Journal of Geology & Exploration
Vol. 1, No. 1, December 2022 : 51 – 57

Spread Of Laterite Nickel Based on Drill Data at PT Manunggal Sarana Surya Pratama, Southeast Sulawesi Province

Muhammad Aswadi[1], Jamal Rauf Husain[2], Ahmad Gazali[3], Alam Budiman Thamsi[4]*
[1] Department of Geological Engineering, Faculty of Engineering, Tadulako University, Indonesia
[2] Department of Geological Engineering, Faculty of Engineering, Hasanuddin University, Indonesia
[3-4] Department of Mining Engineering, Faculty of Industrial Technology, Universitas Muslim Indonesia, Indonesia
Correspondence e-mail: alambudiman.thamsi@umi.ac.id

ABSTRACTS

Modeling of nickel laterite resources is intended to determine the distribution of resources represented in the form of block models. The results of resource modeling indicate the shape and distribution of mineral deposits which can facilitate the mining process and can predict mining boundaries referring to the results of resource modeling. The purpose of this study was to determine the thickness of the saprolite zone layer and the distribution direction of nickel laterite based on drill point data. The data used in the laterite nickel resource modeling are exploration drill data, drill coordinates, and exploration grade classification. Data processing and analysis methods apply block modeling and the variogram method to determine the distribution direction of nickel resources. Based on the results of the cross-section profiles in Section 1 to Section 7, the average thickness of saprolite is 6,605 m, and the block model layer of saprolite which shows high levels of red color (Ni 1.9 - so on) is the most in the north, pink color (Ni 1.5-1.89) is in the north direction before the Ni 1.9 level above, the green color (Ni 1.3-1.49) is in the east and south.

© 2022 Journal of Geology & Exploration

ARTICLE INFO

Article History:
Received 17 August 2022
Revised 19 August 2022
Accepted 30 December 2022
Available 31 December 2022

Keyword:
Resources, Nickel laterite, Grade, Saprolite

INTRODUCTION

Indonesia is a country with the second largest nickel resources in the world. The value of nickel resources owned by Indonesia is 13% of the world's total nickel (Djamaluddin et al., 2022; Jafar et al., 2022). Nickel resources in Indonesia are located on the country's eastern side, namely Halmahera in North Maluku, the Sulawesi region, Gap Island, and the Waigeo Islands (Hariani, 2021). The Eastern Indonesia region, especially in the Southeast Sulawesi Region, has a high potential for nickel laterite deposits (Astuti, 2012).

Nickel laterite is a type of metallic mineral obtained through the process of chemical weathering of ultramafic rocks, which results in residual and secondary enrichment of the elements Ni, Mn, Fe, and Co. Nickel laterite has the characteristics of containing metal oxides with a reddish brown color and contains Ni and Fe (Husain et al., 2022; Nurjayanty et al., 2022). Several factors, including morphology, the rock of origin, and the degree of weathering, influence the formation of nickel laterite deposits. The high level of weathering will affect the lateritization process. The process of forming nickel laterite begins with an intensive process of weathering peridotite rock, then rainwater infiltration will seep into the rock fracture location, forming bedrock. Minerals with a high specific gravity will be on the surface, which will then experience the enrichment of the residue, such as Si, Ca, and Mg elements. Other minerals with mobile properties will dissolve to the bottom and create an accumulation zone with supergenes, such as Mn, Ni, and Co (Lintjewas et al., 2019).

Konawe Regency has a nickel ore potential of 529.9 million tons, a resource value of 460.57 million tons, and reserves of 69.3 million tons; Ni content is 0.6-2% in Puriala District, Routa District, Pondidaha District. Meanwhile, in Konawe Utara Regency, the potential for nickel is 501.8 million tons, with a resource value of 348.5 million tons and reserves of 153.3 million tons. Langgikima District, Lasolo District, Wiwirano District and Molawe District (Nursahan et al. 2013).

The stages in mapping or exploring are carried out to determine the location of nickel laterite in each area (Habibie et al., 2019; Thamsi, 2017; Thamsi et al., 2021). This mapping and exploring activity will provide data that can be used as a reference in determining the distribution pattern and thickness of nickel laterite in the area studied. In order to facilitate the calculation of resources and reserves so that details can be identified, it is necessary to determine the distribution pattern and thickness of nickel laterite. Also, these two aspects are a strong foundation for determining the modeling of nickel reserves and the mine planning stage to be carried out (Hariani, 2021).

Several previous studies have examined the distribution of laterite nickel, namely Estimating Laterite Nickel Resources Using the Inverse Distance Weighting (IDW) Method at PT Vale Indonesia, Tbk. Nuha District, South Sulawesi Province by (Mustika et al., 2015), Identification of Laterite Nickel Distribution Based on Test Pit Results in Kabaena District, Bombana Regency, Southeast Sulawesi Province by (Jafar, 2017), Effect of Bedrock and Geomorphology on Lateralization and Spread of Ni and Fe Levels in Laterite Nickel Deposits PT Tambang Bumi Sulawesi, Pongkalaero Village, Bombana Regency, Southeast Sulawesi by (Anshari et al., 2019), In previous researchers they used the Inverse Distance Weighting (IDW) method while my research entitled Laterite Nickel Spreading Studies Based on Drilling Data PT Manunggal Sarana Surya Pratama, Boenaga Konawe Village North, Southeast Sulawesi uses the variogram analysis method to determine the distribution direction and thickness of Nickel Laterite.

Our research aims to identify the distribution of nickel laterite and determine the thickness of laterite nickel ore to facilitate a deposit's further commercial exploration stage. This research was carried out at the location of the PT Manunggal Sarana Surya Pratama mining business permit in Boenaga Village, Lasolo Islands District, North Konawe Regency, Southeast Sulawesi Province.

METHODS

A few stages were carried out in this study, namely:

1. The preparation stage includes literature study, research proposal, and administration.
2. The stages of collecting data. The data comprises primary data, namely several data obtained directly from the research location in the form of core logging data of 25 samples. Also, secondary data which is also supporting data in this study is assay, collar, lithology, and survey data
3. The data processing stage is computerized with the help of mining software to process exploration drilling data at PT Manunggal Sarana Surya Pratama.
4. Data presentation stage. All data processed and analyzed is presented as a research report (thesis).

Resource Assessment

Mineral resources are mineral deposits expected to be utilized in real terms. Mineral resources with special geological beliefs can be transformed into reserves after a mine feasibility study has been carried out and meets the criteria for mine worthiness. In estimating nickel laterite resources, the following equation is applied: to calculate the tonnage in an ore body or deposit, it is required (Asy'ari, 2012):

1. Block Area (A)
2. Block Thickness(t)
3. Specific Gravity (d)
4. Content (g)

Tonnage = T x A x d

Information:

Q: The average thickness of the ore
A: Block area and
d: Specific gravity

In calculating the average thickness of the ore, the formula is applied:

$$T = \frac{1}{n}\sum_{i=1}^{n} ti$$

Information:
n: Number of drill points
ti: The thickness of the ore at the drill point.

Journal of Geology & Exploration
Vol. 1, No. 1, December 2022 : 51 – 57

In order to calculate the average grade of ore using the formula:

$$T = \frac{\sum_{i=1}^{n} v_{i.g_i}}{\sum_{i=1}^{n} v_i}$$

Information:
G: Average ore grade
gi: Grade estimate
vi: Block volume

The results of resource estimates and calculations will have different levels of confidence. The level of confidence in a calculation result and a reserve estimate is determined by:

1. Validity and completeness of insight in understanding and studying more body data. The estimation results of individuals who already understand the rules of estimation and the genesis of ore minerals will be more accurate than those of mere operators.
2. Data density (grid density) can be trusted as the main data. Data through close sampling is more accurate than remote data.
3. When deciding on assumptions and approaches to variable interpretation, it is done with full responsibility in the scientific and technical aspects (Zibuka, 2016).

The Inverse Distance Weighted (IDW) method is a type of estimation method that uses a simple block model approach and considers the surrounding points. This method assumes that the interpolated values are more similar to closely spaced sample data than distant samples. The weight will change linearly according to the distance between itself and the sample data. The location of the sample data does not affect the weight (Bargawa, 2018)

The outline of this method is as follows:

1. an estimation method in which the average point price estimate is in the form of a linear composite or a weighted average price over several drill hole data around the relevant point. Data that is closer to the estimation point will have a greater weight, while data that is farther away from the estimation point will have a lower weight. The weights are proportional to the distance of the data from the assessment point.
2. The rank options used (ID1, ID2, ID3, …) affect the estimation results. The greater the rank used, the better the results obtained (Rafsanjani, 2016).

The calculation formula for estimating a value by applying the Inverse Distance Weighted (IDW) method can be described as follows (Rafsanjani, 2016):

$$E = \frac{\sum_{i=1}^{n} \frac{x_i}{d_i^2}}{\sum_{i=1}^{n} \frac{1}{d_i^2}}$$

Information:
E: The point to be estimated
N: The amount of data used in the estimation
i: Data point
di: The weight given to the data at point i
xi: Data value at point i

RESULTS AND DISCUSSION

Cross Section Profile

The drill point incision map uses 25 drill points with the incision direction starting from east-west. With 25 drill points, seven incisions are produced.

Section 1 consists of 4-point drill bits (MAS001, MAS009, MAS010, MAS011). The drill point is located at an elevation of 199-204 MDPL. The MAS001 drill point has a borehole depth of 17 meters, a saprolite thickness of 6 meters, and a thickness of 6 meters of limonite. The MAS 009 drill point has a drill hole with a depth of 23 meters, saprolite with a thickness of 2.5 meters, and limonite with a thickness of 15.4 meters. The MAS010 drill point has a drill hole with a depth of 29.2 meters with, a saprolite thickness of 7.4 meters, and a thickness of 15 meters of limonite. The MAS011 drill point has a borehole with a depth of 20.5 meters and a saprolite thickness of 1.7 meters, and a thickness of 13 meters of limonite.

Section 2 consists of 4 drilled points (MAS002, MAS008, MAS012, MAS013). The drill point is located at an elevation of 202-223 MDPL. The MAS 002 drill point has a drill hole with a depth of 8 meters and saprolite with a thickness of 0.5 meters, and limonite with a thickness of 3 meters. The MAS

008 drill point has a drill hole with a depth of 21.7 meters, saprolite with a thickness of 0.7 meters, and limonite with a thickness of 16.6 meters. The MAS012 drill point has a drill hole with a depth of 35 meters and a saprolite thickness of 14.4 meters, and a thickness of 13 meters of limonite. The MAS 013 drill point has a drill hole with a depth of 19 meters, a saprolite thickness of 4.3 meters, and a thickness of 10 meters of limonite.

Section 3 consists of 2-point drills that are cut (MAS014, MAS016). The drill point is located at an elevation of 228-234 MDPL. The MAS014 drill point has a drill hole with a depth of 28.2 meters, a saprolite thickness of 11.4 meters, and 12 meters of limonite. The MAS 016 drill point has a drill hole with a depth of 16.2 meters and a saprolite thickness of 7.2 meters, and a thickness of 5 meters of limonite.

Section 4 consists of 6 drilled points (MAS003, MAS005, MAS006, MAS007, MAS015, MAS 017). The drill point is located at an elevation of 168-226 MDPL. The MAS003 drill point has a drill hole with a depth of 21.5 meters, a saprolite thickness of 7.4 meters, and a thickness of 8 meters of limonite. The MAS 005 drill point has a drill hole with a depth of 9 meters, a saprolite thickness of 0.5 meters, and a thickness of 2.3 meters of limonite. The MAS006 drill point has a borehole depth of 20.5 meters with a thickness of 7 meters of saprolite and 6.5 meters of limonite. The MAS 007 drill point has a borehole depth of 9.5 meters with a thickness of 1.8 meters of saprolite and 1 meter of limonite. The MAS 015 drill point has a borehole depth of 9 meters and a thickness of 3.6 meters of saprolite and 1 meter of limonite. The MAS 017 drill point has a borehole depth of 23 meters and a saprolite thickness of 13.4 meters, and a thickness of 2 meters of limonite.

Section 5 consists of 3-point drill bits (MAS004, MAS 018, MAS020). The drill point is located at an elevation of 244-246 MDPL. The MAS004 drill point has a drill hole with a depth of 28.5 meters with a thickness of 14 meters of saprolite and 6 meters of limonite. The MAS 018 drill point has a borehole depth of 22 meters with a thickness of 13.3 meters of saprolite and 1 meter of limonite. The MAS 020 drill point has a borehole depth of 18.5 meters with a thickness of 1.5 meters of saprolite and 9 meters of limonite.

Section 6 consists of 4 drilled points (MAS019, MAS 021, MAS023, MAS025). The drill point is located at an elevation of 172-249 MDPL. The MAS 019 drill point has a borehole with a depth of 17.5 meters and a saprolite thickness of 11.2 meters, and a thickness of 0 meters of limonite. The MAS021 drill point has a drill hole with a depth of 20.5 meters and a saprolite thickness of 10 meters, and a thickness of limonite of 7 meters. The MAS023 drill point has a drill hole with a depth of 12 meters and a saprolite thickness of 4.6 meters, and a thickness of 2.3 meters of limonite. The MAS025 drill point has a drill hole with a depth of 15 meters, a saprolite thickness of 3 meters, and a thickness of 6 meters of limonite.

Section 7 consists of 2-point drill bits (MAS022, MAS024). The drill point is located at an elevation of 247-250 MDPL. The MAS022 drill point has a borehole with a depth of 5.7 meters and a saprolite thickness of 0 meters, and a thickness of 2 meters of limonite. The MAS024 drill point has a drill hole with a depth of 13 meters and a saprolite thickness of 4 meters, and a thickness of 3.2 meters of limonite.

Statistical Analysis

Statistical analysis will display the quantity of the content contained in the data and outliers, which will invalidate the data when carrying out variogram analysis. In the histogram of figure (1), we can see that some data have values much higher than the average. A value that is too high can cause the variogram analysis to be invalid (Lintjewas, 2019). Therefore, this value needs to be lowered using a cutlier. The mean of the statistical results is 1.4317, and the standard deviation is 0.377; when the above equation is applied, the outlier result is 2.18.

Journal of Geology & Exploration
Vol. 1, No. 1, December 2022 : 51 – 57

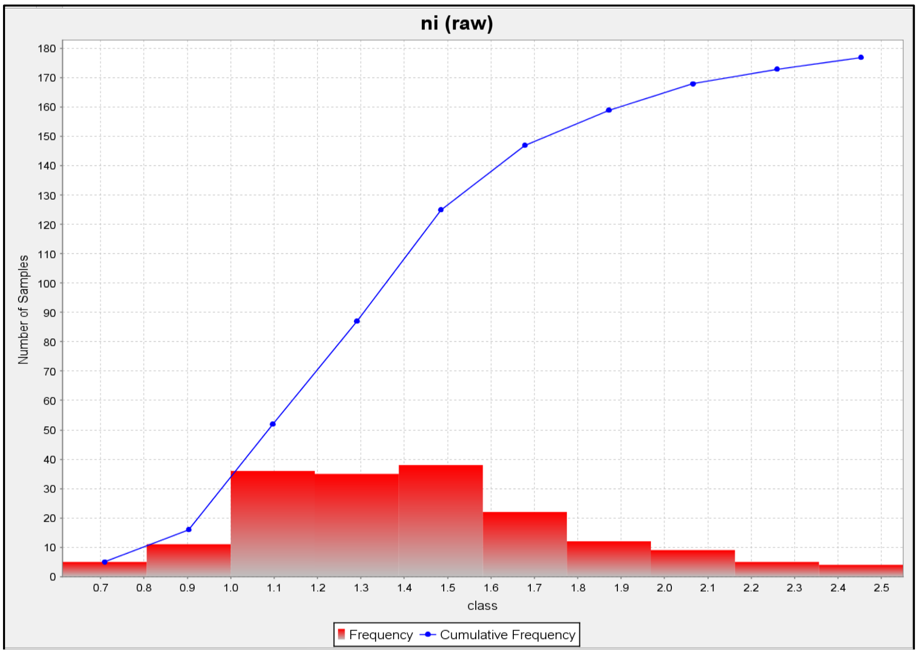

Figure 1. Outlier Histogram

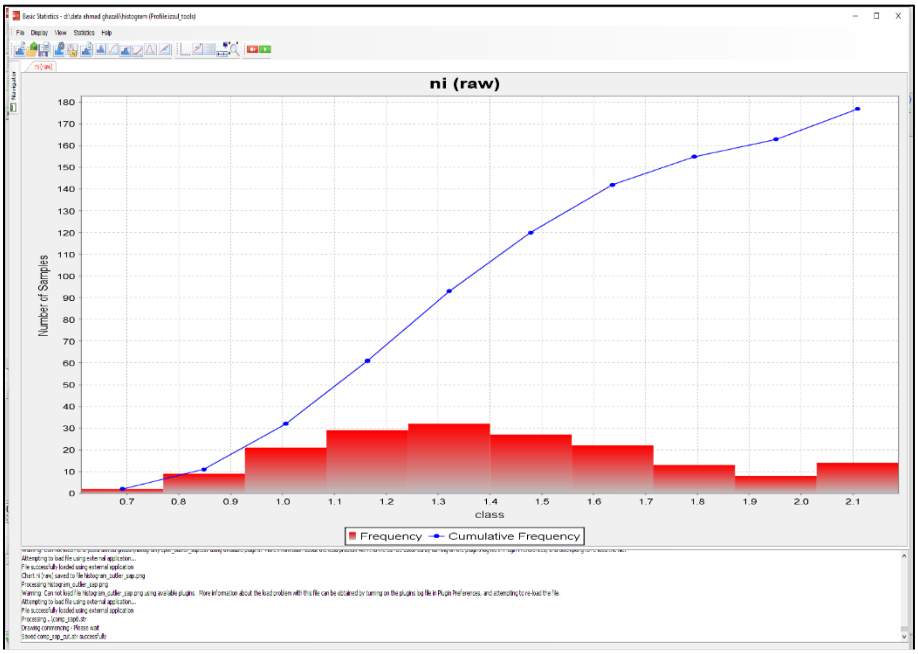

Figure 2. Cutlier Histogram

After the cutlier value is entered to eliminate outliers, the statistical results are obtained with the histogram in Figure 2. The figure above shows the histogram bar ending at 2.187, where the value can be seen from Table 1, namely the maximum value, which is the average limit for nickel content. In table 1, the lower COV results were obtained after the cutlier was carried out, which was 0.21

Journal of Geology & Exploration
Vol. 1, No. 1, December 2022 : 51 – 57

Table 1. The statistical results of the cutlier histogram

Data	Value
Minimum value	0.612
Maximum value	2.187
	Ungrouped Data
Mean	1.422
Median	1.390
Geometric Mean	1.378
Variance	0.126
Standard Deviation	0.356
Coefficient of variation	0.250

Variogram Analysis

Variogram analysis will assist in obtaining values which are the parameters for estimating. The direction of the data search carried out in this study refers to the main axis of the block (Mustika, 2015). These parameters are range, sill, nugget, major/semi-major, and minor. The range value will be used as the radius value when estimating resources, while sills and nuggets are used as differences to determine which estimate is more suitable. Make Haster and John Marek (2001) explained that if the difference between the nugget and the sill is > 50%, then the kriging method does not produce an accurate estimate. It is better to use IDW, and if the nugget is close to the sill, then the kriging estimate is the same as ordinary arithmetic, so it is more good at using polygons (Bargawa, 2018).

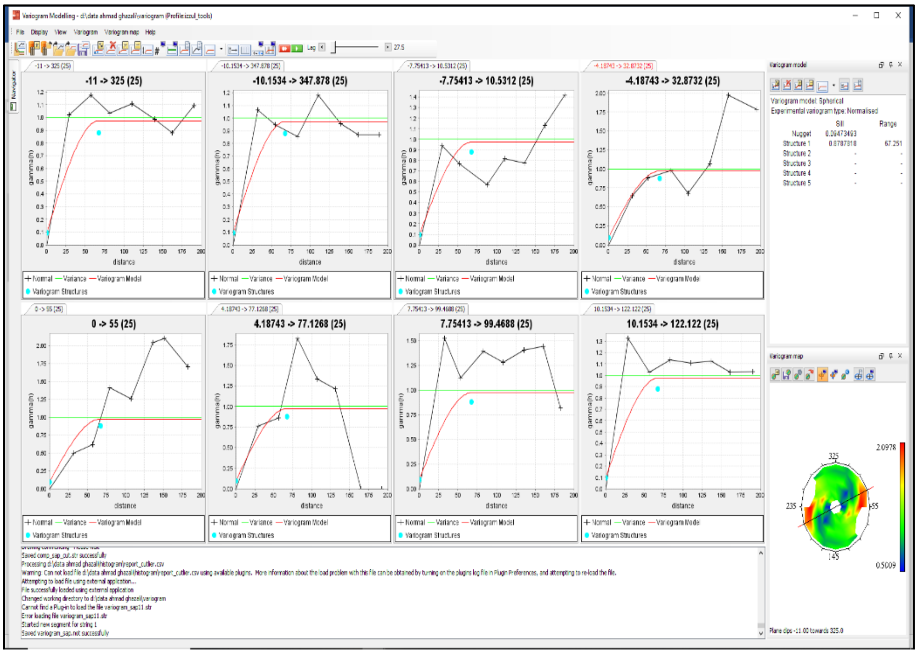

Figure 3. Variogram Model

Referring to the results of the variogram fitting that has been carried out, several parameters are obtained, namely a range value of 67.251, a sill of 0.09473493, and a nugget of 0.8787818.

CONCLUSION

Based on the results of this study, the authors conclude that:

1. Based on the cross-section profile results in Section 1 to Section 7, it can be seen that in Section 1, the saprolite thickness ranges from 7 to 22 meters. Section 2 saprolite thickness ranges from 5 to 32 meters. Section 3 saprolite thickness ranges from 4 to 27 meters. Section 4 saprolite thickness ranges from 5 to 20 meters. Section 5 saprolite thickness ranges from 9 to 10 meters. Section 6 saprolite thickness ranges from 7 to 19 meters. Section 7 saprolite thickness ranges from 6 to 10 meters. The average thickness of saprolite is 6605 m.

2. The results of the variogram fitting process show the direction shown from the variogram model, which shows the direction from southwest to northeast.

ACKNOWLEDGMENT
We thank you very much to:
1. Mr. Dian, the head of the Exploration Division, has given research permission.
2. Brother Bambang Suharwanto, S.T., is the supervisor and person in charge of the field.
3. Brother Mochamad Arif, S.T., is the supervisor and person in charge of the field.

REFERENCE

Anshari, Erwin, and Tri Binajaya Rezky. (2019). Pengaruh Batuan Dasar dan Geomorfologi Terhadap Laterisasi dan Penyebaran Kadar Ni Dan Fe Pada Endapan Nikel Laterit PT. Tambang Bumi Sulawesi, Desa Pongkalaero, Kabupaten Bombana, Sulawesi Tenggara. Jurnal Geografi Aplikasi dan Teknologi, 3(1): 47–58.

Astuti, W., 2012, Pembuatan *Nickel Pig Iron* (NPI) Dari Bijih Nikel Laterit Indonesia Menggunakan *Mini Blast Furnace, Prosiding Insinas*, hal. 66-71.

Asy'ari, M. A. (2012). Geologi dan Estimasi Sumber daya Nikel laterit dengan metode IDW (Inverse Distance Weight) dan Kriging pada Daerah bahodopi Kabupaten Morowali Propinsi Sulawesi Tengah. Jurnal Intekna: Yogyakarta.

Bargawa, W. S. (2018). Edisi Kedelapan Perencanaan Tambang. Yogyakarta: Kilau Book.

Djamaluddin, D., Mulhadramy, M., & Jafar, N. (2022). Comparative Analysis of Mined Reserve Tonnage on "M" Hill Between Mine Plan and Mining Realization. *Journal of Geology and Exploration*, *1*(1), 22–29. https://doi.org/10.58227/JGE.V1I1.6

Habibie, A., Widodo, S., Alim, M. N., Umar, E. P., Lantara, D., Nurwaskito, A., & Thamsi, A. B. (2019). Analisis Losses pada Pemindahan Material LGSO di Front Penambangan. *Jurnal Geomine*, *7*(3), 212–218. https://doi.org/10.33536/jg.v7i3.295

Husain, J. R., Normansyah, N., & Bakri, H. (2022). Structure Control of Iron Ore Education on Sebuku Island. *Journal of Geology and Exploration*, *1*(1), 8–12. https://doi.org/10.58227/JGE.V1I1.2

Hariani, Fadli. 2021. Hubungan Pola Penyebaran Dan Ketebalan Zona Bijih Endapan Nikel. Indonesian Journal Of Earth Sciences. 01(1): 10–16.

Jafar, Nurliah. (2017). Identifikasi Sebaran Nikel Laterit Berdasarkan Hasil Test Pit Kecamatan Kabaena Kabupaten Bombana Provinsi Sulawesi Tenggara. Jurnal Geomine, 5(2): 94–99.

Jafar, N., Wahid R, H., & Widodo, S. (2022). Classification of Ni Levels for Determination Cut-Off Grade in Region X. *Journal of Geology and Exploration*, *1*(1), 1–7. https://doi.org/10.58227/JGE.V1I1.3

Lintjewas, Lediyantje *et al.* 2019. Profil Endapan Nikel Laterit Di Daerah Palangga , Provinsi Sulawesi Tenggara *Profile Of Nickel Laterite Deposit In Palangga*. Jurnal Riset Geologi dan Pertambangan. 29(1): 27–34.

Mustika, Rima *et al.* (2015). Estimasi Sumberdaya Nikel Laterit Dengan Metode *Inverse Distance Weighting* (IDW) Pada PT Vale Indonesia, Tbk. Kecamatan Nuha Provinsi Sulawesi Selatan. Jurnal Geomine. 01(April): 63–68.

Nursahan, Iwan, Vijaya Isnania Wardhani, and Nana Sulaksana. 2013. Penentuan Kawasan Pertambangan Berbasis Sektor Komoditas Unggulan Sumberdaya Nikel Kabupaten Konawe Dan Konawe Utara Provinsi Sulawesi Tenggara. *Buletin Sumber Daya Geologi* 8(2): 1–13.

Nurjayanty, Y., Djamaluddin, D., & Budiman, A. A. (2022). Block Model of Laterite Nickel Reserve in the Sorowako Village Research Area, South Sulawesi Province. *Journal of Geology and Exploration*, *1*(1), 18–21. https://doi.org/10.58227/JGE.V1I1.5

Rafsanjani, M. R. (2016). Estimasi Sumber daya Bijih Nikel Laterit Dengan Menggunakan Metode IDW Di Provinsi Sulawesi Tenggara. Jurnal Geomine, 4(1).

Thamsi, A. B. (2017). Estimasi Cadangan Terukur Endapan Nikel Laterit Cog 2,0% Menggunakan Metode Inverse Distance Pada Pt. Teknik Alum Service, Blok X. *Jurnal Geomine*, *4*(3), 128–130. https://doi.org/10.33536/jg.v4i3.77

Thamsi, A. B., Jafar, N., & Fauzie, A. (2021). Analisis Pengaruh Morfologi Pada Pembentukan Nikel Laterit PT Prima Sentosa Alam Lestari Kabupaten Morowali Provinsi Sulawesi Tengah. *Jurnal GEOSAPTA*, *7*(2), 75–78. https://doi.org/10.20527/jg.v7i2.9114

Zibuka, M. I. (2016). Estimasi Sumber daya Nikel Laterit Dengan Membandingkan Metode Nearest Neighbour Point Dan Inverse Distance Weighting. Jurnal Geomine, 4(1).