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Interpretation Of Nickel Mineral Distribution Using Geomagnet Method

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ABSTRACT: *One area of North Morowali Regency that is suspected of having the potential for nickel minerals is the Tambale region, Mamosalato District. Based on the geological map, rock lithology in the Tambale region is an ultramafic igneous rock (serpentinite, harzburgite, dunite) with a mafic group (gabbro, basalt, diorite). This ultramafic frozen rock is a bedrock carrying nickel minerals. Objective: This study aims to interpret the distribution of nickel minerals based on the distribution of the carrier susceptibility of rocks, using geomagnetic inversion data modeling, in Tambale Village, Mamosalato District, North Morowali Regency. Research method: Identification of the presence of nickel minerals was carried out using the geomagnetic method that utilizes the susceptibility of rock magnetic properties. The susceptibility value is modeled by inversion modeling in 3D using the MAG3D software. Results: The susceptibility of nickel mineral carrier rocks at the study site was interpreted between 0.07540 SI to 0.16336 SI. The susceptibility is a response from ultramafic rocks, namely peridotite, dunite and serpentine rocks. Conclusion: identification of nickel distribution based on rock susceptibility values is located in the south to north and tends to spread to the east of the study location with an average depth of approximately 60 meters below the ground surface. Suggestion: To obtain more complete information, regarding the structure of the laterite layers, it is recommended to conduct a geophysical investigation using the Electrical Resistivity Tomography method. In addition, it is necessary to measure the rock susceptibility in the laboratory to see the mineral content.*

Keywords:- *Nickel, Geomagnet, Susceptibility*

I. INTRODUCTION

Central Sulawesi Province has natural resources of minerals, including industrial metal minerals, building materials and fossil fuels, namely coal and oil. Group A (strategic) is excavated materials, namely oil and natural gas, coal and nickel. Group B (vital) minerals are such as gold, molybdenum, chromite, copper and sulfur. Group C is excavated material (not strategic and vital) includes sand-rock-gravel, granite, marble, quartz sand, iron sand, and clay. For the Central Sulawesi Province, Morowali Regency is one of the nickel mining areas, with an area of around 149,700 ha with an estimated reserve of 8,000,000 (WMT) Wet Metric Ton[1].

The formation of laterite nickel begins with the weathering process of ultramafic rocks (peridotite, dunite, serpentinite). These rocks contain lots of olivine, pyroxene, magnesium silicate and iron silicate minerals. These minerals are unstable and easily undergo weathering processes, which generally contain 0.30% nickel. In the further weathering process, magnesium (Mg), silica (Si), and nickel (Ni) will be left in the solution as long as the water is still acidic. But if it is neutralized because of the reaction with rocks and soil, these substances will tend to settle as hydrosilicate minerals (nickel-magnesium hydrosilicate) which are called garnerite minerals (Ni, Mg) 6Si4O10 (OH) 8 or nickel-carrying minerals[2].

Each type of rock has certain properties and characteristics in the magnetic field that are manifested in the magnetic susceptibility parameters of rocks or minerals. Rock magnetic susceptibility is the magnetic level of a magnet for magnetization. Rock magnetic susceptibility is closely related to the constituent mineral content of rocks. Rock magnet susceptibility influences the magnitude of the magnetic intensity of the rock. The influence can be illustrated by the following equation

$I = kH$

The value of k in the rocks is greater if there are a lot of magnetic minerals are found in the rock[3]. Rock magnetic properties susceptibility describes the behavior of rocks that are under the influence of magnetic fields. The magnetic properties of rock forming material are divided into 5, namely: diamagnetic, paramagnetic, ferromagnetic, antiferromagnetic, and ferrimagnetic.

The magnetic or geomagnetic method is the oldest geophysical method used in detecting magnetic minerals, especially magnetite[4]. This method is the most commonly used method in gold exploration, or exploration for other metals of nickel[5]. The geomagnetic method is performed based on anomalous measurements resulting from differences in contrast of rock magnetic susceptibility under the surface [6];[7]. The difference in relative susceptibility is attributed to the difference in distribution of ferromagnetic, paramagnetic and diamagnetic minerals. The nickel-carrying bedrock mineral is ferromagnetic, so the laterite nickel which is the result of weathering is basically ferromagnetic. Due to this ferromagnetic property, nickel can be detected using geomagnetic method.

II. RESEARCH METODHS

Research using geomagnetic method was conducted in Tambale Village, Mamosalato District, North Morowali District, Central Sulawesi Province. The tools used in this research include: Proton Precision Magnetometer (PPM) 19T GSM brand, Geological compass, Global Positioning system (GPS), Surfer 13 Software, Numeri, Transcor V1.0, MAG3D.

Measurement data in the field was made by intensity magnetic field data based on position and time consisting of base station data and mobile station data. Magnetic field anomaly modeling used MAG3D software to obtain nickel distribution.

III. RESULTS

Total magnetic anomaly (ΔH) was obtained by reducing the measured magnetic field (Hobs) with daily variation correction (Hvh) and IGRF correction (HIGRF). Correction of daily variations (diurnal correction) is to eliminate the effects of external magnetic field measurements by the instrument due to the sun activity that is sunspots that can cause solar storms that affect the earth's magnetic field[8]; [9]. Whereas IGRF correction aims to eliminate the influence of the Earth's main magnetic field [6]. IGRF or International Geomagnetic References Field values were obtained from the results of international agreements based on mathematical models of the Earth's main magnetic field[10];[11]. The following figure shows the result of the distribution of the total magnetic field anomalies (Figure 1).

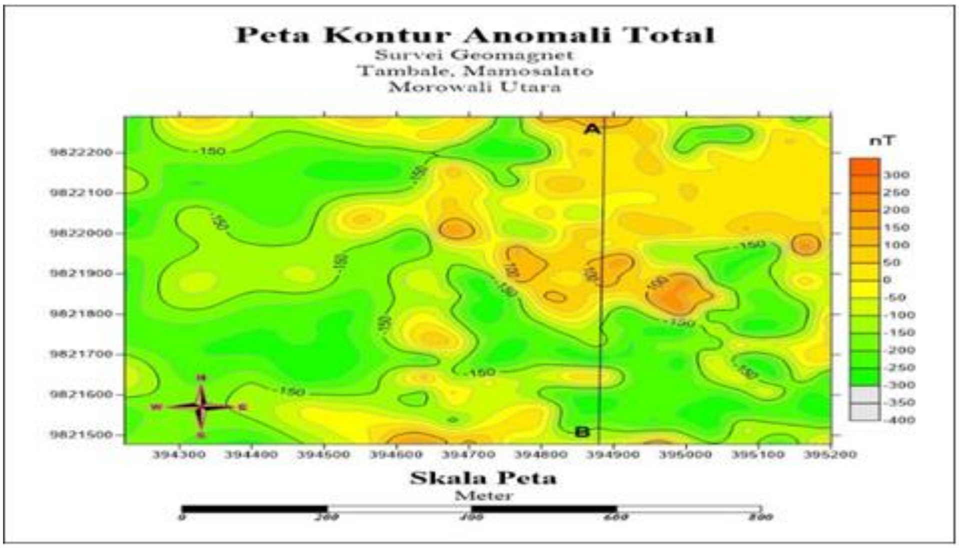

Figure 1. Anomaly distribution of total magnetic fields

A-B line was made based on the assumption that magnetic anomalies of nickel mineral carriers were at positive and large anomalous values. Positive anomaly values were shown with yellowish red parameters. The A-B line was used to calculate the window size (N) as a moving average filter to obtain regional anomalous contours. The results of the Window size using the software number was 4,629401645 ≈ 5. Furthermore, a moving average filter is calculated with the value N = 5 using surfer 13 software. Then, it was obtained regional magnetic anomaly contours (Figure 2). The value of residual magnetic anomaly was obtained by subtracting total magnetic anomaly with regional magnetic anomalies. The residual anomaly contour response is shown in Figure 3.

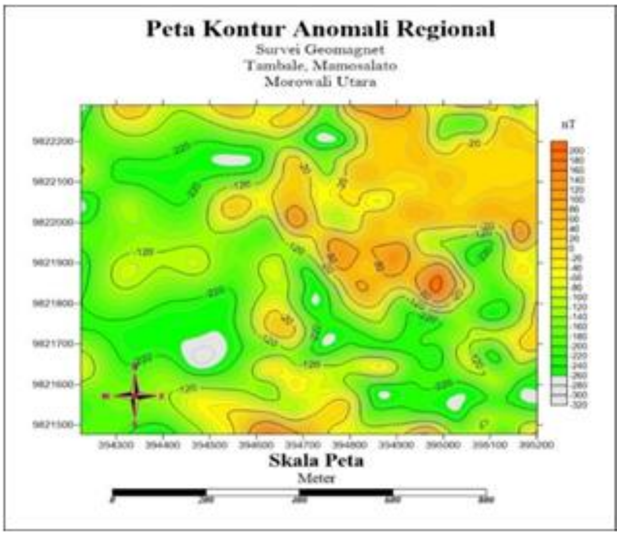

Figure 2. Regional Anomaly Contour Map

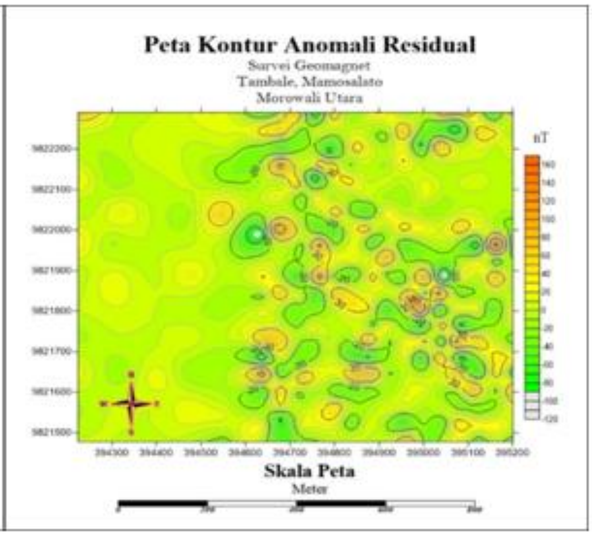

Figure 3. Residual Anomaly Contour Map

The process of modeling rock susceptibility in the location of the study was carried out using MAG3D software. The data input was the residual magnetic anomaly value and topography of the research location measurement point. The distribution of rock susceptibility at the study site obtained from the modeling results is shown in Figure 4.

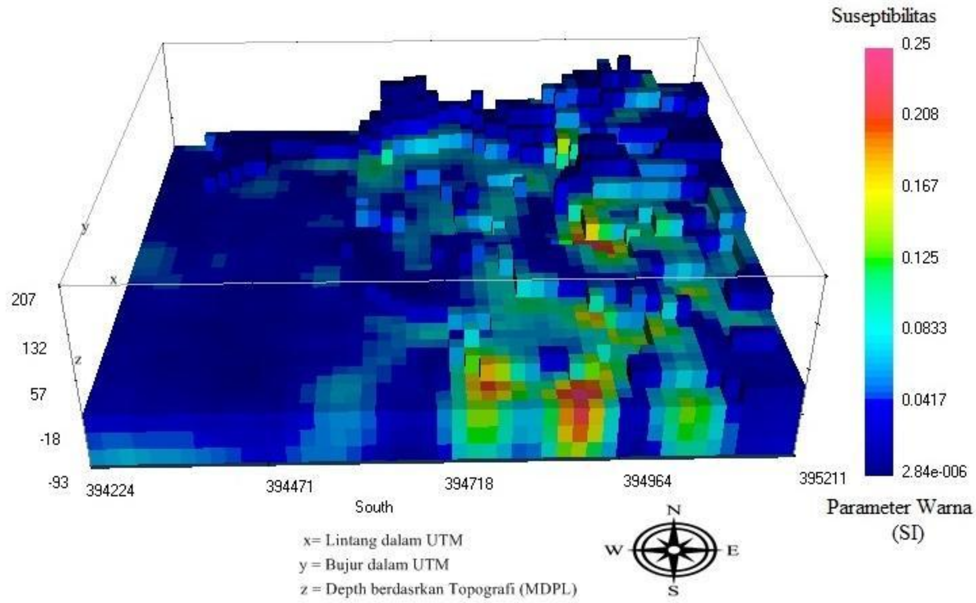

Figure 4. The distribution of rock susceptibility model in the study area.

The contrast of susceptibility values in Figure 4 shows an indication of ferromagnetic rocks at the study site. Ferromagnetic rocks are bedrock in the process of forming nickel mineral deposits. Based on the rock susceptibility response in the study location, the distribution of rock susceptibility is grouped based on the value of susceptibility of rocks and minerals in Table 1. The susceptibility of rocks and minerals was thought to be in the research location. This was supported by the geological conditions in Figure 5 namely ultramafic rock formations, mafic and alluvium rock groups.

Table 1. Rock Suseptibility Value

Batuan & Mineral	Suseptibilitas (SI)
Ilmenite	1,88500
Pyrrotite	1,57080
Peridotite	0,16336
Serpentine	0,14000
Dunit	0,08700
Gabro	0,07540
Basalt	0,07540
Porpiri	0,06283
Limonit	0,00276
Hematit	0,00691
Clay	0,00025

Sumber: Telford,1990

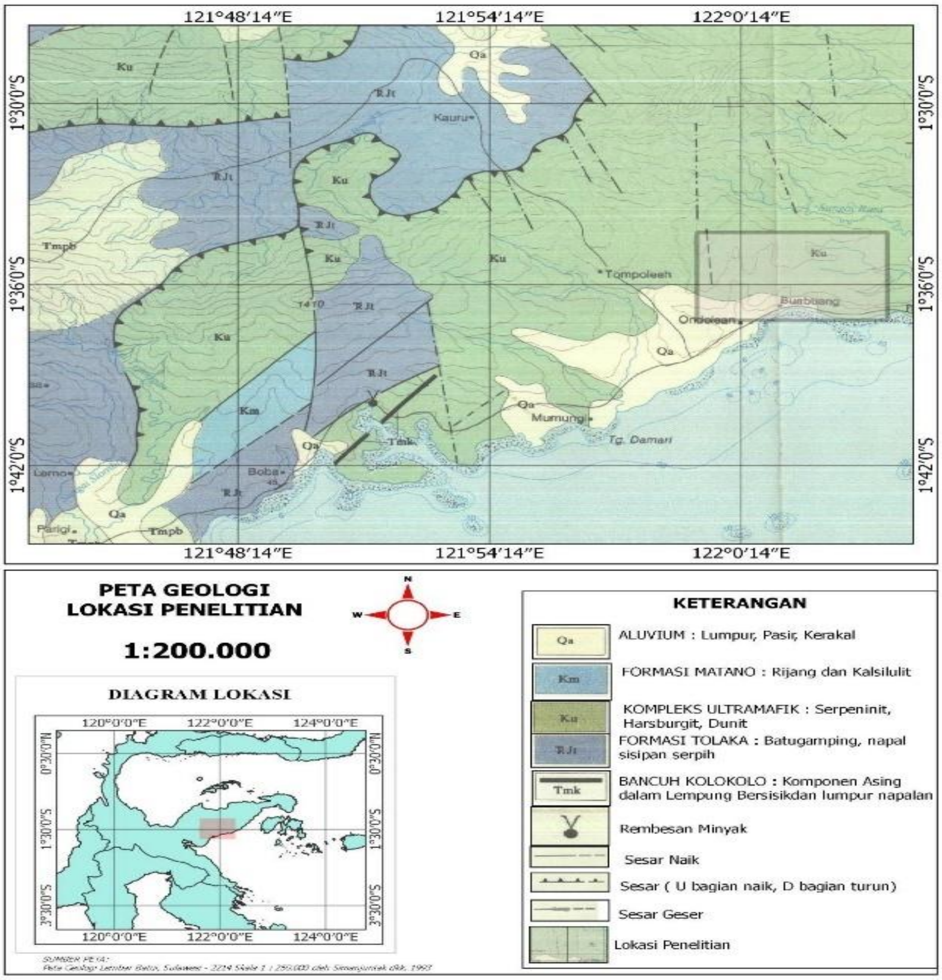

Figure 5. Geological Map of Research Location

The distribution of rock susceptibility in the study location is divided into 3 based on the susceptibility value. 1). The distribution of rocks with rock susceptibility values> 0.16336 SI is shown in Figure 6. The distribution of this susceptibility is thought to be rock with ferromagnesium minerals, namely pyrrhotite and ilmenite minerals. The random distribution of rock susceptibility was only found in the north and south which tended to the east of the study site. 2). The distribution of rocks with susceptibility values ranging from 0.07540 SI to 0.16336 SI shown by Figure 7 is thought to be a response to peridotite, dunite and serpentine rocks. The distribution of the susceptibility of these rocks was in the south to the north which tended to the east of the research location and was found in the western part. 3). The distribution of rocks with susceptibility values of <0.07540 SI is shown in Figure 8. This susceptibility is thought to be a response from mafic rocks namely gabbro, basalt, diabase and porphyria, and sedimentary rocks in the form of clay and gravel. In general, the distribution covers all research locations.

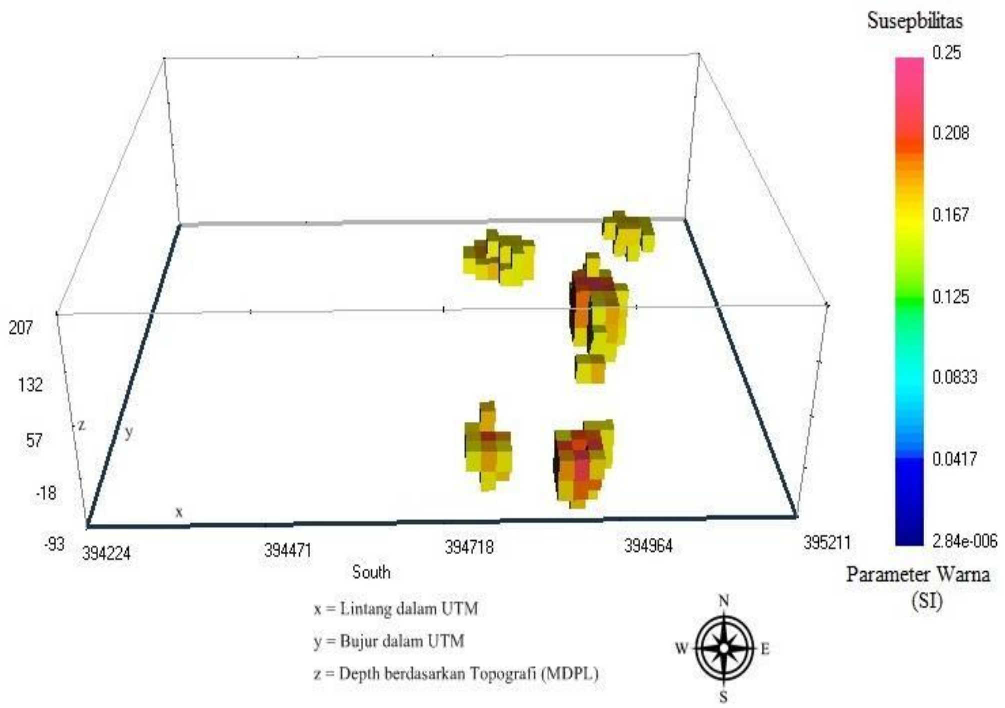

Figure 6. Distribution of rocks with susceptibility values >0.16336 SI

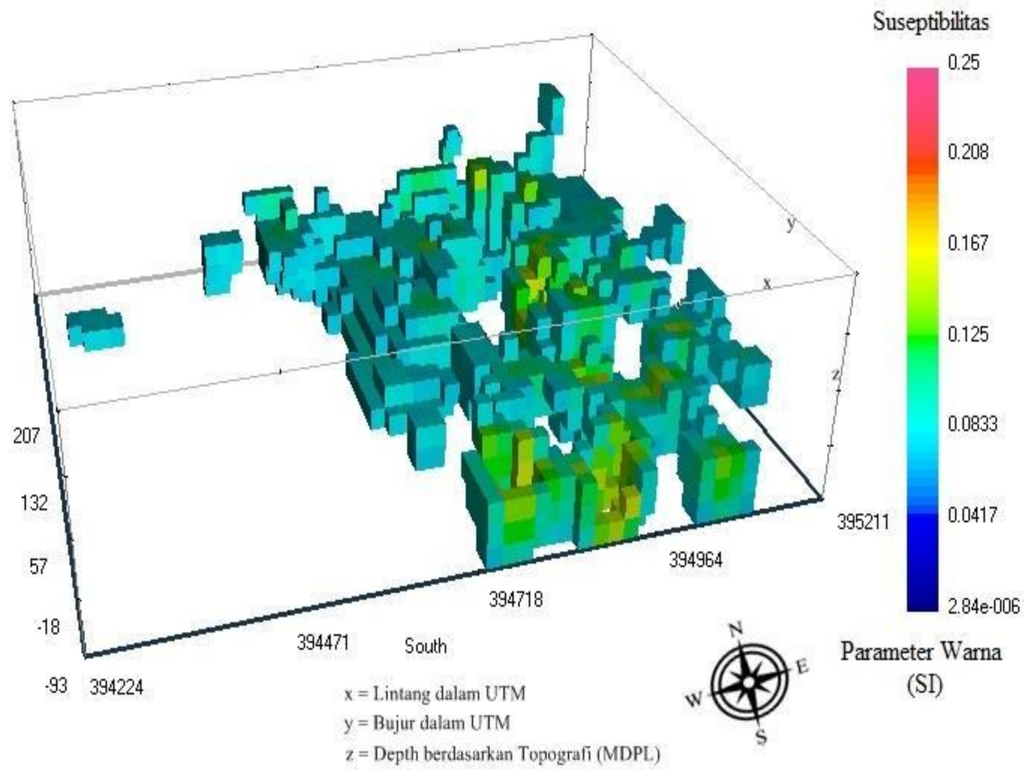

Figure 7. Distribution of rocks with susceptibility values ranging from 0.07540 SI to 0.16336 SI

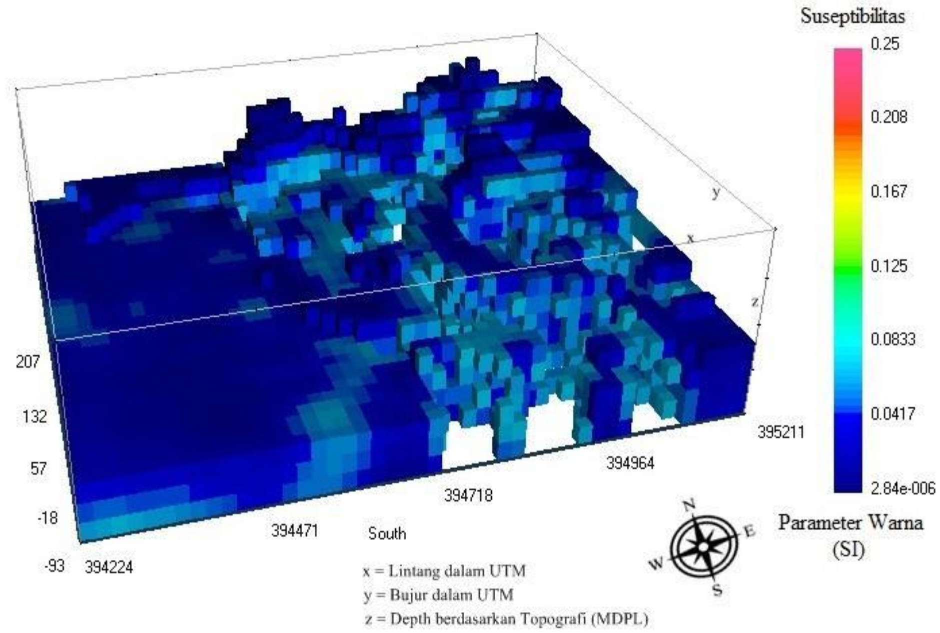

Figure 8. Distribution of rocks with susceptibility values <0.07540 SI

IV. DISCUSSIONS

The process of forming nickel minerals starts from weathering of ultramafic rocks as host rocks, which generally contain 0.30% nickel [2]. This host rock will turn into serpentine peridotite rock due to the serpentinization process. In the process of serpentinization, the host rock does not undergo overall weathering, only less stable minerals that experience weathering. These minerals include olivine, pyroxene, magnesium iron and silicate. During the decomposition and laterization process the less stable minerals, nickel minerals are seen as oxide and hydroxide minerals, such as limonite, hematite and goethite [12].

Interpretation of the distribution of nickel minerals in this study was carried out by analyzing the distribution of the susceptibility values of the carrier rocks. The response of the susceptibility of rocks at the study site was very varied, but the dominant susceptibility response is shown in Figure 8. The distribution of the susceptibility is thought to be mafic rocks and the results of weathering of ultramafic rocks, in the form of clay and gravel. The minerals contained in these rocks were hydroxide minerals namely limonite and hematite minerals which contain high iron minerals.

The distribution of rock susceptibility in Figure 7 is interpreted as a rock with a high nickel mineral content. This rock susceptibility is thought to be peridotite, dunite and serpentine rocks. Peridotite and dunite rocks are ultramafic rocks which contain a lot of olivine and pyroxene minerals. These minerals are unstable and easily experience weathering. Serpentine rock is a metamorphic rock that results from weathering of ultramafic rocks which contain a lot of magnesium silicate minerals, and iron oxide [13]. Peridotite, serpentine is a serpentinized rock in which nickel minerals are deposited with silicate minerals and iron oxides [2]. These minerals settle below the limonite horizone zone, the zone of saprolite horizone. Saprolite horizone is a zone of laterite with an iron content of 10% and nickel of >2% [14]. Laterite zone under saprolite horizone is the zone of the host rock (harzburgite). In this zone, the nickel content is very low but the iron content is very high, because this zone is a zone of residual rock that has no weathering (Figure 6). Based on the amount of nickel mineral content in rocks and the response of rock susceptibility, Figure 7 is interpreted as the distribution of the susceptibility of nickel mineral carrier rocks at the study site.

The depth of the susceptibility of nickel mineral rock (Figure 7) is very varied. This is influenced by the topography of the study site. [13] stated that the slope greatly affects the chemical and mechanical weathering processes of laterite. This chemical and aquatic process greatly affects the content of nickel and iron in the mineral laterization process in rocks. For areas in the study area with relatively sloping topography, the depth of rock susceptibility was found at shallow depths. The shallow depth was in the western and southern part of the research location, with depths ranging from 30 meters to 60 meters below the ground surface. The distribution of rock susceptibility carrying mineral particles at deep depths could be seen in the middle and east of the research location with a depth of about 90 meters below the ground surface. The average depth of rock carrying nickel minerals was around 60 meters below the ground surface.

There are similar studies regarding nickel minerals, for example a study by [15]. The research conducted was the modeling of Resistivity and magnetic IP data to localize laterite nickel deposits in the Southeast Sulawesi LTD region. Magnetic data was used to see the type and characteristics of the material based on its susceptibility response, while the IP Resistivity data was used to describe the zone of mineralization based on its resistivity characteristics. Another study was conducted by [16]. It was a study of geoelectric surveys of the resistivity method for interpretation of bedrock depth in Pakal Island, East Halmahera. The results showed that the minimum bedrock layer was 10 meters and the maximum bedrock layer was at a depth of 56 meters above ground level. In addition to the bedrock, other results obtained were the estimated thickness of the laterite layer, the saprolite layer. The thickness of the saprolite layer obtained ranged from 6-26 meters and 34-56 meters.

The study used the geomagnetic method with inversion modeling techniques performed, describing the pattern of distribution of nickel mineral carrier rocks based on the characteristics of their rock susceptibility. The depth of the nickel mineral carrier rock obtained from this study was about 60 meters below the ground surface. This depth was not depth based on the lateral zone, but the depth of the rock with susceptibility response which was thought to be a nickel mineral carrier rock. Therefore, this research can be used as a guide in further detailed research for exploration.

4.1 Interpretation of Nickel Mineral Carrier Distribution

Interpretation of the distribution of nickel minerals was done by modeling the distribution of the carrying rocks, namely at the interval of susceptibility of 0.07540 SI - 0.16336 SI (Figure 7). Interpretation of the distribution and the depth of nickel mineral rock are shown in Figure 9 - Figure 11.

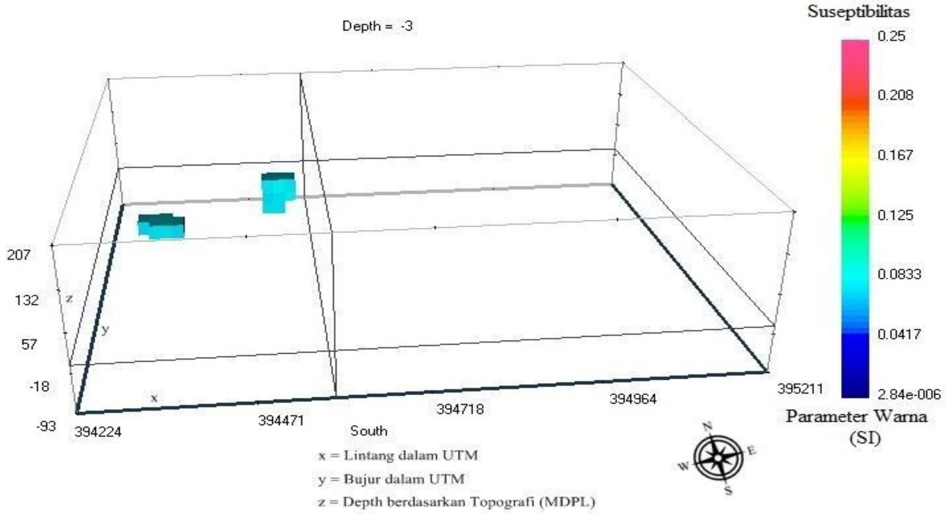

Figure 9. Distribution of nickel mineral carrier rocks part 1

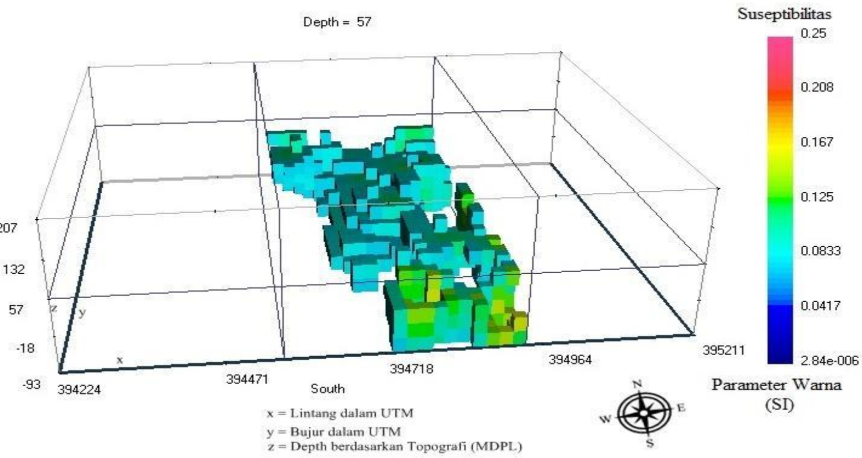

Figure 10. Distribution of nickel mineral carrier rocks part 2.

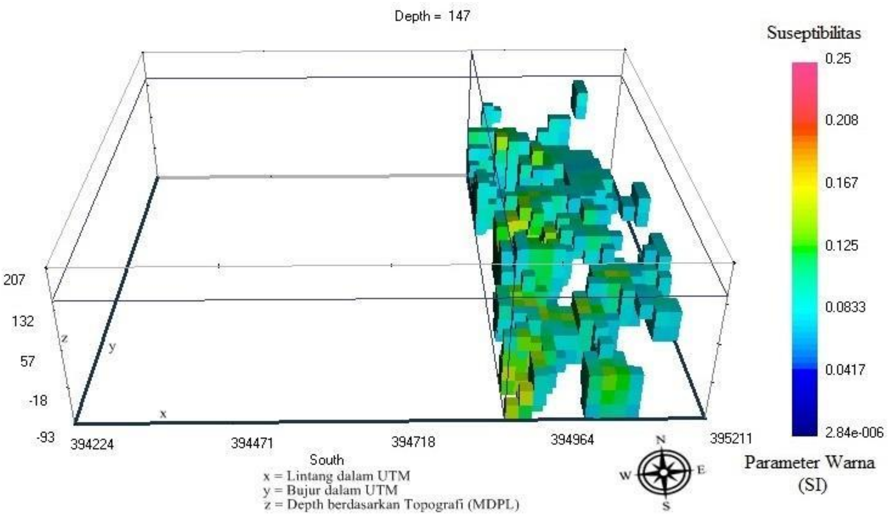

Figure 11. Distribution of nickel mineral carrier rocks part 3.

The distribution of nickel mineral carrier rock of part 1 (Figure 9) shows that the rock distribution was only a little and tended to the north of the study site. For distribution in part 2 (Figure 10), the distribution of the rock decreases to the south of the research location. While the distribution in part 3 (Figure 11) the distribution of rocks tended to spread to the east of the research location. The depth of distribution of nickel mineral carrier rocks was interpreted based on the rock susceptibility model obtained. The depth of the model was based on the topography of the research location with reference to the MDL unit. Interpretation of the depth of the distribution of nickel mineral carrier rocks in this study as a reference was dmt, so that the depth was obtained by looking at the difference between the upper and lower surface of the model. The depth of nickel mineral carrier rocks in each part of the study location is shown in Table 2.

Table 2 Interpretation of the distribution of nickel mineral rocks

Interval Suseptibilitas SI	***Batuan/ Mineral***	***Bagian***	***Permukaan (Meter) Atas***	***Permukaan (Meter) Bawah***	***Interpretasi Kedalaman (Meter)***	***Sebaran***
0.07540-0.16336	*Peridotite, Dunit/ Olivin Piroksen Serpentine Fe-oxida Mg-silikat*	1	27	-3	30	*Barat-Utara*
			-3	-63	60	
		2	147	57	90	*Tengah*
			27	-33	60	
		3	177	147	30	*Selatan-Timur*
			27	-63	90	
			rata-rata		60	

V. CONCLUSION AND SUGGESTIONS

Based on the results of research conducted in Tambale Village, using geomagnetic inversion data, it was concluded that the susceptibility of nickel mineral carrier rocks was between 0.07540 SI to 0.16336 SI. This susceptibility is thought to be ultramafic rocks, namely peridotite and dunite and metamorphic rocks, namely serpentine. The distribution of susceptibility was in the south to the north and tended to spread to the east of the study location with an average depth of approximately 60 meters below the ground surface. To obtain more complete information, regarding the structure of the laterite layers, it is recommended to conduct a geophysical investigation using the Electrical Resistivity Tomography method and measure rock susceptibility in the laboratory to see the mineral content.

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