June 1992 No. 67

QUATERNARY NEWSLETTER

A PUBLICATION OF THE

Quaternary Research Association

QN:

QUATERNARY NEWSLETTER

Editor: Dr B J Taylor
British Geological Survey
Keyworth
Nottingham NG12 5GG

Quaternary Newsletter is issued in February, June and November. 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 for the relevant numbers are 1 January, 1 May and 1 October.

Printed by
Carneval Printers & Publishers Ltd. Long Eaton, Nottingham NG10 4GA
Tel.: (0602) 732485
(Formerly M1 Press Ltd.)

ISSN 0143-2826

Editorial — A Valediction

Several months (and issues) prior to his "agreed" period of office, your current editor has found it expedient to stand down in order to make way for a new editor (James Scourse) so that, in the words of the President, Geoffrey Boulton, "he can attempt to fulfil the additional roles which the Executive Committee has attempted to define for the Newsletter".

Therefore, may I take this opportunity of thanking all those who have made my quarterly tasks that much easier, namely all the many contributors who have kept me supplied with good copy on a wide range of interesting topics and who have, from time to time, raised issues of a controversial nature that have induced some lively debate within these pages.

May I also reiterate my thanks to my BGS colleagues, Linda Wahl (Graphics Officer), Jennifer Evans and Jackie Norman (Typesetters) who have, outside their normal working hours, battled valiantly with your texts and my often indecipherable red ink to produce the various issues under my editorship more or less on time, not an easy task when illness and bereavement has intervened at inauspicious moments in the production process.

As with all publications, mistakes have inevitably been made (despite every effort to produce clean copy) but no blame for these can be laid at the door of M1 Press Limited of Nottingham whose assistance throughout my term of office has been exemplary. My warmest thanks, therefore, go to John Winn and his staff for a job well done!

Finally, I sincerely hope that my friend, James Scourse (see biographical note appended below) will receive the same support I have enjoyed. I first met James at the Botany School, Cambridge in 1982, when I went there to be retrained as a Quaternary palynologist under the then head of the sub-department of Quaternary Studies, Richard West. In the department at that time was Sylvia Pegler, a matriarchal figure held in high esteem by all the many students who repeatedly sought her wisdom and advice. My own particular "problem grain" was *Filipendula* and many a lively discussion emanated from my difficulties with this member of the Rosaceae.

I cannot remember whether James had his "problem grain" but I knew him then, and know him now, as a very amiable colleague with a sound background in Quaternary science and I am confident that he will carry the *Newsletter* forward in the way that all publications should evolve — so adieu Depardieu and all other such trivia and welcome James, to whom all further correspondence should be addressed.

James Scourse — Your New Editor

James Scourse read Geography at the University of Oxford and in 1980 was awarded a First Class Degree and a University Prize for a thesis on the Pleistocene stratigraphy of the Isles of Scilly. After a year at the University of Bristol, he was successful in obtaining a NERC Appeals award to continue research into the Quaternary of the Isles of Scilly; this was undertaken at the Sub-department of Quaternary Research in Cambridge under the supervision of Professor Richard West. This work, which resulted in the award of his doctorate in 1985, incurred a steadily increasing involvement in the offshore Quaternary geology of the Celtic Sea, and close collaboration with the marine geologists of the British Geological Survey. It was on the basis of this offshore work that in the same year, he was appointed to his present position of Lecturer in Marine Geology at the School of Ocean Sciences in the University College of North Wales — after a brief spell as Research Fellow at Girton College Cambridge.

His published papers include studies of the glacial, periglacial, vegetational and sea-level history of the Isles of Scilly, Celtic Sea, central southern England and southern Ireland, and in 1990, he co-edited a Special Publication of the Geological Society on glaciomarine environments.

James Scourse's teaching committments cover a wide range of subject areas whilst his current research interests include the stratigraphy and palaeoenvironment of the NW European continental shelf, SW England and NW Spain and in linking the Quaternary record with related disciplines in marine science; these currently include palaeotidal modelling, mollo-chronology — using banding structures in marine molluscs as high resolution records of environmental change, and evolutionary/chemotaxonomic studies of marine molluscs.

James has been a QRA member since 1981, organised and lead a field excursion to the Isles of Scilly in 1986, and was the local organiser of the annual field excursion to North Wales in 1990.

Dr J D Scourse
School of Ocean Sciences
University College of North Wales
Menai Bridge
Gwynedd LL59 5EY

ARTICLES

TERRACES OF THE RIVER AVON AT TWYNING, GLOUCESTERSHIRE: THEIR STRATIGRAPHY, CLIMATE AND BIOTA

P F Whitehead

Between 1965 and 1975, extensive sections were revealed through Avon No. 2 and No. 4 terraces, during gravel and sand extraction at Twyning, Gloucestershire. Between 1972 and 1975 the writer examined their stratigraphic relationships and biota. The lapse in producing this full statement of events at Twyning has the minor advantage that is can now be related, and will somewhat amplify, the considerable amount of work recently undertaken on the Avon valley (Keen & Bridgland, 1986; Maddy *et al.* 1987; Bridgland *et al.*, 1989; Whitehead, 1989a; Maddy *et al.*, 1991, at a time when its significance in the national context is becoming increasingly appreciated.

AVON NO. 4 TERRACE

The fauna has been mentioned by Shotton (1977) and the artefacts and biota by Whitehead (1988, 1989a). The fluvial sediments cap a hill, the summit of which reaches 38 m OD. The sediments demonstrate two broad lithologies (Figs. 1 and 3; to avoid further delays, readersare asked to accept the limitations of these figures which are intended to permit future workers a clear grasp of the situation on the ground. Traces of the terraces may still survive nearby, here termed 'upper' and 'lower' sediments).

UPPER SEDIMENTS These are gravels in a matrix of reddish to brown quartz sand. They rest on the channeled surface of the lower Jurassic-rich gravels, providing a strong colour break from brown to cream. In some places the lower sediments have been almost totally removed. The terrace gravels nowhere exceeded 4 m thickness, of which the upper sediments contributed up to 3.3 m.

The upper sediments contained many derived Lower Palaeolithic stone tools (Whitehead, 1988) and numerous erratic rocks of north-western provenance derived via the drainage of the River Severn, the largest being a boulder of Uriconian nodular rhyolite weighing 356 kg. Other Uriconian

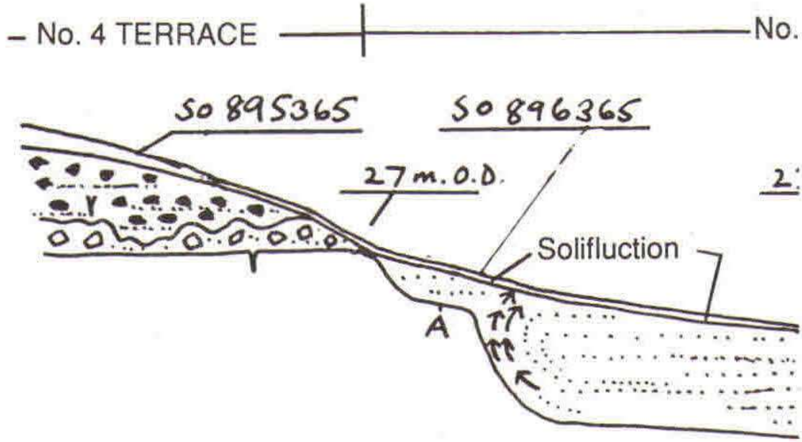


Fig. 1 Section through terraces at Twyning, Gloucestershire

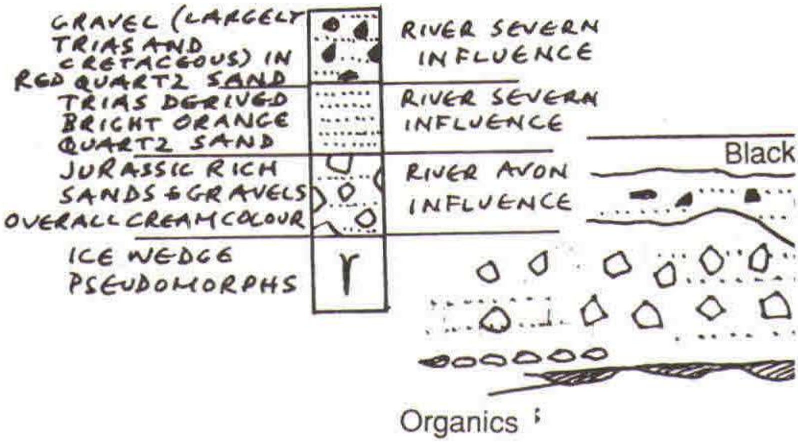
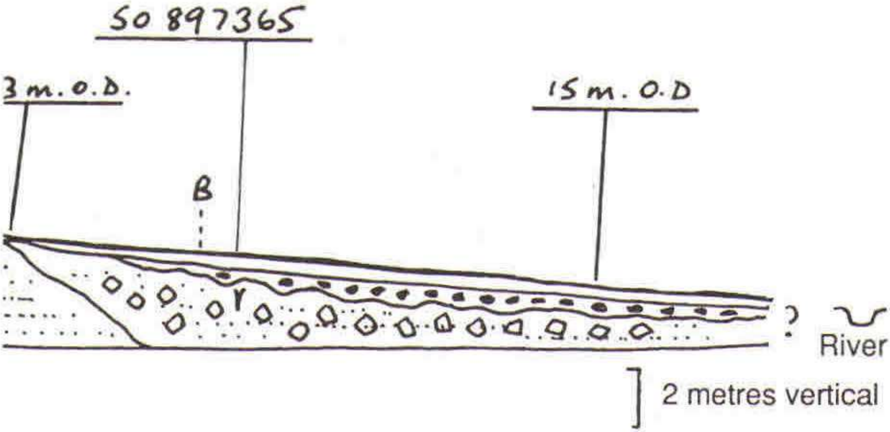


Fig.2 Detailed section at B above

2 TERRACE

All as at 1974



rock (determined by the late Professor F W Shotton) included contorted flow-banded rhyolites, pink and green felspathic rock, and coarse acid sedimentary tuff. From Wales and/or the Lake District came fine-grained andesites, andesitic crystal tuffs and gabbros. Biotite granites matched those from south-west Scotland; garnetiferous mica-schists may be Malvernian. Other rocks included Cambrian sedimentary quartzite, quartz conglomerate, pink siliceous rhythmite, acid pegmatite, and dolerites. Substantial pieces of gymnosperm wood taxonomically close to *Walchia* from the Upper Carboniferous Coventry Sandstone formation (J G Rees, in lit.) were derived from the Coal Measures.

Triassic-derived quartz grains formed the sedimentary matrix, locally clayey. Generally the sediments were well-sorted into thick beds of sand and well-graded stringers of Bunter pebbles from the Kidderminster Formation. In localised areas towards the top of the section, the axes of the pebbles fell randomly, the fine sediment showing no discernible bedding. Rare, but completely convincing ice-wedge pseudomorphs originated toward the top of the section (but not at the level of modern cultivation). The erratics occurred nearly always at or close to the base of the upper sediments.

THE LOWER SEDIMENTS These rest on the solid geology, either a dissected pavement of Lower Lias limestone, or on Lower Lias clay. They are dominated by rounded to subrounded fragments of Oolitic Limestone, the small fraction comprising ooliths and windblown quartz grains (see Briggs, 1984). The Jurassic limestones originate from the Cotswold Hills and their outliers. The shallowly channeled surface of the Lower Lias clay contained molluscs in its fill. Fossil mammal bones and teeth occur at the base of the gravels, at the Lower Lias/gravels contact or embedded in the Lower Lias clay.

Over large areas, the surface of the Lower Lias clay assumed a striking white colour for depths up to 350 mm, and this contained rare contemporary pollen grains.

Biota of the upper sediments

A large right valve of the thermophilous mollusc *Corbicula fluminalis* (Müller) was found 40 mm from their base. There was no other evidence of contemporary biota. This demands careful interpretation. Today, *C. fluminalis* is known living from a limited area of the southern Palaearctic (Mouthon, 1981) and Oriental regions (Ellis, 1962). Ice wedge pseudomorphs, originating in the upper part of this sequence, define a periglacial climate.

Any contention that the valve of *C fluminalis* is far-derived (i.e. from one climatic zone to another) finds little to commend it. My preference is for the shell to be contemporaneous with aggradation, which may mark a dramatically rapid deterioration of climate, which could even have extinguished the

All species of *Microtus agrestis* Linn. from Avon No.2 Terrace at Twyning originally determined by the late Mr J N Carreck have since been redetermined by Dr A P Currant as *Microtus oeconomus* Pallas ie. the northern vole. In ecological terms this makes for a much more satisfactory determination.

local population of *C. fluminalis*. This would align with Sparks (1964). The upper sediments may therefore, represent a limited temperate interlude, and the onset of 'full-glacial' conditions. This is a good indication of the sensitivity of the terrace record, and of the need to pinpoint evidence very accurately.

Biota of the lower sediments

Plant fossils. In December 1972, it was observed that minute rootlets penetrated the surface of the Lower Lias clay at SO 8942 3648. A spot sample 50 mm deep was sent to Dr J Tallis (Manchester) who identified the following grains of contemporary pollen:

Lycopodium cf. *inundatum* L.	1
Pinus spp. inc. *P. sylvestris* L.	5
Ericaceae	2
Plumbaginaceae (?*Armeria*-PFW)	2
Salix herbacea L.	1

This is a restricted flora of open country. Tallis (in lit.) postulated the notion of 'polar desert'. Polunin (1939) called *S. herbacea* a truly arctic plant whilst today, it is well known in Britain as an essentially lithicolous boreal species (Stace, 1991).

Fossil molluscs. Channels up to 140 mm deep in the surface of the Lower Lias clay contained shelly well-graded fine gravel and sand. An 800 gm sample collected at SO 8950 3655 on 10.11.1973 contained:

	count	percentage
Valvata piscinalis (Müller)	42	55.4
Lymnaea peregra (Müller)	5	6.6
Gyraulus laevis (Alder)	1	1.3
Ancylus fluviatilis Müller	5	6.6
Trichia hispida (L.)	1	1.3
Sphaerium sp.	1	1.3
Pisidium sp.	11	7.9
Pisidium casertanum (Poli)	15	10.5
Pisidium subtruncatum Malm	3	3.9
Pisidium nitidum Jenyns	3	3.9
Pisidium vincentianum Woodward	1	1.3

This is the fauna of a small clear water stream or rivulet, possibly the artesian drainage of the aquiclude. The rarity of terrestrial species, particularly *Pupilla muscorum* (L.), is noted. Species depicting larger water bodies, such as *Pisidium amnicum* (Müller) and *Pisidium henslowanum* (Sheppard) are absent.

P. vincentianum is regarded as diagnostic of cold-climate deposits in Britain, although it occurs today much farther south in the Palaearctic, with a related species in Tibet (Dance, 1961). This specimen has been confirmed by Mr B W Sparks. The valve is not markedly tumid, having a degree of convexity (valve thickness × 100/height) of 23. Ten valves from Upton Warren (Coope, Shotton and Strachan, 1961) had degrees of convexity ranging from 28–40, and from the figure in Dance (1961) even this may be exceeded. This is the only record of *P. vincentianum* in the Avon valley, although it may well occur beneath No. 2 terrace.

The ecology of *G. laevis* has, in the past, provoked considerable discussion (Boycott, 1936; Sparks, 1964; Janus, 1965). Kerney (1976) reveals a recently contracted English range, especially in the south. Probably this species is sensitive to anthropogenic effects such as turbidity and pollution. Kerney (1976) shows no modern records for the River Avon and this species may well have become extinct long before 3000 BP (Shotton, 1978) in that river; in its Pleistocene fluvial sediments, however, it occurs widely (Briggs, Coope and Gilbertson, 1975; Keen and Bridgland, 1986; Kennard and Woodward, 1925; Maddy *et al.*, 1991; Shotton, 1968; Whitehead, 1989b).

Fossil mammals. 141 bones and teeth were found, 25% *in situ* at or close to the Lower Lias clay/gravels contact. A tusk from a female Woolly Mammoth (*Mammuthus primigenius* Blum.) was embedded in the Lower Lias clay and could not be recovered and many of the bones have Lower Lias clay deep within their interstices, Mr P G Hardy of Taunton had a further 11 items in his ownership and a molar of *Mammuthus primigenius* is at Crewe Technical College. Secondary calcification of bone is striking; an atlas vertebra of *Bison* weighs 2 kg. A pair of lower molars of *Mammuthus primigenius*, found less than 1 m apart, each had large fragments of alveolar bone in their root spaces. Some bones are gnawed by hyaena although its remains were not found.

A substantial number of bones, shattered or otherwise, have very fresh unweathered surfaces. In the much larger bone assemblage from the Carrant valley (mid-Devensian) such fresh bone is very rare. It may be that the riparian habitat at Twyning No. 4 terrace was available for a significantly shorter period of time. Certainly the mammals were utilising a floodplain with a productive and diverse habitat mosaic. When aggradation removed that habitat, negative evidence suggests that (with the exception of horse) the megafauna fragmented, dispersed, and may even have become locally extinct.

Hitherto No. 4 terrace has produced little in the way of fossil mammals (Jack, 1922; Playle, 1962; Maddy *et al.*, 1991; Symonds, 1861). Therefore, the following analysis for No. 4 terrace is unique but may be compared to three assemblages for regional mid-Devensian sites (Whitehead, 1977, 1990) which are characteristic; the high frequency of horse at Beckford is ascribed to the nearby favoured locality of Bredon Hill. The figures are percentage frequency as a proportion of the 5 species cited:

	No. 4 Twyning	No. 2 Beckford	Aston Mill	Cheltenham
Mammuthus primigenius Blum.	49.3	23.2	30.3	27.8
Coelodonta antiquitatis Blum	26.1	28.5	46.6	37.8
Equus spelaeus type	17.8	37.5	9.0	16.6
Bison priscus Boj.	4.1	8.9	11.7	15.0
Rangifer tarandus L.	1.3	1.7	2.2	2.8

Observations on the fossil mammals

Mammuthus primigenius Blumenbach. Fossils comprise teeth, vertebrae, scapulae, ulnae, ribs and innominate bones. Remains of 18 teeth have laminary Indices (Morrison-Scott, 1948; Whitehead, 1978) from 9.0–10.7 (a right upper M3 with a L.I. or 14.7 is discounted as the measurement is across the expanded bases of the laminae). This degree of laminary compression I regard as typical of 'full-glacial' ecotypes (the so-called "Siberian", not "Ilford" condition). I take it to be an adaptation to diet including a substantial amount of abrasive sediment.

Death occurred at from 10–60 years, the mean age at death being 35. Enamel thicknesses of permanent molars are from 1.6–2.8 mm with a mean of 2.0 mm. In the mid-Devensian of the Carrant valley, the equivalent figures are 1.6–3.0 mm with a mean of 2.0 mm (Whitehead, pers. obs.). There are two aberrant teeth. An upper M3 (tooth formula -7-) has the occlusal surface at 45° to the vertical axes of the laminae. It is paralleled in Kubiak (1965, pl.16) and in England from the Devensian fen gravels of Huntingdon (Whitehead, pers. obs.). The other tooth, described by the late Dr Calvin Wells, is the subject of an appendix to this paper.

Coelodonta antiquitatis Blumenbach. A nasal bone with septum and characteristic teeth place the identity beyond doubt. After extensive comparison, I can see nothing here suggestive of any other species of rhinoceros. The species is here new to Avon No. 4 terrace.

Equus spelaeus type (Owen, 1869) The material comprises 10 teeth, a talus, tibia and metapodials. By whatever name it is known (*Equus caballus* L., *Equus ferus* Bodd.) it is the same horse which characterises the British and west European last glacial. Evidently, this is its first pre-last glacial occurrence in Europe. The horses from the Baginton-Lillington Gravels (Shotton, 1953, 1968) and Avon No. 5 terrace (Whitehead, 1989a) are different species.

Bison cf. *priscus* Bojanus. Represented by a 2nd phalange and an atlas vertebra. Identification based on author's extensive comparative studies supported by Olsen (1960). *Bos primigenius* Bojanus is associated with climatic climax vegetation and, with the exception of the Flandrian, appears to be an extreme rarity in the Avon valley (Whitehead, 1979, 1989a).

INFERENCES FOR CLIMATE FROM NO. 4 TERRACE SEDIMENTS *Salix herbacea* is an essentially boreal species in Britain (Stace, 1991) but Polunin (1939) regarded it as a truly arctic plant. This, combined with *Pisidium vincentianum, Coelodonta antiquitatis* and *Rangifer tarandus* and ice wedge pseudomorphs proves beyond all reasonable doubt that the LOWER SEDIMENTS aggraded in a 'full-glacial' climate.

Compared with Ailstone (Maddy *et al.*, 1991) No,. 4 terrace at Twyning is noticeably the colder. On a continuous climatic curve, however, the two need not be far apart; certainly there is nothing at Ailstone indicative of closed canopy forest. The valve of *Corbicula* with its strong suggestion of ditopism between the upper and lower sediments, points to aggradation in a rapidly vacillating climatic regime.

AVON NO. 2 TERRACE

Fig. 1 demonstrates the two broad sedimentologies underlying No. 2 terrace. Each has a distinct fossil mammal fauna. The two sediments are:

i) orange-pink level bedded fine quartzose sand behind and underlying

ii) cross-bedded sands and gravels, the gravel being almost entirely of Oolitic limestone, and on their chanelled surface orange-brown gravelly quartzose sand indicative of River Severn influence.

Organic silts under the gravels (Fig. 2) accumulated about 36 600 BP (Birm-599). The orange-pink quartzose sand therefore must have aggraded prior to 36 600 BP. Like No. 4 terrace, No. 2 terrace is therefore a composite feature, although only the total-width excavation of it provides the proof of the sediment relationship.

ORANGE-PINK QUARTZOSE SAND. It is particularly noted how these strikingly uniform level-bedded sands extend upwards to about 27 m OD, almost to the base of Avon No. 4 terrace. Farther upstream at Wick, No. 2 terrace extends up the valley side only about as high as the base of No. 3 terrace (Whitehead, unpub.). Jurassic rock, of essentially local provenance, makes no contribution to the sands and pebbles up to 5 mm in diameter are exceptionally rare.

Fig. 1 shows the sands some 6 m thick, although in some places their thickness approached 9 m. The sheer Lower Lias clay valley-side is shown in Fig. 1 with a well-marked bench. This bench extended laterally for 28 m and results from gross instability of the valley side after downcutting, the river-cut platform following valley side failure. This instability must have pertained in its later history, for the terrace sediments show revolute bedding where they meet the valley side (Figs. 1 and 4).

Whilst here deferring to the professional stratigrapher, my contention is that gravity deformation of the valley side, following the completion of terrace formation, is a likely explanation for this unusual phenomenon. The valley side exposed by quarrying was dramatically unstable hundreds of tonnes of Lower Lias clay at a time collapsing down into the floor of the pit.

Biota of the quartzose sands

Plant fossils. The quartzose sand is wholly devoid of plant organics. Dr J Tallis (Manchester) identified pollen from one sample of grey silty clay from a calcaneum of *Bison priscus*, from the river cut platform (SO 89603650). This contained only Tertiary or pre-Tertiary gymnosperm pollen (Tallis, in lit., 22.2.1974), at a time when pre-Pleistocene pollen and spores were being inwashed in to an area devoid of contemporary pollen. A second sample from the inside of a split reindeer antler contained no pollen.

Fossil molluscs. A body whorl of the amphibious gastropod *Lymnaea truncatula* (Müller) was found on the surface of the river-cut platform. No other molluscs were found. This species is not helpful in reconstructing either climate or chronology.

Fossil mammals. Mammal bones and teeth, numbering 135, were confined to the valley-side platform, flooring an embayment into it. The fauna is distinctive, dominated (91.3% of determinable fossils) by bison and reindeer. Elephantids and rhinocerotids are totally absent. The river-cut platform is marked by a thin deposit of pale grey silty clay containing articulated skeletons of the vole *Microtus agrestis* L. The likelihood is that these died in collapsed burrows. It must also say something about flow rates.

Taphonomy. The most convincing application of taphonomy would allow weakened bison and reindeer, swept downstream, to clamber out on to the embayment floor. There they were despatched by wolves. Remains of wolves were found with them, and many bone were gnawed by wolves.

The important point is that the assemblage is in a primary context, a rare situation in fluvial sediments. The disruption of the skeletons is evidently due to the activity of scavenging carnivores.

Observations on the fossil mammals. *Canis lupus* L. Represented by a radius, metapodial, 1st phalange, 5th cervical vertebra and fragmented left upper PM4. Tomlinson (1925) cited no records of this species from Avon No. 2 terrace, although in the buried channel at Aston Mill (37 600 BP—Birm-962), also rich in *Bison*, there is clear evidence of wolf-gnawed bone. The same applies in the early mid-Devensian *Bison*-rich assemblage at Tattershall Castle, Lincolnshire (Rackham, 1978), dated by 14C in the order of 42 000 BP (Birm-409) and 43 000 BP (Birm-341).

Equus sp. Represented by a 1st and 2nd phalange only.

Bison priscus Bojanus. Represented by a single cranium and a wide range of post-cranial material. All of the material represented carcases swept onto the valley-side platform (Fig. 1). The cranial characters (Skinner and Kaisen, 1947) permitted specific identification but the condition of the bone rendered recovery impossible; only the teeth were retained. However, a mass of cranial bone was submitted to the Radiocarbon Dating Laboratory at Birmingham University which found that dateable collagen was not present in sufficient quantity.

Although 56 (69%) individual fossils are referrable to *Bison*, the actual number of animals is 8, polarising towards the ends of the age range.

Rangifer tarandus L. Material from the river-cut platform includes a cast antler with pedicle from an older buck, and a cast antler with pedicle from a younger buck. It is possible, therefore, that reindeer were wintering nearby at this time. Rackman (1978) gave good grounds for their wintering in Lincolnshire at about 43 000 BP. In the Carrant valley upstream, reindeer appear to have arrived in early spring during the period 32 000 BP–26 000 BP, and to have left before the onset of winter. An upper M3 from Twyning has been occluded to root level, indicating the age of animals which succumbed to drowning or wolf predation (see Fuller, 1966).

Microtus agrestis L. Semi-articulated skeletons of 4 individuals were located in the silty clay surfacing the river-cut platform. Isolated teeth and bones of this rodent were recovered over a wide area of the platform surface. Stuart (1976, 1977) cites very few Pleistocene records of this species which prefers rank ungrazed grassland, probably a rare Devensian habitat and therefore, here only because of the inaccessibility of the valley-side embayment.

OOLITIC LIMESTONE GRAVELS. Visible sections in these sediments extended from about 15 m to 23 m OD; they characterise the terrace towards the modern river. The gravels are dominantly of sub-rounded pebbles of Oolitic limestone. The sands are composed of both quartz grains and ooliths providing a striking colour break where their contact with the underlying quartzose sand is visible. The gravels rest either on a dissected pavement of Lower Lias limestone or else on Lower Lias clay, the surface of which is channeled (Fig. 2). These channels contain seams of 'loess-like' material, compressed seams, and occasionally thicker beds, of vegetation.

Close to the gravels/Lias contact, but not everywhere evident is a bed (up to 550 mm thick) of shattered Lower Lias Limestone, flint, Bunter pebbles up 190 mm, Acheulian-type artefacts (Whitehead, 1988), large mammal bones, and larger pebbles of Oolitic limestone. Occasional far-travelled rocks include granite of south-west Scottish type, and Malvernian basal conglomerates.

The gravels are deformed by cryoturbation and ice-wedge pseudomorphs and the formation of a diapir ruptured the Lower Lias limestone pavement. As an indication of probable Severn influence, these gravels are overlain by dark orange-brown quartzose sand rich in Tertiary flint and Bunter pebbles, the whole capped by well structured loams.

Biota of the Limestone Gravels

Plant fossils. The removal of the gravels revealed channel fills on the surface of the Lower Lias clay containing a wide range of plant parts. These were thought to be abandoned braids. Whilst the fill was in places eroded (varying in depth from 18 cm to 90 cm) it was possible to establish that the channels were confluent.

Samples 1 (1300 gm, 12.10.1974) and 2 (1200 gm, 12.10.1974), separated from each other by 109.25 m, are kept discrete because their stratal relationships are uncertain by 17.25 m are here amalgamated. Whereas, Samples 5 (900 gm, 12.10.1974) are 1, was 109.25 m distant from sample 1, and since their stratal relationships were uncertain, they are here separated. The fossils were isolated by wet sieving through a 250 micron sieve.

The organic material was rich in plant fossils with large numbers of leaves of *Salix herbacea* L., calyces of *Armeria*, and valves of *Linum* visible in the field.

Plant macrofossils	Samples		
	1 & 3	5	
Ranunculus subgen. *Ranunculus*	9	1	achenes
Ranunculus subgen. *Batrachium*		1	achene
Thalictrum sp.		5	achenes
Viola sp.	12		seeds
Linum perenne-type		9	valves
Potentilla sp.	1		achene
Umbelliferae		1	mericarp
Heracleum sphondylium L.	1		fruit
Salix sp.	+		twigs
Salix herbacea L.	+		leaves (numerous)

Fig. 3 Sections through Avon No. 4 terrace, Twyning Gloucestershire 1973–1974.

Armeria maritima (Mill.) Willd.	8	3	calyces
Taraxacum sp.		1	achene
Potamogeton sp.		3	fruit-stones
Potamogeton berchtoldii Fieb.	11		fruit-stones
Zannichellia palustris L.	2		achenes
Monocotyledones	+		nodes

Flora and vegetation. I have traced no previous mid-Devensian records of *Heracleum sphondylium* L. or *Potamogeton berchtoldii* Fieb. *H. sphondylium* ascends to 300 m altitude in Scotland and in its subspecies *sibiricum* (L.) Simonkai somewhat exceeds 61°N in Scandinavia (Godwin, 1975). Hultén (1950) regarded *Potamogeton berchtoldii* as circumpolar in the north while Polunin (1939) called *Salix herbacea* an 'arctic' plant even though it is still extant in Britain.

The plant fossils in general were very well preserved and are of immediately local origin. The absence of Cyperaceae is noted. A reconstruction would allow a permanent body of gently flowing water cut through base-rich minerogenic sediments with *Linum* and *Armeria* and probably thickets of *Salix herbacea*, a species widespread in the British last-glacial (Bell, 1970). There is no evidence for trees.

Fossil molluscs and ostracods. 15 species of mollusc and one species of ostracod were recovered. Sample 5 produced nothing in this respect.

Molluscs	Samples 1 & 3
Valvata piscinalis (Müller)	3
Bithynia tentaculata (Linnaeus)	3
Lymnaea truncatula (Müller)	4
Lymnnaea palustris (Müller)	2
Lymnaea peregra (Müller)	11
Gyraulus laevis (Alder)	5
Succinea oblonga elongata (Sandberger)	7
Columella columella (Martens)	1
Vertigo genesii gensii (Gredler)	1
Pupilla muscorum (L.)	184
Sphaerium corneum (L.)	2
Pisidium sp.	3
Pisidium amnicum (Müller)	1
Pisidium casertanum (Poli)	1
Pisidium henslowanum (Sheppard)	9
Pisidium nitidum Jenyns	9
Number of individuals	246

Ostracods. A minimum of 11 specimens of *Candonopsis kingsleyii* (Brady & Robertson) were recovered from samples 1 and 3. This is a species of plant-rich water bodies, not subject to marked fluctuations of level (Dr J E Robinson, pers. comm. 23.4.1975).

An environmental reconstruction from the molluscs allows for a clean clear rivulet with submerged hydrophytes, flanked by basic minerogenic sediments. In places, this sediment was weakly vegetated (*Pupilla muscorum* (L.)), and at the water's edge supported small populations of *Columella columella* (Martens) and *Vertigo genesii* (Gredler).

Fossil beetles. A modest fauna of 18 species was isolated, which fortunately included a number of geographically important fossils. Some of the specimens, including all of the *Pterostichus* subgen. *Cryobius*, notoriously difficult to identify, were submitted to Mr P J Osborne (Dept of Geology, University of Birmingham), whose constructive comments are appreciated.

	Fossil beetles	Samples 1 & 3	5
	Notiophilus aquaticus (Linnaeus)	10	
	Elaphrus cupreus Duftschmid		1
+	*Pterostichus blandulus* Miller	18	
+	*Cymindis* cf. *angularis* Gyllenhal	1	
+	*Diacheila polita* Faldermann	1	
	Calathus melanocephalus (Linnaeus)	1	
+	*Helophorus sibiricus* Motschulsky	1	
	Olophrum sp.	1	
	Tachinus sp.	1	
+	*Simplocaria metallica* Sturm	4	
	Aphodius sp.	1	2
+	*Aphodius holdereri* Reitter	1	
	Apion sp.	1	
	Otiorhynchus arcticus (Fabricius)	13	
	Otiorhynchus ligneus (Olivier)	7	
	Otiorhynchus rugifrons (Gyllenhal)	2	1
	Notaris aethiops (Fabricius)	1	1
	Notaris acridulus (Linnaeus)	1	
	Notaris bimaculatus (Fabricius)	1	

+ extinct in Britain

Largely through the work of the Birmingham School, it is now possible (based on a long series of works principally by Coope) to recognise beetle-based chronozones in the Pleistocene. Even in the absence of its 14C date (36 000 BP–Birm-599) this assemblage has enough species of eastern affinity to place it within the Devensian type III faunas of Coope (1975). At Aston

Avon No. 2 terrace
Twyning, Gloucestershire
12th July 1973.

Upturned quartzose sands resting on Lower Lias Clay valley side.

The late Professor
F W Shotton, MBE, FRS.

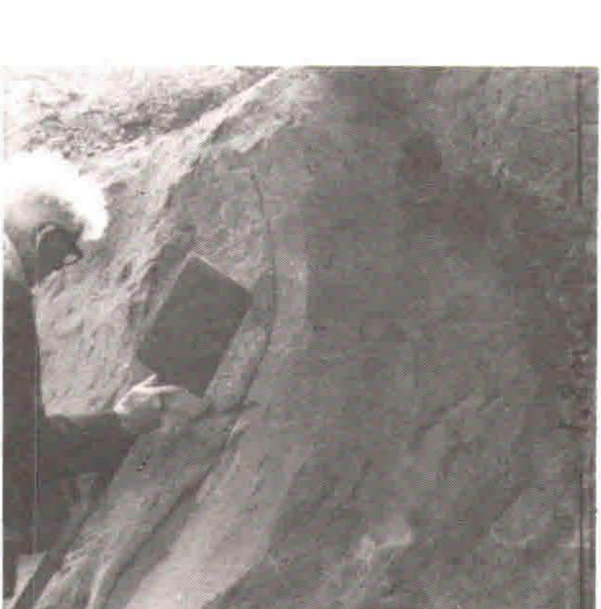


Fig. 4

Mill (Whitehead, 1989c), 13% of Devensian beetles were boreal, boreo-alpine and now extinct in Britain; in the present case, this figure rises to 28% partly due to the markedly eastern element, although the respective percentages (64%, 61%) for species currently extant, or more southerly in Britain than the site, are comparable. This could be due to the special character of the 'chronological moment of time' at Twyning, or to the existence of complex habitat-mosaics or widely varying conditions of the ground.

The environmental reconstruction is elegant and unambiguous, portraying cryoxerotic conditions in an exposed treeless landscape. *Diacheila polita* is a Holarctic typically tundra species (Coope, 1962, 1975) whilst *Pterostichus* (*Cryobius*) *blandulus* occurs no nearer to Britain than the Kanin peninsula (Briggs *et al.*, 1975).

The two carabids *Elaphrus cupreus* and *Diacheila polita* are hygrophilous, but the implication of *Cymindis* is always for xeric conditions on insolated, often very weakly vegetated ground. These conditions are also accepted by *Calathus melanocephalus*. *Simplocaris metallica* is a byrrhid usually found amongst moss-covered stones. It is likely that the polyphagous root-feeding weevils of the genus *Otiorhynchus* are limited by edaphic conditions, the presence of perfectly drained sediments aiding cold-climate survival of the larvae.

Fossil mammals. The author recovered 13 mammalian fossils from the gravels. These are ascribed to *Mammuthus primigenius* Blumenbach, *Coelodonta antiquitatis* Blumenbach, *Equus* sp., *Bison* sp., and *Megaloceras giganteus* (Blumenbach). Prior to this, No. 2 terrace gravels at Twyning yielded remains of *M. primigenius*, *C. antiquitatis*, and reindeer (*Rangifer tarandus* L.) (the late H Green, pers. comm.). Mr W Dreghorn recovered 7 teeth of *M. primigenius* and presented them to St Paul's College, Cheltenham. I have examined these teeth and all are the form with compressed laminae.

This assemblage is typical of Avon No. 2 terrace, with the exception of *M. giganteus*, comments on which are presented as an appendix to this paper.

INFERENCE FOR CLIMATE FROM NO. 2 TERRACE LIMESTONE GRAVELS. The recognition of a diapir and ice-wedge pseudomorphs indicates conclusively a 'full-glacial' climate. This is supported overwhelmingly by the biotic evidence with species (*Columella columella*, *Vertigo genesii*, *Pterostichus blandulus*, *Simplocaria metallic*) of essentially boreal range having relict mountain populations in the European hinterland.

The significance of assemblages containing these boreal species has been discussed by Coope (1970, 1975) who suggested a climate so continental that mean February temperatures were in the order of -20°C. The coprophagous scarabaeid *Aphodius holdereri*, although now Himalayan, extends the concept of climatic continentality.

THE TERRACE SEQUENCE AT TWYNING AND ITS IMPLICATIONS FOR PLEISTOCENE CHRONOLOGY

Recently, attempts have been made to rationalise the terrace hierarchy in the Avon valley (Whitehead, 1989a, Maddy *et al.*, 1989), and its relationship to the Oxygen isotope record (Maddy *et al.*, 1991). Maddy *et al.* (1991) have sought to apply stage and member names to the terraces, following an earlier sophisticated stratigraphic discussion (Bridgland, 1988; Maddy and Green, 1989; Bridgland, 1990). It is now unanimously agreed that the correct sequential history of the Avon terraces is of increasing age upwards. There is therefore nothing to be gained in disposing of the numerical sequence and replacing it with a nomenclatural one, especially since gravels passing under the modern floodplain nowhere form a clearly visible terrace.

For the many workers concerned with terraces from an applied viewpoint, the numerical sequence conveys an instant comparative sense of age. If an argument against this succeeds, then the numerical sequence should also be stated.

The clear relationship of terrace to the isotope record (Maddy *et al.*, 1991) is welcome. The extension backwards in time of the history of No. 2 terrace by Amino-acid ratio dates (Bowen *et al.*, 1989) remains problematical for the time being.

The finite 14C dates provide a convincing portrayal of the development of No. 2 terrace of the River Avon. Finite dates include 38 000 BP from the base of the gravels at Fladbury (Coope, 1962), 36 600 BP (this paper), and 37 600 BP (Birm-962) in a channel pre-dating the formation of the correlative terrace in the Carrant valley. Any suggestion that No. 2 terrace can be extended backwards in its development by 40 000a, must force the conclusion that at most of the sites studied, there is nothing to represent the additional time in terms of biotic evidence.

Although Maddy *et al.* (1991) referred to O.I. glacial stage 6 in their figure 9, the well stated climatic inferences for No. 4 terrace development at Twyning (Whitehead, 1989a) were not referred to. The basal sediments of No. 4 terrace at Twyning I equate with O.I. glacial stage 6, which necessitates the need to accommodate within the terrace sequence a further 'post-Wolstonian' (*sensu* Shotton, 1953, 1976, 1989) 'full-glacial'. The effect of this must be to increase the age of the Wolstonian type deposits.

ACKNOWLEDGMENTS

I thank all the learned and generous students of the Quaternary from whom I have benefited.

REFERENCES

Bell, F G. 1970. Late Pleistocene floras from Earith, Huntingdonshire. *Phil. Trans. Roy. Soc. B.*, 258, 347–378.

Bowen, D Q, Hughes, S, Sykes, G A, and Miller, G H. 1989. Land-sea correlations in the Pleistocene based on isoleucine epimerization in non-marine molluscs. *Nature,* 340, 49–51.

Boycott, A E. 1936. Habitats of freshwater Mollusca in Britain. *Journ. Animal. Ecol.* 5, 116–186.

Bridgland, D R. 1988. Problems in the application of lithostratigraphic classification to Pleistocene terrace deposits. *Quat. News.*, 58, 1–8.

— 1990. Pleistocene stratigraphy of river basin sediments: a reply to D Maddy and C P Green. *Quat. News.*, 60, 10–12.

— Keen, D H, and Maddy, D. 1989. The Avon terraces, Cropthorne, Ailstone and Eckington: *in* Keen, D H (editor). *The Pleistocene of the West Midlands: Field Guide. QRA Cambridge.*

Briggs, D J. 1984. Terraces of the Carrant brook and their relationship with the Cheltenham Sands: *in* Roberts, C (editor). *Geomorphology of the Lower Severn Area.* Brit. Geomorph. Res. Group. St Paul's College, Cheltenham.

— Coope, G R, and Gilbertson, D D. 1975. Late Devensian terrace deposits at Beckford, Worcestershire, England. *Geol. Journ.*, 10, 1–16.

Coope, G R. 1962. A Pleistocene Coleopterous fauna with Arctic affinities from Fladbury, Worcestershire. *Quart. Journ. Geol. Lond.*, 118, 103–123.

— 1970. Interpretations of Quaternary insect fossils. *Ann. Rev. Ent.*, 15, 97–120.

— 1975. Mid-Weichselian climatic changes in western Europe reinterpreted from Coleopteran assemblages in Suggate, R P, Creswell, M M (editors). *Quat. Studies,* 101–108. (Roy. Soc. New Zealand, Wellington).

— Shotton, F W, and Strachan, I. 1961. A late Pleistocene flora and fauna from Upton Warren, Worcestershire. *Phil. Trans. Roy. Soc.* B, 244, 379–421.

Dance, S P. 1961. On the genus *Pisidium* at Upton Warren. *Phil. Trans. Roy. Soc.*, B, 244, 418–421 (appendix to Coope, Shotton and Strachan op. cit.)

Ellis, A E. 1962. British Freshwater bivalve molluscs. *Synops. Br. fauna*, 13, Linn. Soc. Lond.

Fuller, W A. 1966. The biology and management of the bison in Wood Buffalo National Park. Canadian Wildlife Services. *Wildlife Management Book*, 16, Ser. 1.

Godwin, H. 1975. *History of the British Flora.* 2nd ed. Cambridge.

Hultén, E. 1950. *Atlas över växternas utbredning i Norden.* Stockholm.

Jack, A. 1922. A palaeolithic implement from Barton, Warwickshire. *Proc. Prehist. Soc.* E. Anglia, 3, 621.

Janus. H. 1965 *Molluscs.* Burke.

Keen, D H, and Bridgland, D R. 1986. An interglacial fauna from Avon No. 3 terrace at Eckington, Worcestershire. *Proc. Geol. Assoc.* 97, 303–307.

Kennard, A S, and Woodward, B B. 1925. The Pleistocene non-marine Mollusca of the Avon valley. *Quart. Journ. Geol. Soc. Lond.*, 81, 164–167.

Kerney, M P. 1976. *Atlas of the non-marine Mollusca of the British Isles.* Conch. Soc. Great Br./ITE.

Kubiak, H. 1965. The fossil elephants of southern Poland. *Folia Quat.*, 19, 1–43.

Maddy, D, and Green, C P. 1989. A unified approach to the stratigraphy of Pleistocene river basin sediments. *Quat. News.*, 59, 8–13.

— Keen, D H, and Bridgland, D R. 1987. Investigation of a probable Upton Warren interstadial site near Bengeworth, Worcestershire. *Quat. News.*, 52, 16–22.

— — — and Green, C P. 1991. A revised model for the Pleistocene development of the River Avon, Warwickshire. *Journ. Geol. Soc. Lond.*, 148, 473–484.

Morrison-Scott, T C S. 1948. A revision of our knowledge of African Elephant's teeth, with notes on forest and pygmy elephants. *Zool. Soc. Proc.*, 117, 505–527.

Mouthon, J. 1981. Sur la presence en France et au Portugal de Corbicula (Bivalvia: Corbiculidae) originaire d'Asie. *Basteria*, 45, 108–116.

Olsen, S J. 1960. Post-cranial skeletal characters of *Bison* and *Bos*. Papers of Peabody Museum of Archaeology and Ethnology Harvard University, 34, 4.

Owen, R. 1869. Description of the cavern of Bruniquel and its organic contents. II. Equinae remains. *Phil. Trans. Roy. Soc.*, 159.

Playle, B. 1962. The Heathcote mammoth tusk. *8th Ann. Report of the Warwick Nat. Hist. Soc.*, 20.

Polunin, N. 1939. Arctic plants in the British Isles. *Nature*, 144, 352.

Rackman, D J. 1978. Evidence for changing vertebrate communities in the middle Devensian. *Quat. News.*, 25, 1–3.

Shotton, F W. 1953. Pleistocene deposits of the area between Coventry, Rugby and Leamington and their bearing on the topographic development of the Midlands. *Phil. Trans. Roy. Soc.* B 237, 209–260.

— 1968. The Pleistocene succession around Brandon, Warwickshire. *Phil. Trans. Roy. Soc.* B., 254

— 1976. Amplification of the Wolstonian stage of the British Pleistocene. *Geol. Mag.* 113, 241–250.

— 1977. *The English Midlands.* INQUA Excursion Guide A2, 10th INQUA CONGRESS, Birmingham, England.

— 1978. Archaeological inferences from the study of alluvium in the Severn/Avon valleys in Limbrey, S., Evans, J G (eds.). *The effect of man on the landscape: the lowland zone.* Council for Br. Archaeol. Res. Rpt. 21, 27–32,

— 1989. The Wolstonian sequence and its position within the Pleistocene: *in* Keen, D H (ed.). *The Pleistocene of the West Midlands: Field Guide.* QRA Cambridge.

Skinner, M F, and Kaisen, O C. 1947. The fossil *Bison* of Alaska and preliminary revision of the genus *Bison*: revision part 2, *Bison* of Eurasia. *Bull. Amer. Mus. Nat. Hist.* 89, 211–253.

Sparks, B W. 1964. The distribution of non-marine mollusca in the last interglacial in south-east England. *Proc. Malac. Soc. London*, 36, 7–25.

Stace, C. 1991. *New flora of the British Isles.* Cambridge.

Stuart, A J. 1976. The history of the mammal fauna during the Ipswichian/Last interglacial in England. *Phil. Trans. Roy. Soc.* B 276, 221–250.

— 1977. The vertebrates of the last cold stage in Britain and Ireland. *Phil. Trans. Roy. Soc.* B 280, 295–312.

Symonds, W S. 1861. On the drifts of the Severn, Avon, Wye, and Usk. *Proc. Cottes. Nat. Fld. Club.* 3, 31–39.

Tomlinson, M E. 1925. River terraces of the lower valley of the Warwickshire Avon. *Quart. Journ. Geol. Soc.* 81, 137–163.

Whitehead, P F. 1977. Vertebrate fauna from the Carrant main terrace: *in* Shotton, F W. *The English Midlands.* INQUA Excursion Guide A2, 10th INQUA CONGRESS, Birmingham, England. 45–47.

— 1978. Devensian Elephantidae with reference to the terraces of the Warwickshire Avon. *Quat. News.* 24, 12–14.

— 1979. Wild Bovidae from the Evesham area with notes on the status of Giant Oxen (*Bos primigenius* Bojanus) in Britain. *Vale of Evesham Hist. Soc. Res. Papers.* 7, 1–8.

— 1988. Lower Palaeolithic artefacts from the lower valley of the Warwickshire Avon: *in* MacRae, R J, and Moloney, N (eds.). Non-flint stone tools and the Palaeolithic occupation of Britain. *BAR Br. Series.* 189, 103–122.

— 1989a. Development and sequence of depositon of the Avon valley river-terraces: *in* Keen, D H (ed.). *The Pleistocene of the West Midlands: Field Guide.* 37–41. QRA Cambridge.

— 1989b. The Quaternary malacofauna of the Warwickshire–Worcestershire Avon: *in* Keen, D H (ed.). *The Pleistocene of the West Midlands: Field Guide.* 42–50. QRA Cambridge.

— 1989c. Changing environments and Coleoptera faunas from Aston Mill, Worcestershire, England. *Ent. monthly Mag.* 125, 187–198.

— 1990. The vertebrate fauna of the Cheltenham Sands and Gravels. *Quat. News.* 62, 15–16.

Appendix 1

Note on a mammoth tooth from Twyning, Gloucestershire.

Calvin Wells

This tooth is a mandibular R. first molar of a young adult mammoth, (*M. primigenius*), probably close to the 17–20 year age range. The posterior part of the tooth is missing and the surviving part, at occlusal level and at about the junction of the lingual and medial thirds of the tooth, is 82 mm in length. This probably represents about three fifths of the original tooth length (137 mm), or perhaps two-thirds (123 mm). There are eight surviving laminae, the eighth being incomplete. The breadth of the tooth across the sixth lamina is 61 mm, giving a conjectured length/breadth ratio for the complete crown of 2.2 or 2.0. In the mid-occlusal plane, the seven complete laminae occupy 73 mm; reconstructing the damaged eighth shows that they would have measured about 82 mm proximo-distally. This gives a laminar frequency of 9.6 per 10 cm. Assuming the original tooth was 137 mm long, it is likely to have comprised 13 laminae. All the above figures and ratios are well within the limits of normal variation of a mandibular M1 in *M. primigenius.* The present maximum root-crown height (72 mm) is abnormally low.

The missing posterior part of the tooth sets a problem which is not easily resolved. It is just possible that this was due to postmortem cracking with subsequent rolling and polishing of the exposed surface to produce yet one more example of "pseudopathology". An intimate knowledge of the geological conditions in which it was found would no doubt assist in clarifying this.

A common biological finding is that structures and organs which are new developments, in the evolutionary sense, or which have been modified to perform new functions, are often unstable both anatomically and physiologically. Their morphology is likely to be highly variable and is often incompletely adapted to the changed demands which are made on them. In man, the newly erect vertebral column is an excellent example of this. Innumerable anatomical variations are found in it, many of which are severely disabling. Its functional inefficiency is shown by the vast amount of spinal disease and deformity which gravitates to the orthopaedic clincs and by the mass of palaeopathology found in the vertebrae of archaic populations. The general morphology, and especially the functional mechanisms, of teeth in the *Proboscidea* are also new evolutionary devices. The unique process of formation, proruption and tooth replacement in these animals has no close parallels. It might be expected, therefore, that these teeth would show considerable instability which would be reflected in variations of structure, aberrant anatomical features and anomalies of behaviour. These expectations are fully realized for elephants in general and for mammoths in particular. So much so, indeed, that it has been epigrammatically said, with only slight hyperbole, that "all mammoth teeth are abnormal". It is presumably not without significance that abnormalities in the dentition of fossil elephants appear to become somewhat less obtrusive as the millennia go by and greater stability is achieved. The widespread early anomalies tend to become fewer and less severe until the last Siberian mammoths are usually found to have only trivial departures from normality.

Although it is remotely possible that the missing posterior part of this tooth was lost after death there is, however, more compelling evidence that it was shed during life. It seems that the tooth split between the eighth and nineth laminae. The proximal part was then ejected, either as a result of direct pressure from the prorupting second molar, from an infection of the periodontal tissues or from a combination of the two. After shedding (and perhaps during the process, which may have taken several months) pressure facetting developed on the exposed proximal surface of the eighth lamina, with accelerated attrition at its upper part, thereby bevelling the dental tissues round onto the occlusal surface. It is likely that the fracture of the tooth occurred through a vertical plane of weakness which was, itself, probably developmental in origin.

There has been extensive resorption of the roots, with their virtual disappearance distally. This may be due to several causes. It may be largely or entirely the result of abnormalities in the tooth bud, of genetic or developmental origin, to infection of the alveolus and other periodontal tissues, or to metabolic factors of uncertain origin. These latter are often associated with irregular fossae in the tooth which are thought to reflect, in some cases, adverse dietary or nutritional factors. (It is one of these fossae, rather than an interstitial wear facet, that is present on the distal extremity of this tooth). But it is important to realize that these possible causes are not mutually exclusively: juvenile metabolic derangement may lead to structural weakness of the tooth which, in turn, predisposes to dental and periodontal disease.

In the present specimen, the inferior surface of the tooth is covered by an irregular, shiny deposit resembling a hypercementosis. This was almost certainly, in part, a response to some long continued low-grade infection of the surrounding tissues and must be seen as a physiological response which, to some extent, delayed the rate at which the roots were resorbed.

The dentine has been eroded on the occlusal surface of the tooth but the extent of this does not seem to be pathological. Dentine is normally much less resistant than enamel and the degree of attrition found here is no more than commonly results from intra-vitam mastication in these teeth, in this case perhaps slightly accentuated by postmortem soil erosion.

It will be seen that the ultimate interpretation of this tooth is open to nuances of ambiguity and shifts of emphasis. The most probable reading of it, however, is that it was originally of normal size and proportions, that it probably had an inherent plane of developmental weakness, that due to extrinsic or intrinsic stresses it fractured through this plane and that the proximal fragment was ultimately shed, to the accompaniment of a low-grade chronic periodontal infection.

Appendix 2

Giant Deer (*Megaloceras giganteus* (Blumenbach)) in Avon No. 2 terrace at Twyning, Gloucestershire

Mr P F Whitehead

On February 8th 1975, a ramus of *Metaloceras giganteus* (Blum.) with permanent dentition was found under Avon No. 2 terrace gravels at Twyning, Gloucestershire (SO 8971 3570) near the organic fill of shallow channels cut in the Lower Lias clay.

This is the first record of Giant Deer in No. 2 terrace sediments, and the first in the Avon valley this century. This large deer, rivalling moose in size, is now extinct; only bucks were antlered and their span approached 4 m.

The systematics and taxonomy of the megalocerine cervids have been dealt with by a number of authors (Azzaroli, 1953; Radulesco & Samson, 1967; Kurten, 1968; Lister, 1986), and the temporal and spatial range of *M. giganteus* in the British Isles has been defined (Campbell, 1977; Wood, 1967; Jessen & Farrington, 1938; Lister, 1986, 1989; Shotton. 1973, 1980; Stuart, 1974; 1976; 1977; Sutcliffe, 1964). The English records suffer from continuing discussion of the age and relationships of the deposits.

Apart from this specimen, *M. giganteus* is known in the Avon valley only from No. 3 terrace at Eckington, Worcestershire (Strickland, 1858).

The palaeoecology of *M. giganteus*

A pair of fossil antlers of *M. giganteus* may exceed 90 kg in weight (Colhoun, pers. comm., Savage, 1966). Generalising from Chapman (1975), deer antler is 50% mineral, of which 45% is Calcium. A buck Giant Deer would, therefore, have an annual mineral requirement for antlerogenesis at maturity of 45 kg, of which 20 kg would be Calcium. Over a (reasonably postulated) 130 day growth period, the mean Calcium requirement would be 155 gm a day. What is quite remarkable is that the average daily weight increase from antler growth during this time would be 692 gm. Whilst cranial (Lister, pers. comm. 4.2.1978) and post-cranial (Chapman, 1975) bone may be a source of recycled Calcium, it is clear that access to naturally occurring Calcium, in vegetation for example, would have been mandatory.

This is supported by its distribution in relation to the solid geology. Cave records (Mendips, Derbyshire Peak, Kent's Cavern, Caldey Island, etc.) follow the distribution of Palaeozoic limestones whilst other sites (Barrington, Brundon, Beetley) are close to the Chalk. Gravels at Barnwood, Stretton-on-Fosse, and Tattershall Thorpe rest on basic clays, and this situation is extended still further at the famous site of Ballybetagh, County Wicklow, Ireland. The calcareous lake-marls, rich in charophytes, formed a gathering ground for this species in the late-glacial (Savage, 1966). At Kirkmichael in the Isle of Man (Mitchell, 1958), sedimentary conditions were rather similar.

The situation at Twyning, where Giant Deer had access to streams draining the intensely basic Lower Lias clay fed by the erosion products of limestone gravels, is analogous. In riparian contexts, the incision and exposure of calcareous bedrock by fluvial processes acted in favour of Giant Deer; mantle deposits and valley fills did not.

REFERENCES

Azzaroli, A. 1953. La sistematica dei Cervi gigantei e i cervi nani delle isole. *Atti Soc. Toscana Sc. Nat.* 59 A (1952) Pisa.

Campbell, J B. 1977. *The Upper Palaeolithic of Britain.* Clarendon, Oxford.

Chapman, D I. 1975. Antlers, bones of contention. *Mammal Review.* 5, 4, 122–172.

Jessen, K, and Farrington, A. 1938. The bogs at Ballybetagh, near Dublin, with remarks on Late-Glacial conditions in Ireland. *Proc. Roy. Ir. Acad.* 44 B 10 205.

Kurten, B. 1968. *Pleistocene mammals of Europe.* World Naturalist. Weidenfeld & Nicholson.

Lister, A M. 1968. New results on deer from Swanscombe, and the stratigraphical significance of deer in the Middle and Upper Pleistocene of Europe. *Journ. Arch. Sci.* 13, 319–338.

— 1989. Mammalian faunas and the Wolstonian debate. *In* Keen, D H (ed.). *The Pleistocene of the West Midlands: Field Guide.* QRA Cambridge.

Mitchell, G F. 1958. A Late-glacial deposit near Ballaugh, Isle of Man. *New Phytol.* 57, 256.

Radulesco, C, and Samson, P. 1967. Sur un nouveau cerf mégacérin du Pléistocène moyen de la dépression de Brasov (Roumanie). *Geol. Rom.* 6, 317–344.

Savage, R J G. 1966. Irish Pleistocene mammals. *Irish Nat. Journ.* 15, 5, 117–130.

Shotton, F W. 1973. A mammalian fauna from the Stretton Sand at Stretton-on-Fosse, South Warwickshire. *Geol. Mag.* 109, 473–476.

— 1980. An occurrence of the Giant Irish Deer (*Megaloceros giganteus*) as a fossil in Warwickshire. *Cov. Nat. Hist. & Sci. Soc.* 5, 4, 129–135.

Strickland, H. 1858. *In* Jardine's *Memoirs of H E Strickland.* London, Van Voorst, 90.

Stuart, A J. 1974. Pleistocene history of the British vertebrate fauna. *Biol. Rev.* 49, 225–266.

— 1976. The history of the mammal fauna during the Ipswichian/Last interglacial in England. *Phil. Trans. Roy. Soc.* B 276, 221–250.

— 1977. The vertebrates of the last cold stage in Britain and Ireland. *Phil. Trans. Roy. Soc.* B 280, 295–312.

Sutcliffe, A J. 1964. The mammalian fauna: *in* Ovey, C D (ed.). The Swanscombe skull. A survey of research on a Pleistocene site. *Roy. Anthrop. Inst. Gt. Br. & Ireland.* Occ. paper 20.

Wood, C J. 1967. The palaeontology of the river terraces: *in* Ackerman, K J, and Cave, R. Superficial deposits and structures including landslip in the Stroud district, Gloucestershire. *Proc. Geol. Assoc.* 78, 567–586.

EXPLORATORY WORK AT DEN OF BODDAM, A FLINT EXTRACTION SITE ON THE BUCHAN GRAVELS NEAR PETERHEAD, NORTH-EAST SCOTLAND—FURTHER INFORMATION AND A COMMENT

Alastair M D Gemmell
Department of Geography, Aberdeen University

Introduction

In their recent paper on the Buchan Ridge Gravel deposits at Den of Boddam, Saville and Bridgland (1992) review the arguments relating to the origin of these somewhat enigmatic sediments. They make the point that from the evidence of their trench on the west side of Den of Boddam, they can identify four horizons, a soil, a till with a fabric indicative of ENE–WSW ice movement (i.e. onshore from the nearby coast), a 'deformation till' and beneath that the true Buchan Ridge (McMillan and Merritt, 1980) or Cruden Flint (Kesel and Gemmell, 1981; Gemmell and Kesel, 1982) gravel. They also note that the 'deformation till' closely resembles the underlying Buchan Ridge gravels in terms of composition, save for the absence of ghost clasts in the former, but that the fabric of the 'deformation till' is similar to that of the overlying till.

Saville and Bridgland state (p.9) that ' ... present work has shown that the previously published schematic section of this locality (Kesel and Gemmell, 1981, Fig. 3 D) is misleading, either because this earlier section encountered only the till and not the gravel itself or ... because it was cut through stratigraphy disturbed in prehistory. Unless this can be clarified, the results of the previous granulometric sampling (Kesel and Gemmell, 1981, table 1) must be treated with caution.'. This note is intended to provide just such clarification.

Stratigraphy

Figure 3 in Kesel and Gemmell (1981) uses the term 'Flint till' to describe those sediments in which flint and quartzite cobbles were held within a kaolinitic clay matrix. Sand layers interbedded with the 'Flint till' layers are separately identified in the diagrams. Section D in the figure is labelled in the caption as being from Denhead. In fact the section is a schematic derived from 2 pits, some 20 m apart, dug at a cottage at the south end of the track running parallel to the western margin of the Den of Boddam. The excavations were immediately to the west of the cottage, on almost horizontal ground, rather than being from the slopes of the Den itself. The stratigraphy revealed is thus from an almost identical topographic position to that of the trench section described by Saville and Bridgland, but located about 100 m to the south.

With respect to the first interpretation suggested by Saville and Bridgland (1992), that the section encountered only their till horizon, the field log of the larger of the two excavations used to make up section D shows the following stratigraphy:

0–0.3 m	Peaty soil, with small rounded flint cobbles and some chips.
0.3–1.45 m	Cobbles in sandy matrix, 80–85% of cobbles are flint. Frequency of cobbles diminishes upwards in the horizon. Some ghosts of granitic clasts present in the lower part of this horizon.
1.45–1.8 m	Flint 'till' with flint and quartzite cobbles (>80% of flint) and weathered ghosts set in a tenaceous clay matrix. The matrix is an orange colour.
Below 1.8 m	Cobbles of flint and quartzite (again c.80% flint) in a silty sand matrix.

Although the base of the sequence was not reached in either of the pits at this site (in the smaller excavation, the basal horizon of the main section was not exposed), a local farmer reported in conversation that in other excavations in the vicinity he had seen 2–2.5 m of cobble gravels and white sands overlying bedrock.

Discussion

The presence of ghosts of granitic clasts in a horizon with a sandy matrix suggests that at Section D the Buchan Ridge gravels *sensu stricto* (unit 4 of Saville and Bridgland's stratigraphy) lie within a metre of the ground surface. No equivalents of Saville and Bridgland's units 2 and 3 (till and deformation till) were found in Section D. If this linking of horizons is correct, then the sediments below 1.45 m at Section D can be interpreted as sub-units of Saville and Bridgland's unit 4.

Although the possibility that the stratigraphic sequence at Section D was the product of human activity cannot be ruled out on the basis of available evidence, the presence of intact ghost clasts and the absence of flint chips except in the surface layer strongly suggests that the stratigraphy is not a result of post-excavational pit infill, but is *in situ*.

It is of interest also to note that Den of Boddam is regarded as a relict meltwater channel by Saville and Bridgland (1992). As they indicate, both flanks of the Den are marked by large numbers of hollows revealing the presence of flint-extraction pits. This suggests that flint-rich gravels are found within the confines of the channel. A question to which future research could profitably be directed is the elucidation of the relationship between the channel and the flint gravel deposits. If the gravels are *in situ* within a glacial meltwater channel, then the deposition of the Buchan Ridge gravels, at least in this area, must postdate the onset of glaciation. If this is so, then an origin for the gravels as a glacial deposit (Kesel and Gemmell, 1981), or as a glacial erratic (Hall, 1982) is made more likely.

Conversely, if the Den of Boddam has been eroded through a pre-existing deposit of the flint gravels, then little new can be said about the age of the deposit. The presence of concentrations of flint and quartzite cobbles in fluvioglacial deposits associated with the channel would lend support to this idea. Cambering in the Buchan Flint gravel deposits flanking the present meltwater channel would provide further evidence for such a situation, although the presence of slumps associated with prehistoric pit-digging (Saville and Bridgland, 1992) may complicate the interpretation of any such structures.

REFERENCES

Gemmell, A M D, and **Kesel, R H**. 1982. The 'Pliocene' gravels of Buchan: a reappraisal: Reply. *Scottish Journal of Geology*, 18, 333–335.

Hall, A M. 1982. The 'Pliocene' gravels of Buchan: a reappraissal: discussion. *Scottish Journal of Geology*, 17, 336–338.

Kesel, R H, and **Gemmell, A M D**. 1981. The 'Pliocene' gravels of Buchan: a reappraisal. *Scottish Journal of Geology*, 17, 185–203.

McMillan , A A, and **Merritt, J W**. 1980. A reappraisal of the 'Tertiary' deposits of Buchan, Grampian Region. *Report of the Institute of Geological Sciences*, 80/1, 18–25.

Saville, A, and **Bridgland, D**. 1992. Exploratory work at Den of Boddam, a flint extraction site on the Buchan Gravels near Peterhead, north-east Scotland. *Quaternary Newsletter*, 66, 4–13.

A PRELIMINARY INVESTIGATION OF THE "MIDLEY SAND", ROMNEY MARSH, KENT, UK

J B Innes and A J Long
Department of Geography, University of Durham

Introduction

This paper describes the preliminary results of a continuing investigation of the so-called "Midley Sand" (Green and Askew, 1958) recorded near Midley, Romney Marsh. Although the term 'Romney Marsh' only refers to that area of marshland to the northeast of the Rhee Wall, the term is here used to describe the entire tract of reclaimed marshland between the cliffs at Fairlight and Hythe. This area is bounded to the north by a degraded cliff in the Wealden Beds, and to the south by the English Channel (Figure 1).

No previous detailed litho-, bio- or chronostratigraphic investigations of the "Midley Sand" have been made, despite the importance of these deposits to various models proposed for the evolution of Romney Marsh over the last *c*.5000 ^{14}C years before present (BP) (see below). The current research aims to determine the stratigraphic context of the "Midley Sand" and the application through their palaeobotanical and ^{14}C dating techniques, to elucidate the age and depositional history. The results from these preliminary investigations suggest that previous interpretations of the "Midley Sand" require re-appraisal, and that the term "Midley Sand" should no longer be used as a generic description of what is in fact a complex series of sand deposits.

The "Midley Sand" of Romney-March

The most comprehensive survey of the sediments of Romney Marsh was completed by Green (1968), who noted that the general lithostratigraphy of the marsh sequences consisted of four main stratigraphic units:

Younger alluvium
Peat
Blue Clay
Midley Sand

The term "Midley Sand" was used by Green and Askew (1958) and Green (1968) with particular reference to the low level sand deposit recorded beneath the Blue Clay and Peat described above. In places, however, the "Midley Sand" was recorded as a surface outcrop, notably northwest of Lydd, and Broomhill and north of Dymchurch. These surface deposits form conspicuous banks (for example at the type site of Midley (Green and Askew, 1958) and at Broomhill (Tooley, 1990), and trend in a south-west/northeast direction (Figure 1). At these locations, Green (1968) observed that the Blue Clay, peat and Younger alluvium attenuated and wedged out against the sand deposits. Because of this apparent stratigraphic relationship, Green (1968) argued that the "Midely Sand" represented the oldest deposit in the marsh sequence (older even than the Dungeness shingle)and proposed that the "Midley Sand" may once have constituted a far more extensive feature, such as a sand spit or system of sand banks or dunes, which have undergone dissection and re-working during their partial burial by younger deposits.

These early descriptions of the "Midley Sand" have been generally accepted by subsequent workers, whilst the apparent linear surface expression of the "Midley Sand" has been invoked as evidence for an early barrier beach, behind which the younger marsh sediments accumulated. Lake and Shephard-Thorn (1987, figure 21) for example, suggest that the "Midley Sand" represents the remnants of "a once continuous sandy bar which was built across Rye Bay enclosing a lagoon", which pre-dated the

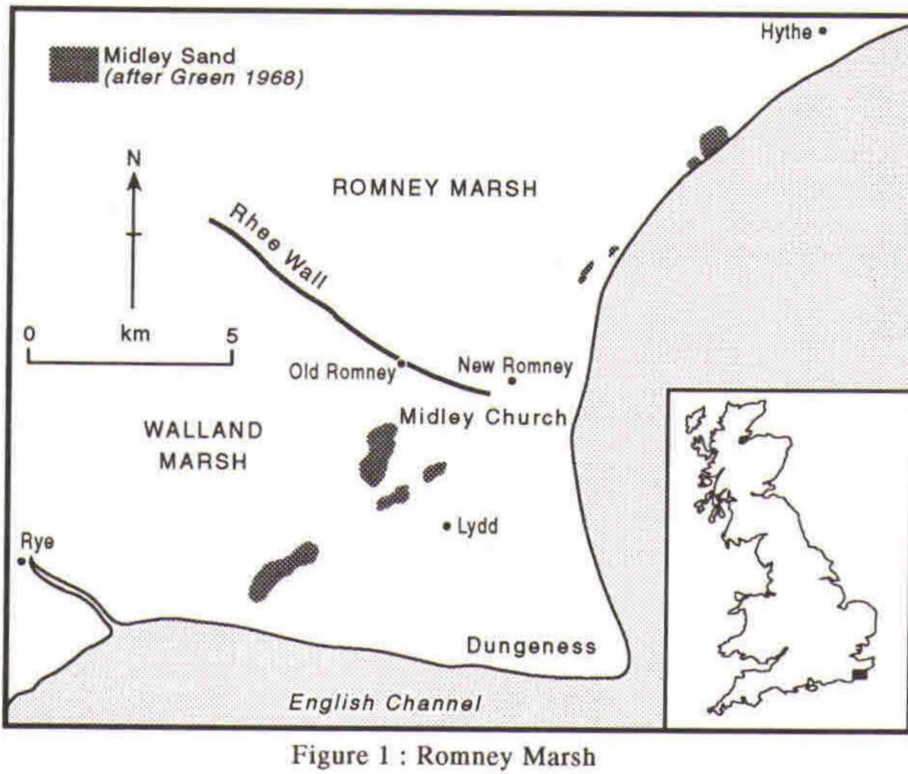


Figure 1 : Romney Marsh

deposition of the Blue Clay described by Green (1968). More recently Greensmith and Gutmanis (1990) have suggested that between 5000–3000 BP, a "nearly continuous NE–SW trending barrier or series of bars, comprising coarse sands in part with a sprinkling of pebbles known as the Midley Sand, developed across Rye Bay". The latter authors have argued that this barrier provided the "depositional framework of a mixed wave-tidal influenced barred shoreline", behind which the marsh sequence described by Green (1968) accumulated, and in front of which the Dungeness foreland evolved.

Central to the above hypotheses are three points:

1. That the "Midley Sand" represents a nearly continuous undulating low-level sand deposit which in places outcrops at the present land-surface.

2. That the "Midley Sand" deposit pre-dates the formation of the recent marsh sequence.

3. That the "Midley Sand" deposits once formed a barrier beach which in part controlled the pattern of sedimentation both to its landward and seaward.

Techniques

Lithostratigraphic data were collected by a gouge sampler, and the sediments described according to the Troels-Smith system of stratigraphic notation (Troels-Smith, 1955). Samples for laboratory analysis were collected with a piston-corer, and all cores were levelled relative to Ordnance Datum (OD) at Newlyn using a Kern Automatic level and levelling staff. Pollen preparation followed standard procedures (Moore and Webb, 1978).

Study area

For the purpose of this investigation, a substantial surface outcrop of "Midley Sand" recorded to the south of Hawthorn Corner (TR 0205 2330) was selected for detailed analysis (Figure 2). The approximate surface extent of the "Midley Sand" recorded in this area has been indicated on Figure 2. The sand outcrop forms a conspicuous mound, rising to an altitude in excess of +3.4 m OD i.e., some 2 m above the height of the adjacent marshland. It forms an elongate exposure, some 800 m in length and approximately 400–500 m in width. Three transects of hand-cores have been completed across this deposit (Figure 2), and the lithostratigraphy of one of these (Transect 2) is presented in Figure 3.

Transect 2 consists of eight hand-cores, three of which (23–25) penetrated the "Midley Sand" outcrop described above. Holocene sediments were sampled to an altitude of *c.*-0.40 m OD, and five main lithostratigraphic units were identified. In all hand-cores a sequence consisting of lower sands, blue clay and peat was recorded, which extended uninterrupted beneath the younger overlying sediments. The latter sediments consisted of two units, with an iron-stained clayey silt and a brown or orange sand with some silt which together formed the uppermost inorganic deposits recorded in most hand-cores. The detailed lithostratigraphy is described below.

The deepest unit recorded in all hand-cores was a dark grey or blue/grey coarse sand, the surface of which was recorded at between c.-0.40 m OD and +0.20 m OD. Overlying this unit was a blue-grey silty clay, which resembled the "Blue Clay" described by Green (1968). Above this was an organic deposit which varied in composition between a *turfa* with some *Phragmites* and rare detrital wood, and a well humified dark brown or black amorphous peat. The peat, typically 0.45 m thick, was recorded at altitudes between c.0 m OD, and in hand-cores 22, 23 and 25–27, the upper contact was eroded. This peat is comparable with the main marshland peat described by Green (1968) and Waller *et al.* (1988) and recorded extensively throughout Romney Marsh. Overlying this deposit in cores 20 and 21 were

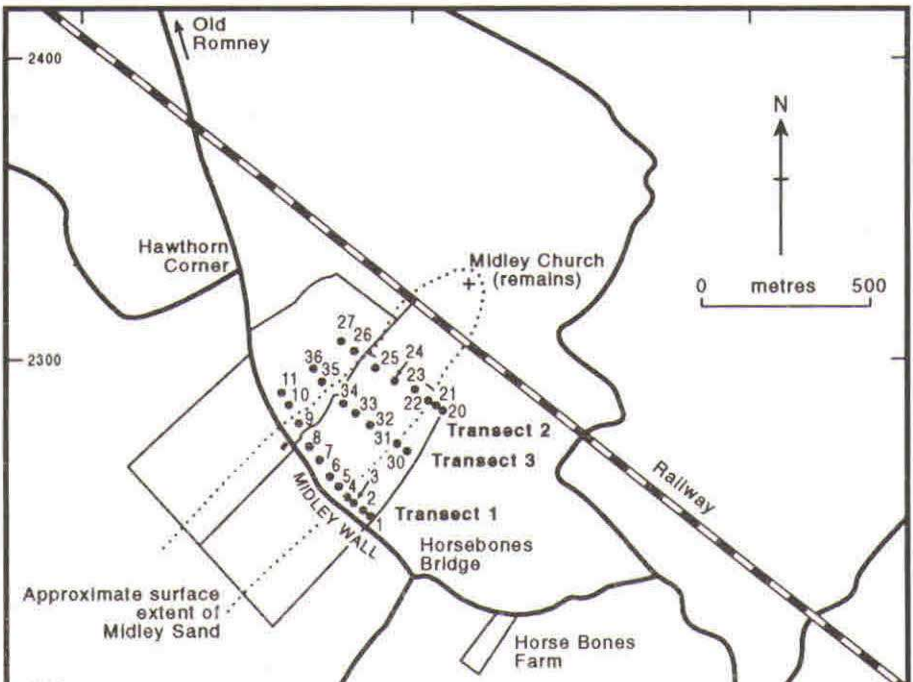


Figure 2 : Site Location

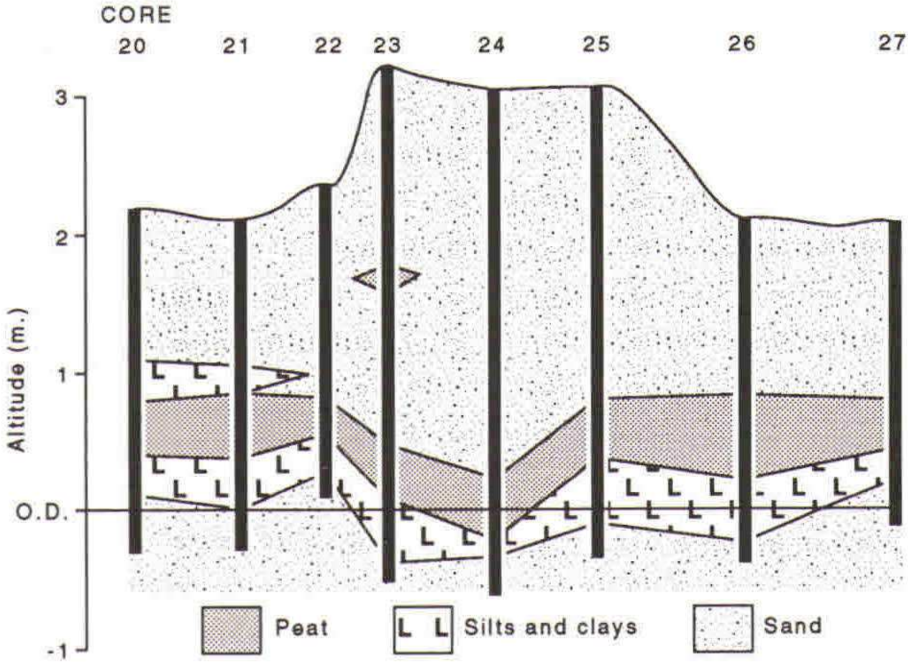


Figure 3 : Lithostratigraphy of Transect 2

grey silty-clays which passed into sands with some silt. In the remaining cores and overlying the peat was a thick deposit of sand extending virtually uninterrupted to the present surface. A localised peat layer was recorded at *c.*+1.80 m OD in core 23.

Three piston-cores were collected from the location of cores 3, 6 and 11 (Figure 2), and the preliminary results of pollen and diatom analysis completed on core 11 are described below. The lithostratigraphy of core 11, which is shown in Table 1 below, is directly comparable with that recorded in core 27 of Transect 2.

Preliminary pollen analysis of the organic sediments sampled in core 11 has clarified their age and palaeoenvironmental history. The blue/grey silty clay which underlies the peat bed is confirmed as being of marine or estuarine origin, as pollen grains of saltmarsh and coastal fringe plants are common in the base of the overlying peat. These include *Armeria maritima*, *Plantago maritima*, Chenopodiaceae, *Aster*-type and *Artemisia*. Isolated grains of these taxa recur throughout the peat bed, showing the relative proximity of coastal conditions to the site during the period of peat accumulation.

Table 1 Lithostratigraphy of core 11

Altitude (m OD)	Depth (cm)	Components
+1.05 to +0.97	85 to 111	Ga4 Grey/brown sand
+0.97 to + 0.27	111 to 163	Sh4, Dl+, Th^2+ Black well humified peat with some detrital wood and rare *turfa*
+0.27 to +0.08	163 to 182	Ag2, As1, Ga1, Th^2+ Blue/grey silty clay with sand
+0.08 to 0.00	182 to 190	Ga4 Blue/grey sand

The pollen asemblages suggest local domination by freshwater reedswamp and fen vegetation, with abundant grasses and sedges. Initially dominated by oak, the woodland vegetation around the site passed through a phase of alder and willow carr formation prior to the establishment of birch woods fringing the wetland. Burial of the peat by the upper sand deposit occurred at a time when coastal-type plant communities were increasing in frequency and the proximity of coastal conditions seems likely, although some of these taxa may also represent unstable sandy soil environments. Some of this instability, if not the sand itself, may reflect some local human impact, since cereal-type and weed pollen which could represent farming or deforestation, occur in the upper levels. The pollen data show the peat formation to be of post-elm decline age (<5000 BP).

^{14}C dates are currently being determined to provide a chronology for the sequence of sedimentation described above. Because previous dating of the main marsh peat has been limited, these results will provide the first absolute age determinations for the accumulation of this deposit beneath the surface outcrop of the "Midley Sand". However, it is likely that the main organic deposit recorded will be younger than 3000 BP, and perhaps even 2000 BP.

Discussion

Although Green (1968) explicitly used the term "Midley Sand" to describe the lower sands beneath the younger marsh sequences, he went on to describe and map a surface expression of this deposit which he also termed "Midley Sand". The preliminary results of the litho- and biostratigraphic data described here now enable a re-appraisal of the age and nature of the "Midley Sand".

The lithostratigraphic results of this study clearly demonstrate that the surface and near-surface outcrop of sand described in the study area and classified by Green (1968) as "Midley Sand", must have accumulated after the deposition of the main marsh peat. The "Midley Sand", therefore, is **not** a single deposit, but comprises at least two different deposits, i.e. an older sand recorded beneath the marsh sequence at depth, and a separate younger high altitude sand which post-dates the development of the main marsh peat. Although these findings require replication at other sites where the "Midley Sand" is recorded at or near the surface, they suggest the need for a re-assessment of models of coastal evolution for the area based on the existence of an early pre-shingle barrier of "Midley Sand". It is recommended that henceforth the term "Midley Sand", with its associated generic connotations, be no longer be used, at least until the relationships of the various sand facies of Romney Marsh have been studied further.

Acknowledgements

This research was completed with the aid of a grant from the Romney Marsh Research Trust. The authors thank Jill Eddison and Dr Michael Tooley for valuable comments and advice during this work. Thanks are also expressed to Mr John Paine for granting access to the land, and to the cartography section of the Department of Geography for help in the production of the figures in this paper.

References

Green, R D, and Askew, G P. 1958. Kent. *Rep. Soil Surv. GB*, No. 10, 21–25.

Green, R D, 1968. Soils of Romney Marsh. *Bull. Soil Surv. GB*, No. 4.

Greensmith, J T, and Gutmanis, J C. 1990. Aspects of late Holocene depositional hitory of the Dungeness area, Kent. *Proc. Geol. Ass.* 101(3), 225–237.

Lake, R D, and Shephard-Thorn, E R. 1987. Geology of the country around Hastings and Dungeness. *Mem. Geol. Surv. GB.*

Moore, P D, and Webb, J A. 1978. *An illustrated guide to pollen analysis.* Hodder and Stoughton: London.

Tooley, M J. 1990. Broomhill Level, East Sussex. In: Jennings, S. (ed) *IGCP Project 274 UK. Working Group Coastal Evolution in the Quaternary. Field Excursion Guide, South Coast.* Annual Meeting 22–24 September 1990.

Troels-Smith, J. 1955. Karakterisering af lose jordater. *Damn. Geol. Unders.* Series 4, 3, 1–75.

Waller, M P, Burrin, P J, and Marlow, A. 1988. Flandrian sedimentation and palaeoenvironments in Pett Level and Lower Rother Valleys and Walland Marsh. In: Eddison, J, and Green, C. (eds) *Romney Marsh. Evolution, Occupation, Reclamation.* Oxford Univ. Comm. Archaeol. Monograph, 24, 3–29.

REGIONAL PATTERNING IN LATE UPPER PALAEOLITHIC MENDIP FAUNAS

K V Boyle
10 Conington Road, Fenstanton, Huntingdon

ABSTRACT

Faunal studies have long concentrated on detailed accounts of site/assemblage content and relative chronology. The present study is an attempt to consider another variable, namely the regional spatial dimension. Based on detailed mapping of species occurrence, regularities in the faunal environment are seen and the spatial structure of the natural resource base can be considered in some detail.

INTRODUCTION

Faunal material from Pleistocene/Palaeolithic sites in the Mendips (Fig. 1) has long received attention from both archaeologists and palaeontologists (Dawkins, 1863, 1874; Jacobi, 1986), attention focusing upon either the characteristics of separate sites and their component assemblages or chronology. Little attention, if any, has focused on spatial patterning across the region. The present discussion aims to go some way towards rectifying this.

Zoogeography, the study of the distribution of animal species, is based mainly on the assumption that species distribution is not haphazard, but ordered in some way and that taxa occur in specific associations in particular contexts where ecological requirements are met. Recognising conditions in which a species occurs today, and relating the known palaeodistribution of the species in question to these conditions, should enable us to shed light on the distribution of animal resources during the Palaeolithic — or any other period under consideration.

If we plot species occurrence on a map, the area covered may be considered to represent the species' range. The area defined represents a minimum range over which predators exploited the resources concerned or where the animals in question died 'naturally'.

Large scale maps of the Mendips and surrounding area were drawn that included all natural water-courses and the 50 m contours. The maps took three forms:

1 **Presence/absence maps.** Although quantitative data are often argued to be of more value than their non-numerical counterparts, the vast amount of such data which is available should not be ignored. The presence

of a species at a site was recorded. Absences were added, although these merely tell us that a species has not yet been recorded at the site in question.

2 Maps showing the occurrence of dominant animals. The problem of 'co-dominant' species arises. It is unlikely that, if quantified, two species would be represented by the same number of elements. However, co-dominance is recorded.

3 Maps showing the distribution of numbers of species recorded. This is used as a rough indication of taxonomic richness although attention concentrates only on the number of large herbivores.

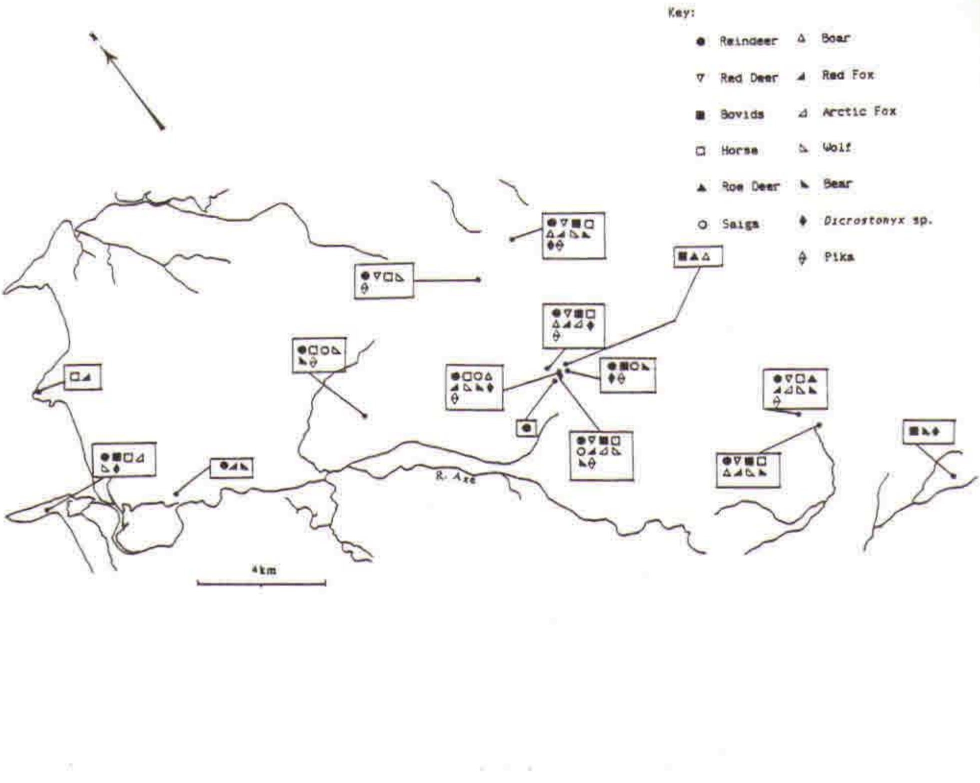


Figure 1 Map of Late Palaeolithic sites in the Mendip area.

Data were derived from sites of 'Late Upper Palaeolithic' age (post-last-glacial maximum). The selection of both sites and species was intentional, in order to form part of a longer term project comparing patterning with that known from sites of comparable age in South West France (Boyle, 1990). A second division was made, however, to take two factors into account, namely:

(i) The apparent disappearance of the mammoth (and more gradual disappearance of the rhinoceros) which occurred some time before approximately 13 000 B.P.

(ii) The change from a continental-type to a more oceanic/moist climate associated with renewed growth of ice.

In the present discussion, only sites from the later period are considered in detail.

SPATIAL PATTERNING OF SPECIES OCCURRENCE

Reindeer occurs in all parts of the Mendips. It is absent from only 20% (3) of the sites including 1 in the Cheddar Gorge area, which may be of a slightly later date. It is also a major species to the east of the region, in the Whatley — Tom Tivey-Brownes triangle in the Frome area. Here, however, no one species dominates the picture.

Given that reindeer is a species which can survive under a variety of conditions, ranging today from the Cairngorms, where it has been introduced, to the Barrenlands of Canada, through Scandinavian woodlands and North American Boreal forests, it is perhaps unwise to attempt to draw precise conclusions from the observed distribution of the species in a small area such as the Mendips. Suffice it to say that the presence of reindeer may imply cold conditions while the pockets of denser temperate-type woodland, which the presence of other species may indicate, were few and far between. This is reinforced if two things are considered, namely the distribution of tundra-indicative collared lemming (*Dicrostonyx* sp.) and the parallel distribution of temperate (woodland) species such as boar and roe deer.

Dicrostonyx sp. is absent from several sites in the Mendips. These absences may be artificial at some sites from which microfauna have not been recorded (or recovered). Of interest, however, are the sites in the Wookey-Ebbor Gorge area, particularly given that roe deer, boar and the more catholic red deer are found here. The presence of reindeer need not, therefore, be indicative of tundra conditions.

In more general terms, temperate woodland species occur to the east of the Cheddar Gorge area during the final stages of the Palaeolithic. In particular, red deer occurs at 6 sites, in valleys well away from the more exposed plateau surface, thereby providing protection from extreme conditions. It is unlikely that red deer ranged widely over the dry plateau surfaces, competition with the reindeer restricting it somewhat. Prior to c.14 000 B.P, it occurred mainly to the west of Cheddar, boar being of a similar distribution but rarer — all occurrences lying along the northern edge of the Mendip range. The roe deer appears to have been absent.

In the case of the horse, a species which today prefers open, grassy landscapes, avoiding soft marshy ground and deep snow, a distribution reminiscent of that of the reindeer is seen in that it is both widespread and abundant. It is absent from 4 sites, including 2 in the Cheddar area. In several cases it is known to be more abundant than the reindeer, for reindeer frequencies (where known) range from 0% to 48%, averaging 19.1%, whereas figures for the horse are generally higher, ranging from 0% to 65%, with an average of 21.7%. Quantitative measures of abundance are, however, still rare, although an attempt is being made to rectify this. Whether or not the importance of horse in the area indicates the presence of large expanses of open grassland environments in the immediate area is questionable. The presence of saiga (a species which today occurs mainly in the dry steppe environment of Kazakhstan (Heptner *et al.*, 1988)) indicates that open grassland was, in all probability, found in the area.

Saiga has been recognised at 4 sites so far (Gough's Cave, Soldier's Hole, Sun Hole and Wavering Down, Wolf Den: Currant, 1987). All of these occur on the south west edge of the Mendips, overlooking the present day South Somerset Levels. It may be that for much of the time between about 14 500 and 12 000 B.P., the area now covered by the Levels was characterised by dry, open grass plain communities — eminently suitable for the saiga, being protected from extreme weather conditions by the Mendip range itself. Both human and non-human predators may have returned to sites on the edge of the Mendips, having sought prey on the dry plain.

In summary, reindeer forms a major part of the fauna at sites on the southern edge of the Mendips. Horse on the other hand predominates on the northern edge although its overall distribution is more spread out. Red deer also dominates in the north of the Mendips at two sites. In each case horse is of equal importance nearby. It is suggested that the flatter Levels, which lie to the north-east of the Mendips, supported large herds of horse and bovids with reindeer on the plateau surface. This latter area may also have supported the small saiga population which occasionally appears. Woodland species occur primarily in the valleys/gorges such as Burrington Combe and Cheddar. These may have provided refuge from extreme conditions elsewhere.

Statistical analysis of the presence/absence data available (Cluster Analysis) from sites in the Mendips reveals two broad groups of species which confirm the patterning discussed above.

1 An open community, comprising reindeer, horse, red deer and the few saiga recorded. Reindeer is substantially more common than red deer, but both species may characterise open, exposed environments of the type probably found on or close to the Mendip plateau. However, both may also be found in woodland environments and thus cannot act as indicator species for either open tundra or woodland communities. Horse and saiga are indicative of cold open grass environments, being found in steppe landscapes today, and in association with both microfauna typical of dry open environments and NAP-rich pollen spectra elsewhere in Late Pleistocene Western Europe, e.g. Moulin-Neuf and Roc de Marcamps in the Gironde, France (Lenoir, 1983; Lacorre, 1939).

2 A woodland group exists in which roe deer and boar represent a warmer element, other taxa being well able to withstand cold (woodland) environments.

A boreal element is characterised mainly by those species which often occupy coniferous woodland today; the wolf, lynx, some bovids and both arctic and red fox. Although arctic fox is often thought of as a tundra species, it may take refuge in woodland during winter months. Hyaena, wild cat, woolly rhinoceros and bears are equally likely to have lived in deciduous woods as in coniferous woods or an open terrain — according to our knowledge of associated fossil floras.

The geographical distribution of these statistically defined 'ecological groups' shows some regularities. Sites at which the woodland group is important are relatively close to water and/or valleys and occur primarily in the east of the region. Open communities are encountered farther towards the west and the present coastline, but many of the sites found close to the Mendip plateau surface in the centre are also characterised by open conditions, this time with isolated pockets of woodland tundra nearby.

DISCUSSION

Many causes can be invoked to explain patterning in species abundance. Not only do the frequencies of each species vary in a regular manner, but also the number of taxa. The latter is known to vary from one biome to another (Putman, 1984) and is a phenomenon reflected in the 'biocoenotic principles' which originate from 'modern' zoogeographic studies. Two principles are of direct relevance to the present study.

1 The more variable the environmental conditions encountered, the greater the number of associated species, primary productivity and environmental complexity.

2 The more the environmental conditions diverge from the norm, the less the species diversity, and the greater the probability of the ecosystem being dominated by a single species.

Given that the 'number of species' (N) provides an initial indication of the degree of complexity, it was decided to consider variation in this variable across the region.

The distribution of the number of species at L.U.P. sites in the Mendips shows two kinds of pattern: horizontal and vertical.

I Immediately prior to the period under consideration, species number peaks in the west (Uphill, n=9) with similar figures at other sites along the broken ridge marking the north-west edge of the Mendip range. At the same time, the number of species declines towards the east. During the later period, however, the spatial trend is not as clear-cut. Species number peaks in Burrington Combe at Aveline's Hole, although pockets of sites with relatively high number of taxa occur in Cheddar and Ebbor Gorge. However, figures are low, the mean being only 3.357 (+/-1.63), as opposed to 4.42 (+/-2.56) during the earlier phase. Such a difference may be explained by several factors including:

(1) A change from a relatively continental to a more moist, oceanic climate. As the flat landscape to the north-west of the Mendips became more moist, so the range of the bovids and horse would move and saiga be limited to the drier Mendip surface.

(2) Assemblages from later sites are, at least in part, due to human activity. We are considering data which reflect not only the environment but also direct human exploitation bias, i.e. selection.

II Prior to 14 000 B.P., there is a clear altitudinal pattern across the whole area; as site altitude increases, so the number of large herbivore species falls (r=-0.874).

During the later episode the relationship is different. A positive correlation is now seen (r=0.523) which, although much weaker than that seen earlier, suggests that a distinct change has occurred. We now see more species at higher sites, perhaps a reflection of more specialised human activity at some sites and natural or carnivore accumulation processes at others. It is a subject which requires further, future attention.

CONCLUSIONS

The distribution of sites at which species occur shows, to some extent, the organisation of the faunal environment and resource base available for exploitation by predators (human or non-human).

The Mendips is a relatively small area and patterning is not seen as clearly as it might be in larger regions. Patterning is more altitudinal and must be sought on a smaller scale. However, some spatial or horizontal patterns are discernible. (1) Woodland species are largely restricted to valley sites, where protection from extreme conditions was offered and vegetation may have been richer. This is particularly noticeable in the Ebbor/Wookey area where tundra indicator species are largely absent. (2) An open component is seen farther west, comprising reindeer, horse, saiga and some red deer. A distinction between tundra and steppe is possible only on a small (and therefore perhaps misleading ?) scale. It is suggested that drier environments are found to the north of the hills, moister conditions on the southern edge. Clearer patterning will probably emerge on extending the region under consideration to include surrounding areas.

ACKNOWLEDGEMENTS

This article is based on part of a paper presented at the QRA Annual Discussion Meeting in Sheffield in January, 1992. Continuing data collection was, in part, funded by a BART grant for which I should like to thank the CBA. I should also like to thank Christopher Hawkes (University of Bristol Spelaeological Society) and Ray Inskeep (Pitt Rivers Museum, Oxford) for their interest and for allowing me to examine material from several Mendip sites.

REFERENCES

Boyle, K V. 1990. Upper Palaeolithic Faunas from South West France: A Zoogeographic Perspective. Oxford, BAR. International Series 557.

Currant, A P. 1987. Late Pleistocene saiga antelope, *Saiga tatarica* on Mendip. *Proceedings of the University of Bristol Spelaeological Society*, 18(1), 74–80.

Dawkins, W B. 1863. On the Hyaena-Den at Wookey-Hole, near Wells. *Quarterly Journal of the Geological Society*, 18, 115–125.

— 1874. Cave Hunting. London, Macmillan.

Heptner, V G, Nasimovich, A A, and Bannikov, A G. 1988. Mammals of the Soviet Union. Vol. 1: Artiodactyla and Perissodactyla. Washington D.C., Smithsonian Institution Libraries and the National Science Foundation.

Jacobi, R M. 1986. The Lateglacial archaeology of Gough's Cave at Cheddar, 75–79; in Colcutt, S N (editor). The Palaeolithic of Britain and its Nearest Neighbours: Recent Advances. Department of Archaeology and Prehistory, University of Sheffield.

Lacorre, F. 1939. La grotte des Fées, à Marcamps (Gironde) ou Roc de Marcamps. *Procès-Verbaux de la Société Linnéene de Bordeaux*, 90, 35–51.

Lenoir, M. 1983. Le Paléolithique des Basses Vallées de la Dordogne et de la Garonne. Bordeaux, Thèse de Doctorat d'Etat ès Sciences, Université de Bordeaux 1.

Putman, R J. 1984. The geography of animal communities, 163–190; in Taylor, J A (editor), Themes in Biogeography. Beckenham, Kent, Croom Helm.

LIGHT ATTENUATION BY LIME AND SELECTION PRESSURES ON WOODLAND SPRING FLOWERS

David M Wilkinson
Dept. Architecture, Landscape and Three Dimensional Design, Manchester Polytechnic, Manchester, M15 6HA, UK

'One of the most striking features of the deciduous forests of the northern temperate zone is the profusion of spring flowers on all but the driest and most infertile soils. The seasonal abundance of flowering in the herb layer marks these forests out from evergreen warm temperate rain forests ... and from the evergreen rain forests of the tropical lowlands and mountains.' (Grubb and Marks, 1989).

The reason for this is thought to be that the herbs are advantaged in temperate deciduous forests because they can 'leaf-out' before the trees, so making use of a 'window' in time when the light level on the woodland floor is much higher than during the summer, when the leaves attenuate much of the light, and higher than in the winter when the trees are leafless but the light flux incident on the woodland canopy is lower.

Five thousand years ago the woodlands in England and Wales on fertile, non-calcareous soils were probably dominated by Lime *Tilia spp.* (Bennett, 1989). The British woodlands of this time are of particular interest since this probably represents the time of the most complete development before human forest clearance began to disrupt the pattern. Similar forests rich in Lime can be seen in reconstructions of the woodlands of much of continental Europe of a similar date (Huntley, 1990).

ATTENUATION

SUMMER		WINTER
Lime	(89)	
Lombardy Poplar	(87)	
Oak/Sycamore	(82)	
Beech/Horsechestnut	(81)	
Ash/Hawthorn	(78)	
Alder	(76)	
Birch	(75)	
Scots Pine	(71)	Scots Pine
	(56)	Hawthorn
	(53)	Beech
	(50)	Oak/Alder/Lombardy Poplar
	(48)	Horse Chestnut
	(46)	Sycamore/Birch/Lime/Ash

Fig. 1 Rank orders of light attenuation; approximate attenuation given in brackets. From Wilkinson (1992).

Oak *Quercus robur*, Sycamore *Acer pseudoplatanus*, Birch *Betula pendula*, Lombardy Poplar *Poplus nigra* 'Italica', Lime *Tilia x europea*, Beech *Fagus sylvatia*, Hawthorn *Crataegus monogyna*, Alder *Alnus glutinosa*, Pine *Pinus sylvestris*, Ash *Fraxinus excelsior*, Horse Chestnut *Aesculus hippocastanum*.

As part of a study of the light attenuation characteristics of trees in the landscape around buildings, the mean light attenuation values for single crowns of mature trees of a number of species have been measured (Wilkinson, Yates and McKennan, 1991; Wilkinson, 1992). These results are summarised in Fig. 1; because the main interest of this study was modern urban trees, several of the species used are not native to Britain. The behaviour of Lime is of particular interest since it has a very high attenuation value in summer but one of the lowest values in winter. This suggests that there would have been particularly strong selection pressures on the ground flora of Lime-dominated woodland to make use of the spring light 'window' compared with woodlands dominated by other species of tree.

In interpreting Fig. 1 it should be realized that the species of Lime that formed the forests of 5000 years ago were probably Small-Leaved Lime *Tilia cordata* and Large-Leaved Lime *T. platyphyllos* (probably largely *T. cordata* in Britain), while the data presented refers to the hybrid between these two species *T. x europea*, since this is more commonly used as a landscape tree. The interpretation presented in this paper is based on the assumption that *T. cordata* and *T. platyphyllos* show similar patterns of light attenuation to the hybrid. Pigott (1989 *a* and *b*) has made similar assumptions about the relationship between tree age and diameter at breast height for *T. cordata* and *T. x europea.*

Acknowledgements

I thank Geoff McKennan, Gordon Dixon and David Pope for comments.

References

Bennett, K D. 1989. A provisional map of forest types for the British Isles 5000 years ago. *Journal of Quaternary Science,* 4, No. 2, 141–144.

Grubb, P J, and Marks, P L. 1989. Spring flowers of eastern North American and European deciduous forests. *Plants Today*, 2, 89–96.

Huntley, B. 1990. European vegetation history: palaeovegetation maps from pollen data—13 000 yr BP to present. *Journal of Quaternary Science,* 5, No. 2, 103–122.

Pigott, C D. 1989a. Factors controlling the distribution of *Tilia cordata* Mill. at the northern limits of its geographical range. IV Estimated ages of the trees. *New Phytol.*, 112, 117–121.

— 1989b. Estimation of the ages of Lime Trees (Tilia spp.) in parkland from stem diameter and ring counts. *Arboticultural Journal*, 13, 289–302.

Wilkinson, D M. 1992. *Modelling light attenuation by urban trees.* Unpublished PhD thesis, Manchester Polytechnic.

— **Yates, D, and McKennan, G T.** 1991. Light attenuation characteristics of seven common British trees. *Arboricultural Journal*, 15, 37–44.

THE USE OF ELECTRICAL CONDUIT (TRUNKING) BOXES FOR THE TRANSPORT AND STORAGE OF SEDIMENT CORES

J R Flenley
Geography Department, Massey University, New Zealand

Ideally, core boxes should be strong, rigid, light in weight, airtight, water-tight, easy to label, easy to open and close repeatedly, opaque, stackable, available in various widths, lengths and cross-sectional shapes, chemically inert, easily cleanable for re-use, cheap and non-bulky.

Over the years, I have used the following materials, with the disadvantages listed:

Wood:	Relatively heavy and bulky, lids need to be nailed on, possibility of carbon contamination.
Bamboo (halved):	Nodal septa damage core, splits when dry.
Windolite:	Difficult to cut, not very strong, rusts, not opaque.
Plastic drainpipe (halved):	Difficult to make airtight, saw-scurf may contaminate core, lids sometimes slip into core, difficult to stack.

Most of these problems are solved by the use of electrical conduit, known as trunking in New Zealand. This is a white extruded plastic material available in three metre lengths. Various cross-sections are available. I use a 40 mm x 40 mm square section box for both piston cores (Walker, 1964) and D-section cores (Jowsey, 1966). Larger sizes and rectangular sections are available. I have the boxes cut to 1 m lengths. Saw-scurf is removed before use, but its white colour reduces the chances of undetected contamination of cores. The lid which makes up one side of the box is stripped off before use, and the core laid in the box. The lid is then pressed back on, forming a very good seal. Special end-pieces, bought separately, are added and retained in position with waterproof tape. The box and the lid are labelled either by writing on them with a waterproof pen, or with Dymo embossed plastic labels, placed top and bottom of the core.

The result is a boxed core which is rather well sealed against air, water and light. A set of cores is easily taped together for porterage and stacks compactly in a cold or humidified chamber for storage in the laboratory. The material is reasonably cheap and may readily be cleaned for re-use. If the possibility of exchange of organic compounds between the core and the box is feared, the box may be lined with metal foil before use. A particular advantage is the ease with which the box may be opened and re-sealed.

REFERENCES

Jowsey, P C. 1966. An improved Peat Sampler. *New Phytol.*, 65, 245–248.

Walker, D. 1964. A modified Vallentyne Mud Sampler. *Ecology*, 45, 642–644.

REPORTS

THE MARINE PALAEOENVIRONMENT 15–9 ka BP IN SHALLOW UK SEAS — A PROGRESS REPORT

J D Peacock
18 McLaren Road, Edinburgh EH9 2BN, Scotland
and
Department of Civil and Offshore Engineering, Heriot-Watt University, Riccarton, Edinburgh EH14 4AS, Scotland.

ABSTRACT

The standard terrestrial climatic sequence (cold, cool, cold, warm) in the 15 000 to 9000 period can be recognised in the marine record of shallow seas, but with modifications, particularly late in the Windermere Interstadial and earliest Flandrian. Furthermore, recent work suggests that sea-levels in the northern North Sea and on the continental shelf adjacent to western Scotland may have been lower during this interval than estimated from terrestrial evidence. A brief account is given of work in progress and topics are suggested for future research.

INTRODUCTION

Marine strata deposited in the nearshore and shelf environment during the full-glacial to Flandrian transition have been investigated in detail at a number of Scottish sites in the last 15 years (Figure 1; summary and references in Peacock and Harkness (1990)). In the more southerly parts of the UK, however, little or no information is available concerning marine palaeoenvironments post-dating the retreat of the Dimlington Stadial (main Late Devensian) ice, though beds interpreted as glaciomarine in the Irish Sea and thought to date from the stadial are known to contain high arctic faunas (Eyles and McCabe, 1989). In the Celtic Sea area, thin glacigenic sediments with cold water microfaunas are attributed to a period about 19 000 BP (Scourse *et al.*, 1990). In this report, I present a brief summary of the present, largely Scottish, position (April 1992), discuss work in progress in the UK and suggest topics for future research.

SUMMARY OF PUBLISHED WORK AND WORK NEARING PUBLICATION

In the earliest part of the period under discussion, much of Scotland and parts of the continental shelf were under the retreating Late Weichselian ice-sheet. With relatively high sea-levels adjacent to the retreating ice and low sea-levels elsewhere, the extent of land and sea also differed considerably from that at present. The record of marine sedimentation is thus complete only for parts of the east coast and the shelf west of the Outer Hebrides. The continental shelf adjacent to Orkney and Shetland has yet to be examined in detail (see below).

Temperature and Salinity

Period before 13 000 BP (Dimlington Stadial)

In Vibrocore 57/-09/89 south of St Kilda (Figures 1 and 2) sedimentation began well before 15 000 BP in a proximal glaciomarine environment and thence in a distal glaciomarine environment until after 13 500 BP. Shallow water (Figure 3), high-arctic foraminiferal and molluscan faunas were present throughout, with water temperatures below a maximum of 4°C and salinities slightly below normal marine (Peacock *et al.*, 1992). Similar shallow water, high-arctic faunas have been reported for the period predating 13 000 BP from the Minch (with reduced salinity, Stornoway 78/4 Borehole, Graham *et al.*, 1990) and from the North Sea (Vibrocore 58/+00/111, Long *et al.*, 1987; see Figure 1) and have long been known in eastern Scotland (Errol Beds and Wee Bankie Beds), where a high-arctic fauna generally indicative of near normal marine salinities presumably dates back from about 13 000 BP to the glacial maximum at 18 000 BP.

Period 13 000–11 000 BP (Windermere Interstadial)

There is evidence from the Minch and from the Clyde (chiefly Stornoway Borehole 78/4, Ardyne and Lochgilphead, Figure 1) for a rapid change from arctic to boreal conditions about 12 800 BP, possibly within 50 years (Peacock and Harkness, 1990), and a return to arctic conditions a little after 11 000 BP (Figure 2). Conditions were generally high-boreal to low-arctic, with summer temperatures some 2–3°C below those of today and with winter sea ice present (Peacock, 1983; Peacock and Harkness, 1990). Similar temperatures have been inferred for the North Sea at this time. There were somewhat warmer intervals between 12 800–12 400 BP and 11 250–10 900 BP. Only the latter has been identified with certainty in the North Sea basin and St. Kilda area, where the time span may have been longer (Figure 2). The earlier amelioration clearly corresponds to that seen in the coleopteran record, when temperatures in England and Wales approached or even exceeded present levels (Coope, 1977; Atkinson *et al.*, 1987). It is much less pronounced in the marine record, possibly because of

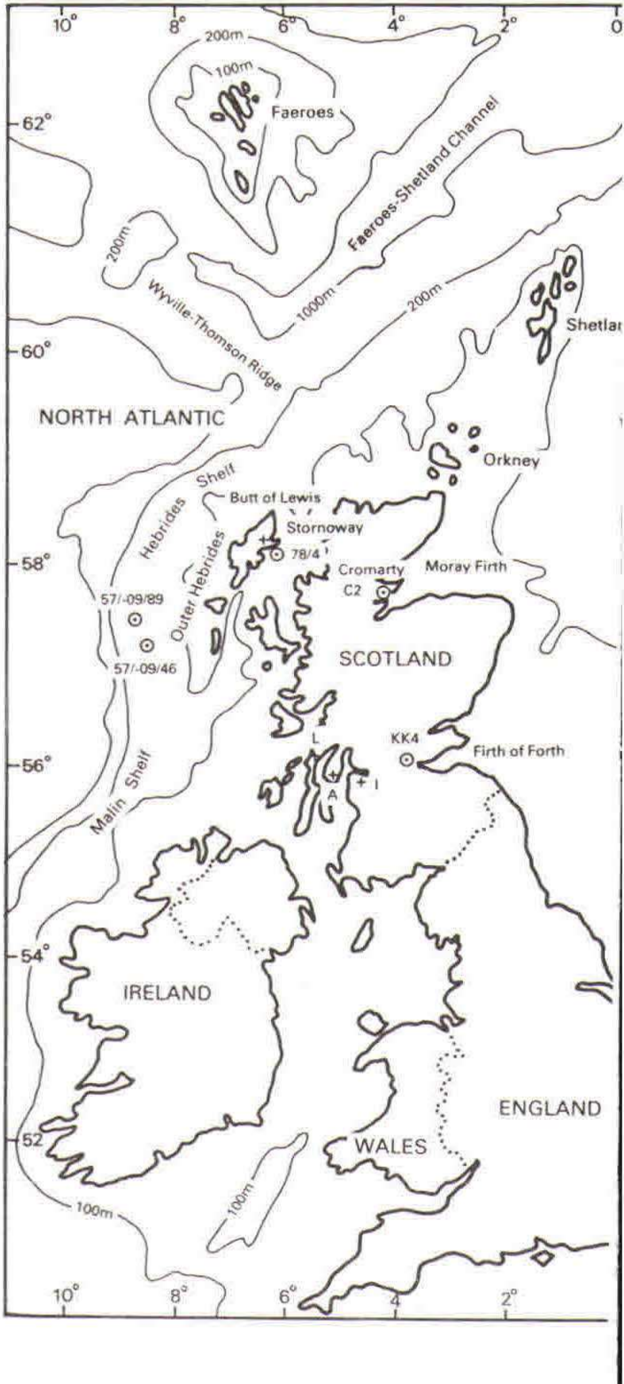
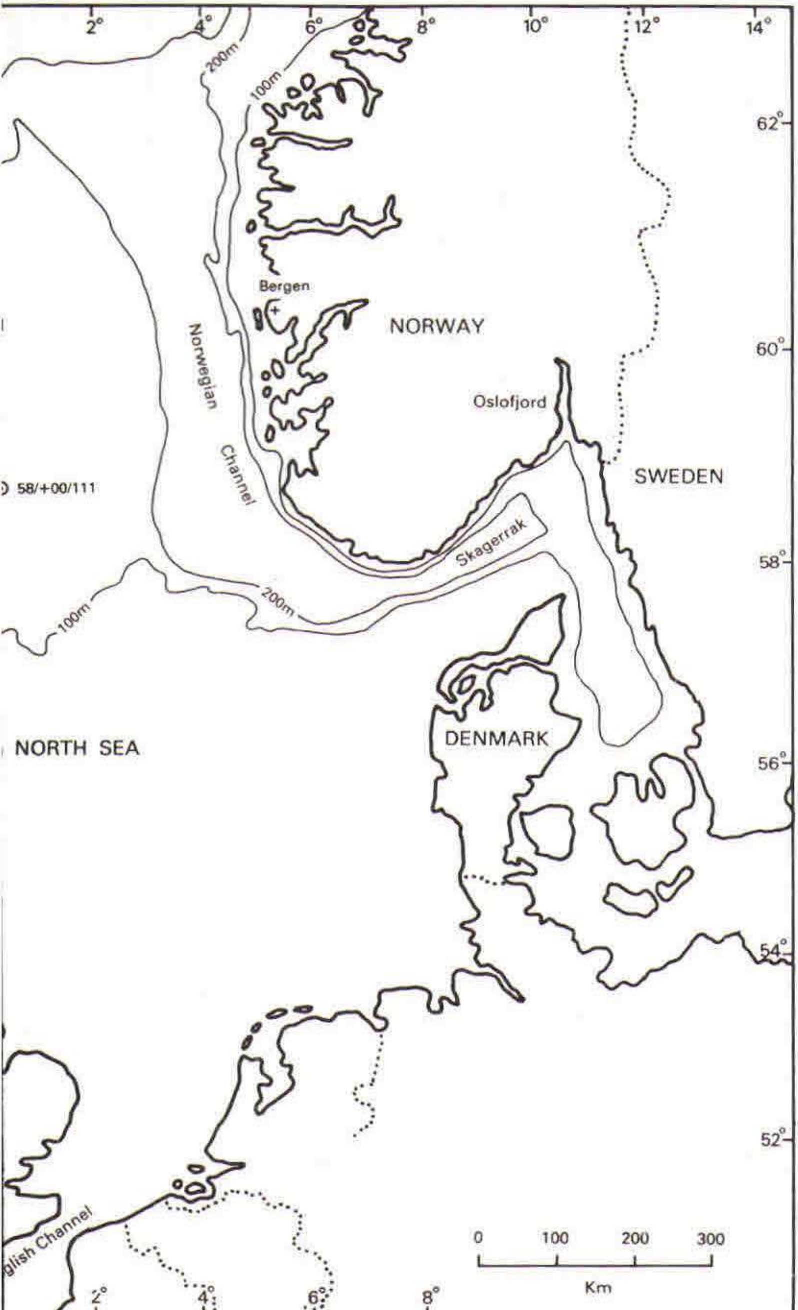


Figure 1 Location map. A, Ardyne; L, Lochgilphead; C2, Cromarty C2 Borehole. Vibrocores 57/-09/46 and 57/-09/89 were taken from a water depth of 155 m. Reproduced by permission of the Royal Society of Edinburgh from *Transactions of the Royal Society of Edinburgh: Earth Sciences*, 81, 385–396.


NORWAY
SWEDEN
DENMARK
NORTH SEA
Bergen
Oslofjord
Norwegian Channel
Skagerrak
100m
200m
58/+00/111
English Channel
2°
4°
6°
8°
10°
12°
14°
62°
60°
58°
56°
54°
52°
0
100
200
300
Km

the rapid fall-off of temperature northwards (Coope, 1977). The later marine amelioration has yet to be identified in the terrestrial record in the UK (Walker and Lowe, 1990). Faunal evidence for a change from relatively deep to relatively shallow water adjacent to the Scottish mainland reflects rapid isostatic uplift, particularly early in the interstadial, but on the continental shelf near St. Kilda the sea remained shallow (Figure 3).

11 000 to 10 000 BP (Loch Lomond Stadial)
Near St Kilda the Loch Lomond Stadial (LLS) is characterised by a shallow water arctic foraminiferal assemblage and boreo-arctic mollusca (Austin, 1991, Peacock *et al.*, 1992). Similar assemblages occur elsewhere in the Minch and the Scottish west coast, but good LLS faunas have yet to be recorded from the North Sea, where strata of this age seem to have been removed in whole or in part during the Flandrian marine transgression (e.g. Long *et al.*, 1986). On the Scottish west coast, the transition from interstadial to stadial conditions (shortly after 11 000 BP) is thought to have taken less than 200 years and from stadial to interglacial conditions (shortly before 10 000 BP) less than 40 years (Peacock and Harkness, 1990). These figures would vary little even if the Late Devensian and early Flandrian radiocarbon 'plateaux' (e.g. Lotter, 1991) are taken into consideration.

Period 10 000–9000 BP (Early Flandrian)
An interesting feature brought out in Figure 2 is the two-stage transition from the LLS into the Flandrian. This is most pronounced in the North Sea (Cromarty C2 Borehole), but is only weakly seen in the Minch (Borehole 78/4) and is absent south of St. Kilda where there is a rapid transition into faunas indicating similar temperatures to the present (Peacock *et al.*, 1992). Though the high-boreal fauna at Cromarty suggests that summer temperatures were below present values in the earliest Holocene, there is no sedimentological evidence for near-shore sea ice (Peacock *et al.*, 1980). Winter conditions must, therefore, have been warmer at this time in the near-shore area than during the Windermere Interstadial. A further feature of interest is that relatively shallow water persisted into the earliest Flandrian on the continental shelf south of St. Kilda (Figure 3).

WORK IN PROGRESS

Northern North Sea
Preliminary work on vibrocores recovered from the North Sea Plateau (60°40'N, 1°30'E) at a depth of about 140 m shows that thin Flandrian sands overlie an undated shell bed of interstadial aspect dominated by *Modiolus modiolus* and *Chlamys islandica*. The unconformable junction between the shell bed and underlying glaciomarine sediments is marked in places by a

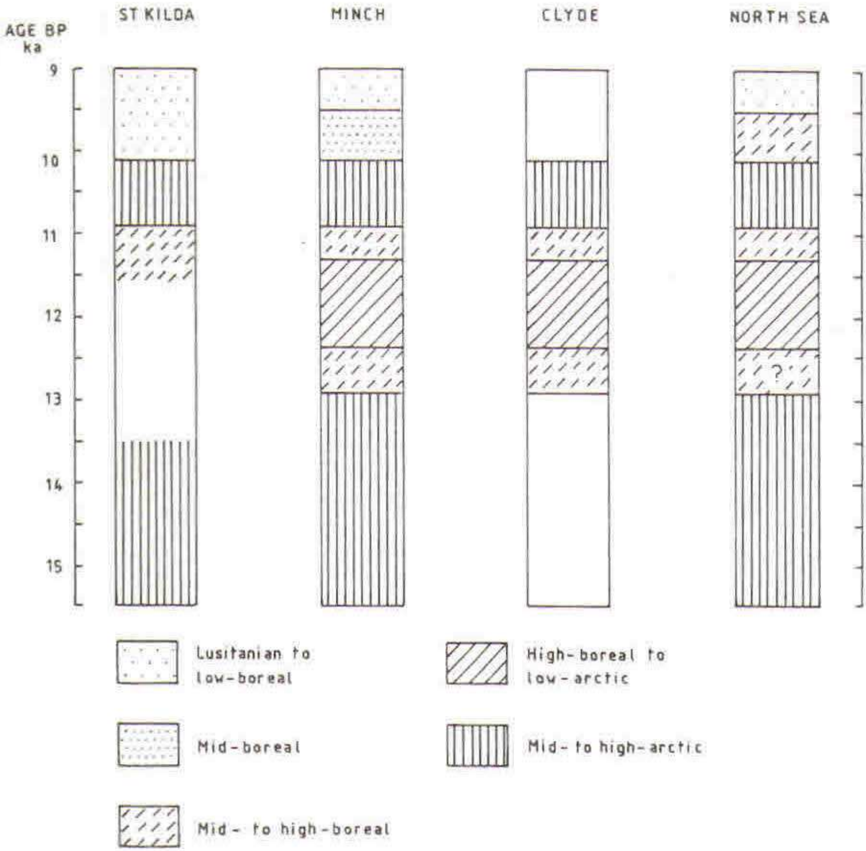


Figure 2 Zoogeographic changes 15 000–9000 BP from the continental shelf south of St. Kilda to the North Sea.

layer of rolled, extremely well rounded shell fragments. Such deposits suggest that this part of the plateau was subject to high energy, shallow water conditions at some period in the Late Devensian and gives some support to the view (Rokoengen *et al.*, 1982; Carlsen *et al.*, 1986) that there was a submerged beach at this level during the Windermere Interstadial and that sea-level may have been as much as 180 m below present between 13 000 and 16 000 BP. [J D Peacock, Heriot-Watt University, Edinburgh.]

West Shetland Basin

A search is being made for suitable vibrocores in the British Geological Survey to find records comparable with those from St. Kilda (see above and following). [J D Peacock.]

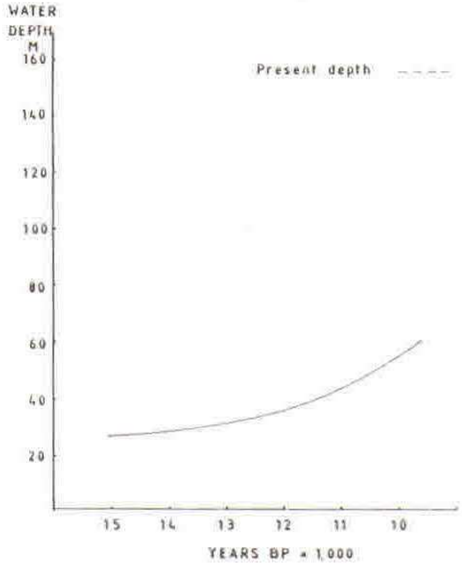


Figure 3 Estimations of water depths (very approximate) derived from palaeontological evidence at the sites of vibrocores 57/-09/46 and 57/-09/89 on the continental shelf south of St. Kilda, 15 000–9000 BP.

St Kilda area

The LLS parts of the two vibrocores mentioned above (57/-09/46 and 57/-09/89) are undergoing further studies to determine the chemistry of volcanic shards at various levels. Preliminary work (Peacock *et al.*, 1992) suggests that the shard peaks may represent various eruptions included in NAAZI and that the shards were carried by sea-ice rather than wind. It is also hoped to determine the stable isotope of benthonic foraminifera from samples on hand for comparison with those from contemporaneous deep sea sediments. Further radiocarbon dating is being carried out on vibrocore 57/-09/46 in conjunction with these studies. [J Hunt and D Kroon, Edinburgh; W E N Austin, Bangor.]

SW Approaches

Preliminary studies of a vibrocore (51/-07/199) taken from a depth of about 118 m have shown that sediments dated to the Windermere Interstadial occur in the Celtic Sea. [J D Scourse and W E N Austin, Bangor.]

SUGGESTIONS FOR FUTURE WORK

Sea-levels on the Continental Shelf

The evidence suggesting low sea-levels for the Late Devensian and earliest Flandrian in the St. Kilda basin (Figure 3) clearly needs to be substantiated as it conflicts with current views (Lambeck, 1991). If correct, it will lead to a radical re-think of Late Quaternary isostatic responses in areas peripheral to the British Isles. The work in progress on Quaternary sediments in the northern North Sea, SW Approaches and the west Shetland basin is a contribution towards this.

Changes in Marine Climate

1. WINDERMERE INTERSTADIAL. The extent to which the 'warm' intervals at the beginning and end of the interstadial can be recognised with certainty elsewhere needs further examination (see Peacock, 1989), including the deep sea. The relationship between the apparently conflicting shallow sea and terrestrial records at the end of the interstadial is of particular interest.

2. LOCH LOMOND STADIAL. The high-arctic mollusc *Arctinula greenlandica* and the distinctive ostracods *Rabilimis mirabilis, Cytheropteron montrosiense* and *C. pseudomontrosiense* found in deposits predating 13 000 BP have yet to be recorded in Younger Dryas strata in British seas. It would be interesting to pursue this matter to see whether it is due to environmental differences (there is a suspicion that marine temperatures during the LLS were slightly higher than during the 13 000 to 26 000 period), but other factors may be involved such as salinity differences and local extinctions.

3. EARLY FLANDRIAN. Further studies are required on early Flandrian faunal changes, particularly in the North Sea and Shetland areas, to determine the validity and extent of two-stage warming and to throw further light on water depths (see above).

Stable Isotope Studies

Comparison of the pattern of stable isotopes through time on the shelf and shallow seas with that in the deep sea will assist detailed comparison of the much higher resolution, but discontinuous record of the shelf with the more continuous, but low resolution record of the deep sea. Some work on this has already started (see above).

Radiocarbon Dating

More radiocarbon dates are needed on marine faunas already collected, for example, from the Sea of the Hebrides. These would make good use of existing, well located material and further tighten the existing climatic framework.

REFERENCES

Atkinson, T C, Briffa, K R, and Coope, G R. 1987. Seasoned temperatures in Britain during the past 22 000 years, reconstructed using beetle remains, *Nature*, 325, 587–592.

Austin, W E N. 1991. *Late Quaternary Benthonic Foraminiferal Stratigraphy of the Western U.K. Continental Shelf.* Unpublished PhD thesis, University College of North Wales.

Carlsen, R, Løken, T, and Roaldset, E. 1986. Late Weichselian transgression, erosion and sedimentation at Gullfaks, northern North Sea. *In* Summerhayes, C P, and Shackleton, N J (editors). *North Atlantic Palaeoceanography.* Geological Society Special Publication No. 21, 145–152.

Coope, G R. 1977. Fossil coleopteran assemblages as sensitive indicators of climatic changes during the Devensian (Last) cold stage. *Philosophical Transactions of the Royal Society*, B280, 313-340.

Eyles, N, and McCabe, A M. 1989. The Late Devensian (<22 000 BP) Irish Sea Basin: the sedimentary record of a collapsed ice sheet margin. *Quaternary Science Reviews*, 8, 307–351.

Lambeck, K. 1991. Glacial rebound and sea-level change in the British Isles. *Terra Nova*, 3, 379–389.

Long, D, Bent, A, Harland, R, Gregory, D M, Graham, D K, and Morton, A C. 1986. Late Quaternary palaeontology, sedimentology and geochemistry of a vibrocore from the Witch Ground Basin, central North Sea. *Marine Geology*, 73, 109–123.

Lotter, A F. 1991. Absolute Dating of the Late-Glacial Period in Switzerland Using Annually Laminated Sediments. *Quaternary Research*, 35, 321–330.

Peacock, J D. 1983. A model for Scottish interstadial marine palaeotemperature 13 000 to 11 000 BP. *Boreas*, 12, 73–82.

— 1989. Marine molluscs and Late Quaternary environmental studies with particular reference to the Late-glacial period in northwest Europe: a review. *Quaternary Science Reviews*, 8, 179–192.

— and Harkness, D D. 1990. Radiocarbon ages and the full-glacial to Holocene transition in seas adjacent to Scotland and southern Scandinavia: a review. *Transactions of the Royal Society of Edinburgh: Earth Sciences*, 81, 385–396.

— Austin, W E N, Selby, I, Harland, R, Wilkinson, I P, and Graham, D K. 1992. Late Devensian and Holocene palaeoenvironmental changes on the Scottish continental shelf to the west of the Outer Hebrides. *Journal of Quaternary Sciences* (in press).

Rokoengen, K, Løfaldi, M, Rise, L, Løken, T, and Carlsen, R. 1982. Description and dating of a submerged beach in the northern North Sea. *Marine Geology*, 50, M21–M28.

Scourse, J D, Austin, W E N, Bateman, R M, Catt, J A, Evans, C D R, Robinson, J E, and Young, J R. 1990. Sedimentology and micropalaeontology of glacimarine sediments from the central and southwestern Celtic Sea. *In* Dowdeswell, J A, and Scourse, J D (editors) *Glacimarine Environments: Processes and Sediments*. Geological Society Special Publication, No. 53, 329–347.

Sejrup, H P, Aarseth, I, Ellingsen, K L, Reither, E, Jansen, E, Løvlie, R, Bent, A, Brigham-Grette, J, Larsen, E, and Stoker, M. 1987. Quaternary stratigraphy of the Fladen area, central North Sea: a multidisciplinary study. *Journal of Quaternary Science*, 2, No. 1, 35–58.

Walker, M J C, and Lowe, J J. 1990. Reconstructing the environmental history of the last glacial-interglacial transition: evidence from the Isle of Skye, Inner Hebrides, Scotland. *Quaternary Science Reviews*, 9, 15–49.

ANNUAL FIELD MEETING REPORT: SOUTH WEST SCOTTISH HIGHLANDS

9–13th April, 1992.

Amongst the early voters on Polling Day were many QRA members setting off to meet in the Royal Hotel, Oban, that evening for the Annual Field Meeting. The meeting was organised by Murray Gray, John Lowe and Mike Walker, aided by a number of enthusiastic party workers with variable Quaternary interests.

After dinner, Murray welcomed everyone to Oban and gave a fine non-political party broadcast on behalf of the Till and Shoreline Alliance in which he laid out the agenda for the next few days. Using a complex diagram (Fig.1.8 in the guide) as a swingometer to demonstrate the relationship between ice and sea level, Murray gave an illustrated account of the sequence of Late Pleistocene events within the South-west Scottish Highlands and pointed out some of the problems involved with the age of various shorelines within the area, particularly the Main Rock Platform. The case for MOP (Masonic Order of Palynologists as defined by President Boulton, later in the meeting) was eloquently presented by Mike Walker who laid down the principle characteristics of environmental change for the area and introduced the key sites in the pollen manifesto. Andy Haggart expanded on some of these ideas and developed some new ones on the distribution of pine woodland during the Holocene.

Adjournment was then agreed and many honourable members retired to the TV lounge to observe more recent events of a political nature. As the results were announced, disbelief and incredulity spread through the audience and many people went to bed in a state of shock as the election result became apparent.

DAY 1 — Misty Mountains

A grey dismal overcast sky perfectly matched the pervading gloom in the dining room the following morning and it was therefore with relief that members were able to escape the agonies of political dissection and turn their minds to Quaternary matters. The first stop was on the northern shore of Loch Etive to examine the kettled outwash associated with the northern margin of the Loch Lomond stadial glacier which had occupied this glen, although the eye of faith was required (the first of many such occasions) to identify the terraces on the southern bank.

The convoy of minibuses and cars then headed east through a landscape hidden in low cloud towards the southern part of Rannoch Moor. Surprisingly, it was not raining as the group walked to the site at Clashgour where Andy Haggart and his colleagues described the results of their research on the development of pine woods. Andy began by stating that there were no extant pine forests in the area, a point disputed by Russell Coope who asked what were the trees just in the mist. There was no such doubt in the geological record because stumps and logs in the peat bog provided clear evidence for the former presence of pine. Pollen analysis of the peat and dendrochronology of the pine stumps showed a complex sequence of pine development, probably associated with changes in precipitation during the Holocene with forest decline being associated with 'pluvials'. General discussion was enlightening but terminated by Murray who had the task of keeping the party on schedule.

After lunch at the Bridge of Orchy Hotel, the group was shepherded onwards by Murray to Loch Tulla. A short climb up the hill from the farm at Achallader brought the group to the proposed viewpoint. Sitting astride a deer fence post, Colin Ballantyne explained the geomorphological features which could be seen from this vantage point, particularly the shorelines of the former glacier-dammed Lake Tulla and the raised delta on which the group stood. Colin was then joined on the deer fence by Geoff Boulton who briefly outlined the landform assemblage associated with ice marginal locations, placing emphasis on cross valley ridges. Broad agreement was reached about the landforms which could be observed in the area. However, the seeds of debate were planted regarding the thickness of Loch Lomond Stadial ice over Rannoch Moor and adjoining mountains. Geoff argued for a much thicker ice cap, an interpretation at variance with the trimline evidence identified on many of the mountain slopes in the area. Intervention by Murray guillotined discussion so that the party could move to the next site.

Much of Rannoch Moor is characterised by hummocky moraine and the group stopped at the side of the main road where Geoff Boulton developed his argument for a much thicker Loch Lomond Stadial ice cap with the aid of a large map of the hummocky moraine distribution — which was unfortunately held reversed and upside down against the side of minibus. Furthermore, the noise of the traffic made discussion difficult until Speaker Gray intervened and promised an emergency debate on the topic during an evening session.

The party then moved to the first key pollen site of the meeting where Mike Walker and John Lowe outlined the research programme which had been undertaken to recover a number of cores from small peat-filled basins in hummocky moraine across Rannoch Moor in an attempt to establish the sequence and timing of Loch Lomond Stadial deglaciation. The pollen 'A Team' then demonstrated the coring procedure traditionally employed at such critical sites. Discussion turned on the amount of time available for ice build up and it was generally agreed that we were in a dating quagmire but that more time was available for ice build up prior to the Loch Lomond Stadial.

A final stop was made in Glen Etive to examine one of the Holocene debris fans which are well developed below many gullies on either side of the glen. Vanessa Brazier outlined her work on these landforms, and in particular the dating of stages in fan development. A group chant on the meaning of 'paraglacial' led to a discussion on initial fan development as a response to deglaciation followed by fan stability until quite recently when changes within the catchment has caused incision into the fan surface.

DAY 2 — Misty Islands

An early start saw the party gathered on the upper decks of the Caledonian-MacBrayne ferry to Mull. Continuing low cloud was now joined by increasingly heavy rain which meant that the various raised shore platforms, described as superb by Murray, were generally hidden from view and once again the eye of faith had to be invoked.

Having arrived at Craignure, the group drove to the first site at the Loch Don Sand Moraine, where they assembled at the edge of the working sand and gravel pit. Murray reminded members of the tight schedule and of the necessity of catching the last ferry to Oban. The Till Boys were quickly away to examine the excellent exposures which showed a complex sequence of sands and gravels, with well developed foreset cross bedding indicating a northerly source, overlain by a thin till. Members were only a brief time in the pit before being quickly herded back by Murray and his henchmen.

Much discussion focussed on the nature of the stratified sediments, from which Doug Peacock had found shells with 'Clyde Bed affinities', and their possible origin. The till was discussed but no definite conclusions were reached before the party was whisked off into the grey gloom of the island.

Because of the weather, the next stop was a viewpoint with no view. Here the Pollen Party explained their policy on key pollen sites which have been examined on the island. Glen More lies in the central part of the island and the pollen site (core not demonstrated) reveals only a Holocene sequence, which suggests that the last glaciers to cover this mountain area were formed during the Loch Lomond Stadial. Rain precluded discussion and the party quickly drove onwards to the next stop. Here, Murray invoked the eye of faith (again) to point out a fragment of high raised platform at c. 51m OD. Following much cynical laughter, he said that it was just as good as the Tulla shorelines but perhaps it could be better seen from the Kinloch pub.

The convoy continued around the island cocooned in their vehicles from the driving rain and wind and seeing little of the island scenery. On the west side of the island, the group stopped at the top of the basalt escarpment to look down on the Gribun site. The group were then encouraged to use the eye of faith to believe that on a clear day, the view to the west over the Inner Hebrides was spectacular. However, the more immediate view looking down was impressive even in the driving rain. At this point Ali Dawson materialised out of the mist to rejoin the group and put the geomorphology of the site into context, proposing that the large arcuate ridge which could be clearly seen beyond the escarpment was a terminal moraine ridge. The very low altitude of the former glacier was explained as being due to high amounts of snowblow off the plateau. In conclusion, Russell Coope eloquently pointed out the various features associated with the agricultural changes of the area from the time of The Clearances to the present day.

The group then drove down and walked to the ridge, or more correctly a number of ridges. Mike Walker and John Lowe described the critical features of a 14m sediment core which had been recovered from the area within the ridge. The stratigraphic sequence is interpreted as being of Holocene age, suggesting that the ridge is possibly of Loch Lomond Stadial age. To demonstrate this, the Till boys showed how easy it is to recover a pollen core. Much discussion focussed on the nature of the basal sediments which show clear laminations - these were generally thought to be rhythmites, but not necessarily of glacial age. The origin of the ridge was hotly debated with the group dividing into those who favoured a glacial origin and a second faction who argued that it could have been a landslide because of the geological situation of basalt overlying Triassic sandstones and shales. There are numerous such slope failures along this coast, although none look like Gribun. Colin Ballantyne suggested that this may be because the landslide has been overridden by glacier ice. No consensus was obtained and the party were hurried on their way by Murray, leaving the problem to be mulled over by the group.

The final stop before lunch was to examine the p forms on the Main Rock Platform along the shore of Loch na Keal. As an eagle soared overhead, there was much discussion on the origin of such features and the age of the platform. A short walk eastwards brought the group to another part of the platform where Ali explained the role of sea ice in platform development by showing how a jigsaw of large rock blocks, which had only moved slightly, could be reconstructed to show an origin by tension caused by sea ice.

After a short lunch stop, during which queuing appeared to be a popular pastime, the group headed northwards past Tobermory, to a wet, windy exposed peat bog at Mishnish. Predictably such sites are critical/key sites for MOP and so it proved. By way of variety, this site was taken as an opportunity for a sales pitch for the Abbey piston corer which has been used to recover basal sediments which are interpreted as being of Lateglacial age, one of only two such sites on the island.

The final site to be visited was at the seaward end of Glen Forsa and returned the party to a geomorphological theme, but no till sections for Billy. Instead, the group found themselves walking over an outwash fan with a distinct ice contact slope and small connecting esker. Murray explained the problem of establishing whether the fan surface was subaerial or submerged, since this was critical in determining of sea level at the time of fan formation. The group walked down the fan towards its seaward limit before returning to the buses and making a quick dash to Craignure in time for the last ferry.

DAY 3 — Nice Views

Bright sunshine at last! The first stop was Pulpit Hill — a viewpoint with a view! Murray was at last able to point out many of the shoreline features and give a brief review of Late Pleistocene events in the area. A short walk from the viewpoint brought the group to a small lake —the first pollen site of the day. Here Richard Tipping briefly described the detailed analysis which he has carried out on this well dated Lateglacial site which shows evidence for a number of climatic fluctuations prior to the Loch Lomond Stadial. An impromptu meeting of MOP was convened as the palynologists went into a separate huddle to discuss, amongst other things, pollen databases.

As ever careful about time, Murray hurried the group onwards to a meeting with Clive Bonsall who is currently excavating a Mesolithic site at Carding Mill. Murray first of all gathered the group and explained that the site was in the front garden of a house and that care should be taken when crossing the newly seeded lawn. Whilst the owners sat having their morning coffee, the QRA walked past the window, crossing the lawn in single file on a wooden plank. Clive put the the present site into context and explained the significance of the Obanian culture. Carding Mill is particularly important because of the large number of human bones (not wood, John!) which have been uncovered amongst other artifacts. Members were intrigued by the presence of a number of different coloured golf tees. These were explained by Clive as aids to the meticulous mapping of the site which also involved an overhead grid from which plumb lines could be dropped (a lesson for the till boys in site description). Discussion included questions on the method of defleshing the bones prior to their collection and dumping in the ossuary. As a variation on a theme, Murray arranged for a quick hail shower to encourage the group to return to their vehicles and drive to the next site.

Gallanach Bog was one of a series of pollen sites being investigated by OAP (Oban Archaeological Project). Barbara Rumsby presented some preliminary results which indicate that this site will be a critical one for Holocene palaeoenvironmental reconstructions in this area.

To curtail discussion here, Murray invoked a shower of rain and the group returned to Oban and drove south to Glen Euchar. At Kilninver, Murray demonstrated the suite of outwash terraces which could be seen extending up valley. The significance of the gradients of the different terrace fragments up valley were discussed in terms of timing and rates of uplift associated with deglaciation. This was discussed with vigour and comparisons were made with features within the Irish Sea Basin with Marshall McCabe being called upon to discuss the similarity of features (± 50m which is just about the same in Irish arithmetic).

En route to Lochgilphead for lunch, a short stop was made at Kintraw where half the group looked at the high Lateglacial shoreline fragment pointed out by Murray, whilst the rest went and examined the impressive standing stone and cairn on the opposite side of the road.

The first stop after lunch was at Dunadd, capital of the ancient nation of Dalriada. Features of archaeological interest at this site included a footprint, a boar of Pictish type and a basin. The summit of the hill provided a good vantage point to view Moine Mhor, a fine domed raised bog, designated in 1987 by SNH (Scottish National Heretics) as a NNR. Discussion at this Big Bog revolved around the evidence for a complex history of relative sea level change, for example the evidence for Clyde beds and the significance of gravel layers within the sequence. Pollen data indicate that peat growth began during Mid-Flandrian time.

The archaeological theme continued at Temple Wood in the Kilmartin valley where a line of Bronze Age burial cairns and stone circles have been excavated. This linear cemetery was probably developed over more than a thousand years. The monuments, decorated with rock art, have been preserved in peat. Again time was limited, but this did not deter several colleagues from clambering down into one of the cairns to hear a detailed account of the excavation from Clive Bonsall.

The day ended with visits to two pollen sites in the Awe valley. The first critical site was in a kettle hole at the southern end of Loch Awe, where Richard Tipping described five complete Holocene sequences which generated much discussion. The presence of a *Pinus* peak in several sequences early in the Postglacial could reflect long distance transport and may be valuable as a stratigraphic marker, although Richard admitted that he could not prove that the peak was synchronous between sites. Mike Walker thought that the pollen assemblages in several of the sequences were rather odd and suggested that they may indicate reworking, although Richard maintained that the pollen spectra were produced by local plant communities. Richard proposed that the pollen data indicated that the kame and kettle landforms were formed at the margin of a Loch Lomond Stadial glacier, although Geoff Boulton refused to "buy the Awe glacier" hypothesis. By the time the troops reached the final pollen site, there were mutterings that the pollen count had become critically high inducing an allergic reaction.

That evening, the party assembled for a lively meeting to discuss in greater detail the issues raised during the field meeting. Initially, the discussion centred on the Main Rock Platform and there were comments that the itinerary had not allowed close inspection of this critical landform. Even a member of MOP suggested that it may have been more profitable to visit the platform instead of one of the pollen sites! Detailed discussion on the age and history of the platform ensued with a number of different views being expressed. It was concluded that alternative lines of evidence, such as offshore deposits or Uranium-Thorium dating, might facilitate progress.

There then followed an intense debate on the evidence used to reconstruct the extent of the Loch Lomond Stadial glaciers in the Rannoch Moor area; this focussed on the apparent discrepancy between the thicker, domed ice cap hypothesis generated by computer modelling proposed by Geoff Boulton and the thinner, flatter ice cap envisaged by Peter Thorp and based on detailed mapping of periglacial trimlines, an approach which has been advocated by Colin Ballantyne. President Boulton maintained that both approaches were based on empirical evidence and that the interpretation depended on theory but stressed that it was necessary to study evidence of the scale of the ice cap rather than individual features in isolation. Dougie Benn and Ian Patterson concluded that the fundamental problem one of geochronology arising from the limitations of current dating techniques. The debate continued in the bar.

DAY 4 — all at sea

In response to the previous evening's discussion, the party left early to visit the Main Rock Platform. This again produced heated debate, particularly with respect to the age of the feature. The party then moved on to a series of sections along the shore of Loch Creran. At Balure, Doug Peacock discussed the little disturbed highly fossiliferous glaciomarine sediments below outwash gravels associated with the Loch Lomond Stadial glacier in this glen. The presence of *Portlandica arctica* indicate colder and more saline waters at this time. The party concluded from the different lines of evidence that the sequence of sea level change in this area during the Lateglacial was more complex than previously thought.

At the end of the meeting, the President proposed a vote of thanks to Murray Gray whose tremendous efforts had made the meeting such a success, and to Mike Walker and his 'magic Mac' for the production of such an excellent guide book. Geoff thanked those participants who had been "splendidly lucid and thoroughly awkward" and ably summed up the feeling of the party by saying that we had been "confused by the arguments, delighted by the landscape and inspired by the occasional streaks of peerless insight".

The major themes of the meeting can be summarised as follows:

a) the nature of ice sheet deglaciation and associated environmental changes
b) the interactions between ice and sea level
c) the history of local vegetational changes and its significance in the broader regional context
d) the extent and thickness of the Loch Lomond Stadial ice cap in area.
e) the archaeological importance of the area to studies of Mesolithic Scotland.

Wishart A. Mitchell
School of Geological and Environmental Sciences
Luton College of Higher Education

Heather Pardoe
Department of Botany
National Museum of Wales

THE UK DURING THE LAST GLACIAL/INTERGLACIAL TRANSITION

Royal Society/IGCP-253 Workshop, Edinburgh
25–26 January 1992

M J C Walker
St David's University College, University of Wales, Lampeter

Background

The aims of this Workshop (convened by Professor G S Boulton & Dr J J Lowe) were to integrate current research on the last glacial/interglacial transition within the UK, and to evaluate the future contribution of UK science to international research programmes on this theme. It was essentially an exploratory meeting (a) to improve the UK database, (b) to examine possible means of improving the general research framework, and (c) to react to a directive from the Royal Society seeking a greater UK involvement in a number of international research programmes (EPOCH, PONAM etc.) and particularly in IGCP-253 Termination of the Pleistocene.

IGCP-253 is an international research programme running from 1989-1994 which aims to examine the nature and expression of abrupt climatic changes at the last glacial/interglacial transition. It is led by Professor J Lundqvist (Stockholm), and contains nine sub-projects. A major focus of UK involvement is The North Atlantic Seaboard Programme (NASP) under the direction of Dr J J Lowe (RHBNC, London). This working group is examining the climatic history of the North Atlantic margins and is attempting to summarise the sequence of regional environmental changes at 500 year intervals throughout the Late glacial and early Holocene. Two meetings have already been held (in London & Iceland).

Presentations

Participants in the Workshop gave a short presentation on their specialist area. These examined the nature of the data, their limitations, and their potential for environmental/climatic reconstruction and modelling.

Palaeobotanical records	Dr M J C Walker (St David's, Lampeter, Wales)
Coleopteran records	Professor G R Coope (Birmingham & RHBNC, London)
Glacier modelling	Professor G S Boulton (Edinburgh)
Periglacial records	Dr C K Ballantyne (St Andrews)
Marine fossil records	Professor J D Peacock (Heriot-Watt, Edinburgh)
Palaeohydrology	Dr J D Maizels (Aberdeen)

Palaeopedology	Professor J Rose (RHBNC, London)
Sea-level records	Dr A G Dawson (Coventry)
Marine sedimentary records	Dr D Long (BGS, Edinburgh)
Tephrochronology	Mr A Newton (Edinburgh)
Geochronology	Dr J J Lowe (RHBNC, London)

Future research

The Workshop then considered priorities for future research with three areas in particular providing a focus of attention. These were:

(a) The offshore record

The significance of the offshore record for providing data on the extent of the last ice sheet and on the pattern and environment of deglaciation was widely acknowledged, and it was agreed that a strategic programme was essential if significant progress was to be achieved. This would involve an inventory of all known cores from the shelf and nearshore areas, and particularly from the North Sea basin. Evidence from seismic records, magnetostratigraphy, ^{18}O profiles and biostratigraphy (Mollusca, Foraminifera, ostracods and diatoms and, where possible, pollen/plant macrofossils/Coleoptera from submerged terrestrial materials), would provide a comprehensive database for establishing, *inter alia*, the offshore extent of the last ice sheet, the pattern and chronology of deglaciation, the nature of sea-level change, palaeoceanographic and palaeoclimatic data and information on the behaviour of both marine and non-marine biota.

b) The period from 13–18 ka BP

Between c.18 and 13 ka BP the last British ice sheet virtually disappeared, yet almost nothing is known about the environment of this time interval, principally because biological evidence is absent. The group examined other possible proxy data sources, including the potential of periglacial and geochemical evidence. The possibility of using data from cave sites was also considered. It was agreed that a major research effort needed to be focussed on this time period in an attempt to develop an environmental context for deglaciation.

(c) Glacier modelling

Recent developments in glacier modelling have provided valuable new insights into the growth and subsequent wastage of the Late Devensian ice sheet and, in particular, on the development, expansion and eventual disappearance of the Loch Lomond Stadial glaciers. Key areas included the deglaciation of the Irish Sea basin where the relationships between the effects of ice-loading, glacio-eustatic change and deglaciation could be examined from both an empirical and theoretical perspective. The spatial relationships between glacier ice and permafrost was also an area of active investigation. Integration of data involving the glacial, permafrost and fluvial regimes and the marine environment is a priority for future research.

Other research areas identified by the Workshop (in no particular order of priority) were:

Tephra identification and characterisation in secure stratigraphic contexts
The extent of crustal depression during the Loch Lomond Stadial
The presence of glacier ice during the Lateglacial Interstadial inferred from coastal evidence
Regional environmental variation during the Lateglacial
The non-glacial component of tectonic subsidence in the southern North Sea
Spatial and temporal variation in Lateglacial vegetation from pollen data
The potential of cave sediments for Lateglacial environmental reconstruction
Lateglacial vertebrate records
Geochemical and mineralogical evidence from lake sediment sequences
Lake palaeohydrology
The production of a large-scale Quaternary map of the UK
Detailed maps of till thickness
Improved seismic stratigraphy from offshore
Determination of sea-level changes on the Continental Shelf
Better data on till lithology and erratic source areas
Lateglacial coleopteran data from central and northern Scotland
Linkage of UK coleopteran records with those from mainland Europe
Better data on fluvial response to deglaciation
Identification of key catchments to test palaeohydrological models
Investigation of high-level trimlines in Scotland and Wales
Reconstructions of independent Loch Lomond Stadial ice caps for use as palaeothermometers
Use of rock glaciers as palaeoprecipitation indicators
The development of a dating protocol
The use of plant macrofossils as media for radiocarbon dating
The production of palaeogeographical maps for the UK during the Lateglacial
More isotopic/geochemical data from the terrestrial environment; e.g. on carbon cycling
The analysis of varved sequences in Lateglacial lake sediments

Research Strategy

(a) Databases

It was the view of the Workshop that a major effort be directed towards the establishment of databases in order to collate the considerable amount of existing data from the various research fields. It was also anticipated that a common GIS framework should be developed so that these should be compatible both with each other and with existing databases. The data would then become a community facility which would be available to all scientists working in the field. Preliminary work would begin immediately on the following areas:

Periglacial data:	Dr C K Ballantyne
Glaciers:	Professor G S Boulton
Fluvial records:	Dr J D Maizels
Sea-level data:	Dr A G Dawson
Offshore records:	Dr D Long
Palaeobotanical records:	Dr M J C Walker
Invertebrate records:	Professor G R Coope
Vertebrates:	Dr A M Lister
Pedological data:	Professor J Rose
Dating:	Dr J J Lowe

(b) Meetings/Conferences

(i) A symposium is to be held at the IBG Annual Meeting at RHBNC, London in January 1993 on the topic "The UK during the Last Glacial/ Interglacial Transition (14–9000 years BP)". This is being organised by Dr J J Lowe in conjunction with IGCP-253 (NASP). Further details can be found in the accompanying Circular.

(ii) An international meeting on the theme of the Last Glacial/Interglacial Transition will be held in May 1994. This will be a one day meeting held under the auspices of the Quaternary Research Association and the organisers will be Professor J Rose and Dr A G Dawson.

(c) Wider participation

The Workshop took the view that, in order for further progress to be achieved, participation from all members of the Quaternary community with an interest in the Lateglacial is essential. Hence, anyone who would like to be involved or who would like to make a contribution should contact either John Lowe, Department of Geography, Royal Holloway & Bedford New College, Egham, Surrey TW20 0EX (Tel. 0784-443565) or Mike Walker, Department of Geography, St David's University College, Lampeter, Dyfed SA48 7ED (Tel. 0570-422351).

REPORT OF THE IGCP PROJECT 274: UK WORKING GROUP ANNUAL GENERAL MEETING AND FIELD EXCURSION, SEPTEMBER 1991

A J Long
Department of Geography
University of Durham

This report arrived too late to be incorporated into the last Newsletter but Antony Long has requested its inclusion this issue.

Editor.

The following is a report of the 1991 Annual Meeting of the IGCP Project 274: UK Working Group, based in the Beauly Firth and organised by Callum Firth and Andrew Haggart. The meeting aimed to demonstrate to members the evidence associated with coastal development and relative sea-level changes from a range of palaeoenvironments in the Beauly, Moray and Dornoch Firths. Evidence is presented in a field guide edited by Firth and Haggart (1991) and available from Callum Firth at West London Institute. In addition, it aimed to encourage Postgraduate members of the Group to give presentations of their work.

The limit of the Devensian ice sheet in the Beauly area has been placed in the eastern Moray Firth (Sutherland, 1984). The deglaciation of the area has been intimately related to changes in relative sea-level, and has in part controlled the coastal evolution of the area. Nearly three full days were spent in the field, with one day devoted to the presentation of papers.

DAY 1 — THE BEAULY AND MORAY FIRTHS

The first day of the field excursion was based in the Beauly and Moray Firths, where a range of sites and associated depositional features were shown to the Group. Sites visited ranged from the low energy, quiet-water depositional environment of the inner Beauly Firth to the high energy outer part of the Moray Firth. In the former, Andrew Haggart and Callum Firth described litho-, bio- and chronostratigraphic data from the Beauly Carselands, and in particular from two sites at Barnyards and Moniack. Moving eastward, Callum Firth demonstrated the raised beach deposits at Ardesier, which was followed by a discussion of the evolution of the Culbin Sands and associated beach ridge deposits by Darren Comber and Kieran Hickey.

A significant difference between morphological and litho- and bio-stratigraphic approaches to data collection was demonstrated during the day, which was to become a recurring theme of discussion throughout the meeting.

DAY 2 — THE DORNOCH FIRTH

The following day, the Group travelled north to the Dornoch Firth and visited a number of sites currently under analysis by members of the Coventry Polytechnic research group headed by David Smith. The first site (Criech) was a sheltered embayment on the north side of the Firth, where David Smith described the Holocene sedimentary record. Particular attention was paid to the interpretation of a sand layer, believed to have been particularly a tsumani event following the Second Storegga Slide on the Norwegian continental slope (thought to have occurred between 8000–5000 BP). Similar deposits of comparable age have been recorded throughout eastern Scotland (Smith *et al.*, 1985), and other examples had been observed by the Group at Barnyards and Moniack on the previous day.

Similar sand bodies, found within finer grained clastic sequences of Holocene age and widely recorded in areas beyond the possible influence of events related to Storegga, have usually been interpreted in terms of longer term changes in the energy of depositional conditions. However, the most convincing argument for this being a tsunami (or storm surge) deposit, was that it could be traced laterally passing from inorganic (formerly intertidal) into organic (formerly supratidal) deposits. The results of a more detailed assessment of the internal stratigraphy of this sand layer with mineral magnetic and particle size analysis was presented by Shaushong Shi and David Smith on the south side of the Dornoch Firth at Ardmore–Dounie. Here, it was argued that within this sand deposit was evidence for five distinct periods of deposition reflecting five waves of progressively lower energy associated with the tsunami event described above.

In the outer Dornoch Firth, higher energy raised beach deposits were described by Callum Firth. Discussion of these features focused on the source of sediment, the changing configuration of the Firth during the Holocene, and the altitudinal relationship between the deposits observed and a former sea-level.

ANNUAL GENERAL MEETING

In the evening, the Annual General Meeting was held under the chairmanship of Ian Shennan. Two main points were discussed. The first was the possibility of Project 274 being extended for a further year (1992–93), although confirmation from the Executive Committee had not been received. It was agreed that the annual field meetings should continue, with or without this extension. Secondly, dates for the 1992 annual meeting in Coleraine, Northern Ireland, were provisionally agreed as being 18th–22nd September 1992.

DAY 3 — POSTGRADUATE PRESENTATIONS AND THE MUIR OF ORD

Much of Sunday was devoted to the Postgraduate members of the Group, and in the morning papers were presented by six Postgraduates. Two papers describing the results of new laboratory techniques were given, with Geoffrey Duller presenting the results of his thermoluminescence dating of material from New Zealand, and Shaushong Shi discussing techniques of particle size analysis. Sue Dawson described the evidence for coastal flooding in North West Scotland, Antony Long discussed patterns of Holocene watertable movements in the East Kent Fens, and David Bedlington described the evidence for Holocene sea-level and crustal movements on the North Wales coast. In addition, Kieran Hickey described the historical documentary record of storms in north-eastern Scotland. In the afternoon Postgraduates were paired with one of the elder figures in the Group in order to discuss their research in more detail. This was an excellent way of receiving advice and criticism from sources not usually available to the Postgraduates present.

Following this, Callum Firth demonstrated to the Group the methodology and field evidence used in identifying tilted shorelines, with an example from the Muir of Ord in the Inner Moray Firth. Discussion concentrated on the criteria for shoreline identification, the processes responsible for shoreline formation, and the methods involved in shoreline correlation.

DAY 4 — MUNLOCHY VALLEY AND BAY

The following morning Callum Firth and Andrew Haggart described the morphological and lithostratigraphic evidence for Holocene sea-level changes in Munlochy Valley and Bay. Once again, attention focused on the relationship between the morphological and biostratigraphical evidence for sea-level changes. There was general agreement that under ideal conditions a combination of morphological and biostratigraphic data should be used in order to confirm the conditions under which the features observed were formed. Finally, a large exposure of glacio-marine sediments was examined by the Group at Ardersier, before the meeting was closed.

ACKNOWLEDGEMENTS

All members of the Group would wish to express their thanks to Callum Firth, Andrew Haggart, and other contributing members for organising such an interesting and stimulating field trip. Thanks are also expressed to John Smith and Aberdeen University for making our stay at Tarradale House so comfortable, and in particular for manning the bar so effectively.

REFERENCES

Firth, C, and Haggart, B A. 1991. *Late Quaternary coastal evolution in the inner Moray Firth: Field Guide.* West London Institute of Higher Education: London.

Smith, D E, Cullingford, R A, and Haggart, B A. 1985. A major coastal flood during the Holocene in eastern Scotland. *Eiszeitalter und Gegenwart*, 35, 1–10.

Sutherland, D G. 1984. The Quaternary deposits and landforms of Scotland and the neighbouring shelves: a review. *Quaternary Science Reviews*, 3, 157–254.

POSTGRADUATE PALAEOECOLOGY CONFERENCE, UNIVERSITY OF NEWCASTLE-UPON-TYNE: 28–29TH APRIL 1992

Basil Davis (Department of Geography, University of Newcastle upon Tyne), sent me an itinerary (see below) related to a conference for postgraduate students held at the University in late April.

Unfortunately, I have been unable to obtain abstracts of the various papers presented but the itinerary demonstrates the range of topics discussed. The next conference of this kind (the fourth) will be held, says Basil, in Sheffield. If it's not too late, perhaps the abstracts and an acount of the highly successful field excursion can go into the next issue of the Newsletter — if that is not too late!?!

Editor

Tuesday 28th

1.00 Welcoming address

1.10 Basal Davis (Newcastle)
Holocene environmental change in lake and river systems in NE Spain.

1.30 Jane Reed (UCL)
The study of past climate change — the potential of diatoms in Spanish salt lakes.

1.50 Adrian Parker (Oxford)
Late-Devensian and Flandrian palaeoenvironmental investigations from the Upper Thames, Oxfordshire.

2.10 Margarita Caballero (Hull)
Quaternary palaeolimnology of Chalco Lake, Central Mexico.

2.30 Coffee break

2.50 Helen Bennion (UCL)
Reconstructing eutrophication histories of ponds in SE England.

3.10 Sue Dawson (Coventry)
Relative sea level change in northern Sutherland, Scotland: a stratigraphic and palaeoecological approach.

3.30 Michael Walsh (Manchester)
The Lateglacial environment of Fife.

3.50 Peter Marshall (Sheffield)
The environmental impact of prehistoric mining activities.

4.10 Tea and biscuits

4.30 Neil Rhodes (Newcastle)
Charcoal analysis, *Calluna* loss and peat erosion.

4.50 Anson Mackay (Manchester)
Peat erosion, sphagnum and pollution.

5.10 Rob Stoneman (Southampton)
Climatic signals in raised peat.

5.30 Sam Hanna (Belfast)
Problems associated with dating blanket mire initiation.

5.50 General discussion, then meal and pub.

Wednesday 29th

9.30 Edward Twiddy (Liverpool)
Radium — 226: a new chronological tool for the Holocene.

9.50 Malcolm Grant (Keele)
Dendrochronological and palynological analysis of contemporary and ancient populations of *Pinus sylvestris* at Whixall Moss, Shropshire.

10.10 Sarah McVickers (Belfast)
Mapping past vegetation in the Mournes, County Down, using palynological and tephrochronological techniques.

10.30 Ribena and buns

10.50 Deborah Long (Keele)
Prehistoric agricultural activity and its effect on the vegetational sequence of the gritstone uplands in the Peak District.

11.10 Lisa Dumayne (Southampton)
Invasion or native? — Vegetation clearance in northern Britain.

11.30 General discussion, award ceremony and lunch.

11.50 Optional field excursion to 'Hadrians Wall country', including visits to Bolton Fell Moss and Fosy Moss.

5.00 Return to Newcastle.

ABSTRACTS

THE LATE QUATERNARY HISTORY OF THE RIVER ERME, SOUTH DEVON

Susan Creak
Polytechnic South West

A thesis submitted in partial fulfilment of the requirements of the Council for National Academic Awards for the degree of Doctor of Philosophy

ABSTRACT

This thesis examines a typical 'drowned' river valley of south-west England. The River Erme drains southern Dartmoor and, in common with other rivers of the region, has a buried channel graded to c.-50 m OD. The channel has been infilled with a variety of sediments, of which the top 6–7 m have been analysed for this study. Augered cores were collected from the modern floodplain and salt marsh areas in the lower part of the valley and studied using particle size, molluscan and radiocarbon analyses.

The main sediment types recovered include a fine silt unit representing the most recent phase of fluvial deposits, which overlies variable horizons of fluvial granitic sands and gravels and brackish organic sands and silts. These are, in places, replaced at depth by shelly silts, sands and gravels deposited under more estuarine and marine conditions. The organic layer has been radiocarbon dated to between 1000 and 2000 years BP and correlated with a former area of marshland recorded in the tithe maps of the region. It is suggested that the Erme valley was more estuarine than today and that alluviation and infilling of the Erme's channel in the last 1000–2000 years has been aided by forest clearance and tin mining on Dartmoor.

All the sediments recovered from the buried channel are derived from local sources of bedrock and have probably been deposited in the last 4000–6000 years. Evidence from the tithe maps suggests that the channel has been stable over the past 200 years.

This work seeks to contribute to the Quaternary knowledge of the south-west of England and, because of the paucity of data concerning these buried rock channels, could be used as a preliminary model against which other rivers in the South West might be compared.

THE GEOMORPHOLOGICAL AND SEDIMENTOLOGICAL EFFECTS OF JÖKULHLAUPS

Andrew J Russell
(Doctor of Philosophy, University of Aberdeen)

The aim of this study was to test a predictive model of the geomorphological and sedimentological effects of floods resulting from the sudden drainage of ice-dammed lakes (jökulhlaups). A process-based, conceptual model for channel and sedimentary characteristics was tested with a jökulhlaup routeway near Søndre Strømfjord, west Greenland.

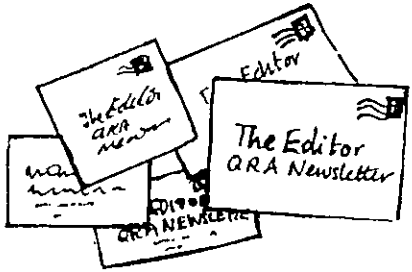
River channel change resulting from a jökulhlaup monitored in 1987 was studied in three channel types along the flood routeway: deltaic, high gradient bedrock-controlled, and low gradient confined valley sandur. Flood powers, sediment supply and channel resistance to erosion were found to vary considerably between the channel types. Consequently, amounts of channel change and the character of the sedimentary record showed extreme variation. In addition, parts of the jökulhlaup channel which experienced backwater effects may have experienced at least two sediment transport peaks.

Variations between the character of deposits found within each of the three channel types reflect local differences in sediment supply, stream power and channel resistance to erosion. Deposition in the delta and the sandur records sedimentation related to a number of jökulhlaups, whilst the spillway and the bedrock-confined channel provide a record of the action of the last jökulhlaup as low stage deposits, as well as that of the earliest flood events as high stage deposits.

This study has shown that it is possible to predict the morphology of channel macroforms. The internal structure of these macroforms is strongly dependent upon both the amount and character of sediment supplied to the channel during a jökulhlaup. The more detailed the knowledge of the controlling variables for any one channel, the more detailed the resulting predictions are. At present, the model concerns only the products of turbulent, Newtonian, water floods. It may, however, be possible to predict thresholds marking the transition to non-Newtonian flows where sediment supply conditions and hydrograph characteristics are known. The model may also be used in reverse to reconstruct the magnitude and frequency of former jökulhlaups where sufficient geomorphological and sedimentary evidence is available.

Andrew is currently a lecturer in Physical Geography in the School of Geography, Kingston Polytechnic, Penrhyn Road, Kingston Upon Thames, Surrey, KT1 2EE.

POST BAG



Dear Brian

The following news item may be of interest to readers of the *QRA Newsletter*:

> Professor Edward Derbyshire, Research Professor in Physical Geography in the University of Leicester, has been elected to a Visiting Professorship, for a period of two years, in the Department of Geography, Royal Holloway and Bedford New College, University of London.

Yours sincerely

Edward Derbyshire

Dear Dr Taylor

My recent article concerning the existence of a possible fossil rock glacier in North Wales (Newsletter No. 66) omitted the reference for Gray et al. (1981) which describes the fossil rock glacier on Moelwyn Mawr. The reference is:

Gray, J M, Ince, J, and **Lowe, S.** 1981. Report on a short field meeting in North Wales 1–4 May 1981. *Quaternary Newsletter* 35, 40–45.

Many apologies
Yours sincerely

Stephan Harrison

Dear Brian

Congratulations on completion of your stint as Editor of this informative newsletter, it has been a pain and a pleasure working with you! We shall miss, missing your deadlines.

All good wishes

JE, JN and LW

NOTICES

PRELIMINARY NOTICE

SHETLAND FIELD MEETING—SEPTEMBER 1993

A QRA field meeting in Shetland is being arranged for 9–14 September 1993. Because several major 'pieces of work' from this area are either in press or in preparation, this will be an opportunity to discuss these works, and evaluate previous research in a part of the British Isles which has been rather neglected by Quaternary scientists until recently. The location of Sheltand makes it extremely important in environmental reconstruction but rather expensive to reach. The outline plan given here, together with current estimated costs (add your own inflation index!), should enable QRA members to reach an early decision about their interest. Please let Jacky Birnie know (Dept. of Geography and Geology, C&GCHE, Shaftesbury Hall, Cheltenham, GL50 3PP; Tel. 0242 532977): —we are unsure of the likely group size, and the degree of comfort demanded!

Outline itinerary

Thursday, 9 September—Ferry departs Aberdeen 1800 hours.
(Accommodation ranges from basic reclining seat to "superior" cabin)
Possible early evening introductory session—pre-Pentland Firth!

Friday, 10 September (Day One)—Ferry arrives Lerwick 0800 hours
South Mainland. Lateglacial pollen sites and radiocarbon dates. Lateglacial landslip or moraine? Scandinavian erratic. Archaeology (view of Mousa Broch, visit to Jarlshof).
(*Possibility of meeting some people at Sumburgh Airport—but not until the afternoon?*)

Saturday, 11 September (Day Two)—**Yell and Unst.** Sea level/tsunami evidence. Ice sheet margin geomorphology and sediments.

Sunday, 12 September (Day Three), **North Mainland.** Fugla Ness (interglacial), Dallican (postglacial environmental history and tephra dating).

Monday, 13 September (Day Four)—**West Mainland.** Sel Ayre (interglacial), Tresta (lateglacial), Scord of Brouster (postglacial). Ferry departs Lerwick 1800 hours.

Tuesday, 14 September—Ferry arrives Aberdeen 0800 hours.

Field guide editors: J Birnie, K Bennett, J Gordon, A Hall, C Firth, D Smith. Other contributions are (and are being) invited.

Preliminary costing (1992 prices):

Return ferry: £93—no vehicle, basic accommodation to £125—berth in 2 berth superior cabin.

Hotel accom. (3 nights)—£120 total or possibility of **Hostel** + bar meals at £45 total (self-catering breakfast). It would be very difficult, but not impossible, to split the group between these two. They would be in very different locations, and this would affect the trip—but please indicate strong preferences.

Minibus/4WD hire ?£20
Field guide/sundries ?

Total cost FROM ABERDEEN £170–£250, depending on level of comfort required.

PALAEOCLIMATE RESEARCH STUDENTS

In Quaternary Newsletter No. 65, I reported briefly on the funding of research relating to the NERC Special Topic 'Palaeoclimate of the Last Glacial/Interglacial Cycle'. No Research Students have been funded by Special Topic funds, and I thought it would be interesting to see how current interest in Palaeoclimate is reflected in awards made for Research Students by NERC.

It is not easy to make such an assessment. Last year, in 1991, awards were made under the Framework system, (designed to enable forward planning in Research Studentship allocations, but effectively abandoned after one year). It is not easy to assess how many of the 1991 Framework studentships actually related to Quaternary interests, let alone more specific Palaeoclimate objectives. However, I have made an attempt to second guess which studentships were Quaternary- (and not simply process-) related, from both the Aquatic and Atmospheric Physical Sciences (AAPG) and the Geological Sciences (GS) Committee lists. I arrive at a total of 9 from GS and 1 from AAPS, making a grand total of 10 Quaternary awards overall. (This compares with 144, the gross number of Geo-topic awards granted; 124 by GS and 20 by AAPS.) My calculator tells me that in 1991 Quaternary topics were 7.3% of the awards approved by GS, 5% of the Geo-topics approved by AAPS, and 6.9% of the Geo-topics awarded overall.

Your assessment of what are Quaternary topics and what are Geo-topics may differ from mine in individual cases but I think the overall pattern is fairly clear. 10 studentships were available from NERC for Quaternary-related study in 1991; 134 were available for non-Quaternary Geo-topics.

In 1992 the situation has changed, reverting from Frameworks to a Topic-related selection that is complicated by the division of departments into 'Q' (uota) and 'non-Q' (uota) categories. Ignoring the latter distinction for the moment, the number of Quaternary awards made totals 12.8 (in relation to 21 topics), and the total number of Geo-topics awards is 157, making Quaternary 8.2% of the Geo-topics awards overall. Most of this very modest improvement has occurred in the non-Q departments (7.3 awards against 13 topics), rather at the expense of the Q departments (5.5 awards against 8 topics). It is no longer possible to distinguish between GS and AAPS Quaternary awards.

As far as I know the only member of the eighteen-strong GS committee with a main interest in Quaternary is John Lowe (RHBNC), i.e. 5.6% of the committee, so the outcome is slightly better than pro-rata representation on the GS committee.

Appended below is a list of the 21 topics available to potential Quaternary NERC Research Students in 1992. Note: only the equivalent of 12.8 awards are available; the strange fractions occur because some topics are in competition with other Quaternary and non-Quaternary topics for actual awards. As I understand it students may propose their own Quaternary topics to Q departments, (even if their topic is not listed), but that this flexibility does not extend to non-Q departments.

'Q' departments

ESR dating of Pleistocene carbonates and dolomites. (Bristol, Geogr. 1/2)

Late glacial and recent sedimentation under the Pacific DWBC on Chatham Drift. (Cambridge, Earth Sci. 3/4)

Late Quaternary sediment budget of a neotectonic sink in Greece. (Cambridge, Earth Sci. 3/4)

Dating landscape development over 10^5–10^6 years. (East Anglia, Envir. 1/1)

Deformation of the continental lithosphere during post glacial isostatic rebound. (Liverpool, Earth Sci. 1/2)

Dating very recent surface processes using cosmic-ray produced 3He in surface exposed rock. (Manchester, Geol. 1/2)

Rates of natural climate change: a study of speleothems. (Open Univ., Earth Sci. 1/1)

Periglacial landslides and permafrost degradation: an Arctic analogue for Pleistocene Britain. (Cardiff, Geol 1/2)

'Non-Q' departments

Quaternary climatic fluctuations in the subtropical Andes: RS-fieldwork approach. (Aberdeen, Geogr. 1/2)

Numerical modelling of glacier response to climate change in Svalbard. (Cambridge, Scott Polar 1/1)

Tree population dynamics and dispersal in rapidly warming climates. (Durham, Biol. 1/2)

Calibration of recent ostracod-based palaeoclimatological reconstructions using instrumental records. (Kingston, Geol. 2/3)

Coleoptera as evidence of palaeohydrological conditions during the last glacial/interglacial transition. (RHBNC. 1/2)

Coleopteran records of the last glacial-interglacial transition in the UK. (RHBNC, Geogr. 1/2)

Luminescence dating of catastrophic Quaternary sea-level rise around the Mediterranean Sea. (RHBNC, Geogr. 1/2)

Mammalian size variation and its relation to palaeoenvironment in the Quaternary. (RHBNC, Geogr. 1/2)

Optical dating of the Rhine terraces. (RHBNC, Geogr. 1/2)

Palaeopedological evidence of regional climatic gradients across Bavaria during the Pleistocene. (RHBNC, Geogr. 1/2)

Holocene palaeohydrology from testate amoebe analysis: developing a model. (South West Poly., Geogr. 1/1)

Alluvial response to environmental change: luminescence dating of late Quaternary sediment systems. (Aberystwyth, Earth Stud.. 1/3)

Palaeolimnology of paired lakes in lowland SW Wales; climatic & anthropogenic impacts. (Aberystwyth, Earth Stud. 1/3).

I hope this comment on NERC Research Studentships for Quaternary topics is of interest. Anyone can extract the above information from NERC's own documents, (but it takes time), and you may find it informative to have it set out in one place. Of course I realise that non-NERC funds are also important in supporting Research Studentships in Quaternary Science and Palaeoclimates. Perhaps the next task is to compile information on the total graduate student input into these fields in the UK.

Brian Funnell
School of Environmental Science
University of East Anglia
Norwich NR4 7TJ

SCOTLAND QUATERNARY LECTURES—A PRELIMINARY ANNOUNCEMENT

A proposal to organize an informal annual meeting of Quaternary researchers during an afternoon of invited lectures was tabled at the Scottish Geographers Conference on 29 February 1992. It was agreed that a circular be sent to all Geography and Geology departments to gauge the degree of interest within Scotland. All pertinent information about a possible annual meeting is appended below but any comments are most welcome.

Justification

The Scotland Quaternary Lectures would provide Scottish researchers involved in Quaternary science and associated subjects with an equivalent to the London Quaternary Lectures. Clearly, the distances involved in travelling to London restrict our participation in the LQL's.

Format and timing

The SQL's would involve two guest speakers (perhaps one from overseas), each presenting a 50 minute lecture on a Wednesday afternoon during May. This timing is thought to be preferred by most University participants but is open to discussion. The lectures would be separated by a substantial coffee and snacks break during which participants could find time to communicate with their fellow researchers.

P.T.O.

Management and Funding

It is proposed that a management committee comprising one representative from each institution be constituted to meet briefly and informally at each SQL meeting to decide upon the venue for the following year. Suggestions for possible speakers and other relevant matters could also be addressed. Expenses for the SQL's will include visiting speakers expenses together with funds for coffee and snacks for approximately 100(?) people. Clearly, it would be prudent to take advantage of the presence of an overseas visitor at one of the UK's Geography or Geology departments. It is suggested that each of the participating institutions hosts the SQL's in turn.

Participating institutions

It is requested that all institutions intending to support the SQL's provide me with a contact name. That person will then be responsible for representing their institution on a management committee at each SQL meeting.

The first SQL

The Department of Geography and Topographic Science, University of Glasgow, is prepared to host the first SQL in May 1993. Suggestions for possible speakers are welcome.

Please complete and detach the form below and send to:

Dr David J A Evans
Department of Geography and Topographic Science
University of Glasgow
Glasgow
G12 8QQ

SCOTLAND QUATERNARY LECTURES

My department intends to participate in the SQL's and I am willing to act as contact person.

Name ....

Department ....

Institution ....

Address ....

....

....

....

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. Most members reside in Great Britain, but membership also extends to most European countries, North America, Africa and Australasia. Current membership stands at c.1000. Membership is open to all interested in the objectives of the Association. The annual subscription for ordinary members is £10.00 and is due on January 1st for each calendar year. Reduced rates apply for students, unwaged and associated members.

The main meetings of the Association are the Annual Field Meeting, usually lasting 3 or 4 days, held in April, and a 1 or 2 day Discussion Meeting held at the beginning of January. Additionally, Short Field Meetings may be held in May or September and occasionally these visit overseas locations. Study Courses on the 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 November, the *Journal of Quaternary Science* published in association with Wileys, and with three issues a year, the Field Guides Series and the Technical Guide Series.

The Association is run by an executive committee elected at an annual general meeting held during the course of the April field meeting. The current officers of the Association are:

President: Professor G S Boulton, Department of Geology and Geophysics, University of Edinburgh, James Clerk Maxwell Building, Mayfield Road, Edinburgh EH9 3JZ

Vice President Professor W A Watts, Provost's House, Trinty College, Dublin 2, Ireland

Secretary Dr M J C Walker, St David's University College, Lampeter, Dyfed, Wales SA48 7ED

Assistant Secretary (Publications): Dr D R Bridgland, 41 Geneva Road, Darlington, Co Durham DL1 4NE

Treasurer: Dr J Gordon, Scottish National Heritage, 2 Anderson Place, Edinburgh EH6 5NP

Editor (*Quaternary Newsletter*): Dr B J Taylor, British Geological Survey, Keyworth, Nottingham NG12 5GG

Editor (*Journal of Quaternary Science*): Dr P L Gibbard, Botany School, University of Cambridge, Downing Street, Cambridge CB2 2EA

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

QUATERNARY
NEWSLETTER

QN:

June 1992 No. 67

Contents

ISSN 0143-2826