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# Metal losses at the Trepça concentrator during the enrichment process

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**Abstract**

**Purpose.** The purpose of this paper is to determine the flow of lead, zinc and silver metals at the enrichment factory in Trepça. The authors have determined the flows of metals discharged into the tailing of Kelmend. In addition, they make a correction for the losses of Pb, Zn, and Ag metals, which are very high.

**Methods.** Ore enrichment has been studied for two years in the production process of lead and zinc concentrates based on the following facts: selective separation of lead and zinc metallic minerals, as well as non-metallic minerals that are present in the ore. Sampling was conducted at the entrance to the ore receiving bunker. The samples were taken according to standards and sent for analysis in laboratories. In the laboratories, the samples were ground in a mill, then dried and sent for chemical analysis. The chemical analyses for Pb, Zn, and Ag were done at the Trepça laboratory, while for 35 chemical elements at the BRGM laboratory in France, with inductively coupled plasma atomic emission spectroscopy (ICP/AES) and inductively coupled plasma mass spectroscopy (ICP-MS) equipment. During the technological process, samples were taken for chemical analysis, and then in the flow, evidence was also taken to analyses the losses of lead, zinc, and silver metals. Mini Tab software was used to perform a T-test for independent samples and then correction was made for these metal losses in the tailing. The method of economic geology for the calculation of the balance of metals was used.

**Findings.** Based on the study of the chemical analysis of ore at the entrance to the receiving bunker, then sampling during the technological process and the flow of metals into the tailing, the amount of metal losses for 2020 and 2021 has been determined. Based on the calculations of the metal balance, the metal losses that affect the economic evaluation are presented. The remains of landfills on the ground affect the pollution of the environment and rivers.

**Originality.** The originality of the study is in the use of the results of chemical analyses obtained in the BRGM Laboratory in France on Pb, Zn, Ag and other conductive elements. A total of 35 chemical elements of tailings, which are presented in this work, have been tested.

**Practical implications.** According to the data of chemical and geochemical analysis, it turns out that in addition to losses of Pb, Zn, and Ag, we also have losses of conductive and rare elements.

***Keywords:*** *lead, zinc processing, metal loss, enrichment plant, flotation, Trepça*

## 1. Introduction

In the world, lead and zinc mines are increasingly facing with the problem of low metal quality in sulphide ores. As a result of this low metal content, the flotation of sulphide minerals is the subject of scientific research for lead and zinc metal production companies. In general, lead and zinc ores are treated in the enrichment process with selective flotation to produce separate concentrates of lead and zinc [1].

Flotation is one of the most widely used techniques to separate valuable minerals from gangue minerals in the mineral processing, because of its ability to treat low-grade and complex raw materials in the fine particle size ranges [2]. Flotation is widely applied in mineral processing for the production of copper-lead-zinc concentrates [3]. Sulphide minerals are naturally more hydrophobic than most of the mineral groups and respond well to flotation [4]. There are many parameters that influence on efficiency of flotation, such as chemical and mineralogical composition of ore, state of the surface of the mineral particles, pulp density, pH value, particle size, reagent type and dosage, and many others [5].

The Jinding Pb-Zn deposit, located in the Lanping basin in Yunnan Province, is the largest Pb-Zn deposit in China and probably the youngest sediment-hosted supergiant Zn-Pb deposit in the world [6]. Based on previous studies, mine wastes in the West Balkan were found to be rich in gold, silver, zinc, lead and copper.

According to recent studies, it has been found that approximately 2.6 gigatons of waste are deposited at 1650 sites covering almost 65 km$^2$ in the Western Balkans. More than half of this material, 55%, is characterized as conventional mining waste, 37% belongs to the processing tailings, and 8% to metallurgical waste [7]. The main elements for economic evaluation of the landfill are: Ag, Au, Pb, Zn, Bi, Cu, Sb, W, In, Mo, Re, while the recovery of the

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Kosovo tailings could bring 7310 million USD inprofit [7]. More than 60 Mt of reserves from tailings have been accumulated in Kosovo. These volumes are distributed over 11 landfills in the vicinity of mine and flotation concentrator [8].

Kosovo is rich in its mineralization potential, with interesting occurrences and polymineral deposits of Pb-Zn-Ag (Fig. 1) in the S sand SE parts of the Trepça Mineral Belt [9], as well as ore fields mineralization, the most important of which are located in Trepça, Hajvali-Badovc-Kizhnica, Artana and Cernac (Figs. 2 and 3), based on the geological data of this mineral belt. The presence of a large number of mineralized occurrences suggests mineralization potential that can be used with economic interest not only today, but also for the future of Pb-Zn-Ag-Au-Bi-Sn mineralization [10]. The Stan Terg Pb-Zn-Ag deposit is located within the Vardar zone of the Trepça mineral belt, consisting of Palaeozoic basement rocks, Jurassic period.

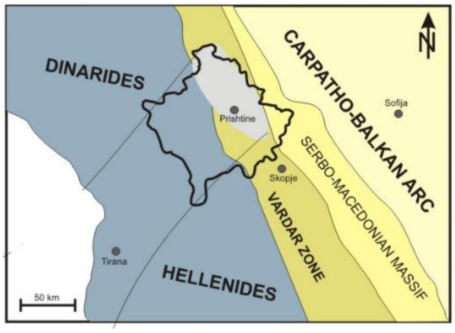


*Figure 1. Position of the Trepça Mineral-Belt in the Vardar zone*

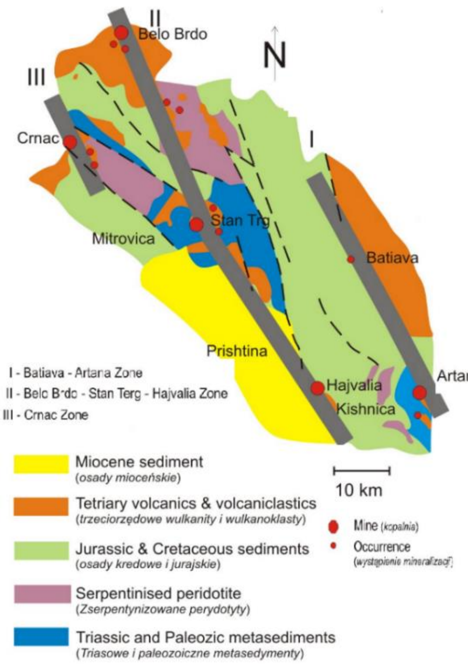


*Figure 2. Trepça Mineral Belt with mines and three mineral-bearing structures*

Cretaceous sediments and rocks of ophiolitic affinities (Fig. 1). These rock units were foliated during the early Tertiary period. During the late Tertiary period, the Balkan area was heavily affected by plutonic, sub-volcanic and volcanic processes, with deposition of mostly granodioritic magmas at depth, andesitic, dacitic and quartz-latite flows and dikes, as well as pyroclastic rocks, mostly tuffs, lapilli tuffs and ignimbrites.


*Figure 3. Map of Kosovo showing Trepça mining concentrators and final processing facilities*

Structurally, the Stan Terg deposit is situated in the centre of the so-called Trepça Mineral Belt. This tectonic zone, within which the Balkan Pb-Zn-Ag-Au deposits are located, is characterized by very strong lineaments and a fracture zone extending towards NW-SE (Fig. 2). On the basis of knowledge gained over the last 60 years on the mineralogy, petrography, genesis and pre-genesis characteristics of the Stan Terg Pb-Zn deposit, four ore zones (zonality) have been distinguished: skarn, sulphide, sulphide-olgonite, and the olgonite zone [11].

Thus, 70 minerals have been identified in the mineral deposit [12]. Mineral associations of the deposit are formed from supercritical hydrothermal solutions. While the deposition of minerals from one, two or more components of the solution is formed in the progressive continuum of a very complex mineralization. In the Trepça mineral deposit, the main minerals are sphalerite, galena, pyrites and pyrrhotite [13]. Among the minerals by the amount of ore, the following minerals are distinguished: pyrites, 24%, pyrrhotite, 35%, galena, 9% and sphalerite, 7%, silicate minerals, carbonates Fe-Mn 20%, and other compounds 5% [14].

The Stan Terg deposit is a typical polymetallic deposit of metasomatic-pneomatolito-hydrothermal contact [15]. Hydrothermal minerals are represented by carbonate sulphides and oxides. These minerals are $FeS_2$, $ZnS$, $PbS$, $FeAsS_2$, $FeS_2$ (marcasite), $Fe_{1-x}S$, $CuFeS_2$, $2PbS \cdot Cu_2S \cdot Sb_2S_3$, $5PbS \cdot 2Sb_2S_3$, $4PbS \cdot FeS \cdot 3Sb_2S_3$, $CuAsS_{3-4}$, $CuFe_2S_3$, $4(Fe, Cu) \cdot S_3(Mg, Al)(OH)_2$, $Cu_2FeSnS_4$, $Cu_5FeS_4$, $Cu_2S$, and $CuS$. Accessory minerals include: cerusite, anglesite, malachite, melanterite, gypsum, limonite, and waste minerals like quartz, calcite, ankerite, and olgonite [16]. Of all these minerals, the following are of higher intensity: pyrrhotite, sphalerite, galena, chalcopyrite, and pyrites. At the same time, the most extensive mineral deposits are: pyrrhotite, chalcopyrite, sphalerite, arsenopyrite, galena and pyrites.

Mineral deposits according to data classifications are: Pb ore with a concentration of 4.51%, Zn with a concentration of 3.11%, and Ag with a concentration of 75 g/t [17].

## 2. Materials and methods

The study material was obtained during ore production for 2020 and 2021 at the Stan Terg deposit of sulphide polymetallic ore. The enrichment research has been carried out over two years of flotation at the Stan Terg deposit, beginning with ore extraction to Pb and Zn concentrate products (Tunnel I Pare). The process of flotation of lead-zinc ore is selective, which enables the production of high-quality lead-zinc concentrates. The production of selective lead and zinc concentrates results in the application of direct concentration by flotation of lead and zinc minerals, not only by the selective separation of these minerals from others, but also by the separation of these minerals from other metallic or non-metallic minerals present in ores. The value of selective concentrates depends mainly on the content of the base metal. However, the value of selective lead and zinc concentrates increases due to the presence of other useful elements in them. Therefore, such concentrates are of particular economic importance, and the process of selective navigation serves to enrich a larger number of elements present in ores. So, in addition to the flotation enrichment process, daily flows are followed by chemical analysis of Pb, Zn, and Ag metals in tailings. In addition to regular analyses, control analyses of the leakage of Pb, Zn, and Ag metals in the Kelmendi tailing have also been performed (Fig. 4).

***Figure 4. Tailing landfill in Kelmendi***

The geological samples were taken at the entrance of the ore receiving bunker. Geological samples were first prepared in the jaw crumb (2×2 mm). Then the ore passes to the 100 mesh site, while the large particles pass to the disc mill and we finally have the ore site. We have the site for 160 mesh sites.

The samples were then sieved in a vibrating sieve. Particles that have not passed through the sieve are again subjected to grinding in a disc mill, and the sieved particles are returned to the vibrating sieve. The temperature in the oven for drying the samples is 105°C. The amount of samples for analysis is 100 g.

We have described in detail the technological process of lead-zinc ore flotation (flotation in the Stan Terg deposit). Ore from the mine is transported by tram *1*, carrying a composition of 80-100 t/h (Fig. 5). The primary ore crusher has a capacity of 600 $m^3$/h and a disaggregation degree of 600/120 mm [18]. The plate supplier ($Q$ = 215-650 $m^3$/h) and tape carrier of minerals in the bunker slope bear *3* are intended primarily for storing crushed ore. The capacity of this bunker is 2000 t with steep ore tape transfer to a crusher-grinder cone ($Q$ = 170-340 $m^3$/h) with a 120/30 mm crushing size. A vibrating sieve *4* with an inertia capacity of 500 t/h unloads cargo into the secondary crusher.

Tertiary crusher *6* with a capacity of $Q$ = 160-220 $m^3$/h is intended for crushing in mines – up to 15 mm. The grinding of minerals on this scale is 30/(5-15). The carrier tape transfers the crushed ore to the nonproduction process of separating final sieve sector *7* in the vibrating separator ($Q$ = 430 t/h).

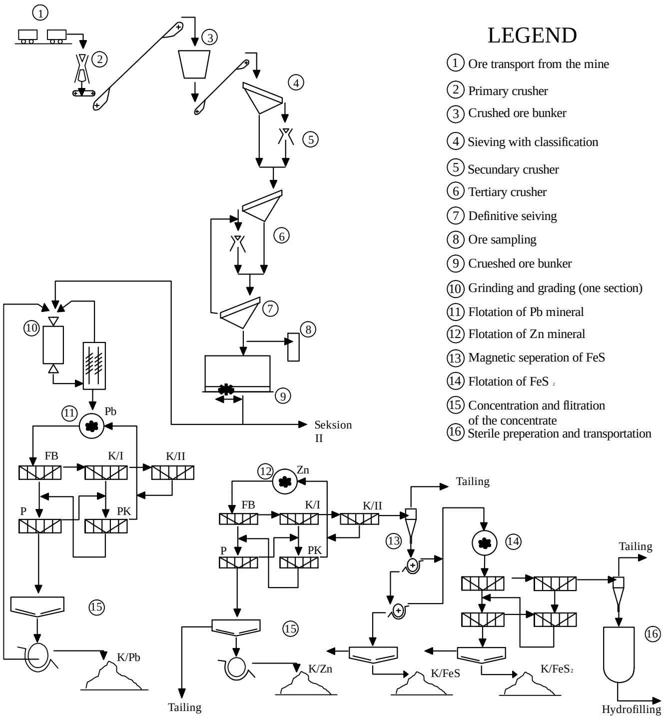


***Figure 5. Technological scheme of flotation in "Tunnel I Pare" – Stan Terg, Trepça***

Sieve sector represents the crushed ore definitely taped at 12 mm, transferred to the crushed ore bunker *9* and sieves for obtaining the product. The process returns to tertiary crushing (Fig. 5). Finally, the ore bunker crushes a record amount of ore, weighed on automatic scales, into product. Instead, this tape is set on the automatic equipment for receiving and shortening ore sample. Recipient samples *8* shared 1% of the ore flow. The sample is divided into parts for determining metal composition at the ore entrance and serves for daily calculation in other mines and flotation concentrators [18].

The ore removed from the bunker becomes the donor in the form of a "star". The last tape before entering the mills is equipped with automatic scales. Ore crushing is done on a stage and performed in farm fields, working in a closed cycle spiral. Classifier flow gains ground with the composition of ore over 65% of the 0.074 mm (or -200 meshes) grade. The ore milling sector consists of two parallel sections, each of which has an ore processing capacity of 500 t/h. If necessary, water in the process enters the mill together with minerals and, if necessary, can be added at the entrance of the classifier. Sand classifier load in the form of a circular back at the entrance of the grinding mill for the leak classifier treated following the flotation process. The flotation process of lead minerals is carried out in two identical parallel sections, each with an incoming ore processing capacity of 1764 t/day. Pulp-containing 35-42% solid phase, with free fall brought in by conditioner *11* that has a volume of 22 $m^3$. Pulp conditioning lasts 10 min. The flotation process base and controller flotation are double grade flotation machines, made for mechanical pneumatic cleaning of three degrees, and cleaning controller flotation is a scale performed on machines. Conditioned pulp enters the free base as a result of the flotation process. Concentrate-based flotation sends three-scale cleaning concentrate, the final concentrate, Pb. After sampling, the automatic pumping system is transferred to the process of decantation and filtration *15*. The flow of treated base flotation process controller doubles grade [18].

Concentrate flotation at second level, along with the flow controller, turns on the air conditioner cleaners, and the flow of second degree flotation presents definitive tailings forming minerals such as Pb and conditioning three-scales sent prior to the cycle of flotation the ore of Zn *12*.

The time required for complete flotation of the mineral Pb is 16 minutes. The flotation scheme of the Zn ore is identical to that of the Pb ore. Pulp at the entrance of the Zn flotation process has a phase composition of 33-38% solid phase. The duration of the flotation process for this mineral is 20 min [18]. Flotation tailings from the controller enter the cleaners and pumping system and are transported during the preparation of the hydraulic filling station *16*, or alternatively, may be transferred to landfill tailings.

## 3. Results and discussion

The mines of Trepça have been operating for over 95 years. During this period, from the flotation process, over 60 million tons of tailings have been received in landfills. These quantities are distributed in 11 landfills in the vicinity of mines and flotation concentrators. First, these landfills affect the pollution of the environment, air and river waters flowing near these landfills. The research on the flow of metals in the flotation of the first Tunnel is the publication of the final report as a public document. The research was conducted in the Kelmendi landfill (with reserves of 10000000 t), according to the analysis made in the laboratory of BRGM in France, 35 chemical elements have been determined in the Kelmendi landfill (S, Pb, Zn, Ag, As, Au , Bi, Cd, Cu, Ga, Ge, Hg, In, Sb, Se, Te, Ti, B, Ba, Sr, Be, Li, Ce, La, Y, Nb, Zr, Ce, Co, Cr, Ni , V, Mo, Sn and W).

The research was conducted simultaneously in the Stan Terg deposit, where 4 samples were taken with 2 kg each at the level of +75 m. Samples were prepared in the first tunnel, sent for analysis to the BRGM laboratory (France) by the inductively coupled plasma atomic emission spectroscopy (ICP/AES) method for 35 elements and by the inductively coupled plasma mass spectroscopy (ICP-MS) method for the traces of Ga, Ge, In, Se, and Te. The analyses performed in the BRGM laboratory, although not repeated, suggest that the losses in Ag, Pb, Zn, Cu, Bi, Ge, Ga, In and Au during the flotation process are significant.

These data are in correlation with the research performed for 2020 and 2021 (in the Trepça flotation). This research on the metals flow in the first tunnel flotation was conducted to improve the flow and reduce large losses (according to production results of Table 1 and Table 2). For discussion, we have taken the results of metals for the last two years (for 2020 and 2021) in the Trepça flotation (flotation Tunnel I Pare).

***Table 1. Metal balance data for 2020 in "Tuneli I Pare" flotation, Trepça***

| Production | Weight | Weight | Metal content | | | The amount of metal | | | Exploitation | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2020 | (t) | (%) | Pb (%) | Zn (%) | Ag (g/t) | Pb (t) | Zn (t) | Ag (kg) | Pb (%) | Zn (%) | Ag (%) |
| Ore | 131708 | 100 | 3.00 | 2.33 | 47.76 | 3951 | 3068 | 6290 | 100 | 100 | 100 |
| K/Pb | 4443 | 3.37 | 61.91 | 0.82 | 849.5 | 2750 | 36.43 | 3774 | 69.61 | 1.187 | 60 |
| K/Zn | 4602 | 3.49 | 3.37 | 46.86 | 46.71 | 155 | 2156 | 214 | 3.925 | 70.27 | 3.41 |
| Tailing | 122663 | 93.13 | 0.35 | 0.43 | | 429 | 527 | | 10.86 | 17.18 | |
| Loss-correction | 122663 | 93.13 | 0.85 | 0.71 | 18.75 | 1045 | 875 | 2300 | 26.45 | 28.54 | 36.58 |

***Table 2. Metal balance data for year 2021 in "Tuneli I Pare" flotation, Trepça***

| Production | Weight | Weight | Metal content | | | The amount of metal | | | Exploitation | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2021 | (t) | (%) | Pb (%) | Zn (%) | Ag (g/t) | Pb (t) | Zn (t) | Ag (kg) | Pb (%) | Zn (%) | Ag (%) |
| Ore | 180285 | 100 | 2.77 | 2.76 | 42.83 | 4993 | 4975 | 7721 | 100 | 100 | 100 |
| K/Pb | 5135 | 2.85 | 71.32 | 0.67 | 990 | 3662 | 34.40 | 5083 | 73.33 | 2.84 | 65.85 |
| K/Zn | 6208 | 3.44 | 2.29 | 48.02 | | 142 | 2981 | | 0.69 | 59.90 | 3.61 |
| Tailing | 168942 | 93.71 | 0.30 | 0.38 | 12.84 | 506 | 641 | 2169 | 23.82 | 39.38 | |
| Loss-correction | 168942 | 100 | 0.704 | 1.16 | 18.21 | 1189 | 1959 | 3077 | 23.82 | 39.38 | 23.93 |

The purpose of this research is to present the metal losses of lead, zinc and silver at the enrichment plant in the (Tuneli I Pare) Stan Terg deposit. According to the data in Table 1, in 2020, ore production was 131708 t. The average metal content of the ore was Pb – 3.00%, Zn – 2.33%, and Ag – 47.76 g/t. Ore content was low due to the ore dilution in the mine during exploitation. According to the above-mentioned results for the Trepça concentrator (Tunnel I Pare), the degree of exploitation (Table 1) of lead and zinc metals is: Pb – 69.61%, Zn – 70.27% (Fig. 6), while the average quality of concentrates is: Pb – 61.91% and Zn – 46.86%.

Table 1 shows that the Pb and Zn losses in the flow of metals in the tailings are significant. The average losses of Pb and Zn during production in the concentrator for 2020 were Pb – 0.35% and Zn – 0.43% (Fig. 7). There was also a loss of other elements. According to the data (Table 1), after correction of metal loss values in tailing, losses are for Pb – 0.85%, Zn – 0.71%, and Ag –18.75 g.

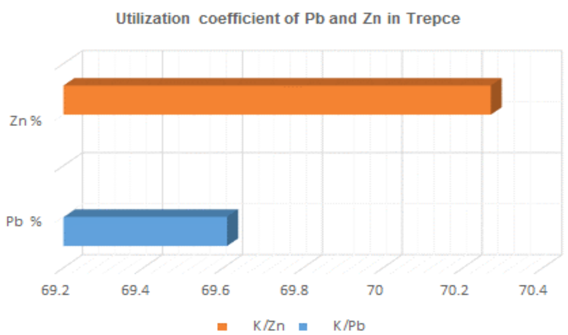


***Figure 6. Exploitation of metals in the Trepça flotation concentrator (Utilization coefficient of Pb and Zn in Trepça)***

The average losses of metals during 2020 were 26.45% for lead, 28.54% for zinc, and 36.58% for silver. The losses were high for lead (1045.49 t), zinc (875.86 t), and silver (2300.73 kg) (the concentrator has been operating since 1984).

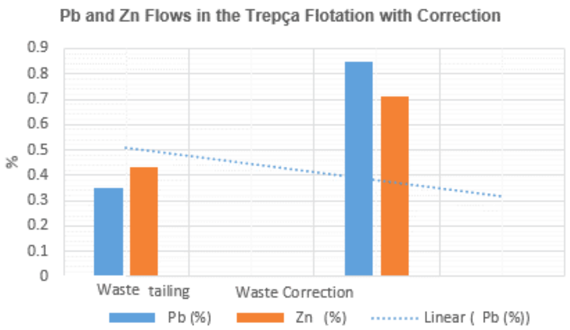


***Figure 7. Metals flows in the Trepça flotation concentrator (Pb and Zn flows with correction)***

In this paper, losses of metals for 2020 are compared to the results of 2021. The purpose of the comparison is to distinguish the differences in loss values of Pb and Zn flow in the flotation process of the Tunnel Pare, Trepça, after one year of production. Figure 8 depicts the metal losses in Pb and Zn by months in 2021. The average losses of Pb and Zn metal for the production in concentrators (for 2021) are: Pb – 0.30% and Zn – 0.38%, which indicates significant losses of metals in tailings.

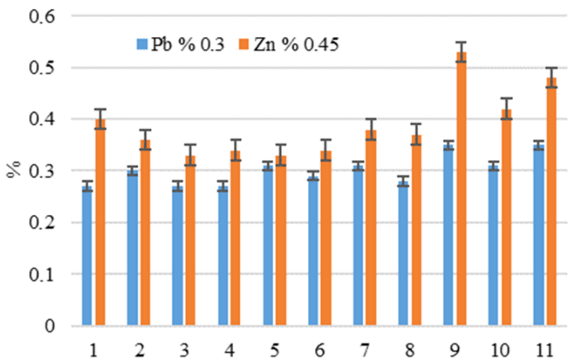


***Figure 8. Metals flows in the Trepça flotation concentrator in 2021 (Pb and Zn flows without correction)***

The analysis results, according to the laboratory, show lower values than those that were actually. During the metal balance calculations, this change has been noticed; therefore, we have corrected the leakage of metal in the tailing landfill.

The correction has shown that the leaks have higher values than the laboratory values (according to Table 1 and Table 2). According to the data (Table 2), after correction of values of metal losses in tailing, losses are for Pb – 0.704%, Zn – 1.16%, and Ag –18.21 g/t. The average losses of metals during 2021 were 23.81% for lead, 39.38% for zinc, and 23.93% for silver. The losses were high for lead (1189 t), zinc (1959 t), and silver (3077 kg).

After correction of Pb and Zn metal losses (Table 1 and Table 2), it is seen that the metal loss values are too high for lead, zinc, and silver.

Pb loss during 2021 ($N = 12$) was $M = 0.3$ ($SD = 0.027$) and during 2020 ($N = 12$) was $M = 0.34$ ($SD = 0.09$). Zn loss during 2021 ($N = 12$) was $M = 0.39$ ($SD = 0.06$) and during 2020 ($N = 12$) was $M = 0.43$ ($SD = 0.02$). To test the hypothesis that metal losses between 2020 and 2021 were associated, an independent samples t-test was performed. Additionally, the assumption of homogeneity of variances for Pb was tested and satisfied Levene's F test, $F(21) = 2.44$, $p = 0.132$. The assumption of homogeneity of variances for Zn also satisfied Levene's F test, $F(17) = 0.38$, $p = 0.544$. The independent samples t-test for Pb and Zn were not associated with a statistically significant effect, $t(13) = 1.77$, $p = 0.1$, respectively $t(17) = 1.17$, $p = 0.257$. Thus, there is no difference in Pb and Zn losses in 2020 compared to 2021. A graphical representation of the means and the 95% confidence intervals is displayed in Figure 9 (level VII-X), the content of pyrite, minerals pyrrhotine, galena, and sphalerite (marmatiti) increases.

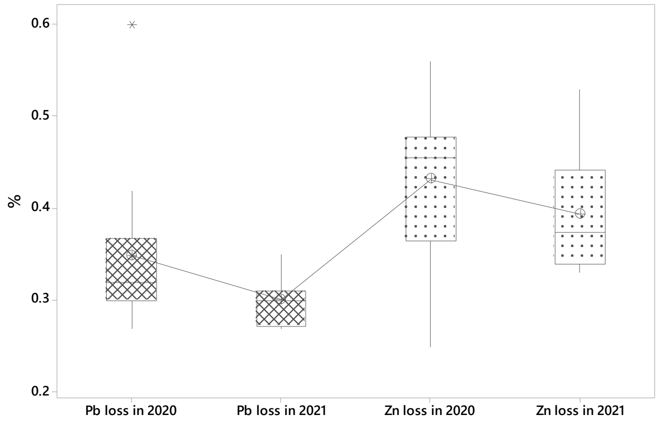


***Figure 9. Pb and Zn losses (with 95% CIs)***

Geochemical anomalies do not indicate the distribution of treatable mineral deposits with increasing depth. The elements that increase with increasing depth (with economic evaluation) are Ag, In, Ga, Cu, As, Ni, Co, Cd, while the content of these elements decreases: Tl, Se, Sb, Sn, Bi, Mn.

During the research, we have found that a quantity of lead concentrate flows into the zinc concentrate, which is also a landfill-like loss. In the future, research should focus on reducing metal outflow through digitalization of flotation process and returning the lead flow to the hydrocyclone.

## 4. Conclusions

The problem of treating the losses of Pb and Zn metals should be continued by research and scientifically processed data on lead and zinc ore production from the polymetallic deposit of the Stan Terg in Trepça. According to the results, the rate of loss in the production of metals such as Pb, Zn and Ag is quite high. Metal losses in Pb-Zn-Ag tailing (sterile) with an average content of 0.35% and Zn – 0.43% for 2020 (after correction) are Pb – 0.85%, Zn – 0.71%, and Ag – 18.75 g/t. The utilization level is low for lead – 69.61%, and zinc – 46.86%. Losses within 2020 are very high for Pb – 1045.49 t, for Zn – 875.86 t and for Ag – 2300.73 kg. This amount of Pb, Zn, and Ag metal flows represents a significant loss during the flotation process. Independent samples t-test was performed for Pb and Zn losses. Results for Pb and Zn losses in 2021 compared to 2020 were not statistically significant, $p = 0.1$, $p = 0.257$, respectively. We propose, in addition to improving the technological process of flotation, to study the mineralogical composition of the deposit. The ore used in the Stan Terg deposit (depth of occurrence from horizon VII-X and below) is mainly pyrrhotite, pyrite, galena, and sphalerite (marmatite). Fe content is very high in minerals and is concentrated on an average of 12.91%. High Zn content comes not only from pyrite, but also from pyrrhotite, sphalerite (a type of marmatite) and sphalerite, affecting the flotation process and also the high Fe content.

The low level of exploitation of a mineral rich in other economic elements (Ag, In, Ga, Cu, As, Ni, Co, Tl, Se, Sb, Sn, Bi) has made its exploitation unprofitable. Based on the results given for the minerals, concentrates, and wastes (sterile), we can conclude that their use is not satisfactory. Therefore, efforts must be made to improve the technological parameters. It is especially important to invest in computerization of the technological process (this flotation has been operating for over 37 years, so it is outdated). In addition to using Pb and Zn concentrate, the new flotation will also be used to extract pyrite concentrate.

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## Втрати металів на збагачувальній фабриці Трепча під час процесу збагачення

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**Мета.** Визначення потоку металів свинцю, цинку та срібла і здійснення поправки на втрати цих металів, що скидаються у хвостосховище Кельменда на збагачувальній фабриці в Трепча.

**Методика.** Збагачення руди досліджувалося протягом двох років у процесі виробництва свинцевих і цинкових концентратів. Відбір проб проводився на вході у рудоприймальний бункер. В лабораторіях відібрані зразки подрібнювали на млині, потім висушували і відправляли на хімічний аналіз. Хімічні аналізи для Pb, Zn і Ag проводилися в лабораторії Трепча, тоді як для 35 хімічних елементів – у лабораторії BRGM у Франції за допомогою обладнання атомно-емісійної спектроскопії з індуктивно зв’язаною плазмою (ICP/AES) і мас-спектроскопії з індуктивно зв’язаною плазмою (ICP-MS). В ході технологічного процесу відбирали проби для хімічного аналізу, а потім у потоці також відбирали докази для аналізу втрат металів свинцю, цинку та срібла. Програмне забезпечення Mini Tab було використано для виконання T-тесту для незалежних проб, а потім було зроблено поправку на втрати цих металів у хвостосховищах.

**Результати.** Визначено обсяги втрат металів за 2020 та 2021 роки на підставі дослідження хімічного аналізу руди на вході у приймальний бункер та відбору проб у технологічному процесі й надходження металів у хвостосховище. Наведено втрати металу, які впливають на економічну оцінку на підставі розрахунків балансу металу. Зазначено, що залишки звалищ на землі впливають на забруднення довкілля та річок.

**Наукова новизна.** Оригінальність даної статті полягає у детальному дослідженні потоків Pb, Zn, Ag і процесі флотації та виявленні їх суттєвих втрат у хвостосховищі.

**Практична значимість.** За даними хіміко-геохімічного аналізу виявляється, що крім втрат Pb, Zn і Ag втрачається низка провідних і рідкісних елементів, що є економічно необгрунтованим.

***Ключові слова:*** *свинець, обробка цинку, втрата металу, збагачувальна фабрика, флотація, Трепча*