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CONSERVATION OF DRIED AND WET ARCHAEOLOGICAL WOOD: THE EXAMPLE OF THE REMAINS OF TWO DUGOUT BOATS FROM THE EASTERN SECTION OF THE LOWER BUG IN POLAND

Michał ANISZEWSKI[1], Grzegorz ŚNIEŻKO[2*]

[1]State Archaeological Museum, 52 Długa Street, 00–241 Warszawa, Poland, [2] Institute of Archaeology and Ethnology of Polish Academy of Sciences, 105 Solidarności Avenue, 00–140 Warszawa, Poland.

Abstract

The article discusses two different methods used to preserve wooden archaeological remains taken from a wet environment. They are described using as an example two dugout boats accidentally discovered in the bed of the Bug River in eastern Poland. One of them, after being discovered and documented, was immediately re-immersed, while the other was air dried for almost two years in an outbuilding. The extremely different storage conditions after extraction from the wet environment forced the use of different conservation methods, which are described in the text.

Keywords*: Dry and waterlogged archaeological wood; Examination and preservation of archaeological wood; Log boats; Dugout canoes; Bug River; Poland*

Introduction

Archaeological objects made of organic materials require special treatment at the place of their discovery. After being removed from their depositional environment, they undergo destructive processes much faster than ceramic or metal objects. Extracting wooden objects from a wet environment - for example from peat, the sea or a river - always requires their proper protection in the period preceding the start of conservation work. The main purpose of this is to keep the artefacts wet. Their drying prevents or reduces the effectiveness of dimensional stabilization, which is the basis for the conservation of this type of object [1, 2]. Lack of proper protection or mistakes made in this area may lead to irreversible damage to the structure of the wood. The shrinkage of degraded, water-saturated wood occurring during drying usually causes irreversible deformations and the formation of numerous cracks in its structure - the anisotropy of these dimensional changes additionally increases the destructive effect of this process [1, 3, 4].

However, it is not always possible to implement the correct conservation procedure at the right time. The aim of this article is to characterize the conservation measures - their effectiveness and the results obtained - in the case of an object that is properly secured after extraction and one that has undergone significant structural degradation caused by improper storage. The examples used are the discoveries of two dugout canoes from the eastern section of the lower Bug in eastern Poland, accidentally made in the last few years (Fig. 1). Along the waterway, their findspots are separated by a distance of 22km, but due to the possibility of

* Corresponding author: grz.sniezko@gmail.com

displacement of the canoes by the river current, the places where they were found were not necessarily the same as the point of original deposition.

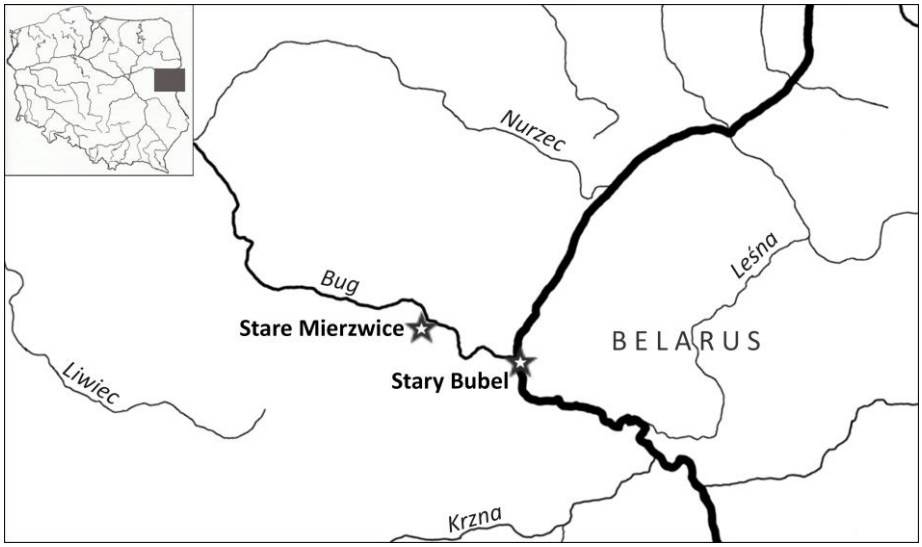

Fig. 1. Location of discovery sites of dugout boats from the eastern section of the lower Bug. Background drawn by M. Dzik, with additions by G. Śnieżko.

These boats are objects that not only performed the same function (communication and transport), but were also carved from the same kind of raw material. Last but not least, both canoes had probably stayed in similar wet conditions for several hundred years. However, the differences between them lie in the different treatment of the objects after their extraction and, consequently, in the conservation treatments possible and the results obtained after carrying them out.

Circumstances of the discovery of the canoes

The first discovery was made at the end of August 2013 in the Bug riverbed near the village of Stary Bubel, commune of Janów Podlaski, Lublin voivodeship. The finder noticed a piece of wood sticking out of the water and decided to get it out and then use it in his garden. The object was close to the bank, and the water level in this place was then about 50cm deep. The discoverer's account shows that at the time of discovery, the part near the stern of the boat protruded above the water. Therefore, it cannot be ruled out that the descending river level had previously exposed this fragment of the dugout, as a result of which the stern itself did not survive. When the finder removed the sand from the inside of the dugout, it floated to the surface and only then did it turn out that it was not a natural piece of wood. The boat floated in the water, thanks to which it was possible to tow it down the river to the ferry in Niemirów, and then transfer it to a farm building. Due to various circumstances, the canoe was not sunk again. The information about the discovery was received by archaeologists in May 2015 and it was only then that the object and the place of its discovery were documented for the first time [5, 6].

The second accidental discovery was made on August 19th, 2015. In the Bug riverbed, near the village of Stare Mierzwice, Sarnaki commune, Mazowieckie voivodeship, the finder noticed a piece of wood sticking out of the water and realised that it was a boat. Due to the fact that the information quickly reached archaeologists, it was verified in the field on the same day. Thus, another dugout was recovered and documented, but after that, it was sunk again.

The appearance and dimensions of the objects, wood species identification

The boat recovered from near the village of Stary Bubel is almost completely preserved - the largest loss is visible in the stern part. In plan, the dugout has a spindle shape, while in cross-section it is semicircular. This is evidence of its construction from a longitudinally halved trunk. While hollowing out the log, a bulkhead and two elements for fastening the bench were formed in the middle of its length, while a mooring rope attachment was formed on the bow (Fig. 2).

Fig. 2. Dugout boat from the village of Stary Bubel. The scale is 4m long. Photo: G. Śnieżko

In May 2015, after almost 2 years of storage in the farm building, the canoe's dimensions were as follows: length - 404cm (originally slightly longer), width - 64cm, maximum height - 30cm, height and width of the bulkhead - 20 and 18cm, the thickness of the sides at the edges - 1.5cm.

The boat discovered in the vicinity of the village of Stare Mierzwice has survived only as a fragment (Fig. 3) - with the bulkhead cracked at the upper edge, which proves that this fragment protruded from time to time above the water level [6]. The preserved fragment has the following dimensions: length - 170cm, width - 49cm, height at the bulkhead - 26cm (thickness - 11cm), bottom thickness - from 1.5 to 3cm at the bulkhead.

Fig. 3. Fragment of a dugout boat from the village of Stare Mierzwice, photos of the bulkhead on the right. Photo: G. Śnieżko

The rounded bottom and the bulkhead tapering towards the top may suggest that the canoe was made of a trunk which was not halved into two equal parts, but only its upper face had been cut off. Such a boat was not very stable, but it had greater displacement.

Microscopic examination of the wood from which both boats were made confirmed the assumption, based on the macroscopic assessment of the material, that the canoes were made of

oak logs (*Quercus sp.*). The current colour of the material in shades of brown turning to black was created as a result of the reaction of the tannin contained in the wood with iron salts in a wet environment [7] - in the case of these two objects, this was the water of the Bug River. In the microscopic image of the sample taken from one of the sides of one boat (Stary Bubel) and the sample taken from the bottom of the other (Stare Mierzwice), the cross-section clearly shows a ring-vascular structure with an arrangement of large vessels in the zone of earlywood and small ones in the area of latewood, and also the very wide rays characteristic for *Quercus sp.* (Fig. 4) [8].

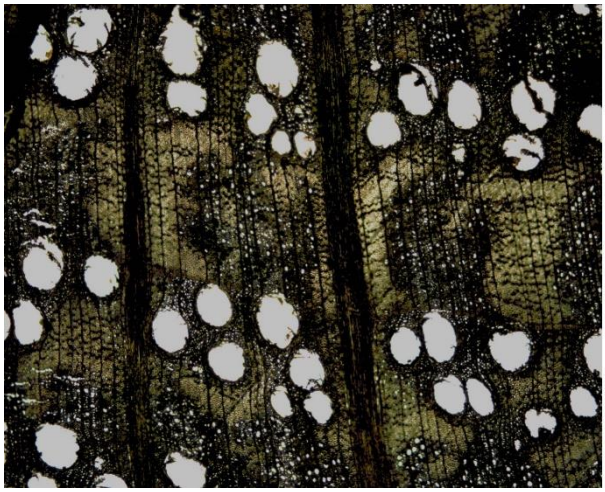

Fig. 4. Microscopic image, cross-section of a sample collected from one of the boats (Stare Mierzwice) – visible oak wood characteristic (*Quercus sp.*). Photo: M. Aniszewski

Dating of the boats

In view of the low variability of dugout forms over the centuries, typological analysis is an unreliable indication for unambiguous determination of the time of creation of the objects described in this article [9]. On the other hand, the state of preservation of these artefacts limited the use of scientific methods of their absolute dating only allowing the assessment of age by radiocarbon analysis. The drying and deformation of the wood of the Stary Bubel boat and the significant degradation of the bulkhead of the canoe from Stare Mierzwice made it impossible to collect samples with a sequence of at least 30 preserved tree rings - meeting the requirements of the dendrochronological method [10]. In the case of the object from Stary Bubel, two wood samples were submitted for ^{14}C analyses, and the first dating was commissioned by the discoverer. The age determined in the Laboratory of Absolute Dating in Cianowice, for the sample from the bow part, indicated a range of 1483–1666 cal AD, with a probability of 93.5% (MKL-2459 sample, LAD in Cianowice Archive). Another sample, taken from the edge of the port side, was sent to the Poznań Radiocarbon Laboratory (sample Poz-76576, PRL in Poznań Archive). The result of the analysis significantly differed from the previously obtained one - the age was established for the years 1152–1260 AD with a probability of 90.2%, although the place of collecting the wood was located further from the centre of the trunk. Currently, it is not possible to explain these discrepancies.

In order to determine the absolute age of the object from Stare Mierzwice, the wood sample was submitted to the Laboratory of Absolute Dating in Cianowice. The conducted analysis showed the range of the years 1305–1431, with a probability of 95.4% (sample MKL-2767, LAD Archive). As noted above, due to the aforementioned significant degradation of the bulkhead, it is not possible to verify this date using the dendrochronological method.

The state of preservation of the relics of the dugouts

The factor having the main impact on the state of preservation of wooden artefacts uncovered at various types of archaeological sites is the type and parameters of the environment in which they remained until their discovery - its oxygenation, humidity, pH, temperature, the presence and type of microorganisms and its susceptibility to seasonal changes. The process of wood degradation is much slower in anaerobic conditions occurring in swamps and peat bogs [1, 11-13]. The degree of degradation of archaeological wood is often determined on the basis of various, more or less sophisticated research methods - physical, chemical or instrumental analyses [14-23]. Artefacts extracted from rivers or seas, as well as other water reservoirs or layers of moist soil are significantly saturated with water absorbed during hundreds or even thousands of years of being left in a wet environment. As a result of complex processes of decomposition of structural components, the absolute humidity of significantly degraded wood may amount to several hundred, or even over a thousand, percent [24, 25]. The water that is found in the wood cells after the removal of artefacts from the river, wet earth or peat, maintains their original shape, preventing the material from shrinking [2, 3]. Thus, in the case of archaeological artefacts made of wood, obtained from a wet environment - one of the main parameters determining the state of degradation of the material from which they were made is its moisture and especially the maximum moisture - determined in laboratory conditions [1, 26, 27]. However, which is not always obvious, the current state of preservation of all types of archaeological artefacts, made of various materials, also depends on their wear and tear damage during their use, or the knowledge and skills of the manufacturer and the technique used to make it.

The condition of the boat discovered near the village of Stary Bubel was assessed at the beginning of June 2015, after just under two years of drying it in a covered farm building. The average wood moisture content measured at several sampling points with the GANN HTR 300 hygrometer on the day of the test (04/06/2015) was 13% - that is, significantly below the humidity of the fibre saturation point, which for contemporary wood of this species is approximately 24%. [28]. This indicates that the material had dried to an air-dry state in which it contained only hygroscopic water, while it was devoid of free water. The consequence of wood moisture below the fibre saturation points and loss of water in submicroscopic spaces was shrinkage - for modern oak wood, it occurs in the hygroscopic range, that is from about 24 to 0 percent humidity [28]. On the other hand, the shrinkage of the degraded material resulted in the already-mentioned irreversible damage to the structure of the object, visible across the entire surface of the boat in the form of longitudinal and transverse cracks. As a result of the stresses accompanying the contraction, one of the sides had become detached, additionally breaking into two parts. At the time of discovery, the dugout had a damaged stern, probably as a result of its temporary exposure above the water level, which contributed to faster degradation of the wood and increased susceptibility to mechanical damage. On the other hand, as a consequence of the anisotropy of dimensional changes during drying, a crack had formed through the whole width of the wood and ran from the bulkhead to the stern end (Fig. 5). This had led to a lowering of the stern and posed a risk of breaking off of a significant fragment of the bottom of the boat. However, as a result of shrinkage of the material, the bow of the canoe had suffered more and was significantly deformed during the warping of the degraded wood.

Of the canoe recovered from the Bug in the village of Stare Mierzwice, only a fragment of the bottom and the bulkhead have survived. During the macroscopic assessment of the object, a varied state of wood degradation was found, probably resulting from seasonal changes in the environmental conditions where the object was deposited (Fig. 6). The bulkhead has numerous transverse cracks, as a result of which the sequence of tree-rings was damaged. There are also visible longitudinal cracks running from the edge of the element to the surface of the bottom, which has survived in better condition. This part of the object had probably been covered with

river sediments and remained constantly in a wet environment. The preserved area of the bottom has a dense structure with visible defects, which are the result of mechanical damage caused by the canoe lying in the river current. The maximum humidity of the sample collected from the bottom after the previous several months' storage of the object in a container with water was over 250%, which classifies the wood as being in state II of conservation according to the classification developed for wet, excavated oak wood [27].

Fig. 5. Visible are numerous deformations as well as longitudinal and transverse cracks of the wood in the stern, formed during the storage of the boat in the outbuilding. Photo: M. Aniszewski

Fig. 6. The remains of the canoe from Stare Mierzwice after it was brought to the State Archaeological Museum Wood Conservation Workshop. The degraded inner surface of the bottom of the canoe, cracks in the bulkhead and its detached fragment are visible. Photo: M. Aniszewski

The course of conservation treatment

Due to the poor state of preservation and the weakening of the structure of the boat from Stary Bubel - especially with a large number of cracks and the risk of further decomposition of the dugout during transport - it was decided to start conservation work at the place of its storage. This was carried out in September and October 2015. Drying wet archaeological wood to a moisture content below the fibre saturation point - when the material shrinkage process has already started - makes it irrational to later use the treatments that are currently applied to achieve dimensional stabilization that are intended for wet wood containing free water [29]. The moisture content of the material of approximately 13% indicated its air-dry condition and the shrinkage of the wood in the range achieved during natural drying. In this case, the basis for preserving the artefact must be the strengthening of its present degraded and weakened structure, which will protect it from further destruction. The conservation treatment began with a thorough cleaning of

the surface of the boat and the crevices from sand, mud, small stones, shells and dried crustacean larvae (Fig. 7).

Fig. 7. Detail of the side of the boat during the removal of river sediment residues. Photo: M. Aniszewski

Fig. 8. The dugout canoe from Stary Bubel after impregnation with Paraloid B-72 and reconstruction of the side. Photo: M. Aniszewski

The dugout after having been retrieved from the Bug was not washed, and its long period of air-drying made the process of removing dried river sediment from the wood surface difficult and extended, however, this layer had undoubtedly slowed down the drying of the material. After thorough cleaning of the object, a disintegrated surface layer covered with a mesh of deep cracks was revealed, illustrating the destructive effect of shrinkage on degraded archaeological wood and proving the poor condition of the boat. During multiple impregnations of the object with thermoplastic resin, the structure of the wood was strengthened, increasing its mechanical strength. For this purpose, a 10% solution of Paraloid B-72 in toluene was used. To slow down the evaporation of the solvent, the boat was covered with plastic sheet after each impregnation.

The cracked fragments in the stern part of the boat were also reattached and an entire strip of the side that had been broken and deformed as a result of contraction was reconstructed, carefully forming its original shape during gradual bending, and then fixing it structurally with resin (Fig. 8).

The proper treatment of the canoe fragment from Stare Mierzwice immediately after its extraction from the river enabled the dimensional stabilization of the object appropriate for wet archaeological wood. After the object was transported to the State Archaeological Museum Wood Conservation Workshop, conservation activities began with cleaning of river sediments from the surface of the artefact. Due to the state of preservation of the object, it was decided to use a two-stage wood impregnation in polyethylene glycol solutions of variable concentration - first with a molecular weight of 400 (PEG-400), and then in a separate bath with a molecular weight of 3000 (PEG-3000). The impregnation was carried out in a specialized tub, equipped with a heating system and circulation with filtering the solution. When the canoe fragment was impregnated with polyethylene glycols, the bath temperature was set to 60˚C to accelerate the diffusion process. Then, in order to reduce the hygroscopicity of the wood, its surface was covered with a solution of high-concentration polyethylene glycol with a molecular weight of 4000 (PEG-4000). After impregnation and slow drying of the wood to equilibrium, the excess PEGs were liquified with a stream of hot air and removed with cellulose cloth.

After cleaning the surface of the object from excess impregnation, the bulkhead was reconstructed by glueing the torn off fragment in place (Fig. 9). Fragment of a boat after conservation is presented on figure 10.

Fig. 9. Reattaching fragment of canoe bulkhead from Stare Mierzwice. Photo: M. Aniszewski

Fig. 10. Fragment of a canoe from Stare Mierzwice after conservation. Photo: M. Aniszewski

Conclusions

The structural reinforcement of the boat found in the vicinity of the village of Stary Bubel protected it against further disintegration, and perhaps - due to its poor condition - even complete destruction. However, the basis for the conservation of wooden artefacts retrieved from a wet environment should always be properly-conducted dimensional stabilization, keeping the wood waterlogged - which was successfully carried out in the case of the canoe fragment discovered in Stare Mierzwice. Dimensional stabilization limits the process of shrinkage of historic, degraded wood, the destructive effects of which are well illustrated by the examples of damage to the Stary Bubel dugout described in this article. In order to be able to effectively carry out conservation activities intended for wet archaeological wood; its humidity must not be lower than the fibre saturation point. The reconstruction of an object disintegrated as a result of shrinkage, resulting from the drying of degraded wood, is possible only to a small extent. Therefore, as mentioned in this study, it is extremely important to properly protect and store wet archaeological wood until the beginning of conservation procedures in a professional laboratory.

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