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Special Assemblages

Participants in the WBRG 1999 Budapest conference (left to right): Ülle Tamla, Elisabeth Brynja, Tina Tuohy, Liina Maldre, Karlheinz Steppan, Heidi Luik, Gitte Jensen, John Chapman, Alice Choyke, Janet Griffitts, Andreas Northe, Noëlle Provenzano, Jörg Schibler, Nerissa Russell, Colleen Batey, Lyuba Smirnova, László Daróczi-Szabó, Daniella Ciugudean, Mária Bíró, Kordula Gostenčnik, Eszter Kovács, Christopher Morris, Sabine Deschler-Erb, Ans Nieuwenberg-Bron, Katalin Simán, Isabelle Sidéra, Mickle Zhilin

CRAFTING BONE - SKELETAL TECHNOLOGIES THROUGH TIME AND SPACE

Proceedings of the 2nd meeting of the (ICAZ) Worked Bone Research Group

Budapest, September 1999

Introduction

Archaeologists and Archeozoologists, both study worked osseous materials (bone, antler and tooth, including ivory, in short all referred to as "bone"). Such reports, however, are often buried at the very back of faunal analyses appended to site reports. Furthermore, the two groups of specialists have had little chance to interact, even within Europe since they tend to attend different conferences and write for different fora.

At the root of this problem lay the arbitrary, largely institutional division between pre- and proto-historians, often imposed on bone manufacturing experts by nothing but formalism in research tradition. The most exemplary series of studies n this field is entitled: "*Industrie de l'os neolithique et de l'age de metaux*" (Bone industry *from the Neolithic and Metal Ages*). Another classic, a book, is sub-titled "The Technology of Skeletal Materials *since the Roman Period*". In very early prehistoric assemblages, attention is often focused on the question of whether a particular piece of bone was worked or not. In later assemblages, it is the intensity of manufacturing that often renders objects zoologically non-identifiable, so that important aspects of raw material procurement, including long distance trade, remain intangible.

The history of raw material use, however, is continuous and many of the constraints and possibilities inherent in skeletal materials are the same whether one is dealing with Paleolithic or Medieval artifacts. Indubitably, the organization of manufacture, the function and value of bone artifacts (as well as some technological innovations such as the regular use of metal tools or lathes), differ substantially between simple and complex societies through time. On the other hand, fundamental questions of tensile characteristics, procurement strategies, style and certain technological requirements are not only similar diachronically, but also open up new vistas when apparently unrelated periods are compared. The function of these objects as social markers, for example, remains remarkably constant through time, even if details vary. The papers in this volume reflect these conceptual similarities and differences as did the papers delivered at the conference itself.

The first meeting of what was to become the Worked Bone Research Group (WBRG) was organized by Dr. Ian Riddler in the **British Museum, London, in January 1997**. The committment and enthusiasm of that first workshop has greatly inspired subsequent efforts in recruiting a wide range of bone specialists, capable of contributing to discussions concerning bone manufacturing.

In keeping with the aims of the Worked Bone Research Group, since 2000 an official working group of the International Council for Archaeozoology (ICAZ), an effort was made to present these papers on the basis of what *connects* them rather than segregating them by archaeological period or region. Contributions mostly include articles based on papers delivered in September 1999 at the second Worked Bone Research Group meeting in Budapest, organized by the editors with the unfailing support of the Aquincum Museum (Budapest) and its staff. Several people who were unable to be present at this conference were also asked to contribute papers. Finally, five of the studies in this volume, originally delivered at a symposium on bone tools organized by Dr. Kitty Emery and Dr. Tom Wake, entitled "*Technology of Skeletal Materials: Considerations of Production, Method and Scale*", at the 64th Annual Meeting of the Society for American Archaeology (Chicago 1999), were added thereby expanding the academic spectrum both in terms of research tradition and geographic scope.

There are a total of 36 papers in this volume. Research was carried out on materials from Central and North America to various regions of Europe and Southwest Asia. The authors represent scientific traditons from Estonia, Hungary, Romania, and Russia, European countries in which, until recently, ideas developed in relative isolation. Other European countries represented include Austria, Denmark, France, Germany, Great Britain, Greece, and Switzerland. Last but not least, the North American scholarly approach is also represented here.

Schools of thought may be said to be exemplified by what used to be Soviet research, well known for pioneering works on taphonomy, experimentation and traceology. Bone manufacturing was first brought to the attention of Western scholars by the publication in 1964 of the translation of S. A. Semenov's *Prehistoric Technology*, published originally in 1957. Scholars in France have also carried out decades of co-ordinated work on operational chains in the manufacturing process from the selection of raw materials to finished products, with special emphasis on prehistoric modified bone. An entire working group, “Unspecialized Bone Industries/Bone Modification”, is directed by Marylene Patou-Mathis. This working group itself is part of a larger research program on bone industry “*La Commission de Nomenclature sure l’Indistrie de l’Os Prëhistorique*” headed my Mme. H. Camps-Fabrer. Several specialists such as Jörg Schibler in Switzerland, have created laboratories where ground laying work has been carried out for years on worked osseous materials, especially from Swiss Neolithic Lake Dwellings and Roman Period sites. Language barriers have often prevented these important bodies of work from being as widely disseminated as they deserve. Arthur MacGregor in England, writing in English, has had a decisive influence on specialists working on more recent Roman and Medieval worked bone assemblages in Europe.

The work of all of these groups as well as certain individual scholars is well known within limited circles. Otherwise, however, the overwhelming experience of most researchers on worked bone have been feelings of isolation and alienation from most archaeological or archaeozoological work related, most importantly, to the absence of an international forum where their often specialized work can be presented and problems discussed.

In spite of the fact that there have been many practical obstacles to information flow between specialists in this field, there are really remarkable similarities of approach which should ultimately lead to the development of more compatible paradigms in research. Agreement on methodologies will have a positive feedback on communications, helping the field to grow and develop properly.

It seems that, at last, archaeologists and archaeozoologists and other specialists are talking to each other and sharing methodologicial points of view. One striking example of this can be seen in the the emphasis on raw materials studied in parallel to types found in the majority of papers in this volume. Previously studies often concentrated on typo-chronological questions, ignoring the questions of raw material morphology and availability. The series published by the *Centre National de la Recherche Scientifique*, edited by Mme. Henriette Camps-Fabrer in France is largely to be credited for beginning this new trend. It contains many papers concentrating on understanding manufacturing sequences and, indeed, from Europe to North America there are papers which explicitly deal with manufacturing sequences in individual assemblages.

There is also a consistent emphasis on experiment and manufacturing techniques present in much of the work in this volume. The related but fraught question of function continues to tantalize and frustrate most specialists. A number of articles attempt to apply techniques of hard science, such as scanning electron microscopy or light microscopy, together with experiment to get objective, “processual” answers to this important group of questions. Other researchers rely deductively on analogy, archaeological context, gross morphology, and textual sources as they try understanding how these objects were used.

When editing the volume, we tried to concentate on the underlying main concepts represented by each paper rather than grouping them diachronically or by geographical region. As a result, contributions follow a line from the theoretical through the problems of raw material selection, manufacturing techniques, experimental work, technical function and socio-cultural interpretations. Obviously many of these papers deal with several of these aspects simultaneously. Finally, analyses of assemblages are grouped to show the current state of general application of these principles as illustrated in papers in the rest of the volume. Reports on bone tool types will ultimately benefit from more unified typologies and also provide researchers with comparitive databases from regions beyond their own.

Finally, a word on the organization of papers in this volume. Although the editors have tried to group these papers by what they see as the main theoretical and methodological thrust of the authors it should be understood that most papers, to a greater or lesser extent, overlap between these artificial sub-titles. Happily, almost all these works include considerations of raw material exploitation, manufacturing and functional analyses and all make some attempt to consider the social context from which these artifacts emerged. It is exactly this cross-cutting of boundaries which allows us to hope that the study of worked osseous materials is well on the way to developing into a discipline in its own right.

In addition to the generous support given by our sponsors and technical editors for this volume, organizing the conference would not have been possible without the active help of numerous colleagues. Special thanks are due to Paula Zsidy, Director of the Aquincum Museum, Katalin Simán, archaeologist and two students from the Institute of Archaeological Sciences (ELTE, Budapest): László Daróczi-Szabó and András Markó. The Hotel Wien, Budapest and its efficient manager provided a comfortable setting for our discussions at a reasonable price. Last but not least, help with abstract translations by Cornelia Becker, Noelle Provenzano as well as Marjan Mashkour and Turit Wilroy should also be acknowledged here.

BONE TOOLS AND WARES FROM THE SITE OF GORNY (1690 - 1410 BC) IN THE KARGALY MINING COMPLEX IN THE SOUTH URAL PART OF THE EAST EUROPEAN STEPPE[1]

Yekaterina Antipina

Abstract: This paper discusses simple chisels from the Late Bronze Age site of Gorny (1690-1410 BC) in the Kargaly mining complex in the south Ural part of the East European Steppe. Experimentally, such chisels have been shown to work better than their metal counterparts. Absence of finished tools is related to their destruction during mining work.

Keywords: Late Bronze Age, Gorny, mining, chisel blanks, experimental archaeology

Résumé: Cet article étudie les ciseaux simples du Bronze final du site de Gorny (1690-1410 av. J.-C.) faisant partie du complexe minier de Kargaly dans la partie sud de l'Oural de la steppe d'Europe de l'Est. L'expérimentation a montré que ces ciseaux étaient plus efficaces que leurs équivalents métalliques. L'absence d'objets complets est à mettre en relation avec leur destruction au cours du travail dans la mine.

Mots-clés : Bronze final, Gorny, exploitations minières, ciseaux, archéologie expérimentale

Zusammenfassung: In diesem Beitrag werden schlichte Beile aus dem spätbronzezeitlichen Fundplatz von Gorny (1690-1410 BC) aus dem Kargaly Bergwerkskomplex im Südural in der eurasischen Steppe vorgestellt. Im Experiment wurde festgestellt, daß solche Beile besser funktionieren als ihre metallenen Gegenstücke. Das Fehlen von Fertigprodukten kann mit deren Zerbrechen während des Gesteinsabbaus in den Minen erklärt werden.

Schlüsselworte: Späte Bronzezeit, Gorny, Bergbau, Beilrohlinge, experimentelle Archäologie

Introduction

Archeologists often find worked animal bones in Late Bronze Age (LBA from here onwards) settlements of the East European steppe. As a rule such collections include tens or, more rarely, hundreds of bone artifacts. Usually the bone artifacts with evident traces of manufacturing (wonderful gloss on the bone surface, traces of sawing and cutting, drilled holes and also, though not as often as desired, ornamental designs) attract the attention of researchers. Finished LBA bone tools can usually be categorized within four groups according to the primary spheres of use: tools or household equipment (fig. 1: 5-11), clothing accessories (fig. 1: 1-3), weapons (fig. 1: 4) and sacral items (Berezanskaya, 1999: 47-51; Kovaleva, 1990; Lyashko. 1994: 154; Usachuk, 1997: 177-178; Antipina, 1999: 115). Some of these finished bone objects have been found in many LBA settlements representing various archaeological cultures (ie. Abashevo, Srubnaya and, Andronovskaya) and are thus widely distributed over the territory of the East European steppe and steppe-forest steppe. For example, tupics from cattle mandibles and polishers from large-size ungulates' ribs (fig. 1: 10, 6-7) (Pryachin & Kileinikov, 1989: 150; Usachuk, 1994: 64). At the same time, LBA bone tools appear less sophisticated (in their forms and technical proficiency) and are also less varied within certain categories in comparison with the richest materials of the bone hunting weapon and tools from the previous Neolithic and Eneolithic epochs and subsequent Iron Age with its animal style decorative motifs (Smirnov & Petrenko, 1963; Sharafutdinova, 1989; Zhilin, 1993). And so despite the numerous brief notes on LBA worked bone in the archeological publications, there are practically no major works specially devoted to the study of LBA bone artifacts and a more accurate definition of their functions. Sometimes half-finished products (or blanks) for typical tools and waste products (or refuse) are analyzed thus moving research towards the reconstruction of the technological points of bone working and manufacturing of some concrete items (Lyashko, 1994; Usachuk, 1998; Antipina, 1999). Such investigations are most interesting and have expanded our knowledge. But there still remains a feeling that the study of LBA bone artifacts from the East European steppe is at present at the level of a more accurate definition of the known facts but not at the level of new discoveries.

However, every researcher has at least once been in a situation when a fragment of animal bone found during the excavations of any period did not appear finished due to the absence of processing traces over most of its surface. At the same time, however, the well-formed working edge of the bone testifies that it was used as a tool (fig. 1: 11). As a rule the functional purpose of such objects remains unidentified. Undoubtedly, the question of their origin and functional purpose has no common answer as it is connected with household activity in the particular settlement. The only possible common characteristic of the tools is that they were probably used for one occasion only. The mystery of such tools leads to the absence of their quantitative evaluations in the settlements under study, and so does not form part of the scientific analysis.

The main purpose of this paper is to attract attention of researchers to such artifacts and to demonstrate that their analysis can have remarkable results. So, for example, the studying of mysterious, almost unprocessed shanks from animal bones has lead to the discovery of the phenomenon of the use of bone tools in mining. The discovery was made when researching the archaeozoological collection from Gorny settlement, part of the LBA copper mining Kargaly complex.

Material and methods

The remains of animal bones form the greater part of the archeological material from the excavations at Gorny. Not less than 1.5 million fragments of animal bones were extracted and studied from the excavated part of the site (the area is only 608 square meters) during the 1992 - 1997 excavations.

The main aim in researching such a quantitatively unique osteological collection was above all the exact identification of both the biological and archeological information based on the osteological materials. Already during the first stages of research, new quantitative estimates were introduced to reveal the character and degree of the artificial processing of the bones together with traditional methods (taxonomical bone identification, the analysis of age-structure, bone-structure according to the parts of the skeleton and other biological characteristics). The new estimates include:

a). Index of bone fracturing (the ratio of absolute number of bone fragments to the volume they occupy in standard volume units - 1 cubical decimeter). For comparison the indexes of artificial fracturing of bones in osteological collections were calculated; on the one hand using the intact skeletons of big mammals, and on the other hand, the kitchen refuse derived from large mammals coming from archeological excavations in medieval and modern cities. The index of "fracturing" for intact skeletons of big mammals was in the range of 0.5 to 5; the index of artificial fracturing in the kitchen remains collections from the large ungulates was in the range of 20 to 50.

b). Quantitative evaluation of artificial impacts (cutting, notches using a thin metal blade, sawing, drilling, breaking etc). The calculation of finished articles from animal bones, half-finished articles and waste according to chronological phases and topographic features of the settlement was carried out separately.

c). Size characteristics for all bone fragments from random samples (not less than 1000 remains) from the various chronological phases to evaluate the character of the fracturing.

d). Evaluation of the ratio of the remains of compact bone and spongiosa in random samples (not less than 1000 remains) from various chronological phases to clarify the degree of completeness of the presence of remains of the different bone parts in the material under study.

Studying the functional purpose of the bone artifacts also became a necessary part of the investigation. Trace analysis, ethnographical data and, in some cases, field experiments were used.

Results

According to the archeological material (pottery, metal, casting forms, stone hammers) the LBA settlement of Gorny belongs to the Srubnaya culture. This intensively studied settlement of miners covers 3.5 square kilometers over a territory of an ore field in the Kargaly mining-metallurgical complex (Chernykh, Kuzminykh, Lebedeva et al, 1999). Nearly 2% of the settlement has been studied on average. However, the settlement happens to be unique and has no analogue among coeval and studied (to a certain degree up to the present moment) mining-metallurgical sites of the Srubnaya and Andronovskaya cultures.

Four subsequent chronological phases covering a period of 300 years were noted in the studied part of the settlement. Fundamentally, only two periods differ in terms of their manufacturing activity: the early (phase I – BM-2963: 1740-1640 BC, calibrated), the so-called period of "pit-huts", where the inhabitants lived during summer and during seasonal ore mining activity; and a later period with fundamental all year-round housing and manufacturing complex 1 (phase II – BM-2692: 1615-1515 BC, cal.). The inhabitants were busy on a daily basis with ore extracting, mineral cleaning and, smelting metal for their own needs. The destruction of this complex was probably the result of the invasion of some alien tribes. Its ruins were covered with some minor deposits of phase III (BM 2964: 1515-1420 BC, cal.) with barely readable traces of seasonal miners' huts and later with heavy debris lacking the construction waste of phase IV (BM 2965: 1525-1410 BC cal.). It is obvious that phase IV represents a dump of various kinds of waste filled by the inhabitants of a neighboring part of the settlement, who exploited the destroyed trench of house-manufacturing complex 1 as it was (Chernykh et al., 1999: 81-91).

Taxonomical identification of animal bones displayed a very similar structure in both the species-structure of the osteological material and the quantitative ratio of domestic ungulates. Ungulates, thus, contributed up to 99% of all bones identifiable to species level (Antipina, 1999: 103-104). The bones of adult cattle represent 83 % not only from those identified to species level but undoubtedly the fragments composing the better part of the unidentified bone fragments as well. Among the identified fragments goat-sheep bone composed 15% of the total identifiable sample and, horse and swine bones made up 1.7% and 0.3% of the total respectively. From this data it is possible to conclude that beef was the main component in the meat diet of the Gorny inhabitants and the bones of cattle were the main raw material for bone tools.

The information derived from the new quantitative evaluations allows us to outline some important characteristics of the Gorny bone collections:

a). Animal bones, and cattle bones above all, from Gorny were highly fractured compared to normal butchering for meat (tab. 1). As taphonomic conditions in the Gorny cultural stratum yielded bone remains in a fine undamaged state, it is also clear that 70% of them displayed signs of manufacture - cutting, sawing, planing etc. Thus, the increased level of bone fracturing is the result of after-kitchen fracturing of the carcasses. The greatest degree of artificial fracturing is characteristic of the second chronological phase which undoubtedly was the period of most intensive manufacturing activity by the settlement's inhabitants;

b). Evaluation of the distribution of the remains according to the parts of the skeleton showed that practically all skeleton parts of the cattle (from the lingual bone to caudal vertebrae and small legs bones) are present in the material and their ratio is quite uniform. This shows that all parts of the skeleton following kitchen processing and those remaining after artificial fracturing were left in the settlement. The absence of any sorting of the bones in terms of skeletal part made it possible to analyze the ratio of compact and spongy tissue remnants from tubular long bones. It turned out that this ratio differs from the theoretical and model ones counted for the found fracturing (correspondingly – compacta: spongy 2:1 or 4:1; Antipina, 1999: 109, 110). On the contrary: the proportion of spongiosa fragments increased up to 1:3 in chronological phases II, IV (tab. 2). It seems that such a reverse ratio in favor of the spongiosa from long bones reflects the real fact that a considerable part of the bone compacta was taken away as a raw material for manufacturing of tools;

c). In addition to the above-mentioned peculiarities of artificial fracturing of long bones it was found that the remains of their compact tissue (from metacarpus and metatarsus mainly) form groups of similar shape and size. Most of all such fragments were found in layers II and IV of the chronological phases. Their measurments showed that the full length of such rectangular fragments is less than 15 centimeters in 97% of the cases and not more than 5 centimeters in 20% of the cases (Antipina, 1999: 109). About 4000 fragments have lengths ranging from 11 to 15 centimeters and form a continuous size-series of shanks (or rods) with a nearly equal rectangular shape and rectangular section (0.5-1 on 1.5-2 centimeters). These shanks were mainly concentrated in the territory of the smelting yard in chronological phase II. Among all these shanks only three fragments displayed absolutely evident traces of working exhaustion on one of the ends, and two other shanks showed specific traces of battering with a stone hammer or something like that. This data suggests to us that the bone shanks may have been half-finished pieces for some kinds of unidentified tools. The study of the same sort of chipped places on the shanks – mainly metacarpus and metatarsus fragments – made it possible to reconstruct their fracturing scheme (Antipina, 1999:100);

d). If the traces of artificial manipulation – cutting, sawing, planing etc. – are found on 70% of all the animal bones found in the cultural layers of settlement at Gorny, then undoubtedly the processed finished ware, their blanks and waste with the traces of concrete manipulation, consist of only 0.7% of the bones identified to the species level (absolute number – only 10,000 bones). The bone tools and ware can be palced then into at least 15 categories. So far it has been possible to calculate the ratio between finished artifacts, their blanks and the most defined waste from their production only for the sample of animal bones from the 1994 - 1997 excavations (Tab. 3), which primarily includes faunal materials from the II and IV chronological phases. It is necessary to stress that Tab. 3 contains data only on bone fragments with evident traces of processing, though the largest part of the waste, especially after the first stage of bone fracturing, does not display evident traces of manufacturing. The blanks and waste for half of the singled out finished ware could be defined unambiguously. For some other categories of bone artifacts, both the blanks and waste, were simply indistinguishable. For example, for the three categories of tools from ribs – polishers, spatulas and punch-presses, well defined in the finished form, the blanks and waste of their production cannot be distinguished for sure;

e). It was possible to document in detail the whole sequence of manufacturing for some of the tool categories found from the stage of the intact bone till the finished bone implements (Antipina, 1999:113). It became clear that the inhabitants of Gorny used completely different parts of the skeleton as starting material for manufacture depending on the category of tool to be produced (tab. 4). Only three categories of bone tools were each manufactured from only one part of the cattle skeleton: tupics – from mandibles, shovels – from scapulae and sacral objects – from radii.

This data shows that the manufacture of bone tools at the Gorny settlement should be considered highly professional and organized. The volume of cattle bone used as a raw material for tools also testifies to this fact. The discovery of 13 tool categories, where the manufacturing of them meant that the natural shape of the bones must be destroyed, again reconfirms the high professionalism of bone manufacturing in Gorny.

Practically all categories of bone tools found in Gorny (with the exception of the most numerous bone shanks - blanks used in the manufacture of some unidentified tools) can be found in bone collections of many other LBA settlements. Direct archeological analogy, publication of the trace-analysis results on the working surfaces of these tools and also ethnographic data made it easier for us to reconstruct their functional purpose (tab. 5). Undoubtedly, the most likely function of bone tools and ware at the settlement of Gorny are household and handicraft uses. These include: skin processing,

Analyzed Characteristics of bone collection	Chronological Stages of Gorny				Gorny - Total	Moscow–modern Town bone refuse	Pskov–Middle Ages town bone refuse
	I	II & III	IV	Without date			
Bone fragment count (total)	34020	395279	1029026	91575	1549900	1040	8620
Volume of bones in dm^3	406	3716	11671	1012	16805	60	432
Fractured bone index	84	107	88	90	92	17	20

Tab. 1 Estimates of fractured bone index in Gorny

Analyzed Characteristics of bones collection	Chronological Stages of Gorny				Fracture model 1	Fracture model 2
	I	II	IV	IV		
Fragment count (total) in random samples of fractured long tubular bones	1590 (100%)	22100 (100%)	11440 (110%)	15340 (100%)	6 (100 %)	10 (100%)
Compacta fragment count	820 (52%)	8840 (40%)	3432 (30%)	5215 (34%)	4 (67%)	7 (70%)
Spongiosa fragment count	770 (48%)	13260 (60%)	8008 (70%)	10125 (66%)	2 (33%)	3 (30%)

Tab. 2 Ratio between Compacta and Spongiosa fragments of long tubular bones in Gorny and in reconstructed models of fractures bones

Category of bone wares	Bone wares number/(%)	Bone blanks number/(%)	Bone refuse Number/(%)	Total number/(%)
Polishers, Spatulas, Punch-pieces	986 (28)	1966 (56)	582 (16)	3534 (100)
Tupis	35 (6)	40 (6.6)	526 (87.4)	601 (100)
Arrows +(?) rectangular bone shanks	3 +? (0.1)	7+2380 (74.4)	820 (25.5)	3210 (100)
Handle, bone cylinders	15 (3)	448 (93)	20 (4)	483 (100)
Awls, Piercing, Needles	71 (4.8)	457 (30.5)	966 (64.7)	1494 (100)
Shovels	5 (62.5)	3 (37.5)	?	8 (100)
Buttons, Buckles	6 (0.9)	16 (2.3)	666 (96.8)	688 (100)
Sacral bones	14 (2.8)	50 (10.2)	426 (87)	490 (100)
Other	5 (12.5)	15 (37.5)	20 (50)	40 (100)
Count of all categories:	1140 (10.8)	5382 (51)	4026 (38.2)	10548 (100)

Tab. 3 Ratio between bone wares, blanks and refuse (in sample from 1994-1997 excavations)

Category of wares	Bones name**											Bones names number for one category of wares
	Mnd	Costa	Vert	Sc	H	R	U	Mtp	Pelv	F	T	
Polishers, Spatulas		+	+	+		+	+	+			+	7
Punch-presses		+	+	+								3
Tupis	+											1
Arrows, shanks	+					+		+			+	4
Handle, bone cylinders					+	+		+		+	+	5
Awls, Piercers		+		+		+	+	+	+		+	7
Needles						+		+			+	3
Plain dishes	+		+	+					+	+	+	6
Shovels				+								1
Buttons, Buckles	+	+	+	+	+				+			6
Sacral bones						+						1
Categories number from one bone name	4	4	4	5	2	6	2	5	3	2	6	

**Abbreviated Latin names of bones: Mnd – mandibles, Costa – ribs, Vert – vertebrae, Sc – scapula, H – humerus, R – radius, U – ulna, Mtp – metacarpus & metatarsus, Pelv – pelvis, F – femur, T – tibia

Tab. 4 The use of different parts of cattle skeleton for manufacture of bone wares

The fields of probable functional purpose of bone ware					
Working with wood and other plant tissues	Skin processing and manufacturing of accessories for clothes	Pottery processing	Weapon manufacturing	Manufacturing of moulds, work with metals and underground mining work	Sacral accessories manufacturing
Polishers, Spatulas, Piercers, Awls, Handle	Polishers, Spatulas, Tupis, Punch-presses, Piercers, Awls, Needles, Buttons, Buckles, Handle	Polishers, Spatulas, Piercers Punch-presses	Arrows	Polishers, Spatulas, Piercers, Bone cylinders, Shovels, Shanks	Sacral bones, Plain dishes

Tab. 5 The probable function of main categories of bone tools in Gorny

wood working, pottery processing, manufacturing of moulds, work with metals, manufacturing of bone accessories for clothing and, ritual activities. It is only natural to suggest that they were manufactured in the settlement itself. All the above-mentioned characteristics of the remains not connected with kitchen activity support this fact. Moreover, the ratio of finished ware to their blanks practically for all categories of bone artifacts ranges between 1:1 and 1:10 which seems natural and normal for household manufacture and use. There are only two exceptions - handles for metal tools and unidentified tools (this ratio is respectively 1:30 and 1:795, tab. 3). The rectangular bone shanks of 15 centimeters length considered above, are just blanks for unidentified tools (fig. 1: 12).

The data and the conclusions obtained concerning most of the bone tools and other manufactured ware seem to be well-founded and not debatable. The two exceptions noted above regarding the ratio of finished tools and their blanks demands further attention, however.

Interpretations of these two exceptions may be different. For example, the absence of a certain number of finished wares may indicate a greater demand or more intensive use of these tools outside of the settlements. Though the open question of unidentified tools from a thick rectangular bone shank provides a wide field for discussion. However, if the volume and final destiny of the finished tools remain in the area of speculation, the fact of the extremely intensive manufacturing of these, as yet, unidentified tools from Gorny is absolutely evident.

Discussion

We have suggested the hypothesis that the thick rectangular bone shanks were used as blanks for spear heads, for lances and arrows (Antipina, 1999:12). Indeed the shank from the compacta of cattle metacarpus or metatarsus with a rectangular section (0.5-1 cm on 1.5-2 cm) are really best to make heads for little spears and big arrows. It may be considered the first stage of bone processing. Moreover, there are intact arrows and blanks for them in the find collection from Gorny (tab. 3), although their numbers are small. In this case, one must never-the-less recognize the fantastic volume of weapon production at this mining settlement although the traces of the need to use weapons for the defence of the settlement are absent. Apparently, the very first attack of alien tribes also marked the final stage in the life of the inhabitants of house-manufacturing complex 1 of chronological phase II.

It is natural to suggest that the finished heads of spears and arrows were apparently used for sale and exchange, since there are so few of them in the archaeological layers at Gorny (Antipina, 1999: 112). This suggestion makes good sense as the results of archeozoological and archeological reconstruction of the Gorny economic system evidently showed that the large volume of livestock exchange for ore formed the basis of food provisioning for the inhabitants (Antipina, 1999:107; Chernykh et al.,1999:100). However, further scientific research in Gorny has shown that this hypothesis ultimately does not stand.

In 1999, an experimental shaft sinking was carried out to reconstruct and calculate the labor expenditure in the Kargaly mines. The question of non-metal tools for mining work was resolved in favor of archeological bone shanks and stone hammers. It turned out that bone shanks used as chisels or wedges were more effective than their metal counterparts especially when professional skills were lacking (it was much easier and simpler to work with them). Bone shanks, 10 to 15 centimeters in length were made from fresh modern metacarpus and metatarsus from cattle.

After one hour work of wedging off the flaky sandstone, specific traces, analogous to the three fragments of archeological shanks, appeared on the working edges of both archeological tools and chisels manufactured from fresh bones. On the opposite ends of these tools traces appeared which were analogous to those found on the two fragments of bone shanks from the archeological material. These were graphic evidence of the blows from stone hammers.

During the course of the experiment, the non-standard length of the shanks (from 11 to 15 centimeters) became understandable. Certainly, it is difficult to get a standard length for the shanks when fracturing the bones, but it is easy to choose necessary shanks. In fact the length of the concrete tool – the bone chisel – depended on the worker's palm width since during the work the entire tool had to fit the palm of the hand. As the experiments showed, the bone shanks were broken during the few first minutes of work if the tool stood out from the palm more than 1.5 - 2 centimeters from the sandstone side and more than 1 centimeter from the striking end. The bone chisel corresponding to the size of the palm was also eventually broken but only after 1.2 - 2 hours of work.

Thus, the results of the experiment showed not only the reality of bone shanks used as chisels in Gorny, but also explained the ratio of the many 'blanks' – in practice ready to be used as finished tools – to the mere five fragments displaying traces of working exploitation. It is evident that all the tools were destroyed during the course of this work and their remnants were thrown out in shafts, galleries and pit-faces. The tools were only manufactured at the settlement. The simplicity and non-processed shape of such bone shanks meant that it was conceptually difficult for us to initially consider them finished tools.

Conclusions

The phenomenon of using fractured cattle bones as tools for mining work, discovered at this LBA miners' settlement, was undoubtedly based on their advantages over wood and metal tools. The field experiments showed that the efficiency of bone tools corresponded to that of metal tools and both types of tools are better than wood chisels or wedges. Metal tools are expensive but durable. However, the short life (good for probably one occasion only) of bone tools was undoubtedly compensated by the minimal labor investment needed for their production and huge quantity of available raw material, cattle bones.

These advantages of bone chisels for use in mining work should cause us to pay more attention in the future to the numerous remains of animal bones which are mentioned in many reports from the excavations in many LBA ore producing regions, for example in the Altai, Kazakhstan, or the Don-river region. It was pleasant to discover that the phenomenon found in the Kargaly mining complex seems to have been a common technological method for the underground mining of ores in the LBA.

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Notes

1 Đŕáîňŕ âűďîëíĺíŕ ďđč ńîäĺéńňâčč ĐÔÔČ, ďđîĺęň ą 97-06-80139

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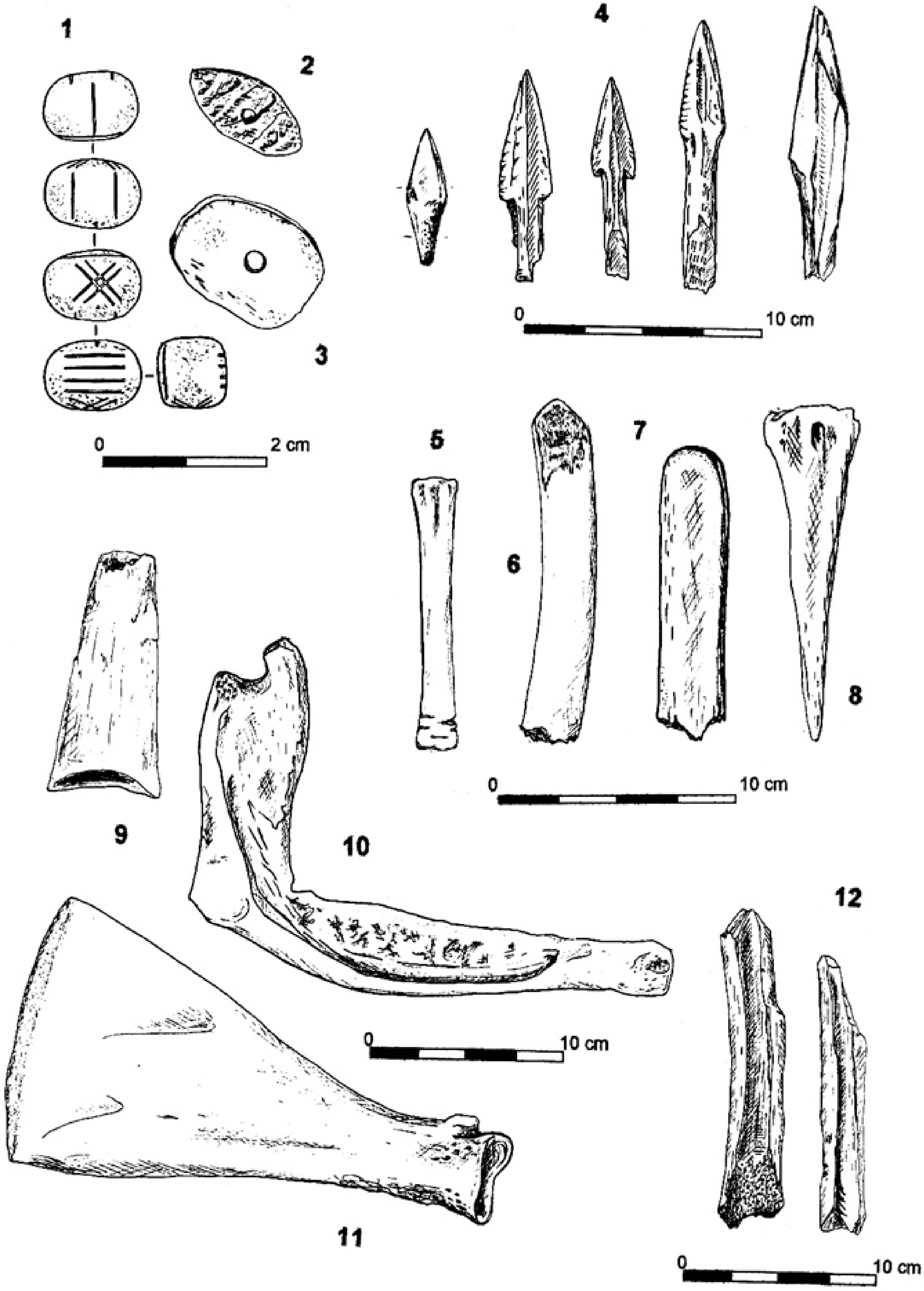

Fig. 1 Late Bronze Age tool types from the East European steppe
clothing accessories: 1-3; weapons: 4; metapodial tool: 5; rib polishers: 6-7; metapodial point: 8; handle: 9; mandible tupic: 10; scapula scraper: 11; rectangular bone shanks: 12