

Approach to Measurements of Block Size and Rock Quality Designation on Nickel Laterite Mine

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Abstract— One of the problems in the nickel laterite is exposed unserpentinized peridotite rock fragments great in saprolite zone. The increasing of block size will reduce mine recovery and make mining operation become high cost.. To create a zoning deployment size of a block of rock, used the approach block volume and rock quality designation (RQD) method. Classification of rock block size is divided into four units: rock type 1, rock type 2, rock type 3, and unfracture. RQD value and volume block calculated from drill core in each spaced 50 meters. The research area is located on the concession. Vale West Block the hill X, Y and Z. The aim of this study to provide integrated information and details about the type of boulder based on the size and distribution so as to simplify the mining process. The method used is the measurement of the dimensions of the boulder adapted to drill point and compare RQD values which have been calculated on the drill log. Classification of rock type and the making of distribution maps using ArcGIS 9.2 software. Analysis of the results obtained at the X area, mostly including rock type 1 and large-sized as much as 35% of the sample surface and 67% of the core sample. In the area Y obtained difference RQD values ie rock type 2 based on the sample surface and rock type 1 based on core samples. In the area of Z also there were different types of rock that is equal to 67% unfractured rock type on the sample surface while the core samples including rock type 2 by 83%. Different types of rocks derived from both methods due to differences in data collection based on the dimensions of rock and core samples are done vertically. In addition, factors topographical differences in all three areas, affecting the deployment of the exposed rock fragments,

Index Terms — Nickel Laterite, RQD, Block Size, Boulder, Block volume

INTRODUCTION

Nickel Laterite nickel ore deposits are a formed from the process of ultramafic rocks such as laterization peridotit and dunite. The process of laterization is generally formed in the areas experiencing temperature changes the contrast and such high rainfall in Indonesia (Sorowako), New Caledonia, Australia, Cuba, the Philippines and Brazil. The process of becoming nickel deposits enriched the economic value is also influenced by several factors, i.e. acidic ground water, physical and chemical weathering, oxidation, environmental

element mobility and time. Two kinds of lateritic nickel ore have to be distinguished, namely limonite types and saprolite type. Limonite type laterite are highly enriched in iron due to very strong leaching of magnesium and silica. They consist largely of goethite and contain 1-2% nickel incorporated in goethite. Absence of the limonite zone in the ore deposits is due to erosion. Saprolite type nickel ore formed beneath the limonite zone. It contains generally 1.5 -2.5% nickel and consists largely of Mg-depleted serpentine in which nickel is incorporated. In the pockets and fissures of the serpentine rock green garnierite can be present in minor quantities, but with high nickel contents - mostly 20-40%. It is bound in newly formed phyllosilicate minerals. All the nickel in the silicate zone is leached downwards (absolute nickel concentration) from the overlying goethite zone [1].

Nickel Laterite sequence from bottom to top is composed of bedrock, limonite and saprolite, Iron capping. Bedrock is the original Nickel Laterite rock is composed by boulder > 75 cm size and block peridotite. Saprolite at the top of the bedrock is nickel enrichment zones which most arranged by bedrock boulder sizes vary greatly. During the excavation of the mine operator should separate the large boulder and certainly not load as ore. Boulder can be transported as waste or moved to secure that do not interfere with the activities of the mining area around the unloading of excavating. Stored in the stockyard saprolitic rock at the time of being transported back to the grizzly portable ascertained transported clean, does not occur in other material from contaminating the outside pile of ore, and a large boulder separated so there is not load to the grizzly. There is no taking of samples conducted in this activity. Large boulder which would affect the operation tools during exploration activities. According to this problem it would require a distribution map boulder to anticipate damage to the equipment.

The RQD was initially introduced for civil engineering applications, it has been quickly adopted in geotechnical works and mining engineering as well [2]. RQD measurements are encumbered with several limitations and that this parameter should be applied with care. People involved in jointing characterization should be better informed how to perform adequate block size, joint density, and block volume measurements, also knowing the limitation

in the RQD. In general, more efforts should be made to work out instructions and information on the block size measurements [3]. Exploration activities have been conducting research on occurrences large blocks of the method of Rock Quality Designation (RQD) on Bedrock zone. Currently the saprolite zones have also appeared on the pitch big chunks that influence the productivity tools. Therefore the object of research is focused on the West Block area by mapping sized gravel of rock. Further types are classified by size boulder Rock Quality Designation (RQD), which is expected to simplify the process of laterite mining.

GEOLOGY

The research areas included in the regional geology Malili Sheet, which is included in the lane ophiolite East Sulawesi form ultramafic rocks. In Geology Mandala East Sulawesi, the oldest rocks are rocks composed of ultramafic ophiolite including dunite, harzburgite, lherzolite, websterite pyroxenite, wehrlite and serpentinite, local mafic rocks including gabbro and basalt. Rocks age is uncertain, but can be estimated with ophiolite in the East Arm of Sulawesi Early Cretaceous - Tertiary [4].

Golightly [5] suggested that nickel laterite ore derived from unserpentinized ultramafic rock is commonly characterized by thinner saprolite, many boulder, but higher in Ni; while the weathering of serpentinized ultramafic protolith tends to produce thicker saprolite but lower Ni content. Specifically Golightly divides the geological region of Sorowako into three parts, namely (Figure 1):

- A unit of sedimentary rocks of Cretaceous age; consists of limestone and Flint in the sea. There is in the western part of Sorowako and is limited by the rate rises with the tilt toward the West.
- Ultramafic rock units early Paleogene age; generally in this type of peridotite, the most experienced serpentinization degrees vary and is generally located in the East. In this unit, there is intrusion-intrusion pegmatites are gabbroic and are found in the northern part.
- Units of alluvial sediments and lake (lacustrine) that was the last, generally in the north near the villages of Sorowako.

The Ultramafik rocks are considered the source are the result of the movement of tectonic plates at the time of Cretaceous – Tertiary when the Pacific plate moving under the Eurasian plate. The terserpentinized rocks by weathering a tropical during the very long, resulting in the deposition of nickel-cobalt laterite. Nickel and cobalt in the manganese oxide and garnierite mineral concentrated primarily on the saprolitic rock layer. Mineralogy of west ore is mainly composed of quartz, olivine, and pyroxene with minor talc, serpentine and spinel; whereas east ore contains principally residual serpentine with subordinate chlorite, pyroxene, amphibole, maghemite, and quartz [6].

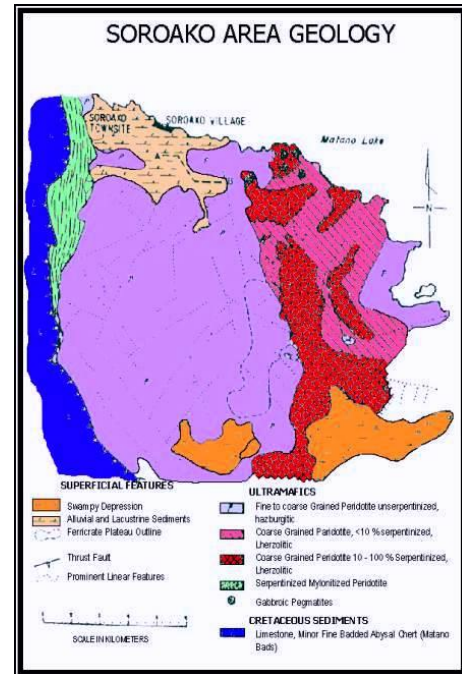


Figure 1. Regional geology of Sorowako [5]

METHODS

This research was conducted using three methods in general, the preparation, field research and statistical data processing.

1. Preparation

This stage is the earliest stages prior to the implementation of field activities, which includes literature and equipment in the field. It is intended to collect secondary data research areas, such as the regional geological study area as a reference in the study.

2. Field Technique

Fieldwork was conducted by surveying directly in the field systematically by standard procedures (Figure 2), in which things are done in the collection of field data, as follows:

- Plotting the location of the measurement point in each interval of 50 meters on the map, based on the coordinates of the point of the existing drill. Measurements carried out in the area exposed and mined out ore, which has shown the existence of boulder on each hill X, hills Y, and hill Z.
- Finding the coordinates of the drill hole in the ground in accordance with the existing drill points on the map, with the help of global position system.
- Mark the location of measurement using a tape meter and an area of 5x5 m, then put up a marker at each drill hole coordinates contained boulder.
- Retrieval of data by way of data recording field, which measures the dimensions of rock consisting of the length, width, and height. Data for each drill points were selected by criteria of rock has a diameter of > 25 cm or the size of boulder. Boulder appearance documentation retrieval conditions and other data in the form of photos (Figure 2).



Figure 2. Field Technique

3. Data Processing

At this stage, the overall results of field measurements collected and performed calculations using RQD formula in Excel, and then made a block diagram of rock volume, and the calculation results RQD Boulder distribution of actual field use software designed ArcGIS 9.2 and the preparation of reports aided libraries, references and the results of previous studies to make inferences about the distribution of the type of rock fragments (rock type) on X area, Y area, and Z area of West Block.

The method is performed during the processing of the data in this study are as follows:

- The data dimensions (length, width, height) boulder drill point based on input into Excel, then calculate the size of the Boulder area, Boulder volume, spacious location, and percentage of Boulder dissemination of any point drill three hills in the field.
- Calculate the percentage of boulder representing each drilling point measured in the field, using the formula:

$$\sqrt{\frac{\Sigma(LXW)}{\text{length of area}}} \times 100 \% \quad (1)$$

- Classify the calculation data measurements every boulder area with the percentage deployment boulder. Calculations on the drilling points in the field to determine the value of RQD and create a map of for distributing boulder.
- From the results of the classification percentage for each deployment of area boulder, then determine the type of rock fragment based RQD values in a drill core log that has been used to classify the types of rocks on the west block as shown in the Table 1.

Table 1. West block of rock type classification

Type	RQD
Unfractured	$\geq 75 \%$
WT1	50 - 75%
WT2	25 - 50%
WT3	$\leq 25\%$

- Make a map of the spread of Boulder based RQD values using ArcGIS software 9.2 for each X, Y, and Z area.
- Classify the size of boulder based on block volume (Table 2)

Table 2. Classification of block volume [3]

Dimensions	Block volume
$10 - 200 \text{ cm}^3$	very small
$0.2 - 10 \text{ dm}^3$	small
$10 - 200 \text{ dm}^3$	moderate
$0.2 - 10 \text{ m}^3$	large
$> 10 \text{ m}^3$	very large

RESULT AND DISCUSSION

The Type of Rock Fragments Area X

Boulder on the area X measurement performed at the location of mined out. At these locations, there are blocks of relatively large size ($\pm 1,500 \text{ mm}$) and hard. Relatively hard material properties causes difficulties in mining (Figure 3). Boulder is measuring location based on previous drilling points. Drill point spread from the north-east of the southwest. Measurements made include length, width, and height boulder. Based on the results of field measurements there are 60 drilling points sized boulder of 77 drilling points. Boulder dimensional data obtained from 60 drilling points is 348 boulders.



Figure 3. Large-sized rock fragments on the area X that makes it difficult of mining

A total of 348 data processed using RQD method to determine the type of rock fragments. Data processing results obtained percentage RQD values based on the data volume of the block. On the area X is dominated by rock type 1 by 35%. The other type was also obtained in the form of rock type without fractures by 21%, rock type 2 by 26%, and rock type 3 by 18% (Figure 4).

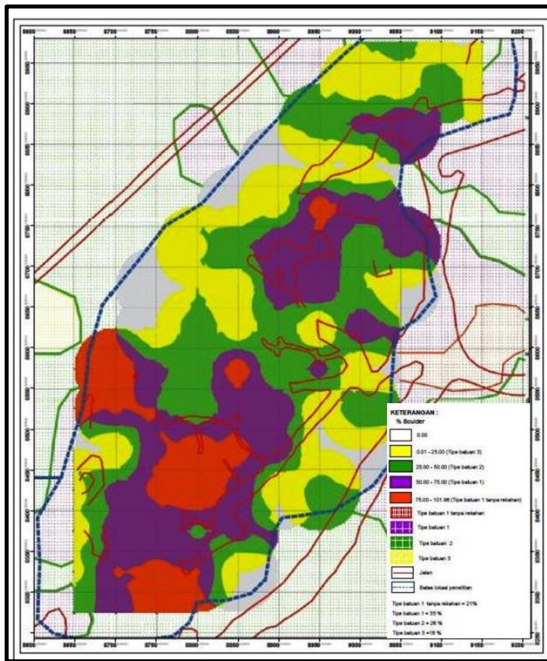


Figure 4. Zoning map of boulder in area X

When compared with the data acquisition RQD of core samples, obtained different results. RQD value based on data from core samples is dominated by rock type 1 by 67%. Another type that found only rock type 2 by 33%. Type 1 without fracture rocks and rock type 3 there is no value (Table 3).

Table 3. The The comparison sample data RQD core sample and block volume, boulder on the area X

Type	RQD	RQD	
		Core sample	Block volume
unfractured	75 - 100%	0%	21%
WT 1	50 - 75%	67%	35%
WT 2	25 - 50%	33%	26%
WT 3	< 25%	0%	18%

Obtaining RQD value of the data processing based on block volume and different core samples. The difference is caused by the data collection parameters. Collecting data in the form of measurement location, measurement, and formulas used. Boulder measured starting at the saprolite zone. The measurements were carried out horizontally on the surface, which covers the length, width, and height boulder. Dimensions are a calculation of the percentage volume parameter boulder. While the core samples, measuring only boulder on bedrock layer only. The measurements were carried out vertically downwards. Calculations using formula calculation core sample length. The data analysis, both methods are illustrated on a map of acquisition RQD based on core samples (Figure 5) and map the acquisition RQD based on the block volume (Figure 6).

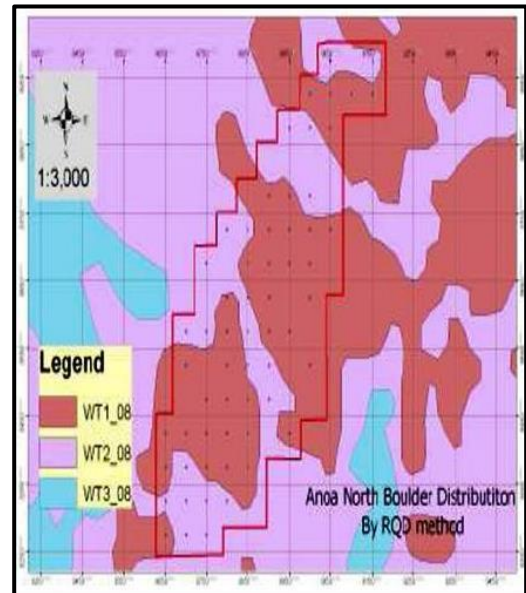


Figure 5. Distribution of boulder based on core sampling at area X.

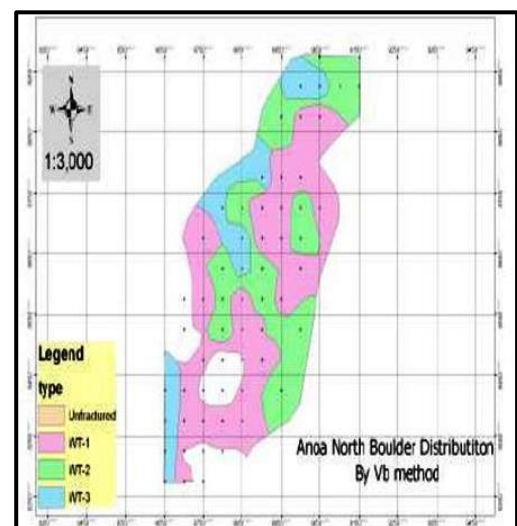


Figure 6. Distribution of boulder based on block volume at area X.

Based on the classification of Palmstrom [3], the measurement of the volume of blocks of rocks area X dominant large boulder ($0.2 - 10 \text{ m}^3$) by 60% (Figure 7). Other sizes are also found namely the boulder size moderate ($10 - 200 \text{ dm}^3$) of 37%. The small size of the fragments ($0.2 - 10 \text{ dm}^3$) of 2%. Boulder the size of a very large ($> 10 \text{ m}^3$) of 1%, and there is no value for the fragment size is very small ($10 - 200 \text{ cm}^3$) (Table 4).

The Type of Rock Fragments Area Y

Measurements conducted in boulder on area Y expose ore locations. At these locations, there are blocks of moderate size (± 900 mm) than the block located on area Z. Relatively hard material properties which cause difficulties in the mining process. Boulder is measuring location based on previous drill point. Drill point spread from the West to the East. Measurements made include length, width, and height boulder. Based on the results of measurements there are 25 drilling points sized boulder of 51 drill point. Boulder dimensional data obtained from 25 drill point is 122 boulders.

Table 4. The data of block volume calculation area X.

Locations	Block volume		%
Area - X	Very Small	10- 200 cm ³	0%
	Small	0.2 - 10 dm ³	2%
	Moderate	10- 200 dm ³	37%
	Large	0.2 - 10 m ³	60%
	Very Large	> 10 m ³	1%

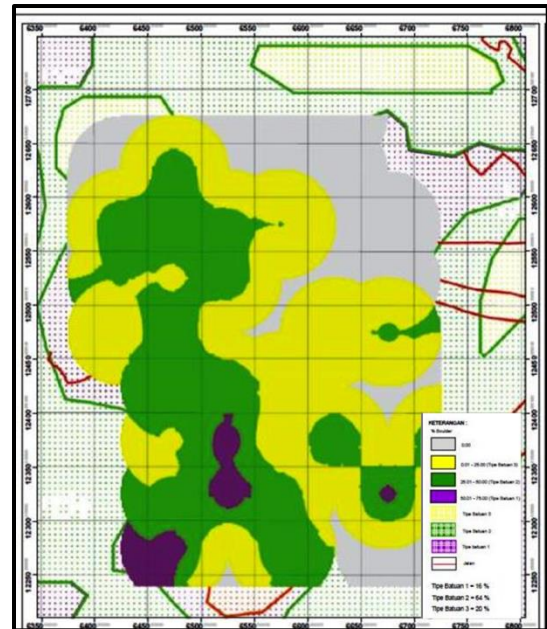


Figure 8. Zoning map of boulder at area Y

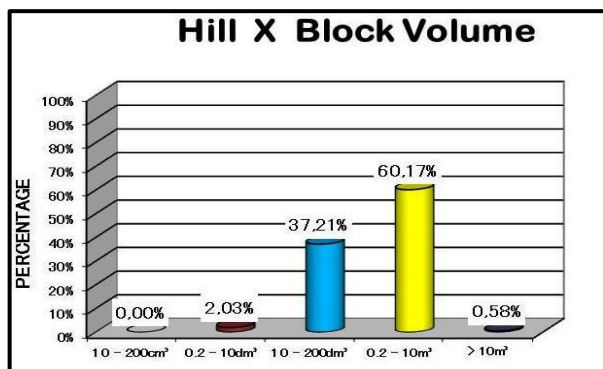


Figure 7. Domination of large volume blocks that include rock type 1

A total of 122 data processed using RQD method to determine the type of rock fragments. Data processing results obtained percentage RQD values based on the data volume of the block. At area Y is dominated by rock type 2 by 64%. The other type was also obtained in the form of rock type 1 by 16% and rock types - 3 by 20% (Figure 8).

When compared with the data acquisition RQD of core samples, obtained different results. RQD value based on data from core samples is dominated by rock type 1 by 54%. Another type that found only rock type 2 by 46%. Type 1 without fracture rock and rock type 3 no value (Table 5).

Table 5. The The comparison sample data RQD core value and block volume, boulder on the Hill Y

Type	RQD	% RQD	
		Sampel core	Block volume
Unracted	75-100%	0%	0%
WT 1	50-75%	54%	16%
WT 2	25-50%	46%	64%
WT 3	< 25%	0%	20%

Obtaining RQD value of the data processing through the beam and sample volume are very different cores. The difference is caused by differences in data collection. Collecting data in the form of measurement location, measurement, and formulas used. Boulder measured starting at the saprolite zone. The measurements were carried out horizontally on the surface, which covers the length, width, and height boulder. Dimensions is a calculation of the percentage volume parameter boulder. While the core samples, measuring only boulder on bedrock layer only. The measurements were carried out vertically downwards. Calculations using formula calculation core sample length. The second result of data analysis above can be seen on a map of acquisition RQD based on core samples (Figure 9) and map the acquisition RQD of block volume (Figure 10).

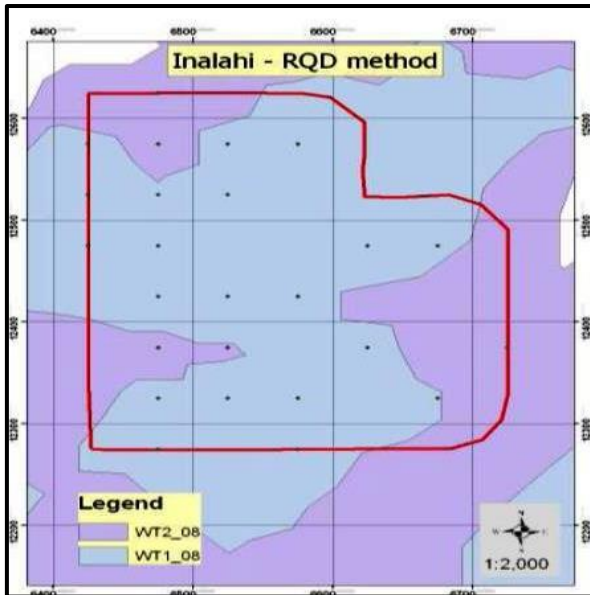


Figure 9. Distribution of boulder based on core sampling at area Y.

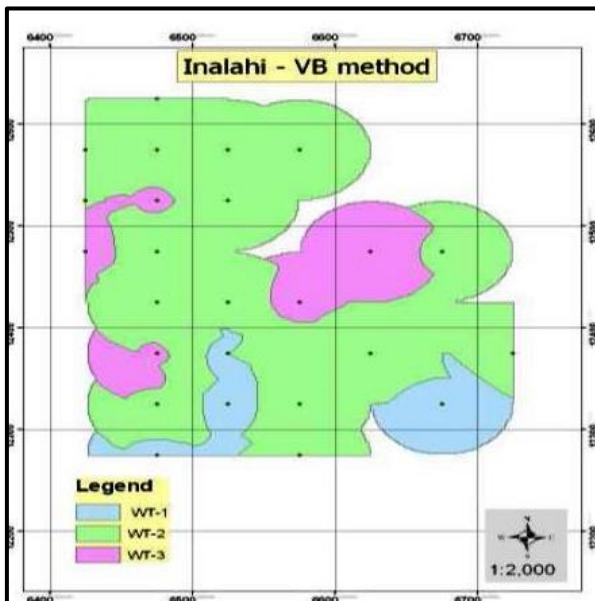


Figure 10. Distribution of boulder based on block volume at area Y

Based on the Palmstrom classification [3], the measurement of the volume of blocks of rocks area Y dominant moderate size ($10 - 200 \text{ dm}^3$) by 56%. Another measure is found only boulder size ($0.2 - 10 \text{ m}^3$) by 44%, while the size is very large ($> 10 \text{ m}^3$), small ($0.2 - 10 \text{ dm}^3$), and very small ($10 - 200 \text{ cm}^3$) there is no value (Table 6). That moderate block volume included in rock type 2 whole large block volume includes of rock type 1 (Figure 11).

Table 6. The data of block volume calculation area Y

Location	Block Volume		%
Area Y	Very small	$10 - 200 \text{ cm}^3$	0.00%
	small	$0.2 - 10 \text{ dm}^3$	0.00%
	moderate	$10 - 200 \text{ dm}^3$	55.83%
	large	$0.2 - 10 \text{ m}^3$	44.17%
	Very large	$> 10 \text{ m}^3$	0.00%

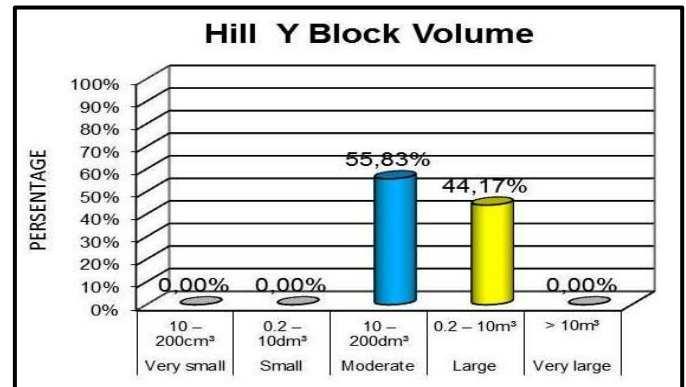


Figure 11. Moderate block volume included in rock type 2 whole large volume block included in rock type 1.

The Type of Rock Fragments Area Z

Measurement of boulder on area Z done on location mined out. At these locations, there are blocks of relatively small size ($\pm 500 \text{ mm}$) of gravel that are at area Y. Relatively hard material properties which cause difficulties in mining. Boulder is measuring location based on previous drill point. Drill point spread from the West to the East. Measurements made include length, width, and height boulder. Based on the results of measurements there are 22 drilling points sized boulder of 70 drill point. Boulder dimensional data obtained from 22 drilling point is 182 boulders.

A total of 182 data processed using RQD method to determine the type of rock fragments. Data processing results obtained percentage RQD values based on the data volume of the block. On the Hill Z is dominated by rock type 3 by 67%. The other type was also obtained in the form of rock type 1 by 4% and rock type 2 by 29% (Figure 12). When compared with the data acquisition RQD of core samples, obtained by rock type 2 some 83%. Another type that found only rock type 3 some 17%. Type 1 without fracture rock and rock type 1 no value (Table 7).

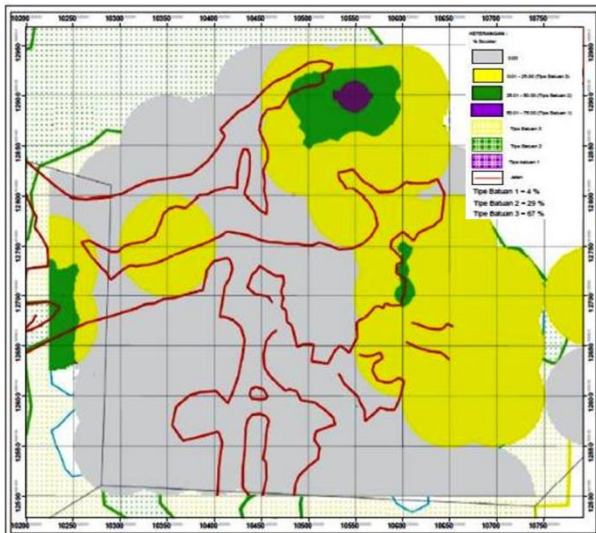


Figure 12. Zoning map of boulder at area Z

Table 7. Results of the comparison sample data RQD core sample and block volume on area Z

Type	RQD	% RQD	
		Core Sample	Block Volume
unfractured	75 - 100%	0%	0%
WT 1	50 - 75%	0%	4%
WT 2	25 - 50%	83%	29%
WT 3	< 25%	17%	67%

The measurement of the volume of blocks of rocks area Z retrieved predominant boulder size moderate-sized (10 - 200 m³) as much as 86%. Another measure that is found is the fragment size small (0.2 - 10 dm³) for 8%. Large boulder (0.2 - 10 m³) as much as 6%, while for very large sizes (> 10 m³) and very small (10 - 200 cm³) no value (Table 8). In the area Z only moderate block volume a significant and included in this type of rock unfractured (Figure 13).

The distribution of Rock Fragment the West Block

Study of dispersion type rock fragments with the RQD method and calculation of the block size to determine the volume block, on all three areas showed a significant difference.

Table 8. Results of calculation block volume on area Z

Location	Block volume		%
Area Z	Very small	10 - 200 cm ³	0 %
	small	0.2 - 10 dm ³	8%
	moderate	10 - 200 dm ³	86%
	large	0.2 - 10 m ³	6%
	Very large	> 10 m ³	0%

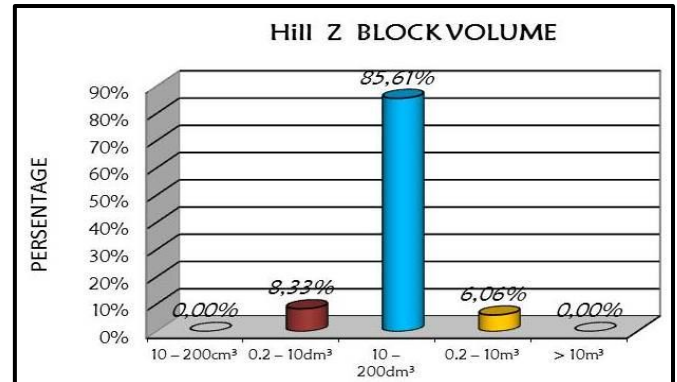


Figure 13. Moderate block volume classified into rock types unfractured

The RQD value on the area X, gained the most in the form of boulder type 1 (50-75%) of 35% and the size of a large volume of classified rocks blocks (0.2 - 10 m³) by as much as 60%. In the area of the Y values obtained RQD dominated type of boulder type 2 (25 - 50%) amounted to 64%, while the volume size of blocks of rocks including moderate (10 - 200 dm³) as much as 56%. RQD value of area Z dominated type of boulder type 3 (25%) of < 67%, while the volume Block of rocks including moderate (10-200 dm³) as much as 86%. In the third area, block size calculation is different and the percentage spread of boulder is not evenly distributed. This is interpreted is affected by the difference of the topography of the area on the third. A large boulder spread on the steep topography, is caused due to the lack of absorption of rainwater. On a steep slope, rainwater will flow to lower areas so that weathering processes which occur more and more small anyway. On the topography of the moderate or small-sized boulder ramps, due to the influence the absorption of rainwater into the rock more and more, so that any physical weathering and erosion.

CONCLUSION

Based on the results of the calculation approach to research and RQD on a boulder the size of laterite nickel mine, concluded that:

1. There are two types of rock block sizes which are common in the field, that is moderate-size (37,21% - 85,61%) and large size (44,17% - 60,17%).
2. Spread the type of blocks of rocks that compares the methods of mapping data on the surface of RQD and RQD method on core samples indicate the presence of a difference because the procedure of measurement and calculation.
3. The data obtained using RQD method on a surface mapping describes the actual conditions on the ground at the mine site is currently active so the result is also more accurate (3D). While the RQD method on a core sample showed only a bedrock, from the results below the surface (2D).

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