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COMPOSITION OF SOME ANCIENT COINS FROM CĂLĂRAŞI DISTRICT ANALYZED BY XRF AND PAA.

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Abstract: *Some silver-alloy coins of various types struck by the Geto-Dacians between the third and first centuries BC, and two other older coins, discovered in Călărasi district, Romania have been analyzed by X-ray fluorescence and proton activation methods. It was found that the title is varying from "pure" silver to billon. The minor and trace element concentration can help to say something about provenance, separation method, fakes, etc. It is also important to know which elements can be put in evidence by the two methods and what is the sensitivity for each element.*

1. Introduction

As far as we know there is a general lack of compositional analyses on the Geto-Dacian coins. This might cause many hypotheses about these artifacts. Two of the most incisive are the following: (*i*) Geto-Dacians did not extract silver but they imported it in exchange for the kitchen salt[1], and (*ii*) the last Geto-Dacian coin issues in date pre-Roman (Inoteşti-Răcoasa, Răduleşti-Hunedoara) were made from copper/bronze very thin silvered[2, 3]. The atomic and nuclear analyses could bring some light on these hypotheses.

The Vârteju-Bucureşti type occupies a special place in the Geto-Dacian coinage. This type of *staters* (the weight is between 7 and 8 g) is very numerous and has also been coined just before the unification of the Geto-Dacian tribes into a unique reign under Burebista. These coins have been struck at the end of the second century BC and in the first three decades of the first century BC, in a Getic *dava* placed somewhere on the inferior course of the Argeş river[5], probably the center of the tribal union of the Piephigi[5]. In this work four such coins found in Oltenița or around it are analyzed.

In what follows a coin (G=12.37 g) from the first copies of the Philip II type (Scărişoara hoard)[6], a Histrian piece (two young male heads facing, side by side, one upright, the other inverted), an Inoteşti-Răcoasa coin, and a drachma (G=2.20 g) Alexander III, the Great - Philip III, Arrhidaeus (imitation) will be analyzed.

2. Experimental Techniques

X ray fluorescence (XRF) with an excitation isotopic source of ^{238}Pu (30 mCi - ring) and a Si(Li) detector was used in order to put in evidence Fe, Cu, Zn, Au, As, Pb, Bi, Hg, Br, Ag Sn and Sb at the surface region of the coins. For a better sensitivity in the region Z ~ 50 an excitation source of ^{241}Am (10 mCi - ring) with a nickel window was used. The method was described in detail in ref. [7].

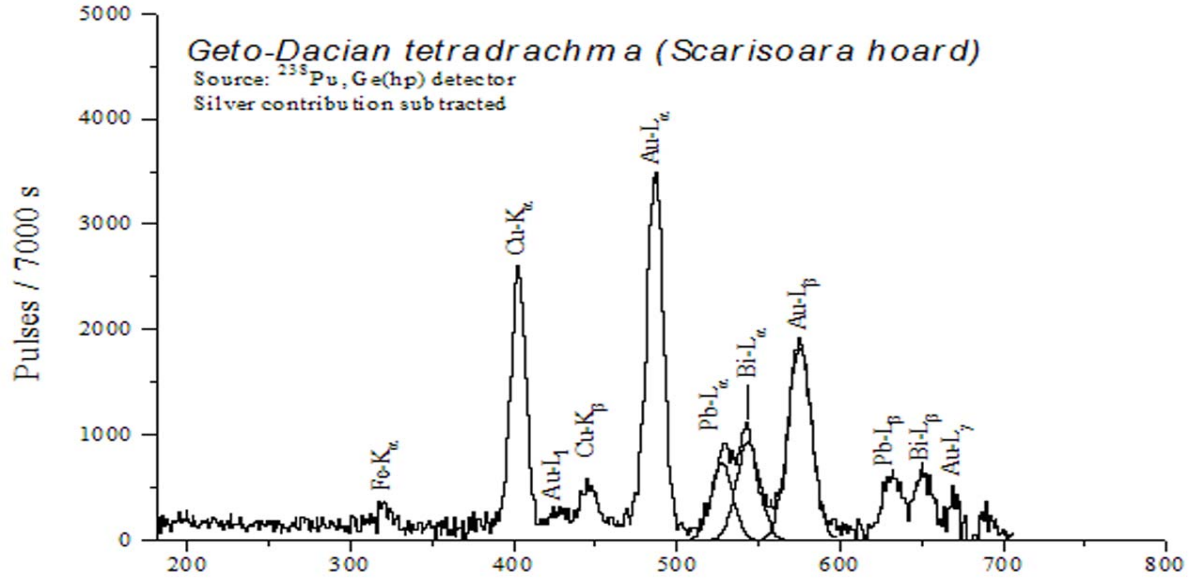

Fig. 1. Part of a XRF spectrum after the silver contribution was subtracted

For bulk analysis the proton activation method (PAA) was preferred being a complete non-destructive, clean blank one. For activation an 11 MeV proton beam of 0.3 μA from National Institute for Physics and Nuclear Engineering –Horia Hulubei Tandem accelerator was used, an energy at which the (p,n) channel is mainly open. The irradiation time was always under 100 sec in order to have a remnant activity as low as possible. After a reasonable cooling time each coin was several times counted at a Ge(Li) γ spectrometer with 2.1 keV *fwhm* for 1.33 MeV (^{60}Co). An X-ray spectrum and a PAA one are shown in Figs. 1 and 2, respectively.

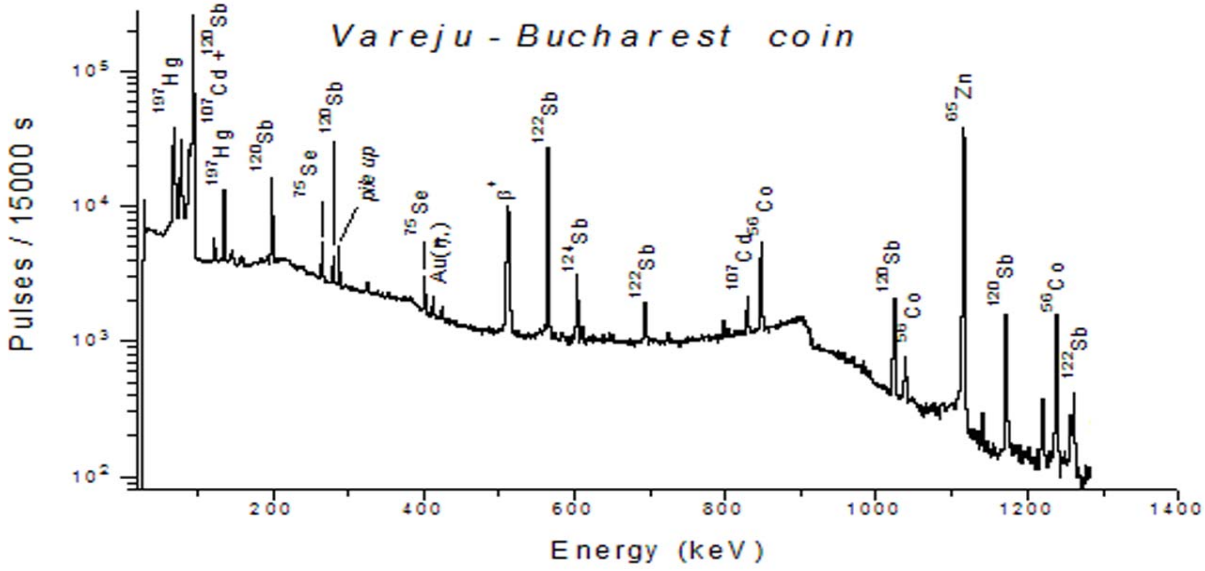

Fig. 2. Gamma-ray spectrum of a Vârteju-Bucureşti coin two days after proton irradiation. The elements seen: Ag, Au, As, Cu, Fe, Pb, Sn, Ti.

3. Results and discussion

The results are given in Table 1. They are concentrations obtained by PAA excepting Bi concentration, which is found by XRF (Bi is not seen by PAA).

Table 1. Bulk element concentrations in % found in the analyzed coins (n.d. = not detected).

Coin	Fe	Cu	Zn	As	Ag	Sn	Sb	Au	Pb	Bi
Istros	≤0.01	19.8	0.07	0.10	80.1	n.d.	0.07	0.17	0.19	n.d.
Tetradrachma	0.01	0.35	n.d.	n.d.	99.1	n.d	n.d	0.32	0.10	0.13
Drachma	0.01	33.6	0.05	0.05	58.0	7.38	0.02	0.35	0.25	0.28
Vârteju - 1	0.01	35.2	n.d.	0.02	62.0	2.13	0.08	0.21	0.12	0.20
Vârteju - 2	0.13	33.8	n.d	0.05	62.9	2.57	0.01	0.20	0.04	0.18
Vârteju - 3	n.d.	40.1	n.d.	0.02	55.6	3.56	0.10	0.22	0.14	0.27
Vârteju - 4	0.01	31.0	n.d	0.004	65.4	2.88	0.24	0.07	0.25	0.13
Inotesti	0.03	72.5	n.d.	0.08	20.2	6.43	0.05	0.06	0.46	0.05

The difference between XRF and PAA concentrations is quite large showing a high corrosion degree. So, for instance, the four Vârteju-Bucureşti (1-4) coins have $c_{Cu}^{PAA}/c_{Cu}^{XRF}$ = 4.28, 2.68,

4,03 and 2.00, respectively. For the same coins $c_{Au}^{PAA}/c_{Au}^{XRF}$ = 0.25, 0.34, 0.23 and 0.20, respectively. For the Istros coin the effect is smaller and almost unnoticed for the tetradrachma.

The high purity of the Philip II imitation tetradrachma is quite remarkable. There is no deliberately alloying with copper and a very good cuppelation (small c_{Pb}). For this coin, $c_{Au}^{PAA}/c_{Au}^{XRF} = 0.64$.

The Istros stater has a surprisingly high concentration of copper. Being older (400-350 BC[8]) than the tetradrachma (323-315 BC[9]), a time when copper alloying was quite unused, about 20% Cu represents a much higher concentration than that necessary for hardening. It is clear that this indicates a debasement, which means, probably, that in Milesian colony on the shore of *Pontus Euxinus* was a shortage of silver in that period. It will be interesting to find out if this copper alloying was a current practice of the Pontic Greek colonies or it is only an accident.

It is worth to remark that the Inoteşti-Răcoasa coin is not only bronze but also it has a noticeable amount of silver. A lot of 14 such coins showed[10] that no one is from copper / bronze but all of them have a silver concentration higher than 15%. So, until a contrary example will be found one can suppose that Geto-Dacians never struck coins from copper / bronze but only silver-alloy more or less debased. This conclusion corresponds to Pârvan's supposition[11].

Finally, if Geto-Dacians used for coins silver ingots from Thasos, as it was supposed in ref. 1, the same purity as in the original Thasian tetradrahmas[12] would be expected. In fact, the Geto-Dacian coins are quite impure, not only that they have a high copper concentration but also much tin and also some arsenic and antimony. So, it is more logical to suppose that Geto-Dacians imported ore instead of silver ingots or they found some ore sources in their own territory. If the last allegation is true some silver slag should be discovered in the future in their old land.

Notes

1. M. Gramatopol, *Arta monedelor geto-dacice*, Ed. Meridiane, Bucuresti, 1997, p.24-25.
2. Ibidem, p.46.
3. C. Preda, *Monedele geto-dacilor*, Ed. Academiei RSR, Bucuresti, 1973.
4. Ibidem, p. 243-245.
5. Ibidem, p.246.
6. Ibidem, p.36.
7. V. Cojocaru, N. Marginean, C. Rusu, Balkan Physics, in press.
8. D.R. Sear, *Greek coins and their values*, Seaby Publications Ltd., London 1978, p. 166.

9. C. Preda, *Istoria monedei în Dacia preromanã*, Ed. Enciclopedicã, Bucureşti, 1998, p. 101. (Here the coin is considered as being issued by Amphipolis).
10. V. Cojocaru, Gh. Poenaru Bordea, private communication.
11. V. Pârvan, *Getica*, Cultura Nationalã, Bucuresti, 1926, p. 603.
12. V. Cojocaru, D. Serbanescu, J. of Radioanalytical and Nuclear Chemistry, **222** (1997)15.