GEOLOGICAL CURATOR

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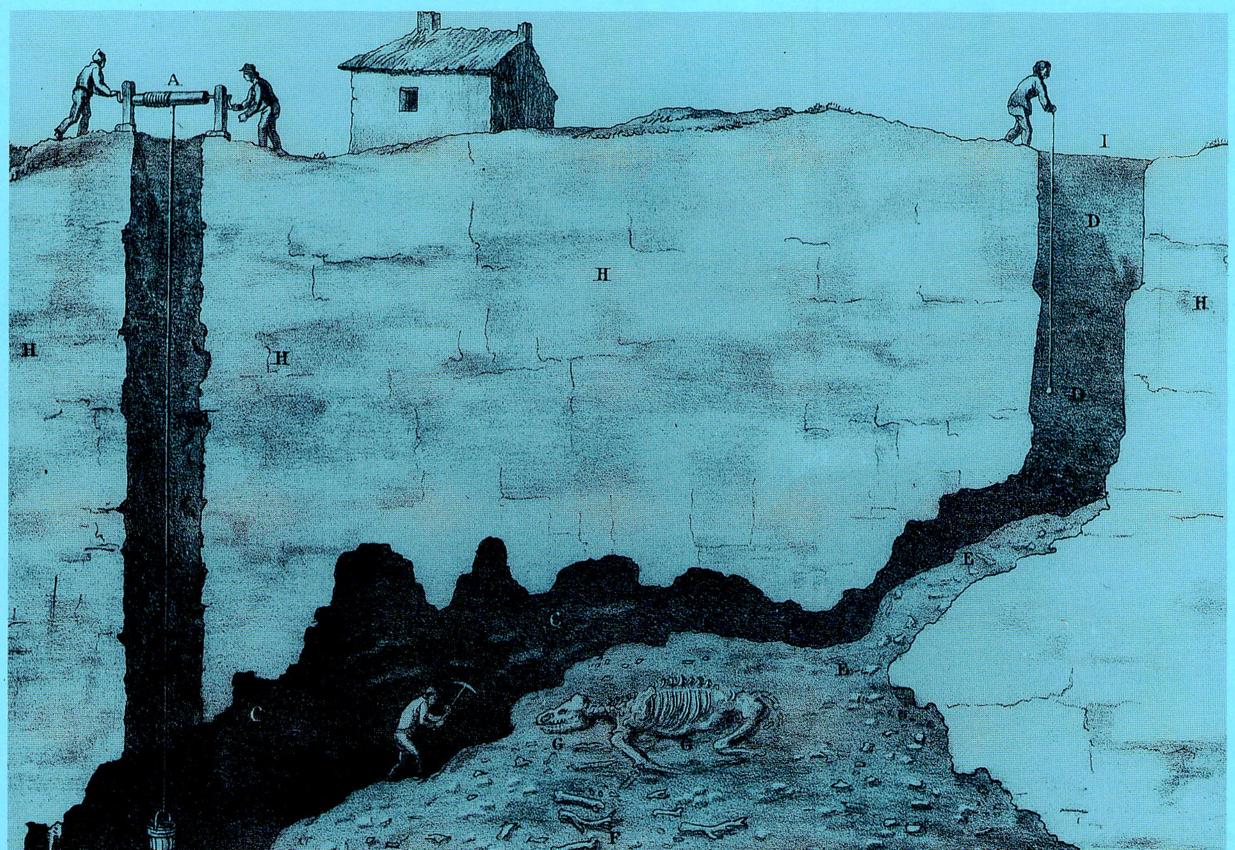

GEOLOGICAL CURATORS' GROUP

The Group is affiliated to the Geological Society of London. It was founded in 1974 to improve the status of geology in museums and similar institutions, and to improve the standard of geological curation in general by:

- holding meetings to promote the exchange of information
- providing information and advice on all matters relating to geology in museums
- the surveillance of collections of geological specimens and information with a view to ensuring their well being
- the preparation of a code of practice for the curation and deployment of collections
- the advancement of the documentation and conservation of geological sites
- initiating and conducting surveys relating to the aims of the Group.

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Cover: Cross-section through cave in the Dream Lead Mine, Derbyshire (from Buckland 1823). See article by Simon Knell on 'Palaeontological excavation: historical perspectives' (pp. 57-69).

THE GEOLOGICAL CURATOR

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GEOLOGICAL CURATORS' GROUP - October 1994

EDITORIAL

This issue of *The Geological Curator* contains seven papers, one note, one contribution to an inovative column *Fact File* as well as *Lost and Found* and book reviews.

Six of the papers were presented at the GCG meeting *Museums and Fossil Excavation* held in Scunthorpe in December 1992, and organised by Simon Knell. This thematic set has been edited by Simon and myself.

The paper by Nora McMillan represents the culmination of a persistant search that began in 1960. Through the *Lost and Found* column Nora managed to track down the nineteenth century Pleistocene shell collection of Mary Hannah Ffarington. Nora's paper presents a modern listing of the taxa contained in this important collection which is now housed in the Clitheroe Castle Museum.

Readers will find the first contribution to a new column *Fact File* which, it is intended, will contain two to three pages of basic information on different topics, of use to the curator. The column was suggested by Nigel Monaghan of the National Museum of Ireland. The first article concerns the Eocene of Bolca, Italy which is famed for its fossil fishes. I would welcome suggestions or indeed copy for further *Fact Files*.

Patrick N. Wyse Jackson
Dublin - 17th October 1994

COLLECTING AND EXCAVATION IN PALAEONTOLOGY

by Simon Knell

Knell, S.J. 1994. Collecting and excavation in palaeontology. *Geological Curator* 6(2): 49-56.

Many existing collections no longer fulfil past functions due to the more sophisticated collecting requirements of contemporary science. The reassessment of collecting rigour has also been driven by conservation concerns. Yet museum collecting policy and practice often continue to reflect interests which are external to the requirements of science. In addition the nomenclature applied to the process of collecting is redefined according to collector objectives rather than social level; the role of the collector is divided into field collector and collection assembler; and palaeontological excavation is given extractive and systematic categories.

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Introduction

A decade ago, an enquirer would have been hard pressed to find written policies on museum collecting in geology; in a post-Registration society every museum with interests in this area has one (Museums and Galleries Commission 1988). Indeed, in the intervening period attitudes to collecting as an activity have changed considerably (Crowther and Wimbledon 1988; Norman 1992). However, whilst museums draw up local guidelines in response to these developments, national objectives for palaeontological collecting remain unaddressed. In addition, the terminology we apply to the actions of collecting, including excavation, and the roles of collectors are poorly defined. Collecting, and collections, must also be re-evaluated in terms of the requirements of the science.

Collecting and the changing needs of science

As repositories of the material evidence of contemporary science, public collections inevitably evolve an historical dimension over time. By the process of description and publication, or simply through collecting, fossils become vouchers used to re-evaluate past research or to be recycled in new studies. As such museum collections are as much archives as they are resources. However, whilst we may be able to recycle collections we have only limited powers to, retrospectively and tentatively, upgrade the quality of collecting which first brought these specimens to light. Whilst collections might appear to transcend time, their use is limited by the quality of the collecting process, which, invariably and, as science progresses, inevitably, falls below current requirements.

In a less sophisticated period poor collecting was less restrictive to collection re-use. Arkell (1939-1943) largely based his study of Corallian ammonites on museum collections; his extensive knowledge of this material in the field gave him license to make inferences about the origins of poorly localised specimens based on their form and preservation.

The systematics of rapidly evolving groups well represented in the fossil record, such as the ammonites, is now complicated by a much greater awareness of interspecific and intraspecific variation, sexual dimorphism and heterochrony (Dommergues 1990). Past collecting practice has rarely produced collections which allow contemporary scientists of this group to disentangle species. As Howarth (1992*a*) states: "It is now widely accepted that single-bed collections of ammonites need to be obtained in order to determine the amount of variation within species and to elucidate the scale of morphological differences between species. Collections from mixed horizons, where the stratigraphical relationships are unknown, are of little use for this basic step in classification". Howarth's study was based on 2,500 specimens, largely collected by himself.

More than fifty years ago museum ammonite collections played an important role in the classifications of L.F. Spath and S.S. Buckman and others; many of these collections now fail to meet the requirements of this aspect of the science. The Monographs of the Palaeontographical Society long flourished on the exploitation of fossils collected by individuals who had little pretence to science. However, in another paper Howarth (1992*b*) demonstrates that where the rigour of past collecting does meet modern needs existing museum collections can retain their role as a primary taxonomic resource even in ammonite systematics. For rare (due to poor preservation potential or site inaccessibility) and slowly evolving constituents of the palaeoflora and palaeofauna, poorly stratified finds in amateur and museum collections continue to feed the science (see, for example, Simms 1989; Donovan and Crane 1992; Weishampel *et al.* 1993).

Effective collecting means that specimens have a use beyond that intended by the field collector; if we do not collect effectively our collections will remain underused. Paul (1989) repeats the often stressed need to measure fossils into position relative to a lithological marker in a logged section and has reviewed how far the current literature (and by inference the collected specimen archive) falls short of this. "It seems that many practising palaeontologists do not record adequate stratigraphic data because they do not think that such information is useful. This is a self-fulfilling prophecy: if the data are not available they cannot possibly be of use". The acceptance of the biozone as the finest level of resolution necessary in data collection determines the courseness of interpretation with which students of palaeontological processes must be content. Most museum specimens cannot even be allocated to the zone from which they were collected.

Importance and cost effectiveness

Regardless of who undertakes the collecting, value judgements must be made regarding the relative importance of the material and data available for collection. Museums are often in receipt of specimens collected by individuals and institutions over which they have had no control. The results of these decisions are reflected in the collected resource and have long term implications for its use.

'Importance' is a key concept in the collecting process - one charged with ambiguity and preconception (Brunton *et al.* 1985; Knell 1991*b*). It is, of course, simply a derivative of science (or history, or economics, depending on your preference) acquired through the process of research and discovery. However, the fact that we protect sites supports the view that fossils have latent importance which we simply exploit and make known, and which exists before the fossil is removed from the field.

A belief in this latent potential can be enforced in the rigour of collecting and makes poor collecting an act of site vandalism (Duff 1979; Knell 1991*a*; Norman 1992). Poor collecting is also cost inefficient as the actual cost of collecting is a tiny fraction of that of keeping collections (Lord *et al.* 1989). Rather than spending less time in the field, as some managers would wish, curators can raise the cost efficiency of collections management by increased fieldwork.

Institutional policy

It has often been stated that our predecessors had better opportunities to collect; that unmechanised industry and underexploited exposures provided specimens of a quality which it would be difficult to match today. This material if it survives at all, survives in museums. Despite modern constraints of ever diminishing exposures, rigorous site protection, mechanised extraction techniques and the competition of hoards of amateur and commercial collectors, there has not been any diminution in the quality of specimens available to science. Indeed based on a greater understanding of the palaeofauna and palaeoflora, the preservational potential of fossils, new technologies for fossil extraction, and the data needs of science, we have much better opportunities for acquiring important material. Some museums are availing themselves of these new opportunities; others seem to be overly constrained by museum policy (see, for example, Crane 1980; Smithson and Rolfe 1990; Coates 1993).

The advantages of collecting policies have been articulated many times since the late 1970s (Malaro 1979). However, through use we are also beginning to understand their shortcomings. In Britain, for example, where nearly all museum provision in geology is in the public sector, collecting policy is largely a function of funding source; collecting in science is not generally controlled by the requirements of the science but by political expediency. A focus on the local is inevitable for those local authority museums which make up the backbone of museum provision but leads, nationally, to incomplete and uncohesive coverage.

When collecting policies began to be taken seriously in Britain the 'Centres of Excellence' concept of the Wright Report (Department of Education and Science 1973) still dominated thinking (Boylan 1977). These ideas were endorsed and encouraged by the GCG at this time (Geological Curators' Group 1977). Unfortunately, centres of excellence for collections never became a reality, except in the rationalisation of university geology departments, and geographical considerations have become the dominant control on collecting for many museums.

Geographical constraint prevents duplication, but if duplication can really exists in palaeontological collections is it a bad thing? Museums are also able to more effectively monitor, understand and interpret their local patch. But local interests also force museums to limit their potential. The overpowering focus on the local means that museums lose sight of their function as part of a national or international database. Rolfe

(1979) discussed the role of specialisation in collecting and tentatively suggested possible national co-operation on collecting policies. He asked whether such a goal of co-operation was Utopian? Since it never really happened to any great degree, perhaps it was. But in the cost cutting 1990s, networking has become fashionable and a few people are again starting to talk again of a national plan for museums. The centres of excellence concept does not require government intervention to become a reality. There is opportunity for the GCG to take a lead here and rather than simply strengthening major collections as the early GCG proposals suggest, such a scheme could also empower the smaller provincial museum. Giving the latter the kudos that comes with a specialist collection also gives the lever that might ensure the survival of specialist curation.

Problems arise when there is no specialist museum provision in a region or area. Which museums, for example, are collecting from the English Gault or Eocene London Clay Formation? How large, data rich or useful is this collected resource? I choose these strata because they are well known and productive, and because the fossils they produce are amongst the most unstable in museums. In my experience, this particular museum resource is much smaller than might be expected and shrinking due to specimen loss. The loss is not only to science but also to the history of geology.

It would be useful to conduct a survey, for sample groups of material, in order to determine what exists in museums, its quality and accompanying data, and which museums are now collecting in this area. Such information would provide invaluable empirical evidence for discussions concerning the evaluation of museum natural science collections planned for 1995. The data may already exist in the research community.

Institutional policy at a higher level also impinges on collecting. Museums tend to be long-lived institutions but a museum's collecting activity is defined by relatively short-lived (in terms of one person being in post) individuals. Bassett (in Rolfe 1979) raised concerns regarding changing research interests but in local authority museums the concern is more fundamental. Where a geologist occupies the position of museum natural scientist there are no guarantees regarding the future of geological expertise at these museums. It has been suggested that over time changes in the interests of those responsible for natural science collections will result in more even recording of the local environment as botanist replaces entomologist who replaced mineralogist and so on. However, there is little evidence to support this notion. Firstly, collecting opportunities are rarely long-lived - a marine reptile may be found locally once in 50 years and then be available for collection for a matter of days. Indeed what is more likely to result from these changes is the successive building and enhancement of collections followed by long periods when they are neither fully understood nor fully exploited.

So museum collecting interests in palaeontology, and indeed every other branch of geology, are not only constrained geographically but also temporally; active collecting may only take place for five years, say, in every twenty in many museums. Collecting methods will range from active high resolution field collecting to reactive acquisition of enquiries and amateur collections or non-acquisition. The highly variable resource produced will drain resources and may detract from what is important. This may not be news but we should question its desirability.

If local museums are to collect more effectively, and to act as a repositories for, palaeontological material then they must establish themselves as long term centres of excellence in both collections and staff. Whilst local interests are important collecting might be improved if museums were less rigorously constrained by geographical boundaries - the arguments against territorialism in science were well practised in the debate over the purchase of 'Lizzie' (*Westlothiana* sp.).

Another questionable mainstay of collecting policies in geology is the word 'representative' - a term so imprecise as to have little meaning. Essentially it implies the gathering of a cross-section of material reflecting the variety of species and forms, modes of preservation, stratigraphic and geographic range of local material. But given the imprecision of taxonomy and the uniqueness of every find context determining what should and should not be collected is extremely difficult. The term encourages passive collecting; it is of little use in selection.

More focused and pro-active collecting requires the formulation of research programmes - programmes of limited extent which enable the collector to build up a detailed knowledge of the material concerned. For national and university museums this approach is central but in local authority museums the word 'research' is still often misunderstood and avoided. Here it is used in its widest sense: the end product need not be a publication, it may simply be manifested in a collection - a three dimensional archive. These programmes may exist for a number of years, and reflect what is seen as important at that time, such as recording disappearing exposures or exploiting the support and interest of a professional or amateur palaeontologist.

Many local museums have developed research programmes although these are rarely stated explicitly. Between 1987 and 1992, Scunthorpe Museum maintained an active policy of collecting the fauna of the Lower Jurassic Frodingham Ironstone, a deposit unique to South Humberside, and in imminent threat of loss (Knell 1994). In 1987, after 130 years of collecting, the museum's holdings had important omissions. This was just one of a number of research projects supported by the museum at that time. Another utilised the skills of amateur palaeontologist, John Keen, in recording the vertebrate fauna of the Kellaways Sand of Lincolnshire (Brown and Keen 1991).

From an examination of the accession records, publications and correspondence of past curators it is clear that they too pursued research projects which reflected the specific needs and opportunities of their time. These included exposures which were then far more vulnerable than those of the ironstone mines. During the 1930s and 1940s, Harold Dudley actively collected from measured sections in Santon Brickpit, and Frodingham and Flixborough Railway Cuttings (Dudley 1942). The brickpit has long disappeared and the railway cuttings are now largely inaccessible. During the early 1960s Phil Powell and Phil Doughty focused their collecting on recording the fauna of the lowest Lias and Middle Jurassic, and included a particular interest in trace fossils (Doughty 1964).

Research programmes are simply a matter of focus and the development of connoisseurship skills. In the case of Scunthorpe Museum, geologists also had to function as generalist museum assistants or natural scientists. Collecting fossils was simply one very small part of the job, but this focus enabled a proactive approach to collecting.

Collectors - finders and keepers?

Records of how material has been collected are uncommon and the terminology we apply to recording the role of individuals in the collecting process is a minefield of confusion and ambiguity. Historians of the science are well aware of the liberal use of the word 'collector'. The most comprehensive attempt to assemble information on named collections in Britain, by the Collections Research Units during the 1980s, made little attempt to define the word. So we have collectors who remove material from the field for themselves or for others, collectors who redistribute material and those who simply build collections. Their roles in constructing a geological resource are very different but all are served by the term 'collector'.

The collecting process is involved and complex, but there are essentially two main activities involved in creating natural science collections. These are undertaken by what might be termed *field collectors* (finders) and *collection assemblers* (keepers). In each case these could be a single person, a group or an institution; they may be the same person, group or institution.

The field collector determines the collecting methodology - what, and how, material and information will be removed from the field and what will be left behind. The collection assembler decides what is added to, and removed from, the collection; he/she also determines how the collection is to be managed and handed down to successive collectors. Both actions require connoisseurship.

The distinction between the two processes is important but rather less clearcut than the above would suggest. Field collectors may be directed by those responsible for assembling the collections, who in return might supply motivation and support in the form of money and resources. Gideon Mantell, is a good historical example: "Drove to Cuckfield, and endeavoured to obtain some fossils from the quarrymen who have been employed by me so many years; but the ungrateful scoundrels refused to let me have one, having found a customer on the spot" (Mantell, 12th December 1830, in Curwen 1940).

The crucial element in determining the quality of an assembled collection is the connoisseurship involved in acquiring the material - yet the collection so assembled may not bear the name of the person who supplied this expertise. As curators we have generally determined what our institutions have collected during our time in post - we are the collection assemblers yet the collection will be referred to as that of the museum. The point is obvious but we should not be fooled into thinking that institutional policy wields more than general influence over what in detail enters the collections. Collecting is essentially about individuals, or groups of individuals, pursuing a common research project within the broad boundaries laid down by the institutional mission (see Secord 1986, for example).

It is however convenient to talk of the institution as collector or at least the focus of collecting. To some extent the distinction is one of resolution. We know, for example, that Edward Charlesworth commissioned palaeontological excavations in Hampshire and elsewhere, in order to support a trade in fossils under the auspices of the British Natural History Society, but we cannot say who collected what fossil. Charlesworth, himself probably acted as arbiter in deciding what should be sold on to subscribers. In essence the BNHS assembled a collection on the grounds of importance and more particularly, saleability. It is convenient to talk of the BNHS as a collector though this would be to gloss over the role of individuals in determining what actually left the excavation site and ended up in the collections of Lady Anne Brassey, James Cunningham and others (see Pyrah 1981; Cleevely and Cooper 1981).

Collecting stereotypes?

A further point of confusion in the collecting process is derived from the sometimes jealous rivalry and territorialism of different communities of collectors. Clemens (1988) has defined collecting according to the groups which undertake it, which in turn relates to how they earn a living. He distinguishes three types of collecting:

1. Professional collecting - that undertaken by professional palaeontologists from universities, museums and other research organisations.
2. Amateur collecting - essentially by hobbyists.
3. Commercial collecting - collecting with the objective of re-sale.

The GCG seminar on palaeontological excavation in Scunthorpe in December 1992 once again exposed often polarised and stereotypical views of these different types of collector; in particular, in the vigour with which "professional" (using Clemens' definition) palaeontologists attack the commercial fraternity. Interestingly, those museum palaeontologists who have actually worked with commercial collectors tell a very different story (Taylor 1988; 1992).

Clemens' terminology is unacceptable on two counts. Firstly, it encourages these stereotypical views of collectors; if you are an amateur geologist you will always undertake amateur collecting. Whether a collector lectures in palaeontology or studies it at weekends need have no bearing on the quality of his/her collecting. It might generally be said that amateurs make poor collections but equally there are many for whom the opposite is true. Secondly, the terminology Clemens uses is liable to misinterpretation, particularly in the UK. The loaded term "professional" is used (some would say misused) very differently in this country, being synonymous with the commercial collector.

A more appropriate and useful distinction can be made by considering the objectives of the collecting exercise. There need be no inference regarding the type of person who might undertake a particular type of collecting:

Scientific collecting

Material collected for the purposes of research, or to contribute to a collection of scientific value; collecting is undertaken in a manner conducive to maintaining the scientific integrity of the material, probably as part of a research programme. This material would also have greater educational value.

Acquisitive collecting

Material acquired with no specific scientific purpose, but simply with the goal of forming a collection.

Commercial collecting

Material gathered with a primary objective of passing it on to a second party in exchange for money or other assets.

There is no reason why these terms should be exclusive. And whilst they might most appropriately be applied to the act of field collecting they could equally be applied to the activities of the collection assembler. Curators might also argue that they collect material for educational and display purposes but the collecting process follows one of the above methods; hopefully the former but this is not always possible.

Fossil excavation - information or specimens?

Excavation is simply one collecting method available to the geologist but in the context of palaeontology it is without formal definition. It has been attributed to any field process involving the extraction of a fossil from its enclosing matrix. This vagueness can be resolved by allocating two more closely defined terms which relate to the objectives of the excavation:

Extractive excavation has the primary objective of collecting one or more particular types of fossil. The most important requirement is gathering specimens. Finds will not be accurately contextualised in three dimensions.

Systematic excavation operates at a higher level of resolution - it aims to gather specimens and scientific data by the systematic removal of rock. This may be centred around a single specimen which the excavation will attempt to place in its detailed palaeoenvironmental context. Alternatively, excavation may be undertaken with the intention of gathering information about a deposit. Systematic excavation does not restrict itself to the study of palaeontological and stratigraphic variables; rock textures, structures and mineralogy are of equal importance. The most important requirement here is gathering information.

Again distinctions between the two can be blurred. In short, systematic excavation can be viewed as the technique generally associated with archaeology (Atkinson 1949; Hirst 1976; Barker 1986); extractive excavation is essentially any *in situ* collecting, though it tends to be applied to larger scale operations.

Extractive excavation

The primary objective of extractive excavation is to disinter fossil specimens. It ranges from extracting the single small invertebrate, to an organised dig centred on a large articulated reptile or the mass collecting of specimens of any size. It is impossible to separate these activities - they are essentially the same, except in terms of potential site damage, and can produce the same kind of information.

Collecting in both geology and archaeology began with the pursuit of cabinet specimens which were exhumed by this method. It continues to form the mainstay of palaeontological collecting. In contrast, in archaeology, due to the limited nature of the resource, it is discouraged - maintained primarily by metal detecting hobbyists. Extractive excavations may begin with the chance find of a few bones of a fossil vertebrate; or result from prospecting or trenching.

Commercial collectors probably form the best known tradition in the extractive excavation of fossils. The commercial extraction of fossils is restricted to parts of the country where opportunities for profit exist; though modern commercial collectors are considerably more mobile than their nineteenth century counterparts. Vertebrate fossils achieve the highest premium and the modern commercial industry remains centred on the classic localities of Lyme Regis and Charmouth where these fossils still come to light at regular intervals. Invertebrate fossils occurring in sufficient quantities, particularly ammonites and trilobites, are also subject to commercial extraction.

Unlike science-led excavation where financial costs generate intellectual benefits, commercial extraction is solely concerned with money. As such, it is possible to summarise the commercial viability of a site, in these terms, as:

$$Vi = R\left(\frac{PQ(F-L)}{f(S)} - FH\right)$$

Where *Vi*, is the commercial viability or potential for profit of the site (£);

R is the size of the total available resource (m^3);

Q is a quality factor; a dimensionless measure of the mean aesthetic or scientific quality or completeness of the fossils contained (scale of 0 to 1; 0 = poorest quality; 1 = perfect);

F is the number of fossils found per cubic metre of rock (specimens/m^3);

L is the loss rate of specimens collected due to problems of extraction and preparation, breakage, and decay (specimens/m^3);

H is the cost of extraction and preparation - a function of the hardness of the rock and its richness in terms of specimens per cubic metre (£/specimen);

P is the maximum price a fossil of this group can achieve - a measure of the market. Price is a function of demand which here is a function of object scarcity and quality. P is then the price of a perfect and unique specimen of this type (£/specimen);

f(S) is a function of scarcity - the rarer and more in demand the fossil, the higher the price possible. Rarity alone is not a factor - there must also be a market. The relationship between price and scarcity is probably not linear. S is the number of specimens known; if $S = 1$ then $f(S) = 1$; if $S>1$ then $f(S)>1$.

Systematic excavation

Systematic excavation in palaeontology mirrors the excavation method of modern archaeology. Indeed, with only superficial modification, the definition of the latter given by Bahn (1992) provides a perfectly workable definition for palaeontology (italics are mine): *The recovery of geological data through the systematic exposure of strata.* Excavation is destructive to any site, and is thus accompanied by a comprehensive recording of all material found and its three-dimensional *context.* As much material and information as possible must be recovered from any 'dig'. A full record of all techniques employed in the excavation itself must also be made, so that future *geologists* will be able to evaluate the results of the work accurately. Excavation is also costly. For both these reasons, it should be used only as a last resort. Excavation can be either partial, in which only a sample of the site is investigated, or total. Samples are chosen either intuitively, in which case excavators investigate those areas they feel will be most productive, or statistically, in which case the sample is drawn using various statistical techniques in order to ensure that it is representative. An important goal of excavation is a full understanding of a site's stratigraphy, which refers to the vertical layering of a site. These layers, or levels, can be defined *lithologically, biologically (e.g. zones)* or arbitrarily (e.g. 10 cm levels). *Systematic excavation in geology differs from other forms of collecting in that it maintains an interest in the three-dimensional context of the data.*

The primary objective of museum field collecting is to add information, in the form of specimens and records, to the collection. Collecting needs to be undertaken in such a manner that as much as possible of the object's original context is retained. Supplementary materials might also be collected for the purposes of contextualising the specimen. The required dataset can be found in Brunton *et al.* (1985)

The geographical and stratigraphic data which give the specimen its spatial context are generally considered particularly important. As museum collections demonstrate all too well this information can be collected at various resolutions. In recording the position of a fossil, practice in geology differs considerably from that in archaeology. Archaeology attempts to maintain the highest possible level of resolution in all three dimensions; geologists tend to lay particular emphasis on stratigraphic context. Stratigraphic relationships are ideally recorded at the highest possible resolution - against a measured section and relative to a reliable stratigraphic marker horizon. The geographical position, and other contextual information, is generally recorded in far less detail even by those who put considerable effort into localising the find stratigraphically.

There are a number of reasons for this:

- Palaeontologists and others are interested in collecting species for limited purposes - taxonomic description, stratigraphic record, display, 'representative collection'. The full dataset is almost limitless - the data collected are those which seem most useful to the project in hand. The need to collect wide-ranging contextual information has been recognised particularly in Pleistocene palaeontology and stratigraphy were teams of experts are involved in the examination of limited extent and availability.

- Many unworked sections are also of limited extent and are seen as being static in space and time; their progressive erosion is extremely slow. The face we see today is assumed to be the face seen by geologists 50 years ago or at least sufficiently so as not to make any difference. The data uncollected in the past remains to be collected today.

- Most fossils are collected from extensive marine deposits which appear to demonstrate little lateral variation over distances of hundreds of metres or kilometres. Where lateral variation in lithology is quite pronounced it may be necessary to typify particular lithologies and their associated faunas. There appear to be no benefits in accurately geographically localising every find.

- A large amount of material entering museums is collected from fallen or blasted blocks, as well as slumped and weathered faces. In these circumstances *in situ* information may be impossible to determine.

- Most sections consist of two dimensional vertical faces which limit the refinement possible in recording lateral relationships.

- Future workers wishing to understand lateral variations in the fauna will wish to undertake their own fieldwork; they will be interested in comparing their own groups of variables. Museums can only collect for current purposes not in the hope of predicting future needs.

There are, however, circumstances when an accurate record is required in all three dimensions and maximum effort is put into recording the full geological context. It is then that systematic excavation techniques are employed (see other articles in this issue).

But surely a time must come when the additional effort in localising a find is not worthwhile? The processes which deposited the bed will determine the maximum possible resolution. Taphonomists have made some interesting studies in Recent marine environments in order to discern the maximum level of temporal resolution of preserved faunas. Flessa *et al.* (1993) have shown that bivalve shells can survive for hundreds of years in the marine environment, where they are regularly exhumed and mixed with later shells. This is termed time-averaging. Mixing also takes place within the sediment due to biogenic agents. To prevent overlap they suggested sample spacing of approximately 0.5 million years for the environment they were studying in Mexico. Obviously in collecting we need to be aware of these constraints, but shouldn't this information be used to constrain interpretation and not data capture?

Future collecting

The purpose of this paper has been to provide context for the discussion of excavation in this issue and to attempt to clarify the terminology which surrounds the processes of collecting and excavation. As a primary and most fundamental activity of museums, and despite the wholesale adoption of policies, palaeontological collecting in Britain remains uncoordinated and at times unnecessarily parochial. Is it not a nonsense that the fluctuating geopolitical landscape of the late twentieth century should determine the record we make of and for the science? Palaeontology does not recognise national, let alone county or borough boundaries; so why should museums be thus constrained?

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PALAEONTOLOGICAL EXCAVATION: HISTORICAL PERSPECTIVES

by Simon Knell

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Palaeontological excavation is common in a limited number of contexts. The techniques used in the excavation of caves were established in the nineteenth century by Buckland, Pengelly and Dawkins and others. Whilst this approaches modern method it was operated within the confines of inductive science prevalent at the time. Open-site excavations of Pleistocene remains began in spectacular fashion with the investigations in American of Peale. The philosophical societies of Yorkshire also pursued their own local research projects which resulted in the early excavation of a marl pit at Bielbecks. Modern methodology is epitomized in the excavations at Rancho La Brea. The excavation of the exceptional fauna of Messel, and of dinosaur sites worldwide, shows the development of techniques chosen to meet local needs. Excavation of the Frodingham Ironstone exploited a unique resource of invertebrate fossils and demonstrates the merit of the technique in exposing rare elements in the fauna and the potential of professional collectors in building public collections using these methods.

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Introduction

Excavation has long been exploited as a technique for the extraction of *in situ* fossils. It has been used in connection with sedimentary rocks and palaeontological material of every age and type, but has found particularly widespread application in a fairly limited number of circumstances. These include the investigation of Pleistocene terrace and cave deposits; localities producing fossil vertebrates; and sites rich in fossil invertebrates displaying exceptional preservation. A detailed review of the use of excavation in these contexts is beyond the scope of this paper, but a survey of past practice provides useful insights into excavation objectives and methodology.

Cave excavation

Among the deposits which have been subjected to systematic excavation perhaps most numerous are those associated with caves and rivers. There are a number of possible reasons for this:

- In the nineteenth century, cave deposits raised questions regarding the association of human remains with those of extinct mammals. Such questions could only be resolved through the systematic excavation of cave earths (see below). In more recent times, these remains have also attracted the interest of archaeologists and anthropologists for whom excavation is the normal mode of investigation and collection.

- The rarity of the material, and the limited extent of these deposits, makes necessary the accurate contextualisation of finds. Again, this is often only possible through systematic excavation. While many early excavators had no qualms about digging out entire deposits, the importance of making a proper record was recognised by the middle of the nineteenth century.

- The search for vertebrate fossils places particular importance on the association of the component parts of the skeleton; excavation makes possible a full understanding of the taphonomic context of articulated or partially disarticulated vertebrate fossils.

- The lack of a natural vertical section in these deposits implies excavation by one means or another. Often these deposits are only revealed through commercial extraction of sand or rock (see, for example, Home 1817; Bishop 1982). The largely unconsolidated nature of these sediments makes them amenable to excavation.

- Being of fairly recent origin, fossil finds can often be placed within the context of the contemporary landscape which itself may have changed only superficially. The latter may supply comprehensive indications of the geomorphological processes and environmental factors which created the preserved deposit.

- The structure of these deposits is often strongly three-dimensional; a full understanding of the stratigraphy

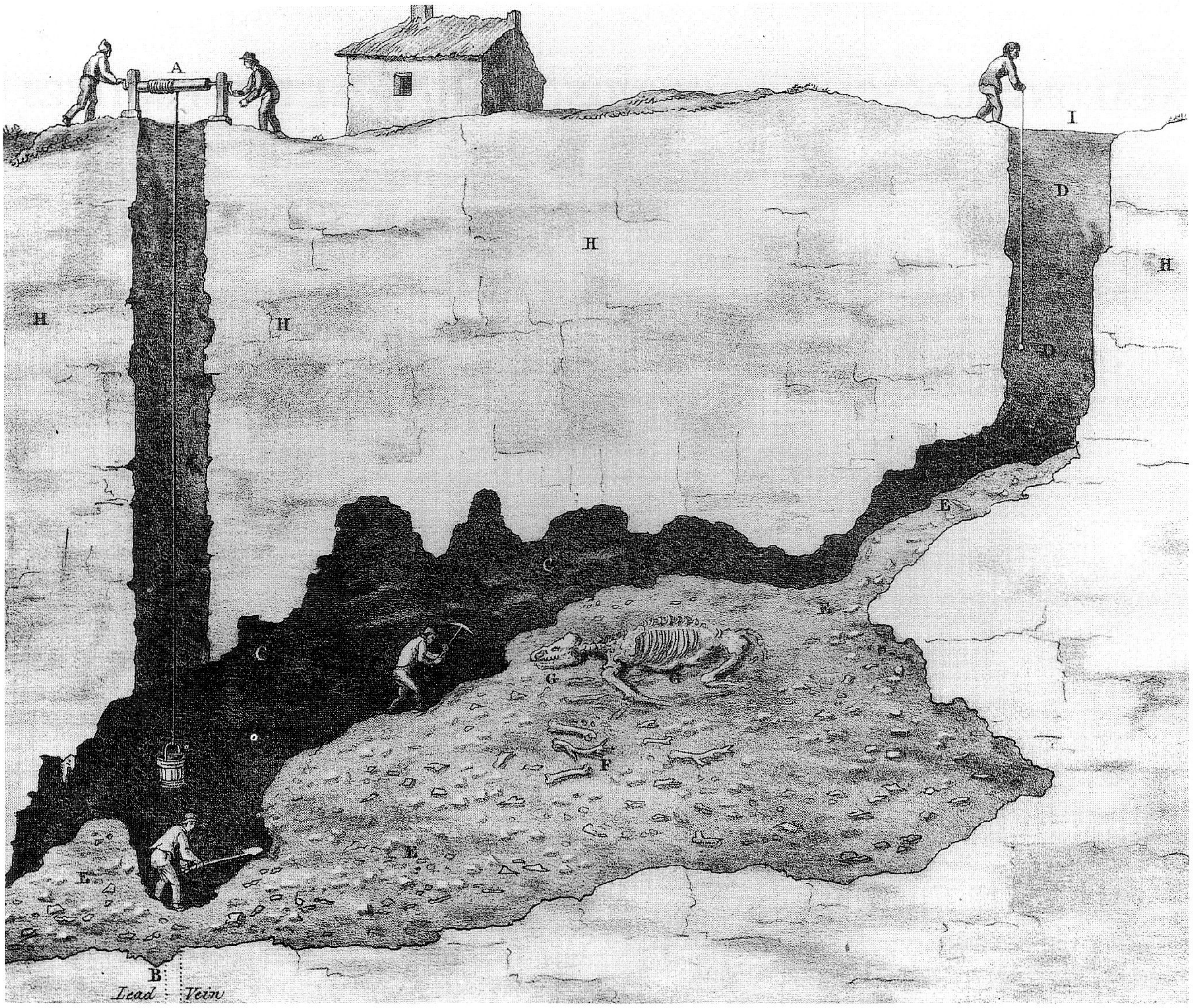

Figure 1. Dream Lead Mine, Wirksworth (from Buckland 1823). The gentlemen geologists of the nineteenth century employed workmen to excavate the finds. Pengelly, Dawkins, Buckland and others gathered the necessary facts by inspecting the sections and the material which had been extracted.

requires the investigation of both vertical and lateral change. By comparison, the older marine deposits, which have provided the bulk our fossil collections, are of considerable extent and demonstrate little significant lateral variation (Ager 1973).

Cave exploration was already well developed in Europe, and particularly Germany, by the time William Buckland (1784-1856) produced his remarkable interpretation of material found in Kirkdale Cave in Yorkshire in 1821 (Buckland 1822). Buckland's hyenas became a national sensation. A year later his already extensive knowledge of the caves of Britain and Europe became the focus of his seminal *Reliquiae Diluvianum* which stimulated a wave of interest in what is now called Pleistocene palaeontology.

Joseph Banks had already instructed Whitby to preserve bones found in caves exposed during the quarrying of rock for the Plymouth breakwater in 1816. Home (1817) gives a detailed account of where the fossils were found and some indication of the techniques used in excavating them: "The cavern was quarried within about a foot of its bottom, the lower clay was not all cleared out, but the bottom was sounded by an iron crow, as rock was everywhere met with". The use of probes to find bones or the extent of the deposit was common throughout the nineteenth century.

The primitive excavation methods of earlier workers can be discerned from the state of deposits in known caves. The cave at Gailenreuth, which Buckland visited in 1816, for example: "The bones of bears, that lie loosely scattered over the surface of the stalagmite, and even on the outside of the cave's mouth, are rejected fragments that have been dug from beneath it, or from the lower cavities; and they are mixed with the recent bones of dogs, sheep, foxes &c. that have entered in modern times by the open mouth" (Buckland 1823).

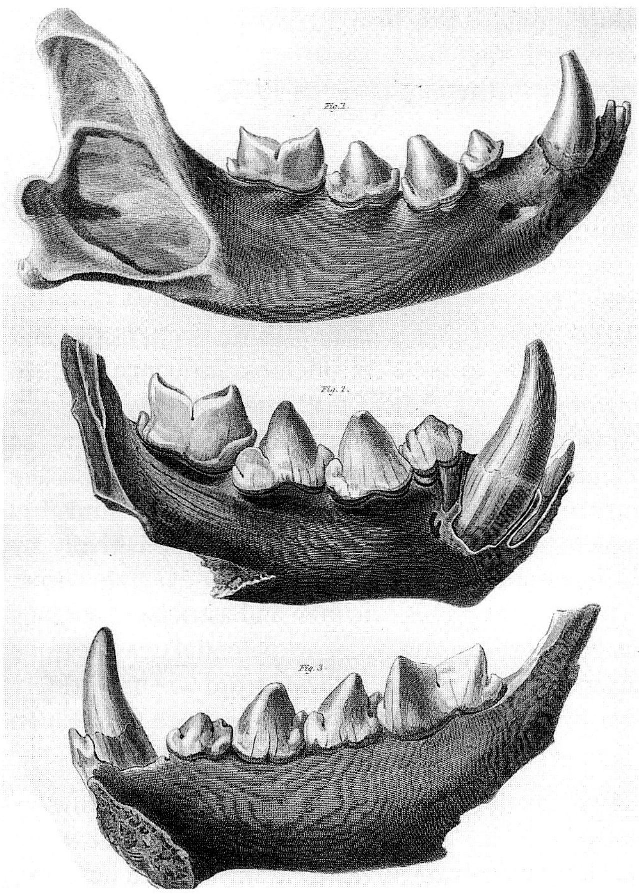

Figure 2. Comparison of a modern Hyena jaw (top) with one from Kirkdale Cave (centre and bottom) (from Buckland 1822). Buckland and his contemporaries used techniques which were sufficient for them to answer the major questions of the day. Now we want to know more but the deposits which produced these finds have largely been lost.

The importance of undisturbed remains to the understanding of the faunal history of caves was well recognised. Buckland's descriptions attempted to isolate different periods in each cave's history; they also give an indication of the objectives and investigative methods of the time.

Pengelly and Kent's Cavern

In terms of the refinement of cave excavation technique the work of William Pengelly (1812-1894) is particularly noteworthy. His exploration of Kent's Cavern near Torquay is probably the best documented palaeontological excavation of the last century. Not only did it generate voluminous accounts in the annual reports of the British Association for the Advancement of Science (BAAS) but its chief investigator also thoroughly documented the history of these and previous researches at the site (Pengelly, 1868-1884). Kennard (1945) also provides much useful information on the early digs there.

Kent's Hole or Cavern had long been known and had been the subject of a number of investigations prior to March 1865 when the British Association excavation began. Best recorded of these are the activities of the Rev. John MacEnery (1796-1841), who collected material from the cave between 1825 and 1829 (MacEnery 1859; Pengelly 1869; Kennard 1945). Material from MacEnery's excavations found its way into the collections of many contemporary British learned societies. Other investigators include Thomas Northmore in 1824, who was inspired by Buckland; Walter Calverley Trevelyan (1797-1879); Buckland himself in 1825; and Robert Alfred Cloyne Austen (later Godwin Austen; 1808-1884) in 1840.

William Pengelly had previously explored the Cavern as part of a small team sent in by the Torquay Natural History Society in 1846. This brought to light some 3000 specimens. On reflection, Pengelly himself writes "it may be doubted, perhaps, that any of the foregoing explorations were conducted with that rigid observance of method which is now held to be necessary" (Pengelly *et al.* 1865). Indeed, early explorers were happy to break through the stalagmite crust and simply pull out bones from the underlying cave earth; some tunnelled under the stalagmite surface.

Despite this lack of method previous collectors were unanimous in believing that flint implements occurred mixed with the remains of extinct animals. However, proof required more rigorous methods and these were developed by Pengelly and others, under the auspices of the Royal Society and Geological Society of London, in the excavation of the newly discovered Brixham Cavern in 1858.

Speaking some twenty five years after this excavation, Pengelly stressed the need for a methodology which would produce results of long-term value: "Hence I resolved to have nothing to do with the 'trial pits' here and there, or with shafts to be sunk in selected places". Instead he developed a technique which involved the removal of strata a bed at a time. He would then have a full stratigraphic record, including dip, and information concerning "not only the different kinds of animals represented in the Cave, but also the ratios which the numbers of individuals of the various species bore to one another" (Pengelly 1897).

Pengelly was, then, already considerably experienced in cave exploration when the BAAS dig began. He had already formulated a method of systematic excavation which would allow the purely inductive analysis of the data collected. Inductivism was a creed which nineteenth century science passionately adhered to; contemporary scientists demanded methods of investigation which were seen to be free from preconceived opinion, beliefs or theory.

The vertical section through the Kent's Cavern sediments consisted of an upper layer of large limestone blocks strewn over the floor having fallen from the roof. Under these lay "black mould" up to a 30cms thick. A stalagmite breccia more than 30cms in thickness occurred beneath this, followed by the cave earth of more than 120cms. The principle bone and implement containing deposit in Kent's Cavern was the 'cave loam or earth', a deposit "without any approach to stratification" (Pengelly *et al.* 1865).

Pengelly began by examining and removing all the accessible areas of black mould. The limestone blocks were then blasted and otherwise removed from the cave. Free of the blocks, he then erected a "datum-line" - a cord stretched from a fixed point at the cave entrance to the rear of the chamber. Parallel lines were then attached at one foot intervals and drawn at right angles on either side. These divided the deposit into what Pengelly termed "parallels". The remaining black mould, which had been hidden beneath the limestone blocks, and the cave breccia, were then removed along each parallel. The cave earth, containing the most important finds, was at last revealed.

The investigation now moved from the horizontal to the vertical plane. A vertical section was cut perpendicular to the datum line at the chamber entrance. "Horizontal lines, a foot apart, are then drawn from side to side across the vertical face of the section so as to divide the parallel into four layers or 'levels', each a foot deep. Finally each level is divided into lengths called 'yards', each three feet long, and measured right and left from the datum-line as an axis of abscissae. In fine, the cave-earth is excavated in vertical slices or parallels 4 feet high, 1 foot thick, and as long as the chamber is broad, where this breadth does not exceed thirty feet. Each parallel is taken out in levels 1 foot high, and in each level in horizontal prisms 3 feet long and a foot square in the section, so that each contains three cubic feet of material".

"This material, after being carefully examined *in situ* by candlelight, is taken to the door and re-examined by daylight, after which it is at once removed without the cavern. A box is appropriated to each yard exclusively, and in it are placed all the objects of interest which the prism yields. The boxes, each having a label containing the data necessary for defining the situation of its contents, are daily sent to the honorary secretary of the committee [Pengelly], by whom the specimens are at once cleaned and packed in fresh boxes. The labels are numbered and packed with the specimens to which they respectively belong, and a record of the day's work is entered in a diary" (Pengelly *et al.* 1865).

By the end of the excavation in June 1880 Pengelly's diary contained a record of 7340 items and their eventual destinations. More than 50,000 fragments had been recovered and many distributed to contemporary scientific institutions (Holden 1979).

Boyd Dawkins

William Pengelly largely restricted his attentions to the geology of Cornwall and Devon, and showed considerable diligence in the recording of one particular site. The correspondence of William Boyd Dawkins (1837-1929) shows a more ambitious character, and one that was to have considerable influence on cave exploration and Pleistocene palaeontology. Whilst Dawkin's methods by his own accounts were as scientifically reliable as any of the time, the cave hunting fever which possessed him and his contemporaries has not been reviewed positively by subsequent workers. Ford (1977), for example wrote: "The hunt for prehistoric man and associated animals meant that every cave became a potential treasure trove and much of the archaeological record was unwittingly destroyed by the insatiable digging of such as Bateman (Thomas Bateman 1821-1861) and Dawkins".

Like Pengelly, Dawkins' writings attempt to throw his researches into a positive light. In his book *Cave Hunting* published in 1874, he was able to describe, retrospectively, his own methodology for cave exploration:

"The instruments which Mr James Parker [1833-1912], Mr [W.] Ayshford Sanford [1818-1902] and myself have found most valuable in cave-hunting, apart from the tools of the workman, are as follows:-

1. A hammer with an ash handle about twenty inches long, inserted into a square head of best steel, ending in a chisel edge in the same plane as the handle, weighing almost eight ounces, and seven inches in length.
2. A steel chisel ten inches long.
3. A prismatic compass.
4. A thermometer for taking the temperatures of the air and water.
5. An aneroid.
6. A steel measuring tape.
7. Abney's patent level which is used for laying down datum line for plan, as well as for taking the dips and angles.

The problem of accurately mapping cave systems and localising finds is particularly complex; caves have variable section and often form a three-dimensional network of passages and chambers. Dawkins used a 'datum line' threaded through the cave system as the basis for his measurements: "In making a plan we have found it useful to mark the datum line by a stout string or wire and to measure from it as the work proceeds, indicating on the sides and floor of the cave the points of measurement, with paint or wooden pegs".

The techniques used in modern cave surveys, particularly in Britain, have been developed and promoted by the British Cave Research Association (BCRA) (Ellis *et al.* 1976; Ellis 1976). They differ relatively little from Dawkin's technique. A framework for recording is based on a skeleton system of measurements which map the direction and relationships of the cave passages. This is achieved using a clinometer, compass and tape measure against a line drawn through the centre of each passage. Measurements can then be made perpendicular to this line to record detail. The BCRA system also incorporates a system of grading and a classification indicating the survey accuracy (see Table 1).

Grade	Accuracy of horizontal and vertical angles	Accuracy of distances
1	Low accuracy sketch; no measurements	
2	(Intermediate)	
3	2.5°	50 cm
4	(Intermediate)	
5	1°	10 cm
6	0.5°	5 cm

Survey detail

Class	Definition
A	All details based on memory.
B	Passage details estimated and recorded in cave.
C	Measurements in detail at survey stations only.
D	When necessary between stations to show size and shape.

Table 1. Cave Survey Accuracy (after Ellis 1976). Accuracy grading of survey centre line for surveys using magnetic compass. Where a theodolite is used the survey is X graded and its grading estimated by comparison with this table; equipment and methods used is recorded.

Similarly Dawkins' (1874) "scientific methods of cave-digging" appear not unlike those employed by modern cave palaeontologists. He describes three approaches aimed at producing finds useful to science. They all begin in the same way: "The first step to take in all cases is to make a plan of the entrance, and to cut a passage down to the rock at the entrance, so as to obtain a clear idea of the sequence of the strata."

His first approach was applied in the excavation of Wookey Hole in Somerset, which had been discovered in 1852 during the digging of a canal to feed the waters of the River Axe to a nearby paper mill. "In the hyaena-den at Wookey Hole, we first of all cut a passage through the cave-earth which extended from the roof to the floor, and then removed the earth on either side in blocks, until ultimately the chamber and passages... were cleared of their contents. Our work was measured every evening, and each bone and object found was labelled with the date which was recorded on the ground plan. Vertical sections were also taken from time to time. This mode, supplemented by constant supervision of the workmen, was sufficiently accurate to satisfy the demands of scientific research". Like Pengelly, and other cave explorers, workmen were employed to undertake the strenuous digging.

Dawkin's account of these excavations shows that he had no compunction about the total removal of the deposit. Buried within his eloquent prose the investigation shows the transition of tangible hard evidence - the *in-situ* preservation of the bones of at least 18 vertebrate species and the indications of occupation and use by both humans and hyenas - into museum collections and a tale of adventure. Between 1862 and 1863, 3,000 to 4,000 fragments were recovered. Though Dawkins made a record of the finds which was as comprehensive as any of the time, the wholesale loss of *in situ* evidence must be mourned.

Dawkins at least acknowledges the importance stratigraphy to accurate collecting; a point recognised by Pengelly and his co-workers and emphasised by modern cave palaeontologists who benefit from a superior knowledge of accumulation processes. Sutcliffe (1976), for example, suggests the excavation of a trial trench, or that a previous trench be re-excavated, in order to expose an undisturbed section. This trench is cut longitudinally to expose as much variation and structure in the deposit as possible. The key elements in further excavation are that "adequate sections must be recorded, disturbed deposits must be recognised; and finds from the various layers must be kept separate".

The demands of site conservation and the need for possible future replication of results require excavations to be of limited extent. So complete were the excavations of nineteenth century workers that there are now few opportunities to reinvestigate their work. Modern palaeontologists also differ in approach in the belief that without knowledge concerning the processes which might account for the accumulation of cave sediments the excavator cannot effectively stratify finds. "The excavation of a bone cave must be treated like a dissection; each horizontal layer, each talus cone, each burial, each burrow being examined separately, if the full history of the deposits is to be reconstructed successfully" (Sutcliffe 1976). The objective of cave excavators from Pengelly's time to the present day has been to understand the sequence of events and the association of finds. Unfortunately, the theory-free inductivism of nineteenth century workers meant that geological sections were seen as static layered deposits from which the mode of deposition might be discerned after the excavation, but that theoretical knowledge of these processes should not influence the gathering of facts.

Dawkins' second excavation method was used in circumstances where the deposits were too thick to cut a complete section. This occurred when he investigated Victoria Cave in the 1870s: "We therefore examined the superficial strata throughout the cave, merely gauging the thickness of those below by sinking three shafts. Where a cave is sufficiently high to allow of the work being carried on, it is better to clear out one stratum before another is disturbed". This was not, however, an innovation of Dawkins, Pengelly had used it during the excavation of Brixham Cavern in 1858 - an excavation which played an important role in bringing about support for exploration of Kent's Cavern.

Dawkin's third approach to cave excavation - "the most elaborate and perfect method of cave exploration" is that developed by Pengelly, and others of the BAAS committee, for the investigation of Kent's Cavern (see above). Although Dawkins promoted the systematic excavation of caves, he appears to have been happy to adapt his techniques as necessary to get results. As all scientists are aware - it is far easier to document scientific technique after the event when circumstances can be used to justify the means employed rather than establishing a mode of investigation at the beginning and sticking to it.

Open site excavations in Pleistocene sediments

Unconsolidated fluviatile Pleistocene deposits are valuable both as a resource for construction and agriculture, and as a repository of fossil remains. Inevitably exploitation for the former leads to interest in the latter. The lack of natural sections makes man-made pits of particular importance and this is as true today as it was in the earliest investigations.

The first Mastodon excavation

One of the best documented and certainly the earliest open site fossil excavation occurred in the United States at the beginning of the nineteenth century. Its leader, Charles Willson Peale (1741-1827), a successful Philadelphian portrait painter and owner of the most important and successful museum in the country, went in search of the most sensational and desirable prize then available to any American museum.

According to contemporary accounts large bones belonging to the biblical Behemoth had been know since the early 1700s (see Sellers 1980). The true identity of these bones as the remains of mastodon was only revealed following Peale's recovery of fairly complete specimens. For the museum entrepreneur looking for the ultimate exhibit, the description of the *Behemoth* (Hebrew, meaning 'beast') could have been written by a marketing agency with that very purpose in mind:

"Now think of Behemoth; he eats greenstuff like the ox. But what strength he has in his loins, what power in his stomach muscles! His tail is as stiff as a cedar, the sinews of his thighs are tightly knit. His vertebrae are bronze tubing, his bones as hard as hammered iron. He is the masterpiece of all God's work, but his Maker threatened him with the sword, forbidding him the mountain regions where all the wild bests have their playground. So he lies beneath the lotus, and hides among the reeds in the swamps. The leaves of the lotus give him shade, the willows by the stream shelter him. Should the river overflow on him, why should he worry? A Jordon could pour down his throat without caring. So who is going to catch him by the eyes or drive a peg through his nostrils?" (Book of Job 40:15).

Peale is often cast merely as a showman despite developing new techniques for the preservation and display of natural history exhibits and demonstrating a clear understanding of the knowledge that can be gained through the collecting of natural objects. He was certainly not a Phineas T. Barnum, nor was he, as Whybrow (1985) suggests, a failure. However, showmanship, or at least an ability to market his sensational finds, proved vital to the survival of his museum and eventually provided him with a comfortable living. He has also been described as an opportunist, but aren't all collectors?

Peale left an excellent record of this early expedition: his diaries, correspondence, sketches and the oil painting, *The Exhumation of the Mastodon* (1806), provide a vivid account. (Incidentally, this painting is attributed to C.W. Peale by his long-time biographer Sellers (1980) (where it is wrongly reproduced); it is correctly reproduced in Sutcliffe (1985) but is here attributed to Rembrandt Peale).

The expedition began in 1801. Hearing that a farmer had a number of large bones collected from deposits on his land, Peale sailed up the Hudson River from New York to the farm of John Masten in Ulster County. Here he found, and negotiated the purchase of, a collection of bones which Masten and his neighbours had, three years earlier, pulled from a marl pit using chains. Peale knew that a complete skeleton was required if the full potential of the discovery was to be realised - these bones were the evidence he needed to mount a full-scale excavation.

Peale returned to the site later that year and developing his own makeshift technologies to drain the pit, he and his paid excavation force of 25 eventually revealed more bones. Unfortunately, the slumping faces prevented the safe recording of the articulated bones *in-situ* and collecting proceeded in haste. These bones combined with those purchased from Masten still did not provide adequate material for a full reconstruction; most importantly the lower jaw had not been recovered. The expedition moved on, searching neighbouring sites using slender poles to probe for hard material likely to be bone. Using this method, and subsequent excavation, they succeeded in finding an additional partial skeleton which would allow a full reconstruction.

By the end of the year the Masten skeleton was mounted and placed on display; the missing parts were reconstructed using information gathered from the remains of the other skeleton. Charles' sons, Rembrandt and Rubens toured the remains of the other skeleton in England in the following year after a moneymaking exhibition in New York. Landing at Brighton, their tour included London, Bath, Bristol and Reading but to little acclaim or profit. The money making potential of exhibits such as this cannot be underestimated - a successful exhibit had the potential to raise income in excess of the costs of excavation. At this time shows of the exotic and peculiar, including touring live animals, were of great public interest. In 1834 the Zoological Society of London acquired an Indian Rhinoceros for which an entrance fee of £3 was proposed but which was reduced to one shilling in 1847 (Holloway 1976). In 1801 the Peales might have hoped to have made a considerable income.

Charles Waterton, never likely to under embellish a story, gives an account of the Masten specimen which he saw in Peale's Museum in 1824: "The skeleton of the mammoth is a national treasure. I could form but a faint idea of it by description until I had seen it. It is the most magnificent skeleton in the world. The city ought never forget the great expense Mr Peale was put to, and the skill and great energy he showed during the many months he spent in searching the swamps where these enormous bones had been concealed from the eyes of the world for centuries" (Waterton 1825). The adjective "mammoth" dates from this discovery.

Peale's techniques for recovering the mastodon skeletons show ingenuity, but while there was an intention for *in situ* study, the end result was extractive excavation differing little from contemporary antiquarian barrow diggers. However, Peale certainly had a model for his excavation technique; he was an acquaintance of Thomas Jefferson who had, some years earlier, directed the systematic excavation of burial mounds on his estates - excavations in advance of contemporary 'archaeology' by perhaps as much as a century.

Bielbecks

One of the earliest open site palaeontological excavations to be undertaken in Britain concerned the discovery of Pleistocene material in a marl-pit in the East Riding of Yorkshire in July 1829 (Vernon *et al.* 1829; Phillips 1875). The Curator of the Hull Literary and Philosophical Society, William Hey Dikes, brought to the attention of John Phillips (1800-1874), then Curator of the Yorkshire Philosophical Society (YPS), the presence of bones at Bielbecks - a solitary farmhouse two miles south of Market Weighton and one mile north-west of North Cliff. Phillips was about to depart on a geological tour of the continent but was considerably excited by the news. He quickly arranged a visit with William Vernon (later styled William Venables Vernon Harcourt 1789-1871), President of the YPS, and William Salmond, an early explorer of Kirkdale Cave. On the 31st July they travelled to the farmhouse and saw the bones of elephant, rhinoceros, deer, ox, and horse, which Dikes had described in his communication, together with those of *Felis* Dikes hadn't seen.

Phillips measured and drew the section exposed in the now partly flooded pit. Foster, the tenant farmer who had recovered the bones could, from memory, relate them to particular beds within the section - Vernon records that the pit covered 8 yards by 20 yards. Vernon also made borings to discover the shape and extent of the deposit. Dikes had found gastropod shells in the underlying marl to which Phillips was able to add further specimens. Of these, Phillips discovered that 12 species belonged to types still found in Yorkshire, encouraging Vernon to support the view that the animals preserved here had survived in cold conditions despite being restricted to warmer zones today. Thus far the discovery amounts to little more than the usual chance find, reported after discovery when the fossil remains were removed from their context.

In October and in Phillips' absence, Vernon took the exploration of the site further and directed the sinking of a new pit near the previous one. He subsequently had removed 600-700 loads of marl. His clearly defined scientific objectives for the excavation were to determine: if the remains were ordered stratigraphically; the relationship between the still extant species of gastropod and the extinct vertebrates; and the mode of deposition (Vernon 1830). The bones were measured *in situ* as they were discovered which enabled Vernon to draw up a table relating the finds to the site's stratigraphy. The bones and shells in this excavation were later identified by Phillips who also deduced from the black "marl" which enclosed them that they had been deposited in tranquil waters beneath the diluvial deposits (Phillips 1875). In the late 1820s the rigour and extent of this investigation was quite exceptional.

Mineral Contents.	Feet.	*Organic Contents.*
Yellow Sand.—In this and the gravel below it a few pebbles of quartz and sandstone	3	*No Bones, Shells, or Vegetable Remains in the Sand or Gravel.*
Gravel—composed of chalk pebbles and sharp flints.	4½	
Gray Marl — indented by the gravel in some places to the depth of three feet, and containing large rolled pebbles of quartz	7	*No Shells or Vegetable Remains in the Gray Marl.* Elephant(Prim.) Numerous small fragments of the tusk and tooth.
	8	Do. Calcaneum.
Mountain limestone and carboniferous sandstone with chalk and flint.	9	Do. Three cervical Vertebræ.
	10	Do. Astragalus. Deer. Branch of horn. Horse. Radius: lower end.
Black Marl— containing minute pebbles of chalk, very few flints; and at the bottom two or three pieces of a fine-grained calcareous sandstone, similar specimens to which may be found in one of the adjacent beds of the red marl, but not including a single fragment of remote rocks. No specimen of these was found below the gray marl.	10	Rhinoceros. Radius: upper end.
	11	Bos. Metatarsal bone. Wolf. Radius.
	12½	Elephant. Humerus, and the head of it detached.
	13	Horse. 1st Phalangial bone.
	½	Do. 2nd Do.
	14	Do. 3rd Do. (col^d Helix.) Elephant? Four caudal Vertebræ.
	14	Duck. Ulna. Clavicle. Tibiæ: lower end.
	15	Bos. Bison. Occiput, part of the frontal and maxillary bones and the horns.
	15	Wolf. R. lower jaw. Condyle of another, R. Humerus, Radius and Ulna, articulating.
	18	Bos. Two molar teeth: upper jaw. *The Black Marl abounds in Shells; chiefly Planorbis complan. Lymnæa palus., and in Vegetable Remains including jointed stems.* Horse. Rib.
Strong blue Marl.—Some clay nodules found in this	22½	*No Bones, Shells, or Vegetable Remains in these alternations.*
Flint Gravel in Marl.	24	
Strong blue Marl.	25	
Flint Gravel in Marl.	½	
Red Marl.	26½	

Table 2. Stratigraphy and finds from the Bielbecks excavation undertaken by William Vernon (Vernon 1830).

The YPS was formed as a direct result of the finds at Kirkdale in 1821, however, by the time of the Bielbecks discovery Vernon "need only remark, that as far as they have been identified they are of the usual fossil species" (Vernon *et al.* 1829). Vernon had to hand an exceptional team of accomplices, foremost amongst these was John Phillips, William Smith's nephew, an expert stratigrapher and palaeontologist who in this year published his seminal work on the geology of the Yorkshire coast.

The finds from the Bielbecks excavation, and the site itself, have been the subject of repeated investigation. Unlike the early cave excavations this deposit was too large, and the YPS too poor, to be totally dug out. The subsequent distribution of the finds also created considerable ill feeling between the Hull and York societies. These are the subject of continuing research.

Rancho La Brea

Of the more recent palaeontological excavations involving Pleistocene mammals probably none is better known than at the Rancho La Brea Asphalt pits in California (Shaw 1982; Sutcliffe 1985). This project sought to rectify the deficiencies of past collecting; the earliest excavations began in 1905 and whilst they produced considerable quantities of material this was not supported by adequate contextual information. Shaw (1982) describes the reopening of 'pit 91' in 1969.

Past excavations had been hampered by slumping and a decision was made to build a wooden shaft which could be extended down into the excavation as the surface was lowered. Sixteen 60ft long I-section steel girders were sunk vertically 50ft into the deposit at intervals around the site. Three inch by twelve inch timbers were then attached horizontally to these uprights. An area 28ft x 28ft was thus enclosed and divided into 3 ft x 3 ft grids - each square located by a number-letter referencing system. Imperial measures were used throughout in preference to SI units as these allowed finds to be linked to earlier excavations. The squares were then systematically excavated in 3ft x 3ft x 6ins blocks. All material over a quarter of an inch in diameter was measured *in situ* to ascertain its three-dimensional position within the deposit. Large bones were measured in up to three places so that their exact position and orientation was recorded. Measurements were taken from the eastern and southern square boundaries of the grid squares and down from zero datum (set at 172ft above sea level). Associated small fragments of material and fragile specimens were removed in a block. Matrix was also collected for lithological and microfossil analysis and a full photographic record generated as the dig continued. Between 1969 and 1980, 400 tons of material was excavated (Shaw 1982).

Older Deposits

Messel

Among European sites none is better known for its fossil excavations, than the mine in the Tertiary oil shales of Messel, near Frankfurt. Fossils have been found here since the first articulated crocodile in 1875 (Schaal and Zeigler 1988). Exactly 100 years later excavation was restricted to scientific organisations - principally universities and museums. In the autumn of 1991, a group from Leicestershire Museums led by John Martin, were invited to assist excavations being undertaken by Karlesruhe Museum. Among the other parties digging that year were students from Tubingen University, some of which were working on behalf of Darmstadt Museum, and a group from the Senckenberg Museum in Frankfurt. Each of these institutions has its own particular area of the pit - the floor was already scarred by numerous trenches and looked like a relic of the First World War.

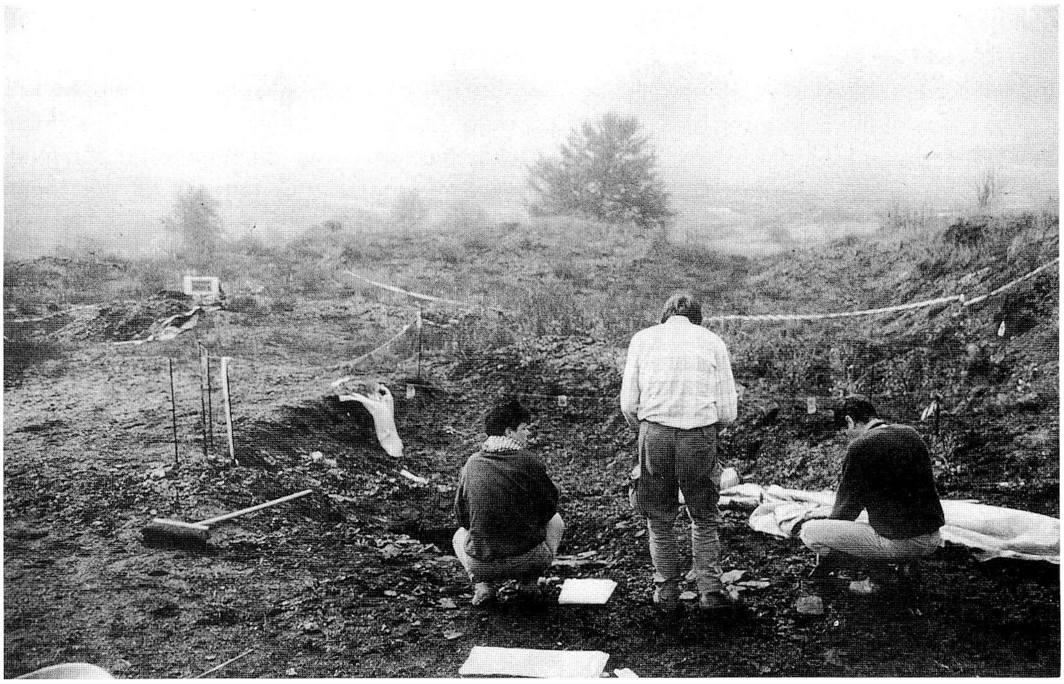

Figure 3. The 1991 Messel excavations: a collaboration between Karlesruhe and Leicestershire Museums. John Martin (right) discussing excavation methods with the Tübingen team at their site.

The lithology consists of soft, finely laminated, shales amenable to splitting with a large knife. During the winter months much of the pit becomes flooded. Between excavations, during the drier months, the sections are covered with tarpaulins to keep the faces moist - the shale rapidly exfoliates on exposure to the drying rays of the sun leaving a structureless, crumbling mess.

Each of the 1991 teams also had its own research objectives - most were involved in unravelling palaeoenvironmental factors and the site's enigmatic stratigraphy. All involved painstaking systematic excavation and the measurement of finds *in situ.* In the case of the Karleruhe excavations the 1m high vertical face was subdivided using evenly spaced bed markers (at 20 cm intervals). A stake placed at a distance of 2-3 m from the face was surveyed into position and all major finds measured into position relative to this marker using distance and magnetic bearing. The bed markers allowed finds to be placed stratigraphically relative to the few determinable marker horizons in the quarry. Plant and insect material formed the bulk of the finds - these were measured to within 1cm of the bed marker. All finds requiring laboratory identification were immediately placed in water and later packed in moist tissue and plastic bags. Position and orientation were recorded for the larger specimens - mainly perfectly preserved fish.

Once a site of large-scale extractive excavation the threats to the future of Messel in the 1980s brought into close focus the vulnerability of the site and how little was known about both its origin and stratigraphy. Modern excavations still hope to uncover exceptionally preserved mammals but in doing so also hope to place them in their full taphonomic and stratigraphic context.

Dinosaurs and other reptiles

It is perhaps appropriate that the most spectacular fossils should generate the most intensive and spectacular excavations. Dinosaur discoveries in the United States of America and elsewhere, and the ichthyosaur producing fossil lagerstätten of Holzmaden, Germany are well-known for their methods of extraction. In the Utah, the Dinosaur National Monument forms a monument not only to the dinosaurs but also to the techniques employed in their recovery; the site is a living excavation. Bone Cabin, Red Deer River and Como Bluff are all now part of dinosaur collecting folklaw and once sites of major excavations. Como Bluff, for example, is scarred by more than 100 pits. Excavations here, in the latter half of the last century, were often conducted under a movable tent which enabled work to continue even during the most severe winter weather (Ostrom and McIntosh 1966). These excavations soon became systematic in as much as every attempt was made to isolate, and not confuse, the bones of particular individuals; however, many of the digs exposed intermingled skeletons which could not be unravelled in the field. The major dinosaur sites were initially discovered through chance finds of bones weathering on the surface; subsequently museum workers turned to prospecting in likely, and often neighbouring, areas.

The methods employed to extract large dinosaur fossils have changed relatively little. Modern workers have access to lifting equipment, excavation machinery, pneumatic drills, and expanding foams; our predecessors used hammers, chisels, shovels and wagons. However, the use of plaster jackets as described by Rixon (1976) remains as common today as it was at the beginning of the century. Gilmore (1921), for example, describes the use of these techniques to extract ceratopsian dinosaurs from heavily indurated rock. He also describes the collecting of just one of 40 partial skeletons of *Triceratops* found by John Bell Hatcher (1861-1904). This specimen was enclosed in a concretionary mass which weighed more than 3 tonnes when it arrived at Yale Museum; it had travelled 64 kilometres (40 miles) in a wagon across rough terrain.

Dinosaur collecting in the US was for many years a form of trophy hunting. Some contemporary workers in Europe took greater care in systematically excavating these finds: the *Iguanodon* skeletons of Bernissart, Belgium, discovered in 1878, took three years to excavate. Each find was measured and recorded on a plan.

Generally, only the larger, more research oriented, institutions have zealously pursued fossil excavation. In both the size and breadth of its collections there is no museum which can compare with the Smithsonian Institution in Washington DC. This museum's drive for the furtherance of knowledge, particularly during the early years of this century, led to a massive programme of collecting. Perhaps not surprisingly in an organisation whose secretary was Charles D. Walcott (1850-1927), fossil collecting was a high priority. The museum's annual reports give a good indication of the type of material then being collected and the techniques employed. These include excavations in some of the oldest fossil bearing strata. Walcott's own research in the Cambrian and Precambrian is a feature of these reports.

The following discovery of an exceptionally preserved Cambrian fauna by Walcott is typical of the collecting process at this time. The chance find of a block of fossiliferous shale which had fallen from the mountainside, during reconnaissance around Field in the Rocky Mountains in 1909, provided the motivation for the following year's excursion. The block preserved in greater detail than had previously been known the fauna of the Middle Cambrian. The party returned in 1910 to locate the horizon from which it had originated. They then spent 30 days quarrying the shale. This was slid down the hill to a trail where it could be split, trimmed and loaded onto packhorses and transported to the railway station, some 3000ft (923m) below (*Annual Report of the Smithsonian Institution* 1911).

The Smithsonian wasn't satisfied simply with the products of its own excavations. In 1915 Frank Springer (1848-1927) was leading various excavations for Silurian echinoderms. "The object of this work was to secure as many specimens as possible for comparisons of this peculiar fauna with those from the European Silurian rocks. Not only was much material obtained by the quarrying operations, but all of the local collections of fossils were purchased" (*Annual Report of the Smithsonian Institution* 1916).

Getting material back to the museum from the wilds of Indiana, for example, was also a problem. In 1919 the Institution's Curator of Palaeontology, Dr Ray Smith Bassler (1878-1961) was seeking exhibition grade specimens, including very large blocks of seaweed. They had been unable to get these to a railway station in the previous year. "This year, conditions being the same, they were carefully wrapped in burlap and padded with a quantity of weeds and laboriously dragged along the rails to the nearest station" (*Annual Report of the Smithsonian Institution* 1920).

Frodingham Ironstone

Relatively few sites are systematically excavated in pursuit of marine invertebrates but during the late 1980s the Frodingham Ironstone quarries near Scunthorpe became the site of one such excavation. The long string of quarries in this part of Britain give outstanding exposures of a unique Lower Jurassic sequence. The Frodingham Ironstone itself is capable of producing large and finely preserved Asteroceratinae ammonites, many of which can be readily polished to produce marketable and highly colourful decor

Figure 4. *Isocrinus robustus* from the Frodingham Ironstone. This specimen was illustrated on the front cover of *Geology Today* 6(4) 1990. Just as in Charles Willson Peale's time, excavation can have publicity potential.

specimens. In 1989, the quarries were discovered by commercial collectors from Whitby and Lyme Regis, perhaps in response to the Ammonite Armada exhibition which demonstrated the extraordinary wealth of fossils to be found there.

The commercial collectors concentrated on Conesby Mine, the last working quarry where the stone was being extracted for hardcore (rather than for the furnaces). Local amateur geologists were both outraged that professional collectors were claiming jurisdiction over the site and that important fossils were being lost to the area. They contacted Scunthorpe Museum which had long been a centre for local amateur interest in geology. The Museum undertook negotiations with the landowner to protect these local interests; and it was agreed that important finds should be deposited in the Museum. In order to administer this agreement and preserve the access of amateurs, the Museum operated a system of permits on behalf of the landowner. As a result of this agreement, which the commercial collectors were only too willing to accept, the finest and earliest known specimen of *Isocrinus robustus*, and the first articulated crinoid from the rock, was donated to the Museum (Figure 4). Subsequently, excavations were undertaken by David Sole and Trevor George based on more formal access arrangements and the purchase of fossil rights but in essence protecting the above agreement.

The method used was very much rough and ready extractive excavation. After a pilot dig in order to obtain some well stratified zonal ammonites, the commercial diggers were largely left to themselves. Contractors extracting the hardcore, drilled and blasted the ironstone - the blasting simply loosened the strata. The ammonite rich upper beds were lifted using large excavators and large blocks split by a JCB with a pneumatic drill ('pecker') attachment. Individual specimens were chipped out or extracted with a rocksaw. In general, fairly large blocks were collected - often several large blocks were collected each having part of one ammonite specimen. Much of this material was sold on in bulk to other dealers/preparators.

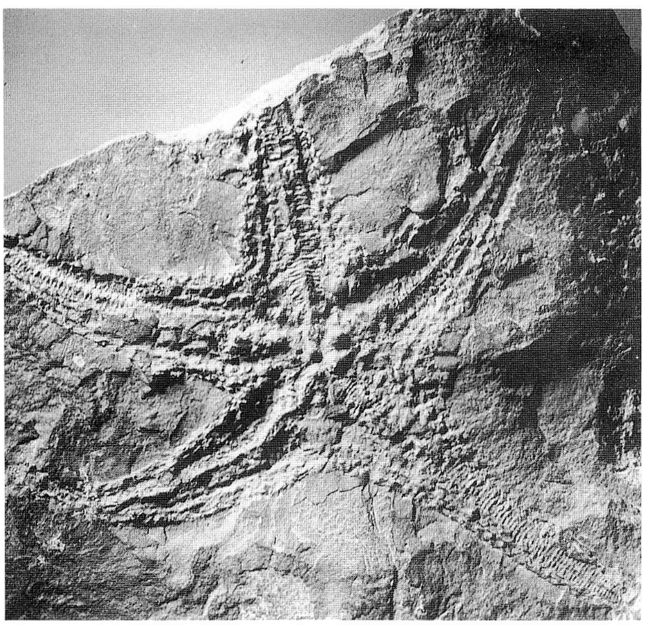

Figure 5. From a knowledge of the requirements for preservation it is possible to direct excavation workers towards lithologies which might be productive. This starfish proves the existance of previously unknown obrution deposits in the Frodingham Ironstone.

The Museum had, with the agreement with David Sole and Trevor George, the pick of any specimen. Like all museums there was little staff time to monitor the excavation on a daily basis but these two collectors were very keen to see their best finds preserved. Based on a knowledge of the existing collections and of past research it was possible to draw up a shopping list of specimens which would enhance the existing collections. In effect this included just about everything except the most common ammonites and bivalves. It was also possible to advise David and Trevor where to look for particular types of fossil. At the top of the list were all examples of articulated echinodermata; one starfish specimen already existed in the Museum and one at the Natural History Museum. The mode of preservation of these and the *Isocrinus* provided evidence of previously unknown obrution deposits in the Ironstone. By directing the collectors to look at every exposed mudstone fragment they were able to locate further specimens of starfish - the Scunthorpe collections now hold some of the finest examples from the British Lias. Rare *Oxynoticeras* specimens were also sought as a priority in order to confirm the stratigraphy of these upper beds; none have yet been recovered from the excavations though morphologically similar species of *Eparietites* and *Angulaticeras* have repeatedly been found and claimed to be the missing genus. The *Angulaticeras* are an extremely rare form previously unknown from this rock. The number of known forms of *Xipheroceras*, another fairly uncommon ammonite genus here, have increased fivefold including species previously only known from continental Europe (K. Page pers. comm.). Several shark fin spines have also been recovered - the first fish fossils found in this deposit.

Systematic excavation of this extremely hard rock could not be warranted in terms of the specimens and information which could be recovered. The rarest and scientifically most valuable elements of the fauna would only be recovered by the processing of massive quantities of rock. Commercial extraction enabled this and provided substantial benefits for all parties. The Museum, despite the relatively small size of its collections, now holds ammonite and echinoderm material of international importance. The commercial collectors have managed to rescue a considerable resource of saleable fossils which would otherwise be hardcore. Ammonites from the Frodingham Ironstone are now found in dealers establishments worldwide, though most are polished or sectioned and are of little use to science. The landowner has gained additional income. Amateur collectors were allowed continued access to the site with the one proviso that rare finds were to be reported, and if required, donated, to the museum. The arrangement was an unusual one, but one which proved, contrary to propaganda from certain quarters, that positive results can be obtained from museums working with commercial collectors. The end of the 1980s and the beginning of the 1990s have been the most important in the 130 year history of collecting from this now threatened rock (Knell 1990*a*; 1990*b*).

Conclusion

The history of excavation in the context of palaeontology is a huge area of research which has hardly been touched upon. The above discussion merely introduces some themes and developments. The relationship of palaeontological technique to that of archaeology has not been investigated though it is unlikely that the former evolved from the latter as might be supposed. A general methodology for excavation seems to have been discovered fairly early on. Fortunately, the hidden subjectivity of purely inductive science has been recognised. Excavation exists today in a more enhanced form because we are aware of how depositional processes affect the structure of a deposit and that this knowledge needs to be applied during the collecting process. Excavation is now undertaken at a finer level of resolution; the shovels of the early diggers at sites like Rancho La Brea have been replaced by brushes and dental tools. The three cubic foot resolution of Pengelly has been increased to an accuracy of 0.25 ins. The spectacular finds revealed by the earliest excavators are now well-known; modern excavations attempt to place these in a more refined context.

Acknowledgements

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GEOLOGICAL SURVEY OF IRELAND: NATIONAL HERITAGE COUNCIL FUNDED CURATION PROJECT OF 19th CENTURY COLLECTION.

M.A. Parkes, A.G. Sleeman and R. Maher
Geological Survey of Ireland, Beggars Bush,
Haddington Road, Dublin 4, Ireland.
Geological Curator 6(2): 70 [1994]

For any GCG members who attended the June 1990 meeting *Geology in Irish Museums* or who read the resulting paper by Sleeman (1992) in this journal, the following news may be of interest. An application to the National Heritage Council in the Republic of Ireland, to complete the curation of the entire fossil collections of the Geological Survey of Ireland (GSI), proved successful earlier this year. As noted by Sleeman (1992) the collection is mostly from the 19th century, collected by officers of the GSI between 1845 and 1889 during the primary geological mapping of the country.

Historical circumstances prevented access to them from 1922 until the late 1970s. From the mid 1980s, the Curator, Dr A.G. Sleeman, began curating the collection to modern standards, and documenting the specimens on MDA cards for a database system compatible with that of the National Museum of Ireland. Until recently some 6000 specimens had been curated, with the limited resources available for the collections.

The present project, being undertaken by Dr Matthew Parkes, assisted by Rosaleen Maher, is to complete the curation and computerisation of the remainder of the collection (more than 2/3rds) by the end of 1995. A type, figured and cited catalogue will be published, and a small exhibition on the significance of the fossil collection will be included in a completely renewed exhibition area in the GSI.

This will be part of the celebrations of 1995 - the 150th anniversary of the GSI. An official history of the Survey will be published, written by Gordon Herries Davies whose earlier work (1983) included chapters on the GSI. Other related events include an exhibition of the watercolours of the Survey geologist George Victor du Noyer (1817-1869) in the National Gallery of Ireland.

A significant boost has been given to the project, through the agreement of Steve Tunnicliff, Curator of the British Geological Survey fossil collections to return many hundreds of specimens, originally sent to the Survey as 'duplicates' when the Irish Survey was a branch of the British Survey. Some have been incorporated into the stratigraphical collections of the BGS over the years, but the majority have remained

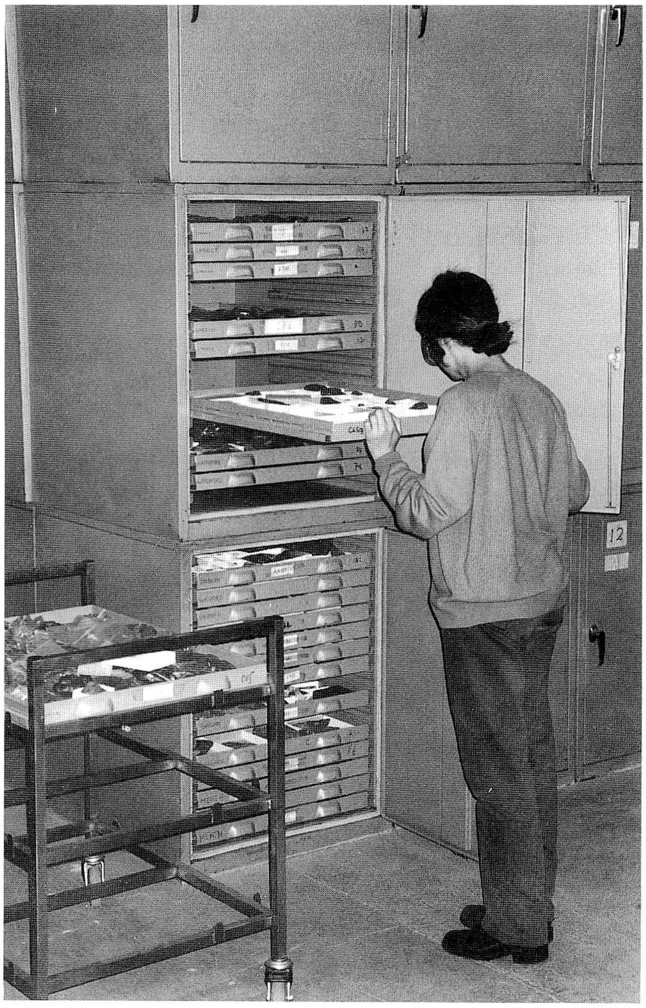

Figure 1. Examining the 19th century palaeontological collections of the Geological Survey of Ireland.

unregistered. These are to be returned at the end of September 1994, for curation back into their original collection.

One aspect of the project which might provoke a few thoughts for those in the UK, is that the funding for the National Heritage Council derives ultimately from the Irish National Lottery,which has been running successfully for several years.

As a final note, if anybody is keen to trace material which may be present in the GSI collections, or has any pertinent information on obscure figures or citations of our material we would be keen to hear from you.

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THE ROLE OF ENGLISH NATURE IN FOSSIL EXCAVATION

by Colin D. Prosser

Prosser, C.D. 1994. The role of English Nature in fossil excavation *Geological Curator* 6(2): 71-74.

English Nature and its predecessor, the Nature Conservancy Council (NCC), have had a long and active association with fossil collecting and fossil excavation. Although the nature of involvement and the reasoning behind it have varied over the years, a strong link between palaeontological conservation and fossil excavation has long been established. In terms of palaeontology and palaeontological conservation, fossil excavation can be both highly beneficial and extremely damaging. English Nature has an important role to play in discouraging irresponsible fossil collecting and excavation, whilst at the same time helping to advance palaeontology and palaeontological conservation through supporting and co-ordinating fossil collecting and excavation carried out at appropriate sites and in a responsible manner.

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Introduction

English Nature, the successor in England to the Nature Conservancy Council, is the statutory advisor to Government on nature conservation in England and works both directly, and through others, to deliver and promote nature conservation, including the conservation of England's rich palaeontological heritage. English Nature's involvement and role in fossil collecting and excavation stems from the activity which currently underpins palaeontological conservation in Great Britain, namely the identification, management, and safeguard of palaeontological Sites of Special Scientific Interest (SSSIs). SSSIs, by definition, include many of the best palaeontological sites in Britain, and as such attract regular proposals for fossil excavation. Under the terms of The Wildlife and Countryside Act 1981, English Nature are likely to be consulted by landowners or fossil collectors over any proposed excavation on an SSSI. Conservation, however, is not confined to SSSIs, and English Nature provides general guidance on fossil collecting practice as well as becoming involved, where appropriate, with excavations outside SSSIs. It is on SSSIs, however, that English Nature is, and has been, best placed to gain experience and develop a role in promoting responsible fossil collecting practice.

Broadly, English Nature's role involves discouraging irresponsible or inappropriate excavations, whilst supporting, co-ordinating and even funding appropriate, responsible excavations which may have a positive scientific and conservation benefit. Inappropriate or irresponsible excavations can do considerable, though often inadvertent, harm to both sites and the reputation of palaeontology and palaeontologists. Such excavations serve only to damage sites and diminish the fossil resource without securing any scientific or educational gain. On the other hand, appropriate, responsibly carried out excavations, ideally involving a wide range of people and specialists, can be very beneficial. They may yield important specimens which advance palaeontology, consequently increasing the scientific value of the site and its profile with local people and the media. This in turn can only lead eventually to greater support for conserving the site.

The challenge, in terms of palaeontological conservation, is to weigh up the advantages of responsible excavation against the need to retain a fossil resource at a given site for future study. English Nature is well placed to meet this challenge, having developed considerable experience in assessing the impacts and benefits that a proposed excavation may have, as well as having experience in the practicalities of excavation and working with a wide variety of fossil collectors and site owners. Should a particular excavation be realised as beneficial, then English Nature can play a role in ensuring that maximum scientific, educational and social/political gain is made from undertaking the dig. In many cases, it is active work on sites producing exciting finds and new theories that gives palaeontology the scientific relevance and value that is needed to gain public and political support for palaeontological conservation.

Rationale for involvement

Over the years much has been written about palaeontological conservation and the ethics of fossil collecting (Crowther and Wimbledon, 1988; Norman and Wimbledon 1988; Norman *et al.* 1990; Knell 1991; Norman 1992; English Nature 1992) and opinions on the rights and wrongs of collecting still differ. Nature conservationists unfamiliar with the science of palaeontology, may find it hard to appreciate how excavation of any type can play an important role in conserving palaeontological sites. However, the successful conservation of a palaeontological site is based on principles different to those which govern how we conserve most other sites of nature conservation value. English Nature's involvement in fossil collecting and excavation seeks to benefit palaeontological conservation on two accounts; scientific and social/political.

Scientific rationale

English Nature's scientific rationale for involvement in excavation is explained in Norman *et al.* (1990) and Norman (1992), and revolves around the belief that the value of palaeontological sites lies in their availability for study, which, in most cases, means the *in situ.* study, collection and removal of fossils. Thus, palaeontological conservation is not seen as 'mothballing' a site, instead it is about establishing how best to manage a fossil resource at a particular site, balancing the current need to use the site against the objective of retaining a fossil resource for future study. The science of palaeontology can only continue to thrive and advance if sites are available for re-examination, collecting and where appropriate larger-scale excavation. After all, without fossil collecting, researchers, museums, schools and the general public would be deprived of specimens, and palaeontological sites risk becoming nothing more than historically important localities with little current relevance. Fossils at most sites are, in effect, a renewable resource and in some cases, such as eroding cliffs and working quarries, collecting is actually required to retrieve specimens before they are lost to the sea or crushed by machinery. It is only at a very few sites where there is a finite fossil resource, such as a lens deposit, where some control on collecting would be desirable. Fossil collecting and excavation is not all good however, and if irresponsibly carried out, can diminish the value of a site through the loss or destruction of scientifically and educationally important specimens which may be of great value in capturing the imagination of the general public and in giving palaeontology an accepted relevance. What is clearly important, at all sites, is the manner in which fossils are collected. English Nature has sought to promote responsible collecting with the objective of educating all collectors to a level where all collecting is undertaken with the site owner's permission, and in a manner which gains maximum information and benefit from specimens, and which minimises damage to sites (Knell 1991; English Nature 1992).

Social/political rationale

The successful conservation of our natural heritage, including sites of palaeontological significance, depends increasingly on public and political support as well as on legislation. In order to attain a social and political acceptance for the conservation of palaeontological sites, it is essential that policy makers and the general public regard palaeontology as a lively, relevant and worthwhile subject. Fossil collecting and the more 'spectacular' fossil excavation, have a vital role to play in achieving this goal. It is through research on sites generating new theories and exciting fossil finds, and by having fossil sites freely available for the use of enthusiasts and educationalists, that palaeontologists can raise awareness and the level of understanding necessary to gain public support. Without active collecting, sites soon lose their scientific relevance and subsequently the need to conserve them becomes harder to justify should they become threatened with development, coastal protection or landfill. On the other hand, however, collecting needs to be undertaken responsibly, as physical damage to sites resulting from irresponsible excavation serves only to tarnish all fossil collectors with a reputation for vandalism, resulting in the loss of public support for palaeontology and consequently for the conservation of palaeontological sites.

Excavation in practice

Having adopted the philosophy towards fossil collecting and excavation outlined above, English Nature has actively co-ordinated, advised on, and funded a number of palaeontological excavations. This wide involvement in excavation has taken place through the day-to-day work of English Nature, namely the identification, management and safeguard of SSSIs.

SSSI identification

This was largely carried out through the Geological Conservation Review (GCR) between 1977 and 1989, with sites selected as GCR sites subsequently being designated as SSSIs. Where sites are well exposed and actively yielding fossils, assessment of the palaeontological importance of a site is relatively simple, as a valuable fossil resource can easily be demonstrated. Many sites, however, have become degraded or overgrown, resulting in it becoming unclear whether or not a fossil resource worthy of conservation still remains. It is in such cases that a scientific excavation may be required. The NCC undertook a number of such excavations as part of the GCR selection process (e.g. Puddlebrook Quarry, Gloucestershire (Cleal 1985); Minchinhampton Quarry, Gloucestershire (Cripps 1985)) which were instrumental in shaping the GCR coverage as it now stands. The main GCR site selection phase is now complete and excavations of this type are no longer common practice. The GCR coverage is, however, dynamic, and on-going minor revision with occasional larger scale revision of some subject areas is inevitable as new sites come to light and as science advances. Further excavation of this type is likely to accompany any such revisions where appropriate.

Site management and safeguard

Having selected GCR sites and notified them as SSSIs, the on-going task of managing and safeguarding them begins. This involves identifying threats and working with site owners and land managers to avoid potentially threatening operations or development, and to attempt, where possible, to actively enhance the scientific value of sites. In some cases enhancement will involve English Nature unilaterally re-exposing faces to reveal fossiliferous horizons, but in most cases excavations are proposed by academics or collectors external to English Nature. These excavations may be part of a research project (e.g. Leicester University's dig at Goggin Road, Mortimer Forest, Shropshire, 1992) or to 'rescue' for museums, particularly important fossil finds (e.g. The Isle of Wight Sauropod (Radley and Hutt 1993) (Figure 1)). English Nature regarded both of these excavations as highly beneficial and was able to contribute funds to the projects. They involved a number of interested parties, specimens were accurately collected and curated, they added significantly to our knowledge of the sites, they had the site owner's consent and co-operation, they raised public awareness and they did not greatly deplete the fossil resource.

Rescue

In the rare but unfortunate cases where attempts to save all or part of a palaeontological site from destruction through development, landfill or coastal protection have failed, English Nature has organised and funded 'rescue' of important specimens. This has been done through 'rescue' digs (e.g. Golden Hill, North Yorkshire, (Wignall 1992)) or by moving specimens to a safe area for study at a later date (e.g.Writhlington, Avon, (Jarzembowski 1991) and more recently Clockhouse in Surrey).

Wider collecting

Quite clearly SSSIs do not include all fossiliferous material and occasionally important specimens will come to light in unprotected areas and need to be collected. An example of this type of situation where English Nature has funded an excavation is Calvert Brick Pit, Buckinghamshire (Martill and Hollingworth 1992). An important role can also be played in advising on and co-ordinating 'Charmouth Bypass type' rescues (Norman 1989), where rapid and well organised fossil collecting involving a wide range of fossil collectors is needed to recover specimens from potentially dangerous construction sites (Figure 2).

Future role?

At present, English Nature tends to become involved in, and fund, fossil excavation and site clearance work on a reactive basis, acting only when a site becomes threatened or when a particular proposal is put forward which may benefit from English Nature co-ordination

Figure1. The site of the Isle of Wight sauropod excavation during a visit by the Palaeontological Association in 1992. English Nature was able to contribute funds towards the excavation of this important and well publicised specimen.

Figure 2. Fossil rescue at Charmouth Bypass. Rescue work of this type, on dangerous construction sites, requires liaison with developers, careful co-ordination and prompt work by the collecting team.

or funding. When assessing the suitability of a proposal for English Nature involvement, the two factors considered to be of prime importance are the conservation benefit in terms of increased knowledge and public appreciation of the site, and the degree of 'responsibility' with which the excavation is to be carried out. The former reflects the benefits the excavation could bring for palaeontology and the long term conservation of the site, the latter is a measure of appropriateness of the excavation, the excavation methodology, and the effect it will have on the fossil resource. There is, however, a need to encourage more people and groups to become involved in the practicalities of earth science conservation, and to raise awareness of the subject. Appropriate site clearance and fossil excavation is one way of achieving this, and English Nature may be wise to consider proactively promoting this aspect of conservation more than is done at present. Whilst some resources will need to be retained by English Nature for emergency rescue digs, a proportion of current resourcing could be promoted and released on a grant based system. This would encourage hands-on involvement and enable local groups and academic project teams to put forward proposals of their choice, providing of course that they are appropriate.

Acknowledgements

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PLIOSAURS AND VOLUNTEERS

by Gordon R. Chancellor

Chancellor, G.R. 1994. Pliosaurs and volunteers. *Geological Curator* 6(2): 75-81.

The 'employment' of volunteers at a medium-sized English local museum is described, paying particular attention to the contribution of geologists. The excavation, preparation and display of a Jurassic pliosaur was carried out by Museum staff and volunteers. The good relationships between the Museum and both amateur geologists and quarry personnel is very important.

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Introduction

In recent years Peterborough Museum has enjoyed a very fruitful partnership between its professional staff and its volunteers. In no area has this partnership been more successful than in the excavation of fossils. This article describes how volunteers have made an enormous, indeed indispensible, contribution to the collecting, preserving and displaying of fossils at the museum.

Geological volunteers at Peterborough Museum

In the last few decades there has been an increasing awareness of the role played by volunteers in Britain's museums. Millar (1991) surveyed the contribution of volunteers in the sector and gave guidance on policy issues and on the management of volunteers. As an indication of the importance of volunteers, the Carnegie UK Trust has recently awarded the Museum Training Institute and The Area Museum Council for the South West a £10,000 grant to develop and pilot a course for managers of museums which 'employ' volunteers.

The Peterborough Museum owes its foundation in the 1870s to the Peterborough Museum Society, who ran it until 1968, when Peterborough City Council took over. From its earliest days the museum was active in promoting geology, and amassed a considerable collection which was especially strong in marine vertebrates from the Oxford Clay.

In one sense, virtually everyone who worked at Peterborough Museum before 1968 was a volunteer, although at least one of the Honorary Curators received a salary in the 1960s. In the late 1970s the National Association of Decorative and Fine Arts Societies (NADFAS) began to organise regular volunteers to work on the museum's social history collections.

By the mid-1980s a corps of more or less regular volunteers had become an established part of the museum workforce, and this remains the present situation. Volunteers assist with a very wide range of curatorial functions in all subject specialisms, although as yet few have performed 'front of house' work. The recent setting up of a team of gallery guides recruited from the Museum Society marks a new departure in this area.

The 'employment' of volunteers at Peterborough Museum is now an established element of the operation of the museum. Each volunteer is asked to read and sign a 'Contract for Volunteers', which sets out the mutual responsibilities of the museum and the volunteer, and also gives recognition of the importance of the volunteer's role. Each volunteer is treated as an honorary member of staff, and is welcomed to all tea breaks and other informal social functions involving paid staff (but not to staff meetings).

Peterborough Museum's volunteers range from young GCSE students,while others are in their retirement. A number come for a few days, then drift off; others are with us for one day each week for a decade or more. Many are unemployed and are filling time or hoping to acquire new skills before they get a job, some are retired, and others do not need to earn a living but are seeking interesting work and perhaps companionship.

A few volunteers have full-time jobs, yet manage to fit a few hours at the museum into their shift schedules! At any one time there are ten or more volunteers, each of whom will give the museum at least half a day each week. If they were paid at, say, £10 per hour this would probably cost the museum at least £400 per week, or add £20,000 to the salaries budget.

In the natural sciences there is little that a volunteer can do without a fair degree of prior knowledge. Peterborough Museum is the environmental records centre for the Peterborough area, and virtually all the active biological recording takes place outside normal office hours by volunteers who, of necessity, are expert naturalists (in this the museum is fortunate in being located near the headquarters of English Nature!). Motivation is, however, a primary requisite for volunteers in natural science; a teenager with a passion for fossils can rapidly learn very useful skills.

It is impossible to describe the activities of geological volunteers at Peterborough Museum without mentioning Mr Alan Dawn. Alan is a retired schoolmaster who has turned to geology late in life, but who's devotion to the science and high standards of work call into question the demarcation between professional and volunteer. Alan has spent practically every Tuesday at the museum for the last ten years, and shows no sign of reducing his commitment. During periods of great activity, as for example during excavation or display preparation, Alan has frequently spent the entire week working for the museum. In fact the only weeks when Alan is not at the museum are when he is away on holiday (i.e. geological field trip)!

As a mark of recognition of his service's to palaeontology, local societies and museums, Alan was awarded the first Palaeontological Association Award for Amateur Palaeontology in 1990, and the Fouleton Medal of the Geologists' Association in 1994.

Other volunteers have made significant contributions to the geological activities of Peterborough Museum in recent years and demonstrate the diversity of people attracted to this kind of work. Charles Lamb, who has now graduated in geology from Imperial College, catalogued the Burghley House geological collection while studying for his 'A' levels. Margaret Gillespie has catalogued the Palaeolithic flint collection, and done much painstaking re-assembly of Oxford Clay vertebrates. Ivor Crowson, a maintenance fitter with Perkins Engines, has been largely responsible for cataloguing new accessions as they are donated or collected.

Hilary Blagborough, now studying for a geology degree at Luton Polytechnic University, has assisted with the excavation and preparation of several vertebrate specimens, as has John Wright, an ex-London Brick employee who's knowledge of the brickyards has been very useful on several occasions. Jeremy Wright (no relation to John) spent several months re-assembling crocodile skulls while gaining work experience for his BTec National Diploma in Science, and Justin Miller, a very keen young palaeontologist, spent two weeks on work experience helping to move the entire vertebrate fossil collection in July 1993. Nigel Truss, a part time student aiming for a geology degree, works on the geology collections most Tuesdays when not taking exams!

Since the mid-1980s Peterborough Museum's staff and volunteers have excavated a considerable number of vertebrate fossils, ranging from Jurassic fish and reptiles, to Pleistocene mammals. Several of the specimens received extensive conservation treatment (in one case this work was contracted out and paid for by the Geologists' Association Curry Fund), and some of the most important skeletons are now on display at the museum. In almost all cases the contribution of volunteers has been indispensible.

During the last few years (1992-1993) there has only been one (partial) skeleton excavated by the museum. This is an ichthyosaur found by someone walking his dog and then reported to the museum and later excavated with the full co-operation of London Brick. One partial skeleton from the Oxford Clay is a poor record by comparison with the number of finds made in other recent years. I attribute this paucity of new finds to the closure of one of the brickpits, and the general slowing down of brick production caused by the economic recession of the early 1990s. Preparation of old pits for landfill now seems likely to rival clay extraction as the most likely process resulting in fossil finds (see below).

As if to compensate for the reduction in Jurassic finds, there have been more Pleistocene mammals exposed in local gravel pits than usual. A silty horizon at the base of the Nene First Terrace has yielded abundant disarticulated bones and teeth, including two woolly rhinoceros skulls and one mandible of the same species excavated in the Spring of 1991, together with several mammoth tusks, one of which has just provided the first carbon date for the gravels of Peterborough.

Excavation of the Dogsthorpe pliosaur

As a detailed example of the processing of a major fossil, I describe here the methods used to excavate and prepare for display an almost complete specimen of *Liopleurodon ferox*, a species generally regarded as top predator in the Oxford Clay sea. The specimen was a chance find at the Dogsthorpe landfill site in Peterborough (Martill 1992) (Figure 1), and quickly became known as the Dogsthorpe pliosaur.

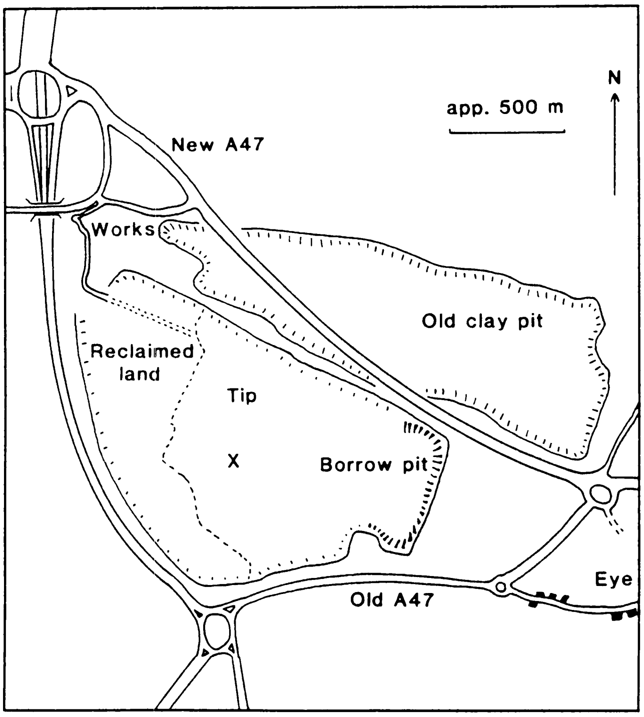

Figure 1. Map showing the location of the new pliosaur discovery, and the final outline of the now abandoned Dogsthorpe clay pit. Diagram courtesy of Dr David Martill.

I first learnt of the find late on the afternoon of Friday 15th June 1990. I was telephoned by the Landfill Manager who told me that large bones had been exposed while bulldozing at the Dogsthorpe landfill site. This site was for fifty years or more a London Brick Company brickpit, the floor of which is composed of Bed 10 of the Peterborough Member of the Oxford Clay. It is well known (see Martill and Hudson 1991) that Bed 10 is where most of the vertebrates are found and it was this level which contained the bones just exposed.

Due to domestic commitments I could not visit the site until the following Monday (why do major finds always occur on Friday afternoons?). Immediately I saw the ribs, paddle bones and vertebrae - some scattered, most *in situ* - I identified the skeleton as a plesiosaur, which constitute about half of all Oxford Clay reptile finds. Since much of the skeleton was clearly encased in large (and very heavy) concretions of a sort only seen in Bed 10 (see Martill 1992, figure 2) I was in no particular hurry to excavate the specimen, and I was actually doubting the value to the museum of yet another apparently headless plesiosaur! I did, however, arrange to return on Thursday of that week with two volunteers.

Within a few days we had sifted through all the loose clay around the skeleton and bagged up all the loose *ex situ* bone. I was then on leave for a week, and left Alan in charge of the operation. Experience has shown that there must be one person in overall charge if over-enthusiasm is not to result in damage to a specimen. By the time I returned one week later it was obvious that one complete flipper had probably been lost forever (such is the price of discovery by bulldozer!). However, another flipper was reconstructed from material found 20 m away where it had been dumped by the bulldozer.

At this stage Alan and myself were joined by Mr Ron McKenna, a professional fireman who usually carries out archaeological excavations for the museum. Ron's

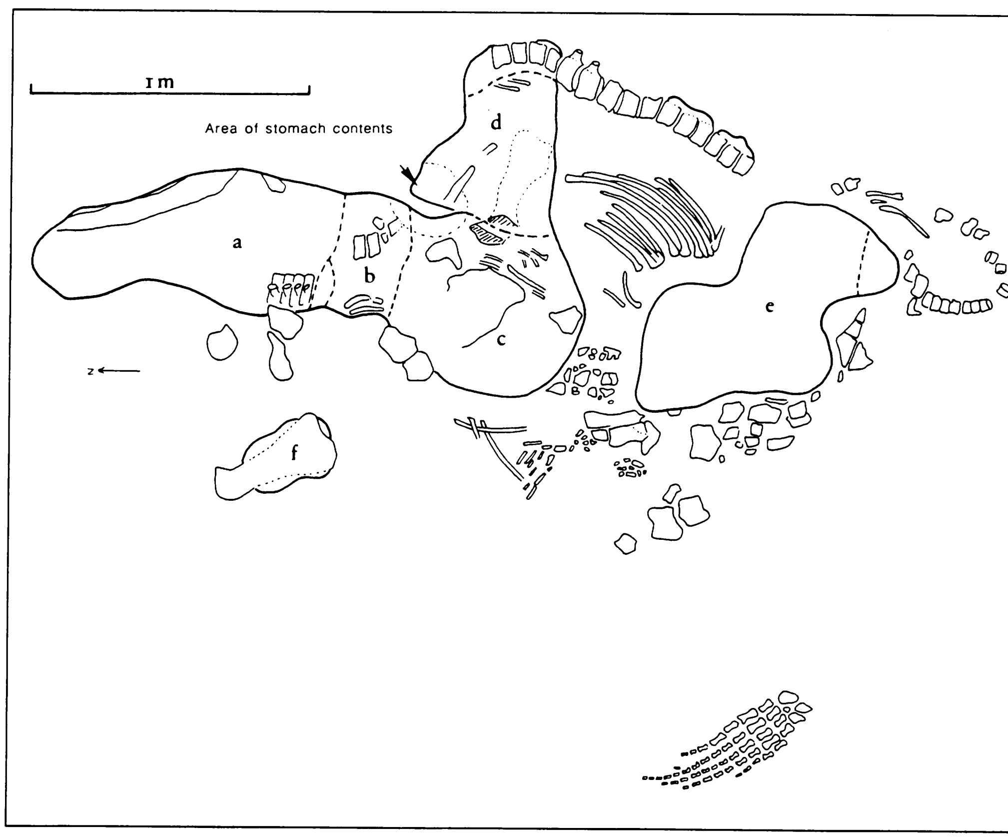

Figure 2. Plan of the skeletal elements of the new pliosaur, as found. Data recorded by Mr Ron McKenna. Diagram courtesy of Dr David Martill - from Martill (1992).

Figure 3. Ron McKenna (left) and Alan Dawn (right) commencing excavation of the pliosaur. At this stage the skeleton was thought to belong to a headless plesiosaur!

physical strength and knowledge of safe lifting techniques, not to mention his archaeological and artistic skills, were a major contribution to our work on this specimen. The entire skeleton was mapped at 1:1 scale on clear acetate sheet using felt-tip pens, and all the hand-portable bones then excavated and taken to the museum, after carefully bagging, numbering, and marking them on the acetate map. Ron later produced a 1:10 reduced scale map of the skeleton which I first used to illustrate a presentation to the Symposium on Vertebrate Palaeontology and Comparative Anatomy, held that September in Milton Keynes. One propodial (labelled 'f' on Ron's map (Figure 2)) was found near the skull but oddly orientated; contrary to the statement in Martill (1992, p.39) this bone was found *in situ*.

In the case of paddle bones, the way up and orientation of each bone was carefully recorded, and some clay from around the ribs was also collected since it seemed to contain a black material which might have been organic. The only tools required for this type of clay excavation are trowels, penknives and brushes, plus polybags and felt-tip pens. Buckets of water for washing bones and tools are also useful, because if there has been a lot of rain the clay gets very sticky and it then becomes almost impossible to see the smaller bones. Sometimes under these conditions one is literally searching for bone by feel and by listening for the characteristic sound of metal against bone which would otherwise not be noticed. Of course plaster jackets are the only way to excavate really complex bone assemblages (Rixon 1976), but this was not necessary in the case of the Dogsthorpe pliosaur.

It was an enormous surprise to discover large teeth protruding from the 'tail' of the specimen, proving at

Figure 4. The head of the pliosaur, encased in a concretion, and the front end of the skeleton including an isolated limb bone just to the right of the half-metre scale. At this stage of the excavation, on 22 June 1990, there were still many loose fragments of bone and many *in situ* elements which were subsequently mapped before removal.

Figure 5. Alan Dawn chiseling limestone from the skull in the museum car park, before carrying it up to the work shop. Even after this 'lightening' operation, the skull still weighed about 0.25 tonne!

once that we had completely mis-oriented the skeleton and that it was probably the most complete Oxford Clay pliosaur found this side of the Great War! A lorry was hired and three of the strongest men on the museum staff helped pack the bone-laden concretions and transport them to museum. One of the concretions slipped during unloading, and as an indication of the potential dangers of moving such heavy fossils this one cracked the concrete base of the museum fire escape!

Shanks and McEwan, who operate the landfill site, provided everything possible to assist with the excavation on what was occasionally a rather unpleasant site. Their most significant contribution to the excavation phase was the provision of a bulldozer and expert driver for loading the concretions onto the lorry for transport to the museum. Company personnel frequently visited the excavation, as did members of their Environmental Advisory Board. Once safely in the museum the media were informed of the find and its importance, and Shanks and McEwan did not hesitate to sponsor the display of the specimen and a booklet about it.

Preparation and display of the Dogsthorpe pliosaur

The very first action taken after the specimen had arrived at the museum was to establish that the museum owned it. This achieved, it was accessioned as PETMG 1990097 and added to the fossil reptile catalogue as R.296. A list of bones was started and henceforth each bone was numbered in Indian ink as R.296.1,2,3 etc.

All the loose bones (i.e. those not in concretions) were taken to the workshop, where they were washed and sorted into card trays, each tray bearing the appropriate

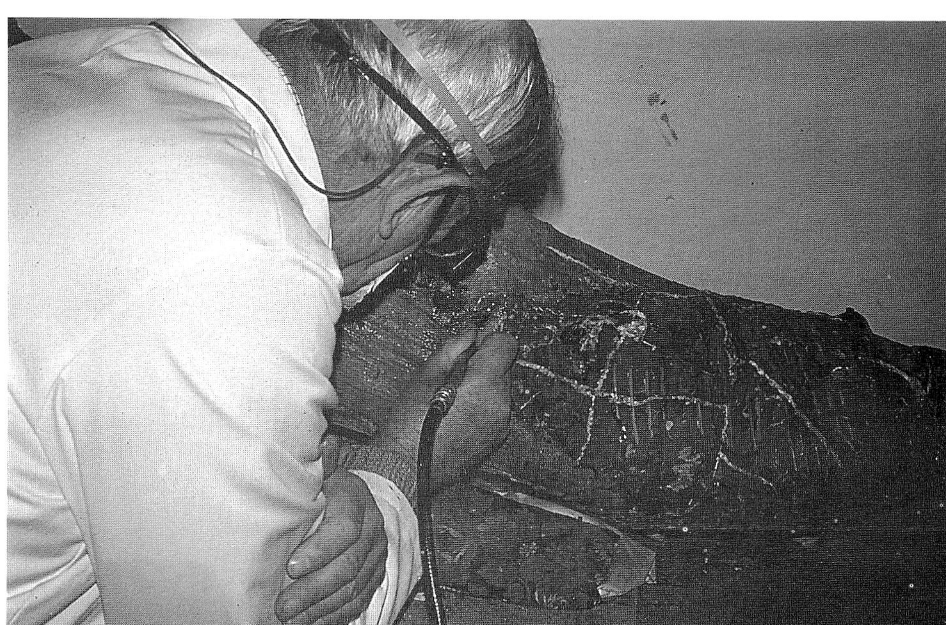

Figure 6. Alan Dawn using a Desoutter air-pen to remove limestone from around the teeth.

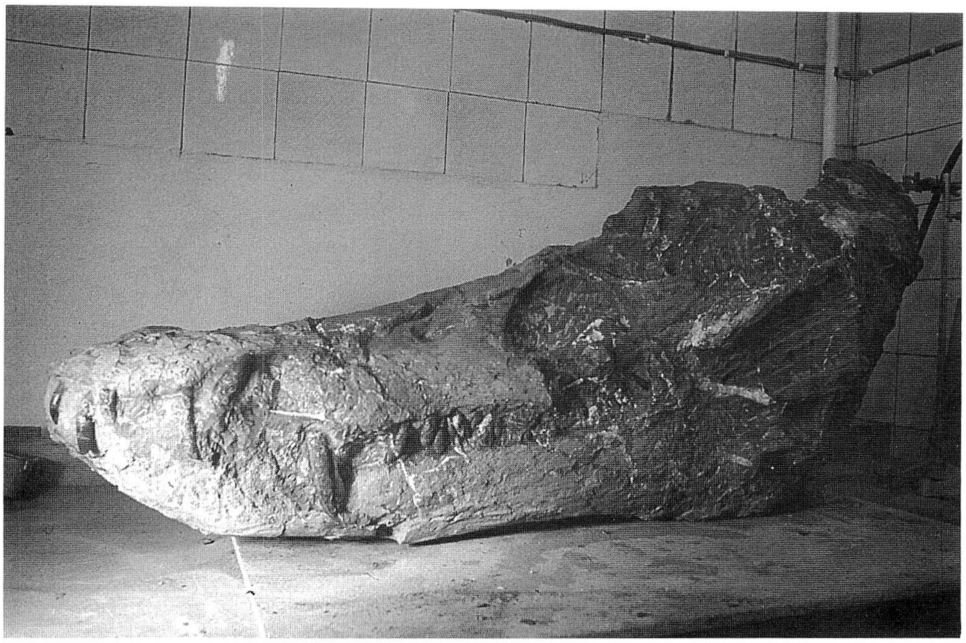

Figure 7. The skull ready for display. To improve visibility the rock matrix was next painted over with blue emulsion to make the bones and teeth stand out.

field collecting number. These bones were then laid out on a full-size tracing of the skeleton, and fractures glued together whereever possible. This process took about six months and was carried out by a small team of volunteers.

Most of the concretions had to be left in the museum car park for a year, while Alan Dawn and I reduced their bulk using an electric disc-cutter to cut grooves in the limestone and then hammer and chisel to remove the remaining ridges. Fortunately the bones lay across the top surfaces of the concretions, so by working with the concretions upside-down this operation caused only minimal damage to the skeleton. The skull was complete and within one concretion which naturally received priority; by the first autumn (1990) this was light enough to carry up the museum stairs (the museum lift only being installed in 1994) to the workshop for mechanical development using air-pen and hammer and chisel. The skull is almost exactly lm in length and weighs perhaps 0.25 tonne, so here again volunteers with muscles are indispensible! It was impossible to remove limestone from around the teeth without some damage to the enamel, but wherever possible damage was immediately repaired using HMG or Paraloid B72 adhesive. Alan Dawn was the only volunteer allowed to work on the skull.

The creature attracted considerable interest, and was soon examined by the country's leading marine reptile experts. The relatively small size of the individual (4.5m length, as against perhaps 12m for the largest specimens), and the lack of fusion of the neural arches to the vertebral centra, suggests that it is sub-adult. The

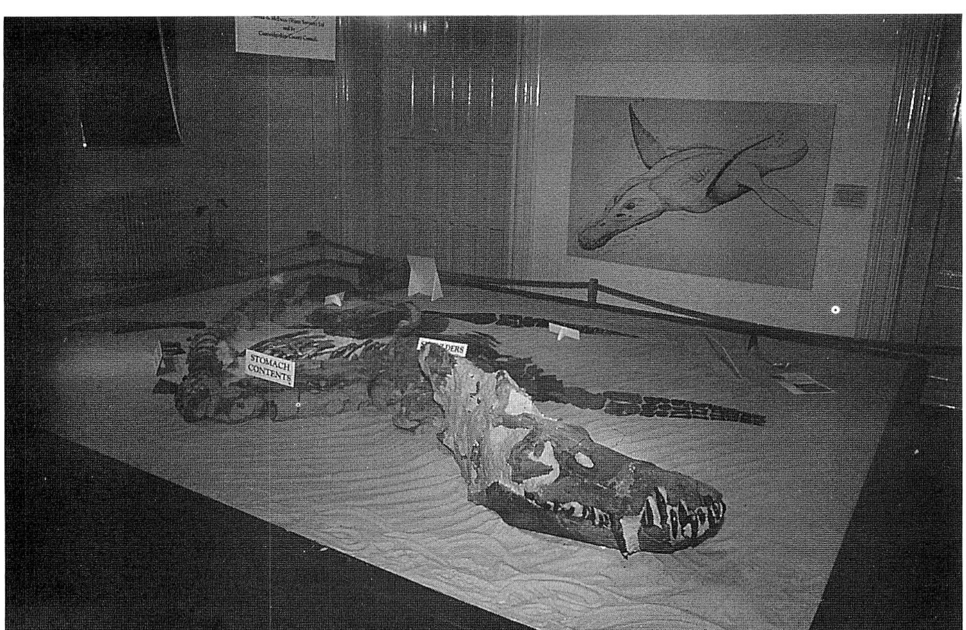

Figure 8. The pliosaur on open display during the summer of 1991 more or less as it was found. The pliosaur is now on display behind glass

presence of a thick black layer of cephalopod hooklets in the gut region is rare direct evidence for the diets of these pliosaurs (see Martill 1992). The articulation of the jaw with the skull, and of both with the post-cranial skeleton may indicate that this individual died on the sea bed and its gut contents may be atypical (in other words, that it died of starvation). There are only one or two specimens of *Liopleurodon* of comparable completeness; usually the mandible or skull is found in isolation from the post-cranial skeleton.

Once sponsorship by Shanks and McEwan was secured, extra funds were granted by the Cambridgeshire Museums Advisory Committee, and detailed plans were prepared for display of the specimen in the summer of 1991. A gallery was booked, a massive wooden plinth was designed and constructed by a local builders firm, and text was written for display panels and a booklet (Duff and Chancellor 1991). John Martin's drawing of the Oxford Clay pliosaur *Peloneustes,* borrowed from Bristol Museum was used to illustrate the specimen, A four metre square platform of polystyrene was laid on the plinth, and the skeleton gradually reconstructed on this as it had been found, the only variation being movement of one flipper and the turning upright of the skull, which had been buried lying on its left side. There remained much limestone surrounding the bones in the concretions, and this was painted with blue emulsion to make it easier for the public to distinguish the bone. Silver sand was laid over the foam base and rippled to give the appearance of the skeleton lying on the sea bed.

The Dogsthorpe pliosaur was on temporary open display during the summer of 1991, and was seen by perhaps 10,000 people during that period, interest in the specimen having been enormously enhanced by coverage on all three local TV news programmes. A room alongside the permanent geology gallery became available towards the end of the summer, and fortunately the pliosaur's display plinth fitted into it (with a few centimetres to spare!). The pliosaur is now on permanent display behind glass.

During the school summer holidays of 1992 two artists were employed by the museum to design and organise the construction of a 7 m-long reconstruction of the pliosaur. A bamboo and chicken wire frame was covered with multi-coloured papiermache, most of the simpler tasks being carried out by children, of whom some 120 participated in some way. The resulting reconstruction was on display at the museum until the April of 1993, when it was taken to a nearby Adventure Playground in the hope that it would survive one summer out-of-doors! The papiermache pliosaur's last journey was featured in a news film on BBC TV's 'Look East', proving yet again the insatiable appetite of the media for prehistoric monsters.

Conclusions

The success enjoyed by Peterborough Museum in collecting Oxford Clay reptiles and fish, and to a lesser extent Pleistocene mammals, is attributable to a partnership between museum staff and volunteers, principally local amateur geologists who want to see important fossils placed in public collections.

Another element of this success has been the carefully nurtured relationship between the museum and the various companies active in clay and gravel extraction and in landfill in Peterborough. This relationship is vital if finds are to be reported by quarry personnel, as invariably excavation must take place within severe time limits before the fossil is covered in spoil or rubbish, or flooded with groundwater.

As an example of what a medium-sized local museum can do in the way of seizing upon chance finds in active quarries, I have described the methods used to excavate and prepare for display the Dogsthorpe pliosaur, found in 1990. I doubt that any other institution would have been able to grasp the opportunity of rescuing this major new fossil, and in this respect the local museum has a vital role to play in saving our natural heritage. One can only hope that current financial restrictions, and the lack of storage space, do not make it impossible to rescue the next prehistoric monster which turns up in a Peterborough quarry!

Postscript

In April 1994 a fairly complete but badly disarticulated skeleton of a pliosaur (*Peloneustes*) was excavated a Whittlesey.

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LOST & FOUND

Compiled by Patrick N. Wyse Jackson

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The latest index to 'Lost and Found' was published in *Geological Curator* 5(2), 79-85.

Abbreviations:

CLEEVELY - Cleevely, R.J. 1983. *World palaeontological collections.* British Museum (Natural History) and Mansell Publishing Company, London.

GCG - *Newsletter of the Geological Curators' Group*, continued as *Geological Curator.*

LF - 'Lost and Found' reference number in GCG.

234 Arthur Humphreys Foord (1845-1933)

Kathleen Histon and Ezio Vaccari (Via Marsala 18, 37128 Verona, Italy) write:

A.H. Foord, who was born in Kent in 1845, worked for the Geological Survey of Canada from 1878-1883, where his first publications were on the micropalaeontology and corals of the early Palaeozoic rocks of Canada. His most famous work is his *Catalogue of Fossil Nautiloidea in the British Museum* (1889-1891), which was followed by a volume on the Bactritidea and Goniatites with G.C. Crick (1897). He also published several papers on nautiloids around this time in the *Geological Magazine*, the *Quarterly Journal of the Geological Society* and in *Annals and Magazine of Natural History.*

He was Curator of the York Museum for a while, and then held the position of Librarian and Editor of Scientific Publications to the Royal Dublin Society from 1891 until 1930. During this time he worked on cephalopod material in the Museum of Science and Art (later to become the National Museum of Ireland) and the Geological Survey of Ireland collections as well as compiling a considerable personal collection which is now housed in various institiuions in Ireland and the U.K.

Foord obtained a Doctorate from the University of Munich in 1896, and his thesis was published as a monograph of the Palaeontographical Society between 1897 and 1903 under the title *The Carboniferous Cephalopoda of Ireland.* The illustrations were drawn by Foord, and engraved onto wood.

He retired to Sussex in 1930 where he died on the 12th August, 1933.

An obituary appeared in the *Proceedings of the Geological Society* 90, lii [1934].

We are keen to trace a portrait of Foord, and any information regarding Foord's life, professional activities, publications, manuscripts etc. would be appreciated.

EXTRACTING DINOSAUR TRACKWAYS: A WELSH EXPERIENCE

by Stephen R. Howe

Howe, S.R. 1994. Extracting dinosaur trackways: a Welsh experience. *Geological Curator* 6(2): 83-88.

Episodes in the history of fossil excavation are explored. Particular attention is given to the development of techniques for the excavation of caves, and for use more widely in Pleistocene palaeontology. Contemporary collecting methods at Rancho La Brea, Messel and Scunthorpe are also discussed.

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Introduction

Occurrences of dinosaurs, whether as skeletal material or as trace fossils, are limited in Wales, where Mesozoic terrestrial deposits (of late Triassic and earliest Jurassic age) are restricted to parts of South and Mid Glamorgan, Gwent and Clwyd. Only six dinosaur sites are known, all occurring in the Vale of Glamorgan where three preserve footprints and three skeletal material. The specimens are especially important as they give an insight into the diversity of dinosaurs and their habitats very early in their history. Many of these are now housed in the National Museum of Wales, with the bulk comprising footprints. The skeletal material is small both in size and quantity, with a little being in the National Museum of Wales and the rest in the collections of the British Geological Survey, Keyworth and the Natural History Museum, London.

The discovery of dinosaur material in Wales is reviewed here, and the extraction, conservation, storage and display of the most recently discovered set of dinosaur footprints are described.

Dinosaur discoveries in Wales

The first discovery of dinosaur tracks in Wales was a set of five, large, tridactyl footprints, which were found in September 1878 by the artist Thomas Henry Thomas on a large slab of Triassic conglomeratic sandstone lying on the green in front of Newton Nottage church near Porthcawl, Mid Glamorgan. The slab measured roughly two metres square and had lain originally in front of the village inn, but its original source is unknown. However, according to W.J. Sollas it is petrographically similar to the beds found at the old Schorlan quarry at Newton Nottage from where he felt it may have come. The footprints were purchased on behalf of the Cardiff Naturalists' Society by Col. Turberville, the then President, and donated to the old Cardiff Municipal Museum. They are now on permanent display at the National Museum of Wales. The footprints were described by both T.H. Thomas (1879) and W.J. Sollas (1879). The latter considered them to be the footprints of a reptile similar to *Thecodontosaurus* or to *Palaeosaurus*, and he named them *Brontozoum thomasi*.

In the early 1880's John Storrie, curator of the old Cardiff Museum, discovered some very worn, unidentifiable footprints close to Lavernock Point, near Penarth. These were not collected but from his description they appear to have occurred near the top of the Blue Anchor Formation (Storrie 1895). As no others were ever found their identification remains a mystery. In the early 1890's Storrie also found two large teeth, which he attributed to *Palaeosaurus*, in the Westbury Formation of Lavernock Point, and in 1893 recovered a mandible of the same genus, associated with some material of the amphibian labyrinthodont, *Mastodonsaurus*, from the same locality.

The first skeletal material was found in 1898, when a workman preparing stone for a wall on Stormy Down, between Porthcawl and Bridgend, Mid Glamorgan, found an impression of the dentary bone of a megalosaurid dinosaur preserved in a block of pale sandstone. It measured 175 mm in length and contained six fully developed, sickle-shaped teeth. The specimen appears to have been found loose on the surface and although its geological setting was unknown it was considered to be of Rhaetian age. The specimen was obtained from the workman by Mr John David of Porthcawl who presented it to the Geological Survey Museum. It was described by E.T. Newton (1899) who appreciated its similarities to megalosaurid dinosaurs but, since there were no records of *Megalosaurus* from the Triassic, felt that it was more appropriately assigned to the allied genus *Zanclodon*, and named it *Zanclodon cambrensis*.

Further reptilian footprints were discovered near Porthcawl in the 1920s. During small quarrying excavations in the grounds of Nottage Court, Newton Nottage, a slab of coarse Triassic conglomerate was exposed that bore three large footprints on its surface. The slab was retained by the owner, Mr G.E. Blundell, and it is still in the possession of the family. These were considered non-dinosaurian footprints and, according to museum records, were ascribed to the ichnogenus *Chirotherium*. This specimen has recently been re-examined by Mike King of Bristol University, who considers it may be a very large *Isochirotherium* or, more likely, *Otozoum* derived from a prosauropod such as *Plateosaurus* (M. King pers. comm.).

During the late 1940s and early 1950s Triassic and/or Liassic fissure in-fillings in the Carboniferous Limestone of the Vale of Glamorgan, many of which contained richly ossiferous marls, were studied intensively. The initial research was undertaken by W.G. Kühne, followed later by K.A. Kermack and P.L. Robinson, whose main interests were in the early mammals contained within these deposits. A mass of tiny bones was extracted from these excavations but it wasn't until the late 1970s and early 1980s that the non-mammalian fauna was examined in any detail. It was amongst material collected by Kermack and Robinson from the Pant-y-ffynon Quarry, near Bonvilston, South Glamorgan in 1952, that Diane Kermack identified the juvenile skeleton of the prosauropod dinosaur *Thecodontosaurus* (Kermack 1984).

Further dinosaurian material did not come to light until 1974 when M.E. Tucker, T.P. Burchette, S.J. England and C.M. Jones, then at University College, Cardiff discovered a number of dinosaur footprints during the course of sedimentological studies of the marginal facies of the Upper Triassic at the Bendricks, near Barry, South Glamorgan. Dinosaur footprints were found on several bedding planes, but by exposing over 25 square metres of one bedding plane, they found over 400 footprints. Two sizes were present, both of which were assigned to the ichnogenus *Anchisauripus* (Tucker and Burchette 1977). Although most were small (105 mm long), tridactyl prints a few, larger (160 mm long) prints also occurred. Originally it had been intended to leave the footprints *in situ*, but soon after the discovery was publicised over-ambitious fossil collectors tried to extract some of the prints. A further problem was their cliff-top location, which is much walked over and, with

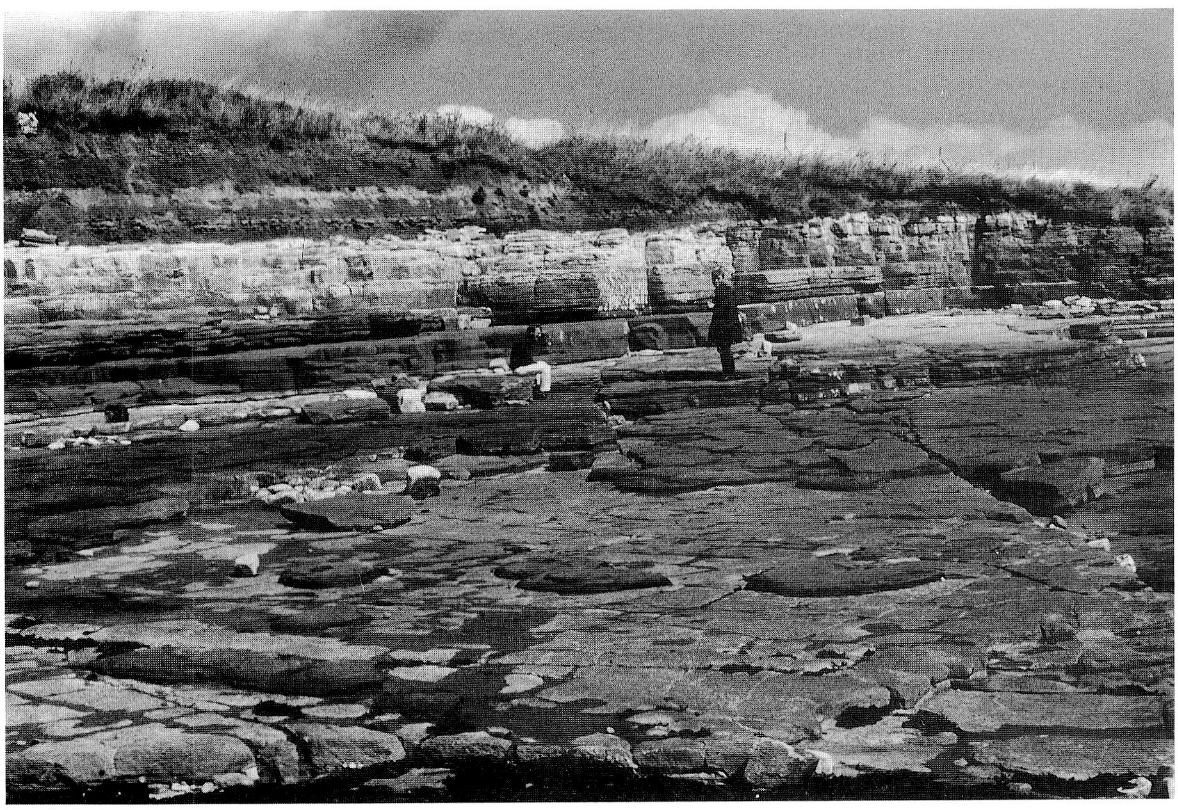

Figure 1. The 1989 dinosaur footprint site at The Bendricks, Barry, South Glamorgan.

the rather soft nature of the freshly exposed thin bedded, graded sandstone on which they were found, was liable to erosion. In order to ensure the preservation of the footprints the decision was taken to remove the pavement to the safety of the National Museum of Wales.

At the time of this discovery a couple of isolated footprints were noted about 300 metres farther west at the Bendricks. These were on a bedding plane near the top of the foreshore and as their location was not publicised, they were left *in situ*. It was not until 1989 that the full extent of this locality was appreciated. Close examination of the foreshore at low tide indicated that further footprints might be present beneath overlying rock and, during the visit of Li Jianjun, a Chinese palaeoichnologist in October 1989, a trial excavation by Li and the author was carried out. This proved that the footprints covered quite an extensive area and, unlike the site farther east, appeared to be aligned in definite trackways. Most were tridactyl prints of a size similar to the largest prints found by Tucker and Burchette, but one of the trackways was cut almost at right-angles by a few much larger footprints that appear to be those of a phytosaur. Their location on the foreshore (Figure 1), below the high tide mark, meant that marine erosion would inevitably ultimately destroy them, and it was decided to remove the best- preserved parts of the trackways to the National Museum of Wales for safe keeping, exhibition and research.

Preparations for the footprint removal.

The footprints discovered at the Bendricks in 1989 generated extensive media interest and coverage, and a television company involved in producing a new series about dinosaurs approached the museum with a request to film the operation of extracting the prints. To fit in with their filming schedules and to help boost publicity for a temporary dinosaur exhibition, the staff at the museum agreed to postpone the removal of the footprints until the following summer, which, also gave the benefit of better weather and longer hours of daylight.

In the intervening months the site was examined further to determine the full extent of the footprints and to decide which parts should be removed. Not all of the prints were worth removing; some had already suffered extensive erosion and were little more than shallow depressions whilst others, due to the variable consistency of the substrate into which they were impressed, were so poorly preserved as to be virtually unrecognisable. The footprints were preserved on the surface of a fine sandstone, of variable thickness, which in turn rested on top of a medium-grained conglomerate and it was obvious from the outset that the slabs of sandstone would have to be split and lifted along the contact between the two beds. In places the sandstone was over 60 mm thick which meant that the cut slabs would be fairly heavy, a fact which had to be borne in mind when the pavement was marked out ready for cutting.

An area of approximately 10 square metres was found to contain footprints, and it was decided that it would be worthwhile lifting and removing more than half of this. Permission for access to the beach, through the adjacent Trading Estate, was obtained which allowed vehicular access to within almost 100 metres of the site, thus keeping the distance over which the slabs had to be manhandled to a minimum. Permission to extract the footprints was also obtained from the owners of the site, Associated British Ports.

Before the footprints could be extracted it was necessary to study the tide tables in order to find a date that would provide the maximum period of low water during the day. This meant operating during a period of spring tides with high water occuring early in the morning and evening, and which gave about eight hours to work on the pavement before the site became flooded. Because the whole pavement would take at least two days to extract, the site would be covered by water for about four hours during each tidal cycle and, if the weather had been bad could have led to damage of the excavated area by wave action. Luckily this stretch of coast is fairly well protected and it was felt that this problem did not pose too great a threat, which in the event it did not.

A few days before excavation was due to begin the whole site was photographed and the footprint area mapped out by laying a large sheet of tough polythene over the surface and inking around each footprint, whether it was to be retrieved or not (Figure 2). This would provide a template, if required, for the reconstruction of the pavement back at the museum.

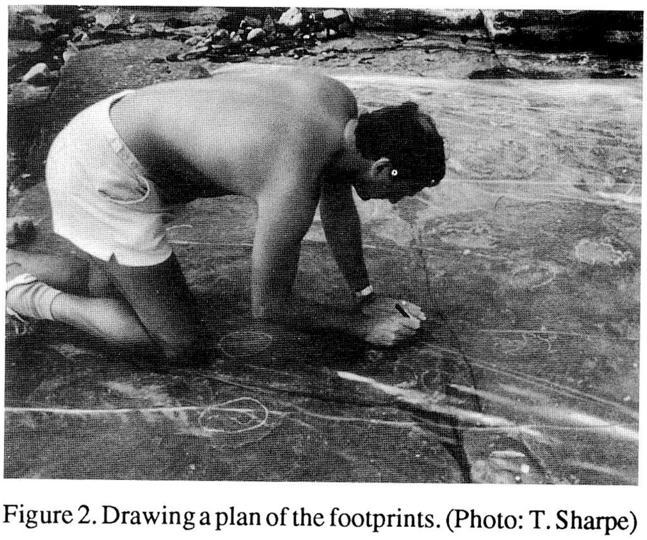

Figure 2. Drawing a plan of the footprints. (Photo: T. Sharpe)

Removing the pavement.

On the day that extraction was due to begin, in July 1990, staff from the Museum arrived on site two hours after high water. By this time the main area to be cut was clear of water and, due to the extremely hot weather, had even dried out. Lines for cutting on the area to be lifted were then marked out using chalk, with care being taken to put the lines well clear of individual prints (Figure 3). Each slab was marked out as large as was possible, to reduce both the number of cuts and the risk of damaging the footprints, but the slabs had to be of a size that could be manhandled across a rugged beach without too much risk to life and limb! Due to distribution of the prints this was not always easy, and inevitably one or two slabs turned out either larger or smaller than originally intended. Once the area was marked out, a diagram was drawn of the pavement and each slab issued a number that was written on the undersurface once it had been lifted.

The relatively flat surface of the 1974 pavement had allowed the use of a large, lawn mower-like pavement saw to undertake the cutting. However, the undulating nature of this later site made this impracticable and it was decided to use a portable, hand-held, petrol driven disc cutter (Figure 4). For safety reasons it was felt that it would be sensible to contract this work out, and a local landscape gardener was employed to undertake

Figure 3. Part of the footprint pavement chalk-marked ready for cutting. (Photo: T. Sharpe)

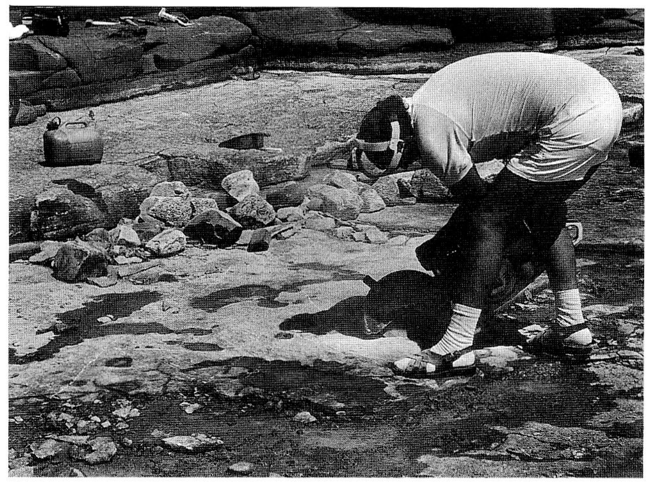

Figure 4. Cutting the footprints with the use of a disc cutter.

the cutting. Each cut was taken to a depth that corresponded as closely as possible to the contact with the underlying conglomerate, and the slab was then freed from the underlying bed with the use of bolster chisels and crowbars.

It was soon found that the contact with the underlying conglomerate was anything but smooth. Large fluctuations occurred, in some cases due to other footprints occurring on the under surface, and in a few cases the thickness of some of the slabs increased alarmingly! As had been expected, not all of the slabs came free in one piece. It was noticeable that around the hottest part of the day there was a greater tendency for them to break up, so to try and overcome this problem the slabs were doused in water before being cut and lifted. This did seem to reduce the problem,but how much of this was due to the effects of the soaking with water and how much to the sedimentology of each particular slab is not known.

A diagram was drawn of each slab as it was removed, outlining all of the breaks, each of which were numbered 1a, 1b, 1c etc., and all of the pieces were kept together during their transportation back to the museum. Fortunately, it was just possible, with the use of brute force, to use a sack truck to help carry the slabs across the beach to the van. For the larger pieces stretchers were made from wooden pallets using lengths of wood passed through the bases to act as handles.

Conservation and storage.

The footprint pavement had been covered regularly by the tide and it was possible that the rock was quite well impregnated with salt and other unknown substances (the beach at the Bendricks would certainly not win a blue flag award!). If left untreated it was possible that the growth of salt crystals could cause splitting of the slabs and it was decided to try and remove any salt by immersing them in fresh water for 6-8 weeks. An immediate problem was where to find containers large enough to take the slabs. This was solved when we were given the use of the old tannery washing pits at the Welsh Folk Museum at St Fagan's which had both ample space and a good supply of water.

Once washed, the slabs were returned to the museum where they were laid out on the floor of one of the stores and allowed to dry out gradually. As they dried some minor splitting occurred along the fine bedding planes in one or two of the slabs, and this was treated by injecting a thin solution of Paraloid B72 into the cracks. Once dried the broken slabs were stuck back together as far as was possible. In the few cases where the slabs had been badly broken they were reassembled into the largest sizes that could be handled without risk of future breakage. It had always been the intention to place as much as possible of the footprint pavement on display within the museum. However, at the time there was no geological gallery, which meant that all the slabs would have to be stored. The slabs from the pavement collected from the Bendricks in 1974 had been stored upright, first in a static and later in a mobile storage system. Although saving space, this method made the slabs rather difficult to handle and led to damage on some of the edges that bore the weight. Much of this pavement was loaned to the Naturhistorika Riksmuseet, Stockholm for exhibition in 1988 and was packed for transport in wooden crates, each slab having been wrapped individually in bubble wrap. This method proved highly successful and because of its potential space saving it was decided to store the newly collected pavement in the same way. Each specimen is fully protected and, if the spaces between each slab are packed tight with packaging materials, once fully laden the crates can be moved about without any risk of damage to the specimens. By making all the crates sufficiently strong, it is possible, with the use of a small fork-lift, to stack the crates one on top of the other, so saving space within the store.

Due to the publicity during the extraction of the pavement, which had included an 'and finally' item on News at Ten, so much public interest had been aroused that it was arranged for a small part of the pavement to be exhibited temporarily in the main hall of the museum, along with other dinosaur material. To achieve this a large, rectangular wooden frame was built, the inside covered in polythene, and the footprints then laid on a bed of damp sand (Figure 5). In our experience we have found it is easier to work with damp sand which, in the open space of a large gallery, soon dries out without causing any problems. For many years we used to cover the surface of the bare sand around the slabs with fine red marl, collected from the local Trias. This generally matched the colour of the rock of the

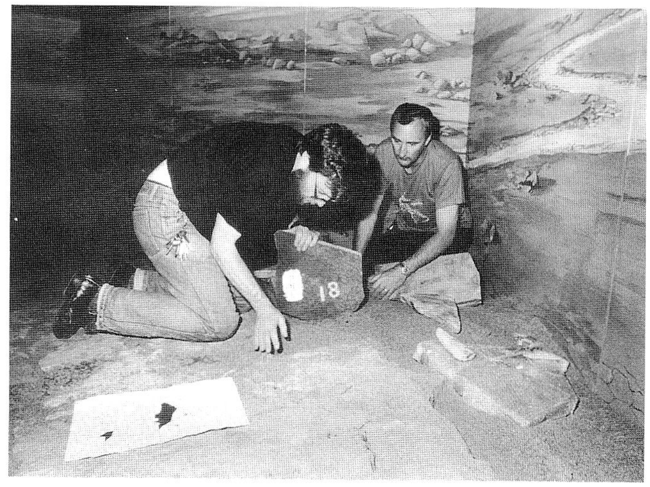

Figure 5. Laying the slabs on a bed of sand ready for display.

pavement, and it was also used to fill the joins between the slabs. We have recently found that the red building sands derived from the Permo-Trias of south Devon are even better. These sands have a considerable silt content and when they dry out form a hard crust, which helps to hold the whole pavement together.

Should footprints be removed?

No matter how much care is taken in removing large areas of dinosaur footprints, some damage will inevitably take place. Removal also divorces them from their environment and context, so devaluing their value and relevance to some extent, so that extraction should always be a last resort. If the conditions and circumstances are right it is desirable to leave the footprints *in situ* and open to examination and interpretation. In France there are sites where dinosaur footprints have been left *in situ*, and are on open display, around which interpretive panels have been provided. Displayed in this way the footprints certainly have a greater impact and relevance. Unfortunately, in both cases in South Wales removal became the only option, firstly through the probablity of man-made erosion and the activities of over-zealous fossil collectors who failed to appreciate that the extraction of individual footprints with a hammer and chisel was an impossibility and, secondly, through the power of marine erosion, both of which would have lead to the eventual destruction of the specimens.

Potential problems associated with removing footprints.

The physical size and weight of these specimens pose certain problems for the curator, both during collection and storage. Generally, because it is necessary to have as few pieces as possible in order to preserve the footprints in the best conditions, the exercise is likely to result in a series of large, heavy specimens. We have

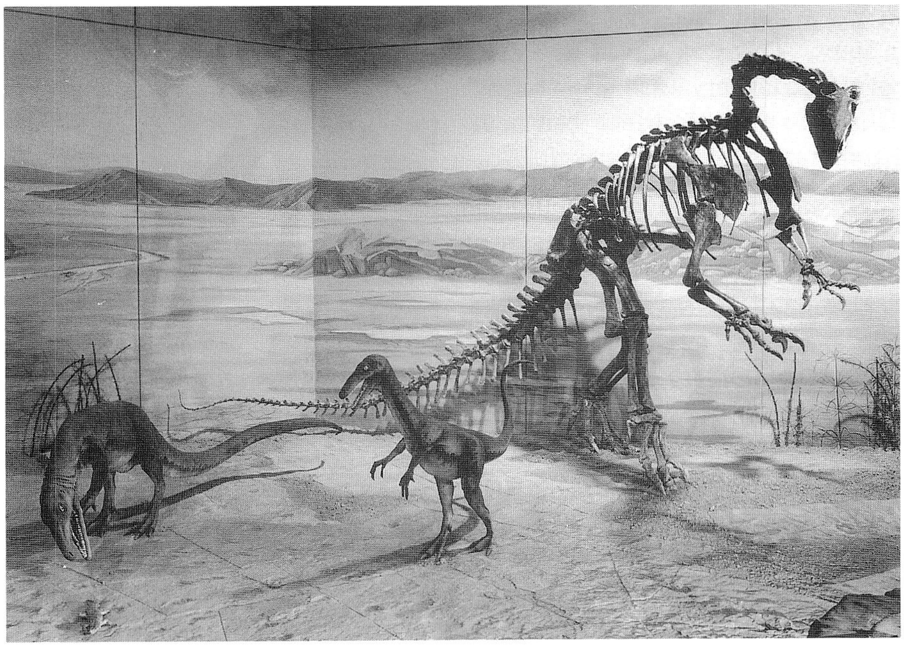

Figure 6. Part of the footprint pavement on permanent display in the *Evolution of Wales* gallery.

been lucky that in both cases it was possible for vehicles to come to within a few hundred metres of the sites. If this had not been possible, serious injuries could have occurred through lifting and manhandling heavy blocks over rough ground, and it was imperative to have enough well equipped manpower available in order to minimise the risk.

The usual saying is that 'all publicity is good publicity' - but it can have its drawbacks. Our publicity department had great success in interesting the media, both local and national, in the dinosaur footprints and what was involved in removing them to the museum. As a result, during the first day of extraction three television crews, three radio reporters and innumerable journalists turned up on site, all of whom had to be furnished with information, interviews and pictures. This was extremely time consuming and, when trying to operate within a limited tidal period, extremely frustrating. This was countered to some effect by having staff on hand whose sole responsibility was to facilitate these media interests.

At the end of the exercise we managed to achieve what we had intended without too many unforeseen problems, and many of the dinosaur footprints are now on display in the new *Evolution of Wales* gallery at the National Museum of Wales. Here they have been incorporated into a reconstruction of the late Triassic environment in which they were formed, and skeletons and models of the kinds of animals that we think made these footprints have been set on top of the pavement (Figure 6). The remainder have been left packed in crates in the stores where they are available for research, loan or temporary display.

Acknowledgments

I thank Dr R.M.Owens for reading and providing helpful comments on this article.

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COLLECTING DINOSAURS ON THE ISLE OF WIGHT, SOUTHERN ENGLAND

by Jonathan D. Radley

Radley, J.D. 1994. Collecting dinosaurs on the Isle of Wight, southern England. *Geological Curator* 6(2): 89-96.

The Wessex Formation (Wealden Group, Lower Cretaceous) of the Isle of Wight is currently yielding increasing quantities of dinosaur remains. This is due to accelerated erosion of coastal cliff sections, and increasing attention from fossil collectors. The Museum of Isle of Wight Geology acquires such fossils through active field work, donations and purchases. The practical framework for museum field activities is summarised, together with an outline of present conservation and display techniques.

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Introduction

No one in the museum world can now fail to realise that dinosaurs are big business. Dinosaur-related exhibitions are appearing throughout the country, and not only in institutions which possess their own skeletal material. In particular, real skeletons are at the peak of their popularity and are becoming increasingly valuable. In spite of this, potential acquisition of any major find must be carefully considered.

Finding dinosaurs

Actually finding a dinosaur is an extremely chancy business in Britain, even for the most experienced fossil vertebrate collector. Despite extensive exposures of Jurassic and Cretaceous rocks, non-marine dinosaur-bearing units are only locally well developed. To further reduce the odds, most of these rocks are hidden beneath fields, towns, glacial drift and river gravels. Add to the formula the unpredictable quirks of vertebrate taponomy and bone diagenesis, and the picture becomes even gloomier.

The south-west (and to a lesser extent the south-east) coast of the Isle of Wight boasts cliff and foreshore sections of weakly-consolidated clays and sandstones, belonging to the Wessex Formation of the Lower Cretaceous Wealden Group (Figure 1). Significantly, these strata are essentially of alluvial origin and have long yielded abundant dinosaur remains to generations of collectors. Herbivores such as *Iguanodon*, *Hypsilophodon*, *Polacanthus* and sauropods dominate the fauna; carnivores are represented mainly by megalosaurid theropods. Evidence for this unique terrestrial biota is supplemented by trackways, gastroliths and other fascinating glimpses of the Wealden world.

The Wealden rocks of the Isle of Wight have now been sufficiently well-researched to indicate just which of the many lithofacies are most likely to yield dinosaur remains. Considerable thicknesses of barren clay and sandstone occur and most bones occur in thin lake, pond or swamp deposits. As a consequence, staff of the Museum of Isle of Wight Geology (referred to herein as the "museum"), volunteers and other collectors tend to target these layers when time is available for field work. Low tides after winter and spring storms are the most productive times for collecting. Not only can freshly washed cliff faces be inspected, but also foreshore exposures, which have been cleared of sand and shingle. Despite a current increase in collecting activities, remains are still constantly being found, as the cliffs erode back at a dramatic rate (Figure 2).

There have been several cases of misunderstanding between collectors and landowners in recent years (see for instance (Radley 1993)). Coastal areas such as the Isle of Wight differ considerably from inland sites in terms of do's and don'ts. The island is unique, not only in the scarcity of alternative inland sites, but also in the geographic restriction of the most productive stretches of coast. These pressures have been partly responsible for collecting-related problems, including cases of over-collecting. Clear-cut cases of illegal collecting appear to be rare.

Staff of the museum are currently producing "collecting guidelines", specifically tailored for the island and

Figure 1. Cliffs of Wessex Formation clays and sandstones in Brighstone Bay, on the south-west coast of the Isle of Wight. Localities such as this often yield dinosaur remains and are frequently inspected by museum staff and other collectors.

intended for all categories of collectors. This aims to emphasise the rudiments of responsible collecting and collection care (as outlined by Knell 1991), rather than present a rigid set of rules.

Museum curators are by no means above the law and have to abide by the same rules as all collectors. Primarily, it is necessary to ascertain ownership of any find (Taylor and Harte 1988).

Unless privately owned, foreshore areas around the Isle of Wight (beaches and rock exposures below high-water mark) are Crown Estate property. There is currently no real problem with responsible collection of eroding geological specimens from these areas. Many interesting dinosaur remains (and most Wealden bones in general) are now found amongst concentrations of poorly-sorted Wealden debris amongst the modern beach deposits. Such "rolled bones" are highly prized by local collectors and are amongst the objects most frequently brought into the museum as enquiries.

In Compton Bay, the National Trust leases the foreshore from the Crown. There now exists a published policy statement for this area (Simson 1991). In short, collection of small fossils is allowable without prior permission, but written consent must be sought for excavation or removal of large specimens, such as dinosaur footcasts or *in situ* bones. Fortunately the National Trust tend to look favourably upon the activities of the museum and

Figure 2. Erosion and slumping of thinly-bedded alluvial sediments in the Wessex Formation at Yaverland, on the island's south-east coast.

bona fide researchers, and permission is normally granted.

Cliffs are a wholly different issue. Permission to dig above the high water mark needs to be obtained from the landowner (often a farmer or the National Trust). Strictly speaking, collection of loose material above the high water mark without landowner's consent is illegal, notwithstanding the probability of erosion and eventual destruction (Taylor and Harte 1988).

The south-western and south-eastern coastal Wealden outcrops of the Isle of Wight fall wholly within the boundaries of the Hanover Point-St. Catherine's Point SSSI and Bembridge Down SSSI respectively. English Nature promote responsible collecting on these SSSI, rather than attempting to enforce restrictions (J. Larwood, personal communication). Guidelines are detailed in *Fossil Collecting and Conservation*: a pamphlet published and distributed by English Nature. Collecting (of a responsible nature) is in fact essential along the Wealden outcrops, as a result of high erosion rates, frequency with which Wealden vertebrates come to light and the susceptibility of most vertebrate fossils to rapid destruction (also see Norman *et al.* 1990 and Norman 1992).

One of the chief threats to the scientific value of island dinosaurs and integrity of dinosaur sites is the excavation and destruction (albeit usually unconscious), of less obvious features such as associated invertebrates, by collectors pursuing bones alone. This serious problem could potentially be partly remedied through publication and distribution of the collecting guidelines (see above).

Museum fieldwork

Over the last fifteen years or so, museum staff and volunteers have located and successfully excavated several partial skeletons. In addition, literally hundreds of individual bones have also been collected. No two excavations are ever alike, and every instance requires different resources and skills of improvisation. Island digs are never easy and are usually extremely wet! Without a keen eye, patience and experience, bone can be difficult to distinguish from host sediment or associated plant remains. The first indications of a substantial find are usually provided by a few scraps of bone on the surface of a foreshore outcrop or cliff face.

From time to time, indications are sufficiently favourable to necessitate a formal evaluation. Above all, any museum acquisition must be thoroughly researched and wholly legal (Paine 1993). Specific factors generally considered include research or display potential, rarity (new record or taxon?), preservation, site location and financial considerations (also see Brunton *et al.* 1985, section A2.1.1). If the evaluation indicates a high possibility of good returns, a dig is planned. Excavations are by no means entered into without considerable forethought as time, funding and storage space are currently extremely limited.

A dig is a complex operation, and normally needs to be executed swiftly. Major threats to any island dig include tides, cliff falls and site raids. The first prerequisite is skilled labour. Volunteers are vital, as the museum only employs two full-time members of staff. There is usually no shortage of local collectors with the patience and enthusiasm to help out, often under extremely difficult conditions. During a recent dig at Barnes High in Brighstone Bay, skilled manpower was obtained from the Department of Geology of the University of Portsmouth, in the shape of undergraduate students. Without their help, several parts of a unique sauropod skeleton would never have been found (Radley and Hutt 1993).

Safety on any dig comprises elements of the Geologists' Association's *Code for Geological Field Work* coupled with everyday common sense. Conditions can vary from day to day and can be extremely challenging, mentally as well as physically.

Money is needed at all stages of the operation for materials ranging from shovels to thermos flasks! During the recent sauropod dig, our budget was supplemented by funding from English Nature and the Geologists' Association's Curry Fund.

The materials needed depends directly on the geological context of the bones themselves. In all cases, it is far better to have the necessary materials (consolidants, tools, camera films, notebooks) already in store for any eventuality, rather than having to hunt round at the last minute.

The majority of Wessex Formation bones are pretty solid, but are often partially encased in tough concretionary sideritic ironstone. Similarly, many of these bones are dark in colour and heavily pyritised. Bones of this nature are found in (or eroded from) so-called plant debris beds, which are poorly-sorted accumulations of flood plain debris, deposited in localised depressions (mainly swamps, ponds and channels) during seasonal storms. These beds now occur as thin lignitic seams within thicker oxidised floodplain alluvial clay and sandy channel deposits (see for instance Daley and Stewart 1979). Fortunately, the pyrite within plant debris bed bones is generally extremely stable. We know of cases where local collectors have left *Iguanodon* bones in gardens for many years, with no apparent adverse effects. In direct contrast, the pyritised lignitic plant material in plant debris beds is highly unstable and does not survive long without treatment, even in the most controlled museum

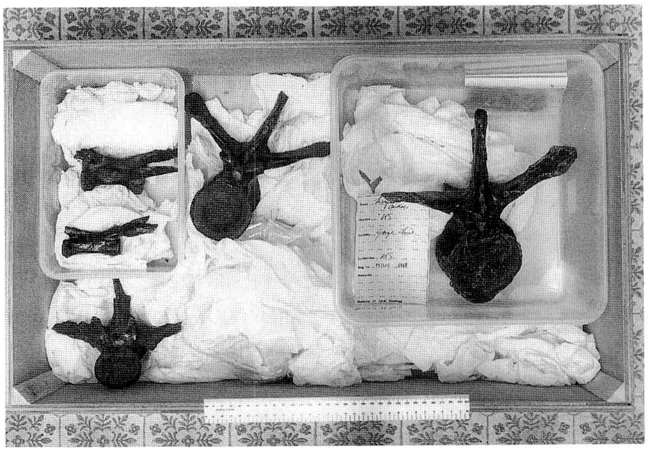

Figure 3. Plant debris bed preservation: well-preserved, partially pyritised caudal vertebrae belonging to a locally collected theropod dinosaur (MIWG 6348). Note the robust, uncrushed preservation and dark colouration. These bones have been coated with a weak Paraloid B72-acetone solution to protect them during handling. The ruler is 30cm long.

Figure 4. A freshly exposed but isolated sauropod femur (subsequently accessioned as MIWG 6484) in oxidised clays on the south-west coast of the Isle of Wight. Note the extensive fractures and pale colouration.

environments. Depending on their location, bones can usually be excavated from plant debris beds with relative ease. The internal mineralisation and sideritic matrix often gives them considerable structural strength which facilitates lifting and transportation (Figure 3). The downside is that substantial articulated remains are rare in plant debris beds. These layers are the chief source of the isolated vertebrate material found as rolled bones and pebbles, amongst modern beach deposits in Brighstone Bay, Compton Bay and at Yaverland, north-east of Sandown.

More rarely, partial skeletons are located. These are sometimes in a poorly pyritised and only weakly mineralised state within oxidised colour-mottled clays, which represent the deposits of ephemoral floodplain ponds or lakes. Such bones tend to be relatively pale in colour. The new sauropod (see above) exemplifies this style of preservation. Although they can be beautifully preserved, the fragility of such bones renders them extremely difficult items to deal with, as the bone surfaces can be little harder than the clay in which they are found (Figure 4). This is where field improvisation enters the picture. A combination of hunting knives, bayonets and trowels is often used; brushes are also useful when conditions are dry. If the remains are substantial (e.g. the new sauropod), excavation can take many months. Periods of large scale backbreaking cliff clearance with picks and shovels are invariably necessary, before the bones can be extracted. As they come to light, bones have to be numbered with waterproof ink and plotted on a site plan. This allows eventual reconstruction and research of the skeleton. Back-up photocopies are essential as these plans often fall apart in the rain, or disintegrate in high winds.

Compilation of associated information (stratigraphic and sedimentological data, occurrence of associated fossils etc.) is an ongoing task, which in some cases continues intermittently for months or years after the last bone has been lifted. Labour-intensive excavations often supply temporary fresh sections in normally weathered or slumped cliff faces. All data is entered into notebooks which are also regularly photocopied. A decent camera is another essential piece of field gear.

Successful extraction of bones is an art. Larger bones of the fragile poorly mineralised type have been invariably shattered by weight of overburden and small-scale adjustment within alluvial clay (Figure 4). These cannot be moved without special support. Surfaces of these are generally covered in aluminium foil, before a layer of dental plaster of Paris is applied (Figure 5). This has to be mixed with fresh water for it to set; inconveniently sea water does not work. Dry conditions also help the process but can never be guaranteed, even during the summer months. This cover will only support one side of a bone. Subsequently, the partially plastered bones have to be prised away from the bedrock and carefully turned over, to repeat the process for the other side. This is an extremely risky operation and bones have been known to collapse at this stage. Ideally, the finished article comprises a bone or bones, partially encased in matrix and wholly supported by a plaster jacket. Smaller associated finds are wrapped in newspaper and/or clay and placed in self-sealing labelled bags.

Site security is always a problem. In a tiny area like the Isle of Wight, attempts to conceal sites are major undertakings and invariably fail. Museum staff and volunteers endeavour to patrol site areas whenever possible, and keep an ear close to the ground. To date, serious site raids have been few and far between.

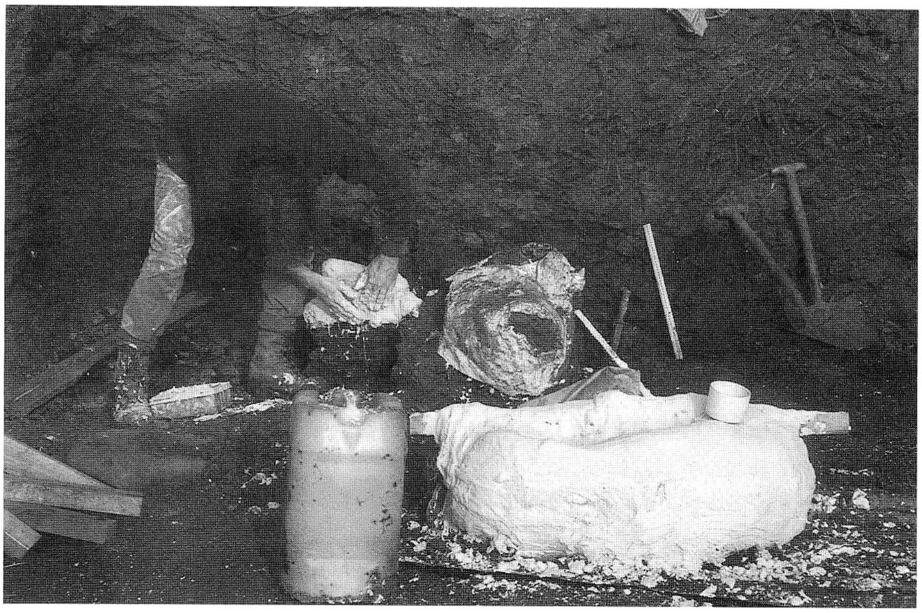

Figure 5. Sauropod excavation at Barnes High, early 1993. Fragile bones are being encased in plaster jackets, prior to lifting.

Safeguarding and preparing the bones

The sheer weight (and often size) of pyritised or plastered dinosaur bones makes them extremely awkward objects to deal with. To further complicate matters, excavation sites are often hundreds of metres from the nearest track and may be perched tens of metres above beaches or below cliff tops. Once again, common sense and manpower gets the job done.

Storage is organised in advance. A suitable atmospheric environment is needed for all Wealden bones in long term storage, to prevent any potential decay. Storage areas should ideally be dark, well insulated and dust free. Relative humidities should be maintained between 45% and 55% (Brunton *et al.* 1985; Paine 1993). Our storage areas at the museum are fairly basic, but just about meet the basic standards needed for proper care. Unprepared bones and skeletons are mainly kept in lidded wooden boxes or in sturdy polythene trays. Many of the massive plastered bones of the new sauropod are being stored in a recently acquired building, a few miles from the museum premises. This facility will ultimately allow environmentally-controlled care of specimens (Radley 1994).

We unwrap our dinosaur bones as soon as possible after they are safely put in storage. Obviously this requires space, which can be difficult to secure in the cramped museum storerooms. In particular, plaster jackets are removed as soon as circumstances allow, to avoid chemical reaction with bone. Bones from plant debris beds have to be freed of clay, encrusting pyrite and sideritic ironstone matrix. Clay can generally be washed off with running water and brushes, however tougher ironstone and pyrite is removed with a combination of pneumatic engraving pens and airbrasive equipment (Figure 6). These powerful precision tools are invaluable for the vertebrate preparator, but have to be used with care and patience. Inexperienced volunteers normally practice on beach-worn bones before tackling anything rare or valuable. After cleaning, plant debris bed material

Figure 6. A pneumatic engraving pen being used to remove pyritic matrix from an *Iguanodon* limb bone fragment.

is slowly and thoroughly dried. Any broken pieces are glued back together using a conservation-quality glue such as Paraloid B72 in pellet form, dissolved in a small quantity of acetone (Figure 7). This glue is entirely reversible by dissolution in acetone (Jaeschke and Jaeschke 1987).

Rare or exceptionally well-preserved pyritised bones are sometimes coated in a weak Paraloid-acetone solution, to protect them during handling (Figure 3). They are then returned to the stores, after numbering and labelling.

Fragile, plastered bones require a lot of time and space for successful conservation. Plaster jackets can be removed with pliers, and clay matrix removed with running water, brushes and needles. Surfaces of these bones are usually too soft for mechanical preparation although some promising results have been obtained through careful use of airbrasive apparatus. Cleaned bones have to be thoroughly glued and impregnated with Paraloid B72 and even then, they have to be carefully handled. A single fragile rib or toe bone will contain hundreds of minute fractures and can take weeks to prepare. Once again, this is where volunteers prove to be very useful.

If a find is too big to prepare in the museum, then we necessarily look for more spacious premises. In the summer of 1993, museum staff and volunteers moved plastered bones belonging to the new sauropod back to the south-west coast of the island, where it was originally excavated. Here a temporary exhibition and preparation area was set up, in a secure barn belonging to the farming family on whose land this dinosaur was found. On two days a week, members of the public were allowed in to watch the preparation process, see other recent finds and ask questions (Figure 8). Steve Hutt (curator of the museum) provided informal talks on the excavation and subsequent preparation. This was a great success, and by October a considerable number of bones had been prepared and were ready for removal back to museum storage.

Research, reconstruction and display

Commoner Wealden dinosaurs are well described and illustrated in the scientific literature. Obviously, these monographs and papers greatly help the reconstruction process. Skeletal reconstructions of rarer species often rely largely on descriptions of similar, but better described foreign species and Steve Hutt's considerable experience in this field. The museum has a strong commitment to accurate portrayal of dinosaurs and their life environments, and presentation of "state of the art" knowledge. Responsibility for this rests fairly and

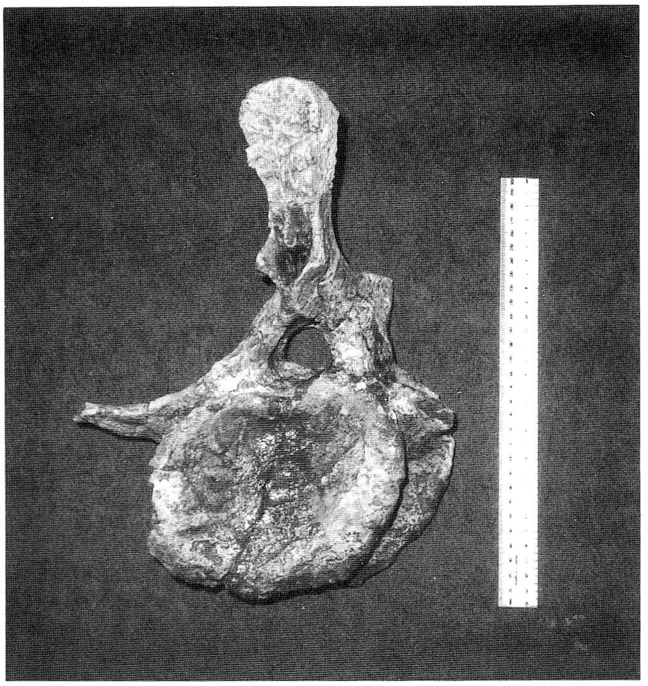

Figure 7. A caudal vertebra belonging to the recently excavated sauropod. The bone is extremely fragile and has been thoroughly glued and impregnated with Paraloid B72 in acetone. Ruler is 30 cm long.

squarely on the shoulders of curatorial staff, who strive to maintain up to date files of relevant scientific papers, books and press cuttings.

The reconstruction technique to be used in the public gallery depends on the size, preservation and completeness of the skeleton. As with excavation and preparation there is no rigid formula, and display style exercises the ingenuity of museum staff and designers. Even after preparation and chemical impregnation, larger bones will not support themselves and have to be mounted as two-dimensional displays (Figure 9), or replicated in fibreglass. As a result, accurate life postures can be produced, based on the latest research. Casting is also essential for producing displayable replicas of missing bones in otherwise well-preserved skeletons. Physical support for three-dimensional reconstructions is provided by welded steel rods. Accompanying text for the skeletons is generally kept brief and non-technical. To a large extent, something as impressive as a real dinosaur skeleton speaks for itself in the eyes of the interested public.

Dinosaurs alone tell us little of the world in which they lived. Evidence of climates, ancient environments and ecology comes from the rocks from which the bones are dug, and the associated fossils. Consequently the displays are augmented with fossil plants, molluscs, and other inhabitants of the Wealden world.

In practice we have a considerable backlog of unprepared and partially prepared material, squeezed into the

Figure 8. Temporary exhibition of recent finds and preparation techniques in a barn at Lower Sutton Farm, near Brighstone.

museum stores. This material is regularly inspected for signs of pyrite decay and other environmental problems.

Only a few finds have ever been fully prepared and fewer still have been put on public display. The backlog will only ever be cleared if the flow of bones through the museum doors ever abates. At present this seems unlikely! Although we now have only limited time for our own fieldwork we often receive donations of new material from local collectors. Occasionally we have sufficient finances to purchase locally-collected material, although sometimes fund-raising events have to be organised (Radley 1994).

In summary, the collecting scene on the island appears to be in general good health, given the pressures being imposed upon the fragile coastline and its fossiliferous outcrops. The Museum sees its role not only as an institution commited to the preservation of Wealden dinosaurs, but also as an advice centre for all collectors, irrespective of motivation.

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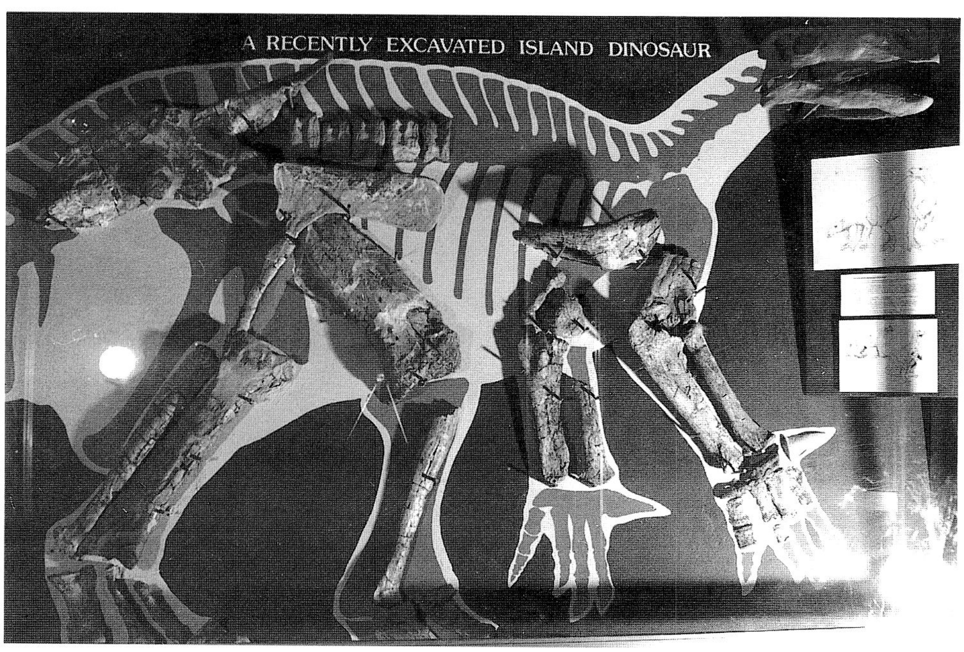

Figure 9. A prepared partial *Iguanodon* skeleton (MIWG 5126). The fragile, weakly mineralised bones have been set into the wall, for support and security.

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MISS FFARINGTON'S PLEISTOCENE SHELLS FROM WORDEN, LANCASHIRE, ENGLAND: AN ANNOTATED LIST.

by Nora McMillan

GEOLOGICAL CURATORS GROUP GCG

McMillan, N.F. 1994. Miss Ffarington's Pleistocene shells from Worden, Lancashire, England: an annotated list. *Geological Curator* 6(2): 97-101.

Mary Hannah Ffarington (*c*.1815-1888) accumulated a large number of Pleistocene molluscan shells from Worden, near Preston, Lancashire. She published a list of them in 1879, and her collection was utilised by a number of molluscan researchers. In 1948 the collections were sold and their location remained unknown until the late 1970s. The collection today consists of 26 gastropod species, one scaphopod species and *c*. 49 bivalve species. The shells have been conserved, labelled with modern accepted names, and are now housed in the Clitheroe Castle Museum.

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Miss Mary Hannah Ffarington (*c*.1815-1888) was a member of a well-known local family of Worden Hall, Leyland, near Preston, Lancs. There was a family tradition of interest in natural history, and eventually a quite considerable museum of natural history and ethnographic material was built up (Cleevely 1983). Hannah's main interest seems to have been geological and over many years (said to have been 56!) she gathered shells from the Pleistocene gravels at Worden, Leyland, and conveniently near her home. The family museum was sold in 1948, and the geological collections bought by the local agent Mr John Forrester. In 1978 he agreed to a 20-year loan of the collection to the Lancashire County Museums Service for conservation and curation. In 1991 by courtesy of Mr John Blundell of the Lancashire County Museums Service the Pleistocene shells from Worden were loaned to the writer, and here is an updated and annotated list of the species represented.

The site

The Pleistocene gravels from which Miss Ffarington obtained her shells were extensively available in the Worden gravel-pit, half a mile south of Clayton Hall in the Leyland district, near Preston. The pit was excavated in a great mound of gravel rising through boulder clay; the gravel exhibited magnificent current-bedding and contained fragments of marine shells (Price *et al.* 1963, p.86).

History

The earliest to notice these Pleistocene shells were apparently William Gilbertson and R.C. Taylor (1830) who listed 16 species of marine shells and stated "The existence of shells, particularly Turbo terebra, among the gravel employed in mending the road betwixt Whittle and Leyland, has long been known. One gravel pit, situated about 3/4 of a mile from the canal at Whittle, is 20 or 30 ft. deep, several acres in extent, and upon higher ground than the canal, which is there 307 ft. above the level of the sea". So it is clear that Miss Ffarington had ample opportunity for collecting shells from these gravels.

In 1834 Gilbertson briefly mentioned the shells again, and so did Murchison in his 1832 presidential address to the Geological Society of London. R.D. Darbishire (1826-1908) was interested in glacial drift shells and was in touch with Miss Ffarington who apparently showed him her collection. Darbishire examined it and published a list of the species in it (1874). He also exhibited "a series of the form *contraria* of *Neptunea antiqua* from the Drift at Worden by Leyland from Miss Farington's (sic!) cabinet" at a meeting of the Literary and Philosophical Society of Manchester on 7th December 1885 (*Journal of Conchology* **5**, p.49).

Five or six years after the Darbishire paper of 1874 Alfred Bell (1915, p.166) examined the Ffarington shells and identified "ninety species in it" (actually 88 species and varieties) which were afterwards recorded in a privately printed catalogue (Ffarington 1879).

Miss Ffarington died on the 29th October 1888, aged 73 (*Times* of 31st October 1888, p.1).

In 1934 the Ffarington shells were referred to by A.C. Nicholson thus (on p.10 of his ms. account): "This collection [Miss Ffarington's] was revised by Messrs

A. Bell and F.W. Harmer, and extends to 88 species and varieties (23 are at the Harris Museum, Preston), the whereabouts of the other and rarer species are unknown. The collection formed over a period of 56 years".

From 1960 onwards I tried to located these shells but with no success until correspondence in the *Geological Curators' Group Newsletter* (Blundell 1978; Jusypiw 1983) produced the desired information and the shells became available.

The collection of Worden shells as received by me comprised 115 circular glass-topped boxes, almost all bearing their original labels. Unfortunately the labels had been stuck onto and across the glass lids and some labels were imperfect or in a few cases missing. Some loose labels were united with their correct boxes.

The majority of the labels were in ink, in the fine Victorian hand of Miss Ffarington; the names used for the shells were old and the labels invariably extended beyond each side of the box. Other boxes (22 in number) bore pencilled labels in the hand of Alfred Bell (by direct comparison with samples of his handwriting) and with more modern names; these labels were shorter and did NOT protrude beyond the edge of the box. The Bell labels were also of a different paper from those of Miss Ffarington.

Every species and variety listed by Miss Ffarington has survived except two (*Venus casina* and *Venerupis pullastra*).

My conservation of these shells has been as follows: all the original labels (both Ffarington's and Bell's) have been transcribed in Indian ink onto a small blue label; on the reverse side the label bears the current name of the species according to Seaward (1990). The blue labels have all been placed *within* the boxes, and this should ensure that future workers have all the data accessible.

Every boxful of shells and shell-fragments has been examined, checked and counted. In a few cases I am not in agreement with some of the identifications of fragments, especially some named by Bell and these cases are noted in the following list of species.

All the Ffarington collection of Pleistocene molluscan shells, including specimens formerly in the Harris Museum, Preston, are now housed in the Clitheroe Castle Museum, Castle Hill, Clitheroe, Lancashire.

LIST OF SPECIES AND VARIETIES

Names according to Seaward (1990). Specimens labelled by Bell are specified; all others labelled by Miss Ffarington.

Gasteropoda

- *Diodora apertura* (Montagu). Two fragments, labelled "*Fissurella reticulata*".
- *Littorina littorea* (L.). Two boxfuls (90 specimens in all). Smaller box labelled by Bell.
- *Littorina "saxatilis"*, the aggregate species. Four.
- *Littorina obtusata* (L.). Two.
- *Turritella communis* Risso. Abundant, several hundred specimens in 2 boxes, smaller with Bell label.
- *Aporrhais pespelecani* (L.). Seven shells, 48 fragments.
- *Natica catena* (da Costa). One.
- *Natica alderi* Forbes. One.
- *Trivia "europaea"*. Five shells, four fragments. It was not possible to determine whether these were *arctica* (Pulteney) or *monacha* (da Costa).
- *Trophon truncatus* (Ström). 93 shells (20 labelled "*Trophon scalaiforme*").
- *Trophonopsis clathratus* (L.). Three. And var. *gunneri*. One.
- *Trophonopsis craticulatus* (Fabricius) [= *fabricii* (Beck) Möller, 1824]. This specimen bears the ms. name "*Trophon Ffaringtoni* A. Bell" in Miss Ffarington's hand. Jeffreys, commenting upon Darbishire's 1874 paper (on p.41) was not quite satisfied about the identity of this shell but it appears to be correctly named.
- *Nucella lapillus* (L.). Abundant, two boxfuls, smaller with a Bell label, *c*. 120 shells and c. 70 fragments. The two largest shells measured 40 and 36 mm high. Another box held three fragments labelled "*Purpura lapillus* var. *imbricata* Lam." and another box a single shell labelled "*Purpura lapillus* var. *carinata*".
- *Ocenebra erinacea* (L.). 204 shells and numerous fragments in 2 boxes, smaller with a Bell label. The two largest shells measured 43 and 40 mm in height (apical whorls missing in both cases).
- *Astyris rosacea* (Gould). Three shells. Labelled "*Pleurotoma laevigata*".
- *Neptunea antiqua* (L.). Abundant in 2 boxes, the smaller with a Bell label. Total of 10 shells and 108 columellar fragments. All the dextral form. The Bell-labelled box contained also a shell and two fragments of *Buccinum undatum*.

- *Neptunea antiqua* (L.). var. *contraria* (L.). Much less frequent than the dextral (ordinary) form, three shells and nine columellae and in a Bell-labelled box were two more columellae. These specimens are the small obese form found also in the Wexford "manure" gravels (see McMillan 1964 for details and figure). One specimen in a separate box is labelled "var. *carinata*".
- *Colus howsei* (Marshall, 1911). Four
- *Colus gracilis* (da Costa). Five.
- *Buccinum undatum* (L.). Abundant, 2 big boxfuls. Abundant, largest box held 15 shells, rest 95% columellar fragments. Smaller box labelled "*Buccinum undatum* (normal)". In a separate box a single shell labelled "*Buccinum undatum* var. *Labradorense* Reeve". A Bell-labelled box contained fragments of *Neptunea* as well as *Buccinum*.
- *Nassarius reticulatus* (L.). Frequent, 2 boxfuls. One box held 50 shells plus *c*. 50 fragments. Largest complete shell 29mm high. Smaller box labelled by Bell contained 30 shells and *c*. 30 fragments. A box labelled "*Nassa nitida* Jeff." with 13 shells.
- *Nassarius incrassatus* (Ström). Seven shells. In another box 2 shells labelled "*Nassa incrassata* var. ?". In the privately-printed list (1879) a var. crassa is listed for *N. incrassata* presumably referring to these shells.
- *Nassarius pygmaeus* (Lamark). Three shells, largest 17mm high.
- *Volutomitra groenlandica* (Beck *in* Möller). One good shell. On back of box in an unfamiliar hand is the inscription "A fossil sp. of *Columbella* extinct Mr G.B. Sowerby". ?handwriting that of G.B. Sowerby.
- *Lora turricula* (Montagu). Two boxfuls, one labelled by Bell held 17 shells, the other 31. Another box with three shells was labelled "*Pleurotoma turricula* var. *pyramidalis* (Ström)".
- *Lora rufa* (Montagu). Three shells. In another box a shell with label "*Pleurotoma nebula* (*Bela woodiana* ? Mr Sowerby?"). In the Ffarington list (1879) is a "*Bela woodiana* Leach? or may be *Pleurotoma nebula* Montagu".

Scaphopoda

- *Antalis vulgaris* (da Costa). Two boxes, both labelled *Dentalium entalis*, one by Bell. Mr C.P. Palmer has kindly examined all the specimens (12 in number) and considers that all are almost certainly *vulgaris* although much worn and fragmentary. One specimen was labelled "*Dentalium abyssorum* Sars"; presumably this is the specimen listed by Miss Ffarington (1879) and possibly also that referred to by Jeffreys (1865, p.197) as "*D. abyssorum* is one of our glacial relics. It occurs in the boulder clay at... Preston (J. Smith as *D. striatum*)". I have failed to trace Smith's record and Mr Palmer considers the specimen incorrectly named and merely *Antalis vulgaris*.

Bivalvia

- *Nuculana pernula* (Müller). Four fragments.
- *Arca lactea* (L.). Two good valves.
- *Glycymeris glycymeris* (L.). Two boxfuls, one with *c*.50 fragments, the other Bell-labelled with 9 fragments.
- *Mytilus edulis* (L.). Two boxes (one labelled by Bell), holding altogether a valve and eleven fragments.
- *Modiolus modiolus* (L.). 14 hinge-fragments and many other fragments. Mislabelled "*Mytilus edulis*".
- *Ostrea edulis* (L.). Eight hinge-fragments and many other fragments.
- *Chlamys distorta* (da Costa). Five fragments.
- *Chlamys opercularis* (L.). Three hinge-fragments and 34 other fragments.
- *Astarte sulcata* (da Costa)? Two boxes, one labelled *Astarte sulcata* contained one valve, 18 hinge-fragments and *c*.25 other fragments. According to Ockelmann (1958; 88) *A. sulcata* and *A. elliptica* can only be separated by microscopic examination of the periostracum. A second box labelled "*Astarte sulcata* (Da C)" by Bell held five hinge-fragments of *Spisula elliptica*, one *Astarte sulcata* (?) and one *indet*.
- *Astarte elliptica* (Brown)? Three valves, *c*.50 fragments labelled "*Astarte sulcata* var. *elliptica*". See note on *A. sulcata* (above).
- *Astarte montagui* (Dillwyn). Six valves, labelled "*Astarte compressa*".
- *Astarte crenata* (Gray). A box labelled "*Astarte crebicostata*" held one complete valve, 12 umbonal bits & 8 other fragments.
- *Astarte borealis* Schumacher. Abundant, two boxfuls labelled "*Astarte arctica* Gray".
- *Astarte undulata*? a single fragment so labelled is perhaps a slip for the "*Astarte undata* ? Gould" in Miss Ffarington's privately-printed list of 1879.
- *Lucinoma borealis* (L.). Two fragments.

- *Diplodonta rotunda* (Montagu). One valve.
- *Arctica islandica* (L.). Very abundant (57 hinge-fragments and very many other fragments). Another box labelled by Bell "*Cyprina islandica*" contained *Lutraria lutraria* (including *c*.20 hinge-fragments).
- *Acanthocardia aculeata* (L.). A single fragment shows the characteristic tubercles clearly, although queried in the 1879 list.
- *Acanthocardia echinata* (L.). Fragments abundant (2 boxfuls). One box Bell labelled as "*Cardium echinatum* or *tuberculatum*" on back of box.
- *Acanthocardia tuberculata* (L.). 86 fragments labelled "*Cardium tuberculatum* (*rusticum*)". These seem to be OK.
- *Cerastoderma edule* (L.). Very numerous fragments.
- *Laevicardium crassum* (Gmelin). 12 fragments labelled "*Cardium norweg-*".
- *Clinocardium ciliatum* (Fabricius). Three fragments labelled "*Cardium islandicum*".
- *Serripes groenlandicus* (Bruguière). One valve.
- *Dosinia exoleta* (L.). Six hinge-fragments and *c*.15 other fragments.
- *Dosinia lupinus* (L.). Five hinge-fragments and 9 other fragments.
- *Callista chione* (L.). Abundant, three boxfuls. The largest box contained 77 hinge-fragments and very many other fragments. A smaller box, labelled by Bell, contained a further 12 fragments. A third, labelled by Bell "*Lutraria elliptica*" contained 15 hinge-fragments of *Callista*, one fragment of *Panomya*, and remaining fragments all *Callista*.
- *Venus verrucosa* (L.). ?Very doubtful! One little fragment so labelled but the species is not listed by either Darbishire (1874) or Ffarington (1879) and I would not care to name the scrap.
- *Venus casina* (L.). Although this species is listed by both Darbishire and Ffarington as "small fragments, v.r." no material was received by me.
- *Venus striatula* (da Costa). *c*.40 fragments in two boxes (including a hinge-fragment).
- *Venerupis rhomboides* (Pennant). Eleven fragments labelled "*Tapes virgineus*". (N.B. on back of box "*Pholas dactylus*?").
- *Venerupis pullastra* (Montagu)? Listed with a query by both Darbishire and Ffarington but no material received by me.
- *Mysia undata* (Pennant). Two fragments.
- *Mactra corallina* (L.). One hinge-fragment.
- *Mactra glauca* Born. One undoubted hinge and eleven fragments. Jeffreys' comments on these Worden shells (in Darbishire 1874) suggests that he saw the shells and he specially mentions *Mactra glauca*.
- *Spisula elliptica* (Brown). A boxful labelled "*Mactra solida*" contained 6 hinge-fragments of *S. elliptica* among many indeterminable fragments and R. valves which may be *S. solida* or indet. Another box labelled *Mactra elliptica* contained nine valves and some fragments.
- *Spisula solida* (L.). Seven thick fragments bear a Bell label *Mactra solida* and seem correctly named. Another box held 2 hinge-fragments and two other fragments labelled "*Mactra truncata*".
- *Spisula subtruncata* (da Costa). Five hinge-fragments and one fragment.
- *Lutraria lutraria* (L.). Very numerous fragments including nine hinge-fragments. A box labelled "*Cyprina islandica*" by Bell held only *Lutraria lutraria*; I have re-labelled this box.
- *Tellina crassa* Pennant. Four fragments.
- *Macoma balthica* (L.). Very abundant, four boxfuls, one labelled by Bell. Another box labelled "*Tellina solidula* (Pult.) (Larger form of the Northern European form *T. balthica* (Philippi)".
- *Macoma calcarea* (Gmelin). Ten fragments with old label "*Tellina proxima* Brown". Three fragments are *M. calcarea*; seven are indeterminant.
- *Abra alba* (W. Wood). Two valves labelled "*Syndosmya alba*" are not that species but *Macoma balthica*.
- *Gari fervensis* (Gmelin). Two boxes, one labelled by Bell, together held two valves, 33 hinge-fragments and numerous other fragments. Very many thick, as already noted by Darbishire.
- *Ensis* sp. Three small bits with label "*Solen siliqua*".
- *Mya truncata* (L.). 46 hinge-fragments and numerous other fragments.
- *Mya arenaria* (L.). Four hinge-fragments and 19 other bits.
- *Hiatella arctica* (L.). Three fragments labelled "*Saxicava rugosa* (*arctica*?)".
- *Panomya arctica* (Lamarck). Two boxes. One (A) held one hinge-fragment and 16 other fragments, labelled "*Saxicava norwegica* (Panopaea)". Box B, labelled by Bell, held 54 fragments (including six bits of *Myatruncata*).
- *Barnea parva* (Pennant). One hinge-fragment.
- *Zirfaea crispata* (L.). 24 fragments.

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FISH AND OTHER FOSSILS FROM THE EOCENE OF BOLCA, ITALY

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Geological Curator 1994; 6(2): 103-105.

Introduction

Eocene fish from northeast Italy can be found in museums and institutions throught the world. A popular misconception is that these fish were collected from a place called "Monte Bolca". Examination of a topographical map or a visit to the area shows that no such "Monte" at Bolca exists, rather there are a number of hills bearing other names. While the majority of fish fossils have been collected from one locality they also occur at others. Important plant and reptilian fossils have also been found in this area.

The village of Bolca lies at the top of the valley of the River Alpone, in the hills of the pre-Alps, some 23 km northeast of Verona.

Geological setting of fossiliferous localities in the Bolca region

In the hills in the Bolca region Eocene limestones are found in association with basalts, tuffs and laterites. The lowest units are those exposed at Spilecco where brachiopods are found. Overlying these are basalts which give way to 37 m of limestones immediately overlain by 19 m of fish-bearing limestones encountered at La Pesciara . There the fish are found in 5 units which have a combined thickness of approximately 6 m. These beds have yielded numerous fish and plant species as well as rarer arthropods. At Monte Postale similar limestones crop out which also contain fish (including a fine example of the angel fish *Eoplatax*), plants and molluscs. Volcanic rocks increase as he succession youngs upwards. At Monte Vegroni lignites and tuffs contain palms. Similarily at Monte Purga, where an impressive church overlooks the village of Bolca, tuffs and lignites (rich in palms and from which a crocodile) are found, where they are overlain by basalt in which good columnar structure is developed.

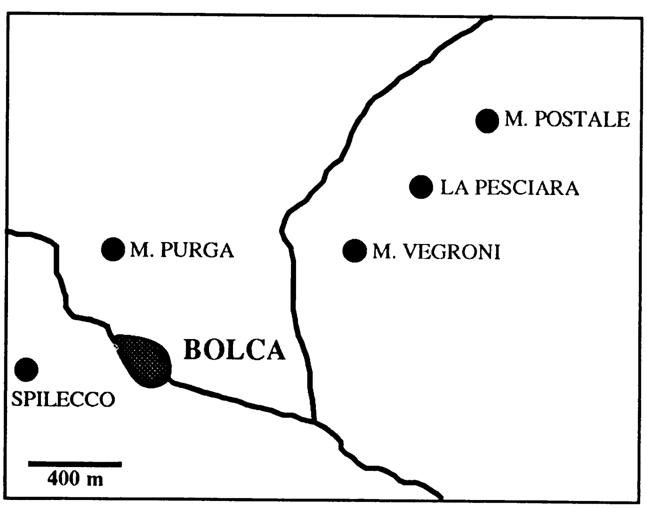

Figure 1. Bolca and the fossiliferous sites in its vicinity.

The limestones were deposited approximately 50 million years ago in a lagoonal environment.

The bulk of fish specimens that have found their way into museum collections were collected at La Pesciara.

EOCENE	MONTE PURGA: Palm-bearing tuffs containing *Latanites* and *Hemiphanicites* and lignites containing *Crocodilus vicetinus*, overlain by basalts with fine columnar structure.
	MONTE VEGRONI: tuffs and lignites with palms and other plants especially *Hemiphanites*, *Phoenicites* and *Morinda*.
	MONTE POSTALE: Limestones. Fish, bivalves, gastropods, nautiloids and plants (especially *Ficus* sp).
	LA PESCIARA: Limestones 19 m thick with 5 fossiliferous horizons (see Blot 1969, p. 27). Fish, plants, and rare lobsters and insects.
	SPILECCO: Limestones with intercalations of tuff and volcanic breccias. Brachiopods and sharks (*Odontapsis* sp.).

Table 1. Stratigraphic arrangement of main fossiliferous localities in the Bolca region. .

History of extraction at La Pesciara

The fossiliferous beds at La Pesciara were discovered accidently in the 1500s when a block tumbled down the hillside and split open revealing the fossilized fish. Stone has been extracted since and has been used for paving, and for building purposes, but the main reason for its exploitation remains its fossil content. Subsequent geological investigations discovered the fossiliferous beds of other adjacent localities discussed above.

Figure 2. View of La Pesciara with entrance to the excavation.

An account of the fish was first published by A. Mattioli in his *Discorsi sopra Dioscoride*, published in 1555 in Venice. The locality and its fauna became well known through the writings of Giovanni Arduino, Abbe Fortis, and others in the eighteenth century. The site then became a mecca for geological and other travellers and a great deal of fossil material was exported. Since 1939 the export of such material was banned.

For the past 200 years the Cerato family have quarryed at La Pesciara, which is reached along a rough road called "Via Eichstätt-Solnhofen". The present owner Massimiliano Cerato has spent a lifetime extracting fish-bearing slabs from an underground excavation which is reached via a short tunnel (Figure 2). His workings are approximately 5 m above those of his father and grandfather. He has worked the quarry with his two sons, largely by hand (although in the past decade mechanical drills have been used to aid extraction) under the scientific direction of palaeontologists from the Museum at Verona.

Four years ago a ban on removal of stone was placed by the Government, who want to include the area in a "National Heritage Site" with better access and documentation. This was done to protect a site deemed to be scientifically valuable. It is a circular arguement - without the extraction the locality becomes redundant scientifically and a place of historical interest only. Numerous petitions have been sent to the Government, and hopefully extraction will recommence in the near future. The Cerato family are conscious of the need to protect the site, and can do so while extracting fossil slabs, and catering for the school and other groups who are frequent visitors to pick over the rejected limestone fragments that lie downslope fromn the entrance to the excavation. The family are also responsible for the Museo dei Fossili in Bolca village where some of the finest specimens are displayed.

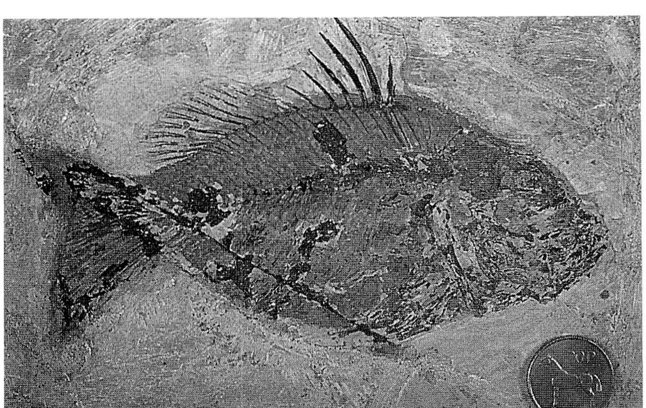

Figure 3. *Archaephippus asper* Volta from La Pesciara. TCD.3644. Diameter of coin is 27 mm.

Museum collections

Since 1939 most if not all specimens have been encorporated into three collections: at the Natural History Museum in Verona, the local Museum at Bolca, and the Natural History Museum in Padova. Blot (1969) lists 44 institutions in Europe and America which contain fish from Bolca. Of these the largest numbers of specimens are to be found in the Carnegie Museum in Pittsburgh, Muséum d'Histoire Naturelle in Paris and the Natural History Museum in London. It is probable that fish are extant in other collections.

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Specialised texts

The Museo Civico di Storia Naturale, Verona publishes a series devoted to the Bolca fossils (*Studi e ricerche sui giacimenti Terziari di Bolca*) and other important papers have been published in its *Memoire del Museo Civico di Storia Naturale di Verona.* Many of these may be still purchased from the Biblioteca del Museo di Storia Naturale, Lungadige Porta Vittoria, 9, 37129 Verona, Italy.

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Figure 4. *Caesalpina eocenica* from La Pesciara. TCD.47319. Diameter of coin is 20 mm

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Acknowledgements

I am grateful to Dr Ezio Vaccari of Verona who brought me to Bolca, and to Massimiliano Cerato who showed me the excavations at La Pesciara. Dr Lorenzo Sorbini is thanked for his hospitality extended at the Museo Civico di Storia Naturale, Verona. I thank Dr T.N. Mitchell (Provost of Trinity College, Dublin) for aiding this research by means of a grant from his Academic Development Fund.

BOOK REVIEWS

Scrutton, Colin (ed.) 1994. *Yorkshire Rocks and Landscape – a field guide.* Yorkshire Geological Society, 224 pp. ISBN 1 873551 08 8. Paperback. Price: £8-99.

Rawson, Peter F. and Wright, John K. 1992. *The Yorkshire Coast.* Geologists' Association Guide No. 34. 117 pp. ISBN 0 7073 0615 9. Paperback. Price: £9-50.

Yorkshire Rocks and Landscape is a guide consisting of 21 excursions, covering a variety of areas of geological interest in Yorkshire. Given the vast area of Yorkshire – even using its pre-1976 boundaries, there must have been some difficulty in selecting sites and defining excursions. The excursions are divided into two main groups; one consisting of the Lower Palaeozoic, Carboniferous and Quaternary of the west, north, and south of the area; the other covers the post-Carboniferous and Quaternary inland as well as on the coast, where there is some overlap with *The Yorkshire Coast.*

The style and format of the guide appears is aimed mainly at beginners and amateurs, and although many of the excursions will be of interest to more experienced geologists, they will have to search beyond this book for additional information. The guide begins with a short review of the geological history of Yorkshire, outlining the development of the area from the Ordovician to the present, briefly describing the overall stratigraphy, tectonic development, climatic and environmental changes, and the effects on landscape and land use. Many geological terms are printed in bold and their definitions may be found in a glossary at the end of the guide. This practice continues throughout the guide.

The excursions themselves are generally of a half to a full days duration. Some involve 5km to 10km of walking, while others, such as the Permian of south-central Yorkshire cannot be carried out without transport between sites. The description of each excursion starts by outlining its purpose, followed by a logistics section which includes details of transport and site access. Relevant maps are also listed and a short review of the geology of the area is given. Illustrations include clear sketch maps, stratigraphical logs, field sketches and a number of photographs.

The excursions cover a range of interests and include a number which I consider unusual in that they cover areas which may be rather poorly known to many. These include the Lower Palaeozoic of the Craven Inliers and the Permian of the Yorkshire Province (the latter covered by two excursions). Hardly surprisingly the Carboniferous is well represented, with excursions to see successions representative of the Dinantian, Namurian and Westphalian of the Pennines and the edge of the Craven Basin. Many of these excursions are within easy reach of the larger centres of population, and may in some cases be useful for teaching purposes. Two excursions are devoted Quaternary geology and geomorphology, and one to the mineralisation of North Swaledale. Most of the Mesozoic excursions are in the classic areas of the North Yorkshire Moors and coast. One excursion provides a useful guide of what is currently to be seen of the Jurassic and Cretaceous across the Market Weighton axis. Finally there is a short section on Yorkshire museums, which provides general information on geological collections opening times and entrance fees.

This guide is much needed, and should be of use to amateurs. The guide may also be of use to teachers, but may require additional material to support the outline of particular excursions. It is not strong on references (probably a deliberate policy), and for those who wish to go into further detail, they will have to search for relevant sources elsewhere.

The second edition of *The Yorkshire Coast* is much expanded and revised from the first edition of 1963 (revised in 1968) incorporating new information resulting from oil exploration in the North Sea. The guide is well illustrated, with clear maps, sections, logs and photographs. The introduction provides an overview of the geology of the area, covering the structural framework, and discussing the palaeogeography and palaeoenvironments in sequence. Basic arguments and evidence pertaining to interpretation are outlined, and relationships to intra- and extra-basinal events noted. This discussion contains references, and this practice is continued throughout the itineraries, providing the opportunity to follow though some aspects in more detail.

The guide consists of fourteen itineraries ranging from Staithes in the north to Bridlington in the south covering much of the length of the coastline. Three itineraries are inland, covering the Egton Bridge and Goathland area, the Hackness Hills, and part of the Wolds. Between them, the itineraries succeed in covering most of the Jurassic and Cretaceous succession and address aspects of the Pleistocene. The Egton Bridge and Wolds itineraries take Pleistocene geology as their main themes.

All the itineraries contain information on relevant maps, safety, and details of access. Lithostratigraphical nomenclature is up to date. The geological content of the itineraries are detailed. They provide descriptions of the successions, lithologies, sedimentary structures, trace fossils and the more important elements of the faunas. Some interpretation is also included. This varies from interpretation of local environments (for example, discussion of the Saltwick Formation east of Whitby on p. 34); to more prolonged discussion such as that on the structural analysis and history of the Peak Fault (p. 49).

The frontpiece states that the guide is designed to accommodate a wide range in the level of background knowledge. To this end, the level of background knowledge required by different itineraries varies. Those for Whitby, Robins Hood's Bay and Egton, for example keep references to a minimum and are generally more descriptive. These sites, despite the tidal situation at the east pier of Whitby harbour are generally of easy access and tend to be tourist spots. Itineraries such as those for Cloughton Wyke to Scalby Ness, and South Bay, Scarborough, Cayton Bay, and Gristhorpe Bay are generally longer, more detailed and contain more interpretation, as well as references to the relevant literature.

Although page for page. about twice the price of *Yorkshire Rocks and Landscape, The Yorkshire Coast* is a valuable guide to a classical area of geological interest. It should be of use in the field to amateurs, students, teachers, and professionals. *Yorkshire Rocks and Landscape* duplicates a number of Yorkshire coast itineraries to some extent. This however, is not a disadvantage, as a the sites are described here in a manner which may be more accessible to the beginner.

David Evans, Department of Geology, Trinity College, Dublin. 4th May 1994.

Ambrose, T. and Paine, C. 1993. *Museum basics.* ICOM in conjunction with Routledge, London and New York, xi + 319 pp. ISBN 0 415 05769 8 (hardback) 0 415 057701 (paperback). Price: £19-99 (paperback).

Museum basics is one of the titles in Routledge's *The Heritage: care - preservation - management* series of museological books. Its stated purpose is 'to provide a basic outline of good practice for museums with few professional staff and limited financial resources'; as the authors point out in their introduction, this means the majority of museums world-wide.

The book is arranged in six sections: introductory; the museum and its users; the development and care of a museum's collections; the museum and its buildings; the museum and its management; and supporting resources and services. Within these sections, the text is further subdivided into 'units', each a few pages long, with a total of 85 units in the book. Some units contain one or two 'boxes' which contain more detailed information or list things to consider; for example the unit on documentation systems includes two boxes, one lists the materials needed for documentation - pens, permanent black ink, catalogue cards, accession register, etc., while the other deals with computerisation. Case studies in some units illustrate how some museums have tackled particular problems.

The range of topics covered is vast, so many are dealt with only at the simplest level. All the latest management fads and jargon are included: performance measurement, SWOT analysis, team briefing - it's all here. The text is well organised, clearly written, and ideas clearly expressed - useful if English is not your first language. The international target audience for the book is obvious in the attempt that has been made to explain some of the terms or 'keywords' used. Because, for example, museum staff are known by different titles in different countries, the book uses 'museum manager' and 'MUSEUM MANAGER' to distinguish a member of staff who manages resources (the former) from the director or curator in overall charge (the latter).

The book does not deal with specific subject areas, apart from a unit on storage. Here geological collections get a special mention to point out two basics: firstly, that geological material is not indestructible and, secondly, that geological specimens are heavy.

My only real criticism of the book is the lack of illustrations. Photographs are used only on the title pages of each section. A few more diagrams and photos would have helped greatly.

This volume provides a useful first step into how to run your museum. If you want an introduction to virtually any museum topic, begin with this book. It does in fact contain the museum basics.

Tom Sharpe, Department of Geology, National Museum of Wales, Cathays Park, Cardiff CF1 3NP, Wales, U.K. 20th July 1994.

Hooper-Greenhill, E. 1994. *Museums and their visitors.* Routledge, New York and London, 224 pp. ISBN 0 415 06857 6. Paperback. Price: £22-50.

Museums and their visitors aims as the preface says "to examine the ways in which museums need to develop their communicative functions and, with examples of case-studies, explains how to achieve best practice" Although this is a wide brief this book goes a long way to achieving this aim.

After an initial chapter which explains why we need to consider visitors and their changing needs, chapter 2 considers communication theory and how this relates to the museum environment. Three chapters concentrate on the museum audience, who the visitor is (with some useful statistics), what the visitor wants and how museums can best respond to this. The visitor's practical needs are discussed, especially those of particular groups such as families, school children, those with special needs and ethnic minorities. A whole chapter is used to look at language and text. This includes the study of exhibition texts and is illustrated with a number of interesting examples. Other chapters look at evaluation of museum visits and learning, and how staff can best help improve learning opportunities in museums. The last chapter is on managing museums for visitors and includes a look at forward planning, policies and marketing. Eilean Hooper-Greenhill does point out though, that policies and plans do not work if they are not put into practice and states that "the potential power of the museum as a communicator lies ultimately in the hands of the managers of the museum". Each chapter stands alone and clearly explains background information and theory, and shows, through case studies (British and worldwide) good practice. I particularly liked the inclusion of advice on where to go for further reading on each subject.

Some of the information in this book will be familiar to those experienced in public service work and in some areas for example in the chapter on responding to visitor needs, further details and examples on how to support different groups such as families would have been useful. However more information would have meant that the book would have been considerably larger! Overall this is a good summary of a very topical subject and a must for any museum officer who is interested in the visitor. I found it stimulating and thought provoking and written in a very accessible style. There is something here for everyone. I particularly liked the chapter on managing for visitors. It is not just a theoretical book but one full of practical ideas - a must for the bookshelves . As Dr Hooper Greenhill says " Inertia in museums and galleries at a time of vast structural and value changes in society will mean almost certain failure..Museums are now required to be more customer - orientated..Museums without clear visions of what they are and might become will be blown by the wind." This book might help develop clear visions.

Kate Pontin, Hillingdon Library Services, Central Library, High Street, Uxbridge UB8 1HD, U.K. 25th July 1994.

Van Rose, S. 1994. *Eyewitness Science, Earth.* Dorling Kindersley, London, 64 pp. ISBN 0 7513 10441. Price: £9-99.

Dorling Kindersley continues to expand its superbly illustrated *Eyewitness* series, with this book written by Susanna Van Rose. In the same format and style as the *Eyewitness Guides*, but distinguished by its bright silver cover, *Eyewitness Science, Earth* forms a useful companion to the other geology titles. The back cover describes the book as suitable for Key Stages 2, 3 and 4 of the National Curriculum, but as with the other volumes, it makes an attractive introduction to geology for adult education classes.

The book is divided into 29 sections, each comprising two facing pages and dealing with a wide range of topics. Beginning with early ideas about the earth, the sections cover the atmosphere, water, minerals, and rocks before moving on to oceanography, continental drift and plate tectonics. These are followed by sections on the interior of the earth, earthquakes, volcanoes and mountain building. Next are weathering, soils, erosion and deposition, before the final sections on dating the earth and the geological timescale.

Each section begins with a summary block of text in larger print, then additional, more detailed text is in smaller point size wrapped around and linked to the illustrations. Throughout, the sections are very usefully cross-referenced. The main feature of the book, though, is the number and quality of the illustrations. The picture research and photography in Dorling Kindersley's books are second to none. This volume includes some superb photos of rock deformation experiments illustrating mountain building and rifting.

The odd mistake has, however, occasionally crept in: a picture supposedly of the Grand Canyon in Arizona is in fact Canyonlands in Utah, but still serves to illustrate the Colorado Plateau as described in the text. My only other criticism is that I would have liked to have seen a fuller index, but then, in a book of 64 pages, how much do you really need an index?

Eyewitness Science: Earth maintains the high standards we've now come to expect of this publisher and at a reasonable price. Make sure that it's on sale in your museum shop.

Tom Sharpe, Department of Geology, National Museum of Wales, Cathays Park, Cardiff CF1 3NP, Wales, U.K. 9th August 1994.

Child, R.E. (ed) 1993. *Electronic Environmental Monitoring in Museums.* Archetype Publications Ltd., Denbigh, Clwyd, 59 pp. ISBN 1873132 50 6. Paperback. Price: £3-50.

Environmental monitoring has a vital role in the preservation and conservation of collections and monitoring techniques are becoming increasingly more technical. This book is the proceedings of a conference on Electronic Environmental Monitoring organised by the National Museum of Wales and The Council of Museums in Wales. Four papers are included with the aim of providing an introduction for people considering using electronic environmental monitoring systems.

Simon Thomas discusses the composition of electronic environmental systems and what features should be looked for when choosing a system. He summarises the major features diagramatically. The second paper, by R.F. Pragnell, describes measuring humidity in normal ambient environments and the role of the electronic humidity hygrometer. The different options available for monitoring and controlling humidity in the museum environment are described; condensation hygrometers, psychrometers, mechanical hygrometers and electronic relative humidity hygrometers.

Data loggers are increasingly being used for measuring and storing environmental data in collections and exhibitions. Information collected from loggers can be down loaded to computer and then analysed. Lucian Hatfield describes what a data logger is and the common features of the software associated with them. In the final chapter J.P. Brown considers how psychrometric data can be used. This section is more for the specialist but is an important addition to the completeness of the book.

This book is a good introduction to electronic environmental monitoring and will be of assistance to anyone considering buying such a system. It is good to see proceedings from conferences such as this published, at an affordable price, so that the information can be widely disseminated. This book also contains advertisements from a variety of companies selling monitoring equipment, which may be of use.

Caroline Buttler, Department of Geology, National Museum of Wales, Cathays Park, Cardiff CF1 3NP, Wales, U.K. 4th July 1994.

Dean, D. 1994. *Museum Exhibitions: Theory and Practice.* Routledge, London and New York. ISBN 0 415 08016 9. Price: £22-50.

A few years ago Professor D.T. Donovan remarked that, 'when we come to the function of museums vis-a-vis the public there are no experts: it is a matter of opinion'. He felt that his opinion on museums was as valid as anyone's. I have never been clear whether Donovan was ignorant of the scholarly literature on which a genuine claim to expertise might be based, or was striking a *faux-naive* attitude for the sake of polemics, or was holding to the peculiarly- English view that amateurs have access to insights that are denied professionals who have studied a subject in depth.

The discipline of Visitor Studies has a large, and now well-organised, literature stretching back almost 100 years, as well as other ornaments of academic life such as international conferences and Ph.D students. *The Visitor Studies Bibliography and Abstracts* (Milwaukee, 3rd edition 1993) summarises 650 articles and books; *L'Evaluation Muséale Publics et Expositions* (Paris, 1989) lists 1,365 works published between 1897 and 1979; and the *Bibliographiezu Museologie, Museumpädagogik, Museumsdidaktik und Besucherforschung* (Berlin, 1993) has 1,868 entries. Some results have come from studying the craft skill of expert practitioners, and some from other disciplines, notably psychology (once behaviourism, now cognitive and social psychology) but also the interpretative sociologies and media studies. Some of the most important have come from empirical work on visitors and exhibits in museums, whether through visitor surveys (the descriptive, natural history approach), exhibit evaluation (akin to applied research), or pure, often experimental, research (the attempt to arrive at empirical generalisations).

Not all investigations have been of a high standard or have stood the test of time, and some show symptoms of the methodological problems that tend to plague work in the human sciences. Nevertheless, there exists a formidable body of knowledge for those seriously concerned with 'museums vis-a-vis the public', whether as practitioners, researchers or critics; and which we can ill-afford to ignore if we wish to be taken seriously. We should be ready therefore to welcome a book that claims to be 'the only textbook of its kind to consider exhibition development from an integrated approach from theory to practice'.

Unfortunately, it disappoints. Its excursions into (pop)psychology are imprudent ('The human brain is in reality two separate brains ...'), and its grasp of visitor research and exhibit evaluation is uncertain. As a practical guide to exhibition making it is better, though certainly not better than several other books currently available. But if for no other reason, it is difficult to recommend this book because of its failure - which almost beggars belief in1994 Europe - to use the *International System* of weights and measures. I can cope, e.g. with Fahrenheit, though not easily over its full range, but ironically the use of foot-candles leaves me totally in the dark.

Roger Miles, Natural History Museum, Cromwell Road, London SW7 5BD, U.K. 4th July 1994.

Miles, Roger and Zavala, Lauro (eds). 1994. *Towards the museum of the future: new European perspectives.* Routledge, London, xiii+203 pp. ISBN 0 415 0949 84. Hardback. Price: £27-50.

Claiming to be "the first book to approach current problems from such a wide perspective" this is certainly a wide ranging collection of essays. A compilation of thirteen articles by six European and three North American museum professionals the volume is also to be available in Spanish from the National University of Mexico.

Topics are grouped into headings under three main categories covering major themes in modern European museum exhibition development, interaction with the public and some of the philosophy underlying modern exhibition design. The various contributions commissioned from the authors deal with these themes with varying success and therein lie the limitations of such an approach.

Architect Ian Ritchie deals effectively with the museum building as a restrictive container limiting scope for modern exhibitions and visitor facilities. This is in contrast to the supposed ideal where the exhibitions dominates and the building is wrapped around it, supplying it needs as in the Popidou Centre. Some of the stark modern designs even baffle the publishers with one being illustrated upside down (fig. 1.11). This useful review is followed by a short article on the philosophy of corporate identity and its reflection in graphic identity.

Melanie Quin gives some useful insights into the European science centre movement from her experiences in the Nuffield Foundation project and more recently in Finland Heureka centre. Robert Lumley looks at the rise in the obsession with "heritage" relating it to current economic decline and a need for escapism to a time when life appeared to be more simple. He also provides food for thought in his discussions about the heritage industry and its effects in developing a sense of place for populations watching changes in their neighbourhood which take place outside their control under the influence of large corporations. The standardisation of European cities as they all achieve the status of being able to boast a MacDonald's or a Body Shop is familiar to all of us and it is an incentive to the curator to maintain the diversity which museums can present to the public. Lumley also reminds us of the need to put myth in its place but recognise its attractions for the greater public.

If the customer is always right, then you need to understand the customer in order to supply their needs. Bernhard Graf discusses the approaches to visitor surveys in Germany with lessons for those in other countries. The needs of family group visitors are dealt with by Paulette McManus who takes us to the world of the social anthropologist, tricking the family as it carries out its hunter gatherer exercises in the museum searching for entertainment and information.

Thirty years of experience with travelling exhibitions in Sweden is recounted by Jan Horth together with useful advice on how to de-mystify the ivory tower and bring its riches to the masses. The special needs of children and their different approaches to learning are described by Gillian Thomas of London's Science Museum. The need to understand this particular museum audience is informative and she makes interesting contrasts between French and American approaches to exhibitions reflecting their cultural differences.

Those of us working in the natural sciences can take comfort in Peter Vergo s view that Natural History museums have the clearest sense of purpose but we can learn from the art world where the same object can be used to illustrate a number of themes or stories. This wider view of science is continued by Roger Silverstone who places museum exhibitions in context within modern media, in particular television.

For my money the book contains more internal problems than museum solutions. The translators for the Spanish edition have formidable task with some essays which might first benefit from being rewritten in a more accessible level of English. This assumes of course that the intention of the authors is to communicate their ideas rather than to communicate their extensive vocabularies of specialist jargon. The essay by Schiele and Bouchard is a classic, being written by specialists in communications. It is more learned than articulate, the 39 footnotes doing little for the readability of a ten-page article. The irony being that it discusses the ways in which scientists communicate their specialities to a general audience through modern exhibitions.

The reason for reading works like this is summarised by Eilean Hooper-Greenhill. Noting the changes in approaches to education through museums she states "Those who are not prepared will find themselves at the mercy of those who are." Pere Alberch s final essay is a call to arms for curators in natural history museums to face up to the reality that if you want to play an active role in shaping the future of your museum, or museums in general, then be informed or beware. This book will not change your life but it may help to understand some of the various professions involved in modern museums.

Nigel Monaghan, National Museum of Ireland, Kildare Street, Dublin 2, Ireland. 31st August 1994.

Child, R.E. (ed.) 1994. *The Conservation of Geological Collections.* Archetype Publications Ltd, London, 65 pp. ISBN 1 873132 60 3. Paperback. Price: £7-50.

This slim volume represents the proceedings of a conference held at the National Museum of Wales in November 1993. Its six short chapters are aimed at curators who have a responsibility for geological collections rather than the specialised conservator.

The five contributors are all on the staff of the National Museum of Wales and their obvious skill and expertise in handling geological material is readily apparent.

In the introduction, it mentions that rock specimens are generally considered to be indestructible and, as a consequence, little thought is given to their continued well-being. In reality, many geological collections are at risk of destruction from the many sources outlined in this text.

I liked this little book as it provided a simple, clear and intelligible appraisal of the important points that need to be thought about when dealing with geological material. At the end of each of the chapters is a short list of references which will guide those interested deeper into the literature. However, one is unclear where the non-specialist could gain access to them! This is particularly relevant, for example, in the article on 'Packaging' when specimen labels are discussed and a particular type suggested. The attention of the reader is also drawn to an article on marker pens but, unlike the labels, no suggestions are made for a suitable instrument, and no list of suppliers is included, whereas details for the source of the labels are included.

Eight colour plates illustrate particular points in the text, including the destructive effects of 'pyrite disease', shrinkage cracks in shale, and an example of the cracking and splitting that can affect the ivory of a Mammoth tusk - the bane of many Curators.

Geological conservation is best left to the specialists and this book does not tell the Curator how to do it. What is does do is provide a valuable insight into understanding the processes that can damage geological material and enable the Curator to recognise these various conditions and take the appropriate action. This book will be a useful addition to Curators' bookshelves, both to remind themselves of the issues involved and to refer to when preparing reports for the non-specialist involving the storage and care of geological material.

Tony Cross, The Curtis Museum, High Street, Alton, Hampshire GU34 lBA, U.K. 1st August 1994.

Trewin, N.H. and Hurst, A. 1993. *Excursion guide to the geology of East Sutherland and Caithness.* Scottish Academic Press, 184 pp. ISBN 7073 0731 1. Paperback. Price: £8-50.

This guide kicks off with an impressive list of supporters and an invitation to join or at least find out more about the Geological Society of Aberdeen and the Petroleum Exploration Society of Great Britain. The invitation appears to be well hidden and sometimes absent from many similar guides and seems to me to be an ideal way to attract more members. In addition to the invitation is a well structured, easily followed, and attractive selection of excursions. With the excursion planner, it is possible to see at a glance the maps needed, the topics covered, the time taken, the problems one might encounter and the highlights of the excursions. The maps and diagrams are large, uncluttered and easily understood. The sketches are well executed and the majority of the photographs have reproduced to a high standard.

I am hard pushed to find fault with this publication. Perhaps the cover could be a little stiffer, although this is a minor grievance of mine with many such guides. I find that the cover tends to curl with use and gets damaged easily. There is no glossary of geological terms for the uninitiated but I find such glossaries more a nuisance than of any practical use anyway. Perhaps the uninitiated should invest in a geological dictionary as this would cover more terms than any excursion guide glossary. The guide will, therefore, be of most use as a guide for teachers of Geology and their students.

This guide achieves exactly what it sets out to do. It provides the user with a weeks worth of stimulating excursions. All SSSI's are clearly marked and any useful information on seeking permission and on safety is also indicated. I believe that this guide should act as a template for future guides of geological excursions. A lot of thought has obviously gone into structuring the guide in a user-friendly manner. The book is not too thick, has a substantial amount of geological and historical information; it is well illustrated, and is a good read. In short, it is well worth the £8.50 retail price.

Neil Clark, Hunterian Museum, University of Glasgow, Glasgow G12 8QQ, U.K. 27th August 1994.

Bateman J., McKenna G. and Timberlake S. (eds.) 1993. *Natural Science Collections in South East Britain.* Published for the South Eastern Collections Research Unit and AMSSEE by the Museum Documentation Association. ISBN 0 095963 85 7. Price £10 - £50 (see below).

The activities of the specialist curatorial groups over the last 20 years represent one of the great advances in the museum profession. The two groups involved with natural history in particular have sparkled with enthusiasm and vigour. Both have been very active in the field of collections research and the BCG was largely responsible for the formation of FENSCORE in 1981. If the careers of such groups have high spots, then they would have to coincide with publications just like the present volume. There have been a number of similar publications, beginning with Hancock & Pettitt (1981) for the north-west, Davis & Brewer (1986) for the north-east and Hartley et al (1987) for Yorkshire and Humberside. Others are in the pipeline. Given the size, number and scope of the south-east's museums, the research and production of a collections register for that part of the country was always going to be a nightmare. The South East Collections Research Unit (SECRU) is therefore to be congratulated on achieving its monumental objective.

SECRU was established with FENSCORE in 1981 and set to work collecting data. This first phase of information gathering ground to a halt under the sheer weight of data in 1985 and it was not until 1989 when Jim Bateman took over the project under the aegis of the Museums & Galleries Commission that publication became a realistic target. Latterly, the Area Museum Service for South Eastern England (AMSSEE, since reborn as SEMS) has provided funding.

The Register is published in three forms - book, computer disk and microfiche. The disks come complete with a Guide to the project and instructions on how to search the data. This reviewer was provided with two 3.5" disks and a Guide, though being based in a contributing museum and boasting our own SECRU Panel member, we already had not only the disks but also the book. These varying formats, and the division of the likely purchasers into contributors, recognised institutions and 'others', complicates the pricing structure with the book being £20, £25 or £50 respectively, the disks £15, £20, or £40, and the fiche £10, £15, or £30. Though I hope no slouch on the PC, this reviewer chose to turn to the book version in the first instance, despite the publishers implicit prompt in sending me the disks only. The Register consists of some 274 pages, though a quick manual count was necessary since there is no pagination. The book is spiral bound. Each page is divided into four vertical columns of text - cramped, but easily readable. The first 88 pages or so comprise the main alphabetical entry to the 1000 plus collections indexed, including both institutional and personal names. Each entry lists biographical details, size and subject of the collection, geographical context and a numeric code which uniquely identifies each collection. The rest of the Register consists of a Subject Index, a Geographical Index, a Location Index and an Associated Names Index. One needs to persevere with these indexes. They look unwieldy and frequently list repetitive collection names and collection numbers which then have to be found in the main entry - not always easy, though practice makes perfect. Also confusing initially is the fact that associated names appearing in the index do not necessarily appear in the main entry. Users must remember that the main database is that held on computer at the MDA in Cambridge and is updated there. For all practical purposes this does not matter as once a name is linked to a collection and museum, enquiries would be directed there.

Space does not permit a fuller discussion of the printed version of the Register since I must also briefly mention the computer disk version. The disks successfully installed themselves on an Elonex 466 with abundant RAM and memory. The database has been collated using FOX Pro and being DOS-based looks rather old-fashioned and clumsy. I hope a future version could be made taking advantage of Windows-based software and more friendly on-screen instructions. The Guide to the database was certainly required and soon it became clear that the database could do all that was required of it, and even boasted how many seconds it had taken to complete a search.

In both the printed and disk versions of the Register I spotted innumerable typographical errors together with a certain looseness of grammar in some of the entries. These features are doubtless the result of gleaning data by questionnaire from harassed curators and captured by non-specialist help, poorly checked. These errors do not detract from the usefulness of the Register, rather adding a touch of idiosyncrasy to an otherwise dry volume. More worrying is the separation of the 'University Museum of Zoology, Cambridge' from the 'University of Cambridge, Museum of Zoology'. I hope that this is a rare mistake.

I applaud the appearance of this work. Every museum with interests in and collections of natural history should have a copy.

References

Hancock, E.G. & Pettitt, C.W. (Eds) 1981. *Register of Natural Science Collections in North West England.* The Manchester Museum.

Davis, P., & Brewer C. (Eds) 1986. *A Catalogue of Natural Science collections in North-East England.* North of England Museums Service.

Hartley, M.M., Norris, A., Pettitt, C.W., Riley, T.H., & Stier, M.A., 1987. *Register of Natural Science collections in Yorkshire and Humberside.* Area Museum Service for Yorkshire and Humberside.

John A. Cooper, Booth Museum of Natural History, Brighton, U.K. 31st August 1994

McAdam, A. D., Clarkson, E. N. K. and Stone, P. 1994. *Scottish Borders Geology.* Scottish Academic Press. Paperback. Price: £9-50.

I think the most eye-catching aspect of this book is the colourful geological map on Plate 1. The colours are intense, but are sufficiently different to make it easy to interpret the boundaries between geological units of different ages. Throughout the book the diagrams, sketches and maps are well executed and help the users in their interpretation and understanding of what they should be looking for. Perhaps a few more diagrams would have been useful in some chapters. Photographs of localities or structures seen there would have enhanced this guide and would have allowed the user to see what they should be seeing without having to rely on diagrammatic interpretation.

The excursions could have been better organised by having a chapter devoted to planning excursions, giving information on approximate time taken to cover the excursions, a summary of rock types encountered, whether the site is a Site of Special Scientific Interest (SSSI) or not and where the nearest hostelry is located. I believe that Siccar Point and Dob's Linn are SSSI's, and that at such localities no bedrock should be hammered without permission from the Scottish Natural Heritage and land owner. Perhaps users should of the guide should not just be encouraged to follow the "Geological Code of Conduct", but should be given a general outline of what it is'

With over twenty excursions listed, this guide covers a lot of ground. I feel that the editors were right in splitting the older Lothians and South East Scotland guide to allow for an increased number of excursions. I know of at least one other geological guide that could take example from this and be split. The dimensions or the book make it a useful field companion, not too bulky or heavy, and fits easily into my raincoat pocket. I feel that future editions of this book will improve only slightly on what is a most attractive, readable, and useful guide to a popular holiday area within easy reach of Edinburgh. Although on the expensive side, you get excellent value for money at £9.50.

Neil Clark, Hunterian Museum, University of Glasgow, Glasgow G12 8QQ, U.K. 27th August 1994.

Editor's note: **The following titles have been received for reviewing in future issues. If any GCG member wishes to review any title please contact the Editor. Books will be sent to the first applicant:**

Wilson, C. 1994. *Earth Heritage Conservation*. The Geological Society in association with the Open University.

Woodcock, N.H. & Bassett, M.G. (eds) 1993. *Geological excursions in Powys, central Wales*. University of Wales Press & National Museum of Wales.

ERRATUM: In the last issue of *Geological Curator* identical accounts were published for the years 1991 (p. 38; stated in error to be those of 1990) and 1992 (p. 43). The correct accounts for 1992 are given below. The editor apologises for this mixup.

Annual Accounts 1992 (4 December 1991 - 3 December 1992)

	1992	1991
Current Account Income		
Subscriptions	3399.00	2490.82
Sale of backnumbers	35.00	2.50
Advertisements/Sponsorship	500.00	500.00
Meetings fees	-	118.00
Inserts	-	60.00
Curry Fund	-	200.00
Transfer	1200.00	-
Expenses Refund	102.00	-
Balance	272.67	143.08
	£5508.67	£3514.40

	1992	1991
Current Account Expenditure		
Geological Curator		
Printing	610.34	570.71
Postage	518.54	-
Sundries	14.24	-
Typing	58.00	100.00
Meetings		
Committee	428.30	108.00
J. Morrell	10.55	-
MA	35.00	-
General	-	452.80
Coprolite		
Print and distribute	1095.73	1091.29
Brighton Medal		
Tower Mint	1339.50	-
Design	37.00	57.50
Other expenditure		
Geologists' Association	-	100.00
Order Books	-	64.63
National Museum Wales	-	180.00
Geol. Coll. Comp.	-	500.00
Working Group Lunch	-	16.80
Postage	30.97	-
Secretarial expenses	50.00	-
Computer Labels	21.78	-
Balance	1258.72	272.67
	£5508.67	£3514.40

	1992	1991
Premier Interest Account Income		
Interest	1130.16	1092.34
A.G. Brighton	-	2376.44
Balance	13771.90	10303.12
	£14902.06	£13771.90

	1992	1991
Premier Interest Account Expenditure		
Transfer to current account	1200.00	-
Balance	13702.00	13771.90
	£14902.06	£13771.90
GCG	12211.83	-
A.G. Brighton	1490.23	-

	1992	1991
Total Income	6366.16	6840.10
Total Expenditure	4249.95	3241.73
	£2116.21	£3598.37

[signed] A. Newman *GCG Treasurer*

[signed] P.S. Davis and K. Sedman *Auditors*

GEOLOGICAL CURATOR

Publication scheme

Two issues of *The Geological Curator* are published for each year (in the Spring and the Autumn); a complete volume consists of ten issues (covering five years) and an index.

Notes to authors

Articles should be submitted as hard copy in the journal style typed on good quality paper (A4 size) double spaced, with wide margins, and if possible on disk (preferably formatted for a Macintosh in Microsoft Word or MacWriteII, although other disk types will be accepted - please quote system type and wordprocessing package used). Three copies should be sent to the Editor, Patrick N. Wyse Jackson, Department of Geology, Trinity College, Dublin 2, Ireland (tel 01 7021477; fax 01 6711199; e-mail: wysjcknp@tcd.ie). Line drawings should be prepared in black ink at the desired publication size. Photographs for halftone reproduction should be printed on glossy paper. Both drawings and photographs should be proportioned to utilise either the full width of one column (85mm) or two (175mm). References in the text follow the Harvard system, i.e. name and date '(Jones 1980)' or 'Jones (1980)'. All references are listed alphabetically at the end of the article and journal titles should be citedin full. Authors will normally receive proofs of text for correction. Fifty reprints are supplied at cost. Major articles are refereed. Copyright is retained by authors.

If submitting articles on disk please note the following:

1. Do not 'upper case' headings. **Keep all headings in upper and lower case.**
2. **Use italics** rather than underline for latin names and expressions, journal names and book titles. **Use bold** for volume numbers in references.
3. Line spacing. Your hard copy should be double spaced. If possible, **single space** your copy on disk. Use a **single (hard) carriage return** at the end of each paragraph.
4. Single space-bar between words, **double space-bar between sentences.**
5. **Do not attempt** to format your article into columns. Use a minimum of tabs and indents.

Regular features

LOST AND FOUND enables requests for information concerning collections and collectors to reach a wide audience. It also contains any responses to such requests from the readership, and thereby provides an invaluable medium for information exchanges. All items relating to this column should be sent to the Editor (address above).

FACT FILE contains basic information for the use of curators. All items relating to this column should be sent to the Editor (address above)

NOTES comprising short pieces of less than two pages are particularly welcome. Please send contributions to the Editor (address above).

CONSERVATION FORUM helps keep you up to date with developments in specimen conservation. Information on techniques, publications, courses, conferences etc. to Christopher Collins, Sedgwick Museum, Department of Earth Sciences, University of Cambridge, Downing Street, Cambridge CB2 3EQ (tel. 0223 62522)

BOOK REVIEWS contains informed opinion about recently published books of particular relevance to geology in museums. The Editor welcomes suggestions of suitable titles for review, and unsolicited reviews (of 500 words maximum) can be accepted at his discretion. Publishers should submit books for review to the Editor.

INFORMATION SERIES ON GEOLOGICAL COLLECTION LABELS consists of loose A4 size sheets, issued irregularly, which carry reproductions of specimen labels usually written by a collector of historic importance. The aim of the series is to aid recognition of specimens originating from historically important collections. Contact Ron Cleevely, Department of Palaeontology, The Natural History Museum, Cromwell Road, London SW7 5BD.

Advertisement charges

Full A4 page	£60 per issue
Half A4 page	£40 per issue
Quarter A4 page	£25 per issue

Discounts for space bought in three or more issues. Further details from the Editor.

Inserts such as publishers' 'flyers' can be mailed with issues of *The Geological Curator* for a fee of £60. 550 copies of any insert should be sent to the Editor.

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All enquiries to the Treasurer/Membership Secretary, Andrew Newman, Department of Archaeology, University of Newcastle, Newcastle-upon-Tyne NE2 4PT (tel/fax. 091 222 7426).

Backnumbers

Backnumbers of *The Geological Curator* (and its predecessor, the *Newsletter of the Geological Curators' Group*) are available at £2.50 each (£5.25 for the double issues of Vol. 2, Nos. 9/10 and Vol. 3, Nos. 2/3; £7.50 for Vol. 4, No.7 Conference Proceedings) including postage. Orders should include payment and be sent to the Treasurer (address above).