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Technical Faculty in Bor,
Mining and Metallurgy
Institute Bor

# 54th International October Conference on Mining and Metallurgy

# PROCEEDINGS

Editors:
Ljubiša Balanović
Dejan Tanikić

18-21 October 2023, Bor Lake, Serbia

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# PREFACE

On behalf of the Organizing Committee, it is a great honor and pleasure to welcome all esteemed participants of the 54th International October Conference on Mining and Metallurgy (IOC 2023), scheduled to take place at the picturesque Bor Lake, Serbia, from October18th to 21st 2023.

The collaborative efforts of the University of Belgrade, the Technical Faculty in Bor, and the Mining and Metallurgy Institute Bor have meticulously organized this year's IOC. Our focus remains unwavering on showcasing the latest research findings and advancements in geology, mining, metallurgy, materials science, technology, environmental protection, and other engineering disciplines. Our primary objective is to foster a dynamic environment where academics, researchers, and industry professionals can come together to share their knowledge, experiences, and innovative ideas while exploring opportunities for collaborative research endeavors.

Our conference agenda is rich and diverse, encompassing plenary sessions, engaging invited lectures, technical presentations, enlightening oral and poster sessions, informative technical tours, a diverse exhibition, and memorable social gatherings. At the heart of this event lies our strong commitment to sustainable development within the mining and metallurgy sector. We are dedicated to exploring ecologically conscious methodologies, responsible resource extraction practices, and cutting-edge technologies that reduce the industry's environmental impact and enhance the well-being of local communities.

The conference proceedings comprise 129 papers authored by individuals from universities, research institutes, and industries in 22 countries. We are proud to welcome participants from Bosnia and Herzegovina, Bulgaria, Canada, China, Croatia, Germany, Greece, India, Iran, Kazakhstan, Libya, North Macedonia, Montenegro, Morocco, Romania, Russia, Slovakia, South Africa, Spain, Turkey, United States, and, of course, Serbia.

We are excited to host the 8th International Student Conference on Technical Sciences (ISC 2023) as part of IOC 2023. This event offers students from Serbia and the wider region a unique chance to showcase their research and discuss the future of their fields with experts.

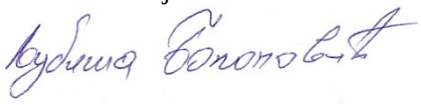
We sincerely thank the Ministry of Science, Technological Development, and Innovation of the Republic of Serbia for their generous financial support. In addition, we express our profound gratitude to all our sponsors, exhibitors, and friends of the Conference for their contributions and unwavering support for playing a pivotal role in ensuring the success of IOC 2023.

We would like to express our heartfelt thanks to all authors, committees, reviewers, speakers, and chairpersons for their invaluable contributions in shaping IOC 2023.

We look forward to welcoming you to the 55th International October Conference on Mining and Metallurgy (IOC 2024), which will be held in October 2024.

On behalf of the 54th IOC Organizing Committee,

Prof. dr Ljubiša Balanović



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# ANALYSIS OF THE EFFECTIVENESS OF DIFFERENT METHODS FOR CUTTING SAMPLES

**Zoran Štirbanović, Vesna Vojinović, Jovica Sokolović, Maja Trumić**

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**Abstract**

*In this paper are presented the results of analysis of effectiveness of four different sample cutting methods: quartering, "chessboard" method, Jones riffle splitter and automatic sampler "Vezin". For the analysis of their performance four copper ore samples with different grain size were used. Grain size composition of samples before and after cutting was determined and used for calculating absolute average deviation and real average deviation which were used for determining effectiveness of used methods. According to the obtained results "chessboard" method was the most efficient for cutting all investigated samples, i.e. it provided the samples with highest representativeness.*

***Keywords**: sampling; sample cutting methods; absolute average deviation; real average deviation.*

## 1. INTRODUCTION

Sampling represents extraction of a smaller portion of material (ore) from a larger mass, according to the precisely established rules so the obtained sample has the same characteristics chemical, physical, mineralogical, etc. like the mass that it was taken from, i.e. it is representative.

In mineral processing, sampling is an operation that is being performed continually along with operating of the process and it main purpose is process control and quality control of final products and by-products as well. Primary samples are usually much larger in quantity than the samples needed for individual experiments or analysis, so it is necessary to cut them, sometimes even in several stages, by using adequate cutting methods. Methods for cutting primary samples that will be applied depend on grain size and quantity of the sample, but some of them can be applied for the same type of samples. The most commonly used methods for cutting samples in laboratory are: quartering, riffle splitters, automatic samplers, composite sampling ("chessboard" method), etc. Their effectiveness can vary depending on their construction and/or materials they are being used [1-3].

Sampling must be undertaken with high precision by applying adequate methodology, because inappropriate sampling can cause technological and economic issues. Sampling errors must be minimized not only during the sampling process but also later when primary samples are being further processed and prepared for analysis and investigation. This is especially important when high value materials are being sampled, i.e. gold containing concentrates [4].

In this paper are presented the results of investigating effectiveness of different methods for cutting samples in terms of their grain size composition before and after cutting.

## 2. EXPERIMENTAL

### 2.1 Materials

For the investigation, four copper ore samples with different grain sizes: -9.50+3.36; -2.36+0.71; -0.71+0.25; -0.25+0.075 mm, were used. In Table 1 is given grain size composition of the used samples, before cutting

Table 1 – Grain size composition of the samples before cutting

| Grain size class (mm) | Sample 1 | Sample 2 | Sample 3 | Sample 4 |
|---|---|---|---|---|
| | Mass (%) | | | |
| -9.50+4.75 | 33.3333 | / | / | / |
| -4.75+3.35 | 33.3333 | / | / | / |
| -3.35+2.36 | 33.3333 | / | / | / |
| -2.36+1.70 | / | 33.3333 | / | / |
| -1.70+1.18 | / | 33.3333 | / | / |
| -1.18+0.710 | / | 33.3333 | / | / |
| -0.710+0.425 | / | / | 33.3333 | / |
| -0,425+0,300 | / | / | 33.3333 | / |
| -0.300+0.250 | / | / | 33.3333 | / |
| -0.250+0.150 | / | / | / | 33.3333 |
| -0.150+0.106 | / | / | / | 33.3333 |
| -0.106+0.075 | / | / | / | 33.3333 |
| Σ | 100.00 | 100.00 | 100.00 | 100.00 |

As it can be seen from the Table 1 all four samples were consisted from three different grain size classes with the same mass participation of the each class, 33,3333%.

## 2.2 Methodology

All four samples were cut by applying four methods for cutting samples: quartering, composite sampling, i.e. "chessboard" method, Jones riffle splitter, and automatic sampler “Vezin” (Figure 1). The procedure was repeated five times for each sample and each applied method.

a) b) c) d)

Figure 1 - Applied methods for sample cutting: a) quartering; b) "chessboard" method; c) Jones riffle splitter; d) automatic sampler “Vezin”

After cutting of each sample, secondary samples were measured and they were sieved on the series of sieves depending on their grain size, in order to determine whether the grain size composition was preserved, i.e. whether the secondary samples are representative.

The results obtained from the experimental part of the research were used to calculate absolute average deviation (AAD) which represents average of the absolute deviations from a central point (mean value of the participation of each grain size class). The equation used for this calculation is:

$$\mathrm{AAD}=\frac{\sum_1^n |X-\bar{X}|}{n} \quad (1)$$

where: $X$ denotes participation of grain size class in secondery sample obtained after cutting, $\bar{X}$ is a mean value of the participation of the same grain size class in secondary sample obtained from n number of repetitions.

Besides AAD, real average deviation (RAD), representing average of the deviations from a real (known) value, was also calculated by using following equation:

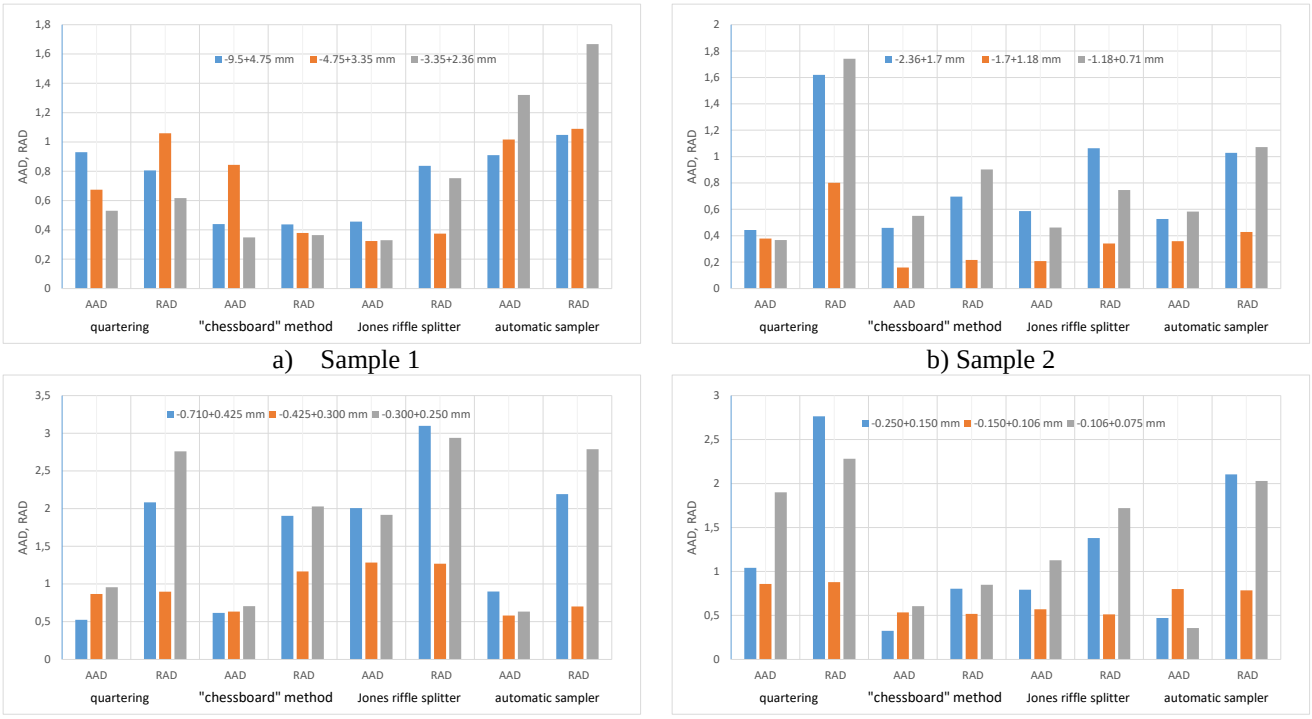
$$\text{RAD} = \frac{\sum_1^n |X - X_R|}{n} \quad (2)$$

In equation 2, $X$ represents participation of grain size class in secondery sample obtained after cutting, while $X_R$ is a real value of the participation of the same grain size class in primary sample.

The main reason why these two deviations were applied was the fact that in this study the hybrid samples, with known participation of each grain size class were used, so the aim was to see whether there are differences between samples before and after their cutting and how big these differences are.

## 3. RESULTS AND DISSCUSIONS

Values for AAD and RAD, calculated for each grain size class of all four investigated samples and for all applied sample cutting methods are given in Figure 2.




a) Sample 1

b) Sample 2

c) Sample 3

d) Sample 4

Figure 2 - AAD and RAD for each grain size class of all investigated samples and for all applied sample cutting methods

As it can be seen from Figure 2, the best results, i.e. the lowest values for AAD and RAD for almost each grain class of all four samples were obtained by applying so called "chessboard" method. Therefore it can be said that this method provides the highest representativeness of the samples after cutting.

According to AAD values for quartering were also low, so the conclusion could be that this method also provides representative samples. However, RAD values for this method are high indicating

that there are some, non-negligible differences between grain size compositions of samples before and after cutting. Similar trend can be observed with values for AAD and RAD for Jones riffle splitter and automatic sampler "Vezin".

The differences between values for AAD and RAD arise due to the way they are being calculated, AAD by using the mean value of grain size participation of the class which can be balanced if similar error occurs more than once and RAD by using the real value of grain size class in primary sample. The good example is grain size class -1.18 + 0.710 mm obtained by using quartering for cutting Sample 2 (Table 2).

Table 2 – Values for $X$, $\bar{X}$, $X_R$, AAD, and RAD for grain size class -1.18 + 0.710 mm (Sample 2)

| $\boldsymbol{X}$ **(%)** | 34.3321 | 35.7777 | 34.9070 | 35.1745 | 35.2048 |
|---|---|---|---|---|---|
| $\bar{\boldsymbol{X}}$**(%)** | 35.0792 | | $\boldsymbol{X_R}$**(%)** | 33.3333 | |
| **AAD** | 0.3677 | | **RAD** | 1.7459 | |

As it can be seen from Table 2, while cutting Sample 2 by applying quartering, all values of grain size class -1.18 + 0.710 mm in secondary samples (after cutting) are more than 1% higher than its real value in primary sample (before cutting), so the mean value is not the best indicator for the representativeness of the sample in this case. However, when dealing with samples from industrial processes the real value in not familiar so it is necessary to perform procedures as precisely as possible.

## 4. CONCLUSION

Sampling is very important operation especially when it is being used for quality control of final products, therefore it must be performed with extreme caution and by applying defined procedures and methodologies, which also applies for manipulation with primary samples, i.e. their cutting. Results of testing four sample cutting methods on four samples with different grain sizes have shown that "chessboard" method has the highest precision and samples obtained by this method are the most representative. However, other three investigated methods: quartering, Jones riffle splitter, and automatic sampler "Vezin", can also be applied for cutting samples but their applicability depends on grain size and quantity of the primary sample.

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