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Archaeometallurgical Studies Metallic Artifacts from the Middle Bronze age Sites of South – East of Azerbaijan

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Abstract- The article devoted research of metallic artifacts from the Middle Bronze Age sites of South – East of Azerbaijan Republic. In the article present the results of quantitative spectral analysis of metallic artifacts from study region. More part of them found in funerary monuments, dated to the period from the XX-XIX centuries BC. The purpose of the study show which alloys and metals were used in the studies periodfor manufacturing of metallic artifacts in study region. The analyses have shown that copper is the basic materials in all of them. Metallurgical results the results of analysis have shown more of artifacts made of tin bronze, one of them of copper arsenic. In study region discovered earliest artifacts of pure antimony, dated XX-XIX centuries BC. Handle of dagger from the admit burial made of tin – arsenic alloys contain 11.1 % tin and 0.85 % arsenic. It shows, that on the southeastern of Azerbaijan tin were enough and seems bring from the territory of Iran. Known, ancient tin mining are absent on the Caucasus. Nearly ancient tin mining fount on the Iran, used beginning of the III millennium BC.

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Archaeometallurgical Studies Metallic Artifacts from t he Middle Bronze age Sites of South – East of Azerbaijan

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Abstract- The article devoted research of metallic artifacts from the Middle Bronze Age sites of South – East of Azerbaijan Republic. In the article present the results of quantitative spectral analysis of metallic artifacts from study region. More part of them found in funerary monuments, dated to the period from the XX-XIX centuries BC. The purpose of the study show which alloys and metals were used in the studies periodfor manufacturing of metallic artifacts in study region. The analyses have shown that copper is the basic materials in all of them. Metallurgical results the results of analysis have shown more of artifacts made of tin bronze, one of them of copper arsenic. In study region discovered earliest artifacts of pure antimony, dated XX-XIX centuries BC. Handle of dagger from the admit burial made of tin – arsenic alloys contain 11.1 % tin and 0.85 % arsenic. It shows, that on the southeastern of Azerbaijan tin were enough and seems bring from the territory of Iran. Known, ancient tin mining are absent on the Caucasus. Nearly ancient tin mining fount on the Iran, used beginning of the III millennium BC. The present study has shown that most of artifacts were melting from raw materials of local origin, there are on the territory of Azerbaijan – Iran.

Keywords: metallic artifacts, analysis, alloys, bronze, antimony, tin deposits, iran.

I. Introduction

The article devoted Archaeometallurgical investigation of metallic artifacts from the Middle Bronze Age sites of South East Azerbaijan. More part of them is found in funereally monuments, dated to the period from XX-XIV centuries BC. According to the study period of archaeological monuments of study region investigated 40 metallic artifacts. The purpose of the study show which alloys and metals were used in the studies period for manufacturing of metallic artifacts in study region. From where bring tin which there are in composition of alloys of study artifacts? Analytical study was conducted using quantitative spectral analysis, specifically for metallic artifacts of copper based, as elaborated by the I. R. Selimkhanov (Selimkhanov, 1960).Patina covered of surface of artifacts. Sample taken for analysis is metallic powder. Analyses were performed at the Department of Archaeological Technology Institute of Archeology and Ethnography of Azerbaijan National Academy of Sciences. Interpretation of the results of analyzes to determine the type of the alloy was carried out taking into account the accepted limits of natural impurity metal-0.5% (Kashqai, Selimkhanov, 1973).

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II. Metallurgical Investigations of Artifacts

Among the findings of the monuments of the South-East of Azerbaijan attracted attention bronze axes. Known archaeology how the original Talysh axes. So far, according to the study period is known, nine such axes (Fig. 1).One of them was discovered by J. de Morgan during excavations in cemetery near the village of Hovel Lerik region (Fig 1, № 1). Three of them found from the cemeteries of Iranian Talysh (South Azerbaijan)by excavationsat J. de Morgan with his brother Henry de Morgan. One of them from stone box, near the village of Khodja Dawud Kepru, it was found with a bronze sword. Two other bronze axeswas found in burial grounds near the village of Aga Evlyar (Fig. 1, № 2, 3,4).These axes draw attention to their relief floral ornaments on the surface of the butt. Other of the bronze axes the same shape as aforementioned axes. One of them was found in a stone box near the village Askhanakeran, Astara region (Fig. 1, № 5). Others axes (Fig. 1, № 6-9),derived from the treasure near the village Lovayn, Astara region. It was accidentally discovered in the chores. It was found about 50 axes. Unfortunately, many of them lost. *Axes* were buried in the ground for safety reasons, if necessary used as a weapon, as well as tools. That's axes were cast in different molds. They were in good condition. He surface is covered with noble patina that seems to be due to the composition of the metal axes. Seem the axes to have been cast in the two double molds. Moulds could be a stone and clay, made of wax. That axes is a special version of the asymmetric axes, which are characteristic of the Talysh metallurgical hearth. These axes are different symmetry, butt and blade does not extend beyond the vertical parallel lines. Compare Talysh axes with asymmetric axes of the Caucasus and Asia Minor allow allocating Talysh axes the special type, of local product. All of axes dated XVI- XIV centuries BC (Makhmudov, 1973).Results of the analytical study axes are shown in table 1.

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Metallurgical classification axes by type of alloys showed the following

1. Tin bronze Cu - Sn 4 artifacts
2. Arsenic tin alloys Cu - As - Sn 1 artifact
3. Copper Cu 1 artifact

Analytical study showed that all of the axes on copper basis. Four of investigated axes made of tin bronze, contain0.9, 9.15, 4.6, 5.03 % tin (table 1, № 3-6).One of them made of arsenic tin bronze, contain 7.0 % tin, 0.5 % arsenic (table 1,№ 2). One axe made of copper,(table 1, № 1). But the natural impurities, constitute the 0.375, which made copper impart hardness.

Table 1 : The results of quantitative spectral analysis of axes of Middle Bronze Age monuments of south – east Azerbaijan

№	Object,Weight Gram (G)	Content Of Elements In Weight %										Type of Alloys
		Sn	Pb	Zn	As	Sb	Au	Ag	Ni	Co	Fe	Cu	
1	Axe, 700 g	0/25	0/005	0	0.1	0.02	0	0.018	0.008	0	0/04	base	Cu
2	Axe, 800 g	7/0	0.015	0	0.5	0.015	0	0.019	0.015	0.01	0/1	base	Cu--Sn As
3	Axe, 400 g	0.09	0.03	0	0.25	0.02	0	0.04	0.01	0	0.08	base	Cu-Sn
4	Axe, 780 g	9.15	0.1	0/035	0.3	0.02	0	0.006	0.08	0.03	0.15	base	Cu-Sn
5	Axe, 875 g	4.6	0.03	0	0.3	0	0	0.028	0.002	0	0.1	base	Cu-Sn
6	Axe, 812 g	5/03	0.08	0	0.25	0	0	0.05	0.01	0	0.08	base	Cu-Sn

Note: № 1,3 from the stone box Askhanakeran, Astara region,№ 2, 4 from treasure Lovayn village, Astara region.№ 5,6 from admit burial Alikemektepe, Jalilabad region.

The next study artifacts were found on the hill Alikemektepe, near the village Uctepe from admit burials №79, №80, and also from ground burials of Jalilabad region. The admit burials, dated XX-XIV centuries BC ,ground burials dated XV- XIV centuries BC (Makhmudov, 2008).Admit burial №79 is a round hole with a diameter 2.6 m, and a depth of m,passing into the camera quadrangular. At the bottom of the camera, a depth of 3 m, were the skeleton revealed traces of a young man in a crouched position on the left side, head to the south. Metal inventory is represented by three temple pendants from silver and antimony beads. Antimony beads presented oval and round, small, cast beads.

Analyzed artifacts were satisfactory safety. In surface is covered with a thick layer of oxide, metal barely saved. Pendants are covered with a dark oxide – gray color and beads whitish – gray color. Weights suspensions were repartitions 1.83 - 1.85 grams. Weights round and oval beads 0.42 - 2.31 grams, one of biconical bead 18.3 grams. The sample taken for analysis is a powder metal oxide weight of 20 milligrams. The analysis results are presented in the following table № 2. Analyses showed that the pendants made of silver without artificial admixtures.

It is known that at the beginning of II millennium BC silver was usually already in the South Caucasus. According to the latest archaeological data, the earliest artifacts with high-grade silver, found in burial mounds near the village of Soyugbulag in Agstafa region, dated middle IV millennium BC. That beads and earrings, content silver until 81.9% (Akhundov, Gasanova, 2007).

The oldest silver artifacts discovered in Iran in the settlement of Tepe Sialk it is buttons, dating the beginning of V millennium BC and a ring in Anatolia in Beydzhesultane, dating from the end of V millennium BC (Wertaim,1964).

On the territory of Azerbaijan silver it occurs primarily in polymetallic ores. Silver ore occurrences are known in Nakhchivan Autonomic Republic, in Karabag region and on the southern slope of the Greater Caucasus (Babazadeh, 2005). In the Nakhchivan Autonomous Republic silver known in Gyumushlug, Agdara, polymetallic, deposits, which is celebrated in galena (lead mineral).Native silver is noted in the alluvial of the river Tartar, on the territory of the Kelbajar region - Karabag.

In Azerbaijan, the process of extracting silver from lead ores, which is called cupellation, apparently began to practice from the middle of IV millennium BC.

Conclusive evidence is the discovery of the earliest drops of silver in the destroyed furnace dating the middle of the IV millennium BC at the settlement Alkhantepe, Jalilabad region of south east Azerbaijan (Hasanova, 2014).

In this study, specific interests have antimony beads. The analytical study, which showed that in the beginning of the II millennium BC in the South Caucasus, has melt of antimony. The deposits of antimony ores are in Azerbaijan there are in Nakhchivan -Darridag, in Lachin district - Levchay, in Kelbajar district -Zod (Babazadeh, 2005).In Georgia - Racha, Zophid deposits (Tavadze, Sakvarelidze, 1959). It should be noted that antimony ores are typically in association with

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arsenic ores such as Darridag field (Babazadeh, 2005). However analyzed artifacts contain no arsenic. The origin of these artifacts should be sought by studying the composition of the aforementioned ore deposits. It is known that when melting the ore arsenic evaporates faster than antimony. Therefore it is easy to imagine antimony ore smelting in which it is rapidly restored and arsenic evaporates at high content stored in the alloy, and at a low content of alloy disappears. That is possible to obtain similar purest antimony. It should be noted that the investigated antimony beads are the earliest antimony artifacts identified in the Caucasus.

It should be noted that most of the antimony deposits of Azerbaijan contain an admixture of arsenic. But Zod deposits where stibnite accompanies gold. However, analyzes antimony beads showed that gold is absent, and the arsenic content is negligible.

The next study artifacts found from the burial № 80. Author excavation notes that the admit burial was a rectangular pit depth of 2.6 meters (Makhmudov, 2008).In the burial camera, beside another inventory, discovered metallic artifacts, which are different than from the burial № 79.Identified artifacts are presented arms, as well as tools and decorations - it is daggers, axes, arrowheads, spearheads, buttons, awl, hook, ring, knife, beads, badgers, hatchet, bayonet, suspensions, figure of man, rots, boiler, axe (fig.№2).

Table 2 : The results of quantitative spectral analysis of metallic artifacts of Middle Bronze Age monuments of south – east Azerbaijan

№	Object, Weight Gram (G)	Content Of Elements In Weight %											Type Of Alloys
		Sn	Pb	Zn	As	Sb	Au	Ag	Ni	Co	Fe	Cu	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Dagger,81.4 g	9.35	0.55	0	0.71	0	0	0.019	0.004	0	0/12	base	Cu-Sn- As-Pb
2	Dagger,111 g	8.1	0.39	0	0.2	0	0	0.07	0.004	0	0.12	base	Cu-Sn
3	Arrowhead, 218 g.	7.5	0.005	0	0.07	0	0	0.11	0.002	0	0.1	base	Cu-Sn
4	Bayonet head, 16.2 g.	3.5	0.1	0	0.93	0.03	0	0.08	0.11	0.02	0.1	base	Cu-Sn-As
5	Hatchet, 142.5 g.	5.5	0.03	0	1.02	0.02	0	0.02	0.006	0.02	0.06	base	Cu-Sn-As
6	Arrow head, 69.5 g.	8.15	0.1	0	0.15	0	0	0.022	0.01	0.025	0.035	base	Cu-Sn
7	Dagger, 154 g.	6.95	0.02	0	0.04	0.02	0	0.012	0.002	0	0.5	base	Cu-Sn
8	Awl, 5.2 g.	3.05	0.005	0	0.3	0.04	0	0.033	0.024	0	0.1	base	Cu-Sn
9	Suspension, 1.83 g.	0.015	0.05	0	0.3	0.2	0	base	0.01	0	0.07	base	Ag
10	Suspension, 1.85 g.	0.003	0.1	0	0	0	0	base	0.015	0	0.015	base	Ag
11	Badge, 2.5 g.	0.25	0.2	0	0.3	0	0	base	0.02	0	0	base	Cu
12	Button, 1.3 g.	0.3	0.2	0	0.25	0	0	0.03	0.02	0	0	base	Cu
13	Button, 1.7 g.	4.6	0.2	0	0.3	0	0	0.05	0.01	0	0.08	base	Cu-Sn
14	Spear head, 315 g.	6.1	0.03	0	0.2	0	0	0.022	0.01	0	0.1	base	Cu-Sn
15	Hook, 14 g.	0.33	0.02	0	0.25	0	0	0.033	0.8	0	0	base	Cu-Ni
16	Arrow head, 8.3 g.	5.5	0.03	0	2.5	0	0	0.007	0.08	0.005	0.01	base	Cu-Sn-As
17	Arrow head, 8.2 g.	2.7	0.18	0	0.25	0	0	0.05	0.021	0	0.005	base	Cu-Sn
18	Button, 7 g.	3.7	0.03	0	0.3	0	0	0.045	0.002	0	0.05	base	Cu-Sn
19	Button, 1.2 g.	5.05	0.03	0	0.2	0	0	0.13	0.002	0	0.1	Base	Cu-Sn
20	Badge, 3.2 g.	7.3	0.005	0	0.03	0	0	0	0.001	0	0.1	base	Cu-Sn
21	Badge, 2.7 g.	10.13	0.002	0	0.05	0.1	0	0.005	0.002	0	0.1	base	Cu-Sn
22	Bead, 2.31 g.	0.001	0.001	0	0.02	base	0	0.0003	0.005	0	0.07	0.03	Sb

Note: № 1-21 from admit burial № 79, 80, Aliemektepe. № 22-29 from admit burial № 79 Alikemektepe, dated XX-XIX centuries BC. № 30 settlement Misharchay 1, dated XXI-XX centuries BC. № 31-33 from ground burial near the settlement of Uchtepe, dated XV-XIV centuries BC. Author of archaeological excavation F. R. Makhmudov.

Metallurgical classification artifacts by type of alloys showed the following

1. Arsenic copper Cu-As 1 artifact
2. Arsenic tin bronze Cu - As - Sn 5 artifacts
3. Tin bronze Cu - Sn 13 artifacts
4. Arsenic tin lead alloy Cu - Sn – As-Pb 1 artifact

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5. Copper nickel alloy
6. Silver
7. Copper
8. Antimony

Cu –Ni	1 artifact
Ag	2 artifacts
Cu	3 artifacts
Sb	7 artifacts

The results of analytical studies showed in table 2. It should be noted hatchet (table 2, № 5) which in its compositions differs from other axes, in its allay hands 1.2 % of arsenic and 5.5 % of tin.

Author ofexcavations indicates that the shape of that hatchet are known in monuments of the III millenium BC (Makhmudov, 2008). The same can be said

about the compositions of the alluy, that alluy stated to appear from the middle of theIII millenium BC (Selimkhanov, 1996-1997).In study period such alloy can be explained by melting scrap containing arsenic. In that burial found the awl, which is also known from earlier monuments, content of 3.05 % tin. It is indicates, that the tools in the studied period became stronger. This is also evidenced analytical study of revealed weapons. Analyses showed that all the weapons made of bronze content of 2.7 - 9.35% tin.In the same burial revealed two tetrahedral bayonets. One of them has a stalk with a nozzle and the other without a dedicated cutting.Analytical study of one of these bayonets weighing 16.2 g showed that its composition is a copper-tin-arsenic alloy containing 3.5 % tin, 0.93 % of arsenic, and the low content of natural impurities of lead, antimony, silver, bismuth, nickel, cobalt and iron.In the complexes of metal artifacts also includes two spearheads (fig 2, № 6,7). The testing spears heads were satisfactory preservation, so the sample selected for analysis is a powder oxides and metal shavings.Analysis of the spear head weighing 218 gram, has shown that it is quite durable, made of bronze containing 7.5 % tin.The second spear head weighing 315 gram contain 6.1 % tin, with minor natural impurities of lead, arsenic, silver, bismuth, nickel, iron (table 2,№ 14). In the same burial discovered three daggers.Analytical study showed that all daggers made of bronze content tin in the range 6.95 - 8.1 % (table.2, № 1,2,7).

Among them, it should be noted, blade of dagger weighing 81.4 gram, which made of the multi-component alloy, containing tin increased admixture of lead - 0.55 % and 0.71% arsenic.The remaining elements of the qualitative and quantitative ratio are natural impurities raw copper ores from which melted this alloy.Among the analyzed artifact there are three arrowheads weighing 69.5, 8.3, 8.5 grams.Analytical study shows that they are copper - based, contain an admixture of tin increased 2.7, 5.5, 8.15 %.One of them with small wings contain, arsenic impurity increased - 2.5 % and the remaining elements represent a minor impurity's of natural raw copper ores (table 2, № 16).

Analytical studies have been also decorations presented four badges in weight from 2.5 to 3.2 grams and five buttons, weighing from 0.7 to 1.7 grams.

The badges like tetrahedral star and buttons were hemispherical. It should be noted that the artifacts submitted for analysis, at best, were satisfactory preservation, coated with a thick layer of oxides. Buttons and barges were completely rusted, the metal is not saved.Therefore we investigated three badgers and four buttons, a satisfactory safety.Sample given for analyses is a powder of green oxide.The results showed that the badges and buttons are made of copper-based alloys. From the three, of badges, one was copper, the other two of bronze containing 7.3, 10.13 % of tin.Other intentions impurities absent, there are only minor natural impurities of raw copper ores (table 2, № 11, 20, 21).Among the investigated artifacts of greatest interest is the fishing hook, which resemblesa weight of 14 grams. Despite the fact that it made from a thin metal sheet with a needle tip, it was goodpreservation.The surface is covered with such a layer of patina, metal saved.The sample taken for analysis, are metal filings.Therefore, the analysis had to be flawless. The analysis showed that the alloy material of the hook, is a copper-nickel, content of 0.8% nickel, the other elements are negligible and are natural impurities of copper ores.In the territory of Azerbaijan nickel ore absent.Therefore, all products containing nickel believed imported (Selimkhanov, 1996, 1997).Indeed, in the territory of Caucasus and also in Azerbaijan, industrial nickel deposits are absent.It should be noted that within the territory of Azerbaijan held intermittently ophiolite belt, which passes through the middle of the Small Caucasus - from areas of Lachin and Kelbajar. In the north - westerly direction the belt through Zod pass and Shahdag Ridge goes to the northern shore of thelake of Geoychaand then pass on the territory in Turkey.In the south-east direction ophiolite belt can be traced to the Iran and hidden under the sediments river of Araks.The length of the ophiolite formation on the territory of Azerbaijan more than 180 kilometer, width from 2 to 16 kilometer, sometimes reaches up to 25 kilometer (Abdullayev, Azizbekov, Kashqai,1961).Ophiolite ores on the territory of Azerbaijan content1.5 % nickel(Babazadeh, 2005).

It should be noted that on the territory of Azerbaijan in the settlement Babadervish of Gazakh area, dated middle of the III millennium BC found another fishing hook. In its compositions contains 0.99% - tin, 1.3% arsenic, the other elements are negligible (Narimanov, Selimkhanov, 1965).When comparing the results of analyzes of both hooks it can be seen that the study hook in its composition is very different from the hook of the settlement Babadervish. However, both hooks are made of durable alloy that can withstand fairly

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heavy loads.The author of excavation the burial № 80 dated it to a period no later than the first quarter of the II millennium BC (Makhmudov, 2008).

The following artifacts are revealed under investigation from the ground burials near the settlement Uchtepe dated XV - XIV centuries. BC (Makhmudov, 2008).It is dagger weighing 378 grams, knife -51.5 grams, figure of man- 8 grams. Analysis show figure of man, made of arsenic bronze, contain 2.3 % of arsenic. Blade of dagger made of tin bronze, contain 0.5 % of tin. Handle of dagger and knife made of copper tin arsenic alloys, contain 11.1, 2.6 % of tin and 0.85, 0.99 % of arsenic (table 2, № 30-33).

III. Conclusion

In conclusion, it should be noted that the present study has shown that most of artifacts were melt from raw materials of local origin.

Classification artifacts showed that in the study period for production artifacts widely used tin bronze.In composition of arsenic tin bronze beginningadd lead.

The development and the extensive system of economic trade and cultural - relationswith Iran of North Caucasus, which passes through the territory of Azerbaijan, has been widely developed in the study period. This is a crucial factor in mass production and widely developed of tin bronze on the territory of Azerbaijan.

From the foregoing, it follows that for the supply of bronze metallurgy of South - Eastof Azerbaijanin study period could be depositsof Iran -Deh Hossain (Helwing, 2009).

In study period on the South East of Azerbaijan also melt silver, antimony, copper – nickel alloy, continued melting arsenic copper, copper, arsenic tin bronze and multi components alloys of copper - tin - arsenic – lead.

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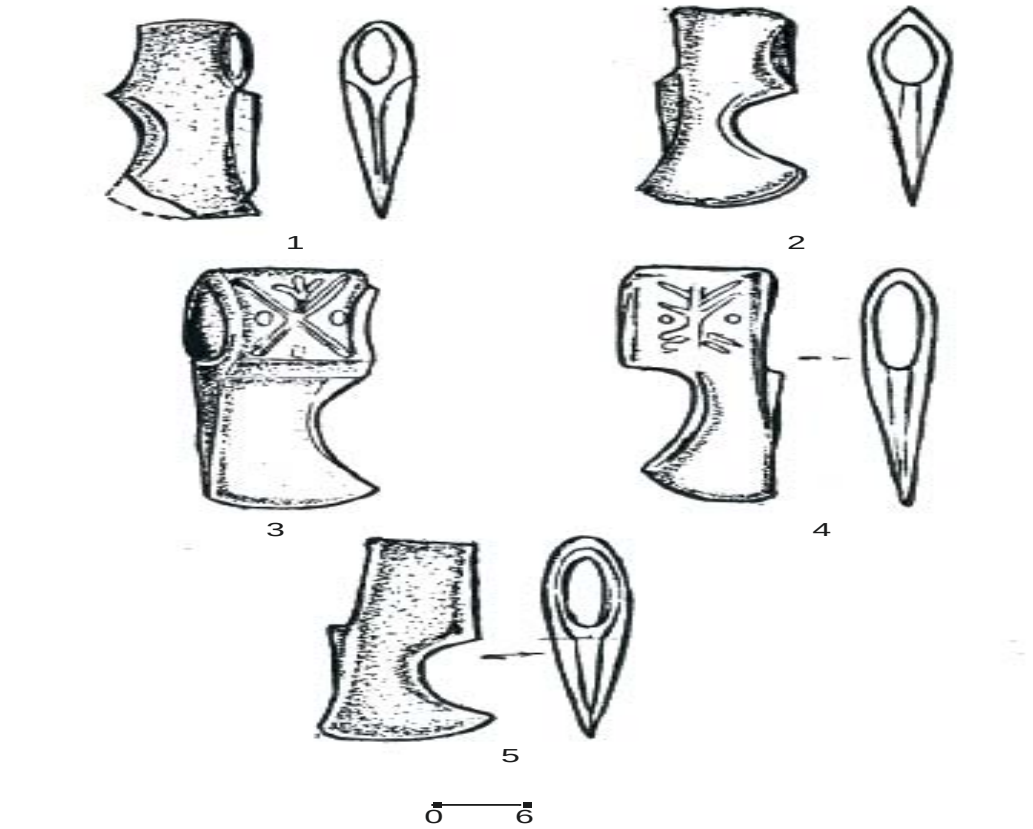


Figure 1 : Axes of Talysh

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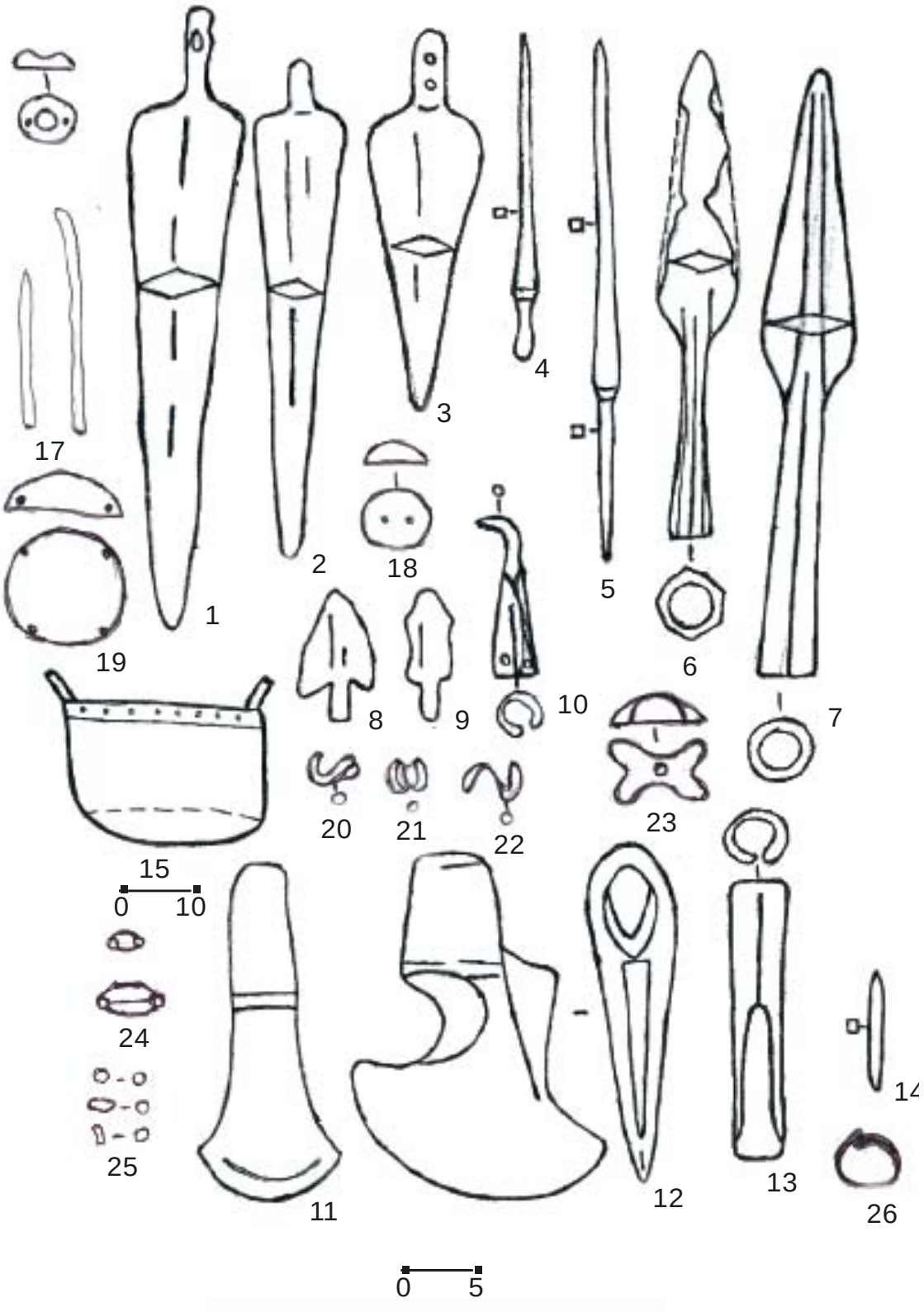


Figure 2 : Metallic artifacts from admit burials of settlement of Alikemektepe

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