

1 Archaeometallurgical Studies Metallic Artifacts from the Middle 2 Bronze age Sites of South -East of Azerbaijan

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7 **Abstract**

8 The article devoted research of metallic artifacts from the Middle Bronze Age sites of South
9 " East of Azerbaijan Republic. In the article present the results of quantitative spectral
10 analysis of metallic artifacts from study region. More part of them found in funerary
11 monuments, dated to the period from the XX-XIX centuries BC. The purpose of the study
12 show which alloys and metals were used in the studies period for manufacturing of metallic
13 artifacts in study region. The analyses have shown that copper is the basic materials in all of
14 them. Metallurgical results the results of analysis have shown more of artifacts made of tin
15 bronze, one of them of copper arsenic. In study region discovered earliest artifacts of pure
16 antimony, dated XX-XIX centuries BC. Handle of dagger from the admit burial made of tin
17 " arsenic alloys contain 11.1

18

19 **Index terms**— metallic artifacts, analysis, alloys, bronze, antimony, tin deposits, iran.

20 **1 Introduction**

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

32 **2 II.**

33 **3 Metallurgical Investigations of Artifacts**

34 Among the findings of the monuments of the South-East of Azerbaijan attracted attention bronze axes. Known
35 archaeology how the original Talysh axes. So far, according to the study period is known, nine such axes
36 (Fig. 1).One of them was discovered by J. de Morgan during excavations in cemetery near the village of Hovel
37 Lerik region (Fig 1 , ? 1). Three of them found from the cemeteries of Iranian Talysh (South Azerbaijan) by
38 excavations at J. de Morgan with his brother Henry de Morgan. One of them from stone box, near the village
39 of Khodja Dawud Kepru, it was found with a bronze sword. Two other bronze axes was found in burial grounds
40 near the village of Aga Evlyar (Fig. 1, ? 2, 3,4).These axes draw attention to their relief floral ornaments on the
41 surface of the butt. Other of the bronze axes the same shape as aforementioned axes. One of them was found in

3 METALLURGICAL INVESTIGATIONS OF ARTIFACTS

42 a stone box near the village Askhanakeran, Astara region (Fig. 1, ? 5). Others axes (Fig. 1, ? 6-9), derived from
43 the treasure near the village Lovayn, Astara region. It was accidentally discovered in the chores. It was found
44 about 50 axes. Unfortunately, many of them lost. Axes were buried in the ground for safety reasons, if necessary
45 used as a weapon, as well as tools. That's axes were cast in different molds. They were in good condition. He
46 surface is covered with noble patina that seems to be due to the composition of the metal axes. Seem the axes
47 to have been cast in the two double molds. Moulds could be a stone and clay, made of wax. That axes is a
48 special version of the asymmetric axes, which are characteristic of the Talysh metallurgical hearth. These axes
49 are different symmetry, butt and blade does not extend beyond the vertical parallel lines. Compare Talysh axes
50 with asymmetric axes of the Caucasus and Asia Minor allow allocating Talysh axes the special type, of local
51 product. All of axes dated XVI-XIV centuries BC (Makhmudov, 1973) The next study artifacts were found
52 on the hill Alikemektepe, near the village Uctepe from admit burials ?79, ?80, and also from ground burials of
53 Jalilabad region. The admit burials, dated XX-XIV centuries BC ,ground burials dated XV-XIV centuries BC
54 (Makhmudov, 2008).Admit burial ?79 is a round hole with a diameter 2.6 m, and a depth of m,passing into the
55 camera quadrangular. At the bottom of the camera, a depth of 3 m, were the skeleton revealed traces of a young
56 man in a crouched position on the left side, head to the south. Metal inventory is represented by three temple
57 pendants from silver and antimony beads. Antimony beads presented oval and round, small, cast beads.

58 Analyzed artifacts were satisfactory safety. In surface is covered with a thick layer of oxide, metal barely
59 saved. Pendants are covered with a dark oxidegray color and beads whitish -gray color. Weights suspensions
60 were repartitions 1.83 -1.85 grams. Weights round and oval beads 0.42 -2.31 grams, one of biconical bead 18.3
61 grams. The sample taken for analysis is a powder metal oxide weight of 20 milligrams. The analysis results
62 are presented in the following table ? 2. Analyses showed that the pendants made of silver without artificial
63 admixtures.

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

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

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

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

78 Conclusive evidence is the discovery of the earliest drops of silver in the destroyed furnace dating the middle
79 of the IV millennium BC at the settlement Alkhantepe, Jalilabad region of south east Azerbaijan ??Hasanova,
80 2014).

81 In this study, specific interests have antimony beads. The analytical study, which showed that in the beginning
82 of the II millennium BC in the South Caucasus, has melt of antimony. The deposits of antimony ores are in
83 Azerbaijan there are in Nakhchivan -Darridag, in Lachin district -Levchay, in Kelbajar district arsenic ores such
84 as Darridag field (Babazadeh, 2005). However analyzed artifacts contain no arsenic.

85 The origin of these artifacts should be sought by studying the composition of the aforementioned ore deposits.
86 It is known that when melting the ore arsenic evaporates faster than antimony. Therefore it is easy to imagine
87 antimony ore smelting in which it is rapidly restored and arsenic evaporates at high content stored in the alloy,
88 and at a low content of alloy disappears. That is possible to obtain similar purest antimony. It should be noted
89 that the investigated antimony beads are the earliest antimony artifacts identified in the Caucasus.

90 It should be noted that most of the antimony deposits of Azerbaijan contain an admixture of arsenic.

91 But Zod deposits where stibnite accompanies gold. However, analyzes antimony beads showed that gold is
92 absent, and the arsenic content is negligible.

93 The next study artifacts found from the burial ? 80. Author excavation notes that the admit burial was a
94 rectangular pit depth of 2.6 meters (Makhmudov, 2008).In the burial camera, beside another inventory, discovered
95 metallic artifacts, which are different than from the burial ? 79.Identified artifacts are presented arms, as well as
96 tools and decorations -it is daggers, axes, arrowheads, spearheads, buttons, awl, hook, ring, knife, beads, badgers,
97 hatchet, bayonet, suspensions, figure of man, rots, boiler, axe (fig. ?2). 2, ? 5) which in its compositions differs
98 from other axes, in its alloy hands 1.2 % of arsenic and 5.5 % of tin.

99 Author ofexcavations indicates that the shape of that hatchet are known in monuments of the III millennium
100 BC (Makhmudov, 2008). The same can be said about the compositions of the alluy, that alluy stated to appear
101 from the middle of theIII millenium BC ??Selimkhanov, 1996 ??Selimkhanov, -1997)).In study period such alloy
102 can be explained by melting scrap containing arsenic. In that burial found the awl, which is also known from
103 earlier monuments, content of 3.05 % tin. It is indicates, that the tools in the studied period became stronger.
104 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 multicomponent 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 bangles were completely rusted, the metal is not saved. Therefore we investigated three badges 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 resembles a weight of 14 grams. Despite the fact that it made from a thin metal sheet with a needle tip, it was good preservation. 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 ??Selimkhanov, , 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 the lake of Geoycha and 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 content 1.5 % nickel (Babazadeh, 2005).

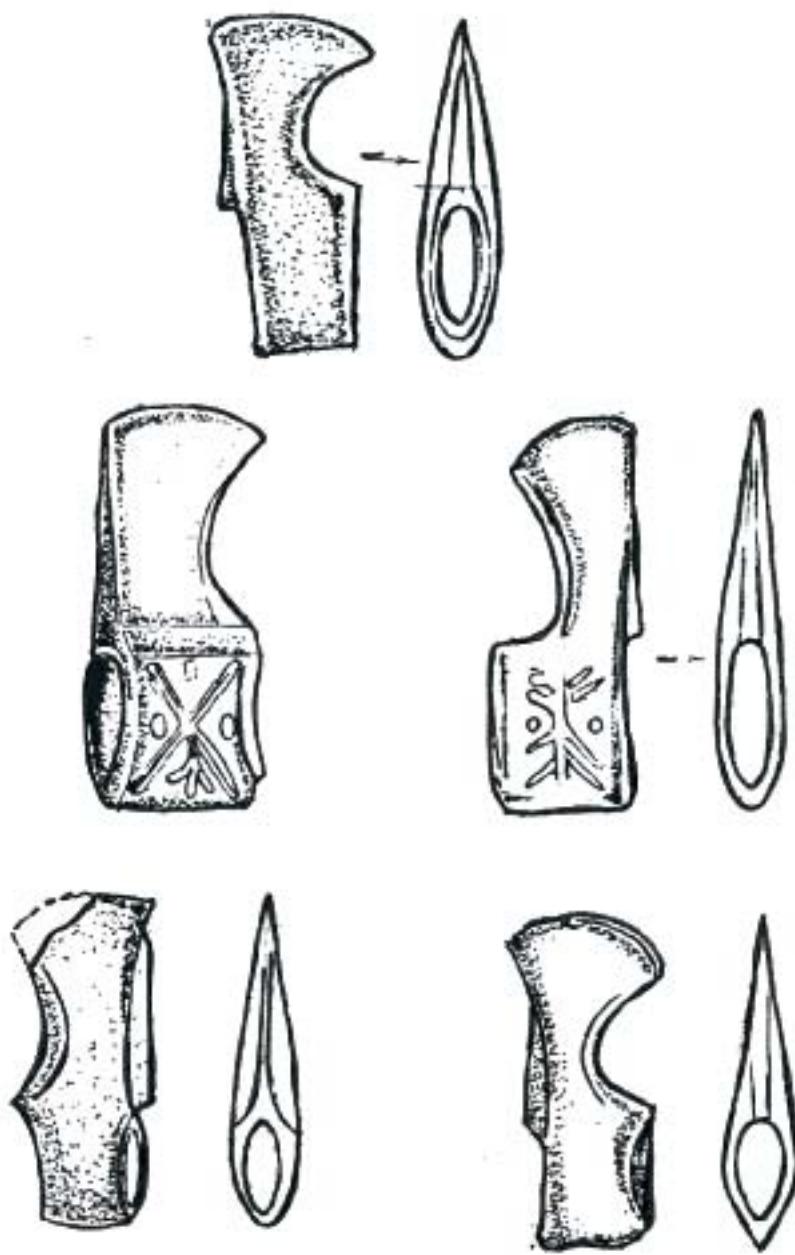
It should be noted that on the territory of Azerbaijan in the settlement Babadervish of Gazakh area, dated middle of the III millennium BC found another fishing hook. In its composition contains 0.99% -tin, 1.3% arsenic, the other elements are negligible (Narimanov, Selimkhanov, 1965). When comparing 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 0 . . ^{1 2}

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Figure 1: Figure 1 :



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Figure 2: 10



Figure 3: Figure 2 :

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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, contain 0.9, 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).

? Object, Weight	Gram (G)	Content Of Elements In Weight %						Au	Ag	Ni
		Sn	Pb	Zn	As	Sb				
1 Axe, 700 g	0/250/005				0.1	0.02		0	0.018	0.008
2 Axe, 800 g	7/0 0.0150				0.5	0.015		0	0.019	0.015
3 Axe, 400 g	0.09 0.03 0				0.25	0.02		0	0.04	0.0
4 Axe, 780 g	9.15 0.1 0/035				0.3	0.02		0	0.006	0.0
5 Axe, 875 g	4.6 0.03 0				0.3	0		0	0.028	0.002
6 Axe, 812 g	5/030.08 0				0.25	0		0	0.05	0.0

Figure 4: Table 1 :

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[Note: -Zod(Babazadeh, 2005).In Georgia -Racha, Zophid deposits(Tavadze, Sakvarelidze, 1959). It should be noted that antimony ores are typically in association with 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.]

Figure 5:

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Figure 6: Table 2 :

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2

Figure 7: table 2 .

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

152 The following artifacts are revealed under investigation from the ground burials near the settlement Uchtepe
153 dated XV -XIV centuries BC (Makhmudov, 2008). It is dagger weighing 378 grams, knife -51.5 grams, figure of
154 man-8 grams. Analysis show figure of man, made of arsenic bronze, contain 2.3 % of arsenic. Blade of dagger
155 made of tin bronze, contain 0.5 % of tin. Handle of dagger and knife made of copper tin arsenic alloys, contain
156 11.1, 2.6 % of tin and 0.85, 0.99 % of arsenic (table 2, ? 30-33).

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

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

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

164 From the foregoing, it follows that for the supply of bronze metallurgy of South -East of Azerbaijan in study
165 period could be deposits of Iran -Deh Hossain (Helwing, 2009).

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

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