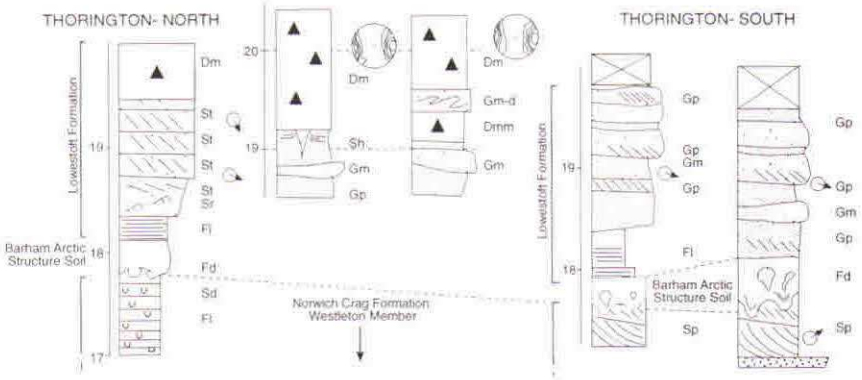

Figure 2. Composite facies logs for the Lowestoft Formation exposed in the south and north pits at Thorington.

Many of the subglacial tills and waterlain sediments associated with the East Anglian ice sheet (Anglian Stage) have recently been reinterpreted as a product of subglacial deformation (Hart *et al.*, 1990; Hart and Boulton, 1991). Two main styles of subglacial deformation have been proposed (Figure 3). 'Constructional deformation' occurs at the glacier margin where there are low basal shear stresses, a thin deforming layer and high longitudinal sediment input from up-glacier. This causes the basal boundary of the deformation, or décollement surface, to move upwards through the subglacial material and sediment beneath this boundary is, thus, deposited. Examples of such deposits occur at Great Blakenham, Suffolk (Allen *et al.*, 1991; Hart, 1994). 'Excavational deformation' occurs up-glacier where there are higher basal shear stresses and overall erosion of the bed. As the glacier advances, the deforming boundary moves downward through the underlying sediment and new material is added to the deforming layer. Examples of such deposits occur at West Runton, Norfolk (Hart *et al.*, 1990). In the case of excavational deformation, the style and amount of deformation are similar throughout the whole sequence, indicating that the sediments have been re-deformed during the continual advance of the ice sheet (Hart *et al.*, 1990).

Lithostratigraphy of deposits exposed at Thorington

Norwich Crag Formation

Deposits exposed at Thorington span two important phases of Pleistocene development. Sands and gravels of the Westleton Member of the Norwich Crag

Formation are exposed in the lower portions of the pit (Figure 2). These sediments are believed to have accumulated at the margins of the 'Crag Sea' at the southern limit of the North Sea Basin during the Baventian/ Pre-Pastonian a Stage (Richards *et al.*, 1999). The lower gravel unit of the Westleton Member records successive phases of steep-faced beach progradation, while overlying sands, silts and clays record lagoonal, estuarine and off-shore deposition subject to high-energy rip-currents (Hey, 1966, 1967, 1980; Mathers and Zalasiewicz, 1995; Richards *et al.*, 1999).

Periglacial structures

Two levels of periglacial structures are recognised in the pit. Both units involve the deformation of the underlying Westleton Member, before Middle Pleistocene glaciation.

Unit 1: The Barham Arctic Structure Soil

The Westleton Beds are overlain by a pervasively deformed horizon of between 1.2 to 2.2 m thickness which extends through the pit, with a base between 14.2 and 17 m OD (Figure 4). In the northern section, the Westleton Member has been deformed into amorphous ductile structures, sorted gravel and sand pods, 'mud-boils' (*cf.* Shilts, 1978) and attenuated, asymmetric, small-scale folds. In

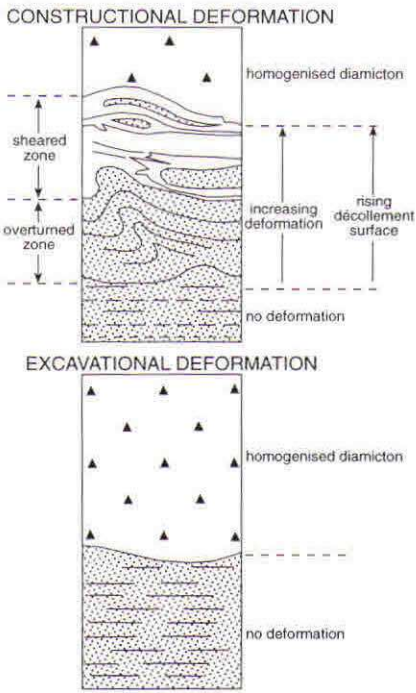

Figure 3. The styles of subglacial deformation (after Hart *et al.*, 1990).

the southern section the unit is arranged locally into two sub-units: i) a lower, laterally impersistent unit composed of tightly folded silty clay and fine sand, whose lower contact is marked by injection tongues and intrusive ball and pillow structures, small-scale faulting, ice-wedge pseudomorphs and frost cracks; and ii) an overlying unit containing medium- to coarse-grained sand and silty clay units which have been deformed into rootless, attenuated folds and other amorphous structural forms. The contact between the units is marked by a variety of 'drop' structures, where the overlying unit intrudes the lower. Where the lower unit is absent, the upper unit forms a sharp contact with underlying pebbly sands and pebbly gravels whose primary sedimentary structure exhibits minor deformation. Although stratigraphic control is lacking, it is most likely that the deformed beds should be correlated with the Barham Arctic Structure Soil, which has been widely attributed to active-layer processes above a regional permafrost table which affected much of southern East Anglia (Kemp, 1985; Rose *et al.*, 1985; Murton *et al.*, 1995). The style of deformation of the unit is consistent with *type 2* involution structures of Vandenberghe (1988). The lateral extent and thickness of this deformed horizon, and the presence of ice-wedge pseudomorphs and frost fissures connected to the base of the involutions, suggest that the unit developed by the progressive degradation of permafrost under a reversed, vertical-density gradient as large quantities of water were liberated above a regionally persistent permafrost table.

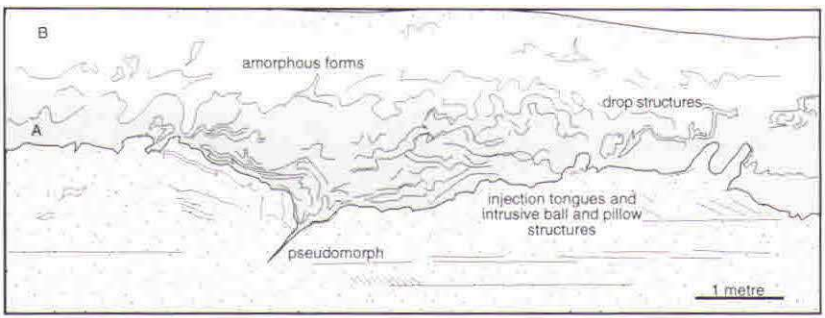

Figure 4. The Barham Arctic Structure Soil at Thorington, south pit, 1995 (to scale).

Unit 2: Arid periglacial structures

A second horizon of periglacial structures occurs immediately below sands, gravels and diamictons of the Lowestoft Formation and marks a further phase of intensely cold conditions immediately before and during the incursion of the British, Anglian ice sheet (Figures 2 and 5). This supports the evidence for variable climatic conditions in the early Anglian Stage that has been proposed elsewhere (Kemp *et al.*, 1993). Truncated sand wedges and frost fissures occur at 19.08 m OD in the northern section (Figure 5), directly underlying homogeneous diamicton of the Lowestoft Formation. The sand-wedge casts contain primary infillings of horizontally bedded, in places graded, fine sand. Surrounding beds are truncated by small normal and reverse faults and adjacent primary sedimentary structures are often locally upturned. As outlined elsewhere (Kemp *et al.*, 1993), the occurrence of the Barham Arctic Structure Soil and a later cryoturbated unit, dominated by sand-wedge casts buried beneath till and glaciofluvial sands and gravels of the Lowestoft Formation, may suggest a change from moist, periglacial environments into arid, permafrost conditions immediately before the advance of the Lowestoft ice sheet. However, the reliability of sand wedges as indicators of palaeohydrological conditions has recently been the source of debate (Kolstrup, 1987; French, 1996). In addition, while a phase of periglaciation following the formation of the Barham Arctic Structure Soil is recorded at Thorington, a further phase of arid, periglacial conditions, preceding the formation of the Barham Arctic Structure Soil, has been recorded elsewhere in Suffolk (e.g. Allen, 1984). The duration of such periods cannot be determined at present but, by analogy with later episodes, this non-glacial 'cold' climate could represent a considerable period of time, if it is indeed solely within the Anglian Stage.

The Lowestoft Formation

Evidence of arid permafrost conditions is absent in glaciofluvial gravels of the Lowestoft Formation which overlie the Barham Arctic Structure Soil in both north and south pits (Figure 2). Palaeocurrent measurements from medium- to coarse-grained pebbly gravels, with plane-stratified, trough and planar cross-bedded sand interbeds, indicate transport to the south and south-east (123-183°). The gravels are composed predominantly of locally derived flint (Table 1), but are also marked by a significant increase in quartz and quartzite pebbles. While there is no direct evidence for the occurrence of fluvial gravels associated with the Bytham River or the River Thames in the exposures at Thorington, it is likely that, as elsewhere in Suffolk, the Lowestoft Formation ice sheet reworked the characteristic quartz- and quartzite-rich gravels associated with the pre-Anglian Thames and its tributaries.

In the south pit, the contact between the Barham Arctic Structure Soil and glaciofluvial outwash of the Lowestoft Formation is marked by a laterally

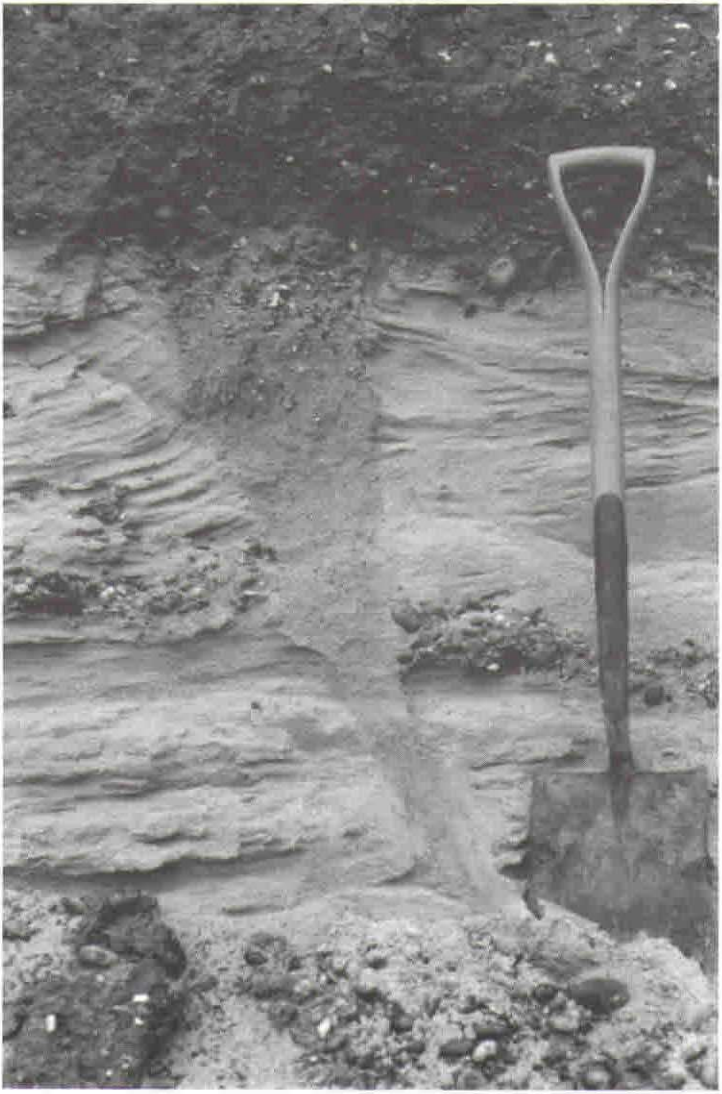

Figure 5. Sand-wedge cast overlain by facies Dm, north pit, Summer 1994.

persistent, 1.6 metre-thick laminated silt unit . The palynology of this unit points to accumulation in a still, freshwater body, possibly a pool or river back channel, during cold-stage, 'full-glacial' conditions (Richards *et al.*, 1999).

Sedimentology and structural geology of diamictons of the Lowestoft Formation at Thorington

Diamictons of the Lowestoft Formation are found in three facies at Thorington:

Massive diamicton (facies Dm)

A single, laterally persistent, apparently massive diamicton forms the upper unit in most parts of both the southern and north pits (Figures 2 and 5). The lithological composition of this unit is shown in Table 1. The lower portions of the unit are characterised by a defined clast fabric which becomes increasingly distinct with height through the unit. The macrofabric, jointing and shear-surface patterns associated with this unit are illustrated in Figure 6. In some locations the diamicton contains crude flow structures, sheath folds and other forms of ductile deformation. The nature of the lower contact with underlying glaciofluvial sands and gravels is planar-erosional, but is marked locally by small-scale ductile deformation features such as drag folds, hook folds and coarse-grained, tectonic lamination.

Truncated sand wedges and frost fissures occur at 19.08 m OD in the northern section, directly underlying the homogeneous diamicton. The sand-wedge casts contain primary infillings of horizontally bedded, in places graded, fine sand (Figure 5). Some examples (Figure 5) exhibit crude grading from fine sands in the lower portions of the cast, to pebbly gravels in the upper parts. Surrounding beds are truncated by small normal and reverse faults, and adjacent primary sedimentary structure is often locally upturned. The upper portions of the sand wedges are truncated by a planar-erosional contact with overlying diamicton units. There is no evidence of deformation of the cryoturbation features during the deposition of the diamicton units.

Locally, facies Dm overlies pervasively sheared and loaded beds or further, laterally impersistent sheared and massive diamicton units:

Stratified diamicton with sand intraclasts

In the north pit, the lower portions of facies Dm are characterised by coarse sand interbeds (subfacies Dms). In places, sand interbeds exhibit inverse-graded laminae, tectonic lamination, transposed foliation and 'eye' structures of sheath folds (Figure 8). Partially deformed, laterally persistent pebbly sand units overlie a lower diamicton (facies Dmm). The diamicton does not exceed 60 cm in thickness and is characterised by very low stone contents and

Table 1. Lithological composition (8-16 mm fraction) of sediments exposed at Thorington.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
flint	97.9	98.5	98.5	98.3	98.0	98.2	96.7	96.4	96.8	84.2	87.6	88.2	71.2	93.0
quartz	0.4	0.5	0.3	0.6	0.6	0.3	1.3	1.8	1.1	2.6	3.0	6.7	3.2	1.4
quartzite	0.8	0.5	0.3	0.6	0.3	0.6	1.0	0.8	0.7	7.9	4.5	3.5	0.7	1.4
chert	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4	0.7	1.9	1.8	0.4	0.4	1.0
sandstone	0.0	0.2	0.3	0.3	0.3	0.3	0.0	0.0	0.0	2.6	1.5	0.0	0.7	1.0
limestone	0.4	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.4	0.5
chalk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.5	0.0
ironstone	0.0	0.0	0.3	0.0	0.3	0.3	0.7	0.3	0.4	0.0	0.0	0.0	0.0	0.0
ign/meta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.8	0.7	1.0
other	0.4	0.2	0.5	0.3	0.3	0.3	0.0	0.3	0.4	0.4	0.6	0.4	0.4	0.7
no.	238	407	399	347	352	327	304	367	277	266	330	254	285	415

1-9 Composition of the Westleton Member of the Norwich Crag; **10-12** Composition of gravels within the Barham Arctic Structure Soil; **13** Lowestoft Formation till (unweathered); **14** Lowestoft Formation till (weathered).

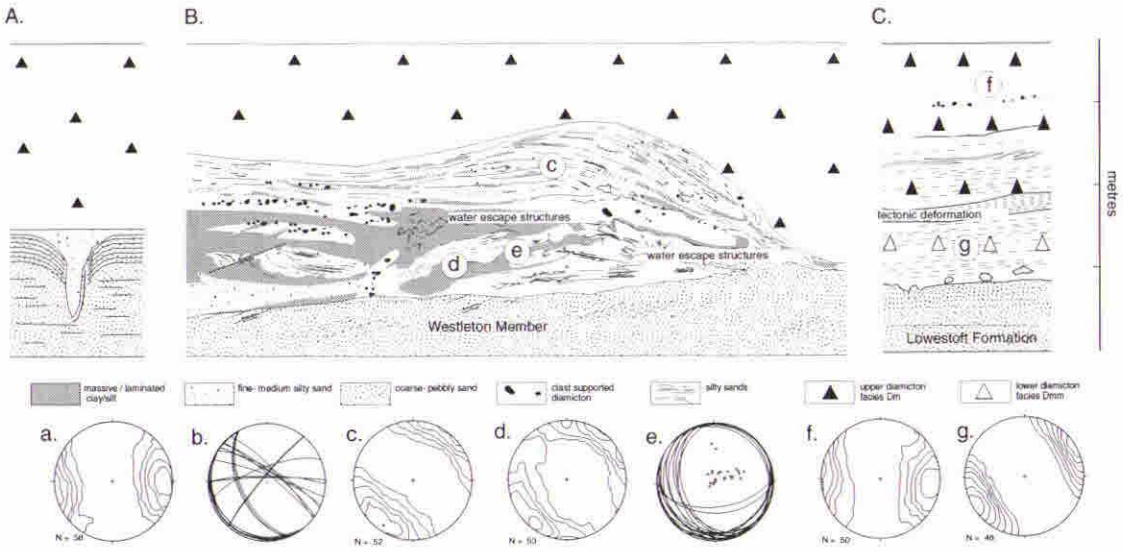

Figure 6.

A. Schematic diagram of homogeneous diamicton (facies Dm) overlying sand-wedge cast showing no evidence of glaciotectonic deformation (see also Figure 5); B. Detail of deformed beds (subfacies Dms-d) underlying upper homogeneous diamicton (facies Dm), north pit 1994 (to scale); C. Detail of deformed beds and lower, stoneless diamicton (facies Dmm) underlying upper homogeneous diamicton (facies Dm), south pit 1996 (to scale).

a. Fabric from facies Dm, north pit 1994; b. Jointing and shear planes measured from facies Dm, north pit 1994; c. Fabric of prolate clasts within deformed silty sand bed, north pit 1994; d. Fabric of prolate clasts within deformed clay-silt bed, north pit 1994; e. Dip and orientation of fold limbs from deformed horizon; silty sands and massive tectonically laminated silty clay bed; f. Fabric from facies Dm, south pit 1996; g. Fabric from facies Dmm, south pit 1996.

extensive jointing . The lower contact of facies Dmm is: i) loaded, where in contact with partially deformed glaciofluvial sands; or ii) planar-erosional, in contact with apparently undeformed sediments. In two locations where the lower diamicton has a planar lower contact, its lower portions contain sand pods with brecciated margins and primary sedimentary structure deformed by small-scale thrust faults (Figure 7).

Massive diamicton with pervasively deformed contact

In some locations in the south pit, facies Dm is often underlain by laterally impersistent, complex deformed beds (subfacies Dms-d, Figure 6B). The upper portions of the deformed complex are dominated by transposed foliation and attenuated sheath folds. The lower part of the complex contains a variety of rooted, attenuated folds, extensional fault systems, thrust faulting and larger-scale (up to 20 cm in thickness) boudinage structures. These shear structures both dissect and are dissected by dish, flame and other diapiric forms. The underlying contact of the deformed complex varies locally; in some locations there is a planar-erosional contact with small-scale conjugate normal and thrust faulting, while in other places glaciofluvial sand and gravel intrude into the complex. Deformation at this contact is in the form of rooted structures, rafts, ball and pillow and dish structures, reflecting active shear and normal displacements.

Prolate clast fabrics within the lower deformed horizons and the lower portions of overlying massive diamicton units in facies 2 and 3 are defined, indicating shear towards the south-east (samples 6 to 8, Table 2). These results are sympathetic with the direction and dip of fold limbs within the deformed units within and immediately below the diamicton complex. These fabrics differ from the strong but locally divergent fabrics exhibited in the upper parts of the diamicton assemblage in both the northern and southern pits (samples 1 to 5, Table 2).

Interpretation: depositional environments and stratigraphical significance of the diamicton associations

The upper diamicton assemblage (facies Dm) at Thorington is likely to be the product of a subglacial deformable bed (*sensu* Hart *et al.*, 1990; Hart and Boulton, 1991), and the lithological composition of these units is typical of that associated with diamictons of the Lowestoft Formation (Rose and Allen, 1977; Allen *et al.*, 1991). Variations in structural style, the nature of contacts and the architecture of component facies are of particular importance in palaeoenvironmental reconstruction. The abrupt contact between the upper homogeneous diamicton and the underlying, undeformed sands and gravels may mark the position of the deforming horizon or plane of décollement

Figure 7. Lower portion of facies Dms, containing sand pods and small-scale thrust faults, south pit, summer 1995.

Table 2. Fabric data from diamictons (Lowestoft Formation) exposed at Thorington. Samples 1-3, upper homogeneous diamicton, facies Dm; 4-5, facies Dmm; 6-8, facies Dm-d.

		eigenvalue	eigenvector	dip
1	S1	0.652	224.9	7.4
	S2	0.287	316.7	13.8
	S3	0.06	107.5	74.3
2	S1	0.735	308.3	12
	S2	0.187	216.1	10.3
	S3	0.077	77.9	74
3	S1	0.821	240.8	5.2
	S2	0.114	150.6	1.9
	S3	0.064	40.4	84.5
4	S1	0.552	218	8.3
	S2	0.37	124	20.1
	S3	0.07	329.3	68.1
5	S1	0.602	113	6.3
	S2	0.332	203.4	3.9
	S3	0.065	325.1	82.6
6	S1	0.718	93.9	9.8
	S2	0.175	188.9	26.9
	S3	0.107	345.7	61.6
7	S1	0.756	122.5	6.5
	S2	0.166	213.5	8.7
	S3	0.076	356	79.1
8	S1	0.816	110.1	15.1
	S2	0.112	176.2	32.1
	S3	0.072	332.2	44.5

between intensively sheared and undeformed sediment. This boundary is thought to represent *excavational* deformation, typically associated with upper portions of an ice sheet (Hart *et al.*, 1990). Elsewhere, the apparently homogeneous diamicton is locally underlain by a sequence of horizons which broadly correspond to the models of subglacial deformation of Banham (1977) and Boulton (1987) and the structural relationships of the unit are very similar to those reported from the Lowestoft Formation at Great Blakenham, Suffolk (Allen *et al.*, 1991). This arrangement is more typical of *constructional*, ice-marginal subglacial deformation (Hart *et al.*, 1990).

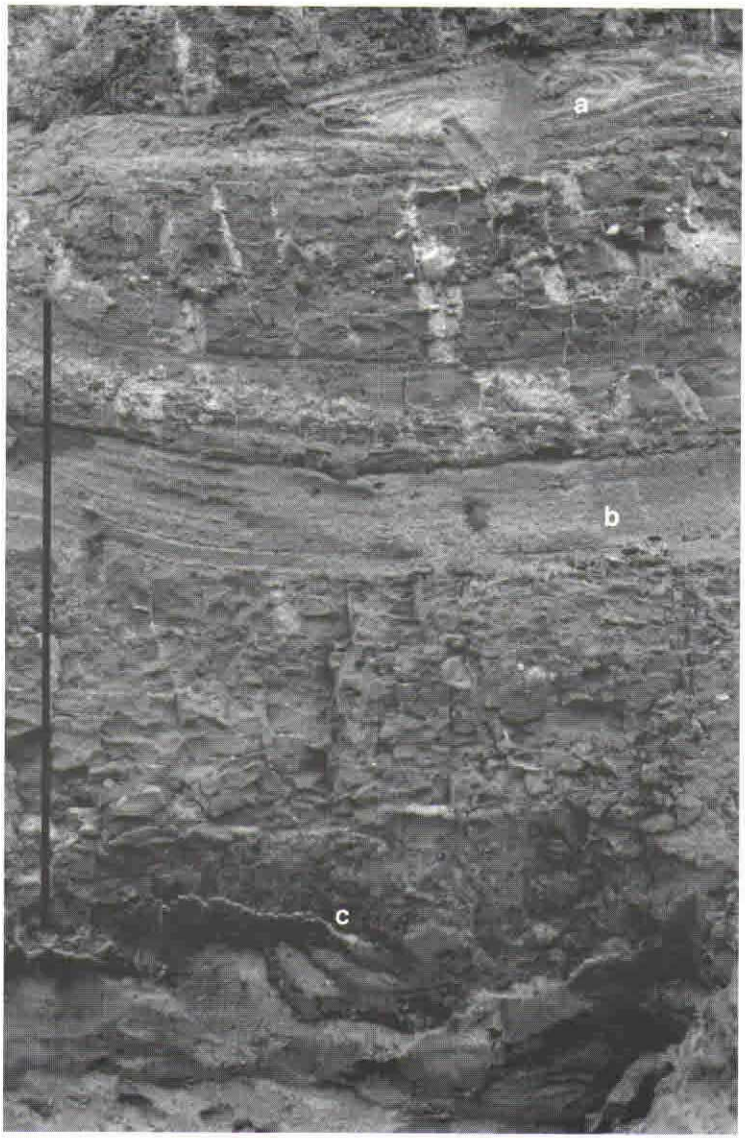

Figure 8. Transposed foliation (b), sand pods (c) and sheath folds (a) in facies Dms, south pit, summer 1995.

Where a single homogeneous diamicton unit overlies apparently undeformed sediments, the contact is marked by the occurrence of undeformed sand-wedge casts. This suggests that the area was subject to permafrost conditions immediately before, and during, the incursion of the ice sheet. Brecciated sand intraclasts, which were observed within the lower units of the diamicton assemblage in the south pit, also attest to the presence of a frozen substrate. Such intraclasts have been reported from subglacial deformable beds in Ontario, Canada (Menzies, 1990). This author suggested that the sand bodies must have been frozen to resist high strain rates as they were entrained into the subglacially deforming bed.

The pockets of deformed sediment which occur locally beneath the homogeneous diamicton (subfacies Dms-d) may represent local pressure melting of the underlying permafrost. Localised pressure melting may have been promoted by local elevation in subglacial pressure or may have been a function of variations in the texture and concomitant variability in the 'frost susceptibility' of the substrate (*cf.* Allen, 1991). Within these pockets, deformation structures record high shear strain rates due to high pore-water pressure gradients between the deforming bed and the permafrost table. The occurrence of diapiric forms which both dissect, and are dissected by, the shear structures suggest syndepositional pressure melting of the substrate during subglacial deformation.

The results of till fabric analyses from deformable beds to reconstruct ice-flow directions are often inconclusive (Hart, 1994). Clast fabrics and structural data from lower parts of the deformed complex (facies Dm-d) suggest ice-movement towards the east and south-east. The strong but variable clast fabrics exhibited by the upper portions of facies Dm may reflect clast realignment during ductile deformation as reported from the upper horizons of subglacially deformed sediments in Iceland (Benn, 1995). Samples 1-5, taken from within the homogeneous diamicton (facies Dm) and stoneless diamicton (facies Dmm) are typical of those associated with a relatively thick deforming layer (Hart, 1994), whereas samples 6-8 are typical of a thinner deforming layer, near the margins of ice sheets, as encountered by Allen *et al.* (1991) and described by Hart (1994) from southern East Anglia.

Conclusions

Two phases of widespread periglacial conditions are recorded in the sediments exposed at Thorington. The first is correlated with the Barham Arctic Structure Soil of Rose *et al.* (1985) and results from active-layer processes above a regional permafrost table, before Anglian Stage glaciation. The second horizon of periglacial structures occurs immediately below the Lowestoft Formation and marks a further phase of intensely cold conditions immediately before and

during the incursion of the British, Anglian ice sheet. This supports the evidence for variable climatic conditions in the early Anglian Stage that has been proposed elsewhere (Kemp *et al.*, 1993).

The diamictons exposed at Thorington, like many of the subglacial diamictons of East Anglia, conform with the models that have resulted from the seminal work of Hart and co-workers (e.g. Hart *et al.*, 1990; Hart and Boulton, 1991). However, the sedimentology, structural geology and facies relationships of the glacigenic deposits of the Lowestoft Formation at Thorington appear to be partly determined by the nature and extent of frozen ground immediately before the ice sheet advanced into the region. The diamictons of the Lowestoft Formation exhibit characteristics typical of *excavational* deformation in association with an underlying, undeformed but *frozen* substrate; whereas the diamictons demonstrate *constructional* deformation in association with underlying, deformed *unfrozen* substrate. As both associations occur at the same level within the quarry complex, it is safe to assume that they formed under similar glaciological conditions and that the style of deformation and facies relationships are at least partly determined by the persistence, or otherwise, of frozen-bed conditions. Therefore, care should be taken in the use of subglacial facies models to describe the nature of deforming bed conditions regionally. These associations also provide evidence for the persistence of intensely cold, arid conditions immediately before and during the advance of the Lowestoft Formation ice sheet.

Acknowledgements

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RHAXELLA CHERT IN EAST ANGLIA - DISCUSSION

David Bridgland

I was very interested to read the note by H.B. Mottram in *Quaternary Newsletter* 88 discussing the provenance of the *Rhaxella* chert found in the Norwich Crag. As part of my Ph.D. research in the late 1970s (Bridgland, 1983, 1986, 1990), I collected durable *Rhaxella* chert from several localities in Yorkshire, so I take issue immediately with the statement about its infrequency there. The Howardian Hills are bristling with the stuff, around Hovingham and Castle Howard, for example! I found that it occurs in all the Oxfordian divisions classified as 'calcareous grit', including the Birdsall Calcareous Grit (Wright, 1972). Sites include Potticar Quarry, Hovingham (SE 660742), Nunnington Quarry and railway cutting (SE 649788) and Rush Quarry, Coxwold (SE 565855). I found instances where *Rhaxella* spicules formed the centres of ooliths, a type that I have seen in glacial drifts. This type was collected from Slingsby Quarry (SE 695745) and Carlton (SE 613888). Both cherts and limestones with *Rhaxella* occur in the Howardian Hills and both occur in glacial gravels and till, although only the durable chert survives into fluvial deposits. I have never been in any doubt that the Howardian Hills area is the source of much of the *Rhaxella* chert found in the drifts of East Anglia and the Thames. I have, however, found occasional pebbles of the rock in gravels of the River Medway. Entirely beyond the transportation limits of the Quaternary glaciations, these must have had a different source. In fact Cretaceous pebble beds in the Weald contain *Rhaxella* chert (Wells *et al.*, 1947; Bridgland, 1983), probably derived from Oxfordian rocks at that time exposed in the 'London Massif', and these are the source of the rare Medway clasts.

It is quite wrong to think that because chert forms a minor part of a formation it will not contribute significantly to pebble-sized, waterlain clastic deposits. The same could be said of flint in the Chalk, but take a look in the bedload of a chalkland stream or on a nearby beach, where the situation is reversed or flint alone occurs. In some areas of the Oxfordian outcrop in Yorkshire an 'angular chert drift' of *Rhaxella* type can be found, comparable to the drifts covering the chert-bearing Greensand of southern England and, of course, flinty soils all over the Chalk outcrop. Weathering concentrates the chert, however small a proportion of the formation it represents. The chert is effectively indestructible, whereas the containing strata are entirely non-durable as far as gravel-sized material is concerned.

I have also collected from other Oxfordian *Rhaxella*-bearing rocks. First the Arngrove Stone (Oxfordshire), which proved to be neither true chert nor

durable, not even appearing in the gravels of local streams. Second, the Purton outlier, near Swindon, was investigated. This, like some of the cherts from north Yorkshire, is oolitic. It lies to the south-west of the likely source areas for the East Anglian Quaternary, however. I too have heard tell of *Rhaxella*-bearing rocks from offshore oil drilling and have seen beach clasts of *Rhaxella* chert, some of them used in prehistory for tool-making, from the coast of Buchan, north-east Scotland. These, however, are very pale. Unlike the Oxfordian cherts I have seen, they are nodular and have a flinty appearance, complete with cortex. They may well be Portlandian in age, as they are similar to some of the cherts from the Dorset Portlandian, which themselves contain *Rhaxella* spicules, although not to the exclusion of other types, as in the Oxfordian cherts. *Rhaxella* chert has also been encountered in buried Oxfordian rocks in boreholes at Penshurst, Kent, and Kingsclere, Hampshire (Wilson, 1968).

I am entirely unconvinced of the value of colour as a means of determining the provenance of rocks. Greensand chert, that other favourite of us gravel lovers, occurs in drifts as dark grey clasts and even as haematite-stained jasperized (red) ones, neither of which can be matched in outcrop and both of which I strongly believe to result from secondary staining. Consider, too, the colour of most flint clasts in drift deposits. Flint, the most durable of all the cherts, is found in numerous hues from white to red. Much of it is rusty brown, but you won't find it like that in the Chalk. The lesson, I'm afraid, is that these siliceous rocks are readily bleached and/or stained, so colour provides little indication of provenance.

Thus, while I'm happy that offshore sources may have contributed (and of course the Yorkshire outcrops continue offshore, although the chert is better developed inland than near the coast), I'm happy that the Howardian Hills area is the source of most of the *Rhaxella* chert found in Anglian glacial drifts and thence reworked into post-Anglian gravels. The Norwich Crag and the Westleton Beds are perhaps more likely to have significant inputs from offshore, given their location. Marine gravels of this sort are typically stained dark grey by manganese. This is true of both the flint and the various cherts in the Westleton Beds, in much the same way as is seen in the much older Palaeogene marine flint gravels of the London and Hampshire basins. This I suspect to be the explanation for the colour of the cherts examined by Mottram.

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A MEMORIAL TO JOHN FRERE

John Wymer and Richard West

The tablet illustrated below (Figure 1) has been placed in the chancel of St Bartholomew's Church at Finningham, Suffolk, a few miles north of Stowmarket. This is a much overdue tribute to a man who was the first person in Britain to recognise palaeoliths for what they were and to realise the significance of their

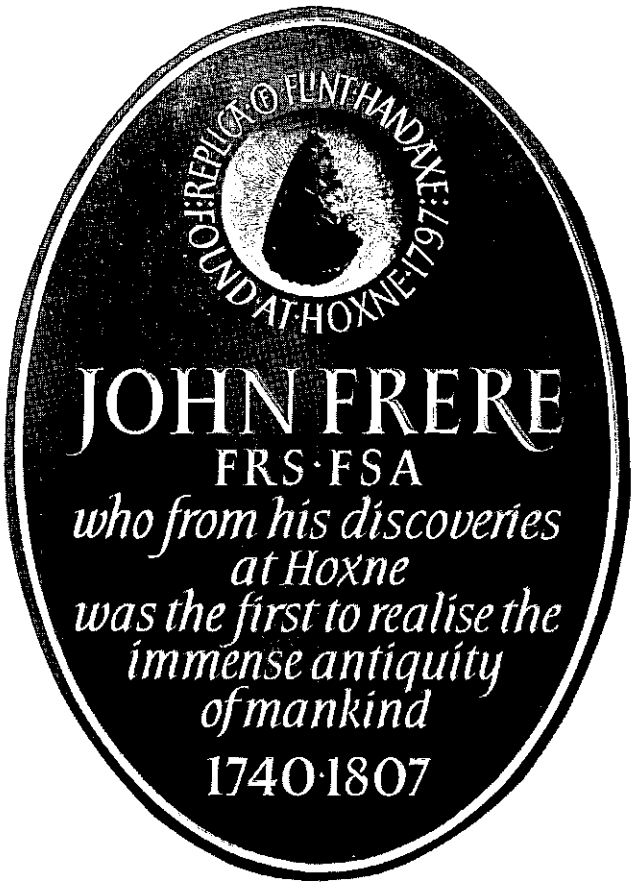

Figure 1. Welsh slate with letters painted off-white and a replica flint hand-axe, in Finningham Church, Suffolk. The slate was designed and cut by the Cardozo-Kindersley workshop in Cambridge.

occurrence in Quaternary deposits well above the level of the floodplains of the rivers Dove and Waveney below them. This was in 1797. It is not unreasonable to regard him as the father of scientific archaeology. The situation of the finds in relation to the landscape prompted his inspired conclusion that these hand-axes, as we should now call them, were "fabricated and used by a people who had not the use of metals", and had been made at "a very remote period indeed: even beyond that of the present world." This was, of course, totally at variance with current thought which on biblical calculations decreed that the world had been created in 4004 BC. The details of John Frere's discovery and report may not be known to all members of the QRA.

It was by chance that John Frere was passing through Hoxne on his way to Eye and, at the top of the hill to the south of the village, he paused to watch the workmen digging clay for bricks in the pit now so well known as the type site of the Hoxnian Stage of the British Quaternary. He noticed that, at a depth "twelve feet, in a stratified soil", the workmen were throwing out flints which he immediately recognised as being of human workmanship. He said that there were so many they were using them to fill ruts in the road! Furthermore, he thought that the overlying sediments were fluvial and he put it: "the ground in question does not lie at the foot of any higher ground, but does itself overhang a tract of boggy earth, which extends under the fourth stratum: so that it would rather seem that torrents had washed away the incumbent strata and left the bog-earth bare, than that the bog earth was covered by them, especially as the strata appear to be disposed horizontally, and present their edges to the abrupt termination of the high ground." Looking behind him, as at present, he realised that the present valleys of the Dove, Waveney and Gold Brook with their floodplains well below him, had been eroded since the deposition of the brickearth and other sediments above the palaeoliths. The vast volume of Norfolk and Suffolk which had been washed away since the hand-axes had been covered by the sediments in the pit convinced him of the enormous amount of time that must have elapsed between their manufacture and the present day, thus the immense antiquity of mankind. He reported his observations in a letter to the Society of Antiquaries of London on 22nd June 1797, where it merely received little response but a somewhat fatuous thanks from the Secretary for his "curious and most interesting communication." However, the letter was published in *Archaeologia* (volume 13, pp. 204-5) in 1800, but, likewise, received little or no comment at the time.

The letter is in fact a model of brevity, such as might even nowadays be acceptable to the editor of a scientific journal. It stressed the significance of the geological situation in which the hand-axes were found, and clearly separated the stratigraphical relations from conjectures about the antiquity of Man.

John Frere was a remarkable man, born in 1740 at Finningham, which was the ancestral home of the illustrious Frere family. He received his M.A. for Gonville and Caius College in 1766 and was Fellow of the Royal Society and the Society of Antiquaries. He later lived in Roydon Hall, near Diss, Norfolk. He was a man of many interests and also held high positions such as High Sheriff of Suffolk and in 1799 M.P. for Norwich. With his antiquarian interests, he was a friend of the noted antiquary Richard Gough. He married Jane Hookham in 1768, a rich woman of high intellect, and had seven sons and two daughters, all of whom became distinguished.

On the bicentenary of his letter to the Antiquaries, namely 22 June 1997, a small party of people with special interest in the Palaeolithic period or the archaeology of East Anglia met at Hoxne to celebrate the occasion. It included the authors of this note and a few other members of the QRA. The Hoxne brickpit was visited, long since unworked, and a contractor's yard and Finningham Church. Within the chancel of the church are several memorials to past members of the Frere family, but none specifically to John Frere, let alone mention of his pioneer conclusions from his observations at Hoxne. This was deplored by the party and it was unanimously agreed that this would be a fitting place to have one, if the Diocese would consent to such. Happily, the Diocese and the Parish Church Council agreed and an appeal was made for funds to have one made. Donations have been generously received from the Frere family, all the major archaeological societies and groups of Norfolk and Suffolk, various institutions including the QRA, and from individuals. This has enabled the prestigious Cardozo-Kindersley workshop at Cambridge to be commissioned to make the tablet, but in Welsh slate, as illustrated. It is a beautiful production and includes a fine replica of a hand-axe, as found by John Frere, made by Phil Harding. It would seem a suitable tribute to a man who perceived the antiquity of mankind sixty years before Evans and Prestwich were convinced of it by the discoveries at Abbeville. They reasoned that if such evidence occurred in northern France, there should be some in Britain. They consulted *Archaeologia*, volume 13, went to Hoxne immediately, dug, and satisfied themselves that it was so.

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LIAISON WITH SCHOOLS: ENHANCING GENERAL AWARENESS OF THE QUATERNARY RESEARCH ASSOCIATION

Tim Lawson

It can be argued that the inclusion of the word 'Quaternary' in the Association's title is not helpful if we are to fulfil our broader aims of educating the wider public about such things as environmental change, landscape evolution and geomorphic process variation (amongst others). In general, the wider public has little appreciation of the meaning of the word 'Quaternary', feeling much more at home with a phrase like 'Ice Age'; nowadays they may even volunteer the phrase 'Ice Ages'! The QRA Executive Committee feels that we should be trying to open up the expertise contained within the QRA membership to the general public, thereby raising the profile of the Association. In order to do this it is necessary for us to find ways of introducing the Association to those who are not yet aware of its existence. We feel a good start would be to approach a receptive audience such as secondary school teachers and their pupils, and offer them access to information and expertise *via* our website. Such interaction should be beneficial to both parties.

Benefits to the Association

The QRA, by the very nature of Quaternary science, is composed of members with very different specialities and interests. Many of these are employed in education – not all within *higher* education – and many might welcome the opportunity to extend the educative process to those in secondary, perhaps even primary, education. The main benefits to the Association if these links are furthered are threefold: firstly, the improved awareness of things to do with the Quaternary; secondly, a raising of the profile of the Association with the general public; and thirdly, the potential attracting of future scientists into some associated area of Quaternary research, there to enhance further our knowledge and understanding. An expansion of the membership might also result, further securing the finances of the Association.

Benefits to schools

At present, secondary school subjects such as geography and biology continue to be popular choices for study at A-level and (Scottish) Higher Grade. However, competition to attract viable numbers of pupils at a time when science subjects in general appear to be decreasing in popularity, means that

such departments really have to *sell* themselves and show the subjects to be both stimulating and *worthwhile*. To help in this, teachers would welcome access to:

1. information about the Quaternary of local areas, which would be useful to support regional- and local-scale case studies that are often a requirement of geography syllabuses, as well as a help in the organisation of local field trips;
2. local experts who might be prepared to offer advice about suitable sites for such field trips, or even to give illustrated talks at the school;
3. more general information to support various themes present in current upper secondary school curricula (e.g. climatic change, geomorphological process change, ecosystem disturbance).

Making contact with school teachers

As the ICT revolution continues apace within our secondary schools, arguably the most effective way of delivering the above would be *via* the QRA website. It is proposed that the website is adapted to provide relevant links to areal information, to other websites whose language is accessible to the non-specialist, and links to named individuals who would be prepared to 'fly the flag' of the QRA by being effective points of contact for schools. Some suggested additions to the website to effect the above are listed below.

As a starting point, QRA members who would be interested in helping to progress this project are asked to contact the author. At this stage we are keen to make sure that we are thinking in the right direction: it is important that people accessing the QRA website find the information that they are looking for, or helpful links that enable them to get to this information. If secondary school pupils are attempting to access this information, it must be presented in a form that is both stimulating and useful, with a minimum of jargon. It would be helpful if fellow members of the QRA who are teachers in secondary schools, sixth form colleges or further education colleges communicate with the author their ideas as to what would be the most useful information to themselves and their students. We also need those members who would be prepared to contribute short areal summaries and individual site descriptions that would form part of the information available on the website.

Suggested additions to the QRA website

These are the author's suggestions based on discussions with various colleagues both within and outside secondary education. Others may well have different suggestions: at this stage, all will be welcomed.

1. Incorporated into the QRA home page (or linked directly to it) one can envisage a map of the British Isles, subdivided into a number of regions. Clicking on a region brings up a brief summary of the Quaternary of that area (or lists sub-regions which link to other summaries). There could be further links to important sites, to more detailed information, with thumbnails of selected pictures and diagrams/maps, links to relevant publications (including QRA field guides – a potential sales point) and a list of local experts' e-mail addresses to enable contact to be made. The success of this approach is to a large degree dependent on members offering to produce the summaries of their work, or the work of others. A standardised format will need to be agreed upon.

2. Additional link pages (perhaps a sub-list 'Schools links' within the current links?) selected for their more general content according to a list of themes that teachers find useful (e.g. glaciology, sea-level change, climatic change, Quaternary chronology, faunal and vegetation changes). Again, interested members might be persuaded to write web pages as summaries of these themes.

Further suggestions should be sent (or e-mailed) to the author at the address below.

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A POLLEN IMAGE DATABASE FOR EVALUATION OF AUTOMATED IDENTIFICATION SYSTEMS: CORRECTION

Andrew Duller, Geoff Duller, Ian France and Henry Lamb

The article by Duller *et al.* (1999) published in *Quaternary Newsletter* 89, unfortunately contained a number of typographic errors. The most important of these were in the list of WWW sites relevant to automated pollen identification that were in the appendix. The correct WWW addresses are listed below:

1. Palynology at the University of Arizona
   http://www.geo.arizona.edu/palynology/
2. Catalogue of pollen types
   http://www.kv.geo.uu.se/pc-intro.html
3. Automatic Identification and Counting of Airborne Pollen Grains
   http://www.informatik.uni-freiburg.de/~ronneber/pollen.html
4. Automated Diatom Identification and Classification (ADIAC)
   http://www.rbge.org.uk/ADIAC/index.html
5. USDA Pollen Laboratory
   http://scrl.usda.gov/scrl/apmru/imms/pollen/index.htm
6. Swedish Museum of Natural History (CD-ROM)
   http://www.nrm.se/pl/cdrom.html.en
7. African Pollen Database
   http://medias.meteo.fr/www/anglais/activites/donnees/

   At present, this site is difficult to navigate. The extensive image archive that has been produced can be found more quickly from the page below:
   http://medias.meteo.fr/apd/maquette/program/output.html

In addition, it has been pointed out that the catalogue of images of British pollen types produced by Keith Bennett (item 2 above), was not funded by NERC, but undertaken by Keith using other sources of income. We apologise for this error.

Reference

Duller, A. W. G., Duller, G. A. T., France, I. and Lamb, H. F. (1999). A pollen image database for evaluation of automated identification systems. *Quaternary Newsletter*, 89, 4-9.

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REPORTS

QRA ANNUAL FIELD MEETING - DURHAM

7th - 10th April, 1999

The Durham Easter Field Meeting spanned an area from close to the Scottish border to south of the Humber, approximately 250 km as the crow flies - surely a claim for an entry into the QRA book of records?

On Tuesday evening, **David Bridgland** welcomed the QRA to Durham with an introduction to the glacial history of the area, drawing out also the problems created by local coal-mining and pointing out the relevance of watching 'Get Carter' to the next day's field session. However, due to the stubbornness of the video recorder, Michael Caine did not make an appearance that night and we had to wait 24 hours before Carter was 'got'. David left us with points of contention to discuss and examine in the field, such as the dating of the raised beaches to Oxygen Isotope Stage (OIS) 5e, as cases for OIS 7, 9 or even 11 could be made and, related to this, the evidence for pre-Devensian glacial activity. **Ian Shennan** followed with a closely argued and systematic cover of the Holocene sea-level data for Durham and Northumberland which lie in a crucial area at the balance point between net uplift in northern Britain and net subsidence to the south, with implications for models of ice thickness and rheology.

Day 1: The Durham coast and the Tees Estuary

The day started at Easington with some impressive trenching through the Upper Till and debate whether the fabric, preferentially dipping to the north-east, reflected ice movement along the coast or was affected by local slope reworking. Thereafter a somewhat demanding descent was well rewarded with excellent exposures of the shelly gravel of the Easington Raised Beach. Conventionally dated as Ipswichian, David Bridgland indicated that it might not be OIS 5e as amino-acid ratio 'dates' suggest OIS 7 or 9, while the altitude of *c.* 35 m OD would not be incompatible with OIS 11. These older estimates led to speculation that the Upper Till could be 'Wolstonian' rather than Devensian. The Lower Till could not be visited but could be seen in the cliff. On the beach, an erratic of porphyroblastic gypsum within slumped till led us back to questioning the direction of travel of the ice as such material outcrops to the south or east, while

other erratics looked to be of Lake District origin. In the literature, Beaumont argued that his Lower Till was deposited from ice approaching from the north-west.

Along the coast at Hawthorn Dene, a palaeovalley infilled with tills and outwash, again raised the question of dating. The infill is traditionally regarded as Late Devensian, but the discussion at the previous site had raised the possibility of an earlier dating, while recent work elsewhere is pointing to the possibility of an OIS 4 ice advance. After lunch, Castle Eden Dene and its tributary Blunts Dene, both filled with glacigenic sediments, also provided examples of recent large-scale landslips. The landslip scars provided plenty of exposures of till and the local 'Middle Sands', often tectonically disturbed. Some of the party stayed at the first exposure on the south side of Blunts Dene, where discussion centred on the genesis of the tectonics, whether glacially or slope-induced, and the provenance of the glacial material. The clasts and matrix could be matched locally to the south or east or more distantly to the west. The last would coincide with Beaumont's Lower Till. Other members of the party explored the denes and visited the glaciofluvial sediments exposed high on the north side of Blunts Dene.

The day ended with evidence for sea-level change from Cowpen Marsh and Seal Sands in the Tees Estuary. A profile from Cowpen Marsh showed a sequence of diamicton, laminated sands and silty clay and Holocene intertidal sand. Recent particle-size and magnetic work on the laminae by Andy Plater supports the view that they were formed in a proglacial lake between the North Yorkshire Moors and an ice mass to the north. The Holocene sediments indicate a relative sea-level rise that decelerated in the mid-Holocene. This site was particularly interesting as diatoms had been used to deduce tidal levels, and from those, sediment accumulation rates.

Some of the party went on to visit a recently re-excavated exposure of Scandinavian till at Warren House Gill.

Day 2: Warren House Gill and the North Yorkshire Moors

For the morning the group split and the main party went to Warren House Gill. After speculation whether this was the site at which the final scene of 'Get Carter' was filmed, discussion centred on an exposure of Scandinavian till. This was grey, clay-rich, shelly but with few stones, though a clast of larvikite was found and small chalk and flint clasts were not uncommon. Discussion moved on to the genesis of the till and the nature of its deformation. Overlying it was the local Devensian Lower Till and 'Middle Sands'. Although much coal

waste has been removed, some remains and it may be several decades before the sea removes it and begins to re-expose the glaciogenic sediments.

The main party then moved on to the North Yorks Moors, to Ewe Crag Slack and Newtondale. **Bob Jones** demonstrated Kendall's lake overflow channels, now largely accepted as ice-marginal or sub-glacial, following Gregory. At Ewe Crag Slack, Bob explained there was interdigitation of peat and valley-slope deposits. The pollen record from the peats covers the Late Devensian to the present, but with reduced taxa in the Boreal and Atlantic, probably due to Mesolithic agricultural disturbance, with significant reductions from the Neolithic onwards. The slope deposits were related to soil wash following the main phases of forest clearance from the Mesolithic onwards. Meanwhile, at North Gill and other sites, **Jim Innes** outlined to the splinter group a complementary story. Charcoal layers and mineral bands within peats can be related to forest clearance by fire with subsequent sediment inwash due to erosion. Near these sites Mesolithic artefacts are found, suggesting a link with agricultural activity from that period onwards.

The parties rejoined in Newtondale which, besides being a spectacular channel, had large-scale landslips. The fascination of Newtondale was greatly enhanced by the passage of five trains hauled by a variety of steam locomotives, an American 2-8-0, a Schools 4-4-0 and a Bulleid West Country light pacific 4-6-2.

The last call of the day was at Seamer Carrs, an enclosed peat area within an undulating topography. This had been mapped as a drumlin field but **Jim Rose** considered that it was part of an extensive morainic area. Detailed mapping would be required to resolve the matter. The Carrs had been investigated by Bob Jones who had found a full Holocene pollen profile. The Carrs had also yielded bones of various large grassland animals, such as deer, including a whole skeleton of *Cervus elaphus*, and ox.

Day 3: Herrington and the Northumberland coast

At our first stop, Herrington, we were welcomed by Crouch Mining Limited and introduced to the work on the site by **David Hughes** and **Derek Teasdale**. A combined spoil tip reclamation and opencast mining programme had revealed an intriguing till complex followed by a lacustrine laminated sequence. The till showed an intermixing of grey and red clays. The grey was typical of the Late Devensian Durham Lower Till with a source to the north and west, the provenance of the red clay was more problematical. The laminated sequence was deposited in a lake, Glacial Lake Wear, between the receding Lower Till ice and the still-advancing Upper Till ice.

The rest of the day was led by **Ian Shennan** examining the Holocene sea-level change evidence, the index points, between Druridge Bay and Holy Island, with some competitive augering at the last site. In the southern area, at Cresswell Ponds (Druridge Bay) and Alnmouth, the regressive points, below intertidal peats, are dated to around 7 ka BP and the transgressive points above the peats at about present OD to 3.5-5.2 kyr cal BP. At Broomhouse Farm, near Holy Island, the regression is dated to 8.2-8.6 kyr cal BP and the transgression to *c.* 6 kyr cal BP, at about 5 m OD. Making due allowance for tidal range, Broomhouse Farm typifies the situation for north Northumberland with mid-late Holocene maximum sea level of *c.* 2.5 m OD, while Alnmouth and Cresswell Ponds show a maximum of less than 1 m OD, an impressive difference over a distance of less than 50 km. At Broomhouse Farm, a coarse sandy layer found within the peats may be of marine origin, representing a major storm event, possibly associated with the tsunami deposits of eastern Scotland as the bracketing dates (*c.* 8 and 7.5 kyr cal BP) are compatible.

Day 4: South Yorkshire, north Lincolnshire

The final day explored the southern limits of the field meeting. At Speeton, **Bill Austin** introduced us to the sequence which includes the temperate Speeton Shell Bed. The date of the Bed is much in contention. It is part of a folded sequence found at an aberrant height, *c.* 30 m OD, suggesting glacial rafting. However an overlying early Devensian solifluction deposit is not folded, suggesting the glaciotectonic activity was pre-Devensian but post the temperate period of deposition. West had recovered pollen indicating an Ipswichian age, but an initial amino-acid ratio on shells by Wilson suggested OIS 7. This 'date' was doubted by Bowen as the shells used had been from museum collections and resin-coated. Re-analysis gave ratios more in keeping with the Ipswichian (OIS 5e), the lowest being 0.154. AAR dating of foraminfera supports this age. This leaves a problem of when the glaciotectonic activity occurred. Earlier workers had argued for a Hoxnian age for the Shell Bed followed by 'Wolstonian' glacial activity. Clearly matters are not yet resolved.

Bielsbeck was a particularly valuable site to visit because, although first recorded in 1829, it has been visited only rarely. We were particularly grateful that the farmer, Mr Craven, kindly built a wall of hay bales to keep out the biting wind. **Danielle Schreve** and **Peter Halkon** arranged displays. Danielle had arranged for mammalian material from York Museum to be available. The assemblage, particularly the co-occurrence of *Palaeoloxodon antiquus* and an 'Ilford-type' *Mammuthus primigenius*, indicates an OIS 7 age. Peter Halkon had plotted finds of complementary material, forming a linear distribution, suggesting a river system, the proto-Foulness.

The final, and most southerly, visit was to the Kirmington Brick and Gravel Pits. The chronology of the stratigraphy of the site is currently being re-appraised by **David Bridgland**. The 'Wolstonian' age of the lower till at the site can be challenged and an Anglian age supported. **Jim Rose** pointed out that the heavy minerals from the till at the base of the sequence, examined by **Hilary Davies**, were typical of the Anglian Lowestoft Till. **Gill Thomas** pointed out that the succeeding peat had a low alder pollen count and so could be ascribed to the Hoxnian. She has taken samples for reassessment. If it is accepted that the gravels could have been post-depositionally shattered in cold conditions, as a deformed ice-wedge cast and shattered pebbles in the gravel pit supports, it is reasonable in roundness analyses to exclude the very angular clasts in order to get at the primary depositional stone shapes. Following this procedure, the gravels in both pits can be seen to be comparable, allowing them to be correlated, and to be subrounded beach pebbles. The height of the gravels indicates a relative sea level of 18-25 m OD, more in keeping with the heights known for OIS 11. Doubt is being cast on the authenticity of the artefacts. **Mark White** has noted that those lodged in the British Museum are unlikely to be authentic. **John Wymer** agreed that many of the Kirmington artefacts, now in various museums, are not good, but would not dismiss them all.

Final comment

The meeting struck a good balance between glacial outcrops, Middle Pleistocene and Holocene sea-level evidence, ancient and Holocene organic sequences, thus catering well for a variety of interests. The level of participation was high and it was very notable that even at the final sites close attention was being paid to the proceedings. Over 80 had attended, one of the highest numbers at recent Easter meetings.

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Christine Buckingham
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FIRST WORKSHOP OF *PALPEAT* - THE PALAEOPEATLANDS RESEARCH GROUP SUPPORTED BY THE QRA

Southampton, 10th September, 1999

The aims of the first meeting of the new Special Group of the QRA were to establish common ground on methodology and working practices, to encourage collaboration between researchers and to act as a springboard for future advances in peatland research. There was inevitably a focus on the use of peatland archives as proxy-climate records, since that has been the research area of much recent activity (and funding!), but all aspects of peatland research are encompassed within the Group and it is intended that future meetings will address questions such as the rate and direction of vegetation change; how processes within the acrotelm and catotelm influence the palaeorecord, and aspects of peatland hydrology.

This successful meeting attracted 28 participants and was hosted by the Palaeoecology Laboratory of the University of Southampton (PLUS). After a short introduction by **Keith Barber** on the aims and purposes of PALPEAT there were presentations on different proxy methods and working practices. **Paul Hughes** (PLUS) examined *Fieldwork methods and plant macrofossil analysis* stressing that the adoption of a common approach to gathering field data would have many benefits, and especially that the careful choice of cores for further analyses is critical if the maximum palaeoclimatic information present in the archive is to be realised (e.g. Barber *et al.*, 1998). Paul then outlined some of the latest advances in plant macrofossil analysis, such as the recognition of different taxa within the Monocots component of the peat. For example, identification of sub-fossil remains of white beak-sedge (*Rhynchospora alba*) significantly improves the precision with which we can recognise the beginning and end of wetshifts – it is often found on past pool margins, as the bog surface shifts to and from wetter conditions and this enables shifts to be seen earlier than would be the case if *Sphagnum* remains alone were identified.

Humification analysis was the subject of the talk by **Frank Chambers** (Cheltenham). Peat humification is regarded as a measure of mire surface wetness at the time of peat formation and its measurement in peat profiles has long been used as a proxy-climate record (Chambers *et al.*, 1997). Frank explained that although humification can change independently of plant species, there were some indications of a 'vital' effect and research is in progress to quantify this. Recently, new techniques such as Near-Infrared Reflectance Spectroscopy (NIRS) and luminescence measurements have been trialled, in an attempt to cut the time needed for analyses – the chemical extraction / colorimetric method presently used is routine but time-consuming.

NIRS, for example, is a rapid non-destructive technique offering the potential to measure and correlate several cores in less time than the analysis of a single core by colorimetry (McTiernan *et al.*, 1998).

Recently a third proxy method, that of *Testate amoebae analysis*, has been given a new lease of life by **Dan Charman** (Plymouth) and his co-workers (Charman *et al.*, 1999). Formerly referred to as rhizopods, testate amoebae are found in most Holocene peats and are especially abundant in *Sphagnum*-rich ombrotrophic peats. Some analyses of testates were performed in the 1960s and '70s but recent work has quantified the relationships between changes in assemblage composition and past moisture and pH levels. More researchers are now using testate amoebae analysis as a technique for reconstructing past hydrological conditions on ombrotrophic peatlands, and it is fast becoming a standard addition to macrofossil and humification analyses. Dan reviewed existing knowledge of testate amoebae in peatlands, identified future research priorities, and suggested protocols for sampling and analysis of peat samples. A QRA Technical Guide produced by Dan's group should be ready in 2000.

After coffee, **Pete Langdon** (PLUS) brought together some of the results of multi-proxy analyses from his recently completed Ph.D. (Langdon, 1999). Pete's research involved palaeoclimatic reconstructions from seven ombrotrophic mires in Scotland, and one of the basic ideas behind the project was to only use bogs with tephra – not just as extra "pinning points" in the chronology, though that was valuable, but also to give us the ability to compare what was happening across Scotland at the time of particular tephra isochrones such as Glen Garry (*c.* 2,100 BP) and Hekla 4 (*c.* 3,830 BP) – both uncalibrated radiocarbon years BP (Dugmore *et al.*, 1995).

Plant macrofossil, colorimetric humification and testate amoebae analyses were used together on the same cores, allowing more certain identification of wetshifts, a technique which had been successfully used by another PLUS researcher, **Dmitri Mauquoy**, now working with Bas van Geel in Amsterdam (Mauquoy and Barber, 1999). Pete presented data from two sites, Langlands Moss (very convenient for the NERC Radiocarbon Laboratory at East Kilbride!) and Temple Hill Moss, in the Pentland Hills, south-west of Edinburgh. These sites and others have revealed numerous phases of climatic change over the mid- to late-Holocene, and from Temple Hill there is a significant periodicity of 1,100 years in both the macrofossil and the humification records – this same periodicity has been found by Paul Hughes at Walton Moss, Cumbria (Hughes *et al.*, in press) and, given the dating uncertainties, it may be the terrestrial expression of the famous "Bond cycles" in the North Atlantic ocean (Bond *et al.*, 1997).

A discussion of the accuracy and precision of various dating methods followed, where the case for AMS radiocarbon wiggle-matching was strongly advocated by Dmitri Mauquoy and Keith Barber, before the group adjourned to the Palaeoecology Laboratory for a convivial lunch of pizzas and vino. During the lunch break, **Jim Milne** (Southampton) gave a demonstration of newly developed software – ***PollenPlus*** - for macrofossil, testate and pollen data entry and diagram production, and posters by Mark Garnett, Andy Gent, Dan Yeloff and Frank Chambers and Dmitri Mauquoy were on display.

The first afternoon session was enlivened by an impromptu talk by **Dicky Clymo** (QMW) using overheads drawn during the lunch break. Two sets of AMS dates, one on peat and the other on the methane trapped within the peat, showed consistent differences, for which Dicky had various explanatory hypotheses and which provoked an interesting discussion. The second afternoon session was a general discussion on *Database issues*. How and in what form should we produce a database of members and their interests? Do we want to emulate the European Pollen Database? If we do, how do we develop protocols for access to centrally held data at the same time protecting intellectual copyright? There was agreement that any listing of members should be in a fairly simple and accessible form, and there was general support for a mailbase list; Keith Barber agreed to look into this. It was also agreed that the database issue and the connection to PAGES was very important, as was the issue of calibration of the palaeopeatland record against documented climate and other proxy climate records. **Darrel Maddy** (Newcastle) stressed the importance of aiming to produce data in the right format for the climate-modelling community.

The final session focussed on the future organisation of the Group and the frequency and type of meetings. May and September were thought to be two of the best months for meetings, and it was also agreed that regular reports of the Group's activities should be made through *Quaternary Newsletter.* Keith Barber reminded the meeting that there would be three peatland talks, and a number of posters, at the Southampton QRA Millennium discussion meeting in January 2000, with a keynote address by Bas van Geel.

Tony Stevenson agreed to host the next meeting in his Newcastle department, with the theme of calibration, statistical procedures and wiggle-matching of proxy records. It was hoped that a field visit to some Border mires might also feature in this meeting. This will be in mid-May 2000 – see the QRA and PLUS websites for the latest news – **http://www.soton.ac.uk/~palaeo/**

The September meeting is now fixed for 13th – 15th September 2000, at QMW, London. It will focus on fungal remains and is being organised by **Jeff Blackford** and **Jim Innes** - contact them at J.J.Blackford or J.B.Innes both at qmw.ac.uk

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FOURTH ANNUAL QRA POSTGRADUATE SYMPOSIUM

Coventry, 13th - 15th September, 1999

This year's symposium was hosted by the Centre for Quaternary Science (CQS) at Coventry University and involved a good mix of old friends from the Exeter symposium and new members. It was opened by **Professor Jim Rose** (Royal Holloway, London), with *A conceptual basis for British Quaternary stratigraphy* followed by a discussion on *Future priorities for British Quaternary research*. This got the symposium off to the best possible start. The first day ended with a wine reception and meal where many interesting discussions were held and later continued in a public house.

The first session was chaired by **Jason Jordan** (Coventry). **Phillip Allen** (Coventry) outlined a modified mapping technique used to produce high-resolution geomorphic maps of Mt Brandon, Dingle Peninsula, south-west Ireland. **Rachel Burbridge** (Leicester) then summarised the evidence for late Quaternary vegetational and climatic history of the Noel Kempff National Park, northern Bolivia, punctuating her talk with scenic slides. **Iain Derbyshire** (Aberystwyth) demonstrated the use of high-resolution records of climatic change and human impacts in the Kenyan rift valley to investigate fluctuations associated with the Medieval warm period and Little Ice Age. The second session was chaired by **Stewart Williams** (Belfast). **Sarah Burton** (Luton) described how palaeoenvironmnents are being reconstructed on Mt Etna using sedimentological and biostratigraphical evidence. Continuing with picturesque locations, **Catherine Barnett** (Birmingham) described the effects of climatic change on Holocene tree lines in the Jotunheimen region of central Norway based on pollen analysis of lake and mire cores. **Shirley Wynne** (Coventry) discussed coleoptera and peat humification records from the Cairngorms and detailed the fragile habitats of some species of beetle clinging onto their last British refuge, and the problems these species and habitats face with global warming. **Jason Jordan** concluded the morning session with a presentation of the late Holocene records and relative sea-level change in the Outer Hebrides. The evidence for periods of storminess are being highlighted through changes in dune movement, diatom analysis and within the sedimentary record. The final session was chaired by **Phillip Allen**. **Eleanor Brown** (Royal Holloway, London), presented evidence of a possible pre-Late Devensian interstadial or interglacial site at the corrie of Balglass in the Campsie Fells, central Scotland. The research will be used to establish a framework for conservation management and the promotion of public awareness of landscape evolution. **Charlotte O'Brien** (Coventry) discussed the Middle Pleistocene climatic history of the Médoc region of south-west France, using detailed plant macrofossil and pollen analysis to reconstruct the vegetational succession of this period.

Finally, **Shaun Hampton** (Coventry) reported the ideas, aims and progress of the INTIMATE programme, an INQUA palaeoclimate subcommission core project. The talk illustrated how isotopic events in the GRIP ice core can be used as a stratotype for the Late Pleistocene North Atlantic region and how this new approach to stratigraphic subdivision could be used as a better alternative to conventional stratigraphical procedures for the last termination characterised by brief and/or rapid high-magnitude fluctuations of climate.

On the final day **Professor David Keen** (Coventry) ran a field excursion visiting important Quaternary sites of the West and South Midlands, to demonstrate the development of the Avon post-Anglian glaciation and also to examine sediments of the pre-Anglian precursor of the Avon and Ingham rivers.

First, a section of mollusc-rich, mid-Holocene sediments was examined at Stratford-upon-Avon, with a probable age being after 4-5 ka BP, the time of the main Neolithic clearances. Next, the group visited a site at Salford Priors, to the south-west of Stratford, where older sediments of meander movements exist of the OIS 5e-4 transition. Later, the Capsthorne area of Worcestershire was viewed, this being the clearest vantage point for the post-Anglian Avon terrace sequence. By the 1980s it had become clear that valley development in this area had taken more than one glacial-interglacial cycle.

Hippopotamus remains in the sediments of terrace 3 suggest an OIS 5e age. Consequently, higher terraces are older: amino-acid ratios indicate an age of OIS 7 for terrace 4. The final stop was at Bubbenhall Quarry (Waverly Wood site), south of Coventry. Here, silts, sands and gravels fill a complex of palaeochannels. The upper two channels have yielded elephant (*Palaeoloxodon antiquus*) bones within fine sand and gravel infills. Artefacts, in the form of two excellent Acheulian hand-axes crafted from Lake District volcanic material, were retrieved at this quarry and produced for the group. Mammalian palaeontology indicates a pre-Anglian, possibly OIS 13 age while amino-acid ratios suggest OIS 15. The field visits stimulated discussion and provided a thoroughly enjoyable day.

Special thanks go to all members of CQS at Coventry, who showed enormous support for the symposium, and to the QRA which produced a very generous contribution towards running costs. Finally, we would like to thank all participants for their involvement and wish Eleanor Brown success for next year's symposium which is to be held at Royal Holloway, University of London.

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QRA ANNUAL DISCUSSION MEETING – MILLENNIAL-SCALE CHANGES

Southampton, 6th - 7th January, 2000

The meeting was hosted by the Department of Geography at the University of Southampton. It attracted over 170 delegates, requiring a change of venue from the Department of Geography to a larger lecture theatre in the Department of Physics.

Day 1

Jane Hart (Southampton) welcomed everyone and commented on the high level of participation. **Mike Walker** (Lampeter), in his capacity as President, opened the first QRA meeting of the new Millennium and commented on the timely nature of the conference and its topics.

The first session, '*Millennial-scale changes from the ocean record*' was chaired by Mike Walker with **Nick Shackleton** (Cambridge) as the first keynote speaker. His presentation was entitled '*Beware millennial wiggle-matching: lessons from the Iberian Margin*' in which he demonstrated that the oxygen isotope (OI) record from planktonic foraminifera can be correlated with the GRIP2/GRIP air-temperature record. However, the variation in OI from benthic foraminifera resembles the Antarctic (Vostok) record, namely the record of global ice volume. His concluding advice was that outside the North Atlantic zone, it might be more appropriate to look for correlations with the Antarctic rather than the Greenland ice-core records.

Over coffee, delegates were able to view the posters. There were over 25 on display and they complemented fully the themes of the meeting. It was good to see the range of national and international collaborative projects indicated by the high number of multi-authored posters.

Grant Bigg (UEA) followed with '*The oceanic response to millennial change: an ocean modelling view*'. His modelling results demonstrated that the oceans can change state very rapidly in a few decades. The duration of oscillations is related to basin residence times. He pointed out that millennial-scale changes are not normally observed in ocean models, as the models cannot be run for sufficiently long 'periods' due to present computer limitations.

The next presenter, **Dick Kroon** (Edinburgh) talked about '*Synchroneity of lithogenic input-benthic isotope variations along the north-west coast of Scotland and $\delta^{18}O$ oscillations in the GISP Greenland ice record for the last 17 kyrs*'. The Barra Fan contains both a high-resolution oceanographic and terrestrial record. Geochemical, foraminiferal and lithological analyses show

that the changes broadly match those in the GISP2 ice core, although Dick did allude to significant climatic cooling at 11.66 kyr which led into the Younger Dryas.

Mark Maslin (UCL) presented the final paper in this session on '*The bipolar climate seesaw and the "comeback kid" conveyor: an investigation into Atlantic Ocean heat piracy and Heinrich Events*'. Mark's talk focussed on the 'pendulum-like' interference between the North and South Atlantic. He noted that the Quaternary interglacials appear as an oddity in the record and that the offset between the Antarctic and Greenland ice cores could be explained by the switch in heat piracy between hemispheres. His stimulating presentation provoked a lively debate, which concluded the first morning of the meeting.

After an excellent lunch in the University Staff Club, **Michael Tooley** (Kingston) took over the role of chairman for the second part of '*Millennial-scale changes in the ocean record*'. **Bill Austin** (St Andrews) was the first speaker on '*Sub-millennial climate variability along the North Atlantic margins*'. This talk complemented the earlier presentation by Dick Kroon and discussed the foraminiferal record from the Hebridean margin as a proxy for the position of the polar front and its impact on the ventilation of the north-west Atlantic. Bill debated the challenge presented by improving chronological control, and he discussed the application of tephrochronology.

Sadly **Barbara Maher** (UEA) was unable to give her presentation so we moved down to warmer climes with **James Scourse** (Bangor) to hear about '*Inter-latitudinal phasing of abrupt climate changes during the last deglaciation: the equatorial record*'. This work on the Congo Fan indicates the relationship between the oscillation of the inter-tropical convergence zone (ITCZ), palaeodischarge events and sea-level change by studying pollen flux. His team's research highlights the importance of a multiproxy approach when interpreting a complex high-resolution record such as this.

After tea and another chance to view posters, **John Lowe** (Royal Holloway) chaired the final session of the day entitled '*Millennial-scale changes from the biosphere*'. **Bas van Geel** (Amsterdam) provided the second keynote talk of the meeting on '*Radiocarbon and ^{10}Be as proxies for solar forcing of climate change?*'. He proposed two scenarios that may explain climate change as a function of solar variations: i) changes in solar radiation affecting ozone production; ii) fluxes of cosmic rays influencing cloud cover. It was his view that solar variations rather than internal dynamics may drive Dansgaard-Oeschger cycles. In addition, he speculated on the information we could obtain from prehistoric skeletons if we were able to speak to them about climate change!

The meeting proceeded with **Frank Chambers** (Cheltenham and Gloucester) and **Jeff Blackford** (Queen Mary and Westfield) speaking on '*Mid- and late-Holocene climatic changes*'. They discussed the evidence for climate periodicity during the Holocene and the importance of distinguishing its cause, namely solar variations, internal variability or catastrophic events. They presented a review of proxy climate data from peat bogs and tested how well observed periodicities could be replicated. The challenge of establishing a reliable chronology was also discussed and they noted that bogs tend to go through phases of response to periodic forcing.

This led on to the final talk of the day given by **Keith Barber** (Southampton) on *'Extending, validating and calibrating the peatland proxy-climate record.'* Keith illustrated the importance of an appropriate field methodology in terms of careful stratigraphic assessment. He focussed on the recent improvements to peatland records by advancements in dating, for example by using tephra; the replication of records; the use of further proxies such as testate amoebae; and time-series analysis to identify periodicities, which suggested dominance of an 1,100- and 600-year cycle.

The first day of the meeting was concluded in style by the conference dinner at the University Staff Club, followed by a demonstration that the scientists as well as the proxy records can (dare I use the word!) - wiggle, at one of Southampton's notable establishments of evening entertainment!

Day 2

The first session of the second day continued the theme of '*Millennial-scale changes from the biosphere*', and was chaired by **Peter Coxon** (Trinity College Dublin). The first speaker was **Rick Battarbee** (UCL) on '*Climate variability and lake sediments*'. Rick discussed the potential of lake sediment records in reconstructing temperature variation, particularly the use of chironomids as an environmental proxy. He pointed out that the exact mechanism linking the sediment record and temperature needs to be understood as, for instance, productivity can increase if a temperature drop is associated with increased wind strength, resulting in enhanced nutrient recycling.

Kathy Willis (Oxford) presented '*Sub-Milankovitch climatic oscillations and their impact on Late Pliocene vegetation dynamics*'. She focussed on the record at Pula Maar in Hungary, which contains approximately 320,000 years of annually laminated sediment. PCA/DCA plots of the results of pollen analysis show two vegetation populations, indicating a switch between boreal and sub-tropical/temperate vegetation types. The record demonstrates Milankovitch and sub-Milankovitch periodicities.

'*CO_2/climate/vegetation interactions in the tropics: millennial-scale variations*' was presented by **Alayne Street-Perrott** (Swansea). She reviewed the impact of CO_2 variations on sub-tropical vegetation change based on the early-glacial and late-glacial sedimentary record from lakes in East Africa and the Ecuadorian Andes. Carbon isotopes from biomarkers and total organic carbon were used to provide a proxy record for vegetation change with specific reference to changes in the ratio of C_3 and C_4 plants. She suggested that one of the main influences on changes in vegetation composition during the early glacial was minima in the atmospheric partial pressure of CO_2. Along with several other speakers, she acknowledged difficulties with chronological control, and stated that variations in regional rainfall patterns were also important, especially during the late-glacial.

After coffee, **Phil Gibbard** (Cambridge) took over the role of chair for the session entitled '*Millennial-scale changes recorded from the cryo/lithospheric record*'. The third keynote speaker of the meeting was **Sigfús Johnsen** (Copenhagen/Iceland) on the subject of '*Deep ice cores from Greenland and Antarctica: the palaeoclimatic record*'. He brought us up-to-date with the progress of the drilling of North GRIP, which is currently 1,700 m down with 1,300 m to go. The siting of NGRIP was chosen to overcome the problems of basal flow, as radio echo sounding demonstrated that the ice layering and bedrock-ice interface is flat. In his review of the palaeoclimatic record from the GRIP ice core, Sigfús recommended that the GRIP5509 flow-model timescale should be used. He acknowledged the need for distinct marker points during OIS 2 and outlined the potential of tephrochronology and Ar-Ar-dating of ash as a correlation tool.

Julian Dowdeswell (Bristol) followed with '*Ice-sheet dynamics and the marine record of environmental change*'. During his presentation, Julian illustrated the processes of sedimentation by ice sheets in the marine environment and the impact of ice dynamics on the scale of the features produced. His view on the mechanism for Heinrich Events in the North Atlantic was that they are not related directly to climate, but instead to internal ice dynamics. However, the synchroneity of ice-rafted debris (IRD) events in other regions, such as the Norwegian Sea, was questioned due to the stochastic nature of iceberg rafting. He emphasised the need for chronological control when wiggle-matching and asked whether or not it is reasonable to expect synchroneity in view of our knowledge of the complexity of glacial systems.

Ian Shennan (Durham) gave the last presentation before lunch on '*Millennial-scale changes in sea level*'. Ian focussed on sea-level change since the last glacial maximum in north-west Scotland. He commented that observations of relative sea-level change involve tracing the transient coastline back into the

past by investigating the stratigraphic record in suites of isolation basins. However, he noted that one must also take into account the likelihood of different tidal dynamics in the past when interpreting the record. Models of sea-level change and deglaciation should be developed in parallel and provide an opportunity to investigate the timing, magnitude and impact of meltwater fluxes and associated feedback mechanisms.

Following another excellent lunch, **Jim Rose** (Royal Holloway) chaired the final session of the conference, continuing the theme of '*Millennial-scale changes from the cryo/lithospheric record*'. The first speaker in this session was **Darrell Maddy** (Newcastle) who presented '*Fluvial system response to millennial-scale change during the last interglacial - glacial cycle: examples from the north-western European and Mediterranean archives*'. Along with several previous speakers, Darrell commented on the challenges ahead to improve the geochronology of palaeoenvironmental reconstructions from fluvial systems. He also suggested that it would be appropriate to work towards improving the geographical coverage of reconstructions along with detailed description and more extensive tracing of the bounding surfaces of lithological units, in order to facilitate cross-validation and inform debate. Although changes in north-west European river systems do appear to be synchronous, the precise responses are dependent on the nature of the drainage basin.

Mark Macklin (Aberystwyth) continued the fluvial theme by presenting a talk on '*British river response to sub-Milankovitch Holocene environmental change: formulating and testing cause and effect hypotheses*'. The talk focussed on the techniques used to elucidate fluvial responses to recent environmental change in northern England and southern Scotland. Again, the problems faced by inadequate geochronology were discussed, although the potential of lichenometry to date more recent depositional events was pointed out. **Tom Coulthard** then demonstrated an exciting, hi-tech and visual simulation of fluvial sedimentation.

Rob Kemp (Royal Holloway) spoke about '*Loess-palaeosol sequences as records of past climate: the search for millennial-scale changes*'. He challenged the traditional view that loess-palaeosol sequences record only the major warm and cold stages. Techniques such as micromorphology demonstrate that loess can be deposited during 'soil-forming intervals' and that loess units are sometimes subject to pedogenic alteration. Therefore, it is appropriate to search for millennial-scale changes in these high-resolution terrestrial sequences. However, Rob did add a note of caution and recommended that good quality proxy data, tight chronological controls and an understanding of the climatic significance of our results are essential nevertheless, before 'jumping on the wiggle-match bandwagon'.

The final talk of the meeting was given by **Andy Baker** (Newcastle) on '*Millennial-scale changes in speleothems: a critical review*'. Andy discussed the potential of speleothem records to elucidate climate change and pointed out that only a small percentage of speleothems contain annual laminations. In addition, Andy acknowledged that not all speleothems respond to climatic change and single speleothem reconstructions are therefore problematic. However, he discussed the high-resolution dating potential of speleothems by uranium-thorium series and the varieties of possible climate proxies such as pollen, carbon and oxygen isotopes and trace elements, although they do require calibration.

The concluding remarks were provided by **Jim Rose**. He emphasised the importance of determining the spatial patterns of climatic change, which was well illustrated by many of the posters and talks. Jim thanked all the speakers and chairs for their excellent input into a very successful meeting, and he described the quality of presentation as at least equal to those seen at AGU. He thanked **Jane Hart**, **Paul Hughes** and **Keith Barber**, the organisers of the meeting, as well as the projection staff for a job well done, and looked forward to the future and to further developments of international significance in Quaternary Science.

The QRA Annual Discussion Meeting at Southampton was an excellent showcase for Quaternary Science at the start of the new Millennium. The diversity and professional standard of presentation of internationally significant research was exceptional. In addition, the administration of the meeting was first class as was the timekeeping. This reflects extremely well on the organisers, the speakers and chairs as well as the Quaternary Research Association. From a personal perspective as a young postgraduate Quaternary scientist, the sheer breadth of the meeting was especially appealing. The opportunity for scientists from the different sub-disciplines of Quaternary science to communicate, network and foster collaboration is vital in order to rise to the challenges ahead. These include resolving the links between the hemispheres, improving chronological control and determining the mechanisms of millennial-scale climatic change.

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REVIEWS

QUATERNARY OF SOUTH AMERICA AND ANTARCTIC PENINSULA VOLUME 12 (1996-1997)

Edited by J. Rabassa and M. Salemme
Published by A.A. Balkema, Rotterdam
ISBN 90 5410 479 1 ISSN 0168-6305 1999. Hardback, £46.00

This special volume of the journal is of particular relevance to vertebrate palaeontologists. There are review papers on the Quaternary vertebrate faunas of Chile, Uruguay and Brazil while many of the papers are concerned with the mainly mammalian fauna of the Pampean area of Argentina. This is reflected in the fact that 11 of the papers are by Argentinian authors with only two from Brazil, one from Uruguay and one joint Uruguay/Argentinian. The editorial board of 17 members is drawn from Argentina (7), USA (5), Brazil (2), France, Chile and Canada. As is usual with this journal, it is not clear what criteria were used in the selection of the papers. All the papers give good bibliographies which would be of use for anyone wishing to explore these subjects further. The English is mostly good and comprehensible.

South America was an island for most of the Tertiary, and spectacular endemic faunas evolved with marsupials, ungulates, xenarthrans (edentates) and rodents well represented. Many animals reached large (>1 tonne) size. Since the Central American land bridge allowed migration to and from North America about 3 Ma ago, major changes and many extinctions of South American animals have occurred. The exact reasons for these extinctions (more North American mammals are now found in South America than *vice versa*) has long been discussed. J. Ferigolo makes an interesting case for low resistance to pathogens being an important factor here with the size and length of breeding cycle being relevant - the smaller the animal and shorter the breeding cycle the more chance there is of immunity developing- thus explaining why the larger animals became extinct more rapidly.

Review papers are given on the Quaternary vertebrates of south Brazil with discussions on the climate (E. Oliveira), lists of fossils with a short section on their biogeography and climate (R. Casamiquela), and a review of research carried out in Uruguay (M. Ubilla and D. Perea).

Most papers relate to the Pampean area of Argentina, particularly to the Lujantian Age of the Late Pleistocene. A. Cione and E. Tonni discuss the

problem of establishing a reliable biostratigraphy for the Pampean area and correlating this with other areas of South America and the rest of the world. Biozones are described and wherever possible related to palaeomagnetic sequences and radiometric ages. A. Cione *et al.* give lists of fossils from this area. Other authors discuss particular groups of fossils: reptiles of Argentina (M. de la Fuente), marsupials from the southern cone of South America and their relationship to living forms (F. Goin), ungulates (M. Bond), caviomorph rodents (M.G. Vucetich and D. Verzi) and murid rodents (U. Pardinas). Xenarthrans (edentates) - a group which included many of the larger, spectacular animals such as the glyptodontids (up to 2 tonnes, armour-plated animals which often had vicious-looking, flexible club tails) and the giant ground-dwelling sloths (up to 6 m long and probably, from a study of their trackways, capable of faster speeds than their present-day relatives) are described by R. Farina and S. Vizcaino. There were large numbers of species of these large animals (19 in one locality alone) most of which were long-thought to be herbivores. These authors compare these with the fauna of present-day Africa and come to the conclusion that, as there are few obvious carnivores, and because of the imbalance this would give to the ecosystem, that some of the "herbivores" may have been partially carnivorous or at least scavengers. Many of these large animals including the giant sloths only became extinct about 11,000 years ago.

It is obvious that much work remains to be done but this volume gives a fascinating glimpse of the wealth of Quaternary vertebrate faunas in the southern part of South America - fossils with which few European palaeontologists are familiar. The paper by E. Tonni *et al.* is an interesting historical record of the dedication of palaeontologists in Argentina and the problems of developing a science in an area dominated by Spain (where many early finds were sent) and later by political and personal feuds.

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COCKERMOUTH (sheet 23) [1], KESWICK (sheet 29) [2], GOSFORTH (sheet 37) [3], AMBLESIDE (sheet 38) [4], BOOTLE (sheet 47) [5] and ULVERSTON (sheet 48) [6]: all Solid and Drift Editions (England and Wales) apart from Bootle (S), (S & D)

Published by British Geological Survey 1997 [1,6,5] 1998 [4] 1999 [3,2]

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Modern, medium-scale 1:50,000 geological maps have been published for the western half of the Lake District in Cumbria, the north-westernmost county of England. A large part of this classic area of glacial landforms and complex underlying geology has not been revised for over a century, apart from the areas along the coast which remained in print at various scales. All these British Geological Survey (BGS) maps are Solid and Drift (S & D) editions that show in colour the Quaternary or drift surface outcrops along with pre-Quaternary solid outcrops and, under the symbols for the drift deposits, indicate the nature of the solid subcrop beneath this cover. As is normal the publication date refers to the electrostatic plot that was available before the maps were printed (review 1999: *Quaternary Newsletter* 87, p. 52). Solid (S) editions of these sheets have also been produced which only show the often very complex pre-Quaternary bedrock geology.

The resurvey of the Gosforth (37) and Bootle (47) coastal sheets and the production of the west Cumbria district memoir have benefited from the extensive geological investigations undertaken around Sellafield (Windscale, etc.) by British Nuclear Fuels and Nirex to investigate the indefinite storage, in a local underground repository, of highly radioactive waste. As this shows that the underlying geology of west Cumbria is highly faulted and unsuitable, it is unlikely that this will be built. In order to understand how a future period of glaciation would probably affect the district, this work included surveying the local drift deposits and offshore geology that reflect the interplay between the

downloading of past ice sheets and changes in global sea level. They both show offshore bathymetry at 5 m intervals relative to Ordnance Datum, and like other recent 1:50,000 maps, these coastal sheets including Ulverston (48) to the south show the offshore geology plotted with the national grid and give details of the local tidal range relative to Ordnance Datum. Below the high water mark within the sheet areas, the colours of all the geological units are subdued by white diagonal lines below the high water mark and not, as on other sheets, only below low water.

Only the Gosforth (37) sheet shows the position of glacial meltwater channels, roches moutonnées marking the direction of ice flow over the bedrock, and the distribution of seabed drift deposits. Compared with the last edition published in 1980 the drift has been completely revised and further subdivided, as for that matter has the underlying solid geology that is now riddled with faults. A cross-section with a greatly exaggerated (x25) vertical scale clearly shows the Devensian and Holocene glacial and marine sediments offshore with their associated pattern of seismic reflectance, while the onshore part is similar to the schematic cross-section often found on the margin of modern terrestrial sheets in this series. In addition there is an insert map showing the overall stratigraphical distribution of Quaternary sediments and the limits of ice readvance at the end of the last glacial period, along with a seabed-sediments map and a basic Quaternary stratigraphy for the areas both onshore and offshore.

The Bootle (47) sheet, instead of appearing as an insert on Gosforth (37) sheet in the last edition, has been produced as a combined edition, with a main solid map and an insert at the same scale showing the drift geology of the small onshore area. This should have been reversed so that the solid geology was confined to the insert, since it is relatively straightforward apart from the margin of the Eskdale intrusion near the edge of the map. That said, the map does have a clearly drawn offshore Quaternary section and an insert seabed-sediment map and classification triangle. However, the neighbouring Ulverston (48) sheet could have been easily extended westwards to include the terrestrial part of the Bootle sheet which is only 4 km wide, and a separate marine edition published for more specialist users. Ulverston is to the north of Barrow-in-Furness and includes the north-western part of Morecambe Bay and the Duddon Estuary on the western side of the Barrow peninsula, an area that was extensively mined for hematite. The coverage of drift geology on this map only includes the intertidal zone, with its fairly large tidal range of about 8 m, while the boundaries of solid formations extend offshore. There is a wealth of detail showing the nature of the near-shore tidal and raised beach deposits along the margins of the estuaries, and farther inland the extent of the glacial, alluvial and slope deposits is clearly shown.

To the north, the Ambleside (38) sheet shows that large parts of the area are

covered in glacial tills and gravels, peat, spreads of alluvium along the main valleys and fan and occasional scree slopes along their sides. This information clearly allows the reader to see on what basis the underlying solid geology has been mapped, as in some places there is very little pre-Quaternary surface outcrop. However, there is no additional information on the drift deposits in the margin, and valuable space is taken up with geophysical insert maps that don't need to be repeated on both the Solid and the Solid and Drift editions of this sheet. More worryingly, the drift geology in places along the western margin of the sheet does not match up with the slightly later survey of the neighbouring Gosforth sheet. Also there are some discrepancies with the Keswick sheet along the northern edge of the map where drift deposits change classification. The Keswick (29) sheet is very similar and clearly shows the extent of the drift deposits, but yet again the alignment of glacial striae on bedrock and other geomorphological features are not shown. Finally, the Cockermouth (23) sheet on the northern margin of the central fells shows how extensively the glacial till is plastered over this lower-lying ground where the local Lake District and Scottish ice sheets converged. Due to the highly variable nature of these deposits, numerous swallow holes developed in this mantle of till after the main ice sheets retreated and are marked by a circle with six short ticks radiating outwards. Where they occur, the small patches of other drift deposits are shown in detail along with areas of made and worked ground, where the bedrock can be seen through the hatching marking the extent of former quarries.

While modern geological maps with good colour selection and clear drafting are clearly welcome, the BGS needs to work harder at presenting Quaternary geology on some of these maps. There is little point in producing a separate Solid and Drift edition if most of the information around the margin of the map is identical to the Solid edition and often significant geomorphological features are ignored.

Reference

Akhurst, M.C., Chadwick, R.A., Holliday, D.W., McCormac, M., McMillan, A.A., Millward, D., Young, B. *et al.* (1997). *The geology of the west Cumbria district.* Memoir of the British Geological Survey, Sheets 28, 37 and 47 (England and Wales).

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ABSTRACTS

THE QUATERNARY GLACIAL HISTORY OF THE ZANSKAR RANGE, NORTH-WESTERN INDIAN HIMALAYA

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Palaeoglacier margins are reconstructed through geomorphological mapping and sedimentology, and are dated using Optically Stimulated Luminescence (OSL) techniques on quartz extracted from related fluvioglacial and lacustrine deposits. A glaciated palaeosurface with broad, gentle slopes >280 m above river level and high-grade metamorphic erratics represent the oldest and most extensive glaciation, the Chandra Stage. This was in the form of an ice-cap with its ice-shed to the south over the High Himalaya. A change from broad glacial troughs to narrow V-shaped gorges, along with large, subdued moraine ridges and drift/erratic limits, defines an extensive valley glaciation, the Batal Stage, with its maximum close to ~78.0 ± 12.3 ka BP (Oxygen Isotope Stage (OIS 4). Distinct sets of moraine ridges represent a less extensive glaciation, the Kulti Stage, which is dated to shortly after the global Last Glacial Maximum (OIS 2), and a minor advance, the Sonapani, is represented by sharp-crested moraine ridges <2 km from current ice bodies. The change in glacier extent and style from the Chandra Stage to the later glaciations may be related to uplift of more southerly ranges blocking monsoon precipitation and incision of the landscape such that ice reached lower altitudes over shorter horizontal distances.

Batal and Kulti Stage Glacier Elevation Indexes (GEIs) calculated for this and adjacent areas increase from south-west to the north-east, but decrease again towards the Indus Valley, reflecting attenuation of the south-westerly monsoon and possible channelling of westerly depressions along the broad upper Indus Valley. GEI values were depressed by ~500 m during the Batal Stage and ~300 m during the Kulti Stage. PalaeoGEI values from across the Himalaya increase from south-west to north-east and from north-west to south-east reflecting summer monsoon and winter westerly precipitation gradients respectively.

Six new OSL age estimates from the Zanskar Range greatly improve the glacial chronology of the north-west Himalaya and reinforce the emerging asynchrony between this region and the Central and Eastern Himalaya, which experienced maximum glaciation during OIS 2 rather than OIS 4. Improved glacier mass balance data, palaeoclimatic proxy data for the summer monsoon and particularly the winter westerlies, and numerical age estimates from Himalayan glaciers are required to explain these asynchronous maxima.

NOTICES

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We need volunteers to help identify and record potential sites. Sites can be your favourite dry valley, old quarry, road cutting, sand pit etc. – basically anything you feel is of interest.

If any of this appeals and you would like to help, please contact me at:

Mike Windle
Secretary
Oxfordshire RIGS Group
18 Fosseway Avenue
Moreton-in-Marsh
GL56 0DT
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3. GLOBAL CONTINENTAL PALAEOHYDROLOGY (GLOCOPH)

The Commission on Global Continental Palaeohydrology was established at INQUA in Beijing in 1991 to undertake research on the global process of water for the continental areas of the Earth using evidence of past changes and emphasising issues relevant to the human habitability of the planet. The primary aim, decided in 1994, was 'to analyse the nature of global and zonal hydrological changes, fluxes and stores using the timescale 100 – 1,000 years with emphasis on those areas which hold the greatest human population and are most sensitive in terms of water resources and global changes'. Professor Leszek Starkel was President of the Commission 1991-1995, Professor Vic

Baker 1995-1999, and Professor Ken Gregory 1999-2003.The officers now are:

President: Professor Ken Gregory, e-mail: Ken Gregory@btinternet.com
Vice President: Professor Vic Baker, e-mail: baker@hwr.arizona.edu
Honorary Vice President: Professor Leszek Starkel,
e-mail: starkel@zgpan.krakow.pl
Secretary: Dr Gerado Benito, e-mail: Benito@cc.csic.es

When GLOCOPH was established there were some 90 researchers involved from more than 30 countries, and there are now more than 200 researchers listed in the active database. Current working groups are:

Palaeoflood hydrology:
Leaders: V.R. Baker, USA; Y. Enzel, Israel; V.S. Kale, India
Models of regional hydrological change and database:
Leaders: K.J. Gregory, M.J. Clark, J. Branson, UK, involving collaboration with theme 4 of FLAG focussed upon the Holocene, led by Professor M.G. Macklin
Palaeohydrology of large rivers:
Leaders: E. Latrubesse, Brazil; L. Starkel, Poland
N. Hemisphere fluvial archives of the last 200 ka (FLAG):
Leaders: Dr Darrel Maddy, e-mail: darrel.maddy@ncl.ac.uk and Professor Jef Vandenberghe, e-mail: vanj@geo.vu.nl

Meetings planned in the near future include:

i) **2000 GLOCOPH 2000: Fourth International Meeting on Global Continental Palaeohydrology**

August 20-28, Moscow: Hydrological Consequences of Global Climate Changes: Geological and Historic Analogs of Future Conditions. Contact Dr Alexander Georgiadi, e-mail: georg@ipcom.ru
This meeting involves collaboration with IGCP GRAND.

ii) **2001 Palaeohydrology Field Conference Meeting in the Yenesei Basin**
Contact Dr Anton Yamskikh, e-mail: root@yamskikh.krashoyarsk.su

iii) **Proposed session at International Association of Geomorphologists Meeting in Japan, 23-28 August**

iv) **2002 Fifth International Meeting on Global Continental Palaeohydrology, India**

Location and dates to be finalized. Contact Dr Vishwas Kale, Department of Geography, University of Poona, Puna, India.

v) 2003 Session at the INQUA meeting

The work of the Commission was successfully presented at the first three international meetings in 1994, 1996 and 1998 when 186 papers were presented, and 8 volumes have been published arising from the proceedings and work of the meetings. The programme planned for 1999-2003 will enable further successful research to be undertaken and published, and collaboration with FLAG is a particularly important development. Palaeohydrological research is particularly timely in view of the great interest in global environmental change and, whereas emphasis to date has necessarily been on the fluvial system and upon the most studied areas of the world, it is intended that in 1999-2003 research coverage will be extended to areas not previously investigated in detail and to other aspects of the hydrological cycle, especially the storage components.

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6. GROUP MANCHE MEETING
University of Sussex, 27th - 28th September, 2000

The notice below should be read in conjunction with the registration form for this meeting, which can be found in the accompanying Circular.

The main advances in our understanding of each theme and the problems remaining will be summarised orally by theme organisers. In addition, written summaries of the themes, for publication in a special issue of the *Journal of Quaternary Science*, will be available to all participants, to promote discussion. Issues arising from the themes and potential areas for future Anglo-French research collaboration will be considered in a round-table discussion.

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Caen University
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QUATERNARY RESEARCH ASSOCIATION

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

Editor, Quaternary Newsletter: *Dr S. Campbell*, Maritime and Earth Science Group, Countryside Council for Wales, Hafod Elfyn, Ffordd Penrhos, Bangor, Gwynedd, LL57 2LQ (e-mail: s.campbell@ccw.gov.uk)

Editor, Journal of Quaternary Science: *Dr J.D. Scourse*, School of Ocean Sciences, University of Wales (Bangor), Menai Bridge, Anglesey, LL59 5EY (e-mail: j.scourse@bangor.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

QN

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