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# Medieval Slag from Gornji Potočari (Srebrenica municipality, B&H): a relationship between initial Ore and metallurgical Processes

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*Abstract:* In this paper, chemical analysis of slag from abandoned medieval mine in Gornji Potočari, Srebrenica municipality was described. Total of 10 metals were analyzed: chromium, copper, cadmium, nickel, cobalt, zinc, silver, manganese, iron and lead. Traces of chromium, nickel, cobalt, copper, manganese and cadmium in the samples point to the fact that the starting ore also contained these elements. Results showed high content of iron (25.11–33.12%), lead (5.90–10.77%) and zinc (1.16–6.79%). The content of silver had a positive correlation with the content of lead, which is in favor of the initial hypothesis that the starting ore was galena (PbS). High zinc content indicates that the sphalerite (Zn,Fe)S was also used in the process, whereas iron most likely emanates from pyrite ($FeS_2$). Galena and sphalerite can be found in Srebrenica area in large quantities. The results of the analysis show that the site was used for the production of lead and silver (from primary ores), intensive mining activity during the Middle Ages, and the latest date that we can account for slag origin is the end of the 16th century.

*Keywords*: lead slag, Middle Ages, AAS, Srebrenica, galena, sphalerite, silver

## Introduction

Throughout history, the territory of Bosnia and Herzegovina has been inhabited by different societies who exploited its rich natural resources. Progress and continuous development of the population in this area was dependent on the exchange of goods and trade with neighbouring areas and its inhabitants. The extraction of rich mineral ores was among the priorities when it comes to exploitation of natural resources and their use in everyday life. Mineral resources of BIH are not limited to one area and almost the entire country at some moment in history was an enormous mine where people exploited, transported, processed and finalized a certain type of ore.[1] There is hardly any area or time period in which some part of the country was not a center of mining activity. During these periods, the eastern part of Bosnia was among those areas where mining has been actively pursued and it reached its peak during the Roman rule and the Middle Ages. Numerous remains of mining activities in this area have already been the subject of scientific research.[2] In the Roman period, this entire area was called Domavia and was the subject of extensive exploitation of silver, lead and gold, which continued throughout the Middle Ages to the present day.[3]

[1] Trubelja / Barić 2011, 11.
[2] Radimsky 1892, 1-24; Ramović 1960, 3.
[3] Pašalić 1954, 47-75.

Estimates indicate that the Romans and Saxons excavated about 780,000 tons of ore, which contained more than 50,000 tons of lead and 120 tons of silver during several centuries of ore exploitation.[4] In this area, the basilica in Staroglavci near Srebrenica was discovered, built in the 5-6 century, probably due to the existence of a mining settlement and mines and the religious needs of the inhabitants of that region who were engaged in mining activities.[5]

Main aims and goals of this paper were to define initial ore or more of them used in the production and the timeframe of exploitation. Quantitative determination of metals in the slag samples was done by atomic absorption spectroscopy (AAS) technique, which can detect small amounts of selected metals from a very small sample size.[6] Also, authors will try to determine if any of the slag samples contained silver, which would prove initial premise that the site was used for silver extraction in the past, more precisely Middle Ages.

## Mining activites in Bosnia during Medieval times

Mining and metallurgical activities in Bosnia stagnated during sixth century, which coincides with Slavic and Avar conquests. Revival of mining industry started again at the end of 12th and beginning of 13th century, during Kulin Ban rule. Merchants from Dubrovnik secured concessions for mines in Duboštica, Kamenica, Olovo, Srebrenica, Fojnica, Ostružnica, etc.[7]

First written document which mentioned mines in Bosnia dates back to the 1349, stating existence of mine pits in Ostružnica, property of Dubrovnik merchant.[8] Serbian and Bosnian mines started their expansion in times when mining activities across the Europe were in downfall and as far as it comes to Bosnia, we can certainly keep track of mining activities from the times of Stephen II and the greatest progress was seen during the reign of King Tvrtko.[9]

[4] Ramović 1960, 38-39.
[5] Škegro 1998, 93.
[6] García / Báez 2012, 11.
[7] Trubelja / Barić 2011, 16.
[8] Kovačević 1961, 18.
[9] Ibid., 139.

## Geological background of the Srebrenica area

The area around the city, which is some 6 km$^2$ in size, is a zone of scattered mineralization in eruptive rocks, partly in the surrounding quartzites and shale sandstones. There are around 70 small veins, consisting of iron sulfide and quartz and scattered mineralization of zinc-lead ore veins leads to their fanlike extension.[10] The geological structure of the area consists of Paleozoic shales, Cenozoic magmatites, quartz-tourmaline-mica rocks (greisen) and Quaternary sediments. If we take orientation in consideration, then this mining area can be divided into: northeast (Sase mine), north (Vitlovac, Divljakuše, Kvarac), northwest (Kazan, Čumavići) and central area (Olovine, Vukosavljevići) ore systems.[11] Furthermore, in the Srebrenica area, a volcanic activity can be observed from satellite images, represented by the ring-shaped morphostructures, which are of metallogenic importance due to the associated lead, zinc, tin and silver deposits.[12] The main minerals occurring in the Srebrenica mining district are Pb-Zn sulphides, followed by marcasite ($FeS_2$), sulfosalts, silver bearing minerals, Mn-siderite and quartz, mostly occurring in the central mining area region.[13] Fig. 1. shows geological map of Srebrenica and the neighboring areas.

## Mining and metallurgical past of Srebrenica

Srebrenica and neighbouring areas are territories where traces of intensive mining and metal processing go back to prehistoric times. Thus, V. Čurčić described a find of a bowl from Tuzla dated to the Bronze Age, which at the bottom contained the remains of galena (PbS), pervaded by limestone veins.[14] As in the Tuzla vicinity there is no known sites of galena, both in the prehistory and present days, the most likely candidates for the origin of ore were Olovo and Srebrenica, areas rich in lead ores and other minerals. Although Olovo is geographically much closer to Tuzla

[10] Ramović 1960, 3.
[11] Radosavljević et al. 2014, 2.
[12] Hrvatović 2006, 61.
[13] Radosavljević et al. 2016, 255.
[14] Čurčić 1908, 83.

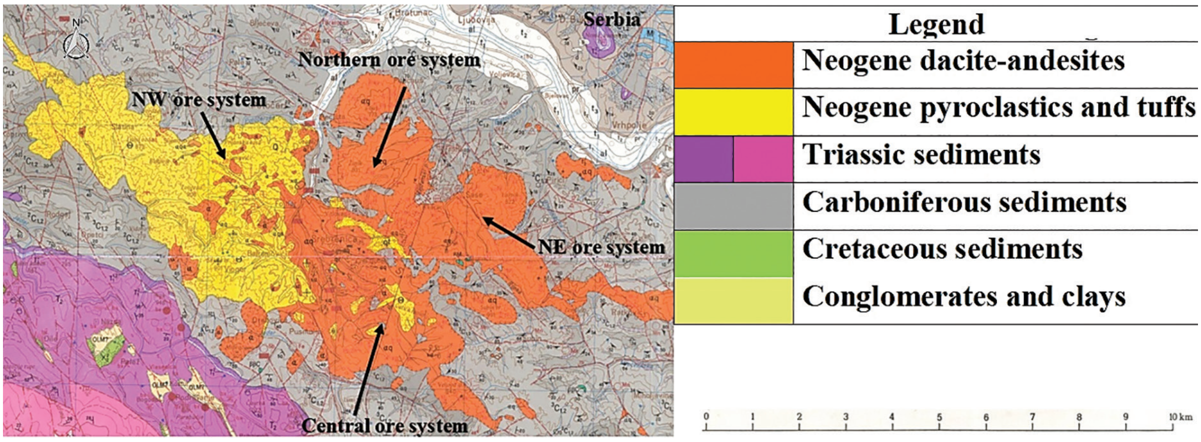


Fig. 1. *Geological map of Srebrenica ore field* (based on: Basic geological map of SFRY, Ljubovija sheet, 1:100000, Zavod za geološka i geofizička istraživanja Beograd, 1959–1963)

than Srebrenica, Čurčić concludes that the Srebrenica mines in the prehistoric times were, however, more famous and much more exploited than those in Olovo and that is the area from which galena in bowl most probably originates.[15] In the area of Srebrenica the lead is occurring together with silver and as such it was exploited. The larger lead-silver slag pits were registered at the Čićevac stream (Srebrenica).[16] Also, along the river Križevica, there is a whole village of old ruins, as well as in the Han Soločuša and the existence of a mine on the southwest side of the Kvarac mountain above Vitolović indicates a place from where ore was probably brought to the above mentioned places.[17] This possibility arises from the existence of boulangerite chunks ($Pb_5Sb_4S_{11}$), found in the slag pits containing 55% of lead.[18] There is also a potential for existence of mine shaft in Kožarica and Lauš village (Kožarica probably corresponds to today's Kozarica settlement).[19] Inside flinted shale the remains of the lead glance (galena) were found at the locality of Olovinski Potok (near the Vodenica ditch). The remains of the slag, along with the remnants of the walls were found too, indicating that this was a smelting place.[20] Mining period in this area can be time framed from the 13th to the beginning of the 15th century.

Silver in the areas which were part of Dalmatia mainly occurs with zinc, lead and pyrite (FeS), with the richest deposits in the Kvarac, Staroglavica and Ludmer mountains between the rivers Jadar and Drina, where one ton of ore yields 8% Zn, 6% Pb and over 100 grams of Ag.[21] The Roman mines in this area were in the following locations: Kvarac–Lisac–Podlisac, Guber–Ajžlica–Vitlovac, Fojhar–Kutlići–Čumavići and areas of Babac, Mihaljević, Lipenović, Brana, Miloljević near Bratunac, Lonjina, hill just above Gradina and Sase, along the Majdanski stream and in places called Mutnjača, Suhi Hrastik, Krivi Brijeg, Potočari and Zalisina.[22] As in some of these locations (Kvarac, Čičevac, Lonjin, Mihaljevići) intensive mining activities were carried out in the Middle Ages, we can rightly say that in other locations ore mining continued during this time period. Silver was most exploited in Srebrenica, which was also the largest mine in the area of Bosnia in that time period. Production within Srebrenica exceeded the one from Central Bosnia mining area.[23]

As for the period of Ottoman rule in these areas, they continued engagement in mining activities in conjunction with old minefields in the Srebrenica and Sase areas. Both mines were the main source of lead and silver in this area. During this period, the main product was silver, while lead and iron were side products, and some of these mines were leased to Dubrovnik merchants.[24] The Srebrenica mine was a significant

[15] Ibid., 84.
[16] Škegro 1998, 92.
[17] Pogatschnig 1890, 125.
[18] Operta 2009a, 164.
[19] Pogatschnig 1890, 125.
[20] Ibid., 127.
[21] Ibid., 92.
[22] Škegro 1998, 92; Imamović 2002, 15.
[23] Kovačević-Kojić 1999, 177; Arheološki leksikon1988, 150.
[24] Trubelja / Barić 2011, 19.

| Date | Location | Metal | References |
|---|---|---|---|
| End of 1st – second half of 2nd century CE | Foča | Copper, gold | Škegro 1999, 65. |
| End of 1st – beginning of 4th century CE | Domavia | Lead, silver, copper | Škegro 1991, 105; Imamović 2002, 7-36; Veletovac 2014, 113-120. |
| 3rd century CE | Domavia | Silver, lead | Pašalić 1954, 62. |
| 7th century CE | Area between rivers Jadar and Drina | Silver, lead | Škegro 1999, 63. |
| 12–13 century | Foča, Ustikolina | Silver, lead, iron | Bojanovski 1988, 210. |
| 1391 | Srebrenica | Silver, lead, copper | Kovačević, 141, 1961. |
| 1451–1512 | Srebrenica | Silver, lead, copper | Trubelja / Barić 2011, 18. |
| 1468 | Čajniče | Iron | Ibid., 19. |
| Early 15th century | Višegrad | Iron | Filipović 2000, 21. |
| Late 15th – early 16th century | Daljegošće | Iron | Trubelja / Barić 2011, 19. |
| Early 16th century | Đevanje | Silver, lead | Ibid. |
| End of 16th – beginning of 17th century | Srebrenica – Sase | Silver, lead | Ibid. |

Table 1. *Timeframe of mining activities in eastern Bosnia from the first century to the 17th century*

source of revenue at the beginning of the 16th century, although it was clear that the production scale was declining, while the production in Sase mine ceased at the end of the 16th and early 17th century. There were some more mines on the left bank of the Drina, the most famous being the Đevanje (the most significant), Mratinci and Hlapovići and iron exploitation was carried out in Daljegošće mine but its operations terminated in the early 16th century.[25]

In the next table, a timeframe of mining activities in the eastern Bosnia is presented, together with the names of locations, date and type of metal exploited.

From all of the above mentioned, it can be seen that the exploitation of east Bosnia mines, in economically justified quantities, started at the end of the first century CE and with minor interruptions lasted most probably by the middle of the 17th century.[26]

Fig. 2. shows a map indicating the locations in the vicinity of Srebrenica, where the ore was exploited in the past, which were mentioned in this paper. For the creation of this map we used old maps from Pogatschnig,[27] Radimsky[28] and Ramović.[29]

[25] Ibid.
[26] Handžić 1985, 332; Imamović 2002, 16.
[27] Pogatschnig 1890, 126.
[28] Radimsky 1892, Tab.1.
[29] Ramović 1960, 42-43.

## Sampling and chemical analysis

Samples of slag for analysis originate from the location in Gornji Potočari, directly along the Potočarska rijeka (coordinates 44° 8' 53.12" N, 19° 17' 27.76" E). The vicinity of the river, road communication and size of the location probably had a decisive influence on the place where refining and melting of ore would take place. The site was found quite accidentally during probe excavations, which had the purpose of searching for persons missing from the 1992–1995 conflicts in that area. The slag layer followed NE – NW orientation, ie. river direction. It is important to note the fact that the slag layers had different composition, which could be detected by visual inspection. The first trench contained mostly iron rich slag, while the slag from the other trench was rich in lead. Fig. 3. shows the trenches and layer profiles from which the test slag was exempted for analysis. Also, chunks of slag were scattered on the surface.

Visual inspection of the samples revealed that samples 2, 3 and 4 had a fluid-like surface, indicating the rapid cooling of the molten material. What is also apparent in samples 2 and 4 is the presence of a secondary limonite, a mineral composed of iron oxides and hydroxides, which occurs in a wide range of colors from yellow to brown.

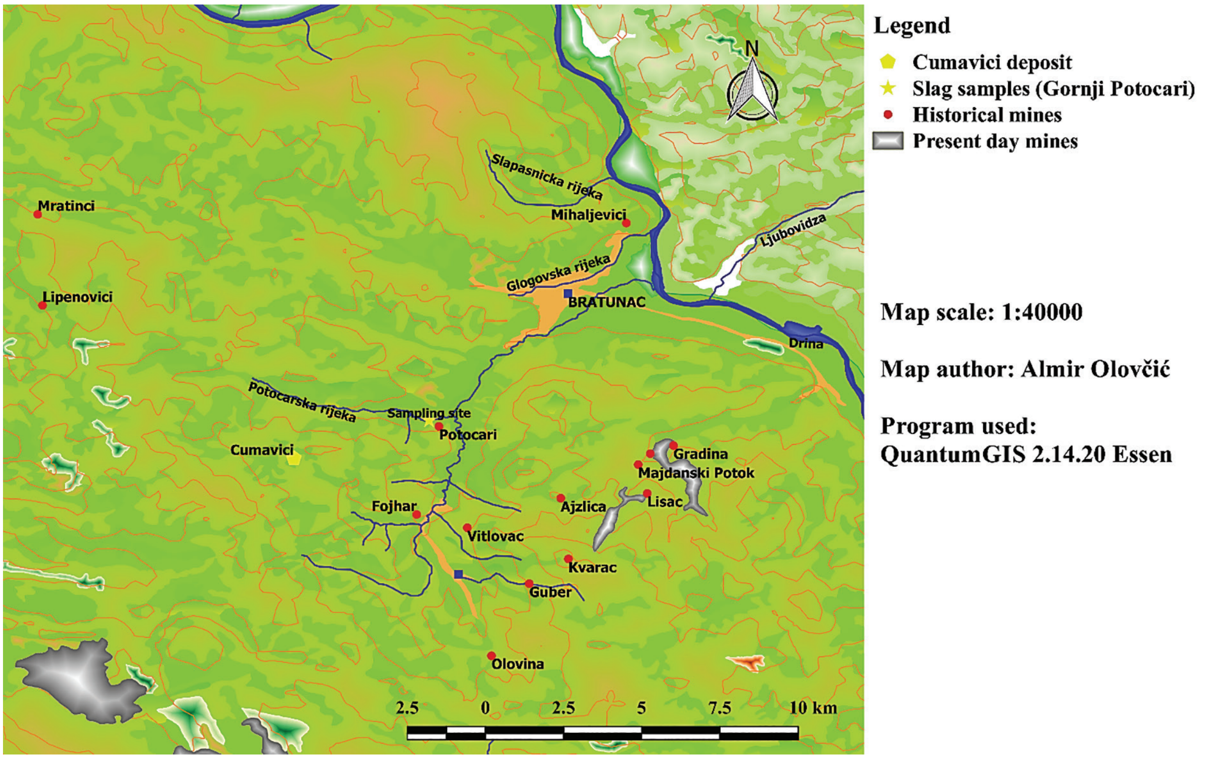


Fig. 2. *Srebrenica and neighbouring area, showing modern day and historical mining areas*


Fig. 3. *Profiles of the slag layers from which samples were exempted* (photo: Almir Olovčić)

Four massive samples of slag from different depths and profiles of trenches were chosen for the analysis. Grinding of these samples was carried out in the laboratory of Faculty of Natural Sciences and Mathematics (Sarajevo), Chemistry department, Chair of Analytical chemistry. For the final assay 0.5 g of each sample was taken with accuracy at ± 0.1 mg. Samples were prepared according to the modified procedure after Olovčić et al.[30] Fig. 4. shows the slag samples taken for analysis and before they were grinded and homogenized. The following elements were analyzed from the filtrate: cobalt (Co), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), manganese (Mn), nickel (Ni), lead (Pb), zinc (Zn) and silver (Ag). The residual precipitate on filter paper, qualitatively determined by gravimetric method to mostly contain $SiO_2$ was not subject of further analysis. Samples with high concentrations of some elements were previously diluted in the corresponding ratio before the instrumental analysis. Elemental analysis was

[30] Olovčić et al. 2014, 862.

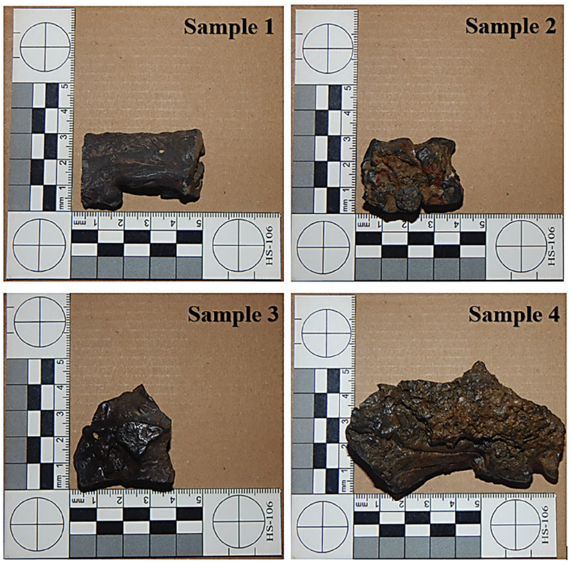


Fig. 4. *Slag samples used for the analysis in this paper* (photo: Almir Olovčić)

performed by atomic absorption spectrophotometry (AAS) technique, on instrument VARIAN 240 FS. Standards used were from Merck (Cd, Cr, Co, Mn, Ni, Zn and Ag), Panreac (Cu, Pb) and Carl Roth (Fe). Standard analytical error for Cd, Mn, Ni, Zn was ± 2 mg/L; ± 5 mg/L for Cr, Co and Zn; ± 0.002 g/L for Pb and Cu; ± 0.2% for Fe. The results of the analysis are expressed as the weight percent of cobalt, chromium, nickel, copper, manganese, silver and cadmium oxides and the weight percent of iron, lead and zinc.

## Results and discussion

The results of the analysis are given in Table 2. It is important to note that the comparison of the results was only possible with samples and papers outside the borders of BIH, since there are no results comparable with ours in the archaeological researches so far in BIH. Even in the world, there are few works dealing with lead analysis, lead production, silver content and provenance of such samples, while on the other hand there is a wide array of papers dealing with the exploitation, refining and processing of iron ores.[31]

Table 2. shows that in all samples silver, zinc, lead and iron were detected in significant quantities.

Before we move to the discussion, it is worth mentioning that samples of slag with similar physical characteristics like the one presented in this paper were found in the Czech Republic, the town of Uničov and dated back to the 13th century.[32]

In Table 3. presented are data from other authors and analysis of lead and zinc rich slag, with reference to the author, type of metal, its content and timeframe of invesigated site.

## Cadmium, Chromium, Cobalt and Nickel

The content of cadmium and chromium in the samples is negligibly low, and their appearance in the slag is the result of the presence of these metals in the initial ore used for production. Thus sphalerite, economically the most important zinc ore can contain up to 5% cadmium, while pyrite, chalcopyrite and galena also contain cadmium in small amounts (ppm).[33] All the minerals listed appear in the economically significant quantities in the area of Srebrenica. Chromium is a microelement in the Earth's crust and in larger quantities is to be found in ophiolite rocks, oxide ores and some sedimentary rocks. As the Srebrenica and neighbouring areas lie at the end of the easternmost part of the Dinaride ophiolite belt[34] thus the occurrence of chromium in analysed slag could be attributed to this geological background.

Cobalt and nickel are two trace elements that can be found in slag from prehistorical and historical times and from their presence one can obtain valuable information about initial ore and metallurgical processes employed, especially when it comes to the partitioning of these elements between slag and molten metal.[35] As in the case of chromium, cobalt and nickel are also part of the ophiolite rocks and analysis of this kind of rocks from different locations in Bosnia showed their high content, ranging for Co from 14 to 142 ppm and from 38 to 2987 ppm for Ni.[36] Other possible source of cobalt and nickel could be pyrite, an iron sulfide ore, which in form of impurities contains a large number of trace elements, including cobalt and nickel.[37]

[31] Ströbele et al. 2010, 191.

[32] Moník / Šlezár 2012, 231-232.

[33] Schwartz 2000, 445.

[34] Hrvatovic 2006, 70.

[35] Pollard / Heron 2008, 125.

[36] Trubelja et al. 1995, 52-55.

[37] Operta 2009a, 173.

| Content (%) / Sample | CdO | $Cr_2O_3$ | CoO | NiO | $Ag_2O$ | CuO | MnO | Zn | Pb | Fe | Undissolved |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.0007 | 0.0043 | 0.006 | 0.008 | 0.005 | 0.11 | 0.52 | 4.46 | 5.90 | 31.91 | 30.30 |
| 2 | 0.0008 | 0.0250 | 0.032 | 0.033 | 0.008 | 0.14 | 0.27 | 3.76 | 6.25 | 25.11 | 38.11 |
| 3 | 0.0007 | 0.0050 | 0.021 | 0.022 | 0.007 | 0.20 | 0.59 | 1.16 | 8.15 | 33.12 | 38.54 |
| 4 | 0.0014 | 0.0052 | 0.008 | 0.008 | 0.020 | 0.09 | 0.21 | 6.79 | 10.77 | 25.90 | 33.65 |

Table 2. *Slag analysis results for the samples from Gornji Potočari by AAS method*

| | | Lead | | |
|---|---|---|---|---|
| | Location | Year/century | Results | Paper |
| PbO | Wiesloch | 1051–1153 | 0.10–1.31% | Ströbele et al. 2010, 207. |
| Pb | Marsiliana | 13th–14th century | 0.01–1.23% | Manasse / Mellini 2002, 190. |
| Pb | Arialla | 13th–14th century | 0.26–1.95% | Ibid. |
| Pb | Soločuša | Roman/medieval | 0.94% | Ramović 1961, 40. |
| Pb | Fojhar | Roman/medieval | 2.32% | Ibid. |
| Pb | Sase | Roman/medieval | 0.62% | Ibid. |
| PbO | Bohutín | 14th century | 3–34.38% | Ettler et al. 2009, 992. |
| | | Zinc | | |
| ZnO | Wiesloch | 1051–1153 | 4.5–18.4% | Ibid. |
| Zn | Marsiliana | 13th–14th century | 0.32–5.26% | Manasse / Mellini 2002, 190. |
| Zn | Arialla | 13th–14th century | 0.58–5.10% | Ibid. |
| Zn | Soločuša | Roman/medieval | 9.61% | Ramović 1961, 40. |
| Zn | Fojhar | Roman/medieval | 6.67% | Ibid. |
| Zn | Sase | Roman/medieval | 5.67% | Ibid. |
| ZnO | Bohutín | 14th century | 0.43–6.23% | Ettler et al. 2009, 992. |
| | | Iron | | |
| FeO | Wiesloch | 1051-1153 | 21–45.0% | Ströbele et al. 2010, 207. |
| FeO | Marsiliana | 13th–14th century | 24.32–41.59% | Manasse/Mellini 2002, 190. |
| FeO | Arialla | 13th–14th century | 26.95–51.59% | Ibid. |
| | | Silver | | |
| Ag | Bohutín | 14th century | 10.5–120.5 mg/kg | Ettler et al. 2009, 992. |

Table 3. *Data from other authors and lead/zinc rich slags analysed (for comparison)*

The presence of cadmium, chromium, cobalt and nickel in all samples goes in favor for the original thesis that the slag originates from the historical period as modern metallurgical processes are much more successful in separating the metal phase from the slag.[38]

## Copper and Iron

By comparing the results for the copper content in our work with the results of other authors, it is evident that the values we obtained are ten times larger than the values for the slag from Stojnica (Serbia), which date back to the first century of Roman rule in this region.[39] As other authors presented their results in other measurement units, comparing the results is complicated and thus any attempt to search for an analogy would be pure guesswork.[40] However, results presented in this paper could be explained simply by geologi-

[38] Mateus et al. 2011, 146.

[39] Merkel 2007, 51.

[40] Ettler et al. 2009, 992; Mateus et al. 2011, 145; Tsaimou et al. 2015, 119.

cal background of the location and neighbouring northwest ore system. Namely, location where slag samples have been found is in the vicinity of Čumavići, a polymetallic ore deposit and part of the NW system, from which the sphalerite samples with high content of iron, copper and lead have been reported.[41] As for the manganese it is apparent that the manganese content correlates with the iron content and the highest values were obtained for samples 1 and 3. Manganese content in the sphalerite from Čumavići is also high, as it is the case with above mentioned metals and in some samples it goes up to 0.15%.[42] The content of iron in the slag below 50% may indicate a great number of factors included. Most important ones would be that the iron extraction process in the past was quite successful or that the initial ore/ores employed in the metallurgical process contained low levels of iron. Above mentioned sphalerite could be one of them or even pyrite, a mineral that often comes with sphalerite and galena in deposits and which unlike hematite, siderite and magnetite, has a much lower iron content.[43] It is to assume that medieval miners during mining process simply gathered minerals, not making any distinction and then during later smelting process extracted lead and silver, leaving iron and other metals in slag as a waste.

## Zinc, Lead, Silver

Finally, as the most important segment we left discussion about the results obtained for zinc, lead and silver. From Table 2. we can see that the sample 4 has the largest content of the above mentioned metals. The large amount of zinc and lead remained in the slag indicates the insufficient knowledge of the high-quality extraction technology for these metals from primary ores, which is a feature of the historical epochs.[44] This can be particularly applied to sample 4 where the content of residual lead is almost 11% and zinc 7%. By comparing the results we obtained with the results of the Srebrenica slag analysis from 1960 on the basis of a presumed quantity of 250,000 tons of material, we can see that the content of lead in this slag does not exceed 2.30%, while our observed content of lead is up to 11%.[45] In slag form Stojnik, lead content is between 4 and 7%, zinc ranges between 4 and 6% and estimates indicate that the total amount of slag at the site is about 3,000 tons.[46] On the other hand, slag from the early Roman period in the Greece contains much more lead and zinc, with values up to 21 and 18% for these two metals, respectively.[47] Such high content of both metals clearly points out to the beginnings of metal-making technology from their ores, unfamiliarity with the process, and a fairly high degree of underutilization of ore content. Also, high zinc content clearly indicates that the sphalerite ((Zn, Fe) S), as the most important zinc ore, was used in the production process.

Origin of zinc and its hight content in analysed slag could be attributed to its ability to always come with galena in the mineral deposits. So its occurrence in the slag analysed in this paper can only be explained in this way, since the industrial exploitation of zinc on a large scale started with industrial revolution. Even the Romans did not systematically excavate zinc ore, since they did not use it.[48]

The production of silver in the past is mostly related to lead ore, since galena (PbS) always contains certain amounts of silver. Our results show correlation between silver and lead content in samples, so the highest content of silver was found in sample 4, which also contains the highest amount of lead. Other authors have also shown that silver is a regular component of slag with high lead content. The content of silver in our samples is much closer to the content of silver in slag from Stojnica than in slag from Greece, which contained up to ten times less silver than our samples.[49] The reasons for this can be found in the fact that the silver from the Bosnian mines throughout history was always priced for its purity and quality and that ore from these areas always contained a significant amount of silver, both galena and silver bearing minerals such as pyrargyrite and tetrahedrite. Also, one should not forget the possibility that the silver in the an-

[41] Radosavljević et al. 2016, 267.
[42] Ibid., 266.
[43] Operta 2009a, 173.
[44] Tsaimou et al. 2015, 119.
[45] Ramović 1960, 40.
[46] Merkel 2007, 52.
[47] Tsaimou et al. 2015, 119.
[48] Imamović 2002, 16.
[49] Merkel 2007, 52; Tsaimou et al. 2015, 119.

alysed slag could partially originate from the tetrahedrite (Cu, Fe, Ag, Hg)$_{12}$(Sb, As, Bi)$_4$S$_{13}$) and pyrargyrite ($Ag_3SbS_3$), silver rich minerals found in Srebrenica hydrothermal deposits[50] and what is even more important is that they are reported in the Čumavići ore deposit, together with other silver rich minerals.[51]

Without additional microscopic and X-ray analysis of initial ores and slags from this area, it is difficult to say from which mining area initial ore is derived for refining and which area contains the highest amounts of silver. This too may not be enough, as geological analyses showed that even the profile of one vein, at one location shows significant differences in the content of metals, especially lead and silver, where silver values range from 17 to 426 g/t.[52]


## Sažetak

## Srednjovjekovna troska iz Gornjih Potočara (Općina Srebrenica, BiH): veza između početne rude i metalurških procesa

U našem radu pokušali smo interpretirati rezultate hemijske analize troske, pronađene u Gornjim Potočarima, odrediti vremenski period iz kojeg troska potiče i početne rude iz kojih je preradom kao nusprodukt nastala troska. Rezultati analize pokazuju da je troska bogata olovom i cinkom, što ide u prilog početnoj hipotezi da su rude korištene prilikom topljenja bile galenit i sfalerit, dvije ekonomski najznačajnije rude gore spomenutih metala, koje u ležištima dolaze zajedno i u velikim količinama su zastupljene u srebreničkom rudnom reviru. Određena količina srebra u trosci i njegova korelacija sa sadržajem olova pokazuje da je i primarna ruda sadržavala ovaj metal. Pored galenita, to su najvjerovatnije i drugi srebrom bogati minerali, poput tetraedrita i pirargirita, koji se mogu pronaći u rudnom reviru Srebrenice. Kako je količina zaostalog srebra u trosci dosta niska, vrlo je vjerovatno da je riječ o lokalitetu na kojem se vršila ekstrakcija olova i srebra iz primarnih ruda, aktivnosti vrlo rasprostranjene u Srebrenici tokom rimskog i srednjovjekovnog perioda. Prisutno željezo najvjerovatnije potiče iz pirita, koji se u ovom kraju redovito javlja u zajednici s galenitom i sfaleritom. Koncentracije ostalih metala u trosci preniske su za neki ozbiljniji zaključak, a njihovo postojanje može se objasniti geološkom podlogom područja i načinom na koji se javljaju kao primjese u olovnim, cinčanim i željeznim rudama.

Kako je vrlo malo radova o olovnoj trosci u svijetu, a kod nas takvih analiza nema, te kako se nije vršilo sistematsko iskopavanje lokaliteta, to je veoma teško smjestiti trosku u neki uži vremenski okvir. Ono što možemo sigurno reći jest da nije starija od kraja 16. stoljeća te da nizak sadržaj zaostalog srebra može ukazivati na to da je lokacija prvenstveno korištena za ekstrakciju ovog vrijednog metala, po čemu je ovaj kraj bio nadaleko poznat u srednjem vijeku. Za neke sigurnije potvrde potrebno bi bilo sistematski istražiti lokalitet, hemijski analizirati početne rude s ovog područja te utvrditi izotopski potpis minerala, troske i artefakata s ovog područja kako bismo dobili potpuniju sliku o metalurškim procesima kroz historiju na ovom području. Uprkos tome, ovakav pristup, koji uključuje hemijsku analizu i interpretaciju dobijenih rezultata na način da ako podaci za samo jedan metal nisu dovoljni za valjane zaključke te u obzir moramo uzeti veći broj metala i geološku podlogu područja, možemo dobiti veoma važne informacije o početnim fazama metalurškog procesa, predstavlja dobru polaznu tačku za daljnja istraživanja o historijatu rudarskih aktivnosti na ovome području.


[50] Operta 2009a, 183-186.
[51] Radosavljević et al. 2016, 257.
[52] Ibid., 256.

## Resources


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nološkim institucijama koje posvećuju veliku pažnju arheološkim proučavanjima te da su rezultati te dugogodišnje međuinstitutske balkanološke saradnje ovekovečeni u brojnim simpozijumima, zbornicima i monografijama. Među zajedničkim poduhvatima ovih institucija, u kojima je Nikola Tasić aktivno učestvovao, često kao *spiritus movens*, svakako treba istaći simpozijum i zbornik Paleobalkanska plemena između Jadranskog i Crnog mora od eneolita do helenističkog doba (Centar za Balkanološka ispitivanja ANUBiH i Balkanološki institut SANU, Sarajevo – Beograd 1991). U kapitalnoj ediciji Centra za balkanološka ispitivanja Praistorija jugoslavenskih zemalja, dobar deo toma posvećenog eneolitu napisao je upravo Nikola Tasić, koji je bio i jedan od urednika ove knjige. Kao vrstan balkanolog Tasić je prepoznao spone balkanologije i arheologije sa interdisciplinarnim proučavanjem trajnijih struktura – karakterističnih za "istoriju dugog trajanja", ali i za antropogeografsku školu Jovana Cvijića.

Tasićeva shvatanja o paleobalkanskom stanovništvu, čime se bavio u mnogim svojim radovima, i danas su vrlo provokativna i aktuelna. Jednom prilikom je izjavio: "Paleobalkanski supstrat, na kome su kasnije iznikle balkanske države, znatno je snažniji i dugotrajniji nego što se misli. On je ta osnova koja se održala vekovima i koju mi danas u jednom ili drugom pojavnom obliku možemo da pronađemo u jezičkoj sličnosti, posebno u stočarskoj terminologiji, u običajnom pravu (...) u muzičkom nasleđu, pa i bliskosti temperamenta (...) Stapanje i mešanje pojedinaca i grupa je proces koji je trajao vekovima i milenijumima na Balkanu (...) Mitovi o čistom ilirskom, tračkom, dačkom poreklu pojedinih balkanskih naroda samo su deo političkog marketinga. A pogotovu onih koji poreklo srpskog naroda nalaze u neolitskoj Vinči, zajedno sa ćiriličkim pismom." (*Jevtić, M.* 2004, Pamćenja i opomene. Razgovori s Nikolom Tasićem, Beograd 2004, 102).

Tasićeva brojna arheološka istraživanja, a pogotovo višegodišnja iskopavanja praistorijske Gomolave, kojima je rukovodio uz Bogdana Bruknera i Borislava Jovanovića, bila su prave arheološke škole, gde su srpski i jugoslovenski stručnjaci i studenti izmenjivali praktična i teorijska znanja sa kolegama iz eminentnih inostranih institucija. Ne bi trebalo, međutim, zaboraviti ni njegova intenzivna, važna i uspešna iskopavanja Gradine na Bosutu, Zlotske pećine, Prčeva kod Kline, Belegiša, kao i Vinče.

U pogledu organizacije naučnog rada, a pogotovo međunarodne naučne saradnje, Nikola Tasić je sam obavljao poslove čitavog jednog ministarstva. Rukovodio je mnoštvom naučnih projekata, organizovao serije međunarodnih simpozijuma i velike svetske kongrese, izložbe, uređivao časopise ("Balcanica", "Archaeologia Iugoslavica", "Arheološki pregled", "Materijali" i dr.), priređivao zbornike i monografije… Treba istaći kongrese Unije za praistoriju i protoistoriju (UISPP), balkanološke kongrese u okviru AIESEE, od kojih je za beogradski (1984) bio jedan od organizatora i svojevrsna pokretačka snaga, kao i seriju međunarodnih simpozijuma o bakarnom i bronzanom dobu, čiji je predsedavajući bio dugi niz godina (1986–1990, u kom periodu je održano 14 simpozijuma) te poljsko-jugoslovenskog kolokvija koji se odvijao u okviru saradnje ANUBiH i Poljske akademije nauka (Krakov). Uz to je s referatima i saopštenjima učestvovao i na mnogim drugim naučnim skupovima, kolokvijumima, ali i na studijskim boravcima u muzejima i naučnim institucijama u Nemačkoj, Italiji, Francuskoj, Čehoslovačkoj, Grčkoj, Austriji, Poljskoj, Rusiji, Gruziji, Mađarskoj, Rumuniji, Bugarskoj, Turskoj, Makedoniji i SAD.

Svojim mlađim saradnicima je pružao retku kombinaciju valjanog generalnog usmerenja, pune naučne slobode i bezrezervne podrške i pomoći. Nikola Tasić je, gotovo magično, s podjednakom lakoćom uspevao da rešava najozbiljnije probleme, bilo da je u pitanju odgonetanje zamršenih slojeva balkanske praistorije, upravljanje institutom, organizacija naučnog skupa ili rukovođenje najvišom srpskom naučnom institucijom. Kada je bio prisutan, jednostavno, sve je bilo u redu.

Iza Nikole Tasića ostao je impozantan naučni opus koji će se još dugo koristiti i neće izbledeti: preko 300 radova, sedam samostalnih knjiga i trinaest kolektivnih monografija, od kojih je nekoliko sam priredio. Valjalo bi između ostalih spomenuti monografije Jugoslovensko Podunavlje od indoevropske seobe do prodora Skita (1984), Eneolithic Cultures of the Central and West Balkans (1995), potom koautorski rad u kapitalnim edicijama Praistorija Vojvodine (1974) i Praistorija jugoslavenskih zemalja (1979), ili u knjigama Scordisci and Native Population in the Middle Danube Region (1992) i Arheolo*ško bla*go Kosova i Metohije (1998).

Međutim, porodici i nama, koji smo imali sreću da ga lično poznajemo i smatramo prijateljem, to je samo delimična uteha. Nedostajaće nam njegova dobrota, široka arheološka erudicija, neiscrpna energija, vedri optimizam, ali i velika građanska hrabrost i beskompromisna vera u potrebu stalne borbe za slobodu i demokratiju.

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