Bulletin of the Natural History Museum, 2011, 4: 51-64.
Received 09 Jun 2011; Accepted 29 Nov 2011.

UDC: 569.61.082.14(497.113)

Technical paper

EXCAVATION, RECONSTRUCTION AND CONSERVATION OF STEPPE ELEPHANT FROM THE CLAY PIT OF THE BUILDING MATERIAL FACTORY "TOZA MARKOVIĆ" AT KIKINDA (SERBIA)

MILOŠ MILIVOJEVIĆ

Natural History Museum, Njegoševa 51,11000, Belgrade, Serbia, e-mail: milos.milivojevic@nhmbeo.rs

In this paper, the procedures of restauoration, conservation and reconstruction of missing parts carried out on the mammoth skeleton found in the clay-mine "Toza Marković" in Kikinda (September 1996) are described. Work methods, chemicals and tools that were used in this process are presented. This paleontological conservation is one of the first done to such a great extent in this part of Europe. The process of bone protection was undertaken in phases and required a meticulous approach to every part of the skeleton. Following the completion of this work, the original skeleton is on display at the National Museum of Kikinda, while two replicas are stored in Kikinda and Belgrade.

Key words: Conservation, mammoth, skeleton, Kikinda

INTRODUCTION

In September 1996, the Natural History Museum was invited by the geologists from “Toza Marković”, where, during the exploitation of clay for needs of “Toza Marković”, an “excavator operator found the remains of a large animal (the excavator bucket had exposed the femur and a neck vertebra). The site was visited by a team from the Museum, including Zoran Marković, curator-paleontologist, then Head of the Geological Sector of the Museum, and Miloš Milivojević, geological preparator. This was the start of immense excavation activities of fossil remains of this animal, which was identified as a Steppe Elephant or *Mammuthus trogontherii* Pohlig.

Description of site

The site was divided into sectors where the remaining pieces of skeleton were expected to be buried (Fig. 1).

Fig. 1. - “Toza Marković” clay mine.

It was soon recognized that most bones, including the vertebral column, pelvic girdle, leg bones, ribs and an excellently preserved skull with a mandible, were situated in the immediate vicinity of the first discovery, and that this was a complete skeleton of a proboscidean from the genus *Mammuthus*. Although this was not the first record of proboscideans in this area, it was unique in that in contrast to previously collected remains (Krstić *et al.* 1988), this was a complete individual lying more than 21 *m* below the surface, in the so-called blue clay that represents the lower level of clay pit exploitation. The layer with the remains is composed of blue-grey sands and appears continuously over the whole area of clay pit. It is composed of muddy and mica-like quartz sand, with greater or smaller additions of clay. The thickness of this layer is variable (0.80-6.20 *m*). It is highly saturated with water and in a hydrogeological sense represents a collector. All these characteristics of sediments were not conducive to the excavation of bones, as there was constant danger of sliding and crumbling. However, with the involvement of trained workers and equipment (excavator) excavation, activities became much easier.

RESULTS

Excavation activities

The speed of excavation was dictated by weather conditions and the rate of exploitation of the clay pit. During the extraction of the femur and vertebra (which were found first) it was necessary to consider cracks in bones formed by the initial impact of the excavator bucket. Primary protection had to be performed in situ, additionally slowing down the excavation process (Fig. 2).

Fig. 2. – Excavation.

Work on these bones was followed by new findings. Each new removal of sediment from the vicinity revealed the remaining parts of the skeleton. The next record was the skull, with excellently preserved upper molars. The tips of the tusks appeared first. The position of the tusks indicated an upright position of the whole skull, making further excavation easier. As the tusks were exposed, they were concurrently bandaged with wooden planks and covered in fine stretchable foil, preventing breakage and sudden desiccation.

The lower jaw was found in the natural position to the skull, indicating without doubt that the animal had died at the site where it was discovered. There was an interesting occurrence of a large amount of muddy water with a specific smell, which was flowing out of the foramen magnum at the skull. This water came out of the brain case and the choanae. The appearance and smell of this liquid indicated that due to sudden immersion of the animal in the mud, and therefore a lack of oxygen, the organic matter was not completely replaced with sediment. This is not an unknown phenomenon and is most often recorded in remains excavated from peat bogs and ice (Lister *et* Bahn 1995). The chemical analysis undertaken and repeated several times in order to determine the percentage of remaining organic matter in the bones, which had previously been subjected to total desiccation in order to get absolutely valid results, yielded the following results (Marković & Milivojević 1997):

SiO_2	7.38%
Fe_2O_3	2.41%
Al_2O_3	50.69%
CaO	9.38%
Na_2O	1.00%
K_2O	0.10%
Loss on ignition (organic matter)	29.03%

In the sediment between the branches of the mandible there was a complete skull of a water vole, indicating the living conditions of that period. The vertebral column with ribs stretched in a northwestern direction from the skull, and a pelvic girdle with attached sacral vertebra at its end are additional proof that this is an *in situ* record. The other leg bones lay intertwined, directed toward the next underlying layer. As expected, the smaller bones (phalanx bones, tarsal and carpal bones and radii) were not recorded in complete number as they were removed either by water or by predators. The greatest mystery is the absence of both shoulder blades. The hypothesis that water or predators took them far away is quite improbable, as an individual bone with meat would have weighed more than 200 *kg*. It is much more realistic to assume that they were removed by prehistoric humans, who used these and similar parts of skeletons to cover their primitive shelters or make some tools (Lister & Bahn 1995).

As it was impossible to extract the skull and the tusks as a whole, they had to be amputated at the level of alveoli. The amputation was performed with a woodcutting saw. These separated parts were placed on a specially constructed wooden sled and with the help of a bulldozer pulled up the slope of the clay pit. They were moved to the place of conservation in the bucket of the same bulldozer. The same procedure was repeated for the pelvis and the larger leg bones, while the others were manually transferred. Video and photo records were made continuously during the excavation process.

Restoration and conservation

All recorded bones were placed in a room with the dimensions 5 × 4 × 3.4 *m*, where the following activities were performed.

Skull. Due to the sudden change in pressure and humidity the skull was subjected to the expected increase in the size of microfissures and cracks. As the bones in the skull are flat bones and therefore only several centimeters thick, damage from excavation and transport was noticed at certain parts. In order to wash the remaining sediment and mud from all the choanae and foramens, it was necessary to separate the flat skull bones along the connecting sutures, which were fairly compact due to the age of this individual. The sediment was washed with a jet of water from the hose. After the controlled desiccation in natural fashion, the bones were connected, conserved and reconstructed in places where parts were damaged. After that the skull was placed on a wooden stand. The skull was connected with a mixture of gypsum and two-component glues (Fig. 3).

Fig. 3. - Conservation of the skull.

The final conservation was performed using a PVA: water solution in a 1:10 ratio. In order to secure the skull parts, long metal rods were used, with plate-like screws 6 *mm* in diameter at the ends. It was necessary to take care of skull morphology during the connecting, and in order to insert the rods it was necessary to use files longer than the diagonal dimensions of the skull (80 *cm*). Before insertion, the rods were covered in a thick layer of two-component glue. The first rod was inserted from the lower left occipital to the right frontal part. The second rod was inserted from the lower right occipital to the upper left frontal part, while the third and the shortest was inserted through the bone mass of the upper jaw. After the rods were inserted, the places of insertion were "masked". These places and sutures were filled with two-component glue. After the glue had dried, it was concluded that consolidation of the skull was complete. These activities took about three months.

Blacksmith activities performed simultaneously with construction included preparing the carrying constructions and bars with a 3 *m* high pulley in order to raise the skull to the metal stand for further conservation (Fig. 4). The stand followed the external contours of skull, nasal openings and upper jaw (Fig. 5.).

Fig. 4. - Metal stand.

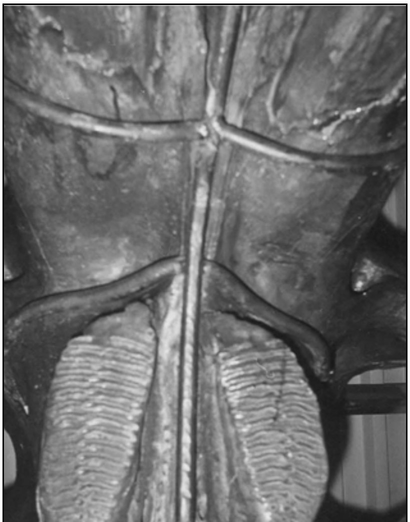

Fig. 5. - Upper jaw.

The thickness of the rods used for the horizontal parts of the stand was 10 *mm*, while the main vertical carrying rod with a tripod was 60 *mm* thick. Stands of these diameters were used due to the extreme weight of the skull and mandible, about 350 *kg*. The holding bar installed at the workshop was 3 *m* high. The skull was raised with a pulley, together with the horizontal part of the stand, to the height of the occipital ridge of 220 *cm*, and after that the horizontal part was welded to the vertical part of the stand. Once the skull was secured it was ready for attachment to the amputated tusks.

Mandible. Although the mandible was excellently preserved, due to its morphology it had to be subjected to similar procedures as the skull. In the symphysis area the armature was built in as a precaution, in order to increase the strength of this disproportionably thin part of the jaw. The process of installing rods was the same as in the skull. After these activities were finished, the mandible was submerged into the solution of PVA and water. The carrying armature of the mandible stand was welded to the skull stand, resulting in the natural anatomic position.

Tusks. Before the start of restoration and conservation activities, a metal bath 2 *m* long and 0,6 *m* wide was made in order to soak the remaining parts of skeleton. The bath was filled to two thirds of its total volume with a solution of PVA and water. The left tusk was submerged first. As the tusks were very long (about 2.70 *m*) it was necessary to periodically turn the tusk over in the solution. The same treatment was then repeated with the right tusk. Due to the specific composition of dentin, the conservation is different than in bones (the surface swelling and formation of bubbles due to the loss of original moisture). The conservation process was long (about a month) as it was necessary to monitor for the development of microfissures and the process of decomposition of tusk core. The final conservation was started only after careful monitoring of these processes. When the tusks were consolidated enough, the metal rods were placed in the metal fastener, in order to carry the weight of the tusks (about 150 *kg* per tusk) and to prevent further swelling during desiccation. The metal fasteners were made of zinc-covered tin, with a possibility of regulation by using bolts (Fig. 6).

Fig. 6. - Mounting metal fasteners.

Four pairs of metal fasteners were mounted on both tusks. They were connected to each other by a metal flat bar 3 *cm* wide and 5 *mm* thick, following the lower curve of the tusk. The contact between the metal fasteners and the flat bar was established by welding. Each flat bar was pressing against the three tripod holds placed symmetrically for balance of tusks.

After the conservation of tusks was finished, they were connected to the skull by precise mounting with fasteners. They were inserted in holes made by drilling in the alveolar part of the tusks. Then they were glued in place, while a metal capsule with inner diameter matching the thickness of fasteners was inserted in the same way at the other side of tusks (Fig. 7-8).

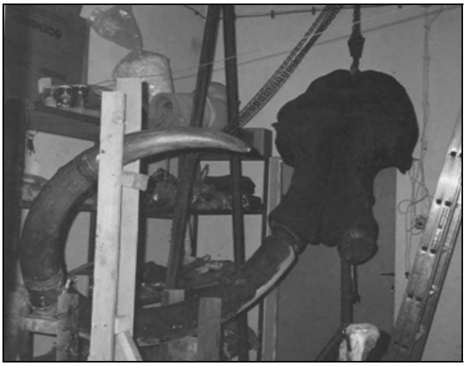

Fig. 7. - Conservation of the right tusk.

Fig. 8. - Conservation of the left tusk.

The end result includes the skull and the tusks mounted in their natural position (Fig. 9).

Fig. 9. - Natural position of the skull.

Pelvic girdle. The next processed part of the skeleton was the pelvic girdle. After the shape of the pelvic girdle was studied, it was determined that this was a female individual (Frade 1955). The edges of the ischial bones bore tooth incisions and marks of tearing apart by predators (hyena). For educative reasons (taphonomy), these parts were purposely not reconstructed. The pelvic bones were treated with the same chemicals as all the other bones. After drying, the pelvic girdle was placed on a specially modified wooden stand.

Leg bones. In contrast to the left femur which was almost intact, the right one was greatly damaged by the excavator bucket. The bone was first submerged in the solution of PVA, and after it was dried the missing part was reconstructed and the joint surfaces were coated in a mixture of gypsum and PVA (Fig. 10).

Fig. 10. - Conservation of the femur.

The humerus, ulna, tibia and fibula bones were treated in the same way as the femur. They were all submerged in the bath with the solution and left to dry naturally.

Axial skeleton. Processing of these bones (vertebra and ribs) was easier as they were well-preserved and more easily manipulated due to their smaller size and weight. They were treated with the same method of soaking and natural drying. The broken ribs were reconstructed by soaking a steel wire (2 *mm* thick) in PVA and then inserting it into both sides of the broken bone. The surfaces where bones were broken were cleaned of sediments and broken bits, coated in PVA and attached. This procedure was used in all cases where smaller bones were to be attached (ribs, vertebra and tiny fragments of large bones).

Missing parts

Shoulder blades. The most difficult part of the skeleton reconstruction was making replicas of the missing shoulder blades. Their size had to be estimated in relation to the other bones. Literature data (Frade 1955) were used to determine the adequate size of shoulder blades for an individual of this size. In order to prepare the replica, it was necessary to use a larger amount of gypsum (about 80 *kg*), armature wire, wire mash (rabitz), and rough cloth as well as special tools (shaping knives, chisels, files, trowels and sandpaper of various sizes of granulation).

Rabitz wire mash was attached to an armature framework that more or less followed the contours of the shoulder blades and then was coated in rough cloth soaked in a thin gypsum solution in water. After drying, gypsum was added in layers until the desired thickness was reached. The ridges and joint surfaces were formed in the same way as the main surface. The final processing was performed by using chisels and sandpaper, according to the morphological characteristics of the model brought from the Collection in the Museum. The final form of the shoulder blades was achieved by using special tools made specifically for this purpose.

Feet. In order to form the replicas of phalanx, carpal and tarsal bones, authentic material from the site was used – clay with a high percentage of grain fineness. It was necessary to consider the contraction of clay which happens during the baking process. In communication with the technologists from “Toza Marković”, it was determined that this particular clay at this level of grain fineness would contract about 10% after the final

Fig. 11. - Modeling of the foot.

desiccation. Therefore the models were larger than the natural objects (as calculated according to the literature data) (Olsen 1979). In order to make the models as simple as possible, the carpal and tarsal parts were made in one piece, while the phalanx bones were each made separately. After the modeling process was finished, the parts were dried for seven days and then baked, which took three days for the phalanx bones and four days for carpal and tarsal parts (Fig. 11).

The parts were then finely processed with sandpaper and small tools in order to present morphological details (ridges, rugose forms). The pieces were connected with steel wire in the same way as the original bones. In order to present them faithfully, stands 40 *cm* high were made of armature wire 10 *mm* thick.

Radii and fibulae. In order to form replicas of radii and fibulae, the same method was used as for the tarsal and carpal area. The appropriate layer of clay was placed on the metal construction of armature wire and then modeled. As the medium was again clay, contraction of material during the drying and baking process was also considered. Literature data and sample specimens brought from the Museum Collection were again a great help. The model was then dried naturally (for seven days) and baked (for four days). After the baking, the radii and fibulae were finished with small tools and sandpaper of different fineness, and then connected with ulnae and tibiae. The connecting was performed in a way similar to the connecting of the skull fragments. In the first step, long files were used to perforate the bones (ulnae and tibiae) and models (radii and fibulae), which were then connected with 30 *cm* long bolts coated in two-component glue (Fig. 12).

Fig. 12. - Joining of the radii and fibulae.

After the glue had dried, a saw for metal was used to remove parts of bolts protruding from the combined skeleton, and the places of protrusion were masked by a mixture of gypsum and PVA.

Storage of remains

Excavation, restoration and conservation activities took place from September 1996 to November 1997, and the entire process lasted until the final exhibition of the specimen (in 2005). Without the stand the whole mounted skeleton reaches a height of 3.70 *m*, a length about 7 *m*, and a maximal width of 2.40 *m* (Marković *et* Milivojević 2000). The original parts of the skeleton are stored in a special glass box which is adequately acclimatized (constant temperature and humidity) and accessible to visitors of the National Museum in Kikinda (Fig. 13).

Fig. 13. - The original skeleton on the exhibition.

The European Reconstruction Agency financed the project of preparing replicas of this extraordinary find. This project included preparing two replicas: one replica for the National Museum in Kikinda and other for the Natural History Museum in Belgrade.

CONCLUSION

Although the excavation and conservation of the Steppe Elephant skeleton took a long time, these activities were successfully finished. The complex nature of these activities necessitated spending a large amount of material means, which the Natural History Museum definitively would not have been able to provide on its own. This includes both the material for processing and the mechanization and staff necessary for this task. It was sheer luck that the discovery happened on the premises of a then successful industrial collective with all the necessary conditions for fulfilling the task (mechanization, staff, blacksmith workshop, metal workshop, artistic workshop, chemical laboratory, technologists, provision of accommodation and food for the team) (Košničar *et al.* 1998). No changes have been recorded on the bones during the periodic checkups from the end of conservation to this day. The specimen of the mammoth from Kikinda was recorded in the book of incoming material for fossil vertebrates of the Natural History Museum in Belgrade under the № 1830.

REFERENCES

Frade, F. (1955): Ordre des Proboscidiens. In: Grassé, P-P. (*ed.*): Traité de Zoologie: Anatomie, Systématique, Biologie 17(1): 715-875. – Masson et Cie, Paris.

Košničar, M., Marković, Z., Milivojević, M. (1998): Primer saradnje privreme i nauke u cilju očuvanja prirodnih vrednosti. In: Zbornik radova VI naučno – stručni skup o prirodnim vrednostim i zaštiti životne sredine: 251-252. – Negotin.

Krause, H. (1978): The Mammoth. In ice and snow?. – Self-pulisher, Stuttgart.

Krstić, N., Novović, M., Koprivica, D., Jovanović, R. (1988): Profil nalazišta mamuta u Kikindi. - Zapisnici Srpskog Geološkog društva za 1985-86. god.: 135-142.

Lister, A., Bahn, P. (1995): Mammoths. – Boxtree Ltd, London.

Marković, Z., Milivojević, M. (1997): Ostaci pleistocenskog proboscida (*Mammuthus trogonterii* Pohlig) u Kikindi. In: Zbornik radova V naučno–stručni skup o prirodnim vrednostim i zaštiti životne sredine: 336-339. – Donji Milanovac.

Marković, Z., Milivojević, M. (2000): Nalaz skeleta pleistocenskog proboscida u gliništu IGM „Toza Marković" u Kikindi (severni Banat, Jugoslavija). - Glasnik (Prilozi za nauku, umetnost i kulturu), Pančevo, Vršac, Zrenjanin, Kikinda: 171-180.

Olsen, J., S. (1979): Osteology for the Archaeologist: The American Mastodon & the Woolly Mammoth: North American Birds: Skulls & Mandibles & Postcranial Skeletons. - Papers of the Peabody Museum of Archaeology and Ethnology, Harvard university 56(3-4): 1-85.

ИСКОПАВАЊЕ, РЕКОНСТРУКЦИЈА И КОНЗЕРВАЦИЈА СТЕПСКОГ СЛОНА ИЗ ГЛИНИШТА ФАБРИКЕ ГРАЂЕВИНСКОГ МАТЕРИЈАЛА „ТОЗА МАРКОВИЋ“ У КИКИНДИ (СРБИЈА)

МИЛОШ МИЛИВОЈЕВИЋ

Р Е З И М Е

Крајем септембра месеца 1996. године, у глиништу ИГМ „Тоза Марковић“ у Кикинди ископан је скелет плеистоценског сурлаша, данас познат под именом кикиндски мамут „Кика“. Након ископавања мамута и обраде на самом локалитету, приступило се реконструкцији и конзервацији свих делова скелета. Процес је трајао неколико година и обухватио је више фаза. По први пут у Србији урађен је један овако комплексан подухват који је захтевао спрегу свих релевантних фактора, почевши од помоћи у људским ресурсима и техници на самом глиништу, хемијске лабораторије фабрике „Тоза Марковић“, до консултација са водећим европским стручњацима у домену конзервације палеонтолошких објеката. У оквиру послова на конзервацији и реконструкцији коришћене су све до тада познате конвенционалне методе заштите фосилизованог материјала и за ту сврху настале су бројне импровизоване алатке и помагала. Као резултат, настао је изузетан музејски експонат који је постављен у витрине музеја у Кикинди 2005. године, и од тада привлачи пажњу и домаће и светске јавности.