Analysis of Physical and Mechanical Rock Properties Based on Geological Domain in the Nickel Laterite Zones at PT Antam Tbk Site Pomalaa, Southeast Sulawesi

by Barlian Dwi Nagara

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ABSTRACT

Nickel deposits operated by PT Antam Tbk, in Pomalaa are dominated by serpentinized harzburgite formed from weathered ultramafic rock. The laterization divided the nickel zone into limonite, saprolite and bedrock. The geological domain of nickel laterite rocks consists of Harzburgite, Dunit, Serpentinite and Undifferentiated Serpentinite which have different mineral compositions and physical characteristics. Therefore, an analysis of physical and mechanical properties was carried out to determine whether the geological domain and deposit zone are related to the physical and mechanical properties. The data was collected from four mining fronts based on the domain and deposit zone. It was then analyzed in the laboratory to be tested by several tests such as physical properties, shear and Uniaxial Compressive Strength (UCS) tests. For physical rock properties, Undifferentiated Serpentinite domain in limonite zone result in smaller value than that of Saprolite. While for mechanical properties, UCS of dunite domain in saprolite zone is relatively higher than that in limonite zone. In Harzburgit domain, the three zones, including bed rock show low cohesion. Furthermore, all domains in bedrock zone contain high cohesion. In conclusion, rock physical and mechanical properties can be used to represent geological domain and deposit zone

INTRODUCTION

PT Antam Tbk has a Nickel mining production operation in Pomalaa, Southeast Sulawesi which has a laterite nickel deposit formed weathering of ultramafic rocks. Based on the geological domain of nickel deposits, the characteristics and mineral composition produced the difference so that an analysis of testing the mechanical and physical properties was carried out to determine the effect of the geological domain in nickel laterite zones on geotechnical analysis.

The geotechnical analysis used for mine plan on slope design and to monitor slope stability during the activity. The results of the geotechnical laboratory test can be a parameter in the calculation of slope stability

LOCATION OF STUDY AREA

The analysis on physical and mechanical properties of nickel laterite deposits conducted in the IUP area of PT. ANTAM, Tbk with the geographical location of the Pomalaa region is a tropical region located in the southeastern of Sulawesi located near the equator at latitude 3O30 '- 4O30' South Latitude and 120O - 122O East Longitude. Pomalaa is included in the Kolaka Regency, while Pomalaa is located in the South of Kolaka City with a distance of ± 29 Km from Kolaka. This road access can also be reached from Makassar the Bone Regency of South Sulawesi by land transportation through Bone Bay on the Bajoe crossing ± 178 Km from Makassar. The route of this research location is Makassar to the Bajoe Crossing (Bone Bay Crossing) to Kolaka then to Pomalaa by air transportation.

GEOLOGICAL DOMAIN

Magma differentiation that occurs makes ultra-base rocks classified according to their mineral composition into peridotite, dunite, harzburgite and wehrlit rocks., Classification by Streckeisen, 1976 (Figure 1).

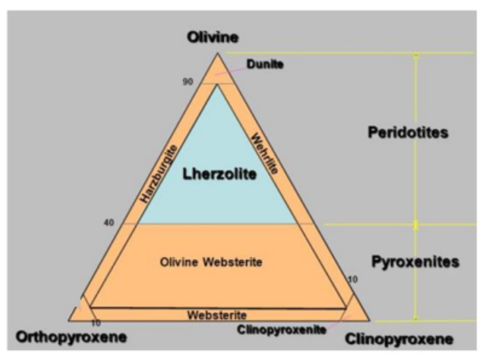

Figure 1 Ultra-Base Rock Classification

Peridotite is a nickel laterite source rock which has a dominant olivine and pyroxene mineral composition and contains silica of less than 45%, Dunite has a coarse-grained texture with minerals that contain general more than 90% olivine, while Harzburgite contains olivine minerals between 40-50% with dominant orthopiroxen.

Ultramafic rock alteration namely serpentinization occurs due to a low temperature geological metamorphic process involving heat and water where ultramafic and mafic rocks with low silica content and hydrolyzed with water become serpentinite. One of the characteristics of serpentine stone is that it has a greenish color. Undifferentiated serpentinite is a serpentinic rock that does not go through the process of differentiation due to the influence of rock deformation and others.

Pomalaa has 4 (four) active mining fronts, namely the Tambang Utara, Tambang Tengah and Tambang Selatan which have different geological domains. The Tambang Utara mine consists of Peridotite, Dunit, Harzburgit, Seperntinite and undifferentiated Serpentinite. (Figure 2). The Tambang Tengah mine consists of Dunit, Harzburgit, Peridotite and undifferentiated Like ignite rocks (Figure 2) and Tambang Selatan mines consisting of Serpentinite and Peridotite (Figure 3).

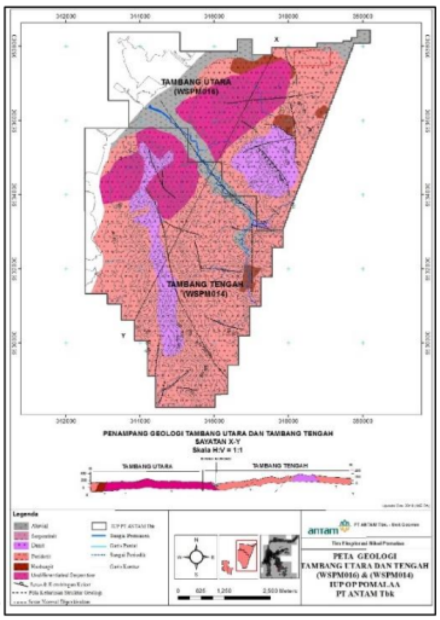

Figure 2 Tambang Utara and Tambang Tengah Geologi Maps

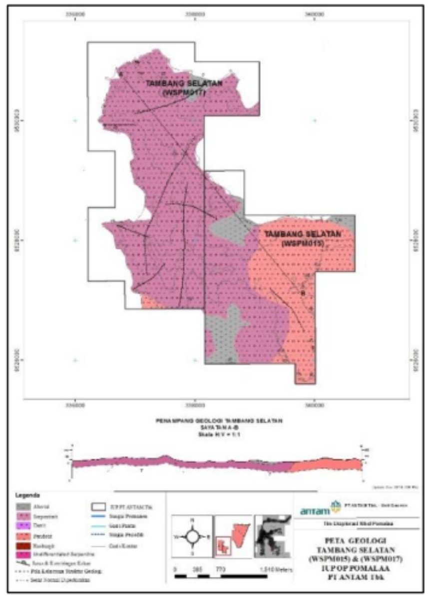

Figure 3 Tambang Selatan Geology Maps

NICKEL LATERITE ZONES

The lateralization process lasts for millions of years starting when ultramafic rocks are exposed on the earth's surface to produce a nickel residue caused by weathering rate factors, geological structure, climate, topography, chemical reagents and vegetation, and time. The lateralization process causes nickel laterite zoning which is divided into:

Limonite Zone

Zone containing residual iron enrichment in laterite profiles composed by hydrated iron oxide. The material is very soft and dominated by clay-sized material. The top is blackish brown which contains hematite minerals. Nickel can be bound to the structure of gutite minerals along with a number of elements such as aluminum, manganese and chromium. The results of geochemical analysis show that nickel content is in the range of 0.4% to 1.5% Ni. The thickness of the limonite zone in the study area ranges from 2 meters to 9 meters.

Saprolite Zone

The saprolite zone is characterized by greenish brown color, has a smooth to coarse texture, the original rock mineral relics are replaced by secondary minerals from weathering products, vein garnierite and silica vein with well-developed boxwork textures that show traces of the structure of the original rock. The thickness of the saprolite zone ranges from ± 10-15 m. Nickel content in the saprolite zone ranges from 1.8% - 3% Ni. (Paper The Geochemistry of Laterite Nickel Deposits in the North Mining, Pomalaa Subdistrict, Kolaka Residency, Southeast Sulawesi Province)

Bedrock Zone

The lower part of the laterite nickel profile, in dark green, consisting of rock fragments of size> 75 cm, and generally contains no economical minerals. The mineral content is close to or equal to that of the original rock, with a rate of Fe ± 5% and Ni and Co between 0.01 - 0.30%.

DATA ACQUISITION

Samples taken on field, including:

1. Material properties of Limonite and Saprolite are taken in each geological domain (Dunite, Harzburgite, Serpentinite and Undiffirentiated Serpentinite) with the Disturbed Sample method.
2. Material bedrock properties are taken in each geological domain using the Undisturbed Sample method.
3. Data Laboratory analysis wiil used as a single slope parameter

SAMPLING PROCESS

Limonite and Saprolite samples were taken at 5 tubes of limonite sample and 5 tubes for saprolite samples. Where to take limonite and saprolite samples using HQ tubes with a length of 50 cm and a diameter of 3 inches. Bedrock sampling were taken in 1 area and 1 front, taken 5 pieces of bedrock (raw bedrock) and cultivated bedrock still in a fresh condition, with dimensions of at least 50 x 100 x 50 cm with each bedrock prepared into 5 bedrock for testing, with Dimensions as follows:
(a) 5 x 5 x 5 cm for physical tests (1 piece),
(b) 5 x 5 x 12 cm for compressive strength test (1 piece),
(c) 5 x 5 x 10 cm for shear test (3 pieces).
Bedrock sampling is obtained from fresh rock, with bedrock conditions that have not been weathered.
The collection of 20 bedrock samples from 4 fronts in 1 day with 4 personnel.

RESULTS AND DISCUSSIONS

Laboratory test for the analysis:

1. Uniaxial Compressive Strength (UCS)
2. Direct Shear
3. Physical Properties

The recapitulation of soil and rock samples that have been taken in the field according to the location of geological domains and nickel zoning refer to Table 1

Table 1 Recapitulation of Total Sample In Geological Domain and Nickel Laterite Zones

Nickel Laterite Zones	Geological Domain			
	Tambang Utara		Tambang Tengah	Tambang Selatan
	Harzburgite	Undifirentiated Serpentinite	Dunite	Serpentinite
Limonit	5 tube for 3 test	5 tube for 3 test	5 tube for 3 test	5 tube for 3 test
Saprolit	5 tube for 3 test	5 tube for 3 test	5 tube for 3 test	5 tube for 3 test
Bedrock	5 boulder for 25 test	5 boulder for 25 test	5 boulder for 25 test	5 boulder for 25 test

Test conducted for approximately 2 weeks and the laboratory test results for Limonite refer to Table 2

Table 2 Recapitulation Results of Limonite Laboratory Test

Limonite	Hazburgit	Dunit	US	Serpentinite
Friction Angle (°)	43,92	43,92	54,29	46,94
cohesion (kN/m2) Residual	42,50	45,50	43,97	54,47
Dry Density (kN/m2)	13,25	12,39	13,22	13,35
Wet Density (kN/m2)	14,78	13,68	14,31	14,88
UCS (Mpa)	0,58	1,00	0,16	0,63

Laboratory test for Saprolite refer to Table 3

Table 3 Recapitulation Results of Saprolite Laboratory Test

Saprolite	Hazburgit	Dunit	US	Serpentinite
Friction Angle, (°)	43,92	43,92	40,56	49,65
Cohesion, (kN/m2) Residual	42,50	51,26	44,47	51,97
Dry Density, (kN/m2)	13,23	13,38	13,22	13,31
Wet Density, (kN/m2)	32,77	16,30	14,31	16,13
UCS (Mpa)	0,53	0,47	0,53	0,26

Laboratory test results for bedrock refer to Table 4

Table 4 Recapitulation Results of Bedrock Laboratory Test

Bedrock	Hazburgit	Dunit	US	Serpentinite
Friction Angle (°)	10,43	12,42	16,46	12,79
Cohesion (kN/m2) Residual	156,92	235,72	408,51	234,25
Dry Density (kN/m2)	26,28	27,06	26,26	26,36
Wet Density (kN/m2)	26,38	27,26	2,70	26,56
UCS (Mpa)	22,61	23,16	25,13	24,32

From laboratory test results there is a classification range for Limonite and Saprolite, a value from geological domain of mechanical and physical properties classified (Table 5) and Bedrock classified (Table 6) however, the classification calculation based on the range between each parameter of Physical and Mechanical properties test results then divided by total samples.

Table 5 Limonite and Saprolite Physical and Mechanical Properties Classification

LIMONITE SAPROLITE	Friction Angle	Cohesion	Dry Density	Wet Density	UCS
Soft	40-45	40-45	12-13	12-13	0.4-0.6
Medium	45-50	45-50	13-14	13-14	0.6-0.8
Hard	50-55	50-55	14-15	14-15	0.8-1

Table 6 Bedrock Physical and Mechanical Properties Classification

BEDROCK	Friction Angle	Cohesion	Dry Density	Wet Density	UCS
Soft	10-12	100-200	25-26	25.5-26.0	22-23
Medium	12-14	200-400	26-26.5	26.0-26.5	23-24
Hard	14-16	400-600	26-27	26.5-27.0	24-25

Based on the classification it can be concluded that Zone Limonite, Saprolite and Bedrock has Physical and Mechanical properties characteristic refer to Table 7 and Table 8

Table 7 Limonite and Saprolite Physical and Mechanical Properties Caracteristics

LIMONITE/ SAPROLITE	Hazburgit	Dunit	US	Serpentinite
Friction Angle	soft	soft	soft/ hard	medium
Cohesion	soft	hard/ medium	soft	hard
Dry Density	medium	medium/ soft	medium	medium
Wet Density	hard	hard/ medium	hard	hard
UCS	soft	soft/ hard	medium/ soft	soft/ medium

Table 8 Bedrock Physical and Mechanical Properties Caracteristics

Bedrock	Hazburgit	Dunit	US	Serpentinite
Friction Angle	soft	medium	hard	medium
Cohesion	soft	medium	hard	medium
Dry Density	medium	hard	medium	medium
Wet Density	medium	hard	soft	hard
UCS	soft	medium	hard	hard

Result of mechanical and physical properties data of limonite, saprolite and bedrock used to calculate safety factor. After that, the value of safety factor will be compare with laboratory results, herewith the safety factor results. Safety factor of limonite and saprolite in geological domain and nickel laterite zones showed the average value of FK limonite in the same amount 2.29, 2.37 and 2.39 Meanwhile, the value of the saprolit is consecutive as 2.31, 2.32 and 2.38 with parameter calculation based on PT Antam Tbk recommendations parameters.

These one of the following safety factor result of Limonite and saprolite zones in Serpentinite rock to show that the laboratory results and safety factor calculation have the similar impact (Figure 4) and (Figure 5)

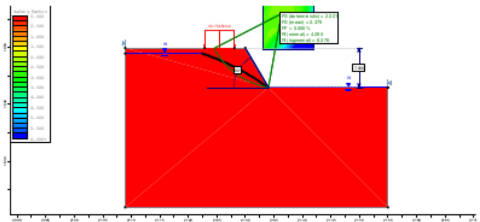

Figure 4 Safety Factor of Single Slope Design Limonite in Serpentinite Rock with Slide Software

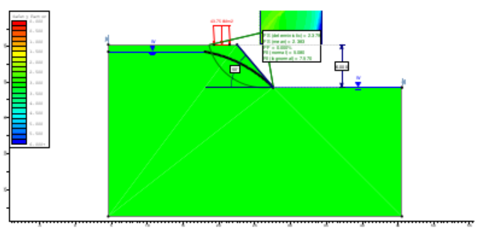

Figure 5 Safety Factor of Single Slope Design Saprolite in Serpentinite Rock with Slide Software

CONCLUSION

In conclusions, for physical rock properties, Undifferentiated Serpentinite domain in limonite zone result in smaller value than that of Saprolite. While for mechanical properties, UCS of dunite domain in saprolite zone is relatively higher than that in limonite zone. In Harzburgit domain, the three zones, including bed rock show low cohesion. Furthermore, all domains in bedrock zone contain high cohesion. In conclusion, rock physical and mechanical properties can be used to represent geological domain and deposit zone, whereas for the further geotechnical analysis geological domain in nickel laterite zones not sensitive to slope stability.

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