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The Use of Natural Scientific Methods in the Study of Leather Items from Archaeological Excavations

This article outlines the results of analyses of footwear and other late medieval and recent leather items. Orthopedic diagnostics are used to assess an early 18th-century woman's shoe from the historic center of Kaluga. The insole, made of tightly fitted cords, suggests that the shoe had a corrective function. Infrared spectroscopy and liquid chromatography were used to analyze the leather of which the quiver found during the excavations in Moscow was made, and to evaluate the technique whereby its surface was processed. Natural scientific methods were used to study the various types of leather and threads, and to reconstruct the decorative techniques. Leather footwear from the medieval town of Galich, near Kostroma, is compared to that from other Central Russian towns, revealing local variations in footwear and the distribution areas of its types. It is concluded that natural scientific methods are helpful in the study of such finds.

Keywords: *History of costume, leather processing, footwear manufacture, archaeological finds, analytical methods, interpretation, multidisciplinary approach.*

Introduction

The daily life of a medieval town, the clothes of the townspeople, and their material culture form one of the main topics of medieval studies today. In Russian scholarship, the study of aspects of everyday life in medieval towns has become possible only with the accumulation of archaeological evidence, growing every year. Artifacts discovered during excavations are the main source also for studying leather production and shoemaking, since there are no manuscript illuminations, guild charters, or artisanal manuals available. The amount of archaeological leather in the moist humic layers containing the remains of Old Russian towns, with shoemakers' workshops or waste disposal sites, reaches tens of thousands of units. However, much valuable information becomes lost at the stage of describing and systematizing that category of archaeological finds. We have elaborated special methodological guidelines for preventing this from happening at that stage of researching footwear—the most common artisanal products (Osipov, Likhter, 2004).

Today, scholarly capabilities have significantly expanded through the use of natural scientific methods and the engagement of experts from other fields of science for obtaining various data that may assist scholars in solving a number of problems far beyond the development of leather production and shoemaking.

Use of natural scientific methods

Orthopedic diagnostics. The possibility of diagnosing orthopedic diseases by the wear-pattern on footwear details has already been mentioned in the literature (Osipov, 2003: 18–20; Kurbatov, Minchenko, 2013).

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Fig. 1. Sewn-in sole (*1*) and insole (*2*) of the first half of the 18th century, from the excavations in Kaluga in 2019.

When processing archaeological footwear, it is advisable to collaborate with orthopedic doctors, who can make the correct clinical diagnosis even from apparently insignificant signs.

While studying the collection of leather footwear of the first half of the 18th century from the 2019 excavations in the historical center of Kaluga, our attention was drawn to a fragmentarily preserved women's shoe. Its insole* turned out to be unusual: it was folded of tightly fitted leather cords molded along the contour of the foot (Fig. 1). The length of the detail, which was originally two-layered, was 23 cm, which corresponds to size 36**.

In other shoes discovered in the same layer, insoles were made of birch-bark or bast, which was typical of the footwear of the same period from other towns. We came across the shoe with the insole described above for the first time; most likely, the insole was manufactured (or adapted) for a specific customer. The need to create such a design, which it was very laborious to manufacture, was probably caused by physical defect of a human foot. For consultation, we invited an orthopedic surgeon*** and showed him the find. When he examined traces of wear on the upper (sewn-in) sole, he confidently diagnosed the owner of the shoe as having transverse flat feet and Hallux valgus*. The doctor agreed with our assumptions about the function of the insole: it served as a shock absorber, which helped the woman to reduce pain.

This orthopedic insole discovered in the deposits of the 18th century testifies to the existence of corrective footwear at that time; it was made by simple shoemakers; they also invented devices that alleviated the suffering of their customers. This example is confirmed by the following conclusion of the French medievalist R. Fossier: "Ignorance, conquered only in the 19th century by the popularizers of medicine, was not complete, since various therapeutic remedies still found the needed application thanks to experience or, if you like, intuition" (2010: 24).

It is known that the first orthopedic institute with a workshop for manufacturing custom-made corrective shoes was founded in 1816 by the German therapist I.G. Heine. In Russia, the teaching of orthopedics was first arranged at the Military Medical Academy of St. Petersburg, at the Department of Desmurgy**, which in 1895 was headed by G.I. Turner—the founder of the Russian school of orthopedics (Travmatologiya…, 2013: 7–9). It is possible that such footwear details will be also found in many earlier assemblages, although orthopedics had not officially existed in Russia until the very end of the 19th century.

*In the footwear of the Modern Age, an insole made of hard leather or bast was usually inserted between the sole and sewn-in sock.

**According to the Paris scale widespread in Europe, 1 point equals 2/3 cm.

***The author is grateful to R.N. Sonin, the orthopedic surgeon of the "Drevo-Orto" workshop, for his professional advice.

*Pathological reversal of the first metacarpal bone, which leads to curvature of the first toe outward. This pathology occurs most often in middle-aged or elderly women, is accompanied by pain, and leads to difficulties in walking.

**Desmurgy is a branch of medicine that studies techniques of applying dressings and bandages.

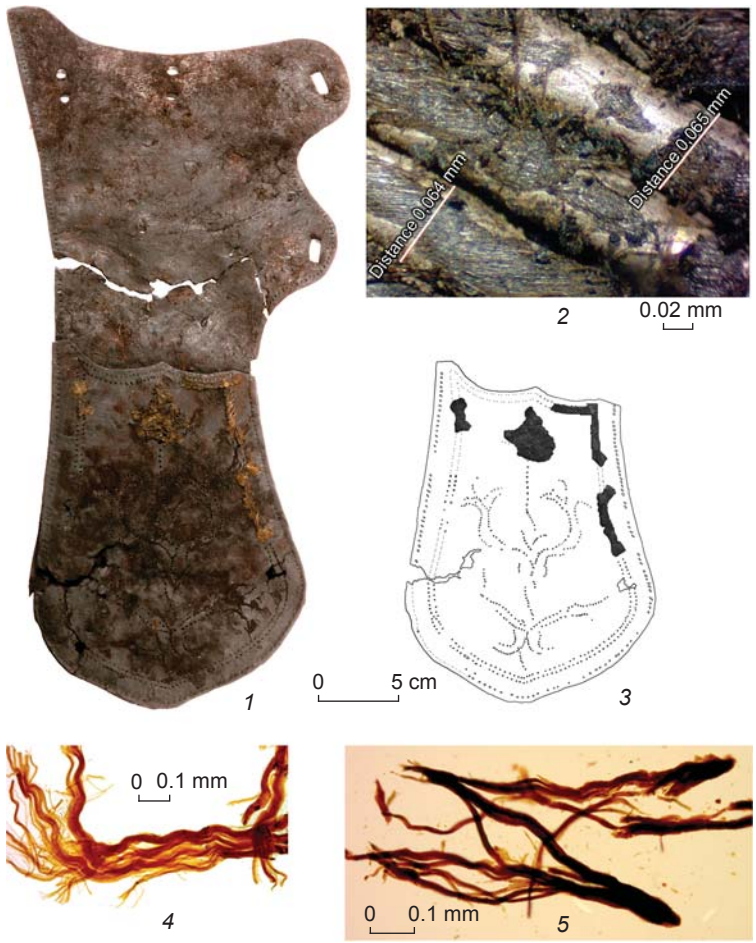

Fig. 2. Leather quiver of the mid to second half of the 17th century, from the excavations in Moscow (*1*), gold threads of embroidery (*2*), pocket with traces of embroidery made with gold threads (*3*), fibers of couching threads (*4*), stitching threads (*5*).

We applied various natural scientific methods to studying a leather quiver discovered by the employees of the OOO "Stolichnoye Arkheologicheskoye Byuro" in Moscow, near Bolshaya Ordynka Street. A unique find from the mid to second half of the 17th century (Osipov, in press) was a flattened case with a rounded bottom and symmetrically-convex sides, with a surviving metal plate and two adjusting buckles*. On the front side, there is a patch pocket decorated with gold embroidery (Fig. 2, *2*). According to A.F. Medvedev, a whip or flail could have been placed in such a pocket (1966: 23).

The publications about quivers kept in museum collections contain no information about the properties of the material from which these were made, types of connecting and decorative seams, composition of dyes, etc.; therefore, we used various methods for obtaining additional information about this find.

Macrophotographing of leather. This was carried out for establishing the species of the leather. The photo shows that the grain* is smooth; nevertheless, the shapes and locations of hair ducts on the surface indicate with a high degree of probability that leather from cattle or a horse was used for making the quiver. The unnaturally smoothed surface of the grain and the increased oiliness of the skin show additional processing of the raw material. In this regard, it is appropriate to recall that in order to increase the durability of leather, artisans subjected it to "boiling"** (Malinova, Malina, 1988: 38, 78; Cameron, 2000).

*To prevent arrow-shafts from interfering with steering the horse, the quiver was worn in an inclined position, with its neck back.

*Pattern on leather surface left from the marks of removed hair bags during the tanning process.

**This term should not be taken literally. The skin was "boiled" by immersing in hot (about 80 °C) liquid: wax, oil, rosin, or other resins (Folks, 2006: 120–127).

Infrared spectroscopy. Using this method* at the Vorozhtsov Novosibirsk Institute of Organic Chemistry (NIOC) SB RAS, ester bonds typical of fats and wax have been detected in leather samples taken for analysis. Their presence confirms the assumption that the "boiling" technique was used for additional leather processing.

Liquid chromatography. The leather was analyzed using the method of liquid chromatography at the Center of Spectral Investigations at NIOC SB RAS for establishing the composition of tannins and the original color of the leather, which had disappeared after a long stay in the soil**. The presence of tannins and ellagic acid in the leather confirmed that raw materials were processed with a tanning solution based on plant extracts. When determining the initial color of the sample belonging to the main detail, the spectra of plant dyes—indigotine (blue) and alizarin (red)—were identified. Depending on the ratio of the dyes, this combination could give a purple color, or when combined with tannins, a green color. No traces of dye were found in the sample of leather from which the pocket was cut. The leather was undyed, and its dark color set off the rich embroidery made with gold threads, on the front surface of the pocket.

RFA analysis. Study of the coating on gold threads, using a micro X-ray fluorescence spectrometer "Bruker M1 Mistral"***, revealed the elemental composition of the shell of gold threads—thin metal foil, which was wrapped around the couching threads (Fig. 2, *2*). According to the spectrometer data, this was silver of a fairly high purity (87.42 %).

Metal suspension loops and decorative onlays have been preserved on the quiver. Analysis of the composition of chemical elements made it possible to establish that the suspension attachment loops and decorative onlay were made of brass.

Study of stitching material. The nature of the stitching threads and couching threads, as well as the technological features of their manufacture, were identified in the Chemical Laboratory of the Restoration Department at the State Historical Museum****. As was discovered during the research, the core of the couching thread, entwined with bands of silver foil, was a spun silk thread twisted in an S-shaped direction (right-sided twisting) (Fig. 2, *4*).

Partially preserved stitching threads were made, not from plant fibers or secretions of the silkworm caterpillar, but from animal sinews (Fig. 2, *5*). It should be mentioned that in the Late Middle Ages and Early Modern Age, the armorers of Middle and Central Asia sewed leather items with sinew threads (Bobrov, Hudiakov, 2008: 195) Russian artisans preferred to use waxed thread—strong twisted linen thread soaked in wax or resin (Osipov, 2006: 62). In rare cases, they chose horsehair as stitching material (Osipov, 2014: 117).

Use of natural scientific methods has made it possible to obtain information about the techniques of decorating the quiver, and to establish qualitative characteristics of raw hides and stitching-material.

DNA-testing of raw materials. Research into the raw materials of urban leather working is very important for elucidating the development of craftsmanship in medieval Russia. Nowadays, the breed of the animal whose skin was used for making items discovered at archaeological sites is established visually by texture-related features on the outer side (grain) of leather, typical of each type of mammal, mainly by the shape and location of ducts remaining from hair shafts on it. Accurate identification is possible in the absence of abrasions on the leather's surface, which is not always the case.

A promising method for identifying the species composition of leather raw material is DNA-testing with a polymerase chain reaction (PCR). The method of molecular genetic diagnostics was invented in 1983 by the American biochemist K. Mullis, for which he was awarded the Nobel Prize in Chemistry. Today, PCR analysis is widely used in forensics and medical practice, as well as the modern food industry, for detecting substitutions of material in raw food. The method, based on multiple selective copying of a specific DNA region with enzymes, ensures a significant increase in small concentrations of certain nucleic acid fragments (DNA) in the biomaterial taken for analysis. Modern compact devices (amplifiers) for PCR analysis make it possible to carry out mass express tests for the identification of species in large batches of leather raw materials (Galkin, Trepalina, 2018: 36).

Identification of regional differences in footwear

The increase in the number of archaeological finds from different areas makes it possible to identify regional differences and establish the boundaries of the distributions of certain types of footwear. Important data were obtained after processing collections of archaeological leather from Galich Mersky, where systematic excavations have been carried out since 2009 by the Kostroma Archaeological Expedition (Novikov, Baranov, Novikova, 2014: 9–19).

*Infrared spectroscopy is a field of spectroscopy that studies the interaction of infrared radiation with substances. This method is based on the phenomenon of absorption of infrared radiation by chemical substances, with simultaneous excitation of molecular vibrations.

**The analysis was performed by E.V. Karpova, the Senior Researcher in the Optical Spectrometry Group, NIOC SB RAS.

***The study was carried out by A.O. Shevtsov, Researcher at the Archaeology Department of the State Historical Museum.

****The analysis was carried out by O.B. Lantratova, the Leading Expert of the Restoration Department.

In 2019, a collection of leather items and artisanal waste amounting to 3992 items was compiled from the finds discovered over an area of 257 m^2 in the deposits of the late 16th to early 18th centuries. The analysis of material evidence made it possible to reconstruct the cutout of footwear models that existed in Galich during the period under study. It was established that the most popular type was soft heelless shoes with one-piece upper parts connected to weakly-profiled soles of symmetrical cutout by means of hidden inserted seams (Fig. 3, *1*, *2*). A cloth or suede cover could be attached to the edge on the top of such a shoe (Fig. 3, *3*). Inside that lining, there was an *obora*—a woolen cord or thin leather band passing through the loop of the back piece, which was sewn above the heel. The top was made of soft leather with vegetable or oil tanning, 1.2–1.8 mm thick. The weakly profiled sole was cut of tougher leather, the thickness of which could reach 4.5 mm. Such footwear, called "kengi", "charyki", or "uledi", was widespread in the Russian North and Siberia, as confirmed by archaeological (Vlasova, 2001: 303; Oyateva, 1973; Vizgalov, Parkhimovich, Kurbatov, 2011: 42–43; Osipov, Chernaya, 2016: 142; Osipov et al., 2017: 114) and ethnographic evidence (Etnografiya russkogo krestyanstva…, 1981: 160).

Soft heelless shoes are almost absent from the materials of excavations in Moscow, Kolomna, Vladimir, Tver, Smolensk, Tula, Kaluga, and other cities of Central Russia. Such shoes have not yet been found even in Kostroma, located 108 km from Galich (Kabatov, 2006, 2011; Lazarev, Osipov, 2020). Mapping the distribution

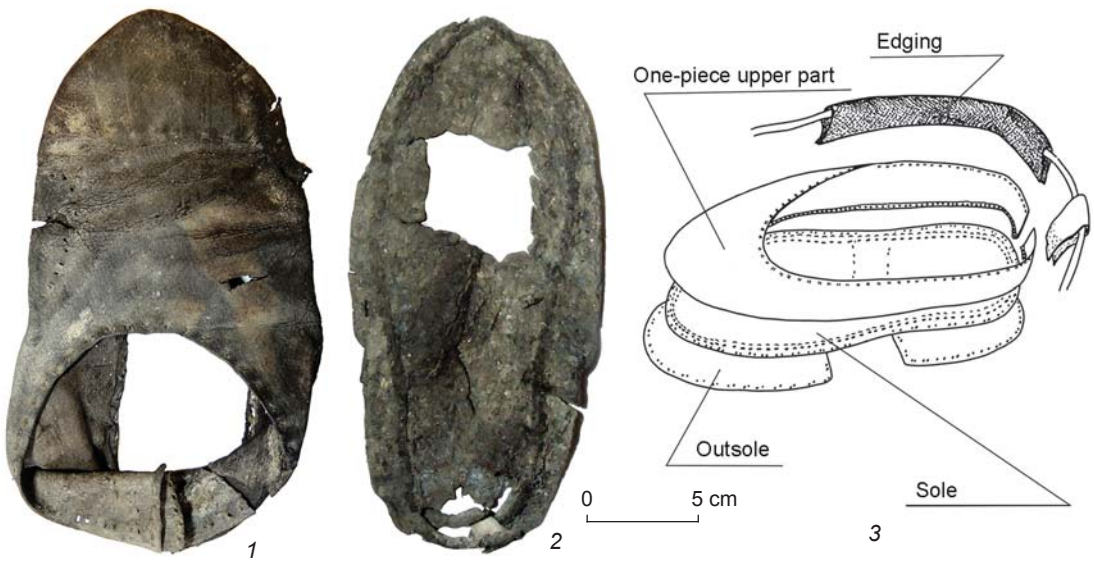

Fig. 3. Soft heelless shoes of the 17th century, from the excavations in Galich Mersky.
1 – one-piece upper part; *2* – sole, hidden seam; *3* – assembly diagram.

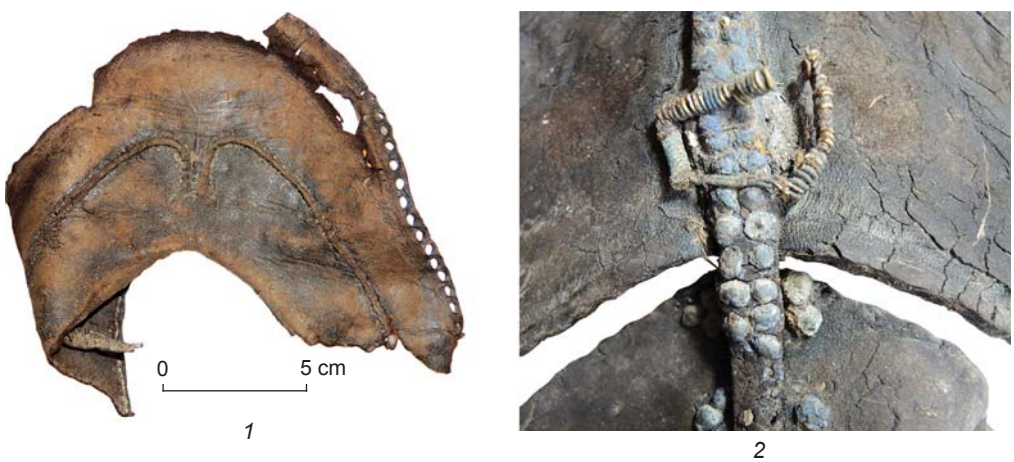

Fig. 4. Shoe crown with thread joint (*1*), gimp of brass wire (*2*), from the excavations in Galich Mersky.

zone of soft shoes has allowed us to establish that the border of the area where such shoes were used was located between Galich and Kostroma, the latter's material culture being more oriented to Moscow.

The specific nature of the Galich footwear was also manifested in the decorative finishing of festive models: as opposed to everyday footwear, people tried to decorate them in various ways. One decoration technique was thread embroidery of the shoe's crown in the form of two semicircles, which formed a protrusion directed towards the rise of the foot (Fig. 4, *1*). This type of decoration was not typical of the towns of Central Russia, but became widespread in Eastern and Western Siberia. The earliest footwear with such decor was discovered during the excavations of the first Russian polar town of Mangazeya (Vizgalov, Parkhimovich, Kurbatov, 2011: 53, fig. 63, *1–3*).

Metal wire fastened over the heel welt was widely used for decorating footwear in the Late Middle Ages. An RFA-analyzer has revealed that the wire was made of brass (Osipov, 2017: 214–217; Lazarev, Osipov, 2020: 316; Osipov, Chernaya, 2016: 144). The boots from the Galich collection were also decorated with cannetille* (Fig. 4, *2*), atypical of the decoration of Russian urban footwear.

A similar technique was used in the adjacent territories, as evidenced by the decoration on festive Kazan boots found in the Volga region (Sattarova, 2004: 21, fig. 11). It might have been borrowed by the Russians from the local population. In this regard, it is advisable to recall a large-scale military campaign conducted by the Moscow State in 1395 (or according to other sources, in 1399) to the Middle Volga region, which was led by the brother of the Grand Prince Yuri Dmitrievich Galitsky (Gorsky, 2003: 126). According to the Voskresenskaya Chronicle, the Russian warriors returned with great booty: "took the land of the Tatars into captivity; and after three months of fighting, returned to the Russian land with a great victory and much booty" (Polnoye sobraniye…, 2001: 72). Obviously, the captured Tatar artisans included shoemakers who had the skill of making metal gimp.

The use of modern methods for studying archaeological finds ensures that a greater amount of information is obtained. For example, analysis of material evidence from the excavations in Galich revealed their significant difference from the finds from other Russian towns and helped scholars to establish a conventional border of the area of northern apparel, including footwear. Differences are also emphasized by the method of embroidering the crowns of low shoes, which disappeared in Central Russia at the time of the Golden Horde.

*From *cañuto* – 'tube'; a thin metal thread twisted into tight spiral.

Conclusions

The rapid increase in the volume of archaeological evidence requires its thorough analysis. Archaeological leather cannot be stored for a long time; therefore, it is advisable to process such finds as quickly as possible. When working with this category of archaeological evidence, it is necessary to use all available methods that may increase the information content of the source and the objectivity of the data obtained, which are needed for subsequent substantiated generalizations.

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