Digging into the Past

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Why excavate?

My talk is about excavations by vertebrate palaeontologists. Excavating means literally, to retrieve something from a covered place, to uncover. In the palaeontological sense, it means to retrieve a petrified proof of past life from the sediments that covered it after its death. In this way, the excavator does nothing else than dig into the past. But why do excavations take place? And how they are done? And how can we teach the visitors to a natural history museum about excavations?

Since the earliest times, people have had the tendency to collect natural objects that are considered beautiful, strange, rare, or unexplainable objects. These natural objects may be alive or dead, such as animals, plants, or parts of them. These natural objects may also be lifeless, such as minerals, stones and not forgetting fossils. Fossils were often regarded as magical, mythical or even medicinal objects.

Naturalists, and later vertebrate palaeontologists, collect fossils. They also try to explain them. Fossils are now collected in order to reconstruct life as it was in the remote past, and this is why paleontologists and museum directors still collect fossils. The majority of fossils, however, are not found on the surface, but have to be collected by means of an excavation.

How to excavate

General rules

An excavation is more than just collecting the desired fossil vertebrate. A good excavator also takes other evidence from the field back home. The general rules for good collecting are,

a) that fossils which belong to other than the desired taxon are collected; this yields information about the palaeo-ecology.
b) that imprints and other negatives of the fossils should be recovered; they yield complementary information.
c) as many specimens as possible should be collected; this gives insight into variation and range.
d) that full preparation of the fossils should be postponed until they reach the laboratory, and part of the surrounding sediment should stay attached; this gives information for stratigraphy. Only broken parts are glued and fragile or weathered material should be consolidated on the spot.
e) the orientation of the fossil in the sediment should be recorded and the connection between the fossil and the type of sediment; this gives information about taphonomy and the palaeo-environment.
f) each fossil should be packed independently, with a label inside the package and one on the outside of the package.

The primary concerns in retrieving vertebrate fossils are that maximum recovery of all elements and any associated material of interest, adhesion of broken parts, consolidation of fragile or weathered material, and accurate documentation and meaningful organization of the find (Rixon 1976). Preparation in the field should be minimal (Croucher and Woolley 1982).

It is prudent to collect uncontaminated samples during all field excursions, particularly in those cases where consolidation of the majority of the material is necessary for its retrieval. This has to be done fast, because the effects of weathering destroy the integrity of the fossil, e.g. specimens in clay soils may begin to crack visibly within hours of exposure to a drier climate.

Element-by-element removal

The exposure of a fossil and its removal from the matrix are two of the most significant factors in determining its future stability and usefulness. Removing the matrix material exposes the specimen to an unavoidable risk of damage. Some methods, such as the use of dynamite, picks and backhoes, greatly increase the amount of cracking and breakage in the material. Manual methods, such as probes and brushes (Fig. 1), are vastly preferable, but they may not be very useful in a very hard matrix or in instances where there is time pressure.

Figure 1.
Manual tools such as brushes and dentist tools are vastly preferable above more damaging tools such as hammers and chisels. Corbeddu Cave, Oliena, Sardinia (Italy).

Figure 2.
Plaster jackets are the best solution to remove fragile or associated fossils.

Element-by-element removal of fossil skeletons placed the bones at severe risk of damage (Scott 1939, Sternberg 1990), and this is particularly true for fragile, huge or complicated specimens, and also for articulated specimens. There are two alternatives for element-by-element removal: rigid jackets and block quarrying.

Rigid jacketing

Rigid jacketing (Fig. 2) was developed in response to the intensive collecting of Cope and Marsh in the 19th century in the USA. We don't know who had the original idea, but it may have been devised by Williston or Sternberg (Shor 1971). Jacketing the bones in the field enabled collectors to preserve the original configuration of the specimens while providing protection against the risks of removal and transportation. Strips of cloth are soaked in a solution that hardens as it dries. Originally, this solution was just flour paste (Simpson 1982), but nowadays plaster is used.

A separating material must be used to ensure that the plaster does not adhere directly to the specimen. Separators between bone and plaster have included Japanese rice paper or other papers with good wet strength. Films or foils are not appropriate separators as they do not sufficiently conform to the specimen.

Block quarrying

The other alternative to element-by-element retrieval of a vertebrate specimen is block quarrying (Fig. 3). In a block, the original orientation of the elements relative to each other, the degree of articulation, and other taphonomic factors are preserved.

Figure 3.
Block removal ensures also the collecting of surrounding matrix. Katharo Plain, Crete (Greece).

Figure 4.
Making a grid system is the first step in every good excavation. F-site, Vatera, Lesvos (Greece).

This makes block removal the best approach to the removal of large vertebrates, large assemblages, complicated structures or associated structures from the field.

Transport

Large fossils and huge blocks as a rule can be of a significant mass and weight. All factors of removal and transportation should be worked out in advance, so that the risk of dropping and breaking is minimised. Transport can hardly ever reach the place of excavation. This means that local carts, lorries or even camels and horses have to take over the first step in the transportation process. Nowadays, even helicopters are an option, if you have enough money.

Documentation

The first step in documentation in the field is to make a grid system (Fig. 4) and make a decision about the size of the quadrants. Enumeration of the quadrants and schematic drawing should be the first page in every excavation log book. Documentation of the methods and materials used is extremely important (Sease 1988). Such records should be kept in a log separate from personal field notes, and the information should be transferred to a permanent specimen record at the collection or institution. The treatment history of a specimen, from its original exposure through its life in storage, is one of the most critical issues of conservation, but unfortunately most often overlooked. Excavators never fail to document the geographic and stratigraphic locality, date of collection, and identification of a specimen, but often they forget to record its physical and chemical treatment history.

These gaps in the specimen record may have grave consequences if addition of a compound provokes an unforeseeable chemical reaction.

In situ sites

Some examples

Not all fossils are removed from the matrix at excavations. Some notable vertebrate fossil specimens (both body and track fossils) are never removed from their original site but are on the other hand exposed and displayed in situ. Some famous examples in the USA include Dinosaur National Monument (Utah), Badlands National Park (South Dakota), Big Bend National Park (Texas), Agate Fossil Beds National Monument (Nebraska), Ashfall State Park (Nebraska), Florissant Fossil Beds National Monument (Colorado), Berlin Ichtyosaur State Park (Nevada), Dinosaur Valley State Park (Texas), Hot Springs Mammoth Site (South Dakota), Dinosaur State Park (Connecticut), Dinosaur Provincial Park (Alberta).
In situ sites in other parts of the world are extremely limited. Examples are Lark Quarry Environmental Park (Queensland, Australia), Dashantu Site (Sichuan, China), and not to forget, the petrified forest on Lesvos (Greece).

Weathering at in situ sites

In situ sites are an excellent way to teach the public about excavations, but they may also engender some problems. Vertebrate fossils left in situ are subject to weathering all year-round. Freeze-thaw cycles and acid precipitation in particular do a lot of damage (Amoroso & Fassina 1983).
Protection of some kind is sometimes afforded by small domes, or open or closed buildings. Most of these protected sites lack any kind of environmental control systems, so that climatic fluctuations, although lessened, are still influential.

Vandalism

The most important problem for in situ sites appears to be security and the always-difficult balance between public accessibility and protection. Several in situ sites have been the targets of thieves and vandals. To cope with this problem, casts may replace the original body fossils, although these too, are sometimes stolen. Fossil trackways are sometimes the target of unauthorized attempts to make plaster

casts, which cause damage to the track surface. At the Dinosaur Valley trackway on the Paluxy River vandals even chiselled human footprints into the trackway.
Also passing animals, sometimes attracted to the shade provided by the covered building, may cause a lot of damage (Agnew, 1984).

Bringing the excavation to the museum

Another way to teach the public about excavations is to take only part of the site as a large block to the museum, and to arrange explanatory exhibits around it. Tools and techniques can be shown by means of short documentaries on screen. It is also possible to bring an element of fun and self-practice into the exhibition, if space and assistance is sufficient. For this, a large shallow container is filled with sediment, covering some fake-fossils. If the target audience mainly consists of children, the sediment may be sandy. If the public are older children and adults, the sediment may even be firm, in the form of sand with water-based glue, so that real tools can be used to remove the sediment from the casts.
Such interactive exhibitions appear to be very successful. Obviously, the elements of surprise and practical skills combine well, and make an explorer of every visitor. After all, we all dream of digging-up a dinosaur in our backyard, whether we are scientists, collection managers or amateurs. The only difference is that the first two groups know that such a discovery would imply lots of careful additional work (documenting, jacketing, transport, cleaning, numbering, determining).

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