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COVER PHOTOGRAPH:

Probable Devensian Lateglacial ice wedge cast at Needham Market, Gipping Valley, Suffolk. See article by J. Rose in this issue.

ARTICLES

FURTHER RADIOCARBON DETERMINATIONS ON REINDEER REMAINS OF MIDDLE AND LATE DEVENSIAN AGE FROM THE CREAG NAN UAMH CAVES, ASSYNT, NW SCOTLAND

N.A. Murray, C. Bonsall, D.G. Sutherland, T.J. Lawson
and A.C. Kitchener

Introduction

In Scotland, there are relatively few sites from which significant number of Pleistocene terrestrial vertebrate remains have been recovered. Particular interest therefore attaches to the Creag nan Uamh caves where many hundreds of bones, teeth and antlers have been found. Predominant among these are pieces of shed reindeer antler, which, together with previously published radiocarbon dates, suggested that reindeer had been present in that area during the Late Pleistocene and early Holocene (Lawson, 1984). Moreover, it had been argued that the most likely agent for the introduction of the shed antlers into the caves was man, and that this site may therefore have been the earliest recognised evidence for human presence in Scotland (Lawson and Bonsall, 1986a, b). New radiocarbon dates presented here extend the range of time over which reindeer was present in the Assynt area and require reassessment of certain of the earlier conclusions.

The Creag nan Uamh caves occur at an altitude of 330m below a steep rock face on the south side of the Allt nan Uamh valley to the SE of Inchnadamph, Assynt (Figure 1). The caves are parts of a former phreatic system abandoned following valley incision such that their entrances are today some 45m above the valley floor. One of the caves was excavated towards the end of last century by Peach and Horne (1917) but the cave from which the results reported here were derived is Reindeer Cave which was excavated in 1926 and 1927 by Callander *et al.* (1927). The results of these latter excavations were never fully published by the excavators but were summarised by Lawson (1981). Additional information on the sediments contained in Reindeer Cave together with details of previous radiocarbon dates were given in Lawson (1983, 1984).

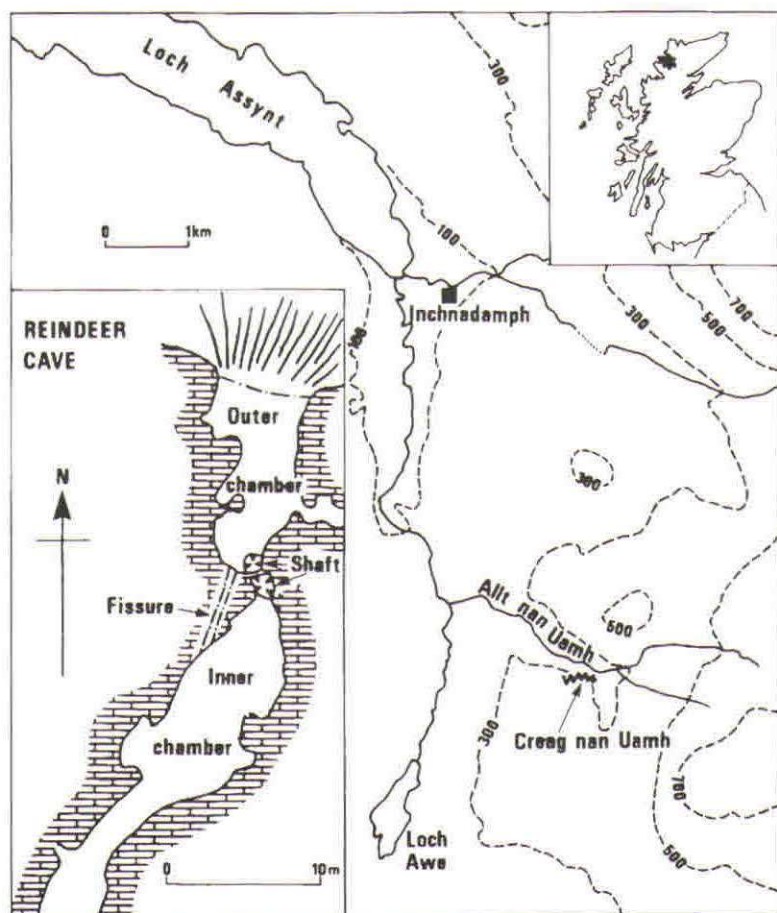


Figure 1. Location of Creag nan Uamh and detail of Reindeer Cave.

Reindeer Cave

Reindeer Cave consists of an outer chamber approximately 12m long by 5m wide which is connected by a narrow shaft approximately 2.5m deep to an inner chamber the full dimensions of which have not been established but which is at least 27m long and 6m broad (Figure 1). A narrow fissure also joins the inner and outer chambers. The outer chamber is also connected by a narrow passage 8m long with the cave to the east and the inner chamber has been established by a smoke test to have a connection to the cave to the west.

The inner chamber was almost filled with silts and lenses of gravels. Bones were only recovered from the top 30cm of the silts. These silts penetrated into the shaft connecting to the outer chamber, this shaft being, prior to the excavations, completely filled above the silts by sandy gravel which contained frequent animal remains, including many fragments of reindeer (*Rangifer tarandus*) antlers.

In the outer chamber the lowermost sediments described were yellow clays overlain by grey clays containing 'quartzite' clasts. Both these layers, which apparently occurred in pockets in the floor of the cave, are probably decomposed bedrock, the 'quartzite' being silicified limestone which can be seen in veins in the bedrock. Overlying these deposits towards the rear of the outer chamber was a bed of non-fossiliferous gravel, up to 0.5m thick, and containing frequent sub-rounded to rounded clasts of lithologies derived from outside the cave system. Resting on this was a distinct gravel, up to 0.9m thick, containing abundant reindeer antler fragments as well as other bones. This gravel occurred throughout the outer chamber and was apparently the same as that which filled the shaft. At the rear of the outer chamber this gravel was overlain by a layer of angular limestone fragments and the whole was sealed by an irregular bed, from 0.05 to 0.6m thick, of red 'cave earth' a sandy-silt with frequent angular limestone fragments. A variety of animal bones were recovered from this bed which was overlain by a few centimetres of sheep dung.

Previous radiocarbon dates on reindeer antler fragments from both the inner and outer chambers (Lawson, 1984) are given in Table 1.

Radiocarbon dating results

As part of an investigation into the movement patterns of reindeer in Britain during the Late Pleistocene (by N.A. Murray), a number of reindeer antlers from the inner and outer chambers and from the connecting shaft were selected for radiocarbon assay. As the previous dates had suggested the presence of antlers of a variety of ages in the cave deposits, only single pieces of antler were selected. The results are given in Table 1.

The original radiocarbon dates were interpreted as indicating three separate periods when reindeer were present in the area around the caves: at about the Middle-Late Devensian boundary; at the time of the Loch Lomond Stadial; and in the early Holocene (Lawson, 1984). The bulk sample date of approximately 18,000 BP from the inner chamber was considered unreliable because it seemed likely that it could have been a compound of the other two age

Table 1. Radiocarbon dates on reindeer (*Rangifer tarandus*) remains from Reindeer Cave, Creag nan Uamh

Location	Material dated	Lab.No.	Radiocarbon age (yr BP)
A. This study:			
Inner cave	Proximal fragment of right metacarpal of neonatal calf	OxA-3788	47,900±3600
Shaft (0-0.9m)	Single fragment of shed antler, female	OxA-3786	31,580±520
Shaft (1.2-1.5m)	Single fragment of shed antler, female	OxA-3792	22,300±240
Shaft (1.5-2.0m)	Single fragment of shed antler, female	OxA-3787	28,800±450
Outer cave	Single fragment of shed antler, female	OxA-3793	43,800±2400
Outer cave	Single fragment of shed antler, female	OxA-3984	28,240±390
Outer cave	Single fragment of shed antler, female	OxA-3985	31,490±570
B. Previous dates:			
Inner cave	Bulk sample of antler fragments	SRR-1789	18,080±240
Inner cave	Single antler fragment	SRR-2103	25,360± ⁸¹⁰ ₇₄₀
Inner cave	Single antler fragment	SRR-2104	24,590± ⁷⁹⁰ ₇₂₀
Inner cave	Single leg bone, juvenile	SRR-2105	8,300±90
Outer cave	Bulk sample of antler fragments	SRR-1788	10,080±70

Note: The locations of the samples are taken from the excavators' original sample labels.

populations determined for the inner cave on the basis of dating single fragments. The bulk sample date from the outer chamber was accepted as being reliable, however, and formed the basis on which the bone-bearing gravels from the outer chamber were thought to originate in the Loch Lomond Stadial.

The new dates are significantly different. First, the three samples from the outer chamber gravel have produced dates ranging from 28,000 to 44,000 BP, at variance with a Loch Lomond Stadial origin for the sediments. These samples were recovered from the outer part of the outer chamber. A broadly similar age (with overlap at one standard deviation) to the oldest of these dates has been recorded from a fragment of a metacarpal from a neonatal reindeer calf from the inner cave.

The three samples from the shaft connecting the inner and outer chambers have dates which fall within the range 32,000 to 22,000 BP. They are not in depth order but in the context of the fill of the shaft (which inclines at about 35°), the crude method of excavation, and possible origins of the gravels, this lack of consistency is not considered a reason to suspect any one of the assays. As a group, they lend support to the previous two single-fragment dates from the inner chamber, and overlap with the range of ages of specimens from the outer chamber. Together, there are seven dated samples which indicate the presence of reindeer during the late Middle Devensian and the early Late Devensian (c. 22,000 to c. 32,000 BP). The concurrence of the ages also supports the contention that the gravel in the shaft is a continuation of the bone-bearing gravel in the outer chamber (as it was considered to be by the excavators).

Discussion

Reindeer presence

It is considered that with evidence for a wide range of ages for the reindeer remains, reliance can only be placed on those assays carried out on single pieces of antler and bone. Accordingly, the available data indicate that reindeer were present in the Inchnadamph area at three periods: at 43,000-48,000 BP or earlier; between 22,000 and 32,000 BP and in the early Holocene. It is not contended that reindeer were not present at the time of the Loch Lomond Stadial, only that there is no reliable evidence that they were. Caution is also to be exercised in acceptance of the oldest dates, for radiocarbon concentrations in such samples are very low and small amounts of younger contamination can produce a finite age from a much older sample (Harkness, 1975). Consequently, these ages may be minima.

The dated reindeer antlers from the gravel layer in the outer chamber and the shaft form part of a large collection of shed antlers consisting of over 800 specimens. Reindeer are unique amongst cervids in that both sexes carry antlers, although the cycle of growth and shedding in males and females is six months out of phase. Adult males shed their antlers in late autumn and early winter, while females shed their antlers immediately after calving in late May or early June (Lent, 1965; Bergerud, 1976). Juvenile males also shed their antlers in late spring and early summer.

Morphological differences in the shape of the shed antler base enable the determination of sex. A study of 752 of the shed antler bases from Reindeer Cave has revealed that 664 (88%) are from females, 37 are from juvenile males, and the remaining 51 are from animals of uncertain sex but probably juvenile males. This combination of females and juvenile males implies that the Assynt area probably formed a calving ground in the past. This interpretation is supported by the occurrence of neonatal calf bones in the silt deposits of the inner chamber at Reindeer Cave. The collection includes a series of very small unfused long bones and several juvenile mandibles. The stage of eruption of the deciduous teeth in these jaws indicates that death occurred within the first week of life.

Modern reindeer populations living in open environments regularly form large herds. At the time of calving, herds of parturient cows seek out the highest and least favourable (in terms of food and shelter) terrain within their annual range. A marked sexual segregation occurs at this time and, while occasional yearling males will accompany their dams onto the calving grounds, no mature adult males will be found within the area (Lent, 1966; Bergerud, 1974).

Modern records also indicate that herds of parturient cows will return to the same calving ground over a period of several decades. The re-use of the Assynt area as a calving ground during several distinct periods (covering thousands of years) suggests that the cows were actively seeking out the environmental conditions provided by the terrain. A similar re-use of calving grounds over long periods of time is indicated by radiocarbon dates on shed antlers from Pin Hole, Creswell (Derbyshire), the dates on antlers from females and juvenile male antlers ranging from *ca.* 43,000 to 13,000 PB. As at Reindeer Cave, parturient females were clearly seeking out the Creswell area as a preferred calving ground during several distinct periods of the Devensian.

Reindeer Cave stratigraphy

Discussion of the stratigraphy of the outer chamber of Reindeer Cave is difficult because the excavation removed all the original material; notes made

at the time were quite rudimentary, and the few sediment samples that were kept were small in volume and not located precisely. However, a number of points may be made. The layer containing the reindeer antlers was found throughout the outer chamber and apparently continued into the shaft. It was stratified, containing thin beds of sand, some of which were continuous across the cave, and thicker lenses of sand with included pebbles. The strata at the rear of the cave dipped towards the shaft. The antler fragments were found throughout its thickness, albeit with concentrations in certain areas. The clasts were a mixture of angular limestone and sub-angular to sub-rounded 'erratic' lithologies derived from outside the cave. From the radiocarbon evidence it can be concluded that the gravel either accumulated over a long period of time or incorporated material reworked from a deposit or deposits of considerable age.

The main conclusion to be drawn at this stage is that there is little support for the interpretation of the gravel as simply being the product of thermoclastic breakdown of the cave roof and walls (*cf* Lawson, 1983), although material derived by such a mechanism is a significant component of the gravel (as it is in the overlying 'cave earth'). Such a process cannot account for the filling of the shaft nor the presence of the erratic material. Moreover, the stratified nature of the deposit and the inclusion of erratic clasts in gravelly-sand lenses is not in accord with a purely thermoclastic origin.

The 'cave earth' is overlain by a layer of sheep dung probably formed in the last few hundred years. Faunal remains from the 'cave earth' include collared lemming (*Dicrostonyx torquatus*), reindeer and sheep. The lemming and reindeer are part of an 'arctic' fauna and could be of Late Devensian or, conceivably, early Holocene age. The sheep bones are presumably of Holocene age, although these (and human artifacts and skeletal remains, see below) may have been incorporated into the deposit as the result of post-depositional disturbance by humans. Thus, the 'cave earth' could be of Late Devensian or Holocene age, or both.

Human presence

It has previously been suggested that the large number of reindeer antlers which were thought to have accumulated during the relatively brief Loch Lomond Stadial were best explained as evidence for the presence of man at that time (Lawson and Bonsall, 1986a & b). However, not only does the present evidence cast doubt on any of the antlers being of Loch Lomond Stadial origin, it also indicates that there are several age groups and that the accumulation of the antlers has taken place over many thousands of years. Thus there is less need to appeal to an agency of collection which behaved purposefully during a short

period. However, the precise mechanism for the introduction of the antler fragments into the cave remains uncertain.

It is of note, however, that a small 'artifact' was recovered during the excavation of the shaft at a depth of approximately 1.8m. The excavators reported this as 'a simple ... implement' (Callander *et al.*, 1927), 'possibly a portion of a spear-point' (Cree, 1927) made from a reindeer antler tine, but published no further details. Unpublished accounts written shortly after its discovery, however, describe it as 63.5mm long, exhibiting ancient breaks at both ends, with a breadth of 9.5mm at one end tapering to 6.5mm at the other, and having at the broader end a deep groove 24mm long which tapers out towards the 'point'. A rough sketch drawn by Cree is reproduced here as Figure 2. The present authors have been unable to trace this piece in museum collections from the site, and are unable to confirm the excavators' description or their interpretation.

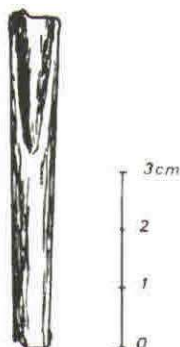


Figure 2. Rough sketch by J.E. Cree of an 'artifact' found in the shaft between the inner and outer chambers, Reindeer Cave. (Reproduced by permission of the Trustees of the National Museums of Scotland.)

Definite artifacts, as well as human bones, were recovered from the red 'cave earth' which overlies the fauna-bearing gravel in the outer chamber of Reindeer Cave, and these clearly relate to human use of the cave. A double-ring-headed pin of walrus ivory has a radiocarbon date of 1900 ± 80 BP, uncorrected for the marine reservoir effect (Hedges *et al.*, 1993). As noted, the dating of human activity and the time-range represented by the 'cave earth' are uncertain but could, in part, be as early as the Late Devensian.

Devensian faunas

Together with the reindeer antler and bone fragments in the inner chamber, shaft and outer chamber, numerous other animal remains were recovered, including brown bear, arctic fox and lynx. It is anticipated that future analysis

and dating of these faunas will reveal that Reindeer Cave contained the most abundant and diverse Devensian faunas yet found in Scotland.

Conclusion

The radiocarbon determinations indicate that there are at least three populations of reindeer remains in Reindeer Cave and cast severe doubt on the validity of the bulk sample radiocarbon assay which suggested the presence of reindeer during the Loch Lomond Stadial. Moreover, the gravels from which the reindeer antlers were recovered in the outer chamber and the shaft do not appear to have originated simply as the product of a short period of thermoclastic breakdown on the roof and walls of the cave. Hence the previous inference that the reindeer antlers were introduced to the cave by man during the Loch Lomond Stadial is not supported.

It is thought that the area around Creag nan Uamh has been used repeatedly during the Middle and Late Devensian and the early Holocene as a reindeer calving ground, the terrain having provided a suitable environment.

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A DEVENSIAN LATEGLACIAL ICE WEDGE CAST, NEEDHAM MARKET, GIPPING VALLEY, SUFFOLK, ENGLAND

J. Rose

During a Royal Holloway, University of London undergraduate field meeting on 1st May 1993, a visit to the Galley Hill Sand and Gravel Pit in the Gipping Valley revealed a structure that has the form of an ice wedge cast. Of particular significance is the fact that this structure is developed, intraformationally, within gravels that are most likely to be of Devensian Lateglacial age. In this case this will be the first record of such a structure in southeast England, and possibly the whole of England beyond the English / Welsh borderland. The implication is that powerful thermal contraction, and hence permafrost was present in this part of Britain in accord with the observations from ice wedge casts in northern Britain (Rose *et al.*, 1985; Worsley, 1987) and pingo scars in southern Britain (Hutchinson, 1980). This is a preliminary record of this observation; further work at the site is in progress.

Galley Hill Quarry (TM102 542) is located, at present, below the floodplain of the Gipping Valley, and sections are kept dry by pumping. The structure that is interpreted as an ice wedge cast is located in sands, silty sands and sands and gravels some 5m below the floodplain surface. At the time of the visit the structure was exposed in two faces and could be seen as a wedge-form with a linear trend roughly north-south. The wedge is approximately 1.2m deep, with a maximum width at the top of c. 0.6m at the southern section and c. 0.4m at the northern section. The internal composition is poorly sorted sand and gravel or silty sand, similar to the overlying beds which are undisturbed, indicating that the structure is intraformational within the gravel body. The upper parts of the host sediments show upwardly deformed structures typical of lateral stresses caused by ground ice growth (Black, 1975) rather than simply collapse in response to fissuring caused by desiccation or dilation. On the basis of this evidence the structure is interpreted as the cast of an intraformational ice wedge formed during the aggradation of the sand and gravel body.

At this stage of the investigation the age of the sand and gravel body can only be inferred by comparison with the succession at Sproughton, some 10 km down the Gipping Valley in an identical geomorphological and stratigraphical position (Rose *et al.*, 1980). At Sproughton, sand and gravel deposits at about 5m below the floodplain surface were radiocarbon dated to between $11,370 \pm 210$

and $10,880 \pm 250$ BP and were shown by the associated insect fauna to be associated with a deteriorating climate. The sand and gravel deposits which contain the inferred ice wedge cast at Galley Hill also contain peat rafts, interbedded silt units with macroscopic plant remains, insect and snail faunas, and will be the subject of further research and dating. The quality of the correlation with Sproughton can therefore be tested, but at the present state of this investigation it is reasonable to assume that permafrost may have begun to form toward the end of the Windermere Interstadial or the earliest part of the Loch Lomond Stadial, adding an additional element to the palaeoclimatic reconstructions currently being put together for this part of the Quaternary of Britain (Funnell, 1992).

Acknowledgements

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PRESENT AND PAST ECOLOGY OF *SPHAGNUM IMBRICATUM* AND ITS SIGNIFICANCE IN RAISED PEAT - CLIMATE MODELLING

Rob Stoneman, Keith Barber and Darrel Maddy

Introduction

As part of two NERC initiatives, the Palaeoclimate and the Tigger programmes, and building on doctoral studies by Haslam (1987) and Stoneman (1993), we are attempting to extend and to quantify the climatic signal found in the stratigraphy of ombrotrophic bogs. Part of this work involves reconstructing the species assemblages of peat profiles by firstly estimating the main components of washed peat samples and then identifying the bog mosses, *Sphagna*, to as low a taxonomic level as possible. We then produce macrofossil diagrams (Figure 1) which can be interpreted using a knowledge of modern bog ecology, much as Barber (1981) did. However, in trying to quantify the record, and in particular, in using a calibration or training set approach, we have come up against a problem in that one of our major taxa, which once formed the great bulk of Holocene peat, is now virtually extinct over a large part of its former range, and where it is still present we have good evidence that it is inhabiting only part of its former niche. This taxa, *Sphagnum imbricatum*, is very easy to identify in the sub-fossil state because of the presence of numerous comb fibrils along branch and stem leaf photosynthetic cells.

Taxonomy of *Sphagnum imbricatum*

Flatburg (1984) distinguishes three subspecies of *S. imbricatum*. In Europe two subspecies are found: a minerotrophic subspecies - *ssp. affine* - and *ssp. austinii* which is restricted to ombrotrophic habitats. These two subspecies are connected by *ssp. imbricatum* found only in the Far East. Branch leaves of the two European subspecies can be distinguished on the basis of comb-fibrils. In *ssp. austinii*, the fibrils are numerous and densely arranged whereas in *ssp. affine*, there are few, and they are only distinct in the lower part of the leaves (Flatburg, 1986). Andrus (1984) regards the two subspecies as distinct species in North American bogs. In Britain, Hill (1988) supports Flatburg's division although Daniels and Eddy (1990) adopt a more conservative view, regarding possible genetic differences in the *S. imbricatum* complex to be masked by habitat induced variations (*cf* Tallis, 1962; Green, 1968) in which *S. imbricatum* adopts a compact or a lax form according to height above water-table. On

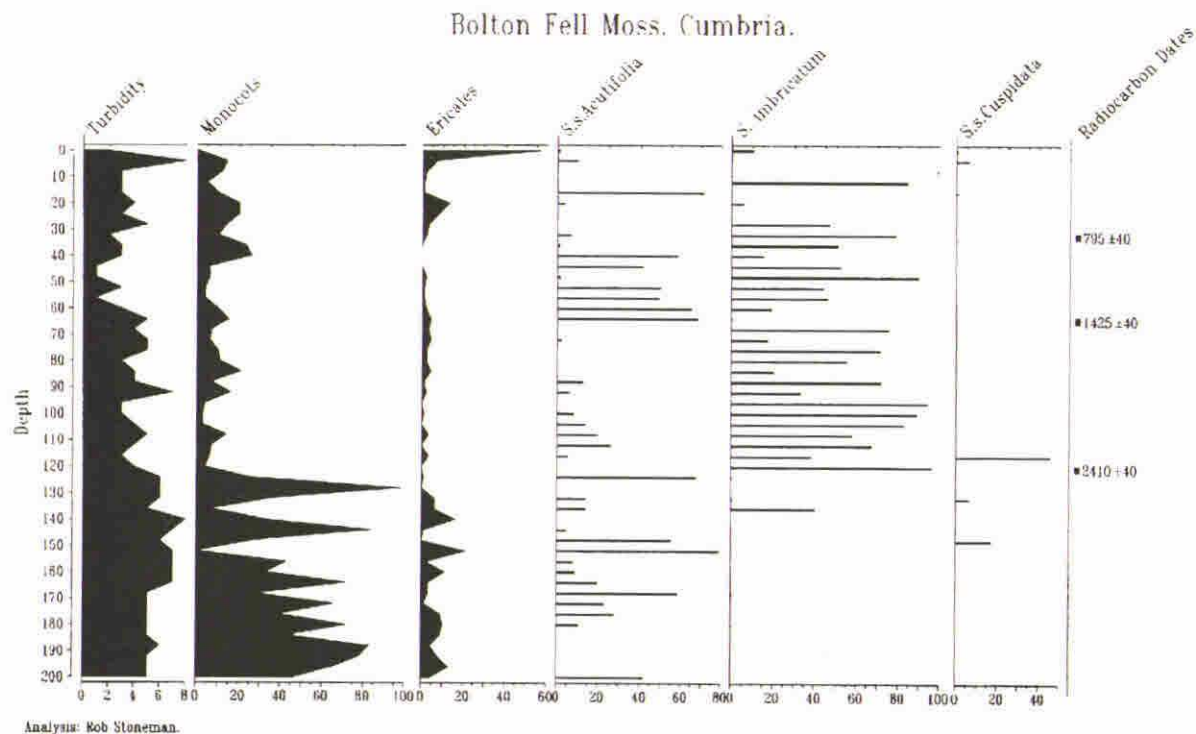


Figure 1. The macrofossil stratigraphy of an exposed face at Bolton Fell Moss. Components are a percentage of total remains > 125µm. Turbidity index is on a 1-10 scale where 2 represents peat of low humification and 10 represents highly humified peat.

ombrotrophic mires any *S. imbricatum* found is likely to be ssp. *austinii*. Therefore, unless specified, *S. imbricatum* is assumed to be that subspecies in this paper.

Present day ecology of *Sphagnum imbricatum*

The ecological niche of *S. imbricatum* ssp. *austinii* with respect to water table is outlined by Flatburg (1986, p.69):

"Usually the cushions (of *S. imbricatum* ssp. *austinii*) are situated well above ground water level and its fluctuations, and therefore also well above the indicative lower *Calluna* limit. However, occasionally the cushions descend continuously to reach upper hollow levels (mainly lawns), and may then be associated with, for example, *S. papillosum*."

Flatburg (p.71) elaborates further:

"among European sphagna, *austinii* is the taxon that ascends to the highest level in bog hummocks."

However, the optimum microhabitat for growth may not be the habitat range in which a species is found. Flatburg (p.81) notes that:

"it is the interaction and growth competition with other *Sphagna* that very largely determines the part of the habitat range, ... (in which *S. imbricatum* grows), ... and this need not necessarily be the optimum part of its range."

Present day growth rates of *S. imbricatum* are slow in comparison with other *Sphagnum* species (Green, 1968; Clymo, 1970) although Green (1968) found much more rapid growth in wet habitats in which *S. imbricatum* (almost certainly ssp. *austinii*) adopts a much laxer form than in dry habitats. Flatburg (1986) writes that the present day habitat niche of *S. imbricatum* ssp. *austinii* is controlled by a slow growth rate and a low ability to compete with other taxa such as *S. papillosum*, *S. magellanicum*, *S. capillifolium* var. *rubellum* and *S. recurvum*. The high hummocks on which the *S. imbricatum* is found today are the only places in which it can effectively out-compete other sphagna, and it can only survive on hummock-tops if the climate is oceanic enough to prevent desiccation. As a consequence, *S. imbricatum* ssp. *austinii* has a markedly oceanic distribution in both Norway (Flatburg, 1986) and the British Isles (Daniels and Eddy, 1990) where atmospheric humidity is high, as is the frequency of precipitation.

Palaeoecology of *Sphagnum imbricatum*

Palaeoecological research indicates that *S. imbricatum* may have occupied a different or a much broader niche in the past. Given the present-day ecology of *S. imbricatum*, it is surprising to find that peats composed from the remains of *S. imbricatum* are so often described as 'fresh' or unhumified. For example, Godwin and Conway (1939) noted layers of *S. imbricatum* dominated peat in "moderately fresh condition". Godwin (1954) writes of coarse unhumified mats of *S. imbricatum* in Irish bogs, whilst Tallis (1965) finds that *S. imbricatum* only flourished in the southern Pennines on very wet blanket peat. On Wynbunbury Moss (a schwingmoor where a thick raft of peat overlies water), *S. imbricatum* is found at the base of the peat deposit suggesting not only colonisation of very wet conditions but also eutrophic conditions (Green and Pearson, 1977). Flatburg (1986) suggests *S. imbricatum* at Wynbunbury may be *ssp. affine*. In the last 15 years or so detailed macrofossil analyses have yielded new data which show *S. imbricatum* existing in both lawn and hummock situations. This is the case at Bolton Fell Moss, where Barber (1981) found *S. imbricatum* grew in both hummock and lawn environments, and in some cases was involved in a succession from pool to lawn habitats. In an investigation of the Main Humification Change in a transect of bogs from Ireland across to Poland, Haslam (1987) suggested *S. imbricatum's* niche to centre on a low-hummock position in the oceanic bogs studied; it did not occur in bogs away from the coastal fringe. Van der Molen & Hoekstra (1988) found the species to be present in both hummock and hollow vegetation reconstructions, but it was more particularly associated with hummocks.

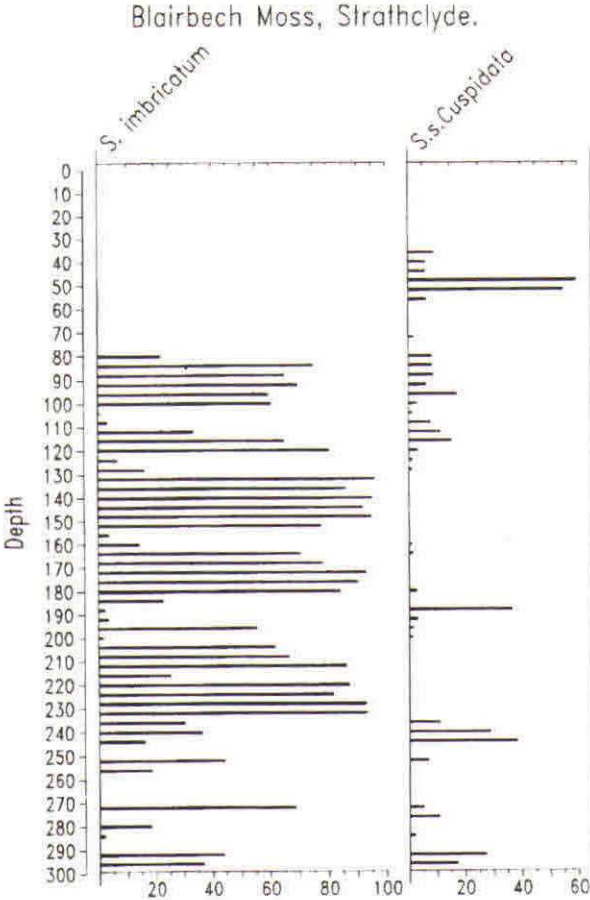
Given the obvious contradiction between *S. imbricatum's* present and past ecology, fresh evidence is presented to shed light on the changing ecology of *S. imbricatum*.

Results

A monolith of peat from a section exposed, by peat-cutting, in the south-western part of Bolton Fell Moss has been analysed for macrofossils (Stoneman, 1993) and is shown in Figure 1. Recent peat is missing from the top of this section having either been cut away or not accumulated due to drainage associated with peat cutting. Figure 1 shows a thick layer of peat, from 116 cm to 10 cm, dominated by *S. imbricatum*. A low turbidity index (relating to the degree of humification - see Stoneman (1993) for details) allied to low levels of monocotyledonous and ericaceous remains suggested that the peat formed from a lawn environment and not from a hummock. The field stratigraphy also supports this interpretation. Indeed at 116 cm *S. imbricatum* and *S. sect.*

Cuspidata associate. *S. sect. Cuspidata* is a distinctly hydrophilous section (Daniels and Eddy, 1990) suggesting *S. imbricatum* to be growing in a wet lawn or an ephemeral pool.

Figure 2 also reveals an association between the two species at Blairbech Moss at 300-290 cm, 245-236 cm, 122-112 cm and 102-80 cm. In these horizons *S. imbricatum* could not have inhabited hummock-tops.



Components: % peat matrix. Analysis: Rob Stoneman.

Figure 2. Selected curves from the macrofossil stratigraphy of Blairbech Moss (from Stoneman, 1993) showing the degree of association between *S. imbricatum* and *S. sect. Cuspidata*. Scales as Figure 1.

Figure 3 shows that the peat, composed primarily from *S. imbricatum* remains, at Walton Moss (between 44 and 60 cm) have an extremely low turbidity index value. Very low values represent very poorly humified peat. Given that this peat is well below the acrotelm, and has therefore undergone acrotelmic decay, it would have experienced much greater decay if the species had been growing on a hummock-top.

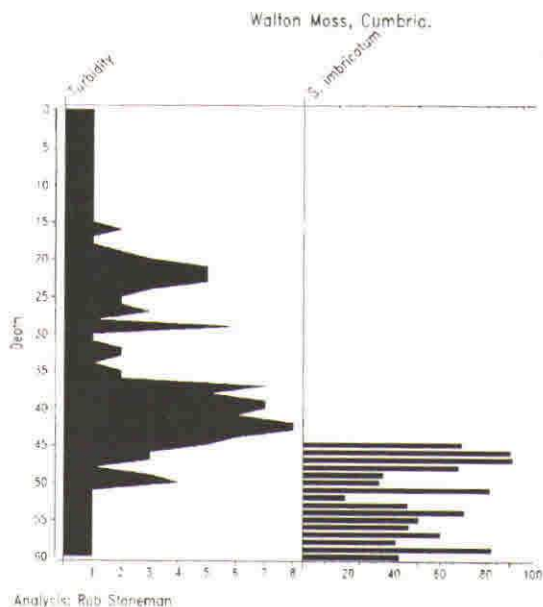


Figure 3. Selected curves from the macrofossil stratigraphy of Walton Moss (from Stoneman, 1993) showing low humification turbidity index values for *S. imbricatum* dominated peat. Scales as Figure 1.

This palaeoecological evidence strongly suggests that *S. imbricatum's* niche has altered. In the past, it appears that the species occupied a wide niche with respect to water-table. In contrast, its present day ecology suggests that the niche in which the species is found has narrowed to hummock-top situations only.

More striking though is the widespread decline of *S. imbricatum* in the British Isles. For example, on Tregaron Bog Godwin and Conway (1939) found *S. papillosum* replacing *S. imbricatum* close to the surface. Replacement of *S. imbricatum* by *S. papillosum* and/or *S. magellanicum* is a common feature

(eg Barber, 1981; Smith, 1985; Wimble, 1986; Van Geel and Middelorp, 1988). On blanket peats Tallis (1965) reports a widespread decline on the southern Pennines and Charman (1990) found *S. imbricatum* to decline at about 500 cal. AD at Cross Lochs in the Flow Country. Further declines are dated to 1400 cal. AD on Carbury Bog, Eire (Van Geel and Middelorp, 1988), 1250 cal. AD on the Goole Moors, Humberhead Levels (Smith, 1985) and to 1450 AD on Bolton Fell Moss (Barber, 1981). However, on hummocks Barber found *S. imbricatum* to exist up to 1800 AD. Goode (1970) also found that on the Silver Flowe, *S. imbricatum* declined in lawn environments but not on hummocks, where *S. imbricatum* is still found today. Stoneman (1993) also found that *S. imbricatum* was replaced by *S. magellanicum* at nine sites across northern England and southern Scotland.

Implications for palaeoenvironmental reconstruction

Barber (1981), Smith (1985), Wimble (1986), Dupont (1986), Haslam (1987), Stoneman (1993) and Barber *et al.* (1993, submitted) have all shown that the macrofossil record of raised bogs may contain a strong climatic signal. Such palaeoenvironmental records are often extracted by calibrating a modern training set against the environmental variable and then constructing a transfer function to elucidate the record (eg Sachs *et al.*, 1977; Birks *et al.*, 1990). This approach assumes uniformitarianism (Birks and Birks, 1980) - that the present holds the key to the past. However, for peat macrofossil / palaeoclimate studies this assumption needs to be treated with caution. This is because it is difficult to assess the palaeoecological niche of *S. imbricatum* by studying its present day ecology and that the demise of a dominant component of a vegetation assemblage will inevitably lead to a re-adjustment of ecological niches for the remaining and incoming species in that assemblage. It becomes difficult to relate directly present day ecology to past ecology and also difficult to relate assemblages occurring after the decline of *S. imbricatum* to those which existed before its decline. Instead, approximations and assumptions are made on the basis of these components' palaeoecology and present-day ecology, despite the danger of circular arguments ensuing. Given that the decline of *S. imbricatum* is related to a concurrent increase in *S. magellanicum* (eg Barber, 1981; Stoneman, 1993) it is fairly reasonable to assume that within lawn environments *S. magellanicum* has outcompeted the lax form of *S. imbricatum*, restricting the species to hummock tops.

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SOME THOUGHTS ON BRUCE LASCELLES "DIATOMS AS RECONSTITUTED QUATERNARY TEPHRA" (QN69, 10-16)

B.K. Maloney and Joanne McVicker

We read the paper by Lascelles with some interest. Providing that the ash cloud reaches a high enough altitude in the stratosphere and the wind is blowing in the right direction there is no reason why ash from Iceland could not travel as far as Wales. There is historical documentation for the presence in Holland (Geikie, 1893 in Hunt and Fannin, in press). Ash from the 1619 eruption of Katla was transported in a south easterly direction as far as southern Sweden (Thorarinsson, 1981). Additionally the 9000 BP Saksunarvatn ash from Iceland has been found in northern Germany (Hunt and Hill, 1993). It must be noted (*cf* van Overeem, 1937; Brown *et al.*, 1964; Schlichting, 1964) that diatoms and other algae can be dispersed by atmospheric winds although the data which we have come across relates to transport by the lower atmospheric winds. We are not inferring that Lascelles' diatom deposits are of this origin but we must dispute the statement that "Before 1986 little information was available as to the general fate of air-borne particulate matter" (p.10). There is a very large but scattered literature on various kinds of particulate matter in the atmosphere dating from at least 1822 onwards, *eg* Alexander (1822). Indeed one of the first diatom analysts, Christian Ehrenberg, was very interested in the origin of red desert dusts (Powers, 1992) and there is a sizable climatological / meteorological and some pedological literature from more recent times concerned with the distribution of such material, *eg* many of the papers in Morales (1979), George (1981), McLeod (1980), Rapp (1983), Stevenson (1969), Vernon and Reville (1983). Perhaps the most well known early account is that of Darwin (1846) describing the dust which fell on ships crossing the Atlantic Ocean. Ehrenberg examined the dust collected by Darwin while the 'Beagle' lay at anchor in the Cape Verde islands and found diatoms and phytoliths in it. Numerous articles on pollen and fungal spore dispersal are to be found in journals such as *Grana*, and inorganic sediment in ice cores has been studied for a long time (*cf* Hammer *et al.*, 1980). Indeed the pollen content of the Mazama, Oregon, and Glacier Peak, Washington, ashes have been used (Mehringer *et al.*, 1977) to estimate the duration of ash deposition. Such analyses can also provide data on the season of eruption and its ecological effects.

The earliest reference on the use of satellite data known to the authors is Heiken and Pitts (1975-76). Information derived from nuclear fallout studies was employed by volcanologists long before the Chernobyl eruption of 1986. Knox and Short (1964) used models of nuclear fallout distribution as a basis to devise

a simple mathematical model of volcanic ash fall distribution. Additionally fluid mechanics theory had been used to model how ash clouds rising into the stratosphere behave (*cf* Cadle *et al.*, 1976; Wilson *et al.*, 1978; Walker, 1981). By 1986 the consequences of eruptions of volcanic ash on the general circulation had also been modelled mathematically (Hunt, 1977; Hansen *et al.*, 1978).

Lascelles gives the impression that ash deposits such as those reported from Northern Ireland (Pilcher and Hall, 1992) and Scotland (Dugmore, 1989; Dugmore *et al.*, 1992) are the result of lower atmospheric processes yet the literature on ash falls, *eg* Walker (1981) and Jakowsky (1986), suggests that material in the lower atmosphere is usually deposited very near the vent as a result of washing out by precipitation or the water content of phreatomagmatic eruptions and that which travels long distances is that which gets into the upper atmosphere and is moved by the upper wind systems. Of course not all eruption clouds penetrate the tropopause and very often ash is not transported over long distances. However, it is theoretically possible for ash to be transported by jet streams and to eventually fall into the lower atmosphere, *ie* to be transported over long distances by a combination of upper and lower atmospheric interaction as a result of the normal cellular circulation. Movement of the Hekla 1947 ash over Ireland and Scotland to be deposited in Sweden (see Salmi, in Thorarisson, 1967) during rainfall is a rare definite example that this can be so and does contradict the view that long distance transport has always to be by upper atmospheric winds. Atmospheric processes are complicated and clearly there is an urgent need for more detailed studies of how ash is moved in the atmosphere.

One of the interesting things which has not yet been attempted but which could eventually be done is to use the data on the thickness of the ash in peats and mathematical formulae such as those of Knox and Short (1964) to try to predict the thicknesses of ash layers to be expected on Iceland, the intervening sea between the island and northern Britain and in northern Britain itself, and to estimate how high the volcanic plume of Hekla 4 for instance reached in the atmosphere. However the problems of marine bioturbation, varied thicknesses resulting from rainfall amounts and intensities and various local processes could make this impossible.

We would draw attention to the fact that at this relatively pioneer stage in tephra studies the use of peats is more advisable than lake sediments. This is mainly because peats are not subject to sediment focussing; it must also be remembered that lake marginal sediments may be liable to erosion and redeposition resulting from changing lake levels and that ash might be brought in to lake deposits by

rivers and streams. Peats are far more stable and provide suitable media in association with pollen analysis to search for evidence of post-depositional movement.

Use of X-rays is only of value to detect subsurface features. Where buried shells or shell fragments occur these are readily detected but where larger inorganic material is present it can be detected but not always identified without excavating it from the core. X-rays are only of use for preliminary investigations.

Although biogenic material from opaline silica phytoliths and diatoms occur in peats studied for their volcanic ash content only an initial investigation has been made of the phytoliths in the form of an undergraduate dissertation (Burns, 1991). The samples examined came from the upper metre of a peat monolith collected from Fallahogy Bog, Co. Londonderry, and encompassed what seems to be the Hekla 1 ash layer. There were no significant changes in the percentage composition of the phytoliths associated with the ash layer but we do not have concentration data. Samples extending back beyond the Hekla 4 ash are available for examination. All the samples were prepared and mounted in the manner described in Pilcher and Hall (1992).

There is no confusion between phytolith and volcanic ash form to the researcher with a background in phytolith analysis where the phytoliths are not amorphous but show indications of plant structure, *eg* long cell, short cell, prickle hair cell and intercellular features. These are very well illustrated in Clifford and Watson (1977), Piperno (1988) and Rapp and Mulholland (1992).

We accept that the mobility of tephra-derived silica is worthy of additional study and research on this is underway by our colleagues in the Palaeoecology Centre. The use of clay mineralogy is also a good idea. We draw attention to the paper by Bennett *et al.*, (1981) which suggests that quartz and aluminosilicates rapidly dissolve in anoxic, organic rich, neutral pH environments. In raised bogs dissolved silicon was found to increase as pH increased with depth. Volcanic ash seems to weather by hydrolysis first to an amorphous aluminosilicate containing calcium, magnesium and potassium (Fitzpatrick, 1986) then into allophane, a 1:1 lattice clay mineral. One may wonder if some of the dissolved silica is not taken out of solution by diatoms. Clearly the whole subject of the behaviour of silica is a highly complex matter, a subject which geomorphologists have been debating for many years in relation to the process involved in laterisation.

On another topic, we would suggest that Lascelles might consider having his diatom rich samples subjected to oxygen isotope analysis as palaeotemperature estimations may then be possible (*cf* Mikkelsen *et al.*, 1978).

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**REPLY TO "SOME THOUGHTS ON DIATOMS AS
RECONSTITUTED QUATERNARY TEPHRA" (B.K.
MALONEY AND JOANNE McVICKER)**

Bruce Lascelles

I am grateful to Maloney and McVicker for their interest in and reply to my raising the possibility that diatom flushes may indicate the previous existence of tephra falls (Lascelles, 1993). Their suggestions for further reading on the movement of dust and other particulate matter, such as bioliths, through the atmosphere are very informative and indicate the complexity of the issue.

However, the main question I wished to address was not the exact mechanism by which material could have reached North Wales, since it is theoretically possible for the normal atmospheric circulation to result in a transfer of material southwards from Iceland, but the fate of that material if it had been deposited in such a region. The study carried out was initially to look for the presence of tephra in this area, at which time the only material available was a lake sediment core from Llyn Cororion (courtesy of R. Watkins) for which there were an associated series of radiocarbon dates (Watkins, 1991). This allowed the location of possible tephra layers, "assuming no or minimal disturbance" (Lascelles, 1993). Peat cores are indeed more suitable for such studies, as noted by Maloney and McVicker, and appropriate cores were recovered for use in future work.

The use of X-radiography (within the limitations of its sensitivity) is of value here, providing an economical and non-destructive method of locating thin, fine-grained tephra layers (Dugmore and Newton, 1992). It has been used extensively to pinpoint possible tephra falls prior to their extraction and identification (Dugmore and Newton, 1992; Blackford *et al.*, 1992).

It is agreed that there is unlikely to be any morphological confusion between volcanic ash and phytoliths when analysing the distinctive forms determined by obvious gaseous exsolution and cellular shapes respectively. However, this distinction is not so clear when faced with tephra that has elongated air bubbles and phytoliths which are derived from irregular intercellular depositions (D.A. Jenkins, pers. comm. 1993). Joanne McVicker also suggests that there may be some confusion between tephra and amorphous plant silica and phytoliths (Hunt, 1993).

Our understanding of the weathering of tephra of Quaternary age does need more studies in depth, especially where the tephra fall was very light and

dispersed in the first place. It is likely that at least some of the dissolved silica will be utilised by diatoms and sponges in the environment; for example Riezebos and Zimmerle (1988) concluded that the world's economic diatomite occurrences all formed in relation to volcanic activity or volcanic rocks.

Dissolution of silicates, including amorphous silica and volcanic glass, is indeed a complex and variable phenomenon, and the geochemistry of tropical oxisols/plinthites ("laterites") is likely to differ significantly from that of temperate histosols ("peats"). The diagrams presented by Rai and Kittrick (1989) illustrate the relative stabilities of glass and amorphous silica, and the weathering products of volcanic glasses in andic soils include typically allophane and imogolite altering to the 1:1 phyllosilicate halloysite (Wada, 1989) rather than the path quoted by Maloney and McVicker. The relationship between soluble/mineral silica and pH noted by Bennett *et al.* (1991) and interpreted in terms of organic acid-silica complexes is of particular interest, although the bog and lake systems I am investigating are consistently of low pH, and such a mechanism cannot be currently invoked.

I welcome the response of Maloney and McVicker and the points they raise about atmospheric transport and the identification and stability of tephra. The prime question as to the possible relationship between tephra and bioliths in organic rich sediments clearly remains a challenge to which future research is to be diverted.

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REPORTS

REPORT ON THE 1993 QRA ANNUAL FIELD EXCURSION TO JERSEY, CHANNEL ISLANDS

5th April - 8th April 1993

A very fruitful excursion to Jersey was had by all with visits to a number of mainly Late Pleistocene and Flandrian sites on the island. The Annual Field Meeting this year was organised by **David Keen** and **Bob Jones** in conjunction with members of the Société Jersiaise. Despite strong winds all the participants arrived safely at the Fort d'Auvergne Hotel in St. Helier for registration. On the first evening the Société Jersiaise entertained the party with a splendid wine reception and buffet dinner in the Jersey Museum, St. Helier. This event was followed by the introductory lecture delivered by **David Keen**.

The first day in the field concentrated on the Pleistocene history of the south-western part of the island and involved a pleasant five km stroll around the Noirmont headland. The first stop was to view small patches of arctic mud in hollows on the rock platform just to the south of St. Aubin. Unfortunately these deposits were completely covered by beach sand. However, the efforts of **David Bridgland** and his trusty spade soon exposed what the group had come to see. Dave earned himself quite a reputation for digging holes and his services were called upon throughout the meeting. The party also had the opportunity to examine the cliff section at Belcroute. Here a lower marine deposit was overlain by a lower head and a lower loess which in turn was overlain by an upper marine deposit, blown sand and sandy head, an upper head and an upper loess. This has been interpreted as evidence for two major cold and two major temperate stages in superposition. **David Keen** suggested that the upper marine deposit was formed by the marine transgression in the Eemian.

After lunch the group visited the very impressive and archaeologically important La Cotte de St. Brelade. Sediments from the ravines in the cliff have yielded hominid remains together with a mammalian fauna suggesting this was an early human occupation and butchery site. Discussion centred on whether the megafauna butchered at this site had been killed after accidentally falling down into the ravines, whether they were encouraged to fall off the cliff by pre-modern humans or had been killed by hunters further afield and then carried to the site. A blasting wind and the towering walls made standing inside the La Cotte site quite a haunting experience.

A short walk from La Cotte de St. Brelade took the party to Portelet Bay. Here a complex of deposits were seen in several sections around the Bay. These

sediments tell a similar story to those at Belcroute. At Portelet Bay it was a shame to see Jersey's natural coastal vegetation being out competed by the introduced Hottentot-fig (*Carpobrotus edulis* (L.) N.E.Br.). On route back to the Hotel the coach stopped at the southern end of Fort Regent, South Hill, St. Helier so that the party could look at the highest Pleistocene marine deposit on Jersey. Here the fossil beach is 31 m above mean sea-level. The elevation of this deposit is probably a result of both eustatic factors and neotectonic uplift.

The combination of a stiff sea breeze and gorgeous sunshine meant that at the end of the first day everyone sat down to dinner with glowing faces. After an epic dinner everyone gathered for a relatively uneventful and short Annual General Meeting. It was proposed that the prospect of an Annual Field Meeting in The Netherlands should be investigated for 1995.

The following day the weather took a change for the worse with intermittent drizzle and rain. In the morning the coach headed north-eastward towards the first destination of the day at Fliquet. At this coastal site a boreal and arctic peat of uncertain age occurs in a gully on the rock platform. On arrival at the site the tide was still in and with excellent timing the peats slowly emerged as David Keen voiced his thoughts on the deposits. Close examination of the compacted organic deposits revealed them to contain large numbers of sedge (*Carex*) nutlets and some Coleopteran remains. The next stop was to view Grouville Marsh and the sand-cordon that impounds the area at the northern end of La Baie du Bieux Château. The Flandrian sequence here suggests that a predominantly freshwater regime that was replaced by more brackish conditions between 6000 and 4000 years BP. During the brackish phase *Alnus* woodland dominated the coastal fringe. There was some debate as to whether this was due to a marine transgression at this time or as a result of the sand-cordon being breached. Grouville Marsh gave Jackie Birnie the first opportunity to display her rather large hand held pollen diagrams, which were to become a feature of the field excursion.

The final visit of the morning was to La Motte. This small island, south of St. Clement, is composed of what Jean-Pierre Lautridou described as "a first class loess". It forms a remnant of a once more continuous cover of loess which draped the rock platform of south-east Jersey. Brigitte van Vliet-Lanoë gave a very interesting account of how she conceived the limons à doublets having been formed. The limons à doublets deposits overlie the loess at La Motte. La Motte is also of archaeological interest because of the presence of a cairn, midden levels and a number of graves. Mark Patton discussed the problems of dating some of these features and conserving this small island which is rapidly being eroded by wave action.

Lunch was taken at Gouray beneath the imposing château at the northern end of La Baie du Vieux Château. The afternoon began with a visit to La Hougue Bie which was described by Mark Patton as "one of Jersey's most important archaeological sites and one of the largest Megalithic passage-graves in western Europe". La Hougue Bie is indeed a magnificent monument comprising of a 12m high artificial mound covering a cruciform passage grave all capped by two Medieval chapels.

On the way to Le Marais de St. Pierre the coach stopped in La Vallée de St. Pierre to look at the Quétivel Mill site. Palynological investigations from the site show a Flandrian record with a long hiatus. The Flandrian sediments at Le Marais de St. Pierre represent infill behind a coastal barrier. Exchangeable cation values and diatom stratigraphy show a sequence of marine incursions into the lagoon. The more prolonged incursions may arise from a transgression in sea level, whilst other breaches may reflect localised catastrophic events.

The last day was spent in western Jersey. At La Baie de St. Ouen the party saw an impressive Flandrian dune system backed by the fossil cliff line. Palynological investigations of organic sediments beneath the dune sand at several sites in the bay have provided a good Flandrian sequence. In the centre of the bay at Le Port a foreshore exposure of compacted sands, clays and peat occurs. This deposit provided further evidence of Flandrian sea-level fluctuations on the Jersey coast. Le Port was directly below the flight path of Jersey Airport and the constant arrival and departure of aircraft made discussion quite difficult at times. It also reminded the participants that the excursion was coming to an end. Early flight departures meant that after this site some members of the party began to leave. During the late morning and afternoon the remaining members of the excursion visited a Early Neolithic to Gallo-Roman on the north-west coast of Jersey at Le Pinnacle and a Palaeolithic site at La Cotte à la Chèvre.

The meeting clearly demonstrated the dynamic nature of sea-level. The pre-Flandrian raised marine deposits and shorelines left by past marine activity are considerably complex. Sea-level fluctuations in the Flandrian are more fully understood because the investigation of coastal lagoon sediments preserved at several sites which provide evidence of transgressive and repressive episodes. Evidence of environmental change could be seen all around Jersey with the occurrence of periglacial slope deposits, head and loess, although the age of some of these deposits is not yet certain. The visit also showed how important and rich Jersey is archaeologically with occupation sites extending back to 250,000 years ago.

M.H. Field

Sub-department of Quaternary Research, University of Cambridge

REPORT ON THE GLASGOW DRUMLIN SEMINAR AND THE FIRST SCOTTISH QUATERNARY LECTURE

27th-28th April 1993

I woke very early on Tuesday morning to fly to Glasgow on the 7.15 flight. It was a strange experience to sit in my fieldwork clothes in a plane, surrounded by business people in their dark suits, and then be driving off in the minibus into the field at 9.00. This meeting was the Glasgow drumlin seminar organised by **Dave Evans** and **Tessa Fergoughty**, and a rare opportunity to see the two experts on Glaswegian drumlins, **Jim Rose** (Royal Holloway, University of London) and **John Menzies** (Brock University, Canada), perform both in the field and in the lecture theatre.

The field trip was very good, and showed me an area in detail which previously I've only rushed through in order to reach the highlands. The trip included a visit to the Drumbeg Quarry near Drymen, lead by **Doug Benn** (Aberdeen) and **Dave Evans** (Glasgow), where we were shown some very interesting proglacial and subglacial constructional glaciotectonics associated with the Loch Lomond Readvance.

In the late afternoon, we returned to Glasgow for the lectures. **Jim Rose** talked about the subglacial streamlined bedform continuum, with interesting and detailed studies of these features on different scales; and **John Menzies** introduced us to his new work on till micromorphology associated with some very well exposed drumlins at Chimney Bluffs, southern coast of Lake Ontario. Both these talks were followed by a lengthy and interesting discussion.

On the following day we heard talks associated with the Scottish Quaternary Lectures. The first talk was given by **Jim Rose** and about the pre-Anglian palaeogeography of Southern England, and the second was an interesting investigation of flutes by **Doug Benn**. Again these talks prompted a lively discussion.

The conference was attended mostly by staff and students from the Scottish Universities, but there was also a party from Northern Ireland, London and Southampton. It was good to see that members of the Geological Survey from Edinburgh also attended. The students, in particular, were an asset to the trip, showing a very high level of interest and asking very difficult and well thought out questions. These students could have made very good PhD students, if only we had the money to support them! The conference was well organised, and we were made feel very welcome by both the Geography Department at Glasgow, and by Dave and Tessa who put in a lot of effort to make the conference a success.

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ABSTRACTS

LATE HOLOCENE PALAEOECOLOGY AND HUMAN IMPACT ON THE ENVIRONMENT OF NORTHERN BRITAIN

Lisa Dumayne (Doctor of Philosophy)
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ABSTRACT

Pollen diagrams from nine mire sites in northern Britain have been constructed to assess the record of human impact on vegetation over the last 3,000 years. Of particular interest is the effect of the Roman invasion and occupation of northern Britain on vegetation, especially that related to the construction of the Hadrianic and Antonine Walls, forts and roads. Pollen analysis was undertaken to investigate whether the impact was widespread across the frontier zone or was related to the proximity to Roman Walls and forts.

During the Roman occupation of northern Britain between AD 71 and AD 411, large amounts of timber and turf were needed for the construction of forts and other structures and it is estimated that a fort 4 acres in size would have needed 22,000 cubic feet of timber for its construction (Keppie, 1986). Woodland was also cleared to create a military clear zone, for the production of lime, for cooking and to create open land for agriculture. The effect of these activities on the environment of the frontier zone has not been intensively studied and few pollen diagrams concerned with the anthropogenic impact on the vegetation have previously been produced from the area (Barber, 1981; Turner, 1979; Davies and Turner, 1979). Therefore, a regional reconstruction of vegetation history has been undertaken and was long overdue.

The results of high-resolution pollen analysis of the nine sites, supported by 25 radiocarbon dates, have demonstrated that the first major and permanent clearance of vegetation at certain sites occurred during the Iron Age, and this is followed by a second clearance relating to the Roman occupation. At Fozy Moss, Northumbria, no Iron Age clearance occurs and the first major clearance occurs at the time of the Roman occupation. The dramatic response of the grass pollen curves and the relatively low level of arable indicators is in accord with the archaeological evidence for the Roman impact being one of woodland clearance for military purposes rather than for settled agriculture. Results

indicate that the degree of clearance is related to distance from Roman structures. Sites close to Hadrian's and the Antonine Wall record the highest levels of grass pollen - 80% at Fozy Moss; 55% at Letham Moss; 40% at Walton Moss and Fannyside Muir. Dogden Moss, situated in the inter-wall area, also displays high grass levels - 50% - attributable to the moss being situated in an area amenable for agriculture. For sites at greater distances from the major archaeological structures, Gramineae percentages are lower. At Carsegowan Moss, Wigtonshire, Glasson Moss, Cumbria and Cranley Moss, Lanarkshire, the Gramineae curves barely reach 30%. This indicates that the Roman occupation was not as intense as at the other sites. Ellergower Moss, Dumfriesshire, is in an area outside the influence of the Roman occupation and here Gramineae levels do not begin to rise until much later.

Thus the hypothesis - that the proximity of an area to the Roman structures will be reflected in a greater degree of forest clearance - is upheld by the above results, but this appears not to have been the first major human impact on the landscape of the region. The record of vegetation change is described up to the present day and evidence for prehistoric agriculture discussed. The concepts of pollen source areas, inter-site variability, agricultural indicators and agricultural indices are explored in relation to the palynological results.

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VEGETATIONAL HISTORY AND PALAEOFOREST RECONSTRUCTION AT WHITE MOSS, SOUTH CHESHIRE, UK

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University

ABSTRACT

The aim of this thesis was to reconstruct palaeoforest layers preserved as subfossil wood within a specific peat deposit - White Moss, South Cheshire, UK. These were then related to their fossil pollen records. Project aims also included reconstructing a site vegetational history, creating a dendrochronological record for the mire and ascertaining the timing and duration of mire colonisation by Scots pine (*Pinus sylvestris*). Four major techniques were employed: palaeoforest exhumation (including the development of a new fieldwork methodology), pollen analysis, dendrochronology and radiocarbon (^{14}C) dating. Pollen diagrams were constructed for a peat profile through deep sediments (site/regional vegetational history) as well as for three shorter profiles taken through a subfossiliferous wood peat. Horizons showing significant vegetational fluctuation, especially events associated with the *Pinus* pollen curve and variation in mire surface hydrology, were ^{14}C dated. Discs were taken from stumps of subfossil Scots pine in order to reconstruct phases of mire colonisation using ring-width measurements and dendrochronological cross-matching techniques. Results of palaeoforest reconstruction are presented and the problems of ^{14}C dating and cross-matching discussed. Five tree-ring chronologies were constructed and wood samples from the ends of these and from long-lived timbers were ^{14}C dated. These dates grouped into two distinct periods: 4645-4320 and 4160-4015 ^{14}C years BP. The subfossil wood was combined with palynological data to identify three phases of declining mire pine woodlands c. 4000 years BP. It is concluded that pine tree mortality was caused by waterlogging of the peat substrate in a series of wet-dry episodes from c. 4300 BP.

DEVELOPMENT AND APPLICATION OF STIMULATED LUMINESCENCE DATING METHODS FOR SEDIMENTS

Sheng-Hua Li (Doctor of Philosophy)

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ABSTRACT

The aim of this thesis was the development of infrared stimulated luminescence (IRSL) as a dating technique, with particular application to sediments which have only experienced short sunlight exposures. The main areas studied concern methods of measuring the IRSL signal from bulk sediment, thermal stability of the IRSL signal from different feldspar minerals, dating of colluvial sediments and luminescence sensitivity changes incurred after laboratory bleaching.

The principal findings from the thermal stability studies are that potassium feldspars have a greater long term stability than plagioclase feldspars and polymineral bulk sediment. Short term thermally unstable IRSL signals were observed after laboratory irradiation and preheating procedures were developed to remove the unstable component.

Loess cores from Rocourt, Belgium, were used to investigate the IRSL signals from bulk sediments. The IRSL signals from pellets allowed an overview of the sedimentary pattern to be obtained in a relatively short time and a normalisation procedure was developed using UV radiation. A portable IRSL system was designed and built.

A competition model was introduced to explain the sensitivity changes of the luminescence signals that occur after laboratory bleaching. Sensitivity changes relate to the age of sample, the extent of laboratory bleaching and the sunlight exposure prior to deposition and either an increase or decrease in sensitivity can occur. The predictions of the model are in good agreement with the results of laboratory experiments and sensitivity changes reported in the literature.

Sediments which were partially bleached at deposition have been studied. Several methods of detecting insufficient bleaching of IRSL signals were introduced. Two empirical methods for the equivalent dose determination were developed, which involve single aliquot procedures.

Using the techniques developed in this study, a dating programme was carried out to establish the geochronological record for colluvial sediment from five sections in Natal, South Africa.

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LATE QUATERNARY STRATIGRAPHY AND RECENT SEDIMENTATION IN THE DYFI ESTUARY, WALES

Zhong Shi (Doctor of Philosophy)

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ABSTRACT

The post-glacial estuarine evolution of the Dyfi Estuary can be divided into four phases. Phase 1: 15,000 - 10,000 yr BP, shallow water, high energy fluvial dominated facies. Phase 2: 10,000 - 6,000 yr BP, deep-water, low energy estuarine dominated facies. Phase 3: 6,000 - 3,500 yr BP, shallow water, high energy, tidal-dominated facies. Phase 4: 3,500 yr BP - present, shallow water, low energy, estuarine salt marsh dominated facies.

Due to lack of data, the present research is not concerned with wave modifying effects. The intertidal zone can be texturally classified into five sub-environments: saltmarsh, high mud zone, low mud zone, sandflat, and cutting them all is an extensive tidal creek network. Each sub-environment displays different textures and sedimentary features responsive to variations in hydrodynamics, with different organic and carbonate contents.

The fundamental sedimentary structure is tidal bedding, which consists of sand-mud couplets. Interpretation of the tidal bedding suggests: (1) The thicknesses of, and structures in, both mud and sand layers of each couplet vary systematically downwards in cores and profiles. Variations are mainly due to differences in current speed and tidal range, to neap-spring differences, and to the possible effect of 'filtering' of currents in the intertidal zone. (2) The patterns of sand-mud couplet thickness variations reflect two main tidal cyclicities: diurnal inequality, and the neap-spring-neap tidal cycle, which is in turn related to the lunar cycle. (3) The mud layer of each couplet represents deposition from suspension at times of tidal slack (no 'ebb' mud during low water), whilst the sand layer is deposited by asymmetrical bidirectional tidal currents in either the ebb or flood half of a tidal cycle. (4) The tidal regime inferred from these couplet variations is a mixed, predominantly semi-diurnal regime, comparable to the present tidal regime.

The recent development of the tidal creek network, analysed from air photos, suggests that the dispersal of tide and wave energies, associated with storm surges, into the tidal creeks is chiefly responsible for their development. Not only do creeks themselves show vigorous erosion, but they also cause considerable reworking of intertidal sediments during their migration.

THE GEOLOGY OF ICE SCOUR

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ABSTRACT

In contemporary Arctic and Antarctic polar and sub-polar seas, icebergs drifting in oceanic and wind-driven currents may impinge upon the seafloor in water depths up to and occasionally exceeding 500m. Where seafloor sediments are unconsolidated the ice keels penetrate and plough forward creating curvilinear iceberg scour marks that are commonly tens of metres wide, 1-2m deep and often several hundred metres (or even several kilometres) long.

Icebergs may come into contact with the seabed in one of two ways. They may drift onto shoaling bank top areas, scouring or grounding occurring as draft exceeds water depth. Alternatively they may increase their draft by unstable roll, caused by combinations of ablation, minor calving events, or as the result of splitting of tabular icebergs that may cause large increases in draft. During the period of iceberg-seabed interaction, which may last from a few minutes to several days or even years, both the seabed and iceberg keel undergo modifications.

When observed from submersible soon after their formation, scour marks that are developed in fine-grained sediments exhibit morphological characteristics not seen in old, degraded scour marks. The flat-bottomed trough of a new scour mark, between two berm ridges, is characterised by the presence of ridge-and-groove microtopography (up to 30cm relief) developed parallel to the scour mark axis. These features are formed at the trailing edge of the keel by clastic material embedded in the ice and by open fissures in the ice. In places along the inner berm margins ridges and grooves may be developed at an angle to the scour mark axis reflecting lateral displacement of material towards the berm as the iceberg moves forwards. Pits up to 1m deep and 2m wide occasionally truncate the ridges and grooves. Pits are formed by the dissolution of small (a few m³) masses of debris-laden ice that were mechanically broken off from the base of the keel and pressed into the seabed by the scouring iceberg. Depressed areas within the scour mark trough may preserve seafloor that has not been affected by ice/seabed interaction. In these regions deposition of bulldozed sediment from the surcharge at the leading edge of the keel may partially fill the narrow voids developed between the seabed and the keel.

Scour mark berms consist of *in situ* fractured but intact blocks of material on the inner flanks, and disarticulated blocks 1-2m high along the berm crest. The outer berm slopes generally consist of pieces of larger blocks spalled from the berm crest resting in relatively finely comminuted, reworked material. The reworked material originates in the leading edge surcharge before being displaced to either side of the keel. Scour mark berms have irregular topography ranging in height from a few centimetres to as much as 6m above the seabed.

Excavations through Quaternary-age scour marks developed in clays of glacial Lake Agassiz reveal intense reworking of the lakebed to depths of at least 5m beneath the deepest part of the scour mark trough. Horizontal thrust faults and low angle normal faults are found beneath the scour marks. Scour-induced displacements of at least 3.5m have occurred along the polished and slickensided surfaces of low angle faults. Fine laminae are generally obliterated by the scouring event, and chaotically-arranged, dislocated fold hinges are seen in the reworked groundmass.

Structures associated with contemporary small-scale scour marks from tidal flats of the St. Lawrence Estuary and Cobequid Bay are well developed and easily seen because of well-developed sedimentary layering. Some of the structures are compared with similar structures from a large-scale scour mark, and similar deformation mechanisms are implied.

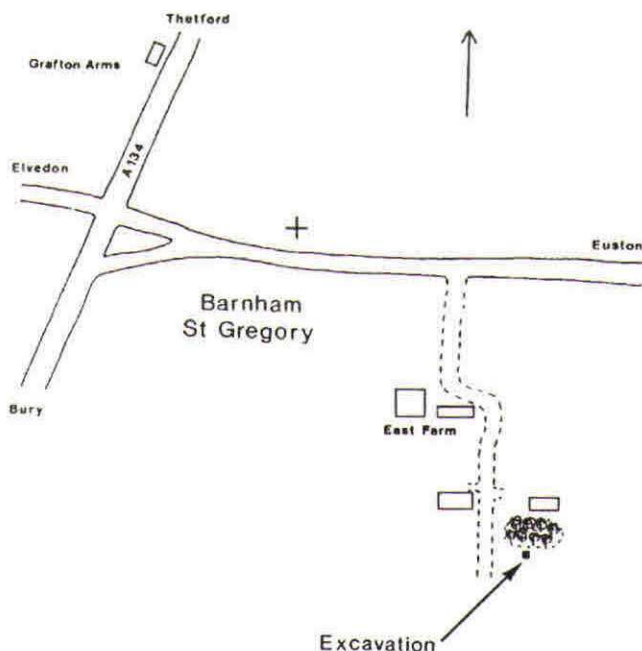
Relict scour marks occur over large areas of high-latitude and polar seafloors, therefore it can be reasonably extrapolated that iceberg scouring in Quaternary glaciomarine sediments has been an important process over a considerable extent of the global oceans. Ice scour is likely to have been important in pre-Quaternary glaciations, and thus its effects should be preserved in lithified sediments. Although such lithified features as bedding plane striations have in rare instances been tentatively assigned a drift ice origin, scour marks have been recognised recently from only two localities in the world, and ice keel turbate facies have not been described at all.

Scour marks and ice keel turbates remain invisible to enquiry because the characteristic types and associations of structures unique to scouring have not been recognised in the context of formation by floating ice. This thesis presents descriptive criteria that should enable workers to recognise the effects of ice scour.

NOTICES

1. OPEN DAY - EAST FARM, BARNHAM, SATURDAY AUGUST 14th

Excavations at the Lower Palaeolithic site at East Farm, Barnham are uncovering both biface and non-biface assemblages associated with a rich fauna. The geological work together with the biostratigraphic and dating evidence suggest that the deposits can be attributed to the interglacial stage immediately after the Anglian. The open day will be held on **Saturday August 14th at 3.00 pm** and will give visitors the opportunity to see the site and view the artefacts. The site is situated 2 miles south of Thetford (TL875787).



Nick Ashton
Prehistoric & Romano-British Antiquities, British Museum

2. PAST, PRESENT AND FUTURE OF UK PALAEOCLIMATE RESEARCH

The NERC Special Topic "Palaeoclimate of the Last Glacial / Interglacial Cycle" was launched in 1989 (see *Quaternary Newsletter* 65, p.22), and most of the investigations funded by that special topic have now been completed. Other projects relating to palaeoclimate objectives have also been funded by the main NERC Research Grants Committees during the same period. Last year the equivalent of around 13 NERC Research Studentships (relating to some 21 topics) were made available for a 1992 start on Quaternary investigations (see *Quaternary Newsletter* 67, p.83). Of these around $7\frac{1}{2}$ awards (for 13 topics) went to 'non-Q'(uota) departments. This year, for a 1993 start, there are around $12\frac{1}{2}$ awards (for 19 topics) for Quaternary (mainly palaeoclimate-related) investigations going to the 'non-Q' departments alone. Opportunities in the 'Q'(uota) departments are additional to these, although this year it is almost impossible to quantify exactly what these are from the publicity material available. It therefore looks as if the Special Topic has provided an additional stimulus for research in this field, or, alternatively, it has conveniently coincided with a period of increased interest in these matters in general.

Some early results of the NERC-sponsored Palaeoclimate research has been illustrated in NERC News (October 1992), and it is anticipated that further results will be included in NERC News for June 1993. Meantime another NERC initiative in palaeoclimate research has emerged in the form of the TIGGER (TIGER with an additional G(eo) component) programme. First allocations were announced in NERC News (January 1993).

In September 1993 an open QRA meeting, "Palaeoclimate '93", will be held at Durham University to present the results of the Palaeoclimate Special Topic research, and the first results of the TIGGER investigations. Through Supplementary and Poster Sessions it will also provide the opportunity for anyone, with anything to say or present on palaeoclimate-related matters, the opportunity to present their own results. It is hoped that through discussions at the meeting the way ahead for palaeoclimate research by the UK Quaternary community can be even further developed and enhanced.

Details of the "Palaeoclimate '93" meeting, and a Booking Form for it, were contained in the QRA Circular for February 1993. Booking Forms should now be returned as soon as possible.

Brian Funnell
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3. TILL MICROMORPHOLOGY: A TECHNICAL WORKSHOP

has been arranged to examine the making, description and interpretation of thin sections of glaciogenic deposits

18-24 September 1993

-at-

Fysisch Geografisch en Bodemkundig Laboratorium
University of Amsterdam
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ORGANISERS:

Dr Jaap J. van der Meer
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Prof John Menzies
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Prof Jim Rose
Department of Geography
Royal Holloway, University of London
Egham, Surrey TW20 0EX
Fax: 44 784 472836

Cost: DFL 750

Accommodation will be at
Internationaal Centrum of the Koninkelijk Instituut
voor de Tropen, Amsterdam

For further details, please contact one of the above organisers at the earliest opportunity, or before 30 June 1993 at the latest

4. INTERNATIONAL CONFERENCE ON THE LAST GLACIAL / INTERGLACIAL TRANSITION

Quaternary Research Association,
IGCP-253 Termination of the Pleistocene / North Atlantic Seaboard
Project
Joint Association for Quaternary Research

Wednesday May 4th 1994
at the Geological Society of London,
Burlington House, Piccadilly, London

As announced in the February 1993 *Circular of the Quaternary Research Association* an Open Meeting of IGCP 253/NASP will be held at the Geological Society on Wednesday May 4th 1994 to present and evaluate current research on the Last Glacial / Interglacial Transition.

The speakers will be:

Geoffrey Boulton (Edinburgh) - Glacial Responses
Eduard Bard (Marseilles) - Ocean Responses
Sigfurs Johnsen (Copenhagen) - Ice Sheet Responses
John Lowe (London) - Biological Responses
Jan Mangerud (Bergen) - North European Responses
Jim Teller (Manitoba) - North American Responses
Chalmers Clapperton (Aberdeen) - South American Responses

The meeting will begin with coffee at 10.00 and the final session will end at 17.45.

A Registration Fee of £10.00 is payable (£5.00 for research students and unwaged) and this should be sent to Prof. Jim Rose, Department of Geography, Royal Holloway, University of London, Egham, Surrey, TW20 0EX, UK. Cheques should be made payable to 'RHBNC'. Further details can be obtained from Jim Rose at the above address (Tel: 0784 443807, 0784 443564, Fax: 0784 472863) or Dr. Alistair Dawson (Tel: 0203 838556, Fax: 0203 221608).

On the following day (Thursday May 5th) at the same venue, the Geological Society will host the annual **William Smith Lecture** and supporting programme. The William Smith Lecturer on this occasion will be **John Kutzbach**, and the topic will be **Modelling Late Quaternary Climatic Change**.

The combined Registration Fee of £20.00 (£10.00 for research students or the unwaged) for both the IGCP 253/NASP Open Meeting and the William Smith Meeting can be accepted on a single cheque if preferred.

5. MODELLING LATE QUATERNARY CLIMATIC CHANGE

Geological Society of London,
Quaternary Research Association
Joint Association for Quaternary Research

Thursday May 5th 1994
at the Geological Society of London,
Burlington House, Piccadilly, London

As announced in the February 1993 *Circular of the Quaternary Research Association* the William Smith Lecture of the Geological Society for 1994 will be given by Dr. John Kutzbach on the topic of **Modelling Late Quaternary Climatic Change**.

Speakers also on the programme will include
Allayne Street Perrott
Bill Ruddiman
Warren Prell
John Mitchell
Sylvie Jouselle

The meeting will begin with coffee at 9.30 and the final session will end at 16.45.

A Registration Fee of £10.00 is payable (£5.00 for research students and unwaged) and this should be sent to Prof. Jim Rose, Department of Geography, Royal Holloway, University of London, Egham, Surrey, TW20 0EX, U.K. (Cheques should be made payable to 'RHBNC'). Further details can be obtained from Jim Rose at the above address (Tel: 0784 443807, 0784 443564, Fax: 0784 472863).

On the preceding day (Wednesday May 4th), at the same venue, the Geological Society, along with the Quaternary Research Association and the Joint Association for Quaternary Research, will host the open meeting of IGCP 253 /NASP to present and evaluate current research on the Last Glacial /Interglacial Transition.

The combined Registration Fee of £20.00 (£10.00 for research students or the unwaged) for both the IGCP 253 /NASP Open Meeting and the William Smith Meeting can be accepted on a single cheque if preferred.

6. NATURAL ENVIRONMENT RESEARCH COUNCIL: RADIOCARBON LABORATORY (NERC RCL)

In November 1990 *Quaternary Newsletter* 62 published a brief statement by Dr. Donald Sutherland, then Chairman of the NERC RCL Steering Committee, outlining the role of this Radiocarbon Laboratory and setting out the procedures for making application for radiocarbon dates. Over the past three years:

- i) the demand for radiocarbon dates has increased, especially by AMS,
- ii) quality control has become more stringent with regard to both methodology and science,
- iii) procedures and funding sources have changed slightly.

This note aims to bring the 1990 document up to date and set out the current procedures in order that the Environmental and Quaternary community may use this important facility efficiently and to the greatest effect.

The NERC Radiocarbon Laboratory

The NERC RCL, at the NEL Technology Park at East Kilbride is a national facility to provide radiocarbon dates for Environmental and Quaternary research carried out by British and collaborating scientists. Dr. Douglas Harness is the Director of the Laboratory. Radiometric determinations and AMS target preparation are carried out at East Kilbride. AMS determinations are obtained through contract with a laboratory elsewhere, using the targets prepared at the RCL. Currently the contract is with the Arizona AMS Facility, University of Arizona, Tucson, USA.

The Laboratory has state-of-the-art liquid scintillation counters, a newly purchased mass spectrometer and is currently setting up new target preparation lines. These developments are part of the process by which the Laboratory has increased the number and the accuracy of samples that can be processed and the number of $\delta^{13}\text{C}$ determinations that can be carried out. It has also allowed the assay of smaller samples than was previously possible. The new target preparation facility is part of the response to increased demand for AMS determinations.

The NERC RCL Steering Committee

Access to the services of the Laboratory is through the Radiocarbon Laboratory Steering Committee (RCL-SC). Because the Laboratory is a national facility

funds are provided, in the majority of cases, through NERC by way of a core grant or through links to research studentships, research grants or other funding initiatives (*ie* Special Topics). The terms of reference of the Steering Committee are to maintain academic standards with respect to Environmental and Quaternary Science and maintain efficient use of this national resource by recommending appropriate and efficient sampling designs and method of determination.

Despite the recent developments outlined above, demand continues to exceed capacity and available funds. It is necessary, therefore, to manage access and this is done on the basis of scientific merit. This approach has the advantage of increasing the degree of interaction between the Laboratory and the users and this is considered crucial to maintain the science at the forefront of the subject area. Indeed, it is believed that if the laboratory were simply a provider of radiocarbon dates, without the constraints of either scientific merit or finance, the quality of research with which it is involved would most probably decline, and the present high reputation of the Laboratory would be affected.

Application procedures

The scientific merit of a particular application is judged solely on the basis of the evidence presented to the RCL-SC. All applications should be made on a Project Application Form (NSS.A3/9), and applicants are requested to give particular attention to all the questions set out on this document. Failure to do this will almost certainly lead to a request from the Committee for additional information.

Questions 1-9 are very brief and require factual information, such as the title of the project, personnel involved, numbers and types of determinations required, timing, other relevant research, and any links, or otherwise, with NERC and other funding sources. Most of this information can be written directly on the application form.

Question 10 is concerned with the scientific case, and this information is submitted as a separate document. This information should be self-contained, but succinct. The following points should be addressed:

- 1) background, giving the scientific context of the project (and site(s) if appropriate). Diagrams should be used where possible to show the provenance of the samples, and the relationship of each sample to the stratigraphic unit from which it was taken.
- 2) methodology used for sampling and history of sample since collection.

- 3) programme of research.
- 4) justification for the number of analyses required. Each sample (or group of samples if appropriate) should be identified and justified separately. It is very important that each sample should be numbered and located clearly on maps, and diagrams (ie sediment logs or pollen diagrams) when the project has geographical or stratigraphical relevance.
- 5) wider justification.
- 6) details of related dates in existence or that have been applied for.
- 7) research experience of investigator.

Where AMS dating is requested, this must be justified in terms of factors such as sample size, or time required to carry out a radiometric determination. For instance: i) stratigraphic precision may require a very small sample; ii) very small pieces of terrestrial material may be needed to avoid hard water contamination; iii) small samples for AMS may significantly reduce cost by cutting freighting charges or reducing the time the liquid scintillation counters are in operation for radiometric determination of samples that are at the older end of the radiocarbon range.

Application from research students must be made through their supervisors. It should be noted that a successful NERC Training Award does not mean that the applicant will have preferential access to RCL facilities. The Steering Committee is fully aware of the time pressures imposed on research students by the three-year funding terms and all effort is made to give these applications priority once they are recognised as having sufficient scientific merit. With regard to applications related to studentships, it is worth noting that valuable time is often lost due to a poorly designed submission which fails to provide all the necessary information. In case of doubt, applicants are encouraged to contact the Radiocarbon Laboratory for advice.

Potential users are encouraged to write to the Laboratory setting out their intention to apply for dates on a future occasion, giving a brief outline of the nature of the research and the number of dates likely to be requested. This enables the Laboratory to plan ahead and contact the applicant should problems be envisaged.

All applications should be made to the RCL-SC through the Secretary to the Committee (Brian Miller) at: NERC Radiocarbon Laboratory, NEL Technology Park, East Kilbride, Glasgow G75 0QU, Fax: 0355 289 829, Tel: 0355 260 037.

Funding sources

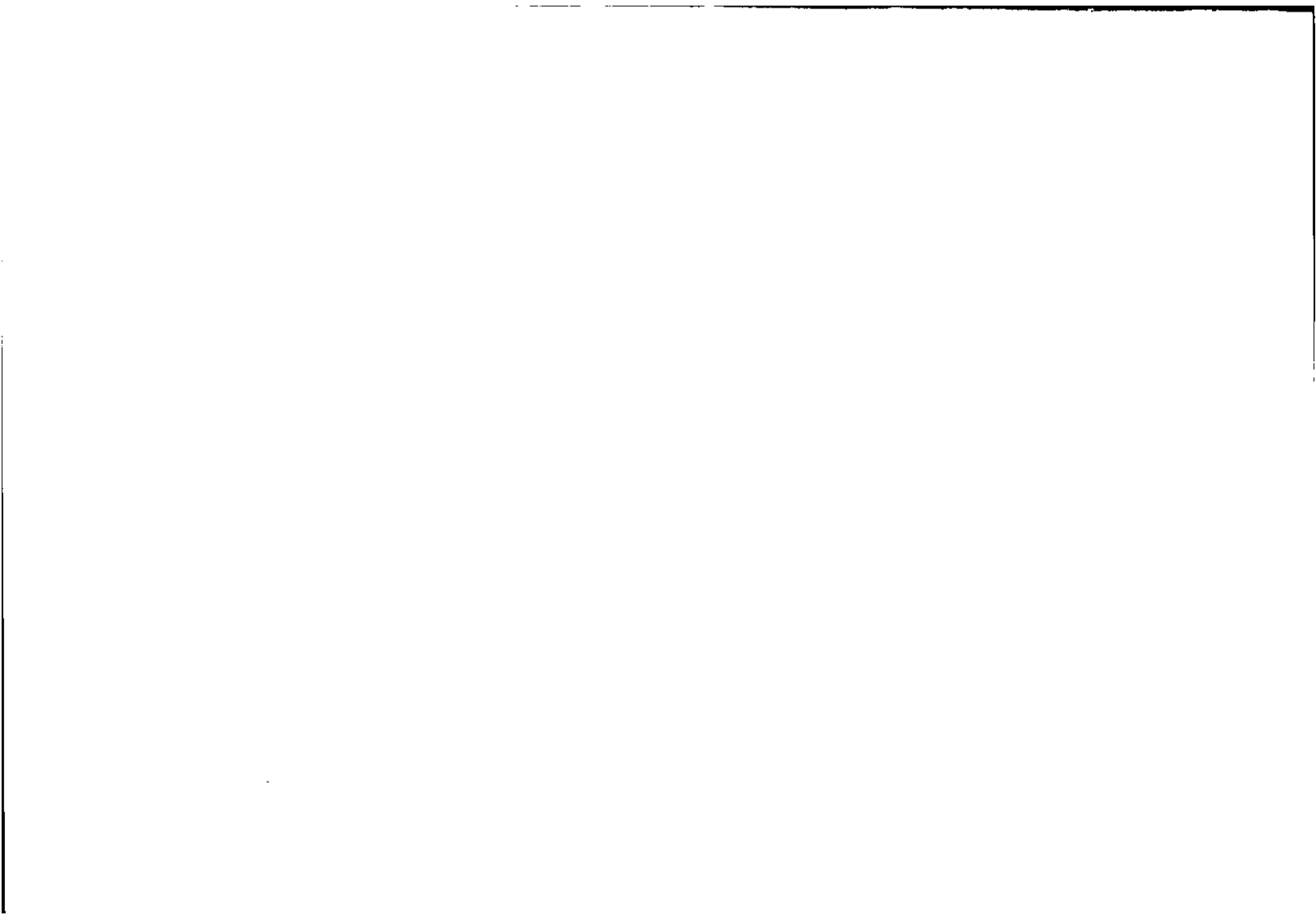
Essentially, the cost of all analyses carried out at the East Kilbride Laboratory are covered by NERC through the Scientific Services budget. Hence the cost of radiometric dates, $\delta^{13}\text{C}$ determinations and target preparation is provided by NERC subject to successful review by the Steering Committee.

The entire cost of ^{14}C AMS dating is normally provided by NERC Scientific Services to those applicants requiring determinations linked to a NERC supported award (Studentship, Research Grant or Special Topic), with funds coming from the appropriate grant awarding source. In normal circumstances, other applicants for AMS dating should apply for supplementary funding, such as through a NERC Small Grant, to cover the cost of accelerator beam-time.

Wider role of NERC Radiocarbon Laboratory

The NERC RCL and its Steering Committee exist to facilitate the pursuit of good quality Environmental and Quaternary science. It is expected that dates provided will be published, although on receipt of results a 'comment' suitable for inclusion in the Laboratory's official date list should be submitted to the Secretary. Additionally, copies of all publications using the dates should be sent to the Laboratory. Enquiries or visits to the Laboratory are welcomes, and can be related to any aspect of radiocarbon analysis. In particular, research students who wish to use the results of radiocarbon assays for the first time are strongly encouraged to visit East Kilbride and arrangements should be made with Brian Miller, telephone: 0355 260 037.

Jim Rose,
Chairman, NERC Radiocarbon Laboratory Steering Committee
May 1993



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 *ca.* 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 and unwaged 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. Short 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 October; the *Journal of Quaternary Science* published in association with Wiley, and with four issues a year, the monograph series *Quaternary Proceedings*; the Field Guides and the Technical Guide series.

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

President: *Professor G.S. Boulton FRS:* Grant Institute of Geology, University of Edinburgh, West Mains Road, Edinburgh EH9 3JW

Vice-President: *Professor W.A. Watts:* Provost's House, Trinity College, Dublin 2, Ireland.

Secretary: *Dr. M.J.C. Walker:* Department of Geography, St. David's University College, University of Wales, Lampeter, Dyfed SA48 7ED, Wales.

Assistant Secretary (Publications):

Dr. D.R. Bridgland: 41, Geneva Road, Darlington, Co. Durham DL1 4NE

Treasurer: *Dr. J.E. Gordon:* Scottish Natural Heritage, 2, Anderson Place, Edinburgh EH6 5NP

Editor, Quaternary Newsletter:

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

Editor, Journal of Quaternary Science:

Dr. P.L. Gibbard: Subdepartment of Quaternary Research, Botany School, Downing Street, Cambridge CB2 2TF

Publicity Officer: *Mrs H. Davies:* Pharm House, Neston Road, Willaston, South Wirral, Merseyside L64 2TF.

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.



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