The Biology Curator

Title: A Summary Of The Care & Preventative Conservation Of Sub-Fossil Bone For The Non-Specialist Or Pleistocene Problems -The Sub-Fossil Scenario

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Source: Andrew, K. J. (1996). A Summary Of The Care & Preventative Conservation Of Sub-Fossil Bone For The Non-Specialist Or Pleistocene Problems -The Sub-Fossil Scenario. *The Biology Curator*, *Issue 5*, 24 - 28.

URL: http://www.natsca.org/article/815

The matter would then have to go to a UK (or possibly a European) court, but the onus would be on the present owner to prove that they obtained it legally. In the event of the court ordering the return of the object then the 'possessor' can claim compensation, although I suspect this would then lead to another court case in the returnee country and probably would be a waste of time.

What should we do about it?

I recommend all curators get a copy of this Convention, and make sure your director and/or committee chair sees a copy. I printed mine off from the World Wide Web, but all the Area Museum Services should have copies available. The BCG Committee will be asked to discuss the Convention, so please let us have your views. It may be necessary to follow the American lead and start lobbying MPs and Ministers to see that they are fully aware of the possible consequences for the cultural life of this country should they gaily ratify the Convention as it stands. In view of the international importance of this matter it may be a time when we should collaborate with both our European counterparts, where they exist, and with SPNHC, to ensure that common sense prevails.

THE ALTERNATIVE 'BEETLE DOWN' LEAFLET

The scurrilous leaflet reproduced in this issue had a mercifully limited circulation some years ago; mercifully limited because had it gained widespread credence it might have stopped all those nice people who come to see us bringing interesting things like the elephant hawkmoth caterpillars without which no curator's day is really complete. Just think, if these so welcome visitors were to stay away we would have to fall back on doing boring things like fieldwork or research to fill our time – yukk!!

A SUMMARY OF THE CARE & PREVENTATIVE CONSERVATION OF SUB-FOSSIL BONE FOR THE NON-SPECIALIST OR PLEISTOCENE PROBLEMS – THE SUB-FOSSIL SCENARIO :

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Introduction

This paper is intended as a summary of the formation, occurrence and conservation problems associated with sub-fossil bone for the non-specialist working on British collections with suggestions for preventative conservation.

The text was first produced as a talk followed by a demonstration of conservation packing techniques for the Biology Curator's Group meeting in Chester in February of 1995. The demonstration showed a number of techniques for mount making, developed from conservation packing techniques learnt at the Horniman Museum (Watkinson, 1987) and at a CCI mount making workshop lead by Carl Schlichting.

Since presenting this paper, two relevant publications have become available. The CCI Technical Bulletin no 14 "Working with Polyethylene Foam and Fluted Plastic Sheet" (Schlichting 1994), is an excellent and well illustrated description of tools, materials and methods for mount making, based on the workshop. "The care and conservation of Palaeontological Material" edited by Collins (1995) includes a chapter by Shelton & Johnson on "Conservation of sub-fossil bone", describing the formation processes of sub-fossil bone in detail and current and historical aspects of excavation, preparation and conservation treatments.

Definition of sub-fossil bone

Sub-fossil bone is bone that has been weathered to some extent and then buried. Following burial, some of the mineral part of the bone (hydroxyapatite) and some of the organic content of the bone (including the structural protein, collagen) are leached away, the amount of leaching depends on the burial conditions, leaving a weakened bone perhaps saturated with hygroscopic salts. Sub-fossil bone is closer in appearance to modern bone than fully mineralised bone.

In true fossilised bones the organic content is replaced with apatite or calcite leading to a very heavy solid specimen with cancellous areas normally filled with mineralisation. True fossilised bone breaks smoothly, modern bone breaks to leave a fibrous surface. Sub-fossil bone breaks without leaving a fibrous surface but is not mineralised, broken surfaces are easily worn down during deposition.

Age

Sub-fossil bone is found in deposits of Quaternary age, the period made up of the Pleistocene which began about 3 million years ago and ended about 10,000 years ago and continuing into the Holocene, from 10,000 years ago to the present day. Since excavated Holocene material is nearly always the realm of archaeologists, this paper will deal with bone of Pleistocene age.

Q	Holocene	Fens & Levels
U A T E R	Upper Pleistocene	Kent's Cavern Kirkdale Joint Mintnor Barrington Raised beaches
R N E	Middle Pleistocene	Swanscombe Cromer Tills Cromer Forest Beds
R Y	Lower Pleistocene	Weybourne Crag Dove Holes Cave Norwich Crag Red Crag

Table 1 – A simplified table of Quaternary deposits

Types of deposit and species found in British museum collections

Sub-fossil material from the Lower, Middle and Upper Pleistocene, a period that included both warm interglacial and cold glacial periods is found in British museum collections. Typical Pleistocene deposit names include Drift, River Terrace, Raised Beach, Till, Cave Earth, Cromer Forest Beds, Norwich & Red Crag. (See table 1)

Bone from the Red Crag and older deposits are normally partially mineralised and therefore do not exhibit typical sub-fossil bone conservation problems. Problems only seems to develop in specimens from the Norwich Crags of the Lower Pleistocene and younger deposits.

The following animals are commonly represented in British deposits; hyaena, cave bear, wild boar, mammoth,

straight-tusked elephant, southern elephant, woolly rhinoceros, hippopotamus, horse, auroch (*Bos primigenius*), red deer, giant Irish deer and fallow deer. Only larger vertebrates are represented in the average museum collection, the majority appear to be the result of chance finds from gravel pits or eroding sea and river cliffs. Small mammals were certainly present in the Pleistocene but rarely seem to be systematically collected outside the larger museums. However, museums with excavated material from caves such as Kent's Cavern and Windy Knoll tends to contain a wider representation of species.

Sub-fossil species are represented most commonly in the following order, as limb bones, teeth, antlers, tusks, vertebrae, jaws with teeth, complete skulls with teeth or antlers or both and very occasionally, as complete mounted skeletons, however these are normally composites. In other words, bones, antlers and teeth or tusks. In exceptional circumstances, horn and hair can be preserved and in permafrost conditions, complete frozen bodies, for example the frozen Siberian mammoths and Blue Babe a frozen bison from northern Canada. The later of these types of material are rarely found in British collections, although bones from the recently extinct Moas of New Zealand are occasionally present.

Conservation problems encountered with sub-fossil bone

Conservation problems can be categorised as follows into the following agents of deterioration:

unsuitable relative humidity / physical damage / pollution – i.e. dirt

Effect of unsuitable RH on specimens

Since sub-fossil material retains an organic content and is normally anisotropic, being made up of layers of enamel and dentine or cancellous and compact bone, storage at the correct and stable relative humidity is important in order to prevent damage. The worst-case scenario for sub-fossil material is a rapidly fluctuating relative humidity with a change of more than 10% over a day. In these conditions, the organic and inorganic constituents of the bone and the differently mineralised parts of the material respond unequally to the RH change. The specimen will therefor develops stresses leading to cracks along growth lines and the boundaries between different types of material these will open and contract and propagate further with the RH fluctuations, causing the specimen to fall apart. Display case lighting, where light fittings or starters for fluorescent tubes are inside the cases can cause these types of fluctuations within cases where lights are switched on and off every day.

Older collections: Dry sub-fossil bone is best stored at between 50 and 60% relative humidity with as little daily fluctuation as possible, serious damage will result if the specimen is exposed to conditions below 40% RH. Storing specimens inside containers and cupboards will buffer the extremes of RH variations in the storage room.

Williams (1991) describes the effects of low relative humidity on bat teeth, no damage occurred above 50% RH, but as the relative humidity dropped below 50%, teeth began to develop cracks and splits, the canines being the most sensitive. This is certainly borne out if the teeth of modern mounted animals are inspected – very few will have un-cracked canines.

Recently collected specimens: Recently collected specimens are most at risk from damage due to sudden drying out. A specimen when first collected will normally be saturated with salt-bearing water and could generate a relative humidity in a closed environment as high as 90%. If such a specimen were brought into a centrally heated museum, it could suddenly be exposed to relative humidity in the low 30s, causing cracks and splits to develop. The types of damage likely to develop, and all too often found in conservation surveys are as follows:

Tusks: outer layer peels back and falls into strips, inner dentine core breaks up into small rhombs.

Teeth: delaminate and splits along enamel/dentine layers, dentine occasionally warps

Bones: split and warp.

If relative humidity changes are less sudden but severely fluctuating, salt crystals will move to the surface or crystallise out along cracks and can also cause the specimen to break up. Day(1989) and Koob (1984).

Prevention of relative humidity related damage in newly collected material: A freshly collected specimen from a water logged environment (especially salt-water) will need to be soaked in several changes of clean water to remove as many water soluble salts as possible. Keeping the item in water will also prevent drying out although it can make the item loose structural strength and become rather weak and squashy as the collagen component swells when saturated with water. After washing, the specimen should be wrapped in wet acid-free tissue and plenty of polythene and passed on to a conservator.

If the specimen is not soaking wet, it should be wrapped in acid-free tissue and thick polythene as this will allow the specimen to generate a microclimate of the correct relative humidity inside the wrapping. It should then be passed on to a conservator.

If a conservator is not available, complex treatments, especially of larger groups of bones, should not be attempted. However, in order to avoid the type of damage described above from rapid drying of the occasional specimen, a slow drying technique using a humidity tent is described here. If at any point cracking or warping starts to develop, a conservator should be consulted.

A humidity tent is essentially a large bag of thick polythene constructed around some kind of rust-proof framework, taped up with masking tape. The specimen is sealed inside the tent with a dial hygrometer to check relative humidity. If the relative humidity drops suddenly, additional moisture can be introduced into the tent by using shallow containers of water with a cotton wool wick to encourage evaporation. See Figure 1. Drying out will take several months, probably up to a year for a large tusk.

During recent conservation of two large tusks, nylon electrical tie wraps spaced at 5cm intervals have been used successfully to prevent distortion during drying, they are also useful for securing slivers of the outer layers of antlers or teeth from lifting away from the body of the specimen. (see figure 1) Drying under pressure is not a new idea, older collections often contain tusks bound with copper wire or jubilee clips and elephant teeth encased in tightly fixed wire or waxed string. Although the specimen may have cracked, binding seems to prevent serious distortion. Nylon tie wraps have the added advantages of being easy to adjust and tighten during drying, they do not corrode in high humidity and are fairly easy to remove and re-use.

Figure 1. A humidity tent containing a large tusk, bound with nylon tie wraps

Physical damage

Many sub-fossil bone specimens are large and difficult to store in conventional storage units. Because of the awkward nature of such specimens, they are often left on open shelves or on the floor, leading to physical damage such as abrasion and breakage.

Specimens that are not completely flat will, when placed on a flat surface, rest on only three points, the effects of gravity will be transmitted through these points and can lead to crushing or fracturing (Fitzgerald, 1989 for 1987). It is therefore important that specimens are supported across the whole of their base.

Prevention of physical damage using mounts and supports: Small specimens are best supported in acid-free tissue nests (Watkinson 1987) or plastazote cut-outs inside acid-free card trays. (see figure 2). Plastazote cut-outs can also be used in larger low-acid boxes or drawers, (see figure 3). Large specimens are best supported on carved mounts made from plastazote layers held together with standard adhesives, hot-melt adhesive or a hot-air glue gun, (see figure 4) the thickness and density of foam required can be calculated using the CCI packaging slide rule (Strang 1990). Where the volume of plastazote needed becomes un-economic, bean bags made from Tyvec or un-bleached washed calico and filled with plastazote scraps or polystyrene packing beads can be useful (see figure 5).

"Storage of Natural History Collections: Ideas and practical solutions" ed. Rose & de Torres 1992 describe a range of storage methods, including corrugated plastazote drawer dividers and form-fitted palettes. Sclichting (1994) is highly recommended for mounts using combinations of polyethylene foams and plastic sheet. Plastazote, Ethafoam, Correx and Coroplast are the equivalent UK tradenames.

Whatever solution is arrived at for mount making, the materials used must have good long-term ageing properties in order that they will not degrade or harm the specimen. Suitability can be checked by consulting the CIN materials database, where tests undertaken by institutions such as CCI on adhesives and other materials are available for consultation. "Materials in Conservation" (Horie 1987) is a useful guide to adhesives and consolidants, a one week Institute of Archaeology summer school is also available on this subject. A conservator should be able to give advice or carry out the Oddy test (Blackshaw & Daniels, 1978). The following table lists materials to avoid and possible alternatives.

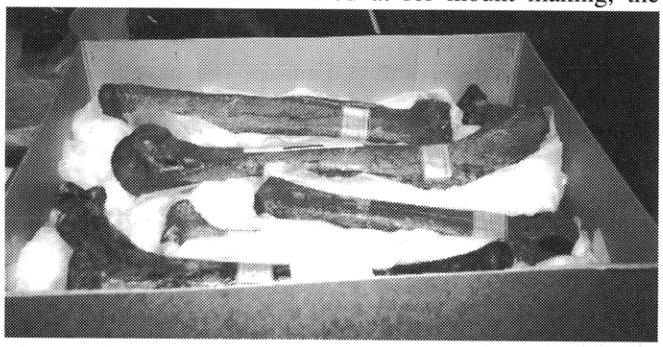

Figure 2. Moa bones re-packed into acid-free tissue nests in a low-acid box for Worcester Museum & Art Gallery

Material	Problem	Alternative
Acidic paper & card	Embrittles & shatters	Acid-free paper, low acid card
Polyurethane foams	Degrades to sticky granules, burns with toxic fumes	Polyethylene foams
PVC Plastics	Yellows and gives off chlorides	Polyethylene, polypropylene, polystyrene plastics
Cotton wool	Clings to specimens, difficult to remove	Acid-free tissue nests, plastazote foam
Commercial adhesives	Formulae change without warning	Conservation grade adhesives

Table 2 – materials to avoid in collection storage

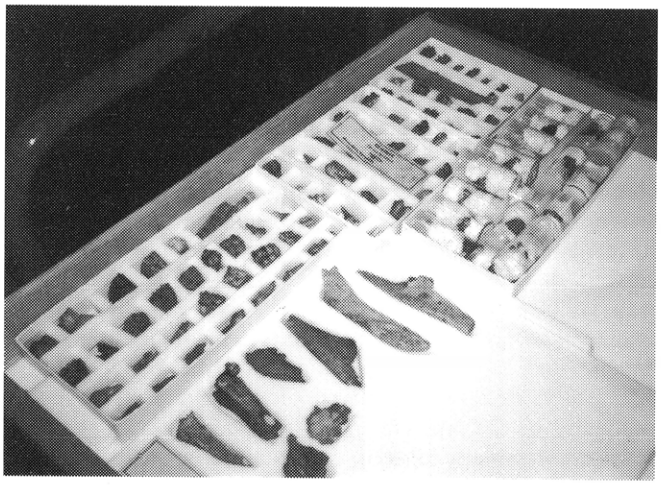

Figure 3. Plastazote cut-outs in specimen trays and a drawer at Bolton Museum

Dirt

The best way to deal with dirt on specimens is to prevent its build up in the first place. Good housekeeping in museum stores can prevent dust from becoming a problem but specimens must also be protected from dust. This means storing specimens in lidded boxes inside cupboards with doors, or if the specimens are large, making extensive use of dust sheets and dust curtains on open shelves. The best materials to use for dust sheets are washed, un-bleached calico and spun-bonded polyethylene (Tyvec). Both can be cut and easily sewn up with a sewing machine to the desired shape. Velcro is an ideal fastener for dust sheets and dust curtains.

Cleaning specimens: Removing loose dry dust from robust specimens is a task that can be carried out by collection staff. Dust should be brushed off the specimen with a soft paint brush (a 1 inch domestic paint brush is ideal)

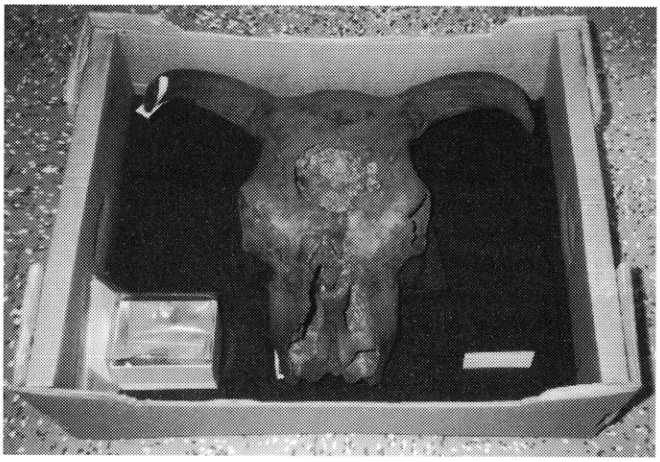

Figure 4. Carved plastazote mount held together with hot-melt glue for Kettering Museum.

and into the nozzle of a small vacuum cleaner. The vacuum cleaner nozzle should be covered in fine netting to prevent any dislodged pieces from being sucked in. The combined soft brush and vacuum cleaner system demonstrated during the BCG visit to Leiden Museum to clean the bird collection was a modification of this system. The National Trust Manual of Housekeeping (Sandwith & Stainton 1991) contains examples of cleaning procedures.

Wet cleaning is not to be recommended for the non-specialist, one cleaning method, solvent or detergent is not equally applicable to all types of bone, teeth or antler. Wetting old very dry sub-fossil bone, and probably also older osteology collections is not to be recommended, it can lead to a rapid increases in volume and consequent dramatic splitting. The solubility of adhesives must also be considered.

If cleaning of entire collections is required, a planned programme of collection maintenance or conservation work should be able to attract grant aid for a conservator. Alternatively, a conservator could supervise a programme of work undertaken largely by volunteers after training.

A brief summary of conservation treatments

Most older collections of sub-fossil bone tend to have been consolidated as a matter of course. Consolidants were often organic, in time, these degrade to a yellow or brown coating, often brittle and peeling off in flakes along with a thin layer of the underlying bone. The advent of artificial polymers provided a huge range of alternative consolidants, often with such a low glass transition temperatures that a thick layer of dirt has later sunk into the degraded coating. Some coatings stay moderately soluble and are not too difficult to remove,

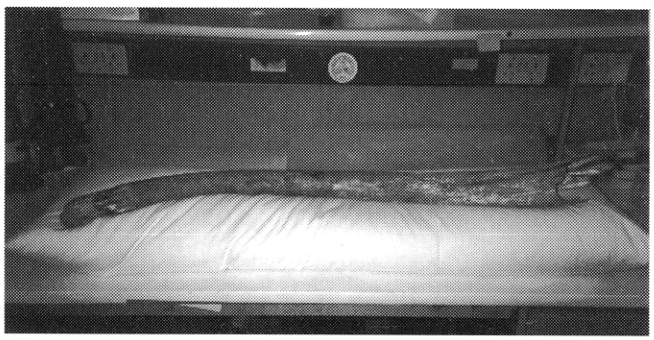

Figure 5. Calico and polystyrene bead bean-bag mount for a large tusk from Audley End House

others are more problematic such as the misnamed "soluble nylon" or thickly applied PVAcs, it is rare that a treatment record exists for consolidated specimens.. Howie (1984 & 1995) gives a summary of materials used to conserve fossil specimens and suggestions as to their solvents, these is a useful guide when faced with a specimen and no record card.

Unless an old treatment is actively damaging the specimen, or is deemed unacceptable from an aesthetic point of view, removal may be too difficult to warrant the attempt. However, where breaks need to be repaired, removal of the surrounding consolidant may be necessary to facilitate the new repairs.

The almost universal application of consolidants to sub-fossil bone suggests that consolidation has in the past been thought of as the means to mitigate and even prevent damage caused by the effects of poor storage conditions. If specimens can be protected from the agents of deterioration, particularly those discussed above, i.e.. incorrect relative humidity, physical forces and pollution, consolidation should only be necessary in special cases. It should be remembered that consolidants are all organic molecules and will therefore distort the effects of carbon 14 dating and may make the bones unsuitable for other types of test.

Techniques for consolidation are described in Doyle 1983 & 1987, Koob 1984 and Pearson 1992 but are best left to specialist conservators.

Conclusion

Most conservation problems with sub-fossil bone can be avoided if standard preventative conservation techniques are used to remove the risks of damage from the agents of deterioration, in particular by improving specimen support through good storage mounts, prevention of dust accumulation and regulation of relative humidity. Major improvements can be made in this area by curators and volunteers using simple cleaning techniques, minor repairs with conservation grade adhesives and the packing techniques described in the references cited. A humidity tent will enable non-specialist staff to undertake slow drying of the occasional accession of a newly collected specimen. All other conservation tasks are best undertaken by specialist conservators.

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Watkinson, D. (1987) ed. *First aid for finds*. 2nd edition. Rescue and UKIC Archaeology Section. pp 114

Williams, S.L. (1991) Investigation of the causes of structural damage to teeth in natural history collections. *Collections Forum*, 7(2)

Sources & suppliers

Specialist items

Paraloid B72 – two manufacturers produce this adhesive in tube form:

"Conservation Adhesive, Stephen Koob's formula" by Conservation Resources, Pony Road, Horspath Industrial Estate, Cowley, Oxford OX4 2RD Tel 01865 747755

HMG Paraloid B72 adhesives, (available direct from HMG and also from Conservation Resources, there seems to be some confusion in the CR catalogue between the cellulose nitrate and Paraloid versions of HMG products).

Plastazote and other polyethylene foams – currently manufactured by a subsidiary of BP, museum-sized quantities sold through a network of suppliers, several example below:

Polyforms, Cherry Court Way, Leighton Buzzard, Beds LU7 8UH Tel 01525 852444

Plasmar Ltd – Neachells Lane Wednesfield, Wolverhampton, West Mids. WV11 3QG Tel 01902 307711

Bury Cooper Whitehead Ltd, Hudcar Mills, Bury, Lancs., BL9 6HD Tel 0161 764 2262

Birmingham Rubber & Plastics

Low-acid boxes

W.Clarke & Co, Birmingham 0121 692 1512

G. Ryder & Co Ltd. Denbigh Road, Bletchley, Milton Keynes, Bucks MK1 1DG 01908 375524

Acid-free card trays with clear acetate lids

W.Clarke & Co, Birmingham 0121 692 1512

Acid-free tissue paper

Any good paper supplier including:

Faulkener's Fine Papers, 76, Southampton Row, London WC1B 4AR Tel 0171 831 1151

Atlantis European Ltd, 146 Brick Lane, London E1 6RU Tel 0171 377 8855

Correx/ Corruplast

Henry Sutcliffe Ltd, Hulme Street, Salford, M5 4PX Tel 0161 745 7724

Corruplast Ltd, Madleaze Industrial Estate, Bristol Road, Gloucester GL1 5SG Tel 01452 301 893

Twinplas Ltd, Greycaine Road, Watford, Herts WD 4JP tel 01923 230191

Cordek Ltd, Industrial Estate, Billingshurst, West Sussex RH14 9EY tel 01403 78383

Tyvec – Spun-bonded polyethylene

WM Supplies UK Ltd, Park Mill, Royton, Oldham, OL2 6PZ – 0161 624 5641

Un-bleached calico – small quantities from fabric shops, larger amounts from

Items easily available in the high street

Olfa craft knives – available from good craft and art shops, cheaper copies are not as good.

Olfa self-healing cutting mats – same source as above

Hot melt glue guns – mine is made by Arrow (about £20) and came from a hardware shop, less sophisticated models sold in DIY shops.

Hot melt glue sticks – commonly available from hardware & DIY shop .

Hot air gun – Black & Decker paint stripping gun (about £25), more sophisticated models have variable heat control and a selection of nozzles, sold in DIY and hardware shops.

Nylon electrical tie wraps – available if a variety of lengths, sold in small packs in car part shops and in larger quantities at Maplin.

Overseas Publications:

CCI Technical Bulletin no 14 & CCI Packaging slide rule. Available from CCI, 1030 Innes Road, Ottawa, Ontario, K1A 0M5, Canada Tel 010 613 998 3721

CIN database: available via subscription and modem, UK contact, the Conservation Unit, Museums & Galleries Commission, 27 Queen Anne's Gate, London. Likely to be available on the Internet soon.

SPNHC storage book: available through SPNHC, Preservation Equipment Ltd, Church Street, Shelfanger, Diss, Norfolk IP12 2DG Tel 01379 651 527 should also import it.

CONTACTS

BCG Chairman: Mike Graham, Towneley Hall Museum, Towneley Park, Burnley, Lancs BB11 3RQ. (tel 01282 24213)

BCG Secretary: Steve Thompson, Scunthorpe Museum, Oswald Road, Scunthorpe DN15 7BD (tel 01724 843533)

Monitoring collections at risk: Mike Palmer, Liverpool Museum, William Brown Street, Liverpool L3 8EN.

Membership details etc: The Treasurer, Ms Kathie Way, The Mollusca Section, The Natural History Museum, Cromwell Road, London SW7 5BD. (tel 0171 938 8892)

ISSN 1355-8331

Published and printed at Northern Whig Ltd., 107 Limestone Road, Belfast, BT15 3AH.