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ESTIMATION OF IGNEOUS ROCK RESERVE USING GEOELECTRIC METHOD IN BIYUKU VILLAGE, BANGKO DISTRICT, JAMBI PROVINCE

ESTIMASI CADANGAN BATUAN BEKU DENGAN METODE GEOELEKTRIK DI DESA BIYUKU, KABUPATEN BANGKO, PROVINSI JAMBI

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Abstract. The earth's subsurface can be composed of various rocks such as igneous rocks, sedimentary rocks, and metamorphic rocks. Determination of rock types below the surface is carried out using geophysical methods. This study aims to identify Rhyolite-Andesite Rock using the 2D geoelectric method of the Wenner-Schlumberger configuration used in determining the initial reserves of Rhyolite-Andesite mining materials by utilizing subsurface resistivity values based on 2D and 3D resistivity cross-section analysis. The results of the petrological analysis showed that the rock was rhyolite lava rock which was interpreted to come from the Rhyolite-Andesite Volcanic Formation of the Quaternary age. Interpretation of resistivity values is divided into 2 groups, namely values <350 Ωm interpreted as weathered igneous rocks due to structure and groundwater, then values > 350 Ωm interpreted as fresh igneous rocks of quarry mining materials (rhyolite). Initial reserve estimates based on 3D resistivity model blocks with a cutoff value of > 350 Ωm interpreted as rhyolite igneous rock have reserves volume 584,595.9461 m3.

Abstrak. *Bawah permukaan bumi dapat tersusun atas berbagai batuan seperti batuan beku, batuan sedimen, dan batuan metamorf. Penentuan jenis batuan di bawah permukaan dilakukan dengan menggunakan metode geofisika. Penelitian ini bertujuan untuk mengidentifikasi Batuan Riolit-Andesit menggunakan metode geolistrik 2D konfigurasi Wenner-Schlumberger yang digunakan dalam penentuan cadangan awal bahan tambang Riolit-Andesit dengan memanfaatkan nilai resistivitas bawah*

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permukaan berdasarkan analisis penampang resistivitas 2D dan 3D. Hasil analisis petrologi menunjukkan bahwa batuan tersebut merupakan batuan lava riolit yang diinterpretasikan berasal dari Formasi Vulkanik Riolit-Andesit berumur Kuarter. Interpretasi nilai resistivitas dibagi menjadi 2 kelompok, yaitu nilai <350 Ωm yang diinterpretasikan sebagai batuan beku lapuk akibat struktur dan air tanah, kemudian nilai >350 Ωm yang diinterpretasikan sebagai batuan beku segar hasil tambang (riolit). Estimasi cadangan awal berdasarkan blok model resistivitas 3D dengan nilai batas >350 Ωm yang diinterpretasikan sebagai batuan beku riolit memiliki volume cadangan 584.595,9461 m³.

1. INTRODUCTION

In general, Indonesia is crossed by an active volcanic area or can be in the Ring of Fire, Sumatra Island is one of the islands in Indonesia that is crossed by the active volcanic area. The presence of inactive volcanic activity results in the existence of extrusive and intrusive igneous rock reserves. Determination of subsurface reserves is carried out using a geophysical approach. In determining the existence of igneous rock, the application of the geoelectric method is carried out because it uses resistivity parameters, the resistivity of igneous rock has a higher resistivity value compared to the surrounding rock because the compactness of igneous rock is able to withstand the flow of electric current that spreads and causes the resistivity value to be read high, in contrast to sedimentary rocks such as sandstone and mudstone which have low resistivity values. because of the content such as kaolin and water which are conductive (Hurriah & Jannah, 2015). The research location is in Biyuku Village, Bangko Regency, Jambi Province which is dominated by the existence of extrusive igneous rocks which are interpreted to have formed at the age of Quarter (QTk), the exposed igneous rocks contain fresh igneous rocks and weathered igneous rocks. In this study, petrological analysis and geoelectric methods with Wenner-Schlumberger configuration were applied to describe subsurface conditions and determine the Volume of reserves for igneous rock mining.

2. LITERATURE REVIEW

The application of the resistivity method can be used for exploration of groundwater, andesite rock, structural geology and others (Prabowo et al., 2020); (Wahyono et al., 2022); (Pesma et al., 2024). Referring to previous research, we apply it to estimate the reserve volume. Based on the regional geology of the geological map of the Solorangun sheet, Sumatra (Suwarna, 1992), in general, the research area consists of several main geological correlations, namely surface deposits, volcanic rocks, intrusive rocks and tectonites, which play an important role in the formation and characteristics of local geology. Geomorphologically, the Biyuku area is located on the eastern wing of the Bukit Barisan and is filled with quarter volcanic deposits. The Buyuku area consists of undulating land which is a low area with an altitude of several tens of meters above sea level. The rivers in this area have a meandering flow pattern and a branching to rectangular pattern, with the direction of flow generally parallel to the direction of the main geological structure (Suwarna, 1992).

Based on the geological map (**Figure 1**), Biyuku Village is included in the Kasai Formation (QTk) which consists of lithology, Tuff, Pumiceous Tuff, intercalation of tuffaceous sandstone, claystone. However, field surveys found that the research area was filled with chunks of igneous rock, so it is suspected that the rocks do not come from the Kasai Formation (Qtk). The igneous rocks exposed in the quarry area are thought to be part of the Rhyolite-Andesite Volcanic Rock Formation

(QTv), based on the initial survey results, Rhyolite-Andesite lava, intercalated sand tuff, and tuff can be seen on the surface.

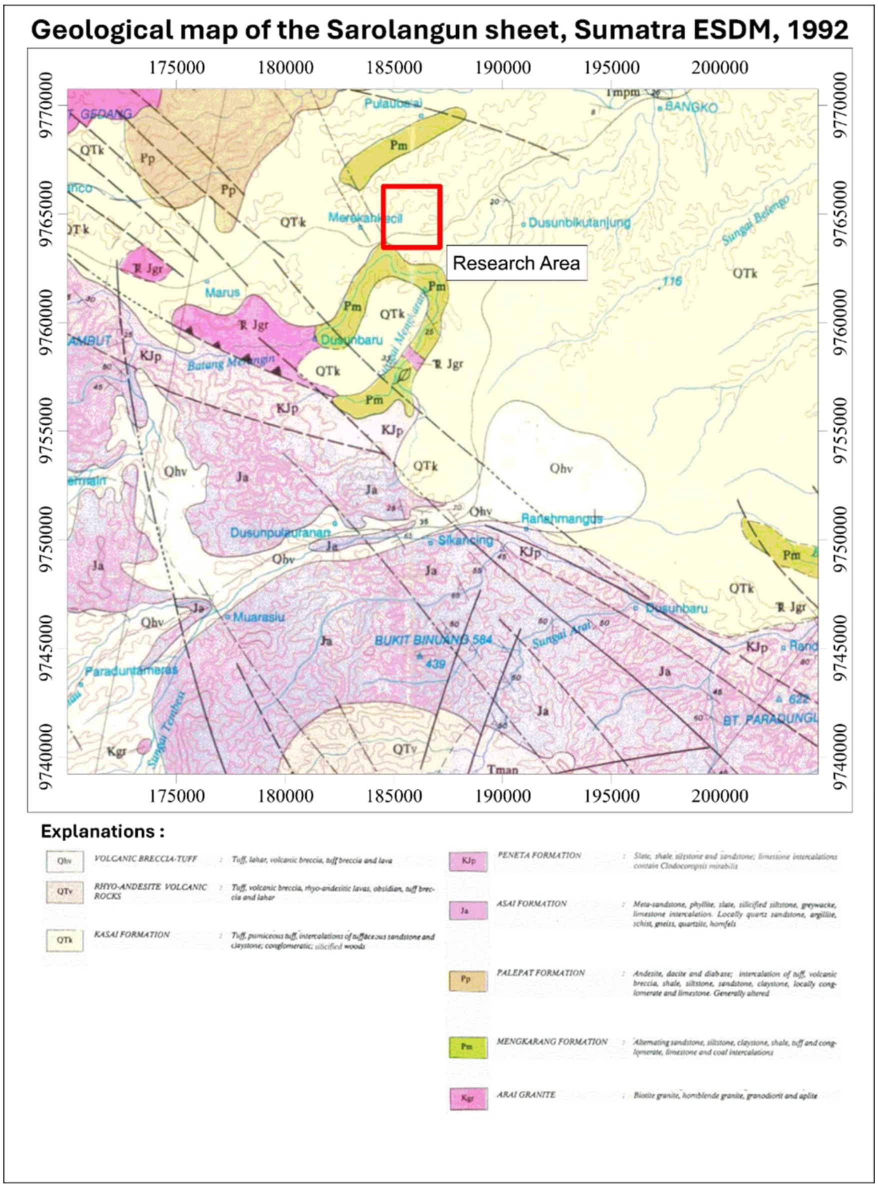

Figure 1. Geological Map of the Sarolangun Sheet, Sumatra (Suwarna, 1992).

3. RESEARCH METHODS

In this study, to describe the form of igneous rocks, a geoelectric method approach was used and a block model approach was used to determine the volume.

3.1. Resistivity Geoelectric Method

Geoelectric method is one of the geophysical methods that studies the nature of electric currents in the earth and how to detect them on the earth's surface. This includes measuring potential and measuring currents that occur both naturally and due to current injection into the earth, one of which is the resistivity geoelectric method (Wijaya. 2015). The distribution pattern of electric current flow with two current electrodes and two potential electrodes below the surface is shown in **Figure 2**.

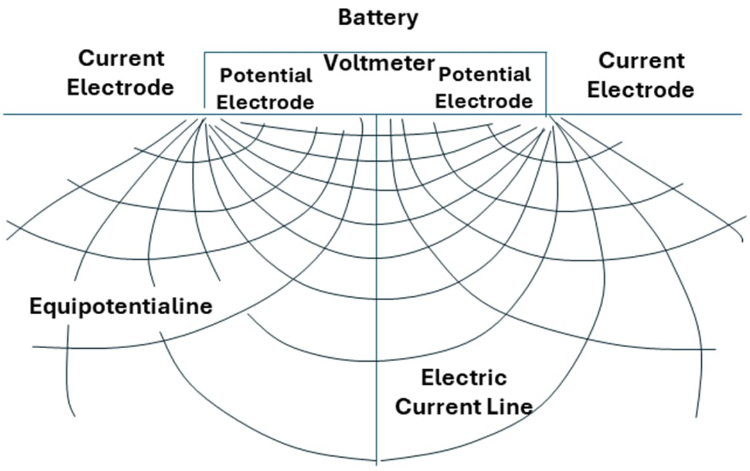

Figure 2. Distribution pattern of electric current flow with two current electrodes and two potential electrodes below the surface redrawn from (Tarungan & Singarumbum. 2016).

3.2. Wenner-Schlumberger Configuration

The Wenner-Schlumberger configuration is a combination of two geoelectric methods, namely Wenner and Schlumberger, which are designed to combine the advantages of both in subsurface exploration. This method is used in resistivity geoelectric surveys to obtain more accurate information about underground structures (Susilo, et al. 2022). The Wenner - Schlumberger Configuration equation is written as:

$$K = n(n+1)\pi a \quad (1)$$

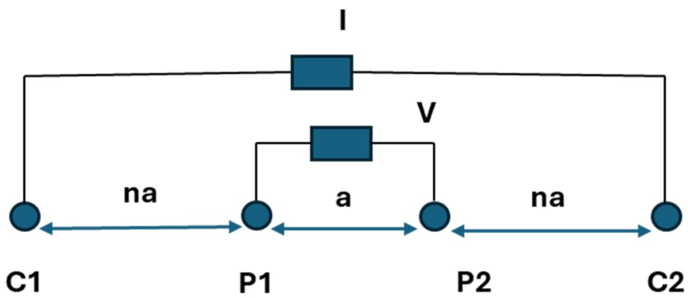

Figure 3. Electrode arrangement in the Wenner–Schlumberger configuration (Redrawn from Kanata and Zubaidah, 2013).

3.3. Reserve Calculation Method

Inverse modelling of mineral deposits is generally done using a block model. The dimensions of the block model are made according to the mining design, namely having the same size as the height of the ladder. All parameters such as rock type; rock quality and topography can be modelled in the form of regular blocks obtained using common estimation methods. In the framework of the block model, a type of polygon estimation is known with the distance of the nearest point (rule of nearest point), namely the value of the estimation result is only influenced by the nearest value or in other words the nearest point (block) gives a weighting value of one for the estimated point, while the point (block) that is further away gives a weighting value of zero (has no influence) (Notosisworo. 2005).

The volume calculation equation is written as:

$$Volume = Number\ of\ Counted\ Block \times Block\ Volume \quad (2)$$

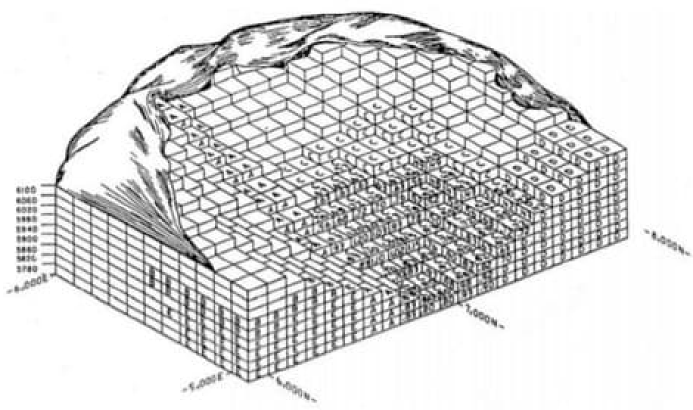

Figure 4. Volume calculation using the block method (Notosiswoyo, 2005).

4. RESULTS AND DISCUSSION

The design of the geoelectric method survey was carried out by cutting the igneous rock outcrops located in the planned quarry mining area, after cutting sample or outcrop of igneous rock on research area, we run geoelectrical method survey. The geoelectric method measurement was carried out with a total of 5 lines depicted by the yellow lines *Q11, *Q12, *Q13, *Q14, *Q15 the distance is same 160 m and four rock samples at mine location (S point) were taken for petrological analysis to determine the type of igneous rock and validation in the research area, which is shown in **Figure 5**.

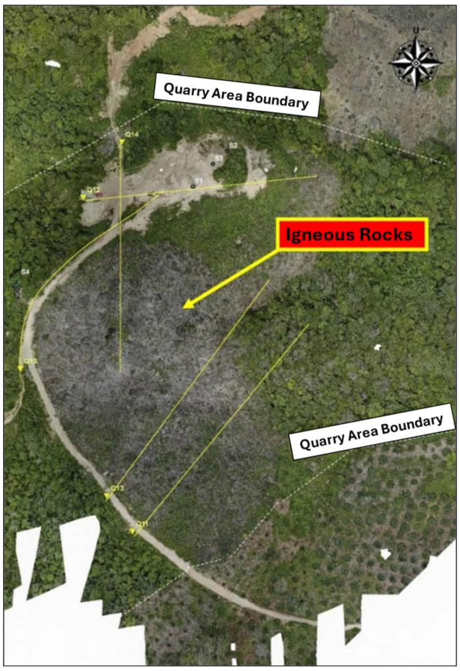

Figure 5. Design of geoelectric measurement survey and samples via drone photogrammetry.

4.1. Petrological Analysis

Field conditions can be seen in **Figure 6** where the rhyolite rock outcrops appear to have been weathered and in **Figure 6c** is a sample taken for petrological analysis. Petrological analysis was carried out by taking 4 samples (S1, S2, S3, and S4) of igneous rocks in the research area, the results of the petrological analysis of the rocks have a reddish grey colour with a massive rock structure in the field conditions of the exposed rocks that have experienced weathering. Rock texture analysis has a texture.

- Crystallinity : Holocrystalline
- Granularity : Aphanitic
- Crystal Boundary : Euhedral
- Crystal Form : Equidimensional
- Crystal Relationship: Pan-idiomorphic

The results of the mineral analysis (%) on the rocks produced.

- Quartz : 30%
- Na-Plagioclase : 40%
- Ca-Plagioclase : 5%
- Biotite : 15%
- Hornblende : 5%
- Muscovite : 5%

Table 1. Sampling location.

Sample Location			
Name	X	Y	Z
S1	185981	9764975	108
S2	186005	9765000	100
S3	185995	9764991	102
S4	185856	9764908	135

Figure 6. (a) Igneous rock outcrop, (b) Igneous relief conditions in the field, and (c) Sample 4 slightly weathered rhyolite igneous rocks.

The naming of igneous rocks is done using the classification according to (Huang, 1962) in **Figure 7**, based on the classification of rocks in the research area is rhyolite igneous rock, interpreted rhyolite rock is lava rock located in the Rhyolite-Andesite Volcanic Formation Aged Quarter.

<table>
<tr><td rowspan="4">Volcanic</td><td>Bedded Or fragmental accumulations, surface flow, and ejecta</td><td>Pyroclasstic, Glassy</td><td colspan="9">Tuff Breccia Tuff-breccia Agglomerate
High-silica glass obsidian, perlite, pitlhstone, pumice Low-silica glass tachylite</td><td></td></tr>
<tr><td rowspan="3">Surface flow or shallow dikes</td><td rowspan="3">Porphyroaphanitic or aphanitic</td><td colspan="4">Quarts Porphyry</td><td rowspan="3">Trachyte</td><td rowspan="3">Andesite</td><td rowspan="3">Basalt</td><td rowspan="3">Phonolite</td><td rowspan="3">Leucitite
Nephelinite
Nepheline Basalt +Olivine
Leucite Basalt</td><td rowspan="3"></td></tr>
<tr><td colspan="2">Rhyodacite</td><td colspan="2" rowspan="2">Dacite</td></tr>
<tr><td>Rhyolite</td><td>Latite</td></tr>
<tr><td rowspan="2">Plutonic</td><td rowspan="2">Deep to Hypabysal dikes, minor intrusive</td><td>Porphyritic</td><td>Granite porhyry</td><td>Quartz monzonite porphyry
Monzolite porphyry</td><td>Granodiorite Porphyry</td><td>Tonalite porphyry</td><td>Synite porphyry</td><td>Diorite porphyry</td><td>Gabbro porphyry Diabasic texture
Diabase</td><td>Leucite porphyry
Neopheline porphyry</td><td></td><td></td></tr>
<tr><td>Panidiomorphic pegmatitic aplitic</td><td colspan="4">Granite -pegmatite
Aplite</td><td colspan="5">Menette (Orth.-B.)
Vogesite (Orth.-H.)
Lamporphyre
Kersantite (Plag. - B.)
Malchite (Plag. -H.)</td><td></td></tr>
<tr><td colspan="2">Larger intrusives</td><td>Granular</td><td rowspan="2">Granite</td><td rowspan="2">Quartz monzonite
Monzolite</td><td rowspan="2">Granodiorite Porphyry</td><td rowspan="2">Tonalite</td><td rowspan="2">Syenite</td><td rowspan="2">Diorite porphyry</td><td rowspan="2">Grabro
Olivine grabro
Anorthosite</td><td rowspan="2">Nepheline synite</td><td>Ijolite</td><td rowspan="2">Hornblendite pyroxenite dunite Serpentinite peridotite</td></tr>
<tr><td colspan="2">Usual occurrence</td><td>Usual texture</td><td>Missourite +Olivine</td></tr>
<tr><td colspan="2" rowspan="3">Mineral composition</td><td>Charecteristic</td><td>M.B.H.*</td><td>B.H.P.</td><td>B.H.P.</td><td>B.H.P.</td><td>B.H.P.</td><td>B.H.P.</td><td>B.H.P.</td><td>Orthoclase</td><td>Alkaline pyrocenes</td><td></td></tr>
<tr><td rowspan="2">Essential</td><td colspan="4">Quartz : Present</td><td colspan="5">Quarts : Absent</td><td rowspan="2">Mafic minerals only B.H.O.P.</td></tr>
<tr><td>Orth. > Plag.</td><td>Orth. = Plag.</td><td>Orth. < Plag.</td><td>Chiefly sodic plag.</td><td>Chiefly orth.</td><td>Chiefly sodic plag.</td><td>Chiefly calcic plag.</td><td colspan="2">Feldspathoids: Lucite, Nepheline, cancrinite, etc.</td></tr>
<tr><td colspan="3">Rock type</td><td colspan="4">Silicic</td><td colspan="2">Intermediate</td><td>Mafic</td><td colspan="2">Alkalic</td><td>Ultramafic</td></tr>
</table>

Figure 7. Classification of igneous rocks according to Huang (1962).

4.2. Resistivity Analysis

Resistivity analysis is carried out by interpreting the geoelectric cross-section (**Figure 8**). The creation of the model block is carried out with the rule of nearest point parameters by performing 3D Gridding. The 3D grid parameters are carried out using the Inverse Distance method and using anisotropic properties and the maximum value of the rule of nearest point on the XYZ axis is 1.5 m, considering that values greater than 1.5 have high subsurface uncertainty.

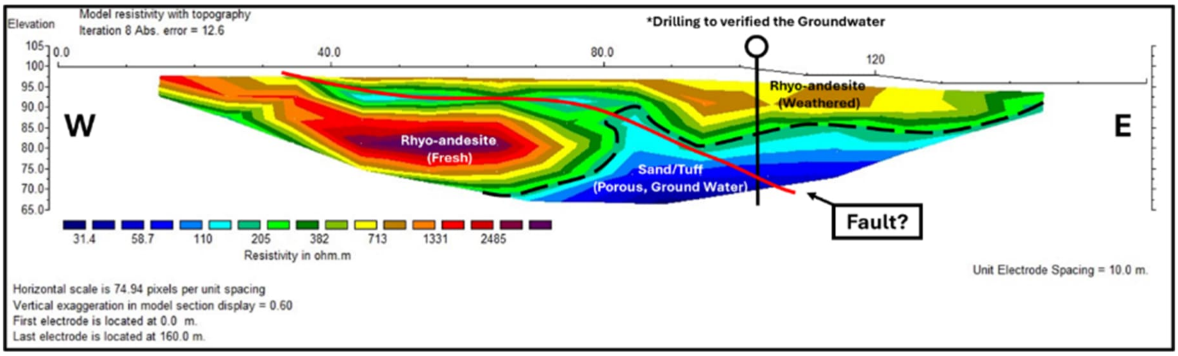

Figure 8. Interpretation of 2D geoelectric cross-section line number Q12 with West – East direction.

The results of the resistivity model block are obtained in **Figure 9a** and **Figure 9b**. Based on the resistivity cross-section, the resistivity value can be divided into 2 groups, namely values <350 Ωm interpreted as moderate to high weathered rhyolite igneous rocks due to the presence of shallow structures and becoming groundwater traps, causing low resistivity values due to rocks filled with water, then values > 350 Ωm which are interpreted as slightly weathered to fresh igneous rocks of quarry excavation materials (rhyolite). Rocks with resistivity values > 350 Ωm are considered to have good quality because high resistivity values indicate that the rocks are not affected by structures and the minerals contained in the rocks are still fresh. The results of the resistivity cutoff > 350 Ωm (fresh rhyolite) in the model block are shown in **Figure 9c** and **Figure 9d**. The estimates made are initial reserves using the block model approach so that the reserves of the research area can increase if there is a lot of detailed exploration data. Initial reserve estimates based on the 3D Resistivity model block with a cutoff value > 350 Ωm interpreted as fresh rhyolite igneous rock have reserves volume of 584,595.9461 m^3.

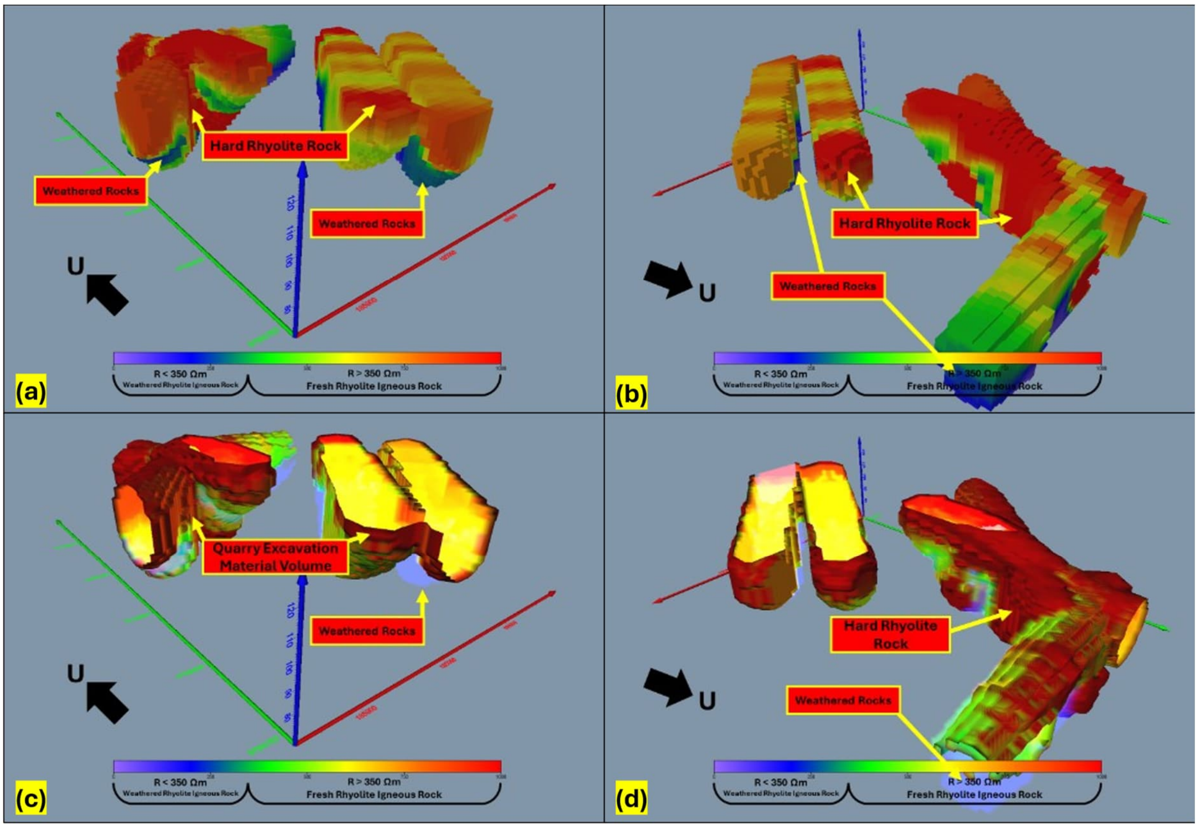

Figure 9. (a) 3D resistivity model in the northeast direction, (b) 3D resistivity model in the southwest direction, (c) Block shape of the volume distribution of rhyolite igneous rock with a resistivity cutoff greater than 350 Ωm in the northeast direction, and (d) Block shape of the volume distribution of rhyolite igneous rock with a resistivity cutoff greater than 350 Ωm in the southwest direction.

5. CONCLUSION

The results of the study showed that igneous rocks as quarry excavation materials are rhyolite lava based on petrological analysis. The results of the interpretation of the distribution of rhyolite igneous rocks are at resistivity values > 350 Ωm considered to have good quality because high resistivity values indicate that the rocks are not affected by the structure and the minerals contained in the rocks are still fresh. The estimated reserves of fresh rhyolite rocks as excavation materials have reserves of 584,595.9461 m^3. The reserve value is the initial reserve value so that reserves can increase with the addition of further exploration data.

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