Textiles from the princely grave in Poprad-Matejovce, Slovakia

Challenges and questions for the future

Tereza Štolcová, Dorte Schaarschmidt

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The project, initiated in 2006 in Slovakia, is focused on the excavation, conservation, and interpretation of the Germanic princely grave in Poprad-Matejovce, dating back to the late 4th century AD. The research aimed to salvage organic materials and document the excavation. Numerous in situ blocks containing textiles were recovered and subsequently processed in a laboratory. However, questions persist regarding long-term storage and future research. Challenges include assessing the potential for new discoveries, determining the necessity of retaining all samples, mitigating the risk of contamination, and understanding the impact of long-term storage on organic materials, such as textiles. Addressing these issues is crucial for preserving the valuable textiles from this significant archaeological find. Finally, in 2023, this long-term work culminated in the establishment of a permanent exhibition, "The Prince of Poprad and his Grave", which is on display in the Podtatranské Museum in Poprad.

Textilien aus dem Fürstengrab in Poprad-Matejovce, Slowakei

Herausforderungen und Fragen für die Zukunft

Das 2006 in der Slowakei initiierte Projekt befasste sich mit der Ausgrabung, Konservierung und Interpretation des aus dem späten 4. Jahrhundert n. Chr. stammenden germanischen Fürstengrabs in Poprad-Matejovce. Die Forschung zielte unter anderem darauf ab, das im Grab erhaltene organische Material zu bergen und zu dokumentieren. Während der Ausgrabung 2006 wurden zahlreiche Blockbergungen mit Textilien aus der Fundstelle entnommen und anschließend im Labor bearbeitet. Nach Abschluss der Laborarbeiten bleiben jedoch weiterhin Fragen zur Langzeitlagerung und zur zukünftigen Forschung. Hierzu gehören eine Einschätzung des Potentials für neue Entdeckungen und die Notwendigkeit der langfristigen Probenaufbewahrung, weiterhin die Einschätzung des Kontaminationsrisikos der Proben sowie das Verständnis der Auswirkungen der Langzeitlagerung auf fragile, organische Materialien. Die Beantwortung der Fragen ist entscheidend für die Erhaltung und zukünftige Forschung an den wertvollen Textilien dieses bedeutenden archäologischen Fundes. Die Arbeit mündete schließlich 2023 in der Dauerausstellung „Der Fürst aus Poprad und sein Grab" im Podtatranské Museum in Poprad.

The discovery of the princely chamber grave from Poprad-Matejovce was made in 2005 and garnered significant scientific attention already during the four-month excavation in the following year. Researchers from the Slovak Academy of Sciences' Institute of Archaeology (IA SAS) collaborating with the Podtatranské Museum in Poprad and German conservation specialists from the Museum für Archäologie Schloss Gottorf (Museum of Archaeology) in Stiftung Schleswig-Holsteinische Landesmuseen Schloss Gottorf (Foundation of Schleswig-Holstein State Museums at Gottorf Castle) in Schleswig, achieved a remarkable feat of archaeological recovery. The excavation presented numerous logistical and technical challenges. The subsequent conservation process involved a methodical disassembly, detailed documentation, and meticulous cataloguing of hundreds of artifacts and structural elements of the tomb. This complex undertaking required a multidisciplinary approach that brought together archaeological, conservation and scientific expertise from many institutions, including the Lower Saxony State Service for Cultural Heritage in Hanover at a later stage.[1]

The princely tomb

The two-chambered tomb was situated within a five-meter-deep pit on a small elevation under the Tatra mountains (Fig. 1). The outer chamber was constructed from interlocking logs with a flat roof made of a single layer of beams, with external dimensions of 4.28 m × 3.22 m × 2.30 m. The inner, sarcophagus-like chamber, with a length of 2.89 m, width of 1.67 m and height of 1.73 m, was constructed in the form of a house with a gable roof (Fig. 3). Here, the craftsmen used a horizontal frame structure with four corner posts. The wall panels were inserted into the frames using the muntin-and-plank technique and the gable roof was constructed in the same way. Both chambers were crafted from European larch wood and due to their exceptional preservation exhibited a unique opportunity to analyse the construction techniques and processes employed (Fig. 2).[2] The architectural style of the inner chamber reflects the Roman funerary tradition known as "domus aeterna".[3] Examination of the wooden chambers reveals traces of measurements, drilling, cutting and tool marks, providing tangible evidence of the ancient craftsmen's skills.

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1 Top view of the chamber grave in Poprad-Matejovce during its discovery in 2005

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2 Reconstruction of the building process of the chamber grave

The tomb's exceptional preservation can be attributed in part to its having been robbed in antiquity which appears to have occurred shortly after the burial. Robbers dug up a tunnel into the antechamber of the tomb, where they constructed a makeshift fireplace. Evidence of their presence included scattered pinewood chips (likely remnants of torches), damaged furnishings, and broken artifacts. Tools used to breach the tomb—a hoe and two wooden shovels—were also found here. A heavy iron axe was discovered in the inner chamber. The intruders removed three roof beams to gain access, and a long branch left in a roof hole suggests they assessed the tomb's depth. Based on this evidence, the robbers likely removed all valuable objects, leaving behind only a few artifacts. The impermeable subsoil, combined with the tomb builders' use of charcoal and sealing clay, contributed significantly to the tomb's preservation, but it was the following flooding of the grave site after its re-opening, which sealed it as a time capsule for the future.[4]

The grave contained the remains of a 20-year-old Germanic man from the Tatra region, likely buried between 375 and 380 AD.[5] DNA analysis revealed hepatitis B, possibly contributing to his early death. This discovery provides valuable insights into the health and social context of the local elite of the so-called North Carpathian group.

The outer burial chamber contained items associated with funeral feast and purification rituals, including a bast container with toiletries, a candlestick base, piglet remains, a brass bucket, a mortarium, clay drinking vessels and a large round table on one foot (Fig. 4).[6] A small wood-working bench was also found here. Objects from the inner chamber were the personal belongings of the deceased or jewellery and status objects, including a gold pendant made of a solidus of Emperor Valens minted in Trier between 375 and 383 AD. There was also a silver decorated funeral bed turned on lathe.[7] Various leather ornaments and strips, including a complete bow case were spread around the grave. Textiles were found in many layers and in different modes of preservation.[8] Components of a wooden funeral bier were arranged atop and along the walls of the inner chamber.[9]

3 The original of the inner chamber on display at the Podtatranské Museum in Poprad

4 A deathbed crafted from yew wood, featuring turned decorative elements, and a large circular monopodium fashioned from a single piece of maple wood on display at the Podtatranské Museum in Poprad

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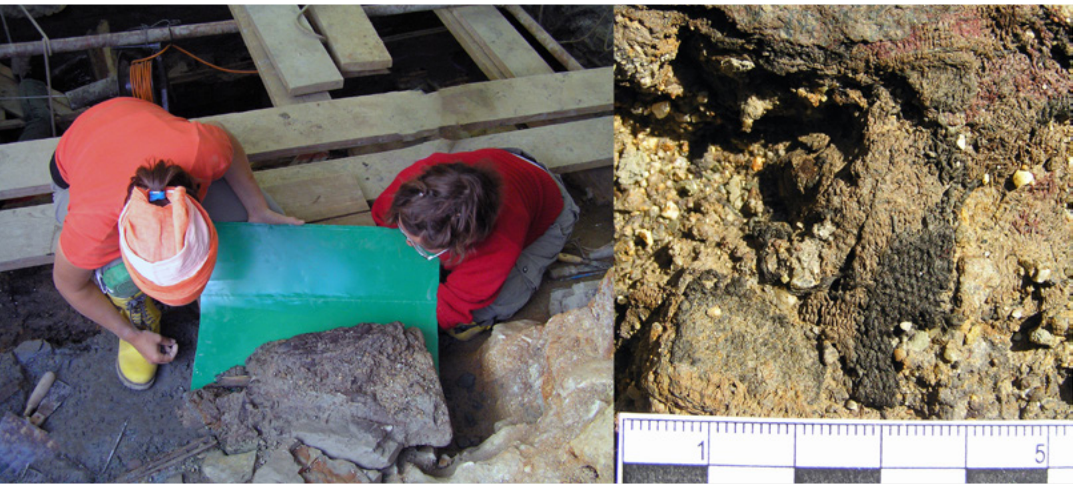

5 Removal of a block with remnants of a woollen tapestry in the tomb's antechamber

Retrieval of fragile finds during field excavation

The Poprad-Matejovce grave was excavated in 2006. Its waterlogged environment and organic-rich contents necessitated interdisciplinary expertise. During the excavation a large water pool was constructed adjacent to the archaeological site. It was filled with fresh water and covered with a tent to store long timbers from the grave and serve also as a flotation station. To mitigate microbial growth, the water was regularly exchanged. This method proved effective in preserving the organic materials and facilitating the handling of large wooden finds. As the excavation deepened, suspended benches were used to uncover artifacts carefully. Wooden artifacts were sprayed with water and covered to protect them from the elements. Textiles and other organic finds were challenging to recover due to their decayed state. Therefore, all these fragile artifacts were excavated as in situ blocks and stored in a cold and dark cellar of the Podtatranské Museum (Fig. 5). In total, 25 in situ blocks were recovered on site. The blocks varied in size, ranging from a few centimetres to as large as four metres. The largest block incorporated two long floor timbers from the outer chamber, measuring approximately 410 cm × 40 cm × 40 cm. The fieldwork aimed to document contexts, sample meticulously, and preserve organic finds for transport and further examination and conservation.[10]

All wooden components of the grave, including furniture, and in situ blocks with wood, textiles and leather were transported to the Museum für Archäologie at Schloss Gottorf, Schleswig, Germany. This transport load weighed approximately 10-12 tons in total. To prevent deformation and ensure safe transportation, the in situ blocks and the other fragile artifacts were secured with a custom packaging method using clear plastic foil and – if necessary – a protective outer layer of plaster bandages.[11] To maintain the moisture during transportation, wooden artifacts were wrapped in water-soaked rubber foam, clear plastic foil as well as an additional layer of non-transparent foil, which proved highly effective. After their arrival at the museum, the wooden finds were unwrapped, cleaned, and stored in water. The in situ blocks were frozen at -20 °C to prevent further decay. Freezing, while potentially causing physical damage, was still the best option for preserving many organic-rich blocks.

Treatment of in situ blocks in the laboratory

Between 2008 and 2015, in different working campaigns, 16 out of 25 in situ blocks from Poprad were treated under laboratory conditions in the restoration workshops.[12] The unopened nine blocks were reserved for future research remaining frozen at the IA SAS in Nitra.

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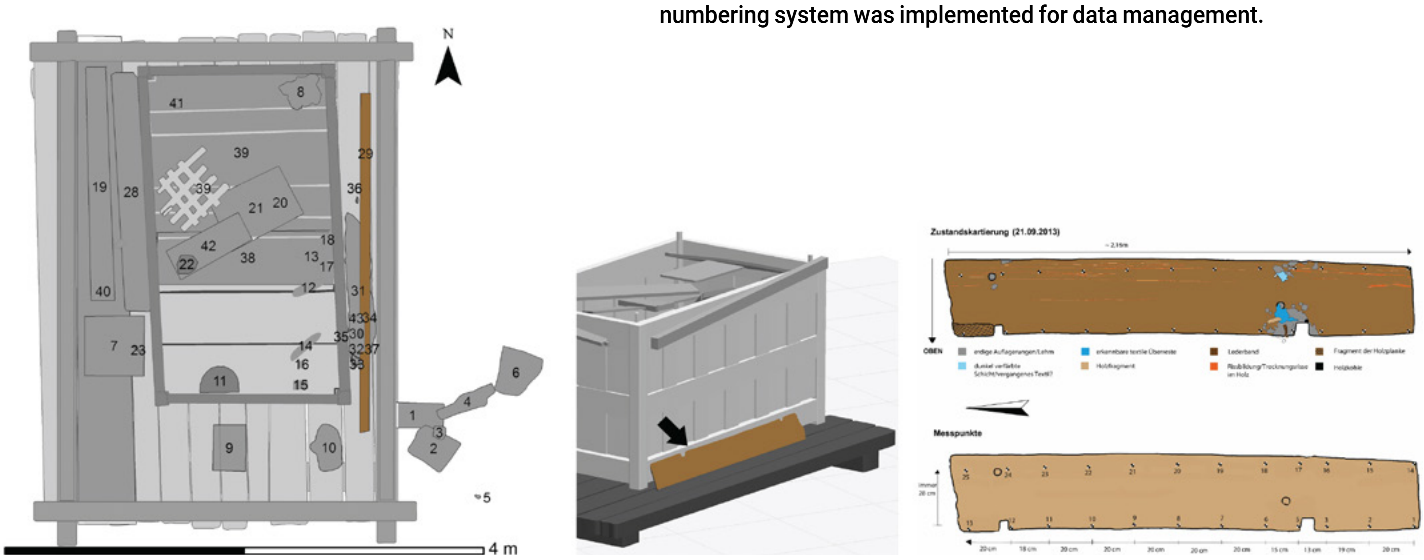
6 Laboratory documentation of organic material on an in situ block

7 GIS-based general plan of the grave

The excavation of in situ blocks required a meticulous cleaning and documentation process which was developed during the first stage of laboratory work and further modified throughout the ongoing treatment. First, stable and cold laboratory conditions with a suction unit were established to support the preservation and prevent microbiological contamination of fragile organic finds in the large waterlogged in situ blocks (Fig. 6). Then the block was photographed from above, including measuring points, and digitally mapped, thus enabling the integration of all documentation data into the general geographic information system database (Figs. 7, 8).[13]

The excavation itself required precise instruments, such as dental tools, tweezers, brushes, dissection pins, a Blitzfix foam, and a miniature suction bulb. A fine airbrush with demineralized water was used to remove soil from fragile textiles and leather. An adjustable operation microscope with a drawing tube facilitated excavation, cleaning, and documentation of delicate textile remains and their context (Fig. 9). Thus, even the finest structure of textile remains in the soil of an in situ block could be traced. Detailed mapping and photography were employed to record the spatial relationships and characteristics of artifacts. A standardized numbering system was implemented for data management.

8 2D and 3D visualization of the plank, removed in one piece with the textiles from the grave, and its subsequent mapping and measuring in the laboratory



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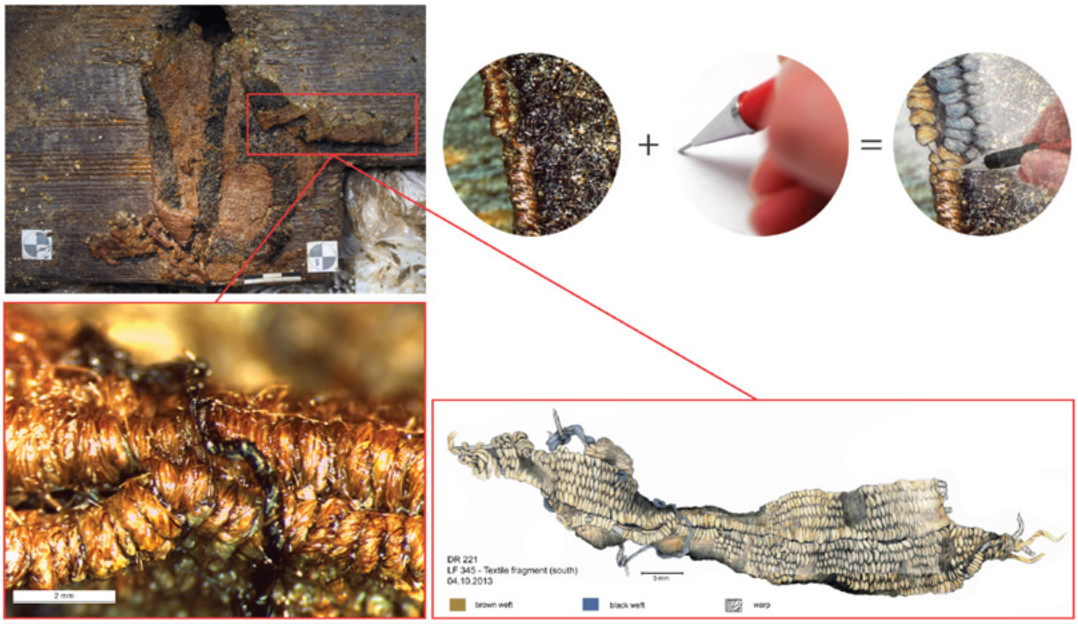


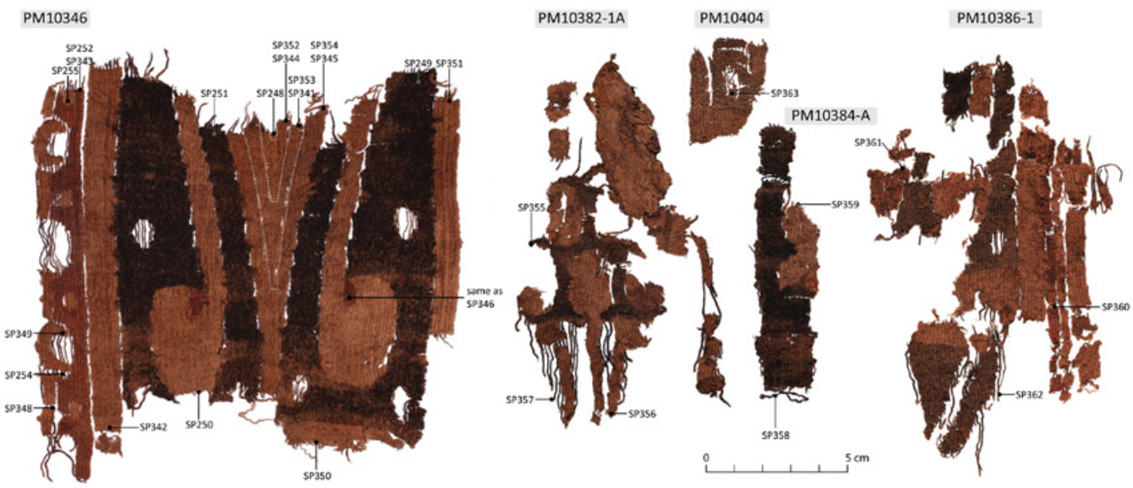
9 Documentation of tapestry textiles in the laboratory

Scientific analysis

To answer the scientific questions of various disciplines within the international research project, samples of organic materials were already taken during the excavation in Slovakia and later during the laboratory investigations of in situ blocks in Schleswig and Hanover. All of them were catalogued according to the standardized system. Sampling points were mapped consequently, and the data was integrated into the geographical information system as well.

Laboratory analyses provided great insights into the composition, origin, and processing of materials. Regarding the recovered textiles, the following analytical methods were implemented: colour and dye analysis, fibre and textile analysis using reflected and transmitted light microscopy as well as a scanning electron microscope, strontium and carbon-nitrogen isotope analysis for provenance and 14C for dating the material.[14] Respectively, samples were taken from the very well-preserved tapestry textile for the warp and weft threads of different colours (black, brown, red and purple) in sufficient quantity and length so that material, isotope and dye analyses could each be carried out on sections of the same threads (Fig. 10).

10 Mapping of the sampling points taken for colour and dye analyses, strontium isotopes and fibre and textile analyses



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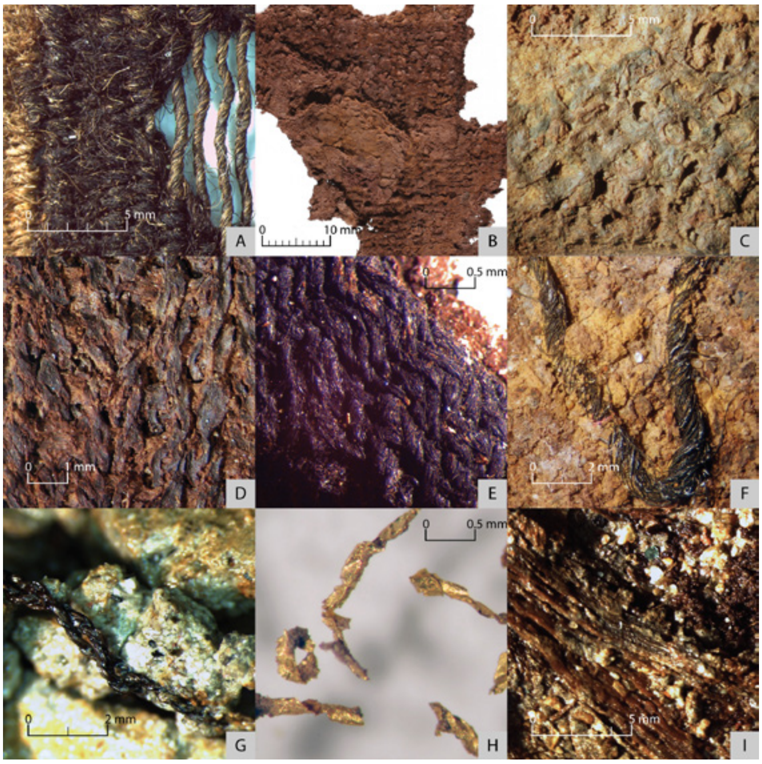
Textiles from the grave

The textile collection from Poprad-Matejovce includes up to 100 items discovered during fieldwork in Poprad in 2006 or recovered from in situ blocks examined in laboratories in Schleswig and Hanover. Textile fragments were scattered throughout the whole grave – in the bottom of the inner and outer chamber and along the so-called robbers' pathway (antechamber).

Due to their extremely poor condition, most textiles were documented and analysed in situ during the processing of the blocks before being discarded. Only a few were able to be conserved. Not all of these textiles or their samples underwent conservation treatment but were preserved frozen for future analysis. It can be assumed that a few of the nine unprocessed and still frozen in situ blocks contain further textile items as well.

Textile fragments revealed a diverse range of manufacturing techniques, including tapestry, simple tabby and twill weaves, tablet-woven bands, sprang textiles, and various single or plied threads (Fig. 11).[15] Some bast fragments have also been uncovered. They might belong to a bast container or be the remains of ropes. The presence of gold threads indicates the existence of luxurious textiles. Their exact function within the tomb remains uncertain, but they could have belonged to the deceased's clothing or bedding, suggesting their noble status and connections to the Roman world.

Apart from tapestry textiles, other structures were poorly preserved, mostly in form of an impression in the clay or in layers stuck in lumps of clay, highly degraded, flattened and with almost no identifiable structure. Tabbies are balanced, made of 0.5 mm to 1 mm thick threads with hardly recognisable spin direction, usually z- or s-spun, sometimes S2z-plied threads. Only one fragment could be identified as woollen thread. The same applies to seven tablet-woven fragments, which were highly degraded. The analysis has shown that one of the pieces was made on nine four-holed tablets, which corresponds to circa 36 threads per cm. The pattern 3S-3Z-3S consists of three S-twisted tablets alternating with three Z-twisted tablets.[16] One tablet-woven starting-border appeared also as a part of a tapestry textile.[17] A charred textile fragment from the inner chamber was made from a very fine 0.2 mm thick z-spun linen thread and consists of a simple interlinked sprang 11/11 structure with alternating z and s twists in each row.[18] Gold threads scattered all over the floor of the inner and outer chambers include remnants of gold strips wound around a decayed organic core. Additionally, narrow, straight strips of gold leaf, measuring approximately 1 mm in width and 20 µm in thickness, were recovered. Finally, a preserved gold thread, consisting of a black core and seven spiral loops, suggests its original integration into a larger embroidered textile.[19] Single woollen threads and several S2z-plied threads appeared in degraded organic layers. They could be parts of larger textile pieces, e.g., a tapestry.



11 Types of textiles found in the grave:
A – tapestry
B – tabby
C – twill
D – tablet-woven band
E – sprang
F – single thread
G – plied thread
H – gold threads
I – bast

The most well-preserved textile find is a multi-coloured tapestry composed of approximately 150 fragments.[20] Located in a narrow gap between the chambers and the antechamber, it was likely disturbed by the robbers. It was woven in a weft-faced tabby weave using z-spun threads in both systems. The weave count was approximately 8–10 warp threads and 12–23 weft threads per centimetre, with thread thicknesses ranging from 0.4–0.8 mm in the warp and 0.3–0.8 mm in the weft. Dye pigments included madder and iron mordant for wine-red hues, tannins and iron mordant for dark brown, and kermes for crimson red. Kermes, a valuable red dye derived from insect parasites on Mediterranean oaks, strongly suggests the tapestry's Roman origin.[21] The central decorative motif and gold embroidery further corroborate this connection. The fragments may have once formed part of a larger decorative fabric or blanket but could also be a part of the clothing.

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Textile conservation strategies

Archaeological textiles require special conditions like extreme dryness, permafrost, carbonization, or anaerobic waterlogged environment to withstand the deterioration process throughout time.[22] As described above, textiles from Poprad came from waterlogged environment. Based on the water saturated excavation site and the acidic type of soil surrounding the grave, the preservation of woollen textiles such as tapestry was favoured whereas many other structures were heavily degraded and fragmented only to disintegrate soon after exposure. The necessity for textile conservation treatment became increasingly evident only during the later stages of the laboratory excavation, when the tapestry was discovered. Proper recovery and detail-oriented documentation of textile remains are crucial not only for extracting maximum information but also for establishing a foundation for professional conservation.[23]

In addition to the largest piece of tapestry, several tapestry fragments of different sizes have been found amid the organic materials of the grave. All pieces were made of wool and insofar in a good state of preservation as it was possible to retrieve them from the in situ blocks and clean them. To facilitate detailed examination and future exhibition of the fabrics in Podtatranské Museum in Poprad, conservation was necessary. Dry and clean textiles are easier to inspect, handle or transport and – given the right storage conditions – less likely to develop mould or deteriorate further.

Unlike well-researched methods for waterlogged wood, archaeological textile conservation methods are fewer and often problem-specific concentrating on a single scientific question.[24] Furthermore, limited time and resources constrained textile treatment. Initial tests on original textile fragments using various drying methods led to extremely fragile material that was prone to damage. Thus, a short experimental series was developed to determine a suitable treatment including a conserving agent. The preservation process consisted of three essential steps: cleaning, applying a conserving agent and drying. Given the water-saturated finds and airbrush recovery, water-based cleaning was ideal. Additionally, chelating agents were used to break up incrustations on the fabric and in-between threads. Low molecular polyethylene glycols (PEG 400 and PEG 600) in various concentrations (5 % and 10 %) were selected as conserving agents. These PEG compounds can act on an intercellular level and PEG 400 has been widely used for archaeological textile conservation, often in combination with other materials: as a consolidant and as a plasticizer.[25] Following another method[26], one sample was treated with lanolin (5 % in white spirit) and solvent-dried, while another one was dried untreated as a reference.

The drying process focused on two of the most material-friendly methods available for waterlogged organic materials: vacuum-freeze drying and solvent drying. Both procedures aim to prevent the damaging capillary forces caused by water that occur during the drying of waterlogged materials.[27] Solvent drying was used only for the lanolin-treated sample and a control piece. An original textile fragment (wool, slit tapestry, brown weft, 3 cm × 2 cm) was used for testing. It was cleaned, divided and the different pieces then subjected to various treatments. Fragments were photographed and microscopically measured before and after conservation to compare treatment effects. Measurements included maximum length, width, surface area and the thread width (Fig. 12).

Except for thread thickness average, the measured dimensions were not rounded, and changes were only defined as increases or decreases in size. Results showed shrinkage in untreated specimens and size expansion in samples treated with PEG 600 as well as lanolin. Other specimens appeared inconclusive or with mixed results. Without going into further detail about eliminating possible conservation methods which ultimately led to 10 % PEG 400 and freeze-drying, it must be noted that interpreting experimental trials, especially those conducted with original archaeological materials, require caution. Even within a single fragment, preservation can vary greatly, thus affecting comparability.[28] It follows, that the uneven textile structure and decomposition level impacts on treatment behaviour. Reflected light microscopy, despite software-based measurements, is limited by its dependence on the user. Inaccurate or mismatched measuring tools can affect data, and treatments themselves can also impact the measurement results. All treatments utilized soaking baths. Despite carrier support, submergence might have loosened the textile structure, which would have reflected in an increase in size. This applies in particular to solvent dried samples, as these have undergone multiple bath changes.

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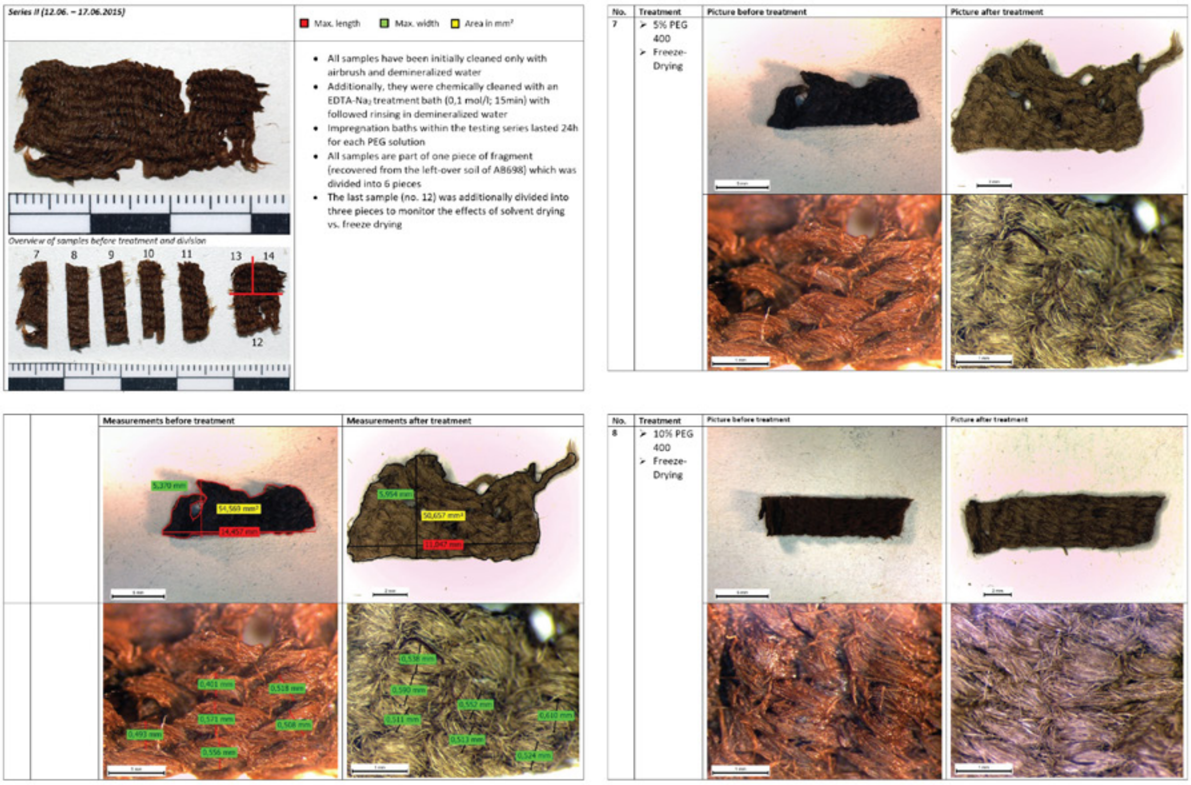
12 Excerpt from the textile sample series showing samples of textiles, their evaluations and measurements before and after conservation treatment



No.	Treatment	Measurements			
			Before treatment	After treatment	Evaluation + size increased - size decreased
7	➢ 5% PEG 400 ➢ Freeze-drying	Max. length	14.457 mm	11.047 mm	-
		Max. width	5.370 mm	5.954 mm	+
		Area in mm²	54.569 mm²	50.657 mm²	-
		Ø Yarn thickness	0.507 mm	0.548 mm	+
8	➢ 10% PEG 400 ➢ Freeze-drying	Max. length	14.295 mm	14.013 mm	-
		Max. width	3.685 mm	3.509	-
		Area in mm²	47.364 mm²	49.162 mm²	+
		Ø Yarn thickness	0.407 mm	0.481 mm	+
9	➢ 5% PEG 600 ➢ Freeze-drying	Max. length	13.538 mm	13.208 mm	-
		Max. width	3.687 mm	4.034 mm	+
		Area in mm²	48.981 mm²	50.850 mm²	+
		Ø Yarn thickness	0.422 mm	0.431 mm	+
10	➢ 10% PEG 600 ➢ Freeze-drying	Max. length	12.748 mm	13.263 mm	+
		Max. width	3.500 mm	3.924 mm	+
		Area in mm²	45.694 mm²	47.187 mm²	+
		Ø Yarn thickness	0.401 mm	0.412 mm	+
		Max. width	4.900 mm	4.865 mm	-
		Area in mm²	54.329 mm²	52.725 mm²	-
		Ø Yarn thickness	0.325 mm	0.399 mm	+

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Public presentation

After 18 years of research, the extraordinary tomb from Poprad has been exhibited to the public since 2023 at the Podtatranské Museum in Poprad.[29] "The Prince of Poprad and his Grave" exhibition takes visitors on a journey through five rooms, exploring the life and times of a 4th-century AD prince in Slovakia. Discoveries from the archaeological excavations and laboratory analyses are presented alongside detailed information on the tomb's conservation and restoration. The exhibition, available in three languages, is designed to be accessible to all, using modern technology and high-quality replicas created by traditional crafts (Fig. 13).

Organic artifacts, including textiles, are carefully preserved in climate-controlled display cases. The famous Poprad tapestry is showcased alongside a meticulously crafted replica made by experts of the Moravian Gobelin Manufactory in Valašské Meziříčí (Fig. 14).[30] For items too delicate to display, digital touchscreens provide detailed images and scientific analyses. The exhibition offers a unique glimpse into the past and shows the remarkable preservation of this ancient find.

Challenges, questions and conclusions

While the research on the princely tomb was concluded, a challenge awaits us soon regarding the remaining nine unprocessed in situ blocks, which have been maintained frozen for 18 years now. This raises further questions: Are the organic materials still as well preserved after this long time as they were at the time of the excavation? Can we rule out contamination of the blocks and their contents now and in the future? Can we guarantee that the fragile organic materials will not suffer any further damage in the long term when frozen? And finally: What new investigation methods will there be in the future? Should we truly retain all samples, including those that are severely degraded or composed primarily of sediment, for potential future discoveries?

13 Ideal reconstruction of the princely burial in the central room of the Podtatranské Museum in Poprad

14 A detailed view of the replica slit tapestry from Poprad, exhibited with original fragments at the Podtatranské Museum in Poprad

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While we cannot say exactly what the future will bring in terms of new and innovative investigation methods, it is unfortunately the case that, even in a supposedly safe, frozen state, we cannot guarantee that the last nine blocks will not suffer further damage. Experience has shown that, despite the precautions and appropriate packaging, an unwanted freeze-drying of these finds can occur during long-term storage in the freezer. This would inevitably mean the destruction or severe damage to some of the organic materials. Furthermore, even with the best intentions, exceptional situations such as power failures or simple equipment damage to the freezers cannot be categorically ruled out. At best, these would only lead to contamination of the finds during uncontrolled thawing; at worst, however, they would lead to decomposition or contamination by microbiological infestation.

To prevent a complete drying out caused by unintentional freeze-drying or other future damage, the last blocks should be thawed, processed, and stabilized as soon as possible. Prior to any invasive procedures, a high-resolution CT scan should be conducted to assess the internal structure and composition of the blocks. As there are no PEG conservation facilities in Slovakia for treatment of potential organic finds, international cooperation should be sought to ensure optimal preservation. Alternatively, such a facility should be built locally.

Through years of working with in situ blocks, we have learned that less is often more. Therefore, during laboratory analysis, it is crucial to collect and keep only those samples that can be immediately analysed (using techniques such as scanning electron microscopy [SEM] combined with energy dispersive X-Ray analysis [EDX], high-performance liquid chromatography with diode-array detection [HPLC-DAD], radiocarbon dating [^{14}C], DNA sequencing, isotope analysis, zooarchaeology by mass spectrometry [ZooMS], etc.) to minimize contamination from handling or long-term storage. While it is important to save some non-conserved material for later, we need to be selective. More effort should be put into choosing the right samples and making sure they are stored properly. It is suggested to develop a detailed protocol based on experiments to guide researchers on how to prepare these samples for a long-term storage.

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Notes

1 LAU 2014. The research and conservation of the grave was carried out by the three main institutions: Institute of Archaeology of the Slovak Academy of Sciences in Nitra; Podtatranské Museum in Poprad and Centre for Baltic and Scandinavian Archaeology (LEIZA-ZBSA) together with the Museum of Archaeology in the Foundation of Schleswig-Holstein State Museums at Gottorf Castle in Schleswig. The overall evaluation of the tomb is done by Nina Lau (LEIZA-ZBSA) and Karol Pieta (IA SAS), textiles and leather finds were processed by Tereza Štolcová (ISA SAS). Other research team members came from Belgium, Czech Republic, Denmark, Germany, Poland, Slovakia and Switzerland. Catalogue of all finds from Poprad grave in LAU/PIETA/ŠTOLCOVÁ ET AL. 2022

2 LAU/PIETA 2014. Archaeobotanical analyses of the wood were carried out by Mária Hajnalová (Department of Archaeology, Constantine the Philosopher University in Nitra) and Jana Mihályiová (IA SAS).

3 LAU/VON CARNAP-BORNHEIM 2021, p. 328

4 LAU/PIETA 2017

5 Anthropological analyses were carried out by Július Jakab and Zuzana Hukeľová, both IA SAS (HUKEĽOVÁ 2024). For the scientific dating of the grave see also MEADOWS/HAJNALOVÁ 2024

6 LAU/VON CARNAP-BORNHEIM 2021, Tab. 1, Fig. 2

7 LAU 2017

8 ŠTOLCOVÁ 2015; ŠTOLCOVÁ/LAU 2013; ŠTOLCOVÁ ET AL. 2014; ŠTOLCOVÁ/ZAJONC/VANDEN BERGHE 2023

9 LAU/VON CARNAP-BORNHEIM 2021, p. 329

10 ŠTOLCOVÁ/ZINK/PIETA 2009; ŠTOLCOVÁ/ZINK 2013; ŠTOLCOVÁ ET AL. 2014

11 ZINK 2024, pp. 57–66

12 The laboratory processing was carried out by Tereza Štolcová and Dorte Schaarschmidt in cooperation with Gabriele Zink in the Museum of Archaeology in the Foundation of Schleswig-Holstein State Museums at Gottorf Castle in Schleswig and in the Lower Saxony State Service for Cultural Heritage (NLD) in Hanover

13 ŠTOLCOVÁ/ZINK 2013, Fig. 9

14 Colour and dye analyses: Ina Vanden Berghe, Royal Institute for Cultural Heritage (IRPA-KIK), Brussels, Belgium (ŠTOLCOVÁ ET AL. 2017; ŠTOLCOVÁ/ZAJONC/VANDEN BERGHE 2023); fibre analyses: Silvia Mitschke, Reiss-Engelhorn-Museen, Mannheim, Germany (ŠTOLCOVÁ ET AL. 2014; ŠTOLCOVÁ ET AL. 2017); strontium isotope analyses: Karin M. Frei, National Museum of Denmark, Copenhagen (FREI/FREI 2024); 14C dating and carbon/nitrogen isotopes: Isotoptech Zrt., Debrecen, Hungary (MEADOWS/HAJNALOVÁ 2024)

15 ŠTOLCOVÁ ET AL. 2014

16 ŠTOLCOVÁ/ZINK/PIETA 2009, Fig. 10

17 ŠTOLCOVÁ/ZAJONC/VANDEN BERGHE 2023, p. 49, Fig. 3

18 ŠTOLCOVÁ ET AL. 2014; SEILER-BALDINGER 1994, p. 52, Fig. 95b

19 ŠTOLCOVÁ ET AL. 2014, Fig. 7

20 ŠTOLCOVÁ ET AL. 2017; ŠTOLCOVÁ/ZAJONC/VANDEN BERGHE 2023

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