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USE-WEAR ANALYSIS OF COPPER-ALLOY ARTIFACTS. A WINDOW OF OPPORTUNITY OR A DEAD END?

ANALIZA TRASEOLOGICZNA ARTEFAKTÓW ZE STOPÓW MIEDZI. OKAZJA DO BADAŃ CZY ŚLEPY ZAUŁEK?

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ABSTRACT: A world seen through the lenses of a microscope can lead to exceptional discoveries. Regarding archaeology, it can grant us knowledge about the possible usage of certain artifacts in the past. Previously unrecognized and unclassified fragments of flint and bone can be reinterpreted as a completely different item. Throughout the years there were a small few astounding scientist who laid foundations and improved on this part of archaeology. In this already tight-knit group of researchers there is an even smaller group of people who are interested in applying use-wear analysis to copper-alloy artifacts. It is quite a different approach. You still look for signs of usage or any other traces but the difference in material and overall structure of an artifact makes for quite a difficult task. The multiple issues and setbacks such as corrosion, acidity of the soil, the composition of alloys, conservation or simple mismanagement of an artifact can lead to a lot of misleading conclusions. Despite all those problem you can still gather data from use-wear analysis on metal. But can it be used in forming any sort of narrative or is just a “collection of pretty pictures”?

KEYWORDS: Use-wear, traceology, copper-alloy, bronze, theory, method

In order to properly discuss the topic of the paper, defining use-wear analysis should be an utmost priority. There is a certain linguistic divergence between “western” and “eastern” worlds. The English phrase *use-wear* by definition is strictly focused on the *usage* of an item in the past (Korobkowa, 1999, p. 11). The word *traceology* used widely in the former countries of the Eastern Bloc is definitely more adaptable. It includes any sort of *trace* left on a human-made object. But as it is commonly known, definitions do not always match-up with reality. One cannot focus entirely on the traces of usage whilst omitting other changes done to the surface of an artifact (Horn, Holstein, 2017, p. 99). To put it simply use-wear analysis in archaeology is a scientific field that blends functional, macroscopic and microscopic analysis in order to tell a more compelling narrative of an item. In Poland one of the best known "textbooks" for that type of research is a book titled *Narzędzia w pradziejach. Podstawy badania funkcji metodą traseologiczną* published by G. Korobkowa in 1999. Usually the text is cited and used to this day as a starting point (Pyżewicz, 2021, p. 334) of most studies concerning flint, stone and bone artifacts despite few inconsistencies and outdated research. Unfortunately G. Korobkowa did not consider items that were made out of other materials or served a different function than a tool. The author of this publication defines traceology as: "Traceology is a method, that allows us to identify and interpret traces of human activity, left on a surface of non-metal tools. [...] The overall cognitive goal of traceology is the reconstruction of former craftsmanship and the economy of the prehistoric communities [...]" (G. Korobkowa, 1999, p. 11).

Unfortunately by this definition use-wear analysis on copper-alloys should not event exist. The latter part of a quote is also excluding other aspects of human life in the past beside the ones stated. One very interesting thing to note is a fact that G. Korobkowa was a student of S. A. Semenov who is considered the father of traceology/ use-wear analysis. He was also the author of the first proper synthesis of the method itself (Semenov, 1970). The book *Prehistoric Technology, an Experimental Study of the oldest Tools and Artefacts from traces of Manufacture and Wear* can be considered very outdated by today standard, but this statement is only partially true. Chapters describing the process of observation and documentation are indeed archaic. The reason for it is the fact that the book was published over fifty years ago. On the other hand descriptions of traces found on flint and bone and their definitions are still in use today. Semenov did in fact anticipated further development of the method itself and did not exclude metal artifacts as a potential source of data. More so he did mention microscopic analysis of metal jewellery in his book. To quote the author: "Microscopic observation on jewellery of coloured metals, bronze, silver and gold has yielded quite fruitful results. [...] However, work in this field began only a few years ago and its results will be published later on, [...]" (Semenov, 1970, p. 5).

Regrettably that is all that is known about the aforementioned research. It's still a really important quote that proves that use-wear analysis on metal was considered applicable over fifty years ago. The fact that jewellery was taken into account is also an indicator that the first definition mentioned was inaccurate even in 1999. The author would like to note that he does not condone research done by G. Korobkowa but rather a certain manner of "exclusion" performed by her. It is incredibly difficult to create a definition that could explain something in a simplified manner and simultaneously not lose at least a part of its meaning.

In 2014 a book titled *Use-Wear and Residue Analysis in Archeology* as part of the Manuals in Archaeological Method, Theory and Technique series was published. This comprehensive publication could be used as a proper starting point for further studies. For the purpose of this article chapter 9 written by Carmen Gutiérrez Sáez and Ignacio

Martín Lerma should be considered as the most important. The text could be used as a foundation or even as a text book for microscopic analysis of metal artifacts. In this chapter most of the traces found on copper-alloy items are well defined and divided into three separate groups (Gutiérrez, Lerma, 2014, p. 183). The authors state that their work began in the year 2002 and still needs to be expanded upon and continued. The data collected to this point (the year of publishing) is astounding in its quality and quantity. It consists of experimental and comparative studies of traces found on copper-alloy artifacts and replicas (Gutiérrez Sáez, Lerma, 2014, p. 175–182).

For the purpose of this and any following papers the author would like to propose description of traceology defined as: *A method of finding and interpreting any traces of human activity left on the surface of human-made or natural objects*. Usage of such definition is not unheard of in archaeology and is widely accepted in modern studies (Beyries, Hamon, Maigrot, 2021, p. 11–12; Sych, 2014, p. 31–33; Zagrodnia, 2021, p. 265–266). Even that broad description is not without a flaw. It excludes any sort of traces that correlate with post-deposition processes such as oxidization. But for the time being the proposed definition will have to suffice.

THREE CATEGORIES OF TRACES

The next part of the publication is supposed to focus on differences between the so called "classic" use-wear analysis and the one focused on copper-alloys. In order to properly define them we need to describe the three basic categories (called *mechanisms*) of traces on metal as proposed by Christian Horn and Isabela von Holstein (Horn, Holstein, 2017, p. 91–95).

The first one is named *consequences of plastic deformation*. This is the category that can be described as the one closest to the more *classic* approach to use-wear analysis (Kasprowicz, 2021, p. 22). The reason for it is that this mechanism includes traces interpreted as ones linked with usage of an aritfact in the past. The surface of an item can be glossed, polished or covered with silica residue similar to exterior of flit and bone artifacts. But in contrast the plasticity and the physical properties of copper and its alloys trades the *more traditional* traces for that are specifically defined for metal. Those are; *dents*, *dullness of the blade and the tip*, *chips, wavy edges* and *asymmetry of the blade/working edge* (Sych, 2016, p. 53). Microfractures are also present on copper-alloy tools and weapons but their overall shape and form differs from those that appear on bone artifacts (Horn, Holstein, 2017, p. 92–93). Aside from the aforementioned micro-fractures most of the residual signs of usage can be captured using a standard optical reflected-light microscope using a range of magnification between 20x to 150x (Kasprowicz, 2021, p. 49). A good example of those traces can be found on a bronze knife (dated 1100–900 BCE) found in Poznań-Starołęka district during railway construction in the later half of XIX century (Gedl, 1984, p. 31, tab. 37). Although severely lacking in archaeological context, artifact provides a solid amount of traces found on its work surface. The blade is chipped, dent, wavy and severely asymmetrical (fig. 1) which points to its intense usage for a prolonged period of time (Kasprowicz, 2018, p. 37). The knife point is also heavily dulled pointing some sort of stabbing motion done with the tool (fig. 1). Even with a lot of archaeological data missing or non-existent, use-wear analysis can still provide us with new informations considering artifacts.

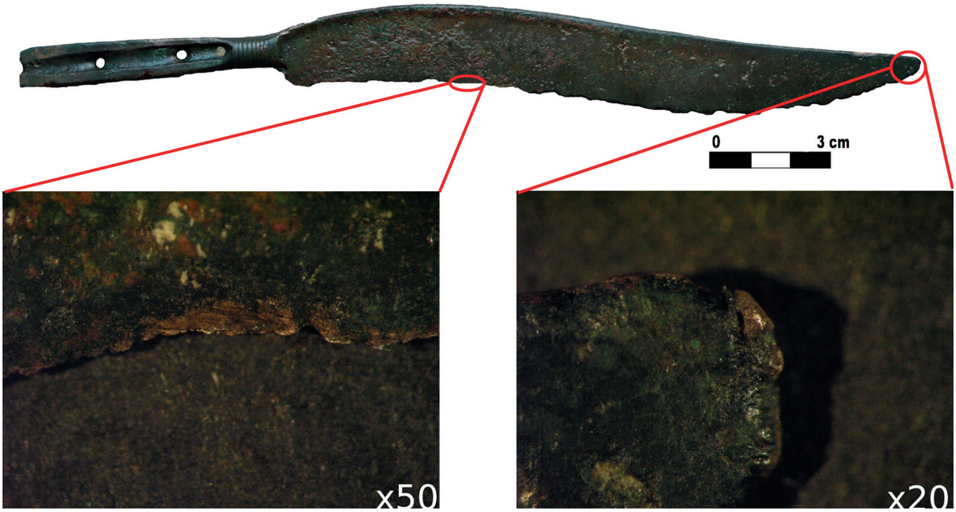

Fig. 1. Bronze knife from Poznań-Starołęka with close-ups on the blade section and the point (author: Marcin Kasprowicz)

While often omitted or hard to detect, the second mechanism, called *repair* is proven to be immensely important in order to form a proper narration. Even though the name suggests only the "fixes", the category itself includes an array of traces that can be linked not only with them, but also the production process of an item (Kasprowicz, 2021, p. 22). Similarly to the *consequences of plastic deformation* the range of magnification starts form x20 up to x200. Some traces can also be observed *with a naked eye*. The *repair* mechanism can provide us with important data considering the life cycle of an artifact. Lack of any traces can also lead us to a plausible conclusion that an item was unused after its initial creation (Sych, 2016, p. 35). Traces of metal-casting and production are usually proven difficult to find. The main reason for it is that any residual metal such us the pouring cup or casting seam was simply cut off and the remains were ground and polished in order to remove imperfections (Molloy, 2011, p. 69). A similar problem can be found with traces of hammering. In case of tools or weapons used for cutting, chopping etc. one of the most important post-casting step is hardening the edge in order to make it usable (Molloy, 2011, p. 71). After that process the surface was also ground and polished making the traces of hammering barely visible. In rare cases its the only sing of *repairs* that can be observed. Such is the case with a small fragment of a bronze sickle from Czarnków (Czarnków-Trzcianka County) dated 1000–800 BCE (Gedl, 1984, p. 63). The artifact is heavily corroded and bears no clear sing of usage. On the cutting edge there is a clear sign of hammering surrounded by a *wave* left by the heavy impact (fig. 2.).

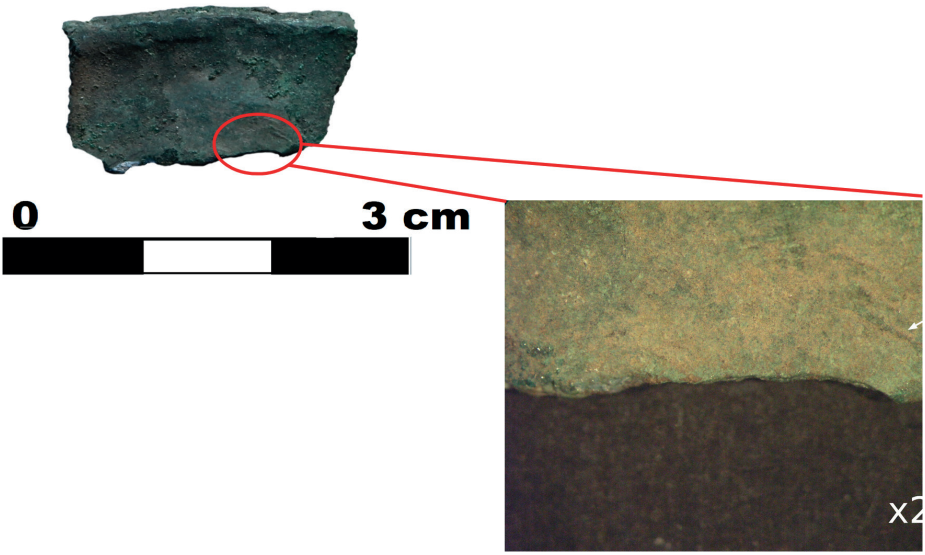

Fig. 2. Fragment of a bronze sicle from Czarnków with a closeup of hammering traces (author: Marcin Kasprowicz)

The last mechanism described is *corrosion*. Despite the name it also includes any traces of conservation and any changes done to its structure and surface after its initial deposition. Copper is quite resistant to the oxidisation process, yet it is not immune to it (Głowacka, 1996, p. 313). One of a really useful (but subjective) way to asses the potential of further analysis is to define the advancement of the corrosion process. Copper can oxidise (CuO) but it can also react with sulphur, carbon($CuCO_3$) and chlorine ($CuCl$) compounds that are found naturally. The most known form of corrosion of copper-alloys is copper(II) carbonate hydroxide, the bright-green patina found on copper rooftops and bronze/brass statues. Depending on an advancement of changes in structure and surface of an artifact, the corrosion process can be helpful in preserving certain kinds of traces. One of the methods of categorisation of the advancement of corrosion is a simple table proposed by C. Horn and I. C. C. Von Holstein (Horn, Holstein, 2017, p. 96). Dividing various artifacts into groups allows us to initially assume the potential of further analysis. It is important to note that even the most corroded items should still be a subject of studies. As an example of corrosion I would like to compare two hoops of the same bronze necklace (fig. 3). On the left hoop the surface seems almost untouched by corrosion and on the right one crystals of copper (II) carbonate are clearly visible. The picture also showcases the uneven rate of the corrosion process which can be either a setback or "*a blessing in disguise*" depending on the preservation state. The conservation process mentioned earlier will be further described in the setbacks section of the article.

Fig. 3. The contrast of the corrosion process between two hoops of a necklace (author: Marcin Kasprowicz)

TRACES OF FABRICS AND LEATHER ON COPPER-ALLOYS

Besides the aforementioned categories, one particular set of traces sparked the authors interest. In traceology of bone artifacts exists a possibility of differencing between marks left by contact with materials such as wool, plant fibres and leather. Unfortunately a lot of times bone or antler artifacts that reassemble any sort of spike are categorised as awls without a lot of thought. It is important to note that in recent years the approach shifted from that to the reinterpretation of old materials with usage of microscopic analysis (Stelmasiak, 2017, p. 7). This and the fact that use-wear analysis of copper-alloy artifacts is mostly focused on weapons and tools (Horn, Karck, 2019) made the author interested in any traces that can connect items to their contact with fabrics or leather.

An experimental study was performed in the period between 27.02.2020 and 01.03.2021 with mostly positive results (Kasprowicz, 2021). A set of eight pins based on finds from the late bronze age and early iron age were replicated by Albin Sokół of Biskupin Archaeological Museum. The alloy consisted of 90% Cu and 10% Sn so a "*classic*" mix. The point of each pin was hammered into shape in order to reinforce it. Surface was polished with charcoal dust to eliminate any traces of metalworking processes thus making it ready for the experiment. Pins were divided into groups of two and marked as N (control group, unused), S (Red deer [*Cervus elaphus*] leather), W (wool fabric with a high concentration of lanolin) and L (Linen fabric as an example of plant fibre). The replicas were used to punch holes in material samples and were polished with it. Pins were analysed with a microscope three times. On 28.02.2020 raw unused replicas were documented and categorised. On 20.07.2020 The first batch of experimental traces were found, and on 01.03.2021 the analysis was concluded with another set of traces. The limited amount of analysis was caused by Covid-19 limitations at that time. Even with that setback over 536 photos were made and the overall results could be described as successful. The main focus point of the study were the pinpoint and pivot as they were most affected by the contact with fabric or leather (fig. 4).

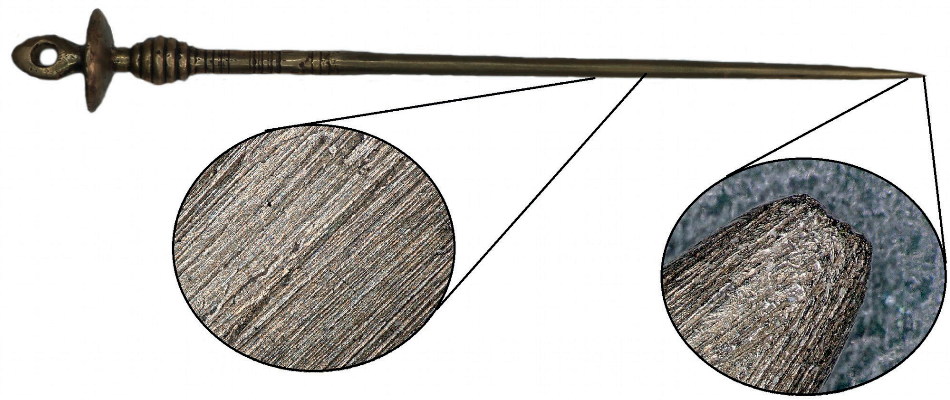

Fig. 4. Bronze pin with observation focus points (author: Marcin Kasprowicz)

Overall the experiment helped to differentiate traces connected to certain types of materials. The most visible change in surface is caused by leather with the surface becoming glossy. Grooves left by final polishing with charcoal dust could be described as flattened. It is probably the most distinct out of all three (fig. 5b). One of the most difficult to describe on its own is the woollen fabric. Traces are something between leather and linen with the surfaces partially glossed and partially scratched (fig. 5c). These are the ones that the author is most uncertain of. The final set of traces is the one left by contact with linen fabric. The surface appears to be scratched and the light reflected from the surface seems sharp (fig. 5d). The following compilation was made to showcase the differences between the traces.

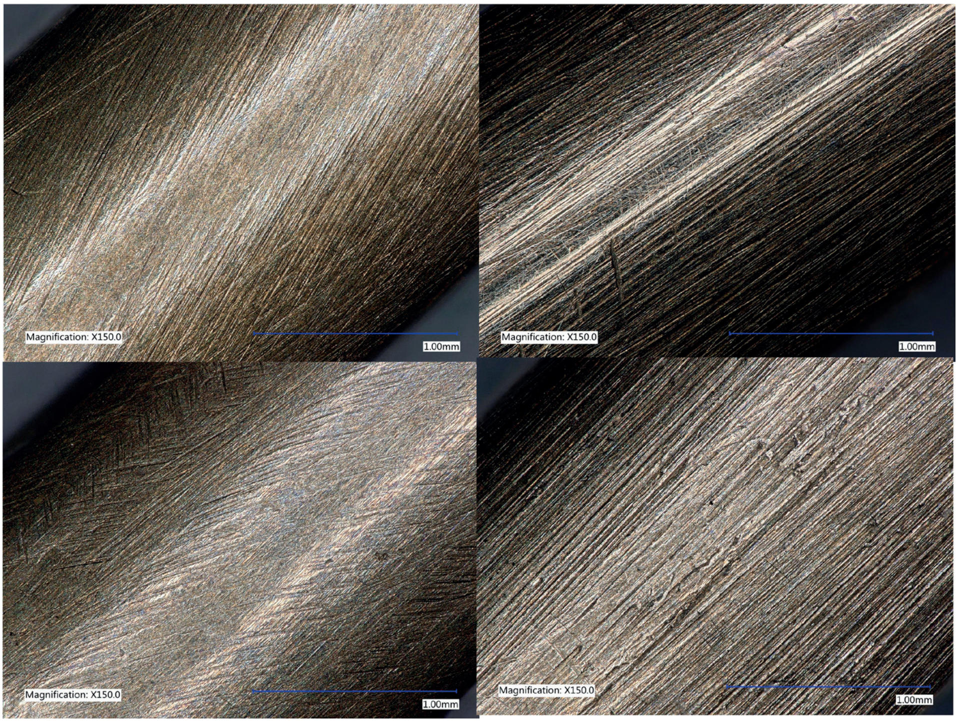

Fig. 5. Compilation of traces on bronze pins. From top left: a) unused, b) leather, c) wool, d) linen (author: Marcin Kasprowicz)

SETBACKS IN USE-WEAR ANALYSIS

In the previous paragraphs corrosion process was mentioned. Even if it is an interesting process on its own it could lead to the destruction of any sort of traces on the artifact. It is important to note that the rate of corrosion and its severity depends on a number of factors. In some cases the process left almost no impact. Unfortunately in majority of cases corrosion can be a significant setback. Some times a macroscopic observation can already lead to some conclusions as is the case with the item from Smuszewo (Wągrowiec County). This small piece of bronze is heavily corroded to the point that it has become brittle and its surface is rough with no point that could be analysed with microscope (fig. 6). The only thing found was little amount of organic material that could be tied with post depositional processes (Kasprowicz, 2018, p. 38).

Another important setback is the experience of the person conducting the research and knowledge about the studied material. Cleaning and preparing a sample for microscopic analysis should be done with at least a basic understanding of reactions of materials with chemical solutions. One of the most popular cleaning fluids

Fig. 6. Small bronze fragment from Smuszewo (author: Marcin Kasprowicz)

used in traceology is pure ethanol. It works fine when you need to clean organic residue from flint or bone artifacts. That is not the case with copper and its alloys. It reacts with copper oxides on the surface creating stains (fig. 7.) and disrupting research. The best chemical solution used for copper and its alloys is acetone which is non reactive with copper.

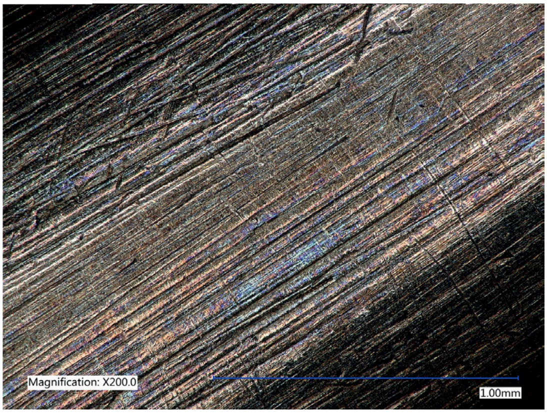

Fig. 7. A surface of experimental bronze pin with a surface damaged by ethanol (author: Marcin Kasprowicz)

Conservation seems to be one of the ultimate setbacks for microscopic analysis. In a lot of cases that is unfortunately the truth. Especially when analysing material from the archives and previous excavations. Throughout XIX and the first half of the XX century the aim was to conserve the artifact at all costs. This often resulted in layers of lacquer, sanding of the surface, gluing parts together with insoluble compounds (fig. 8). Fortunately the methods in conservation of metals moved significantly forward. In some cases preservation of the surface can even help further use-wear analysis. At this point author highly recommends a publication titled *Influence of conservation of copper and bronze artefacts on traces of production and use-wear* by Dawid Sych, Kamil Nowak, Marcin Maciejewski, Beata Miazga and Justyna Baron in 2020 in Archaeological and Anthropological Sciences 12: 141. The paper perfectly showcases the negative and positive aspects of the conservation process. Even though there are some positive aspects and conservation itself preserves the artifact, it should still be considered as a setback.

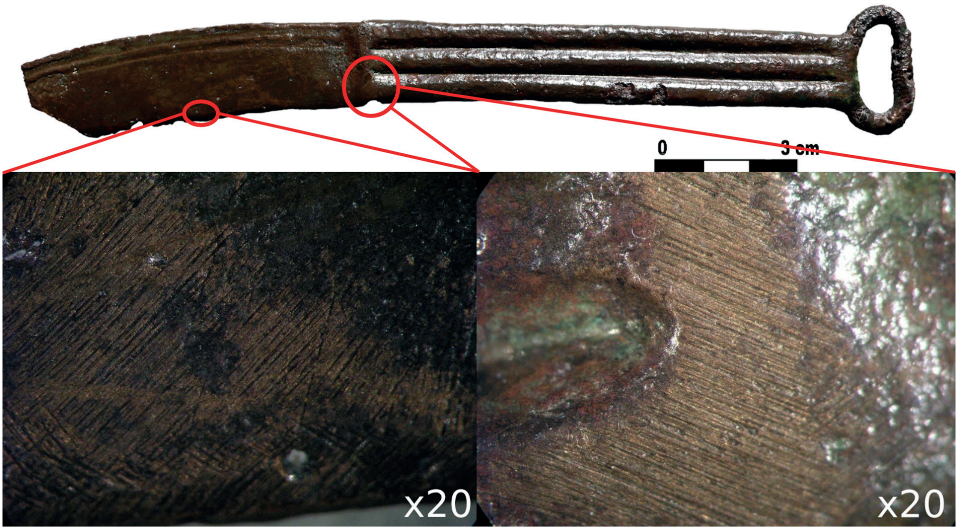

Fig. 8. Bronze knife from Śmiełów. The surface is polished with sand paper or similar material and covered in lacquer (author: Marcin Kasprowicz)

The importance of context is well known in the world of archaeology. The possibility to discern whether an artifact served a practical or ritual purpose could help us form a coherent narrative. With a lot of metal deposits they are found randomly or with a use of a metal detector (eg: Kasprowicz, Majorek, Teska, 2019, p. 21–27). This means that even with a perfectly preserved artifact we are still missing a lot of potential data. In case of use-wear analysis we can assume the function of certain items but we cannot finish the narrative (eg: a heavily used tool being a part of grave goods).

IS USE-WEAR ANALYSIS ON COPPER-ALLOY ARTIFACTS A DEAD END?

As it is usual in archaeology, the answer is "yes and no" at the same time. On one hand the presented examples can be used to form a narrative that could get us closer to a better understanding of the past. The way that certain items were used, or with what material they had contact with, grants us a previously unobtainable knowledge. In similar way the process of creating a tool, weapon or a piece of jewellery, shows us not only the technology of that time but also the creativity, intellect and the ability to work around certain problems. Thanks to the modernization of the conservation process we can see traces that were previously unobtainable. By using what use-wear analysis has to offer we can ask important scientific questions. It is important to remember that "life" of an item is closely related to the actual life cycle of its user. It also includes the deposition of an item whether as a grave good, a sacrificial deposit or just being discarded after it served its purpose. Use-wear analysis does not hold all the answers but it could bring us ever so slightly to the reconstruction of the past.

Unfortunately use-wear analysis of copper-alloy artifacts faces its greatest problem not during or after conducting a study. The difficulty sprawls from the lack of modernised unified approach and no firmly stated methods of conducting a study. Of course there is nothing inherently wrong with it and a lot of great papers have been published considering that field. The authors aim is to show how much streamlined and cohesive forming a narrative could be with a set of methods created specifically for non-ferrous metal analysis. There is also the issue of perceiving microscopic analysis as just another method of documenting an artifact. Fortunately this changes throughout the years and probably soon the issue will disappear entirely.

As a closing remark the author would like to note that, as long as there are researchers who still conduct use-wear analysis, new methods will emerge and the knowledge about the subject will expand. So traceology of copper-alloy artifacts is not a dead end but needs to be based of clear set of methods and scientific questions. Perhaps in time a new, updated "textbook" will emerge to be used as a foundation for further research and to expand on the one published in 2014 by Carmen Gutiérrez Sáez and Ignacio Martín Lerma.

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ANALIZA TRASEOLOGICZNA ARTEFAKTÓW ZE STOPÓW MIEDZI. OKAZJA DO BADAŃ CZY ŚLEPY ZAUŁEK?

Streszczenie

Powstanie tekstu zostało bezpośrednio zainspirowane referatem o tym samym tytule, wygłoszonym podczas Poznań Young Reaserches Archaeology Conference 2021. Wstęp do artykułu skupia się wokół braku jednolitej definicji analiz traseologicznych przedmiotów ze stopów miedzi, odwołania do jedynego tekstu, który można nazwać podręcznikiem do tego typu analiz oraz próby stworzenia krótkiej autorskiej definicji problematyki. Następnie opisane zostały trzy szeroko pojęte kategorie śladów uchwytnych na przedmiotach ze stopów miedzi. Są to kolejno: *konsekwencje deformacji plastycznych*, *naprawy* oraz *korozja*. Dla każdej z kategorii powołano się na wybrane przykłady z poprzednich badań autora. Zwrócono również uwagę, że w kategorii *naprawy* uwzględnia się procesy produkcyjne przedmiotu, a w kategorii *korozja* procesy podepozycyjne oraz konserwację zabytków. Następna część artykułu opisuje eksperymenty dotyczące powstawania śladów po kontakcie wyrobów ze stopów miedzi ze skórami, tkaninami wełnianymi oraz tekstyliami roślinnymi. Są to badania autorskie przeprowadzone w latach 2020–2021 w ramach pracy magi-

sterskiej. Kolejny element artykułu skupia się wokół zagrożeń i utrudnień podczas wykonywania analiz traseologicznych na przedmiotach ze stopów miedzi. Wymienione zostały czynniki ryzyka, z którymi musi się liczyć badacz, takie jak: korozja, materiał konserwowany ponad 50 lat temu, brak kontekstu, niepewne pochodzenie zabytku czy stosowanie nieodpowiednich środków czyszczących. Ostatnia część artykułu to krótka dyskusja i przemyślenia na temat dalszego potencjału analiz traseologicznych na przedmiotach ze stopów miedzi. Autor wyraził nadzieję, że metoda nie przestanie być rozwijana i że w przyszłości uda się wypracować wspólne podstawy metodyczne oraz stworzyć tekst będący rozwinięciem jedynego tekstu, który może być traktowany jako podręcznik.