

Comparison Of Quarry Resource Estimation Using Cross Section And Contour Methods At PT. X, East Java, Indonesia

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ABSTRAK

PT X, yang berlokasi di Pasuruan, Jawa Timur, telah melakukan eksplorasi sirtu (pasir dan kerikil) di wilayah Izin Usaha Pertambangan (IUP) seluas 12,12 hektar. Penelitian ini bertujuan untuk mengestimasi kualitas dan kuantitas sirtu menggunakan dua metode, yaitu Cross Section dan Contour. Hasil estimasi menunjukkan bahwa volume tanah pucuk yang diperoleh melalui metode Cross Section adalah 428.253 m³, sedangkan metode Contour menghasilkan volume yang sedikit lebih rendah, yaitu 417.964 m³. Untuk volume lumpur, metode Cross Section memperkirakan volume sebesar 7.404.289 m³, sedangkan metode Contour memberikan estimasi yang lebih tinggi, yaitu 7.579.433 m³. Perbedaan hasil estimasi antara kedua metode ini disebabkan oleh jarak antar sayatan yang digunakan dalam pengukuran serta perbedaan pendekatan metodologis. Total selisih volume yang diperoleh dari kedua metode tersebut adalah sebesar 175.144 m³. Studi ini memberikan wawasan penting mengenai potensi sumber daya lumpur di wilayah IUP ASA dan menunjukkan bagaimana berbagai metode dapat memengaruhi hasil estimasi. Dengan informasi ini, diharapkan perusahaan dapat membuat keputusan yang lebih baik dalam pengelolaan dan pemanfaatan sumber daya lumpur yang ada. Penelitian ini juga menekankan pentingnya pemilihan metode yang tepat dalam eksplorasi sumber daya alam untuk mendapatkan estimasi yang akurat dan andal.

Kata Kunci: Penampang dan Kontur, Estimasi Sumber Daya, IUP Eksplorasi, Geolistrik

ABSTRACT

PT X, located in Pasuruan, East Java, has been exploring for sirtu (sand and gravel) in a Mining Business License (IUP) area of 12.12 hectares. This study aims to estimate the quality and quantity of sirtu using two methods, namely Cross Section and Contour. The estimation results show that the volume of top soil obtained through the Cross Section method is 428,253 m³, while the Contour method produces a slightly lower volume of 417,964 m³. For the sludge volume, the Cross Section method estimated a volume of 7,404,289 m³, while the Contour method gave a higher estimate of 7,579,433 m³. The difference in estimation results between the two methods is due to the distance between the incisions used in the measurements as well as differences in the methodological approach. The total difference in volume obtained from the two methods amounted to 175,144 m³. This study provides important insights into the potential sludge resources in the ASA IUP area and shows how different methods can affect the estimation results. With this information, it is hoped that the company can make better decisions in the management and utilization of existing sludge resources. This research also emphasizes the importance of choosing the right method in natural resource exploration to obtain accurate and reliable estimates.

Keywords: Cross-section and Contour, Resource Estimation, Exploration IUP, Geoelectricity

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INTRODUCTION

Indonesia is one of the developing countries that is rich with the potential of its natural resources. There is a lot of unexplored potential that can be utilized for the benefit of many people. Along with the times, physical development such as industrial and housing development continues to increase. As is the

case with one of the potential rock mineral excavation materials in the Wonosunyo Village area, Gempol District and Sukoreno Village, Prigen District, Pasuruan Regency, East Java Province is sirtu.

PT. X is one of the companies in Indonesia engaged in the mining of sirtu minerals. located in Wonosunyo Village, Gempol District and Sukoreno Village, Prigen District, Pasuruan Regency, East Java Province with a total Mining Business License (IUP) area of 12.21 Ha. Resource calculation is needed by PT. X with the aim of knowing the amount of potential resources at the location being worked on. The search for sirtu research areas requires various scientific disciplines, including geological science which is always used in exploration activities and mining science to process sirtu reserve resource data. PT. X as a research site, is one of the sirtu rock mining companies that is currently still exploring located in Pasuruan Regency. Exploration activities continue to be carried out in this research area is a geophysical exploration that will use geolistic methods. The geoelectric method is carried out with the aim of obtaining rock lithology to be used as a reference in estimating sirtu resources.

Resource estimation is intended to estimate the amount of quality or amount of excavated material deposits that will be mined. As in the case of PT. X will calculate the estimated sirtu resources in the exploration IUP. In resource calculation activities, it is necessary to require data on the layering of mineral deposits below the surface, the data is obtained by means of subsurface mapping or geological mapping surveys to determine the shape, distribution and location of mineral deposits.

Sirtu resource estimation is an important project work and a big responsibility in evaluating mining projects. The benefits of resource calculation are that it provides the quantity and quality of a deposit, provides an estimate of the three-dimensional shape of the deposit of minerals, the quantity of resources determines the life of the mine and the limits of mining activities are made based on the amount of resources. In Indonesia, in determining mineral resources and reserves following the reference of the Indonesian National Standard, namely SNI 4726 of 2019 concerning guidelines for reporting mineral resources and reserves, it is emphasized that the clarification of resources is divided into three parts, namely proven resources, indicated resources and measured resources. Each is distinguished based on the level of geological confidence. In determining the amount of sirtu resources at PT. X.

One way to calculate resources is the Cross Section and Contour method with the consideration that this method is appropriate for use in estimating rock excavation resources, especially excavation materials that have a high level of continuity and are homogeneous, so in this study the authors estimated resources using the Cross Section and Contour method with the guidelines for gradual change (rule of gradual change). Where this method has equations, namely the mean area and frustum equations. This method is used to obtain data on the quantity (tonnage) of sludge resources.

The resource estimation method using cross section has been used by several researchers such as, estimation of rock sand resources using cross section method in Bantarbolang District, Pemalang Regency, Central Java. Budi Purnoko, resource estimation using cross section method at the mining location of Sungai Piyuh District, Mempawah Regency and Muhamad Siswanto, 2014, resource estimation of andesite PT Radian Delta Wijaya in Sadu Village, Soreang District, Bandung Regency, West

Java). Therefore, it is necessary to estimate the right and efficient resources and the results that are closest to the actual so that later the company can be used as a reference in mining activities. From the analysis of these problems, this research will focus on how the geological conditions at PT. X, how the distribution of sirtu excavation material at PT. X, determining a more accurate method for sirtu estimation results at PT. X, and how the classification weight of sirtu resources at PT. X.

METHODOLOGY

In this research, the author employs both quantitative and qualitative research methods, focusing on the estimation of sand and gravel resources at PT. X, located in Wonosunyo Village, Gempol District, and Sukoreno Village, Prigen District, Pasuruan Regency, East Java Province. The research implementation begins with a literature review to gather relevant information from various sources, including previous reports and research journals. Data collection involves both primary and secondary data; primary data is obtained directly from field measurements, encompassing geological information such as topographic conditions, geological structures, and lithology, while secondary data is sourced from company reports that include topographic maps and geoelectric survey data [17]. Once the data is collected, data processing is conducted to generate the necessary information. This process includes creating topographic maps using spreadsheet software and ArcGIS, developing cross-sections based on the topographic maps, and calculating the area and volume of resources using appropriate formulas. Data analysis is performed by calculating the resource volume for each block based on optimal cross-section distances, thereby providing an accurate estimation of the sand and gravel resource potential at the research site. This research methodology is designed to offer a comprehensive overview of the sand and gravel resources available at PT. X. To calculate the volume of excavated materials, two main methods are used, namely Mean Area and Frustum, with the following explanation:

a. Mean Area Method

Used to calculate the volume by assuming two consecutive cross-sections and the average area multiplied by the distance between the cross-sections.

b. Frustum Method (3D Trapezoid)

This method is more accurate because it calculates the volume based on the geometric shape of the frustum or truncated cone section.

Surpac 6.6.2 software is used to print topography and estimate resource volume, with the following steps:

1. Data Input. Entering coordinate and elevation point data from GPS survey results into the Surpac module.
2. Cross-section Creation. Using the cross-section feature to create vertical sections based on the distribution pattern of drill/test trench data.
3. Lithology Modeling. Merging field data (outcrops/test trenches) to build a 3D lithology model.

4. Volume Estimation. Using the volume calculation feature on a specific geological block or domain based on geometric volume methods such as Frustum.

c. Geoelectric Data Processing (Schlumberger Configuration)

Resistivity data measurement is carried out using the Schlumberger configuration geoelectric method, and the measurement results in the form of resistance values are converted into apparent resistivity values using the following formula:

Apparent resistivity formula (apparent resistivity) :

- a. Resistivity calculation spasi 1 dan 2

$$\rho_a = \frac{V}{I} \times K$$

Where:

ρ_a = Resistance pseudo type (Ohm Meter)

V = Potential Difference Volts

I = Power Current (mA)

K = Geometry

RESULTS AND DISCUSSIONS

Geological Condition Investigation

Geological investigation is carried out to find out the geological conditions that occur at this time, besides that in conducting a series of geological investigations can also pay attention to the height and lowest point at the research location. Geological study itself includes several aspects, namely topography, geomorphology, geological structure, lithology and stratigraphy of the research location.

1. Topography of the Research Area

The research area of PT. X features a low hilltopography, with the highest elevation reaching 325 meters and the lowest at 200 meters. The average thickness of the soil cover layer is less than 0.746 meters.



Figure 1. Topography Map

2. Geomorphology of the Research Area

The morphology of the area includes gently sloping hills with a slope gradient of 5-15%. The rocks in this region are volcanic in origin, derived from the Penanggungan Volcano, consisting of laharic breccia and tuff.

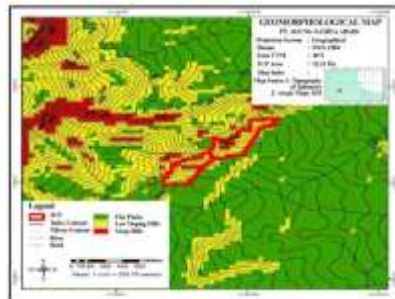


Figure 2. Geomorphology Map

3. Geology of the Research Area

The geological structure of the area does not exhibit active features such as faults or folds. The stratigraphy is primarily composed of volcanic rocks dating from the early to mid-Pleistocene.

4. Stratigraphy and Lithology at the Research Location

The lithology in the research area includes volcanic rocks, characterized by various types such as tuff and breccia. The stratigraphic layers reflect the volcanic activity of the region, with significant variations in composition and thickness.



Figure 3. Geological map of the study area

The stratigraphic column of the study area can be seen in Figure 4 below.

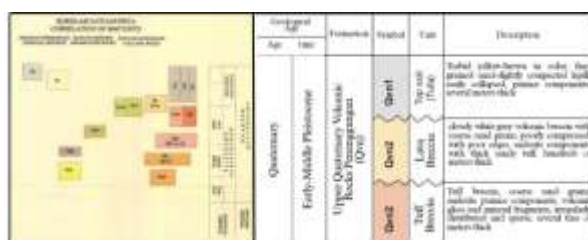


Figure 4. Stratigraphic Column of the Study Area

5. Groundwater Surface Survey

The groundwater surface survey indicates an average depth of the water table at approximately 70 meters for residential wells and up to 100 meters for agricultural fields. Measurements were conducted manually to determine the depth of water in the wells.

Distribution of Breccia Mining Materials at the Research Location

This section discusses the distribution of breccia mining materials at the PT. X site. The research utilized two primary methods: test pits and geoelectric measurements. The findings indicate the presence of three distinct rock layers: Top Soil (0 - 0.39 m), Tuff (0.39 - 1.22 m), and Breccia (1.22 - 3 m). The analysis of resistivity data from geoelectric measurements revealed the characteristics of these layers, contributing to the understanding of the geological conditions and the potential for breccia extraction in the area.

The test pit measurements conducted at the PT. X site revealed three distinct layers of gravel rock at a depth of 3 meters, with a trench size of 1.5 m in width and a length of approximately 40 m, excavated at an 80° angle using an excavator for accessibility. The first layer consists of top soil mixed with tuff, ranging from 0 to 0.39 meters. The second layer is composed of tuff, found between 0.39 and 1.22 meters. The third layer is breccia interspersed with small gravel, extending from 1.22 to 3 meters. The characteristics of the rocks indicate that the top soil contains fine and coarse particles (0.05-0.25 mm) with a rounded shape and a yellow-brown color, while the breccia has angular particles (0.08-2 mm) in yellowish-brown to white hues, and the tuff consists of fine and coarse particles (0.05-0.08 mm) that are grayish-white in color. The model and sampling of test trenches in the research area located at GL_01 geoelectric point of PT. X can be seen in Figure 5 and Figure 6 as follows.

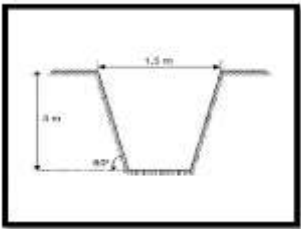


Figure 5. Test trench model

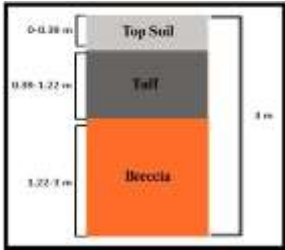


Figure 6. Sampling test trenches

The process of making trenches with heavy equipment and outcropping documentation of the sampling activities of the test trench at point GL_01 geoelectric as follows:



Figure 7. Documentation of making test trenches with heavy equipment



Figure 8. Documentation of test trench outcrops



Figure 9. Documentation of outcrops in the study area



Figure 10. Documentation of outcrops in the study area

The sampling map of the test trench at the GL_01 geoelectric point of PT. X is as follows:



Figure 11. Test Trench Sampling Map

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1. Geoelectric Method

The geoelectric method employed in the research at PT. X involved conducting surveys at six strategically selected points, with varying distances between them. This approach aimed to obtain resistivity values up to a depth of 100 meters across the exploration area. The primary goal was to identify the types of mineral layers present, their thickness, and the groundwater table's depth.

The survey utilized the Schlumberger configuration, a common technique in geoelectric studies, allows for vertical sounding to assess subsurface resistivity distribution. This method involves arranging electrodes in a straight line, with one pair used for current injection and the other for measuring potential difference.

The results from the geoelectric measurements provided insights into the lithological layers and their distribution, which are crucial for understanding the potential for mineral extraction in the area. The resistivity data were correlated across the survey points to create a comprehensive picture of the subsurface geology. This correlation helps in identifying the thickness and extent of the mineral deposits, as well as the presence of groundwater.

2. ~~5.2.4~~ Geoelectric Measurement Results Data

The measurement results can be explained in (table 1) and (Appendix I), the table of measurement results describes the span of the electrode, the potential difference and the electric current flowing through the stretch of electrodes at the measurement point. The results of the geoelectric data measurement of the schlumberger configuration obtained measurement results of 19 measurement spaces with varying accuracy of voltage readings, voltage readings per-1 meter in spaces 1 to space 10, and then space 15 to space 55 voltage per-5 meters.

Table 1. Schlumberger configuration geoelectric measurement results

(a) spasi	AB/2	MN	V	I
1	2.5	1	0.559	76.2
2	3	1	139.9	59.1
3	4	1	107.2	60.3
4	5	1	40.1	34.2
5	6	1	31.6	34.1
6	8	1	34.7	53.1
7	10	1	20.3	49.3
8	10	4	69.8	49.2
9	12	4	46.3	43.5
10	16	4	30.5	45.8
15	20	4	18.6	45.1
20	25	4	14.1	55.8
25	30	4	11.1	57.4
30	40	4	5.1	32.5
35	40	16	12.1	31.8
40	50	16	22.5	73.2
45	60	16	22.6	86.2
50	80	16	11.2	52.6
55	100	16	10.8	57.9

4.3. Data Processing in Geoelectricity

The results of this data processing are presented in Table 5.4 and Appendix J, which include essential information such as the spacing (a), the length of the potential electrode span (AB/2), the length

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of the current electrode span (MN), the potential difference (V), the electric current (I), the geometric factor (K), and the apparent resistivity value (Pa). This data provides a comprehensive overview of the geological conditions at the research site.

To illustrate the calculations, the resistivity values were computed for two measurement spacings, namely spacing 1 and spacing 2. For spacing 1, the resistivity was calculated using the formula $P_a = V/I \times K$, resulting in a value of 0.13828 ohms. In contrast, for spacing 2, the same formula yielded a resistivity value of 65.071 ohms. These calculations indicate a significant difference in the apparent resistivity of the subsurface materials between the two spacings, which can be interpreted to understand the geological characteristics of the area. The results are vital for assessing the potential mineral resources present beneath the surface.

2.4. Interpretation of Geoelectric Data

The interpretation of geoelectric measurement data was conducted using the applied software "IP2Win Resistivity Sounding" to determine the actual resistivity values. The interpretation results for GL_01 revealed six layers of resistivity readings, each representing different rock types at the research site. The analysis indicated that the top layer (0-1.22 meters) consists of topsoil interspersed with tuff, while the middle layer (1.22-67.4 meters) is identified as breccia interspersed with tuff, and the bottom layer (67.4-100 meters) is breccia combined with tuff.

The resistivity values obtained from the interpretation indicate that breccia has a resistivity range of 75-200 ohm-m, with significant breccia presence at depths of 1.22-67.64 meters below the surface. The lithological log, derived from geological mapping of the Malang area, suggests that the rock formations in the study area belong to the Qvn formation, consisting of volcanic breccia, lava, tuff, breccia tuff, agglomerate, and lahar. This log can be utilized to estimate the thickness of the gravel layers beneath the surface, aiding in the assessment of gravel resource potential.

Additionally, a correlation profile was created to provide a clearer understanding of the geological conditions beneath the Earth's surface. The lithological logs indicated four distinct layers: topsoil, tuff, breccia, and breccia tuff, with the thickest layer being breccia at 56.46 meters. The geoelectric measurements were conducted using the Schlumberger configuration with the ARES Multielectrode system, which injects current into the ground to measure potential differences. The data collected, including electric current (I), potential difference (V), and electrode spacing, were processed to determine both apparent and true resistivity values.

3.5. Geoelectric Data Processing

The processing of geoelectric data was conducted to determine the apparent resistivity (ρ_a , apparent) of subsurface materials. This was achieved through calculations using the resistivity formula (Equation 3.1), which yielded values for the apparent resistivity of the geological formations. The results of this data processing are presented in Table 5.4 and Appendix J, which includes parameters such as electrode spacing (a), half the length of the potential electrode (AB/2), the length of the current electrode (MN), potential difference (V in volts), current (I in amperes), geometric factor (K), and the apparent

resistivity value (Pa). An example of the calculation for the measurement data at point LG_01 for spacings 1 and 2 is also provided.

Resistivity calculation spasi 1 dan 2

$$Pa = \frac{0.559}{76.2} \times 18.85 = 0.13828 \text{ ohms}$$

$$Pa = \frac{139.9}{59.1} \times 27.489 = 65.071 \text{ ohms}$$

The calculated value is the value of the apparent resistivity of the rock, at spacing 1 and spacing 2 , from manual calculations using the resistivity equation.

Table 2 Results of Geoelectric Data Processing GL_01

(a) spasi	AB/2	MN	V	I	K	Ro_a
1	2.5	1	0.559	76.2	18.85	0.13828
2	3	1	139.9	59.1	27.489	65.071
3	4	1	107.2	60.3	49.48	87.965
4	5	1	40.1	34.2	77.754	91.168
5	6	1	31.6	34.1	112.31	104.08
6	8	1	34.7	53.1	200.28	130.88
7	10	1	20.3	49.3	313.37	129.04
8	10	4	69.8	49.2	75.398	106.97
9	12	4	46.3	43.5	109.96	117.03
10	16	4	30.5	45.8	197.92	131.8
15	20	4	18.6	45.1	311.02	128.27
20	25	4	14.1	55.8	487.73	123.24
25	30	4	11.1	57.4	703.72	136.08
30	40	4	5.1	32.5	1253	196.7
35	40	16	12.1	31.8	301.59	114.76
40	50	16	22.5	73.2	478.31	147.02
45	60	16	22.6	86.2	694.29	182.03
50	80	16	11.2	52.6	1244	264.9
55	100	16	10.8	57.9	1951	363.9

Volume Results and Resource Clarification Using Cross Section Method and Contour Method

1. Classification Resource Sirtu on Site Study

Exploration conducted by PT. X in Wonosunyo Village, Gempol District, and Sukoreno Village, Prigen District, Pasuruan Regency, East Java Province, covers an exploration IUP area of 12.12 Ha. The exploration methods used consist of direct and indirect exploration.

Data from the geoelectric survey, conducted at 6 points with varying distances between points, were used as a reference for resource classification. The distances between geoelectric points are as follows: GL_01 to GL_02 (90.99 m), GL_02 to GL_03 (85.99 m), GL_03 to GL_04 (100 m), GL_04 to GL_05 (100 m), and GL_05 to GL_06 (85.99 m). With a distance between points of no more than 100 meters, the resource classification in this study is included in the measured resource category, which is used to create a resource estimation model. The geoelectric data interpretation map can be seen in Figure 12.

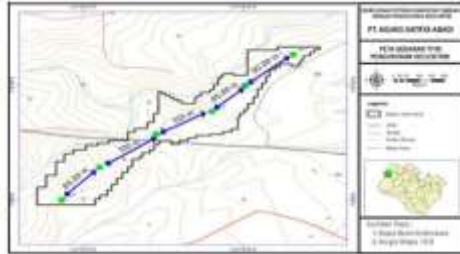


Figure 12. Map of Distances Between Geoelectric Data Points at the Research Location.

2. Classification Volume Calculation Resource Measurable With Cross Section Method and Method Contour

A. Subsurface Lithology Modeling

The purpose of subsurface lithology modeling is to determine the distribution, thickness and direction of lithology in 3 dimensions. This can be done using the help of Surpac 6.6.2 software. With subsurface lithology modeling, it will then become the basic material for data processing and calculating the volume of sirtu resources (estimated targets). The data needed to create geological modeling are topographic contours, geoelectric data in the form of collar data, surveys and lithology. The following is a measured resource modeling.

1) Modeling Measurable Resources

In the modeling of measured resources, it is based on the correlation of survey data. geoelectric, so that model measurable resources covers the entire exploration IUP area of PT. X. The measured resource model is made with the upper limit of the topographic contour and the lower limit of the lithological thickness based on the modeling results of the geoelectric correlation data. Related to the measured resource model, it can be seen in Figure 13 below.

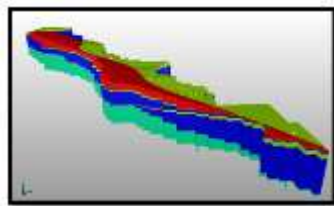


Figure 13. Scalable Resource Models

B. Resource Estimation

Mineral resources are mineral deposits located beneath the earth's surface that can be utilized for certain needs. Resource estimation is carried out at the PT. X Exploration IUP location with the aim of knowing the amount or value of the sirtu resources at the research location. The method used to calculate the sirtu resource estimation at the research location is the method Cross Section and i contour method. Cross Section Method i was chosen because the application of this method is relatively simple, easy to understand and quite accurate. While the contour method has a very

accurate level of accuracy but is not suitable for use on discontinuous deposits. The Cross Section method and the contour method are appropriate for use on sirtu deposits, especially in this research location, because sirtu deposits are classified as simple geometry and also have a high level of homogeneity.

1) Estimation of Resources Using Cross Section Method

The application of the method calculation of resources using the Cross Section method, the incision is made cutting perpendicular to the topographic contour with i distance between incisions that have been determined as wide as the area boundary with reference to the outermost boundary of the exploration IUP as the resource boundary.

The calculation results of the area of each cross-sectional section are carried out using Surpac 6.6.2 software to calculate the volume of sirtu resources using the Mean Area and Frustum formulas. The Cross Section method is applied with the Rule of Gradual Change guidelines, because the dimensions of the cross-sectional sections are not always constant. By connecting sufficient cross-sectional sections, the estimated volume of resources can be obtained from two cross-sectional sections. The next step is to calculate the estimated sirtu resources using the Cross Section method with the application of the gradual change guidelines and the formulas mentioned.

a) Making an incision

Make a cross-sectional section on the i topographic contour i of the research area with i exploration IUP limits and i radius limits. applied as a resource boundary. The cross-sectional section is made in a way vertical cut contour topography with using the help of Surpac 6.6.2 software. The distance between the incisions cross-section with a distance of 25 meters then 33 sections were obtained on the measured resources

b) Calculate the area of each container

After making the cross-sectional section, the next step is to calculate the cross-sectional area using the help of Surpac 6.6.2 software and calculate the ratio of the two cross-sectional areas as a whole, this is done in order to find out the volume formula that will be applied. The comparison result if between two cylindrical cross-sections or $(L1/L2)$ produces a value greater than 0.5, then the formula applied is the Mean Area formula and if i is shaped like a truncated cone or $(L1/L2)$ produces a value less than 0.5, then the formula used is the Frustum formula. Based on the comparison results between the two cross-sectional areas that can be seen in table 2

c) Calculation of Sirtu Resource Volume

Calculation of the volume of gravel resources is done by adding up the results of the volume calculation of each cross-section whose value is already known with i using the Mean Area and Frustum formula

d) Volume End of the gravel resource using the Cross Section method

The calculation of resources is carried out with the aim of determining the total volume of the resources of the gravel deposits that can be increased to the next stage. The main stage in estimating gravel resources is to create a geological model of the gravel deposits using geoelectric survey data references obtained from the exploration study of PT. X. In this study, the Cross Section method is applied in calculating the estimation of gravel resources.

2) Estimation of Resources Using Contour Method

The contour method with the gradual change guideline (Rule Of Gradual Change) is the reference of the Cross Section method because this method better describes the original condition of the topography of the research area. The difference is also due to the existence of a surface between two contours that is closer to reality when compared with between two cross sections. The next step in calculating the estimation of sirtu resources using the Cross Section method with the application of gradual change guideline using the Mean Area and Frustum formula equations are as follows:

a) Delineation of the line limit resource

Drawing of the boundary line of the area influences the contour method with a distance between the contour elevations, namely equal to 1 meters. The highest contour calculated in the research area is at an altitude of 325 meters above sea level, while the lowest contour calculated in the research area is at an altitude of 219 meters above sea level with a distance between the elevations of 1 meter at the measured resource.

b) Calculating the area of resources

After determining the distance between contours, the next step is to calculate the area between contours using the help of Surpac 6.6.2 software and calculate the ratio of the two areas between contours as a whole, this is done in order to find out the volume formula that will be applied. The comparison result if between contour i or $(L1/L2)$ produces a value greater than 0.5, then the formula applied is Mean Area formula and if it is shaped like a truncated cone or $(L1/L2)$ produces a value less than 0.5, then the formula used is Frustum formula. Based on the comparison result between the two areas between the contours that can be seen in table 5.7.

c) Calculation of Sirtu Resource Volume

Calculation of the volume of gravel resources is carried out by adding up the results of the volume calculations from each incision between the contours whose values are already known using the Mean Area and Frustum formulas.

d) Volume End of the gravel resource using the contour method

The calculation of resources is carried out to determine the total volume of resources of sirtu mining deposits that can be increased to the next stage. Sirtu mining deposits using geoelectric survey data references obtained from PT. X's exploration study. In this study, the contour method is applied in calculating the estimation of sirtu resources.

3) Cross Section Method

Cross Section method uses a vertical cross section/ cross section cutting the topography perpendicularly obtained from the section section of the structure of each deposit of mining material that is below surface. In this study, the cross section method was made vertically with a distance between sections of 25 meters, so that 33 sections were obtained on the measured resource. After each cross-sectional area is known, then calculate manually using Microsoft Excel software using a predetermined formula to obtain the value of the volume of the resource. The following is a map of the measured resource section path that can be seen in Figure 14 below.



Figure 14. Map of Measured Resources Section

4) Contour Method

The contour method uses a horizontal cross-section according to the topographic conditions obtained. In this study, the contour method was made horizontally following the existing contour with a distance of 1 meter between elevations, the layers contained can be seen from the results of the geoelectric survey so that they can be said to be measurable resources. After each area between the contours is known, then calculate manually using Microsoft Excel software using a predetermined formula to obtain the value of the resource volume. The following is a contour map with an elevation of 1 meter which can be seen in Figure 12 below.

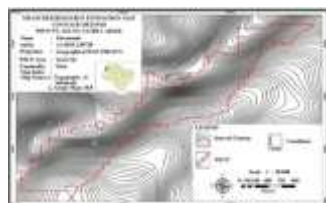


Figure 15. 1 meter Elevation Contour Map

With the known area of each cross-section and cross-section trajectory, the volume of the resource at the research location is calculated using the Cross Section method and contour with application of the gradual change guideline using Mean Area and Frustum formula equations. Thus, the results of the calculation of the measured resources from the section 1-1 to 33-33' to obtain the volume results require two cross-section areas/two cross-section sections. The following are the results

of the calculation of the volume of breccia resources of one of the lithologies of the research location in the classification of measured resources using the Cross Section method with the application of the gradual change guideline from section 1-1.

- a. Calculation of the *Mean Area equation* for cross-sections 1 -1' and 2-2' of breccia rock.

$$V = 25 \times \frac{4.336 + 4.351}{2}$$

$$V = 108.596 \text{ m}^3.$$

- b. Calculation of the *Frustum equation* on the 4-4' and 5-5' cross-sections of breccia rock.

$$V = \frac{25}{3} (1.591 + 8.554 + \sqrt{1.591 + 8.554})$$

$$V = 115.280 \text{ m}^3.$$

The volume results of the measured resource classification of breccia lithology using the Cross Section method are 3,219,883 . m³ . The following are the results of calculating the volume of breccia resources of one of the lithologies of the research location in the classification of measured resources using the contour method with the application of gradual change guidelines from elevation 220-221.

- a. Calculation of the *Mean Area equation* at elevations 220 and 221 breccia.

$$V = 1 \times \frac{12.038,87 + 19,228,52}{2}$$

$$V = 390,842 \text{ m}^3.$$

- b. Calculation of Frustum equation at elevation 219 and 220 breccia.

$$V = \frac{1}{3} (1,717,16 + 12,038,87 + \sqrt{1,717,16 + 12,038,87})$$

$$V = 6.101 \text{ m}^3.$$

Geoelectric Data Interpretation

At point GL_01 where 6 layers with different rho values were produced, the values reviewed based on the rho values have quite large rho values in the 3rd and 5th layers, but in the 1st, 2nd, 4th and 6th layers are smaller, this can be indicated that the top layer 0-1.22 meters is in the form of top soil interspersed with tuff, the middle layer 1.22-67.4 meters is indicated as breccia rock interspersed with tuff, and the bottom layer 67.4-100 meters is indicated as breccia combined with tuff.

Table 3. Geoelectric Interpretation Results GL_01

Number	Depth (m)		Resistivity (Ohm-m)	Lithology Interpretation	Thickness (m)
	Top	Base			
1	0	0.39	17739.73	Top soil	0.39
2	0.39	1.22	9.12	Tuff	0.83
3	1.22	3.2	458.73	Breksi	1.98
4	3.2	11.18	31.92	Tuff	7.98
5	11.18	67.64	830.52	Breksi	56.46
6	67.64	100	58.74	Breksi tuff	32.36

The results of the data interpretation show that the resistivity value of the breccia is 75-200 ohms, in GL_01 there is breccia at a depth of 1.22-67.64 meters below the earth's surface. The parameters for determining the lithology log are the rock formations in the research area found on the Malang geological sheet map at the research location. The rock formations in the research area are the Qvn formation, which is composed of volcanic breccia, lava, tuff, tuffaceous breccia, agglomerate and lava. The lithology log can be used to estimate the thickness of the sirtu rock layer below the surface so that the data can be used in estimating sirtu rock resources. Can be seen in (figure 16).

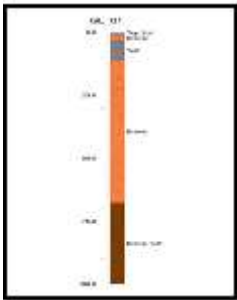


Figure 16. Lithology log GL_01

Correlation cross-sections are also made to find out the geological conditions below the earth's surface more clearly. From each lithology log shows that there are 4 layers of lithology, namely top soil, tuff, breccia, and tuff breccia where the composition of the first layer of top soil with a thickness of 0.39 meters, the second layer of tuff with a thickness of 0.83 and 7.89 meters, the third layer of breccia with a thickness of 1.98 and 56.46 meters and the fourth layer of tuff breccia with a thickness of 32.36 meters of all the rock layers that exist the thickest layer is in the breccia rock with a thickness of 56.46 meters.

Differences in Test Trench and Geoelectric Observation Results

Geological observations in this study were conducted using test trench and geoelectric methods. A 3-meter-deep test trench identified three layers: topsoil, tuff, and breccia. Meanwhile, the geoelectric method up to a depth of 100 meters found four layers: topsoil, tuff, breccia, and tuff breccia. The difference in results is due to the difference in observation depth. In conclusion, the excavation material at the location in the form of class C sirtu is not good because there are tuff inserts between the breccia.

Recapitulation of Breccia Resource Estimates

The results of the cross section method and contour method calculations can be seen in the table summarizing the results of the resource estimation below:

Table 4 Summary of Resource Estimation Results

RECAPITULATION OF RESOURCE ESTIMATION IN CROSS SECTION METHODS AND CONTOUR METHODS

METHOD	SYSTEM	VOLUME				
		BRX	BRX*TF	TF	TS	Total Segments
		(m ³)	(m ³)	(m ³)	(m ³)	(m3)
CROSS SECTION METHOD	VERTICAL SECTIONS ARE INDICATED	4,284,314	8,613,242	609,677	603,277	14,110,511
	VERTICAL SECTION INDICATED	3,490,949	6,908,959	453,861	428,253	11,282,023
	MEASURED VERTICAL SECTION	3,219,883	3,618,176	566,230	428,693	7,832,982
CONTOUR METHOD	CONTOUR INTERVAL 25m (INCEPTION)	4,678,326	7,498,013	615,937	595,595	13,387,870
	CONTOUR INTERVAL 5m (INDICATED)	3,508,406	6,972,457	432,062	424,502	11,337,427
	CONTOUR INTERVAL 1m (MEASURED)	3,281,902	3,868,276	429,255	417,964	7,997,397

Difference in Calculation Results

Difference in Calculation Results of this measured resource looking at the amount of sirtu resources, in finding the volume of sirtu resources, it can be known after the volume of resources can be reduced by the volume of the topsoil layer and the results of calculations using the cross section method and contour method are as follows:

1) Cross Section Method

The volume of the sirtu resource has been reduced by topsoil so that the volume of the sirtu resource obtained is the estimated result of the sirtu without topsoil from the results of the vertical section direction. measured at a distance of 5 meters so that the estimated result of the cross section method is 7,404,289 m³.

2) Contour Method

The volume of the sirtu resource has been reduced by topsoil so that the volume of the sirtu resource obtained is the estimated result of the sirtu without topsoil from the contour interval results with a distance of 1 meter so that the estimated result of the contour method is 7,579,433 m³.

The final result of the volume estimation using the cross section method is 7,404,289 m³, while the contour method produces 7,579,433 m³. The difference between the two methods is 175,144 m³, with the contour method giving a larger result. This difference is caused by the cross section method which assumes a linear surface along the incision distance (25 m), so if there is a high elevation between two incisions, the calculation results will be smaller. The incision distance that is too far also results in

uncalculated volume. On the other hand, the contour method uses a closer distance between contours (1 m), so it is more accurate and can represent the entire research area. Calculations are carried out from the highest to the lowest elevation, resulting in a larger volume estimate with the contour method compared to the cross section.

CONCLUSION

Geological conditions in the PT. X Exploration IUP area show the presence of four lithological layers, namely topsoil, tuff, breccia, and tuff breccia, with hill morphology converting from gentle to low hills at an altitude of between 200-325 meters above sea level. Based on geoelectric data, the distribution of sirtu mining material varies with varying thickness and lithological composition at each measurement point. Estimation of resource volume using the contour method produces a larger value (7,579,433 m³) than the cross section method (7,404,289 m³), with a difference of 175,144 m³, which is caused by differences in spatial approaches between the two methods—the contour method is more representative of elevation variations. Based on the distance between geoelectric points that does not exceed 100 meters, the estimate of sirtu resources is included in the classification of measured resources.

To support the accuracy of estimates and future exploration, it is recommended to increase the density of geoelectric measurement points and reduce the distance between latitude planes in the calculation volume.

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