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THE ARCHAEOMETALLURGIC EXAMINATION OF THE BRONZE PLATE BELT FOUND IN TOMB 350 OF THE TLI GRAVEYARD OF THE KOBAN CULTURE (South Ossetia)

Purpose of the examination

The population of the Koban culture was an actor of outstanding importance in the Caucasus in the late Bronze Age — early Iron Age period (Чшиев 2007). The peoples of the mountains lying between the Ancient East and the steppe transmitted and spread the various cultural and technological elements, objects and object types not only towards the neighbouring areas but quite far, for instance, as far as the Carpathian basin, which can be followed from the Early Bronze Age. As the first step, we would like to get fundamental information about the metallurgy of the Koban culture and the base material used through the complex analysis of a richly decorated belt dating back to the 7th century B.C., made from a bronze plate that was surely manufactured in the Caucasus and found in grave 350 of the Tli graveyard. We have chosen this particularly typical and easy-to-follow object type — and specifically this find — from the extremely rich selection of material, because the sequence of scenes apparent on this belt, out of the almost 350 similar known objects, from the archaeological viewpoint suggested even at first sight that it reflects the taste and beliefs of the Koban

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culture extremely strongly and typically. The significance of our metallographic analyses is also increased by the fact that up to now no complex investigations have been conducted to determine the exact composition of the Caucasian belts (Castelluccia 2017, 15). In relation with the XRF testing of the artefacts kept in the British Museum the authors themselves also called attention to the fact that because of the presence of a thick surface corrosive layer, the 86.5% copper and 13.5% tin, as well as a small amount of other elements, for instance arsenic, silver and antimony, we observed do not reflect the actual composition (Curtis 1996, 123; Curtis & Kruszyński 2002, 53–56, 93–98). Therefore, the test results of the object we now selected may serve in the future as the basis of comparative analyses of base material used for Koban plate belts and, more widely, by Caucasian Bronze metallurgy in general. For our part, following the currently conducted basic tests, we are planning to conduct further analyses of other types of objects found in two remote areas but apparently showing parallels in their forms, in order to determine the place of their preparation.

The analysed object and its archaeological context

In years 1983–1986 and 1988 on the south side of the Central Caucasus in the cemetery of the settlement of Tli, dated back to the Koban culture, Bagrat Tehov excavated approximately 150 additional graves originating from the era of the Koban culture, mostly from the 9th-6th century B.C., which he published in a summarised form in 2002 (Техов 2002; 2006). For our examination, one of the most exciting finds, a richly decorated plate belt was in tomb No. 350. The dead body was placed in a sleeping position, with his legs pulled up, laid on

Fig. 1.: The bronze belt from the 350. grave of Tli cemetery (Republic of South Ossetia). It is dated to the 7^{th} century B. C. (based on 1-4a: Техов 2002)

his right side in the rectangular casket inlaid with stones and sank to a depth 2.1 m, in which a significant amount of charcoal and pieces of ochre were also found. They used grey clay to prepare the bottom of the tomb, in which the deceased men lay with his head pointing towards the west. Apart from the belt made of bronze plate and decorated with a sequence of scenes, the most important bronze objects found next to him included a dagger, arcuate fibula, a disc with chain and additional chain links, two rings, a shepherd's axe with geometric decoration and the remains of a wooden handle attached to it, and a jug with fluting on its side and with zoomorphic handles. The archaeologist dated the group artefacts to the 7th century B.C (Техов 2002, 17). He observed that men and women both wore belts with the difference that men also had an ornamented belt that they wore with their festive clothes and they were buried with that. According to the archaeologist, one of the most typical finds of the Koban cultural heritage is the 92.5 cm long, 15.3 cm wide and 0.5 mm thick plate belt found in tomb No. 350, the surface of which is decorated with human figures riding in wagons and hunting, between an entwining double spiral running along its sides (Техов 2002, 210). On the slightly incomplete archaeological finding the two ends of the set of scenes running frieze-like on it, are closed with 8 triangles, turned towards each other at their points in pairs and the same number of typical Caucasian axes (**Figure 1**). The set of scenes is divided into two parts in the middle by an animal, turning his head backwards, with its mouth open, and having oval ears, whose highly placed tails, starting in an arch, and turning upwards at the end is longer than its body. There is a narrow ribbon on its neck; there are spots under it and in the middle of its torso and a six-leaf rosette on each of its thighs (**Figure 2**). The craftsman of the age clearly indicated that it was a male animal, however, he unfortunately represented the stretched ends of his legs only roughly, which the archaeologist defines as flippers (плавник) based on its triangular shape, but still considers the animal to be a predator (Техов 2002, 211). To the left of the animal, which can be clearly determined to be feline based on its physical constitution and posture, there is a

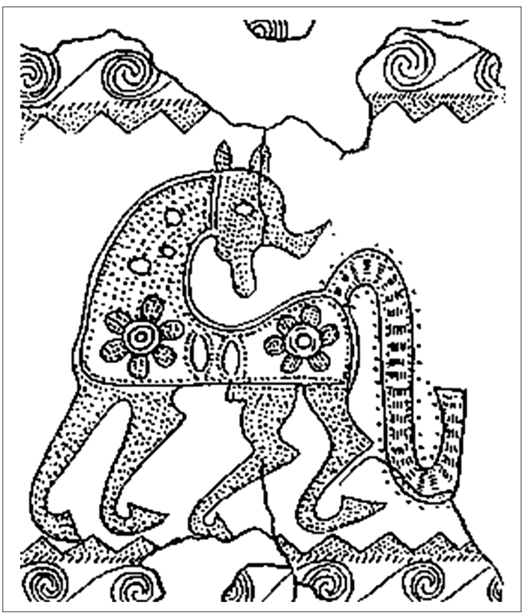


Fig. 2.: Presentation of Bars on the richly decorated belt (Tli, 350. grave)

wagon, whose wheels with their spokes imitate the Sun, pulled by two horses, and on its chequered floor plate a man, the driver is standing (wide belt on his waist), holding the rein in his outstretched right hand, and a long cane in his left hand raised above his head. The horses have been tied to the beam and made to bear a yoke, and the reins run separately from the bits to the driver's hands. The male figure in front of the horses, who is not wearing a belt, leads the wagon by holding the rein in his hands and arms stretched out long. Under his feet a wild boar appears, whose body is decorated with carvings as a chessboard, and behind it another animal is apparent, defined by the archaeologist as a roe (Техов 2002, 212, T. 20–21). In front of these there is a deer with antlers, with a narrow ribbon on its neck, and his body is so decorated with carvings as a chessboard. Unlike the other games, the latter two of the animals do not bear such signs – apart from the antlers – that would expressly indicate their male sex (**Figure 3**). At the left side of the image, two round-headed male predators appear, with their mouths wide open, having highly placed tails starting out in an arch and pointed at the end. Under the narrow ribbon tied on their neck 3 round-oval patches, and 2 on their sides, respectively, can be observed and on their thighs the symbol of the Sun is apparent in a shape completely similar to the wheels of the carriage. Their legs clearly end in strong claws, although in the original publication it is not mentioned (Техов 2002, T. 20). It is also important to mention that not only on the object examined, but in other cases as well (Tli 363, Sagaredžo 5: Техов 2002, T. 35.; Castelluccia 2017, Pl. 102) frequently the male genital organs of felines were not depicted in a hidden way as it can be observed in nature, but in a more visible way as it is apparent in the case of canines (**Figure 2**).

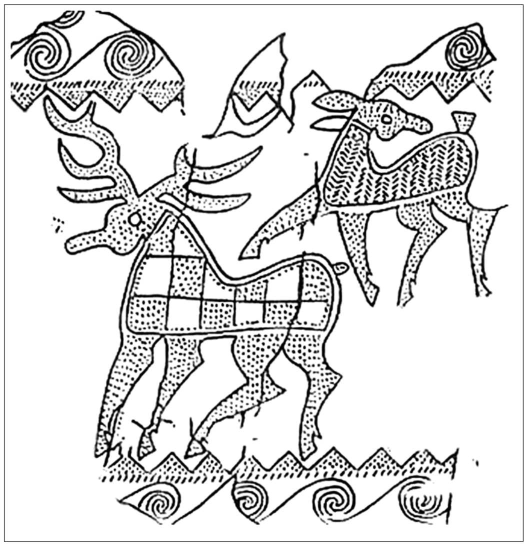


Fig. 3.: The antlered red deer, the hind and the fawn (Tli, 350. grave)

On the right side of the belt plate, behind the predator's back there are two animals depicted with their heads down, with crescent-shaped horns, which are defined as bulls (Техов 2002, 213, T. 22). Under the narrow ribbon tied on their necks 3 round-oval patches can be seen, and 2 on their sides, respectively, and on each of their thighs a waterfowl is apparent. Their legs end in hooves similar to those of the deer. In the image, the antlers of the deer and the moon-shaped horns are filled out with dots or with horizontal lines, which is repeated in other cases, too (Lorut 14, Maralyn Deresi 5: Castelluccia 2017, Pl. 87, 98) and suggests that the creator deliberately differentiated between the two types of horns. According to Manuel Castellucia, it is not possible to decide whether it is a cow or a goat in the picture (Castelluccia 2017, 116), while he clearly defines animals depicted with similar horns as goats (Castelluccia 2017, Fig. 72). As opposed to the low-placed tail, straight back of cattle and their two horns pointing to the side, the belt shows the male animals of a species having highly placed tail, arched back and frontal type of forehead. These differences are especially prominent, if we look at, for instance, the images on the shield of Sarduri II, among the especially life-like presentations of Uruartu (Пиотровский 1955, Рис. 20). According to Bagrat Tehov, based on the archaeological findings, the residents of Tli bred cattle in the 7th-6th century. At the same time, in addition to a number of ram heads he mentions only one single bullhead-shaped dangler found in a child's tomb (Tli 398. tomb: Техов 2002, 481), and maybe one more find suggests cattle also (Tli 346. female tomb: Техов 2002, T. 13,2, T. 71,4). In the material collected by Sabine Reinhold, covering the entire area of the Caucasus, there is a similarly insignificant number of such images that may suggest the depiction of cattle based on the position of their horns, in addition to the high number of ovine animals (Reinhold 2007, Abb. 39. A5A., Taf. 202. 24, Taf. 215. 23., Taf. 284. 39, Taf. 470. 11–16). It is obvious that only the achaeozoological examination of the animal bones found on the settlements of the era may provide an accurate picture of farming in the Koban culture, the proportion of the various animal species, but the representations and the cattle bones found scattered in the tombs suggest that the significance of the ovine exceeded that of the cattle by far. This observation further underpins that the craftsman having prepared the belt was not expected in particular to show cattle on the belt plate, not to mention that with the exception of the horses, all the other are wild game. Moreover, these are all such animals that in the specific region were the favourite prey of not only people, but also of feline. On the other hand, an image similar to the crescent-shape horned animals appears only among game on the plate belt of tomb No. 419 (Техов 2002, T. 95). There, the slender animal with a medium-length tail – on the basis of its antlers that start out on the top of its head and that, as the image suggests, are strongly decorated (*Capra caucasica cylindricornis*) (**Figure 4a-b**). The wide-spread awareness and significance of the animal, that was easily and clearly identifiable for the whole community at that time due to such type of deliberate shaping of the antlers, is well reflected by the fact that even in the area of the remote Hallstatt culture similar images can be found in several cases, and on top of that, in the form used on the Caucasian belts (Tli 322., 419, Samtavro 289: Castelluccia 2017, Fig. 69. Fig. 72D; Техов 2002,

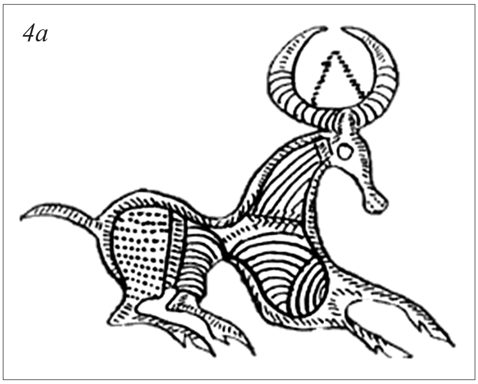


Fig. 4a: Presentation of Tur on the belt from 419. grave of Tli cemetery
Fig 4b: Skull of Tur at the sanctuary of Rekom (Republic of North Ossetia-Alania, 2019)

T. 93), a supplement placed between the horns also appears (Kleinklein, Kröll-Schmiedkogel: Prüssing 1991, T. 117., 121).

On the belt plate examined, among the crescent-shaped horned animals, a round-headed fish with six fins can be seen, whose tail ended in triangle shape, and in front of them a man is depicted who is just about to shoot his arrow and wearing a wide belt. The arrows are aimed at two antlered deer whose bodies are decorated with carvings looking as a chessboard, which is interpreted by the author as a hunting seen (Техов 2002, 213). However, it is important to note that the arrows did not lodge into the animals and apart from the antlers no other specific signs of the male sex are shown in the case of these animals, either (**Figure 6**). The right side of the image is closed with a predator, completely similar in appearance to the closure on the other side. On both sides of the feline, located in the middle of the belt plate and turning left, the animals turning to the outer sides looked each other in the eye when the object was worn

Together with the two plate belts found in the Tli cemetery tomb 425.,which may also be dated back to the 7th century B.C. and that were found earlier also according to the excavator (N9 40-б and 215-б) the find showing some connection with the Urartu art (Техов 2002, 210) depicts most of the animals that can be seen on the object examined now, however, with a lot more detail, almost in life-like quality (lion, fish, rosette, herbivore, etc.). On this belt decorated in three bands we can also see two sets of scenes, separated in the middle on the back, looking right and left, divided by the sun, rosettes, palmettes, etc (Техов 2002, T. 100). The left side is closed with twice three lions with manes, i.e. male lions (*Panthera leo persica*), their highly placed long tails start in an arch, curving upwards at the end, ending in a pointed or more open fur balls. The depiction of the winged animals, also shown in three columns in the middle part, is completely

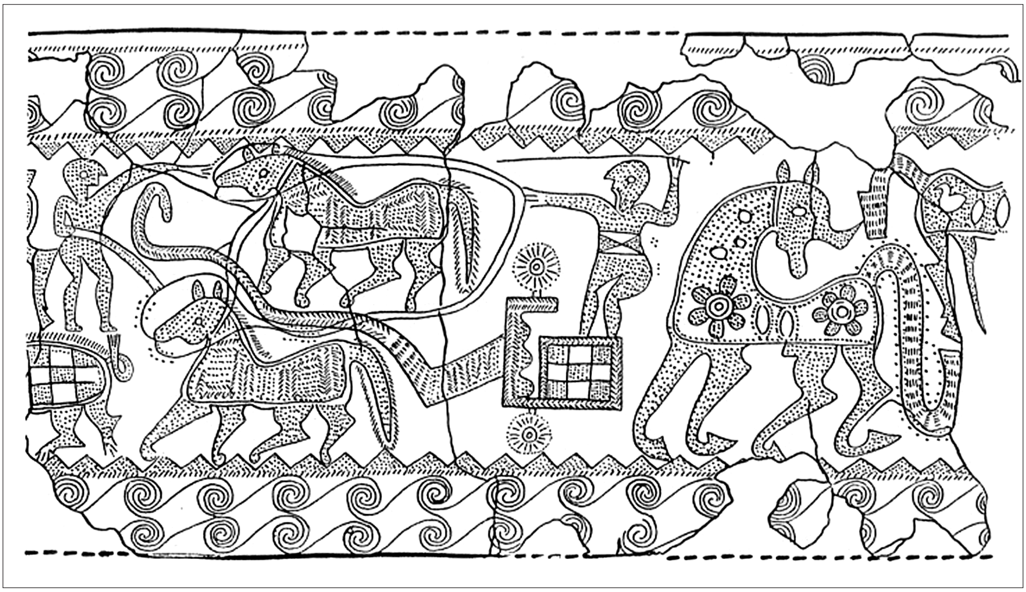


Fig. 5.: The tarpan horse guided by neck yoke (Tli, 350. grave)

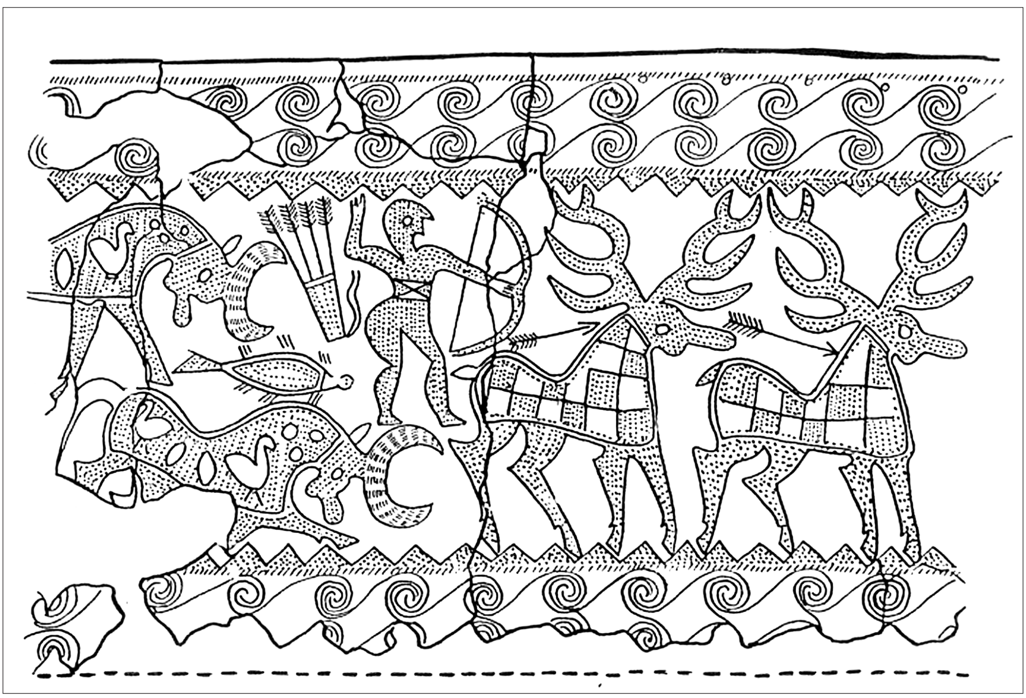


Fig. 6.: The presentation of the wonder deer which cannot be hunted by fired arrows on the Koban plate belt (Tli, 350. grave)

similar, complemented with a headdress, often apparent on the images of the new Hittite period and the Urartu (Loon 1966, Fig. 22, Pl. XXIX). In two of the columns there is an obvious possibility to identify the animal as a lion, and the three animals located at the centre line are identified by the excavator as winged bulls. On the right hand side of the belt a row of palmette is followed lions, trees of life, bulls, rosettes, winged lions, cross-shaped decorations, goats, trees of life, and lions stretching to the last image field, which is so incomplete due to the damage to the object that it is not possible to figure out what could have been there. The end of the belt on this side, divided into three fields, is closed by two winged horses, and two horsemen wearing pointed Urartu helmets, and goats standing on the branches of the tree of life.

According to J. Curtis, structures divided to a right and left side, the use of space divided horizontally and vertically, the topics related to hunting and travelling, the images of hunters, soldiers, horses, wagons and various game, often separated by plant or geometric motifs, are included among the characteristics of the Urartu belts (Curtis 1996, 118). He also calls attention that it is important to distinguish between the trans Caucasian belts and the Urartu bronze belts that use a different technology, are affected by the art of the Ancient East, and within that mostly Assyria, and which often depict mythical creatures and mythological scenes. On the Caucasian belts it is not typical to combine the different animals and to depict mystical creatures (Curtis 2017, ix). As opposed to a number of authors, who directly connect the images of the Caucasian region to the animal style of the Russian steppe he also takes the position, which is becoming increasingly wide-spread (Lang, 2012) since the publication of the book of Dagny Carter (Carter 1957, 125) that it is a very simplified picture, and that Trans Caucasian art is most likely a sub-group within the wider artistic koine of the Eurasian cultures (Curtis 2017, ix). Manuel Casteluccia in his monograph came to the conclusion as a result of his examination that the individual artistic traditions existing in the Caucasus since the Bronze Age survived into the Early Iron Age. The area was strongly affected by Mesopotamia through the Urartu Kingdom, while the effect of the people of the Iranian plateau and the steppe can be demonstrated to a lesser degree. The craftsmen of the Koban culture always decorated their objects according to the local taste and traditions and with animals in their immediate environment (Castelluccia 2017, 392).

Even this short outlook well reflects that the parallels within the cemetery of the bronze plate belt we now examine and found in Tli tomb No. 350 — further reinforcing the opinion of Bagrat Tehov — indeed show strong and direct influence of Urartu in respect of the topic, structure and motifs of the images. We can find examples of most of the elements in the artefacts of the new Hittite, Urartu art. It is just the remarkably strong influence of the Ancient East why this time we make an attempt to call attention to the details, the greater or lesser differences that may reflect the local customs and relations. The representation of the wagon on the plate belt found in tomb 350 is identical in a number of miniscule details — from the arched wagon beam to the harness lead separately — for instance to the images on the figurines of the Karkamis-Gazaintep, Aslantepe-Malatya from the new Hittite period, already referred to. This also well reflects that the strong and direct influence of Urartu on the Trans Caucasian art is a lot earlier and transmits elements of wider-scale roots to the north. The belt examined now also shows a deer in front of the wagon, corresponding to the antecedent images, which may suggest an interpretation of this scene that is similar to the images serving as examples. However, we must not leave out of consideration some minor differences. The type of the horses and the manner of harnessing them is much more archaic that in the contemporary areas of Urartu. The plate belt shows a small, bigheaded, roughly-built horse, resembling a Tarpan (**Figure 5**). At the same time, on the pictures of the new Hittite, Urartu steles graceful, tall horses pull the chariots. Moreover, instead of the yoke put on the whither, as applied there, the Trans Caucasian images consistently show a much older neck yoke (Sevan, Astchi blur 14: Castelluccia 2017, Pl. 104., 108). The figurines depict well visibly the phallus of the deer chased with a wagon and hunted for, in addition to the antlers (**Figure 7**), which is missing from our belt plate (**Figure 1**). This cannot be accidental, or due to the smaller size of the representation, as in the same place the male sexual characteristics of the predators are well visible. However, behind the deer there is a smaller animal of similar body and leg position (**Figure 1**), which was defined by the excavator as a roe (Texob 2002, T. 20). It is thought- provoking though that in an otherwise

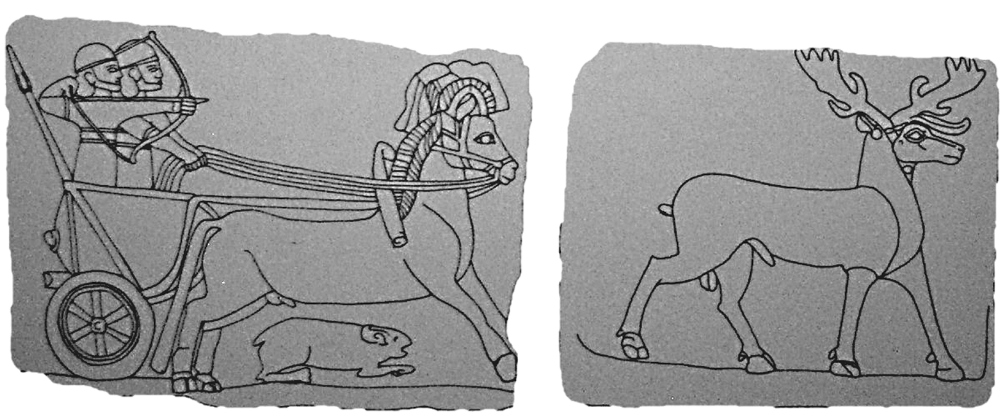
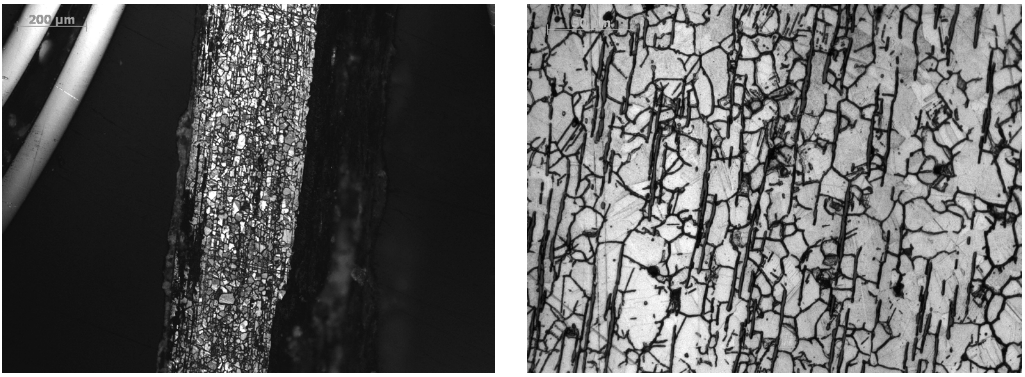


Fig 7.: Hunting of deer hart on a Neo-Hittite relief from Karkemish (Museum of Anatolian Civilizations, Ankara)

strongly male environment the antlers are missing just from this animal. On the Urartu belts that may be regarded as the immediate antecedent we did not find images depicting a deer and a roe together. Reviewing the Caucasian material led to a similar conclusion. However, for instance, as János Makkay has earlier called attention in the course of the research of the early Iranian relations, on one of the Luristan bronze bits and the Seven siblings gold-covered silver plate found in Kurgan we can see that an antlered doe is breast-feeding her calf (Makkay 2006, 24, Fig. 1., 21), making the sex of the animal obvious for everyone despite the antlers it wears. Therefore, the repeated interpretation of this detail of tomb No. 350 is by all means justified and well-based: it is not a roe behind the antlered deer but its calf (Szabó 2019). On the wagon drawn in accordance with the Urartu antecedents the driver follows an antlered but female deer, whose gender is additionally emphasised by the local artist by showing her calf behind her (**Figure 1**). The way the image on the plate belt is depicted, which, in all of its details, reflects the local taste and beliefs, has especially high importance for our analysis, as from the aspect of archaeology it confirms in itself that the object we selected is a creation of the metallurgy of the Koban culture despite the preceding Urartu images.

Metallographic examinations

After cleaning the plate belt, for our tests we selected a sample from among the tiny non restored pieces left out of the preliminary set. For the metallographic test the sample was embedded in cold cast resin, adjusted to the examination of the cross section of the plate. It is essential to apply cold cast resin so that thermal stress would not cause any change in the structure of the examined sample. The sample was prepared in a manner usual in the case of copper alloys (with SiC granules of the grain size of 220, 600, 1200 μm at the rotational speed of 300 rpm), and after polishing (on baize spread with 3 and 1 μm diamond paste at the rotational speed of 150 rpm), then etching (K_2CrO_4 etching with dipping) the micro-structure of the sample was examined with an optical microscope. It is well visible on the ground surface that the metal has a re-crystallised fine-grain structure over its entire cross section (**Figure 8a**). The microscopic image shows long, elongated inclusions crossing over the re-crystallised grains (**Figure 8b**). The edges of the sample, which is the surface of the plate, are strongly corroded, which strongly affects the grain structure close to the surface, too. The parts along the grain boundaries also show the traces of corrosion. The grain structure and the shape of the object suggest that the last phase of production was cold plastic deformation followed by softening. (Contrary to the presence of charcoal remains observed in the tomb we could not find any suggestion of the burning of



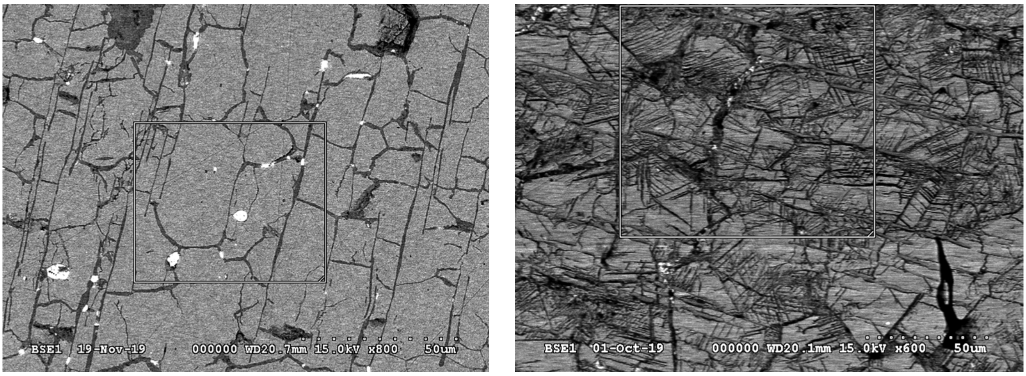
a *b*

Fig. 8.: The micrographs taken form the microstructure of the sample from the belt plate made by Zeiss Axio Scope. A1 in polarized illumination (magnification 50x) **(a)** and bright field (magnification 500x) **(b)**

the bones in other cases, either, therefore it is likely that this factor does not need to be taken into consideration in the evaluation of the grid structure.) The strongly elongated shape of the inclusions suggests substantial formation, which is also substantiated by the nature of the object and its macroscopic sizes. We conducted SEM-EDS tests on the prepared sample in order to determine the composition of the sample, to identify the elongated inclusions and reveal additional details.

SEM-EDS tests

During the composition analysis the sample was examined in various aspects (**Figure 9, table 1**). The basic matrix is essentially a copper-tin bronze alloy. In addition to this, sulphur and lead elements have also been detected in a smaller quantity. Differences in composition are apparent between the areas close to the surface and affected by corrosion, and the metallic parts. The test results of the metallic area (**Figure 9a**) reflect that 11% Sn was detected, while in the corroded product (**Figure 9b**) 17% Sn. The Sn content of the surface is almost one-and-a-half times the basic matrix, due to the increase of the Sn content in the corrosion processes. This observation has to be taken into consideration by all means, even in general in the case of non-destructive (surface) tests. It is not corrosion in itself that causes a high surface content of Sn or another component, but it does increase the measurable concentration in case of specific components. In addition to that, however, the way the object is worked also has a significant effect both on the manner and speed of corrosion, and the distribution of tin in the object as well as its micro structure. Apart from the corrosion processes, the manner of working has a determinant effect on the alloy



a *b*

Fig. 9.: SEM-EDS micrographs taken from the sample of belt plate made by a Hitachi CFE 4300 equipment. Average elemental composition analysis were made inside the signed areas far from the surface **(a)** and in the corroded area **(b)**

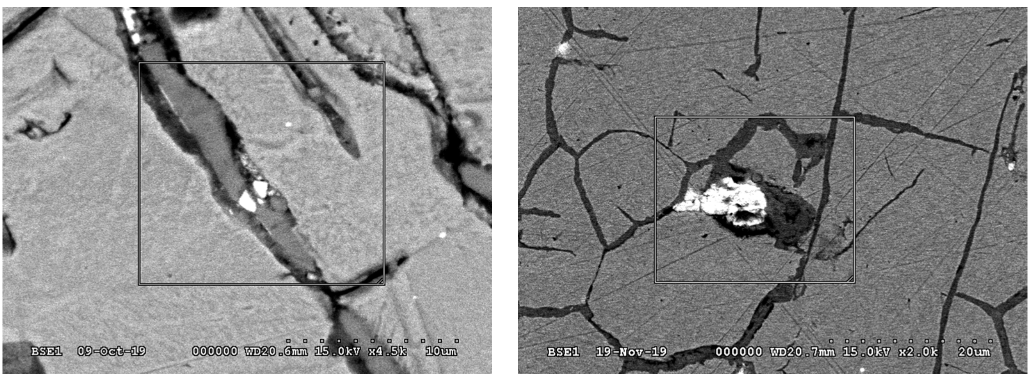


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Fig. 10.: Investigation of inclusions by SEM-EDS: elongated sulfide inclusions and lead drops **(a)**, silver segregation in the corrosion product

quantity present in the corrosion product and the metallic substance underneath. That is, in all tests and evaluation the superpositioned processes and the composition of the surface must be analysed in a complex manner, and the thickness of the metal affected by corrosion may be emphasised by taking the above into consideration.

Using phase analysis we revealed that the long, elongated inclusions, also visible in the optical microscope, are copper-sulphide inclusions (**Figure 10a paragraph 6**). Sulphide inclusions are well ductile, and both the shape of the inclusion and the delicate structure of the sample suggest that the object was exposed to substantial formation, i.e. more than 50%, then the even, fine grain

Table 1.: The results of the SEM-EDS elemental analysis. Area of interest is shown in Fig. 9a-b, the values are presented in weight percentage

Area	C	O	S	Cu	Sn	Pb
Fig. 9a	0,62	2,05		84,08	10,79	2,47
Fig. 9b	1,03	5,46	1,64	74,87	17,0	

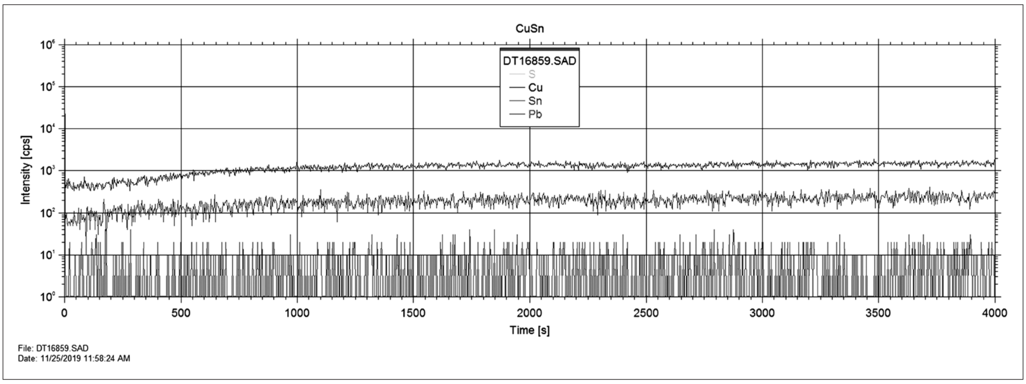
Table 2.: Results of the SEM-EDS elemental analysis of inclusions in the belt plate. The point of analysis can be seen in Fig. 10a-b, the values are presented at weight percentage

Point	O	Cu	S	Sn	Pb	Ag
10.a. ábra 6	1,94	78,14	19,91			
10.a. ábra 8	13,18	29,24	13,36	4,52	53,06	
10.a. ábra 9	4,34	65,15		6,95	10,20	
10.b. ábra Ag	15,30	44,27				40,43

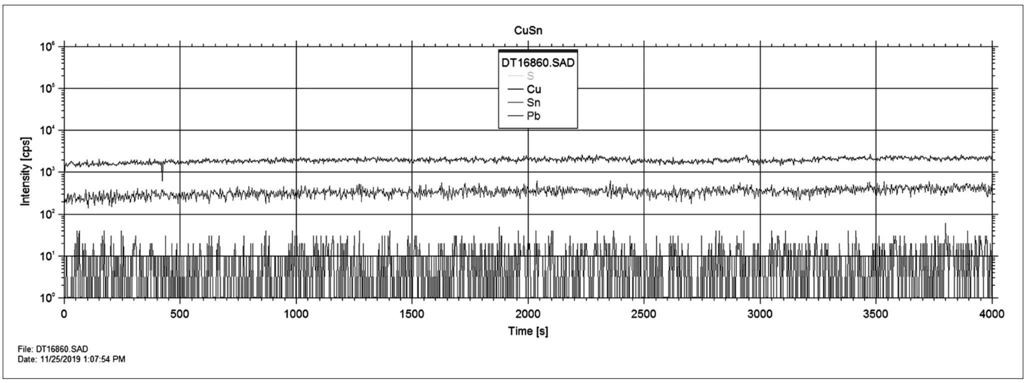
structure was developed due to the subsequent thermal stress and thermal treatment. The tin content of the object also demonstrates that. This tin content is the limit within which bronze is still malleable and shapeable. Its expansion, i.e. ductility, strongly decreases from ~10% tin content when extra tin is added Hot forming is not possible, as metal becomes fragile at a high temperature and such fine grain structure would not develop either. Softening was presumably necessary because of the subsequent working and processing. In this case, we also mean bending and decoration by that.

Typically, lead was detected near the sulphide inclusions, in the form of drops, which usually appear in such alloys. Naturally, we can also find lead drops embedded in the metal matrix separately, but the phases becoming solid at the end of the crystallising process are typically close to each other (**Figure 9a**). In the corrosion product Ag accumulated, which was found in the form of tiny nuggets. This latter may be often found in the corrosion layers of other objects as well, however, it is more characteristic of the specific source of ore than the quantity of lead.

It was possible to analyse only tiny bits of fragments due to the importance, decoration and condition of the object under review. Therefore, we attempted to find out what information we can obtain with such special tests that would cause significantly smaller, even invisible destruction. Naturally, for the validation of the results we used the results of optical microscope and SEM-EDS analyses. The techniques selected included SNMS and FIB-SEM test procedures.



0-0,5 μm



0,5-1 μm

Fig. 11a: The results of SNMS measurements. A small piece of the belt was used to the test **(Fig. 12b)** on which a circular area with diameter 1mm was excited and evaporated. The graphs show the proportion of the main constituents as a function of evaporation time. Due to the constant excitation the evaporation time is directly proportional to the depth. During the testing time continuously growing tin content was measured

In the SNMS procedure (secondary neutral mass spectrometry) a small surface element of the sample was exposed to inductively coupled argon plasma (13,5 MHz high frequency plasma), as a result of which the surface layer gets charged and it sublimated. This way the surface layer was pulverised and the pulverised elements were detected with a mass spectrometry (**Figure 11a-b**). By using this method the layer was pulverised to the depth of approximately 1 μm. It is well visible on the spectra that no change appeared in the Sn content (17%), that is, we measured a high tin content. By comparing this surface

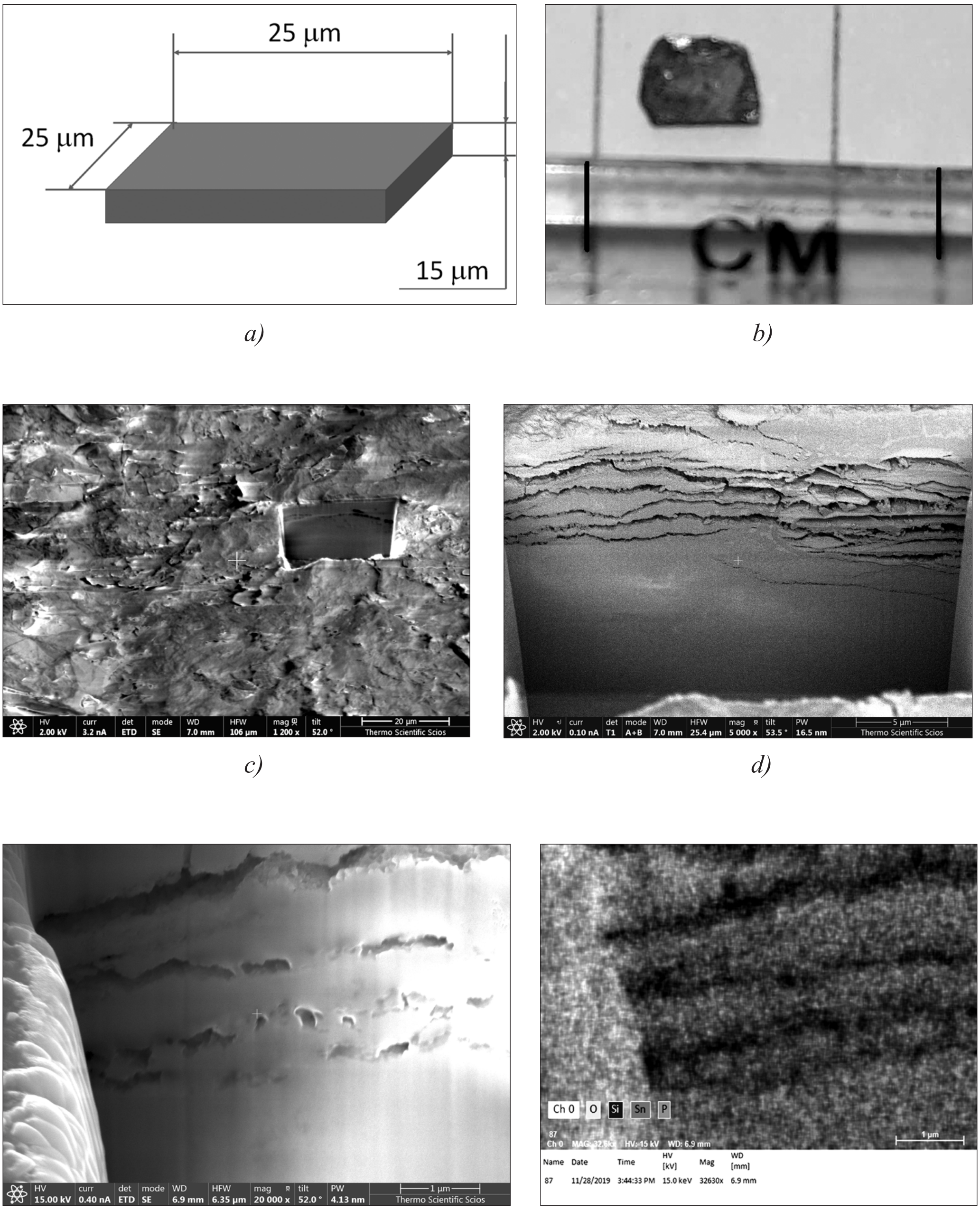


Fig. 12.: A 25x25 μm window was milled by FIB-SEM method on the surface of that sample which was previously investigated by SNMS technique, too. The final depth of the window was 15 μm. At this depth also that tin content was measured which is specific to the corrosion layer and higher than the average tin content of the raw metal

analysis to the previously presented SEM-EDS test, it is apparent that at a depth of 1 μm it is also the corrosion layer that is dominant. The alloying content detected here is not identical to the composition of the basic matrix. In the course of the measurement, the equipment does not convert the measured physical characteristics (mass spectrometer counts) to direct concentrations, as it happens in the case of SEM-EDS. The reason for that is that we use the equipment for special high-sensitivity ***measurement***. However, the composition, in respect of three elements (we detected sulphur in a small quantity for this) may be calculated after averaging the curves: Sn: 17.3%, Pb: 0.61% Cu: remaining percentage. The question is raised what could be measured deeper than the reviewed 1 μm.

In the FIB-SEM test the surface is exposed to gallium ions, however, here the purpose is only to gradually remove the surface layer (**Figure 12a-f**). The analysis is performed with the traditional SEM-EDS procedure on the surface remaining under the removed surface. In the FIB-SEM test a slice of the size of 25x25 μm and the depth of 15 μm was cut out. The figures well reflect that even in this range the effect of corrosion was perceivable, as the tin content was 17%. The map of elements of **Figure 12f** shows that corrosion product was measurable. Here, we refer back to the test results of the optical microscope analysis, where the effects of corrosion were also apparent in the grain structure close to the surface of the plate, which are higher than 15 μm in case of ~500 μm thick a plate. Naturally, it comes from the nature of corrosion that no specific value can be provided, however, we had to take this into consideration in all of the tests conducted.

Evaluation

Summarising the metallographic examinations it may be concluded that the preparation of the belt plate started out from some cast primary form, which was bronze with high tin content, i.e. ~11 mass%. The alloy itself was also hard due to the high tin content, however, following that it went through a significant extent of cold processing. This is reflected by the long, elongated sulphide inclusions crossing over the grains. (The interrupting of the cold processing with technological softening due to the extensive hardening of the alloy may not be ruled out. After the last phase of forming, the plate was heat-treated and softened to make the finishing operations (engraving, carving, bending) easier to perform. The final softening resulted in a delicate and even texture. The plate itself is strongly corroded, thus the impacts of corrosion can be perceived even far from the surface (compared to the thickness of the plate. The alloy is slightly polluted with lead, which can be found in a separate phase, in small drops – as it is usual in the case of the prehistoric objects –mainly in the environs of encased sulphide. The accumulation of silver could not be observed in the base metal while it was apparent in the corrosion product, which has to be taken into consideration especially in the evaluation of the base material used for the preparation of the object. In relation with the plate belt found in the Caucasus — serving as a bridge between the Ancient East and the world of the steppes — based on the experience of our earlier examinations it has to be emphasised that in the present case nothing suggested that the lead and silver impurities related to the direct dosing of tin, the alloying agent known from written sources of the age (Gyöngyösi et al. 2017).

The archaeological observations and analyses pointed out that the representation apparent on the plate belt, even despite the Urartu prefigurations, reflect in all details the local taste and belief system, and is a product of the metallurgy of the Koban culture, which was essentially confirmed by the results of the archaeometallurgic examinations. The base material used for preparing the plate belt found in tomb 350 of the Tli cemetery, also taking into consideration the geographical environment of the excavation site, was highly likely to originate from such an area among the diverse ore sources of the Caucasus where ores containing Pb and Ag can also be found in addition to the sulphide copper ores, which, as polluting elements, seeped into the alloy during smelting.

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REFERENCES

CARTER, D. (1957): *The Symbol of the Beast. The Animal-Style Art of Eurasia.* The Ronald Press, New York.

CASTELLUCCIA, M. (2017): *Transcaucasian Bronze Belts.* BAR International Series 2842, BAR Publishing, Oxford.

CURTIS, J. (1996): Urartian Bronze Belts. *Zeitschrift für Assyriologie und Vorderasiatische Archäologie* 86, Munich 118–136.

CURTIS, J. (2017): Preface. In: CASTELLUCCIA, M.: Transcaucasian Bronze Belts. *BAR International Series* 2842, BAR Publishing Oxford, ix.

CURTIS, J. & KRUSZYŃSKI, M. (2002): *Ancient Caucasian and Related Material in the British Museum*. British Museum Occasional Paper no. 121, London.

GYÖNGYÖSI SZ., ERDÉLYI Z., JUHÁSZ L., BARKÓCZY P., SZABÓ G. (2017): A réz ötvözésének technológiaváltása Európában a Ha D időszak pannon bográcsainak archaeometallurgiai vizsgálatai alapján. *Wosinsky Mór Múzeum Évkönyve* XXXIX, 7–27.

LANG, A. (2012): Urartu und die Nomaden: Zur Adaption altorientalischer Motive im reiternomadischen Kunsthandwerk des 7.-5. Jh. v. Chr. in Eurasien. In: Kroll, S., Gruber, C., Hellwag, U., Roaf M. & Zimansky, P. (eds) *Bianili-Urartu. Tagungsbericht des Münchner Symposiums.* 12.-14. Oktober 2007. Peeters München, 281–293.

van LOON, M. (1966): *Urartian Art. Its Distinctive Traits in the Light of New Excavations.* Istanbul.

MAKKAY, J. (2006): *The Miracle Stag*. Tractata Minuscula 48, Budapest.

PRÜSSING, G. (1991): *Die Bronzegefässe in Österreich.* Prähistorische Bronzefunde II/5.

REINHOLD, S. (2007): *Die Spätbronze- und frühe Eisenzeit im Kaukasus.* Bonn.

SZABÓ 2019 How and why do the deer and the bars appear on the belts used in the Caucasian Koban culture? Nartamongæ XIV, 1–2. 50–77.

ПИОТРОВСКИЙ, Б. Б. (1955): *Кармир-Блур.* III. Ереван.

ТЕХОВ, Б. В. (2002): *Тайны древних погребений.* Владикавказ.

ТЕХОВ Б. В. (2006): *Археология южной части Осетии.* Владикавказ.

ЧШИЕВ, Х.Т. 2007. *Памятники кобанской культуры на территории Северной Осетии.* Археология Северной Осетии. Т.1. Владикавказ.