Compositional analyses of a Reutlingen 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), at the Tandem accelerator of National Institute for Physics and Nuclear Engineering from Bucharest, Magurele, Romania. The results of the analyses and the comparison with the composition of other swords from the same geographic area, the Danubian plane from Bulgaria and Transylvania regions, show that the sword from Giurgiu could be relatively associated with the swords from Bulgaria, having also the same stylistic, temporal and geographical similitude.

1 Introduction

The compositional scheme of a Bronze Age sword, Fig. 1, recently discovered near Giurgiu, a town situated in the south of Romania on the Danube, has been studied 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 Spălnaca deposit, in Transylvania, dated also in the Bronze Age.

2 Archaeological considerations

2.1 Site of discovery of the sword

The sword has been discovered by Ion Cercel in 1981 in the Mihai Eminescu street of the city of Giurgiu, Romania, in the course of diggings related to the installation of underground electric cables. Since then the sword has been kept by Ion Cercel, who presently is retired, in his house from the Oinacu commune, district of Giurgiu, in southern Romania. In 1999, by a happy concurrence of events, this interesting artifact became available to us, and we take this opportunity to thank Ion Cercel who has been kind to render us the sword for study and analyses.

According to the author of the finding, the artifact has been found at a depth of approximately 1.1 m, no other bronze objects existing in its vicinity. Foundations of buildings from the late medieval period were known to exist in the area, but it seems that no such archaeological remains existed in the specific place where the sword has been found. It seems that the site where the sword has been discovered lies outside the medieval city, buildings being erected there only in the period after 1821.

2.2 Description of the sword

The sword 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 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. 1. 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 and described, with a special view to artifacts attested on Romanian territory, by T. Bader. 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. 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 Drăjna de Jos, district of Prahova, Romania, catalogued by T. Bader with numbers 188 and 189 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” (Kurzschnitt).

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, and recently discoveries have been reported even in Anatolia. 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.

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 Drăjna 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. The 7 specimens discovered on the territory between the Danube and the Balkans arise from Orjahovo (Orehovo), Vărbica (deposit II), Bajkal, Kruševo, Balkanski and Vasil Levski, to which one adds the specimen of smaller dimensions from the Raz-
grad Museum (inventory No. 117), discovered in the neighborhood. 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 Vârbića, both cited as belonging to the Guşteriţa variant by T. Bader. These two specimens have been ascribed in the early horizon of the culture of the fields of urns (von Brunn stages I-III) by B. Hänself, respectively in the subgroup I defined by I. Panayotov (the second horizon of deposits from Bulgaria: XIII\textsuperscript{th} century B.C.). 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 XII\textsuperscript{th} 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-Domânesti (Bronze D, circa XIII\textsuperscript{th} century B.C.) Consequently, taking into account the analogies proposed by us with the specimens from Drajna de Jos, Orjahovo and Vârbića II, we favor a dating of the short sword from Giurgiu in the XIII\textsuperscript{th} century B.C., probably towards the end of the century; a date around 1200 B.C. is very likely.

3 Experimental

3 samples from the body of the sword: 1 sample from the tip of the sword and 2 samples from the hilt have been flatted and irradiated with protons of 3 MeV, in a irradiation chamber at the FN Tandem accelerator of National Institute for Physics and Nuclear Engineering from Bucharest, Magurele.

The beam current was kept below 10 nA to maintain a count rate of about 250 counts/s, which implies negligible dead-time and pile-up corrections. X-rays were detected with a HPGe (100 mm\textsuperscript{2}mm) detector with 160 eV energy resolution at 5.9 keV. The X rays spectra have been recorded on a PC with a MCA interface. In the frame of the experimental conditions the following elements have been observed: As, Co, Cr, Cu, Fe, Ni, Pb, Sn and Zn.
Table 1: Composition of the sword from Giurgiu, by PIXE

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

4 Results and Discussions

The results of PIXE analysis on the samples from 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 %.

The composition of the 3 samples from Giurgiu has been compared with the composition from similar 6 swords from Danubian regions from Bulgaria [22] and some different archaeological objects from the Bronze Age Șpălnaca deposit, Transylvania [23].

We present further, in the Table 2 the results of the analyses published by E. N. Černyh, for several of the swords with tongue at the hilt from Bulgaria. [22]

1: Vârbica 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, %

| 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|
| 5  | 0.3| ?  | 0.005| 0.03| 0.3 | 0.9 | ?  | 0.35| 0.02| -   | >0.001|
| 6  | 7  | 0.05| -  | 0.0015| 0.01| 0.04| 0.25| 0.005| 0.05| 0.015| <0.01| >0.003|

In Table 3 are shown the elemental composition for all considered objects: the Giurgiu sword, the swords from Bulgaria and different bronze objects from Transylvanian deposit at Șapânca. 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.

Fig. 2 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.

One could remark that the sword from Giurgiu has 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.
Table 3: Ratios of concentrations, in bronze objects of the same type: Giurgiu sword samples, by PIXE, the Bulgarian swords, by atomic spectroscopy, bronze objects from Splanaca, Transylvania, by neutron activation

| Sample       | As/Cu x 10^6 | Co/Cu x 10^6 | Fe/Cu x 10^6 | Ni/Cu x 10^6 | Sn/Cu x 10^6 | Zn/Cu x 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            |
| Splanaca1    | 6848         | 0            | 0            | 0            | 188600       | 0            |
| Splanaca2    | 1193         | 0            | 79700        | 0            | 3250         | 0            |
| Splanaca3    | 16600        | 0            | 44400        | 0            | 0            | 0            |
| Splanaca4    | 12300        | 0            | 50900        | 0            | 0            | 0            |
| Splanaca5    | 13100        | 0            | 0            | 0            | 81600        | 0            |
| Splanaca6    | 22100        | 0            | 0            | 0            | 0            | 0            |
| Splanaca7    | 15900        | 0            | 135000       | 0            | 0            | 0            |
| Splanaca8    | 23000        | 0            | 32900        | 0            | 0            | 0            |
| Splanaca9    | 67400        | 0            | 98100        | 0            | 0            | 0            |
| Splanaca10   | 2090         | 0            | 0            | 0            | 0            | 0            |
| Splanaca11   | 7900         | 0            | 21600        | 0            | 0            | 0            |
| Splanaca12   | 7180         | 0            | 0            | 203100       | 0            | 0            |
| Splanaca13   | 15600        | 0            | 12600        | 0            | 1770         | 0            |
| Splanaca14   | 10360        | 0            | 334000       | 0            | 0            | 0            |
| Splanaca15   | 2408         | 0            | 0            | 0            | 0            | 0            |
| Splanaca16   | 13170        | 0            | 7970         | 0            | 0            | 0            |
| Splanaca17   | 7460         | 0            | 49700        | 0            | 0            | 0            |
| Splanaca18   | 2900         | 0            | 0            | 253400       | 0            | 0            |
| Splanaca19   | 3400         | 0            | 0            | 0            | 0            | 0            |
| Splanaca20   | 7160         | 0            | 0            | 0            | 0            | 0            |
| Splanaca21   | 44900        | 0            | 0            | 0            | 0            | 0            |
| Splanaca22   | 19200        | 0            | 0            | 0            | 0            | 0            |
| Splanaca23   | 32600        | 0            | 19800        | 0            | 4200         | 0            |
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 Vârbica II, we favor a dating of the short sword from Giurgiu in the XIII\textsuperscript{th} century B.C., probably towards the end of that century, around 1200 B.C.
References

[1] P. Schauer, *Die Schwerter in Süddeutschland, Österreich und in der Schweiz*, Stuttgart, 1971 (PBF, IV, 2), p. 132 and following, who distinguished this type in the frame of the "normal type", Naue II, Sprockhoff II a, Nenzingen.

[2] T. Bader, *Die Schwerter in Rumanien*, Stuttgart, 1991 (PBF, IV, 8), p. 86.

[3] It is difficult to realize a correspondence between the previous classification proposed by Alexandrina D. Alexandrescu, *Dacia N.S.* s10, 1966, pp. 117-189 (especially p. 133 and following) and that of T. Bader, because the Reutlingen type has not been identified in the frame of the ensemble of the "normal type" at the moment of the publication of the 1966 study.

[4] No. 188: I. Andrieșescu, *Nouvelle contribute sur l’âge du bronze en Roumanie. Le dépôt de bronzes de Drajna de Jos et l’épée de Bucium*, Dacia, 2, 1925, pp. 349-350 and plate I/1, Alexandrescu, op. cit., p. 178, Cat. No. 104 and fig. XXII/3; No. 189: Andrieșescu, loc. cit. and plate I/3 (fig. 2), Alexandrescu, op. cit., p. 177, Cat. No. 100 and fig. XV/1. Out of both artifacts, only about half (or less than half) of the blades has been conserved, the tongue, and for the piece No. 188 almost the entire hilt. Alexandrescu assumed ("vermutlich") that No. 101 of his catalogue belongs to the same artifact with the fragment No. 100, an assumption not retained by Bader.

[5] As regards the dimensions, but not entirely as type, our sword can be compared to the item discovered around Razgrad (Museum of Razgrad, inventory No. 117), published by I. Panayotov, T. Ivanov, *Dve bronzovi orășija ot Razgradki okrąg*, Arheologija, 1979, 1, pp. 29-33, No. 2 and figs. 1/b, 2/b. The conserved length of this sword (of the Nenzingen type, Nane II, but more evolved), out of which only the hilt is missing, is 48.3 cm.

[6] T. Bader, op. cit., p. 100.

[7] A. Müller-Karpe, *Anatolische Bronzenschwerter und Südosteuropa*, in C. Dobiat, editor, *Festschrift für Otto-Herman Frey zum 65. Geburtstag*, Marburger Studien zur
Among the three artifacts, one (fig. 2/4) arises from the region of Bodrum (Caria) and shows analogies to the Bucium variant (Bader, Cat. No. 240), another, from the museum of Burdur, is only mentioned as being closest to the first, and a third (fig. 5/1) has been discovered in the Bolu region (at half distance between Istanbul and Ankara), and is likened by the author, among other, to Bader, Cat. No. 239 (Mateesti variant).

[8] T. Bader, op. cit., p. 100: "Vereinzeilt sind die Exemplare aus der Dobrudscha (Techirghiol), aus Muntenien (Drajna de Jos), Oltenien (Bălceşti, Mateesti) und aus der Moldau (Ilişi, Bucium) bekannt. Selten und nicht bedeutend sind die Funde des Schwerttypus Reutlingen aus Bulgarien (Orechovo, Vărbica, Smirov dol) und aus dem ägäischen Raum (Mykene-Akropolis)". The provenance of the sword from Tărgovişte-Valea Voievozilor (Bader, Cat. No. 166, close to the Ighiu variant) is uncertain; cf. Al. Vulpe, Dacia N.S. 22, 1978, p. 372.

[9] I. Panayotov, Thracija, 5, 1980, p. 183 and map 2 at p. 180. We have added to the two pieces from the south of Bulgaria (Pavelsko, okr. Smoljan and Kričim, okr. Plovdiv) the item from Smirnov dol (okr. Pernic): M. Čohadžev, Studia Praehistorica 5-6, 1981, p. 145 and following and fig. 2; V. Ljubenova, in Dritter Internationaler Thrakologischer Kongress Wien-Sofia II, Sofia, 1984, p. 150, fig. 2. The latter item, published after the study of Panayotov, is ascribed by Bader, op. cit. p. 96, also to the variant Guşteriţa.

[10] B. Hánsel, PZ 45, 1970, pp. 33-34 and fig. 2/2; E. N. Černyh, Gornoe delo i metalurgija v drevnejšej Bolgarii, Sofia, 1978, p. 237 and figs. 64/5; Panayotov, op. cit. p. 181 and fig. 3/2.

[11] B. Hánsel, op. cit., pp. 35-36; E. N. Černih, op. cit., p. 237 and fig. 65/2; I. Panayotov, op. cit., pp. 181-182 and fig. 3/4.

[12] B. Hánsel, op. cit., pp. 36-37 and fig. 2/3; E. N. Černih, op. cit., p. 237 and fig. 65/4; I. Panayotov, op. cit., p. 183 and fig. 4/1.
[13] A. Milčev and N. Kovačev, *Neonarodvani pametnici ot Sevlievko*, Arheologija, 1967, p. 40, fig. 1; I. Panayotov, op. cit., p. 183.

[14] D. Ivanov, *Novi materiali ot bronzovata i željaznata epoha, sährianavani v Rusenskiia Muzej*, Godišnik na muzeite ot Severna Bâlgaria 4, 1978, pp. 5-9 and figs. 2/a-b; I. Panayotov, op. cit., p. 183 and fig. 4/3.

[15] B. Hänsel, op. cit., pp. 37-38 and fig. 2/4; I. Panayotov, op. cit., p. 183 and fig. 4/2.

[16] I. Panayotov, T. Ivanov, op. cit., pp. 29-30 and figs. 1/b, 2/b.

[17] T. Bader, op. cit., p. 96.

[18] W. A. von Brunn, *Mitteldeutsche Hortfunde der jüngeren Bronzezeit*, Berlin, 1968.

[19] B. Hänsel, op. cit., p. 34 and note 19, respectively p. 35, where the fragment of sword from Vârbica is dated in conjunction with other constituent pieces of the deposit which present analogies with types from Güsterita: ”die übrigen Gegenstände des Hortfundes legen seine Datierung in die frühe Urnenfelderzeit, d.h. in die v. Brunnschen Stufen I und II mit hinlänglicher Sicherheit fest”. Cf. p. 36: ”beide [the items from Orjahovo and Vârbica (authors’ note)] vertreten den gleichen Horizont bzw. die <<Typenfront>>, die in Griechenland mit dem Ende der mykenischen Zivilisation im späten 13. Jahrhundert verknüpft ist”.

[20] I. Panayotov, op. cit., pp. 182 and 185. The typology of the author is somewhat unclear. Cf. p. 181 (the items of swords with tongues at their hilt from the Bulgarian territory ”can be related to two subgroups with no sharp differences between them”), pp. 181-182 (where included in the first subgroup are the pieces from Pavelsko, Orjahovo, Kričim and Vârbica II), p. 182 (”the link between the first and the second subgroup is achieved by the sword from the village of Bajkal”, close to which are the items from Kruševso, Gradinite-Vasil Levski, Balkanski and the museum of Razgrad), p. 185 (”in a purely formal respect we differentiate three subtypes. The first one we mark as Pavelsko type. [...] This subtype is synchronic to the Orjahovo subtype to which we also relate the fragments from the blade and a trapezum-like plate on the
the hilt. Here we also include the swords from the village of Balkanski, district of
Razgrad and the one from the village of Kruševo, whose definition is not absolutely
certain because of bad state of its upper part”). We add that E. N. Černyh, op. cit.,
p. 237, includes in the M-6 group (Nenzingen II), alongside the items from Orjahovo
and Vârbica, also the sword from Vasil Levski.

[21] T. Bader, op. cit., pp. 99-100.

[22] E. N. Černyh, op. cit., pp. 357 and following; table with the results of spectrographic
analyses. For the definition of the chemical categories X-XII see pp. 178-179.

[23] A. Olariu, *Studies of Archaeometry by Atomic and Nuclear Methods*, Ph. D. Thesis,
University of Bucharest, 1998.
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