SOME METALLURGICAL ASPECTS OF ANCIENT SILVER COINS DISCOVERED IN ROMANIA - ORIGINALS AND IMITATIONS

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ABSTRACT

The paper presents an extensive archaeometrical study of two categories of ancient silver coins - Apollonia and Dyrrachium silver drachmae and Dacian drachamae. The coins of the former type were emitted by the-above mentioned Greek colonies which were under Pompejus authority during Ist Century B.C., while the latter type were Dacian imitations of the coins emitted by the Macedonian king Phillip II. All analyzed coins circulated in Dacia during the Ist Century B.C.; they were found on the territory of present Romania. As an explanation for the presence of a large number of Apollonia and Dyrrachium drachmae on the Dacian territory, it was speculated that these coins were used by Pompejus as a payment for the Dacian mercenaries fighting in the civil war on his side. To determine the elemental composition of the coins, two analytical methods were employed: Energy Dispersive X-Ray Fluorescence (ED-XRF) based on radioactive source excitation (^{241}Am and ^{238}Pu) and in-vacuum 3 MeV Proton Induced X-ray Emission (PIXE). For Apollonia and Dyrrachium drachmae, the following types of coins were found: original coins, debased coins (silver content down to 70%), official counterfeits - coins minted with the original dies - made out of bronze, official counterfeits of tin, and plated coins - bronze core covered with a 0.2-0.5 mm silver layer. For the Dacian drachmae, an interesting evolution of the tin content was put in evidence.

KEYWORDS: silver drachmae, Dacia, Apollonia, Dyrrachium, ED-XRF, PIXE, plated coins, tin, bronze

INTRODUCTION

The great number of Greek silver coins emitted during the Ist century B.C. and found in the Balkan – Carpathian regions aroused a sharp interest among the numismatic researchers [1]. Many Apollonia and Dyrrachium drachmae, all emitted during the Roman civil wars, were discovered in several hoards found on the actual Romanian territory. The archaeologists and numismatists tried to explain the large diversity of these coins which presented differences in weight and in physical aspect. The present study aimed to support the visual and metrological classification of the drachmae emitted by the ancient Greek commercial cities of Apollonia and Dyrrachium (nowadays Albania) into originals, counterfeits and plated coins, taking into account their elemental composition.

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The other objective of our study consisted in the study of the second phase of the so-called Dacian drachmae coinage, consisting in barbarian imitations of the coins emitted by the Macedonian king Philip II [2]. These coins were issued between c. 150 and c. 70 B.C., when the Celtic contribution almost completely disappeared and the minting centres were shifted from the West and North to the South of Dacia. Most of Dacian drachmae have on the obverse a head and on the reverse a horse and a horseman. Almost all of them have a high degree of stylization - see figure 1, where a comparison between an imitation of a Macedonian Philip II coin (α) and a schematized coin of Vârteju-Bucureşti type (β) is presented. The weight of the Dacian coins is reduced compared with the one of the original Macedonian coins, ranging from 11-17 g down to 4-5 g. The numismatists [2] defined the following types – the names were given after the places where the largest coin hoards were discovered: Dumbrăveni, Adâncata-Mânăstirea, Vârteju-Bucureşti, Inoteşti-Răcoasa, Cladova-Saschiz and Aninoasa-Dobreşti for the extra-Carpathian Dacia and Medieşu Aurit, Aiud-Cugir, Răduleşti-Hunedoara, Petelea and Toc-Chereluş in North-West Dacia (Transylvania).

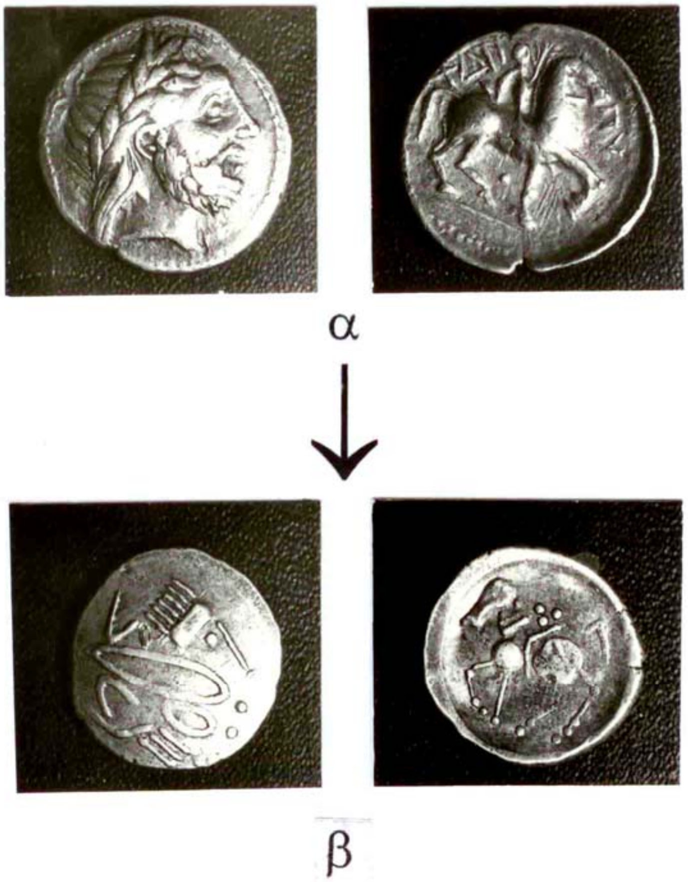

Fig. 1 - From imitation (Philip II of Macedonia drachma) to schematization (Vârteju-Bucureşti drachma)

1. EXPERIMENTAL

Visual examination and weighing, the first steps of numismatists work, are sometimes insufficient to classify ancient coins; therefore, in some cases, elemental analysis might bring some additional information. In this study, ED-XRF (Energy-Dispersive X-Ray Fluorescence) [3] and PIXE (Proton Induced X-ray Emission) [4] methods were used to determine the elemental composition of the analyzed drachmae.

A selected number of Apollonia and Dyrrachium coins were analyzed by using in vacuum 3 MeV PIXE. The proton beam was delivered by the Bucharest 8 MV FN HVEC (High Voltage Engineering Corporation) Van de Graaff Tandem accelerator. A Canberra GL0110P – Low Energy Germanium Detector (100 mm^2 area, 10 mm thickness, 0.075 mm Be window thickness, 160 eV FWHM at 5.9 keV). The range of 3 MeV protons in silver-copper alloys with different compositions is about 30 μm. However, the analyzed depth is actually determined by the attenuation of the emitted characteristic X-rays, and it is even lower than the range of protons – around 10-20 μm for the K_α line of Cu in the case of silver and bronze alloys. PIXE analyses were performed on the coins that showed no signs of corrosion and for which a relatively uniform silvery appearance (indication for a high content of silver) was observed.

ED-XRF analyses were performed by using a spectrometer based on a 30 mCi ^{241}Am annular source and a Si(Li) detector (FWHM: 190 eV at 5.9 keV). In this case, deeper depths from coins surfaces can be probed – maximum excited depth was around 100 μm. Moreover, the characteristic X-rays of heavier elements (Ag, Sn) came from a deeper depth in the coins than in the case of PIXE. Taking into account that PIXE method, involving the use of a particle accelerator is more expensive than ED-XRF, ED-XRF was used to analyze most of the coins.

The Dacian drachmae were measured only by ED-XRF and with two X-ray detectors - a Si(Li) and a HPGe. The efficiency of the HPGe detector is better than that of the Si(Li) detector, aspect that is important for the detection of elements with Z~50. For the Dacian coins, measurements with two excitation sources were made for every coin: ^{238}Pu (annular, 30 mCi) and ^{241}Am (annular, 10 mCi, with Ni window for attenuation of X- and soft γ-rays, making the 59.5 keV γ-ray the only important for the characteristic X-ray excitation). ^{238}Pu excites better the elements with low Z (K shell) and Z~80 (L shells), while the ^{241}Am source is more appropriate for the detection of elements with Z~50. A comparison of the X spectra obtained for the same silver coin excited by the two sources is given in figure 2.

The calibration was made by means of pure metallic foils (99.99% purity) from Goodfellow - Cu, Ag, Sn, Au, Pb. A home-made software - XNEW - was used to obtain the quantitative results. The X-ray line intensities were calculated by taking into account the spectra of pure metallic standards measured in the same geometry as the analyzed sample. The results quoted for Ag and Sn concentrations measured by ED-XRF have a standard deviation of 1.5 %. A standard deviation less than 10 % is characteristic for the reported Cu, Au, Pb, Bi and other minor elements, and goes up to 25% and 50% for concentrations of 0.05% and 0.02%, respectively.

Prior to analyses, all examined coins have been mechanically cleaned by using alcohol wiping.

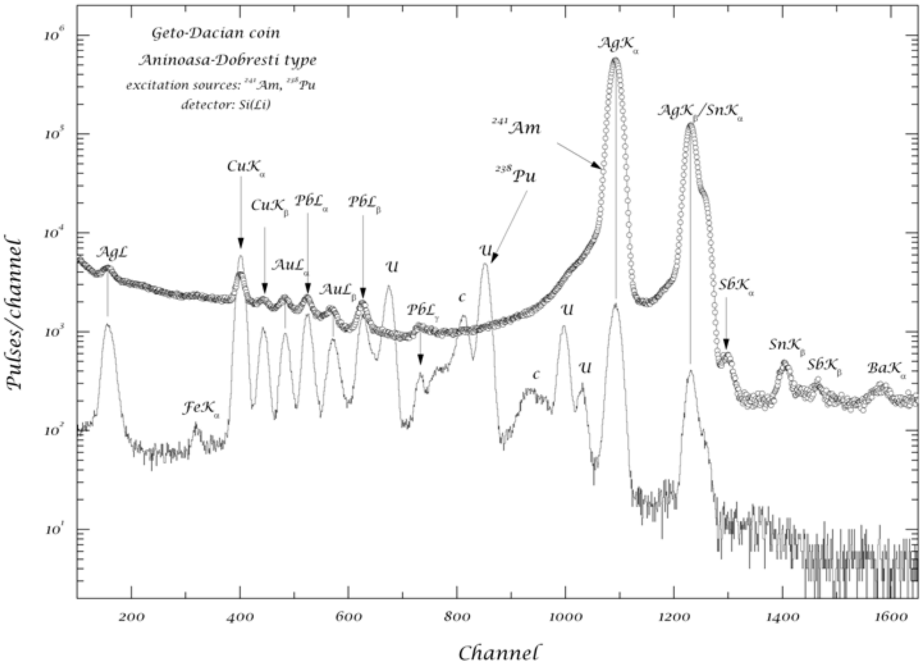

Fig. 2 - X-ray spectra of a Dacian coin - Inoteşti-Răcoasa type - excited with ^{238}Pu (line) and ^{241}Am (circles); Si(Li) detector

2. RESULTS AND DISCUSSIONS

It is known today that there are some main causes that make the silver surface to differ of bulk concentration of the coin: segregation during casting, deliberate thermal and chemical treatment (heating in flux of air followed by pickling in natural acids), natural chemical corrosion that make less noble metals to oxidize more rapidly and quit the surface (mainly by wearing), post excavation cleaning. In fact, what is the signification of the analyses performed by surface methods, such as PIXE and ED-XRF? Does it give some valuable information? Beck et al. [5] suggested a model based on the Cope's model [6]. According to her model, for Ag content higher than 92% there is no significant difference between bulk and surface composition; however, below 92% Ag, some differences between the bulk and surface composition start to appear. In any case, PIXE, and mainly ED-XRF, with its higher investigated depth, can provide at least orientative values for the elemental concentrations and can help in the classification of silver coins.

245 Apollonia and Dyrrachium drachmae, struck in the Ist century B.C., belonging to Ţării Crişurilor Museum, Oradea and to "Vasile Pârvan" Institute of Archaeology, Bucharest were analyzed in this study. These coins were found in various places on the Romanian territory, most of them in the North-West of Transylvania and South-East of Walachia regions. The results for Apollonia and Dyrrachium drachmae are summarized in table 1. After the completion of analyses, the coins can be grouped into several categories, taking into account their chemical composition.

Table 1 – Composition of Apollonia and Dyrrachium drachmae

Group no.	Ag(%)	Cu(%)	Au(%)	Pb(%)	Br(%)	Sn(%)	Fe(%)	Trace elements
I (78 coins)	96…98	0.5…2	0.2…0.8	0.2…0.7	-	traces	traces	Bi
II (107 coins)	78…92	4…20	0.2…0.8	2…4	-	traces	traces	Bi
III (5 coins)	95…97	0.5…1	0.7…1	0.5…1.0	0.1…0.2	traces	traces	Bi
IV (54 coins)	-	67…72	-	0.1...0.4	-	28…33	0.5…1.5	Sb
V (one coin)	-	7	-	0.1	-	90	3	Ni, Sb

Because of the high silver content and refined aspect of the coins belonging to the first group, one can assume that these drachmae are the original ones, minted of Macedonian silver. The percentage of copper in the second group of coins is higher than in the previous case. The conclusion is that copper was deliberately added to the alloy, reflecting a difficult economic situation during the civil wars. These drachmae were struck in Apollonia, using Dyrrachium dies belonging to MENISKOS and XENON magistrates. The third group of drachmae is similar in composition to the first group, but presents a relatively high content of bromine, fact that leads to the supposition that local silver was used to manufacture them. Another important group is bronze Dyrrachium drachmae, found in South-East of Romania. Some of these coins were covered with a thin (submicronic) layer of tin, which can be partly noticed by visual examination. The tin layer was strongly corroded. The Cu-Sn proportion was most likely unbalanced, triggering a frailty process because of the high content of Sn. Moreover, the absence of Zn brings lead to a certain degree of porosity that could be noticed in the appearance of some coins. The result of this alloying is a compound named “white bronze”, which can easily be mistaken for silver. This was in fact, the intention of the manufacturer. This artifice was used in extreme situations, when silver resources were completely exhausted. This aspect is in agreement with Plinius statements, which mentioned in his “Historia Naturalis” that Romans used for tinning two lead-tin alloys: argentarium (50% tin) and tertiarium (33% tin). The same alloys were used as well for coins, which were coated with a very thin layer of molten material. Only one coin (listed at the end of table 1), with low weight and strongly oxidized, differs in composition from the above one. One could assume this Dyrrachium drachma bearing the inscription XENON was minted using Illyrian tin.

A special case was the one of plated drachmae. Almost since the invention of coinage, imitation silver coins have been manufactured by attaching a silver layer, with the same composition as the contemporary official coinage, on to the surface of a base metal core [7]. In the case of copper (bronze) cores, this process could be carried out by coating the surface of the core with a layer of solder consisting of a silver-copper alloy, or by attaching a layer of silver foil to the surface, either by soldering or by heating to form a layer of eutectic at the interface of the silver and copper. This latter technique is, in effect, a self-soldering process, known today as Sheffield plating. In the Roman Republican and early Imperial periods, a common technique of manufacturing silver plated forgeries was the application of silver foil. Some of the analyzed coins had a crust broken in some areas, especially on the edge, making the core visible. Our results – PIXE measurements on coins edges corroborated with visual observations performed with an optical microscope (×50) - indicate the use of the following plating mechanism: a 0.2-0.5 mm thick crust made of high purity silver (95-97%), broken in some areas, bearing an inside core (0.2-0.3 mm), made of bronze (90-97% Cu, 3-10% Sn) and a very thin (a few microns) tin-lead layer between crust and core used as soldering interface. No evidence of Sheffield plating was found. As a possible economic and political explanation for these last categories of coins, one can assume that during the Roman civil wars (Ist century B.C.) - Caesar versus Pompejus, and Octavianus versus Brutus - the connection with Macedonian silver mines was often interrupted. Therefore, the local administration started to mint plated coins just with a silver skin. After ingot exhaustion, the coins were only made of bronze, and the silver was reduced to a thin covering; sometimes even this silver covering was replaced with a tin one. These coins have a very elaborate aspect; one can conclude that they are struck using the original dies. Historically, all these aspects are in agreement with the fact that many Dacians participated in the Roman civil wars as mercenaries, on Pompeius and Brutus side.

The results obtained by ED-XRF for the coins belonging to the second phase of Dacian coinage are given in table 2. All coins from this table seem to be authentic, although the Cladova-Saschiz coin with such a low Au concentration (0.04%) raises some doubts. However, taking into account the reduced number of coins belonging to this type - they are very rare, only 8 pieces being listed in [2] - it is very difficult to asses the originality of this coin. Usually, the elemental composition found by ED-XRF technique was approximately identical for both sides (obverse and reverse) of the same coin. If the obverse and reverse spectra overlapped on the PC screen, they were added and the data processing was continued with the sum spectrum. But there are cases when appreciable differences were found. For instance, the Vârteju-Bucureşti type coin [8] found in Cârlomăneşti (nr. 26399) have obverse/reverse concentrations for Cu, Zn, Ag, Sn, Au, Pb and Bi of 0.48, 0.47, 1.13, 1.13, 0.9, 1.12 and 1.13, respectively, while another coin (nr. 26526) has the ratios practically inverted: 2.25, 1.75, 0.72, 0.69, 0.55, 0.69 and 0.79. The reason for this seems to be connected with the gravity segregation. This can be explained in the following manner, based on the following multi-step model of the process involved in obtaining a coin:

(1) Melting of the constituent metals in a clay crucible, resulting in a mixture as a globule or as an ellipsoid; if the noble metals are present at low concentrations, the alloy wets the crucible walls, resulting in a disk form [9];
(2) The transformation of the ellipsoid into a disk by hammering;
(3) The heating of the disk in an oven. If the heating is long enough, segregation could appear due to different density of the constituents;
(4) The red-heated disk is set by chance with one of the faces on the patterned base die for struck.

Vârteju-Bucureşti Cârlomăneşti hoard [8] is composed both from quaternary alloy (Ag+Cu+Sn+Pb) coins and coins plated with a binary alloy (Ag+Cu) foil. In the later, no traces of gold and bismuth were found, and lead is at a very low level ($Pb \approx 0.03\%$). It was for the first time when plates imperfectly joined were clearly seen on the edge of some Dacian coins. Any of the plated coins analyzed by us was deteriorated so much that the core could be analyzed. Anyhow, such a silver alloy ($Cu \sim 23\%$) with very low gold content ($Au/Ag < 0.01$) is very uncommon, although not impossible to be found. A silver source with such a low gold concentration probably existed in Bohemia. The standardization inside of every particular issue is very poor, if there is any. However, the constancy of some parameters - e.g. the weight and the average diameter of the Răduleşti-Hunedoara coins - is surprising. Their average weight is 10.31 ± 0.27 g and the average diameter is 30.2 ± 0.4 mm, with unusual small dispersions for that epoch: 2.6 and 1.4 %, respectively. It is logic to suppose that tin was deliberately and gradually introduced in the Dacian coinage only after 150 B.C. If this hypothesis is considered, one could establish the chronology of the coin types. Taking into account the correlation between the Ag and Sn concentrations in extra-Carpathian types, the following temporal sequence was deduced: Dumbrăveni, Cladova-Saschiz, Adâncata-Mânastirea, Vârteju-Bucureşti, Vârteju-Bucureşti (Cârlomăneşti) and Inoteşti-Răcoasa. The average fineness and the average weight of the issues corroborate the supposition. At the same time, it seems that the tin alloying suddenly appeared after 150 B.C. in the

Transylvanian mints (see table 2). It is likely that this practice entered the South and East Dacia via Transylvania. Considering their peculiar composition, but also their metallurgical characteristics, one can consider that Vârteju-Bucureşti Cârlomăneşti type coins could be defined as forming a distinct type, despite of the fact that their image is more or less similar with Vârteju-Bucureşti coins.

In figure 3, a graph of tin concentrations versus copper concentrations is given for all the coins in reported in table 2. The squares represent the extra-Carpathian coins. By solid squares are marked the Inoteşti-Răcoasa coins and by open squares the rest of the extra-Carpathian coins. It seems that bronze was used for alloying the first issues because tin and copper are positively correlated (correlation coefficient $\rho = 0.802$). For the last types, both extra-Carpathian Inoteşti-Răcoasa and Transylvanian Răduleşti-Hunedoara, a negative correlation seems to exist ($\rho = -0.20$ and $\rho = -0.64$, respectively), as if the copper component was partially substituted by tin, feature more striking for Transylvanian coins.

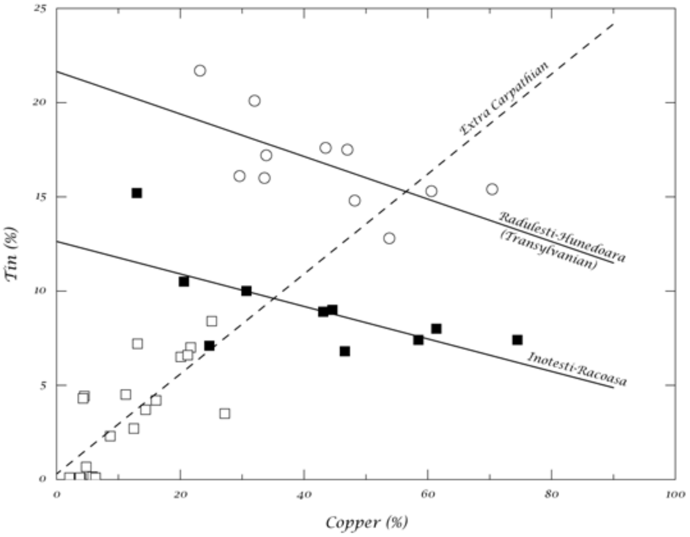

Fig. 3 - Diagram of tin versus copper concentrations for Dacian silver coins struck in the c.150 – c.70 B.C. period: the squares represent the extra-Carpathian coins and the circles the Transylvanian Răduleşti-Hunedoara coins. A particular case of the extra-Carpathian coins - the Inoteşti-Răcoasa hoard - is represented by solid squares; the open squares represent the rest of the extra-Carpathian coins.

3. CONCLUSIONS

The present study allowed a classification of Apollonia and Dyrhrachium drachmae found on Romanian territory; connections between the coins composition and historical aspects of the corresponding minting period were drawn. Hard economical and political times were characterized by debasement, reflected in our study by the increased content of Cu of drachmae. In the case of Apollonia and Dyrrachium drachmae, the plating procedure was revealed as a solution for the Roman civil war times.

As concerning the second phase of Dacian drachmae coinage, the conclusions are the following:

- There is a reduction of the fineness with the time, specific to almost every Dacian coin issue;
- Tin concentration in coin increased with the time, at the beginning of the second phase being more or less proportionally to copper concentration. This could suggest that bronze was used instead of copper in alloying silver. A very high correlation is not expected because the ratio Sn/Cu in ancient bronzes is far from being a constant. In the last Dacian issues (Inoteşti-Răcoasa and Răduleşti-Hunedoara), it seems that tin was partially replaced by copper;
- It seems that tin alloying appeared first in Transylvania coinages around 150 B.C.; the procedure later on migrated to the South- and East Dacia;
- The preference for adding tin (and maybe also lead) in Ag/Cu alloys was probably due to the fact that tin attenuates the red color of copper, resulting a silvery nuance of the alloy. In addition, the melting point of alloy is lowered, result which is important for an unsophisticated metallurgy. The scarcity of silver in the 150 – 70 B.C. period must be also considered. Although tin does almost not exist in the crust of the Romanian territory, bronze objects - weapons, medals, ornaments,statues, and forgeries of Apollonia and Dyrrachium coins - were common enough and easy to be found in the studied period;
- Lead concentration also increased in time, leading to a quaternary alloy (Ag+Cu+Sn+Pb), such the one found in Vârteju-Cârlomaneşti and/or Răduleşti-Hunedoara issues. Such alloys were generalized in the Roman coinage, but much latter (c. 250 A.D.);
- Although hundreds of Dacian coins were investigated, no coin made of out bronze or copper was found, except for a few proved modern fakes. At the same time, it seems that the issue of official “fake” bronze coins was a practice in the extra-Dacian territories.

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Table 2. The composition of some Dacian coins from 150-70 B.C. period obtained by ED-XRF method[a].

Type	Inventory number	G (g)	Cu (%)	Ag (%)	Sn (%)	Au (%)	Pb (%)	Bi (%)	Other elements (%)
Extra Carpathian									
Dumbrăveni	IA[b] 5466	9.80	2.20	96.60	0.07	0.72	0.20	0.04	Hg: 0.10
Dumbrăveni	Private collection	[c]	2.10	96.20	< 0.10	0.68	0.34	0.04	Hg: 0.10
Cladova-Saschiz	Private collection	12.00	3.90	94.40	<0.10	0.04	0.16	n.d.	Ni: 1.20; Zn: 0.10
Adâncata-Mănăstirea	Private collection	10.19	5.80	92.80	0.14	0.55	0.62	n.d.	
Adâncata-Mănăstirea	Private collection	8.92	12.50	82.70	2.70	1.43	0.45	0.20	
Adâncata-Mănăstirea	IA 5752	7.23	4.30	88.40	4.30	1.45	1.17	0.27	
Aninoasa-Dobreşti	IA 5615	14.69	6.30	92.30	0.10	0.48	0.75	0.05`	
Aninoasa-Dobreşti	IA 5622	13.93	3.80	94.60	<0.10	0.84	0.53	0.07	
Aninoasa-Dobreşti	Private collection	13.94	4.80	92.70	0.66	0.82	0.94	0.05	Hg: 0.05
Vârteju-Bucureşti	MAO[d] 100	7.80	8.70	87.00	2.30	1.00	0.30	0.29	As: 0.03, Sb:0.07
Vârteju-Bucureşti	MAO 101	7.48	14.40	80.20	3.70	1.15	0.22	0.23	As: 0.07
Vârteju-Bucureşti	MAO 102	7.14	11.20	82.30	4.50	1.26	0.31	0.25	As: 0.02, Sb: 0.10
Vârteju-Bucureşti	MAO 103	7.02	16.10	78.30	4.20	0.36	0.71	0.19	Sb: 0.23
Vârteju-Bucureşti (C) [e,f]	IA 26410	4.24	14.34	70.14	12.90	0.45	1.87	0.16	Zn: 0.12
Vârteju-Bucureşti (C)[e]	IA 26410	4.00	25.10	64.10	8.40	0.43	1.65	0.16	Zn: 0.14
Vârteju-Bucureşti (C)[e]	IA 26414	5.32	20.10	63.30	6.50	0.34	1.46	0.13	Zn: 0.19
Vârteju-Bucureşti (C)[e]	IA 26417	4.57	27.20	66.50	3.50	0.26	2.26	0.11	Zn: 0.15
Vârteju-Bucureşti (C)[e]	IA 26435	5.39	13.10	77.20	7.20	0.29	1.87	0.17	Zn: 0.12

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[a] n.d. = not detected.

[b] IA = "Vasile Pârvan" Institute of Archaeology, Bucharest.

[c] Weight not measured.

[d] MAO = Museum of Archaeology Olteniţa.

[e] Discovered and probably struck at the Dacian *dava* Cârlomăneşti-Buzău – and also denoted by a (C).

[f] The figures represent the average of the obverse and reverse concentrations.

Type	Inventory number	G (g)	Cu (%)	Ag (%)	Sn (%)	Au (%)	Pb (%)	Bi (%)	Other elements (%)
Vârteju-Bucureşti (C)[e]	IA 26469	4.48	21.70	68.70	7.00	0.27	2.03	0.15	Zn: 0.14
Vârteju-Bucureşti (C)[e]	IA 26488	4.30	21.20	70.20	6.60	0.26	1.49	0.13	Zn: 0.10
Vârteju-Bucureşti (C)[e]	IA 26526	5.07	31.44	58.30	6.60	0.30	1.61	0.12	Zn: 0.12
Inoteşti-Răcoasa	IA 235/244	6.00	58.50	32.80	7.40	0.23	0.95	0.06	
Inoteşti-Răcoasa	IA 235/252	5.92	46.60	44.30	6.80	0.37	1.68	0.22	
Inoteşti-Răcoasa	IA 235/253	4.63	74.50	15.90	7.40	0.24	1.60	0.04	Zn: 0.30
Inoteşti-Răcoasa	IA 235/254	5.83	61.40	29.00	8.00	0.20	0.72	0.04	Zn: 0.20
Inoteşti-Răcoasa	IA 235/255	5.91	43.10	45.60	8.90	0.60	1.49	0.13	Zn: 0.15
Inoteşti-Răcoasa	IA 1172/7	5.69	24.70	66.70	7.10	0.36	0.91	0.10	Zn: 0.08
Inoteşti-Răcoasa	IA 1172/8	3.84	44.60	44.80	9.00	0.29	1.08	0.09	Zn: 0.10; Br traces
Inoteşti-Răcoasa	IA 1172/9	5.13	20.60	66.80	10.50	0.50	1.41	0.10	Zn: 0.06
Inoteşti-Răcoasa	IA 1172/10	3.23	13.00	69.30	15.20	0.51	1.77	0.12	Zn: 0.03, Br traces
Inoteşti-Răcoasa	IA (fragment)	[g]	30.70	56.70	10.00	0.43	1.91	0.11	Zn: 0.09
Transylvanian									
Medieşu-Aurit	Private collection	7.04	3.70	88.70	4.70	0.62	2.26	n.d.	
Toc-Chereluş	Private collection	[g]	60.60	22.70	15.3	0.14	1.24	n.d.	
Răduleşti-Hunedoara	MNIR[h] 38958	10.20	70.40	13.10	15.40	0.34	0.50	0.08	As: 0.10
Răduleşti-Hunedoara	MNIR 38964	10.20	47.00	33.70	17.50	0.36	0.70	0.14	Zn: 0.20, As: 0.40
Răduleşti-Hunedoara	MNIR 39022	9.92	29.60	52.80	16.10	0.50	0.50	0.14	Zn: 0.20; As: 0.15
Răduleşti-Hunedoara	MNIR 39031	10.61	33.60	48.70	16.00	0.44	0.60	0.18	Zn: 0.20; As: 0.30
Răduleşti-Hunedoara	MNIR 39033	10.41	48.20	33.70	14.80	0.30	2.00	0.38	Zn: 0.20; As: 0.40
Răduleşti-Hunedoara	MNIR 39040	10.81	53.80	31.60	12.80	0.36	0.80	0.12	Zn: 0.30; As: 0.20
Răduleşti-Hunedoara	MNIR 39051	9.99	32.00	46.00	20.10	0.61	0.80	0.17	As: 0.30
Răduleşti-Hunedoara	MNIR 39060	10.55	43.50	36.80	17.60	0.40	0.90	0.16	Zn: 0.40; As: 0.20
Răduleşti-Hunedoara	MNIR 39067	10.29	33.90	46.50	17.20	0.27	1.30	0.28	Zn: 0.20; As: 0.30
Răduleşti-Hunedoara	MNIR 39109	10.11	23.20	53.00	21.70	0.92	0.50	0.15	Zn: 0.30; As: 0.20

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[g] Weight not measured

[h] MNIR = National Museum of Romania's History, Bucharest