Limestone Resource Estimation Using Block Model Approach in the Wuluhan Area, Jember Regency, East Java Province

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Abstract

The research location is in an IUP area of 142.23 Ha owned by PT. Gunung Kelabat Citra Abadi located in Lohjejer Village, Wuluhan District, Jember Regency. The IUP area used as the research location has limestone potential based on the lithology that composes the area and the ongoing exploration activities, but the ongoing exploration activities have not yet carried out limestone resource estimation. Based on this background, the purpose of this research is to determine the geological conditions and rock characteristics in the Mining Business Permit area, the direction of limestone resource distribution, and limestone resource estimation. The analysis of geological conditions and the direction of limestone distribution is based on geological mapping activities combined with subsurface geological data, limestone characteristics are based on the results of laboratory testing of physical and mechanical properties of rocks, while resource estimation is carried out using the block model method. The results of the analysis show that the geological conditions in the IUP area are relatively simple, reflected by the geological structure in the form of minor fractures, and variations in lithology which are divided into limestone breccia and reef limestone, with limestone characteristics having a compressive strength value between 428,690 kg/cm2 – 483,447 kg/cm2, and an internal friction angle value of 14o – 25.03o, and a measured resource estimate of 181,032,021 Tons consisting of a limestone breccia volume of 70,969,553 tons and a reef limestone volume of 110,062,467 tons minus a soil volume of 2,241,105 tons.

Keywords: *Block model method; Limestone; Resource estimation*

1. Introduction

According to SNI 4726:2019, a mineral resource is defined as a mineral deposit with the potential to be processed and utilized economically. A mineral resource can be upgraded to a reserve after a feasibility study is conducted and the deposit meets the criteria for mineability. Mineral resources are classified into three categories based on the level of geological confidence: inferred, indicated, and measured resources[1]

Limestone is one of the rock types that can be utilized to meet various societal needs [2]. It is commonly used as a material for construction and infrastructure [3]. This aligns with the increasing number of infrastructure development projects, such as the Probowangi (Probolinggo–Banyuwangi) Toll Road and various regional-scale infrastructure projects [4]

In response to this demand, it is necessary to conduct exploration and estimation of limestone resources to meet the required quantity of mineral materials. Resource estimation is an effort to determine the potential quantity of limestone within a given area using specific methods, such as the block model method, which is based on both empirical considerations (field observation data) and theoretical considerations (interpretation and prediction) [5]

The principle of resource estimation is based on a range of results and a resource model constructed through an approach that reflects actual conditions, as obtained from exploration activities.

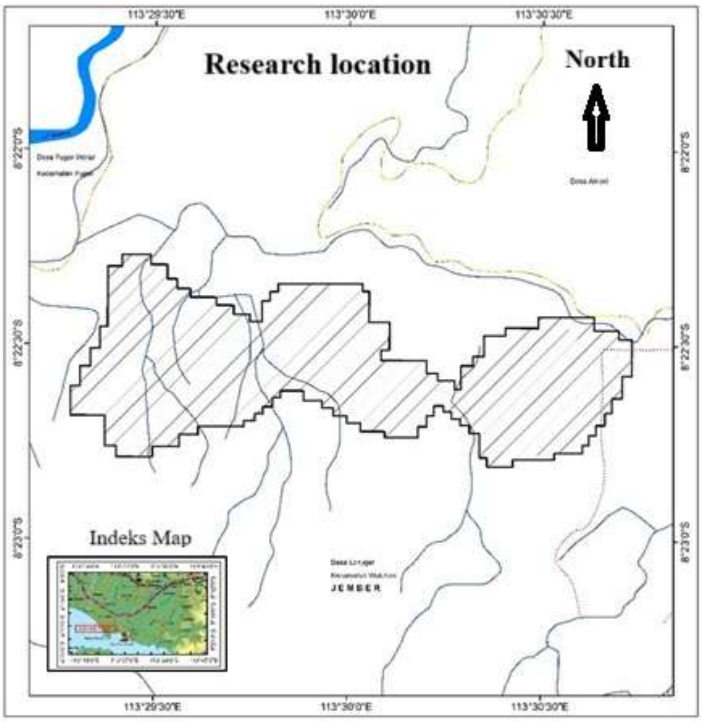

Figure 1. Research location

In this study, the method used is the block model method. This method involves defining the boundaries of the deposit, including block boundary determination, area measurement and correction, average parameter value calculation, volume calculation, and reserve estimation of the deposit and its useful components for each block [6]. This method was selected because it is suitable for the research area, which has varying lithologies, and because it offers a high level of geological confidence. The block model method enables a detailed geological interpretation by dividing the area into blocks of specific sizes [7]

The research location is situated within the Mining Business Permit (IUP) area of PT. Gunung Kelabat Citra Abadi (GKCA), located in Lohjejer Village, Wuluhan Subdistrict, Jember Regency, East Java Province, covering an area of 142.23 hectares. PT. Gunung Kelabat Citra Abadi is a mining company engaged in limestone mining for backfilling purposes. The IUP area of PT. GKCA is positioned between the coordinates 113°29’22.560” to 113°29’21.440” East Longitude and 8°22’16.050” to 8°22’27.340” South Latitude (Figure 1).

2. Method

The stages of resource estimation are divided into several parts, namely: the creation of a database obtained from detailed exploration activities, data interpolation, and the construction of a block model based on the established database to represent the geological model of the study area. Using this block model, it is possible to estimate the resource values based on geological data and resistivity values [8].

To estimate the limestone resources in the IUP area of PT. GKCA, the block model estimation method is used. The blocks are generally square in shape, with side lengths typically ranging from ½ to 1/5 of the distance between drill holes. The total resource is calculated by summing the tonnage of each block, while the average grade of each block is obtained through grade calculation weighted by tonnage.

Inside the block model, there are smaller units called sub-blocks. These sub-blocks contain various data such as assay data, geological data, and others. In constructing the block model for the study area, maximum and minimum coordinate values (X, Y, Z) are required.

The database used for the block model estimation consists of four main types of data: collar data, survey data, geological data, resistivity data, and topographic data [6]. These datasets are then processed using RockWorks 16 software to model the geological conditions and estimate the volume of each lithological unit.

The principle of the block model estimation method is to divide the area to be calculated into blocks of specific sizes, based on certain factors. These factors include the depth and thickness of the deposit, data availability, and computational capability [9].

The lithological data interpreted from resistivity data of geoelectrical surveys is numerically interpolated using a cell-based interpolation technique called horizontal lithoblending, available in the RockWorks 16 software package [10]

Grid nodes are sequentially assigned values corresponding to the interpreted lithology class based on their proximity to each geoelectrical survey point.

This algorithm places voxels by examining the area surrounding the boreholes, searching within an expanding diameter circle. Initially, voxels are placed around each borehole. The algorithm then works outward from the boreholes, voxel by voxel, placing the next "circle" that effectively categorizes lithology horizontally outward from each borehole.

Before estimating the value of resources using the block model method, it is necessary to create a database based on the results of detailed exploration activities, this aims to determine the pattern of distribution of information points.

3. Results and Discussion

3.1. Geology Local Data

Based on the results of detailed exploration, it is known that in the research area, carbonate rock characteristics were found which were identified as reef limestone units and limestone breccia units which have similar physical characteristics to the Puger Formation of Middle-Late Miocene age.

The stratigraphic relationship between the reef limestone unit and the limestone breccia unit is interfingering, indicated by random changes in rock characteristics without showing clear boundaries. The rock units at the PT. Gunung Kelabat Citra Abadi IUP location can be divided into two units, namely the reef limestone unit and the limestone breccia unit. The distribution of rock units is presented in the local Geological Map in Figure 2.

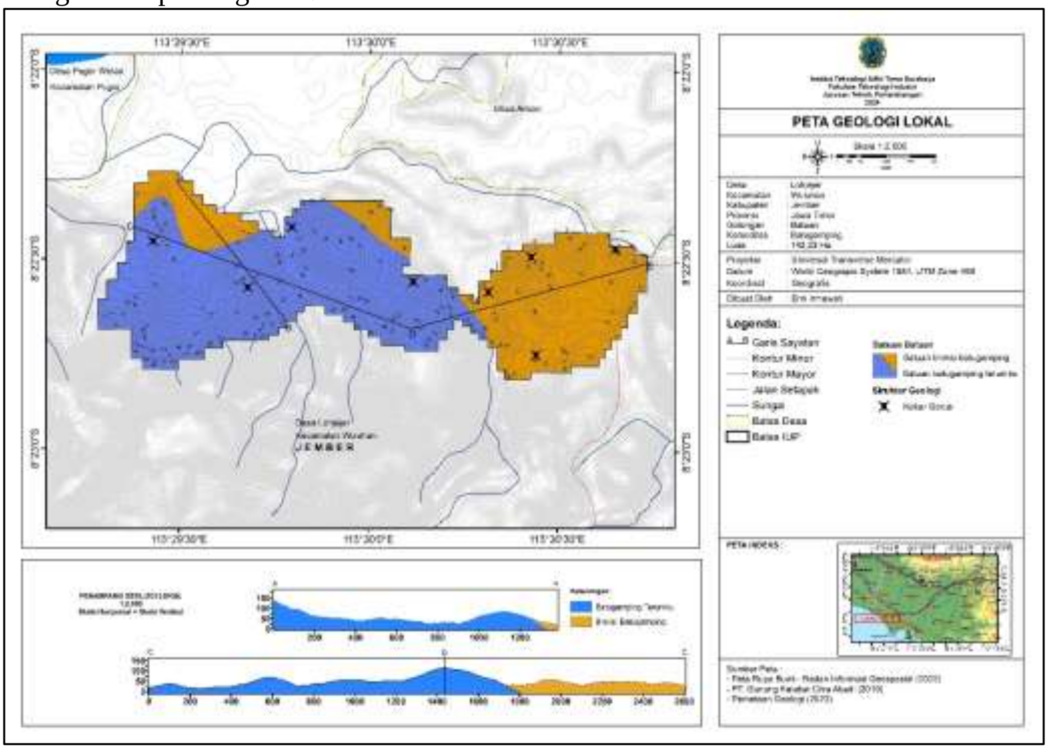

Figure 2. Geologi Local Map

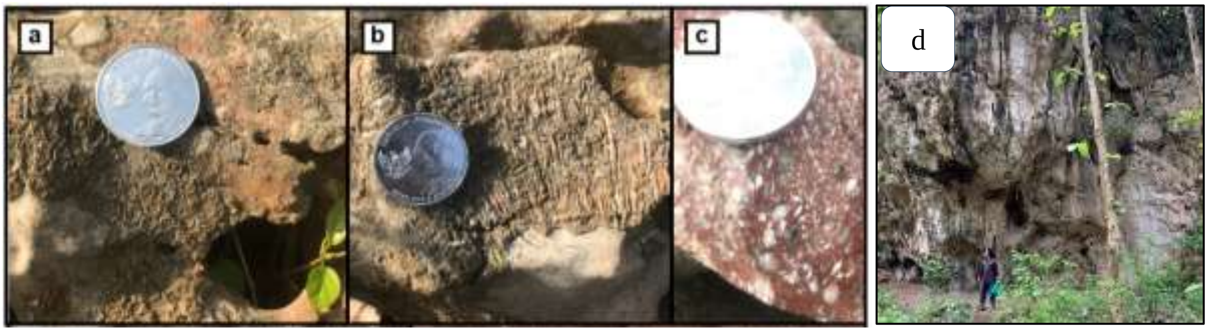

Figure 3. The sample shows (a) and (b) coral fragments, (c) as well as large benthonic foraminifera fossils, and (d) Reef Limestone Outcrop

The reef limestone unit shows textures that indicate the origin of organism components such as branching coral bodies that are glued together and form a hard framework with fine-sized carbonate material during the deposition process (autochthonous), as well as fragments of other organism remains such as large foraminifera fossils and mollusks, have a moderate to high level of compaction, indicating a massive sedimentary structure that can be seen in Figure 3.

Meanwhile, based on petrographic observations represented by three thin section samples, the texture appearance is classified using Embry & Klovan (1971) as floatstone, rudstone and wackstone.

The limestone breccia unit is widely exposed in the central to eastern part of the research area in the form of cliffs with thicknesses varying from less than one meter to more than three meters and is locally exposed as in-situ hill rocks with a thickness of half to one meter. This rock unit has megascopic characteristics of reacting strongly with HCL solution, white and bright gray in fresh conditions and brownish gray in weathered conditions, showing a texture of gravel (2-4 mm) to cobble (64-256 mm), a matrix of carbonate material of fine sand to medium sand, poorly sorted, open packing, indicating a massive sedimentary structure. The composition of the fragments of the limestone breccia is carbonate material including skeletal such as foraminifera, mollusks, as well as medium to coarse sand-sized material. In this unit, fragments of reef fragments were also found (Figure 4).

Petrographic observations show a texture appearance with a grain size of fine gravel (4mm-8mm) to very fine gravel (2mm-4mm) and interparticle porosity. The composition of the rock is composed of Carbonate Mud and Skeletal. The observed skeletal is mostly benthonic foraminifera. Porosity appears to have been replaced by carbonate crystals. The rock names based on thin sections are Lime-breccia calcirudite and Floatstone.

Figure 4. Limestone Breccia Unit Outcrop

3.2. Geoelecetric Data

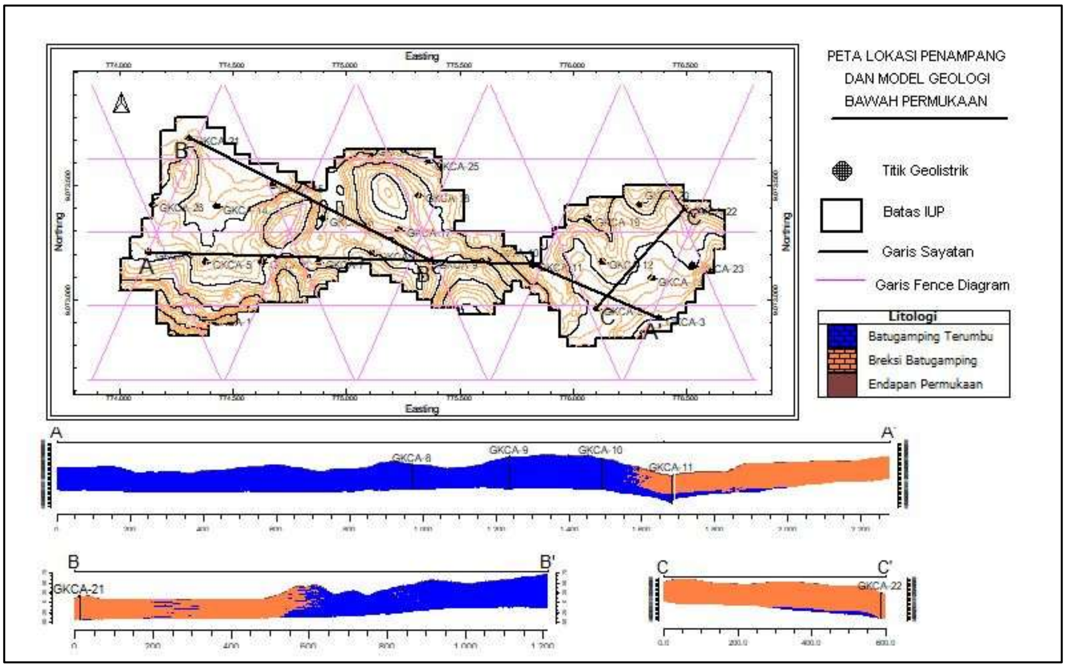

Figure 5. Subsurface cross-section map based on geoelectric data

The geophysical survey was conducted using the Schlumberger configuration geoelectric method. The survey yielded 26 points, 50–150 meters apart, and a geoelectric penetration depth of 50–90 meters. These indicated reef limestone and limestone breccia units. This data was then used as the lower limit for resource estimation, while the upper limit was determined by topographic data.

Based on the results of the interpretation of geoelectric data and surface geological mapping, modeling is then carried out to obtain a representative picture of subsurface geological conditions (Figure 5).

3.3. Model block estimation

Based on the results of the detailed exploration activities, resource estimation was carried out using the block model method which was poured into a database in the form of collar data, geological data, survey data and rock resistivity data. After the database creation was completed, the next step was to create a block model based on the minimum and maximum values of the X, Y and Z points of the area to be estimated, after which each block was divided based on the desired block model size, namely 5 x 5 x 2 meters, with the aim of making the modeling more detailed. In creating a geological model for resource estimation, the horizontal lithoblending interpolation method is used. This method utilizes the working principle of this interpolation method: interpreted lithology data from geoelectrical survey resistivity data is given a numerical code (G-value). Based on this code, data in empty areas will be filled in based on data from the nearest survey point. Interpolation using this method is performed horizontally from each nearest point (Figure 6).

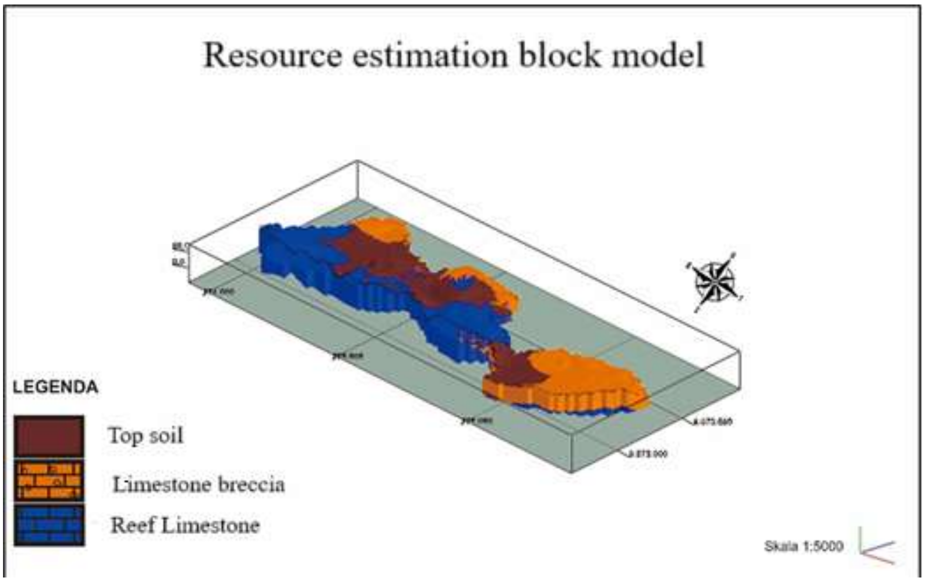

Figure 6. Resource estimation block model

After calculating the resources by entering the lithology parameters of limestone breccia and reef limestone as well as the subsurface limits based on geoelectric data, and the rock density of 2.4, the calculation results are obtained in Table 1.

Tabel 1. Resource estimation results

No	Material Type	Resource estimation		Area (Ha)
		Volume (m^3)	Tonase	
1	Limestone Breccia	31.711.150	70.969.553	142,23
2	Reef Limestone	43.593.400	110.062.467	
Total		75.304.550	181.032.021	142,23

4. Conclussion

The estimated resource reaches 181,032,021 tons with a limestone breccia volume of 70,969,553 tons, a reef limestone volume of 110,062,467 tons, and a soil volume of 2,241,105 tons. According to resource classification, including the measured resource classification.

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