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AN ATTEMPT AT INTERPRETING UNTYPICAL MODIFICATIONS OF FLINT ARROWHEADS: AN EXPERIMENTAL AND USE-WEAR PERSPECTIVE

ABSTRACT

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This paper summarizes the findings from the research into modifications formed as a result of storing and transporting flint copies of arrowheads inside a leather quiver. The study was inspired by the fact that Late Neolithic and Early Bronze Age projectile points bear untypical microwear traces interpreted in many different ways in the literature on the subject. The aforementioned features (detected primarily in the uppermost parts of the artefacts) include: hide working polish as well as co-existing rounding and smoothing of the surface. With the aim of gaining a deeper insight into the subject, the authors conducted an experiment and performed a traceological analysis of arrowheads replicas. During the experimental phase, the microwear formation process was monitored using the microscopic equipment. As a result, distinctive traces on the tools were identified. This fact supported the hypothesis that leather quiver exerts its impact on the arrow points stored inside.

Key words: projectile points, leather quiver, use-wear analysis, microwear traces, experiment
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INTRODUCTION

The dynamic development of use-wear analyses initiated in the 1960s (Semenov 1964; Tringham *et al.* 1974; Odell and Odell-Vereecken 1980; Keeley 1980) has led to the situation when "typological tool forms", formally distinguished and variously classified, are more and more often subject to functional verification aimed at identifying their use-wear traces. Since then, researchers interested in microscopes and their practical application in archaeology have been exploring issues concerning the use of artefacts which are potential elements of throwing weapons, such as geometric microliths, tanged points and various types of projectile points, including bifacial arrowheads (e.g. Juel Jensen and Brinch Petersen 1985, 45; Dumont 1988, 249–252; Šajnerová-Dušková 2007, 73–75; Winiarska-Kabacińska 2009, 451).

In order to confirm the widely accepted opinion on the function of those flint artefacts as projectile points of throwing weapons, tests have been carried out to find out whether items produced in experiments and then "shot", bear traces of reproducible modifications after they hit the target. Crucial experiments designed to solve the problem were conducted in Denmark and since then, their results have been regarded as a model (Fisher *et al.* 1984; also Pyżewicz 2013, 31–36; Dmochowski and Pyżewicz 2012). Indeed, deformations of the edges caused by the impact against the target (bright striations or specific damages to the edge, called impacts, single or grouped within the microrelief of the tool) have proven to be distinctive in relation to the natural flint surface (cf. critical comments on this topic in Rots, Plisson 2014). Because similar microtraces have often been detected on the surface of flint artefacts (e.g. Fisher *et al.* 1984, 38; Osipowicz 2010, 82; Pyżewicz 2013, 105, 136–138), the reason for the convergence seems clear: the specific nature of the traces recorded on the artefacts results from their use as projectile points of arrows.

RESEARCH PROBLEM

The microtraces caused by hitting the target are identical on geometric microliths and on various types of projectile points, also on smaller arrowheads typical of the later periods (cf. Rots and Plisson 2014). This is related with the physical properties of flint. The similarities result primarily from the same mechanical deformations of the surface of the point, especially when it pierces an animal carcass and brushes against a bone (Pyżewicz 2013, 35–36).

Research presented here has not focused on the microliths, but on bifacially retouched arrowheads known in the Neolithic Age and the later periods. Archaeological literature often defines them as projectile points of arrows. In their publications, Jerzy Libera and Galina F. Korobkowa quote a few examples of other functions of the arrowheads. They write that the microtraces recorded on the surface of those artefacts suggest various forms of functional use, from harvesting insets (similar to sickle blades), through borers, to blades of composite knives (Korobkowa 1999, 101; Libera 2001, 42–44).

Micropolish, rounding and smoothing visible on the sides of the arrowheads should be considered very unusual, especially on the tips and/or barbs and ridges (more on the subject in Analysis and Discussion). Those changes of microrelief may be interpreted *a priori* as a result of work on soft animal tissue, e.g. of piercing the skin, or of postdepositional processes. That kind of deformation has been noted e.g. in microscopic analysis of several arrowheads from two Corded Ware funeral sites in Małopolska: Koniusza, Proszowice district (Drobniewicz 1979, 91), and Zielona 3, Proszowice district (Winiarska-Kabacińska 2008, 333–334). Many similar modifications of the sides or tips have been recorded by Wolski in analysis of items recovered from the Early Bronze cemeteries in Małopolska: Orliska Sokolnicke 1, Tarnobrzeg district, Podkarpacie province (Czopek *et al.* 1993) and Raciborowice Kolonia 1 and 2, Chełm district, Lublin province (Ślusarski and Ślusarska-Polańska 1988).

The authors propose yet another hypothesis to explain the polish, rounding or smoothing noticeable on the tips and edges of the arrowheads. In this approach, which will become the keynote of this paper, the deformations were formed entirely by chance when the arrowheads rubbed against the leather inside of the quiver. A suggestion of this kind was put forward by Małgorzata Winiarska-Kabacińska several years ago (2008, 334).

The problem has recently been taken up in the archaeological literature (Pyżewicz 2012, 100–101), and initial experimental tests have confirmed Winiarska-Kabacińska's suggestion. Nevertheless, the authors have decided to verify the findings with further testing, which may help to view the issue more directly and include the results into a wider debate, going beyond the Mesolithic range. In our view, a more detailed description both of the material used and of the experiment itself is necessary. It seems important to specify the raw materials analysed by the authors (see below), because they may have affected the dynamics of the formation of the microtraces.

A distinctive element of our experiment in comparison with the experiments carried out by Katarzyna Pyżewicz is that we have used a different kind of replicas of the flint tools: not geometric microliths, but arrowheads produced with pressure technique and partial bifacial retouching. Overall, their shape differs from the Mesolithic forms listed above; therefore, the deformations of microrelief may be discernible on the items at a different pace and may cover different areas. However, the kind of traces resulting from rubbing against the quiver should not be significantly different, which allows us to verify Katarzyna Pyżewicz's findings and to develop her theses.

The choice of bifacial arrowheads for the research material has not been a coincidence. It has been determined by: 1. modifications documented on a number of artefacts of that type, confirmed by several microscopic analyses; 2. the sepulchral, and thus not random, context of many recovered arrowheads, including those with microtraces, which creates a clear cultural and chronological background; 3. a general shortage of information about the ways of using the arrowheads for other purposes than as projectile points of arrows; therefore, a shortage of analyses verifying certain hypotheses proposed in the literature (see Discussion).

To conclude: if the experiment reveals the modifications of the microtexture described above, particularly those on the tips and edges of the arrowheads, which will be determined in use-wear analysis, the interpretation of the role of the quiver will be strengthened. Moreover, the issue, only mentioned in the literature to date, will be complemented with a new valuable experience.

This paper may be considered as a contribution to the debate about different ways of using the products commonly identified with projectile points of throwing weapons.

PREPARATION AND IMPLEMENTATION OF THE EXPERIMENT

In the preparatory phase of the experiment, the following issues were considered as the most important: an appropriate way of making the flint arrowheads and the leather quiver, and a standardised method of keeping a record. These elements of the experiment are described below.

Eight flint arrowheads (Table 1; Fig. 1) have been made with a copper inset with the pressure technique. The blanks were produced from massive flakes detached from the cores without preparation with a mineral hammer stone. The thickness of the flakes did not exceed 0.5 cm.

Most of the items show scaled bifacial edge retouch, not very regular (cf. Budziszewski and Włodarczak 2010, 46–52). On one arrowhead (Table 1: 6; Fig. 1: 6), there is partial pseudo-laminar retouch (see Libera and Zakościelna 2013, 227). Some items (Table 1: 2, 4, 5, 8; Fig. 1: 2, 4, 5, 8) may be described as arrowheads with deep arched notches, while

Table 1. Metric values of flint arrowheads used in the experiment

No.	Raw materials	Length (cm)	Width (cm)	Thickness (cm)	Angle (degrees)
1	Chocolate flint	2,5	1,6	0,3	15
2	Volhynian flint	2,5	2,0	0,4	40
3	Volhynian flint	2,4	2,0	0,5	60
4	Świeciechów flint	2,2	2,0	0,3	50
5	Jurassic flint	2,2	1,8	0,5	30
6	Volhynian flint	2,6	2,3	0,4	20
7	Rügen flint	2,5	2,3	0,2	15
8	Obsidian	1,6	1,4	0,2	20

others (Table 1: 1, 3; Fig. 1: 1, 3) have shallow symmetric hollows. One item has no notch (Table 1: 6; Fig. 1: 6); another has two notches symmetrical with respect to its axis (Table 1: 7; Fig. 1: 7). The barbs of items 3, 4, 7, 8 (Table 1; Fig. 1) are situated symmetrically; those of the other items are asymmetrical (Table 1: 1, 2, 5, 6; Fig. 1: 1, 2, 5, 6).

On the basis of their metric traits, the items may be divided into the following groups:

a) large stocky items (Table 1: 2, 6, 7; Fig. 1: 2, 6, 7),

b) large slender items (Table 1: 1, 3; Fig. 1: 1, 3),

c) small stocky items (Table 1: 4, 5; Fig. 1: 4, 5)

d) small slender items (Table 1: 8; Fig. 1: 8).

Six items were made of good quality material: Volhynian, chocolate or Rügen flint or of obsidian; two items were made of Świeciechów or Jurassic flint (Table 1).

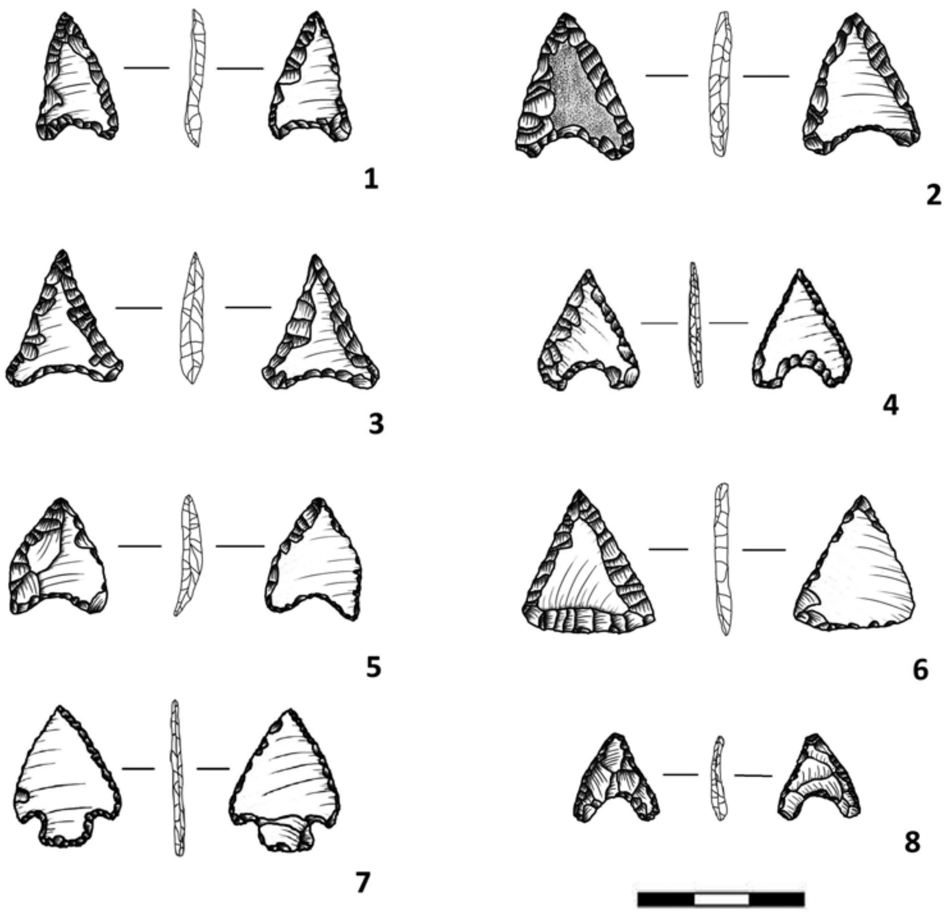

Fig. 1. Flint arrowheads used in the experiment (drawing by M. Kalita)

All the items are replicas of archaeological artefacts. Equivalents of most arrowheads (Table 1: 1–5, 7; Fig. 1: 1–5, 7) may be found in materials from settlements and cemeteries of the late Neolithic and Early Bronze cultures, including the Bell Beaker and the Mierzanowice cultures (e.g. Budziszewski and Włodarczak 2010, 49; Bąbel 2013, 142). The triangular item without a notch (Table 1: 6; Fig. 1: 6) can be assigned to the Funnel Beaker culture (Gumiński 1989, 134, 141) or the Globular Amphora culture (Mazurowski 1977, 156, 162). The obsidian item (Table 1: 8; Fig. 1: 8) is similar in its form to small slender flint arrowheads produced by the Mierzanowice culture (Bąbel 2013, 44).

The items were inserted into carved splits in the shafts with pieces of leather, without any bonding substance. The shafts were made from common hazel twigs (*Corylus avellana*) with an overall length of 90 cm and a diameter of approx. 0.9 cm.

The 60-cm-long quiver was sewn together from a rectangular piece of pigskin with leather straps. In its form, it resembles the quiver found with Ötzi the Iceman from the Ötztal Alps (Sulzenbacher 2011).

After completing the necessary preparations, the experiment was carried out. The aim was to cause uncontrolled rubbing of the surface of the flint arrowheads against the bottom of the leather quiver. It was decided that the most effective way of achieving that aim would be to walk or march with the quiver, the arrows inside it, for a long time. The walks took 2 hours a day for 30 days, which made 60 hours altogether. In the remaining time, i.e. for approx. 660 hours (with a break for microscopic verification), the arrows rested inside the quiver.

RESEARCH METHODS

The microscopic observation was carried out with an Olympus SZX16 stereo microscope (magnification: 10,5–172,5 x) and an Olympus BX51-P polarizing microscope (magnification: 40–1000 x), compatible with a special photographic equipment and the CELL programme for photomicrography. The use-wear analysis involved the low- and high-power methods (Odell 1981; Odell-Vereecken 1980; Keeley 1980). Before inserting the arrowheads under the lens of the microscope, the items were cleaned in a solution of ethyl alcohol. All observations were recorded on “tool cards”, prepared separately for each item (one of the cards is presented in Fig. 2). Keeping a detailed record made it possible to detect changes in the morphology of the flint items at each stage of the analysis and helped to identify the causes of their deformations. In order to make the modification clearly visible, the same parts of the microtopography were photographed at various stages of the experiment (Fig. 3 A, B).

Tool card

"Quiver" Project

Arrowhead No. 1 - one of the eight projectile points placed in the quiver.

Action

Transport of the quiver with the arrows placed inside - provoking uncontrolled rubbing of the arrow projectile points (arrowheads) by the leather bottom of the container;

Maturing of the arrows in the leather quiver.

Way of working

Shaft	Left - right hand
Hazel; Lack of a bonding substance.	Not applicable

Drawing

■ photo 1, 2, 3, 4
(Fig. 3A: a, b, c, d)


1

Type of tool and its description

Arrowhead formed by the pressure method;
using fabricator with a copper inset;
a flake blank obtained from the core without preparation by means of a mineral hammer stone;

Asymmetrical wings; a symmetrical, shallow notch;
bifacial, surface, edge retouching;

Dimensions: length 25 mm, width 16 mm, thickness 3 mm.

Work direction	Working time
Accidental rubbing of the leather.	60 hours - transport of the quiver; 660 hours - maturation of the arrows in the quiver.

Worked material

Arrowheads coming into contact with the dry surface of the leather quiver.

Raw material

Chocolate flint

Tool change during work

No macroscopically visible deformations;

Under the microscope - weak rounding of the top of the specimen: tip, edges and ridges. In addition, the presence of a generic weak polish was recorded.

Use-wear analysis

At the tip - matt, "greasy" polish "overlapping" the microrelief. It is characterised by the presence of a distinctive scattering and the lack of a clear contrast to the unmodified area;

Micropolish is the most intense in the protruding parts of the microtopography (edges, tip, ridges). Further away from the discussed areas the polish gradually disappears.

Photo 1, 2, 3, 4 (Fig. 3A: a, b, c, d).

Fig. 2. An example of the tool card (by D. Wolski)

USE-WEAR ANALYSIS

The use-wear (traceological) analysis was carried out in three stages (Fig. 3: I–III), during which the transformations of the microtexture of the arrowheads were recorded. Each phase of microscopic observation was preceded by inspecting the items on a macro scale, with the aim of detecting any morphological changes which may have resulted from use. However, the macroscopic view revealed no such changes.

The first stage consisted in careful microscopic observation of the relief of the newly produced items. Of course, no functional modifications were detected (e.g. Fig. 3: I).

During the subsequent phases of the experiment, the authors monitored deformations within the microtopography caused by the contact between the arrowheads and the inner layer of the leather quiver. In the middle of the testing phase, microscopic verification was carried out, related to the second stage of the project (Fig. 3: II). Two items (Fig. 1: 1, 4; Fig. 3: A, B) showed minor transformations: slight rounding of their tips, especially at the very top, but also of their side edges and ridges. No distinctive polish was detected.

In the third (and final) stage of the testing, almost all of the analysed items, except the obsidian arrowhead (cf. comments on the unique nature of microtraces on artefacts made of volcanic glass, Setzer 2004, 55–56) showed the subtle surface modifications mentioned above (Fig. 3: III). At this stage, polished surfaces, considered as a crucial diagnostic element, were noticed on two arrowheads (Fig. 3, A, B), those with still undeveloped microtraces recorded in the second phase. The structure of the polish corresponded to the transformations caused by work on soft animal tissues: skin and/or flesh. Some of the traces were so developed that they provided the basis for more detailed description of the polish and, in effect, for interpretation. They were matt, greasy and overlapping, scattered in a characteristic way, and they contrasted slightly with the areas without the deformation (Fig. 3, A: c, d; B: c). Significantly, the polish covered primarily the protruding parts of the texture, edges and ridges, and disappeared with the growing distance from those areas (Fig. 3, A: c; B: c). Additionally, both flint items with the polish showed ultimately an enlarged range of rounding and greater clarity in comparison with the second stage of the observation (see Fig. 3: II, III).

When discussing the functional modifications finally recorded on the items, it is worth considering the whole structure of the raw material with regard to the tool assemblage. Only the obsidian arrowhead did not show any discernible microtraces. As noted above, in the last phase of the observation, distinctive transformations of the microrelief were discerned on two replicas made of chocolate or Świeciechów flint. Three arrowheads made of Volhynian flint and single items made of Jurassic or Rügen flint had surface modifications still undeveloped when the experiment ended, and therefore they provided no basis for interpretation. They may be compared with Figure 3 (Fig. 3 A: b, B: b) and thus identified with the middle stage in the analysis of the two items for which the dynamics of the microwear formation was ultimately the most pronounced. It is likely that the use-wear traces

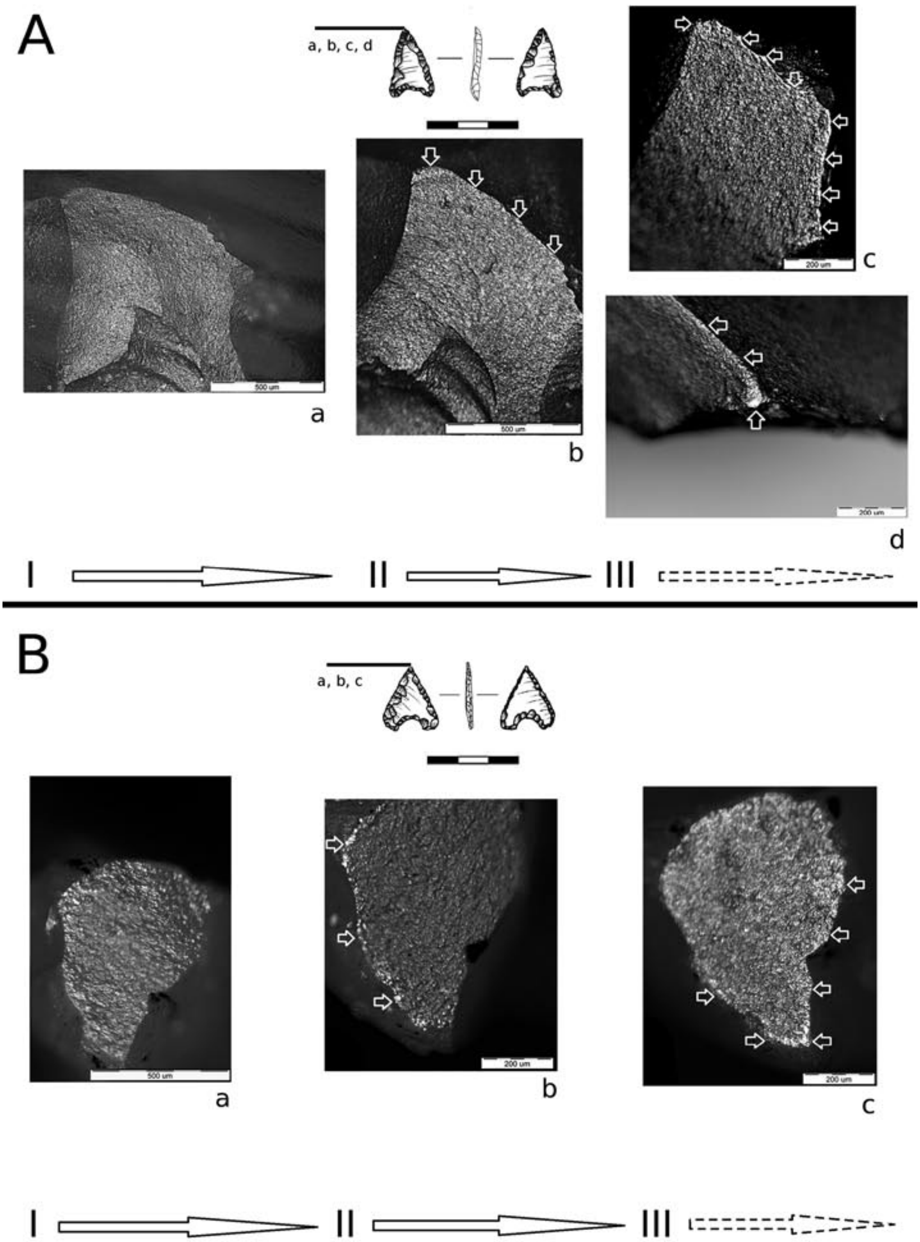

Fig. 3. Microtraces (rounding and polishing) on the surfaces of the arrowheads carried in the leather quiver; *I, II, III along with the arrows* show the stages of the observation during which intensifying modification of the microrelief has been recorded; *dashed arrow* indicates that further development of the modification might have taken place if the experiment had lasted longer. The applied magnification: 120 x and 150 x (Fig. by M. Kalita; photo by D. Wolski)

on all the arrowheads in the leather quiver would have increased in intensity with time. After a month of testing, however, clear patterns were documented only on the chocolate or Świeciechów flint items. Since the well-developed microtraces were recorded only on two types of rock, the question arises whether the obtained results may be applied to other functional analyses of artefacts. Research into the relationship between various raw materials can lead to interesting conclusions, e.g. about the differential rate of polish covering the flint structure (cf. Pyżewicz and Rozbiegalski 2012, 535–537). To make sense of such findings, however, discussion about the relationship between the type of rock and the development of polish should take place after receiving more numerous and more diverse data. Comprehensive analysis of microtrace formation in various categories of flint may be an interesting subject for further research.

It is now worth considering other possible determinants of the polish developing on the examined arrowheads. In general, factors affecting the changes in the working edge may be divided into static and dynamic. The former type includes the angle of the edge and the form of the item, the raw material of which the tool is made and the kind of the processed material. The dynamic category includes the nature of work done with the artefact (pressure, sequence, variability of the contact angle), the intensity of the work (gentle, intense, variable movement) and the degree of the work speed of the item (falling, rising; gradually or sharply) (cf. Pawlik 1995, 18). The experiment presented here involved primarily the static factors related to the random movement of the projectile points in the quiver. Although the dynamic factors should certainly be taken into account, they could not be measured in the case of the experimental sample. Moreover, other aspects may interfere with examining the formation of microtraces as well. As mentioned in the paragraph above, the major limiting factor is the number of items tested in the experiment, but the analysis of each determinant in terms of its contribution and significance to the modifications, however interesting, is beyond the scope of this study.

To sum up: despite the small number of the analysed items and a relatively short period of testing (approx. 1 month), the arrowheads showed the expected modifications. This was clearly reflected in almost all the items, two of them in particular. The hypothesis concerning the impact of the leather quiver on the flint arrowheads has thus proven to be accurate.

DISCUSSION

It may be assumed that the polished area would have expanded if the experiment had continued, and there would have been wider smoothing on the surfaces of the items, which were in direct contact with the leather quiver. Presumably, the diagnostic microtraces would also have shown on other arrowheads used in the experiment. The traces did not develop, due to the short time arranged for the experiment. Prehistoric archers had undoubtedly stored their arrows for much longer than the ones kept in the artificially created "laboratory" conditions. This may explain why the deformations visible on prehistoric artefacts are considerably more developed than those on their replicas (cf. Winiarska-Kabacińska 2008, 334, Fig. 4; Van Gijn 2010, 209, fig. 8.4).

The location of the modifications, sometimes very invasive, seems also to be important. Arrowheads from Orliska Sokolnickie 1 and Raciborowice Kolonia 1 and 2 (several items), subjected by Wolski to use-wear analysis, have shown matt polish and smoothing on their upper parts, while their other areas are free from deformations (unpublished data). Analogous changes in the microrelief have frequently been noted during use-wear analysis of materials recovered from other sites. Barbara Drobniewicz has observed strong smoothing on the tips of arrowheads which make up series recovered from the Corded Ware cemeteries in Koniusza (Drobniewicz 1979, 91–92) and Żukowa (Machnik 1966, 236, table XVII). Comparable results have been obtained in microscopic analysis of an assemblage of arrowheads from Zielona 3, a sepulchral site related to that taxonomic unit. Use-wear patterns such as polish, rounding or smoothing have been recorded not only on the tips of the examined artefacts, but also on their side edges and within their "wings" (Winiarska-Kabacińska 2008, 333–334). According to Annelou van Gijn, many arrowheads or, more precisely, their barbs found in the Netherlands and dated to the late Neolithic and Bronze Ages, are characterised by markedly blunt microrelief as well as rounding and polishing (van Gijn 2010, 200: fig. 8.1., 208–209; fig 8.4). Similar transformations have been recorded on Mesolithic microliths. Katarzyna Pyżewicz writes that this is mostly "[...] bilateral polish [...] usually accompanied by more or less intensive rounding of the protruding parts. It covers the entire side edges or separate areas, i.e. the places where potential use-wear traces may be expected to show (the putative working edges)" (Pyżewicz 2012, 100).

The described use-wear patterns show certain regularity: they have been recorded on specific items, i.e. arrowheads or insets, which are elements of throwing weapons. Moreover, the modifications have been noted in the same areas, limited to the tips, barbs and sometimes the side edges and ridges. Researchers agree on the functional origin of those deformations, explaining that they were caused by unspecified contact of the tools with soft animal tissue, usually skin. However, detailed interpretations differ markedly from one another, which may result from the unsatisfactory state of research into the precise relationship between the "skin" microtraces and the specific actions which occur during their development. Korobkowa states that arrowheads with those traces were used to pierce animal hide (Korobkowa 1999, 101; see also Winiarska-Kabacińska 2008, 334), while other authors accept other hypotheses as well. For example, Drobniewicz, quoting Tixier (1976, 21), writes that "[...] projectile points with two wings and a tang recovered from the site in Bordj Mallala in Algeria [...] were used for drilling ostrich eggs, as evidenced by the [...] smoothing on their tips and the linear traces transverse in relation to the longitudinal axis of the tool" (Drobniewicz 1979, 92–93).

The nature and distribution of the microwear traces on the arrowheads may be explained as resulting from: (1) an undetermined function related to the processing of animal carcasses; (2) the arrowhead hitting and penetrating animal soft tissues (Pyżewicz 2012, 100); (3) the cutting of a soft material (Drobniewicz, 91); or (4) contact with a haft (Winiarska-Kabacińska 2008, 334). A. van Gijn proposes yet another interpretation. He supposes that the barbs of the arrowheads were intentionally abraded with soft rock (presumably, with sandstone or the like) to give them better penetrating power; in consequence, when an arrowhead pierced someone's body in the battle, it was more difficult to remove and often caused quicker death (2010, 208–209). The fact that the microtraces have sometimes been recorded only on the "wings" of the artefacts is worth considering. This may be explained by a different way of storing the arrows. The points could have been kept temporarily in the shaft with their tips turned upwards, when only their barbs touched the bottom of the leather quiver. As a result, taking the tools out of the quiver was much easier, and the risk of damaging them was minimised (Bernadeta Kufel-Diakowska in personal communication). But the location of the changes may be accounted for in yet another way. Some arrowheads could have been modified intentionally, which removed the use-wear traces from their lateral parts and tips, leaving the marks only on their barbs.

Notwithstanding the above theories, the hypothesis concerning the effect of the leather quiver on the arrowheads kept inside it seems plausible; moreover, it has been supported by the experimental empirical research. However, the recorded microtraces caused by the storage and transport of the arrowheads inside the quiver cannot at present be distinguished from the deformations resulting from work on animal soft tissue (cf. Pyżewicz 2013, 243–244). This necessitates selective interpretation. To settle the problem in terms of the homogeneous nature of the functional modifications, attention should be paid to the details of the location and the varying intensity of the use-wear patterns recorded on the arrowheads. Such an approach may create an opportunity to find regularities in the distribution of the traces, and this in turn may provide further solutions to the issue.

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