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ARCHAEOMETRIC STUDY OF A BRONZE AGE SWORD DISCOVERED AT GIURGIU, ROMANIA

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Abstract. The compositional scheme of a Bronze Age sword, found near the town of Giurgiu in Romania has been determined by the method of particle-induced X-ray emission (PIXE). The elemental composition of the sword was compared with the composition of other swords from the same geographic area, the Danubian plane from Bulgaria, and Transylvania regions. Both the physical analyzes and the archeological considerations show that the sword from Giurgiu could be associated with the swords from Bulgaria, having compositional, stylistic, temporal and geographical similitudes.

Key words: Bronze age, archaeometrie, PIXE analysis.

1. INTRODUCTION

The compositional scheme of a Bronze Age sword, discovered at Giurgiu, has been determined using the method of particle-induced X ray emission (PIXE), at the Tandem accelerator of National Institute for Physics and Nuclear Engineering from Bucharest, Magurele, Romania. In order to have a comparative study of composition we have considered also the composition of 6 swords of the same type and from the same period from the south of Danube in Bulgaria, and some different copper-based alloy objects from Spalnaca deposit, in Transylvania, dated also in the Bronze Age [1].

2. EXPERIMENTAL METHOD

Three samples from the body of the sword: one sample from the tip of the sword and two samples from the hilt have been flatted and then irradiated with

protons of 3 MeV, in a irradiation chamber at the FN Tandem accelerator of National Institute for Physics and Nuclear Engineering from Magurele.

The beam current was kept below 10 nA to maintain a count rate of about 300 counts/s, which implies negligible dead-time and pile-up corrections. The characteristic X-rays of the analyzed samples have been detected with a HPGe (100 mm^2mm) detector with 160 eV energy resolution at 5.9 keV. The X rays spectra have been recorded on CANBERRA acquisition system. In the frame of the experimental conditions the following elements have been observed: As, Co, Cr, Cu, Fe, Ni, Pb, Sn and Zn.

The X ray spectra have been processed off line and then the concentrations of the elements have been calculated.

3. RESULTS AND DISCUSSIONS

The results of PIXE analysis on the samples of the sword from Giurgiu are shown in the Table 1. The values of the concentrations are given in %. The instrumental errors are generally less than 15%. We made corrections of the elemental concentrations so that the total value in the sample to be 100%.

Table 1

Composition of the three specimens of the sword from Giurgiu, %

Sample	As	Co	Cu	Fe	Ni	Sn	Zn
Sword tip	0.3530	0.0440	88.2	0.0838	0.3090	10.4	0.6173
Sword big hilt	0.0855	0.0171	85.5	0.3850	0.3250	13.7	0.0470
Sword small hilt	0.2860	0.0224	89.5	0.4740	0.3400	9.35	0.0313

The composition of the 3 samples form the Giurgiu has been compared with the composition from similar 6 swords from Danubian regions from Bulgaria [2] and some different archaeological objects from the Bronze Age Spalnaca deposit, Transylvania [3].

We present further, in the Table 2 the results of the analyzes published by E. N. Černyh, for several of the swords with tongue at the hilt from Bulgaria [2].

1: Vărbica II (10945), category X
2: Orjahovo (9431), category X
3: Pavelsko (9220), category X
4: Bajkal (9432, analysis of the hilt; 9433, analysis of the blade), category X
5: Kričim (9210), category X
6: Vasil Levski (10892), category XI.

For all specimens included in Table 2, the copper is the dominant element.

Table 2

Composition of swords from Bulgaria [2]

	Sn	Pb	Zn	Bi	Ag	Sb	As	Fe	Ni	Co	Mn	Au
1	10	0.2	0.01	0.05	0.06	0.06	0.07	0.007	0.05	0.02	–	< 0.001
2	10	0.14	0.01	0.01	0.06	0.04	0.6	0.05	0.4	0.04	–	≈ 0.01
3	12	0.3	?	0.005	0.06	0.25	0.3	0.003	0.25	0.03	–	≈ 0.003
4	7	0.12	0.006	0.003	0.05	0.3	0.8	0.01	0.3	0.012	–	< 0.01
	10	0.3	?	0.005	0.03	0.3	0.9	?	0.35	0.02	–	> 0.001
5	7	0.05	–	0.0015	0.01	0.04	0.25	0.005	0.05	0.015	< 0.01	> 0.003
6	5	0.09	–	–	0.0001	0.015	0.1	0.012	0.035	0.003	–	–

In Table 3 are shown the elemental composition for all considered objects: the sword from Giurgiu, the swords from Bulgaria and different bronze objects from Transylvanian deposit at Spalnaca. Ratios of concentrations are considered for interpretation of the results to avoid the errors in the absolute calculations of the concentrations. It has been reported value zero in the cases the value of concentrations has been under the limit of detection.

Table 3

Ratios of concentrations, in bronze objects of the same type: the specimens of the sword from Giurgiu, by PIXE, the Bulgarian swords, by atomic spectroscopy, bronze objects from Spalanaca, Transylvania, by neutron activation analysis

Sample	As/Cu × 10^6	Co/Cu × 10^6	Fe/Cu × 10^6	Ni/Cu × 10^6	Sn/Cu × 10^6	Zn/Cu × 10^6
Giurgiu1	4000	500	950	3500	118000	7000
Giurgiu2	1000	200	4500	3800	160000	550
Giurgiu3	3200	250	5300	3800	104500	350
Bulgaria1	779	223	78	556	111305	111
Bulgaria2	6750	450	562	4500	112500	112
Bulgaria3	3430	343	34.3	2860	137300	0
Bulgaria4	8710	131	109	3265	76190	65
Bulgaria5	10140	225	0	3945	112700	0
Bulgaria6	2700	162	53.9	539	75530	0
Bulgaria7	1055	32	1270	369.4	52780	0
Spalnaca1	6848	0	0	0	188600	0
Spalnaca2	1193	0	79700	0	3250	0
Spalnaca3	16600	0	44400	0	0	0
Spalnaca4	12300	0	50900	0	0	0
Spalnaca5	13100	0	0	0	81600	0
Spalnaca6	22100	0	0	0	0	0
Spalnaca7	15900	0	135000	0	0	0
Spalnaca8	23000	0	32900	0	0	0

(continues)

Table 3 (continued)

Sample	As/Cu × 10^6	Co/Cu × 10^6	Fe/Cu × 10^6	Ni/Cu × 10^6	Sn/Cu × 10^6	Zn/Cu × 10^6
Spalnaca9	67400	0	98100	0	0	0
Spalnaca10	2090	0	0	0	0	0
Spalnaca11	7900	0	21600	0	0	0
Spalnaca12	7180	0	0	0	203100	0
Spalnaca13	15600	0	12600	0	1770	0
Spalnaca14	10360	0	334000	0	0	0
Spalnaca15	2408	0	0	0	0	0
Spalnaca16	13170	0	7970	0	0	0
Spalnaca17	7460	0	49700	0	0	0
Spalnaca18	2900	0	0	0	253400	0
Spalnaca19	3400	0	0	0	0	0
Spalnaca20	7160	0	0	0	0	0
Spalnaca21	44900	0	0	0	0	0
Spalnaca22	19200	0	0	0	0	0
Spalnaca23	32600	0	19800	0	4200	0
Spalnaca24	8900	0	0	0	0	0

Fig. 1 presents the diagram of ratios of concentrations: Sn/Cu versus As/Sn for the analyzed samples in the present study, and also for Bulgarian and Transylvanian objects, analyzed by atomic spectroscopy and respectively neutron activation analysis.

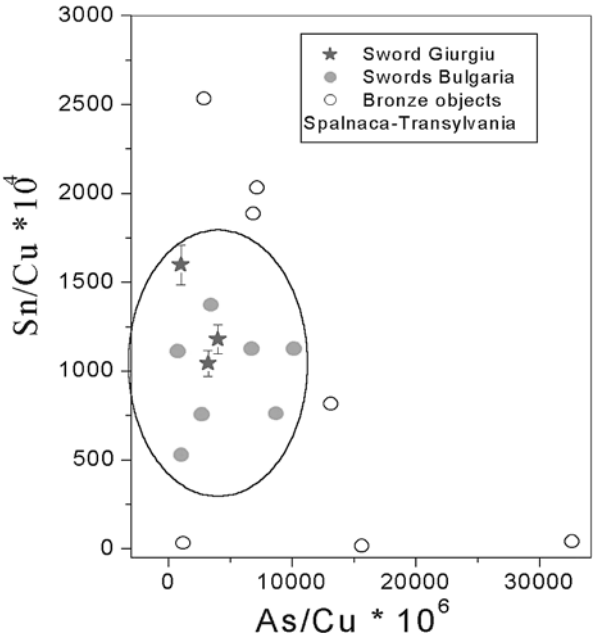

Fig. 1 – Ratios of concentrations Sn/Cu versus As/Cu.

One could remark that the specimens of the sword from Giurgiu have a relative closer composition to the Bulgarian ones, especially for the elements: As, Cu, and Sn. The objects from Transylvania are situated relatively outside the cluster formed by the objects from Giurgiu and Bulgaria.

4. ARCHAEOLOGICAL CONSIDERATIONS

The sword presented in Fig. 2 is in a good state of conservation, being preserved almost entirely, and has the following dimensions: total length 39.5 cm, width at base 5.3 cm, width at the tip 2.9 cm, thickness at base 0.9 cm, thickness toward the tip 0.6 cm, length of the hilt with missing terminal part 9 cm, length of

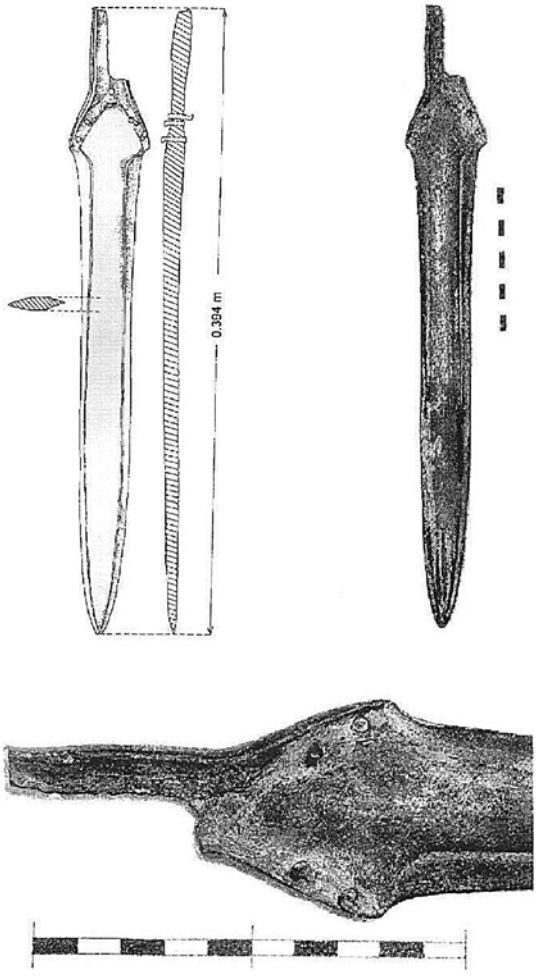

Fig. 2 – Schematic drawing of the Reutlingen type sword found at Giurgiu.

the blade 30.5 cm. On the blade of the sword one can observe, on both faces, channels situated at approximately 0.4 cm from the two edges, as shown in Fig. 2. The blade has a biconvex profile. In the zone of the hilt there are five orifices for the rivets of binding of the hilt and also three rivets still left in the orifices. It is possible that in the missing part of the hilt three more orifices should have existed for the binding of the hilt. The alloy is of a very good quality having a green-dark grey patina.

The sword belongs to the Reutlingen type defined by P. Schauer [4] and described, with a special view to artifacts attested on Romanian territory, by T. Bader [5]. Choosing as a criterion of classification in the first place the number of fixation orifices from the blade and the hilt, but also the shape of the nervure of the blade, the latter author distinguished several variants [6]. Due to the fact that the sword under consideration presents a large median nervure and which is slightly rounded, we think that it is most resembling to two fragmentary pieces belonging to the deposit of Drajna de Jos, district of Prahova, Romania, catalogued by T. Bader with numbers 188 and 189 [7] and included in the Gușterița variant of the Reutlingen type. Moreover, the Giurgiu sword has much smaller dimensions, so that it could be rather considered a "short sword" (Kurzschwert) [8].

Artifacts of the Reutlingen type have been discovered over a very large area from the south of Scandinavia to Peloponesos and from the Rhine basin to the Black Sea, [9] and recently discoveries have been reported even in Anatolia [10]. However, the spreading is not uniform, existing some regions of concentration and others represented by much fewer discoveries. Among the latter, one counts the extra-Carpathian zone in Romania and the territory of Bulgaria and Greece [11].

It is however interesting that, in the Balkan area, the discoveries are concentrated mainly in the southern part of Romania, Wallachia, and in the north of Bulgaria, some of them just on the Danube line. In addition to the two pieces from Drajna de Jos, on the Romanian territory one finds specimens belonging to some variants in the ensemble of the Reutlingen type: Bălcești and Mateești (district of Vâlcea), Techirghiol (district of Constanța). On the territory of Bulgaria there are 10 discoveries of swords with tongues at the hilt, of which 7 to the north and 3 to the south of the Balkans [12]. The 7 specimens discovered on the territory between the Danube and the Balkans arise from Orjahovo (Orehovo) [13], Vărbica (deposit II) [14], Bajkal [15], Kruševo [16], Balkanski [17] and Vasil Levski [18] to which one adds the specimen of smaller dimensions from the Razgrad Museum (inventory No. 117), discovered in the neighborhood [19]. Among these specimens the first two belong to the Reutlingen type.

The artifact from Giurgiu has very close analogues (except, of course, for the dimensions) just in the sword from Orjahovo and in the fragmentary artifact from Vărbica, both cited as belonging to the Gușterița variant by T. Bader [20]. These two specimens have been ascribed in the early horizon of the culture of the fields of urns (von Brunn stages I–III) [21] by B. Hänsel [22], respectively in the

subgroup I defined by I. Panayotov (the second horizon of deposits from Bulgaria: XIIIth century B.C.) [23]. On the other hand, T. Bader dates, as a function of the synchronisms revealed by the various deposits, the great majority of the specimens belonging to the Reutlingen type discovered on the territory of Romania in the Cincu-Suseni period (HaA1, circa XIIth century B.C.), but ascribes three or four deposits (among which is also the one from Drajna de Jos) for the slightly earlier period Uriu-Domănești (Bronze D, circa XIIIth century B.C. [24]). Consequently, taking into account the analogies proposed by us with the specimens from Drajna de Jos, Orjahovo and Vărbica II, we favor a dating of the short sword from Giurgiu in the XIIIth century B.C., probably towards the end of the century; a date around 1200 B.C. is very likely.

5. CONCLUSIONS

We could express the idea of an association of the sword from Giurgiu with the Bulgarian swords, having a close composition and also similitude in typology, geographic area and dating. Taking into account the analogies proposed by us with the Bulgarian specimens, especially those of Drajna de Jos, Orjahovo and Vărbica II, we favor a dating of the short sword from Giurgiu in the XIIIth century B.C., probably towards the end of that century, around 1200 B.C.

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