Journal Techno, Vol. 8, No.2, 2022, pp. 131 - 146
ISSN. 2461-1484

GEOLOGY AND THE EFFECT OF BOULDER SIZE CONCRETION TO BAUXITE LATERITE DEPOSIT QUALITY AT DJANRA AREA, SANDAI DISTRICT, KETAPANG REGENCY, WEST KALIMANTAN

Sutarto, Agus Harjanto*, Paschalis Pindyka Aji Kurniawan
Geological Engineering, Universitas Pembangunan Nasional "Veteran" Yogyakarta
**Corresponding author:* aharjanto69@yahoo.com; paschalis.dika@gmail.com

Abstract

The research area is located in Djanra areas Sandai District, Ketapang Regency, West Kalimantan. The research methods used are surface geological mapping, bauxite sample collection, also studio and laboratory analysis. Laboratory analysis includes petrographic analysis, XRF, and wet analysis. The geomorphology of the study area is dominated by denudational and anthropogenic landforms as a result of mining activities. The constituent rocks are Kerabai andesite units which are Middle-Late Cretaceous and are intruded by Sukadana trachyte units which are of Late Cretaceous period. The geological structures found are a shear joint with the main southwest-northeast direction and the normal right slip fault. Bauxite laterite deposits in the research area have varying overburden and ore thicknesses. Distribution of concretion size of boulder to depth in the study area varies. Based on the results of the study, the boulder size concretion can affect the quality of bauxite laterite deposits. Where on DJANRA-1 hill is declared feasible to be taken and mixed with smaller concretions because it meets quality standards.

Keyword: *Bauxite, Concretion, Boulder, Quality, Sandai*

INTRODUCTION

Indonesia is one of the unique countries in geologically. The country is located at three large plate boundaries, namely the Eurasian Plate, the Indo-Australian Plate and the Pacific Plate. At the meeting of the three plates, geological processes took place for a long time. The positive impact is that Indonesia is one ofthe countries rich in mineral resources due to the geological location.

As a country located on the equator, Indonesia also has a tropical climate. These climate characteristics are high rainfall and the duration of sun exposure is relatively the same throughout the year. The influence of these conditions is the weathering of rocks that occur intensely. Weathering is not always detrimental, but can also produce an economic mineral deposit if it occurs under certain conditions. Mineral deposits formed because the main influence of weathering is called residual deposits. One of the most famous residual deposits is bauxite.

Bauxite is an ore from aluminum (Al) formed from host rock with a high Al content, low iron (Fe) and a little free silica (Si). Bauxite is one of the most sought-after major commodities in the world. Almost all kitchenware, electronics and automotive use Al metal. So massive bauxite exploration is needed to offset the world's needs for Al metal. In Indonesia, bauxite ore can be found abundantly, one of which is in Ketapang Regency, West Kalimantan Province.

Bauxite has the form of concretion as a result of mineral accumulation that is immobile or is lost in leaching. Bauxite concretion has varying sizes, ranging from gravel (2 cm) to boulder (> 10 cm). The difference in size of the concretion can also vary at each ore depth. In addition, variations in the size of the concretion can also have differences in ore quality based on the percentage content of Al_2O_3, Fe_2O_3, SiO_2, and $RSiO_2$. In this study, the authors focused the discussion on the size of the boulder concretion (> 10 cm) which could affect the quality of bauxite laterite deposits. Especially because the boulder size is directly discarded at the washing plant. Even if treated properly, the size ofthe boulder can be used to increase the total quality of bauxite.

RESEARCH SITE

The research location is in the Djanra and surrounding areas, Sandai District, Ketapang Regency, West Kalimantan. These locations include the PT. Cita Mineral Investindo area.

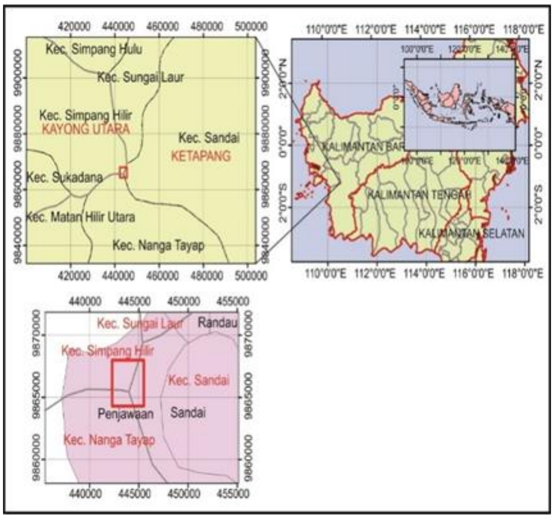

Figure 1. Research Site

PURPOSE AND OBJECTIVES

The purpose of this study is to conduct surface geological mapping, subsurface geological mapping using test pit samples, determine bauxite deposit characteristics, and determine the effect of the boulder size concretion on the quality of bauxite. The purpose of this study was to find out the landform units of the study area, find out the stratigraphic relationship of the study area, determine the structural geology that developed in the study area, determine the characteristics of bauxite laterite deposits in the study area, determine the distribution of bauxite boulder size to depth in the study area, determine the effect of boulder size concretion (> 10 cm) to the quality of bauxite laterite deposits based on levels of Al, Fe, SiO_2, and $RSiO_2$, and determine recommendations for improving the quality of bauxite based on the presence of boulder size concretions.

METHODOLOGY

The research methodology used consists of several stages, starting from literature studies, field observations, data collection stages, data processing and analysis stages, the final stage is data presentation stages and reporting. At the stage of data collection, some data needed include geomorphology, lithology, geological structure, and bauxite concretion samples. In the data analysis phase, it is divided into two, the first is studio analysis in the form of stereographic analysis to interpret structural geology data. Then the second is laboratory analysis to determine the name of the rock and find out the grade of bauxite. In the last stage, it presents data in the form of track maps and observation locations, drainage pattern maps, geomorphological maps, geological maps, and slope maps. Besides that, a scientific work report is also carried out in the form of an essay.

REGIONAL GEOLOGY

I. Regional Physiography

Sandai area is located in Ketapang Regency, West Kalimantan. Regionally, Ketapang is an area that belongs to the Schwaner Block.

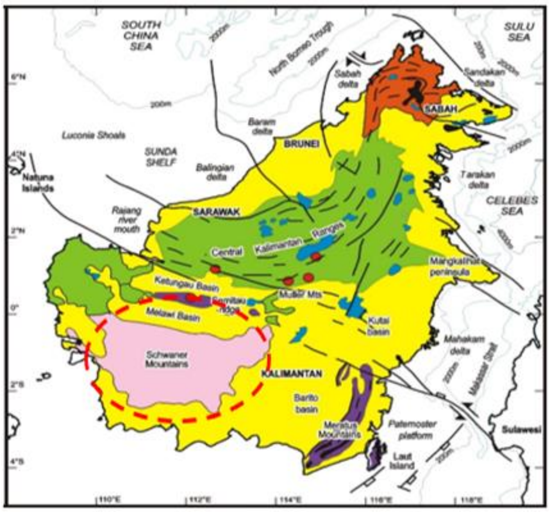

Figure 2. Borneo Island Physiography (Hall, 2009)

The Schwaner block is a basement composed of Cretaceous granite and tonalite (Satyana, et al, 1999). According to Amiruddin (2009), the Schwaner Block (Figure 2.) is a batolith consisting of Tonalit Sepauk and Granit Laur. Tonalit Sepauk is predominantly composed of tonalite, granodiorite, and a little granite. Most of these rocks have intermediate compositions and are a little felsic and lead to calc-alkali. While Laur Granite consists of monzogranite, granodiorite, and syenogranit, slightly tonalite, quartz diorite, and diorite.

In more detail, the division of landscape in the study area, namely:

a. Plain of alluvium (beach) and litoral.
b. Corrugated lowlands.
c. Mountainous plateau.

II. Regional Stratigraphy

Regionally, the lithology that can be found consists of the Ketapang Complex, Sukadana Granite, Kerabai Volcanic Rock, and Alluvium Deposits (Geological Map of Ketapang Sheet by Keyser and Rustandi, 1993 in Soetopo, et al, 2011). The stratigraphic sequence of the Geological Map of the Ketapang Sheet from old to young is as follows:

a. Ketapang Complex (JKKe)

Consisting of claystone, fine sandstone to coarse clay, lithic arenite, shale, and slate. There are also locally dolomite and limestone. These rock complexes are estimated to be Jurassic - Late Cretaceous, which is nonconformity above Malihan Pinoh Rocks and suppressed unconformably under Kerabai Volcanic Rocks but in some places contact is interfingerred.

b. Sukadana Granite (Kus)

Consisting of several types of rocks including monzogranite, quartz monzonite, syenogranite, and alkali-feldspar granite, a bit of quartz quartz, a little diorite and gabro (Keyser and Rustandi, 1993 in Soetopo et al. 2011). The age of Sukadana Granite is the Late Cretaceous.

c. Kerabai Volcanic Rock (Kuk)

Most consist of andesite, pyroclastic rocks in the form of tuff, lapilli stone, volcanic breccia, agglomerates, there are also porphyritic lava, intruded by hydrothermal veins. Age of Kerabai Volcano Rock is estimated to be the Late Cretaceous - Paleocene.

d. Alluvium and swamp deposits (Qa)

Consisting of gravel deposits, sand, silt, mud, peat, and boulders that have not been lithified. This unit overlays unconformably above other older rock units.

III. Regional Structural Geology

Kalimantan was formed in the Mesozoic Period, the results of mixing ofiolite, archipelagic arcs, and microcontinent crust taken from South China and Gondwana, then crushed by sedimentary material, used accretion in the core of the Alpenner mountain range used by Mesozoics. Almost all of Kalimantan is part of the Sunda Shelf formed at the beginning of the Kenozoic (Hall, 2002). Pieters, et al (1993a) and Amiruddin (2000b) compiled it during the Early Cretaceous formed ofiolite and tectonic range. The cause is subduction which leads to the south by the Proto South China Sea down below the Sunda Shelf.

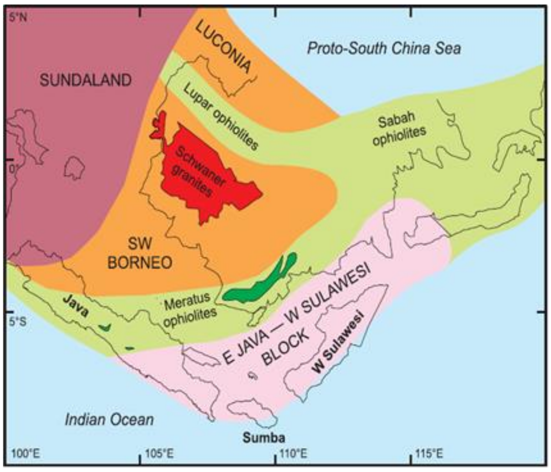

Figure 3. Condition of Kalimantan Island during the Cretaceous Period (Hall, 2009)

According to D. Sudana, B. Djamal and Sukido (1994) lineages are generally northeast-southwest and west-east, in some places trending north-south to northwest-southeast. This line is found in Kerabai Volcano, Ketapang Complex, and Granite-Diorite Complex.

IV. Geology of Djanra Areas

a. Geomorphology of Djanra Areas

Based on morphography, morphometry, active morphostructure, passive morphostructure, and morpho-dynamics, the landform units of Djanra and surrounding areas (Table 2.) can be divided into the following:

a) Strong corrugated hilly landform unit (D1)
b) Medium wavy hills landform unit (D2)
c) Weak corrugated hills landform unit (D3)
d) Denudational plain land area unit (D4)
e) Flood plains landfoms unit (F1)
f) Pit landform unit (A1)
g) Washing plant landform unit (A2)
h) Waste dump landform unit (A3)
i) Hauling road landform unit (A4)

b. Stratigraphy of Djanra Areas

The stratigraphic division of the research area namely Djanra areas uses an unofficial lithostratigraphy naming system in the Indonesian Stratigraphic Code (1996), which naming rock units based on rock physical characteristics observed in the field, lithology type, uniformity, and stratigraphic position on existing rock units above or below it.

Based on observations and looking evidence that appear in the field, the stratigraphy of the Djanra areas in sequence from old to young are as follows:

1) Kerabai andesite unit including andesite lithology, has a dark gray color, fine-medium faneric (<1-2 mm), inequigranular crystal size. The mineral composition observed was dominated by crystal, plagioclase (labradorite), K-feldspar, quartz biotite and opaque minerals. An alsodiorite lithology with fresh dark gray color, medium faneric crystal size (1-3 mm), and equigranular. The mineral composition observed was plagioclase (oligoclase), K-feldspar, biotite, quartz, and opaque minerals.
2) Sukadana trachyte unit, consists of the trachyte with fresh dark gray color, has afanitic-medium faneric (<1-3 mm), inequigranular crystal size. The mineral composition observed was dominated by K-feldspar, plagioclase (oligoclase), biotite, quartz, and opaque minerals.
3) Alluvial depositsproduced bysettling due to transportation of material around the river, including exsitu.

c. Structural Geology of Djanra Areas

1) Joint of LP13

Based on the results of the stereographic analysis, the main stress direction is **southwest-northeast**.

2) Djanra 1 Fault

Based on the results of the stereographic analysis, the name of fault can be determined which namely as **Normal Right Slip Fault** (Rickard, 1972).

RESULT

1. DJANRA-1 Bauxite Laterite Characteristics

a. Contact Ore-Kong

The overburden is soil yellowish brown, has a thickness of 4 m. The bauxite ore zone is brownish red with a thickness of 6 m. While the kong/clay zone is red with a thickness of 1 m.

In the overburden zone, Al_2O_3 grades are relatively below 36% because there is little or no bauxite concretion in them. The content of Al_2O_3 in ore zone is above 35% on average, because bauxite concretion does indeed form well in the zone. Whereas in the kong zone, Al_2O_3 grades have decreased again, because the zone is dominated by clay with high grades of silica and minimal bauxite concretion content. Mineralogically, the overburden zone is dominated by clay minerals. The ore zone is dominated by gibsite minerals, with a small amount of quartz and clay. Whereas in the kong zone is dominated by clay minerals and a little quartz. While the red color from kong comes from hematite minerals which are also present in abundance. There is no gibsite mineral content, causing the kong zone to be considered uneconomical.

b. Contact Ore-Bedrock

The overburden which is soil has a thickness of 4 m with a yellowish brown color. The ore zone has a thickness of 6 m, with a brownish red color. The bedrock zone has a red color with a thickness of 2 m.

The overburden zone has Al_2O_3 grades below 35%, soft textures, and a massive structure. In the ore zone, Al_2O_3 grades increase to more than 35%. Then in the kong zone, Al_2O_3 grades again declined even though they were not significant because they were still relatively above 35%. But the bedrock zone has been considered uneconomical and has a crumbly texture. The abundant minerals present in the overburden zone are clay minerals, there are also quartz and gibsite, but are less significant. In the ore zone, there are very abundant gibsite minerals, little hematite, quartz, and clay. Even plagioclase are present as trace minerals. As for the bedrock zone, the plagioclase mineral present is quite significant because in this zone it still shows original texture and original composition of bauxite-forming host rocks.

2. DJANRA-2 Bauxite Laterite Characteristics

a. Contact Ore-Kong

The overburden zone in the form of soil has a yellowish brown color with a thickness of 2,3 m. The ore zone is brownish red with a thickness of 8,6 m. As for the kong zone it has a thickness of 1 m and is brownish yellow in color.

Al_2O_3 grades in the overburden zone ranged from 30%, indicating that minimal bauxite concretion is present in this zone. The ore zone has an average Al_2O_3 level of >35%, indicating that bauxite is indeed formed well in this zone. Whereas for the kong zone, Al_2O_3 grades, only around 30%. This shows that in the kong zone bauxite concretion is less significant or even absent. The mineral that dominates the cover zone is goethite, resulting in a yellow color. Also present are a few clay minerals as well as hematite in this zone. Then in the main mineral ore zone found is hematite, thus giving the dominant color red. After that, gibsite is also the dominant mineral present in this ore zone. The present clay minerals are less significant and act as impurities. There is also quartz which acts as a trace mineral. In the lowest zone, namely kong is composed of clay minerals as the main component. The possibility of abundant clay minerals is a mineral that has a yellow base color.

b. Contact Ore-Bedrock

Overburden zone has a thickness of 1,9 m, yellowish brown in color. The zone below, the zone of ore has a thickness of 2,3 m in brownish red. As for the lowest zone in the form of bedrock, the thickness is around 1,75 m and is red.

Overburden zone has an average Al_2O_3 content of 30%, indicating that in the upper zone the bauxite concretion contained is minimal or even non-existent. Then in the ore zone, the level of Al_2O_3 increases to >35%, indicating that indeed the bauxite concretion is indeed well compressed in the zone. There are also quite a lot of Fe minerals in the ore zone. As for the bottom zone, namely bedrock, the value of Al_2O_3 is still relatively high to touch 40%, but it is considered less economical because in that zone the concretion is not hard textured and tends to break easily.

3. DJANRA-3 Bauxite Laterite Characteristics

a. Contact Ore-Kong

The overburden has a yellowish brown color and thickness around 3 m. In the ore zone, it has a large enough thickness of 6 m with the dominant color is brownish red. For the kong zone, the colors owned are in the form of red with a thickness of about 2 m.

The results of the grade analysis indicate that the overburden zone has a Al_2O_3 content of about 30%. Just like in the previous hill, this number shows that this zone is not found in bauxite concretion. In the ore zone, the percentage of Al_2O_3 has increased to an average of >30%, indicating that the bauxite concretion forms well in this zone. Then in the lowest zone in the form of kong, the percentage of Al_2O_3 has decreased even though it is still above 30%, but it is considered not economical because of the minimal content of bauxite concretion. The main minerals that make up the ore zone are gibsite and hematite, with other minerals in the form of a little quartz. In the overburden zone, the main minerals are goethite, resulting in a yellowish color and there are also other types of clay minerals. As for the kong zone, the main minerals present are clay minerals, and a little hematite

b. Contact Ore-Bedrock

The overburden is only thin, which is 0,7 m and is yellowish brown in color. As for the ore zone, it is relatively thick at about 7,3 m and is dominated by a brownish red color. For the lowest zone in the form of bedrock has a thickness of 1 m and bright red.

Al_2O_3 levels in the overburden zone are 35%, due to the lack of concretion content in this zone. For ore zones, the content of Al_2O_3 has increased significantly to >35%, this is due to the formation of bauxite in this zone. Finally for the bedrock zone, Al_2O_3 levels again decreased to about 30%, indicating that the concretion contained had begun to soften and not hard anymore. It is seen that the main minerals that make up the ore zone are gibsite and hematite, there are also a few clay minerals. The mineral content of gibsite makes a high percentage of Al_2O_3 in the ore zone. Then in the overburden zone, the geotite mineral acts as the main mineral followed by other clay minerals.

4. Effect of Boulder Size Concretion (> 10 cm) on Bauxite Quality

a. DJANRA-1 Hill

In general, the quality of the total DJANRA-1 hill grade to depth changes when the boulder size concretion is mixed into small size concretions. Where the biggest change is at a depth of 9 m, because the percentage of the presence of concretion size is very large. Whereas in more detail, the element Al_2O_3 increases sharply at a depth of 9 m, but there is also an increase in the $RSiO_2$ elements even though the price is very small.

The graph in addition illustrates the distribution of the quality of bauxite in all DJANRA-1 hill test pits. The diagonal line is the limitation of the concretion of the size of the boulder and the small size. Where if the test pit is located above the line it indicates that the concretion size of the boulder in that place has a higher level, and vice versa.

For example, the boulder size concretion on the DJANRA-1 hill has an average grade of Al_2O_3 higher than the small size concretion. Whereas at the grade of $RSiO_2$, it turns out that the small size concretion has a higher value than the size of the boulder concretion

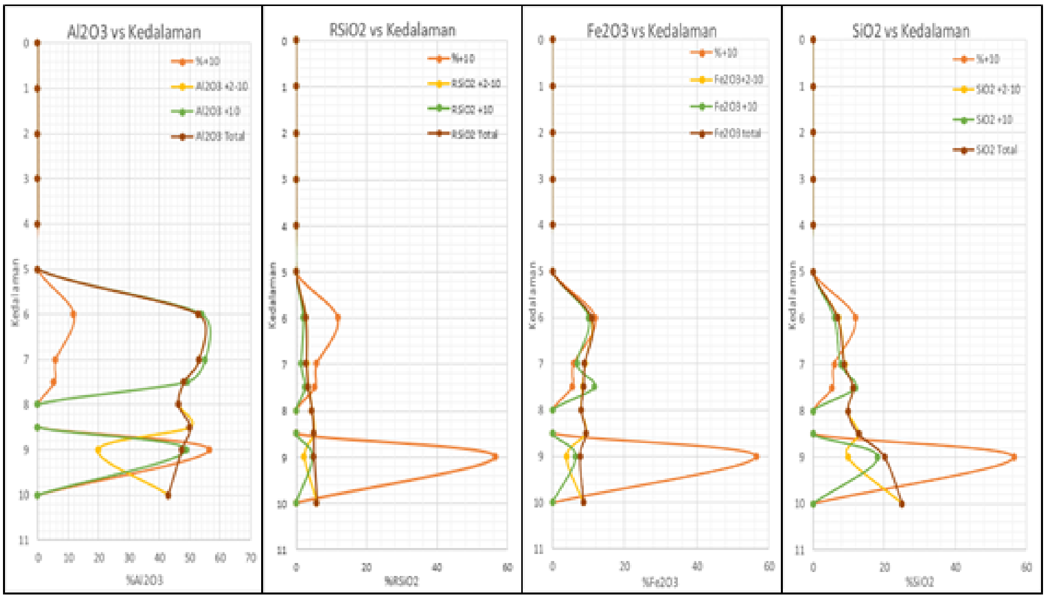

Figure 4. Quality Chart Bauxite Against Depth of DJANRA-1

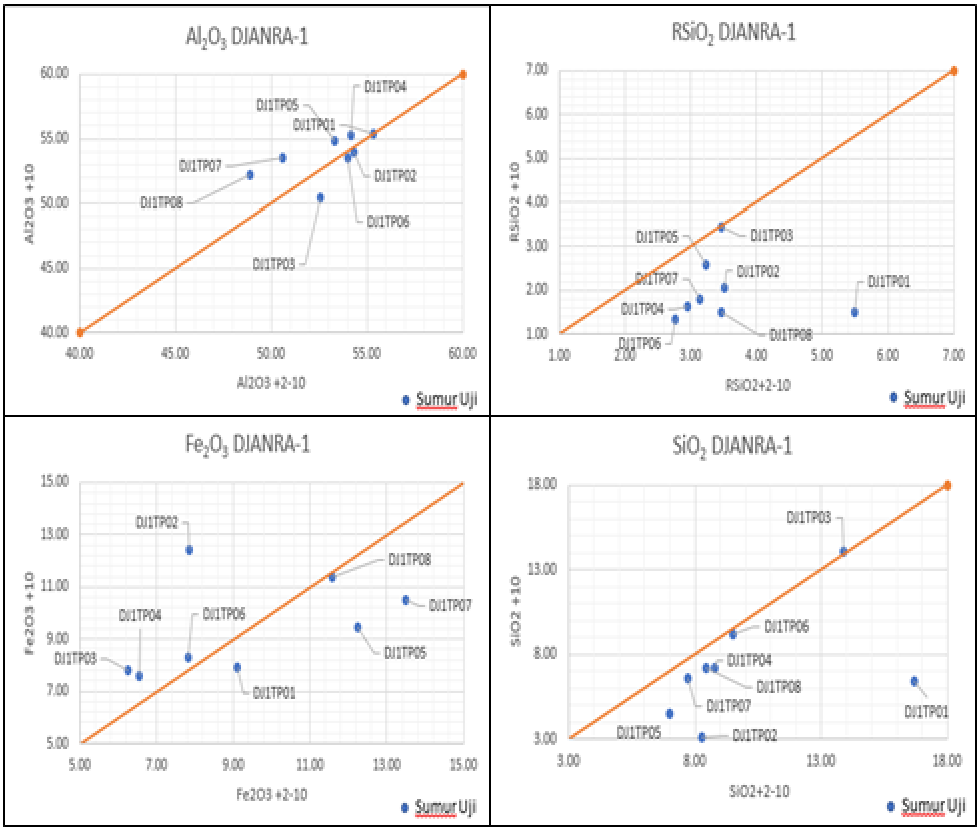

Figure 5. Quality Chart Test pit of DJANRA-1

b. Bukit DJANRA-2

In general, the quality of the total DJANRA-2 hill grade to depth changes when the boulder size concretion is mixed into small size concretions. Where changes are large enough at a depth of 3-4 m, because the percentage of the presence of concretion size is quite large. In more detail, the elements of Al_2O_3, Fe_2O_3, and SiO_2 lacked a significant increase. Whereas the grade of $RSiO_2$ actually decreased significantly at a depth of 3-4 m.

The graph below illustrates the distribution of the quality of bauxite in all DJANRA-2 hill test pits. There are 10 test pits on this hill.

Based on the graph, almost all the test pits on the DJANRA-2 hill have an average grade of Al_2O_3 on the concretion of the boulder size higher than the small size concretion. Whereas at the average grade of $RSiO_2$, it turns out that the small size concretion has a higher value than the boulder size concretion. That is, if you want to reduce the total grade of $RSiO_2$, the concretion of the boulder size can be mixed with small size concretion and the quality of bauxite will increase.

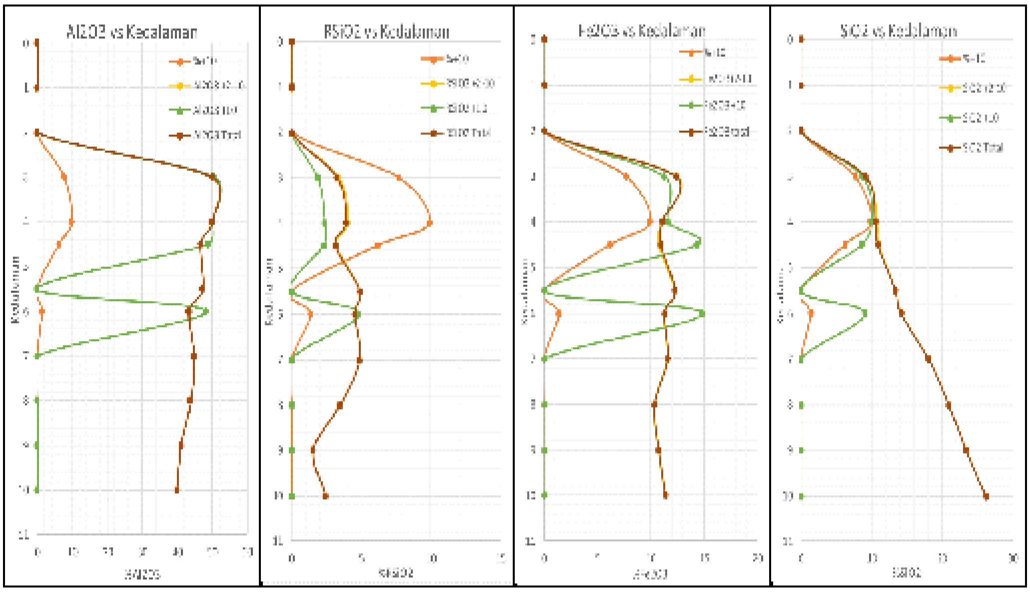

Figure 6. Quality Chart Bauxite Against Depth of DJANRA-2

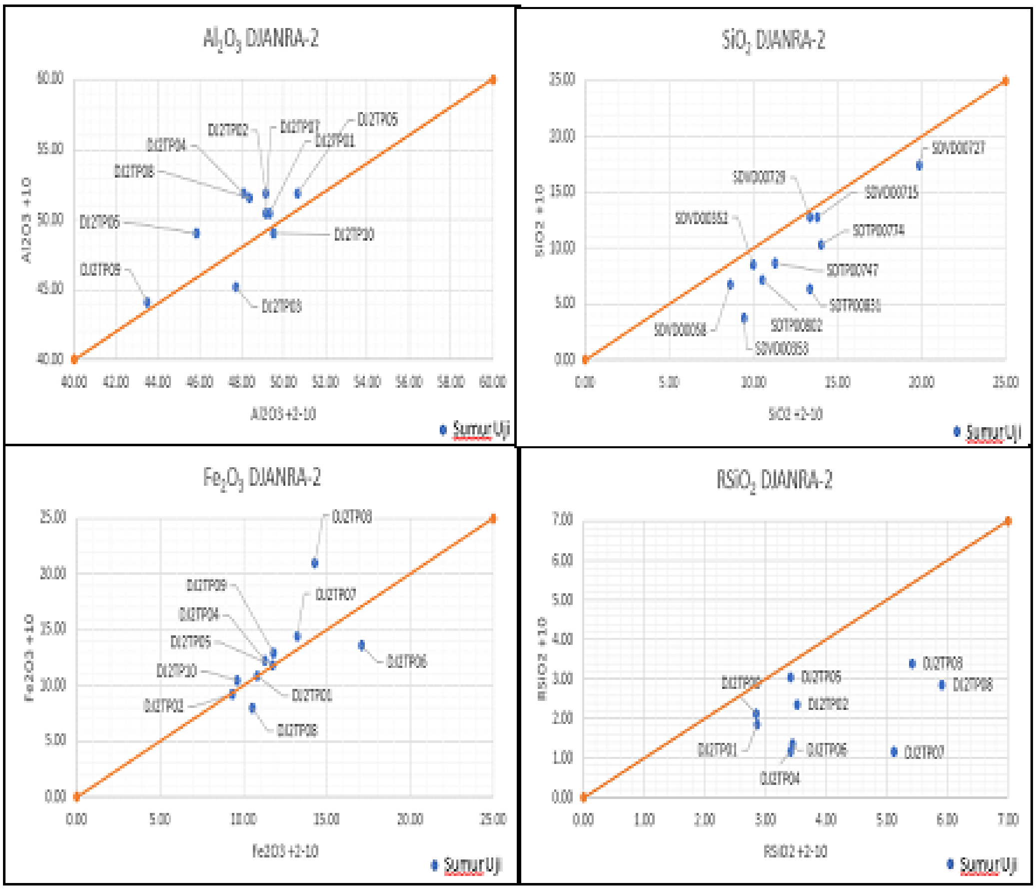

Figure 7. Quality Chart Test pit of DJANRA-2

c. Bukit DJANRA-3

In general, the quality of the total DJANRA-3 hill level to depth changes when the boulder size concretion is mixed into small size concretions. Where considerable changes occur at a depth of 6 m, because the percentage of the presence.

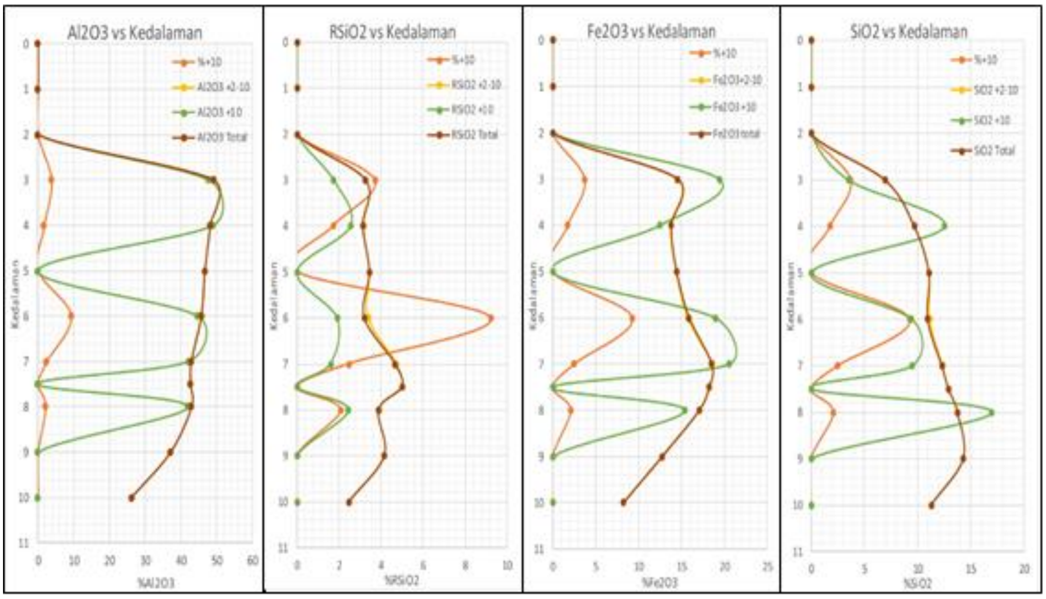

Figure 8. Quality Chart Bauxite Against Depth of DJANRA-3

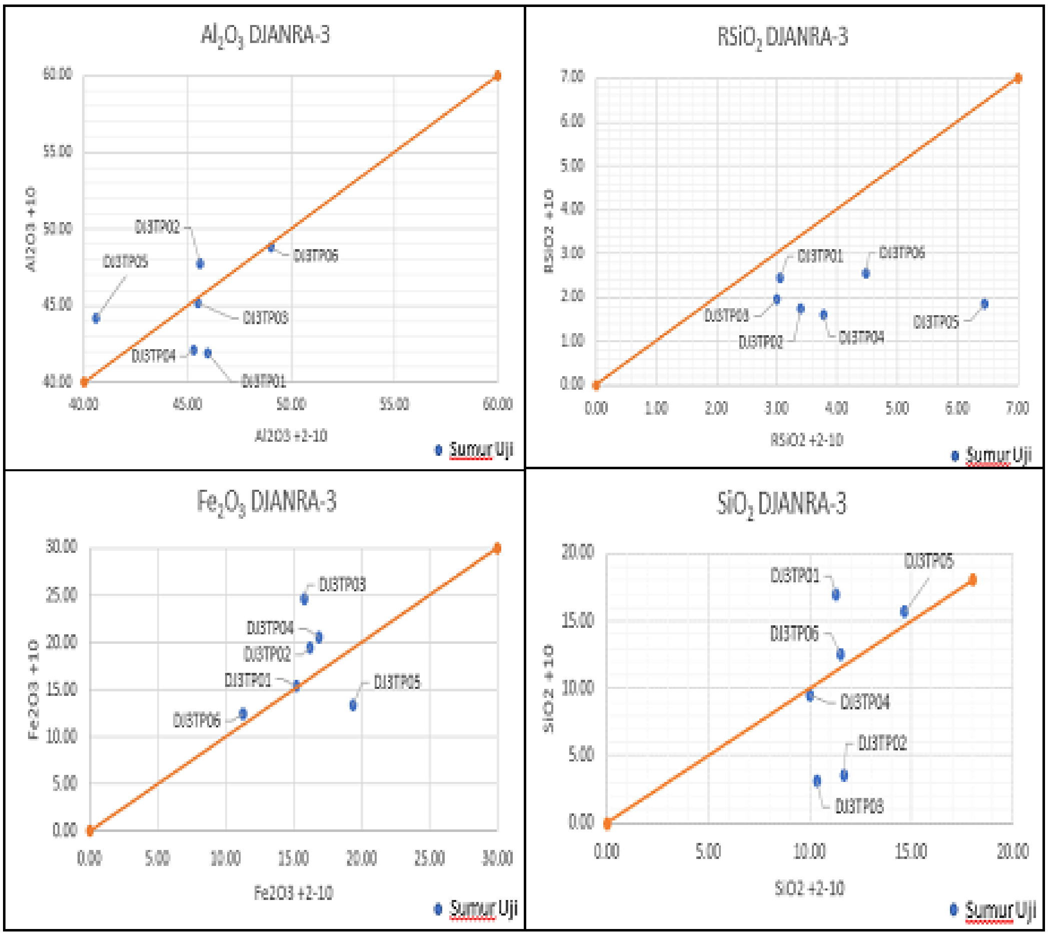

Figure 9. Quality Chart Test pit of DJANRA-3

In more detail, the elements of Al_2O_3, Fe_2O_3, and SiO_2 lacked a significant increase. Whereas the grade of $RSiO_2$ actually decreased quite significantly at a depth of 6 m.

The graph in addition illustrates the distribution of the quality of bauxite in all DJANRA-3 hill test pits. There are 6 test pits on this hill.

Based on the graph, almost all the test pits on the DJANRA-2 hill have an average grade of Fe_2O_3 in the concretion boulder size higher than the small size concretion. Whereas at the average grade of $RSiO_2$, it turns out that the small size concretion has a higher value than the boulder size concretion. That is, if you want to reduce the total grade of $RSiO_2$, the concretion of the boulder size can be mixed with small size concretion and the quality of bauxite will increase.

5. Factors Controlling The Quality of Boulder Size Concretion in The Djanra and Surrounding Areas

a. Slope

Based on the slopes of the Djanra areas, on the hill DJANRA-1 has a steep, rather steep slope. Whereas in the hills of DJANRA-2 and DJANRA-3, the dominant slope is steeply sloping. While from the results of the analysis it was found that the quality of the boulder size concretion (> 10 cm) on the DJANRA-1 hill was relatively better than the DJANRA-2 and DJANRA-3 hills. Where if seen from the ratio of Al_2O_3/SiO_2 has a value >6. This value indicates that on the DJANRA-1 hill, the content of Al_2O_3 derived from clay minerals (kaolinite) is low. If you look at the field conditions, the steep slope of DJANRA-1 hill is the main factor that triggers the difference in the quality of bauxite, specifically the boulder size. Where the steeper the slope, the better leaching of silica by water. Therefore, in the DJANRA-1 hill, the SiO_2 content (especially kaolinite) in bauxite deposits is relatively low.

b. Parental Rock

Based on the constituent rocks of the Djanra areas, on the third hill the focus of the research has the same host rock andesite. So that the main rock factor in the form of andesite is what makes the value of Fe_2O_3 on the three hills quite large. Because Fe is an immobile mineral, then when there is leaching by water, the element will not dissolve. Rather, it remains behind and ultimately has the concretion of becoming bauxite.

c. River (water source)

Based on the river and drainage patterns in Djanra areas, it can be seen that only the hill DJANRA-1 which is located adjacent to the big river. While the hills of DJANRA-2 and DJANRA-3 are not located near the river or far from the surface water source. Factors in the location of water sources or rivers can also be considered as the cause of differences in the quality of bauxite, especially the concretion of the boulder size (>10 cm). It is clear that on the hill DJANRA-1 has more water supply than the other two hills. So that it causes more intense weathering and leaching which then produces better quality bauxite deposits.

d. Structural Geology

The last factor that can be considered as the controller of the quality of bauxite deposits, especially the concretion of the boulder size (>10 cm) is the structural geology. But because weathering is very intense and the tendency has changed to bauxite laterite deposits. Then there can be no direct appearance of the structural geology in the field. But in theory, the structural geology is one of the main factors controlling the quality of bauxite. Because water which acts to leach host rock can only pass if there are joints or fractured.

CONCLUSION

The Djanra areasare composed of the andesite unit of Kerabai and the trakit Sukadana unit. The developing structural geology has a southwest-northeast direction. The formation of bauxite deposits in the Djanra areas are affected by the host rock and the structure.

The boulder size concretion in the Djanra areas has a varied depth distribution. The variation in the percentage of presence of boulder size concretions can affect the quality of the total bauxite laterite deposit. There are four main controlling factors namely slope, host rock, river, and structural geology.
Based on this study, only the boulder size of DJANRA-1 hill is taken to improve the total quality of bauxite.

REFERENCES

Aleva, G. J. J. (1994). *Laterites: concepts, geology, morphology, and chemistry*. Wageningen: International Soil Reference and Information Centre (ISRIC).

Amiruddin, A. (2009). Cretaceous orogenic granite belts, Kalimantan, Indonesia. *Jurnal Geologi dan Sumberdaya Mineral*, *19*(3), 167-176

Bateman, A. M., & M. L. Jensen. (1950). *Economic mineral deposits* (Vol. 259). New York: Wiley.

Hall, R. (2002). Cenozoic geological and plate tectonic evolution of SE Asia and the SW Pacific: computer-based reconstructions, model and animations. *Journal of Asian Earth Sciences*, *20*(4), 353-431.

Keyser, de F. & E. Rustandi. (1993) *Geologi Lembar Ketapang, Kalimantan, Lembar 1414, Skala 1:250.000*. Departemen Pertambangan dan Energi, Direktorat Jendral Geologi dan Sumberdaya Mineral, Pusat Penelitian dan Pengembangan Geologi, Bandung

Mutakyahwa, M. K. D., J. R. Ikingura, & A. H. Mruma. (2003). Geology and geochemistry of bauxite deposits in Lushoto District, Usambara Mountains, Tanzania. *Journal of African Earth Sciences*, *36*(4), 357-369.

Patterson, S. H. (1967). Bauxite reserves and potential aluminum resources of the world. Washington DC: United States Government Printing Office

Ramadhan, F. R., Y. Aribowo, D. A. Widiarso, & A. Betraz. (2014). Geologi, karakteristik dan genesa endapan laterit bauksit PT. Antam (Persero) Tbk, Unit Geomin, Daerah Kenco, Kabupaten Landak, Provinsi Kalimantan Barat. *Geological Engineering E-Journal*, *6*(1), 80-95.

Satyana, A. H., D. Nugroho., & I. Surantoko. (1999). Tectonic controls on the hydrocarbon habitats of the Barito, Kutei, and Tarakan Basins, Eastern Kalimantan, Indonesia: major dissimilarities in adjoining basins. *Journal of Asian Earth Sciences*, *17*(1-2), 99-122.

Streckeisen, A. (1974). Classification and nomenclature of plutonic rocks recommendations of the IUGS subcommission on the systematics of igneous rocks. *Geologische Rundschau*, *63*(2), 773-786.

Streckeisen, A. (1979). Classification and nomenclature of volcanic rocks, lamprophyres, carbonatites, and melilitic rocks: Recommendations and suggestions of the IUGS Subcommission on the Systematics of Igneous Rocks. *Geology*, *7*(7), 331-335.

Subiantoro, L., B. Soetopo, & D. Haryanto (2011). Kajian Awal Prospek Bahan Galian Monasit Mengandung U dan Elemen Asosiasinya di Semelangan Ketapang, Kalimantan Barat. *EKSPLORIUM*, *32*(155), 1-16.

Sukandarrumidi. 2009. *Bahan Galian Industri.* Yogyakarta: Gadjah Mada University Press

Threet, R. L. (1973). Classification of translational fault slip. *Geological Society of America Bulletin*, *84*(5), 1825-1828.

Toreno, E. Y. (2012). Karakteristik Cebakan Bauksit Laterit Di Daerah Sepiluk Senaning, Kabupaten Sintang, Kalimantan Barat. *Buletin Sumber Daya Geologi*, *7*(2), 45-56.

Valeton, I. (2010). *Bauxites* (Vol. 1). Amsterdam: Elsevier Publishing Company.

Van Bemmelen, R. W. (1970). *The geology of Indonesia* (Vol. 1). Den Haag: Martinus Nijhoff.

Verstappen, H. T. (1983). *Applied geomorphology: geomorphological surveys for environmental development.* New York: International Institute for Aerial Survey and Earth Science (I.T.C).