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Moulding and cast replication of outcrops: a tool in geoconservation

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ABSTRACT

We describe the application of standard palaeontological techniques of replication to novel and challenging environments in the field. We outline some of our projects that have involved the moulding of whole outcrops, followed by the production of casts from these moulds. This extends replication from primarily a research and educational tool to a technique that supports geoconservation. Where important sites are threatened, this type of 'rescue palaeontology' allows vital information to be collected and archived without damaging the outcrop.

1. Introduction

For thousands of years fossils have been collected for various reasons, even mystical ones (McNamara, 2012). In earlier centuries the gentry bought fossils to adorn their 'cabinets of curiosities' and many of these became vitally important for palaeontological research (Agassiz, 1833–1843). Museum curators have always collected or bought specimens for public display. The finding and preparation of spectacular fossils is very specialised work, requiring skill, time and experience, and is often done by local collectors. Whatever the original motive for this work, many of these specimens eventually reach museums via wealthy collectors. One of the earliest and best-known professional fossil collectors was Mary Anning, whose 'sea monsters' (Ichthyosaurs) now adorn the walls of the Natural History Museum. Her original reason for collecting was economic (Tickell, 1996), to sell, but in retrospect her activities were acts of rescue, as the fossils she collected from the beach at Lyme Regis would otherwise have been destroyed by the sea.

However, it is not possible for all museums to have examples of the fossils they would like as some are very rare. Two of the most iconic fossils on display in the London Natural History Museum are replicas:

> the Apatosaurus skeleton that dominates the main hall is one of twelve copies, each of 300 separate bones, cast in plaster, presented to the crowned heads of Europe in 1904 by the man who financed its discovery, Andrew Carnegie (Rea, 2001).

The first Archaeopteryx was bought, unseen, by Richard Owen in 1863 from a German collector (Dr Haberlein) for the British Museum (Wellnhofer, 2009). As only ten others have since been found, most museums have to show replicas. In 2011 the 'London' specimen was declared to be the type specimen, and is now due to go on public display for the first time in late 2012 (NHM, 2011).

In 1866 Henry Ward published a catalogue "Casts of Fossils from the Principal Museums of Europe and America". These were plaster replicas from European collections to illustrate the science of geology for educational and scientific institutions in the new American universities and museums (Ward, 1866). The book details over 1200 specimens, from foraminifera through invertebrates, meteorites, gold nuggets, to complete Pleisiosaurs.

This paper explains how today we use replication techniques similar to those used for over 150 years, but by using modern materials we can work on whole outcrops and the replicas can support research and site conservation as well as education and display (Edwards and Williams, 2011; Larwood, 2011).

2. Moulding an outcrop in the field

Traditionally, moulds have been made from a suspension of latex rubber in water, which is painted on to the surface to be moulded and built up in many layers, allowing each to dry before the next is applied (Clarke, 1972). Latex is still used for large moulds in hot dry climates such as South Australia because it is cheap (Gehling, pers. comm., 2008) but is often impractical in the

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Fig. 1. Outcrop cleaning: the large bedding plane at Charnwood Forest. Two British Geological Survey workers cleaning the face: the upper part has been power washed and cleaning continues below.

damper conditions of Britain. Also, experience shows that latex moulds lose flexibility, becoming hard, brittle and unusable in a few years. We use catalyst-set RTV (Room Temperature Vulcanising) silicone rubbers that take up to 24 hours to set, depending on temperature, but adding a chemical accelerator shortens the setting time (Bentley Advanced Materials, 1996) Silicone rubbers are much more expensive than latex, but are very flexible, stable and durable; some of our moulds are still in use after 40 years.

Before beginning a project, landowner permission is secured and checks are made on access and safety on the outcrop. Rubber does not adhere to wet rock, so a dry day is needed. An accurate image of the outcrop is also essential, either photograph or laser scan, so that the final casts can be assembled to reproduce the outcrop precisely. All loose rock, soil and vegetation must be removed. A scrubbing brush and water are usually sufficient, but heavy lichen cover is treated with herbicide some weeks before the cleaning. A high pressure water jet such as a patio washer can be useful, see Fig. 1., but before applying the rubber the rock surface must be completely dry. The surface preparation can be time-consuming, sometimes taking as long as the moulding process itself, but it is vital.

The outcrop is then coated with silicone rubber using a paintbrush, working the rubber over all the surface detail to ensure a first thin, flawless layer (bubbles in the rubber, for example, would be replicated in the cast). When this layer has set, more rubber is painted on to build up a mould of suitable thickness. The 'art' here is to use just enough rubber to obtain a good mould. With a high relief surface, the rubber has to be thick and rigid enough to hold its shape during casting, but must not grip protruding fossils so firmly that they become detached with the mould. The mould can be strengthened by incorporating fibrous material in later layers: hessian is the cheapest while fibreglass mesh is also convenient. As a mould can weigh 5–10 kg m^{-2}, larger outcrops are moulded in sections, usually joint-bounded, and less than 10 m^2, for ease of handling.

When the rubber is fully set, the mould is carefully removed. Small moulds are kept flat, larger ones are rolled up for transport. Finally, any remaining traces of rubber are cleaned from the outcrop.

Casting is done in a workshop, first ensuring that the mould has retained its original shape, using plaster of Paris backed with 'builders' foam for lightness. Both of these layers can be reinforced with hessian or fibreglass mesh. Resulting casts can weigh less than 10 kg m^{-2} and so are easy to transport, mount on a wall, handle on a bench or store. Larger display casts can be further strengthened with fibreglass or made in several sections.

3. Four case studies from the UK (Fig. 2) are described below

3.1. Yorkshire coast, England: a rescued trackway for conservation and display

A theropod trackway on a series of Jurassic sandstone slabs was rescued from a cliff-face. The outcrop had been sawn into 20 pieces on site and brought to the Yorkshire Museum, but the challenge was how to display it, as the slabs of rock were of variable thickness, very heavy and they did not look impressive on the floor where space is very precious. Lightweight casts of the surface were needed, one for a wall-mounted display and another for a travelling exhibition. The pieces of rock were moulded individually and then a composite mould was made, over 5 m long and 1 m wide. The rock slabs went into storage and may not be on public view again. A cast of the complete trackway (weighing less than 10% of the original) is now installed on the wall in the National Trust visitors' centre at Robin Hoods Bay, Yorkshire, near the site of the original outcrop.

3.2. Charnwood, Leicestershire, England; archiving an outcrop for research and conservation

In Charnwood we replicated several small localities with important fossils, some of which are in public places and under threat from carved graffiti and other vandalism. The most challenging was a steeply dipping bedding plane of 150 m^2, up to 10 m high. It is covered with a profusion of Ediacaran fossils, many not yet described. Most of this bedding plane was inaccessible and covered by a thick layer of moss and lichen (Fig. 1.). The aim of the project, initiated by Natural England, was to reproduce the whole outcrop so that it could be stored as an archive at the British Geological Survey (BGS), Keyworth.

The face had to be accessed from the top, by rope and harness, even for cleaning (Fig. 1). For moulding, an adjustable 'platform' was made from ladders and scaffold plank that could be lowered

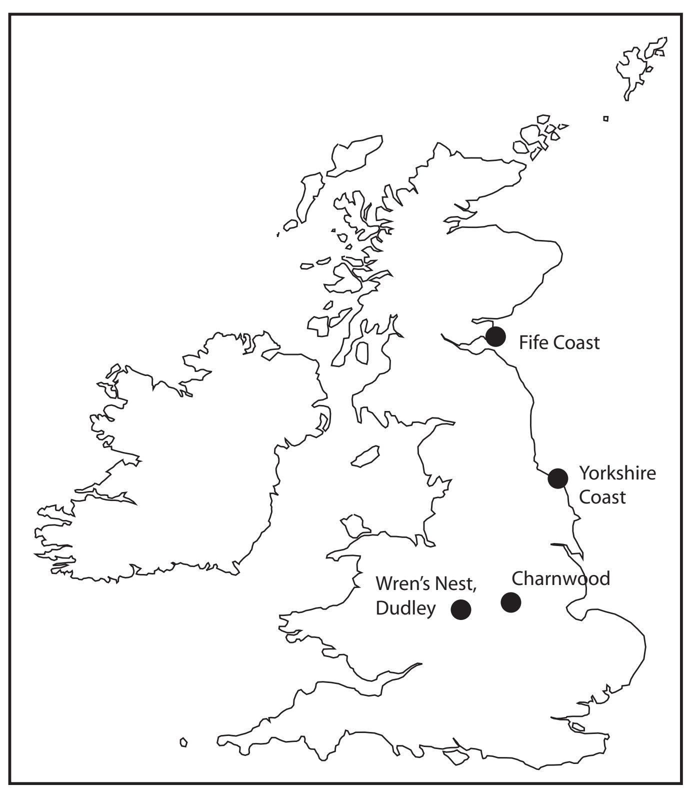

Fig. 2. Map of the UK showing the location of moulding and cast replication case studies.