Extraction and restoration of the dinosaur bones of Quseir Formation, Western Desert, Egypt

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Abstract

The Western Desert of Egypt has good exposures of Late Cretaceous successions. These successions contain evidence of dinosaur bones bedded in compact mudstone of the Quseir Formation, Campanian age. These fossils are highly affected by the paleoenvironments of the host layer and recent weather factors. The rate of sedimentation and the degree of the current energy are almost the main factors of the mode of preservation of the vertebrate fossils. The dinosaur fossils are very rare in the Cretaceous deposits of Egypt; therefore, any evidence of these bones will increase the knowledge of the form and the distribution of dinosaurs of the African continent. The extraction of these fossils from the host layers needs highly expert paleontologists and special tools to avoid damaging these fossils during the extraction. Here, we explain the extraction and restoration methods of the dinosaur fossils from the south of the Western Desert of Egypt. These methods are explained here in successive steps, which the paleontologist could gradually guide for the vertebrate fossil extraction.

Keywords: Dinosaur, Egypt, extraction, Restoration.

Introduction

The Egyptian Western Desert is considered one of the best localities in the world, containing natural heritage sites, with attractive landscapes and ecotourism sites comprising vertebrate fauna. There are three main localities containing dinosaurs from the Late Cretaceous in the Western Desert, chronologically order, the Cenomanian deposits of Bahariya oasis [**1, 2**]; the Campanian deposits of Kharga and Dakhla oases [**3, 4, 5, 6**] and the Maastrichtian deposits of Dakhla oasis [**3, 7**].

The vertebrate fauna extracted from different types of sedimentary rocks. The embedded vertebrate fauna in the host rock had distinct taphonomic conditions that can evaluate the valuable information from studying these collected faunas. These taphonomic conditions include the mode of preservation, abrasion, fragmentation, articulation, etc.

The host rock type plays an important role in preserving these vertebrate faunas. Sandstones are the best host rock, with higher porosity and permeability. The high porosity and permeability allow penetration of the dissolved minerals either into the cavity inside the bones producing permineralization process or during the exchange of the organic matter by the surrounding minerals producing replacement process. The vertebrate fauna embedded in the mudstone are more articulated and suited close to each other. The mudstone is often highly cracked, which may easily damage the fauna. The mudstone is often compacted by a load of overlying layers, causing the squeezing of the fauna. Moreover, these layers can store water, causing an increase in the rate of moisture, resulting in the fragmentation of the fauna by changes in temperatures. The mineralization in the fossils is easily altered by the gypsum found in the mudstone, causing change in the real size and destroying most of the faunal internal structures. The limestone can preserve the fauna well, but it is very hard to extract them.

The paleoenvironmental parameters such as the rate of energy of the current and the rate of sedimentation play an important role in the preservation of the fauna where the high current may transport the skeleton for a long-distance causing abrasion and scattering of the skeleton before settling in the host rock [**8, 9, 10**]. The high sedimentation rate of the host rock enhances the preservation of the vertebrate fauna. It reduced the long-time exposure of the fauna in the substrate, reduced the abrasion of the fauna and avoided the scattering and fragmentation of the fauna by predators and other bioerosion activities.

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The type and shape of the bone can share in the assessment of their mode of preservation, where the dense and heavy bone transport only for a short distance, but the light bone may transport for a long distance, which causes abrasion and fragmentation of the bones, [**11, 8, 12**].

The dinosaur bone bed in the study area

The dinosaur bones bed in Kharga and Beris oases are rare and highly weathered if recorded. The dinosaur elements in the Quseir Formation southwestern Desert of Egypt are embedded in hard glauconitic and compacted mudstone of the uppermost layers of Hindaw Member [**10, 13, 14, 15, 16**].

The dinosaur bones are highly physically and chemically weathered. The bones are abraded, fragmented, and occasionally affected by the gypsum alteration of the mudstone. Moreover, the mudstone is highly cracked and intercalated by large gypsum veins. Therefore, extracting the dinosaur bones is difficult and requires time and expertise.

The dinosaur bones are taphonomically scattered after death due to the transportation for some distance by the water currents. They are often embedded in the A-zone of the layer (the upper surface) [**8**], with a low sedimentation rate, resulting in high physical and chemical weathering of these bones. The dinosaur bones recorded in the study area are associated with highly fragmented turtle and crocodyliform bones, giving clear evidence of a high energy and low sedimentation rate.

Extraction and preparation of the dinosaur bones

The extraction method of the dinosaur bones follows the protocol used by the New Valley Vertebrate Paleontology Center.

a) Fieldwork

1- Studying the previous works of the prospected area stratigraphy, paleoenvironment, and paleontology.
2- Searching for exposed surfaces along the study area.
3- Recording any bone evidence,
4- Evaluating the evidence whether there are associations or not.
5- Reporting faunal assemblage.
6- Sweeping the upper weathered friable sand surface surrounding the bone (**Fig. 1**).
7- Marking and detecting the uncovered bone with some paper or tissue to reach the maximum extension of the scattered and separated bone elements (**Fig. 2A**).

Fig. 1. Sweeping the upper weathered friable sand surface surrounding the bone to detect the maximum extension of the scattered bone elements.

8- Marking and detecting the uncovered bone with some paper or tissue to reach the maximum extension of the scattered and separated bone elements (**Fig. 2A**).
9- Gluing all the uncovered bones during the excavation by PVA (polyvinyl acetate).
10- Digging around the circumference of the bone extension with heavy tools such as hummers, shovels, brushes, pockets, satrap, Hilti, and others (**Fig. 2B**).

Fig. 2. **A**) the dinosaur bone elements in the mudstone, **B**) Digging around the circumference of the bone extension.

11- Dividing the separated dinosaur elements into isolated parts, covering the exposed bones with paper or tissue paper (**Fig. 3A, B**).

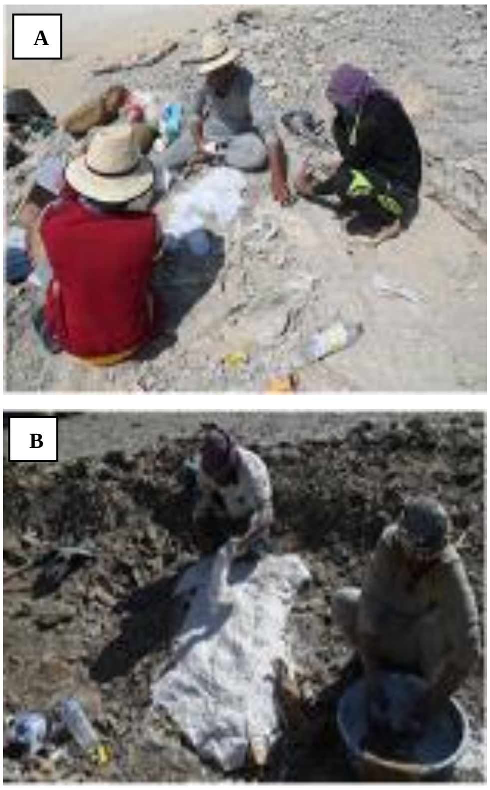

Fig. 3. **A**) Covering the dinosaur bone elements with wet tissue, **B**) Rapping the dinosaur bone elements with burlap and gypsum solution.

12- Digging deeply around each separated dinosaur bone element with fine tools (if possible) using an electronic grinder machine (**Fig. 4**).

13- Covering the separated dinosaur element with a wet paper tissue and then with a wet newspaper in two to three layers to save the bones.

Fig. 4. Digging deeply around the separated dinosaur bone element.

14- Rolling each separated part by burlap strips immersed in gypsum solution (three to four layers) to make a strong gypsum jacket to protect the bones (**Fig. 5**).

15- Separate the gypsum jackets from the bed with some heavy tools such as a satrap and hummer, and then turn over the gypsum jacket until the bottom side is obvious (**Fig. 6**), then remove the excess sediments from the bones.

16- Cover the exposed surface with burlap and gypsum solution to complete the two sides of the gypsum jacket containing the dinosaur bones.

17- make quadrates by robes in definite measures such as one meter square for each quadrate above the discovered skeleton or the partial skeleton, to can draw the shape of the skeleton by its depositional state can study the taphonomic features of the discovered skeleton

18- Transport the gypsum jackets to the laboratory: The gypsum jackets containing bone fossils are sometimes very heavy and it is difficult to lift them above the car by hand. Therefore, the lifting of these jackets by tractor, but it is very hard for the tractor to move in soft staking sediments, so that we use Landcruiser cars and sometimes the jackets are slide on the soft sediment slopes to the floor of the locality of the discovered fossils.

Fig. 5. Rolling the upper surface of the gypsum jacket with wet paper and burlap and gypsum solution.

Fig. 6. Turning over the gypsum jacket until the bottom side is obvious.

b) Laboratory work

Cleaning and restoring the extracted vertebrate fauna need more time and much work in the laboratory. The removal of the sediments over the fossilized bones needs highly experienced and trained workers. It is favorable to have a CT scan of the gypsum jacket containing the bones to detect the morphology of the collected bones without extracting the bones from the surrounding sediments. Removing sediments needs

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special tools such as air scribes with different sizes (from 0.1 to 0.9 mm). To clean and restore the vertebrate fauna use the following protocol:

1. Cut the upper half of the gypsum jacket (only the burlap with gypsum) with care until reaching the bones (**Fig. 7**).

Fig. 7. Cutting the upper half of the gypsum jacket.

2. Remove the soft sediments slowly by brushing over the bones and gradually gluing the uncovered bone (**Fig. 8**).

Fig. 8. Removing the soft sediments over the bones of the upper surface of the gypsum jacket

3. Remove the consolidated sediments around the bones by air scribe of suitable size according to the hardness and the amount of sediments over the bones. The preservation of the fossils controls the size of the air scribe used (from 0.1 to 0.9mm) (**Fig. 9, 10**).

Fig. 9. Removing the solid sediments around the dinosaur bones by air scribe.

Fig. 10. Different sizes of air scribes were used in removing the sediments around the dinosaur bones.

4. Glue the cracked and fragmented bones with some cohesive materials such as UHU or any other strong glue.
5. Photograph the cleaned materials in the gypsum jacket before removing them.
6. Separate each bone element from the gypsum jacket (if possible).
7. CT scanning of the bone after cleaning and restoration (**Fig. 11**).
8. Measure, describe and identify the bone elements.
9. Display them or restore them in special places.

Fig. 11. CT scanning of the bones after cleaning and restoration.

Conclusion

The dinosaur fossils reported in the compact mudstone of the Quseir Formation in Kharga and Beris oases in the Western Desert are highly affected by the paleoenvironmental parameters.

The sedimentation rate and the current's energy are the main factors in the preservation of the dinosaur's bones. The extraction of these fossils was following the extraction protocol, starting by detecting the extension of the bones in the study area and making gypsum jackets above the discovered bones on the two sides. The restoration of dinosaur bones requires special tools for cleaning, such as different sizes of air scribes, dental picks, and brushes. The bones' restoration and gluing use chemical materials such as polyvinyl acetate (PVA) or Paraloid B72 dissolved in acetone and some adhesive materials such as UHU. The extraction, cleaning, and restoration methods depend on the mode of preservation of the bones and the type of the host rock.

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