Pre-mining Waste Rock Sampling – A Case Study in Sample Selection

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Abstract

This paper presents a systematic or targeted approach used in a case study for selecting waste rock samples for Environmental Impact Assessment (EIA) study. The sample selection process involved reviewing the geochemical characterisation report from a previous EIA report, examining the diamond drill hole database, and assessing sulfide assays. By comparing the sampling data from the previous report with the drill hole data, common factors were identified. Thereafter, classic statistical methods, such as calculating averages, medians, and percentiles for sulfur assays, were used to identify sampling gaps in the study area.

Although time intensive, the systematic sampling approach, coupled with comprehensive data analysis techniques, facilitated a detailed understanding of the environmental geochemistry associated with waste rock materials.

Keywords: Sample Selection, Representativity, Sampling Program

Introduction

Digby Wells Environmental was assigned the task of conducting an Environmental Impact Assessment (EIA) for a prospective greenfield opencast mine. This paper specifically focuses on the sampling program of the EIA, with a specific emphasis on the environmental geochemistry component related to potential waste rock materials.

The geochemical exploration phase entails a rigorous drilling program that plays a crucial role in identifying undiscovered mineral deposits. This program involves the sampling of the drill core, which provides valuable information about the extent of mineral sources (Zuo, Wang, Xiong, & Wang, 2021). The drill core covers a significant portion of the exploration area and encompasses the various rock types that will be excavated during the project. This offers insights into the potential waste rock materials that might be deposited in a waste rock dump facility. The exploration phase generates a comprehensive database that includes the location of exploration holes, grade assessments, and visual observations of geological conditions such as discrete geological units, mineralization, alterations, and weathering/leaching. These data is very valuable for selecting waste rock samples before the operational phase of mining.

Approach

During the sample selection process, a three-step approach was employed, which involved (1) reviewing the existing information, (2) identifying the common factors between the reviewed information, and (3) addressing any gaps in the previous sampling efforts. It was crucial to ensure that an adequate number of samples were taken to effectively capture the variability and central tendencies of the target parameters, including measures such as average, median, and percentiles (5th, 50th, and 95th). The approach aimed to provide a comprehensive and representative characterization of the waste rock material at reduced costs.

Description of the databases

A previous geochemical study collected a total of 369 waste rock samples. The samples were collected from sections of the drill core or rejected drill chips from Reverse Circulation

(RC) drilling. The sample descriptions included lithologies, sulphur assays and drill core logs.

To supplement the previous work, a Diamond Drilled Hole (DDH) database was provided by the client, which contained 6685.37 core intervals from 84 exploration holes (*Table 1*). The core intervals considered in this study were from exploration holes drilled after the EIA process. The objective of our study was to select approximately 50 samples from the DDH database by identifying gaps in the previous sampling programme. The information available in the DDH database included exploration hole ID, depths, lithologies and lithology codes, alteration characteristics, chalcopyrite-pyrite ratios, estimated copper percentage, and visual representations of estimated sulphide and total sulfur percentages.

A common factor identified between the previous study database and the DDH database was total sulfur. The previous report provided laboratory results for total sulfur, while the DDH database represented total sulfur visually. To facilitate comparisons and identify any gaps, the total sulfur data from the previous report, referred to as the Acid-Base Accounting (ABA) database, was merged with the DDH database.

Total Sulfur (ABA and Visual Analysis)

Total sulfur was identified as the common factor across all the reviewed available information, and classic statistics and exploratory data analysis techniques (Hawkes & Webb, 1962; Tukey, 1977) were employed to establish clear relationships within the data. These techniques included calculations for minimum, mean, mode, median, maximum, range, standard deviation, median absolute deviation, coefficient of variation, quartiles, quantiles, percentiles, skewness, kurtosis, and graphical displays such as histograms and cumulative frequency distributions. These analyses aimed to uncover the underlying structure of the data and mitigate the impact of outliers on the results (Kiirzl, 1988; Reimann, 2005).

Figure 1 illustrates the relative distribution of drill core intervals based on lithologies. The dominant lithologies in the pit were identified as VIN SCC (Volcanic Intermediate-Coarse Porphyritic – Oxidized), VIN MIX (Volcanic Intermediate-Coarse Porphyritic – Mixed), and VFL MIX (Volcanic Fine Laminated – Mixed). The previous report analyzed a total of 65, 21, and 10 samples from these lithologies, respectively, and indicated that 80% of these waste rocks have the potential for acid generation. Additionally, VIN MIX and VIN SCC were found to be the most problematic materials in terms of leachate quality.

To identify gaps within the database, various plots and statistical analyses were conducted. The box and whisker plot were employed to display the distribution of total sulfur across different lithologies and exploration holes. The box represents the interquartile range (25th to 75th percentile), with the line indicating the median (50th percentile). The whiskers extend to the maximum and minimum values recorded. Figure 1 presents the box and whisker plot for the distribution of total sulfur (both ABA and visual representation) relative to exploration holes and lithologies. Statistical analysis utilized a total of 2200 visual total sulfur analysis results from the DDH database to supplement the 369 samples from the ABA database already analyzed. A comparison between the two databases revealed that the ABA total sulfur ranged from 0.3% to 8.4% (as shown in Table 2), with 95% of the ABA analyzed samples exhibiting sulfur concentrations above 1.0%. The mean and

Table 1 *Distribution of drill core intervals for Pit*

	ABA database	DDH Database	Total
Count (n)	369	5035	5404
Lithologies	59	47	
Number of Exploration Holes	65	84	149
Intervals Total of Core (meters)		6685.37	6685.37

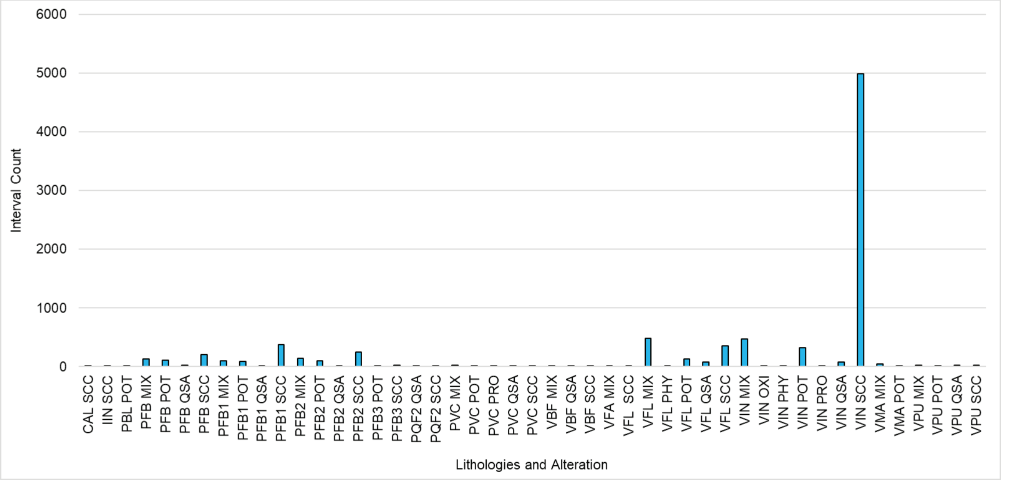

***Figure 1** Stratigraphic distribution of drill core intervals*

***Table 2** Statistical Analysis Interpretation for Pit*

Statistical Analysis	ABA TS	DDH TS	Statistical Analysis	ABA TS	DDH TS
Mean	4.02	3.84	Skewness	0.27	0.83
Standard Error	0.30	0.02	Range	8.1	6.32
Median	4.00	3.64	Minimum	0.3	1.06
Mode	2.30	3.18	Maximum	8.4	7.38
Standard Deviation	1.90	1.09	Sum	157	8442
Sample Variance	3.60	1.20	Count	39	2200
Kurtosis	-0.39	1.48	Confidence Level (95.0%)	0.61	0.05

median total sulfur values were 4.0%, and the 95th percentile was 0.61%. The similarity between the median and mean values suggests that the database is symmetric.

Within the DDH dataset, the total sulfur ranged from 1.2% to 7.4%, with all visual assessment data indicating total sulfur concentrations above 1.0%. The mean total sulfur was calculated as 3.8%, the median was 3.6%, and the 95th percentile was 0.05%. The slightly lower median compared to the mean suggests a right-skewed distribution, indicating a non-symmetric database.

Through the analysis of cumulative percentage plots in Figure 4, several gaps in the total sulfur data were identified. These gaps fell within the ranges of 0.9-2.2%, 3.3-4.9%, and 6-7%, indicating the need for further analysis within these ranges. Another gap was observed in the exploration holes located in a specific area, where only visual total sulfur analysis had been conducted. In contrast, other regions lacked any total sulfur analysis in their exploration holes. Consequently, this identified gap became the focus for sample selection within those specific exploration holes.

The second step involved identifying gaps in total sulfur data relative to different lithologies identified during core logging (Figure 3). It was noted that VIN lithology was the dominant lithology type, and 65 samples had already been analyzed for this category. Therefore, no additional samples were needed for this lithology type. Instead, additional samples were selected from minor lithologies to supplement the ABA database or to analyze lithologies that had not been previously analyzed.

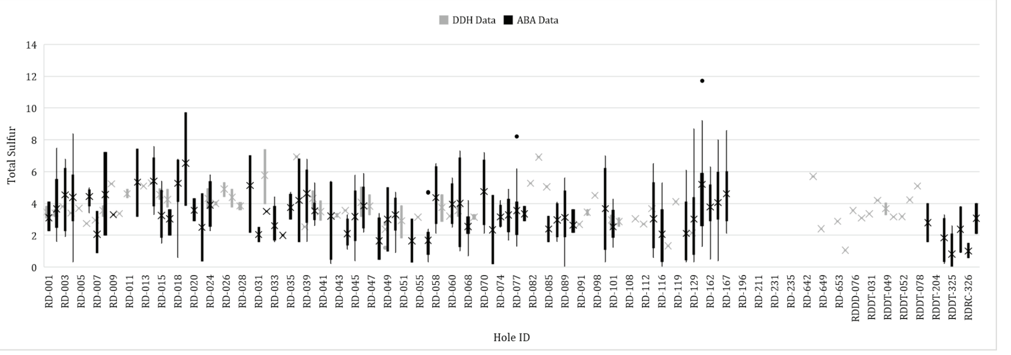

***Figure 2** Exploration holes relative to total sulfur*

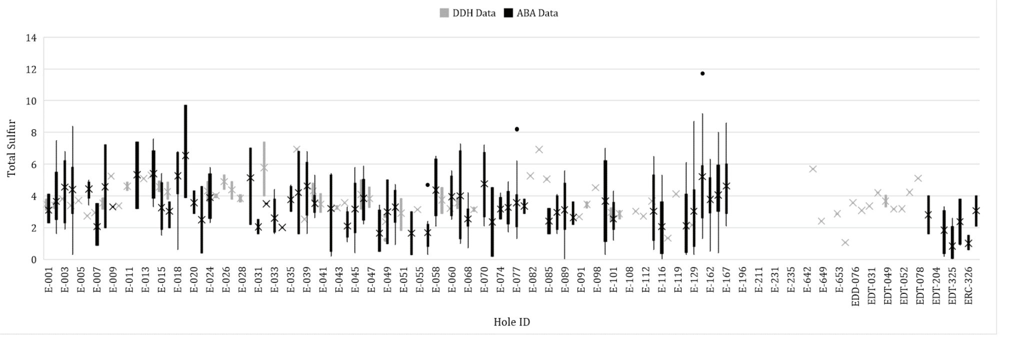

***Figure 3** Pit Lithologies Relative to total sulfur*

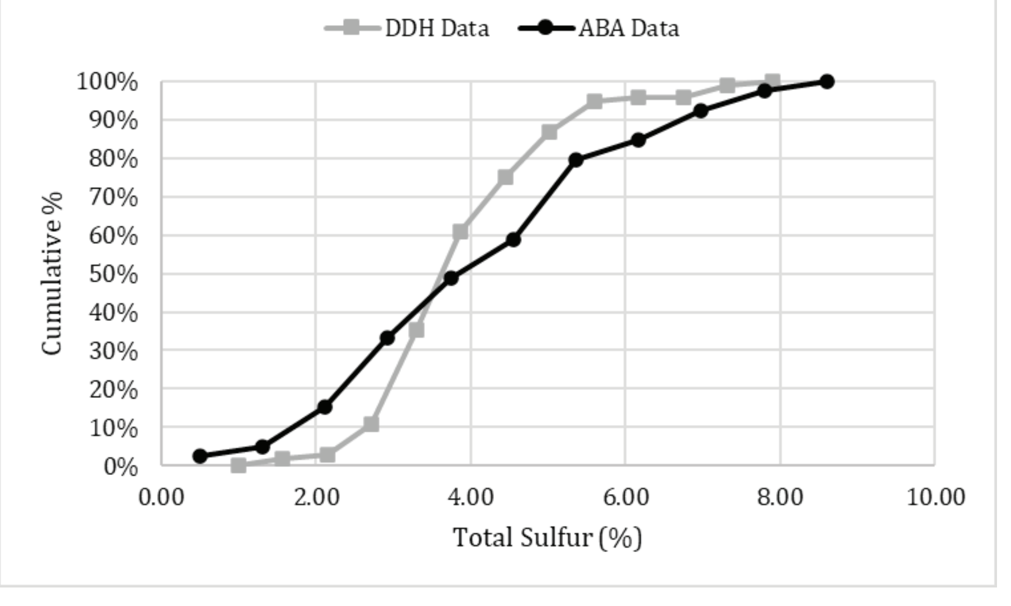

***Figure 4** Cumulative frequency plot for ABA and DDH database*

Pit Wall Samples and Spatial Representativity

Another important gap identified was the absence of pit wall samples in the previous EIA. To address this gap, pit wall sample selection was conducted using Leapfrog software, with access provided by the geologist. The objective was to understand the chemistry of these rocks, as they have the potential to influence the quality of the pit lake water. Leapfrog software was utilized to create a 3-dimensional model of the resource, incorporating all available exploration holes. Based on depth and lithologies, samples were selected from the pit wall and Figure 5 indicates only the exploration holes where pit samples were selected.

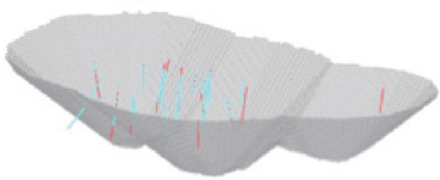

***Figure 5** Leapfrog pit wall sample selection*

To visualize the distribution of the selected samples and ensure comprehensive coverage, a scatter plot was generated. This plot depicted exploration hole IDs on the x-axis and depth on the y-axis, providing a visual representation of the sample distribution across different depths. The scatter plot allowed for a comprehensive assessment of the selected samples, ensuring that they not only addressed the identified gaps in total sulfur and lithologies but also covered various depths (as shown in Figure 6).

Assessment of the Sampling Approach

A targeted or systematic geochemical sampling approach was adopted in this case study. The approach allowed for the collection of samples from specific locations of interest. This targeted sampling helped focus efforts on the gap areas to avoid unnecessary duplication of samples. By utilizing the systematic approach, the sampling was optimized to cover a large area efficiently while minimizing costs. This approach helped allocate resources effectively and reduce unnecessary sampling efforts in areas less likely to yield valuable results. The approach ensured that representative samples were collected, leading to accurate and reliable data.

On the other hand, depending on the complexity of the project, this systematic approach can be time-consuming. Review of previous information and data, interrogation of the data, extensive consultation with site geologist, and integration with Leapfrog block modelling all require significant time and resources. This factor should be considered in project scheduling and budgeting.

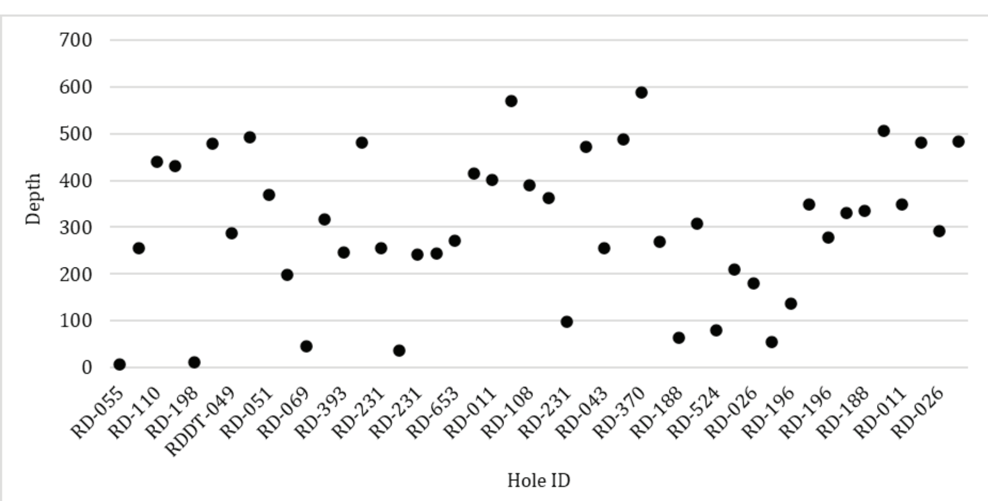

***Figure 6** Spatial representativity relative to depth if the Pit*

Conclusion

The targeted sampling approach adopted in this study allowed for focused efforts on specific areas of interest, minimizing unnecessary sampling. By optimizing the sampling process, it efficiently allocated resources and reduced costs. Additionally, the approach ensured representative samples were collected, leading to accurate data and reliable interpretations. This systematic sampling approach, coupled with comprehensive data analysis techniques, facilitated a detailed understanding of the environmental geochemistry associated with waste rock materials. If the time intensive limitation is considered in project scheduling and budgeting, then the approach is excellent for geochemical sampling program for environmental assessments.

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