CONSIDERATIONS ON THE XRF ANALYSES ON SELECTED PREHISTORIC GOLD OBJECTS FROM THE COLLECTIONS OF THE NATIONAL HISTORY MUSEUM OF ROMANIA

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Abstract: Several prehistoric gold objects from the collections of the National History Museum of Romania were analysed using X-Ray Fluorescence (XRF) method. All items are dated to the Bronze Age and Early Iron Age and come from the intra-Carpathian area of Romania. The composition of the analysed items is discussed in connection to their typology, chronology, geographical distribution, and association in treasures.

Keywords: Bronze Age – Early Iron Age, gold objects, gold composition, XRF analysis.

INTRODUCTION

Several prehistoric gold finds belonging to the collections of the National History Museum of Romania were analysed using X-Ray Fluorescence (XRF) method, in the frame of ARCHAEOMET[1] project (2005–2008). In an attempt to ensure a certain degree of cohesion to the research and, at the same time, to allow a meaningful comparison between finds, this set of items was selected taking into consideration their distribution map, chronological frame and typological characteristics. The finds come from the intra-Carpathian area – forming two more or less defined clusters, one in the NW part and another one in the central part of Romania, in Transylvania (fig. 1) –, and are dated to the Bronze Age and Early Iron Age. As it was considered of interest to determine whether there are any trends in the use of gold during this time span, the items were selected mainly from well-known categories, with many representatives in this area (ornamental discs, hair-rings, bracelets, beads), though without neglecting rarer or even unique items (for example, the gold vessel from Biia or the gold cones from Pecica).

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[1] For details on the project, see: www.arheomet.ro.

SCIVA, tomul 67, nr. 1–2, Bucureşti, 2016, p. 53–83

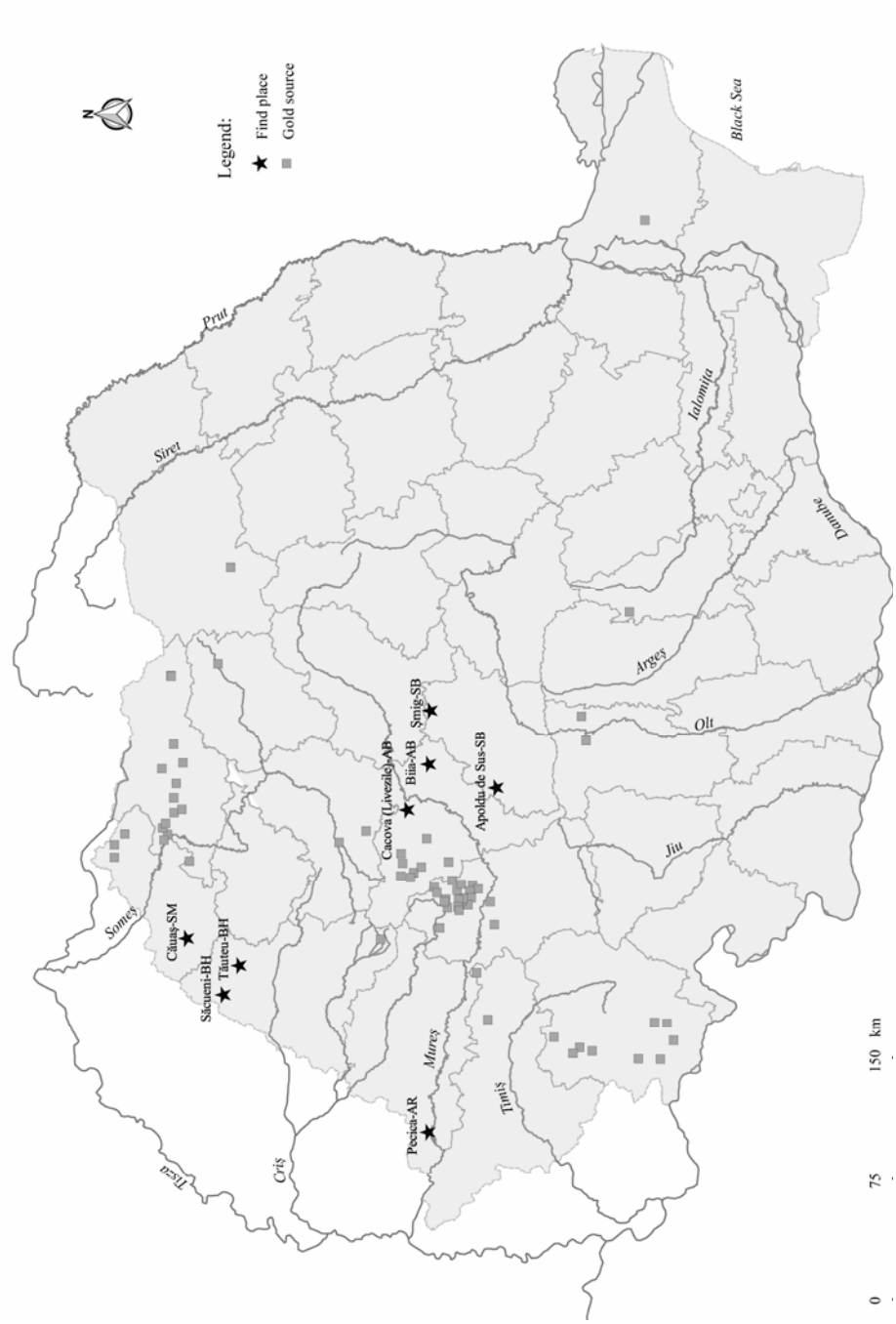

Fig. 1. Distribution map of the treasures and hoards mentioned in the text.

CONTEXT AND ASSOCIATION

An important aspect which should be emphasised is that the vast majority of the Bronze Age and Early Iron Age gold treasures and single finds are characterised either by incomplete and/or uncertain information regarding their context, integrity, and association of items, or even, in the worst case scenario, by the total lack of such information. Unfortunately, the items forming the subject of the present article do not represent an exception to this rule, as they were found during agricultural activities or other kind of land exploitation, and later recovered by different institutions, or purchased directly on the market, with no supplementary or plausible information. The attempts of gathering or correcting existing data are further complicated by the fact that many of these objects represent old discoveries, being found during the second half of the 19th century and the first half of the 20th century. Thus, the gold vessel from Biia (cat. no. 2) was found during gravel exploitation[2]; Căuaş (cat. no. 4)[3], Pecica (cat. no. 5)[4] and Şmig (cat. no. 7)[5] treasures were found during agricultural activities; Săcueni treasure (cat. no. 6) was found in a vineyard[6]; the Tăuteu hoard (cat. no. 8) was found on a pasture[7]; the Cacova treasure (cat. no. 3) was acquired from an inhabitant of the Aiud area, no additional information being available[8]. As a result, the integrity of these finds, the association of items into treasures and their original preservation state are far from certain, doubts being expressed, along time, in connection with these aspects. For example, rumours circulated that the gold vessel from Biia was found together with other gold objects[9]; also, information existed that some of the bracelets from Căuaş were cut after discovery[10], only two entire items and four fragments joining the collections of the Numismatic Cabinet of the Romanian Academy[11]; in the case of the Săcueni treasure, the information is that there were originally eight discs[12]; some doubts exist regarding the complete recovery of the hoard from Tăuteu[13]; for the Şmig treasure the question is whether there was one or more treasures. To all these, the supplementary difficulty of being shared between three museums, and the loss in the meantime of some of the items, should be added[14].

Based on the available information, it can be considered that the majority of the analysed objects come from treasures, with the notable (but, as mentioned before,

[2] Popescu 1956, p. 232, footnote 3; Schroller 1925, p. 114; Soroceanu 2008, p. 228, footnote 219.
[3] Bader 1978, p. 122, cat. no. 20; Kacsó 2014, p. 105–106.
[4] Dumitrescu 1937–1940, p. 127.
[5] Luca, Pinter, Georgescu 2003, p. 216.
[6] Bader 1978, p. 128, cat. no. 79; Nestor 1932, p. 120.
[7] Petrescu-Dîmboviţa 1961, p. 81.
[8] Popescu 1956, p. 203.
[9] Schroller 1925, p. 114; Mozsolics 1965–1966, p. 48–49, fig. 12, 19/4–6, 20–21.
[10] Bader 1978, p. 122, cat. no. 20.
[11] Iliescu 1968, p. 87.
[12] Bader 1978, p. 128, cat. no. 79; Nestor 1932, p. 120; Popescu D., Popescu V. 1955, p. 869.
[13] Dumitrescu 1935–1936, p. 225.
[14] Mozsolics 1965–1966, p. 52–53; Rusu 1972, p. 49–50, cat. no. 66; Burda 1979, p. 65.

a little doubtful) exception of the gold vessel from Biia (cat. no. 2). The associations of items, as they are known at present, vary greatly both in number and typological diversity. The number of items ranges from two objects, in the treasure from Apoldu de Sus, to more than 200, in the treasure from Şmig. There are treasures that could be described as homogenous: Apoldu de Sus (cat. no. 1) – two similar hair-rings, attached to each other; Căuaş (cat. no. 4) – bracelets with lozenge-shape cross-section; Săcueni (cat. no. 6) – four ornamental discs; Tăuteu (cat. no. 8) – five notched rings and two fragments from similar items. The treasure from Pecica (cat. no. 5) contains two types of objects, one disc and 48 gold sheet cones. The treasure from Şmig (cat. no. 7) is the most heterogeneous, containing discs, hair-rings, earrings, one bracelet, beads, and an ingot. The treasure from Cacova (cat. no. 3) could be, eventually, considered as situated somewhere between these two categories, since it contains five hair-rings, but of different types.

CHRONOLOGY AND TYPOLOGY

As already mentioned, from a chronological point of view, the finds belong to the Bronze Age and Early Iron Age, but difficulties usually appeared when attempting to specify a more precise chronological framework.

The treasures from Apoldu de Sus and Cacova, containing spiral rings and hair-rings with round shape made of gold bar, can be dated to the end of the Early Bronze Age – Middle Bronze Age, or the Middle Bronze Age. The category of hair-rings is traditionally associated to this chronological framework, with possible survivals during Late Bronze Age – Early Iron Age. They were attributed to these periods based on typological criteria (constructed mainly on their shape) and association with other categories of items in treasures and funerary contexts[15]. The treasure containing ornamental discs from Săcueni (based on the typological characteristics of the items[16]) and the treasure from Pecica (based on the presence of the ornamental disc and the characteristics of the small clay vessel which contained the gold items[17]) were also assigned to the Middle Bronze Age.

The treasure from Căuaş contains bracelets with lozenge-shape cross-section, a type characteristic for the Late Bronze Age – Early Iron Age[18].

The notched rings from Tăuteu can be dated to the Hallstatt B1, supported by their association in the hoard with bronze objects characteristic for this phase of the Early Iron Age[19].

[15] Popescu 1956, p. 200–205; Popescu 1962, p. 403–404; Rusu 1972, p. 41–42; Zaharia 1959, p. 103–134.

[16] Popescu 1956, p. 209.

[17] Dumitrescu 1937–1940, p. 127–131.

[18] Rusu 1972, p. 34.

[19] Müller-Karpe 1959, p. 127; Petrescu-Dîmboviţa 1961, p. 106; Popescu 1962, p. 410–411; Rusu 1972, p. 36; Petrescu-Dîmboviţa 1977, p. 136–137.

The determination of the chronological frame for the Biia gold vessel is more difficult because of the combination between its unique shape and decoration, which contains motifs in use for a long time during Bronze Age and Early Iron Age. As a result, it was successively assigned to different chronological frameworks, from Middle Bronze Age to Late Iron Age[20]. The newest and most detailed research on this artefact concludes with its dating to Hallstatt B[21].

The treasure from Şmig was dated to the Late Bronze Age – Early Iron Age (Bronze D – Hallstatt A)[22], although attention was drawn to the fact that the association of these items rather indicates their accumulation in time[23]. More recently, the research conducted on fragments of the bronze vessel that contained the treasure led to a change of the chronological framework as late as Hallstatt C[24], for the moment of its deposition. Of course, from the point of view of the present discussion it would be much more useful to determine the moment when the respective gold items were made, an attempt that can rely only on typological criteria. The two hair-rings of oval-oblong shape (heart-shape), made of gold bar, from Şmig belong to a type which is associated mainly to the Middle Bronze Age, although, in this case, they were considered later, based on the general dating of the treasure to the Late Bronze Age – Early Iron Age[25]. Also, the decorated discs are a very familiar presence during the Middle Bronze Age[26]. The bracelet made of lozenge-shape cross-section gold bar with open tapered ends was dated to the Late Bronze Age – Early Iron Age, as well as the two rings (earrings?) made of torsion bar, and, less clearly, due to the long period of use for this category of jewellery and lack of typological expressivity, the round gold beads[27].

COMPOSITIONAL ANALYSIS

The non-destructive analysis of the items was performed using the XRF technique at the "Horia Hulubei" National Institute for Nuclear Physics and Engineering (IFIN–HH) Măgurele, Bucharest. The employed experimental set-up contains an ^{241}Am (10 mCi) annular radioactive source and a HPGe horizontal detector (energy resolution FWHM: 180 eV at 5.9 keV).

[20] Schroller 1925, p. 114; Mozsolics 1965–1966, p. 48–49; Popescu 1956, p. 232; Rusu 1972, p. 40, footnotes 12, 49; Burda 1979, p. 66, cat. no. 20; Soroceanu 2008, p. 235.

[21] Soroceanu 2008, p. 235.

[22] Rusu 1972, p. 49–50.

[23] Popescu 1956, p. 205.

[24] Soroceanu 2008, p. 209–211, 420–421, cat. no. 147, fig. 75B.

[25] Rusu 1972, p. 41. It may be suggestive that the two hair-rings from Şmig were presented by M. Rusu as the only items of this type known for Bronze D – Hallstatt A, all other similar finds being dated earlier.

[26] Popescu D., Popescu V. 1955, p. 881 (associated to the Wietenberg culture); Popescu 1956, p. 205.

[27] Rusu 1972, p. 34–36, 39–41.

A pure (99.9%) thick gold foil from the National Bank of Romania was used to evaluate the contribution of the γ-ray peaks emitted by the ^{241}Am source, particularly the 26.3 keV line, which overlaps with Sb K_α line. Several modern gold and silver coins and certified reference materials were used to calibrate the set-up.[28]

The spectra were acquired for 1500 seconds, to allow the detection of trace elements, such as antimony (Sb) and tin (Sn).

The XRF compositional results for each object are given in Table 1, being expressed in weight % and normalised to 100%. The overall relative uncertainties were less than 1% for gold, increased up to 10% for silver and copper, reaching 20% for trace elements.

The following items were subjected to compositional analysis: two hair-rings from Apoldu de Sus (cat. no. 1.1); the vessel from Biia (cat. no. 2.1); five hair-rings from Cacova (cat. nos. 3.1–5); two bracelets and four bracelet fragments from Căuaş (cat. nos. 4.1–6); the disc and two cones from Pecica (cat. nos. 5.1–2); three discs and one disc fragment from Săcueni (cat. nos. 6.1–4); two discs, one bracelet, two hair-rings, one bead, two rings (earrings) from Şmig (cat. nos. 7.1–6, 8–9); two notched rings from Tăuteu (cat. nos. 8.1–2) – a total number of 29 items. Some limitations in handling the artefacts occurring during the analysis must be mentioned. In the case of Apoldu de Sus treasure, the hair-rings are attached to each other (allegedly from prehistoric times – treasured as such), so the analysis took place on both rings simultaneously and the result represents, in reality, the mean value of metal composition for both items. Similarly, the 48 gold sheet cones from Pecica are exhibited on a thread, forming a sort of necklace, and could not be separated while conducting the analysis; because of this, cones 6 and 7[29] were simultaneously analysed, too.

The analysed objects belong to the following categories: hair-rings (nine items – eight measurements); rings (twisted/notched earrings/hair-rings) (four items); bracelets (seven items); discs (seven items); beads (one item); vessels (one item); cones (two items – one measurement).

DISCUSSION

The precious metals content of the analysed objects ranges between 72.44% and 94.85% for gold, and between 5.00% and 27.12% for silver. Copper was measured in all cases, being always present, with values between 0.06% and 1.15%. Tin was measured for 14 objects, and detected in 12 cases, with concentrations between 0.02% and 0.22%. In two cases, the XRF analysis also revealed traces of antimony: 0.02% Sb for the vessel from Biia and 0.01% Sb for one of the discs from Săcueni (cat. no. 6.2) – see Table 1.

[28] Constantinescu *et alii* 2010.

[29] The National History Museum of Romania, inv. nos. 11359–11360.

Table 1

Results of the XRF analyses (n.d. = not determined; n.m. = not measured)

Cat. no.	Name	Item	Au (%)	Ag (%)	Cu (%)	Sn (%)	Sb (%)
1.1	Apoldu de Sus	Hair-ring	75.41	24.50	0.09	n.d.	
2.1	Biia	Vessel	84.36	15.11	0.48	0.03	0.02
3.1	Cacova	Hair-ring	88.85	10.81	0.31	0.03	
3.2	Cacova	Hair-ring	74.50	25.40	0.10	n.m.	
3.3	Cacova	Hair-ring	80.06	19.71	0.23	n.m.	
3.4	Cacova	Hair-ring	78.82	21.11	0.07	n.m.	
3.5	Cacova	Hair-ring	76.38	23.20	0.42	n.m.	
4.1	Căuaş	Bracelet	87.05	12.41	0.46	0.09	
4.2	Căuaş	Bracelet	87.61	11.92	0.43	0.05	
4.3	Căuaş	Bracelet	86.03	13.41	0.48	0.08	
4.4	Căuaş	Bracelet	85.30	14.12	0.52	0.06	
4.5	Căuaş	Bracelet	85.20	14.20	0.54	0.06	
4.6	Căuaş	Bracelet	85.49	13.83	0.56	0.12	
5.1	Pecica	Cones	76.88	23.00	0.12	n.m.	
5.2	Pecica	Disc	73.54	26.31	0.15	n.m.	
6.1	Săcueni	Disc	74.43	25.51	0.06	n.d.	
6.2	Săcueni	Disc	73.21	25.66	0.99	0.12	0.01
6.3	Săcueni	Disc	74.99	23.64	1.15	0.22	
6.4	Săcueni	Disc	75.59	24.23	0.16	0.02	
7.1	Şmig	Disc	77.64	22.21	0.15	n.m.	
7.2	Şmig	Disc	80.22	19.21	0.57	n.m.	
7.3	Şmig	Bracelet	86.07	13.41	0.52	n.m.	
7.4	Şmig	Hair-ring	89.91	9.91	0.18	n.m.	
7.5	Şmig	Hair-ring	94.85	5.00	0.15	n.m.	
7.6	Şmig	Bead	72.44	27.12	0.44	n.m.	
7.8	Şmig	Ring (earring?)	80.78	18.22	1.00	n.m.	
7.9	Şmig	Ring (earring?)	83.85	15.12	1.03	n.m.	
8.1	Tăuteu	Ring (earring?)	85.14	13.91	0.95	n.m.	
8.2	Tăuteu	Ring (earring?)	92.97	6.00	1.01	0.02	

It can be noticed that, from the total number of 29 objects, 12 present a rather low percentage of gold (less than 80%), 15 present a percentage of gold between 80% and 90%, while two objects show values of gold content higher than 90%. The variation in the percentage of gold is consistent with the use of electrum, the natural alloy of gold and silver. The question rises if the metal was exploited from primary or secondary sources. The presence of tin could provide a possible answer, since previous analyses conducted for Europe on primary gold, as well as placer gold, showed that, while tin and platinum are lacking in gold from primary deposits, placer gold regularly contains tin and, in some cases, platinum, too. It was even argued, based on results of studies on a large number of gold finds from the Bronze Age to the beginning of our era, that placer gold was the only gold available, for, with very few exceptions, all finds contain certain amounts of tin[30]. From 29 analyses, in 14 cases the percentage of tin was measured, this trace element being present for 12 objects and not determined for

[30] Hartmann, Sangmeister 1972, p. 626.

two (the hair-rings from Apoldu de Sus and one of the discs from Săcueni (cat. no. 6.1) – see Table 1). If the above-mentioned observation is correct, it could be presumed that at least several of the analysed items were made of placer gold, with some degree of caution caused by the fact that, for more than half of the analysed objects tin was not measured.

The variation of gold content in the natural alloy could prove itself interesting in one regard: it was observed that the composition characteristic of a sample from a primary gold source would not necessarily be maintained in downstream placers because of the propensity of silver to leach out more rapidly than gold. In other words, the further the gold nugget has been carried from the place of its origin to the place where it is discovered, the smoother and more purified it is; the nearer it is found to its place of origin, the rougher and less pure it is[31]. On one hand, this observation taken alone would suggest that, at least for the objects with a lower percentage of gold, the use of a primary source is a possibility, especially in those cases where tin was either not determined (Apoldu de Sus) or not measured (Cacova; Pecica). On another hand, the frequency of the presence of tin when this trace element was looked for could simply indicate that gold was collected in some cases nearer to its place of origin, and at a greater distance downstream (and possibly in time too) in other cases.

The results of the XRF analyses are also presented as figures. Figures 2 and 3 are based on the gold-silver correlation in the analysed artefacts: the first graph from the perspective of the objects' association in finds, and the second from a typological perspective. Figure 4 presents the silver-copper correlation, in an attempt to investigate closer the connection between objects of the same type or from the same treasure.

It should be noticed that the sequence of the results as shown in figures 2 and 3 does not evidence any clearly defined compositional clusters. The two apparent gaps that could, at first, be interpreted as shaping three clusters reflect a difference of no more than 3% Au in both cases, but this clustering it is not sustained by the results shown in figure 4.

As already mentioned, one of the investigated aspects concerns the relation between the items' gold composition and their association in treasures. From this perspective, it can be noticed that the treasures show different degrees of homogeneity (fig. 2).

The treasure from Şmig is characterised by the highest variability: one of the two hair-rings has the highest percentage of gold (94.8%) and a bead the lowest (72.4%) from the whole analysed group. The rest of the objects are literally scattered all over the graph. A totally opposite image is offered by the treasure from Căuaş, which is the most homogenous one: the bracelets and fragments of bracelets have a percentage of gold between 85.20 % and 87.61%. Also, the percentage of copper is very similar for all the items (0.43%...0.56%). It is interesting to notice that, in the case of these two treasures, the degree of

[31] Cooke *et alii* 1999, p. 102.

homogeneity in composition seems to match the degree of typological variation of the items belonging to them.

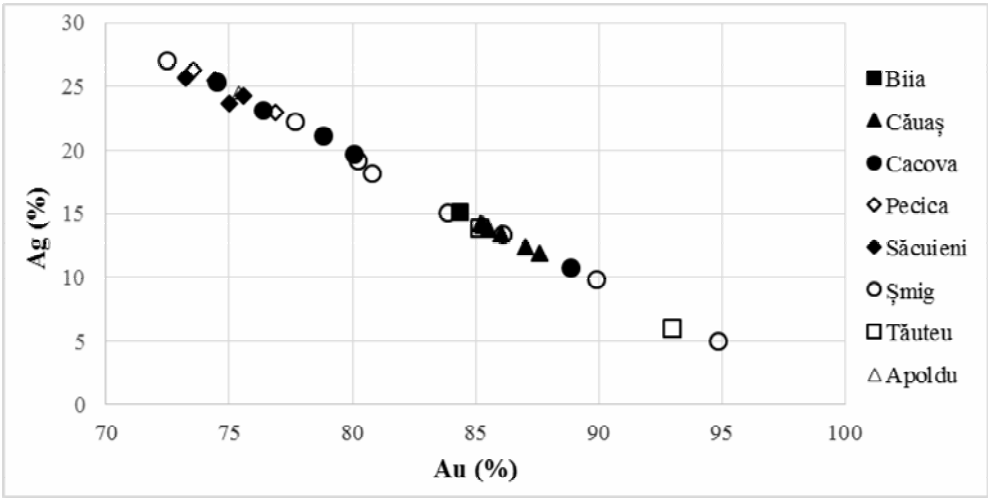

Fig. 2. Gold and silver contents of the analysed items in correlation with their association in treasures.

The four discs from Săcueni present close values for the percentage of gold (73.21%...75.59%), but some questions could arise from the fact that one of them has a tin-free composition, and another one has traces of antimony. The objects from Pecica also show values close to each other, but the representativeness of the result is decreased by the fact that not all the items belonging to the treasure were analysed. An interesting image presents the treasure from Cacova: while four of the items could be considered as relatively close to each other, with values for gold ranging between 74.50% and 80.06%, the fifth item, which is also the most impressive in size and weight (cat. no. 3.1), has a percentage of 88.85% Au. The results for the rings from Tăuteu treasure are not very conclusive, since only two of the five complete items were analysed, but it can be noticed that both present high percentages of gold in the natural alloy.

The possible relation between the gold composition and the types of the analysed objects was also investigated (fig. 3).

All the analysed bracelets (six from Căuaş and one from Şmig) belong to the type with lozenge-shape cross-section and opened tapering ends, and they form a remarkably homogenous group, with 85.20%...87.61% Au and 0.43%...0.56% Cu. Taken separately, the similar results for the six bracelets from Căuaş could be explained by the use of a single batch of gold for casting or hammering all the items. The fact that this group includes not only all the bracelets (complete and fragmentary) from Căuaş, but also the bracelet from Şmig (a smaller and much lighter item), makes this situation more interesting, if the type of these bracelets is taken into account. The lozenge-shape cross-section bracelets were often described

in the archaeological literature as pre-monetary objects[32], and the fact that their composition might prove to be extremely homogeneous could be considered as a further argument in favour of this hypothesis. Although other explanations for this similarity should not be excluded, it would still be very useful to conduct more compositional analyses on similar artefacts of the same kind, in order to determine if the situation observed in this case has a general character or it is only a coincidence.

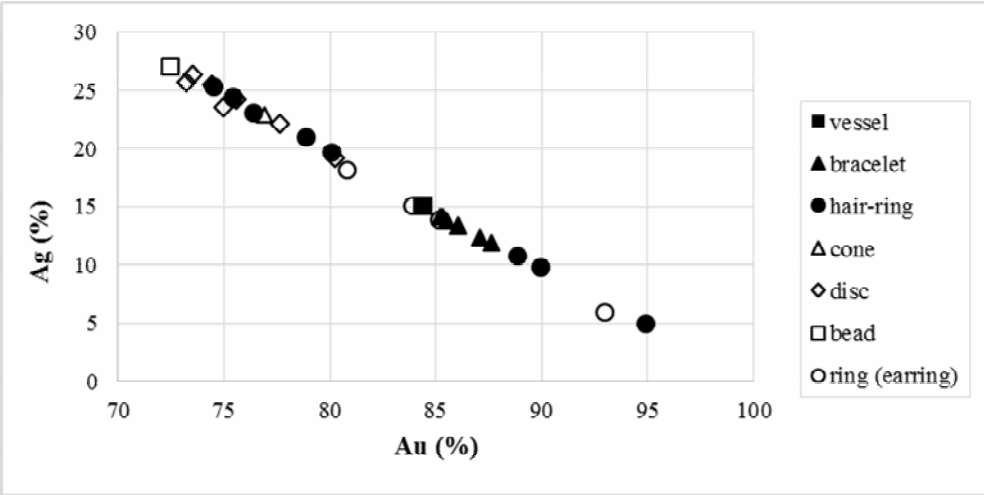

Fig. 3. Gold and silver contents of the analysed items in correlation with their typology.

The decorated discs can be described as a rather homogenous group, although not in the same way as the bracelets. All of them have a lower percentage of gold (73.21%...80.22%), but they are not so clustered in figure 2. It can be also noticed that the values of gold concentration for the two discs from Şmig are both higher than the values determined for the discs from Săcueni.

The hair-rings seem to be rather split into two loose clusters: six of the analyses show values of 74.50%...80.06% Au (four of the hair-rings from Cacova and the hair-rings from Apoldu de Sus), while the other three items (one from Cacova and the two hair-rings from Şmig) have values between 88.85% and 94.85% Au.

The bead from Şmig has the lowest percentage of gold from the whole group, but until more items from this category are analysed it is risky to jump to conclusions.

The twisted and notched rings have in common the fact that they are characterised by rather high percentages of gold, but without forming a cluster. It is especially interesting to remark that the two twisted rings from Şmig, which clearly form a pair (possibly earrings), also have very similar compositions.

[32] Popescu 1956, p. 211–212; Ciugudean 2010; Kacsó 2014, p. 110–111.

In order to verify the observations made until now, the correlation between silver and copper was also investigated (fig. 4).

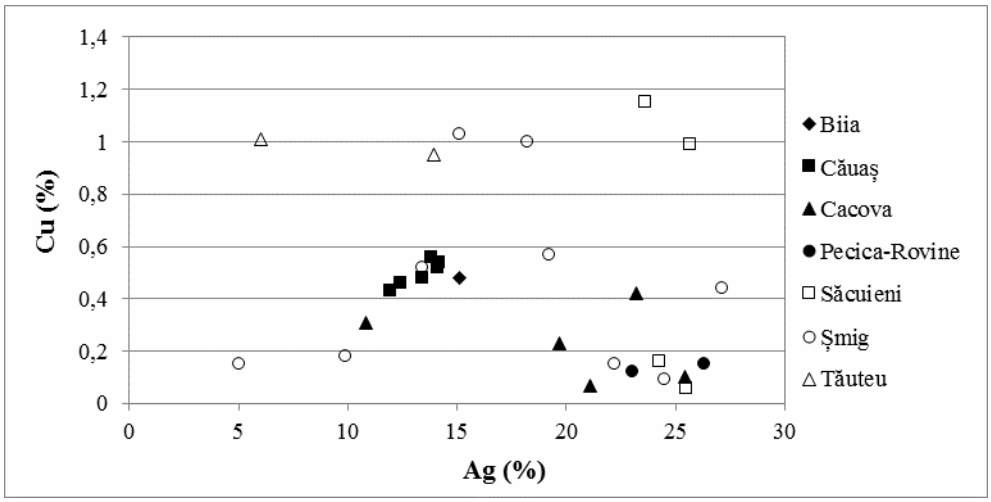

Fig. 4. Silver and copper contents of the analysed items.

When trying to correlate the type and the composition, probably the clearest result is the compositional cluster of all bracelets with lozenge-shape cross-section, result that matches very well the situation shown by the correlation graph Au-Ag (fig. 3). Interestingly, closest to their composition is, so far, the composition of the vessel from Biia, with the difference that, in the case of the gold vessel antimony, besides tin, is also present as trace element. The decorated discs have all high percentages of silver (19.21%...26.31%), grouping them on the right part of the graph, but the variation in the percentage of copper prevents them from forming a real single cluster. Two of the Săcueni discs (cat. nos. 6.2–6.3) have very similar compositions, with both high percentages of silver and copper. Another small cluster seems to be formed by the other two discs from Săcueni, the disc from Pecica and one of the discs from Şmig (cat. no. 7.1), while the other disc from Şmig (cat. no. 7.2) is different from both groups, but still compositionally closest to aforementioned item from Şmig (cat. no. 7.1). The hair-rings represent, so far, the category with the highest degree of variability, with values, for silver, between 5% and 25.40%. Still, they have in common low values of copper (0.07%–0.42%), a fact that keeps their composition in the lower part of the graph. The two hair-rings from Şmig are closest to each other and in the same time quite close to the big, heavy item from Cacova (cat. no. 3.1). The other four hair-rings from Cacova seem to form a loose cluster, to which the hair-rings from Apoldu de Sus are associated. It may be interesting to notice that this compositional group practically superposes the second cluster of discs' compositions. The results for the two torsion rings from Şmig confirm the impression offered by figures 2–3, their composition proving to be very similar. Very close to them is situated one of the notched rings from Tăuteu (cat. no. 8.1), while the

other (cat. no. 8.2), although further away in the graph due to its higher purity, is still closer to this group than to any other item in terms of composition.

From the point of view of the relation between the association of the items per treasures and composition, the homogeneity of the treasure from Căuaş and the great compositional variability that characterises the treasure from Şmig are sustained by the results presented in figure 4. The disc and the cones from Pecica are close to each other on the graph, but, again, it should be emphasized that the analysis of a larger number of gold cones would be useful in determining if the treasure is homogenous from compositional point of view. Four of the hair-rings from Cacova are close enough from the compositional point of view to suggest a tentative relation between them. The result for cat. no. 3.1 could be discussed in comparison to the others in terms of typology, origin/source, or chronological framework (in view also of its closeness to the two hair-rings from Şmig). Anyway, its original attribution to the Cacova treasure (the uncertainty of the association of items in treasure was already mentioned) can be neither confirmed, nor denied by its composition, as long as, on one hand, its general shape and weight could simply indicate the use of one bigger gold nugget (and, as such, the result of chance/choice), and, on the other hand, the number of analyses conducted on hair-rings is too reduced to offer a statistical basis for comparison.

An interesting aspect indicated by the graph in figure 4 is the presence of a higher amount of copper in some of the items. By comparing the amount of copper determined in the Transylvanian gold samples and the ones obtained for the analysed artefacts, it can be noticed that copper concentration in the items is higher than in the native gold (approx. 0.1%)[33]. This increased copper content in the artefacts might be related to the presence of accompanying copper minerals in gold dust and nuggets – e.g. chalcopyrite ($CuFeS_2$) – "fool's gold", with a shiny aspect, similar to real gold, and to the primitive processing of the raw material.

A very difficult question to address is the relation between the composition of the analysed gold objects and their chronology and geographical distribution. So far, it seems that the items that can be more safely related to the Middle Bronze Age were made using gold of lower purity, while the objects connected with any degree of confidence to the Late Bronze Age and Early Iron Age are, on average, of higher purity gold. Future XRF analyses will show if there is really a trend in this direction. From the perspective of their geographical distribution, there seems to be no real connection between the gold composition of the items and their discovery place, but again the analysed objects were too few to allow drawing any steady conclusions. Still, it is quite likely that the composition of the gold objects reflects rather certain points of origin and distribution patterns than their final deposition place. Returning to the observations made earlier in connection to the two possible categories of gold sources – primary or secondary – used for these artefacts, it was considered useful to compare the results of the analyses conducted on them with a series of analyses conducted on gold samples from Transylvanian

[33] Constantinescu *et alii* 2012.

gold mines and placer gold, respectively, and presented in the two following graphs (figs. 5–6)[34].

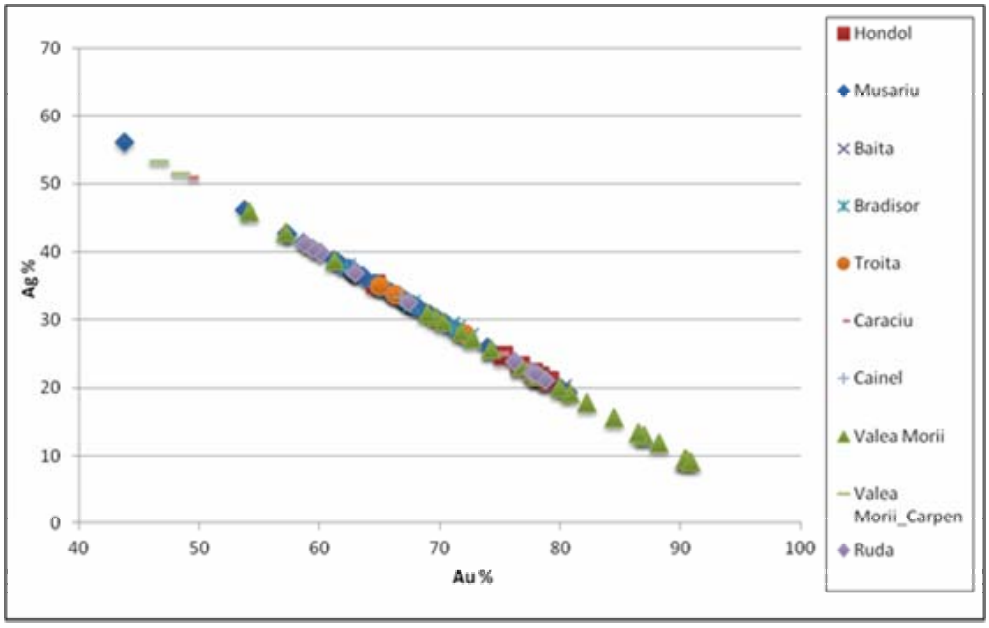

Fig. 5. Composition of gold samples from Transylvanian gold mines (after Cristea 2013, p. 40, fig. 48).

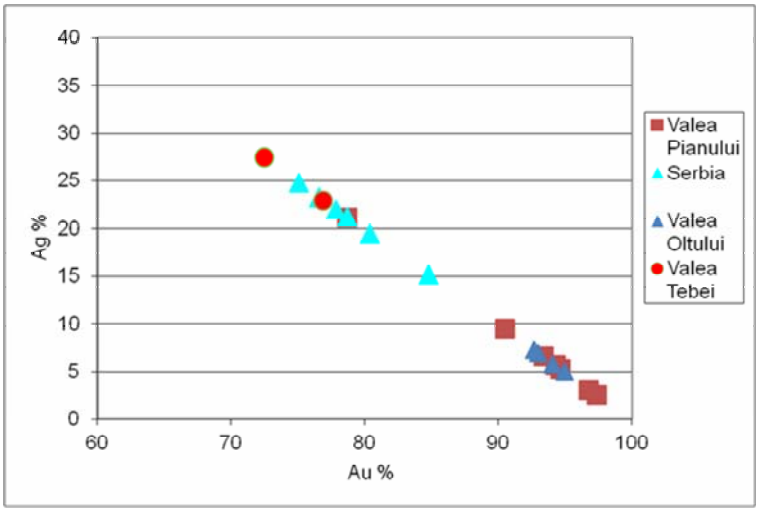

Fig. 6. Composition of gold samples from placer gold (after Cristea 2013, p. 45, fig. 51).

[34] Cristea 2013, p. 40, fig. 48, and p. 45, fig. 51.

The analyses conducted on samples from gold mines in the Brad – Săcărâmb District show a wide variation of gold in the natural alloy, from as low as 45% (Musariu and Caraciu mines) up to values around 90% (Valea Morii), but with the majority of samples clustering between 60% and 80% Au (fig. 5). Some of the samples present also traces of Fe, Mn, Zn, Pb and Sb[35]. The samples of placer gold create a cluster in the case of Valea Pianului and Valea Oltului, with values between 90.5% and 97.4%, and between 92.7% and 95% respectively, but offer very low values, between 72.5% and 76.9%, for Valea Ţebei (fig. 6). The presence of Sn was observed in samples from Valea Pianului and Valea Ţebei[36]. These results match, in general, those of the prehistoric items, and it seems quite probable that the native gold used in their case was local. The question whether the metal was obtained from primary or secondary sources is more difficult to solve. Statistically speaking, there are more chances for objects with high purity to have been made of placer gold, as there are for objects with lower purity to have had mine gold used for them. But, the high purity of gold in the case of some mine gold samples (e.g. Valea Morii) indicates that a certain degree of prudence is necessary. On the other hand, the results for the placer gold from Valea Ţebei show that gold of lower purity could have been collected also from rivers' valleys. The presence of tin in some of the analysed objects stresses their relation with secondary sources of gold, despite their rather low purity.

More compositional analyses, either confirming or contradicting the results presented here, are necessary in order to obtain information that will provide a pertinent view on the prehistoric gold metallurgy, sources, techniques and exchange in this area, and for this period.

Acknowledgements

We have to remember the essential contribution of the late Viorel Cojocaru, who conducted the XRF measurements.

Work performed in the frame of ARCHEOMET project (2005–2008), funded by the Romanian Ministry of Education, Research and Innovation – see http://www.arheomet.ro/.

CATALOGUE

1. Apoldu de Sus (*Nagyapold*, *Grosspold*, *Apoldul Mare*), Sibiu County (fig. 1). Two hair-rings, attached to each other[37], most probably dated to the Middle Bronze Age. They were part of the collections of the Brukenthal National Museum, Sibiu[38], until 1973, when they were transferred to the newly created National History Museum of Romania[39].

[35] Cristea 2013, p. 40, 42.

[36] Cristea 2013, p. 44.

[37] Mozsolics 1973, p. 200 (as belonging to the museum from Sibiu, although it is doubtful if the reference is made to this find, the two items being described as *Kettenglieder*, not *Lockenringe*).

[38] Inv. no. A.724.

[39] *Registru inventar MNIR*, vol. 27, 1973.

1.1. Inv. no. 47589 (fig. 7/1)
W = 5.70 g (total); D = 1.24 cm (each item)
Two hair-rings, fastened together, made of massive gold bar, with circular cross-section, hammered, undecorated. Thinner in the middle and thickening progressively, tapering towards the ends. Good preservation state, but they present a few scratches.

2. Biia (*Magyarbénye*), Şona Township, Alba County (fig. 1). The gold vessel represents a chance find, being found either in or near the riverbed by a local worker digging for gravel, on the bank of Târnava River. There are several uncertainties regarding the exact location, moment, and integrity of the find. Most probably, the vessel was found along the river bank between the villages of Biia (*Magyarbénye*) and Sânmiclăuş (*Betlenszentmiklós*)[40], in 1895[41], or earlier, in 1879[42]. What can be certainly said is that the gold vessel was found before July 4th 1895, when it was brought to the Brukenthal Museum, Sibiu, and offered for acquisition[43]. Possibly, it was a single find, although rumours circulated that it was found together with other gold objects[44], more precisely eight other objects (one bracelet and seven hair-rings)[45]. Since the moment of its discovery, the gold vessel was successively dated to different periods, in the beginning of the 20th century to the so-called "Thracian – Cimmerian circle", and later to periods from the Middle Bronze Age to the Early Iron Age (Hallstatt A–B)[46].
The gold vessel was part of the collections of the Brukenthal National Museum[47] until 1973, when it was transferred to the newly created National History Museum of Romania[48].

2.1. Inv. no. 47584 (fig. 7/2–4)
W = 143.92 g; D max = 9.8 cm; D mouth = 8.7 cm; H = 5.8 cm[49]
Vessel made of gold sheet, hammered and decorated in the *au repoussé* technique. Its body is hemispherical, flattened; the rim is opened to the exterior. Two handles start from the rim

[40] Popescu 1956, p. 232, footnote 3.
[41] Burda 1979, p. 66.
[42] Mozsolics 1965–1966, p. 48.
[43] Popescu 1956, p. 232, footnote 3 (citing the Inventory of the Brukenthal Museum, no. 160/1895); Soroceanu 2008, p. 228, footnote 219 (with a detailed presentation of find conditions).
[44] Schroller 1925, p. 114.
[45] Mozsolics 1965–1966, p. 48–49, fig. 12, 19/4–6, 20–21. In fact, it seems that the author indicated 1879 as the finding year based mainly on the fact that she considers the gold vessel as part of a treasure. The bracelet and the hair-rings were purchased by the Hungarian National Museum during 1880, from a jeweller from Zlatna, who indicated Biia as the finding place.
[46] Middle Bronze Age (B IIIa), associated to the Hajdúsámson cultural milieu (Mozsolics 1965–1966, p. 48–49); not later than the limit between Period III and Period IV in the Scandinavian Bronze Age (Schroller 1925, p. 114); although excluding Biia and other finds from his list of Late Bronze Age – Early Iron Age (Bronze D – Hallstatt A) gold finds from Romania, based on the earlier chronological frame proposed for them by A. Mozsolics, M. Rusu considers such a dating wrong (Rusu 1972, p. 40, footnotes 12, 49); the limit between Hallstatt A and B (Burda 1979, p. 66, cat. no. 20); Hallstatt B (the 10th – 8th centuries BC) (Soroceanu 2008, p. 235); Late Bronze Age – Early Iron Age (the 13th – 12th centuries BC) (Leahu 2010, p. 131, cat. no. 4).
[47] Inv. no. A.716.
[48] *Registru inventar MNIR*, vol. 27, 1973.
[49] The weight and dimensions of the objects are given in conformity with the information found in the inventory of the National History Museum of Romania. There are minor differences between the successive registers, as the objects were re-measured and re-weighed over time, so the newest information was preferred for this article.

and arch down, free, ending in a double spiral[50]. The vessel's shoulder is decorated with a zigzag motif made of dots. On the maximum diameter of the vessel there are two horizontal rows of protuberances. On the bottom there are two circles made of round protuberances. The exterior circle is separated in quarters by four motives made of three concentric circles each, with central protuberance. A fifth similar group, made of two concentric circles with a central round protuberance, is placed in the central position on the bottom of the vessel. The vessel is complete, but it presents scratches and slight deformations, especially on the rim and on the superior part of the body.

3. Cacova (present day Livezile; *Vládháza*, *Urháza*)[51], Alba County (fig. 1). The treasure contains five gold objects: three hair-rings with round shape and different sizes, and two spiral rings (*Noppenringe*). It was purchased by the Romanian state in the city of Aiud, in 1929[52]. Consequently, nothing is known about the conditions in which it was found, or the original number of items and their association.

These types were probably in circulation from the Early Bronze Age up to Early Iron Age. It is difficult to establish a closer chronological frame for the hair-rings, as well as their cultural affiliation, because, usually, these objects come as single finds, or they are found together with types having similar chronological problems. They were considered to belong to the Early Bronze Age and Middle Bronze Age[53], or to the Middle Bronze Age – Early Iron Age period[54]. The spiral rings represent a less familiar type for the territory of Romania, being more common in funerary contexts from Serbia, Slovakia and Austria, dated to the end of the 3rd millennium – the beginning of the 2nd millennium BC[55]. The association of the hair-rings with the spiral rings would thus suggest a rather early chronological framework; unfortunately, their association in the treasure cannot be positively ascertained. On the other hand, the association of earlier and later types can be also interpreted in terms of heirlooms.

3.1. Inv. no. P 23485 (fig. 7/5)
W = 29.18 g[56]; D = 2.34 cm
Massive hair-ring made of thick gold bar, hammered, thinner in the middle and thicker at the ends. It has a circular form, with overlapping ends. The central section of the ring is circular; at the ends the cross-section of the gold bar becomes rather oval. The ends are rounded. Good preservation state, but the gold bar was chipped in several spots, especially on the external surface of the ends and on the internal surface of its central section, where there seems to be even cut marks.

[50] The shape of the vessel suggested to D. Popescu the comparison with a leather bag (Popescu 1956, p. 233).

[51] The old name of the village (Cacova) was preferred, since it is under this name that the find is known in the archaeological literature.

[52] Popescu 1956, p. 203, fig. 121/1–2, 5.

[53] Popescu 1956, p. 237 (not for this find in particular, but for the hair-rings as a category).

[54] Rusu 1972, p. 41 (this find is not discussed as such in the text, although it is presented in the "Catalogue of treasures and single finds of gold from Bronze D and Hallstatt A" as Livezile (Cacova) at p. 46, cat. no. 36).

[55] Ţârlea, Popescu 2013a, p. 55.

[56] This hair-ring is considered the heaviest item of this category from Romania (Burda 1979, p. 64).

3.2. Inv. no. P 23486 (fig. 7/6)
W = 5.30 g; L = 15.8 cm; D = 1.4 cm; H = 1.46 cm
Ring made of thick gold wire, hammered, in form of a spiral with four oval loops (three complete, plus the ends). The wire has circular cross-section. The preservation state is relatively good; on the central loop the wire is slightly bent from exterior to interior; it is scratched and chipped.

3.3. Inv. no. P 23487 (fig. 7/7)
W = 4.75 g; D = 1.44 cm; H = 0.8 cm
Ring made of double wire, in form of a spiral (two complete loops, plus the ends), with one of the ends cut. The wire has circular cross-section. Good preservation state, with slight scratches.

3.4. Inv. no. P 23488 (fig. 7/8)
W = 4.53 g; D = 1.34–1.43 cm
Massive hair-ring, hammered, made of gold bar with circular cross-section. The item is circular, with overlapping ends. The bar is thinner in the middle, thickens towards the ends, and tapers at the ends. The preservation state is relatively good; slight deformation in the central region, with fissures and exfoliation; hit marks and scratches, with the metal chipped, on the exterior surface.

3.5. Inv. no. P 23489 (fig. 7/9)
W = 4.40 g; L = 2.55 cm; H = 1.91 cm
Gold object in form of an "anchor", hammered. Most probably, it was initially a hair-ring; at the present time, the bar is twisted and bent. It is thinner in the middle, thickened towards the ends, tapering at the ends. It has a lozenge-shape cross-section. Except for the fact that the bar is twisted, it has scratches, hit marks and torsions of metal.

4. Căuaş (*Érkávás*), Satu Mare County, close to the "Sighetiu" island, in the former swamps of the Eriu River, in the location called *Unghiura Molnăreştilor*[57] (fig. 1). One of the numerous finds from this area, the treasure Căuaş IV[58] contains, at the present time, two massive bracelets and four fragments of bracelets[59]. It was found in the autumn of 1965, during agricultural activities. It is possible that, initially, the deposition area was a swamp[60]. The finders fragmented two of the (presumably) four bracelets originally forming the treasure, and they sold the items to a jeweller. The objects were confiscated in 1966, deposited, in a first phase, at the National Bank, moved to the Numismatic Cabinet of the Romanian Academy during 1967 and, later, exhibited in the Treasure Room at the National History Museum of Romania[61].
The open bracelets with lozenge-shaped section and tapering ends are present in the most important treasures, sometimes in great numbers (up to 20 items and more), and also in bronze hoards, during Late Bronze Age – Early Iron Age (Bronze D – Hallstatt A)[62]. This situation seems to indicate a preference for this type during this chronological stage, especially when compared to their total absence from the bronze hoards and gold treasures

[57] Kacsó 2014, p. 110.
[58] The first three finds (Căuaş I–III) are bronze hoards.
[59] Rusu 1972, p. 45, cat. no. 17 (the author talks about four massive bracelets with lozenge-shaped section); Kacsó 2014, p. 109.
[60] Bader 1978, p. 122, cat. no. 20, fig. 89/3–4.
[61] Kacsó 2014, p. 106–107.
[62] Kacsó 2014, p. 111–119 (with a catalogue of finds).

of the Middle Bronze Age (Bronze B–C) and their sporadic presence in the Hallstatt B hoards. It was considered that, unlike the bronze bracelets of this type, casted in two-part moulds, the gold ones were worked through hammering. Most of the bracelets lack any kind of decoration[63]. Objects with lozenge-shaped cross-section are known in different sizes, bracelets being considered only those large enough to be worn on the arm. The bracelets and rings of this type are, sometimes, considered as standard pre-monetary objects and, based on this hypothesis, there were attempts to put their weights in connection to different ancient weighing systems[64].

4.1. Inv. no. P 23474 (fig. 8/1)
W = 136.35 g; D = 6.69–7.59 cm
Gold bracelet made of a bar with lozenge-shape cross-section and prominent ridges. The bar is tapering progressively towards the overlapping ends. The item is complete, but showing signs of blows which left the ridges chipped and cracked, and the surface with scratches and cracks.

4.2. Inv. no. P 23475 (fig. 8/2)
W = 137 g; D = 5.8–6.59 cm
Gold bracelet made of a bar with lozenge-shape cross-section and prominent ridges. The bar is tapering progressively towards the closing ends. The item is complete, but showing signs of blows, which left the ridges chipped and cracked, and the surface with scratches.

4.3. Inv. no. P 23476 (fig. 8/3)
W = 34.50 g; L = 4.29 cm
Fragment of gold bracelet made of a bar with lozenge-shape section. The fragment shows marked signs of blows, which left the ridges chipped and cracked, and the surface with scratches, as well as marks of negligent, rough cuts at the extremities.

4.4. Inv. no. P 23477 (fig. 8/4)
W = 21.85 g; L = 4.71 cm
Fragment of bracelet made of a bar with lozenge-shape cross-section. The fragment shows marked signs of blows, which left the ridges chipped and cracked, and the surface with scratches, as well as marks of negligent, rough cuts at the extremities.

4.5. Inv. no. P 23478 (fig. 8/5)
W = 25.60 g; L = 3.72 cm
Fragment of bracelet made of a bar with lozenge-shape cross-section. The fragment shows marked signs of blows, which left the ridges chipped and cracked, and the surface with scratches, as well as marks of negligent, rough cuts at the extremities.

4.6. Inv. no. P 23479 (fig. 8/6)
W = 13.75 g; L = 1.73 cm
Fragment of bracelet made of a bar with lozenge-shape cross-section. The fragment shows marked signs of blows, which left the ridges chipped and cracked, and the surface with scratches, as well as marks of negligent, rough cuts at the extremities.

[63] Rusu 1972, p. 34.
[64] Popescu 1956, p. 211–212.

5. Pecica – Rovine, Arad County (fig. 1). The treasure was found, by chance, in the spring of 1938, during agricultural work in the place (field) called "Prunişte", in the vicinity of the important Bronze Age site from Pecica – *Şanţul Mare*. The find consisted in a small clay vessel with two handles, 10.2 cm high, belonging to the Vatina culture, which contained 48 gold cones, a small gold disc and two *Columbella* shells. The treasure was considered to belong to the Middle Bronze Age, based mainly on the clay vessel[65]. The gold cones have no close analogies, and similar gold discs were dated by different authors overwhelmingly to Early and Middle Bronze Ages[66]. It is considered as a possibility that the gold cones represent an imitation of a necklace made of animal teeth[67].
The treasure was part of the collections of the National Museum of Antiquities[68] until 1971, when it was transferred to the newly created National History Museum of Romania[69].

5.1. Inv. no. 11354–11401 (fig. 8/7)
W total = 12.63 g; H = 1.3 cm; D = 0.6 cm
Gold objects in the shape of small cones, made of gold sheet, 48 in number. The cones are perforated approximately at their middle height, so they could be hanged, either as individual pendants, forming a necklace, or as ornaments on textiles. Their preservation state is quite good, but the gold sheet is extremely thin and very fragile.

5.2. Inv. no. 11402 (fig. 8/8)
W = 0.21 g; D max = 1.32 cm; D min = 1.28 cm
Small disc, made of gold sheet, round to oval in shape, curved in profile. It has two opposite perforations on the ridge. Probably it served as an ornament sewed on textile. The object is decorated with small prominent dots, in the *au repoussé* technique. Good preservation state.

6. Săcueni (*Székelyhíd*), Bihor County (fig. 1). The treasure was found, by chance, in 1927, in a vineyard. From the total number of eight, only four decorated discs were saved (three in good condition and a small fragment). Initially, the treasure probably weighed around 200 g. It is unknown whether the fragmentary disc was initially in this state, or it was fragmented after being found[70].
The discs were dated to the Middle Bronze Age[71], and considered representative for the Otomani culture[72], or the Hajdúsámson type[73]. The existence, in the vicinity, at the location named "Cetatea boului"[74], of an Otomani settlement of the "island" type could bring some additional strength to this cultural attribution, built on typological arguments.

[65] Dumitrescu 1937–1940, p. 127–131.
[66] Gogâltan 1999, p. 101, cat. no. 32, fig. 41/1, 5, fig. 42 (the Mureş culture); Mozsolics 1965–1966, p. 51 (the author mentioning 58 gold cones); Popescu D., Popescu V. 1955, p. 869; Popescu 1962, p. 400, 407.
[67] Popescu 1956, p. 205–206, fig. 122.
[68] Today the Institute of Archaeology "Vasile Pârvan", Bucharest. Inv. no. 80/64 (disc); 79/64 (cones).
[69] *Registru inventar MNIR*, vol. 8, 1971.
[70] Bader 1978, p. 14, 128, cat. no. 79, fig. 89/5; Nestor 1932, p. 120–121 (the author discusses only two of the eight discs); Popescu D., Popescu V. 1955, p. 869; Leahu 2003, p. 103–104.
[71] Popescu 1956, p. 209.
[72] Popescu D., Popescu V. 1955, p. 869, 871.
[73] Mozsolics 1965–1966, p. 51.
[74] Bader 1978, p. 128, cat. no. 79.

The treasure was purchased from a merchant selling gold objects from Oradea, and became part of the Penkert Collection, at Săcueni[75]. The treasure was confiscated by the General Inspectorate of Militia, Economic Branch, and transferred to the National History Museum of Romania in 1974, where it remained in custody until recently, when it was acquired by the museum from the heirs of the original owner[76].

6.1. Inv. no. 334.706 (former inv. no. C 1744) (fig. 9/1)
W = 27.95 g; D = 9.01 cm
Disc made of thin gold sheet, circular, curved in profile, with four perforations on the ridge. The decoration is made in the *au repoussé* technique. The disc presents a central round protuberance, surrounded by two circles made of dots. They are encircled by a spiral motif, made of dots, and the ridge is doubled by another circle made of dots. The preservation state is relatively good, but a small fragment is missing from the ridge, near one of the perforations, where the object is also cracked.

6.2. Inv. no. 334.707 (former inv. no. C 1745) (fig. 9/2)
W = 26.70 g; D = 8.01 cm
Disc made of thin gold sheet, circular, curved in profile, with three perforations on the ridge, and the fourth near the centre of the object. The disc has a central round protuberance and it is decorated in the *au repoussé* technique. The central prominence is encircled by a row made of prominent dots. A second row of dots doubles the ridge of the object. Between the two circles of dots, there is a motif in double spiral, made of dotted band (three lines and between them a row of dots). The preservation state is relatively good, but a small piece of the ridge is missing, and the gold sheet is cracked.

6.3. Inv. no. 334.708 (former inv. no. C 1746) (fig. 9/3)
W = 23.72 g; D = 8.01 cm
Disc made of thin gold sheet, circular, curved in profile, with four perforations on the ridge. The central round protuberance is more marked than in the case of the other two discs, and a band decorated with a triangular motif surrounds it. This band is, in its turn, encircled by two rows of spirals made of dots (three lines and, between them, a row of dots), and a dotted band on the ridge. The decoration technique is *au repoussé*. It presents several cracks, including some starting from one of the perforations.

6.4. Inv. no. 334.709 (former inv. no. C1747) (fig. 9/4)
W = 1.80 g
Fragment from the ridge of a disc, made of thin gold sheet. The preserved decoration consists in a repeated motive, a band (a row of dots between two lines), in the *au repoussé* technique. The disc seems to be flatter than the others. It is in a poor state of preservation.

7. Şmig (*Somogyom*, *Schmieg*, *Schmiegen*, *Sumugus*), Aţel Township, Sibiu County (fig. 1). The treasure was found in 1880, during agricultural activities, on the spot named "Corbul" (*Korbuj*)[77], in a bronze vessel placed in a clay vessel[78]. It was mentioned that the

[75] Bader 1978, p. 128, cat. no. 79.
[76] *Registru inventar MNIR*, vol. 225 C.
[77] Luca, Pinter, Georgescu 2003, p. 216.
[78] Mozsolics 1965–1966, p. 52.

treasure was found in two phases, so the initial association of items could be uncertain[79]. If it was only one treasure, it contained a great number of objects, weighing 531.95 g, now present in the collections of three different museums. Hungarian National Museum: 26 decorated discs (20 preserved in 1972); 18 hair-rings (16 preserved); 13 *saltaleoni*; 158 gold beads (149 preserved); five 'silver' beads; one oval gold ingot; two fragments from the bronze vessel; one fragment from the clay vessel[80]. The National History Museum of Transylvania, Cluj-Napoca, Romania: two discs, one hair-ring, one ring. The National History Museum of Romania: one bracelet with lozenge-shaped cross-section, two hair-rings, two torsion rings, two discs, three gold beads, one 'silver' bead, one fragment of the bronze vessel[81].
The bracelet with lozenge-shape cross-section was attributed to the category of standard pre-monetary objects[82], similar to the finds from the Căuaş IV treasure. The presence of the gold discs, usually seen as characteristic for the Middle Bronze Age, led some archaeologists to consider possible that the treasure was accumulated during a longer period of time[83]. Based on the newest items (the clearest chronological indicator being the bracelet), the treasure was dated to Bronze D – Hallstatt A[84]; but the presence of the bronze vessel and its characteristics could indicate an even later moment for its deposition into the ground, the end of Hallstatt B and Hallstatt C[85].
The treasure was part of the Brukenthal National Museum's collections until 1973[86], when it was transferred to the newly created National History Museum of Romania.

7.1. Inv. no. 47575 (fig. 9/5)
W = 9.40 g; H = 1.5 cm; D = 6.3 cm
Disc made of a circular gold sheet, curved in profile, decorated in the *au repoussé* technique. The disc has a round central protuberance surrounded by two rows of dots, with a groove between them. Between these rows and the ridge, there are three bands made of three rows of prominent dots each. Between each two bands, there is a group of three prominent buttons. The disc has a ridge decorated with a row of prominent dots, and four perforations. The preservation state is quite good, but the object is deformed, cracked, and with small fragments missing from the ridge. It presents some impurities on the back side.

7.2. Inv. no. 47576
W = 4.50 g; D = 3.7 cm
Disc made of a circular gold sheet, curved in profile, decorated in the *au repoussé* technique. The disc has a central round protuberance, surrounded by a groove and a row of dots. A similar row is present near the ridge, which has two perforations. The preservation

[79] Burda 1979, p. 65.
[80] Inv. no. 180/1880/1–29.
[81] Popescu D., Popescu V., 1955, p. 871; Mozsolics 1965–1966, p. 52–53, fig. 14/1–6, 15/1–14, 16/1–11; Rusu 1972, p. 49–50, cat. no. 66 (the author mentions two gold beads, but in fact there are three gold beads under the same inventory number).
[82] Burda 1979, p. 65; Popescu 1956, p. 213.
[83] Popescu 1956, p. 205.
[84] Rusu 1972, p. 49–50.
[85] Soroceanu 2008, p. 209–211, 420–421, cat. no. 147, fig. 75B.
[86] Inventory numbers: A.735 (disc); A.736 (disc); A.731 (bracelet); A.737 (hair-ring); A.732 (hair-ring); A.738 (three beads under the same inventory number); A.739 ("silver"/"common metal" bead); A.734 (earring); A.733 (earring).

state is quite good, but the object is slightly deformed (especially on the ridge), cracked on the ridge, and scratched. It presents some impurities on the back.

7.3. Inv. no. 47577 (fig. 9/6))
W = 32.5 g; D max = 6.86 cm; D min = 6.4 cm
Massive bracelet, hammered, oval in form, made of a gold bar with lozenge-shape cross-section. It is thicker in the middle and it tapers progressively to the overlapping ends. Good preservation state.

7.4. Inv. no. 47578 (fig. 9/7)
W = 7.85 g; L = 3.5 cm
Hair-ring made of a gold bar. Initially, the bar had lozenge-shape cross-section, but it was flattened through hammering. The bar is thinner in the middle, thickens progressively, and then thins again at the ends. The ring is oval-shaped. The ends are strongly overlapping, and the extremities are much curved towards the interior of the ring. Good preservation state.

7.5. Inv. no. 47579 (fig. 9/8)
W = 4.65 g; D = 1.4 cm
Hair-ring made of a gold bar, hammered, thinner in the middle, progressively thickening to the ends, abruptly thinning at the very ends. In the median area, the bar is round in section, and the thicker part is plan-convex. The ring is round in shape, the ends are overlapping, and the extremities are curved towards the interior. The item presents hit marks.

7.6. Inv. no. 47580/1–3 (fig. 9/9)
W = 1.20 g[87]; H = 0.4 cm; D = 0.43 cm[88]
The three gold beads have cylindrical shape and are perforated. They present slightly different dimensions, being in a satisfactory state of preservation.

7.7. Inv. no. 47581
W = 0.20 g; H = 0.25 cm; D = 0.35 cm
Gold bead, cylindrical in form, perforated. Because of its whitish colour, it was considered that the bead was made of common material (probably tin) or silver. It is in a satisfactory state of preservation.

7.8. Inv. no. 47582
W = 4.0 g; D = 2.3 cm
Ring (earring?), circular in shape, made of a gold bar of square cross-section, hammered. The bar is decorated through mechanical torsion, and presents this torsion until close to the ends, which are smooth and much overlapped. The bar has the maximum profile at the middle of its length, decreasing progressively towards the ends. Preservation state: slight deformation, signs of gold testing.

7.9. Inv. no. 47583
W = 3.7 g; D = 2.55 cm
Ring (earring?), circular in shape, made of a gold bar of square cross-section, hammered. The bar is decorated through torsion. The bar is twisted until close to the ends, which are

[87] It is unclear if the weight is given for one or for all three beads. The latter variant seems more probable.
[88] The dimensions are given for the biggest of the three beads.

smooth and much overlapped. The bar has the maximum profile at the middle of its length, decreasing progressively towards the ends. Good preservation state.

8. Tăuteu, Bihor County (fig. 1)[89]. The hoard, consisting in a big clay vessel containing the bronze objects and a small clay vessel containing the gold rings (five complete; two small fragments, bent and attached to each other), was located approximately 600 m SW of the township's limit, and 120 m N of the meander of the Sălaș Rivulet. The hoard was found in September 1934, by Francisc Bálogh, aged 10, while he was herding cattle on the township's pasture. The bronze and gold objects, as well as the small clay vessel, were taken by the child and his father. The place was subsequently dug by the local Solyom Pál, with no result. The objects were seized later from several merchants. A field research was conducted in 1936 by Frideric Ardos, as well as a small excavation during the interval November 13th – December 14th 1945 by Mircea Petrescu-Dîmbovița and Corneliu Mateescu. Although no other items were found, this research allowed several observations regarding the discovery context. The hoard was allegedly found on the southern slope, washed by water, of the Sălaș (*Szállás*) hill, in an area with no known settlement. It opened only towards E and S, with forest in the rest, forming a secondary valley, closed towards W and SW, in comparison with the wider and more open valley of the Bistra River. The hoard was found at a depth of only 0.05 m, with several objects practically at the surface. The present number of objects, comprising the gold rings, is 48. The information offered by the finders indicated that a big clay vessel (polished; black-brown) contained the bronze objects (in no particular order) and the small clay vessel contained the gold rings placed in a whitish powder. The objects were: one axe with median wings; 11 socketed axes; four sickles; one knife; four saw-blades; two blade tips; 12 bracelets; two buttons; five fragments of raw bronze; five gold rings and two fragments of gold rings[90].
The objects entered the collections of the museum of the "National House" Oradea, after being seized by the gendarmerie because the gold items were not declared in time[91]. Later, the hoard arrived to the National Museum of Antiquities in two lots: 27 bronze objects and five gold rings[92] in the spring of 1935, 16 bronze objects in the fall of 1940 (the second lot with the wrong indication of their find place as Terebeș[93]). As a result, already in 1936, some questions have been arisen around the integrity of this discovery, being mentioned that, initially, there were more objects than those that were recovered (seized from several merchants)[94], and also doubts being expressed that the objects were all part of the same find[95].

[89] Frequently, the find from Tăuteu is present in the archaeological literature under the wrong name of Tăuteni.

[90] Dumitrescu 1935–1936, p. 225–234; Petrescu-Dîmbovița 1961, p. 81–114, fig. 1–5; Petrescu-Dîmbovița 1977, p. 136–137, fig. 329/1–12, 330/1–19, 331/1–17; Ţârlea, Popescu 2013b, p. 223, cat. no. 35.

[91] Ardos 1936, p. 72.

[92] Most probably, all gold items (five complete rings and two fragments – often numbered as only one item because of their intertwining, and equally often omitted in the archaeological literature when this discovery is mentioned).

[93] Petrescu-Dîmbovița 1961, p. 81.

[94] Ardos 1936, p. 73, the author enumerating only the following items (p. 72–73): six bronze rings, one socketed axe, two bronze buttons, one knife, two knives in form of spear with two cutting-edges, one half of a socketed axe, two knives with two cutting-edges, five gold rings, one small clay vessel, five copper ingot fragments and fragments of clay vessels dated to the Bronze Age.

[95] Dumitrescu 1935–1936, p. 225.

Based on the already mentioned association with the bronze objects and on the similarity with other finds, these objects are considered to belong to Early Iron Age, more precisely to Hallstatt B1, the Moigrad – Tăuteu hoarding horizon[96].
The gold rings from Tăuteu were included, based on shape and decoration, in the category of notched rings, named also of Brăduţ type, after the eponym hoard[97]. They have a round shape and are made of a thin gold bar, decorated on the entire surface, with the exception of the ends, which are thin and pointed, close to each other or slightly overlapping. The Brăduţ type represents a variant of the notched rings for which the vertical notches alternate with false 'triangular' or oblique torsions[98]. Three of the complete items from Tăuteu have the length of the gold bar separated by their decoration into nine (two rings), respectively seven (one ring) segments, the other two being decorated with simple circular notches on their entire surface, with the exception of their ends[99].
The hoard was part of the collections of the National Museum of Antiquities[100] until the beginning of the '70s, when it was transferred in its entirety (bronze and gold objects) to the newly created National History Museum of Romania.

8.1. Inv. no. 8992 (fig. 10/1)
W = 10.20 g; D = 5.5 cm
Ring made of a gold bar with circular cross-section and tapering ends, with notched decoration. Good preservation state.

8.2. Inv. no. 8993 (fig. 10/2)
W = 7.20 g; D = 3.4 cm
Ring made of a gold bar with circular cross-section and tapering ends, with notched decoration. Good preservation state.

8.3. Inv. no. 8994 (fig. 10/3)
W = 5.90; D = 3.32 cm
Ring made of a gold bar with circular cross-section and tapering ends, with notched decoration. Good preservation state.

8.4. Inv. no. 8995
W = 3.05 g; D = 2.43 cm
Ring made of a gold bar with circular cross-section and tapering ends, with notched decoration. Good preservation state.

8.5. Inv. no. 8996 (fig. 10/4)
W = 2.40 g; D = 2.12 cm
Ring made of a gold bar with circular cross-section and tapering ends, with notched decoration. Good preservation state.

[96] Müller-Karpe 1959, p. 127; Petrescu-Dîmboviţa 1961, p. 106; Petrescu-Dîmboviţa 1977, p. 136–137; Popescu 1962, p. 410–411; Rusu 1972, p. 36.
[97] Popescu 1956, p. 228.
[98] Dumitrescu 1935–1936, p. 231; Rusu 1972, p. 36.
[99] Oanţă-Marghitu 2013, p. 224, cat. no. 35.1–35.5.
[100] Inventory numbers: IV 5374–5389, 5414, 5416–5424, 5426–5441.

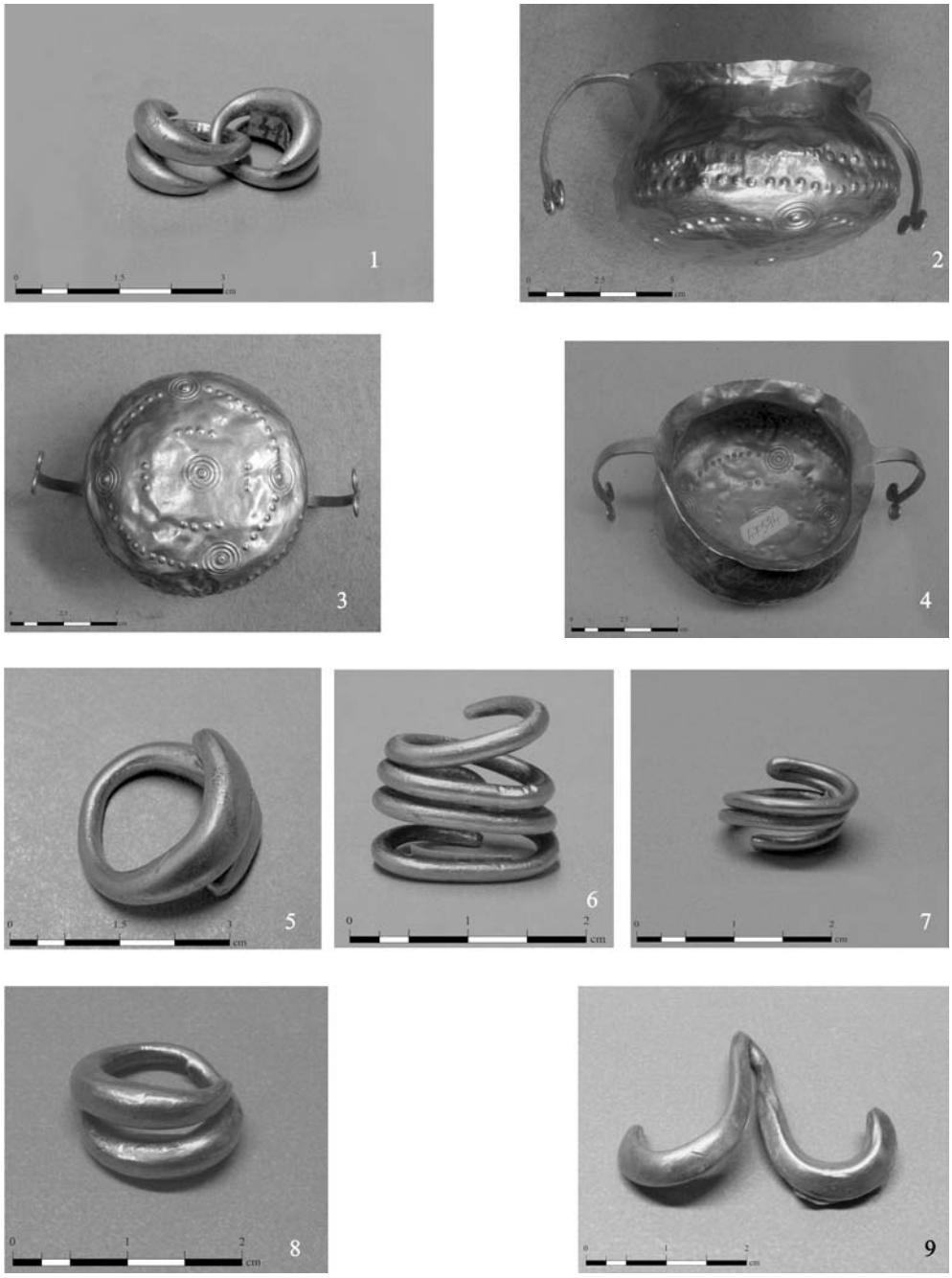

Fig. 7. Gold objects: 1. Apoldu de Sus (cat. no. 1.1); 2–4. Biia (cat. no. 2.1); 5–9. Cacova (cat. nos. 3.1–5).

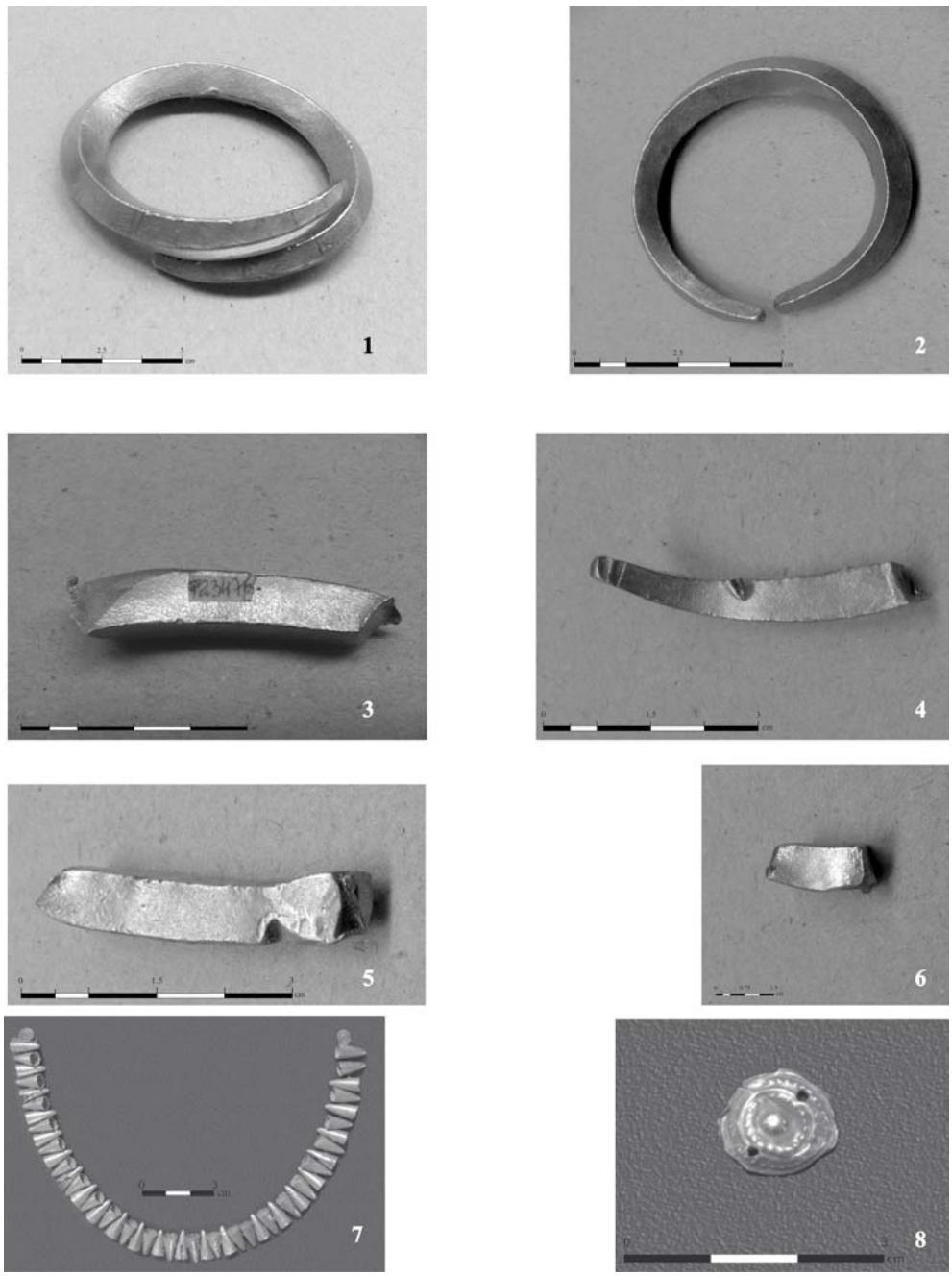

Fig. 8. Gold objects: 1–6. Căuaş (cat. nos. 4.1–6); 7–8. Pecica (cat. nos. 5.1–2).

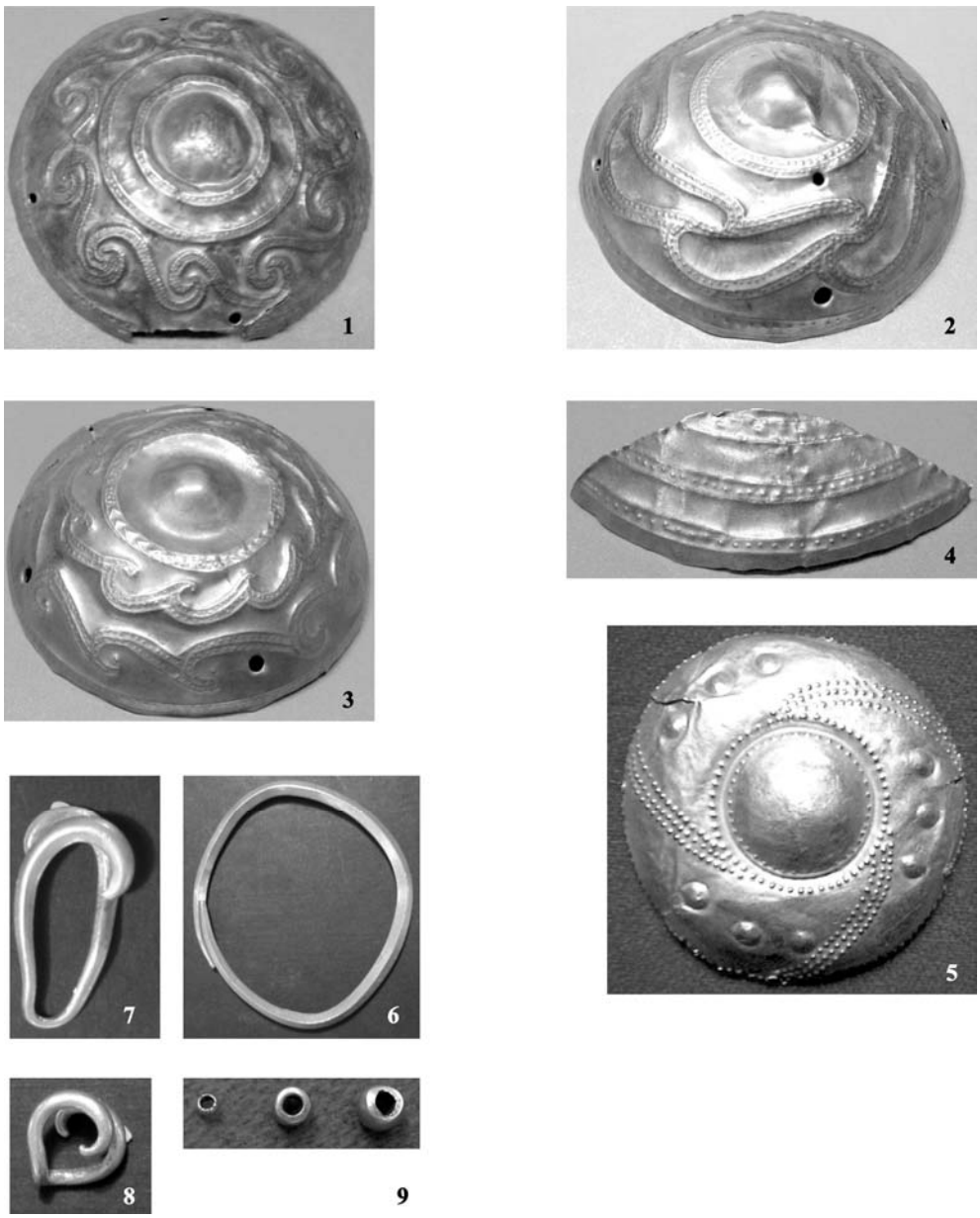

Fig. 9. Gold objects: 1–4. Săcueni (cat. nos. 6.1–4); 5–9. Şmig (cat. nos. 7.1, 7.36).

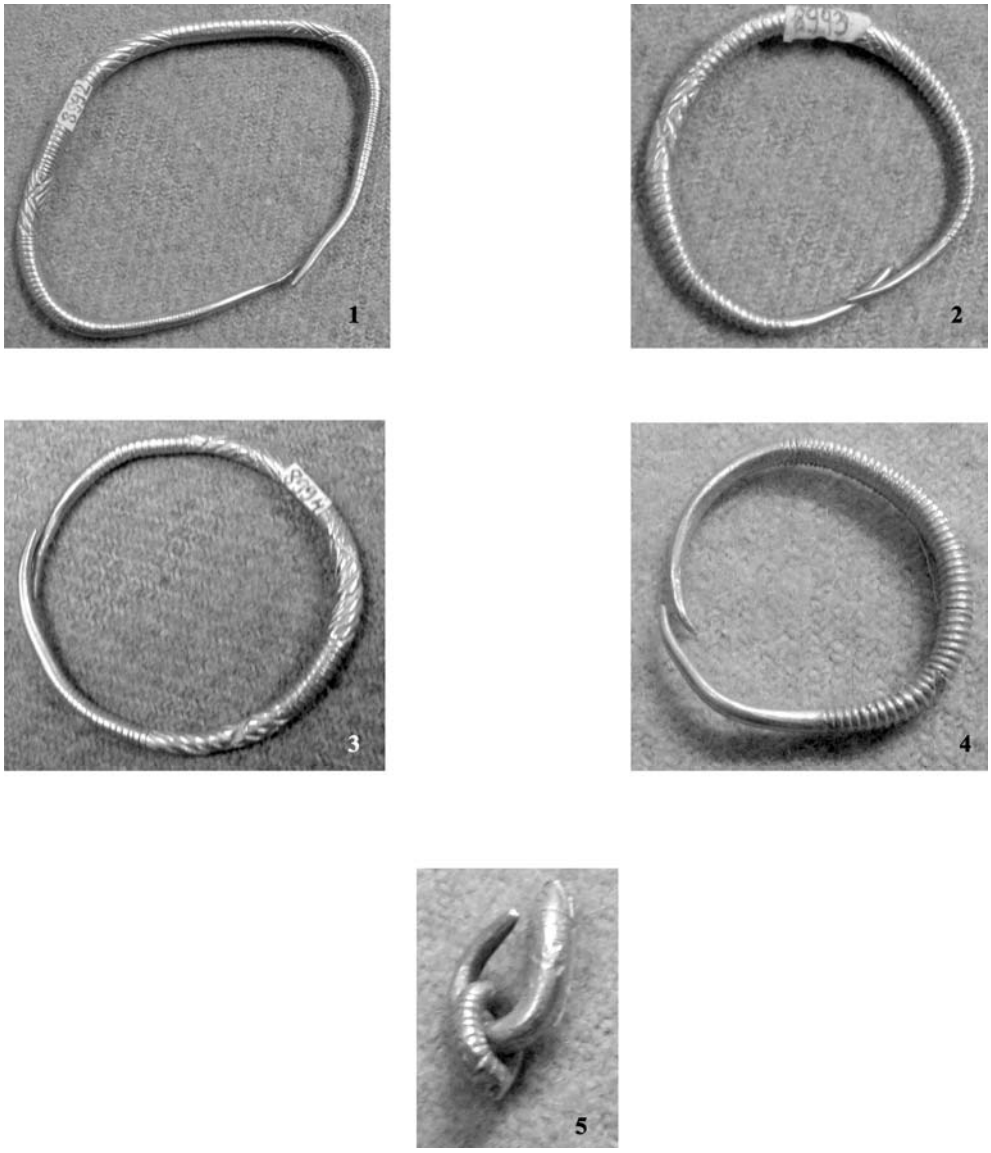

Fig. 10. Gold objects: 1–5. Tăuteu (cat. nos. 8.1–3, 8.5–6).

8.6. Inv. no. 8997 (fig. 10/5)
W = 1.20 g; L = 1.0 cm
Two fragments of notched rings, both from the ends of the gold bar. It is difficult to determine if the fragments belonged to one item or if they were cut from two different rings.

BIBLIOGRAPHY

Ardos 1936	F. Ardos, *Date arheologice privitoare la Oradea şi judeţul Bihor*, Familia 3, 4, 1936, p. 61–76.
Bader 1978	T. Bader, *Epoca bronzului în nord-vestul României. Cultura pretracică şi tracică*, Bucureşti, 1978.
Burda 1979	Ş. Burda, *Tezaure de aur din România*, Bucureşti, 1979.
Ciugudean 2010	H. Ciugudean, *Piesele de aur din depozitul Cugir I şi relaţia lor cu sistemele metrologice din Bronzul târziu*, Apulum 47, 2010, p. 23–40.
Constantinescu *et alii* 2010	B. Constantinescu, E. Oberländer-Târnoveanu, R. Bugoi, V. Cojocaru, M. Radtke, *The Sarmizegetusa bracelets*, Antiquity 84 (326), 2010, p. 1028–1042.
Constantinescu *et alii* 2012	B. Constantinescu, D. Cristea-Stan, A. Vasilescu, R. Simon, D. Ceccato, *Archaeometallurgical characterization of ancient gold artifacts from Romanian Museums using XRF, Micro-PIXE and Micro-SR-XRF methods*, Proceedings of the Romanian Academy, Series A, 13, 1, 2012, p. 19–26.
Cooke *et alii* 1999	R. Cooke, I. Isaza, J. Griggs, B. Desjardins, L.A. Sanchez, *Who Crafted, Exchanged, and Displayed Gold in Pre-Columbian Panama?*, in J. Quilter, J.H. Hoopes (eds.), *Gold and Power in Ancient Costa Rica, Panama, and Colombia*, 1999, p. 91–158.
Cristea 2013	D. Cristea, *Studiul aurului din România în vederea stabilirii provenienţei obiectelor arheologice din patrimoniul cultural naţional*, Rezumatul tezei de doctorat, 2013, http://www.unibuc.ro/studies/Doctorate2013Februarie/CRISTEA%20DANIELA.
Dumitrescu 1935–1936	V. Dumitrescu, *Le dépôt de la fin de l'âge du bronze découvert à Tăuteni*, Dacia 5–6, 1935–1936, p. 225–234.
Dumitrescu 1937–1940	V. Dumitrescu, *Funde aus der zweiten Periode der Bronzezeit im Bezirk Arad*, Dacia 7–8, 1937–1940, p. 127–131.
Gogâltan 1999	F. Gogâltan, *Bronzul timpuriu şi mijlociu în Banatul românesc şi pe cursul inferior al Mureşului. Cronologia şi descoperirile de metal*, Timişoara, 1999.
Hartmann, Sangmeister 1972	A. Hartmann, E. Sangmeister, *The Study of Prehistoric Metallurgy*, Angew. Chem. Int. Ed. 11, 7, 1972, p. 620–629.
Iliescu 1968	O. Iliescu, *Tezaurul de obiecte premonetare de la Căuaş*, Creşterea colecţiilor. Caiet selectiv de informare 23–24, 1968, p. 87–88.
Kacsó 2014	C. Kacsó, *Date noi cu privire la tezaurul de aur din epoca bronzului de la Căuaş*, in R. Gindele (ed.), *Arheologie în context regional şi european. Studii în onoarea lui Németi János la aniversarea a 75 de ani*, StComSatuMare 30/1, 2014, p. 105–124.
Leahu 2003	D. Leahu, *Consideraţii cu privire la falerele de aur din epoca bronzului descoperite pe teritoriul României*, CA 12, 2003, p. 89–107.
Leahu 2010	D. Leahu, *Vaso di Biia*, cat. no. 4, in E. Oberländer-Târnoveanu, L. Ungaro (eds.), *Ori antichi della Romania. Prima e dopo Traiano*, Milano, 2010, p. 131.

Luca, Pinter, Georgescu 2003	S. Luca, Z.K. Pinter, A. Georgescu, *Repertoriul arheologic al judeţului Sibiu. Situri, monumente arheologice şi istorice*, Bibliotheca Septemcastrensis III, Sibiu, 2001.
Mozsolics 1965–1966	A. Mozsolics, *Goldfunde des Depotfundhorizontes von Hajdúsámson*, BerRGK 46–47, 1965–1966, p. 1–76.
Mozsolics 1973	A. Mozsolics, *Bronze- und Goldfunde des Karpatenbeckens. Depotfund horizonte von Forró und Ópályi*, Budapest, 1973.
Müller-Karpe 1959	H. Müller-Karpe, *Beiträge zur Chronologie der Urnenfelderzeit nördlich und südlich der Alpen*, Berlin, 1959.
Nestor 1932	I. Nestor, *Der Stand der Vorgeschichtsforschung in Rumänien*, BerRGK 22, 1932.
Oanţă-Marghitu 2013	R. Oanţă-Marghitu, *Depozitul de la Tăuteu, jud. Bihor*, cat. no. 35.1–35.5, in R. Oanţă-Marghitu (ed.), *Aurul şi argintul antic al României*, Catalog de Expoziţie, Muzeul Naţional de Istorie a României, Bucureşti, 2013, p. 224.
Petrescu-Dîmboviţa 1961	M. Petrescu-Dîmboviţa, *Date noi cu privire la depozitul de bronzuri de la Tăuteu (r. Marghita, reg. Crişana)*, ArhMold 1, 1961, p. 81–114.
Petrescu-Dîmboviţa 1977	M. Petrescu-Dîmboviţa, *Depozitele de bronzuri din România*, Bucureşti, 1977.
Popescu 1956	D. Popescu, *Prelucrarea aurului în Transilvania înainte de cucerirea romană*, MCA 2, 1956, p. 196–250.
Popescu 1962	D. Popescu, *Asupra unor tezaure de aur din epoca bronzului*, SCIV 13, 1, 1962, p. 399–411.
Popescu D., Popescu V. 1955	D. Popescu, V. Popescu, *Asupra tezaurului de aur de la Ostrovul Mare*, SCIV 6, 3–4, 1955, p. 865–881.
Rusu 1972	M. Rusu, *Consideraţii asupra metalurgiei aurului din Transilvania în Bronz D şi Hallstatt A*, ActaMN 9, 1972, p. 29–63.
Schroller 1925	H. Schroller, *Die Goldschale von Hermanstadt*, JahrbBSM, Kronstadt, 1925, p. 114.
Soroceanu 2008	T. Soroceanu, *Die vorskythenzeitlichen Metallgefäße im Gebiet des heutigen Rumänien / Vasele de metal prescitice de pe actualul teritoriu al României*, Bronzefunde aus Rumänien III, Bistriţa – Cluj-Napoca, 2008.
Ţârlea, Popescu 2013a	A. Ţârlea, A.-D. Popescu, *Aurul şi argintul în epoca bronzului şi prima epocă a fierului*, in R. Oanţă-Marghitu (ed.), *Aurul şi argintul antic al României*, Catalog de Expoziţie, Muzeul Naţional de Istorie a României, Bucureşti, 2013, p. 48–63.
Ţârlea, Popescu 2013b	A. Ţârlea, A.-D. Popescu, *Depozitul de la Tăuteu, jud. Bihor*, cat. no. 35, in R. Oanţă-Marghitu (ed.), *Aurul şi argintul antic al României*, Catalog de Expoziţie, Muzeul Naţional de Istorie a României, Bucureşti, 2013, p. 223.
Zaharia 1959	E. Zaharia, *Die Lockenringe von Sărata-Monteoru und ihre typologischen und chronologischen Beziehungen*, Dacia N.S. 3, 1959, p. 103–134.

OBIECTE PREISTORICE DE AUR DIN COLECȚIILE MUZEULUI NAȚIONAL DE ISTORIE A ROMÂNIEI REZULTATELE ANALIZELOR PRIN FLUORESCENȚĂ DE RAZE X

REZUMAT

Mai multe obiecte preistorice de aur, selectate din colecțiile Muzeului Național de Istorie a României, au fost analizate folosindu-se metoda fluorescenței de raze X (XRF), în cadrul proiectului ARCHAEOMET (2005–2008). Obiectele în cauză au fost datate în epoca bronzului şi prima epocă a fierului şi provin din spațiul intra-carpatic. Compoziția pieselor respective este discutată în corelație cu tipologia, asocierea în tezaure, cronologia şi distribuția geografică a acestora. Rezultatele indică folosirea în această perioadă a *electrum*-ului (aliaj natural al aurului cu argintul), exploatat, cel mai probabil, din surse secundare (aur aluvionar). Există tezaure extrem de omogene din punctul de vedere al compoziției metalului (de exemplu, tezaurul de la Căuaş), dar şi tezaure ale căror piese sunt caracterizate prin compoziții extrem de variabile (de exemplu, cel de la Şmig). Se observă o posibilă legătură între categoria/tipul obiectelor analizate şi compoziția aurului utilizat, mai clară în unele cazuri (brățările cu secțiune rombică datate în Bronz D – Hallstatt A), sau între asocierea obiectelor şi compoziția metalului (cele două verigi torsionate din tezaurul de la Şmig, care, cel mai probabil, reprezintă o pereche de cercei, au şi o compoziție aproape identică). Deşi lotul analizat este mult prea restrâns pentru a fi statistic reprezentativ, se poate presupune o oarecare legătură între utilizarea aurului nativ cu o anumită puritate şi perioadă: Bronzul Mijlociu pare caracterizat de folosirea unui aur cu un titlu mai slab, conținând un procent mai ridicat de argint, în timp ce, începând cu Bronzul Târziu şi la începutul primei epoci a fierului, pare să se fi preferat un aur cu o puritate mai mare. Este de văzut dacă analizele viitoare, pe loturi mai mari de obiecte, vor confirma sau infirma această observație. Cea mai slabă legătură pare să existe până acum între compoziția aurului utilizat şi distribuția geografică a descoperirilor, ceea ce are sens dacă se iau în considerare şi alți factori, precum surse de materie primă utilizate, ateliere şi arii de distribuție pentru diferite categorii de obiecte în diferite perioade.

Cuvinte-cheie: Epoca bronzului – prima epocă a fierului; obiecte de aur; compoziția aurului; analiză compozițională XRF.

EXPLICAȚIA FIGURILOR

Fig. 1. Harta cu răspândirea tezaurelor menționate în text.

Fig. 2. Conținutul de aur şi argint al pieselor analizate, în corelație cu asocierea lor în depuneri.

Fig. 3. Conținutul de aur şi argint al pieselor analizate, în corelație cu tipologia lor.

Fig. 4. Conținutul de argint şi cupru al pieselor analizate.

Fig. 5. Compoziția eşantioanelor de aur obținute din minele aurifere din Transilvania (după Cristea 2013, p. 40, fig. 48).

Fig. 6. Compoziția eşantioanelor de aur obținute din aluviuni aurifere (după Cristea 2013, p. 45, fig. 51).

Fig. 7. Piese de aur: 1. Apoldu de Sus (cat. nr. 1.1); 2–4. Biia (cat nr. 2.1); 5–9 Cacova (cat. nr. 3.1–5).

Fig. 8. Piese de aur: 1–6. Căuaş (cat. nr. 4.1–6); 7–8. Pecica (cat. nr. 5.1–2).

Fig. 9. Piese de aur: 1–4. Săcueni (cat. nr. 6.1–4); 5–9. Şmig (cat. nr. 7.1, 7.36).

Fig. 10. Piese de aur: 1–5. Tăuteu (cat. nr. 8.1–3, 8.5–6).

Tabel 1. Rezultatele analizelor prin metoda fluorescenței de raze X (n.d. = nedeterminat; n.m. = nu a fost măsurat).