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Lombardic ornaments from San Mauro cemetery at Cividale, Italy

Analyses and technology

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Abstract: A group of very significant Lombardic ornaments from the cemetery of San Mauro at Cividale del Friuli (Udine) in Italy has been examined and analysed with X-ray fluorescence spectrometry. The objects are now part of the collections of the National Museum of Cividale del Friuli. Among the objects there are several so-called stirrup or radiate-head bow fibulae, one of which also shows an interesting cloisonné decoration, an S-shaped fibula with cloisonné, a unique gilded and nielloed equal-armed fibula with two opposite faces or masks, belt buckles and belt plates, a necklace with gold pendants with filigree and granulation, a vessel of probable Byzantine origin and a golden cross. The composition and the production technology of the single pieces are discussed in detail in the paper with relevant comparisons.

Keywords: Lombards, fibulae, gold cross, buckles, XRF

Introduction

The migration of Langobards (or Lombards) from Northern Europe took several centuries.[1] They crossed a large part of Europe and, coming down to Italy, they took with them other populations, such as for instance Goths, Gepids, Alans, Eastern Goths and Sarmatians. In 568 AD, the Lombards moved to Italy from Pannonia (modern day West Hungary: Transdanubia), where they had settled after their migration from north of the Danube and after defeating Heruls and Gepids. King Alboin occupied North-Eastern Italy almost without fighting, as the region was almost depopulated after the Gothic war (535–554). In 569 he created the duchy of Cividale del Friuli that was then handed over to Gisulf I.[2] Because of its location, the duchy was considered a strategic bulwark and the most important defense from invasions from the East, for instance by Byzantines or by the Avars. Langobard Cividale was a prosperous and rich town, as demonstrated by the luxurious good recovered from the five Lombardic cemeteries identified in various areas around the modern town.[3] The cemeteries are still now only partly excavated because they are in residential areas and the exploration can only be carried out in case of emergency excavations. The cemetery of San Mauro, from which the items discussed in this paper come, was known since the end of the 19th century, when the first grave was discovered. Later, particularly during the construction works of the railway in 1916, some more graves came to light.[4] The more extensive excavation in 2012 in occasion of the urban

1 Pagano 2013a.

2 Priester 2004; Maczynska 2004, 188–196; Paolo Diacono 1971; Riehl 2008, 281–291; Meier 2020, 805–845.

3 Borzacconi 2013.

4 Borzacconi – Giostra 2018, 236–239.

redefinition of the town area around the station brought finally to light 79 graves that could be dated to different phases, between the end of the 6th and the end of the 7th centuries AD.

The grave gifts clearly reflect the social status and the differences in wealth of the buried persons. The cemetery of San Mauro seems to have been in use from the beginning of the Lombardic immigration from Hungary, already in the first twenty years of permanent Lombardic residence in Friuli, as it was also the case with the cemetery at Gallo, but not with the larger cemetery *della ferrovia* [of the railway] that seems to have been in use in a later period.[5]

This paper presents the results of the analyses carried out in 2004 on a selection of significant metal grave goods at request of the Soprintendenza archeologia, belle arti e paesaggio del Friuli-Venezia Giulia in occasion of the rearrangement of the National Museum of Cividale, when new vitrines were also provided. These data have never been published before.

Lombardic metal objects are certainly a suitable topic for a Bronze Conference held in Hungary i.e., in the region from which this population arrived to Italy.

Fig. 1. Necklace (inv. no. 24060) from Grave 39 of a high-status lady, with red, blue, white, orange, brick red and green glass beads, amber beads, gold spacers and six gold anthropomorphic pendants with filigree and granulation (photo by A. Giumlia-Mair).

Fig. 2. Detail of the anthropomorphic pendants (L.: ca. 1.5 cm) with filigree and granulation. The gold is very pure, but it contains traces of mercury. It is possible that part of it had been recovered as filings from amalgam gilded silver objects or even from mosaic tesserae by using mercury (photo by A. Giumlia-Mair).

Fig. 3. Detail of the back of the anthropomorphic pendants showing a repair on the third pendant from the right, possibly a soldering accident that happened while attaching the filigree at the front of the gold sheet (photo by A. Giumlia-Mair).

5 Ahumada Silva 2013; Borzacconi 2013.

Method of analysis

As most of the finds selected for analysis were in rather good condition, it was not possible to take destructive samples from them and therefore we decided to use X-ray Fluorescence spectrometry (henceforth XRF), a well-known non-destructive analytical method which can determine the chemical composition of an object without sampling or touching it.[6] However, it must be noted that, should the object to be analysed be covered by a rough or thick patina, the upper layer has to be carefully removed in a very small area in order to guarantee reliable results. In the case of the objects from the San Mauro cemetery this was not necessary, as the finds are in quite good condition and the patina, when present, like for instance on vessel inv. no. 23890, is compact and thin.

Fig. 4. This radiate-head bow fibula (inv. no. 24675) (L.: 13.7 cm) from Grave 53 of an adult woman shows ornaments in Lombardic Style I and Style II. This suggests a date to the 1st–2nd decades of the 7th century. The silver of the fibula is alloyed with a recycled quaternary alloy from an amalgam gilt object (photo by A. Giumlia-Mair).

Fig. 5. The feline heads and other ungilded parts of the fibula are decorated with niello containing Cu, Zn, Sn and Pb. The photo shows a detail of the intricate gilded decoration (partly damaged) on the plate, the niello inserts on the silver and the bird of prey. The surface was selectively amalgam gilded as 1.3% Hg was determined in the gold. This was done by mixing gold filings with mercury to obtain a paste and apply it on the surface. The mercury was then driven off by evaporation i.e., by heating the object at ca. 352 °C. The surface was finally polished (photo by A. Giumlia-Mair).

The XRF equipment can quantify over 30 elements and quickly determine the elements present in the object and their relative concentration. The device is transportable (not portable!) and it consists of the head with the X-rays source, a support with devices that control stability and position, a large transformer, a stabilizer, and a laptop computer with the dedicated analytical program. The head of the system is equipped with a collimator that changes the diameter of the beam as required, a laser pointer indicating the exact area to be analysed, and a device controlling the distance from the sample. When the distance is correct (within the acceptable span of ± 0.1 mm) an audio signal is heard, and the measurement can be performed. The X-rays are emitted by a miniaturized X-ray tube. The size of the irradiated area has a diameter of around 1.5–2 mm, but the analysed spot can be smaller or larger, as required by the surface texture, the detail to be analysed and the size of the object.

The measurements are performed at a fixed angle and from a fixed distance from the sample, by illuminating with X-rays a small, flat and cleaned area on the object for a short time (typically 3–5 minutes), but, if required, the time can be longer. At least three readings were obtained for confirmation in case of unclear results.

6 Helmig et al. 1989; Lutz – Pernicka 1996; Longoni et al. 1998; Uda et al. 2005; Mendoza Cuevas – Perez Gravie 2011; Giumlia-Mair et al. 2018.

Past experiences have shown that a wide range of elements—and in particular metals and alloys—can be simultaneously quantified with a high degree of precision if proper standards and some cautions are used.[7] The different standards of various composition employed during our measurements have been expressly produced by AGM Archeoanalisi for the analysis of ancient metal alloys and represent an important tool in the evaluation of the results.

The equipment can be taken to the object—virtually anywhere—and can perform analyses in situ, even on excavation. In sum, the method offers a fast, effective, and low-cost performance and is ideal for museum pieces which cannot be sampled.

Fig. 6. Detail of the back of the feline heads. The texture of the silver on the back shows numerous bubbles and an irregular surface and suggests the use of an open mold (photo by A. Giumlia-Mair).

The data obtained was subsequently processed to achieve quantitative results. Interference effects, such as, for instance, enhanced results for elements such as iron, or low results for zinc in a copper matrix, and similar phenomena, were considered, while evaluating the results.

Fig. 7. Radiate-head bow fibula with gilding and niello (inv. no. 23883) (L.: 8.8 cm) from the rich Grave 27 of an around 7 years old female child. The silver contains around 12% copper, 3% zinc, 3% lead. The thick gold layer and the lack of traces of mercury suggest that on this fibula a gold leaf was applied instead of an amalgam (photo by A. Giumlia-Mair).

Fig. 8. Radiate-head bow fibula with gilding and niello (inv. no. 23883) seen from the back. The photo shows the fastening mechanism, the corroded iron pin, the silver catch-plate, the gilded copper-based elements that connect arch and feline heads to the fibula body (photo by A. Giumlia-Mair).

7 Cf. for example, Hahn-Weinheimer et al. 1995; Lutz – Pernicka 1996.

Results and discussion

One of the most impressive pieces among those analysed for this research is the necklace (inv. no. 24060, Grave 39) with six golden anthropomorphic pendants and multi-coloured beads (Fig. 1). The person buried in the grave was a high-status female, aged between 17 and 25 years. It is quite interesting to note that the anthropological investigations suggest that she was not a Lombardic woman but belonged to a different ethnic group. This woman most probably came to the Lombards through marriage. Beside the necklace she also had radiate-head bow fibulae similar to examples found in the Pannonian Plain and in Italian graves, dated to the early period of the Lombard migration to Italy. As shown by the analyses, the gold of the necklace is very pure, with only low traces of copper, silver, and mercury. The traces present in the alloy, specifically those of mercury, suggest that some gold filings taken from an amalgam gilded object were added to the gold of molten Byzantine coins. The pendants represent human faces (Fig. 2) with long hair, long beard, and mustaches, depicted with filigree of twisted wires and rather thick granulation representing the eyes and perhaps hair-locks on the shoulders or perhaps large brooches on the shoulders. The first face on the left has lost the

Fig. 9. Radiate-head bow fibula with gilding, niello and almandine inlays (inv. no. 23894) (L.: 11.6 cm) from Grave 21, dated to the last third of the 6th century, of a woman of 17–25 years belonging to the highest social class and to the first generation of the Lombards who immigrated to Italy (photo by A. Giumlia-Mair).

Fig. 10. One of the almandines on the halfmoon-shaped *cloisonné* on fibula (inv. no. 23894) is missing and the cross-hatched decorated gold foil backing, called boxed pattern, boxed waffle pattern or *quadrillage* is exposed. Its function was that of enhancing the light reflection effect and the colour of the transparent stones (photo by A. Giumlia-Mair).

Fig. 11. Detail of fibula (inv. no. 23894). The fourth feline head from the left, originally made of silver, gilded and nielloed, was replaced with a slightly smaller feline head made of copper containing 2.2% lead, without gilding and niello. The abundant iron corrosion visible on the top left comes from the iron rods connecting the heads to the arch and the body of the fibula (photo by A. Giumlia-Mair).

Fig. 12. S-shaped fibula with almandine cloisonné, amalgam gilding and niello (inv. no. 23891) (L.: ca. 4 cm) from Grave 21, dated to the last third of the 6th century. The silver alloy contains 17% copper, 8% zinc, 5% lead, 2% tin, and ca. 1% gold (photo by A. Giumlia-Mair).

Fig. 13. S-shaped fibula (inv. no. 23891) seen from the back. The pin was made of iron, and is now lost. The catch-pin is cast together with the silver body. A small repair can be recognized at the top (photo by A. Giumlia-Mair).

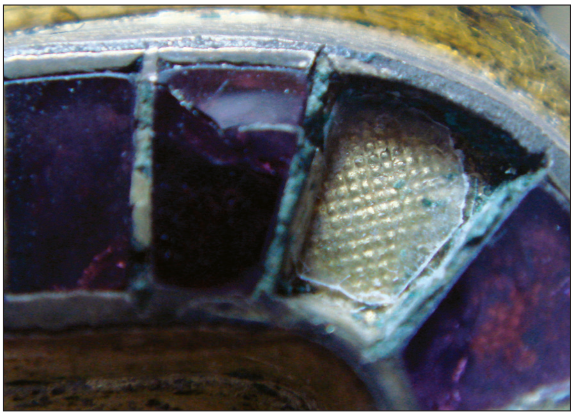

Fig. 14. Detail of the S-shaped fibula (inv. no. 23891). The backing of the almandine plates is a gold foil with simple waffle pattern, not a boxed pattern as on fibula inv. no. 23894. This suggests the existence of different jeweller's workshops at Cividale: this fibula shape is thought to be of Italian manufacture (photo by A. Giumlia-Mair).

grain of gold on its left shoulder, while the third face from the left shows a repair at the back (Fig. 3) that with all probability hides a soldering accident that happened while attaching the filigree on the front of the gold sheet: a precise control on the high temperature necessary for working on gold was not easy to achieve. The gold employed for the wires and the granulation shows the same composition of the gold of the background. The analysis of the larger blue bead of the necklace revealed that the colouring agents of the glass were copper and cobalt, while lead was used as stabilizing element for the glass. Lead was also employed as stabilizer for the glass of the red bead, and in this case the colouring agent was copper. Eight larger beads consist of amber; some of them are rather altered on the surface.

A similar necklace consisting of slightly larger beads in the very same colours (white, red, orange, brick red and green), but no amber beads, was found in Grave 24 of the cemetery called *della ferrovia* [of the railway].[8] The buried person was an older lady, between 50 and 60 with a rich selection of grave goods. Her necklace shows beads that are larger than those of the example from the San Mauro cemetery, but it has only four gold pendants and four barrel-shaped beads, used in the reconstruction as spacers for the pendants. As discussed by Borzacconi and Giostra[9] a further parallel is known from Grave 17 at Nocera Umbra, but such pendants with filigree and granulations are found all around the Alps in the last three decades of the 6th and the first decade of the 7th century.[10]

8 Borzacconi – Giostra 2018, 251, Fig. 23.

9 Borzacconi – Giostra 2018, 251.

10 Ahumada Silva 2010, 83–84, Pl. 39, 125; Rupp 2005, Pl. 29.

Fig. 15. Cast copper-based pan (inv. no. 23890) (L.: ca. 40 cm) for hand washing from Grave 21. The metal is a copper-based alloy containing 4% tin, 6% zinc, and 2.3% lead. All parts, basin, foot, and handle with hook have been cast together in one piece (photo by A. Giumlia-Mair).

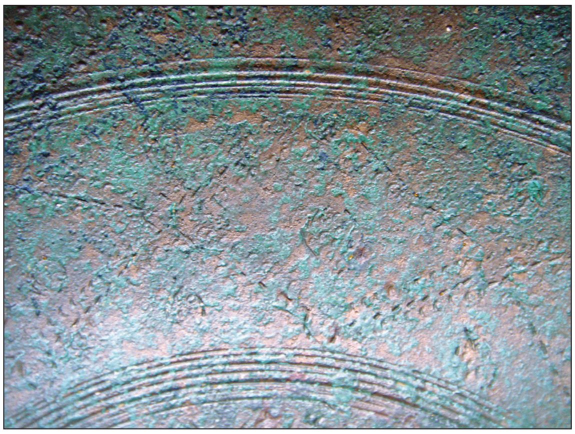

Fig. 16. Detail of pan (inv. no. 23890). The entire internal surface of the pan is intricately decorated by cold working with a thin chisel, the concentric circles are cast. The undecorated flat rim bears a Greek inscription: ΝΙΨΕ ΥΓΙΕΝΩ ΚΥΡ(Ι) 'May you wash in good health, Lord' (photo by A. Giumlia-Mair).

In the same grave there was also a pair of radiate-head bow fibulae made of gilded silver decorated with niello,[11] similar to some of the examples from the cemetery of San Mauro. As already mentioned, a pair also comes from Grave 39 in the cemetery of San Mauro, but these two fibulae (inv. no. 24059) have not been analysed, because they were on exhibition and could not be removed from the vitrine.

The analysed radiate-head bow fibulae comparable to specimens from the necropolis of the *ferrovia* are inv. no. 23894 from Grave 21, inv. no. 23883, from Grave 27, and inv. no. 24675 from Grave 53. The general characteristics of this fibula shape have been discussed by Bertolini.[12] Two further very similar examples of the same type of fibula have been examined at the microscope, but not analysed. These are (inv. no. 24676) that builds a pair with the analysed specimen (inv. no. 24675), and the radiate-head bow fibula (inv. no. 24679).

The radiate-head bow fibula (inv. no. 24675, Grave 53), which was found together with the fragmentary fibula (inv. no. 24676) but has been described as coming from a different mold, was analysed in more detail (Fig. 4). The burial of Grave 53 was that of an adult woman. The fibulae are dated to the first/second decade of the 7th century. They show two different styles: the Lombardic Style I with zoomorphic decoration and Style II (on the head- and footplate) with a complex and intricate decoration.[13] This is the only example of a mixture of styles found in Italy up to now. The analysis carried out on the clean surface at the back of the fibula showed that the silver employed contains around 14% Cu, 7% Zn, 4% Pb, 3% Sn and 2% Au. The low amount of gold determined in the silver suggests that some gilded object had been molten down and recycled to produce the fibula. Then the silver had been alloyed with a recycled copper-based alloy, made of a quaternary alloy containing copper, zinc, tin and lead, certainly from an older ornament or some small representative object, as the high zinc content suggests. The gold layer on the stylized bird of prey (Fig. 5) on the side of the fibula body doubtlessly comes from amalgam gilding (also called fire gilding or mercury gilding), as 1.3% Hg could be identified in the gold.[14] The process of amalgam gilding involves mixing filings of gold, or pieces of gold wire and/or foil fragments with mercury, to form a paste called amalgam. The paste was

11 Borzacconi – Giostra 2018, 251, Fig. 23.

12 Bertolini 2017.

13 Pagano 2013b, 33.

14 See Giumlia-Mair et al. 2002; Giumlia-Mair 2020, 5–8.

applied on the surface of the object to be gilded and the piece was heated to slightly below 352 °C, the temperature at which mercury evaporates. In this way the mercury could be eliminated, and a thin gold layer remained on the surface. The layer was opaque and slightly porous, therefore it had to be polished with tools made of smooth wood or bone to avoid damage to the gilding.[15] The analysis on the thin gold layer also determined 15% Ag, 9% Cu and 1% Pb, however these elements come certainly from the silver alloy underneath, and not from the gilding. Some traces of lead in gold might in some cases be an indication that the gold had been purified with lead, however in the case of the Lombardic fibulae for which recycled metals were employed, this hypothesis does not seem credible.

The second feline head from the left was also analysed and the results showed that silver with the same composition of the silver alloy employed for the body had been used for the decorative heads, while the silver alloy of the rope-shaped decoration on the fibula bow shows a different composition with 7% Cu, 4% Zn, 1% Pb and traces of tin. In this case the silver was also diluted with a quaternary alloy, but with a smaller amount of it. The feline heads were fixed to the head of the fibula with thin iron elements, which are now heavily corroded and rusty.

The niello employed as decoration on the feline head also seems to have been made by mixing the same silver alloy with sulphur in a crucible and melting it to obtain the black sulphides with an almost vitreous appearance that, crushed to powder, mixed with a flux, and reheated to the consistency of a paste, could be applied in the keying cut on the surface of the silver. The presence of elements such as copper, zinc, tin, and lead in the silver lowers the melting point of the niello and facilitates its insertion into the cut recesses in the silver.[16]

The remains of the pin for the fastening of the fibula consist of a brass alloy containing around 82% Cu, 16% Zn and traces of lead and gold. The gold traces certainly come from the gilding process. The pin is a functional element and had to be intensively hammered to be shaped to a thin point and hardened, therefore the artisan employed an alloy without lead to avoid problems during the working process.

The differences in decoration of the two fibulae brought up the idea that they might come from different molds,[17] however the dissimilarities are very small and in the case of the two fibulae from Grave 53 there is only one divergent detail at the top of the central plate: on one of the fibulae it looks like a tripartite band placed on both sides, while on the other it looks like a beaded line on both sides. This might simply come from a small final touch-up on the wax model after the extraction from a mold and/or later, when finishing the fibula. A second possibility is that a fibula itself, and not a master model of lead or wood, had been employed to produce a second almost identical one by pressing it on soft clay, casting wax into the keying left by the fibula and finally retouching the wax model after extracting it from the clay and adding the catch-pin in wax on the back. Alternatively, the clay could have been slightly re-elaborated by adding the details described above and baked to be used as a direct mold into which the silver alloy could be cast. In this case a second half mold would have been necessary to obtain the catch-pin. However, this hypothesis is less credible as the texture of the silver on the back of both, the bow of the fibula and the decorative animal heads attached to it with an iron rod, shows innumerable bubbles and an irregular surface suggesting the use of an open mold (Fig. 6).

Radiate-head bow fibulae very similar to these are known from many other sites such as the rather close Romans d'Isonzo, Grave 327, and from Nocera Umbra,[18] but also from Hungarian cemeteries

15 Giumlia-Mair 2020, 5–8.

16 La Niece 1983; Giumlia-Mair 2012; Giumlia-Mair 2017; Giumlia-Mair 2020.

17 Bertolini 2017, 238–239.

18 Rupp 1997; Rupp 2005.

(for instance Szentendre, North of Budapest, Grave 54 and 29; Gyönk, between the Lake of Balaton and the Danube, Grave 1 and Rácalmás near Dunaújváros, Grave 2) and Austrian (Mödling near Vienna, Grave 2).[19] As these fibulae belong to an early typology, this distribution might suggest possible itinerant metalworkers, import of both, objects and models, and/or that the artisans moved to Italy together with the migrating Langobards, because the large distribution with over 60 examples in the various cemeteries of Cividale[20] seems to indicate the existence of a local specialized workshop.

The smaller and less intricately decorated radiate-head bow fibula with gilding and niello (Fig. 7) (inv. no. 23883), from the rich Grave 27 of an around 7 years old female child, shows a similar (but not the same) silver composition with around 12% Cu, 3% Zn, 3% Pb. The decorative motives are less well defined and intricate than those of the fibulae discussed above, a large part of the niello on the body of the fibula is now lost and the feline heads are completely gilded. The fastening mechanism was made of iron and is now completely altered and corroded (Fig. 8). The gilding on this fibula is of excellent quality, apparently thicker than the gilding on the other objects analysed, and no mercury could be identified in it. Both, the aspect of the gold layer at the microscope and its composition suggest that in this case leaf gilding was employed. Gold leaf was produced by beating between parchments several gold sheets first. The so obtained gold foils were then extracted from the parchment and treated further, by placing them between thin layers of the so-called beater's skin, obtained from the intestine of bovines, and beating them until the desired thickness was reached. When the gold was reduced to leaf and had reached the desired thickness, it could be applied on the surface of the object to be gilded with organic adhesives, such as for instance plant gums and resins or animal glues.[21] A second way of applying the gold leaf was that of exploiting the extreme malleability of this metal: the leaf could stick on the carefully degreased metal surface, be it copper and copper alloys, silver, or iron, just by pressing, rubbing and burnishing it with wood-, bone- or even ivory tools of different shape. The bond could be enhanced on silver by heating the object and promoting some diffusion of the two metals into each other.[22]

As further comparison, also the interesting instance of radiate-head bow fibula with gilding, niello and almandine inlays (inv. no. 23894, Grave 21) (Fig. 9) was analysed. The very rich grave belonged to a 17–25 years old woman and the finds, dated to the last third of the 6th century, suggest that she belonged to the highest social class and to the first generation of the Lombards who immigrated to Italy. The preservation of this piece is not as good as that of the previous examples: the surface is altered, and some copper corrosion products can be seen on the gilding as well, the niello inserts are missing on several areas and the keying is in general smaller and shallower.

The most distinctive details of this fibula are the two almandine cloisonné inlays: one half-moon-shaped on the head of the fibula and the second an elongated boat-shaped cloisonné on the bow. One of the almandine plates on the halfmoon-shaped cloisonné is missing and the cross-hatched decorated gold foil backing is now visible (Fig. 10). This kind of decoration is called boxed pattern (also boxed waffle pattern or *quadrillage*) and consists of a grid of regularly spaced squares in which nine tiny pyramidal depressions can be seen. Its function was that of enhancing the light reflection effect and the colour of the transparent stones. Different types of patterns are known.[23] The boxed pattern is the most elaborate (together with the ring-and-dot or ring-stamped pattern),

19 Bierbrauer 1991; Bóna – B. Horvát 2009; Bertolini 2017, 240.

20 Cf. Bertolini 2017, 233, Fig. 7.

21 See Giumlia-Mair 2020.

22 Giumlia-Mair 2020, 5.

23 Avent – Leigh 1977; Meeks – Holmes 1985; East 1985, 140–141; Nijboer – van Reekum 1999; Tulp – Meeks 2000, 13–24.

the better known and perhaps the best quality pattern on backing foils of gold employed in the Early medieval period under transparent stones, mostly almandines and, in less prestigious items, red glass. The gold foils are very thin. In this case as the foil is *in situ* it was not possible to measure its thickness. As example, we can mention that in one of the most famous cases of garnet decorated items i.e., in the Sutton Hoo finds with over 4,000 garnet cloisons,[24] the thickness of the gold foil was 0.02–0.03 mm. The studies by Meeks and Holmes[25] demonstrated that brass and bronze were suitable materials for the dies employed to achieve this kind of pattern. Ivory was also found to be tough enough, but understandably its durability was inferior to that of the dies made of metal. Wooden dies were instead too soft and easily damaged. The gold foil had to be backed by a 4–8 mm thick lead sheet placed on an anvil or any solid surface to achieve best results. Experiments carried out on a massive lead base or on a thin lead sheet placed on wood instead did not give good results.

Fig. 17. Large buckle (inv. no. 24175) (L.: ca. 7 cm) from Grave 34, 4-year-old male child, end of the 6th –beginning of the 7th century AD with cast decoration and punched cross-hatched pattern (photo by A. Giumlia-Mair).

Fig. 18. Detail of buckle (inv. no. 24175) showing the cross-hatching pattern. This is not a boxed pattern, but a simple waffle pattern similar to that observed on the S-shaped fibula (inv. no. 23891) (photo by A. Giumlia-Mair).

The gold foil backing on the fibula from the San Mauro cemetery shows the classical boxed pattern with nine depressions inside a square of thicker lines, under flat almandines. The analysis of the red stones in the cloisonné identified iron and aluminium in a silica matrix, as expected in the case of almandines.

The analysis of the body metal of the fibula indicates the use of an alloy of silver mixed with a quaternary alloy as it contains 12% copper, 8% zinc and 2% lead, 12% tin and traces of gold. The relatively high tin was most probably added to the alloy to lower the melting point and possibly to achieve a more silvery colour. The addition of 40% of weight in different metals to the silver is the reason for the opaque aspect of the fibula.

The third animal head from the right was also analysed and its alloy is similar to that of the fibula body, with 12% copper, 11% tin, 8% zinc, 1.8% lead and traces of gold. We can suppose that the other heads consist of the same alloy, however the fourth head from the left (Fig. 11) shows a different, rather reddish colour and is not decorated with niello and gilding. The analysis showed that it is made of a copper alloy containing only 2.2% of lead. This is certainly an ancient replacement of the lost element, carried out by a less skilled artisan than the one who produced the fibula. Nevertheless, the addition of around 2% of lead to copper is quite interesting, because this is the amount of lead necessary to reach the maximum fluidity of the molten metal to facilitate the casting. Unalloyed copper is very difficult to cast because it bubbles and shoots out of the crucible in droplets,

24 East 1985; Care Evans 1986.

25 Meeks – Holmes 1985, 155.

and it solidifies very quickly, easily building casting faults. There is no doubt that the lead was added to copper with the aim of producing the small copper head without casting faults. A second possible hypothesis is that the artisan had planned to use amalgam gilding on the copper head, because unalloyed copper or copper with only very low percentages of lead and tin can be gilded with this method, without forming dark or opaque spots on the gilt surface, while alloys with high lead and tin content form an amalgam with the mercury used for the gilding and produce greyish stains on the gilding. However, no traces of gilding could be identified on the surface of the copper head, while the rather abraded and damaged thin gilding layer on the gilt parts of the fibula contains 0.7% mercury. The niello decoration contains copper, zinc and lead and therefore it is similar to that of the fibula (inv. no. 24675) from Grave 53.

Grave 21 also contained an S-shaped fibula (inv. no. 23891), made of silver with almandine *cloisonné*, gilding and niello (Fig. 12). This fibula shape is considered a type made in Italy. The silver employed for the body contains 17% copper, 8% zinc, 5% lead 2% tin and traces of gold (around 1%). The measurement was carried out on the back plate of the fibula (Fig. 13), without any traces of gilding, therefore the gold might come from the recycling of a silver object decorated with gilding.

The pin is missing, being of iron it completely corroded away. A small repair of a casting fault is visible on the back plate and can also be recognized on the front as a slight bump under the gilding. The analysis of the repair determined 18% copper, 8% zinc, 4.8 lead, 2% tin, and 1% gold. This alloy seems to be the same one that was also used for the body and this fact suggests that this small repair was carried out when the piece was produced. The gilding layer was applied on the surface by the technique of amalgam gilding employed for other objects presented in this paper. The gold contains around 1–2% of copper and silver and around 0.8% mercury.

The analysis of the slightly protruding niello decoration showed that it consists of silver, containing some copper, zinc, tin and lead, beside the necessary sulphur, while the gold must be related to the gilding process and perhaps to abraded particles of gilding adhering on the porous surface of the niello. The backing of the small almandine plates is a gold foil with cross-hatched pattern, however in this case it is not a boxed pattern, but a simple waffle pattern without squares defined by thicker lines as in the radiate-head bow fibula (inv. no. 23894) discussed above. The production of the different kinds of cross-hatched foils employed as backing for transparent and translucent stones has been discussed in detail by various authors.[26] The analysis of the red stones confirmed the use of almandines. The use of different cross-hatched foil as backing for almandines on objects from the same grave is interesting and suggests the existence of different jeweller's workshops in the town (Fig. 14).

Another very impressive find from Grave 21 is a cast copper-based pan (inv. no. 23890) (Fig. 15) for hand washing, with a sentence in Greek on the rim saying ΝΙΨΕ ΥΓΙΕΝΩ ΚΥΡ(Ι) i.e., "May you wash in good health, Lord". The entire internal surface of the pan is intricately decorated by cold working with a thin chisel, but the concentric circles that define the four decorated areas are cast (Fig. 16). The back of the pan is undecorated except for the concentric circles at the base of the foot, and the handle is provided with a hook for hanging up the pan. The well-wishing sentence on the undecorated rim of the pan was punched with a rounded and hollow tool. The metal is a quaternary alloy i.e., an alloy with copper as a base, alloyed with 6% zinc, 4% tin, and 2.3% lead. The alloying elements tin, zinc and in particular lead are quite low for an object of this size. Most probably the artisan wished to obtain a vessel with a rather golden colour and avoided higher lead percentages, because the addition of this metal renders the alloy dark and opaque. Nevertheless, the addition of around 2% of lead achieves the maximum fluidity of the molten metal and helps to obtain an object

26 See for instance Meeks – Holmes 1985; Adams 2006.

Fig. 19. The buckle (inv. no. 24574) (L.: ca. 6 cm) from grave 44 is made of iron with silver- and gold-coloured inlays. The silvery inlays on the buckle are made of 43% tin, 39% silver, 11% copper, 2% zinc, and 1% lead. The gold-coloured inlays are made of brass i.e., copper containing 21% zinc and only traces of lead (photo by A. Giumlia-Mair).

without casting faults. This kind of alloy was widely employed in Late Antiquity for prestigious objects. All parts of the vessel, including the hook, show the same composition and appear to have been cast in one piece. This alloy can easily be hammered and bent to form the hook. The vessel might be of Italian or Byzantine production.

A splendid, quite large, but regrettably heavily corroded buckle from the same cemetery (inv. no. 24175) from Grave 34 (Fig. 17) can give some clues on the production process of the cross-hatched gold foils. The person buried in Grave 34 was a male child, around 4 years old, and the finds can be dated to the end of the 6th – beginning of the 7th centuries AD. The buckle is made of a good quality quaternary alloy with 23% zinc, 2% tin and 1.2% lead and is gilded. In this case the gilding is almost completely covered by copper and iron corrosion products, however the measurement on areas where the gilding is corrosion free indicate that the gold is rather pure. With all probability also in this case we are dealing with amalgam gilding, in spite of the fact that the gilded alloy contains rather high zinc and also tin and some lead. As the analyses of the gilded fibulae from San Mauro have shown, Lombardic jewellers did not mind using alloys that produced greyish spots on the gilding. The backing of the buckle is made of rather corroded iron and a rectangular iron plate is attached on the heavily decorated buckle plate, on which several zoomorphic motifs of Style II can be distinguished. However, the most interesting detail on this find are the cross-hatched marks (Fig. 18) on the area next to the buckle that must have been imprinted hot on the wax model before casting, together with the other motifs. The small, hatched squares are similar to those found on the S-shaped fibula and are alternated with a beaded V-shaped pattern on a diamond shape. On this buckle-plate there were certainly no cloisonné decoration or inserted stones because the imprints would be too shallow to keep a stone, even a flat almandine, in place. It is quite clear that the artisan found the buckle plate too simple with 'only' three different decorated bands and decided that the area next to the buckle needed some more pattern. The second plate (inv. no. 24176), belonging to the same buckle, shows two more different pattern and the same cross-hatched imprints alternated with small bow shaped imprints. Not many dies for boxed or waffle pattern are known up to now. One made of a quaternary alloy, the Tjitsma die, was found in Friesland,[27] but it is in 'positive' form and was interpreted as a master template for making wax impressions used as models for lost wax casting of negative dies, while the other ones known are negative dies. Five negative dies with different patterns have been found in Denmark.[28] Apparently, the metalworker that manufactured the buckle also had a positive die, which was similar to the Tjitsma die, but with a simple waffle pattern, and employed it in different ways.

A further buckle from the San Mauro cemetery (inv. no. 24574) from Grave 44 is made of iron with silver- and gold-coloured inlays (Fig. 19). The grave, dated to the last third of the 6th century, belonged to a warrior of high social standing, aged between 25 and 35, buried with an infant child. The objects found in the grave allow to date the burial to the end of the 6th – beginning of the 7th centuries AD. The silvery inlays on the buckle are made of a complex alloy consisting of 43% tin, 39% silver,

27 Tulp – Meeks 2000.

28 Tulp – Meeks 2000, 20, Fig. 7, representing four of the dies.

Fig. 20. Equal-armed fibula with two opposite faces, gilding and niello (inv. no. 24100) (L.: ca. 11 cm) from Grave 41 of a high-status 9 years old male child. The body of the fibula is a silver alloy with 9% copper, 5% zinc, 1.4% lead (photo by A. Giumlia-Mair).

Fig. 21. Detail of one of the faces on equal-armed fibula (inv. no. 24100) showing the gilding on silver and the niello decoration. Most of the triangular niello inserts on the silver arch are lost, but the niello lines and the beard are still in place. The niello decoration seems to contain antimony, which gives a bluish nuance to the black material (photo by A. Giumlia-Mair).

11% copper, 2% zinc, and 1% lead. This kind of alloy is very elastic, can easily be formed to wire, is corrosion resistant and keeps a silvery colour. The gold-coloured inlays are a good quality brass i.e., copper containing 21% zinc and only traces of lead. This is a malleable and ductile alloy, very suitable for the production of wire. The brass inlays were examined at the microscope and revealed the helicoidal seam, which is typical for twisted wire. The analysis of the inlays on the matching decorative plate (inv. no. 24575) showed that both the silvery and the gold-coloured alloy have the same composition of the ones on the buckle.

The fibula with two opposite faces (inv. no. 24100) from Grave 41 (Fig. 20) is a unique piece without any parallels. The grave belonged to a high-status ca. 9-year-old male child, who was buried with weapons and the spurs of a horseman. The fibula shows the Lombardic theme of the human mask between two snakes with an eagle head that might even be the representation of Odin. The body of the equal-armed fibula is made of a silver alloy containing 9% copper, 5% zinc, 1.4% lead and gold traces. It is a better alloy than those used for the radiate-head bow fibula e and the S-shaped fibula, as it contains more silver and less alloying elements. The pin was made of iron, as shown by the rusty remains, but it is almost completely lost. The decoration on the central arch was carried out with a hot tool on the wax model, as can be inferred from the casting fault on the central ridge, which originally was covered by the gilding layer, now slightly damaged. After the casting was completed and the object cooled down, the artisans cut away the casting channels and vents and removed the casting skin and the fins with abrasives such as pumice stone, sand, marble powder and wood ashes. The piece was polished and the keying for the niello prepared. The gilding must have been carried out first. The gilding layer is relatively thick and still in good condition. The analysis determined 1–2% copper and silver and 0.7% mercury in the gold, demonstrating again that the gilding was done by using an amalgam with mercury. It is quite interesting to observe that the gilding was accurately polished on all areas without decoration, but it is still rather opaque on some areas on the bow, because the polishing was more difficult on the indentations. The areas decorated with niello i.e. the beards and the rounded finials are not gilded and show a slightly purplish colour. This is due to the presence of sulphides on the silver, while the bluish tinge of the niello comes from traces of antimony in the niello mixture (Fig. 21).

Fig. 22. A cross made of gold sheet (inv. no. 24099) (H.: ca. 7 cm) Grave 41, was probably attached on the veil that covered the face of the deceased child. The metal employed is a very pure gold with only around 1% of copper and silver. This suggests that Roman *solidi* might have been molten down to produce the cross (photo by A. Giumlia-Mair).

A cross made of gold sheet (inv. no. 24099) (Fig. 22), which was probably attached on the veil that covered the face of the child, was also found in Grave 41. The arms of the cross are perforated at the corners for the thread that would have fixed the cross on the veil. The metal employed is a very pure gold with only around 1% of copper and silver. This composition suggests that for the cross production Roman *solidi* might have been used. The decorative motif in zoomorphic Style II shows interwined animal figures and human masks around the central roundel. The decoration was stamped on the sheet from the back with a matrix, made of a rather hard material, perhaps hard wood, as shown by the sharp lines on the back of the cross. Being very soft and malleable, the gold sheet had to be supported by a soft material, such as pitch, leather, or sulphur, so that the gold would not be damaged. The sheet was cut after stamping the decorative pattern on it.

Both the equal-armed fibula with masks and the cross, together with the remains of a (not analysed) silver decoration of a wooden bowl with intertwined human figures strongly remind of Northern motifs. A good parallel is for instance found in the figures represented on two gold sheets (Fig. 23) from Bolmsö in Småland dated to 550–800 AD.[29] The identical representation on two sheets of gold of a man with a long V-shaped beard and a double arch over his head repeats the scheme of the equal-armed fibula (inv. no. 24100) from Grave 41 of San Mauro, albeit without snakes and/or eagles.

Conclusions

A group of the most significant metal finds from the necropolis of San Mauro has been studied from the metallurgical point of view and the results give us some clues on the working processes and the technologies employed by the Lombardic metal artisans. The pieces have been examined with various optical devices and non-destructively analysed by X-ray fluorescence spectrometry (XRF). The analysis results and the observations show that many of the pieces have been produced by using recycled metal. This is evident even in the case of good quality objects, as for instance the fibula (inv. no. 24675) from Grave 53. The ornament is quite elaborate and finely finished with gilding and niello inlays, but in the silver of the fibula body, besides the common copper addition to the precious metal to make it more resistant to wear, evident traces of tin, zinc, lead and even gold have been determined.

29 Andersson 2008, 87–89, with figure.

Fig. 23. The gold sheets from Bolmsö in Småland dated to 550–800 AD. Such figural gold sheets represented various kinds of figures and were mostly found in post-holes in the remains of buildings and had probably an apotropaic function. These gold sheets repeat the scheme of the equal-armed fibula (inv. no. 24100), with a doubled bearded man under a triple arch (photo from Andersson 2008, 89).

All 'silver' fibulae show this kind of composition, suggesting that the silver had been alloyed with quaternary alloys or leaded brasses, often gilt, that had been previously employed for decorative objects. The decorative niello application found on various areas of the fibulae contain the same elements and it might have been produced with the same alloy employed for the fibula body, mixed with sulphur in a crucible to obtain the black and vitreous material to be applied in the keying. The gilding layer on the various fibulae—except perhaps the radiate-head bow fibula with gilding and niello (Fig. 7) (inv. no. 23883) from Grave 27 for which gold foil might have been used—had been applied by fire gilding, by mixing gold filings with mercury and applying this paste on the surface to be gilded. The mercury was then driven off as a vapor by heating the piece to a temperature of around 325 °C. The gold employed for gilding is of excellent quality.

The cross (inv. no. 24099) from Grave 41 is made of a very pure gold, with only 1% of copper and silver. This seems to indicate the recycling of Roman *solidi* with a similar composition. The anthropomorphic pendants of necklace (inv. no. 24060) from Grave 39, are characterized by an applied granulation and filigree work. Their composition is similar to that of the cross, but they also contain some mercury. Part of the gold of the necklace had most probably been recovered by filing the gold from silver objects with gilding gilt or even from recovering the gold from mosaic tesserae by using mercury.

In this period the use of recycled metal is not surprising. It is well known that from the 3rd century AD the exploitation of mines decreases, and it stops altogether when the Roman empire collapses. At this time the main metallurgical production consists of skilled and specialized recycling of metal scrap of any kind and composition. As it is the case with all populations of Germanic origin, the Langobards (or Lombards) were known for their ability as blacksmiths, but also as goldsmiths. Their personal ornaments, for example fibulae and buckles, as well as decorated horse trappings, are finely worked, quite elaborate and show a particular taste for colour: they combine silver, gilding, niello, and red stones mounted as small plates, as for example on the crossbow fibula (inv. no. 24675) from Grave 53 and the S-shaped fibula (inv. no. 23891) from Grave 21. The XRF analysis of the red stones determined the presence of iron and aluminium in a silicate matrix, that identify the stone as almandine, a variety of garnet, found in magmatic-, effusive-, and occasionally also in metamorphic rocks.

The buckle and the decorative elements of trappings (inv. nos 24574, 24575) from Grave 44 are made of iron with silver- and gold-coloured inlays. These are not made of precious metal but consist of an especially golden coloured brass and of an alloy containing silver, tin and around 2% of copper. The niello decoration on the equal-arm-type fibula (inv. no. 24100) from Grave 41 shows an interesting composition with unusual traces of antimony, which gives to niello a bluish nuance. The purplish hue on the silver is due instead to the presence of sulphides.

The magnificent pan with a punched sentence in Greek on the rim, which stylistically might be of Byzantine production, is made of a quaternary alloy containing Cu, Sn, Zn and Pb, rather typical for Late Antiquity and for the Byzantine contexts.

The practice of intensive recycling precious metals, copper-based alloys and even iron and steel artifacts can be traced back to the 3rd–4th centuries AD, when the invasions of groups and tribes coming from the North and East changed the equilibrium and the economy of the Roman empire, and a number of mines that had been exploited until then, could not be further maintained.[30] After the collapse of the Western Roman empire the specialized workers necessary for the proper functioning and organization of mines could not be found anymore, so that only mineral deposits with an old mining tradition, for instance some mining sites in the Oriental Alps, continued to be exploited, but were not sufficient to cover the demand, and the metalsmiths had to turn to the reuse of metal scrap all over Europe, while objects and tools of wood and stone became the most common.[31] This situation can be recognized in many regions, particularly in Eastern Europe, but not only. A good example are the gold objects from Crimea of Lombardic tradition[32] with an erratic composition and partly very high silver and copper in gold. The Hunnic, Lombardic and Merovingian ornaments from Hungary analyzed by E. Horváth[33] evidenced that even a pair of visually almost identical brooches from Kajdacs (Grave 52) were produced using two completely different, and certainly recycled, silver alloys, and illustrated the decline of quality of silver alloys in the course of the 5th–6th centuries AD. The analysis of the large group of 157 Hunnic, Lombardic and Alanic ornaments from Nagyszéksós, dated to the 5th century AD, and interpreted as the offerings for the funerary pyre in honor of king Uptar[34] evidenced a clear distinction of the different traditions and workshop habits of the three groups.[35] The typical Hunnic gold ornaments, bulky and heavy with almandine inlays, were mainly cast using the almost pure gold of the solidi (98–99% Au) paid by the Romans to king Ruga.[36] The Lombardic gold alloys had a silver content between 3 and 6% and a copper content up to 3% and were richly ornamented with almandine cloisonné. The cloisonné technique is commonly considered typical for the Germanic tribes.[37] Finally, the Alanic artifacts were characterized by a composition with 6–7% silver and very little copper, mostly under 1%. The Alanic materials could be divided into two groups: plates with smaller round or oval cabochon stones belonging to the chalcedony group, framed with an imitation of beaded wire, and a second group with larger and unframed stones.[38] Both the Lombardic and the Alanic materials gave indication for having been made by using re-melted older silver and gold items. The difficulties in obtaining freshly smelted copper, silver and iron, and freshly collected gold continued for many centuries. For instance, the metal finds from the 10th century cemetery of Kiskunfélegyháza clearly illustrate the situation: the ornaments still show Germanic style features and were made with recycled silver, containing some gold and mercury from molten amalgam gilded silver objects. The copper-based alloys contain low percentages of tin, zinc and lead and can be considered quaternary alloys obtained by mixing scrap metal.[39] Only in the 13th–14th centuries, almost at the dawn of the Renaissance, with the revival of sciences and experiments in various fields, new mines were discovered, mining devices were invented, and efficient methods of exploitation were introduced, finally revitalizing metallurgy.

30 Forbes 1993, 63
31 Le Goff 1983, 222–223.
32 La Niece – Cowell 2008, 154–155, Tabs 1–2; Craddock et al. 2010.
33 Horváth 2013, 287, Fig. 14.
34 Bóna 1991, 46–60.
35 Giumlia-Mair 2013.
36 Giumlia-Mair 2013, 15–16.
37 Giumlia-Mair 2013, 16–18.
38 Giumlia-Mair 2013, 18–19.
39 Török – Giumlia-Mair 2022.

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