

## ANCIENT METALLURGICAL TRADITIONS AND CONNECTIONS AROUND THE CAPUT ADRIAE

A. Giumlia-Mair<sup>#</sup>

AGM Archeoanalisi, Via E.Toti 8, I – 39012 MERAN (BZ), Italy

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### Abstract

*In the last decade several archaeological projects concerning metallurgical tradition and techniques, were carried out on metal finds from various sites around the Northern Adriatic and in the Eastern Alps. The pieces, made of different metals, are dated to various periods, between the Late Bronze Age and Late Antiquity. The results of different kinds of analytical techniques, applied to several hundreds of archaeological metal artefacts from this area, are presented and evaluated in the paper. The different metallurgical techniques and traditions, identified during the researches are illustrated, compared and interpreted. An overview of the available data and of the general trends of ancient metallurgy in this broader area is attempted.*

**Keywords:** *Archaeological metal artefacts; Analytical techniques; Caput Adriae*

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### 1. Introduction

In the last decades several analytical projects were carried out on archaeological metal objects, dated to different periods, coming from the broader area around and between the Eastern Alps and the Upper Adriatic Sea coasts. Aim of these projects was the investigation of materials, metallurgical techniques and local metalwork traditions, from Prehistory to Roman times and Late Antiquity, in this relatively large area, called in archaeology

the Caput Adriae, i.e. the Head of the Adriatic. An important target of this research is the reconstruction of the metal trade and of the metal routes in the different periods. As metals were by far the most valuable and the most important materials from the economic point of view from the Neolithic to the first half of the 20<sup>th</sup> c. AD (even now metals are second only to mineral oil), the knowledge about trade patterns and trade routes would ultimately also allow a better understanding of the economy and therefore also of the politics and of the reasons for the historical

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<sup>#</sup> Corresponding author: [giumlia@yahoo.it](mailto:giumlia@yahoo.it)

development of the various periods.

Several groups of metal finds were analysed in the course of different projects, so that many hundreds of analysis results can now be evaluated and discussed. The analytical projects were partly carried out by using different analytical methods (see below). In the comparison of different groups of materials it is therefore necessary to state the kind and the precision of the methods.

In this paper the different metallurgical techniques and traditions, identified during the various researches will be illustrated, compared and interpreted and an overview of the available data and of the general trends of ancient metallurgy in this broader area will be attempted.

## 2. Experimental

Most analyses of copper-based items were carried out by using either Inductively Coupled Plasma Spectrometry (ICP-OES) or Atomic Absorption Spectrometry (AAS) or both - i.e. in some cases ICP was the main method used, however also AAS was employed for determining for some elements, for example antimony, arsenic and bismuth - except in the cases in which other methods, such as X-rays Fluorescence Spectrometry (XRF) or Energy Dispersive Spectrometry on the Scanning Electron Microscope (SEM/EDS) are specifically mentioned. Surface analysis methods like XRF and SEM/EDS were employed mainly in the case of intact pieces, when sampling would have meant unacceptable damage to the object, when the issue was mainly that of determining major alloys components or when the museum did not allow sampling. For all analyses carried out after 2000 the

objects were first checked, before sampling, by non-destructive XRF analysis. The ICP and AAS results have a precision of approximately +/- 1-2% for Cu, +/- 5% for elements present at a level of around 5%, but deteriorate to +/- 50% at the detection limits for each element. The quoted standard deviation is 1%.

## 3. Discussion

In the Southern part of the Alps, with the notable exception of Trentino/South Tyrol [1, 2, 3] there are only very modest copper ore deposits [4]. In particular in the region Friuli-Venezia Giulia there are almost no other ores than iron deposits, possibly exploited since Roman times [5]. This fact in some way simplifies the question on the origins of the locally employed copper: it had to be imported from elsewhere. The source of copper might have been the rich deposits in Trentino [1-3], in Austria [6] and in particular in the Grauwacken area, or even, at least in the earliest phase, copper deposits in Serbia. Fairly recent lead isotopes studies have shown that the copper used to produce the finds from the site on the Mariahilfberg, belonging to the Neolithic Münchshöfen culture of Central Europe, dated to the second half of the 5<sup>th</sup> millennium BC, might have come from the Serbian mines of Majdanpek, even though this Austrian area is one of the richest copper-mining zones in Europe and on the site some extremely early traces of smelting of sulphidic ores were found [7]. Indeed, the mines of Rudna Glava in Serbia [8] and Ai Bunar in Bulgaria [9] are considered the earliest mines in Europe.

The earliest copper object found in Northern Italy up to now is a pointed tool

dated to the mid- or to the recent Neolithic and found at Bannia-Palazzine di Sopra (Pordenone). The point is most probably made of native copper, hammered into shape with a rounded piece of rock. It has not been possible to take a destructive sample from the object, so it was decided to use XRF- and SEM/EDS, which have shown that it is made of unalloyed copper with only very low impurities [10].

The few Eneolithic finds in Friuli-Venezia Giulia seem to be distributed along the route on the river Natisone, between Aquileia and Oriental Alps, and from Central Carnia. Only small flat axes and a single example of Kozarac-type axe can be dated to this period. The analyses of three examples from Muina (Carnia), Sedulis (S. Giovanni di Casarsa) and from Gabrovizza di Savogna (Cividale), identified trace elements which seem to be typical for the rich deposits of Salzburg and Tyrol, but also in Slovenia there are deposits which might be compatible with this trace elements pattern [21]. On the example from Sedulis some traces of cold working are visible (Fig.1), but nothing similar can be seen on the other two pieces. As the studies by Budd on the Mondsee-type axes [22] and by Kienlin on the Altheim-type axes from Austria, Bohemia and Moravia [23,24] have shown, there was in the Eneolithic an evolution in the production technology of axes: in the second phase more extensive cold working was used. Because of the traces of working and of their typology the axes from Sedulis and from Muina seem to belong to the later Eneolithic period.

The group of analysed objects dated to the Bronze Age found in the region Friuli Venezia Giulia is rather small, as only very few metal finds dated to this period were found, while in Slovenia, Austria and in the

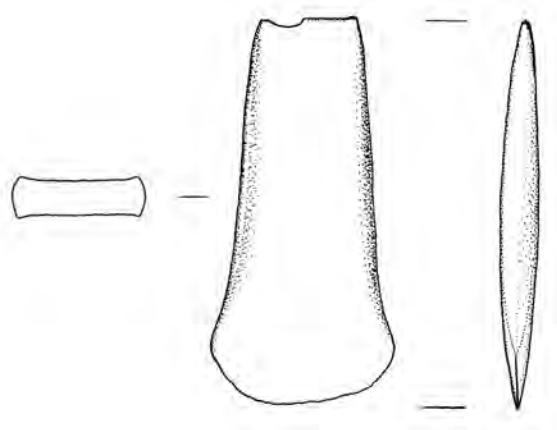


Fig. 1. Small flat axe from Sedulis (Friuli-Venezia Giulia, Italy), dated to the second phase of the Eneolithic (drawing AGM Archeoanalisi).

Italian region Trentino the number of finds is much higher. This fact reflects the lack of copper mines in Friuli. The analyses carried out on the slag remains found in Trentino have demonstrated that they can be correlated with the polysulphidic metal ores from the Fersental/Valle dei Mocheni mining area, which consist of chalcopyrites, pyrites, galena and sphalerite. These ores were employed through the Bronze Age, as there are no particular differences in the composition of the slag from the different sites, except that in the earlier period there is less plate slag and no slag sand and in the later period the slag cakes are larger [11].

In the Austrian Alps the local chalcopyrites were exploited. The smelting processes were very similar and the composition of the slag varies only slightly, depending on the composition of the ores and on the variations in the smelting process phases, so that it is quite difficult to use the trace elements for the determination of the provenance of the metal [11].

In Slovenia several copper mines are known, such as for example Cerkno, Toplice,

Škofje, Novine and Novaki, but there are some deposits also in the Western Sovodenj and in the Šebrelje and in the Pohorje areas [12]. Fahlerz-type ores were employed in Austria since the Neolithic [13,14], and this kind of ores were also employed in Slovenia and in Friuli-Venezia Giulia. However it is quite interesting to note that this kind of ores were apparently not employed in Switzerland until the Hallstatt A2 period, i.e. around 1050 BC [15].

In the Final Bronze Age there is a decrease in the use of tin and this suggests that there were problems with the supplies of this rare metal [5]. The same problem is recognizable in Slovenia, where a very large number of artifacts has been carefully and in a very detailed way analysed by Neva Trampuž Orel [16-19]. Also here a crisis in the tin trade is evident.

In Italy there seems to be a similar phenomenon: for example the finds of the Recent Bronze age sites Cingoli and Tolentino, in the Italian region Marche, contain much more tin (with an average of around 10%), than the objects belonging to the site of Variano in Friuli, dated to the Final Bronze Age, which only show an average of around 4 % [5]. In the Friulian site Variano (Fig.2) the small objects found - mainly awls, points and sickles - are mostly made of

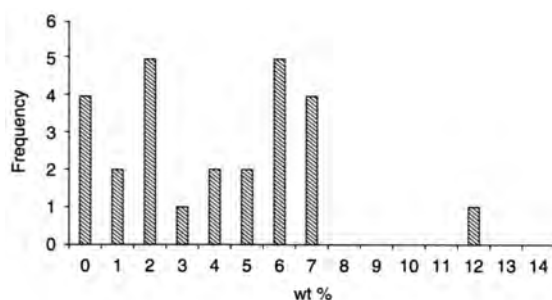


Fig. 2. Histogram of the Sn content in the Final Bronze Age finds from Variano (Friuli-Venezia Giulia, Italy).

low tin bronzes (range 0 - 6 % Sn). Thin points, needles, wire rings or wire-chains are mostly made of unalloyed copper, while the few massive tools, such as axes, are made of bronze with around 10% of tin and 1-2 % of lead. Lead is still used as simple cheap additive to the copper and has no real metallurgical function [20]. A much larger number of analyses would be necessary to have a more precise and detailed picture of the whole situation in the local Final Bronze Age, but already these few data give some indication.

The transition period between Final Bronze Age and Early Iron Age and the following centuries deserves special attention, as at this time the trade and metal supply pattern seems to become more complex and there are clear indications of a widened net of connections with very different areas.

With the increase of the economic significance of the S.Lucia/Most na Soči facies, the role of the populations in the Caput Adriae seems to have changed from the more passive role of buyer/trader and perhaps small producer of metals to a more powerful position. As the fortified sites identified up to now in Slovenia demonstrate, the population clearly controlled the strategic passages through the Alpine passes and along the river Isonzo down to the Adriatic. The important surveys and the excavations by Drago Svoljšak [25] showed that along the main trade routes in today's Slovenia there were fortified settlements, such as Ravelnik, near Bovec, the two gradišče near Robič, and Koritnica, on the confluence of the mountain streams Koritnica and Bača and on the route to the place which in the full Iron Age became the important iron production centre of Bohinj.

It is also important to note that in this period, at the onset of the Iron Age, the very ancient amber route, which in the course of the Bronze Age crossed the Alps at the Brenner pass, came down to the Lake of Garda and followed the valley of the Adige river to the sea, was moved to the East and crossed the Alps in Slovenia, following then the Soča/Isonzo valley down to the Adriatic. In this way all passes and roads to the Hallstatt territory in the northern Alps, to the territory of the Dolenjsko facies in the Sava basin and down to the Friulian Plain were under the power of the S.Lucia/Most na Soči group. Through its fortified sites this facies directly controlled the trade on the ancient amber route and the imports coming from the plain and the sea, directed to the North.

The cultural and trading connections of this territory in this period are quite clear from the wide choice of finds imported from far away regions in the settlements of the Caput Adriae.

The most famous piece is perhaps the Etruscan oinochoe from grave 3145 (Fig. 3) in the necropolis of Most na Soči, excavated by Marchesetti in 1894, but in the same necropolis are also present for example small glass vessels and anthropomorphic glass beads from the Eastern Mediterranean, ornaments made of Baltic amber [26] and Glasinac-type fibulae [27,28] (Fig. 4). Exotic goods are found also in many more settlements in the large area around the Caput Adriae. A horsebit made of incised antler of a type known in the Danubian-Carpathian area was excavated in the settlement of Ciastiei-Pozzuolo del Friuli (Udine) [29], and it is also well known that pottery of Daunian-type, i.e. from the eastern Italian coast, has been found in Magdalenska Gora, Trnovo (Ilirska Bistrica), Nesactium,

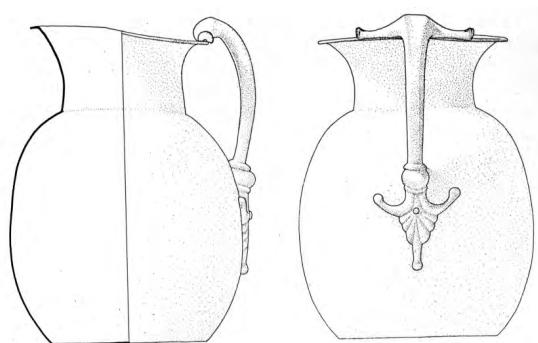


Fig. 3. Etruscan oinochoe from grave 3145 from the necropolis of S.Lucia/Most na Soči, excavated by Marchesetti in 1894 now in the Trieste History and Art Town Museum [drawing from 26].



Fig. 4. Fibula of Glasinac-type inv.nr. N 9625, Trieste, from the necropolis of S.Lucia/Most na Soči, imported from the Bosnian territory (Photo A. Giumlia-Mair)

Pula, Zadar and Jagodnja Gornja [30].

The researches carried out on Iron Age materials from this area indicate that in this period much less unalloyed copper was used and also low-tin bronzes are less frequent. The introduction of appropriately employed leaded bronzes for castings can be dated to

the beginning of the local full Iron Age, at the beginning of the 8<sup>th</sup> century BC. The copper employed for sheet metal and hammered parts is carefully purified and alloyed with tin only [5]. The debris of an Iron Age workshop found in a ditch at Pozzuolo del Friuli was identified as dross, i.e. purification slag, and this, together with the fact that less well refined copper was employed for everyday metal objects, demonstrates that the refining of the copper was carried out in the workshop and not by the copper traders. The traders had more interest in selling unpurified copper of major weight, but they also seem to have collected scrap metal for recycling [31]. The recycling of bronze scrap is documented already in the Late Bronze Age in the site of Variano (Udine), where two small bars of bronze with 7% of tin have been recovered. No bronze objects of this composition could be identified among the finds from the excavation and it seems quite clear that the local smiths prepared their own alloys by adding copper or tin in the required proportion to obtain the kind of alloy they needed [20]. A very similar small bronze bar with 7% of tin was also recovered from the excavation at Pozzuolo del Friuli and this suggests that there was stockpiling of scrap which was re-melted and traded in form of small bars with a standard composition of around 7% of tin in the bronze alloy [32,33].

From the trace elements in the impure copper it seems that the same metal was used in the whole area of the *Caput Adriae*, from the Friulian Plain up North to the mountain zone of Carnia and to the Slovenian sites, i.e. that the sources of copper were the same and that the metal was distributed by the traders in a capillary way on the same paths used for many centuries. Some details of the trade

routes can also be reconstructed from the composition of particular objects in particular sites. A rather interesting result of the analyses of the materials from the necropolis of Paularo (Udine) in Carnia, a site near today's border to Austria, is that while the copper employed for the manufacture of the locally produced objects resulted (not surprisingly) to be the same employed in the site of S.Lucia/Most na Soči, the use of tin resulted to be very different and much less abundant. Paularo was an important and rich site, because it controlled one of the most important and comfortable alpine passages to the Hallstatt settlements on the Northern side of the Alps. The wealth of the site is reflected in particular by the use of many heavy and thick bronze ornaments of personal use (Fig.5) found in the graves [34,35], but the tin content is in general very low and there are even objects made of unalloyed copper. It is quite clear that the tin supply was difficult and that the trade route for this metal was different from that of copper [5].

It is quite interesting to note that the use of tin in the bronzes from the famous site Sanzeno, in Trentino, seems to be quite different from both that determined in Slovenia and in Friuli. Indeed the group of vessels analysed for a project of the Soprintendenza di Trento contain very high percentages of tin, up to 14%, even in the case of parts produced by hammering. The high tin content must have required careful and repeated annealing, but apparently the aim was that of producing a very shiny and bright bronze of light colour. As comparison the parts of vessels made of sheet metal at S.Lucia/Most na Soči only very seldom reach 12% of tin. The cast parts of vessels from Sanzeno contain up to 15% of tin, while

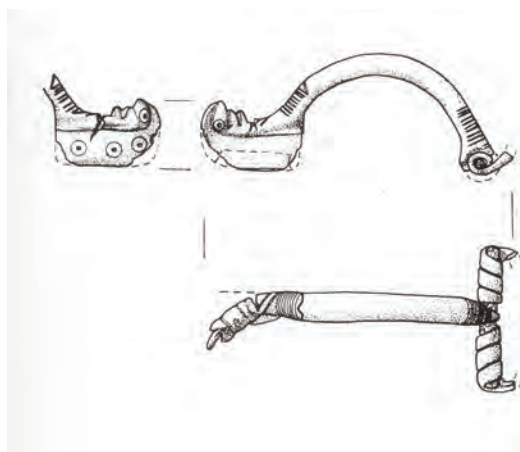


Fig. 5a. Paularo-type fibula. This fibula type seems to imitate the ostalpine Tierkopf-type fibula, diffused from Switzerland to Hungary and from the Danube to the Caput Adriae. (drawing from 35)

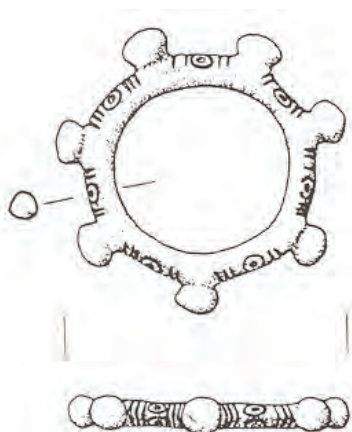


Fig. 5b. Pendant with seven knots, belonging to the Paularo-type fibula. Similar pendants are found in the same areas of the ostalpine Tierkopf-type fibula, but the number of knots is different (4, 5, 6). Seven knots pendants seem to be a peculiarity of the Paularo site. (drawing from 35)

the ones from S.Lucia/Most na Soči barely reach 11% of tin. As already pointed out, the tin content of the bronzes from Paularo is in general very low, with a mean of around 8%. This seems to indicate that tin was more

readily available in Trentino, than in Slovenia and Friuli and the possible reason might be the important trade route which came down from Northern Europe, the Baltic and through the Erzgebirge. The source of tin might have been either Cornwall and its sea trade along the Northern coast, or even the Erzgebirge, where apparently cassiterite was found in river placers as late as in the Renaissance [36,20].

As discussed elsewhere the geographic distribution of specific objects can help in the identification of some of the most important trade routes. A good example are for instance the ostalpine Tierkopf-type fibulae which circulated in the entire area of the Iron Age koinè, from Switzerland to Hungary and from the Caput Adriae to the Danube around Regensburg in Germany, with a high concentration around the Drava and the Sava rivers, and show the close trade connections in this very large territory. However the way in which specific trade goods were distributed is better illustrated by the example of the Certosa 7F-type fibula which is found along the Istrian and Dalmatian coast, on the Sava and its affluents, down the Isonzo river and in the Alps, while two single pieces, found in the Northern Italian regions Veneto and Lombardia seem to indicate that there was also some connection through the Adriatic, perhaps from Istria to the Po delta.

The distribution of the Bandbogen-type fibula shows that the connections were the river valleys through and down the Alps and not the wide Po Plain, as this kind of fibula is found along the rivers Sava, Drava, Isonzo, Isarco, Adige and in the alpine valleys [5,35].

A rather impressive case of analytical researches carried out on specific objects of special composition which allowed the

reconstruction of close connections and even the determination of the same religious beliefs in a relatively large area are the almost identical anthropomorphic pendants found in the cemeteries of S.Lucia/Most na Soči on the river Isonzo (Fig. 6), in Paularo (Carnia, Italy) (Fig. 7) and in Vače – Slovenia (Fig. 8) [41].

The pendants represent a female deity set



Fig. 6. Anthropomorphic pendant found in the richest grave of the necropolis of S.Lucia / Most na Soči on the river Soča / Isonzo in Slovenia, dated to the late 6th- early 5th c. BC. The person buried in the grave was a high status woman (Photo A. Giumlia-Mair)



Fig. 7. Anthropomorphic pendant found in the richest grave of the necropolis of Paularo in Carnia (Friuli-Venezia Giulia, Italy), dated to the late 6th- early 5th c. BC. The person buried in the grave was a high status woman (Photo A. Giumlia-Mair)



Fig. 8. Anthropomorphic pendant found in the 19th century, in a rich grave of the necropolis of Vače in Slovenia, now in the Natural History Museum in Vienna. The pendant is dated to the late 6th- early 5th c. BC and the person buried in the grave was a high status woman (Photo A. Giumlia-Mair)

on a stylised boat decorated with concentric circles and animal heads. The animals were interpreted as aquatic birds, while the concentric circles are commonly identified as solar symbols. More anthropomorphic pendants of smaller size were originally hanging from the goddess' "boat" and, after some scholars, most probably signified fertility, as the representation of her children, or perhaps of her male companions or satellites. The water birds signify powers over water, earth and air, as in the beliefs of the time these animals dominate all three elements. Water birds are therefore often represented on sacred objects, in particular vessels, in many archaeological contexts around the Alps and in Central Europe.

The three astonishingly similar ornaments are dated to the late 6<sup>th</sup> - early 5<sup>th</sup> c. BC. They were produced by casting and it is possible that they come from the same mould or perhaps even that one of them was used as model to produce copies. The slightly



different details of the decoration were carried out before casting, directly on the wax model produced either with the original mould or copied from the finished original piece. After casting the metal into the mould the surface was cleaned from the casting skin and polished, with very little cold working.

The three pendants could not be sampled and were non destructively analysed by XRF. For each piece 6-9 measurements were carried out on cleaned areas. Surprisingly the alloy used for the pendant resulted to be a copper containing 6-8% Sn, around 4% of arsenic, some lead, antimony and silver.

Copper alloys containing arsenic were used at the beginning of copper metallurgy in Europe, already in the second half of the fifth millennium BC, for example on the Mariahilfbergl in Brixlegg (Austria) [7], or in some Spanish Chalcolithic settlements dated to the third Millennium BC [37], but mainly in the Early Bronze Age all over Europe: However from the Middle Bronze Age, after the introduction of copper-tin alloys - which have better working properties and do not produce poisonous fumes - copper-arsenic alloys seemed to have been completely abandoned. Therefore the use of copper alloys containing arsenic for the production of ornaments dated to the Iron Age resulted quite surprising.

The presence of arsenic changes the properties of the copper which hardens faster when wrought, but it also confers a beautiful silvery grey nuance of colour to the surface of cast objects, because of the phenomenon of inverse segregation. As several laboratory experiments showed [38,39], this can occur in copper alloys already with 1-2% of arsenic in the alloy. On the surface of the cast pieces made of this material there is the formation of small quantities of the low melting point

eutectic with 21% of arsenic on the surface of the castings (Fig. 9). The phenomenon is currently called “arsenic sweat” and it

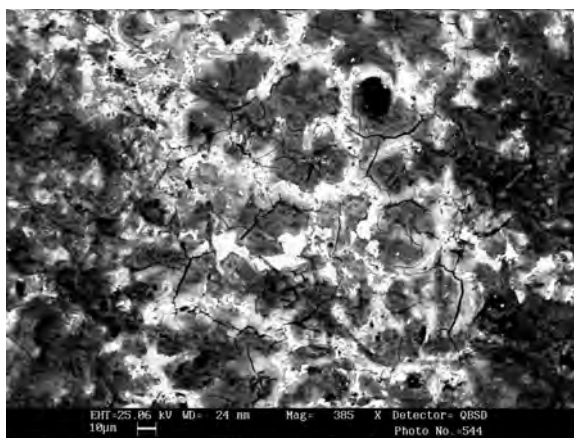


Fig. 9. SEM micrograph in back scattered mode of the surface of a copper containing arsenic and antimony, showing the formation of the low melting point eutectic with 21% of arsenic on the surface of the castings. (Micrograph A. Giunlia-Mair)

involves the pushing of the eutectic through interdendritic filaments (or feeders) to the surface, where it solidifies and forms the typical silvery layer. The maximum limit of solid solubility of arsenic in copper is 7,5% As. The microstructure of the eutectic shows a solid solution phase  $\alpha$  and a compound  $\gamma$ , containing 29,65 As ( $\text{Cu}_3\text{As}$ ).

The compound  $\gamma$  is still malleable and can be worked, while in the case of inverse segregation of tin in copper the so-called “tin sweat” is extremely fragile and it breaks if worked by hammering [40]. Copper alloys containing antimony also build up a segregation layer on the surface and behave under the hammer like copper-arsenic alloys. Therefore the presence of both arsenic and antimony greatly enhances the segregation phenomenon and produces a more compact

silvery layer. In the pendants the silvery effect was even more enhanced by the presence of 1-2% of silver, but also of nickel and some cobalt. The pendants had therefore a very noticeable silvery colour.

We do not possess any analytical data on the objects from the necropolis of Vače, however around 150 copper-based finds from the necropolis of Most na Soči and around 130 copper-based finds from the necropolis of Paularo have been analysed by the author and none of them was made of a similar alloy. It is therefore quite clear that these were very special items and had a particular meaning. A second very important point for the interpretation of these silvery ornaments is the fact that the anthropomorphic pendants were found in both cemeteries in the richest grave of the whole necropolis, together with very rich burial gifts. The persons buried in these special graves were socially important women and in both cemeteries there was only one grave with these characteristics. The choice of a silvery metal for the pendants is to be connected with the cult of a moon and fertility goddess [41].

The anthropomorphic pendants from Most na Soči, Vače and Paularo have characteristics which remind those of the well known wheel-shaped pendants, found around the Alps in many sites and dated to the period between the Late Bronze Age and the Early Iron Age [42]. These are also found in exceptionally rich graves of socially important women, together with representative pieces of jewellery and other kinds of precious gifts [43]. Teržan suggested that these persons were socially important women, belonging to a special class, who played an important role in the settlements and performed special rituals or ceremonies within the community [36]. With

all probability these women were a kind of priestess or perhaps female shamans.

These pendants are normally made of tin-rich alloys of silvery colour, however, among the more common examples there are a few made of copper with high concentrations of As, Sb (0,8-1,2 %), Ni and Co (0,9—1,00 %), as well as some Sn (8-12%), therefore of alloys similar to those of the anthropomorphic pendants. A large group of wheel-shaped pendants was found in the Kanalski Vrh hoard [49], analysed by Dr Neva Trampuž-Orel of the Narodni Muzej Ljubljana [44-46]. Four wheel-shaped pendants from the same hoard (Fig. 10) and three more from different sites in Friuli were also analysed by SEM/EDS and by XRF by the author. Two specimens showed the typical cored dendritic structure, the silvery

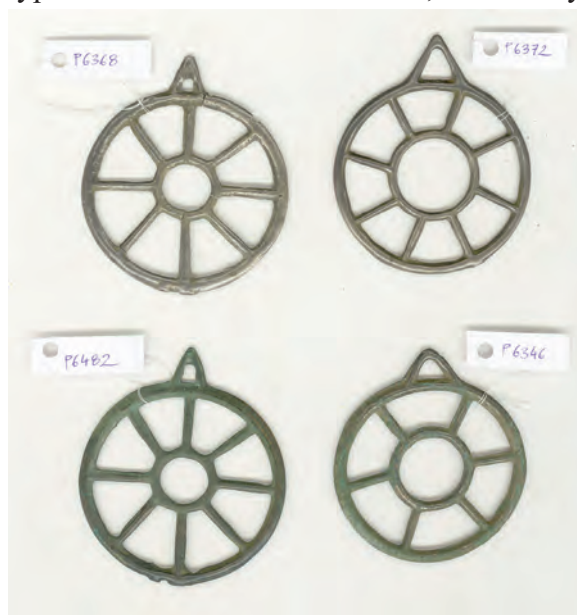


Fig. 10. Four wheel-shaped pendants from the Kanalski Vrh hoard. These are found in the graves of socially important women and are made of high Sn alloys or of copper with high concentrations of As, Sb, Ni and Co, as well as some Sn. This copper circulated in form of pick ingots. (Photo A. Giumlia-Mair).

colour due to inverse segregation and to the presence of As, Sb, Co and Ni. A more detailed discussion on wheel-pendants and their distribution and significance can be found in [41].

This very same composition is also characteristic for the well known pick ingots dated to the Late Bronze Age, recently studied in detail by Neva Trampuž-Orel [46], who identified this material as an intermetallic phase formed during the smelting process of polymetallic ores as an intermediate layer between copper and slag and suggested that the ore deposits from which this metal was extracted might be the mines of polymetallic ores, in the so-called Grauwackenzone in the Eastern Alps, where important prehistoric mines, such as the Mitterberg mine, or the ones in the Schladming and Liezen areas, were located [47,48].

It is quite interesting to note that pick ingots have been recently found in fragmentary conditions in some graves of Villanovan cemeteries dated to the 8<sup>th</sup> century BC, in the area of Bologna. Up to now only one has been published and it was found together with a fibula made of the same material [51]. We do not know through which path they arrived to Bologna, but they seem to have been deposited in the graves as precious material a couple of centuries after the time they are commonly dated to. Perhaps also these ingots should be better studied and their date reconsidered.

Pick ingots might be relevant for the reconstruction of the evolution of ancient economy not only because they seem to have been considered precious and their fragments were perhaps even used as premonetary material, but also for a further reason. Some of the minor elements which are part of their

composition, namely cobalt and antimony, are the most important and typical colorants of the glass production of Novo Mesto. While the early glass objects found in the Caput Adriae were imported from the Eastern Mediterranean, in the 8th century BC, there is suddenly a very copious production of multicoloured and variously decorated glass beads (Fig.11) in the Doleniska, i.e. in the Novo Mesto area. Nowhere in the Iron Age there exists such a copious glass production of excellent quality [52,53], and, as discussed elsewhere [35,54] the materials employed in particular for the cobalt blue and the bright yellow glass, obtained with antimony salts, might very possibly have been the slags of the pick ingots, circulating in this period. The main component of metallurgical slag is SiO<sub>2</sub>, containing various metallic salts, depending on the ore composition. However SiO<sub>2</sub> is



*Fig. 11. Multicoloured glass beads with apotropaic eyes from the area of Novo Mesto, Doleniska, Slovenia, dated to the Iron Age (Photo from 52).*

also the main component of glass, and the glass colours are given by metallic salts. There is a high probability that the working remains of the polymetallic copper used for the pick ingots were employed as colouring agents in the glass production of Novo Mesto where there are apparently quartziferous sands of good quality [52,53], which could be used for the production of glass. Indeed, at Novo Mesto colorless glass remains were also found [54] and this demonstrates that the colouring and working of glass must have been carried out in this area.

The close connections and the correlations between metallurgy and glass production should be kept in mind for deeper studies in the future.

#### 4. Conclusion

The development of metallurgy in the large area around the Eastern Alps is for the moment studied only in outline, however already the scant analysis results can give an idea of the evolution of the local metallurgical tradition. It is evident that the copper was imported into the Friulian plain from the extraction centres. In the earliest period some copper imports might have come from the Balcan area, while later the metal supply seems to come from the North. Copper and tin clearly came through different routes and the distribution in the different North Italian regions was rather irregular. The circulation of metals and of finished objects greatly increases in the Iron Age, as the many finds, coming from very different Central European and Mediterranean regions, in the pivotal area of Slovenia clearly demonstrate.

Significant indicative elements on both economy and social life can be obtained

from the study of representative objects with a social meaning, such as ornaments worn by high status persons. An excellent example are wheel-pendants and anthropomorphic pendants presented in this study.

The Balcanic regions were also the source of metal imports in Roman times, but up to now the researches carried out on materials of this this important period are very limited.

Glass production is closely connected with metallurgy and the correlated study of metal objects, metal working remains and the composition and the manufacture of glass would be extremely important for the reconstruction of trade patterns.

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