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# Modeling and Estimation of Nickel Laterite Resources Using Geocomputing Methods at North Konawa, Southeast Sulawesi

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**Abstract:** Administratively, the research area is located in the Waturambaha area, North Konawe, Southeast Sulawesi province. The method used in determining the distribution and estimation of Ni laterite measurable resources is one of the geocomputational methods, Inverse Distance Wieght (IDW). From the interpolation of 82 drill points, it was concluded that the distribution of Ni levels is quite high (COG ⩾ 1.2%) discriminated dominantly in the central to northern part and some points in the northwest of the study area, while low-grade Ni (<1.2%) is distributed in the northeastern to southeastern part of the study area. Based on distributed ore modeling in the central to northern parts of the study area on limonite layers with a thickness of 2 – 4 m while in saprolite layers the thickness ranges from 6 – 12 m. Waste in the limonite layer with a thickness of 5-10 m while in saprolite 4-7 m. Modeling the distribution of Ni by the IDW method in the study area obtained a measured resource volume of Ni of 1,196,450 m³ which was then multiplied by the density of each layer (limonite and saprolite) and obtained a tonnage of ni measured resources of 1,854,500 M/T with 1.39% ni average.

**Keywords:** Measurable Resources; Geocomputation; Modeling; IDW; Ore; Waste.

## 1. Introduction

Nickel is one of the most important mining commodities in the world. Nickel is generally produced into several types such as fine metal, powder, sponge, and others. Of these several types, more than 60% is used as a raw material for the manufacture of stainless steel or stainless steel. Nickel has two types of deposits, namely nickel laterite and nickel sulfide where the world's reserves of lateritic nickel deposits are 70% and nickel sulfide deposits are 30%, but until now 58% of world nickel production still comes from nickel sulfide deposits, while the total production is from nickel deposits laterite only 42% [15]. This study is intended to model the distribution and calculate the estimated measured resources of Ni laterite in the research area. The method used in determining the distribution and estimation of Ni laterite measured resources is the Inverse Distance Weight (IDW) Method. Other sections also discuss geological conditions such as morphology, stratigraphy, lithology, petrography, and geological structure. Tectonic history has been interpreted initially with the western Sulawesi/southern arm of Sulawesi accruing in the Cretaceous to the western margin of Sundaland/ Southeast Asia covering parts of the continent. Tectonic collisions involve the placement of ultrabasic rocks in the eastern and southeastern parts of Sulawesi which then become laterization zones as well as stratigraphic bedrocks, basins, and subbasins in this region. The Ophiolite Complex in the Southeast Arm of Sulawesi Island consists of ultramafic and mafic rocks as well as pelagic sediments. Ultramafic rocks consist of harzburgite, dunit, werlite, lerzolite, websterite, serpentinite, and pyroxenite [10][17].

Ultramafic rocks are composed of the main mineral's olivine, pyroxene, and amphibole which are dark when fresh. The decomposition of these primary minerals causes dissolved elements to settle at certain points. Laterite is a source of several economical minerals including bauxite and nickel (Ni), manganese (Mn), copper (Cu), gold (Au) and platinum group element (PGE). This process is dynamic and slow, so the laterite profile shows the evolution of laterization stages. The forming process of laterite nickel deposits is driven by geological, climatic, hydrological, and geomorphological condition that occur as laterization in ultramafic rocks and is influenced by non-ultramafic rock types which apparently inhibit laterization and cause lower nickel content. Structural aspects are also very influential [9][13][19].

GeoComputation is at the forefront of research in GIS and geospatial analysis, heavily influenced by the latest developments in programming, computing and user interface design. Individual Geo Computational methods are effective solutions in the study of spatial analysis and use in many software packages with widespread use [21]. A digital elevation model (DEM) is a raster data model that is used to visualize surface variations. This can be determined by collecting the measurements of a point and then calculating that point's value on a given surface [8][14]. Geocomputing is a branch of geology that examines the basics of computing and computer applications in geology. Mineral Prospectivity Modeling (MPM), also known as Mineral Prospectivity Mapping, seeks to identify potential areas for exploration for certain types of undiscovered mineral deposits. In essence, predictive modeling is the process of building integration functions that relate a set of geological features to identify targeted mineral deposit [4][16].

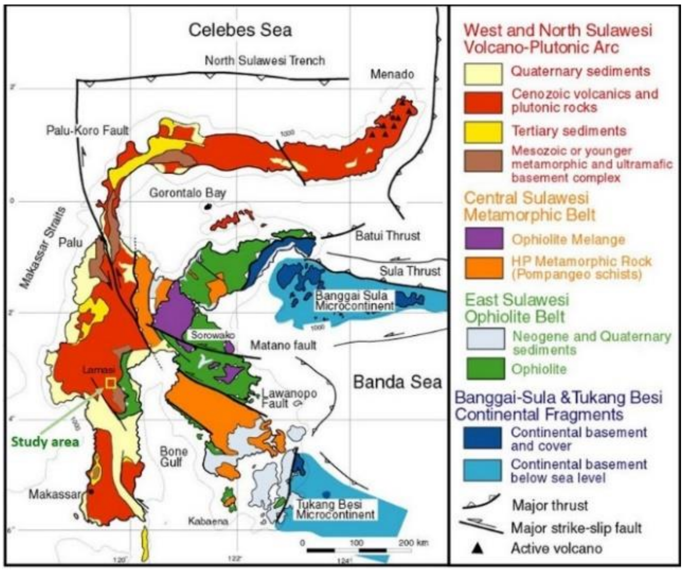

Figure 1. Map of Technono-Stratigraphy of Sulawesi Island (Kadarusman, 2004)[11]

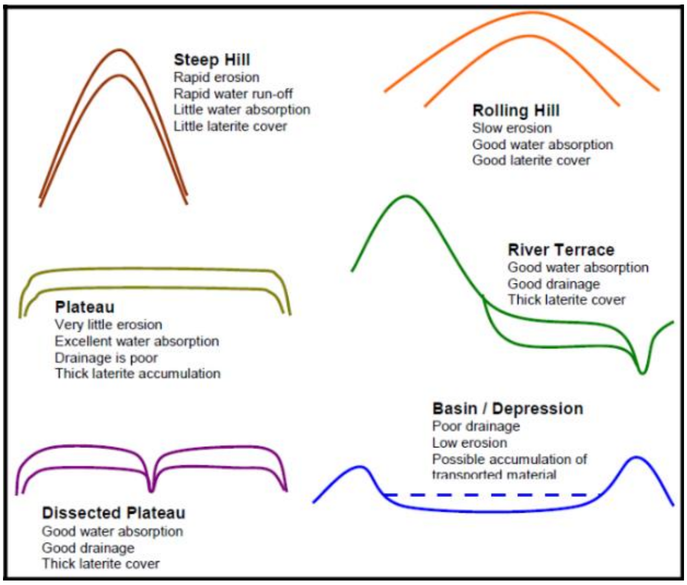

Figure 2. Laterite topographic composite diagram (Ahmad, 2006)[1]

Chemical weathering in ultrabasic rocks is usually accompanied by fractionation of the elements into soluble and water-insoluble types. Water-soluble elements will later leach out of the weathering system while water-insoluble elements will be left behind as residual enrichment. The thickening of limonite and saprolite zones is one of the influences caused by the high rate of weathering in an area. The thickness of the layer can be seen only at each drill point and in general the thickness of the laterite soil layer is not the same and the nickel contained in the soil layer is also not evenly distributed. Golightly (1979) divided 4 laterite zones, namely the limonite zone (LIM), the medium grade limonite zone (MGL), the saprolite zone (SAP), and the bedrock zone [7][20]. Determination of prospective reserves of an area from the results of drilling at the time of exploration activities, analyzed in chemical laboratories. The results of the grade analysis are then averaged from bottom to top Cut Off Grade [2]. A mineral resource is the concentration or presence of minerals that have economic value and have reasonable prospects for eventually being extracted economically. The location, quantity, levels, geological characteristics, and sustainability of mineral resources must be known, estimated or interpreted based on specific geological evidence and knowledge, including sampling. Mineral resources are grouped by geological confidence level in the categories of guessed, designated, and measurable [3].

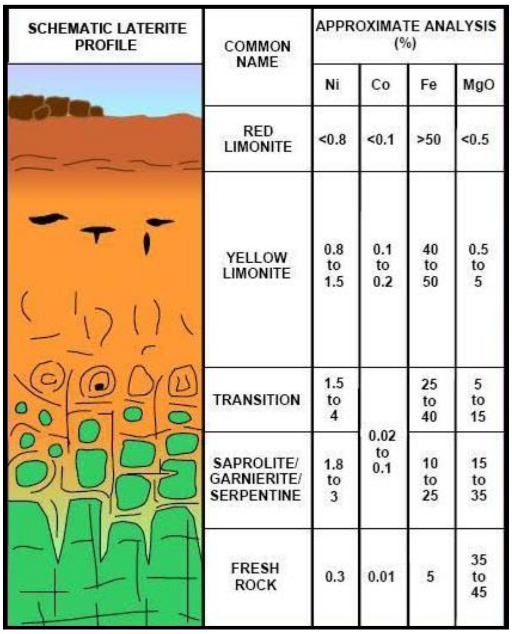

Figure 3. Generalized laterite profile (Elias, 2002)[5]

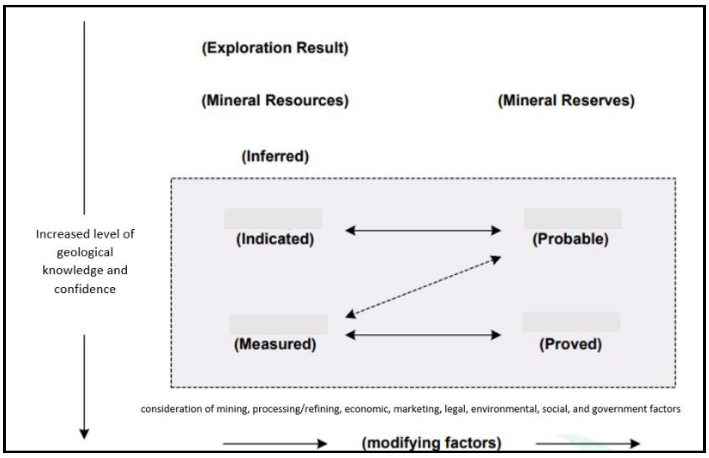

Figure 4. Relationship between exploration output, mineral resources, and reserves.

## 2. Research Method

The method used is taking field data such as morphology, lithology, and structure data. Then laboratory analysis for petrographic incisions. Next, geological maps are made using field data and structural analysis. Create surface Ni distribution maps using the ArcGIS 10.7 The geocomputation method was carried out in which field data such as sampling data in the form of (x, y) were made 2d maps and the Ni surface distribution was analyzed. Then field data such as structural data is simulated into the dips application to determine the main stress direction. Field data visualization into 2d and 3d maps is an implementation of geocomputation. Then drilling data such as assay, collar, survey, and geological data are loaded in one spreadsheet which is entered into the surpac 6.6.2 application to show subsurface 3d models and calculate the estimated available resources using a model block that refers to coordinates (x,y,z). The Inverse Distance Weight (IDW) method can also be defined as an estimation method with a simple block model approach by considering surrounding points. In the calculation of Total Ni Tonnage obtained from the calculation of Ni volume multiplied by the density of each layer, namely limonite and saprolite and bedrock which had previously been measured and determined by the company [12].

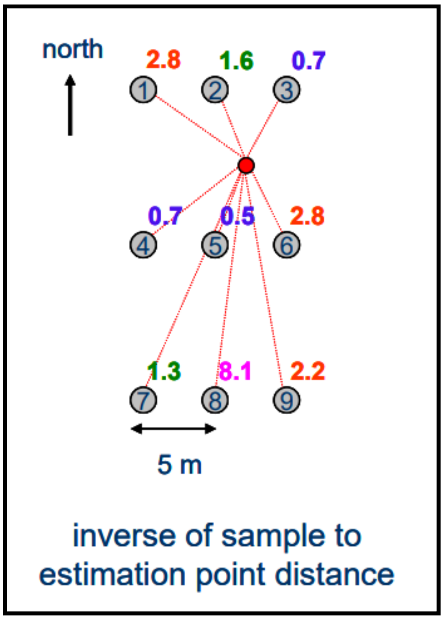


Figure 5. Inverse distance estimation – samples weighted by distance.

Table 1. Weighting Formula (w)

| For ID one degree | For ID two degree (IDS) | For ID n degree |
|---|---|---|
| $w_j = \dfrac{\frac{1}{d_j}}{\sum_{i=1}^{j} \frac{1}{d_i}}$ | $w_j = \dfrac{\frac{1}{d_j^2}}{\sum_{i=1}^{j} \frac{1}{d_i^2}}$ | $w_j = \dfrac{\frac{1}{d_j^n}}{\sum_{i=1}^{j} \frac{1}{d_i^n}}$ |

Then the estimated value (Z*):

$$Z^* = \sum_{i=1}^{j} W_i Z_i$$

Information:
Z* = estimated level
j = amount of data
i = i-th degree (i=1,.....,n)
di = distance between estimated points with an estimated i-th point (m)
k = power
Z = original content

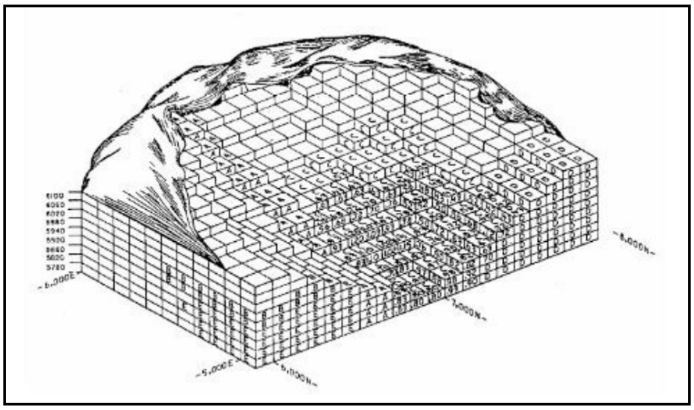

Figure 6. Example of dimension of estimation result with Block Model

## 3. Result and Discussion

3.1 Results

3.1.1 Morphology

The morphology of the study area has a topography generally composed of ultramafic rocks of the Peridotite type. In the east is a slope of 8 ° - 30 °, steep relief, an altitude of ±250 meters above sea level with topographic conditions mostly unopened and in forest areas. In the west is a slope of 8 °-30 °, steep relief, an altitude of ±150 meters above sea level with topographic conditions. Most of them are not open and in forest areas form undulating hills.

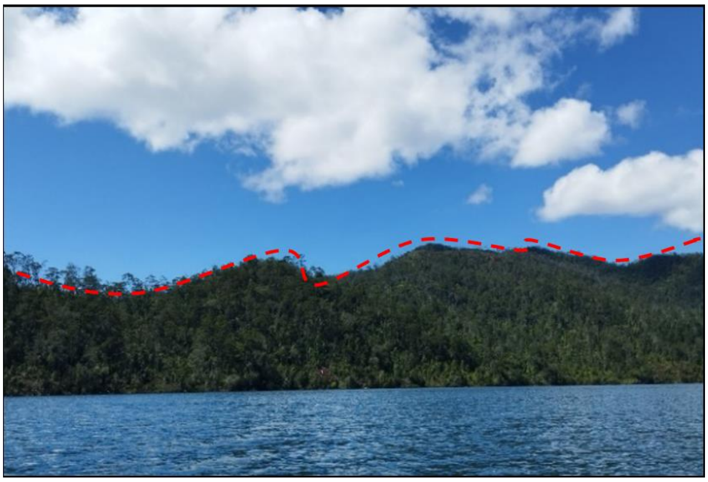

Figure 7 Morphological appearance of undulating hills on block X with photo direction N80°E

3.1.2 Lithology

Based on field data, the unit is composed by peridotite lithology. Megascopic features have physical characteristics of greenish gray in a fresh state and blackish-gray in a weathered state. The crystallinity of this rock is holocrystalline, the granularity of the form of franerytic, euhedral–hehedral mineral form. With olivine and pyroxene minerals and base mass. Based on these physical characteristics, this rock is called Peridotite [6].

Figure 8. Peridotite outcrop in the study area with photo direction N110°E

The incision of this igneous rock is brownish absorption color, and pink, blue, yellow, purple, and gray interverence color, holocrystalline chrysanility texture, faneritic granularity, equigranular relation, subhedral-hehedral shape, consisting of minerals in the form of Olivine (45%), Clinopyroxine (30%), Orthopyroxine (20%), and opaque minerals (5%), with a mineral size of 0.2 – 2 mm. Based on the classification [18] then this rock is called Lherzolite.

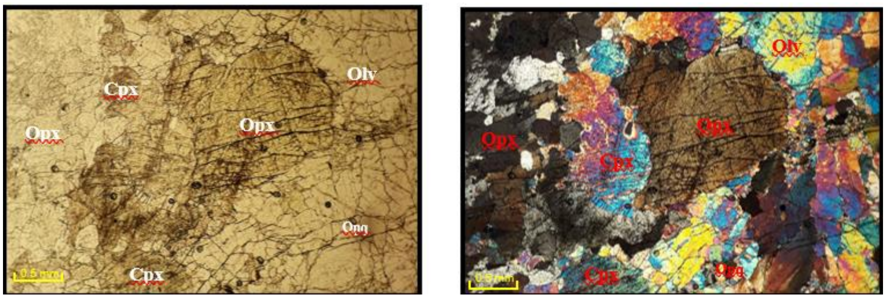


Figure 9. Petrographic appearance of Lherzolite on LPA/ST1 incision showing mineral content consisting of Olivine (olv), Clinopyroxine (Cpx), Orthopyroxine (Opx), and opaque minerals (Opq)

3.1.3 Geological Structure

Based on field data and interpretation of the stocky structure in the study area is nonsystematic stocky with the main assertion direction relative northwest - southeast.

Figure 10. Robust structure in perdidotite lithology photographed in the direction of N 91°E

3.1.4 Laterite Nickel Deposition Profile of Research Areas

Limonite layers found in the study area consisting of red limonite and yellow limonite have physical characteristics, namely brownish red to yellowish color, no longer have the residual texture of the original rock, soft hardness, clay size to coarse sand, and the minerals found are hematite, manganese, and goethite. The saprolite layer found in the study area has the characteristics of yellow to green and still shows the residual texture of the original rock, grain size, grains to brangkal (4mm – 64mm), and minerals commonly found in the form of chrysopras, garnierite, maghemite and serpentine. Bedrock found in the study area has characteristics that are gray-black, massive structure, and minerals found are olivine, serpentine and pyroxene and silica. Based on the physical characteristics found, the layer of each laterite profile can be determined which is divided into limonite layer, saprolite layer and bedrock layer.

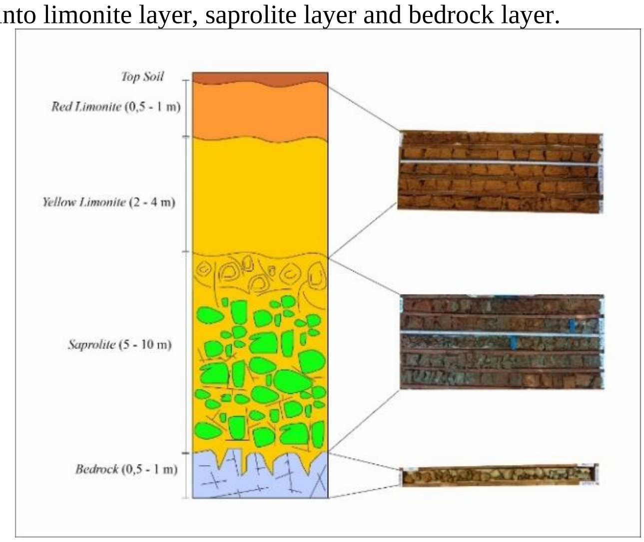


Figure 11. Example of laterite profile of the research area

3.1.5 Ni Distribution Patterns in Research Areas

The pattern of Ni distribution in the study area is obtained from the results of laboratory testing at each drill point. Then the Ni levels in the limonite and saprolite layers were averaged. The results were then incorporated into Arcgis 10.7 and then it was known that the distribution of dominant Ni northwest to the center of the study area.

Table 2. Average levels of Ni in limonite and saprolite layers in the study area

| hole_id | total depth | avg ni | hole_id | total depth | avg ni |
|---|---|---|---|---|---|
| IA.01.02 | 11.5 | 1.524143 | IB.04.03 | 6 | 1.8595 |
| IA.02.02 | 8 | 1.629 | IB.04.04 | 13.7 | 1.606 |
| IA.06.05_TRS | 16.8 | 1.5825 | IB.04.05 | 7.8 | 1.414 |
| IA.07.04_TRS | 9.1 | 1.3945 | IB.05.02 | 5.8 | 1.335333 |
| IA.07.05_TRS | 7.2 | 1.709 | IB.05.03 | 8.5 | 1.297 |
| IA.08.03_TRS | 11.2 | 0.851286 | IB.05.04 | 4.4 | 0.3865 |
| IA.08.04_TRS | 13.5 | 1.2415 | IB.05.05 | 6.4 | 0.580545 |
| IA.08.05_TRS | 5 | 0.407714 | IB.05.06 | 8.6 | 1.273 |
| IA.08.06 | 6 | 0.452625 | IB.06.01 | 14.5 | 1.348778 |
| IA.08.07 | 3.5 | 0.4686 | IB.06.03 | 23 | 1.53425 |
| IA.08.08 | 6 | 1.333 | IB.06.04 | 9 | 1.362 |
| IA.09.04 | 6.9 | 1.208 | IB.06.05 | 3.9 | 0.682 |
| IA.09.05 | 6.9 | 0.652133 | IB.06.06 | 18.5 | 1.428 |
| IA.09.05_TRS | 6.5 | 0.5452 | IB.07.01 | 16.5 | 1.483222 |
| IA.09.06 | 5.5 | 0.645308 | IB.07.02 | 19.8 | 1.3018 |
| IA.09.06_TRS | 3.8 | 0.4686 | IB.07.03 | 22.3 | 1.551222 |
| IA.09.07 | 2.5 | 0.609667 | IB.07.04 | 13.3 | 1.3245 |
| IA.11.01 | 13.5 | 1.756 | IB.07.05 | 7.5 | 0.754 |
| IA.11.02 | 17 | 1.256 | IB.07.06 | 15.5 | 1.3668 |
| IA.12.01 | 17 | 1.979625 | IB.08.01 | 19.5 | 1.501143 |
| IA.12.02 | 11.5 | 1.528222 | IB.08.02 | 15.7 | 0.940563 |
| IA.12.03 | 10.3 | 0.571267 | IB.08.03 | 17 | 1.249 |
| IA.12.04 | 6.5 | 0.582571 | IB.08.04 | 15 | 1.231 |
| IA.12.05 | 1.5 | 0.480333 | IB.08.05 | 18 | 1.277667 |
| IA.12.06 | 9 | 0.7902 | IB.08.06 | 11.5 | 0.855571 |
| IB.01.01 | 19 | 1.5228 | IB.09.01 | 9 | 1.617 |
| IB.01.03 | 5.9 | 0.561857 | IB.09.02 | 5.5 | 0.6676 |
| IB.01.04 | 3.4 | 0.64375 | IB.09.03 | 8.5 | 1.213 |
| IB.01.05 | 1.8 | 1.333 | IB.09.04 | 11.2 | 1.241333 |
| IB.01.06 | 3.4 | 0.762 | IB.09.05 | 10 | 1.428667 |
| IB.02.01 | 10.5 | 1.5165 | IB.09.06 | 6.5 | 1.489 |
| IB.02.03 | 6 | 0.607 | IB.10.01 | 4.4 | 0.9412 |
| IB.02.04 | 2.5 | 0.5085 | IB.10.02 | 5.8 | 0.711714 |
| IB.02.05 | 4.4 | 0.723833 | IB.10.04 | 4 | 1.348 |
| IB.03.01 | 23 | 1.6556 | IB.10.05 | 24 | 1.666333 |
| IB.03.02 | 17.3 | 1.409923 | IB.10.06 | 9.8 | 1.3825 |
| IB.03.03 | 9 | 0.689583 | IB.11.01 | 10.5 | 0.703545 |
| IB.03.04 | 4.9 | 1.281 | IB.11.02 | 6.7 | 0.597375 |
| IB.03.05 | 6.6 | 0.6428 | IB.11.03 | 8.5 | 0.705556 |
| IB.04.01 | 12.4 | 1.633545 | IB.11.04 | 10.6 | 1.493 |
| IB.04.02 | 22.6 | 1.439923 | IB.11.05 | 9 | 0.7365 |

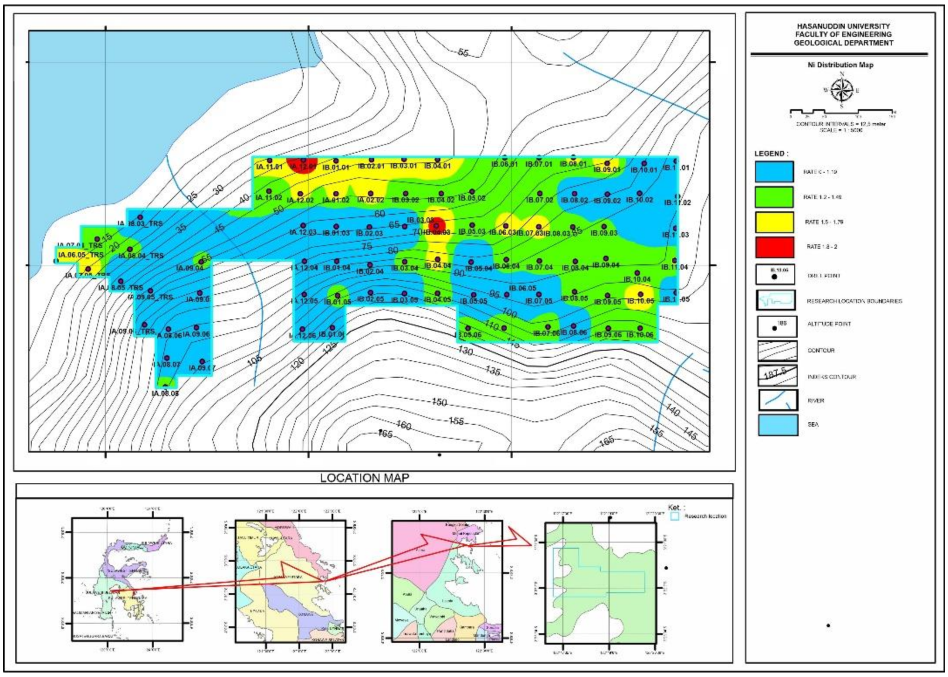


Figure 12. Distribution of Ni using the IDW method

3.1.6 Modeling and Estimating Measured Resources

Through the results of logging data analysis of 50 m space, Ni distribution modeling was made, and Ni resources were calculated in the research area using the IDW method using the Surpac 6.6.2 application. The model displays blocks measuring length x width x depth = 5 m x 5 m x 1 m. The modeling made is Ni distribution modeling and ore and waste distribution modeling. Ore in this case is classified into nickel with a content of ≥1.2% and waste, namely nickel with a content of ≤1.2. After the drill point data is imported in surpac 6.6.2, then DTM is created from each layer which is then connected to produce a laterite profile block model, then the value of Ni content and ore and waste in the model block is displayed.

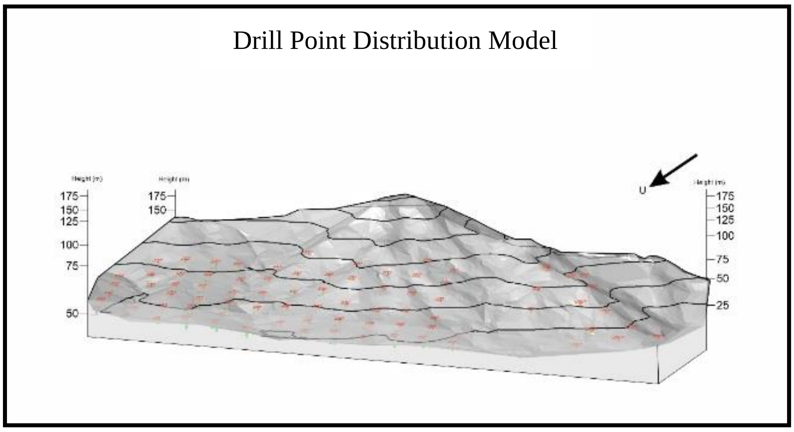


Figure 13. 3D Topography and drill point distribution by height

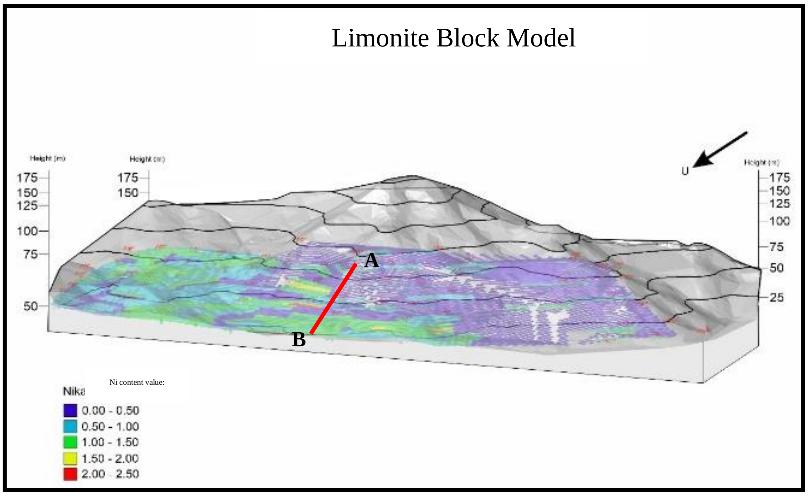


Figure 14. 3D modeling of Ni distribution on limonite layer with 50-meter spaced logging data

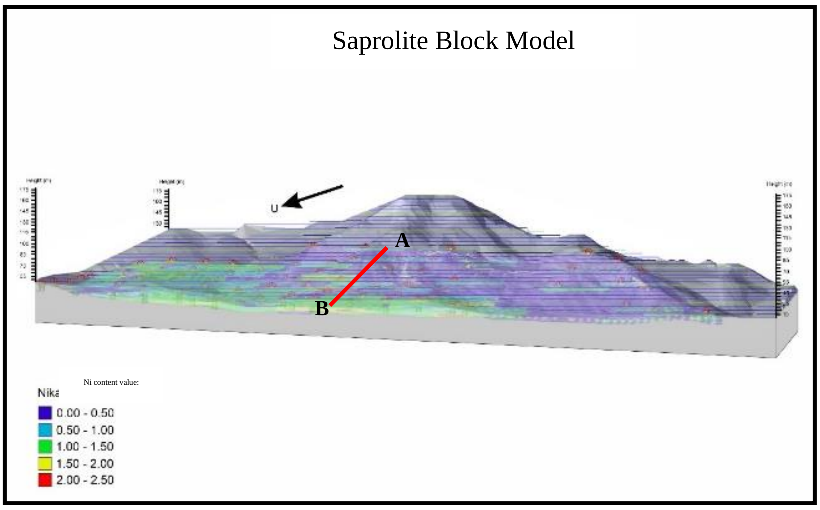


Figure 15. 3D modeling of Ni distribution in saprolite layer with 50 meter space logging data

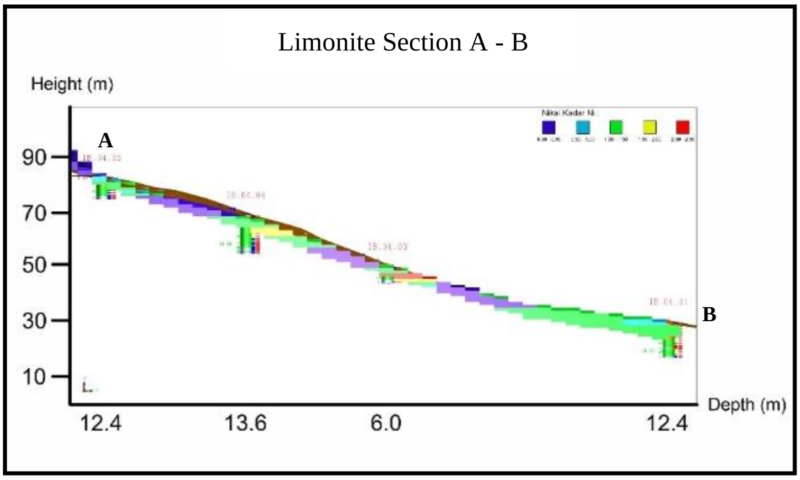


Figure 16. Vertical Appearance of Ni Distribution in *section* A-B limonite layer

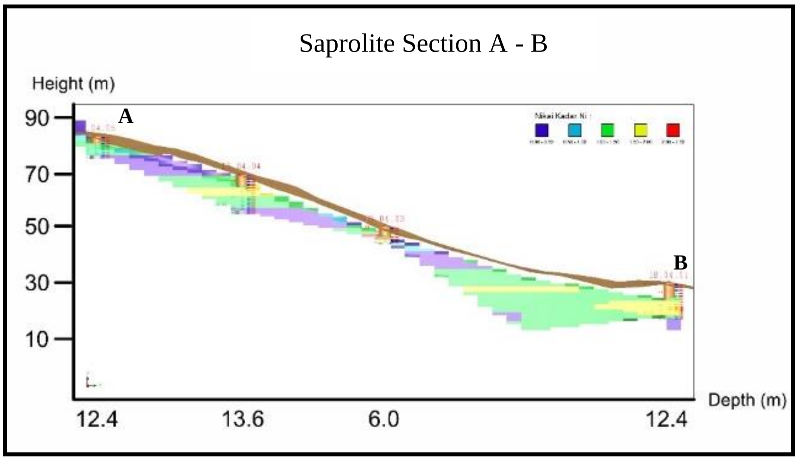


Figure 17. Vertical Appearance of Ni Distribution in section A-B saprolite layer

Through modeling the distribution of Ni (Figure 13 and Figure 14), it can be seen that high levels of Ni are predominantly distributed in the central to northern part of the study area and decreasing in levels in the northeast to southeast of the study area. Based on the vertical appearance of the block model in the limonite layer section A-B (Figure 15) observed areas with Ni levels according to COG (≥1.2%) predominantly distributed in the central to northern part of the study area. Meanwhile, based on the vertical appearance of the block model in the saprolite layer section A-B (Figure 4.1, 6), it is observed that areas with Ni levels according to COG (≥1.2%) are predominantly distributed in the central to northern parts of the study area. From both cross-sections, it shows this enrichment in the research area tends to be in the middle to northern part of the study area. Modeling the distribution of Ni levels will later become a reference in mining planning.

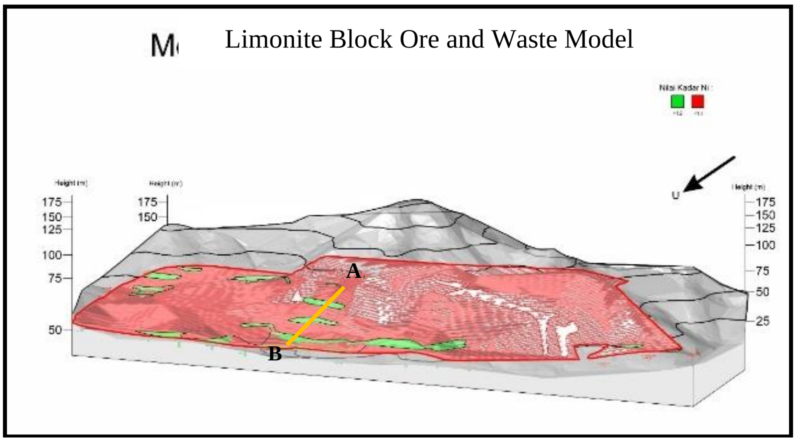


Figure 18. 3D modeling of *Ore* and *Waste* distribution on limonite layer with 50 meter space logging data

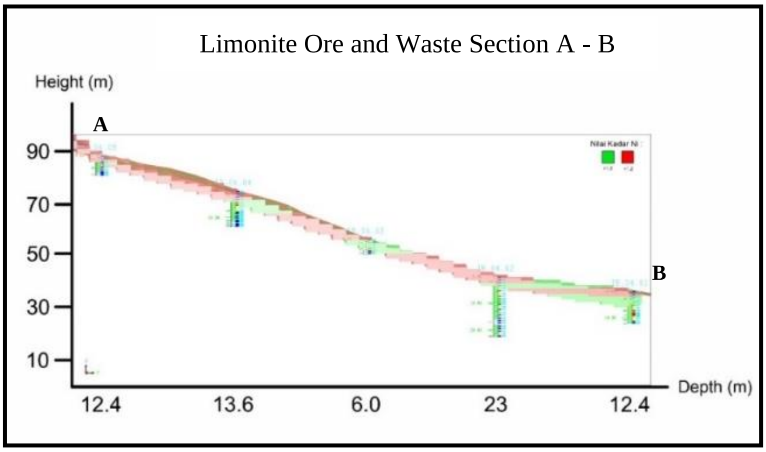


Figure 19. Vertical Appearance of *Ore* and *Waste* distribution in limonite layer *section* A-B

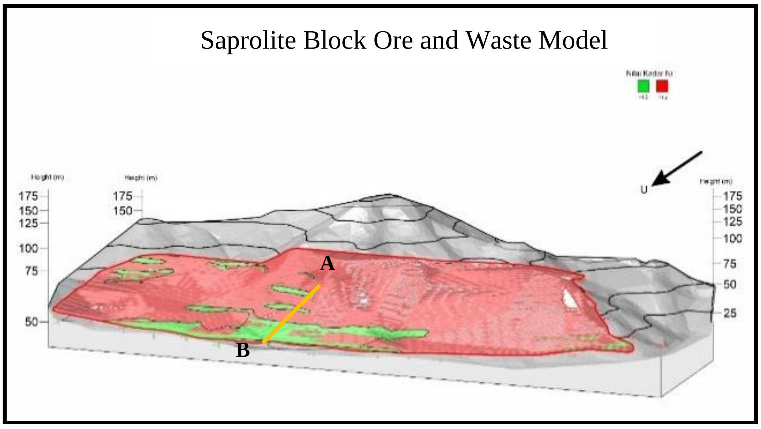


Figure 20. 3D modeling of *Ore* and *Waste* distributidistribution at layer with 50 meter space logging data

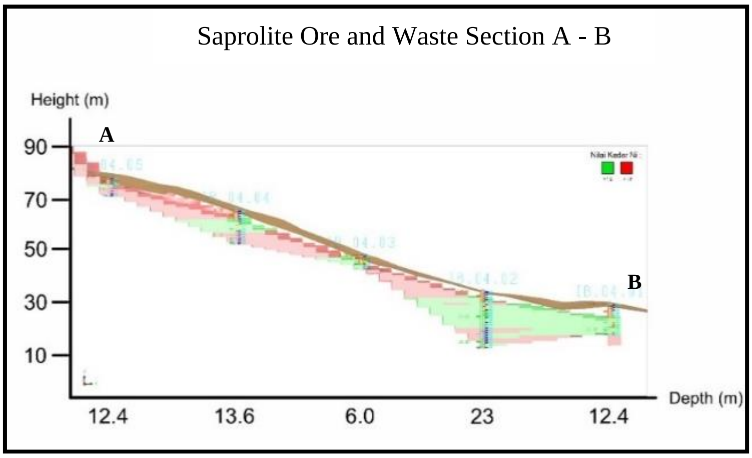


Figure 21 Vertical Appearance of *Ore* and *Waste* distribution in saprolite layer *section* A-B

To distinguish Ni that has levels above and below the predetermined COG (Cut of Grade), it is divided into 2, namely Ore and Waste. Ore is Ni with a content of $\geq$1.2% and waste is Ni with a content of <1.2%. Based on the modeling of ore and waste distribution (Figure 17 and Figure 19), it is known that the distribution of ore is predominantly distributed in the central to southern part of the study area. Based on the vertical appearance of the ore block model and waste section A-B (Figure 18 and Figure 20) it looks at areas with ore content spread in the central to northern part and at some point, in the northwestern part of the study area. Ore in the limonite layer has a thickness ranging from 2 - 4 m and in the saprolite layer with a thickness of 6 - 12 m. Waste in the limonite layer is quite thick, spread from northeast to southeast ranging from 5 - 10 m, while in the saprolite layer is thinner with a thickness ranging from 4 - 7 m. Seen from both incisions, Ore tends to be concentrated in the middle to south of the study area. Modeling the distribution of ore and waste will later become a reference in mining planning so that it can be estimated the total waste that must be taken to get the desired ore. Through the Ni grade block model and ore and waste block model, further estimation of the measured resources of the Ni research area was carried out. The design of the resource estimation system must look at the parameters that have been determined as a control unit in calculating and standardizing the drill database. The database is based on several variables such as hole id, drill point coordinates (easting, northing, elevation/x, y, and z), laterite nickel lithology, namely limonite (LIM), saprolite (SAP), bolder (BLD) and bedrock (BRK), borehole depth (eon/end of hole), thickness of each nickel laterite layer (depth from-depth to), and Ni content data. Estimation of measured resources in the research area using technical limitations among them data sources of test results of sample drill point spacing of 50 m, drill influence radius of 25 m with the area estimated calculated using the Arcgis10.7 application based on the outermost drill point obtained at 192,000 m2 or 19.2 ha. Then an estimate was carried out using the Inverse Distance Weight (IDW) method including calculating the volume and tonnage of Ni and knowing the average level of Ni so that the following results were obtained.

Table 3. Measurable Resource Estimation of the study area

| Profil | *Ore/Waste* | Ni % | *Density (kg/m³)* | Volume (m³) | Tonase (M/T) | Avg Ni % |
|---|---|---|---|---|---|---|
| Limonit | *Ore* | >1.2 | 1.55 | 69.600 | 107.880 | 1,36 |
| | *Waste* | <1.2 | 1.55 | 528.025 | 818.439 | 0,62 |
| Saprolit | *Ore* | >1.2 | 1.55 | 247.750 | 384.013 | 1,42 |
| | *Waste* | <1.2 | 1.55 | 1.010.825 | 1.566.779 | 0,52 |
| Total *Ore* | | | | 1.196.450 | 1.854.500 | 1,39 |

The total volume of ore in the study area is 1.196450 m3. The Ni tonnage is obtained from the calculation of ore volume multiplied by the density of limonite and saprolite (1.55 kg/m3). From the calculation results, Ore tonnage is 1,854,500 M/T with an average Ni content of 1.39%.

3.2 Discussion

The morphology of this area is characterized by Peridotite type ultramafic rocks which have steep relief and are mostly covered by forest areas. The lithology of the study area is also composed of Peridotite rocks, especially Lherzolite based on their mineral content. The geological structure in the study area is non-systematic joints with the main accentuation direction relatively northwest-southeast. The study area also has a lateritic nickel depositional profile consisting of limonite layers, saprolite layers, and bedrock layers. The limonite layer in the study area consists of red limonite and yellow limonite, while the saprolite layer has a characteristic yellow to green color and still shows the remaining texture of the original rock. The bedrock found in the study area consists of blackish-gray massive structures. The distribution pattern of Ni in the study area was obtained by laboratory testing at each drill point and the results showed that the dominant distribution of Ni was northwest to the center of the study area. The table shows the average Ni levels in the limonite and saprolite layers in the study area, which were then entered into ArcGIS 10.7 for further analysis. In the results of this study, there are several things explained related to morphology, lithology, geological structure, profile of nickel laterite deposits, and distribution patterns of Ni in the study area.

The morphology of the study area is dominated by peridotite ultramafic rocks. The topography of the area has a slope of between 8° - 30°, with an average elevation of between ±150 to ±250 meters above sea level. Most of the area has not been cleared and is a forest area with undulating hills. Based on field data, the rocks found in the study area are peridotite rock types. This rock has physical characteristics in the form of a green-gray color in a fresh state and grayish-black in weathered conditions. This rock is holocrystalline, its granularity is faneritic, and has euhedral-hehedral mineral form. Peridotite rock consists of the minerals olivine and pyroxene and ground mass. Based on these physical characteristics, this rock is called peridotite. Apart from peridotite, lherzolite rocks were also found. This rock has a purplish-brown absorption color, as well as interference colors in the form of pink, blue, yellow, purple and gray. This rock is also holocrystalline with chrysanility texture, faneritic granularity, and subhedral-hehedral shape. Iherzolite rocks consist of the minerals olivine (45%), clinopyroxene (30%), orthopyroxene (20%), and opaque minerals (5%) with a mineral size of 0.2 - 2 mm. The geological structure in the study area is non-systematic stocky with the dominant direction relatively northwest - southeast.

The profile of nickel laterite deposits in the study area consists of layers of limonite, saprolite and bedrock. The limonite layer consists of red limonite and yellow limonite, which are purplish-brown to yellow in color, and range in size from loam to coarse sand. The minerals found in this layer are hematite, manganese and goethite. The saprolite layers are yellow to green in color, with grain sizes ranging from 4 mm to 64 mm. The minerals found in this layer include chrysopras, garnierite, maghemite, and serpentine. The bedrock in the study area has a blackish gray color with a massive structure. The minerals found in this bedrock are olivine, serpentine, pyroxene, and silica. The nickel distribution pattern in the study area was obtained from the results of laboratory tests at each drilling point. Then the average value of Ni content in the limonite and saprolite layers was calculated and entered into ArcGIS to map the distribution pattern of nickel in the study area. The mapping results show that the pattern of distribution of nickel varies in each layer of laterite deposits. In the limonite layer, the lowest nickel concentration is in the southwest and the highest concentration is in the southeast. Meanwhile, in the saprolite layer, the lowest concentration of nickel is found in the northwest and the highest concentration is found in the southeast. This shows that the distribution pattern of nickel in the study area depends on the depth of the layers and the types of minerals contained therein.

## 4. Related Work

Nickel is an important mineral raw material globally, over 60% of which is used as a raw material for stainless steel production. Lateritic nickel deposits account for 70% of the world reserves, while nickel sulfide deposits account for 30%. However, 58% of the world's nickel production still comes from nickel sulfide deposits, and only 42% of total production comes from lateritic nickel deposits. The aim of this study is to model the distribution and calculate the estimated measured resource of Ni laterite in the study area using the inverse distance weighting method. In addition, the study describes various geological conditions such as morphology, stratigraphy, lithology, petrology and geotectonics. The formation process of lateritic nickel deposits is driven by geological, climatic, hydrological, and geomorphological conditions. These conditions occur as laterization of ultramafic rocks under the influence of non-ultramafic rock species that would inhibit laterization and degrade nickel. Structural aspects are also very influential. GeoComputation, at the forefront of GIS and geospatial analysis research, is heavily influenced by the latest developments in programming, computing, and user interface design. A digital elevation model (DEM) is a raster data model used to visualize surface changes, and geocomputing is a branch of geology that studies the fundamentals of data processing and computer applications in geology. Mineral Prospectivity Modeling attempts to identify potential areas for prospecting for specific types of undiscovered mineral deposits. Predictive modeling is the process of relating a set of geological features to create an integration function that identifies a deposit of interest.

When studying mineral prospecting, a commonly used method is Mineral Predictive Modeling (MPM), aimed at identifying potential areas for exploration of undiscovered mineral deposits. The MPM process involves building an integration function that relates a set of geological features to identify a deposit of interest. This approach is an essential tool for mining companies to assess new areas and plan future exploration programs [4][16]. The Inverse Distance Weight (IDW) method is commonly used to accurately model distributions and calculate estimates of measured nickel laterite resources. The IDW method is a spatial interpolation technique used in geostatistics to estimate the unknown values of unsampled locations based on the values of nearby sampled locations. This technique is widely used in geospatial analysis and is embedded in many widely used software packages [21]. Structural aspects also greatly influence the formation of lateritic nickel deposits. The ophiolite complex on the southeastern side of Sulawesi consists of ultramafic and mafic rocks and pelagic sediments. Ultramafic rocks are composed of the main minerals olivine, pyroxene and amphibole and are dark when fresh. Dissolved elements are deposited at specific points as a result of the decomposition of these primary minerals. Laterite is a source of several economic minerals such as bauxite, nickel (Ni), manganese (Mn), copper (Cu), gold (Au) and platinum group elements (PGE). This process is dynamic and slow, so laterite profiles show the evolution of laterization stages [9][13][19].

In geology, geocomputing is the field that studies the fundamentals of computation and computer applications in geology. Geocomputing involves the use of Digital Elevation Models (DEMs). This is a raster data model used to visualize surface changes. This can be determined by collecting measurements of a point and calculating the value of that point on a given surface [8][14]. At the forefront of research in GIS and geospatial analysis, GeoComputation is heavily influenced by the latest developments in programming, computing, and user interface design. In summary, the exploration and estimation of nickel laterite resources is a complex process involving various techniques and factors, including mineral predictive modeling, inverse distance weighting, structural aspects and geocomputing. These techniques and factors are important for mining companies to effectively evaluate new areas and plan future exploration programs for nickel laterite deposits.

## 5. Conclusion

Based on data analysis that has been carried out in the research area, the following conclusions can be drawn; 1) Based on modeling Ni levels using the IDW method using the Surpac 6.6.2 application, it can be seen that the distribution of Ni (COG $\geqslant$1.2%) in the middle to northheast of the study area, while low Ni levels (<1.2%) are distributed in the northeast to southeast of the study area. As for the modeling of ore and waste section A-B in the limonite and saprolite layers, areas with ore content are spread in the middle to north and several points in the northwest of the study area with thicknesses ranging from 2 - 4 m in the limonite layer and 6 - 12 m in the saprolite layer. Waste on the limonite layer with a thickness of 5 – 10 m and on the saprolite layer of 4 – 7 m. Seen from both incisions, ore tends to be concentrated in the middle to south of the study area, and 2) Through modeling the distribution of Ni using the IDW method using the Supac 6.6.2 application in the research area, the volume of Ni measured resources was obtained at 1,196,450 m3 which was then multiplied by the density value of each layer, namely (1.55 kg / m3) and obtained the tonnage of Ni measured resources of 1,854,500 M/T with an average Ni content of 1.39%.

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