Uluslararası İleri Doğa Bilimleri ve Mühendislik Araştırmaları Dergisi
Sayı 8, S. 208-214, 3, 2024

Araştırma Makalesi

International Journal of Advanced Natural Sciences and Engineering Researches
Volume 8, pp. 208-214, 3, 2024

Research Article

https://as-proceeding.com/index.php/ijanser
ISSN: 2980-0811

The Implementation of Canadian Standards for Quality Assurance/Quality Control in the Mining Sector

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(Received:17 April 2024, Accepted: 25 April 2024)

(2nd International Conference on Scientific and Innovative Studies ICSIS 2024, April 18-19, 2024)

ATIF/REFERENCE: Majdouli, K., algouti, A., Algouti, A., Lamrani, K., Lakhlili, M., Laadimi, Y., Jdaba, N. & El Kihal, I. (2024). The Implementation of Canadian Standards for Quality Assurance/Quality Control in the Mining Sector. *International Journal of Advanced Natural Sciences and Engineering Researches*, 8(3), 208-214.

Abstract – The Qa/Qc (Quality Assurance / Quality Control) report plays a crucial role in the mining industry by ensuring the quality and integrity of surveying and sampling data for mineral resources. The Qa/Qc report is primarily used to monitor the accuracy and precision of test results and to detect errors or biases in the data. The impact of the Qa/Qc report on mineral resources can be significant. If surveying, sampling, and laboratory analysis data are unreliable due to quality issues, this can result in errors in mineral resource estimates. For example, poorly executed surveying data, improperly collected samples, or contamination during sample preparation can lead to underestimation or overestimation of mineral grades, which can have a negative impact on the economic feasibility of a mining project.

A rigorous Qa/Qc report can help minimize these errors and ensure data reliability. Reliable data is crucial for making informed decisions regarding mining exploration, project development, and mining production management. Governments, investors, and regulators often require detailed Qa/Qc reports to ensure that drilling and sampling data are accurate and that mineral resource calculations are precise, which can have a significant impact on mineral resource assessment and management. Implementing such programs requires better database preparation and data processing, as well as a dynamic and cooperative relationship with geologists and laboratories.

Keywords – Quality Assurance, Quality Control, Mining Industry, Sampling Data, Accuracy, Precision

I. INTRODUCTION

In Morocco, the term "Qa/Qc" receives little attention and remains underdeveloped, but recently decision-makers have started to recognize the risks posed by data uncertainties, sometimes leading to disastrous economic feasibility impacts.

The terms "Qa/Qc" and "Qc" are often used interchangeably, without regard to their true meanings. In reality, quality control is only one facet of the broader concept of "Quality Assurance/Quality Control". Qa/Qc aims to estimate, control and reduce the risk associated with a data system. According to the Canadian Institute of Mining (CIM), Qa and Qc can be defined as follows:

- **Qa: Quality Assurance**

This is the design of a data collection and organization system that is adequate for its intended use, providing solid confidence in the veracity of the final results. In simple terms, it encompasses all planned or systematic actions necessary to ensure appropriate confidence in the data collection and estimation process (ICM, 2013). Quality assurance is proactive, seeking to prevent errors and defects before they occur. [5]The quality assurance program typically consists of written protocols describing at least the sampling, sample preparation and analysis protocols, and translating into practices and methods introduced into the operations of the ore value chain from sampling to production, to ensure the quality of geological information with adequate confidence. These practices include:

- Georeferenced information: the geographical location of outcrops and samples, the location of remote sensing data, topographical data, geophysical data, etc;
- Descriptive information: geological description (lithology, mineralogy, alteration, structures, etc.), physical parameters (color, hardness), climatic context (temperature, precipitation, humidity, etc.);
- Measurable parameters: density, deviation, recovery rate, structural parameters, etc;
- Analytical information: Sampling (strategy, methods, preparation), analytical methods, etc.;
- Data integrity: Structure of numerical information; Data entry; Database integrity; Backup and security, etc.;

- **Qc : Quality Control**

[1]Quality control of collected measurements, through various actions such as inserting control samples into batches sent to laboratories, auditing databases and laboratories, validating qualitative data (logs), estimating uncertainty in interpretive (geological) data, monitoring temporal drifts in results, etc. More precisely, these are the systems and mechanisms put in place to provide quality assurance. The four steps of quality control include:

- Setting standards,
- Performance evaluation,
- Action if necessary,
- Planning improvements.

Unlike the principle of Qa, which aims to prevent problems, the goal of quality control is to detect them, in case they occur, assess their magnitude, and take appropriate measures to minimize their effects. Therefore, quality control is reactive; it tests effectiveness and safety and seeks to identify errors and defects after the product has been manufactured. (Armando Simon Méndez, 2011).

II. MATERIALS AND METHOD

The steps taken to ensure the quality of the collected samples:

a) Sampling

Sampling is a critical phase in mining exploration, aimed at extracting a representative portion of the surveyed area for subsequent laboratory analysis. This analysis seeks to determine the precise average content of desired elements. This extracted portion, known as a "sample," undergoes laboratory testing post-collection. The analysis results are pivotal in evaluating ore quality, aiding geologists in gauging deposit profitability and strategizing mining operations.

b) Mechanical preparation of samples

[4]The process of mechanical sample preparation is of paramount importance for ensuring the representativeness of analytical results. However, it also carries inherent risks of errors due to material heterogeneity. These errors may include structural destruction, grinding of coarse elements embedded within the fine earth, and potential loss of fine elements. Additionally, there is a risk of introducing contaminants into the samples during the preparation chain. Sample reception and preparation serve as the initial steps in the quality assurance process. It is at this stage that the laboratory receives the samples and begins to assess their representativeness of the study area. To ensure accuracy, the laboratory establishes rigorous preparation and conditioning protocols.

Despite efforts to mitigate errors, every sampling endeavor introduces multiple potential sources of error. These may stem from various factors such as texture, structure, ore distribution, sampling technique, application method, and the specific sampling instrument used. Therefore, meticulous attention to detail and adherence to standardized protocols are essential to minimize errors and ensure the reliability of analytical results.

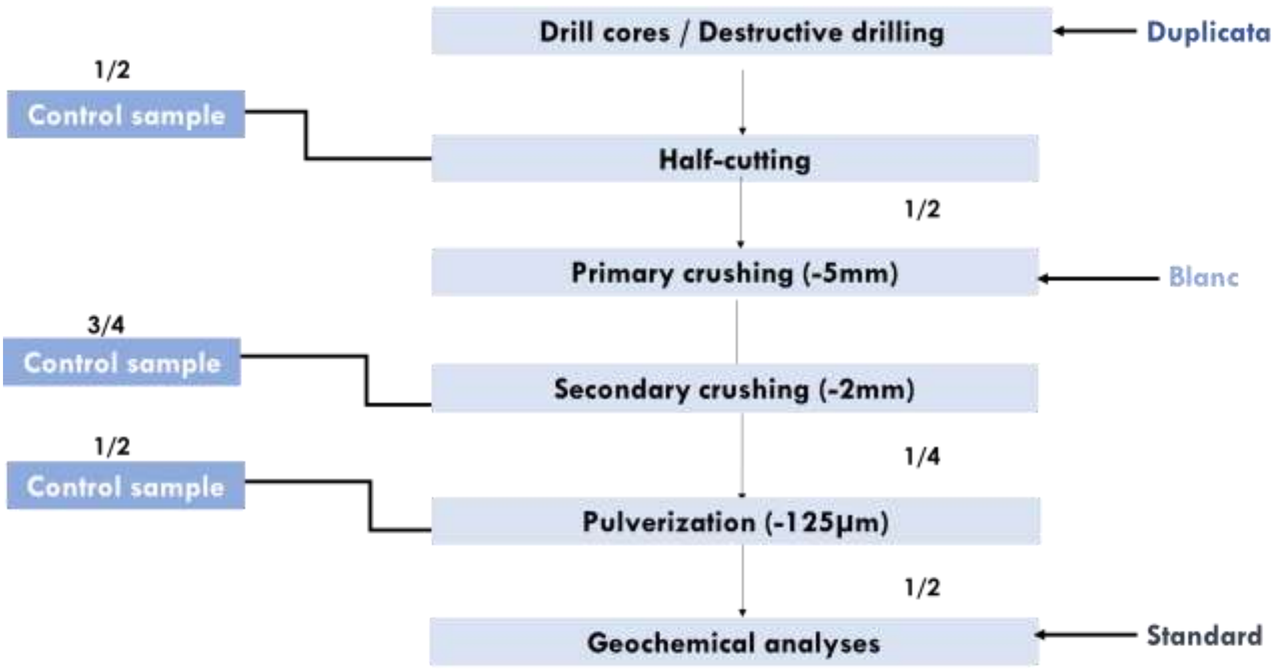

Figure 1 : The process of mechanical sample preparation

c) Insertion of blanks

[2]Blanks are sterile samples on which the presence of elements subjected to analysis has been confirmed to be below the corresponding detection limit (zero mineralization). They are used as a baseline control to ensure that analysis results are not affected by contamination. Therefore, their insertion aims primarily to monitor contamination during the mechanical preparation of samples, which can occur mainly at the crusher

and grinder stage due to insufficient cleaning of the equipment. In this case, mineralized samples contaminate the subsequent samples. To address the risk of contamination, either a local blank sample (carrot samples with low concentration, sterile material) or commercial material with negligible concentration (industrial silica) is used. In our case, we used local quartz.

d) Insertion of standards

[2]Standard samples are reference samples with a well-defined content of minerals of interest. They are used to calibrate measuring instruments and to verify the accuracy of analysis results. It is important to mention that for a reliable estimation of analytical accuracy, standards must have the same type of constituent minerals, the same concentrations, and the same metal speciations as the samples being analyzed. Two types of standards can be used: certified or commercial standards and internal or secondary standards developed by the mining company's internal laboratories.

e) Insertion of Duplicates

A duplicate is a sample collected in duplicate in the field with the aim of controlling and ensuring the quality of samples. It allows establishing replicability if analyzed in the same laboratory or reproducibility if analyzed in two different laboratories, of sampling work. Therefore, the duplicate must be as representative as possible of the parent sample, knowing that duplicated samples must be shipped to the laboratory under two different identifications.

Quality control of analyses through control charts

[3]After the completion of the sampling, preparation, and assay process, the measured results (grades) are transformed into graphs known as control charts.

Qa/Qc control charts, or statistical control charts, serve as graphical representations utilized to track the progress of results for a specific analytical method. They are commonly employed tools for evaluating the quality of measurement data. These charts allow for real-time monitoring of measurement data, enabling the identification of variations or trends that may signal issues within the measurement process. Qa/Qc control charts, rooted in statistical principles, feature a centerline denoting the average of the measurement data and upper and lower control limits computed based on the standard deviation of the measurement data. Subsequently, the measurement data are depicted on the control chart as individual points or clusters, depending on the frequency of measurement and the quantity of data collected.

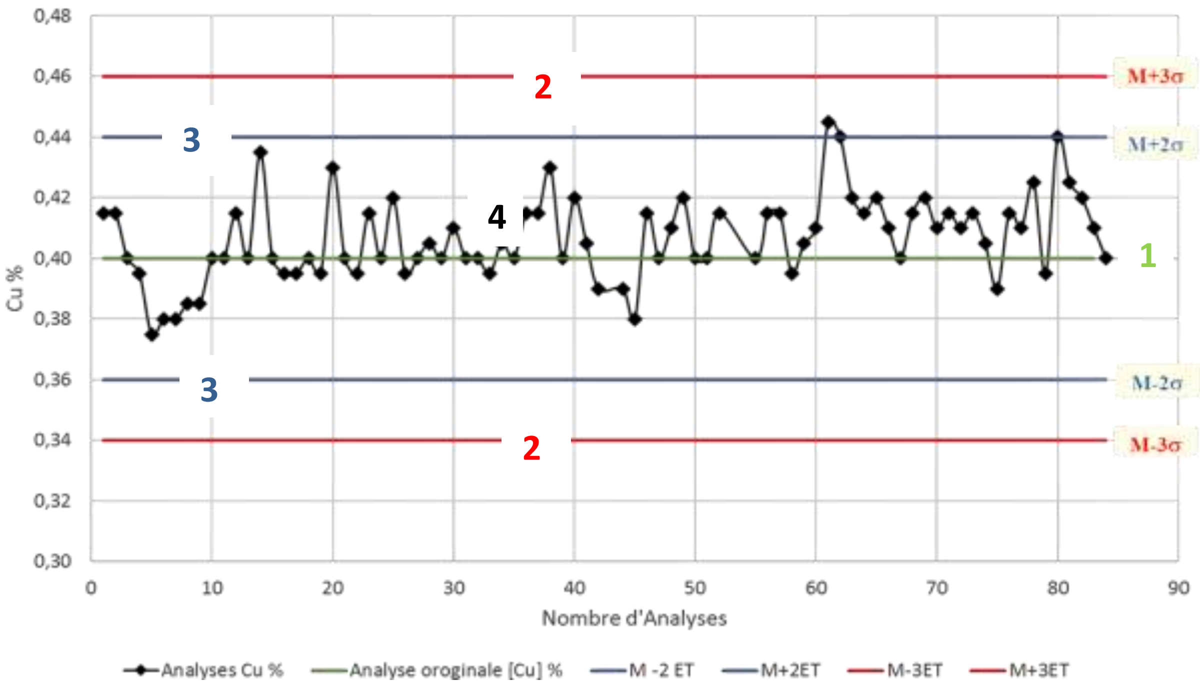

Figure 2 : Example of a control chart used to monitor the quality of analyses

III. RESULTS

The Qa/Qc protocol is consistently upheld, and in the mechanical workshop, it is evidenced by the insertion of error control samples: Blanks, Standards, and Duplicates, with an insertion rate equivalent to 0.2, meaning that for every 10 samples, one control sample is inserted, starting with a blank, followed by standards, and a duplicate sample. All these measures are undertaken to ensure the quality of analyses and minimize contamination, instrumental performance, and human errors as much as possible.

Analysis of Qa/Qc control charts allows for monitoring and enhancing the quality of measurement processes by promptly identifying trends or significant deviations. This can help prevent measurement errors, improve data accuracy, and reduce costs associated with rework or rejections. Qa/Qc control charts are thus an essential tool for companies aiming to maintain high-quality standards in their measurement processes.

A control chart consists of:

- (1) : A centerline corresponding to the target value m,
- (2) : Two lines located at m +/- 3 srepro representing the control limits,
- (3) : Two lines located at m +/- 2 srepro representing the surveillance limits,
- (4) : The curve of individual results obtained during the control points.

Srepro: the standard deviation of internal reproducibility, defined by each laboratory.

IV. DISCUSSION

The distribution of results around the target and relative to the control limits enables validation or initiation of control if necessary. Consequently, five scenarios arise:

1- Random Fluctuation Around the Target

The results curve fluctuates randomly on both sides of the target value within the control limits. This indicates that the analytical process is stable, ensuring the "accuracy" of the results

2- Upper or Lower Trend

This occurs when several consecutive points are observed to be consistently higher or lower than the average, indicating a bias error in the analysis method.

3- Increasing or Decreasing Trend :

In this scenario, we observe several consecutive points showing a consistent upward or downward trend. This indicates a degradation in the accuracy and/or precision of the analysis method.

4- A point falls between the surveillance limits and the control limits:

A data point falls within the range delimited by the surveillance limits and the control limits. In this scenario, heightened attention is warranted, and careful monitoring is advised during the subsequent data collection.

5- The last point has crossed a control limit:

The latest data point breaches a control limit. This event triggers an alarm, prompting the need for result verification and, if necessary, the implementation of suitable corrective measures.

Validation or adjustment of parameters: Following the accumulation of a significant dataset, an assessment is conducted to validate or modify the parameters of the control chart. Should the control chart exhibit abnormalities, recalibration of the target value and/or reproducibility standard deviation is required based on all collected data points since the inception.

V. CONCLUSION

The Qa/Qc (Quality Assurance / Quality Control) report plays a crucial role in the mining industry by ensuring the quality and integrity of surveying and sampling data for mineral resources. The Qa/Qc report is primarily used to monitor the accuracy and precision of test results and to detect errors or biases in the data. The impact of the Qa/Qc report on mineral resources can be significant. If surveying, sampling, and laboratory analysis data are unreliable due to quality issues, this can result in errors in mineral resource estimates. The impact of the Qa/Qc report on mineral resources can be significant. If the data from drilling, sampling, and laboratory analysis are not reliable due to quality issues, it can lead to errors in mineral resource estimates. For example, poorly executed drilling data or improperly collected samples, or even contamination during mechanical sample preparation, can result in either underestimation or overestimation of mineral grades. This can have a negative impact on the economic feasibility of a mining project.

ACKNOWLEDGMENT

The authors are extremely grateful to the Director Laboratory Geosciences, Geotourism, Natural Hazards and remote sensing/Faculty of sciences Semlalia in Marrakech, University Cadi Ayyad, Morocco for their constant encouragement and support for this study.

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