# CORRELATION DEGREE SERPENTINIZATION OF SOURCE ROCK TO LATERITE NICKEL VALUE THE SAPROLITE ZONE IN PB 5, KONAWE REGENCY, SOUTHEAST SULAWESI

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**ABSTRACT**

The PB5 study area, Konawe district, Southeast Sulawesi is a mining area included in the IUP of PT Sulawesi Cahaya Mineral which is dominated by serpentinized ultramafic rocks. Geological mapping, drilling data, petrographic analysis, X-Ray Fluorescence (XRF), and magnetic susceptibility are used to identify the characteristics of serpentine minerals, characteristics of serpentinization levels, and the correlation of serpentinization levels to nickel laterite levels in the study area. The serpentine mineral types in the study area are lizardite, chrysotile, and antigorite resulting from the alteration of olivine and pyroxene minerals. Lizardite is characterized by mesh, bastite, and hourglass textures. Chrysotile is characterized by filamentous textures and antigorite is characterized by interpenetrating and interlocking textures. The serpentined rocks are predominantly low serpentine with the mesh and bastite textures of the lizardite characterizing the early mineral alteration processes of olivine and pyroxene. Antigorite begins to be present in rocks that experience medium-high serpentinization levels and indicates that antigorite is the result of a high-intensity serpentinization process. The serpentinization level of the study area is divided into 3 (three) types, namely (1) low serpentinization characterized by the serpentine distribution of 0%-39%, LOI <7%, and magnetic value of $0^o$-$5^o$, (2) medium serpentinization with the serpentine distribution of 40%-59%, LOI 7-10%, and magnetism value of $5^o$-$10^o$, and (3) high serpentinization characterized by the distribution of 60%-100%, LOI >10%, and magnetism value >$10^o$. Rocks that experience low serpentinization and medium serpentinization levels have a fairly good nickel content development with Ni concentration factors of 5.13 units and 4.34 units. While rocks that experience a high level of serpentinization have poor nickel development with a Ni concentration factor of 2.43 ppm.

Keywords: serpentinization, nickel laterite, ultramafic, grade nickel.

## INTRODUCTION

The demand for nickel is increasing every year, so there are many geological studies related to nickel (e.g. Lintjewas, et al., 2019; Sufriadin, et al., 2009). Nickel is an ultramafic rock weathering residue containing ferromagnesian compounds (Fe and Mg). The nickel laterite formation process occurs due to weathering of rocks caused by the rise and fall of groundwater levels that last millions of years. One of the factors that cause the lateralizing process is the mineral serpentine, the result of the serpentinization process that altered ferromagnesian-rich minerals such as olivine and pyroxene. The serpentinization process which altered ultramafic rocks has an influence on laterite formation, namely the addition of $H_2O$ compounds to olivine and pyroxene minerals that will form water crystals so that it will make weathering relatively more massive. In the serpentinized ultramafic rocks, the resulting saprolite is more cohesive, generally, yellowish green in color, the boundary between the limonite and saprolite zones is generally easier to distinguish and rarely contains boulders, if any, they still tend to contain high nickel content.

The focus of this research is to identify the correlation between serpentinization and nickel grades in the hope that the host rock and distribution of nickel-containing high grades can be identified, thus helping to determine which areas have more potential for detailed exploration.

## GEOLOGICAL SETTING

The study area is included in the Regional Geological Map of Lasusua Sheet and Bungku Sheet (Rusmana et al., 1993), consisting of KU formation in the form of Ophiolite, (Figure 1). consists of lherzolite, harzburgite, wherlit, dunite, serpentinite, websterite, diabase, and gabbro of Cretaceous age. Based on the results of geological mapping that has been carried out, the study area consists of two rock units, namely, the serpentinized



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harzburgite unit and the serpentinized dunite.

The regional geological structure of the study area is the result of the collision of active continental margins so that tectonic movements occur repeatedly. The geological structures found in this area are in the form of faults and fractures. Faults and alignments in this area generally have a northwest-southeast direction in line with the active Lasolo Left Horizontal Fault. In addition, there is the Anggowala Right Horizontal Fault which has a relative northwest-southeast direction. Fractures are found in all rock types. Fractures in igneous rocks generally show irregular directions. Matano Fault is the main fault in a northwest-southeast direction. This fault shows movement and is thought to be connected to the Sorong Fault. Both are strike-slip fault systems that may have formed since the Oligocene.

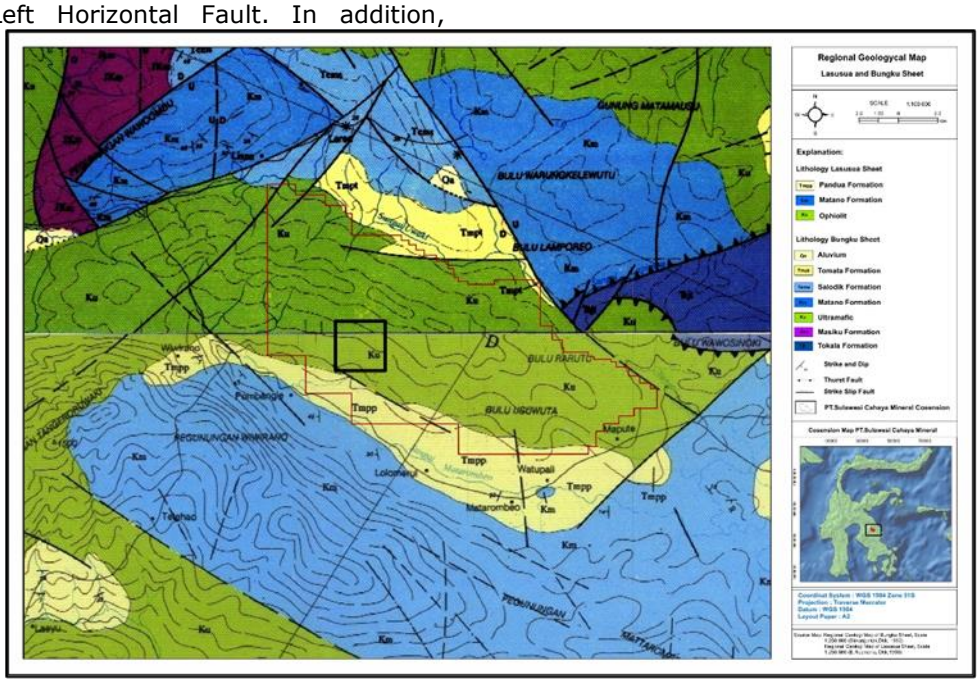


Figure 1. Regional Geological Map of Lasusua Sheet (Bottom) and Bungku Sheet (Top) (Rusmana, et al., 1993).

## RESEARCH METHOD

The object of the research is ultramafic rock (result from geological surface mapping and subsurface/drilling), including mineral alteration, nickel laterite, and geochemistry. The observation of the geological field has been done for about three months in northwest Sulawesi. As a result of this activity, selected samples were taken to do the next laboratory, such as petrographic and geochemistry analysis.

Thirty-five samples were taken from both surface and subsurface samples to do petrographic, and twenty-two samples were chosen for geochemical analysis (X-Ray Diffraction and magnetic susceptibility). All of these have been done to identify texture, mineral composition (primary and secondary mineral), host rocks of nickel laterite, the composition of oxide elements and nickel grade, and distribution of nickel grade.

## RESULT AND DISCUSSION

The results of petrographic analyses show that there are 3 types of rocks in the study area, namely: harzburgite, dunites, and serpentinite. The serpentine mineral is an alteration of olivine and pyroxene minerals or an alteration of the serpentine mineral itself. Based on the petrographic analysis, the identified serpentine minerals are lizardite, chrysotile, and antigorite. Lizardite can be found in all rock samples characterized by mesh, hourglass, and bastite textures. Chrysotile is characterized by a vein texture with a fibrous, parallel appearance, and may result from the replacement of lizardite in the bastite texture. Antigorite can be characterized by interpenetrating and interlocking textures. In general, the three different forms of serpentine minerals tend to have similar optical qualities; nevertheless, each serpentine mineral differs and is unique due to its unique texture and unique shape (Figure 2).



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According to petrography and geochemistry, the level of serpentinization in the study area is divided into three categories: low, medium, and high serpentinization (Kadarusman, 2003 and SOP Logging PT Sulawesi Cahaya Mineral).

1. Low serpentinization

   As a result of surface mapping, low serpentinization rocks are categorized as having a serpentine mineral distribution of 5 - <40%, an LOI value of <7%, and a magnetism level of <5°. Serpentinisation is commonly found in harzburgite. The following highly serpentinized harzburgite samples exhibit phaneritic granularity, holocrystalline, inequigranular, hypidiomorph crystal form, and mesh texture. The mineral composition consists of olivine (40%), orthopyroxene (35%), lizardite (20%), and opaque minerals (5%). Based on the normalization of serpentine mineral calculations, this rock has a serpentine mineral content of 23.5% and is included in the low serpentinization level. The LOI value of this rock sample is 6.91% and the magnetic level measurement results have a value of 3.09º. Meanwhile, the result of the subsurface shows the rocks that experience a low level of serpentinization have the following characteristics distribution of serpentine minerals 5 - <40%, LOI value <7%, and magnetic level <5°. This type of serpentinization distribution can be found in harzburgite with characteristics of phaneritic granularity, holocrystalline, inequgranular, hypidiomorphic crystal shape, mesh, and schiller texture. The mineral composition consists of olivine (35%), orthopyroxene (30%), iddingsite (10%), lizardite (20%), and opaque minerals (5%). Based on the normalization of serpentine mineral calculations, this rock has a serpentine mineral content of 23.5% and belongs to the low serpentinization level.

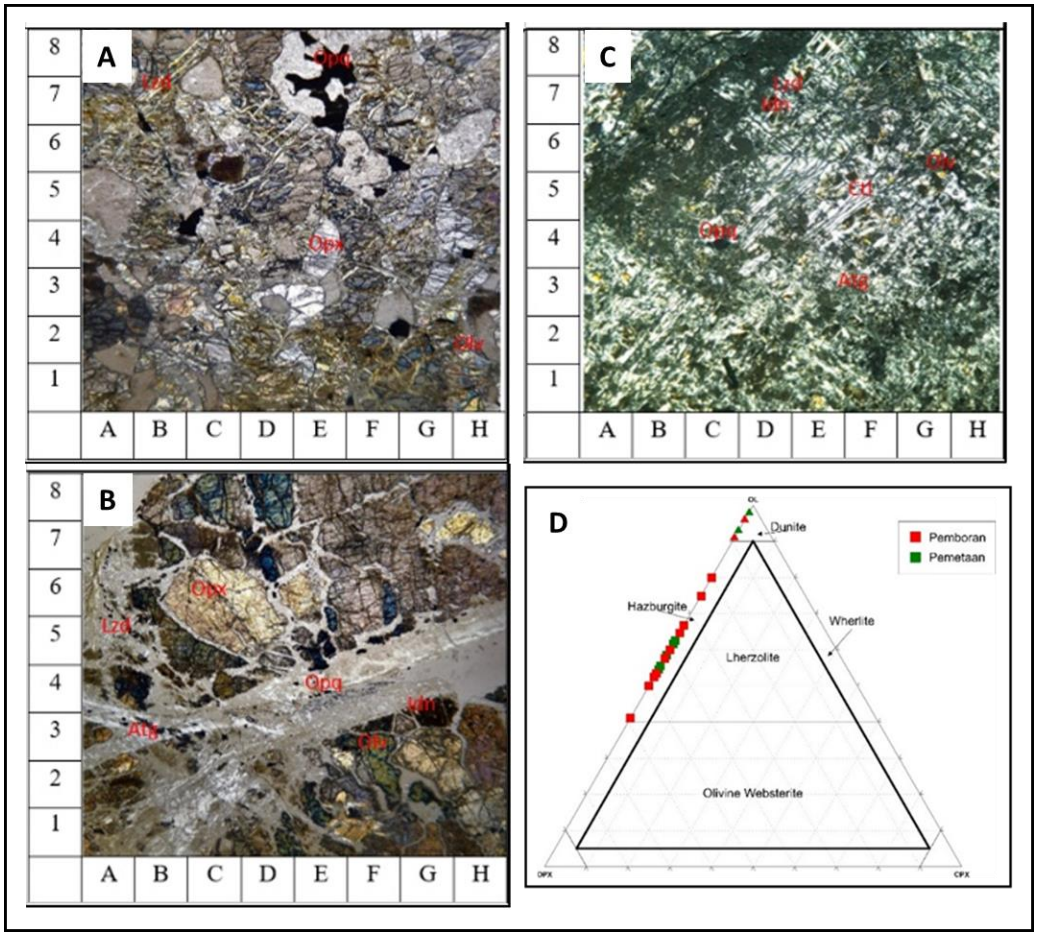


Figure 2. photomicrograph serpentinized – ultramafic rocks. A) low serpentinization; B) medium serpentinization. C) high serpentinization. D) Mineral plotting results from geological mapping rocks (green) and drilling core samples (red) (Streckeisen classification, 1978).



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2. Medium serpentinization
   The rocks studied by the geological surface results experienced medium level of serpentinization having characteristics of serpentine mineral distribution >40 - <60%, LOI values >7 - <10%, and magnetic levels >5º - <10º. This type is commonly found in harzburgite. The following harzburgite samples show phaneritic granularity, holocrystalline, inequigranular, hypidiomorphic, mesh texture, bastite, veinlets, and interpenetration. The mineral composition consists of olivine (30%), orthopyroxene (25%), iddingsite (3%), lizardite (25%), antigorite (16%), and opaque minerals (1%) (Figure 9). Based on the normalization of serpentine mineral calculations, this rock has a serpentine mineral content of 42.7%, which is included in the medium serpentinization level. The LOI value in this rock sample is 9.7% and the magnetic level measurement results have a value of 7.07º. While a result of the subsurface, the rock exhibits medium serpentinization levels that have characteristics of serpentine mineral distribution >40 - <60%, LOI values >7 - <10%. This type can be found in Harzburgite and Dunite, Serpentinization results from harzburgite showing phaneritic granularity, holocrystalline, hypidiomorphic, mesh, and schiller textures. The mineral composition consists of olivine (20%), orthopyroxene (15%), iddingsite (10%), lizardite (30%), antigorite (20%), and opaque minerals (5%). Based on the normalization of serpentine mineral calculations, this rock has a serpentine mineral content of 23.5% and is included in the low serpentinization level. The LOI value of this rock sample is 6.91% and the magnetic level measurement results have a value of 3.09˚.

3. High serpentinization
   Rocks from surface geological mapping experience a high level of serpentinization and have characteristics of serpentine mineral distribution >60 - 100%, LOI value >10%, and magnetic level >10º. This type is mostly found in harzburgite showing phaneritic granularity, inequigranular, holocrystalline, hypidiomorphs, mesh texture, bastite, interlocking, interconcentration and veinlets. Mineral composition of olivine (10%), orthopyroxene (10%), iddingsite (5%), lizardite (25%), antigorite (35%), chrysotile (15%), and opaque minerals (5%). Based on the normalization of serpentine mineral calculations, this rock has a serpentine mineral content of 83.3% and is included in the high serpentinization level, has an LOI value in this rock sample has a value of 11.71% and its magnetic level is 12.48º. Meanwhile, the result from the subsurface shows that rocks that experience a high level of serpentinization have characteristics of serpentine mineral distribution >60 - 100%, LOI value >10%, and magnetic level >10º, this type of serpentine is commonly found in Harzburgite and serpentinite. The serpentinization level of serpentinite rocks shows non-foliation, nematoblastic, hypidioblastic - xenatoblastic structures, serpentine and orthopyroxene index minerals, mesh, hourglass, veinlet, interlocking, and interpenetrating textures. Composition of orthopyroxene (5%), lizardite (45%), antigorite (35%), chrysotile (10%), and opaque minerals (5%). The serpentine mineral content of 95% belongs to the high serpentinization level. The LOI value of this rock sample is 12.86% and the magnetic level measurement results have a value of 9.06º.

The results of the comparison of laterite nickel relationships in rocks that experience a low level of serpentinization generally tend to have a good nickel content by showing values >1% in the saprolite zone with a thickness of >5 m. In borehole G123317, the laterite Ni content in the saprolite zone is ±2.81% with a thickness of 5 m, and the bedrock has a SiO2 value of ±40.19%, MgO ±28.69%, Fe ±5.15%, and Ni value of 0.28%. In borehole G111701, the Ni laterite content in the saprolite zone is ±1.61% with a thickness of 17.4 m, and the bedrock has a SiO2 value of ±45.24%, MgO ±33.38%, Fe ±6.54%, and Ni value of 0.31%. In both boreholes, it can be represented that rocks that experience a low level of serpentinization tend to have a good nickel content. This can be shown by the nickel concentration factor in both boreholes which shows a value of 10.22 times and 5.19 times when experiencing nickel enrichment (figure 3).



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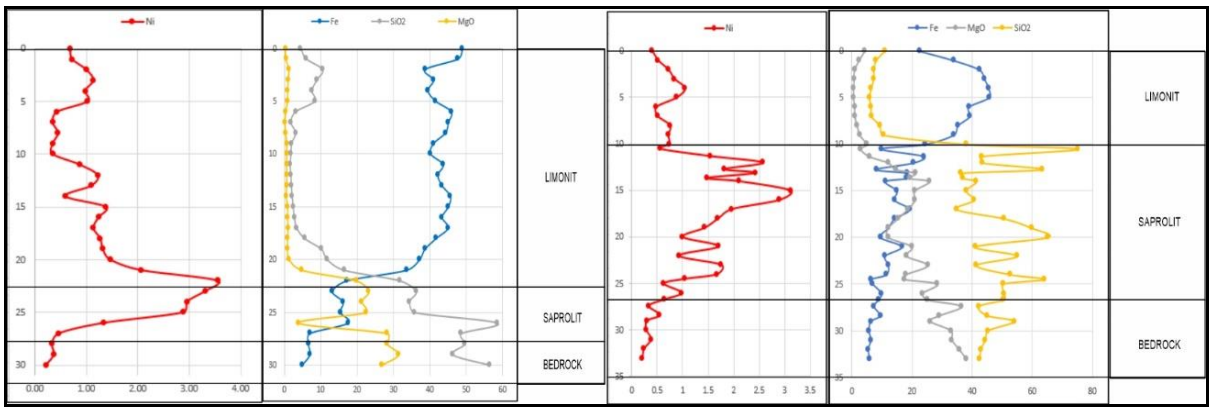


Figure 3. Laterite profile graphs of boreholes F130917 (left) and F122501 (right) based on geochemical data.

Meanwhile, in medium serpentinization at borehole G110101R, the Ni laterite content in the saprolite zone is ±1.74% with a thickness of 6 m, and the bedrock has a SiO2 value of ±43.84%, MgO ±31.28%, Fe ±7.51% and Ni value of 0.41%. In borehole G120101, the Ni laterite content in the saprolite zone is ±1.49% with a thickness of 11 m, and the bedrock has a SiO2 value of ±42.10%, MgO ±36.44%, Fe ±5.49%, and Ni value of 0.20%. In both boreholes, it can be represented that rocks that experience low levels of serpentinization tend to have good nickel content (figure 4).

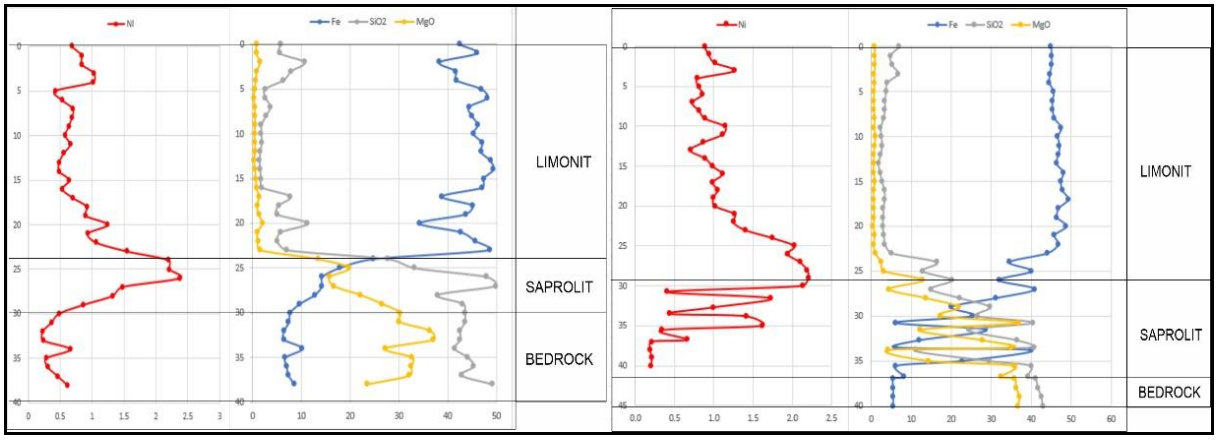


Figure 4. Laterite profile graph of boreholes G110101R (left) and G120101 (right) based on geochemical data represented medium serpentinization.

The Well E113301 represents high serpentinization, the laterite Ni content in the saprolite zone is 0.43% with a thickness of 0.7 m. The bedrock has SiO2 values of ±39.64%, MgO ±37.2%, Fe ±5.41%, and Ni values of 0.21%. This borehole has a fairly shallow laterite profile and has a total thickness of 3.5m (Figure 5). This is due to the poor weathering intensity of the rock and the poor Ni laterite enrichment process. The concentration factor in this borehole shows a value of two times in the enrichment of Ni laterite.



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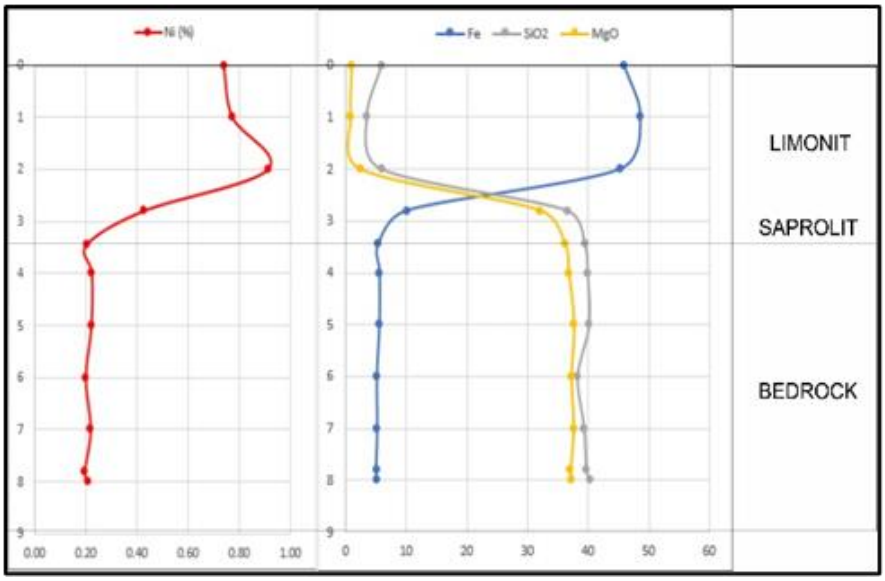


Figure 5. Graph of laterite profile of borehole E113301 based on geochemical data.

The factor of rock serpentinization level on nickel content can be shown in the laterite nickel enrichment process. The results of the Ni laterite concentration factor show that rocks with low and medium serpentinization levels show good nickel development. While rocks that experience a high level of serpentinization, nickel laterite shows poor development.

Bedrock that experiences low and medium serpentinization levels tend to show relatively high $SiO_2$ and MgO values compared to highly serpentinized bedrock. This is because the drilling data profile of rocks with low and medium serpentinization levels in the saprolite zone shows the presence of residual weathering material from rocks that are boulder to pebble size – in grain, indicating that weathering occurs well and the results of relatively high $SiO_2$ and MgO values due to the influence of the residual weathering material. Whereas in the drilling profile of rocks with a high level of serpentinization in the saprolite zone, the formation tends to be thin, and the Ni enrichment is not very good. Based on the drilling profile data, this highly serpentinized rock has a thin saprolite zone, but the limonite zone has a thick thickness. The correlation results of rocks that have experienced serpentinization levels with laterite nickel levels in the saprolite zone, the tendency to have good laterite nickel development from weathering is shown by rocks that experience low and medium serpentinization levels.

It can be assumed that the saprolite zone is where the 16 drill locations in the research region with laterite nickel concentration are located. When considering the impact of the level of serpentinization on rocks, there are 7 boreholes with nickel levels that have mining potential, including 5 borehole points from rocks that experience low levels of serpentinization and 2 borehole points from rocks that experience medium levels of serpentinization (Figure 6).



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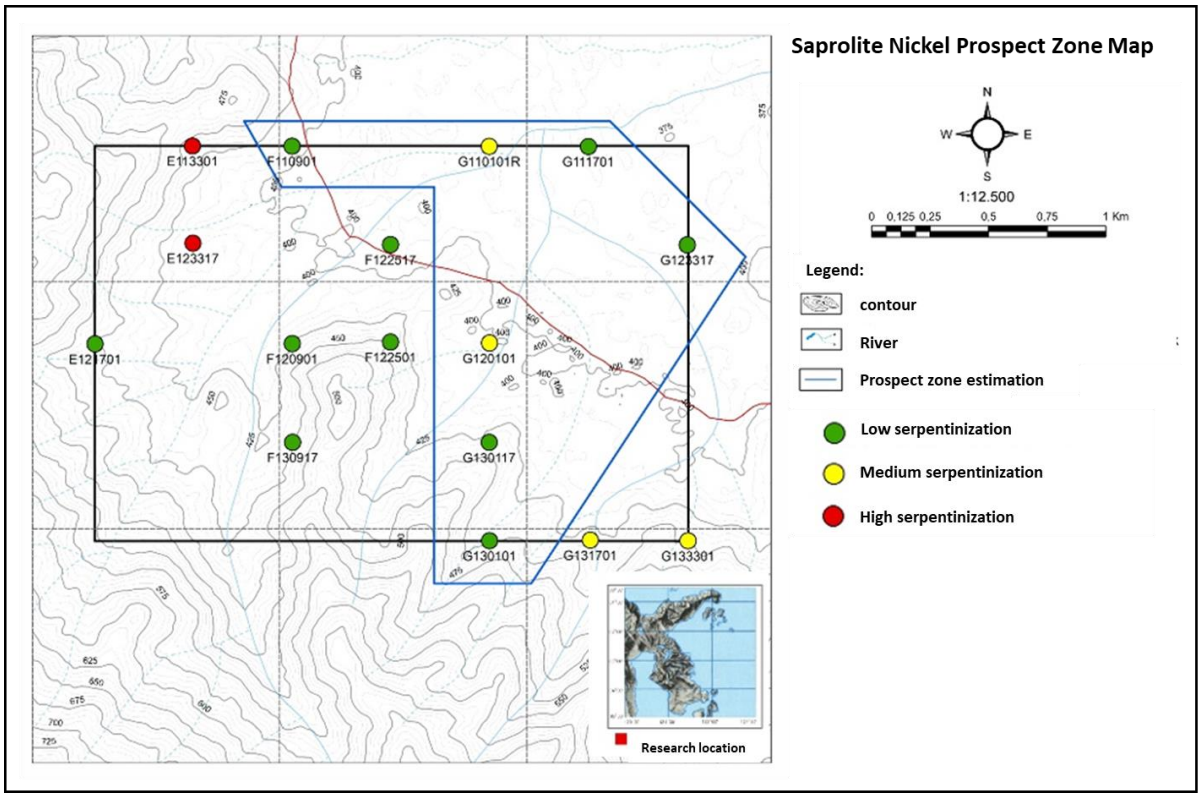


Figure 6. Prospect Zone Map of nickel laterite in the saprolite zone in the study area.

Correlation of serpentinized rocks with a laterite nickel content in the saprolite zone, the most influential factor is in nickel enrichment in the saprolite zone. Good laterite nickel enrichment tends to be found in rocks that experience low and medium levels of serpentinization. In the study area itself, rocks that have low and medium serpentinization levels have a tendency for good nickel content with a relatively thick saprolite zone thickness. Based on the nickel concentration factor in the saprolite zone, rocks that experience a low level of serpentinization show an average Ni value of 5.13 times in Ni enrichment, with the smallest value being 1.72, and the largest value is 10.22. Then, the rocks that experience medium serpentinization levels show an average Ni value of 4.74 times in Ni enrichment, with the smallest value being 3.02, and the largest value being 6.57. Finally, rocks with a high serpentinization level show an average Ni value of 2.43 times in Ni enrichment, with the smallest value being 2, and the largest value is 2.85.

## CONCLUSION

Serpentine minerals in the study area are dominated by altered harzburgite host rock, some altered dunite, and serpentinite rocks. Serpentine minerals that can be identified are lizardite with mesh, bastite, and hourglass textures. Chrysotile is a vein texture with a stringy appearance. Antigorite is characterized by interpenetrating and interlocking textures. The level of serpentinization in the study area is divided into three categories, namely, low, medium, and high serpentinization.

Correlation of serpentinization level to the laterite nickel content in the saprolite zone, the most influential thing is in the nickel enrichment process. In the study area, the rocks that experience low and medium levels of serpentinization have a fairly good development of laterite nickel content in the saprolite zone with a relatively thick thickness. Meanwhile, rocks that experience a high level of serpentinization have a poor development of laterite nickel content and a thin thickness.

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