Metallurgy and Technology of the Hunnic Gold Hoard from Nagyszéksós

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The Hunnic treasure of Nagyszéksós was found in 1926 in a vineyard near the village of Nagyszéksós just outside of Szeged, in the Hungarian County Csongrád (Fig. 1). With the exception of a few pieces — such as the cup and the fragmentary bowl which are now in the Hungarian National Museum in Budapest — it is now stored in the Móra Ferenc Museum in Szeged. Up to now the hoard has never been on display and no technical description exists. Part of it was shown to the public on the occasion of exhibitions, for example, in the exhibition "Germanen, Hunnen und Awaren, Schätze der Völkerwanderungszeit" in Nuremberg in 1988 (Kürti 1988). The exhibition "Hun Gold" was organized in the Móra Ferenc Museum in Szeged in 2003 (Kürti 2003). Some of the pieces, in particular those of Alanic tradition, were on display in the exhibition "Attila und die Hunnen" in the Historisches Museum der Pfalz in Speyer in 2007 (Kürti 2007, fig. p. 261). The most complete work on the hoard was published by Fettich (1953). The finds consist of 157 golden objects and fragments, many of which are decorated with inlays of gemstones — such as garnet, rock crystal, possibly amethyst — and of red glass. Among the finds there are also lumps of metal looking like molten silver. During the emergency excavation carried out by Ferenc Móra no human remains were identified, but there was a large number of very precious and symbolic gifts. The complex of Nagyszéksós is most probably what is left from the offerings on a funerary pyre erected for the death of a king — who has been tentatively identified with Uptar — or at least for the death of an important member of the royal family. Uptar/Oktar was, together with Rua/Ruga, the predecessor of Attila, and if this identification is right, the finds have to be dated to around 430 CE (Bóna 1991, pp. 46-60). Funerary pyres accompanied by ritual banquets were the special prerogative of males of the royal family or, at least, of males of very high rank, while socially important women were buried without the ritual burning of gifts on pyres (Bóna 1991, p. 149).

Fig. 1. Map showing the location of Nagyszéksós.

It is also important to mention that when Móra arrived on the site, he discovered that the children of the village had been exchanging shiny metal pieces for apples and slices of pumpkin pie for quite a while (Kürti 1988). The 157 fragments of objects recovered by Móra during his excavation are therefore apparently just a small part of a much larger hoard. A large number of objects belonging to the hoard presumably found their way to the international market and are now on display in the cases of several large museums in the world (see for example Bóna 1991, p. 162, Fig. 63 and p. 261, n. 63).

This paper presents the results of ca. 280 X-ray Fluorescence Spectrometry (XRF) analyses and 290 examinations by different magnification devices and digital microscope carried out on most of the objects belonging to the Nagyszéksós hoard. The only pieces which have not been analysed by XRF are ca. 10 very small fragments of gold sheet; however they have been examined with the microscope to try and find out to which piece they belong. In some cases this could be done with a high degree of certainty. The aim of this research was to determine the composition of the gold and of the silver alloys and to identify the manufacturing technique. A further intention was that of grouping the pieces belonging to the hoard according to their composition and manufacture, and to attempt a distinction between the different metallurgical traditions of the artisans who created the various ornaments.

Xiongnu and Huns, short historical background

Around 370 CE, the nomadic tribes from the vast plains of Central Asia, known in Europe as the Huns, crossed the River Volga, and invaded the territories of Alans and Goths. The two populations were easily defeated and subjugated. In 425 CE the Huns founded a kingdom in the Pannonian Plain (today's Hungary and part of Romania) and settled down in the area between Tibiscus/Tisza–Cris/Körös and Maros, where they had their capital, made of tents around the *ordu*, i.e. the fortified king's camp. From here they attacked the Eastern Roman Empire in Thrace, Cappadocia, Armenia and Syria. After a treaty, they became mercenaries of both the Western and the Eastern Roman Empire, and of the Goths, and greatly increased their number by incorporating more ethnic groups such as Gepids, Sarmatians, Scirii and Rugians.

The origin of the Huns and in particular the question of their possible relationship to the Xiongnu have been the subject of yet unresolved scholarly dispute. The earliest mention of the Huns in Western classical texts is found in the *Periegesis* of Dionysius (730). The text is dated to the 2nd century CE, and lists the Huns together with Skythi, Caspii and Alani as tribes living around the Caspian (Müller 1861, p. 149). Dionysius' contemporary, the geographer Claudius Ptolemy mentions the Huns as a Sarmatian population in his *Geographia* (III, 5, 25). The Huns conquered various tribes, among them the Alans and Aorsi and Germanic Gepids, Goths and Skires living in the Aral and Black Sea regions. The population of the Hunnic Kingdom spoke many languages, and the names of the warriors have Hunnic, Germanic, Latin, Iranian etc. origins (Mänchen-Helfen 1973, p. 382).

The Xiongnu founded a steppe empire on the northern borders of China around the end of the 3rd century BCE (see Di Cosmo 1999; 2011). At its greatest extent, it controlled territories across much of Inner Asia, but had fragmented by the beginning of the Common Era. Some scholars have challenged the commonly held identification between Xiongnu and Huns, because the Xiongnu apparently spoke a proto-Siberian language that has never been encountered or identified in Europe (Vovin 2000). However, there is very little evidence about their language; in any event, there is good reason to think that the Xiongnu polity was a multi-ethnic one. While much has been written about a connection between the names Xiongnu and Huns, the chronology and direction of transmission are at very least complex, and it is difficult to prove that the sources in various languages and spread over several centuries are referring to the same nomadic peoples (see Atwood 2012 for the most recent and detailed analysis).

Among the numerous Hunnic-related tribes there would seem to be many aspects of shared material culture, religion, customs, rituals and way of life (Grignaschi 1980; Kradin 2005). Yet, to what extent do certain shared elements — such as the bow, the golden diadems worn by women, or the so-called nomadic mirrors that were adopted as well by Alans, Gepids and Goths — prove an association between Xiongnu and Huns? (See Tomka 1994, 29-34; 2008; Brosseder 2011.) Some have cited the evidence of large bronze cauldrons, apparently used for funerary rituals, which have been found all across the huge area extending from the Great Wall to the Black Sea and the Pannonian Plain. However, as Ursula Brosseder has recently emphasized (2011, p. 415), "the attempt to prove centuries' long connections by means of the category of cauldrons is methodically not convincing."

Archaeological finds, in particular coins, demonstrate that there was an early trade route through the territories of these tribes from the northern Pontic area to Central Asia, China and India, dated to at least the 2nd century BCE (Mielczarek 1997; see also Polos'mak et al. 2011). Several classical and late antique texts (Josephus VII, 7, 4; Jordanes XXXIV, 178; Strabo 23, XI, 8) also mention the important trade route from the Caspian coast to the Sea of Azov, Armenia, Media, "Babylonia" and to India. In the Pannonian Plain, near the *ordu*, gold coins of the Indian king Kumaragupta (414–455 CE), the Sasanian king Bahram V (420–438) and a Kidarite ruler have been found. That the "Huns" from Central Europe had wide connections extending across Central Asia cannot be doubted. The different metallurgical traditions shown by the finds from Nagyszéksós partly reflect the multiple ethnicities of the "Hunnic Kingdom."

Methods of analysis

All pieces belonging to the Nagyszéksós hoard, with the exception of a few very small fragments of sheet metal, have been non-destructively analysed by X-ray fluorescence spectrometry (XRF). This is a well-established method and it has been applied for several decades in archaeology (Hall et al.1973; McKerrell 1974; Hackens et al. 1977; Helmig et al. 1989) as a non-destructive analysis that can simultaneously determine the presence of over thirty elements without touching the finds. This kind of analysis offers a good performance, particularly with precious metals, as they do not alter, and it does not require drilling as is the case with other methods such as Atomic Absorption or Inductively Coupled Plasma

Spectrometry. The measurements are performed by illuminating a small, flat and cleaned area with x-rays for a short time (typically 5–10 minutes), but the measurement can also be longer, if required. In the case of small objects or small details the analysed area can be reduced to 1mm. The measurements are accomplished at a fixed angle and from a constant distance from the sample. At least three readings have been obtained for confirmation in case of unclear results.

XRF is a surface analysis method, and we have to keep in mind that the surface composition of most ancient objects is altered by oxidation and corrosion. Even in the case of precious metals, the less noble elements in the alloy can leach out. On the surface remains an enriched metal that is much purer than it was originally. The surface is not always representative of the whole object and silver and copper can be underestimated. The only way to solve this problem would be the abrasion of the surface, but this was obviously not possible. Nevertheless, in the case of the Nagyszéksós hoard — found several decades ago and repeatedly cleaned — it has been mostly possible to find a spot which showed traces of abrasion and the measurement has been performed on the cleanest areas. The problem of the presence of molten silver on the surfaces could also be avoided by checking the metal under the microscope before the measurement. In several cases, in particular with burnt pieces, the alloy was altered and the results could not be improved even when the analysis was repeated several times on different areas. The uncertain results are evidenced in *italics* in the Table of Results (p. 29 below).

Past experience has shown that a wide range of elements can be simultaneously quantified with a high degree of precision if proper standards and some precautions are used (cf., for example, Hahn-Weinheimer et al. 1995; Lutz et al. 1996). The comparison of previous analyses, carried out by AAS and XRF on the same samples, demonstrated that over 90% of the XRF results were well within $\pm$ 20% of the corresponding AAS results. Several different standards, each with a different composition, as similar as possible to the alloys in use in antiquity, and expressly produced by AGM Archeoanalisi for the analysis of ancient metal alloys, have been employed as standards for the measurements. They represent an essential tool for a precise evaluation of the results and greatly improve the performance of the XRF equipment.

The transportable device can be taken to the object — virtually anywhere — and can perform analyses *in situ,* even on excavation. For the analyses of the Nagyszéksós hoard a transportable X-ray fluorescence equipment especially developed for the examination of cultural heritage objects, and with a dedicated program for metal analysis, was brought to the Móra Ferenc Museum in Szeged. The same equipment was brought to the Hungarian National Museum in Budapest for the analysis of the remaining pieces of the Nagyszéksós hoard on display in Budapest, so that the same procedure could be applied. Before the analysis all objects were examined by optical microscopy to recognise possible wear traces, indications on manufacture and other working details, such as the different kinds of decorative beaded wire. A second important aim was that of finding the best spots for analysis and avoid the areas on which molten silver had dripped in the fire of the funerary pyre. In some cases the thin layer of silver alloy was not visible to the naked eye, and could be detected only after the analysis, when the silver results were unusually high, or under the microscope.

Discussion of analysis results

The analyses have shown that most of the objects are made of a gold alloy with a purity of over 90% and that around 30% have a purity of over 95% (Histogram no. 1, p. 27 below). The high silver results shown by Histogram no. 2 and in the table are due to contamination with silver from the rivets employed to attach the different parts of the ornaments or possibly from silver objects molten in the fire of the pyre. The results due to contamination are written in *Italics* in the table, so as to be clearly evidenced. These data were not taken into consideration for the statistics and for the histograms.

Silvery remains

The traces of the silver rivets or of the silver which had been utilised as backing for the garnets are relatively easy to identify, as most of them are still visible on the back of the single objects; however none of the hypothesised silver objects can be identified. The only remains are shapeless silver lumps, some of which are intermingled with semi-molten gold sheet or gold foil (Fig. 2). This seems to suggest that the silver

Fig. 2. Photo taken through the microscope showing the remains of a semi-molten gold sheet (Inv. No. 2002-21.74) in a silver lump.

Fig. 3. The largest piece of silver alloy contains 20% of copper and only traces of gold (Inv. No. 2002.21.75). This was most probably the original composition of the silver objects. This alloy could be used for vessels, boxes and mirrors.

objects were decorated with gold or had some gold details. Regrettably this makes it almost impossible to establish which kind of silver alloy was used. Most of the molten silvery lumps also contain high percentages of gold, certainly coming from the gilding or from the molten gold details. Only in a few cases, for example with the largest piece of silver in the hoard (Inv. No. 2002.21.75; Fig. 3) and with the silvery remains inside the bowl (Inv. No. 162) in the National Museum in Budapest, the gold content is quite low and the remains can give us a good idea of the composition of the original silver alloys. In both cases the silver contains 15–20% of copper. This composition was commonly employed in antiquity for silver alloys utilised to produce functional objects, for example, for vessels, boxes or small containers and mirrors (see for example Pike et al. 1997; Lang et al. 1984; Lang and Hughes 1985; Bachmann 1993; Giumlia-Mair 1998; 2000). Purely decorative objects had instead a higher purity. The silver lumps from Nagyszéksós are not large; we can therefore hypothesize that the objects were small luxury containers, vessels or even cast decorative objects such as large fibulae. The fact that they had gold plated details might confirm this tentative hypothesis, but the size of the shapeless pieces of silver and the presence of gold are the only objective clues we have.

Gold alloys

The analyses of the whole group of items from Nagyszéksós allow us to distinguish several trends in the alloying practice. In most cases the different groups of alloys also correspond to different production techniques, as shown by the examination of the manufacturing details of the single pieces. For a better understanding of the technology employed by the artisans in the production of the objects it is important to examine the groups with similar characteristics, and produced with alloys of similar composition.

The lowest silver and copper content (around 99 – 100% Au) have been determined in the torques (Inv. No. 2002.21.1), in the heavy gold buckle (Inv. No. 2002.21.2; Fig. 4) and in the many fragments of decorated gold sheets (Inv. Nos. 2002.21.76 – 2002.21.144). The choice of using very pure gold for the production of gold sheets is partly due to the properties of this extremely malleable and ductile metal that, if very pure, can be easily beaten into foils of a few microns. However in this case the sheets are relatively thick (ca. 0.05 mm). All fragments have to be defined as sheet (and not as foils), as they are always thick enough to sustain their own weight. The high purity of the gold would not have been necessary for sheets of this thickness. However, the color of the precious metal must have been an important criterion in the choice of the alloy. The surface covered by the gold sheets must have been rather large and therefore the color would have attracted the attention of the onlookers. The sheets have been utilised on the handles of daggers (for example Inv. Nos. 2002.21.34; 2002.21.35; 2002.21.153) and as decoration on flat parts of ceremonial or parade saddles. Apparently, for these representative objects, certainly belonging to an important member of the royal family, if not to the king himself, it was important to have decorations with the bright color of real and very pure gold. The same criterion must have determined the choice of metal for the torques (Inv. No. 2002.21.1) — made of a thick bar of very pure

Fig. 4. This large gold buckle (Inv. No. 2002.21.2) is made of gold of very high purity, similar to that used for the torques and the gold sheets.

gold — and for the impressively large and very heavy gold buckles (Inv. Nos. 2002.21.2, 2002.21.6), probably part of the ceremonial horse fittings or weapons of the royal personage.

It is commonly thought that the gold used by the Huns came from the molten and re-used Roman coins, received as *tributus.* Every year the Romans paid a *tributus* of 160 kg of gold coins to Ruga, and later, at the time of Attila, the *tributus* became as large as 300 kg of gold coins. These must have been the *solidi,* i.e. the gold coins introduced by Constantine in 310 CE to replace the *aurei*. In 368 the fineness of the *solidi* was increased from 95% (the fineness of the earlier *aurei*) to 99% (see for example Johns 2010); so the gold employed for the torques, the large buckles and most of the gold sheet, might indeed come from the molten Roman coins received by Ruga and Uptar.

A different class of gold alloys, with a silver content between 3 and 6% and a copper content from under 1 to around 2%, was used for a group of objects with a very distinctive cloisonné decoration (Fig. 5; Color Plate Ia). *Cloisons* are gold walls soldered on a metal sheet to form cells in which stones can be inserted. In this group of objects flat garnets are mounted in triangular or semicircular cells. The cloisonné buckles (for example Inv. Nos. 2002.21.3; 2002.21.5 and 2002.21.10), the fittings with gold rivets and without beaded wire decoration around the stone mounts (for example Inv. Nos. 2002.21.7; 2002.21.8; 2002.21.11; 2002.21.12, 2002.21.13; 2002.21.14; 2002.21.30; 2002.2131; 2002.21.32; 2002.21.33), and the round decoration which probably was part of a bowl (Inv. No. 2002.21.69) belong to this group. These kinds of alloys — of excellent quality — are harder than pure gold and not as easily scratched or damaged. The color is still similar to that of unalloyed gold, as the low silver content is counterbalanced by the low copper percentage. In some cases, for example in the cicada-shaped fitting Inv. No. 2002.21.30, the patterned sheets used as backing for the flat garnets can be still seen.

Cloisonné ornaments are commonly considered typical products of artisans working for tribes of Germanic origin. Several tribes who spoke some kind of Germanic language, such as the Visigoths, Heruls or Eruls, Gepides, Burgundians, Franks, Suebians, Vandals and Alamans were first subjects and then allies of the Huns (Bóna 1988, pp. 119–21; 1991; Zasetskaya 2007; Menghin 2007). Part of these tribes were pushed out of their territories and, between 378 and 406, invaded the territories of the Western Roman Empire and, in due time, caused its fall.

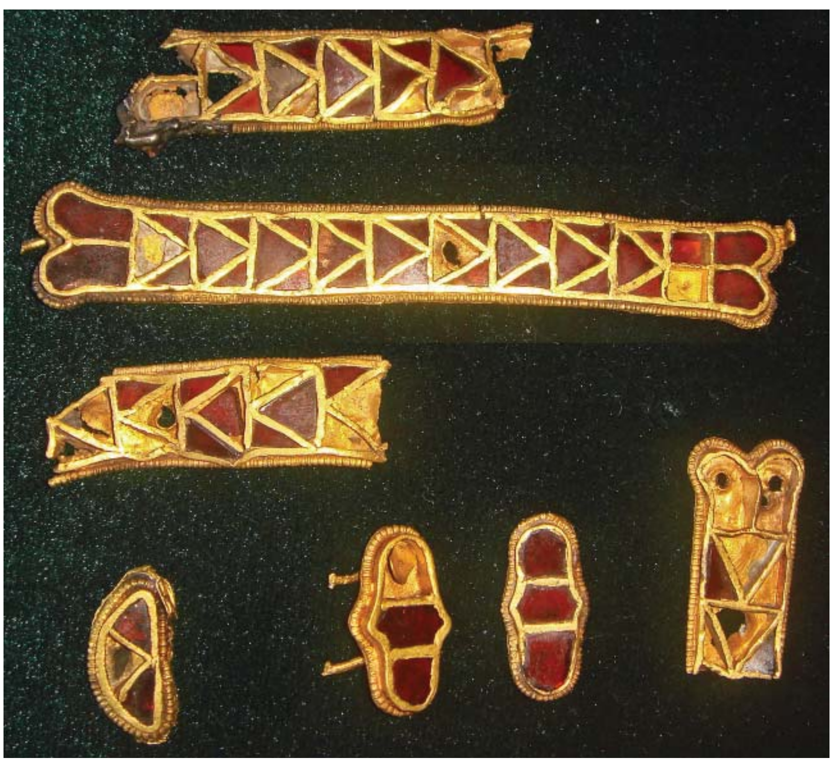


Fig. 5. Selection of cloisonné objects (Inv. Nos. 2002.21.17; 30-33; 38-40). This group is made of gold of excellent quality with ca. 3-6% Ag and 1-2% Cu. With the addition of Ag and Cu the gold is harder and not as easily scratched. The rivets for fixing these ornaments are of gold.

Among the cloisonné objects, different alloys and technologies can also be distinguished. A group of objects shows higher contents of alloying elements and seems to belong to a different metallurgical tradition from that of the cloisonné objects just discussed. The cloisonné fitting with square end Inv. No. 2002.21.9, for example, contains up to over 8% of silver and over 6% of copper. The rivets contain over 8% of silver and over 9% of copper. This alloy is harder and more suitable for rivets, but very different from the alloy of the rivet of the eagle-head fitting, with around 5% of silver and only 0,5% of copper, or of the pointed fitting, with around 3,2 % of silver and 2,7 % of copper. In the case of the latter pieces, the alloy is very similar to that of the actual object to which they belong, and the rivets are rather soft. The larger ornaments with three round garnets (Inv. Nos. 2002.21.27 and 2002.21.28) contain much higher silver percentages (up to almost 20%) and relatively high copper (up to 14%) and are clearly different from the alloys discussed before, but also from the alloys employed for the very similar ornaments Inv. Nos. 2002.21.25 and 2002.21.26. It has to be mentioned that

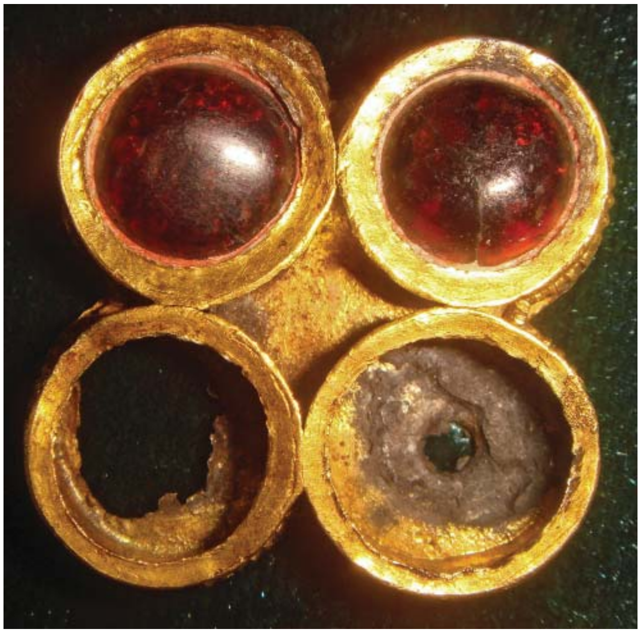


Fig. 6. This large decoration with 4 garnets (2002.21.49), and a group of other objects, seem to belong to a different metallurgical tradition. They contain higher percentages of Ag (up to 20%) and Cu (up to 14%). Many of the rivets of this group are made of silver.

the high silver and copper percentages obtained from the measurements on the back sheet of these pieces are due to contamination, while in the case of the larger pieces they reflect the real composition of the stone mounts. The stones of the smaller trefoil-shaped ornaments are cabochons, while the stones still in place in the larger trefoil-shaped ornaments are flat garnets with a round cut. Apparently the gold of the larger trefoil ornaments was diluted with some brass.

A further example of alloy with higher silver and copper contents (up to around 9% Ag and over 10% Cu) was used for the large decoration with four garnets (Inv. Nos. 2002.21.49-50; Fig. 6). Very high silver (around 15% Ag) and copper (12% Cu) have also been observed in most of the alloys of the cloisonné studs with crescent shaped garnets (Inv. Nos. 2002.21.52–53). Possibly these ornaments were made of a much harder alloy, because they were applied on horse fittings that were actually used, and were not just representative items like many other objects of the hoard. The differences in composition are quite striking, and the manufacture is of excellent quality. For example the beaded wire is accurately worked; many details and the appropriate choice of alloys demonstrate excellent workmanship. These objects with higher contents of silver and copper therefore seem to belong to a different metallurgical tradition. Very few Germanic or Gothic gold objects dated to this period and coming from this area have been analysed, and in general very little analytical work has been carried out on all kinds of materials dated to the first half of the 5th century CE in this region. Appropriate comparisons are lacking, but the composition suggests that the cloisonné ornaments with higher silver and copper percentages might perhaps have been produced by some of the many ethnically different tribes that moved around with the nomadic Huns as their vassals or allies.

Some gold objects from Crimea, dated between the 4th and the 7th century CE, have been recently analysed in the British Museum (La Niece and Cowell 2008, pp. 154–55, tab.1 and 2; Craddock et al. 2010). Their silver and copper contents are more similar to those of this group of finds. The percentages of alloying elements in the gold are rather irregular, with a very wide range of 4 – 30% for silver and 0.5 – 5% for copper. The silver content is mostly higher than the copper content, as is generally typical for ancient gold alloys.

A further difference is that the rivets for fixing the ornaments on a support — certainly made of some organic material now lost in the fire — are made of silver instead of gold as in the previous group. In the studs with crescent-shaped garnets, the head of the silver stud was flattened and polished, certainly to be used as backing for the garnet. These rivets are the only ones in the entire hoard preserved in an acceptable condition. The analysis has shown that the alloy is silver with gold traces and around 20% of copper. This alloy is quite hard and therefore very suitable for rivets.

The decorative plates (Fig. 7; Color Plate Ib) with regularly mounted rectangular stones (Inv. Nos.

Fig. 7. The decorative plates (2002.21.21–24) with elongated and protruding stones are considered typical for the Hunnic tradition. The alloys employed contain ca. 3% Ag and 2% Cu. The rivets are of silver, the decoration around the rim is an imitation of beaded wire (see also Fig.18).

Fig. 8. The elongated stones of some of the plates (Inv. No. 2002.21.22) seem to be of different materials. The first on the right is garnet, the second shows inclusions suggesting either imperfections of the stone or perhaps red glass, and the third has a purplish color like an amethyst. Note also the detached strip imitating beaded wire (see also Fig.18).

Fig. 9. The plates with oval or round cabochon stones (Inv. Nos. 2001.21.41–42 and 54–68) are considered typical Alanic ornaments and were applied on a saddle and on horse fittings. The gold of this group of items contains 6–7% Ag and only very little Cu. Two groups can be recognized: one with smaller stones and a frame of beaded wire imitation and one with larger stones without a frame.

2002.21.21; 2002.21.22; 2002.21.23 and 2002.21.24) seem to belong to yet another group. The gold alloy contains around 3% of silver and 2% of copper, with the exception of the rivets and the beaded wire. The plates consist of a gold sheet framed by an imitation of beaded wire (see below). Gold strips were soldered onto the plate and around the stones to hold them in place. The stones are protruding and the upper side is rounded and carefully polished. The examination at the microscope showed that different kinds of stones have been used. Plate Inv. No. 2002.21.22 was cut and shows only three inlaid stones in a row (Fig. 8), while the first on the left is lost. The first stone on the right has the dark red color of the garnet, the second shows some bubbles or inclusions in the transparent stone, and the third is very transparent and shows a very purplish colour. Decorative plates with protruding stones are considered typical of the Hunnic tradition. The examples from Nagyszéksós look very similar to the stone-inlaid plates of diadems worn by Hunnic women (see Bóna 1991, pp. 147–49), but the size and the number of inlays are different, and it would be difficult to assemble them on a diadem. Ornamental plates of this type could have been applied on saddles, horse fittings, weapons or representative belts, and it is now impossible to attribute them to a specific object.

Alanic-type objects

The plates (Fig. 9) with round or oval cabochon stones (Inv. Nos. 2002.21.41–42 and 2002.21.54–68) are considered typical Alanic ornaments (Kürti 1988; 2007). The Alans were, like the Sarmatians, a population of Iranian language (Alemany 2000) perhaps originating from the Aral region. After having been overwhelmed by the Huns, they moved to the Caucasus or joined the nomadic Hunnic warriors and fought at their side as appreciated archers and riders (Botalov 2009, pp. 140–57; Kazanski 2008, Quast 2008, p. 276). The integration was so complete that in the 4th century CE Vegetius mentions "Hunnorum Alannorumque natio," the "nation of Huns and Alans" (3.26). With all probability the plates with round or oval cabochon stones (Inv. Nos. 2002.21.41–42 and 2002.21.54-68) belonged to a set of ornaments for a saddle and matching horse fittings. The analysis of the alloys of these objects evidenced peculiarities that seem to indicate a different origin. They contain 6–7% of silver and only very little copper, mostly less than 1%. The cabochon stones are not garnets, but seem to belong to the family of the chalcedonies (i.e., a cryptocrystalline form of silica with many varieties: agate, aventurine, carnelian, chrysoprase, heliotrope etc.). The stones seem to have had, with all probability, a bluish colour, as shown by the few less altered examples. Only in one case the stone can be easily identified: the inlay of the small fragment with one single stone still in place (Inv. No. 2002.21.66) is clearly a cabochon cut rock crystal. Regrettably, most stones are lost and many show a whitish colour, most probably due to the exposition to the intense heat of the pyre. The low copper content suggests that this metal was present in the gold as impurity and that only silver was added to the gold or, perhaps more probably, that a silver alloy containing copper was added to the gold. The alloys are similar, but there are differences in the manufacture. The fragments can be distinguished in two groups. The first is characterised by smaller stones and by a frame of beaded wire imitation, while the second group shows larger, unframed stones.

Fig. 10. The 23 pyramidal sequins (Inv. Nos. 2002.21.29 a-z) are also considered Alanic. They are made of the same alloy and come apparently from the same piece of gold sheet with 9% Ag and 3% Cu. Gold alloys of this composition with relatively high Ag and low Cu might be distinctive for Alanic production.

The 23 pyramidal sequins (Inv. Nos. 2002.21.29 a-z; Fig. 10) with decorated rims are also considered typical decorations of Alanic garments (see for example Bóna 1991, pp. 162–66; Anke et al. 2008, pp. 19–20). The four small holes on the corners were evidently used for sewing the ornaments on thin fabric. The nine analysed pieces are all made of a malleable alloy containing around 9% of silver and 3% of copper. One of the analysed sequins (Inv. No. 2002.21.29 x) is burnt and shows traces of molten silver on the surface. They were all obtained from the same metal sheet, struck with a die to produce the pyramidal shape and the decorated rims. As in the horse fitting ornaments attributed to Alans, the silver content is relatively high, and much higher than the copper content. This might be a distinctive and indicative detail for this kind of Alanic-type production of gold objects. Very similar, indeed almost identical sequins have been found in Carthage, Tunisia, in the Koudiat Zaateur Treasure (Ben Abed 2008, p. 332), dated to the second half of the 5th – early 6th century CE, belonging to a "Vandal" context. Mounted troops of Alans, Huns and Ostrogoths led by Alatheus and Saphrax fought on the side of the Visigoths, for example at Adrianople, and in 378 they became federates of the empire in Pannonia. Most probably, a contingent of these troops took part in the migration of the Vandals and Suevi to the West. Saphrax is a name of Iranian origin (Kazanski 2008, p. 255).

Wooden bowl decorations

Among the items found at Nagyszéksós, there are rhomboidal gold sheet fragments (Inv. Nos. 2002.21.71-73 and 2002.21.157) with a rudimentary decoration around the rims and rivet holes. These objects, as well as the ribbed strip with one rounded end (Inv. No. 2002.21.70) were certainly used as decoration of wooden bowls. The alloys contain around 7% of silver and 2% of copper (analysis results with lower percentages were determined on damaged pieces, altered by fire, and should not be taken into consideration). Their composition is similar to that of the alloys used for the richest cloisonné ornaments of better quality and perhaps they belong to the Hunnic metallurgical tradition. The fragment of triangular decoration (Inv. No. 2002.21.157) seems to be thinner, slightly different from the other examples and might belong to a cheaper bowl, perhaps only produced for funerary use.

The cup and the bowl from Nagyszéksós

The composition of the gold of the cup (Inv. No. 81.1.1, gold Inv. 160; Fig. 11) from Nagyszéksós, now in the National Museum in Budapest, clearly differs from those of other objects. The metal can be considered an *electrum* alloy, with around 11% of silver and only ca. 3% of copper. The slightly different composition of the ring-shaped foot might be due to surface enrichment, caused by the oxidation of the less noble metals of the alloy. This seems to be confirmed by the slightly lower copper content. The bowl of the cup was cast by lost wax technique with a carefully worked wax model. The internal part of the spaces left for the stones still bear the marks of the work carried out on the wax

Fig. 11. The cup (Inv. No. 81.1.1, gold Inv. No. 160) from the Nagyszéksós hoard, now in the Hungarian National Museum in Budapest is made of an electrum alloy with 11% Ag and ca. 3% Cu. The separately cast foot has a slightly different composition, but this might be due to oxidation. The cup was cast by lost wax technique by using a carefully worked wax model and has been interpreted as an object of Iranian origin.

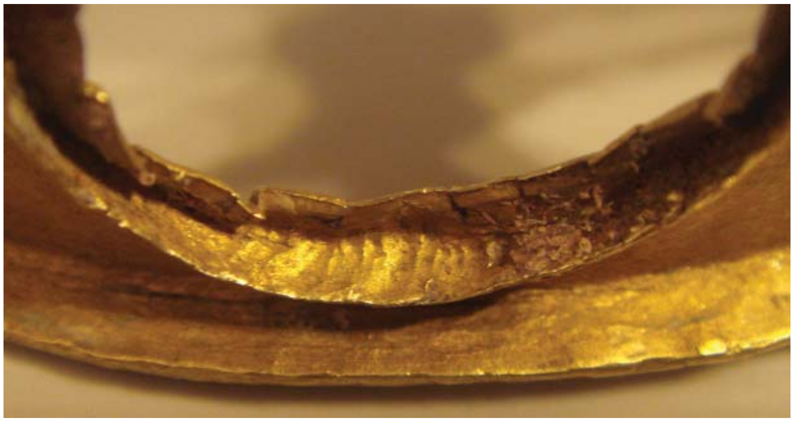


Fig. 12. The internal part of the spaces in which the stones were set on the cup still bears the marks of a warmed metal tool used on the wax model. The now lost inlays were described as brown glass; however it is more plausible that the glass was originally red and was altered by the fire.

with a warmed tool (Fig. 12). The remains of the inlays were described as "brown glass"; however it is more plausible that the glass was originally red and that it was altered by fire. The glass roundels were set into place in the round holes and fixed by pressing the soft gold alloy on them, so that they did not fall out and the cup could be used for drinking. Istvan Bóna has interpreted the cup from Nagyszéksós as an object of Iranian origin and compared its shape to that — almost identical — of some contemporary Iranian glass cups. One is in the Museo Nazionale d'Arte Orientale in Rome, Inv. No. 2705 (Bóna 1991, p. 168, Fig. 64; p. 261, n. 64). Another has been found in a grave dated to the Northern Zhou Dynasty in China, at Li Xian, Hopei (An 1986, pp. 173–81, Fig. 1, tab. 1–2) and a third very similar example, dated to the 4th century CE, has been published by von Saldern (1963, p. 12). An analogous motif and a rather similar technique are found on the "pectoral" from Wiesbaden, consisting of a gold torques with two hinges and a part which looks like the lid of a small jewelled box adapted as a pendant. Alternatively, the pendant has been interpreted as part of a Parthian bracelet (Bernhard 2007, p. 124). The piece is a gold plate, apparently hinged, decorated with round, triangular and square-shaped garnet (or possibly red glass) inlays and with a leaf-shaped movable element with three differently cut red stones. The most important feature of the pendant from Wiesbaden is an inscription on the back with the name Artachshatar, i.e. the Lat. Artaxerses or Ardashir I, the founder of the Sasanian Dynasty who, at the time of Alexander Severus (222–235 CE) attacked Mesopotamia, Syria and Cappadocia (*Hist. Aug., Alexander Severus*, LV). It is quite clear that the decorative piece had been looted and re-used as pectoral, most probably by a socially prominent Hunnic warrior. The Iranian name on a piece with a construction similar to that of the cup from Nagyszéksós seems therefore to confirm the hypothesis of an Iranian origin of both the vessel and its decorative technique. The rim of the cup was cast together with the bowl, while the ring of the foot is a separate casting. Inside the foot there is an inscription in Greek letters, written as dotted lines with a pointed chisel and a small hammer.

The fragmentary bowl (Inv. No. 81.1.2, gold Inv. Nos.161a, b, c, and 162; Fig. 13) is made of an alloy containing around 10% of silver and only traces of copper. All parts, also the cells of the decorative rosette in the center of the bowl, are made of the same alloy and were certainly cast in one piece. If the cell-work had been soldered onto the plate, as commonly thought, the cells would show a different composition, because of the presence of the solder that would diffuse around the soldering line. The stone inlays are now lost, but were most likely protruding in the center of the bowl.

Fig. 13. The fragmentary bowl (Inv. No. 81.1.2; gold Inv. Nos.161a, b, c, and 162) is made of an alloy containing around 10% of silver and only traces of copper. The rosette was cast by lost wax technique in one piece with the bowl. The production technique is similar to that of the cup.

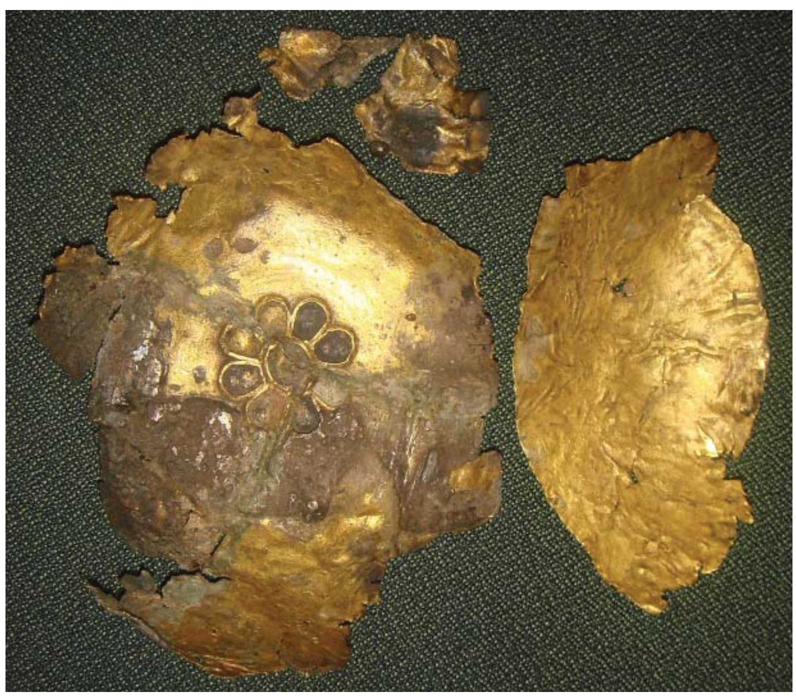


Fig. 14. Gold mask, ca. 5th–6th century CE, excavated at Boma in the Ili region of Xinjiang. Collection of Ili-Kazakh Autonomous District Museum, Inv. No. 97YZS4.

Only the heavy Hunnic-type objects, such as the torques, the very large buckles and some of the richer cloisonné objects (e.g., the buckle Inv. No. 2002.21.05 and the eagle fitting Inv. No. 2002.21.07) are characterised by extremely low copper percentages, while the silver content can vary. This seems to suggest that gold alloys with very little copper can be attributed to the Hunnic metallurgical tradition, and therefore that the rich cloisonné ornaments made of these alloys might not necessarily be objects of Germanic origin, as hypothesised.

Regrettably, up to now no analyses have been performed on the amazing gold objects with garnet decorations, excavated at Boma in Xinjiang. Some of them closely resemble some of the Nagyszéksós finds and in particular the stone setting on the cup and the bowl in Budapest. These are two garnet decorated gold vessels, and a gold mask [Fig. 14; Color Plate II] with features depicted with garnet inlays (Koch 2007). The construction of the cells on the vessels from Boma is similar to that of the central rosette inside the bowl from Nagyszéksós and the shape and the stone setting are similar to that of the cup. The cells of the mustache and eyebrows on the mask look like the cells of the cicada-shaped finials (Inv. Nos. 2001.21.17–20) from Nagyszéksós. The crescent-shaped garnets which depict the beard of the mask are similar to those of the studs (Inv. Nos. 2001.21.52–53); however the mount of the Boma mask is of much better quality and workmanship, with the cells of the single crescent stones surrounded by an accurate granulation. The "Western" characteristics of the cup with panther handle and of the other finds from Boma, have been discussed in detail by Lin Ying (2008). She interpreted them as objects produced in the Turkic Empire of Central Asia and adds that these populations "transmitted material and cultural achievements between East and West, but also combined in their own distinct culture the elements of different civilisations" such as the Byzantine, Iranian, Indian and Chinese (Ying 2008, p. 25).

The researches of Périn et al. (2006) have shown that the vast majority of archaeological garnets, in particular in the 5th – 7th centuries CE, come from the metamorphic belts in Rajasthan and the east coast of India. Some examples come from Ceylon as do most of the garnets used in Roman times. Pyropes from Eastern Europe have only been employed since the 7th century CE. The large amount of garnets on Hunnic-type gold items, but also on the jewellery of other populations coming from the Sarmatic Plain, the Aral region and the Caucasus, makes one wonder whether these stones did not arrive to Europe through land trade over the ancient mountain routes through Xinjiang, Ferghana, Bactria or Parthia (Giumlia-Mair et al. 2009, pp. 40–41) instead of having been brought on sea routes.

It is just possible that the cloisonné pieces with consistently higher silver and copper content discussed above belonged to a different, perhaps Germanic tradition. This could explain the noticeable differences in the use of gold alloying elements for cloisonné-decorated pieces of similar appearance. It is also important to note that the addition of silver (and of copper) hardens the gold alloy and renders the objects more resistant to wear.

Technological details

The nogaika elements

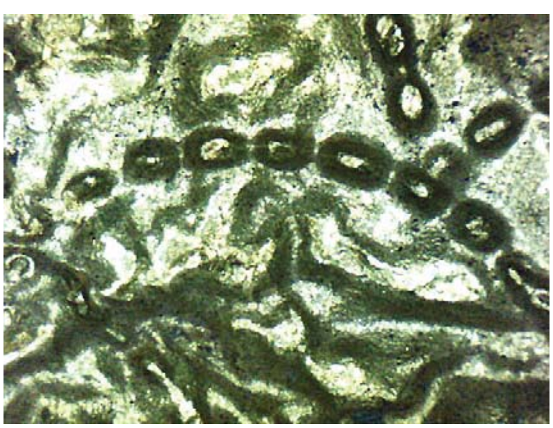
Only very few of the objects contain higher Cu percentages. One of them is the stone setting of the *nogaika* or *kamcha*, i.e., of the horsewhip which, according to Byzantine sources, indicated a high status. The large stone setting has been interpreted as the decoration at the end of the *nogaika* handle (Kürti 1988; 2007). Its alloy contains around 10% of silver and 7% of copper. This composition ensures a better resistance to wear and renders the alloy very suitable for a stone setting like this. It is noteworthy that the other pieces identified as decorative parts of the *nogaika*, such as the ribbed bands (Inv. Nos. 2002.21.36 and 2002.21.37) and the thinner gold cylinder (Inv. No. 2002.21.44), most probably all positioned at higher points above the handle, are made of a much softer gold alloy, containing around 5% of silver and 1% of copper, because they did not need to be particularly resistant to wear.

The dagger decorations

Three relatively thick fragments of decorated gold sheets still show that they had some stone inlays. They have been interpreted as decorations of dagger handles. The analyses of the fragment with the Inv. No. 2002.21.34 identified a gold alloy with around 9% of silver and 1% of copper, but the fragment is burnt and the composition might have been different before being damaged by fire. The thick decorated band, used as reinforcement for the handle rim, is in better condition, and made of a gold alloy with around 7% of silver and 2% of copper. The second decorated gold sheet with mounts for stone inlays (Inv. No. 2002.21.35) was also damaged by fire and its alloy contains around 5% of silver and 1% of copper. The upper ring alloy contains around 9% of silver and 5% of copper and is much harder than the rest of the metal. The original composition of the decorated sheet possibly showed higher alloying elements, but among the gold sheet fragments there is also a small decorated fragment (Inv. No. 2002.21.153) with the remains of a mount for a stone, in much better condition than the two damaged pieces. Its alloy contains 5,4% of silver and 1,4% of copper and it is similar to the fragment with Inv. No. 2002.21.35. The two fragments might belong to the same object and the alteration due to the fire might be less extensive than suggested by the condition of the fragments.

Fig. 15. As shown on the microscope picture, some of the decorated gold sheets have a distinctive scale pattern with slightly irregular marks and a thicker mark almost in the middle of the arch. These marks have been identified on the objects with the analysis numbers 202–204, 237–243, 246 and 260 (Inv. Nos. 2002.21.86–88; 121–127; 130 and 143).

Fig.16. A number of gold sheets with scale pattern could be attributed to a different object after the examination with the microscope and the comparison of the composition. Their decoration shows wider arches and smaller marks (analysis numbers 221, 222, 250 and 257, Inv. Nos. 2002.21.105, 106, 133 and 140).



The examination with jeweller magnification lenses and under the microscope of the gold sheets hypothetically belonging to daggers has drawn attention to the fact that the gold sheets had been decorated from the front and not by repoussé, as commonly thought. The actual dagger handle, apparently made of an organic material is lost, but the fragments still preserve the cylindrical shape with the thicker decorated band at the top, so that the position of the sheet is quite clear. The decoration lines and dots are all deeper than the surface of the sheet and in relief on the internal side. As very similar tools — or, in some cases, even the same ones — have been used to decorate all gold sheets it can be assumed that this was the common practice and all decorations were produced on the *recto*, i.e. the external part of the sheets.

Decorated gold sheets

The composition of the gold sheets and the examination under the microscope allowed the identification of decorations carried out with particular tools and of pieces belonging together or at least produced in the same workshop and with the same tool. The pattern was most probably obtained with a tool made of carved bone or ivory. Metal tools are not suitable for this purpose, because their points and edges are too sharp for soft gold metal sheets. The present study helped to distinguish different scale patterns obtained with different tools. The first, and one of the most distinctive details identified with the microscope, is a scale pattern with slightly irregular marks and in particular a thicker dot clearly recognisable on the arch of the scale pattern (Fig. 15). The marks of this particular tool were identified on the objects with analysis numbers 202–204, 237–243, 246 and 260. A further distinctive scale pattern shows a wider arch and very small horizontally elongated marks (analysis numbers 221, 222, 250, 257; Fig. 16), while a third scale pattern is characterised by a narrower arch and oval marks (for example analysis numbers 249 and 235). Some of the fragments are decorated with irregular dotted lines (analysis numbers 231, 233, 234, 244, 271). A herringbone pattern (analysis numbers 231, 233, 234, 247, 271) and a distinctive checked pattern (analysis numbers 230, 251, 253–255) were also identified.

Decorative "beaded" wires

On the objects from Nagyszéksós there are different decorations made by applying beaded wires or beaded wire imitations. In antiquity, gold wire was commonly produced by cutting thin strips or thin square rods from a metal sheet with a sharp blade and twisting them (see, e.g., Ogden 1982, p. 46). To obtain a regular thickness and to smooth the wire the twisted strip was rolled between two blocks of wood or stone, but the spiral-shaped line obtained by twisting is mostly visible under the microscope. The "real" beaded wire was then annealed to be made softer, and rolled under a swage block, i.e., a block with a groove cut with the pattern the goldsmith wanted to achieve. A swage block for beaded wire was cut so as to obtain a beaded pattern on part of the wire length. The same procedure was then repeated on the entire wire. No traces of drawn wire could be seen. The beaded wires employed as frame for the cloisonné cells or for the cabochon stone mounts are usually soldered on the flat and protruding gold sheet, itself soldered at the back of the stone mounts and are of different quality and workmanship. For example, the beaded wire on the large stone setting of the *nogaika* is very regular and almost perfect, while the wires on the crescent shaped mounts are much more irregular and less accurate (Fig. 17a and b). The beaded wires on the Hunnic and Alanic pieces are not made in the usual way, but they seem to have been cast in a mould

Fig. 18. Several items, in particular those considered Alanic (Inv. Nos. 2001.21.41–42 and 54–68), are framed by an imitation of beaded wire (see also Figs. 7 and 8). The protruding "globules" are visible on only one side of the decorative strip. The other side is flat and soldered on the gold sheet support.

or shaped by hammering a thin rod into a keying prepared so as to obtain an imitation of beaded wire. The protruding "globules" are visible on only one side of the decorative strip, while the other side is flat and soldered on the gold support to build a frame for the object (Fig. 18).

Fig. 17a, b. The beaded wires are of different quality and workmanship, and several groups can be distinguished. The microscope picture 17a shows the very regular and accurate beaded wire on the stone setting of the nogaika *(Inv. No. 2002.21.43), while 17b shows the less accurate wire of the crescent mounts (Inv. Nos. 2002.21.52–53).*

Conclusions

None of the items recovered at Nagyszéksós are real jewels, with the only exception of the heavy gold torques. All other objects and fragments belong to saddles and horse fittings, and weapons fit for a warrior king or a royal warrior. Even the decorations for wooden bowls belong to the type which could be tied to the saddle and carried to war. The only pieces that are not necessarily prerogative of a warrior and belong to a different class of objects are the cup and the bowl now in the Hungarian National Museum in Budapest. Both seem to be objects of Iranian origin, or at least they show peculiarities that might be typical for populations from Central Asia, the Caucasus or Iran. In the present work, the detailed examination of the single items made it possible to distinguish objects of different workmanship and to group them according to their composition and production techniques.

The Romans paid around 160 kg *tributus* in gold coins to Ruga every year. Certainly some of the gold of the objects of Nagyszéksós comes from *tributus*. However, as we have seen, this is not always clear, and in some cases it looks as if the technology and perhaps also the metal were brought from far away and from different regions. Many more analyses of Hunnic or Hun-related gold objects will be necessary to achieve a good general picture of the metallurgical traditions and trends in the vast territory in which the Huns moved and lived, however the study of the Nagyszéksós hoard has given a glimpse into the goldsmith practice of the time and can be considered one of the first steps in the study of Hunnic metallurgy.

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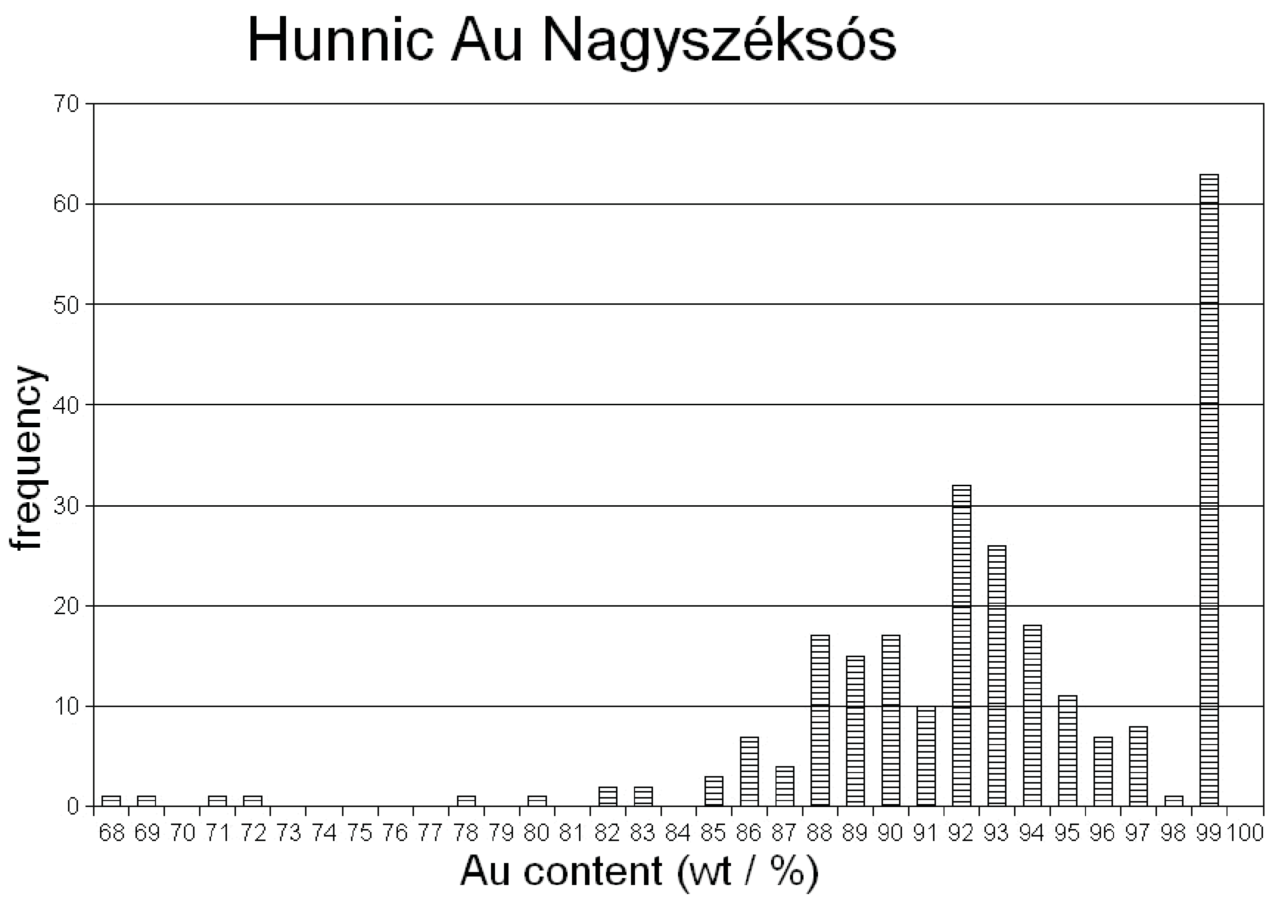
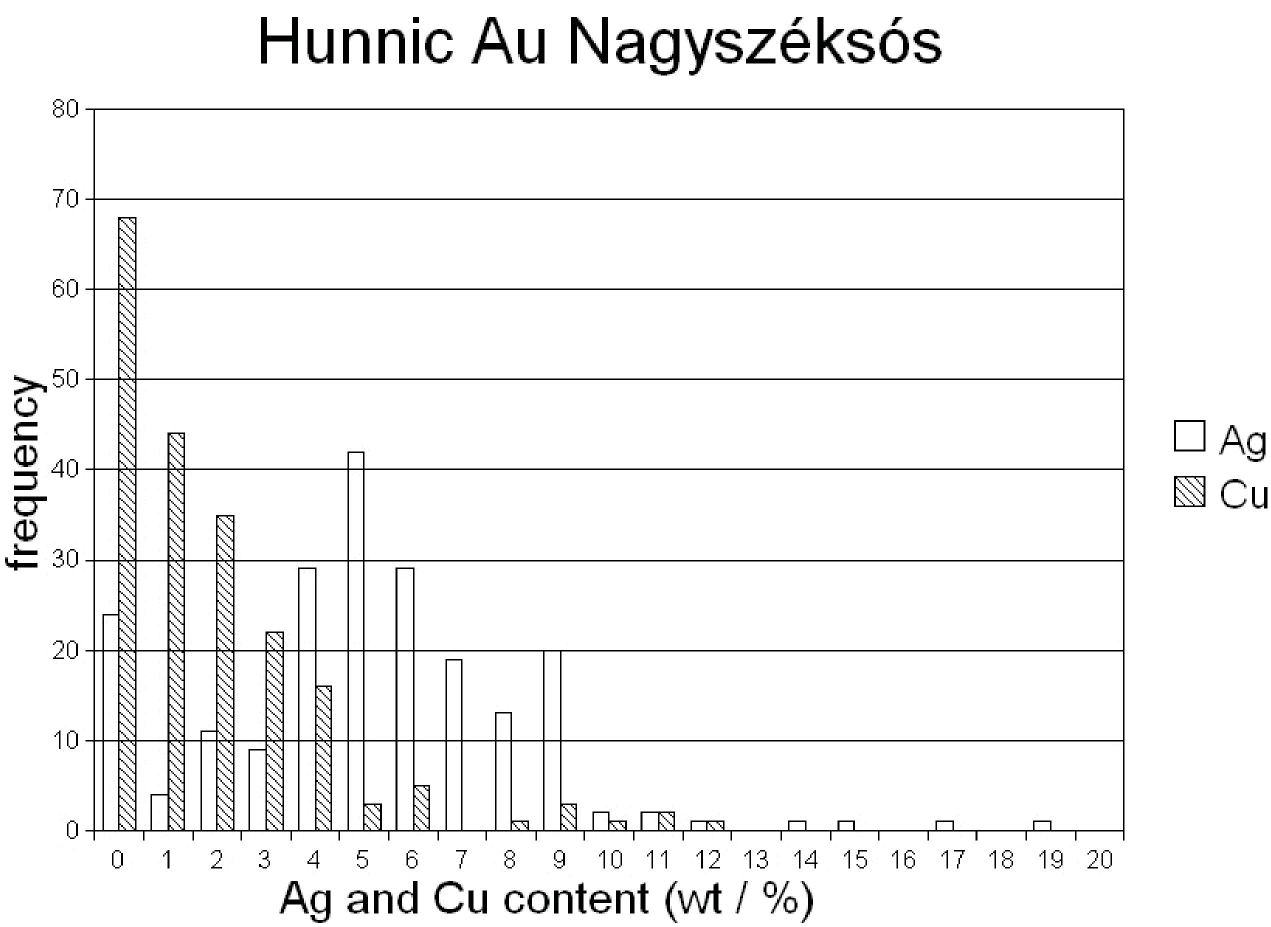


Histogram 1: The histogram shows the frequency of the gold content (weight %) determined in the finds from Nagyszéksós. The metal of the group of objects made of very pure gold (99–100%) consists of some ceremonial objects and gold sheets and comes probably from molten Roman solidi received as tributus. The group with 92–96% Au consists mainly of cloisonné ornaments of excellent quality, while the objects with lower and irregular Au on the left side of the histogram are cloisonné ornaments of different manufacture belonging to another metallurgical tradition.



Histogram 2: The histogram shows the frequency of the silver and copper contents (weight %) determined in the finds from Nagyszéksós. The objects with low Cu % are mainly gold sheets, but also Alanic ornaments. The objects with 4–6% Ag are the cloisonné ornaments of good quality, while those with high and irregular Cu and Ag contents correspond the the cloisonné ornaments of different, less accurate workmanship.

XRF Analyses of Hunnic gold artefacts from Nagyszéksós

no.	Object	inv.no.	Part	Au	Ag	Cu	Fe	Zn
1	torques	LTSZ001	torques	99.2	0.3	-	-	-
2	*torques*	*LTSZ001*	*silvery traces*	69.8	25.4	3.1	0.5	-
3	*torques*	*LTSZ001*	*silvery traces*	65.3	37.2	5.7	0.2	-
4	torques	LTSZ001	hook decorat.	99.6	0.2	-	-	-
5	torques	LTSZ001	att. fragment	93.7	4.5	0.6	0.6	-
6	belt buckle	LTSZ002	loop	99.1	0.3	0.5	-	-
7	belt buckle	LTSZ002	tongue	99.1	0.4	0.6	-	-
8	belt buckle	LTSZ003	loop	92.9	5.5	1.7	0.2	-
9	belt buckle	LTSZ003	tongue	93.6	5.1	2.2	-	-
10	belt buckle	LTSZ003	stone frame	88.8	7.6	3.3	0.2	-
11	belt buckle	LTSZ003	rivet	88.3	5.4	3.6	0.7	-
12	belt buckle	LTSZ003	sheet	89.1	7.2	3.3	0.4	-
13	belt buckle	LTSZ004	loop	93.0	5.8	0.5	0.2	-
14	belt buckle	LTSZ004	tongue	93.1	5.7	0.6	0.2	-
15	belt buckle	LTSZ004	stone frame	93.6	5.7	0.4	0.3	-
16	belt buckle	LTSZ004	sheet	93.7	5.3	0.5	0.2	-
17	cloisonne buckle	LTSZ005	stone frame	93.2	5.1	0.7	-	-
18	*cloisonne buckle*	*LTSZ005*	*sheet 1*	63.0	46.5	0.5	-	-
19	*cloisonne buckle*	*LTSZ005*	*sheet 2 dark*	67.1	4.2	0.3	28.4	-
20	cloisonne buckle	LTSZ005	sheet 1 clean	95.2	4.3	0.5	-	-
21	cloisonne buckle	LTSZ005	sheet 2 clean	95.1	4.4	0.5	-	-
22	cloisonne buckle	LTSZ005	rivet 1	94.8	4.8	0.3	-	-
23	cloisonne buckle	LTSZ005	tongue	95.5	4.2	0.3	-	-
24	cloisonne buckle	LTSZ005	loop	98.0	2.8	0.2	-	-
25	cloisonne buckle	LTSZ005	silver drop	92.3	7.7	tr.	-	-
26	large buckle fragment	LTSZ006	loop	92.1	5.5	2.4	-	-
27	*large buckle fragment*	*LTSZ006*	*silver blob*	24.3	63.3	12.4	-	-
28	eagle fitting	LTSZ007	back sheet	94.1	5.4	0.4	-	-
29	eagle fitting	LTSZ007	sheet recto	94.8	4.8	0.5	-	-
30	eagle fitting	LTSZ007	rivet	93.9	4.9	0.5	0.6	-
31	pointed fitting	LTSZ008	stone frame	96.4	3.4	-	0.2	-
32	pointed fitting	LTSZ008	rivet	97.3	3.2	2.7	-	-
33	sq. cloisonne fitting	LTSZ009	cloisonne wall	86.4	8.1	6.5	tr.	-
34	sq. cloisonne fitting	LTSZ009	back sheet	86.3	8.4	6.3	-	-
35	sq. cloisonne fitting	LTSZ009	rivet	86.2	8.3	9.6	-	-
36	sq. cloisonne fitting	LTSZ009	rivet	86.0	8.4	9.6	-	-
37	cloisonne buckle	LTSZ010	stone frame	91.2	7.2	3.8	-	-
38	cloisonne buckle	LTSZ010	tongue	94.9	4.5	1.6	-	-
39	cloisonne buckle	LTSZ010	loop	94.6	4.6	1.8	-	-
40	cloisonne buckle	LTSZ010	cloisonne wall	90.7	7.2	3.5	-	-
41	*cloisonne buckle*	*LTSZ010*	*stone*	-	-	-	tr.	-
42	boot decoration	LTSZ011	back sheet	95.1	4.6	2.2	-	-
43	boots decoration	LTSZ012	back sheet	95.2	4.9	2.1	-	-
44	*boots decoration*	*LTSZ011*	*rivet remains*	79.8	12, 5	7.9	0.5	-

no.	Object	inv.no.	Part	Au	Ag	Cu	Fe	Zn
45	3 points	LTSZ013	verso	90.2	7.6	2.2	-	-
46	3 points	LTSZ013	recto	90.8	6.9	2.3	-	-
47	3 points	LTSZ014	verso	90.9	7.2	1.9	-	-
48	*3 points*	*LTSZ014*	*rivet a*	-	1.2	98.5	tr.	-
49	*3 points*	*LTSZ014*	*rivet b*	4.3	2.2	94.5	-	-
50	3 points	LTSZ014	stone frame	90.1	6.7	3.1	-	-
51	curved point fitting	LTSZ015	verso	93.1	4.6	2.3	-	-
52	curved point fitting	LTSZ015	cloisonne wall	93.2	4.6	2.2	-	-
53	*curved point fitting*	*LTSZ015*	*rivet*	63.6	28.9	7.4	-	-
54	curved point fitting	LTSZ016	verso	93.2	4.5	2.3	-	-
55	curved point fitting	LTSZ016	cloisonne wall	93.0	4.6	2.4	-	-
56	curved point fitting	LTSZ016	recto sheet	93.2	4.7	2.1	-	-
57	cicada fitting	LTSZ017	stone frame	97.2	1.7	2.1	-	-
58	*cicada fitting*	*LTSZ017*	*rivet*	80.2	8.2	10.5	0.2	-
59	cicada fitting	LTSZ018	stone frame	93.4	5.2	4.4	-	-
60	cicada fitting	LTSZ019	stone frame	88.9	6.3	5.2	-	-
61	cicada fitting	LTSZ020	stone frame	89.2	5.8	4.9	-	-
62	dec. plate	LTSZ021	sheet recto	95.6	1.9	2.7	1.8	-
63	dec. plate	LTSZ021	sheet verso	96.9	2.5	0.6	-	-
64	dec. plate	LTSZ021	beaded wire	90.6	7.1	1.3	-	-
65	*dec. plate*	*LTSZ021*	*rivet*	72.4	22.4	4.2	0.3	-
66	dec. plate	LTSZ022	sheet recto	96.5	2.7	1.8	-	-
67	dec. plate	LTSZ022	sheet verso	96.2	2.8	1.0	-	-
68	dec. plate	LTSZ023	sheet recto	96.0	2.9	1.6	-	-
69	dec. plate	LTSZ023	sheet verso	96.4	2.8	0.8	-	-
70	dec. plate	LTSZ023	rivet	90.7	7.3	2.0	-	-
71	dec. plate	LTSZ024	sheet recto	95.7	3.1	1.2	-	-
72	3 stones decoration	LTSZ025	stone frame	88.4	7.7	1.9	-	-
73	3 stones decoration	LTSZ025	sheet	88.4	6.3	3.6	-	-
74	*3 stones decoration*	*LTSZ025*	*rivet*	52.2	28.4	17.0	2.4	-
75	3 stones decoration	LTSZ026	stone frame	78.6	7.6	4.1	5.7	-
76	*3 stones decoration*	*LTSZ026*	*back sheet*	69.1	20.6	8.7	1.6	-
77	3 stones decoration	LTSZ027	stone frame	68.0	19.7	11.2	1.1	-
78	*3 stones decoration*	*LTSZ027*	*back sheet*	69.4	17.9	14.5	0.2	tr.
79	3 stones decoration	LTSZ027	beaded wire	88.8	9.2	2.0	-	-
80	3 stones decoration	LTSZ028	stone frame	86.0	17.7	4.2	4.1	-
81	3 stones decoration	LTSZ028	back sheet	86.1	11.2	4.4	0.3	-
82	3 stones decoration	LTSZ028	beaded wire	89.1	9.1	1.8	-	-
83	sq. sheet ornament	LTSZ029	a	89.4	8.9	2.7	tr.	-
84	sq. sheet ornament	LTSZ029	b	90.3	9.2	2.5	-	-
85	sq. sheet ornament	LTSZ029	c	90.1	9.3	2.6	-	-
86	sq. sheet ornament	LTSZ029	d	90.2	9.3	2.5	tr.	-
87	sq. sheet ornament	LTSZ029	e	89.8	9.5	2.7	-	-
88	sq. sheet ornament	LTSZ029	f	90.1	9.2	2.7	-	-
89	sq. sheet ornament	LTSZ029	g	90.4	9.2	2.4	-	-
90	sq. sheet ornament	LTSZ029	h	89.3	9.4	2.2	1.1	-
91	sq. sheet ornament	LTSZ029	x	90.3	9.2	2.5	-	-
92	*sq. sheet ornament*	*LTSZ029*	*x silver blob*	48.5	43.7	5.2	2.6	-

no.	Object	inv.no.	Part	Au	Ag	Cu	Fe	Zn
93	double cicada fitting	LTSZ030	sheet verso	97.8	0.7	1.8	-	-
94	double cicada fitting	LTSZ030	rivet	93.7	3.6	2.5	0.2	-
95	double cicada fitting	LTSZ030	beaded wire	93.5	5.7	0.8	-	-
96	cicada fitting	LTSZ031	back sheet	94.6	4.6	1.8	-	-
97	cicada fitting	LTSZ031	cloisonne wall	91.1	6.2	2.7	tr.	-
98	cicada fitting	LTSZ031	beaded wire	91.6	5.9	2.5	-	-
99	cloisonnè strap	LTSZ032	cloisonne wall	91.4	6.1	2.5	-	-
100	fitting fragment	LTSZ033	sheet recto	93.1	4.9	1.2	0.5	-
101	dagger sheet	LTSZ034	sheet	89.6	9.6	0.6	0.2	-
102	dagger sheet	LTSZ034	top ring	90.8	7.3	1.9	-	-
103	dagger sheet	LTSZ035	sheet	94.9	4.5	0.6	tr.	-
104	dagger sheet	LTSZ035	upper ring	86.3	8.8	4.9	tr.	-
105	*dagger sheet*	*LTSZ035*	*silver blob*	9.4	79.3	8.1	3.2	-
106	ribbed band	LTSZ036	rim	93.7	4.9	0.8	0.4	-
107	ribbed band	LTSZ037	band	93.9	5.2	0.9	-	-
108	cloisonne decoration	LTSZ038	verso	89.5	6.3	5.2	-	-
109	cloisonne decoration	LTSZ038	cloisonne wall	89.4	4.8	3.3	2.3	-
110	*stone inlay*	*LTSZ038*		-	-	-	17.3	-
111	cloisonne decoration	LTSZ038	beaded wire	93.2	4.6	3.2	-	-
112	cloisonne decoration	LTSZ039	verso	94.0	4.1	1.9	-	-
113	cloisonne decoration	LTSZ039	rivet	88.1	9.2	2.7	-	-
114	cloisonne decoration	LTSZ039	cloisonne wall	92.6	4.8	2.6	-	-
115	cloisonne bow	LTSZ040	back sheet	92.8	5.3	1.9	-	-
116	cloisonne bow	LTSZ040	cloisonne wall	91.1	5.4	3.5	-	-
117	cloisonne bow	LTSZ040	beaded wire	88.5	6.2	3.8	0.5	-
118	*cloisonne bow*	*LTSZ040*	*rivet*	5.6	78.0	8.1	-	-
119	mounted stone	LTSZ041	stone frame	91.2	8.4	1.6	0.5	-
120	mounted stone	LTSZ041	back sheet	91.7	8.7	1.6	-	-
121	mounted stone	LTSZ041	beaded wire	90.7	8.1	1.2	-	-
122	single stone mounted	LTSZ042	stone frame	92.9	9.4	1.7	-	-
123	single stone mounted	LTSZ042	sheet	92.3	9.5	1.2	-	-
124	single stone mounted	LTSZ042	wall	92.6	9.1	2.2	tr.	-
125	single stone mounted	LTSZ042	beaded wire	92.8	9.3	1.9	-	-
126	stone mount nogaika	LTSZ043	back sheet	83.4	9.6	7.0	0.3	-
127	stone mount nogaika	LTSZ043	wall	83.5	9.7	6.8	-	-
128	stone mount nogaika	LTSZ043	beaded wire	82.7	10.9	6.4	0.2	-
129	cylindric sheet	LTSZ044	sheet	94.8	4.5	0.7	-	-
130	buckle plate	LTSZ045	back sheet	92.8	5.9	1.3	-	-
131	buckle plate	LTSZ045	beaded wire	90.5	6.4	3.1	-	-
132	*buckle plate*	*LTSZ045*	*Ag blob*	39.5	46.3	14.2	-	-
133	buckle plate	LTSZ045	wall	93.1	5.4	1.5	-	-
134	buckle plate b	LTSZ045	verso	92.9	5.4	1.7	-	-
135	*buckle plate b*	*LTSZ045*	*rivet remains*	53.8	27.9	18.3	tr.	-
136	buckle plate b	LTSZ045	beaded wire	91.8	5.5	3.7	-	-
137	buckle plate c	LTSZ045	verso	93.8	5.4	1.8	-	-
138	buckle plate c	LTSZ045	beaded wire	91.8	5.6	3.6	-	-
139	arrow-shaped fitting	LTSZ046	wall	89.0	6.7	3.5	0.3	-
140	arrow-shaped fitting	LTSZ046	back sheet	92.9	5.3	1.8	-	-

no.	Object	inv.no.	Part	Au	Ag	Cu	Fe	Zn
141	arrow-shaped fitting	LTSZ046	rivet	91.1	6.4	3.5	-	-
142	arrow-shaped fitting	LTSZ047	wall	93.6	5.2	1.2	-	-
143	arrow-shaped fitting	LTSZ047	rivet	89.0	7.7	3.3	-	-
144	*arrow-shaped fitting*	*LTSZ047*	*silver blob v.*	2.5	88.1	8.7	tr.	-
145	arrow-shaped fitting	LTSZ048	wall	92.3	5.2	2.0	0.2	-
146	arrow-shaped fitting	LTSZ048	att. fragment	92.8	5.3	1.9	-	-
147	arrow-shaped fitting	LTSZ048	rivet a	92.6	5.2	2.2	-	-
148	arrow-shaped fitting	LTSZ048	rivet b	92.7	5.3	2.0	-	-
149	large 4 stones fitting 2	LTSZ049	cloisonne wall	87.9	6.0	4.8	1.3	-
150	large 4 stones fitting 2	LTSZ049	back sheet	87.8	6.2	4.5	1.5	-
151	*large 4 stones fitting 2*	*LTSZ049*	*stone*	-	-	-	tr.	-
152	large 4 stones fitting 2	LTSZ049	beaded wire	88.5	6.1	4.7	1.7	-
153	large 4 stones fitting	LTSZ050	cloisonne wall	81.0	8.7	10.3	tr.	-
154	large 4 stones fitting	LTSZ050	back sheet	85.6	8.9	5.7	0.8	-
155	*large 4 stones fitting*	*LTSZ050*	*upper stone r.*	-	-	-	tr.	-
156	*large 4 stones fitting*	*LTSZ050*	*lower stone r.*	-	-	-	tr.	-
157	large 4 stones fitting	LTSZ050	beaded wire	89.1	5.8	4.6	0.5	-
158	single stone fitting frg.	LTSZ051	cloisonne wall	88.9	6.2	4.9	tr.	-
159	single stone fitting frg.	LTSZ051	rim	89.2	6.0	4.8	tr.	-
160	single stone fitting frg.	LTSZ051	back sheet	89.0	6.2	4.8	tr.	-
161	single stone fitting frg.	LTSZ051	beaded wire	89.0	5.9	4.7	0.4	-
162	stone crescent stud	LTSZ052	stone frame	71.2	12.5	8.3	-	-
163	*stone crescent stud*	*LTSZ052*	*rivet*	3.5	75.8	18.9	0.5	3.3
164	crescent shaped stud	LTSZ053	wall	69.9	15.4	11.3	1.2	1.2
165	*crescent shaped stud*	*LTSZ053*	*rivet*	3.7	70.1	24.4	0.8	-
166	crescent shaped stud	LTSZ053	back sheet	82.9	9.2	9.9	-	-
167	crescent shaped stud	LTSZ053	beaded wire	72.9	14.9	12.2	-	-
168	plate fitting	LTSZ054	sheet recto	93.0	6.3	0.7	-	-
169	plate fitting	LTSZ054	sheet verso	92.7	6.7	0.7	-	-
170	plate fitting	LTSZ054	beaded wire	92.5	6.9	0.6	-	-
171	plate fitting	LTSZ055	sheet	93.1	5.4	1.5	-	-
172	plate fitting	LTSZ055	sheet verso	93.5	5.4	1.1	-	-
173	plate fitting	LTSZ056	sheet	92.7	6.8	0.5	-	-
174	plate fitting	LTSZ056	sheet verso	92.5	6.9	0.6	-	-
175	fitting, bow	LTSZ057	sheet recto	94.2	5.7	1.2	-	-
176	fitting, bow	LTSZ057	sheet verso	94.3	5.8	1.0	-	-
177	plate fitting fragment	LTSZ058	sheet verso	94.6	5.7	0.7	-	-
178	plate fitting	LTSZ059	sheet recto	92.6	6.8	0.6	-	-
179	plate fitting	LTSZ059	sheet verso	92.6	6.7	0.7	-	-
180	plate fitting	LTSZ060	sheet recto	92.7	6.5	0.8	-	-
181	plate fitting	LTSZ061	back sheet	95.6	5.8	0.6	-	-
182	plate fitting	LTSZ061	recto	94.1	5.6	1.3	tr.	-
183	plate fitting	LTSZ062	verso	95.3	3.9	0.8	-	-
184	plate fitting	LTSZ062	recto	94.5	3.8	1.7	tr.	-
185	plate fitting	LTSZ063	verso	92.6	6.9	0.5	-	-
186	plate fitting	LTSZ064	verso	92.7	6.7	0.6	-	-
187	plate fitting	LTSZ065	recto	92.8	6.5	0.7	-	-
188	rock crystal fitting	LTSZ066	back sheet	94.3	5.2	0.5	-	-

no.	Object	inv.no.	Part	Au	Ag	Cu	Fe	Zn
189	rock crystal fitting	LTSZ066	wall	94.4	5.0	0.6	-	-
190	*rock crystal fitting*	*LTSZ066*	*stone*	-	tr.	-	-	-
191	plate fitting	LTSZ067	verso	93.6	6.6	0.7	-	-
192	plate fitting	LTSZ068	recto	92.1	7.1	0.8	-	-
193	cup decoration	LTSZ069	back sheet	94.7	3.9	1.8	-	-
194	cup decoration	LTSZ069	stone frame	93.3	4.7	2.3	0.7	-
195	cup decoration	LTSZ069	beaded wire	88.5	7.4	1.8	-	-
196	ribbed cup dec.	LTSZ070	centre	89.8	7.3	2.9	-	-
197	ribbed cup dec.	LTSZ070	rivet	90.0	6.8	3.2	-	-
198	triang. cup dec.	LTSZ071	centre	88.9	7.6	3.1	-	-
199	*triang. cup dec.*	*LTSZ071*	*silvery remains*	53.5	27.8	18.8	-	-
200	triang. cup dec.	LTSZ072	centre	90.0	6.9	3.1	-	-
201	triang. cup dec.	LTSZ073	clean area	89.3	7.2	3.5	-	-
202	*small silver blob a*	*LTSZ074*	*centre*	2.3	80.3	13.5	0.3	tr.
203	*small silver blob b*	*LTSZ074*	*centre*	2.5	82.6	12.6	-	tr.
204	*small silver blob b*	*LTSZ074*	*gold inside*	78.5	18.8	2.3	0.4	-
205	*small silver blob c*	*LTSZ074*	*centre*	2.3	84.7	12.8	0.2	-
206	*melted silver blob*	*LTSZ075*	*recto*	2.8	76.2	21.2	0.7	2.2
207	*melted silver blob*	*LTSZ075*	*verso*	39.4	41.5	17.8	0.9	tr.
208	*melted silver blob*	*LTSZ075*	*top*	5.7	70.2	20.5	0.3	2.2
209	gold sheet	LTSZ076	recto	95.1	4.7	0.2	-	-
210	*gold sheet*	*LTSZ076*	*silver verso*	5.2	86.5	8.3	-	-
211	gold sheet	LTSZ077	recto	87.4	8.3	4.3	-	-
212	*gold sheet*	*LTSZ077*	*blob verso*	tr.	27.8	58.9	4.5	-
213	gold sheet	LTSZ078	recto	88.3	7.8	2.9	tr.	-
214	*gold sheet*	*LTSZ078*	*silver verso*	2.6	88.6	6.2	1.3	-
215	gold sheet	LTSZ080	recto	99.8	tr.	tr.	-	-
216	gold sheet	LTSZ081	recto	99.9	tr.	-	-	-
217	gold sheet	LTSZ082	recto	99.8	tr.	tr.	-	-
218	gold sheet	LTSZ083	verso	99.9	tr.	tr.	-	-
219	gold sheet	LTSZ084	recto	99.9	tr.	tr.	-	-
220	gold sheet	LTSZ085	verso	99.8	tr.	tr.	-	-
221	gold sheet	LTSZ086	recto	100	-	-	-	-
222	gold sheet	LTSZ087	recto	99.6	0.3	-	-	-
223	gold sheet	LTSZ088	recto	99.4	0.4	-	-	-
224	gold sheet	LTSZ089	recto	99.9	-	0.3	-	-
225	gold sheet	LTSZ091	recto	99.9	tr.	-	-	-
226	gold sheet	LTSZ092	verso	99.5	0.4	-	-	-
227	gold sheet	LTSZ093	recto	99.8	tr.	-	-	-
228	gold sheet	LTSZ094	recto	99.8	-	tr.	-	-
229	gold sheet	LTSZ095	recto	99.9	tr.	-	-	-
230	gold sheet	LTSZ096	recto	99.9	tr.	tr.	-	-
231	gold sheet	LTSZ096	verso	99.9	tr.	-	-	-
232	gold sheet	LTSZ097	verso	99.7	tr.	0.2	-	-
233	gold sheet	LTSZ098	recto	99.8	tr.	tr.	-	-
234	gold sheet	LTSZ099	recto	99.2	0.3	0.4	-	-
235	gold sheet	LTSZ100	recto	99.5	0.3	0.2	-	-
236	gold sheet	LTSZ101	recto	99.2	0.4	0.4	-	-

no.	Object	inv.no.	Part	Au	Ag	Cu	Fe	Zn
237	gold sheet	LTSZ102	verso	99.9	tr.	tr.	-	-
238	gold sheet	LTSZ103	recto	99.9	tr.	tr.	-	-
239	gold sheet	LTSZ104	recto	99.9	tr.	tr.	-	-
240	gold sheet	LTSZ105	verso	99.8	-	0.2	-	-
241	gold sheet	LTSZ106	recto	99.9	-	tr.	-	-
242	gold sheet	LTSZ107	recto	99.7	-	0.3	-	-
243	gold sheet	LTSZ108	recto	99.6	0.3	tr.	-	-
244	gold sheet	LTSZ109	recto	99.5	0.6	-	-	-
245	gold sheet	LTSZ110	verso	99.5	0.3	0.2	-	-
246	gold sheet	LTSZ111	recto	97.6	2.3	tr.	-	-
247	gold sheet	LTSZ112	recto	96.5	2.4	0.9	-	-
248	gold sheet	LTSZ113	recto	94.5	3.5	2.0	-	-
249	gold sheet	LTSZ114	recto	99.9	-	tr.	-	-
250	gold sheet	LTSZ115	verso	99.8	tr.	tr.	-	-
251	gold sheet	LTSZ115	recto	99.9	0.8	tr.	-	-
252	gold sheet	LTSZ116	recto	99.8	tr.	-	-	-
253	gold sheet	LTSZ117	recto	97.4	2.1	0.5	-	-
254	gold sheet	LTSZ117	recto 2	97.3	2.1	0.6	-	-
255	gold sheet	LTSZ117	recto 3	98.5	1.1	0.2	-	-
256	gold sheet	LTSZ118	recto	99.8	tr.	tr.	-	-
257	gold sheet	LTSZ119	verso	99.9	-	tr.	-	-
258	gold sheet	LTSZ121	recto	99.6	0.3	tr.	-	-
259	gold sheet	LTSZ122	recto	99.4	0.3	0.2	-	-
260	gold sheet	LTSZ123	recto	99.9	-	tr.	-	-
261	gold sheet	LTSZ124	recto	96.9	2.3	0.5	-	-
262	gold sheet	LTSZ125	recto	99.2	0.4	0.2	-	-
263	gold sheet	LTSZ126	verso	99.8	tr.	tr.	-	-
264	gold sheet	LTSZ127	recto	99.9	tr.	tr.	tr.	-
265	gold sheet	LTSZ128	recto	99.8	tr.	tr.	-	-
266	gold sheet	LTSZ129	recto	99.6	tr.	0.3	-	-
267	gold sheet	LTSZ130	verso	99.7	0.2	tr.	-	-
268	gold sheet	LTSZ131	recto	99.9	tr.	tr.	-	-
269	*gold sheet*	*LTSZ131*	*silver blob*	60.2	34.4	5.4	-	-
270	gold sheet	LTSZ132	recto	99.8	tr.	tr.	-	-
271	gold sheet	LTSZ133	recto	99.3	0.4	0.2	-	-
272	gold sheet	LTSZ134	recto	99.7	tr.	0.2	-	-
273	gold sheet	LTSZ135	recto	99.9	-	tr.	-	-
274	gold sheet	LTSZ136	recto	99.5	0.2	0.3	-	-
275	gold sheet	LTSZ137	recto	99.6	tr.	0.3	-	-
276	gold sheet	LTSZ138	recto	99.5	0.2	0.3	-	-
277	gold sheet	LTSZ139	verso	97.7	1.2	tr.	-	-
278	gold sheet	LTSZ140	recto	99.8	tr.	0.2	-	-
279	gold sheet	LTSZ141	recto	99.9	-	tr.	-	-
280	gold sheet	LTSZ142	recto	99.8	tr.	tr.	-	-
281	gold sheet	LTSZ143	recto	99.6	0.4	-	-	-
282	gold sheet	LTSZ144	recto	99.5	0.3	0.2	-	-
283	rivet	LTSZ145	head	86.8	8.7	4.2	-	-
284	dagger sheet	LTSZ153	verso	92.1	5.4	1.4	-	-

no.	Object	inv.no.	Part	Au	Ag	Cu	Fe	Zn
285	sheet fragment	LTSZ155	verso	92.9	4.7	2.4	-	-
286	triangular fragment	LTSZ157		94.5	3.5	2.0	-	-
287	Nagysz. Cup BP	160	foot ring	87.7	11.3	1.6	-	-
288	Nagysz. Cup BP	160	body	86.2	10.7	3.1	-	-
289	Nagysz. Cup BP	160	upper rim	86.2	10.9	2.8	-	-
290	Nagysz. Bowl BP	162	large fragment	90.1	9.8	tr.	-	-
291	Nagysz. Bowl BP	162	inside	88.5	7.2	4.3	-	-
292	Nagysz. Bowl BP	162	rosette	90.2	9.7	tr.	-	-
293	Nagysz. Bowl BP	161a		90.1	9.8	tr.	-	-
294	Nagysz. Bowl BP	161b		90.2	9.7	tr.	-	-
295	Nagysz. Bowl BP	161c		90.1	9.8	tr.	-	-
296	*Nagysz. Bowl BP*	*162*	*incrustation*	1.8	83.6	14.6	-	-

Note: The analysis results reported in Italics in the table should be only considered semi-quantitative. These uncertain data are due to the bad preservation of the burnt pieces.

Plate I

a

b

Plate II