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ARCHAOMETALLURGICAL STUDIES OF SPEAR HEADS AND ARROW HEADS OF THE MIDDLE BRONZE AGE SITES OF AZERBAIJAN

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ABSTRACT

Quantitative spectroscopy analysis of spear heads and arrow heads of Middle Bronze Age sites of Azerbaijan (second part of the III to the middle of the II millennium BC) has been made to determine the type of the alloy taking into account the accepted limits of natural impurity in metals (- 0.5% and more). The analyses have shown that copper is the basic materials in all of them. Metallurgical classification the results of sixteen analysis spear heads have shown three of them made of arsenic copper, eight of tin bronze, two of arsenic tin bronze, two of lead tin bronze. Analytical investigations of seventeen arrow heads shown: four of them made of arsenic copper, seven of tin bronze, two of lead tin bronze, one of arsenic tin bronze, two of copper and one of copper lead alloys. Analysis of spear heads and arrow heads shown seven artefacts made of arsenic copper. It shown, that in the Middle Bronze Age on the territory of Azerbaijan continued smelting arsenic copper. But great part of artefacts made of tin bronze, containing tin in the range 2.6 - 12 %. Spear heads from burial mould dating of XVIII - XVII centuries BC of South - West Azerbaijan nearly Iran, Asia Minor contain 12 % tin. Arrow heads from admit burial dating XX - XIX centuries BC there are south-east on the Azerbaijan near border Iran, contain 8.15 % tin. It is shown, that tin on the territory of Azerbaijan in the study period, was available and deriving from territories of Iran, Asia Minor. Known, as ancient tin mining are absent on the Caucasus. Ancient tin mining found on the territory of Iran, Asia Minor, Afghanistan and Central Asia, mostly used in the beginning of the III millennium BC. Sumerian texts dated of III millennium BC position the origin of tin somewhere east of Mesopotamia, so that Iran and its neighboring countries Susa at the late part of the III millennium BC participated in the tin trade, where tin brought to Mesopotamia and there was widely trade. Tin also was imported on the South Caucasus from Mesopotamia, because through that territory trade route existed between Near East with North Caucasus-Maykop. At the final stage of the study period XVI - XV centuries BC expensive import of tin was supplemented by lead from local deposits. Lead was used as an alloying component in five investigated artifacts. The present study has shown that most of spear heads and arrow heads, were melt from raw materials of local origin with addition of imported tin.

KEYWORDS: Azerbaijan, analysis, alloys, arsenic copper, bronze, lead, tin deposits, Iran, Mesopotamia

1. INTRODUCTION

The article devoted archaeometallurgical investigation of spearheads and arrow heads from the Middle Bronze Age sites of Azerbaijan. More part of them are found in funereally monuments, dated to the period from the second part of the III to the middle of the II millennium BC. According to the study period of archaeological monuments of Azerbaijan investigated 16 spear heads and 17 arrow heads. The purpose of the study show how various compositions of alloys depending by the chronology and which alloys were used in the studies period for manufacturing of spear heads and arrow heads in study period on the territory of Azerbaijan? 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 artefacts of copper based, as elaborated by the I. R. Selimkhanov (Selimkhanov, 1960). All artefacts is good preservation. Patina cover surface of all artefacts. Samples taken for analysis without oxides it 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 beginning of - 0.5% and more (Kashqai, Selimkhanov, 1973).

2. METALLURGICAL CHARACTER OF SPEAR HEADS AND ARROW HEADS

The results of the analytical research spear heads are shown in table 1. 1. Metallurgical classification spear heads by type of alloys showed the following:

1. Arsenic copper Cu-As 3 artefacts
2. Arsenic tin bronze Cu-As-Sn 2 artefacts
3. Tin bronze Cu-Sn 8 artefacts
4. Lead tin bronze Cu-Sn-Pb 2 artefacts

Three spear heads made of the arsenic copper contain 0.7, 1.64, 2.8%, arsenic (table.1 № 2, 8, 13). Deposits of arsenic ores are widely represent on the territory of Azerbaijan (Courcier et al. 2008). The remaining elements are the natural source of copper ore impurities from local deposits. They are from the burial mounds Gobustan, Dashsalahli (Gazakh district) and Hachbulag (Dashkesan district). The first

two spear heads of burial mound dating from the second half of the III millennium BC. The third artefacts - from the burial mounds, dated XVIII - XVII centuries BC (Narimanov, 1961).

Eight spear heads made of tin bronze (table 1. № 3, 4, 6, 7, 9, 12, 14, 16). The tin contain in the range 3.72 - 8.7%. The ancient of them date the second half of the III millennium BC. They are found in the burial mound Kyudurli - Sheki district, Gobustan, Khankendi - Garabagh (Hasanova A2008, A2009; Hummel, 1948). The rest of them discovered from admit burials, dated XX-XIX centuries BC Alike-mektepe hill (Makhmudov, 2008) and from the stone box Gyzylburun dated XVIII - XVII centuries BC Nakhchivan Autonomous Republic (Aliev, 1991).

Two spear heads of tin bronze found from the sites date the end of final stage of the study era XVI - XV centuries BC. They discovered from the ground burial Dashyuz - Sheki district, settlement Galajig - Nakhchivan Autonomous Republic (Hasanova, B2008; Aliev, 1991). Spear heads of the burial mound of Gobustan dated to the second half of the III millennium BC contain of 8.7% tin. This suggests that at this time the tin on the territory of Azerbaijan was enough. Of leadtin bronze made two spear heads (table 1, № 10, 15). One of them content of 10.8% tin, 5.6% lead, the other impurities are negligible. Found in the ground burial near Sheki city dated XVI-XV centuries BC (Akhundov, 2001). Next spear heads of lead tin bronze, found from the burial mound Chalkhangala-Nakhchivan Autonomous Republic which content 12 % tin, admixture of lead 0.55 % (table 1, № 10). Among the spear heads one of them, made of copper (table 1, № 11). However, in its composition there are natural raw impurities - zinc, arsenic and other elements that a total of about 1%, which made copper hardness (Gasanova, A2014). For the manufacture of early spear heads, dated of second half of the III millennium BC used as arsenic copper and tin bronze, but artefacts of tin bronze more, than arsenic copper. As spear heads a military weapons require special strength, apparently so, since the early stages of the study era, for they manufacturing used expensive - imported tin. Since the beginning of the II millennium BC for manufacturing of spear heads used mainly tin bronze and lead-tin bronze.

Table 1. The results of quantitative spectral analysis of spear heads

№	Artefacts	Composition (weight %)												
		Cu	Sn	Pb	Zn	As	Sb	Au	Ag	Bi	Ni	Co	Fe	Mo
1	spear head	95.47	3.35	0.04	0.01	0.64	0.2	0.05	0.002	0.03	0.007	n.d	0.2	n.d
2	spear head	98.75	0.03	0.04	0.2	0.7	0.2	n.d	0.01	0.01	0.004	n.d	0.05	n.d
3	spear head	95.53	3.72	0.05	0.23	0.03	n.d	n.d	0.01	0.007	0.005	0.002	0.41	n.d
4	spear head	95.38	3.8	0.03	n.d	0.32	0.03	n.d	0.01	n.d	0.26	0.013	0.15	0.003
5	spear head	91.72	6.92	0.04	n.d	1.04	0.13	n.d	0.059	0.03	0.046	n.d	0.01	0.001
6	spear head	90.71	8.7	0.03	n.d	0.3	0.035	n.d	0.17	n.d	0.3	n.d	0.05	0.005
7	spear head	94.83	4.43	0.03	n.d	0.32	0.015	n.d	0.088	n.d	0.18	0.006	0.1	0.003
8	spear head	97.79	0.06	0.05	0.05	1.64	0.03	0.003	0.048	0.10	0.02	n.d	0.2	0.005
9	spear head	93.71	6.1	0.03	n.d	0.02	n.d	n.d	0.022	0.005	0.01	n.d	0.1	0.002
10	spear head	86.71	12.0	0.55	0.01	0.4	0.05	n.d	0.07	0.02	0.15	0.002	0.03	0.01
11	spear head	97.11	0.05	0.04	0.44	0.3	n.d	n.d	0.051	n.d	0.004	n.d	2.0	0.015
12	spear head	90.96	7.59	0.07	n.d	0.5	0.05	n.d	0.0015	0.015	0.4	0.007	0.4	0.012
13	spear head	96.65	0.007	0.3	n.d	2.8	0.003	0.001	0.04	0.04	0.05	0.003	0.1	0.011
14	spear head	94.27	4.8	0.03	0.01	0.3	n.d	n.d	0.01	0.03	0.01	0.02	0.52	n.d
15	spear head	82.35	10.8	5.6	0.3	0.2	0.2	n.d	0.056	0.03	0.05	0.005	0.4	n.d
16	spear head	92.90	6.35	0.05	n.d	0.3	0.05	n.d	0.043	n.d	0.3	n.d	0	n.d

Note:

Weight of spear heads range of 13-320 gram. № 1, 4 to 6, 8, 9- burial mound of Gobustan. № 2- burial mound of Dashsalahli, Gazakh district, № 3- burial mound of Kyudurli, Sheki district, № 7 - burial mound Khankendi, Garabagh № 10, 11- burial mound of Chalkhangala, Nakhchivan Autonomous Republic, № 12- stone box of Gyzyilburun, Nakhchivan Autonomous Republic, № 13- burial mound of Hachbulag, Dashkesan district. № 14- ground burial of Dashyuz, Sheki district. №15 - ground burial near the Sheki city. № 16 - settlement Galajig the Nakhchivan Autonomous Republic. № 1- dated middle of III millenium BC, № 2-8 dated second part of III millenium BC, № 9-XX-XIX centuries BC, № 10 - 13 dated XVIII-XVII centuries BC, № 14-16 dated XVI-XV centuries BC.

Results of research metallurgical interpretation spear heads by type of alloys showed, that the tin is the main alloying element for making spear heads. The presence of tin is observed from the early stages of the study period and even earlier, from the middle of the III millennium BC (Selimkhanov, 1996-97; Hasanova, B2014).

The next group of investigated artefacts it is the arrow heads, which occupy an important place among weapons.

It should be noted that the arrow heads in the archaeological monuments on the territory of Azerbaijan appeared in the Middle Bronze age.

Results of the analytical study are shown in table 2.

Metallurgical interpretation arrow heads by the type of alloys showed the following:

1. Arsenic copper Cu-As 4 artefacts
2. Arsenic tin bronze Cu-As-Sn 1 artefact
3. Tin bronze Cu -Sn 7 artefacts
4. Lead - tin bronze Cu-Sn-Pb 2 artefacts

Four arrow heads melted of arsenic copper, contain 0.75 - 1.4 % arsenic.

Two of them are from the burial mound Dashsalahli, dated the second half of the III millennium BC and from the settlement Kultepe II, dated XX-XIX

centuries BC (table.2, № 1, 8). The next two - from the stone box Gyzyilburun, dated XVI - XV centuries BC the final stage of the study period (table. 2, № 9, 10). Arrow heads from the settlement Kultepe II, contain of 1.4% arsenic. Only one arrow heads from the admit burial of Alikemektepe, dated XX-XIX centuries BC made of arsenic tin bronze, contain 2.5% of arsenic, 5.5% of tin (Makhmudov, 2008; Hasanova, 2009). Seven arrow heads made of tin bronze. The tin content is in the range 0.8 - 8.15 %. Arrow heads from admit burial Alikemektepe hill, contain of 8.15% tin. It should be noted, that this monument is located near the tin deposit of Deh-Hossein in Iran (Helving, 2009). Five of tin bronze artefacts dated the second half of the III millennium and XX-XIX centuries BC. They are identified in ground burial the village Alhasly, Lachin district, in admit burial Alikemektepe hill and in settlement Kultepe II. Only two arrow heads of tin bronze originate from monuments XVI - XV centuries BC, the final stage, the study period. Two arrow heads made of lead - tin bronze, those are discovered from the stone box Gyzyilburun area Nakhchivan Autonomous Republic, dated XVI - XV centuries BC (table. 2, № 14, 17). The first arrow heads content of 6.0 %

tin, 0.99% lead, second of them 2.6 % tin, 1.24 lead. The remaining elements are negligible, are natural impurities of local copper ores. This fact confirms that at the end of the study period metallurgists - beginning to supplement Import tin of ores from local deposits (Gasanova, A2014).

Deposits of lead ores there are on the Lesser and Big Caucasus (Courcier A, Kuparadze D. Pataridze D, 2008). In the studied era, their using does not a particular problem.

Two arrow heads made of copper containing about 0.63-0.65% natural various impurities of local copper ores. This is an indication that the using copper was quite hard (Hasanova, A2014). One arrow heads made of lead copper, contain 1.46% of lead. However, natural impurities other elements in the alloy composition are more that 1%, which also gives the alloy hardness.

Results of the study metallurgical classification arrow heads in separate stages studied period showed the following. Bronze arrow heads appear on the territory of Azerbaijan in the studied period. For the manufacture of arrow heads, beginning of the study period in the formulation of the alloys, boldly introduced tin, where its content is in the range 2.7 - 8.15% (table 2, № 1-8). Five arrow heads of tin bronze and only two of arsenic copper, made at the early stages of study period (second half of the III millennium BC; XX-XIX centuries BC). This suggests that in the early stages of investigated period could not yet supplement tin ores from local deposits.

At the final stage of the study period XVI-XV centuries BC, the number of arrow heads from tin bronze reduced, appear arrow heads made of lead - tin bronze. Contain tin in alloys decreases and the ranges from 0.8 to 5.5 % .

Table 2. The results of quantitative spectral analysis of arrow heads

№	Artefacts	Composition (weight %)												
		Cu	Sn	Pb	Zn	As	Sb	Au	Ag	Bi	Ni	Co	Fe	Mo
1	arrow head	98.70	0.001	0.04	0.2	0.75	0.15	n.d	0.01	0.025	0.01	n.d	0.07	0.011
2	arrow head	95.34	3.15	0.42	n.d	0.3	0.3	n.d	0.04	n.d	0.05	n.d	0.1	0.005
3	arrow head	92.21	7.5	0.005	n.d	0.07	n.d	n.d	0.11	0.005	0.002	n.d	0.1	0.007
4	arrow head	91.47	8.15	0.1	n.d	0.15	n.d	n.d	0.022	0.03	0.01	0.025	0.035	0.003
5	arrow head	91.85	5.5	0.03	n.d	2.5	n.d	n.d	0.007	0.01	0.08	0.005	0.01	n.d
6	arrow head	96.88	2.7	0.08	n.d	0.25	n.d	n.d	0.05	0.005	0.021	n.d	0.005	n.d
7	arrow head	96.55	2.7	0.07	0.25	0.18	0.03	0.0003	0.08	0.005	0.02	0.008	0.1	0.012
8	arrow head	98.12	0.003	0.15	0.02	1.4	n.d	n.d	0.002	0.003	0.002	n.d	0.3	0.002
9	arrow head	98.20	0.06	0.1	0.06	1.2	0.1	n.d	0.02	0.002	0.05	n.d	0.2	n.d
10	arrow head	98.77	0.15	0.03	0.03	0.8	0.1	n.d	0.02	0.01	0.08	n.d	0.01	0.004
11	arrow head	99.40	0.04	0.01	0.15	0.04	0.003	n.d	0.082	n.d	0.3	0.001	0.1	n.d
12	arrow head	99.33	0.1	0.07	0.05	0.2	0.1	n.d	0.03	0.005	0.1	n.d	0.01	0.005
13	arrow head	97.46	0.2	1.46	0.1	0.2	0.2	0.002	0.04	0.05	0.08	0.002	0.2	0.003
14	arrow head	92.28	6.0	0.99	0.2	0.3	0.05	n.d	0.03	0.01	0.1	0.03	0.01	n.d
15	arrow head	98.45	0.8	0.15	0.15	0.05	0.02	0.002	0.082	0.001	0.27	0.001	0.02	0.015
16	arrow head	94.19	5.05	0.1	n.d	0.1	0.12	n.d	0.005	0.004	0.023	0.3	0.1	n.d
17	arrow head	95.45	2.6	1.24	0.1	0.25	0.1	0.002	0.027	0.004	0.1	0.02	0.1	0.005

Note:

Weight of arrow heads rage of 8.5-16 gram. № 1-burial mound of Dashedlahli, Gazakh district, № 2-ground burial mound of village Alhasly, Lachin district. № 3-6 admit burial of Alikemektepe, Jalilabad district, № 7,8 - settlement Kultepe II, the Nakhchivan Autonomous Republic. № 9-15, 17 stone box Gyzylyburun, the Nakhchivan Autonomous Republic. № 16 ground burial of Boyuk Gyshlag, Tovuz district. № 1,2-second part of III millennium BC, № 3-8- XX-XIX centuries BC, № 9-17- XVI-XV centuries BC.

This suggests that the craftsmen - metallurgists, at the final stage, the study period made experimented and tried to replace import tin of local ores (Hasanova, A2014). Classification spear heads and arrow heads showed that in the early stages of the study

period for production spear heads, used tin bronze and arsenic copper. But in XVIII- XVII centuries BC in composition of tin bronze beginning add lead. For the manufacture of arrow heads in the early and later stages, used arsenic copper and tin bronze. At

the final stage, the study period in alloys commonly used lead, because tin was expensive. It should be noted, the earliest mining's of tin there are in Asia Minor, it is Kestel mine (Yener, 1989; 1993). The researchers note, beginning of the III millennium BC this mining's could be used for bronze metallurgy of Asia Minor and Mesopotamia, but could not meet the needs tin across of Anatolia and Mesopotamia (Weisgerber, Cierny 2002). Recent results of radiocarbon analysis mine showed, that the mine was used during the III millennium BC and the ore of this mine is cassiterite (Yener, 2000). The latest research has shown that in Iran there are deposits of tin in the Zagros Mountains. The beginning of their mining, dated to the IV - III millennium BC. Tin mines are located in the central Zagros, it is Deh Hossain deposit. This is probably the tin of that deposit, delivered to Susa and later in Mesopotamia (Helving, 2009). Tin deposits there are in Afghanistan, on the border with Iran, identified a number of large and small tin deposits. That could supply the tin of ancient metallurgy of the Caucasus and the Middle East (Stesh, Pigott, 1986). Equally important were the tin deposits in Central Asia (Uzbekistan, Tajikistan). Mineral of tin, there are in granitic rock and alluvial. Most of them are indigenous, which are known to occur in the deep zones among granitic rocks, but, despite this, the ancient miners were available. This is proven by numerous ancient mining, discovered on the territory of these deposits (Weisgerber, Cierny 2002). It should be noted, that the bronze artifacts of the monuments nearly to Iran, Mesopotamia, Asia Minor, content of more tin, then sites localized far of that's regions. Revealed on the territory of Azerbaijan, beginning of the second half of the III millennium BC there is abrupt transition from arsenic copper to tin bronze.

3. CONCLUSION

In conclusion, it should be noted that the present study has shown that most of spear heads and arrow heads were melt from raw materials of local origin with addition import tin. Some artefacts also detect-

ed (0.3-0.4% Ni). The earliest studies did not identify nickel in copper ores on the territory of Azerbaijan (Selimkhanov, 1996-97). Nickel seems to be associated with ophiolite belt in the Caucasus (Courcier, Gasanova, Hauptmann, 2008). Also indicated furnace dated XVIII-XVII BC discovered in Sheki area. Slag discovered near furnace analyses made in Baku detected (0.02 % Sn) It is say about development metallurgy in study region (Hasanova, 2011). Interpretation spear heads and arrow heads showed that in the early stages of the study period for production spear heads, used tin bronze and arsenic copper. But in XVIII- XVII centuries BC in composition of tin bronze beginning add lead. For the manufacture arrow heads in the early and later stages, used arsenic copper and tin bronze. At the final stage, the study period in alloys commonly used lead, from local deposits, because tin was expensive. Despite the fact, that the territory of Azerbaijan, is rich of deposits of various nonferrous metals (As, Pb, Sb, Zn), which could well substitute tin and unlikely to stimulate here early transition to the production of expensive tin bronze. However, the development and the extensive system of economic trade and cultural - relations with the Near East countries 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 Azerbaijan since the second half of the III millennium BC could be deposits of Asia Minor (Kestel), Iran (Deh Hossain), western Afghanistan, and with the beginning of II millennium BC perhaps from Central Asian sources of tin. On the South Caucasus tin, probably delivered as a result of trade and exchange transactions as of Mesopotamia, where was, conducted trade of tin and from the territory of Iran, which hosted the caravan route with tin, as well as from Asia Minor, Central Asia, which can used, also on the territory of Azerbaijan.

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