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Comparative Analysis of Water Content in Laterite Nickel in the Limonite and Saprolite Zones in the North Morowali Mine Area

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ABSTRACT : *Based on data from the Geological Agency, Directorate General of Minerals and Coal in 2013, laterite resources in Indonesia reached 3,565 million tons of ore or the equivalent of 52.2 million tons of Ni metal, this shows that studies on the exploration and processing of Ni laterite will be increasingly popular. Ni laterite is a deposit resulting from weathering of ultramafic rocks which then undergoes leaching. This study aims to analyze the comparison of water content in limonite and saprolite zone laterite nickel deposits in the North Morowali Region. Factors that affect the water content of the soil, including seen from the structure of the soil, soil that has a structure that is not dense (weak), then the permeability is high because it has small pores, so it is able to pass water. Therefore, it is important to carry out a comparative analysis of water content in limonite and saprolite zone nickel laterite deposits in the North Morowali area for mine planning needs.*
KEYWORDS. *Nickel, Laterite, Moisture, Limonite, Saprolite, Morowali Utara*

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I. INTRODUCTION

Nickel is one of the metal elements resulting from the chemical weathering process of ultramafic rocks which are rich in the metal elements Ni, Fe, Mn, and Co (Syafrizal, 2011). Lateritic nickel ore is one of the abundant mineral resources in Indonesia. Laterite nickel ore reserves in Indonesia reach 12% of the world's total nickel reserves, which are spread over the islands of Sulawesi, Maluku and the small islands around them.

Nickel laterite deposits are found in the limonite zone, saprolite zone and saprock zone. Each of these laterite zones has different mineral content and nickel content. The weathered zone of lateritic nickel ore deposits is classified into two parts, namely the saprolite zone with high nickel content located above the bedrock and the limonite zone with low nickel content located above the saprolite zone. The prominent difference between the two types of ore zones is the content of Fe (Iron) and Mg (Magnesium). The saprolite ore zone has low Fe and high Mg content, while the limonite zone has high Fe and low Mg content (Dalvi, et al., 2004).Nickel laterite is a material from regolite (a layer of rock weathering that covers the bedrock) originating from ultra-alkaline rocks containing the elements Ni and Co. Laterite comes from the Latin word later (Guilbert and Park, 1986) which means brick or forms blocks arranged like bricks. One of the factors that influence the formation of nickel laterite deposits is morphology, rock of origin, and level of weathering (Kurniadi et al., 2017).

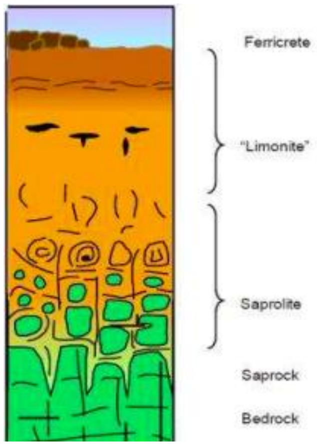
Nickel laterite is formed in areas that are located in the zone of change in the groundwater level. The change from the dry season to the rainy season will affect the movement of the groundwater table so that it is suitable for the formation of laterite. Clay-type Ni laterite deposits in Murrin Murrin consist of five zones, namely: unweathered country rock at the base, saprolite, smectite, limonite (better known as the ferruginous zone), and colluvium at the top (Wells & Butt, 2006; Marsh & Anderson, 2011). Oxide deposits, dominated by Fe oxyhydroxides (such as goethite), form a layer between the pedolite and the saprolite (Golightly, 1981; Gleeson, et al., 2003). Ni laterite deposits in Moa Bay, Cuba are examples of this type of oxide deposits (Gleeson, et al., 2003). This precipitate has a Ni content of 1.27% (Freyssinet, et al., 2005). These oxide-type deposits are formed from the weathering process of serpentinized peridotite (harzburgite) rocks and dunites in the Mayari-Baracoa ophiolite belt (Roqué-Rosell, et al., 2010).The formation of nickel laterite which consists of four horizons, namely (Elias, 2002):

a. The iron cap, which is a mixture of goethite and limonite, is dark red in color. This layer has a high iron and low nickel content, which is about 60% Fe. Sometimes found hematite and chromiferous which are the top layer of lateritic ore and become overburden during lateritic nickel ore mining.

b. The limonite layer is an iron-rich layer of around 40-50% Fe, fine in size and red-brown or yellowish in color. In limonite, most of the nickel is in goethite (as a solid solution), some is in manganese oxide and litiophorite. In this layer, talc, tremolite, chromiferous, quartz, gibbsite and maghemite are sometimes found.

c. Saprolite layer. In this layer, the main mineral is serpentine ($Mg_3Si_2O_5(OH)_4$); Nickel substituted for Mg. Saprolite ore has a higher nickel content than that found in the limonite layer, which is around 1.5-3% Ni. The magnesia and silica content is also higher, but the iron content is low.

d. Bedrock (bedrock). This section is in the form of lumps measuring >75 cm. In general, the nickel content is small, around 0.2-0.4% nickel. This zone experiences strong fracturing and is occasionally open and filled with garnierite and silica. This fracture is thought to be the root zone, which is a zone with high nickel content in the form of veins in bedrock. Figure 1. The following is a picture of the nickel laterite profile.



Fe	MgO	Ni	Co
>50%	<0.5%	<0.6%	<0.1%
40-50%	0.5-5%	0.8-1.5%	0.1-0.2%
10-25%	15-35%	1.5-3%	0.02-0.1%
5%	35-45%	0.3%	0.01%

Figure 1. Nickel Laterite Profile (Elias, 2002)

Rainwater containing CO_2 from the air seeps up to the two groundwater surfaces while leaching unstable primary minerals such as olivine and pyroxene. Groundwater percolates slowly to the boundary between the limonite and saprolite zones, then flows laterally and is further dominated by horizontal solute transport. Laterite deposits are formed from the weathering of ultramafic rocks such as peridotite caused by the effects of climate change. Weather changes the composition of rocks and dissolves the elements Ni, Co, and Fe. Elements that are carried along with the solution such as magnesium and silica will experience precipitation which allows the formation of new minerals (Sukandarrumidi, 1999).

Solutions containing nickel resulting from the precipitation of soluble elements will enter the saprolite zone. In this zone ultramafic rocks will accumulate with nickel-containing elements and will precipitate back into the fractures through the transportation of groundwater that enters these fractures so that this saprolite zone will become saturated with nickel elements. The elements left behind in the limonite zone such as Fe, Mg, Co and Ni will experience slower weathering caused by a lack of concentration of groundwater in this zone so that the nickel content in the limonite zone will be less than the nickel content in the saprolite zone (Budi, S. & Subagio, 2018)

Comparative analysis of water content in limonite and saprolite zone laterite nickel deposits in the North Morowali Region needs to be known for mine planning needs. The presence of water in the limonite and saprolite zone samples is influenced by groundwater or water infiltration from the surface. Factors that affect the water content of the soil, including seen from the structure of the soil, soil that has a structure that is not dense (weak), then the permeability is high because it has small pores, so it is able to pass water. Therefore, it is important to carry out a comparative analysis of the water content in nickel laterite deposits of the limonite zone and the saprolite zone in the North Morowali area (Jamalun, et al., 2021)

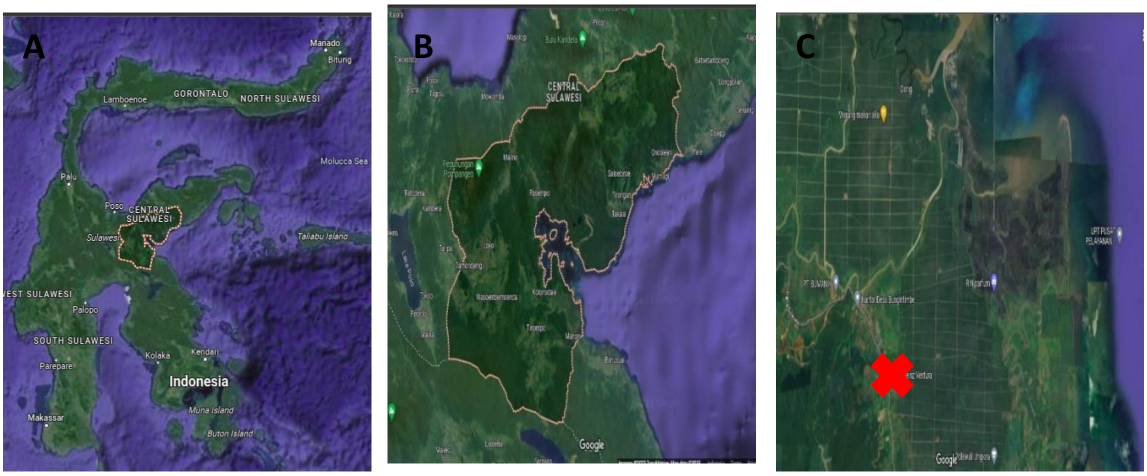


Figure 2. Research Location : Indonesian Map (A), South Sulawesi Province (B), Maros Regency (C).

II. METHODOLOGY

This research includes laboratory experimental research and is categorized as quantitative research. The sample for this study was Ore from the exploration department from drilling results from mining activity locations in the North Morowali area (Figure 2.). The sampled part is the limonite and saprolite layers from the drill hole (LR4312). In the drill hole samples were taken (8 samples of the limonite layer and 9 samples of the saprolite layer) every 1-4 meters in depth according to differences in lithology. Each sampled portion is taken ¼ part of the core and stored in a porcelain cup whose empty weight is known. Then do the wet preparation, namely reducing the particle size and volume of the material. Then weigh the weight of the empty cup, then weigh the weight of the empty cup + sample then dry the sample in a Draying Oven to determine the water content according to ASTM D-2216-71 for ± 8 hours at 105^0C to evaporate all the water in the sample.

III. RESULTS AND DISCUSSION

The thickness of laterite deposits varies depending on the morphology of each area. Morphological conditions greatly affect the circulation of water and other elements. In sloping areas, water will move slowly so that it will have the opportunity to go deeper through cracks or rock pores. In steep areas, water will flow over the surface and intensive erosion occurs. Accumulation of sediment is generally found in areas with a gentle to moderate slope. The type of constituent rock/source rock is very influential on the formation of nickel laterite. Different lithologies will produce different mineral compositions and will affect nickel geochemistry in a nickel laterite deposit (Ahmad, 2008).

Soil consists of three elements, namely: soil grains or solid particles (solid), water (water) and air (Das, 1988). Guidelines for testing water content follow ASTM D-2216-71 procedures and to calculate soil water content can be done using the equation below:

$$W=\frac{M2-M3}{M3-M1}x100\%$$

dimana:

w =moisture content (%)
M1 =empty cup weight (grams)
M2 = weight of cup + wet soil (grams)
M3 =weight of cup + dry soil (grams)

Table 1. Moisture content of limonite and saprolite samples

No	*Sample ID*	*Lithology*	*Empty Dish (gr)*	*Wet Sample + Dish (gr)*	*Dry Sample + Dish (gr)*	*Water Content (%)*
1	LR-4312 0,5	SOIL	406,7	1878,8	1350,7	35,87
2	LR-4312 01	LIM	408,6	1959,3	1399,4	36,11
3	LR-4312 02	LIM	411,2	3118,8	2073,5	38,61

4	LR-4312 03	LIM	410,5	2720,1	1708,7	43,79
5	LR-4312 04	LIM	410,0	3074,6	1840,8	46,30
6	LR-4312 05	LIM	410,6	2748,1	1485,7	54,01
7	LR-4312 06	LIM	410,0	2284,5	1257,2	54,80
8	LR-4312 07	LIM	410,7	2163,2	1173,5	56,47
9	LR-4312 08	LIM	389,6	1896,5	1011,4	58,74
10	LR-4312 09	SAP	389,8	1977,8	1587,1	24,60
11	LR-4312 10	SAP	411,0	2047,7	1640,5	24,88
12	LR-4312 11	SAP	410,5	2213,5	1666,7	30,33
13	LR-4312 12	SAP	410,3	2453,0	1521,7	45,59
14	LR-4312 13	SAP	410,2	2490,3	1626,3	41,54
15	LR-4312 14	SAP	410,5	2677,7	1704,9	42,91
16	LR-4312 15	SAP	389,3	2470,7	1652,6	39,31
17	LR-4312 16	SAP	389,6	2367,3	1748,6	31,28
18	LR-4312 17	SAP	389,5	2611,1	1897,8	32,11

Source : Primary Data, 2022

Based on the results of testing the water content of the limonite layer using an oven, the average water content for each drill hole (LR 4312 01 to 08) was 36.11%, 38.61%, 43.79%, 46, 30%, 54.01%, 54.80% and 56.47%. The average grade for the limonite layer of all drill holes is 48.60%. The water content in the saprolite layer using an oven obtained the average water content for each drill hole (LR 4312 09 to 17), namely 24.60%, 24.88%, 30.33%, 45.59%, 41.54%, 42.91%, 39.31%, 31.28%. The average grade for the saprolite layer from all drill holes is 35.05%. The presence of more groundwater in the saprolite layer causes the water content to be higher than in the limonite layer. In addition, the effect of infiltration from the surface tends to be towards the groundwater table. These two factors cause the core sample from the saprolite layer to have a higher moisture content than the core sample from the limonite layer.

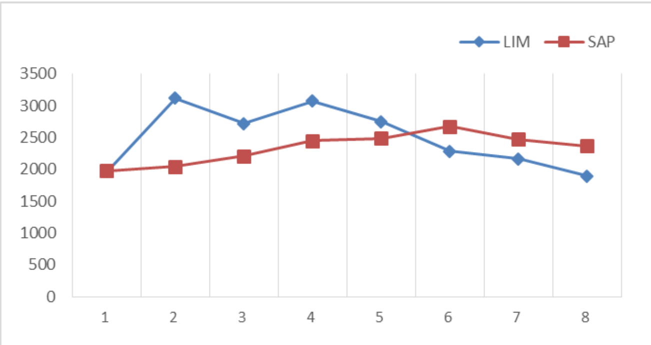


Figure 3. Wet Sample (gram) Limonite Zone and Saprolite Zone

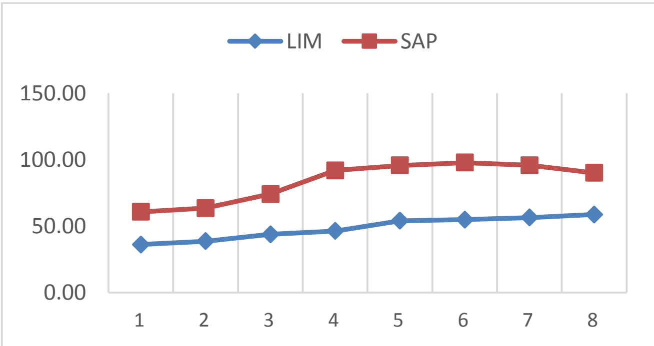


Figure 4. Water Content (%) Limonite Zone and Saprolite Zone

One of the factors that affect soil water content is seen from the soil structure. Soils that have a dense (steady) structure have low permeability because they have large pores, so they are unable to allow water to pass through. Permeability greatly affects infiltration because it is the ability of the soil to retain water. If the ability of the soil to hold water is small, it will affect infiltration. Thus, soil in irrigation canals that have low permeability will cause high water to be lost (seeps), and vice versa.

IV. CONCLUSION

Based on the research that has been done, it can be concluded that the effect of water content on the gradation zone is for the Top Soil and Limonite Zones, the deeper the soil depth in this zone, the higher the % water content. The average water content of the limonite layers of all drill holes is 47.89% while in the saprolite layers the average moisture content is 34.73%. This is due to the presence of groundwater in the saprolite layer and the influence of water infiltration from the surface

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