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Conservation of the Skeleton of the *Palaeoloxodon antiquus* Forest Elephant (aged 80 000–100 000) from the Collection of District Museum in Konin – the Research and Conservation Practice

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Słowa kluczowe: konserwacja, konsolidacja, kości archeologiczne, szkielet słonia leśnego, paleontologia

Abstract

The article presents the exploratory and conservation-wise problematic aspects of the bones obtained from the skeleton of a forest elephant *Palaeoloxodon antiquus* (Falconer & Cautley, 1847), that lived during the Eemian Interglacial period 80–100 000 years ago. This preserved skeleton, currently in the collection of District Museum in Konin, is particularly valuable due to being one of the largest skeletons in Europe that remained almost complete. The necessity of undertaking conservation processes has been caused by the poor state of its preservation – partly because of degradation of the materials applied during conservation in the 80s of the 20th century and later on, as well as numerous bone tissue damages; there also emerged a possibility of using materials and treatments improving value of the object, aesthetically and exhibition-wise. The publication presents the history of the skeleton and its conservation, the condition, the outline of its bone structure, and the results of instrumental research (ATR-FTIR) of derivative materials composition. Moreover, it shows the assumptions for and course of conservation and restoration works. The performed procedures allowed to stabilize the skeleton, reduce formation of new cracks and cavities, and to restore didactic and exhibition value, enabling the skeleton to be returned to a permanent museum exhibition. The works were twice awarded the 1st prize in the category – conservation and protection of cultural heritage in the prestigious competition Museum Event of the Year "Izabella 2018" and "Izabella 2019" organized by the Wielkopolska Museum Foundation under the patronage of the Marshal of the Wielkopolska Province.

Abstrakt

Konserwacja szkieletu słonia leśnego *Palaeoloxodon antiquus* (80–100 tys. lat) ze zbiorów Muzeum Okręgowego w Koninie – badania i praktyka konserwatorska

W artykule zaprezentowano problematykę badawczo-konserwatorską związaną ze stanem kości należących do szkieletu słonia leśnego *Palaeoloxodon antiquus* (Falconer&Cautley, 1847), żyjącego w czasie interglacjału eemskiego (80–100 tys. lat temu). Konserwowany szkielet ze zbiorów Muzeum Okręgowego w Koninie jest szczególnie cenny, ponieważ należy do największych i najbardziej kompletnych szkieletów dawnych zwierząt w Europie. Powodem podjęcia działań konserwatorskich był głównie zły stan zachowania obiektu, częściowo degradacja materiałów konserwatorskich użytych w latach osiemdziesiątych i później, a także liczne zniszczenia tkanki kostnej oraz możliwość zastosowania materiałów i zabiegów poprawiających cechy estetyczne i ekspozycyjne szkieletu. W opracowaniu omówiono historię zabytku i jego konserwacji, stan zachowania, zarys budowy kości oraz wyniki badań ATR-FTIR materiałów wtórnych. Przedstawiono ponadto założenia oraz przebieg prac konserwatorsko-restauratorskich. Efektem przeprowadzonych zabiegów jest ustabilizowanie szkieletu, ograniczenie możliwości powstawania nowych spękań i ubytków oraz przywrócenie walorów dydaktycznych i ekspozycyjnych, a w konsekwencji powrót szkieletu na ekspozycję muzealną. Wykonane prace zostały dwukrotnie nagrodzone I nagrodą w kategorii

„konserwacja i ochrona dziedzictwa kulturowego" w prestiżowym konkursie Wydarzenie Muzealne Roku „Izabella 2018" i „Izabella 2019" organizowanym przez Fundację Muzeów Wielkopolskich pod patronatem Marszałka Województwa Wielkopolskiego.

The bones preserved belong to *Palaeoloxodon antiquus* forest elephant (Falconer & Cautley, 1847), obtained from the Upper Pleistocene (the Eemian Interglacial) raw soil humus of the lignite mine in Konin. The skeleton was revealed on 24th February 1984 at the depth of 13 metres during the earthworks in the "Jóźwin" pit. Unluckily, there has also been the part which went unnoticed by the mine's employees at the time and therefore has been irretrievably lost in the mining pile. The bones were secured and extracted by archeologists Krzysztof Gorczyca and Miroslaw Ciesielski – the employees of District Museum in Konin. In the report, Gorczyca states that frost and the lack of the time for the necessary preparation caused that freshly excavated wet bones froze, than cracked and crumbled[1]. After having been obtained, the bones were sent for examination, marking and preservation to the Department of Paleozoology at the Polish Academy of Sciences in Warsaw. The works were conducted by the renowned paleontologist, Gwidon Jakubowski PhD (fig. 1, 2). The analysis conducted by him proved the skeleton to be the most complete specimen of this species found on Polish soil (the excavated bones make up about 70% of the skeleton) and one of the largest and the most complete in Europe[2].

Forests elephants were the largest land mammals inhabiting Europe in Pleistocene era. The adult male could reach 4,5 m in height. The elephant from "Jóźwin" measured more than 4 metres at the withers (4,05 m from the metacarpus to the upper edge of the shoulder blade) and belonged to the group of the largest specimen found so far[3].

1 Krzysztof Gorczyca, "Sprawozdanie z badań ratunkowych szkieletu słonia leśnego ('Palaeoloxodon antiquus') w Jóźwinie gm. Kleczew, woj. konińskie", *Zeszyty Muzealne* [Muzeum Okręgowego w Koninie / District Museum in Konin] 2 (1988): 5.

2 The precise morphological description of the extracted skeleton bones is contained in Gwidon Jakubowski's elaboration – Gwidon Jakubowski, "Stanowisko słonia leśnego – 'Palaeoloxodon antiquus' (Falconer & Cautley, 1847) w górnym plejstocenie odkrywki Jóźwin kopalni węgla brunatnego 'Konin' ", *Zeszyty Muzealne* 2 (1988): 13–87.

3 The Larramendi research has shown that the elephant from Konin was a male, aged about 50, his height being 390 cm at the withers and his body mass of about 11,5 tons, which placed him among the largest European representatives of the species. Bones belonging to larger individuals have been uncovered in Upnor, England and Taubach, Germany, Asier Larramendi, "Shoulder Height, Body Mass, and Shape of Proboscideans", *Acta Palaeontologica Polonica* 61, no. 3 (2016): 537–574.

Fig. 1. Paleontologist Gwidon Jakubowski PhD, with his assistant Krystyna Marczak, during the very first conservation works on the uncovered skeleton – the right thigh bone, as shown in the photo. Warsaw 1984. Picture from the Archives of the District Museum in Konin

Fig. 2. Paleontologist Gwidon Jakubowski PhD, with his assistant Krystyna Marczak, during the very first works on the forest elephant's skeleton. In the photograph there can be seen vertebrae and ribs. Warsaw 1984. Picture from the Archives of the District Museum in Konin

After the process of conservation in 1987, the bones were shown at the specially arranged paleontologist exhibition in District Museum in Konin (fig. 3). Along with the bones, there was also displayed the life-size realistic sculpture of elephant – reconstruction made of synthetic resin on the basis of the uncovered skeleton. The model was made by two sculptors: Krzysztof Kuchnio and Marta Szubert, under the supervision of professor Teresa Wiszniowska and Paweł Socha, PhD from the Institute of Paleozoology at the University of Wrocław.

Fig. 3. A piece of the permanent paleontology exhibition in District Museum in Konin, presenting particular bones of the skeleton and the history of its uncovering process. Photo I. Lorek

Due to the poor condition of the skeleton, in the years 2017–2020 the chosen bone parts were transferred to The Department of The Conservation-Restoration of Architecture and Sculpture at Nicolaus Copernicus University for re-maintenance[4]. When choosing bones, their condition was taken

[4] The works were conducted under the supervision of Piotr Niemcewicz, Hab. PhD, Aleksandra Gralińska-Grubecka, PhD, Katarzyna Polak, M.A., and the team: Monika Kujawa, M.A, Andrzej Podgórski, PhD, Barbara Ćwiklińska, M.A, Milan Charytoniuk, M.A, Katarzyna Bubieńczyk, Maria Drzewiecka i Aleksandra Jaros.

into account, the ones with many cracks and unaesthetic appearance were selected. The necessary selection of bones was determined by the amount of funding, because all works were carried out under four grants from the Marshal's Office and are still continuing.

Because of the unique character of the material and the previous conservation processes, before the actual works commenced it had been necessary to conduct detailed analysis of the bones' state of preservation and of conservation materials, as well as to compile the methodology of conduct.

Chemically, a bone consists of composite materials: inorganic ingredients – mainly calcium carbonates and phosphates (bone hydroxyapatite) that constitute about 60–70% of its mass[5], that are responsible for its hardness and mechanical durability; and of organic compounds in form of collagen proteins, containing 90% of organic waste fraction[6], giving it required elasticity. Macroscopically in turn, a bone consists of so-called compacted substance – *substantia compacta* (that builds bone stems and covers their epiphyses to a varying degree, as well as forms the surface of flat bones of various thickness) and of cancellous bone – *substantia spongiosa* (that fills up epiphyses of bones and forms so-called diploë of flat bones). Tissue of compacted substance is very durable, whereas cancellous bone is fragile, particularly when macerated, and can be much prone to mechanical damage. It should be emphasized that there is no difference between both of these "components" as far as their chemical composition is concerned – they differ when it comes to spatial structure though. Chemical structure of a bone significantly affects tissue's preservation state in posthumous environment which can be characterized by chemically, physically and biologically variable factors that change with time and space (geographically) – e.g. microorganism appearing in the immediate vicinity. Both composition and chemical structure of a bone residing in sediments and on the surface change due to decompositional and diagenesis processes. In extreme cases a bone might undergo total destruction, and sometimes the process of preservation, including fossilization, that allows it to remain unchanged for millions of years. Hence, not the time of residing is of importance here, but physical and chemical conditions of post-deposition environment. One of the most important of them is pH of

[5] Adam Bochenek and Michał Reicher, *Anatomia człowieka*, vol. 1 (Warszawa: PZWL, 1990).

[6] Ann L. W. Stodder, "Taphonomy and the Nature of Archaeological Assemblages", in *Biological Anthropology of the Human Skeleton*, ed. Anne Katzenberg and Shelley Saunders, (New Jersey: Wiley-Liss, 2008, 2nd edition), 71–116.

soil[7]. The state of bone's preservation is therefore the resultant of the time of influence of certain factors that affect its chemical composition, as well as of mechanical factors. Committing ourselves to preserving both the whole skeleton as well as individual bones, we have to take into account that the same type of bones, or even the very same bone, belonging to the same species of vertebrate, may turn out to differ significantly in terms of its chemical composition, physical properties and mechanical durability. It forces us to have individual approach in every case of a bone restored.

In 2017, before the bones were sent to the conservation team, the skeleton in question had been examined by the team of paleontologists to check its state of preservation[8]. That expertise showed significant degradation due to the methods and agents used for previous processes of conservation – which did not saturate equally into the whole structure of the bones – the time lapse since the last process of conservation, and various storing conditions: it was stored in the basement of the museum, then at the exhibition; as well as changing conditions, humidity and temperature-wise. It caused damage to glue adhesive joints, there emerged cracks, losses and chipping of the sensitive cancellous bone. The steel reinforcing bars underwent the process of electrochemical oxide corrosion. Moreover, some of the bones have not been pasted together properly and they have shifted with time.

The results of the examination conducted made it possible to select adequate bones for the consecutive stages of conservation work, spread in time. During the first stage in 2017 seven bones underwent the process of conservation: right shoulder blade (collection inventory number: MOK/P/289/2), right thigh bone (collection inventory number: MOK/P/289/7), jaw (collection inventory number: MOK/P/289/14), 6th thoracic vertebra Th6 (collection inventory number: MOK/P/289/66), 12th thoracic vertebra Th12 (collection inventory number: MOK/P/289/72), 7th left rib L7 (collection inventory number: MOK/P/289/101), 8th left rib L8 (collection inventory number: MOK/P/289/98). During the second stage of work in 2018 the following bones were being taken

7 Low pH is conducive to destruction of a bone, neutral or basic – to preserving a bone. It is suggested that with the immediate vicinity of lower than 5,3 pH, a bone is bound to undergo quick destruction, Claire C. Gordon and Jane E. Buikstra, "Soil, pH, bone preservation, and sampling bias at mortuary sites", *American Antiquity* 46, no. 3 (1981): 566–571.

8 The team consisted of Krzysztof Stefaniak, assistant professor, Adam Kotowski, PhD from the Department of Paleozoology at the University of Wrocław, and Dariusz Nowakowski, PhD from Wrocław University of Environmental and Life Sciences. Krzysztof Stefaniak, *Analiza konserwatorska szkieletu słonia leśnego Palaeoloxodon antiquus (Falconer & Cautley, 1847) ze zbiorów Muzeum Okręgowego w Koninie* (Wrocław: University of Wrocław, 2017).

care of: 3rd cervical vertebra C3 (collection inventory number: MOK/P/289/58), 4th cervical vertebra C4 (collection inventory number: MOK/P/289/59), 5th cervical vertebra C5 (collection inventory number: MOK/P/289/60), 6th cervical vertebra C6 (collection inventory number: MOK/P/289/61), 7th cervical vertebra C7 (collection inventory number: MOK/P/289/62), 1st thoracic vertebra Th1 (collection inventory number: MOK/P/289/63) and 2nd thoracic vertebra Th2 (collection inventory number: MOK/P/289/64).

During the third stage of conservation that has begun in 2019, the following bones are being preserved: right fibula (collection inventory number: MOK/P/289/9), fragments of pubis bone with acetabulum (collection inventory number: MOK/P/289/10), fragments of skull with incisive bones, maxilla and upper bones M3 (collection inventory number: MOK/P/12), 7th thoracic vertebra Th7 (collection inventory number: MOK/P/289/67), 9th thoracic vertebra Th9 (collection inventory number: MOK/P/289/69), 14th right rib P14 (collection inventory number: MOK/P/289/93) and 12th left rib L12 (collection inventory number: MOK/P/289/94).

During the fourth stage of work in 2020 eight ribs are being preserved: 2nd right rib P2 (collection inventory number: MOK/P/289/100), 7th right rib P7 (collection inventory number: MOK/P/289/97), 10th right rib P10 (collection inventory number: MOK/P/289/95&119), 11th right rib P11 (collection inventory number: MOK/P/289/92),

12th right rib P12 (collection inventory number: MOK/P/289/105), 14th right rib P14 (collection inventory number: MOK/P/289/93), 12th left rib L12 (collection inventory number: MOK/P/289/94) and 13th left rib L13 (collection inventory number: MOK/P/289/96).

To start with, a number of conservation-wise examination processes was conducted in the Department of the Conservation-Restoration of Architecture and Sculpture, among which were for example: determining the occurrence range of individual materials used for conservation, their identification with usage of spectroscopy in infrared (Fourier analysis with amplifiers)[9], solubility and swelling properties tests. There was drawn out the methodology of cleansing surface and removing particular materials, then there were prepared the composites for supplementing structural and superficial cavities. Furthermore, there were conducted several attempts to gain mechanical

9 The infrared analysis was conducted by Marta Chylińska PhD, with the use of Alpha-P spectrometer produced by Bruker. Spectra FT-IR were recorded by using an ATR attachment with diamond cristal. The range of measuring equippment was 4000–400 cm^{-1} while its resolution was 4 cm^{-1}.

stabilization and to lamination of the bones, along with the assessment of usability of particular epoxy resins and glass fabrics of various thickness.

The transparent, yellow-shade coating which covered the whole surface of the object, the white mass and bright yellow resin that occurred in joints between certain elements, the resin that had been used for impregnation and pasting the bones together, as well as the soft mass covering the teeth, have all undergone spectroscopy in infrared examination. The table 1 below shows the results of the examinations conducted:

Table 1. The results of the composition of conservation samples by spectroscopy in infrared examination

Type of sample	Characteristic bands (cm^{-1})	Function group/ type of relation/	Identification *
1. Transparent coating on the surface of bones	3282, 3081 2927, 1448, 1398 1629 1536, 1334, 1237 1079, 1033	OH, NH C-H C=O C-N, CNH C-O	The main component of the sample examined is protein substance – probably animal glue (picture 4)
2. White glue joints	2962, 2935, 1433, 1370 1729 1226 1073, 1018, 944	C-H C=O COO C-O	The main component of the sample examined is polyvinyl acetate (picture 5)
3. Transparent, yellowish resin, present in bone tissue structure	2958, 2933, 2873, 1465, 1387 1721 1266, 1239 1142, 1063, 1020	C-H C=O COO C-O	The main component of the sample examined is poli (methyl methacrylate) (picture 6)
4. Light yellow resin present in the joints	3618, 3443, 3371 1581, 1456, 3057, 3026, 2924 2854, 1383, 1361 1733 1606 1508 1104, 1029 915	OH, NH C-H C=O $C_{Ar}=C_{Ar}$ $C_{Ar}-C_{Ar}$ C-O-C C-O	The main component of the sample examined is epoxy resin (picture 7)
5. White soft mass covering the teeth	2956, 2916, 2848 1472, 1462, 1378 729, 719	C-H	The main component of the sample examined is paraffin (picture 8)

* The analysis made basing on the presence of bands characteristic for the particular material and on compatibility level with the reference spectrum.

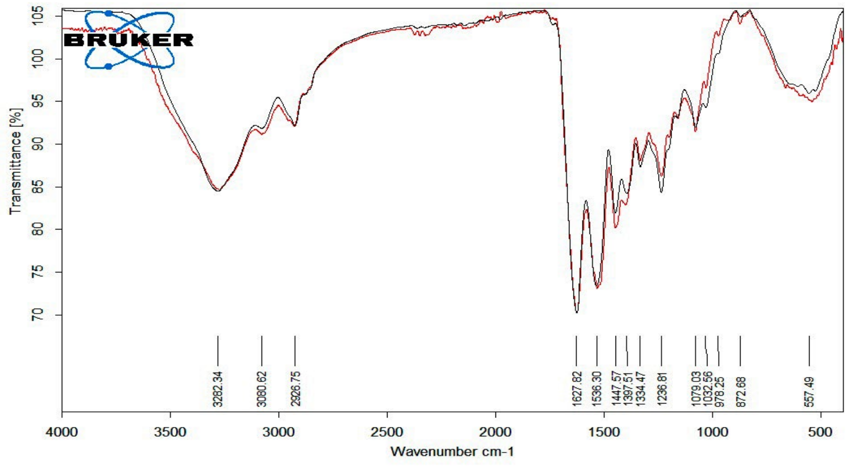

Fig. 4. The ATR-FTIR spectrum of the sample no. 1 (black) congruent with the model spectrum of animal glue (red)

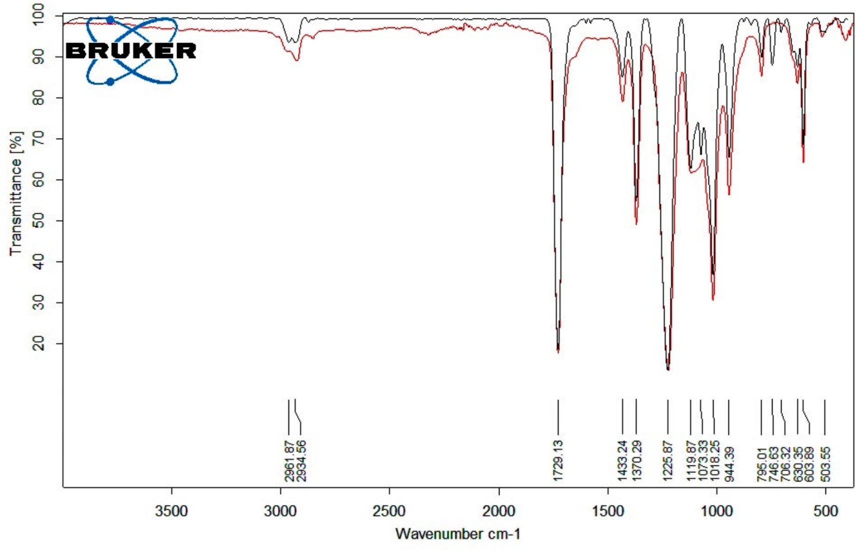

Fig. 5. The ATR-FTIR spectrum of the sample no. 2 (black), in most of its part congruent with the model spectrum of polyvinyl acetate (red)

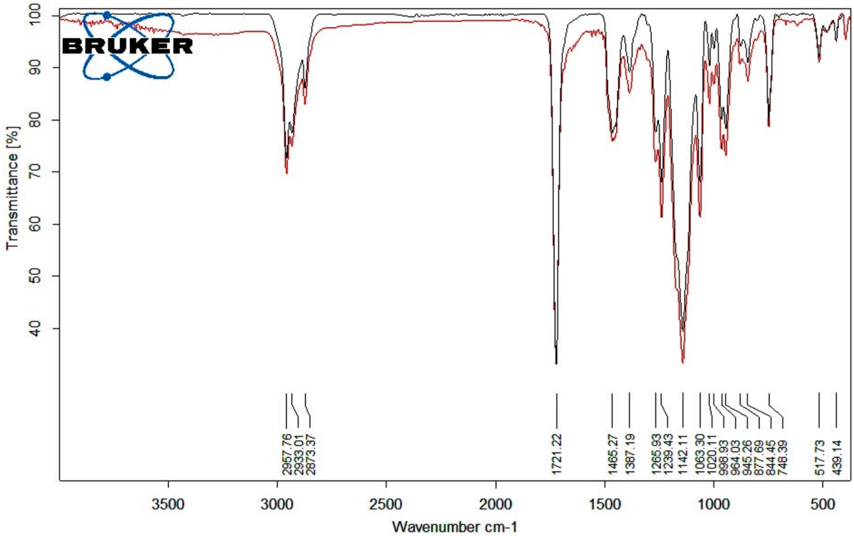

Fig. 6. The ATR-FTIR spectrum of the sample no. 3 (black) congruent with the model spectrum of poli(methyl methacrylate), the part of thermoplastic resin Osolan KL (red)

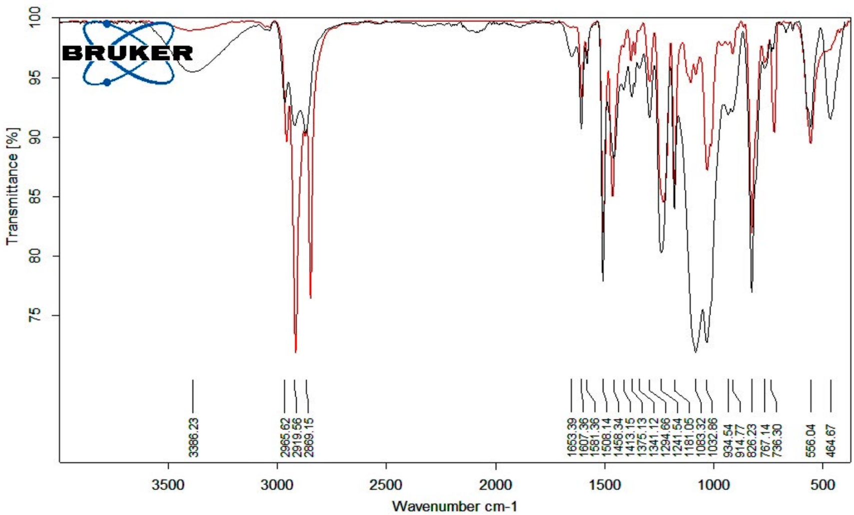

Fig. 7. The ATR-FTIR spectrum of the sample no. 4 (black) congruent with the model spectrum of epoxy resin (red)

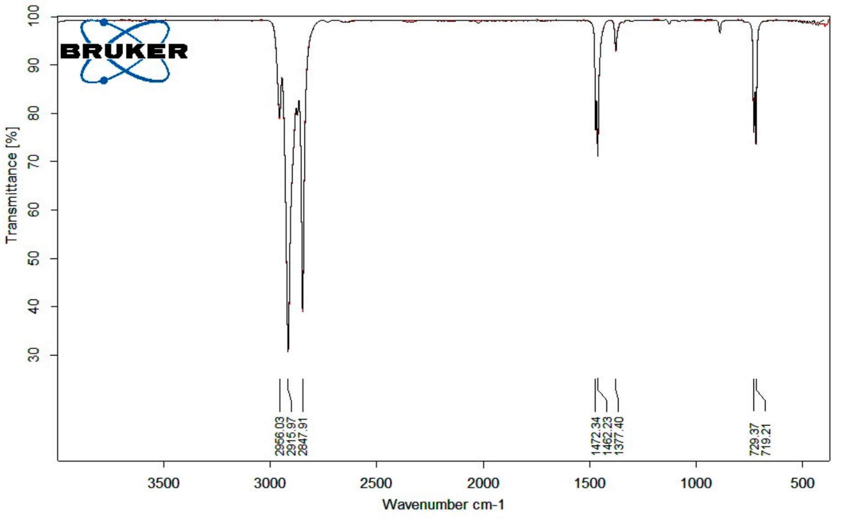

Fig. 8. The ATR-FTIR spectrum of the sample no. 5 (black) congruent with the model spectrum of paraffin (red)

The examination conducted allowed to identify the five basic materials introduced during the previous processes of conservation. In order to paste together the petty cracked elements, polyvinyl acetate (probably in the form of popular water dispersion) of has been applied, sometimes with the addition of a cellulose filler (wadding). The bone structure, the constructional bonding and the weakened internal spaces have been supersaturated with thermoplastic resin – butyl methacrylate copolymer with the small amount of methacrylic acid. It was probably a solution of Osolan KL[10]. This material used to be popular with conservators in the 80s. Currently, it is no longer produced. Furthermore, for some of the joints (e.g. in the area of the thigh bone) there has been used epoxy glue, probably Epidian 5, whereas the teeth and

[10] Osolan KL is basic butyl methacrylate copolymer with methacrylic acid, dissolved in ethyl acetate, with solution concentration of about 50%. Its acid value is 10–18 mg KOH/g. This copolymer is characterized by its good adhesion to other materials: glass, leather, fabrics, concrete and plastics. Under the influence of UV radiation, there occurs crosslinking of resin, without simultaneous dissolution into volatile products. Prior to impregnation, the highly concentrated commercial product required dilution to desired concentration with usage of solvent; on the basis of: Kinga Szczepińska, "Historycznie stosowane impregnaty do wzmacniania zniszczonego drewna polichromowanego – próba przeglądu. Część II: Impregnaty syntetyczne", *Acta Universitatis Nicolai Copernici. Zabytkoznawstwo i Konserwatorstwo* 46 (2015): 504–505; Jerzy Ciabach, *Badania nad przemianami żywic termoplastycznych pod wpływem promieniowania nadfioletowego* (Toruń: UMK, 1982), 42.

some of the jaw bones have been covered with paraffin. The whole surface of all bones has been saturated with animal glue.

After these conservation materials had been identified, there was conducted another examination over the methodology of their removal: e.g. solubility and swelling tests in selected organic solvents[11]. The consolidation done in the past was the crucial treatment and in fact determined the current course of conservation. Impregnation with Osolan KL limited the potential of retreatability using currently recommended mineral binders. The latest research show the big advantages of compatible and hydrophilic hydroxyapatite, which can bind fragile bone together and give enough mechanical strength[12]. Consolidation with Osolan KL even if theoretically is "reversible" in fact is an irreversible operation. It is likely to be impossible to remove a polymer from bone structure without destruction of the morphology[13]. In connection with the above a decision was made only on partial extraction. Excess of polymer was removed from the bones surfaces and cracks using compresses soaked with toluene and ethyl acetate and mechanical cleaning. Because the swelling included only the surface layer of the resin, in order to effectively remove it the conservators had to perform the procedure repeatedly: laying a solvent compress, mechanical removal of the swollen resin, and, subsequently, consecutive applications of a compress.

The joints formed on the basis of epoxy resin helped *N,N*-dimethylformamide compresses swell excellently. The removal method was similar to that of the consolidant.

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11 Samples, extracted from the object and similar in size, were immersed in selected solvents in test tubes: turpentine, acetone, toluene, ethyl acetate, methylene chloride, ethylene chloride, tetrahydrofuran, dimethylformamide. There was measured the time of swelling and, consequently, time of dissolving of the resins in order to, after the solvent compress had been lain on the object, effectively remove the partly swollen resin. Aleksandra Gralińska-Grubecka, Piotr Niemcewicz, Katarzyna Polak, „Dokumentacja prac konserwatorsko-restauratorskich kości należących do szkieletu słonia leśnego Palaeoloxodon antiquus (80–100 000 lat temu) ze zbiorów Muzeum Okręgowego w Koninie (I etap)" (conservator's documentation, Toruń 2017, Muzeum Okręgowe w Koninie), 19–20.

12 Alexis North, Magdalena Balonis, and Ioanna Kakoulli, "Biomimetic Hydroxyapatite as a New Consolidating Agent for Archaeological Bone", *Studies in Conservation* 61, no. 3 (2016): 146–161; Fuwei Yang et al., "Conservation of Bone Relics Using Hydroxyapatite as Protective Material", *Applied Physics A Materials Science & Processing* 122, no. 479 (2016): 1–5.

13 Jessica S. Johnson, "Consolidation of Archaeological Bone: A Conservation Perspective", *Journal of Field Archaeology* 21, no. 2 (1994): 228.

It was easiest to remove the glue joints formed on the basis of (poli)vinyl acetate and the animal glue coatings after having left them to swell up with a warm wet compresses and a water vapour. The paraffin were removed very easily with the balsamic turpentine.

While elaborating on the state of preservation of the bones sent to conservation, we ought to distinguish between the state of preservation of the bone material itself, and the state of the bones in the light of the conservation works conducted in the 80s and later on[14].

The forming of the largest losses and cracks has been caused by the accidental exploration of the material. Among the said fragments of the skeleton, the following were the most damaged: the right shoulder blade (fig. 9–12), the right thigh bone (fig. 13–14), the 6th thoracic vertebra, the 7th cervical vertebra and the 1st thoracic vertebra.

Fig. 9. The state of preservation of the right shoulder blade before conservation work. Photo A. Gralińska-Grubecka

[14] The itemized state of preservation of the particular bones with description of the course of the research and conservation and restoration work was included in two post-completion documents: Gralińska-Grubecka, Niemcewicz, Polak, "Dokumentacja prac konserwatorsko--restauratorskich (I etap)"; Aleksandra Gralińska-Grubecka, Piotr Niemcewicz, Katarzyna Polak, "Dokumentacja prac konserwatorsko-restauratorskich przy siedmiu kręgach należących do szkieletu słonia leśnego Palaeoloxodon antiquus (80–100 000 lat temu) ze zbiorów Muzeum Okręgowego w Koninie (II etap)" (conservator's documentation, Toruń 2018, Muzeum Okręgowe w Koninie).

Fig. 10. Thick, unsightly lain joints meant to bond the cracked fragments of the shoulder blade. The spaces between them were filled with wadding tampons. Photo A. Gralińska-Grubecka

Fig. 11. Deep crackings and deformations present in the right shoulder blade. The surface is strongly stained. Photo A. Gralińska-Grubecka

Fig. 12. One of the fragments of the broken shoulder blade, with unsightly and cracked joints. Some of the bondings lack joints which had crumbled away, posing a threat for stability of the whole piece. Photo A. Gralińska-Grubecka

Fig. 13. The state of preservation of the right thigh bone before conservation work. Photo A. Gralińska-Grubecka

Fig. 14. Corroded steel reinforcement in the right thigh bone. Heavy contamination of the bone surface had been caused by adsorption of dirt into the pores of gluten glue. Photo A. Gralińska-Grubecka

Deep cracking, partly pasted together by resin during previous conservation procedures, were present in the 6th and 7th cervical vertebra and in the 12th thoracic vertebra. The shoulder blade remained preserved without the back part of the uncinate process, the acromial end, half of the front edge and the entire back edge along with the back part of the supraspinatous fossa. Just like the shoulder blade, the right thigh bone was shattered during earthworks. When the extracted elements underwent integration, it turned out that fragments of the upper bone stem was missing.

Despite numerous cracks, unlike the bones that have been mentioned above, the jaw with two molar teeth has remained almost complete, with the exception of ramus mandibulae ends, i.e. articular processes (fig. 15). Lower molar teeth, despite numerous petty cracks, have also remained in whole (fig. 16).

The 6th thoracic vertebra had significant losses in construction, caused by destructive impact of an excavator. There only remained the stem with processus transversi. On the other hand, the 12th thoracic vertebra remained almost untouched – it only lacked one of the proccessus transversi and fragments of processus spinosus.

The 7th left rib, despite having been cracked at half length, was preserved in a very good condition without substantial losses. The case of the 8th left rib looked much worse though, with many more crackings and petty losses in the stem area.

Fig. 15. Cross-crackings of the jaw. The elements have been inaccurately glued, with clearly visible shifts. Photo A. Gralińska-Grubecka

Fig. 16. Crackings in molar teeth deeply embedded in alveoli, requiring cleaning and assemblage work. Photo A. Gralińska-Grubecka

That second type of mechanical damage that weakened internal bone structure must be perceived as natural process of ageing of this 80–100 thousand-year-old material, that had been placed in the soil for the whole time. Inevitable gradual degradation of the organic components which formed osteoid have caused partial decrease in bone elasticity. That resulted in crackings. Changeable environmental conditions – humidity and temperature – made the material "move". All of the bones have undergone partial distortion and cracking, they had losses of various size and chippings, particularly at the edges of preserved elements.

In spite of above mentioned damages and degradation changes, the bone material has been preserved in quite good condition in terms of its mechanical parametres, especially in the cortical bone area. The cancellous bone was in worse condition, which is visible primarily in the shoulder blade area.

During the previous conservation procedure the whole surface of the bones was intensively supersaturated with animal glue. That glue coating caused a change in bone colour (yellowing and graying) as well as unnatural surface gloss. Additionally, that coating adsorbed dust and dirt which had negative impact aesthetically. In many parts the glue film cracked, peeled off and separated from the bone tissue (fig. 17). Osolan KL, used for impregnation, due to too much stickiness of the solvent used, have not supersaturated the structure of the tissue, especially the porous cancellous bone (fig. 18). Therefore most of the parts of cancellous bone were crumbling and falling apart. Some of the joints that were made using Osolan KL shifted slightly and thus made it more difficult to set the remaining pieces of broken fragments correctly[15] (fig. 19). Most of the white or white and yellow glue joints which based on dispersion of polyvinyl acetate cracked and crumbled away while adhesion of the rest of them was distinctly weakened.

The conservation work was conducted in accordance with superior guidelines conveyed by the team of paleontologists. The assumption was made not to reconstruct the missing parts unless they are logical continuation of the supplemented fragment. It has been proposed, due to aesthetic value, to integrate fill-ins of the losses texture- and colour-wise with the material that surrounds them.

[15] It ought to be emphasized that all of those procedures were condcucted in accordance with general knowledge of the times, and, first of all, basing on conservation materials which were then accesible. Conducting of the procedures enabled integration of respective bones, securing them and preserving them until today.

Fig. 17. The surface of the bones was covered with contaminated, cracked and separated coating of gluten glue. Photo A. Gralińska-Grubecka

Fig. 18. The jaw. Picture presents the fragments filled up with thermoplastic resin Osolan KL. Photo A. Gralińska-Grubecka

Fig. 19. The 8th left rib L8 with numerous crackings going right through. There noticeable numerous bondings and fill-ins based on Osolan KL resin, which shifted, making it difficult to insert the remaining broken pieces. Photo A. Gralińska-Grubecka

The decision was made to remove derivative materials: coatings of the surface, resins from the fill-ins, separated glue coatings and bondings that joined the elements together. It was also decided to unstick warped bones, cleanse them thoroughly, impregnate them structurally and to re-paste them with more attention to details and to the finishing touch. Some of the glue bondings that were well made and well preserved, were allowed to remain.

At the beginning of the procedure, the surface of all the bones was cleansed. Heavy smudges were removed with the usage of non-ionic surfactants, and other uneasily washable smudges – with a mixture of enzyme agents. The separated coatings of gluten glue were carefully removed with a scalpel. The pieces of glue film which had been adhesive to the surface of the bones were removed after having been bulged with compresses of warm distilled water. Thanks to the precise removal of gluten glue, the bones regained their original warm and homogenous colour.

Because of partial degradation of the materials used for pasting, and due to the appearance that visually broke the aesthetics of individual bones, what negatively impacted the specimen's reception, it was decided to remove the visible glue joints completely. Most of the fragments were unstuck, and the wadding fill-ins that had been inserted there by the usage of polyvinyl acetate, were also removed (fig. 20). There were also removed all the constructional reinforcements made of corroding materials – rods and tubings of ferroalloys.

In order to secure the bony material from impact of changeable environmental factors and in order to stabilize it, and to structurally strengthen the cancellous bone, there was made a decision to impregnate all of the specimen structurally. In that case (due to the presence of Osolan Kl resin inside bones), there was applied the solution of compatible thermoplastic acrylic resin Paraloid B-72, because of its excellent lightfastness, high enhancement effect and possibility of even structure saturation[16]. After the bones had been unstuck and cleansed, there was conducted an impregnation of the usage of two methods: bath method and vacuum method. It enabled the solution to easily penetrate the extensive spatial layout of trabeculae and medullary cavities. After seasoning and vaporization of the solvent, a very good enhancement effect was achieved.

The next step forward was to glue the individual elements. To doing so, there were epoxy glues chosen. It was dictated by its stability and high mechanical durability of joints which is particularly important while pasting together large elements of small cross-section (fig. 21).

Large, heavy elements – the jaw, the right thigh bone and structurally complicated thin-walled shoulder blade – were reinforced with reinforcement mesh made of stainless steel bars as well as with duralumin tubes. When the long fragile ribs and processus spinosus were being glued to the stem of the 6th thoracic vertebra, there was also used internal reinforcement made of duralumin rods[17].

A wide range of supplements forced the conservators to use two-ply supplement system. The undercoat layer which was used to fill in all of the deep losses, were made on the basis of epoxy resin and a light granulate of foamy marbles[18] (fig. 22, 23). Some of those fill-ins also had constructional responsibilities because the fill-ins reinforced the stability of joints of the particular elements. In some places there were epoxy and glass laminates inserted under large fill-ins, e.g. in the right thigh bone.

[16] Paraloid B-72 is believed to be the best resin used for consolidation of bones which do not have the dampness issue. Johnson, "Consolidation of archaeological bone", 227.

[17] The reinforcements were inserted with epoxy resin EPO® 150, thickened with glass sand. That resin was selected due to its high UV radiation resistance and desirable low viscosity.

[18] Such composition, thanks to EPO® 150 epoxy resin, provided the material with high mechanical durability and small mass of the fill-ins, due low volumetric weight of the porous filler Poraver®.

Fig. 20. Small fragments of the right shoulder blade after unsticking and cleansing before the procedure of structural impregnation. Photo A. Gralińska-Grubecka

Fig. 21. Fragments of the right shoulder blade after impregnation, during fitting of fractures before pasting together. Photo A. Gralińska-Grubecka

Fig. 22. Filling in the losses in the jaw – application of the base layer. Photo A. Gralińska-Grubecka

Fig. 23. The thigh bone during filling in of the losses. On the left there can be seen application of the coloured topcoat layer. Photo A. Gralińska--Grubecka

As a surface layer there was used a composition basing on white Portland cement 52,5 R and natural marble dust, of similar colour to the monument. A mineral mortar was proposed due to its lightfastness that guaranteed long-term maintenance of the fill-ins' colour in unchanged shape. In order to improve cohesion, adhesion and the rheological and ductile properties, the composition was modified with redispersible resin (Vinnapas 5044N). The composition was being tinged step by step in the mass – the properly selected mixtures of mineral pigments were applied to each filled spot individually (fig. 23).

During the last stage of preservation the fill-ins were integrated and secured with protective layer of acrylic varnish that protects the specimen from UV radiation.

The right shoulder blade, due to its thin-walled construction that is exposed to carry heavy loads and undergoes strong stresses, was strengthen with thin laminate made of textile glass mat and epoxy resin Araldite® 2020. The choice of that resin – known for its low stickiness level, excellent castability and high resistance to UV radiation – together with fine textile glass mat guaranteed that the laminate was almost unnoticeable and the whole construction was strengthen (fig. 24, 25).

Had the conservation and renovation work finished, the bones were returned to the permanent paleontology exhibition in the rooms of the historic granary of District Museum in Konin (fig. 24–31). The remaining bones of this skeleton are bound to undergo conservation in stages within the years to come. In March 2019 the subsequent part of bones was delivered to the laboratory. Among them, there are numerous skull fragments with intermaxillare bones, maxillare bones and upper bones M3 (inventory number MOK/P/289/12, fig. 33) which are in a particularly bad condition; a cracked pubic bone with the missing, requiring a complicated process of sculptural reconstruction pelvic acetabulum (inventory number MOK/P/289/10, fig. 32). Undoubtedly, the biggest challenge is going to be a reconstruction of the tusks which, having been extracted from the ground, fell apart into hundreds of little pieces.

Fig. 24. The right shoulder blade after the conservation and renovation work was finished. Thin-walled construction covered with the textile glass mat laminate. Photo A. Gralińska-Grubecka

Fig. 25. The fragment of the right shoulder blade after the conservation and renovation work was finished. The numerous fill-ins were integrated and protected with the layer of acrylic varnish with UV protector. Photo A. Gralińska-Grubecka

Fig. 26. The jaw after the conservation and renovation work was finished. Photo A. Gralińska-Grubecka

Fig. 27. The jaw after the conservation and renovation work was finished. Photo A. Gralińska-Grubecka

Fig. 28. The 12th thoracic vertebra Th12 after the conservation and renovation work was finished. Photo A. Gralińska-Grubecka

Fig. 29. The right thigh bone after the conservation and renovation work was finished. Photo A. Gralińska-Grubecka

Fig. 30. The 2nd thoracic vertebra Th2 after the conservation and renovation work was finished. Photo A. Gralińska-Grubecka

Fig. 31. The 3rd cervical vertebra after the conservation and renovation work was finished. Photo A. Gralińska-Grubecka

Fig. 32. The pubic bone with pelvic acetabulum is due to undergo conservation in 2019 under the third stage of conservation and renovation work (inventory number MOK/P/289/10). Photo A. Gralińska-Grubecka

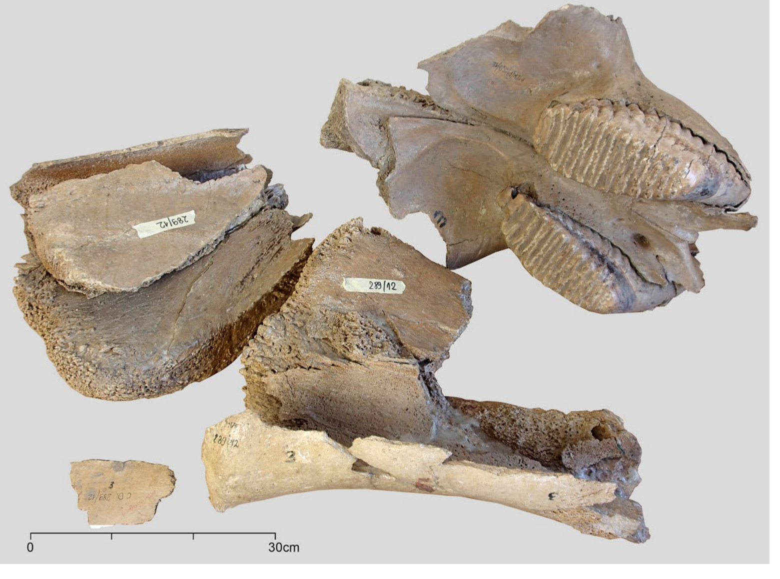

Fig. 33. Numerous skull fragments with intermaxillare bones, maxillare bones and upper bones M3 (inventory number MOK/P/289/12), due to undergo conservation in 2019. Photo A. Gralińska-Grubecka

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