Bone and Antler

Softening techniques in prehistory of the North Eastern part of the Polish Lowlands in the light of experimental archaeology and micro trace analysis

The aim of the analysis is to find which methods of softening bone and antler were most effective for when using stone tools. Four methods were analysed: long term immersion in water, boiling in water, soaking in sorrel and soaking in sour milk. The results of micro trace analysis carried out on the tools used in the experiments are also presented, the aim being to compare the micro traces on the tools used to work the softened bone/antler.

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1. Introduction

One of the basic questions looked at when describing organic artifacts is the way they were made. The reconstruction of the actions used to make them is without a doubt very important. It allows us to identify the techniques used and the way tools were operated to produce the items, this in turn gives us some information on the level of knowledge and the skill of those who made them. How can we do this however when these artifacts have not been preserved for most of the North East of the Polish Lowlands? What to do, if we only have an assemblage of stone artifacts and a few cultural objects of unsure function? The questions after all remain the same: how and what was worked, what tools were used etc. Experimental archaeology and micro trace analysis can be of great help here.

2. The goals of the article

The aim of this work is the presentation and analysis of some techniques for softening bone and antler,(1) which could be available to those using these resources during the Stone Age as well as their verification during experiments on both materials with the use of flint tools.

This article has been divided into three parts. The first for these describes techniques of softening both the studied materials. The basis for conclusions here was mainly experimental archaeology.

The second part of this work describes the results of a trace analysis which was conducted on the stone tools used in the experiments. The aim of the trace analysis was to describe and characterize the different signatures left on the stone tools by different methods and materials used in these experiments.

The third part of this work was an attempt to identify softening techniques used in the Terminal Paleolithic, Mesolithic and Neolithic periods in the north east parts of the Polish Lowland.(2) This was based upon trace analysis of stone tools from archaeological contexts and the results of experimental work from the previous chapters.

The issues addressed in this work are inseparably connected with the different ways of softening bone/antler in the Stone Age. The described methods of softening bone and antler are known from ethnographic parallels and archaeological experiments. The use of some of these is suggested by archaeological finds. The analysis was intended to identify the most useful of these methods and to confront these with evidence found on archaeological artifacts. This allows us to suggest the methods most likely to have been used in prehistory.

The complexity of the process of making bone tools as well as the questions asked during the analysis in this work has imposed certain limitations. The treatment of bone and antler with the use of stone tools is a complicated process in which the stone tools are used in many ways (sawing, scraping, scratching, drilling etc.). In order to produce more concise and clear results(3) one of these actions had to be chosen, in this case it was sawing. Sawing was preferred to other actions because the length of the working edge and the type of marks left on it allowed for a more precise identification and comparison. Also the longer working edge on the stone tool made it more probable that the traces were preserved on the artifacts recovered from archaeological contexts. The character of the sawing action was also important because it is usually the earliest action taken (sawing a small piece to be worked out of a bigger fragment) when compared to other actions used to form a bone/antler object.

3. Methods adopted

The work was based on two analytical methods: micro trace analysis on stone tools and experimental archaeology. Micro trace analysis is a method which attempts to identify use wear on archaeological artifacts (tools) which makes it possible to find their function. For the purpose of this work artifacts from 20 sites from the terminal Paleolithic through to the Neolithic were used. Microscopic analysis was conducted using a Nikon SMZ-2T microscope-

(1) In order to simplify the discussion an abbreviation "bone/antler" will be used. Treating these to material together is justified by the fact that the use wear traces on tools used to work these materials are almost identical (*Korobkowa 1999*, 43).
(2) On most sites, taken into account in this article, organic materials such as bone and antler have not been preserved, or have only been preserved in small fragments. Such conditions occur on most Stone Age sites of north east parts of the Polish Lowlands (especially those from Chełmno Land). Micro trace analysis of stone tools found here may be one of few methods which make it possible to get to know methods of working organic materials in this area.
(3) Especially the differences in use wear traces, which come from working materials and for which different softening methods have been used.

computer set. This equipment allows us to zoom in on an object upto 12,6×, it also allows us to digitize and rework the computer images. Photos included in this work were taken using a Zeiss-Axiotech microscope-computer set, which allows zoom up to 50×. Flint tools which were subject to microanalysis were cleaned with pure ethanol. Tools used in experiments were additionally washed thoroughly with detergent. Experiments described in this work are only examples of ones conducted at an earlier date, they do however form the basis for the conclusions drawn here. Each experiment was preceded by a series of experiments confirming the observations which the author makes here. They can therefore be accepted as representative of all the experiments conducted by the author up to this date. Steps were also taken to make sure that as many "outside" factors were eliminated from the experiments as possible in order to make the results more representative and uniform in method. For all experiments unretouched blades of similar length (shortened if necessary) were used, all the blades were struck off the same core of chocolate coloured flint. The time of all experiments was also made uniform, one hour was accepted as sufficient(4) to leave clear traces on tools. Similar rules were applied to bone and antler material, all antler came from one red deer shedding. All bone used during the experiment was fresh bovine tibias from one animal. The choice of bone type is not accidental. It comes from experience gained during earlier experiments. Bones of more delicate structure (for example ribs) soften too much and too quickly, thus the ease of working in this type of material could lead to premature finishing of the experiment. This would have a detrimental effect on the intensity and type of were left on the tools used in the experiments, and could lead to errors in the conclusions. All experiments were conducted by one person.

Each of the described methods was conducted separately for bone and antler.

4. Archaeological finds

The decisive majority of Stone Age bone and antler artifacts found so far, are finished or almost finished objects. They are usually very well smoothed and polished, this stops us from finding out how they were worked in the earlier stages of their production. Others are half finished products in different stages of production. Usually they are covered with clearly readable cut and drilling marks of different kinds, these can be useful for the purpose of defining the tools with which they were made. Of course the can help us to study only a small part of the production process, and not its entire course. Even aligning a series of such artifacts in a technological line will not give as the full knowledge concerning the process of their production.(5) This is because we can only see the "separate images" and not the whole "picture". We cannot say what was happening with the worked materials during the stages of production which are not documented on uncovered artifacts. Were they additionally worked in some way which is impossible for us to trace in present times?

In this part of the article we will try to characterize artifacts which can give us some information about the possible techniques of softening bone and antler in Stone Age.

The utilization of bone and antler softening methods in Stone Age is a matter under discussion. Even though a decisive majority of researchers studying this problem have no doubt that such methods were employed (*Bagniewski 1992; Żurowski 1974; Kempisty 1961*), so far not one archaeological artifact, which could definitely confirm this, has been uncovered. The form of discovered items usually only suggests that it would be impossible to produce them without softening the raw material used for their production. Antler finds from Stellmoor A and Meindorf sites (*Lindemann 2000*) are the only artifacts which seem to be directly connected with softening of the raw material. The recovered antler deposits had been left in shallow water for the purpose of softening (Lindemann's interpretation). Antlers were showing sings of some introductory work. Artifacts from Meindorf are also covered with grooves and drilling holes which could be interpreted as the traces of sampling the softness of the material during the processing. Both of these finds are associated with Ahrensburgian Culture. Another find which could be a direct proof of utilizing softening processes in the Stone Age period, is the equipment of two, burials (mentioned by K. Żurowski *1974*) from Władimicz (presently known as burials from Sungir near Włodzimierz). The burials are dated to the Upper Paleolithic (*Renfrew, Bahn 2002*, 373). The skeletons were equipped with javelins made out of mammoth tusks. The spearheads of both javelins were straight. Utilization of softening technique seems to be necessary for achieving such results. Bone armlets often found in burials associated with Brzesko-Kuyavian Group of Lengyel Culture are an example of a similar character (B*ednarczyk, Czerniak, Kośko 1980; Jażdżewski 1938,* 41-42; *Maciejewski 1952*, 187; *Rajewski 1958*, 30). These, usually beautifully decorated, items are most often made out of ox ribs (*Żurowski 1974*), which had to have been bent to form for the required shape. The degree to which the bones are bent suggests that this could not have been

(4) This time was shorter if the tool was damaged before its culmination.

(5) Compare remarks concerning the so called operation chain (*Inizan, Roche, Tixier 1992*)

(6) Softening of raw material was also required during the production of decorated bone and antler artifacts of the Mesolithic period (*Płonka 2003; Galiński 2002a, b*).

(7) Bone is built out of organic substances (aprox. 35 %) and non organic substances (aprox. 65 %). The non organic part of the bone gives it its strength, while the organic substances give it elasticity (*Cnotliwy 1973*, 24-25). About 51 % of the bone is made up of calcium phosphates (according to *Lindenmann 2000* - 85 %), 11% is made up of calcium carbonates and the rest is: calcium fluoride, magnesium phosphates and magnesium salts. The precise chemical make up of antler is unknown by me, but it is very similar to bone (*Hodges 1964*, 153; *Owen 1993*, 7; *Lindemann 2000*,11)

(8) Quoted literature includes positions where bone and antler softening is not described in detail and is only mentioned as one of the working methods.

(9) Or both.

done without softening them first (*Jażdżewski 1938*). Such hypothesis has been confirmed by the experimental investigation of K. Żurowski (*1974*), as well as by the independent experiments of this article's author.

The above mentioned artifacts seem to be all of products which can directly confirm the utilization of softening technique in Stone Age period. Yet the conducted experiments suggest that practically all the more complex items made of those materials are a confirmation of utilization of this technique during this period. Most of them would simply be impossible to make with flint tools without softening the bone or antler of which they were made. The ineffectiveness of flint tools working in unsoftened bone is decisive. As the described experiment will prove, flint tools are inappropriate for working bone and antler material. At the same time they are very suitable for working softened material. Assuming that such presumption is correct, we could state that the skill of softening bone and antler material was already known in Upper Paleolithic period, which is confirmed by multiplicity of known forms and decorations from this period (*Chochorowska 2002; Kaczanowski, Kozłowski 1998,* fig. 21, 29; *Leroi-Gourhan 1996*, 104-112), especially characteristic it richness of form of figural art (*Kempisty 1961*; *Leroi-Gourhan 1966*, 102).[6]

5. Methods of working antler and bone

Both bone and antler are hard and resistant materials to work with, especially when using stone tools.[7] Therefore, when attempting to work these materials it is necessary to soften them. This process is not easy because the aim is not merely to soften the material but to make sure that when finished it will return to its normal hardness durability and elasticity. Both bone and antler can of course be worked without softening but as is demonstrated in this work, this is very hard and time consuming work.

Much has been written about the necessity of softening bone/antler (*Bagniewski 1992*, 18; *Cnotliwy 1956*; *1973*, *Hilczerówna 1961*; *Owen 1993* – more literature there). Quite a lot has also been written about method of achieving this. The most commonly mentioned[8] methods are immersing in water (*Cnotliwy 1956*, 152-154; *Edholm 1999*, 74; *Lindemann 2000*, 8; *MacGregor 1985*, 63; *Newcomer 1976*, 293; *Schibler 2001*, 52) and boiling in water (*Baales 1996*; *Cnotliwy 1973*, 41; *Izjumowa 1949*, 19; *Szafrański 1961*, 44; *Watts 1999*, 62; *Żurowski K. 1974*, 3-23; *Tamla Ü., Maldre L. 2001*, 372; *Zhilin M. G. 2001*, 150). More rarely mentioned are: softening in sorrel (*Kempisty A. 1961*, 138; *MacGregor 1985*, 63-64; *Żurowski 1950*, 1974; *Drzewicz A. 2004*, 48-52), sour milk (*Żurowski 1974*, 3-23; *Drzewicz A. 2004*, 48-52), formic acid (*Pawlik A. 1992*, 57), ashes or lye[9] (*Bagniewski 1992*, 18; *Moszyński 1929*, 338, *Rajewski 1950*), water with ashes (*Bagniewski 1992*, 18), oil (*Hołubowicz 1956*, 144) and, known only from ethnographic observations, in urine (*Newcomer 1976*, 293; *Hanh J., Scheer A., Waibel O. 1991*, 33). In this work the focus was on four methods of softening antler and bone, and their usefulness in working these materials with flint tools. Described here is the authors experience in softening these materials by: immersion in water, boiling in water, immersion in sour milk and immersion in diced sorrel. Also included in this work are examples of experiments on unsoftened bone and antler, they are meant as a comparison for experiments which use softened antler and bone. The number and types of tools used in experiments are showed in **tables 1 and 2**. The ta-

Type of tool	Method	Immersing in water	Boiling in water	Softening in sorrel	Softening in sour milk	Unsoftened material
Scraper		3	5	6	-	2
Saw		6	12	9	4	17
Whittling knife		3	4	1	-	-
Borer		1	2	2	-	-
Burin		-	4	2	2	-
Chisel		-	-	2	-	-
Totals		**13**	**27**	**22**	**6**	**19**

■ **Table 1** The number and types of tools used in experiments with the bone softening methods.

Type of tool	Method	Immersing in water	Boiling in water	Softening in sorrel	Softening in sour milk	Unsoftened material
Scraper		2	2	1	2	2
Saw		3	4	3	3	5
Whittling knife			2			
Borer		2				
Burin		2	2	4	2	3
Chisel			1			
Totals		**9**	**11**	**8**	**7**	**10**

■ **Table 2** The number and types of tools used in experiments with the antler softening methods.

bles give information only about the number of experimental tools used in the wear analysis, they do not speak about the number of experiments made with the bone/antler softening methods.

5.1 Experiments with bone and antler softening

Working unsoftened bone and antler

Experiments described in **table 3** are meant to demonstrate the difference between working softened bone/antler and material which has not been softened. The huge contrast between the working quality of softened and unsoftened materials as well as the difference in the effectiveness of stone tools in both these "types" of materials may be a good starting point for discussion about bone and antler softening methods in prehistory. I haven't found any ethnographic examples of working untreated material with stone tools, but there are many experimental works on this subject (*Keeley 1980*, 42-49, 55-60; S*chibler 2001*, 52; *Hahn, Hein 1995*, 18-21; *Korobkova 1999*, 42-45, 55-58, 71-73, 108-109 and many more).

Working bone and antler softened by immersion in water

This is one of the simplest bone and antler softening methods, it is also one of the lengthiest, and it is simply to immerse the material in water for many days. This technique has often been used in experiments which aim to reconstruct the prehistoric softening methods of bone/antler (*Edholm 1999; Lindemann 2000; Wescott, Holladay 1999*). It is also known from ethnographic observation. Until recently it was still being used by Caribou hunters from west Greenland (*Lindemann 2000*). It is also the only method of softening bone/antler whose use seems to be confirmed in archaeological material. Such suggestions have been made towards finds from sites like Stellmoor A and Meindorf (*Lindemann 2000*). Some scientists maintain that it could have also been used in the Mesolithic (*Zhilin 2001*, 150). Its beginnings may have been as far as the upper Paleolithic.[10]

Working bone and antler softened by boiling in water

Boiling in water is a derivative of the method described above, but it is a lot less time consuming, which causes it to be among the most used methods[11] of softening bone and antler.[12] "Boiling in water" is a softening technique which has already been written about in archaeological literature *(Cnotliwy 1973,* 41; *Żurawski 1974*). It is thought of as one of the most useful, especially in the initial stages of working bone (*Tamala, Maldre 2001*, 372; *Watts 1999*). More over it is a method known from ethnographic observation. Untill recently it was used by North American Indians (*Baales 1996*) and Asian peoples: the Czukcz, the Koriak and the Kamchedal (*Izjumowa 1949*, 19).[13] Some scholars suggest that it was used in the Mesolithic (*Zhilin 2001*, 150). Boiling is the only bone/antler softening method described by ancient written sources, it was mentioned by Pausonius and Plutarch (after *Żurawski 1974*, 4). In Poland experiments with this method were conducted by W. Szafrański (*1961*, 44).

Working bone and antler softened by immersion in sorrel

Softening in diced sorrel is known only from experiments. The softening agent here is the acid which acts while the bone/antler is immersed. Bone can be softened with acid which removes its inorganic parts. This process is supposed to turn the bone into a soft, elastic collagen mass, which is much easier to work in than unsoftened material (*Kokabi 1994*). In Poland this method has been described by K. Żurowski (*1950*; 1974). He was the first and probably the only scholar so far to experiment in this area in Polish archaeology.

The sorrel used in this experiment had not been diced. Boiling water was simply poured on the sorrel which was than set aside for one week to sour. The materials (bone and antler) were then put into it and left aside for another month. A litmus paper measurement showed the sorrel to have pH of 4.

Working bone and antler softened by immersion in sour milk

As with the sorrel method this one is also known only from experimental studies. In Poland experiments with this method have been conducted by K. Żurowski (*1974*). Softening in milk is very similar to the sorrel method. The softening agent is the acid which is released while the materials are soaking in the milk.

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(10) In an experiment conducted by J. Hahn and W. Hein, which intended to reconstruct Aurignac bone flutes, it was suggested that this method was used in that period (*Hahn, Hein 1999*).

(11) By scientists experimenting with techniques of bone and antler working.

(12) It is also a method used by „traditional" societies to soften and bend wood (*Comstock 1993*b).

(13) Even in the XX century this method was used to soften bovine horns in Northern Poland (*Łęga 1960*, 73).

(14) In this experiment both materials were soaked in sour milk for about one month.

(15) An analysis of the character of the softening effect showed it to be very similar to the effect achieved with water. This is probably not a coincidence. It was probably the water (of which milk is mainly composed) which was the deciding factor in the way the materials softened. This is confirmed by observations of the processes which occurred in the standing milk. After 1.5 weeks three layers (with time more clearly divided) were visible in the milk, on the top a thick layer of fat formed, under it a couple of centimeters of a white sediment (most likely the proteins). The rest of the container (70-80 %) was taken up by a clear liquid – water.

(16) Because of the presence of other acids (fatty) in the liquid and the lack of proper equipment it was impossible to clearly measure the percentage of the milk acid solution. These factors mean that most of the time the pH level is not accepted to be strong enough (*Budsławski, Drabent 1972*, p. 180).

(17) The weak softening effect on both materials was confirmed by samples of both materials.

(18) During K. Żurowski's experiment just four days were enough to soften the bone (*Żurowski 1974*).

(19) It is impossible to establish the exact temperature. The experiment was conducted during the autumn, and the milk was standing outside. The average temperature of the surrounding most probably did not exceed 10 °C.

Working unsoftened bone	Working unsoftened antler
A fragment of bovina tibia, 8 cm long and up to 0.9 cm thick was used. After just two minutes of work the blade started to show the first signs of wear (single flakes fell out). At this point the notch on the bone was still practically invisible. After another two minutes the working edge was covered with a regular multi degree working retouch. However the blade was still effective and the notch was now 1 mm deep (and about 7 cm long). After another 3 minutes the effectiveness of the working edge visibly lessened. Its working edge become more regular and stopped flaking off as easily. The depth of the notch changed almost unnoticeably. After another 8 minutes of work the experiment was ended (all together 15 minutes). The blade was still usable, but its working edge was so blunt that it was ineffective. During that time the notch on the bone reached 2 mm in depth. **Conclusion:** Bone, which has not been softened, is particularly difficult to work with stone tools, because they damage so quickly that to make one, not very complex, item would require several blades.	Working edge used during the experiment was central part of the blade and that which is closest to the bulb of percussion. This way of working was dictated by the shape of the tool. An antler piece 10 cm long and 2.5 cm wide was used. The first damage on the blade (single flake off) was noticed after 2 minutes. After another 3 minutes multi degree retouch developed on some parts of the blade. The tool started to get stuck in the 1 mm notch. Within the next 5 minutes of work the depth of the notch increased to 2 mm. The blade had become covered with a tall multi degree use wear retouch. The working edge become fairly ineffective, however it was still usable. After another 2 minutes the blade became so blunt that further work was impossible. Further effective work would require a sharpening retouch of the blade or change of the tool. Total working time was 12 minutes. **Conclusion:** Antler, similarly to unsoftened bone, is a difficult material to work. The experiment described above showed that working in unsoftened antler with stone tools is ineffective. Cutting out of one antler sliver would require several stone blades.

■ **Tab. 3** Working unsoftened bone and antler.

Experiments

The first experiments[14] were only a partial success, although both bone and antler were softened slightly. The softening effect though was not the result of the milk.[15] During the experiment the milk was tested several times with litmus papers, but the pH proved to be close to neutral through out the process, at first the pH was 6.5 – 6, later it dropped but only to 5, which is only a very weak acid.[16] After that it did not drop any further. The released acid was therefore too weak to soften bone or antler.[17]

The failure of this part of the experiment was not due to poor quality of milk, as all milk used in the experiment was fresh milk, in order to avoid complications with processed milk. The time of the experiment also was long enough.[18] The deciding factor (as later experiments have shown) was low temperature,[19] which prevented the milk from fully souring. Another problem was that meat was not cleaned off the bone carefully enough and the remaining fragments increased the rotting effects. Further experiments were conducted with a temperature of 25 °C and the materials (bone) were first boiled and cleaned. Before the materials were immersed in the milk it was set aside for 5 days in 30 °C temperature, which allowed full souring. In the moment of immersing the materials the pH of the milk was 4.

Experiments are summarised in **table 4.**

5.2 Conclusions

Working bone

All methods of bone softening described in this work have their advantages and their use definitely makes working bone easier. Probably the best of the four methods is immersion in water. The only disadvantage is that bone has to be immersed in water for a long time, however this results in a very well softened bone throughout its matrix and makes working very easy.

Two methods come in second (equal in usefulness as far as the author is concerned), boiling in water and immersion in sour milk. Boiling in water is a very quick method, work can be started within a few minutes of when the water starts to boil. This method though has disadvantages. First of all the softening effect is short lived, also boiling only affects the surface. For these reasons the bone has to be reimmersed in boiling water very often. Also too much boiling damages the material.

Immersion in sour milk is a very good method for softening thin bones, it allows you to bend the material. The disadvantage is that in the case of larger bones the effect is only surface (aprox. 3 mm) deep.

Of the four methods immersion in sorrel seems to be least useful. The main advantage is that the softened bone is more elastic thus allowing you to bend it. However the list of disadvantages is long: a long time for the method to work, seasonal availability of the plant and the character of the attained effect and it's usefulness for working the material with flint tools.

However it has to be said that all four methods described do soften the bone and definitely make it easier to work the material. The effectiveness of the stone tool is increased more than tenfold, when compared with non softened bone. Working bone with stone tools without any form of softening seems entirely ineffective and is practically pointless in the view of the author.

Immersion in water	
Bone	**Antler**
Method Water immersion is one of the most effective softening methods. It is a mistake to start working it too early though. If the material has not been soaked for long enough it will only be softened on the surface. The best way of controlling how far in the water has soaked is by periodical drilling into the material. After the material has soaked for long enough it becomes easy to work. Water immersion (like other softening methods) is not useful for working on whole bones (large animal tibia). For the best effect immerse only fragments. Water should have immediate access to both the outside and the inside of the bones. Division of bone prior to their softening is also confirmed ethnographically (*Baales 1996*). The basic advantage of this method is that it works throughout the thickness of the bone being worked. Also very important is the length of time the bone remains soft after it is taken out of water. In this method it is long enough to allow working without additional breaks to sustain the effect. Of course if the bone is worked for a long time eventually the bone starts to harden and it does become necessary to immerse it again. However if the bone was well softened the first time then breaks to re soak it shouldn't be longer than one day. Immersion in water allows bone to be bent (*Newcomer 1976*, 293).(i) So far experiments have shown that this is only possible with fairly thin bone (up to about 2.5 mm). Attempting to bend thicker bones has so far resulted in their destruction, this could however be caused by incorrect working methods. In any case it is a delicate process which requires much care to be taken with the bone.	**Method** Water immersion is a good way to soften antler (*Schibler 2001*, 52), although as the experiments have shown bone is better softened by this method. The advantages of this method, when used on antler, are the same as with bone. The main advantage again is the depth of the effect, which allows work to continue without breaks to soften further layers of the antler. As important is the long time which the effect lasts, although as the experiments show it is shorter than that observed with bone. It allows any simple object to be made without the need for further softening. During the experiment no attempts were made to bend the antler objects. However taking into account the observed intensity of the softening effect it should be possible, especially with thinner objects .(ii)
Tool As has been mentioned above, water immersion is one of the best ways to soften bone. This fact has great implication for the tools which are used to work material softened in this way. Stone tools are particularly resistant to damage here, and very effective. The main factors which make working bone easier are the degree to which it is softened and the time period the effect lasts. The fact that the bone is softened through out it's thickness means that the working tool does not strike "layers" of harder material (which does happen with other softening methods), and therefore the blade does not get chipped off. The effectiveness and resistance to damage of stone tools is such that often simple short term work in this material does not leave any traces on the blade.(iii) The longest lasting tools were used for up to 2-2.5 hours and could make many (more than ten each) bone objects.	**Tool** A flint tool working in water softened antler behaves similarly to one which works in water softened bone. The work is made easier by the intensity of the effect as well as the time it lasts. The degree to which the tool is softened means that it practically doesn't get chipped and the only effect the work has is a slow blunting of the blade. While working with antler softened in this way it is important to remember that it should be constantly moist,(iv) but not wet. As with water softened bone the flint tools proved particularly effective here and could last for up to 2-2.5 hours in some cases, and in that time could be used to make several simple objects.

■ **Tab. 4a** Working softened bone and antler.

i Bill Holm writes abort the usage of this method to prepare the material for production of American composite bows (*Holm 1982*, p. 130).
ii These suppositions are confirmed by experiments conducted by B. Holm (*Holm 1982*).
iii No traces are visible even under the microscope.
iv The necessity of moisturizing hard organic materials during work was also noticed by A. Pawlik (*1993*).

Boiling in water	
Bone	**Antler**
Method Boiling in water may be accepted as a fairly good bone softening method. Its basic advantage is the fact that it is "quick". It does have certain limits though, larger bones soften only on the surface and it is therefore not possible to gain effects which would allow the bone to be safely bent. Bending bone is only possible when boiling fairly thin bones, for example ribs, under the condition that they do not come from animals larger than the modern pig. This method has another disadvantage, experiments have shown that lengthy boiling (about 8-9 hours) damages the internal structure of the bone, as it washes out the organic parts of the bone. The bone becomes brittle and useless. Another aspect of this method is the constant need for re soaking the bone. After it is taken out of water it quickly hardens and allows only a few minutes of effective work.[i] The degree of the softening effect depends very much on its moisture. Even after a few minutes of re boiling the bone allows further work to be recommenced. The boiling time does not matter much here (with the exception of afore mentioned "over boiling"), after a few minutes of boiling the bone is soft enough for the work to commence.	**Method** Boiling in water is without a doubt one of the best ways to soften antler. This material yields much more to boiling than bone. The differences in the softening effect on both materials are clearly visible. Although bone softened after just a few minutes and antler took about two hours of boiling, after this time the softening effect increased in steps, after this point it also surpassed the effect boiling had on bone. Despite this difference the way of working is the same as with bone, after drying the antler becomes hard immediately, it therefore needs to be immersed in boiling water often. But again, a few minutes of reboiling returns the antler to its soft state. The thickness of the antler fragment (unlike the situation we had with bone) has little importance. Of course in thicker fragments the softening process takes longer. However the way antler softens allows for processing even very thick fragments. The described softening method also allows the antler to be bent,[ii] this does still require care and some experience. It is only "safe" to straighten already cut slivers (not thicker than a couple of millimeters) by a little. Unlike bone the effect of "over boiling" hasn't, as yet, been noticed.
Tool Boiling in water as with any other softening methods, noticeably increases the effectiveness of the flint tool, working in material prepared this way. The tool can work several times longer than in unsoftened material. It allows for the carrying out of planned work without the need to change or retouch the tool. Working in boiled bone allows the flint tool to work upto 2.5-3 hours. In this time you can make several needles, perforators or blades. At the same time the method has some limitations, the need to re boil the bone object extends the time needed to do planned work.	**Tool** Antler softened with boiling is a very easy material to work in with flint tools. It is important to make sure the material is soft enough before work commences, as was mentioned earlier the softening takes effect in leaps, thus starting the work too early can result in quick destruction of the tool. After softening the antler no longer poses problems, which meant that the tool is damaged more slowly than in softened bone. The only problem is the outer layer of the antler (1 mm usually, although it can be thicker), which is harder than the inside. As with bone, one stone tool can be used to make several objects out of this material.

■ **Tab. 4b** Working softened bone and antler.

i Similar results as mentioned by K. Żurowski (*1974*).
ii Compare with B. Holm's experiments (*Holm 1982*).

Immersion in sorrel	
Bone	**Antler**
Method Soaking bone in sorrel is a fairly good softening method. Its main advantage is the fact that it allows the bone to be bent.[i] This method does also have many disadvantages, the biggest problem is the length of time which it takes to soften the material. Soaking bone in sorrel which has had time to sour already, makes no difference as the extra time it takes to prepare the sour sorrel equalizes this (*Żurowski 1974*). Sorrel is also a seasonal plant, which means that this technique can be used only over its short vegetation period[ii] and the only way to preserve sorrel (known to the author) is to freeze it.[iii] Working bone softened this way in its own rights poses no special problems, the bone is softened evenly and the effect lasts for a fairly long time. It should however be noted that the softening effect is not as good[iv] as with other methods described in this article. The time in the sorrel slurry does not increase the softening effect much.[v] In the longest conducted experiment so far the materials (bone and antler) were soaked in sorrel for 7 weeks, this did not increase the softening effect reached after one month.	**Method** Soaking antler in sorrel is a fairly good way of softening it. The effect is probably more acute than in the case of bone. The method does however have a range of disadvantages[vi] which in my mind eliminate it from being a primary softening technique for antler. Similarly as with bone the advantage is the depth of the effect and its duration. It allows almost any small item to be made without additional softening. It should be pointed out though that the character of the softening effect[vii] makes working this material a lengthy process.
Tool Working bone softened with sorrel can cause some problems. The bone is not softened as much as with other methods and the tools are used up quicker. The advantage of this method is the way the bone is softened, the effect is even and lasts for a long time before the bone needs to be resoftened. Working materials softened in this way is easy and effective despite the increased work investment. The bone has to be moisturized often to prevent the tool from getting stuck.	**Tool** The way in which antler is softened by sorrel allows the tool to work in it for a long time, some blades have served as long as 2.5-3 hours. The edge of the tool working in sorrel practically doesn't get retouched. The blade blunts in such a way that the thinnest parts of it is rubbed down and rounded, this type of micro retouch is similar to that observed on blades used to cut meat. As with other methods of softening it is important to remember moisturizing the object being worked.

■ **Tab. 4c** Working softened bone and antler.

i This statement is confirmed by experiments conducted by K. Żurowski (*1950*, *1974*) and independently by experiments conducted by the author of this article.
ii Not to mention that in many areas where bone and antler have been worked sorrel does not grow, because of climatic or soil conditions.
iii The entire process is also made fairly unpleasant by the (to put it delicately) unpleasant smell of the sour sorrel and the material soaked in it. We can expect that this did not bother our ancestors as much as the whole process would have been conducted outside in fresh air (and after all what do we know of how they would have treated this smell?). I advise anyone who wishes to argue this point to conduct their own experiment before they comment.
iv At lest that seems to be what experiments conducted by the author of this article show.
v After the first month.
vi Already described in the description of experiment no. 7.
vii The antler is evenly softened but it is fairly hard and difficult to work.

<table>
<tr><th colspan="2">Immersion in sour milk</th></tr>
<tr><th>Bone</th><th>Antler</th></tr>
<tr><td>Method

Softening with sour milk is a good method of softening bone, however it has some limits. It is undeniably a good way of softening thin pieces of bone. Working thicker elements may require further softening because of the quick re-hardening of the material being worked. The maximal depth of the effect (in these experiments) was 3- 3.5 mm, this is not enough to work with thicker bones. The depth of the effect can not be increased because of the aforementioned decomposition of the milk after the first week. Perhaps a good idea is to refresh (exchange) the sour milk every few days. I did not try it.

Soaking in sour milk does allow the bone to be bent, this was proven by K. Żurowski's experiments (1974) and independently by the author.

While working it is important to remember to moisturise the material as this makes the process easier.</td><td>Method

Soaking in sour milk (when compared to other tested methods) is not the best way of softening antler. It is useful when working small objects. But larger items may require other methods as the antler starts to harden after just 30 minutes of being taken out of the milk. This fact means that longer work is only possible with more breaks for resoftening of the material. These breaks get longer with time as soaking the material for a short time only allows another few minutes of work. Over time the antler hardens quicker and quicker, and requires longer breaks in the milk. A good way of solving this problem would be long (few day) breaks, however the problem of milk disintegration remains.</td></tr>
<tr><td>Tool

Working bone softened with sour milk is without doubt easy, this was confirmed by the above described experiment, where during one hour of work the tool practically did not change at all. As other experiments have shown it could have been used for at lest another hour. The tool almost doesn't get chipped, a delicate retouch is only formed when the tool breaks through to the unsoftened layer of bone. The blunting of the tool is caused by its rubbing down rather than chipping.</td><td>Tool

Working antler softened in this way is fairly easy, problems may appear when it starts to harden, which can be easily eliminated by resoaking it in milk. The tool working in antler softened with milk behaves much like the tool used in bone softened in the same way, and requires the same treatment. As with bone it is good to moisturize the antler often.</td></tr>
</table>

■ **Tab. 4d** Working softened bone and antler.

Working antler

On the basis of conducted experiments it is clear that antler responds differently to softening methods than bone. Some techniques work better on bone than on antler and vice versa. In the case of antler there is no one method which works best. All applied methods work well on this material. However there are some differences between them which allow us to distinguish the most useful techniques. The borders between the different methods are not as clear as they are when softening bone.

Probably the most useful methods for softening antler are long term immersion in water and boiling in water. As with bone the biggest advantage of boiling antler in water is the fairly short time necessary to achieve the softening effect. The intensity of the achieved effect is also important here, antler softens to a far greater degree than bone, although it requires longer boiling. The disadvantage again is the need to return the material to boiling water often, thus causing an undesired waste of time and breaks in work.

The biggest advantage of softening antler by long term immersion in water is the longevity of the effect as well as the depth of the effect. This method allows you to finish work on the material without additional softening.

Unlike bone antler is better softened by immersion in diced sorrel than in sour milk. The basic disadvantages of immersion in diced sorrel remain the same as before, however it achieves more in depth and long term effect on antler than sour milk. Sour milk is only useful on antler if we are dealing with a thin sliver which requires little shaping work.

However as with bone all described techniques of softening antler definitely make it easier to work. Shaping unsoftened antler with flint tools is very difficult and particularly ineffective.

6. Wear traces on flint tools

This part of the article describes the use wear traces registered on tools used in the experiments. The description use the terminology introduced by G. F. Korobkowa (*1999*, 17-21). The rules for their identification and documentation have been described by J. Małecka-Kukawka (*2001*, 22-23).

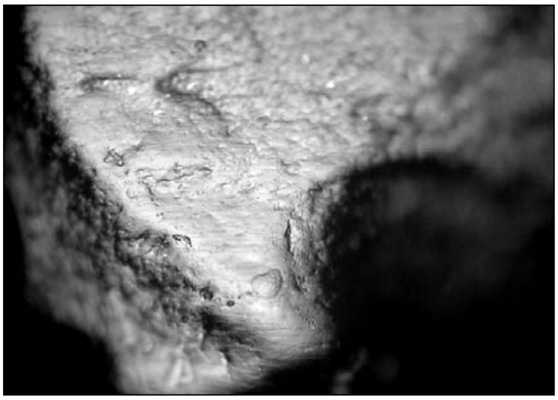
The aim of the analysis conducted here is to characterize differences in the use wear traces on tools used for bone and antler, softened (or not) with different methods. The results will be used to help analyze prehistoric tools from archaeological excavations. Description of the experiments is summarised in **table 5**.

		Use wear retouch	Line of working edge	Polish	Line Marks
Unsoftened	Bone	Full, bifacial multi step retouch was registered, it completely destroyed the working edge of the tool. Many micro hinges and crushed sections.	discontinuous, serrated	Bright patchy line polish, formed mainly on upstanding parts of the working edge. The polish is ground into the structure of the flint (**Photo 9**) and visible only on the working surfaces of the tool.	Next to the line polish scratches of differentiated length and width concentrated on the polished parts of the working edge.
	Antler	Full, bifacial multi step retouch was registered, it completely destroyed the working edge of the tool. Many micro hinges and crushed sections.	discontinuous, serrated	Faint polish focused mainly on upstanding parts of the working edge of the tool (**Photo 10**). It contrasts strongly with unworn parts of the blade. The polish is patchy and in some places turns into a bright polish. The edge of the blade is not polished.	Mainly line polish (see **Photo 10**). Apart from that, loose sporadic scratches outside of the polished area were noticed.
Boiling in water	Bone	Full continuous, bifacial, multi step use wear retouch covers the whole working edge of the tool. Sporadic micro hinges and crushed sections only on the most worn parts of the tool blade.	wavy and discontinuous	Faint polish close to the edge, only on the sides of the working edge of the tool. Blade practically un-polished. The existing polish is patchy and located on upstanding parts of the working edge (**Photo 1**). Also visible are many patches ground into the structure of the stone. The areas between clear polish patches are covered with a delicate faint polish worked into the structure of the stone.	Mainly line polish (**Photo 1**) was registered, also visible sporadic scratches on the most worn parts of the tool.
	Antler	Very delicate continuous, bifacial one step retouch covering the entire working edge. Multi step retouch visible only on some parts of the tool blade. Line of the working edge – wavy, discontinuous.	wavy, discontinuous	Faint polish close to the edge. It is relatively weak, it fades into the flint structure (which it delicately wears off) and fluently passes into unpolished area (**Photo 2**). Polished areas are found mainly on working surfaces of the tool. Its edge is practically unpolished.	Practically unnoticeable, however the polish is very slightly linear.
Soaking in water	Bone	Presence of delicate, bifacial, single step retouch noticed along the whole working edge of the tool. Only in some areas does the retouch become damage in the form of a multi step chipped edge, with some micro hinges.	continuous, slightly wavy	Continuous, bright polish which contrasts with the unworn part of the tool. The polish is grouped in patches on the more outstanding fragments of the working edge (**Photo 3**). It grinds delicately into the stone structure. The polish is only visible on the working surfaces of the tool, the blade is practically unpolished.	Visible mainly in the form of linear polish (**Photo 3**). Also present are short thin scratches which form groups and are laid out very close to each other. Line marks do not reach outside of the area taken up by the polish.
	Antler	Visible only as single flake outs, rarely small clusters of two or three negatives. The retouch is bifacial and practically does not damage the working edge of the tool.	continuous, straight, practically unchanged	On the working surfaces of the tool faint unclear polish has developed along the edge, it enters the structure of the stone (**Photo 4**). The blade of the tool is covered with a bright shiny "spilling " polish which grinds into the structure of the stone. The blade is visibly rounded in section.	Practically invisible. Only a faint line polish is visible.

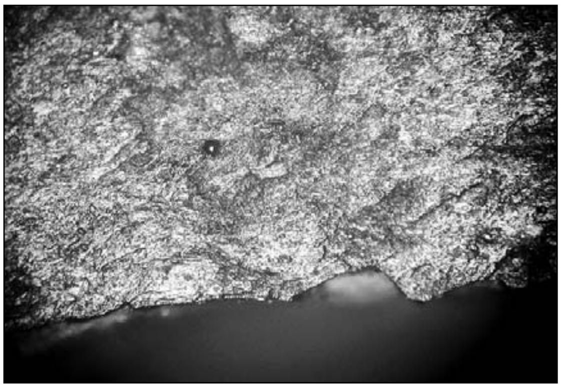
■ **Tab. 5a** Wear traces on flint tools.

		Use wear retouch	Line of working edge	Polish	Line Marks
Soaking in sorrel	Bone	Single step, bifacial retouch covers the entire working edge of the tool. Only in some areas does this retouch turn into chipped sections with visible micro hinges.	irregular, wavy and discontinuous	Most of the working edge is covered with a faint, continuous polish which grinds into the structure of the stone. More upstanding parts of the working edge are covered by a patchy mirror polish, which destroys the structure of the stone (**Photo 5**). The polish concentrates mainly on working faces, the edge is almost free of polish.	Mainly line polish. Also visible are long thin scratches which are present only on the areas of mirror polish.
	Antler	Very fine bifacial retouch covering most of the working edge of the tool. Retouch is broken by single larger negatives.	continuous, slightly wavy	Delicate faint polish in a stripe along the whole length of the working edge of the tool. It is broken by patchy mirror polish on the upstanding parts of the tool, which rubs into the structure of the stone (**Photo 6**).	Situation close to that observed in the case of bone softened with this method. Mainly a linear polish, with addition of single scratches in the surface of this polish.
Soaking in sour milk	Bone	Mainly a small and delicate single step, discontinuous retouch, sometimes broken by larger flake outs.	continuous, slightly wavy	Clear, shiny and ground into the structure of the stone. It merges fluently into the unworn part of the tool. The polish covers not only the faces but also the edge of the blade. In some areas a shiny mirror polish has been noted (**Photo 7**), similar to that observed in the case of tools used for materials softened in sorrel.	Mainly linear polish (see **Photo 7**). Apart from this different types of bright scratches have also been noticed, they do not extend outside the area of the polish.
	Antler	Single step, bifacial, small continuous retouch, sometimes broken by larger flake outs. The retouch extends over the entire working edge of the tool. Line of the working edge – wavy, discontinuous.	wavy, discontinuous	The main observation is a kind of "glazing" covering the blade of the tool. The effect is similar to that observed on tools used for skin (**Photo 8**). Also noted is a shiny polish along the edge of the tool which grinds into the structure of the stone, fluently merging into unpolished areas (this type of polish is observed mainly on the faces of the tool). On the upstanding parts of the blade a bright polish ground into the structure of the stone (with beginnings of a mirror polish).	Observed only as linear polish (**Photo 8**).
Soaking in water	Bone	Presence of delicate, bifacial, single step retouch noticed along the whole working edge of the tool. Only in some areas does the retouch become damage in the form of a multi step chipped edge, with some micro hinges.	continuous, slightly wavy	Continuous, bright polish which contrasts with the unworn part of the tool. The polish is grouped in patches on the more outstanding fragments of the working edge (**Photo 3**). It grinds delicately into the stone structure. The polish is only visible on the working surfaces of the tool, the blade is practically unpolished.	Visible mainly in the form of linear polish (**Photo 3**). Also present are short thin scratches which form groups and are laid out very close to each other. Line marks do not reach outside of the area taken up by the polish.
	Antler	Visible only as single flake outs, rarely small clusters of two or three negatives. The retouch is bifacial with practically no damage to the working edge of the tool.	continuous, straight, practically unchanged	On the working surfaces of the tool faint unclear polish has developed along the edge, it enters the structure of the stone (**Photo 4**). The blade of the tool is covered with a bright shiny "spilling " polish which grinds into the structure of the stone. The blade is visibly rounded in section.	Practically invisible. Only a faint line polish is visible.

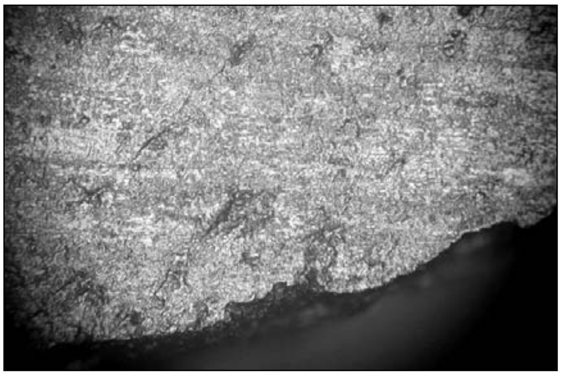
■ **Tab. 5b** Wear traces on flint tools.



■ **Photo 8** Flint saw used on antler softened by immersion in sour milk (×250, ob. ×20).



■ **Photo 9** Flint saw for unsoftened bone (×125, ob. ×10).



■ **Photo 10** Flint saw for unsoftened antler (×125, ob. ×10).

6.1 Conclusions

The analysis of use wear traces from the experimental flint tools has led to some interesting conclusions. First of all let's consider whether antler and bone should be treated as being the same in archaeological literature which talks about micro trace analysis. In the introduction to this work it has been pointed out that this approach of treating the two as the same was justified by the lack of differences between micro traces left by the two materials on flint tools (*Korobkowa 1999*, 44). All through this is confirmed by the traces read from the tools used in the experiments the issue is not closed to discussion. It is a fact that both materials damage flint tools in similar ways and leave similar traces (retouch character, polish, and linear marks). However there are also some clear differences to be pointed out, most importantly antler damages flint[20] to lesser degree than bone. The created retouch is much more delicate and practically always one step. Sometimes, as experiments have shown, it is almost invisible. In the case of bone this retouch is much clearer and often multi stepped, micro hinges are also visible. Similar differences are visible in the character of the polish and the linear marks. In the case of antler the polish is usually faint and inline with the structure of the stone (**Photo 2, 4**). The linear marks in this case are practically not visible. In the case of bone the polish is clear and ingrained in the structure of the stone with very clear line marks (**Photo 1, 3**).

These differences however while clear on the experimental tools may not be visible on artifacts. It has to be taken into account that the time of the experiment was fixed and a tool which has been worked for a long time on antler will be similar to one that has only worked for a short time in bone. Therefore to tell what the tool was used for, it would be necessary to know for how long it was used, this of course is not possible with artifacts.

The way in which worked antler damages a flint tool causes another problem. Poorly visible signs of use wear might not be identified when archaeological material is being looked at.[21] If the tools used in these experiments were found on archaeological sites they would most likely not be identified at least in some part. This is an important issue as each tool was used for a full hour and was used to cut many antler flakes. Most prehistoric tools would not be used for as long as this.[22]

The next important question we need to ask here, is whether there is a possibility of telling apart tools used for materials softened by different techniques. This is important because it influences the type of questions which will be asked of the archaeological stone tool assemblage in the next stage.

Micro trace analysis of the experimental tools used in this work[23] did not unfortunately point out a means for telling apart differences between the different softening methods.[24] The micro traces observed on these tools are all very similar. It should be said that while in the experimental tools it would be possible (with very clear and

(20) When talking about softened materials.
(21) In extreme cases these tools might be mistaken for ones which have been used on meat or leather.
(22) Unless the object being made was particularly complicated or the flint tool was used in a place where lots of antler was being worked on i.e.: an antler workshop.
(23) As well as other tools used in earlier experiments.
(24) At least not at this stage.
(25) If of course the methods described here were used in prehistory.
(26) Long term immersion in water and boiling in water.
(27) Immersion in sour milk and in diced sorrel.
(28) Not as clear on tools used to work material softened by sour milk.
(29) Functional Tool – term used to characterize the way a tool was used while taking into account the material it was used to work in e.g.: skin scraper, meat knife etc (compare to *Młecka-Kukawka 2001*, s. 23).
(30) The role of saws was often fulfilled by burins. As experiments have shown incision is more effective in bone than sawing it.
(31) All of the above mentioned functional tool types were earlier experimentally tested many times, for the purpose of processing bone and antler, with the utilization of softening method described in the article. Micro traces observed on them were basically the same as those on the saws used in the experiments. On all of the tools used for processing material softened with the use of acids, a mirror like polish was observed (compare **Photo 11, 12**); on tools used for processing material softened with "water" methods faint polish (or bright shiny polish in strongly worked areas) delicately grinding into the stone's structure (compare **Photo 13, 14**).

characteristic traces) to tell apart the different softening methods in archaeological material this would be practically impossible. Nevertheless trace analysis of the experimental tools has led to identification of some characteristic traits which might make this identification possible in the future.(25) These traits do not apply to single methods but rather to certain groups of methods. Namely interesting differences have been noticed between the "water"(26) methods and the techniques which are based on natural acids.(27) Both groups are similar in many aspects but there is one important distinguishing characteristic. In methods based on natural acids a certain kind of polish is created on flint tools which is not created on tools used to work material softened in the water techniques. It is a very characteristic flat mirror like sheen which can be identified mainly on tools which were used to work sorrel softened material (**Photo** 5-7).(28) It has been observed that this sheen is created fairly quickly and is characteristic enough that it should be possible to identify on archaeological artifacts. Here however it has yet to be found. This could be for one of two reasons: either sorrel/sour milk was not used in prehistory to soften bone and antler, or it is due to the poor state of study, i.e. not enough trace analysis has been made so far. Answering these questions requires time.

As it has been noted all ready trace analysis does not make it possible to identify the individual softening methods used on bone and antler. It should however be quite easily possible to identify whether a tool was used in softened or unsoftened material, the micro traces are quite clearly distinct between the two. Unsoftened material leaves a multi level retouch on the tool working it and destroys the working edge entirely. Clear signs of shattering and micro hinges are also present. When looking at tools used on softened materials it is clearly visible that the retouch is on one level and has almost no influence on the shape of the working edge. Similarly in the case of the polish and the linear marks there is a clear difference. In the case of tools used on unsoftened material the edge of the tool is damaged so quickly there is no time for either of these types of traces to develop, the polish can only develop on the convex sides of the working edge. It is usually bright and ingrained in the structure of the flint. The linear marks (if developed at all) are observed as loose irregular long scratches. In the case of the softened material the polish is long, faint and covers the entire working edge. In the more stressed areas it turns into a bright mirror like polish. The linear marks are usually observed here as linear polish.

7. Methods of bone/antler working in the Stone Age

Introduction

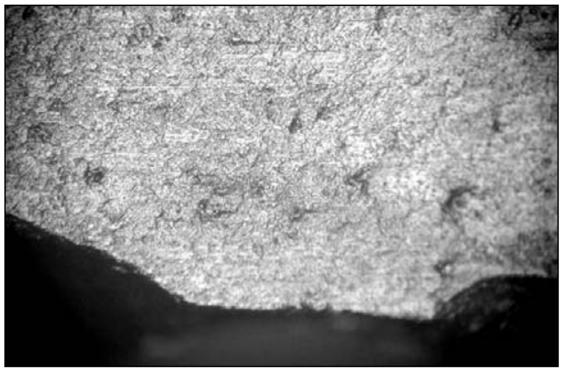
In this chapter Stone Age tools used in bone/antler processing have been subject to micro trace analysis. In contrast to the "experimental" part of the work, all functional(29) tools used to work both bone and antler have been identified here. Saws – excellent in the comparative analysis of the experimental tools – in the archaeological finds are quite rare,(30) which forces us to use also other types of tools in our analysis to build a reliable base for our conclusions. Therefore apart from saws: scrapers, burins, planes and borers were also taken into account.(31)

The fundamental aim of this part of the work was the identification, within the analyzed archaeological material, tools which were used to work bone and antler. The final aim was to talk about the bone/antler softening techniques which could have been used in the different periods of the Stone Age.

A detrimental factor was the post depositional damage the artifacts have suffered. In some cases problems were also encountered because of the multi-functionality of some tools.

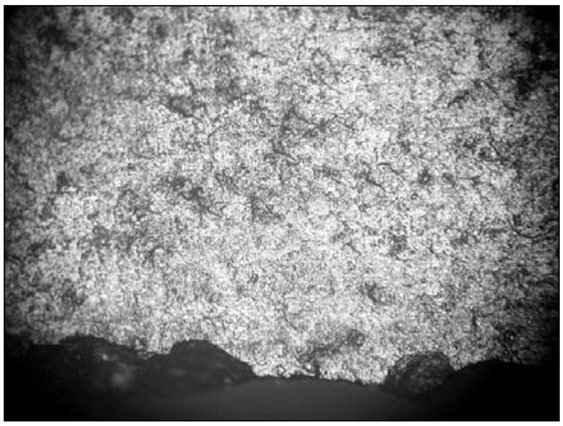
Some 183 tools, used to work bone/antler, from 20 sites were analyzed for micro traces. The sites represent a chronological range from the Terminal Paleolithic through the Mesolithic to the Neolithic. All sites represented here are located in the north-eastern region of Poland. All were excavated archaeologically. Over all some 7000 flint artifacts were recovered.

■ **Photo 1** Flint saw used on bone softened by boiling water (×250, ob. ×20).



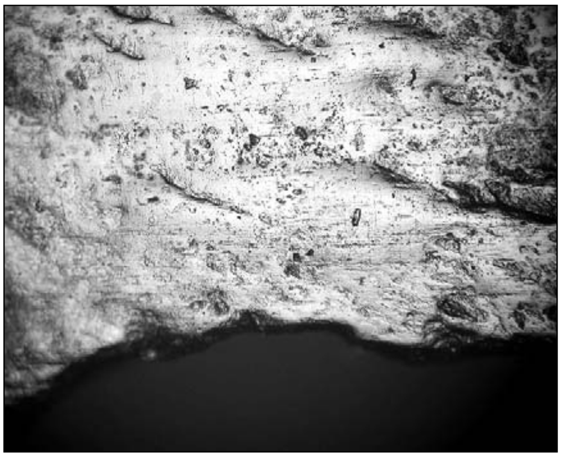
■ **Photo 2** Flint saw used on antler softened by boiling water (×125, ob. ×10).

■ **Photo 3** Flint saw used on bone softened by immersion in water (×125, ob. ×10).



■ **Photo 4** Flint saw used on antler softened by immersion in water (×125, ob. ×10).

■ **Photo 5** Flint saw used on bone softened by acid from a sorrel mash (×125, ob. ×10).



■ **Photo 6** Flint saw used on antler softened by acid from a sorrel mash (×125, ob. ×10).

Terminal Paleolithic

Analysis was conducted on Terminal Paleolithic artifacts uncovered on a Stare Marzy site (site 5, Dragacz commune, Kuyavian–Pomeranian voivodship; *Cyrek 2001, 2002*). The study takes into consideration 8 out of the discovered flint concentrations[(32)] uncovered on the site (Flint-concentrations: I-VI, VIII, X – total of 1418 flint items). Micro trace[(33)] analysis of those items has led to identification of 288 artifacts with traces of utilization. 43 of those tools were associated with treatment of bone/antler. After taking into account the fact that some tools had more than one function,[(34)] 47 tools have undergone a further analysis. Microscope analysis was conducted on: 30 scrapers, 1 plane, 3 borers and 13 burins. As a result 10 tools used to work softened[(35)] bone/antler were identified as well as 17 tools used to work unsoftened material.[(36)] Use wear traces visible on the other 10 tools were not clear enough to draw any conclusions as to the state of the material they were used on. Among the tools used to work softened bone/antler scrapers dominated. Both on the scrapers and on burins working in softened material characteristic "bright" polish and linear marks were registered, on the immediate edge which had contact with the worked material (**Photo 15**).[(37)] The retouch visible on them is one, two or in rare cases multi degree and the linear marks do not exceed the area of the bright polish. Tools classified as working in unsoftened material in most cases have a multi degree retouch, with a damaged working edge, functional retouch and faint polish on the edges. Linear marks do not appear at all or are represented by single scratches of differing width and length (**Photo 15**). Tools used to work softened bone/antler did not differ in form to those used in unsoftened material. In both cases fairly short blades (aprox. 3 – 3.5 cm) were used, if necessary with some corrections. The analysis of the size of the tools suggests however that blades used to work in softened material were chosen with greater care. The size of the blades used to work softened material is very similar in most cases and practically standard. Their length fits in between 3 and 3.5 cm, while their width (with one exception) 2.3 cm (**Fig. 1.1; 2.1-3, 5, 8-11**). Tools used to work unsoftened material vary in size considerably (**Fig. 1.2-6; 2.1, 2, 4, 6-7**). Both, very small – up to 2.5 cm long and 1 cm wide, as well as large – over 5 cm long and 3 wide tools were registered here. This situation might be the result of different functions the tools were used for. Tools used for working sof-

(32) Of a seasonal hunter-gatherers encampment character.
(33) Executed by L. Czajkina from the Russian Scientific Academy in St. Petersburg.
(34) A Tool with traces of utilization in two different ways were counted as 2 tools.
(35) Traces fund on these tools were probably the result of work in softened material, however the tools were used for too short a period or were too damaged (post depositional) to say so with 100% certainty.
(36) The fact that the tool was used to work unsoftened material does not rule out the possibility that it might also have been used in softened material. The tools might also have been used just as the material was hardening (this comment applies also to other periods analysed).
(37) For comparison purposes a picture of that type of micro traces from an experimental tool used to work bone softened by boiling in water has been included (**Photo 13**).
(38) The preparation of the materials to be worked is an activity which requires time (look earlier notes on softening techniques), it therefore had to be planned in advance. The person doing the work most likely knew what work will need to be done and what tools would be needed to do it. Therefore it is reasonable to assume he picked flint blades of parameters most suitable to his needs, this might be why the tools are almost a standard size.
(39) Compare notes on the damage taken by flint blades in softened and unsoftened material.
(40) For example when a bone tool needed quick repairs. It was than unsoftened or perhaps boiled and worked on with any tools available, thus of differing sizes.
(41) The sites probably differ chronologically as well. Analysis of the Sąsieczno tools suggests that it is a preboreal or boreal site while the sites in Lubicz are probably Atlantic in age.
(42) Information abort the location of the site and character of the flint tools are to be found in a work by K. Cyrek (*2002*).
(43) On both: the tools used to work the softened and hard material traces were fund which were analogical to those identified earlier on terminal Paleolithic tools.
(44) This is fairly important as the other burins were largely micro burins where the working edge is formed by breaking a blade.
(45) A flat polish which grinds down the structure of the flint, it's charter pointing to long uniform usage, where the tool was held at the same angle to the material being worked for a long time.
(46) Similar traces were visible on experimental tools used for the same function.
(47) Information about the localization of the sites and the character of the archaeological material fund here can be looked up in a work by S. Kukawka (*1994*).

tened material are probably used for actions which were foreseen and planned[38] or, which might also take more effort.[39] While the tools used for unsoftened material were probably used for actions which required little effort, perhaps unplanned corrections.[40]

Analysis of micro traces on tools used for softened bone/antler does not allow for a precise identification of the softening method used. With some certainty we can however exclude the possibility of natural acid techniques. Because the characteristic mirror polish was not found on any of the tools. Micro traces visible on tools (the type of polish present) make it more likely that water methods were used. Especially probable is the "water soaking", which is made likely because the tools lack a multi step retouch often found on tools used to work materials softened by boiling.

The Mesolithic

Micro trace analysis was conducted on 97 tools from this period. They came from four archaeological sites: Sąsieczno (commune Obrowo) site no. 4, Lubicz (commune Lubicz) sites no. 12, 13 and 18. Because of the typological differences[41] between the sites in Sąsieczno and Lubicz they will be introduced separately.

Sąsieczno, commune Obrowo, site no. 4[42]

Two flint-concentrations have been discovered on this site, from which 3723 flint artifacts were excavated. One of those scatters probably represents the remains of a partly sunken building, the other has the character of a seasonal hunting camp, both concentrations were well preserved. Micro trace analysis of this assemblage was conducted by the author of this article. All together 386 items had use wear traces.

The micro trace analysis on this site has led to the identification of 61 tools used to work bone and antler. After taking into account that some tools had multiple functions this number rose to 65 tools. This group included: 35 scrapers, 6 planes, 6 saws, 14 burins and 4 borers. Further analysis allowed us to conclude[43] (compare **Table 2**) that: 10 of these tools were definitely used to work softened bone/antler, 11 were probably used for softened material and 12 were used for unsoftened bone/antler. The traces found on 32 remaining tools were not clear enough to conclude whether they worked in softened or unsoftened material. Tools used in softened bone/antler are particularly well worked. It's worth noting that burins formed almost one halve of all (securely identified) tools used to work in softened material. All burins used in softened material are "claws"[44] (**Fig. 3.1, 7, 8, 11**). When you take into account the traces which registered on them (**Photo 17**),[45] we can suspect that they were used to cut the material to prodeuce for example simple grooves.[46] Scrapers used to work the softened material are effectively the same in form as ones used to work hard (unsoftened) material. In both cases the working edge of the tool was re touched (**Fig. 3.3-6, 9-10**).

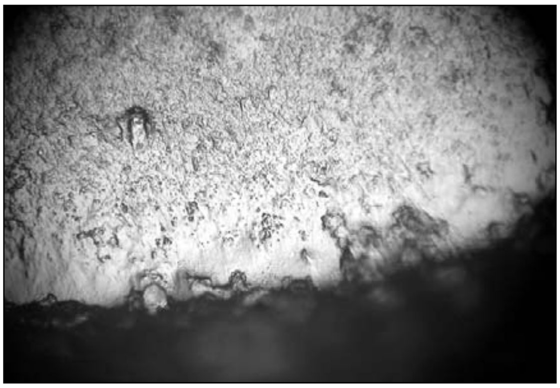
The analysis of the size of tools working in softened and hard material did not establish any major differences between them. On both kinds of material (softened and hard) similar and at the same time varied blades were used. In both cases we have examples of very large (**Fig. 3.3-4**), and small (**Fig. 3.10-11**) tools.

It is also difficult to say anything about the similarities between the different tools as there is not enough of an analytical base to do so. Tools identified on this site, which were used in softened bone/antler, are mainly burins, while those working in unsoftened material are largely scrapers.

Lubicz, commune Lubicz sites no: 12, 13 and 18[47]

The excavations was of a rescue character and conducted because of a planned investment in this area. From these sites 1230 flint artifacts were excavated. Micro trace analysis (conducted by the author of this article) identified 216 pieces which bore marks of being used.

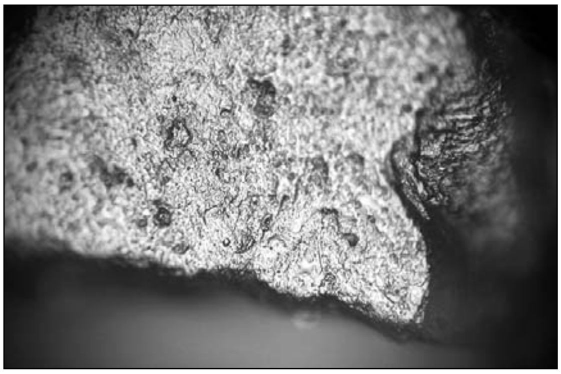
■ **Photo 7** Flint saw used on bone softened by immersion in sour milk (×250, ob. ×20).



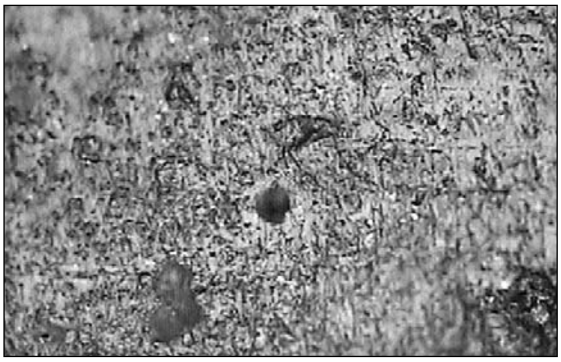
■ **Photo 11** Flint scraper used on bone softened by acid from a sorrel mash (×250, ob. ×20).

■ **Photo 12** Flint awl used on bone softened by acid from a sorrel mash (×250, ob. ×20).

■ **Photo 13** Flint scraper used on antler softened by immersion in water (×250, ob. ×20).



■ **Photo 14** Flint awl used on antler softened by immersion in water (×250, ob. ×20).



■ **Photo 15** Use ware traces visible on a Late Palaeolithic scraper used for softened bone/antler (×250, ob. ×20).

■ **Photo 16** Use ware traces visible on a Late Palaeolithic scraper used for unsoftened bone/antler (×125, ob. ×10).

■ **Photo 17** Use ware traces visible on a Mesolithic awl used for softened bone/antler (×250, ob. ×20).

The micro trace analysis of Mesolithic tools from Lubicz sites has identified 36 tools which were used to work bone/antler, 39 when we take into account multi functional tools. Among the tools analyzed were: 32 scrapers, 2 planes, 2 saws, 2 burins and 1 borer. As a result of the microscope observations the following have been identified (compare **Table 3**): 12 tools which were definitely used in softened material, 9 tools which were probably used in softened material and 8 tools which were used in unsoftened material. In 10 cases it was impossible to say whether they were used to work softened or unaltered bone/antler.

In both softened and unaltered material the most numerous tool is the scraper. At first glance no major differences were noted between the two groups of tools (apart from the micro traces which pointed to what material they were used in). In both cases similar blades were used to make the tools and the working edge was prepared for the work (retouched). However a more detailed look at the tools has led to the discovery of some diversity between the two groups. Statistically speaking scrapers used to work softened material were made out of smaller blades of similar dimensions.(48) None of them are longer than 3 cm and the width is usually 1.5 cm (**Fig. 4.3, 5-8, 12**). Scrapers used on unsoftened material are slightly more massive, the length is usually 3 cm and their width is usually about 2 cm (**Fig. 4.1, 2, 10**).

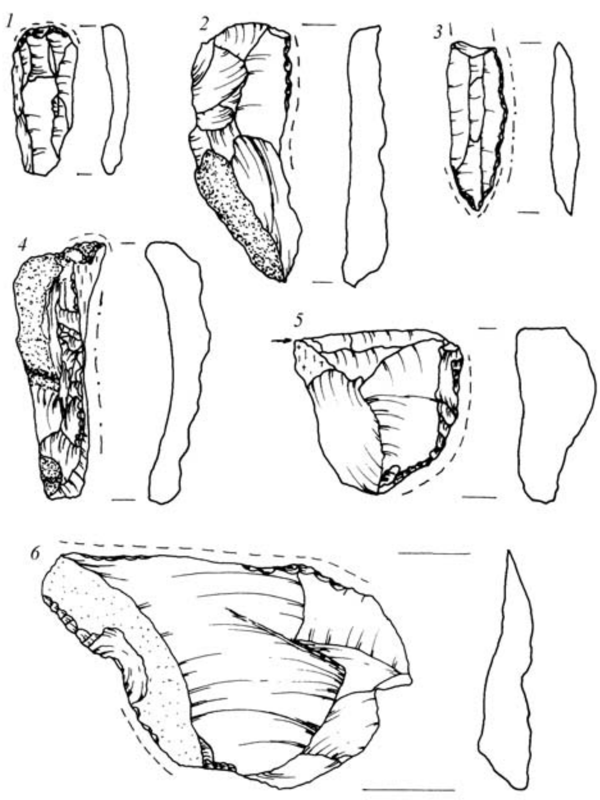
The analysis of the tools from Lubicz has shown some differences between them and the tools from Sąsieczno. The differences apply mainly to the polish. On the tools from Lubicz the polish is definitely less intensive, fainter and with less effect on the structure of the stone (**Photo 18**). These differences could be the result of the tools from Lubicz(49) being less worked or (and this I think is more probably) it could be the result of a different softening technique being used. The current state of studies of this problem makes it impossible to draw a definite conclusion.

Conclusions

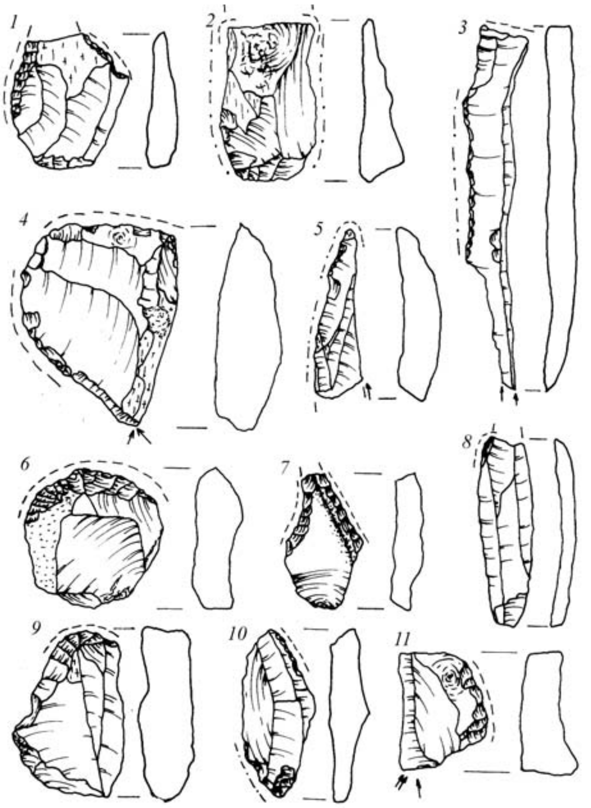
As it was suspected the analysis of the Mesolithic material did not allow for a certain identification of one of the bone/antler softening methods used in the Mesolithic. However the fact remains that a softening method was used in this period. The results of the analysis from all four sites even seem to suggest that several softening methods were used. Similarly as with tools from the Terminal Paleolithic the use of organic acid can probably be ruled out (due to the lack of tools with a mirror polish). Use wear traces from Sąsieczno (lack of multi step retouch, bright linear polish slightly ingrained into the stone structure and the rounding of the edge of the tool) rather point to the use of water soaking. On the tools from Lubicz a faint surface polish was present, which can be the result of working material (probably antler) softened with boiling(50) (this maybe confirmed by the presence of a multi step use wear retouch).

The tools used to work bone/antler in this period were differentiated in type, form and size. However tools used to work softened materials show a degree of standardization(51) and are usually smaller. Bone and antler which were unsoftened were often worked with tools made out of random blades and were quite different in sizes and form. Some types of tools were associated to a particular “type” of material. This is the case with “claw” burins from Sąsieczno. They were used predominantly to work softened bone/antler and were probably used for one function only.

(48) Compare the notes on this state of things with notes made on Terminal Paleolithic tools.
(49) When taking into account that micro traces suggest that the tools are well worn and that the wear is repetitive this is probably impossible.
(50) Compare to traces visible on experimental tool of this kind (**Photo 13**)
(51) Most have similar proportions.
(52) Most artifacts come from sites which were midden like in character.
(53) During the micro trace analysis of the materials, to which the author had access, no tools used to work bone/antler were identified in among those that belonged to the late Linear Band Pottery Culture.



■ **Fig. 1** Stare Marzy, comm. Dragacz, site 5. A selection of Late Paleolithic tools used for bone/antler working. Scraper used for softened bone/antler (1); scraper used for unsoftened bone/antler (2, 5-6); dual function tools: scraper -•- and borer --- used for unsoftened bone/antler (3); dual function tool: scraper for unsoftened bone/antler -•- and hide scraper --- (4).



■ **Fig. 2** Stare Marzy, comm. Dragacz, site 5. A selection of Late Paleolithic tools used to work bone/antler. Scraper for unsoftened bone/antler (1, 4, 6); scraper used for softened bone/antler (5, 9-11); borer for unsoftened bone/antler (7); awl used for softened bone/antler (8); dual function tools: scraper used for softened bone/antler -•- (2, 3, 10) and: awl for softened bone/antler --- (2), hide scraper --- (3, 10).

Neolithic

Introduction

In this work tools from 15 different Neolithic sites[52] were analyzed. These come from two different archaeological cultures: the Linear Band Pottery Culture and the Funnel Beaker Culture.[53] The material remains from the two cultures are treated separately. Because of fairly big differences in the size and dimensions of the tools from one of the cultures (due to large chronological extent of the sites) metric analysis was abandoned in this case.

Linear Band Pottery Culture

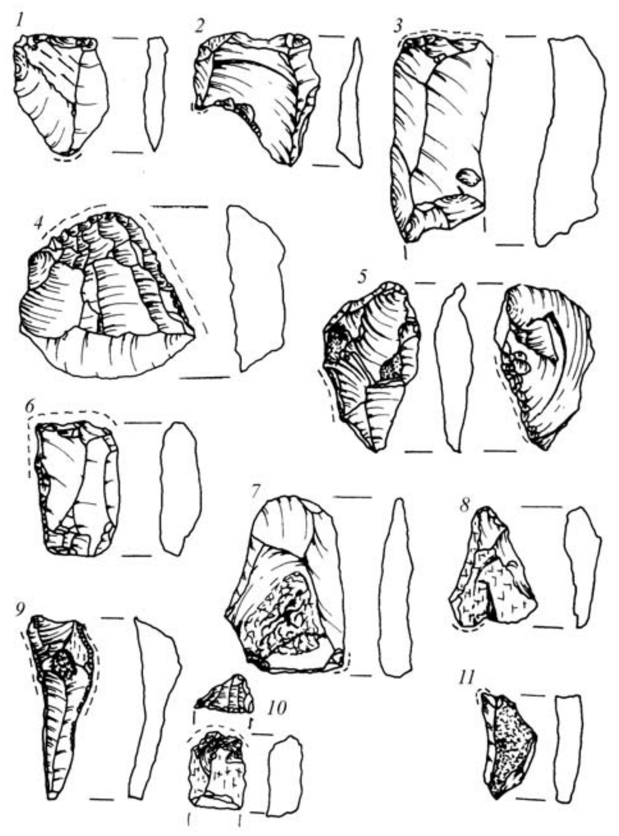
Nineteen tools used to work bone/antler were analyzed. They came from 5 different sites of this culture.[54] One of the tools had two function therefore 20 tools were analyzed. Among those tools were: 5 scrapers, 1 plane, 4 saws, 7 burins and 3 borers. Micro trace analysis of the above mentioned tools led to the identification (compare **Table 4**) of: 2 tools used to work softened bone/antler, 6 tools probably used to work softened material and 2 tools used in un- altered material. In 10 cases it was impossible to come to a conclusion about the character of the material on which the tools were used.

The large percentage of tools which were impossible to analyze is due to the fact that most of them were not well worked. Usually only weak traces and a fine (but multi degree) retouch were visible. A faint polish was sometimes also recognized. Only in one case (burin) a clear and well developed bright polish (in places ingrained in the stone) and linear marks (**Photo 19**) were recognized. This artifact came from Annow (site no. 7) and was most likely used to work bone/antler softened by water soaking (this seems to be confirmed by the type of polish present) (**Fig. 5.1**).

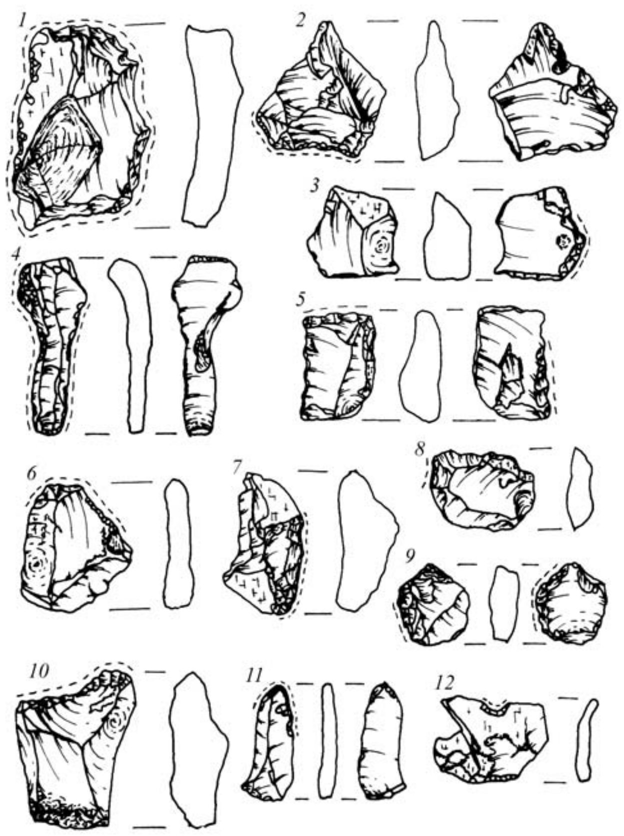
A small amount (two examples,[55] **Fig. 5.1, 2**) of the tools securely qualified as being used in softened material, did not mirror the intensity of the usage of the softening techniques used by the society of the Linear Band Pottery Culture. This might be the result of errors made during the first trace analysis of the flint tools included in this work.[56]

Funnel Beaker Culture

In this group 24 tools used to work bone/antler were analyzed, they came from 111 sites of the Funnel Beaker Culture.[57] When multi functional tools are taken into account 29 separate tools were identified and analyzed. Among those the following were found: 11 scrapers, 1 plane, 12 burins and 2 borers. During trace analysis 6 tools used to work softened



■ **Fig. 3** Sąsieczno comm. Obrowo, site 4. A selection of Mesolithic tools used to work bone/antler. Awl used for softened bone/antler (1, 7, 8, 11); awl used for unsoftened bone/antler (2); scraper used for unsoftened bone/antler (3, 4, 6, 9, 10); dual function tool: scraper/plane for softened bone/antler --- (5)



■ **Fig. 4** Lubicz comm. Lubicz, site 12, 13, 18. A selection of Mesolithic tools used to work bone/antler. Scrapers used to work unsoftened bone/antler (1, 2, 9, 10); scraper used to work softened bone/antler (3, 5-8, 12); scraper/plane used for softened bone/antler (4); borer used for softened bone/antler (11).

bone/antler were identified (compare **Table 5**). Another 4 tools were found which were probably used in softened bone/antler and 15 tools which were used in material which was not classified and 4 which were used on unsoftened bone/antler.[58]

As with the tools from the Linear Band Pottery Culture it was impossible to determine the degree to which bone/antler was softened in most of tools analyzed. However without doubt softening techniques were known and used relatively often by the Funnel Beaker Culture. Tools used in softened material were after all found on most of the sites taken into account, and micro traces which are observed on them (**Photo 21**)[59] suggest a relatively long period of usage. Among the tools which were used in softened bone/antler the borers deserve special mention (**Fig. 5.4, 5**). Both cases had very clear and well preserved usage marks (**Photo 20**), which also point to the usage of water methods.

(54) Boguszewo, Gruta commune site no. 41; Ryńsk Wąbrzeźno commune site no. 42; Annowo, Gruta commune site no. 7: Wielkie Radowiska, Dębowa Łąka commune sites no. 22 and 24. More detailed information can be found in a work by J. Małecka- Kukawka (*2001*).

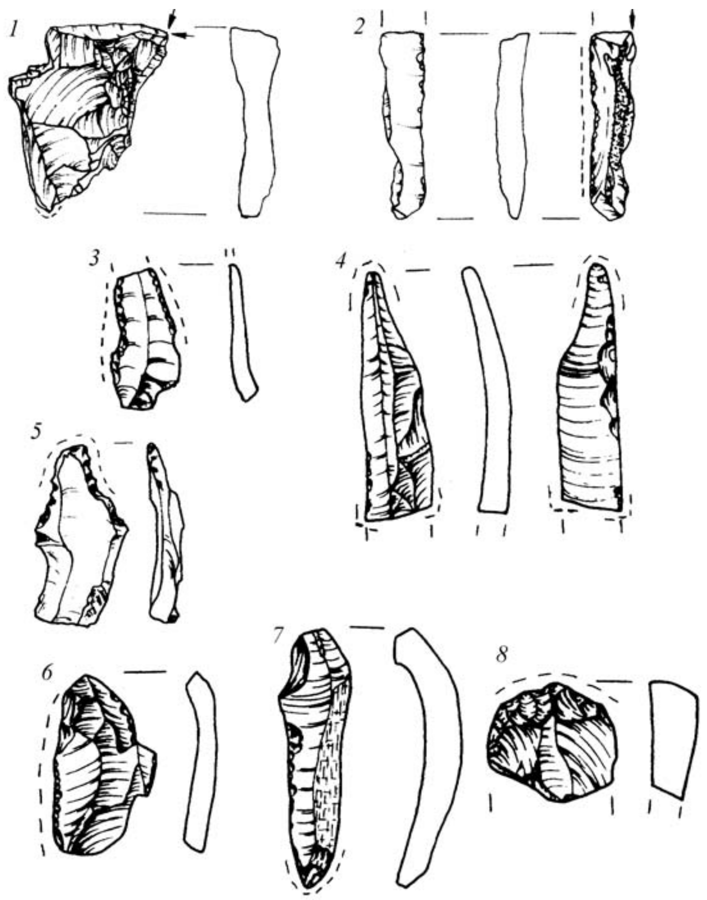
(55) On these tools traces similar to those from the Terminal Paleolithic and the Mesolithic were found.

(56) Flint material from the Linear Band Pottery Culture which were taken into account in this work were analyzed priori to experiments which allowed the identification of tools used to work in softened bone/antler. The basic quality used to identify tools used to work bone/antler was the multi degree retouch, but as was discussed earlier this retouch does not develop on tools used in softened material. Therefore those tools might have been miss identified or missed altogether. As this work was based only on tools classified as bone/antler working tool and ignored all tools classified as working other materials and unused this could have led to errors. In order to correct this all flint artifacts from the sites discussed should be re examined.

(57) Osiek, Obrowo commune, site no. 9; Lembarg, Jabłonowo Pomorskie commune, site no. 94 and 96; Linowo, Świecie nad Osą commune, site no. 25; Smogorzewiec, Obrowo commune, site no. 9; Wełcz Wielki, Grudziądz commune, site no. 10B; Niemczyk Wrocławki, Papowo Biskupie commune, site no. 1; Gogolin, Grudziądz commune, site no. 15; Klamry, Chełmno commune, site no. 7 and 8; Mgoszcz, Lisewo commune, site no. 2. More detailed information in J. Małecka-Kukawka (*2001*).

(58) As with the Linear Band Pottery Culture tools the analysis was conducted before the experiments which allowed the identification of tools used to work softened bone and antler. So the results may not represent the true intensity of bone/antler working and the usage of softening techniques used by the Funnel Beaker Culture.

(59) Softened bone/antler scraper (Gogolin, Grudziądz commune site no. 15) – linear polish/wear.



■ **Fig. 5** Tools used to work bone/antler. The linear band pottery culture (1-3), funnel beaker culture (4-8). Awls used for softened bone/antler (1, 2), scraper used for softened bone/antler (6, 8) and for unsoftened bone/antler (3), and a borer used for softened bone/antler (4, 5, 7).

■ **Photo 29** Bone arm-ring produced using softening techniques.

Conclusions

As with to the Terminal Paleolithic and the Mesolithic tools it was impossible to securely identify individual methods used to soften bone/antler in this period. However micro traces on the tools make it likely that "water" methods were used. Perhaps a repeated micro trace analysis of all the tools (which were looked at) could make this hypothesis more likely, however this is impossible at the moment.

8. Recapitulation

Different methods of working organic material in the Stone Age are a very wide topic. Studies in this area are made difficult by the small amount of archaeological evidence, which is indispensable, they are also made more difficult by the lack of suitable analytical methods. In at least some of the problems experimental archaeology combined with micro trace analysis can be very helpful as was shown above. Both methods have their disadvantages however but they do make it possible to approach subjects thus far closed or open in only a very small fragment.

As was mentioned in the introduction: bone and antler working was a complex process, and the analysis undertaken in this work was only meant to shed some light on one stage of this process. Despite this many of the problems mentioned remain unsolved, and others remain only partially answered. Among the goals which have been achieved we can count:

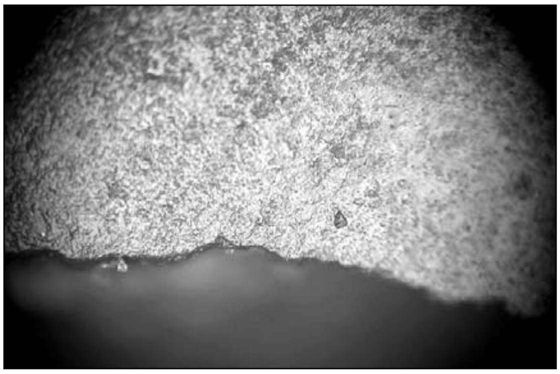
The experiments have made it possible to describe characteristic marks left on tools used to work softened and unsoftened bone/antler.

Micro trace analysis of the prehistoric artifacts has allowed the identification of tools which have been used to work softened materials, which confirms that bone/antler softening methods were known and used in the Terminal Paleolithic, Mesolithic and Neolithic.

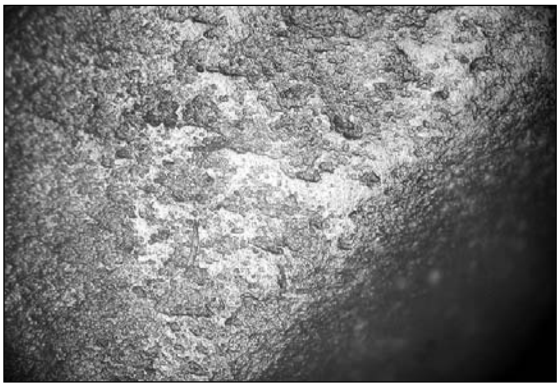
The experiments have allowed some conclusions to be made about the methods of work and the way stone tools are damaged by working softened bone/antler. The experiments have also allowed some conclusions about the advantages and disadvantages of individual methods.

It was impossible to answer the basic question of what softening methods were known in the different time periods. Some suggestions however have been made (concerning utilization of water methods) which at this point seem very likely and which could be confirmed by further analysis.

Several important questions regarding micro trace analysis as an analytical method were addressed in this article. As was shown some softening techniques cause the flint to wear in ways which are far from those thought typical of bone/antler working (*Korobkowa 1999*, p. 108) until now. Scientists using the classical set of traces may not identify these tools or may interpret them incorrectly. This problem needs further investigation.



■ **Photo 18** Use ware traces visible on a Mesolithic scraper used for softened bone/antler (×250. ob. ×20).



■ **Photo 19** Use ware traces visible on a Neolithic awl used for softened bone/antler (×125; ob. ×10).

■ **Photo 20** Use ware visible on a Neolithic borer used for softened bone/antler (× 250, ob. ×20).

■ **Photo 21** Use ware traces visible on a Neolithic scraper used for softened bone/antler (×250, ob. ×20).

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Summary

Mots-clés: âge de la pierre, archéologie expérimentale, tracéologie, ramollissement des os et des bois.

Cet article présente notre travail d'analyse des méthodes de façonnage des os et des bois animaux pendant la Préhistoire. Comme cette étude nécessitait aussi de se pencher sur la technique de ramollissement de ces matériaux, l'expérience a été divisée en trois phases.

La première a été consacrée au façonnage expérimental de l'os et du bois, par le biais d'expérimentations archéologiques. La procédure spécialisée a permis une standardisation du travail et l'élimination des facteurs extérieurs influents.

Des lames de silex brutes de longueur identique ont été utilisées sur des bois de cerfs et des tibias d'animaux (bétail). Le temps d'expérimentation a été fixé à une heure, lorque les outils ne s'usaient pas avant.

Cette expérience a permis de relever les facteurs de variables (comme le degré de déssechement, la dureté ou la fossilisation des os) qui ont un impact sur le résultat final.

Le choix des os utilisés dans cette expérience découlait du résultat de plus anciennes expériences. Si la structure de l'os est trop délicate, comme sur les côtes par exemple, l'usure est trop rapide.

L'expérience de l'artisan est aussi un facteur déterminant car plus il maîtrise son art et plus rapide et efficace est le travail. Cela a aussi un impact sur les traces d'outil.

Différentes méthodes de ramollissement des os et des bois ont été expérimentées : trempage dans l'eau, cuisson dans l'eau, trempage dans une solution d'oseil haché et mouillage au lait acide. Certains os et bois ont été ramollis avant leur façonnage pour établir des comparaisons.

L'objectif était de relever les méthodes les plus efficaces pour le façonnage de os et bois animaux avec l'aide d'un outil en silex. L'observation des résultats suggère qu'à l'Age de la Pierre les méthodes de mollification des supports par bains d'eau ou par cuisson devaient être les plus utilisées.

La deuxième phase d'expérience portait sur l'analyse tracéologique des outils en silex utilisés lors de l'étape précédente et les micro-traces laissées sur les matériaux ramollis.

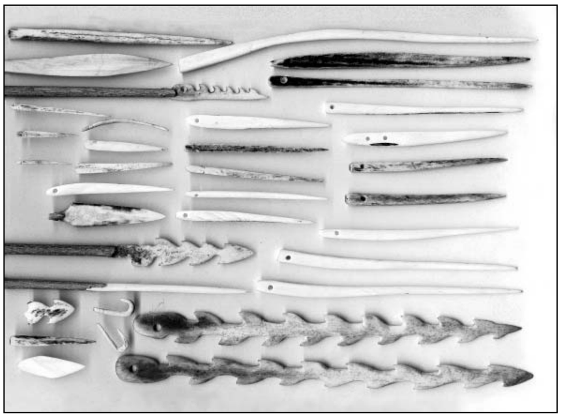
Dans un premier temps, la problématique a été abordée sous la forme de recherches bibliographiques sur de précedentes analyses tracéologiques. Une des hypothèses relevées propose que la méthode de façonnage est identique pour les os et les bois animaux en raison d'une

■ **Photo 22** Softening bones by boiling them in water.

■ **Photo 23** Cutting bone with a flint blade.

■ **Photo 24** Whittling a softened antler.

■ **Photo 25** Polishing a bone needle on a sandstone slab.



■ **Photo 28** Bone and antler products made using flint tools and softening techniques.

absence de différence dans les traces d'outils. Cette argumentation est étayée par une analyse tracéologique d'outils créés expérimentalement.

Si les micro-traces sur les os et les bois sont identiques, il y a toutefois des différences visibles au niveau des retouches et des traces linéaires entre matériaux ramollis ou non.

Après ces recherches, une description des micro-traces a été faite, dont la comparaison permet de proposer l'hypothèse que les outils utilisés diffèrent si les matériaux ont amollis ou non. Il a été constaté que certains outils ne laissent pas de traces sur des matériaux mous.

L'analyse de ces traces prouve qu'il reste des problèmes dans l'identification des outils préhistoriques, comme par exemple ceux utilisés pour le travail du cuir ou la découpe de la viande. Ainsi, une partie des découvertes archéologiques reste encore mal identifiée. Quant-aux outils utilisés pour l'expérience sur les os et les bois, ils n'ont jamais duré plus d'une heure et il est croire qu'il en est de même pour la majorité des outils préhistoriques. Finalement, cette phase a révélé la méthode d'identification des méthode de ramollissement des os et des bois animaux sur la base d'analyses tracéologiques de vestiges.

La troisième et dernière phase du travail a été occupée par la reconstitution de techniques utilisées pour le façonnage de ces matériaux à différentes périodes : la fin du Paléolithique, le Mésolithique et le Néolithique. Cette analyse repose sur des études tracéologiques d'outils préhistoriques et sur des précedentes expériences. 183 outils en silex ont été analysés au microscope. Tous étaient utilisés pour le travail de l'os et du bois et viennent de vingt différent sites datés de la fin du Paléolithique à la fin du Néolithique du Nord-Est de la Pologne.

Pour la grande majorité de ces pièces, il a été possible d'identifier le façonnage d'os et bois ramollis ou non. Les traces usagères visibles sur ces outils ont été décrites et les différentes formes utiles pour le travail des matériaux traités ou non ont été identifiées.

Knochen und Geweih. Techniken zum Aufweichen in der Urgeschichte des nordöstlichen Teils des polnischen Flachlandes im Licht der experimentellen Archäologie und der Mikrospuren-Analyse

Das Ziel dieser Arbeit ist die Vorstellung und Analyse einiger Techniken zum Aufweichen von Knochen und Geweih, die während der Steinzeit angewendet worden sein können sowie ihr Nachweis durch Experimente an beiden Rohstoffen mit dem Einsatz von Flintgeräten.

Dieser Artikel wurde in drei Teile untergliedert. Der erste Teil beschreibt die Techniken des Aufweichens beider untersuchter Rohstoffe. Die Abfolge erlaubt eine Standardisierung der Arbeit und einen Ausschluss externer Faktoren. Flintklingen gleicher Länge wurden angewendet, um Geweih vom Rothirsch und um Langknochen vom Rind zu bearbeiten. Verschiedene Methoden zum Aufweichen wurden getestet: Kochen im Wasserbad, Einlegen in ein Wasserbad, Einlegen in Sauerampfer und Einlegen in Sauermilch. Die Absicht war dabei, die Effektivität der verschiedenen Methoden zum Weichmachen zu vergleichen. Die Beobachtungen legen nahe, dass es sich beim Einlegen und Kochen im Wasserbad um die wahrscheinlichsten in der Steinzeit angewandten Techniken gehandelt haben dürfte.

Der zweite Teil erläutert die Resultate einer Spurenanalyse, die bei den in den o. g. Experimenten verwendeten Steingeräten durchgeführt wurde. Das Ziel war es hier, die Unterschiede von bei der Bearbeitung durch auf verschiedene Weise aufgeweichten oder auch unbehandelten Knochen und Geweih entstandenen Gebrauchsspuren zu charakterisieren. Die Ergebnisse können bei der Auswertung von urgeschichtlichen Gerätefunden Verwendung finden. Die Analyse der Gebrauchsspuren von rekonstruierten Flintgeräten hat dabei einige interessante Daten erbracht: Zuerst ist zu fragen, ob Geweih und Knochen wie bisher üblich in der archäologischen Fachliteratur bei der Ansprache von Gebrauchsspuren gleich zu behandeln sind. Tatsache ist, dass beide Rohstoffe Flintgeräte in vergleichbarer Weise beschädigen und gleichartige Spuren hinterlassen (Retuschencharakter, Politur und lineare Einritzungen). Andererseits sind auch eindeutige Unterschiede zu erkennen, vor allem dass Geweih den Feuerstein wesentlich weniger beschädigt als Knochen. Die nächste Frage ist, ob es möglich erscheint, anhand der Gebrauchsspuren zu erkennen, auf welche Weise die Materialien aufgeweicht wurden. Die Mikrospuren an den Flintgeräten waren alle sehr ähnlich, aber es gibt ein wichtiges Unterscheidungskriterium: Durch die Anwendung von natürlichen Säuren kann eine besondere Art der Politur erkannt werden, die nicht bei Flintgeräten entsteht, mit denen Material bearbeitet wurde, das mit den Methoden des Aufweichens im Wasser erzeugt wurde.

Der dritte Teil behandelt den Versuch, die angewendeten Aufweich-Methoden im Endpaläolithikum, im Mesolithikum und im Neolithikum in den nordöstlichen Bereichen des polnischen Flachlandes herauszuarbeiten. Auf Basis einer Spurenanalyse an 183 Flintgeräten aus archäologischen Befunden von zwanzig unterschiedlichen Fundplätzen Nordostpolens vom ausgehenden Paläolithikum bis in das Endneolithikum sowie der o. g. Resultate wurde dabei diese Untersuchung durchgeführt.

■ **Photo 26** Shearing needles off a bone with an antler wedge.

■ **Photo 27** Bending a softened bone.

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