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# Modeling the Deformation of Bone Points: Archaeological and Experimental Data*

*Bone and antler tools are a highly informative category of artifacts. Variously sized and shaped projectile (spear, harpoon, arrow, and dart) points spanning the periods from the Paleolithic to recent centuries are of special importance. In this article, we review the most noteworthy directions in Western (European and North American) experimental research performed in the 20th and early 21st century, outline the results of our own experiments in using bone points, and discuss parallels among Siberian and Eastern European prehistoric cultures. In our experiments with the use of an archery bow, special attention was paid to fastening the arrowhead to the shaft and to properties of the material (bone and antler). Most experimenters believe that deformation of bone points is a reliable indicator of their artificial nature and of the ways they were used in hunting (as projectiles or for preparing animal skins), warfare, or ritual activities. The latter include symbolic shooting at rock drawings before hunting and at landscape features such as crevices and trees, as exemplified by a ritual practiced by the California Indians.*

Keywords: *Archaeology, experiment, projectiles, bone points, deformation, hunting, ritual.*

## Introduction

Bone tools belong to a unique category of implements that were widely used in almost all regions of the world and that maintained their importance and effectiveness throughout all archaeological periods (the Paleolithic, Neolithic, Bronze Age, and Iron Age). Bone (antler) materials also provide information and make it possible to reconstruct their processing techniques, to determine their functional purpose and possible reasons for damage and wear. The experimental method plays a primary role in these studies. In the 20th and the 21st centuries, international archeological science has gained diverse experience in modeling destruction processes in stone and bone points of projectile weaponry (arrows and darts) from the Paleolithic to the Metal Age, using experimental methods.

This article overviews the most interesting studies of international (European and American) experts, and presents the results of our own experiments that have made it possible to clarify the process of deformation of stemmed bone arrowheads after shooting at stone and bone, and to verify the accuracy of suggestions on their use in hunting, warfare, and rituals.

## The range and specific results of international studies

Experimental study into the properties of projectile points made of stone, volcanic glass (obsidian), and organic materials (bone, antler, wood, shells) has a long-standing tradition. Thus, from 1935–2009, *American Antiquity*, one

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of the leading U.S. archaeological journals, published a series of articles on the deformation of stone and bone points in missile weaponry (arrows and darts).

One of the first experimental studies of deformation process in bone points was conducted in the 1930s by E.E. Tyzzer (1935–1936). The study confirmed the hypothesis that the so-called simple bone point (one of the most common finds on the East Coast of the U.S.) was an arrowhead, but not a fragment of bone that resulted from food consumption. For testing his hypothesis, Tyzzer compared the damage known from these finds with experimental samples. He paid great attention to the nature of damages and their possible causes. During the experiment, arrows equipped with simple bone points were shot at stony loam and gravel. A common type of damage was lateral spallation at the "heavy" edges (the center of gravity in each point was shifted to one of the edges) and at the tip of the projectile point.

S. Arndt and M. Newcomer, followed by C. Bergman (Arndt, Newcomer, 1986; Bergman, 1987) conducted meticulous studies of deformation features in bone points and tips from the Stone Age archaeological collections of the British Isles, Northern Europe, and the Levant. Thus, using materials from the site of Ksar Akil (Lebanon), Bergman observed that bone and antler points seemed to have been more practical; they were made faster and could be repaired easier. In addition, antler was preferred over bone by the ancient inhabitants of the settlement (73 % and 27 %, respectively) (Bergman, 1987: 125).

The destruction of stone-tipped darts was described in a study by G. Frison (1989) on the experimental use of implements in the Clovis culture (the prehistoric Paleo-Indian culture in North America, 11,500–10,800 BP). The possibility for using these implements in hunting mammoths was tested on African elephants. Another interesting study was conducted by J. Cheshier and R. Kelly, who studied the influence of the shape and weight of the stone dart tip on its penetration capacity (2006).

In 2009, a collective work (Waguespack et al., 2009) on the benefits of stone points over the sharpened shafts of arrows was published. The following results were obtained from shooting the bow at a plastic model: the stone tip penetrated only 10 % deeper than the sharpened shaft, while the costs of its production and operation were significantly higher. These data suggest that stone points (particularly those made of decorative varieties of raw materials and of very large size) illustrated prestigious technologies and performed a ritual function (Tabarev, 2005–2009).

Among recently published works, we should note a collection of articles in the BAR series (Ancient…, 2010) that contains a variety of studies on the technology, functional purpose (use-wear), and cultural interpretation of bone tools: publications of the Argentine researcher N. Buc on macro- and micro-deformation (see, e.g., (Buc, 2011)), and studies of J. Bradfield and his colleagues on bone points and tips in archaeological and ethnographic collections from South Africa (see, e.g., (Bradfield, 2012)). One of the latter studies provides a detailed classification of deformations in bone points, such as a spiral fracture, hairline fracture, oblique fracture, beveled fracture, transversal fracture, and their numerous varieties (Bradfield, Brand, 2015).

According to the majority of international experts in experimental archaeology, deformation of the point is one of the reliable signs indicating the artificial origin of the object, and also a basis for hypotheses concerning the functional purpose of points.

## Experimental modeling of deformation processes in bone points

An experimental study was conducted by A.P. Borodovsky following the analysis of a series of destroyed bone points from the Early Iron Age deposits in Denisova Cave (Derevianko, Molodin, 1994: 46, fig. 39; 103). The tip of the striking part in the majority of these objects was damaged, which was interpreted as a result of ritual shooting at the wall of the cave (Ibid.: 44, fig. 37, *10*; 46, fig. 39, *6*; 103; 132). During the experiments (shooting was carried out at rock surface using a traditional archery bow with a tension force not exceeding 15 kg), such type of destruction in bone points was confirmed (Fig. 1–3). Another feature of damage in bone tips when they were shot at a rock surface, which was established experimentally, was the spalling of the arrowhead edges (Fig. 2). This type of damage also occurred in the experimental series (Ibid.: 44, fig. 37, *11*). However, not all fragments of bone arrowheads of the Early Iron Age from Denisova Cave can be correlated with the results of shooting at rock surface (Ibid.: 46, fig. 39). This is especially true for the points with broken stems (Ibid., fig. 39, *11–14*). Experiments have quite clearly shown that shooting at rock with an arrow equipped with a bone arrowhead resulted in the turning of the stem towards the impact (Fig. 4). This, however, did not lead to the destruction of the stem as is typical of the fragments of points from Denisova Cave. In the experiment, two variants of attaching the point to the shaft have been tested: rigid hafting with coiling (Fig. 2, 3) and simple insertion into the split end of the shaft (Fig. 1, *1*, *2*). In the former case, after colliding with a stone surface, the arrowhead would become somewhat twisted in the place of its attachment to the shaft (Fig. 3), while in the latter case, the arrowhead would almost completely slip out of the split end of the shaft (Fig. 4, *2*). Thus, the destruction


*Fig. 1*. Experimental bone points.


*Fig. 2*. Experimental bone point (Fig. 1, *5*) after shooting at a stone surface.

*Fig. 3*. Experimental bone point (Fig. 1, *6*) after shooting at a stone surface.

*Fig. 4*. Experimental bone point (Fig. 1, *1*) unattached to the shaft after shooting at a stone surface.
*1* – collision of bone point with a rock surface; *2* – location of bone point after striking the rock surface.

of stems in the points from Denisova Cave was unlikely the result of shooting at the rock, and moreover, the finds include some points with clear signs of trimming with a metal blade (Ibid.: Fig. 39, *13*).

*Fig. 5.* Flat bone of a cow skull with the fragment of the tip remaining from the experimental bone point.

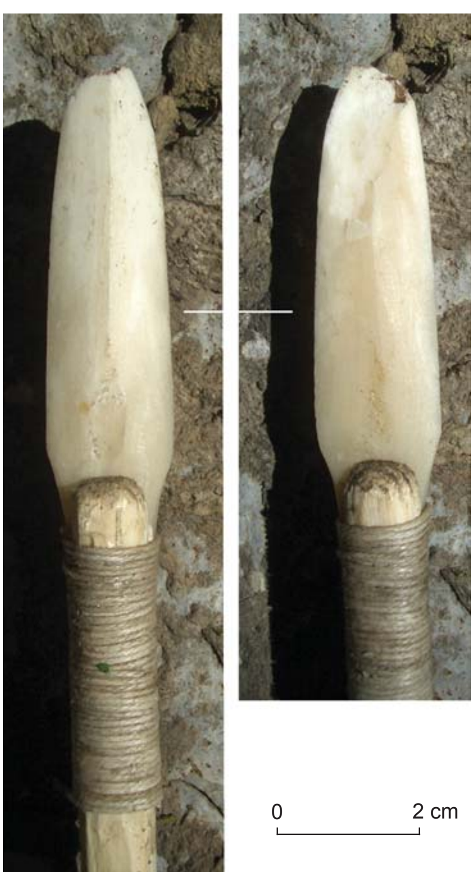


*Fig. 6.* Experimental bone point with destroyed tip after shooting at a cow skull.

The nature of damage to bone tips after colliding with rock surface is clearly conditioned by the structure of bone material (Borodovsky, 1997: 162, pl. 1). The density of the medium with which the bone point would collide, is of particular importance. In particular, the experiments have shown that after the impact of a bone point with a material similar in density, for example, with a tubular bone in the prey's body, it does not become destroyed, but the shaft of the arrow breaks inside soft tissues, and the arrow cannot be removed without surgical intervention. When the bone point collides with less firm flat bone (for example, a vertebra, a scapula, or bones of the skull), it enters deep into the bone, and, as the experiments have shown, the point may break off at the tip (Fig. 5, 6). According to archaeological data, an example of such penetration is known from burial 15 of Object No. 4, located near the town of Sukhanikha in the Minusinsk Depression, where a bone arrowhead was discovered in the lumbar vertebra of the buried person (Koni…, 2010: 109). This location corresponds to one of the most common areas struck by metal arrowheads, known from pictorial materials of the Ancient World and the archaeological data of the Metal Age on the territory of South-Western Siberia (Borodovsky et al., 2010: 44, fig. 11, *3*, *16*).

Samples of destruction of bone tips after shooting at less firm flat bones exhibit completely different features as compared to the results of collision with rock surface. The main difference is that in the former case (impact on bone), a long spall is formed on the tip, which covers a significant part of the general plane of the blade (Fig. 6), while in the latter case (collision with a stone surface), the destruction of the tip does not always involve the blade (Fig. 3). Another feature of damage in bone points when shooting at a sufficiently dense surface is lateral spalls of the blade, noted already by Tyzzer (1935–1936) (Fig. 2). Thus, we can conclude that shooting at rock surface with arrows equipped with bone points results in very distinctive damage to the arrowheads. Furthermore, in interpreting the damage of the bone points it should be noted that these objects belong to the category of universal implements (Borodovsky, 1997: 193, pl. 32), and therefore their various deformations could have been associated with an additional range of uses.

## Conclusions

In general, experimental results obtained by international experts and the authors of this study, associated with deformation of bone arrowheads, combined with archaeological and ethnographic data, make it possible to estimate the real striking capacities of bone arrowheads when they are used for hunting, military, or ritual purposes. Each of these areas is an extremely interesting field for research and discussions.

The range of uses of bone points for hunting and fishing is very wide, involving not only direct striking of prey, but also processing of products obtained from hunting (leather, skins) or fishery (Borodovsky, 1997: 193, pl. 32). The multifunctional nature of some of the bone points is paralleled by quite early emergence of specialized implements. Thus, the above-mentioned projectile points from South Africa (Namibia) include clearly distinguishable thin and elegant arrowheads with poison applied to their tips before hunting, and also heavier arrowheads apparently intended for striking a different kind of prey. The difference in the morphology of the objects is confirmed by the various nature of their use-wear and deformation (Bradfield, Brand, 2015).

The discussion about the time of emergence and the specific features of projectile points used in intergroup conflicts or, in other words, the objects of weaponry, is still continuing. A number of European experts believe that projectile points maintained their multifunctionality for a long time, whereas specialized projectile points for warfare appeared sufficiently later. Thus, using the Neolithic and Bronze Age materials from Europe, J. Chapman has offered the following sequence: implements for hunting with a possible use in warfare, implements for warfare also preserving a utilitarian function, and finally, specialized implements for warfare (1999). A different point of view was expressed by H. Luik: the analysis of the arrowheads found at the Bronze Age sites and fortified settlements in the Baltics (1st millennium BC), clearly showed that blunted points made of elk antlers and small bone points were used for hunting, while larger and more carefully produced points, spurred or non-spurred, were obviously intended for military purposes (2006).

Finally, the ritual use of bone points and, accordingly, the specific nature of their deformation are associated with a variety of rituals and ceremonies in the societies of hunter-gatherers, breeders, and farmers. Such rituals included, for example, ritual shooting at rock drawings before hunting, and shooting at specific targets or features of landscape. As an example, we may point to a sacred object in California (USA). While on a scholarly trip, A.V. Tabarev visited canyons not far from the town of Riverside, where the sacred sites of the Native Americans have been preserved. One of the sites was a narrow horizontal crevice at a height of about 10 m, where, according to the explanation of the American colleagues, one had to shoot a bow in such a way that the arrow would get stuck in the rock. Until now, several dozens of stone, metal, and bone arrowheads of all ages have remained in the crevice (Fig. 7). Judging by the numerous fragments of arrows at the bottom of the cliff, it was not an easy task to hit the target. Most likely, this procedure initially had a ritual meaning and served as a confirmation of the excellent capacities of the shooter and his hunting skills, and over time, acquired a purely competitive nature.

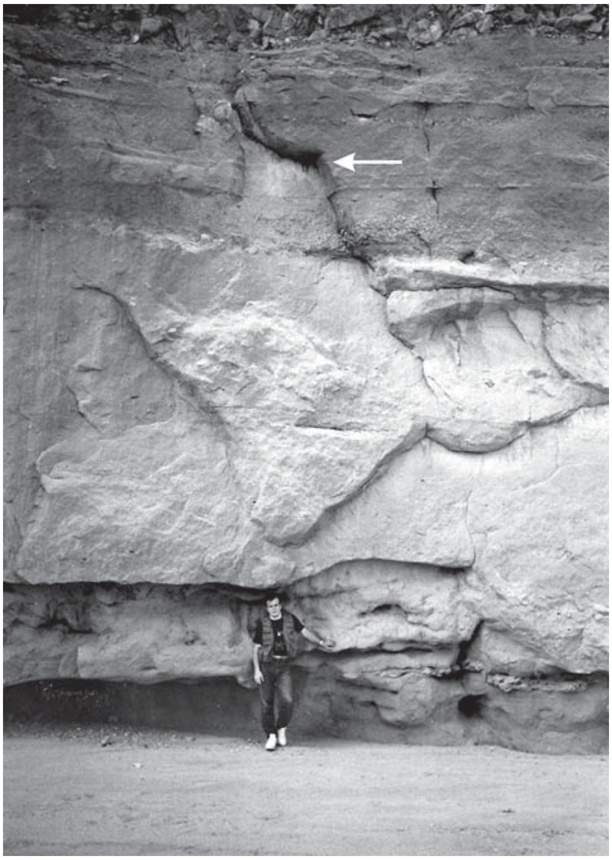

*Fig. 7.* Ritual object in canyon near the town of Riverside (California, USA). Photograph from the archive of A.V. Tabarev.

Further research on this subject and accumulation of experience on the part of Russian and international experts seems to be a very promising field involving a wide range of experimentation and archaeological interpretations.

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