3D Block Model of Elements Distribution in Laterite Nickel Deposits

Andi Ilham Samanlangi

Email: Andhis79[at]yahoo.com
Mining Engineering, Engineering Faculty, Universitas Pejuang RI Makassar

Abstract: ***This study aimed to determine the 3-dimensional block model of elements in laterite nickel deposit. The method used in this study included drilling data, then analyzed using X-RF to get value of the element and grade from laterite nickel and ArcGIS program used to model the distribution of nickel elements laterally. The study concluded that in the block model, distribution of Ni colored yellow indicating Ni grade range from 0 to 1.2%, red color from 1.2-1.5, blue color from 1.5 to 1.8 and green color > 1, 8% of Ni grade. In block model of Fe distribution colored blue indicating Fe grade range from 3.15 to 10.25%, yellow color from 10.25 to 25.14%, green color from 25.14 to 35.69%, and brown color > 35,69% of Fe grade. In block model of MgO distribution colored red indicating MgO grade range from 0.25 to 10%, blue color 10-20%, yellow 20-30%, and green color > 30% of MgO grade. In block model of Co distribution colored yellow indicating Co grade range from 0-0.1%, green color 0.1-0.2%, red color 0.2-0.3%, and blue color > 0.3% of Co grade. In block model of SiO_2 distribution indicating SiO_2 grade range from 1-15%, green color 15-30%, yellow color 30-45% ,and blue color > 45% of SiO_2 grade. Elements distribution vertically indicated the degree of variation and mobility difference of the elements. Ni, MgO and SiO_2 tended to be concentrated in the saprolite zone while Fe and Co tended to be concentrated in the limonite zone.***

Keywords: Nickel, Distribution Elements, 3D Models, ArcGIS, X-RF

1. Introduction

Indonesia has very abundant natural resources including mineral resources, so it always becomes a target for investment in mining. As we know that investments in mining require not little cost even very much. Therefore, in the process of exploration require great accuracy and responsibility for reducing the risk of losses that can be obtained. After the exploration stage, modeling and estimation of resource or reserve need to be performed very carefully and responsibly. Deposit modeling aims to provide an overview about geological conditions and geometrical characteristics of deposit, so require analysis of the ore body models to determine the mine method.

Estimation of resources or reserves are also performed to determine the quantity of deposit that considered be economical to mine. So in this stage, require a method that can provide approach with the total of existing resources or reserves.

2. Basic Theory

Sulawesi Island is located on convergent zone among three lithosfer plates, they are Hindia-Australia plate that moves to the north, Pacific plate moves to the west, and Eurasia plate in the north side of Sulawesi Island moves to the south. (Herman and Hasan Saidi, 2000)

According to Hamilton (1979), based on lithology association dan tectonic development, Sulawesi Island and around divided into 5 tectonic provinces, they are: (1) West Sulawesi Tertiary Volcanis Arc, (2) Minahasa-Sangihe Volcanic Arc, (3) Central Sulawesi Cretaceous-Paleogene Metamorphic Belt Associated Pelagic Sediment, (4) East Sulawesi Createaceous Ophiolite Belt, (5) Banggai-Sula Microcontinent Fragment derived from Australia continent.

Regional Geology of Study Area

In general, study area included East Sulawesi geology province, which was characterized by a set of metamorphic rocks, serpentinite, gabbro, basalt and pelagos Mesozoic sedimentary rocks (Sukamto, 1981). The rocks exposed in the area of inventory activities ranging from Paleozoic to Quaternary, according to Rusmana E., et al. (1993).

Geomorphology

Regionally, study area included in the geological map of Lasusua - Kendari located in the southeast arm of Sulawesi Island. Morphology of Lasusua - Kendari could be divided into four units, namely the mountains, hills, karst area, and lowland (Rusmana, et al, 1993).

Genesis of Laterite Nickel Deposit

Nickel laterite is a residual product of the chemical weathering of ultramafic rocks. This process occured for millions of years, started when the ultramafic rocks exposed on the surface of the earth. Weathering on the peridotite caused elements with low mobility to immobile as Ni, Fe and Co were enriched residually and secondarily (Burger, 1996).

Based on its formation process, lateritic nickel deposit was divided into several zones with varying thickness and grade. Zones with intensive jointing intensity perhaps would have thicker profile than those less intensive of jointing.

Weathering is very closely related to the chemical and physical processes that vertically is a profile description of ultramafic rocks change become laterite deposit. Profile change of ultramafic rocks included paleotopography profile (Golightly, 1979) or the weathering profile (Butt, 1993).

Elements Distribution

Horizontally, distribution of Ni depended on the direction of the groundwater flow which greatly influenced by the shape of the slope (topography). Groundwater moving out from the areas with high elevation towards the lower elevation, where most of the groundwater contained Ni, Mg and Si flowed into the leaching zone or zones where groundwater fluctuations took place. On fractures of the rock, Ni would be trapped and accumulated in area accorded with existing fractures, while the slopes tended to flat - moderate were areas of nickel enrichment (Golightly, 1979).

Analysis XRF (X - Ray Fluorescence)

XRF is a tool used to analyze the chemical composition and the concentration of the elements contained in a sample by using spectrometry methods. XRF is commonly used to analyze the elements in a mineral or rock. Element analysis was performed qualitatively and quantitatively. Qualitative analysis was to analyze the types of elements contained in material and quantitative analysis wasto determine the concentrations of elements in the mineral/rock.

Research Methods

Generally, this study was divided into several stages, they are: field investigation such as drilling, data from this stage used to know the depth and distribution of laterite zones. Laboratory analysis was performed to get elements and their grades. Modeling was to know elements distribution model in nickel deposit based on the laboratory analysis data.

3. Results and Discussion

Block Model of Ni Distribution

Block models describe subsurface models in three dimensions in the study area. The yellow color is a block distribution model of Ni with grades range from 0 to 1.2%. The red color is the distribution blocks model of Ni with grades range 1.2 to 1.5%. The blue color is the distribution blocks model of Ni with grades range 1.5 to 1.8%. The green color is a distribution block model of Ni with grades > 1.8%. The results of Ni block model illustrates that Ni with high grades form the block at a relatively low elevation and a block model of low Ni grade of the block models describe elements at a relatively high elevation. Block model of Ni followed the distribution thickness of the elements and drilling patterns, in which Ni from low grade to high grade will form a block model pattern based on size of block. (Figure 1)

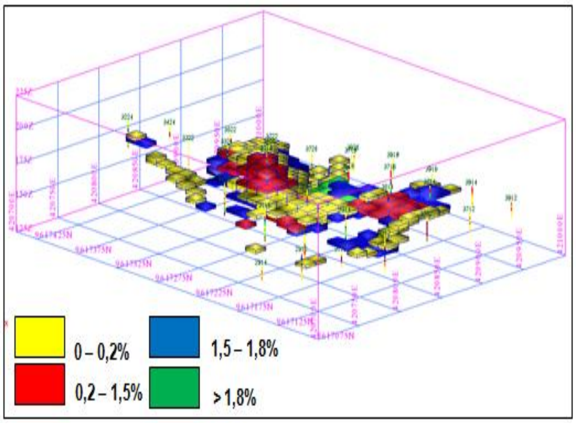

Figure 1: Block Model of Ni Distribution

Block Model of Fe Distribution

The blue color is a block model of Fe grade range from 3.15 to 10.25%. The yellow color is the block model of Fe grade range from 10.25 to 25.14%. The green color is a block model of Fe grade range from 25.14 to 35.69%. Brown is a block model of Fe grade of> 35.69%. Block models of Fe grade is the result of drilling data processing and chemical analysis. From the results of three-dimensional modeling can describe block model of elements distribution. Distribution of high grade Fe formed blocks model at relatively high elevations and low grade Fe formed the block model at a relatively low elevation. Block models of Fe formed based on the thickness of elements distribution, drilling depth and topographical patterns in the study area. Block models of Fe distribution have limitations of blockfrom classification results and describes the element distribution patterns. (Figure 2)

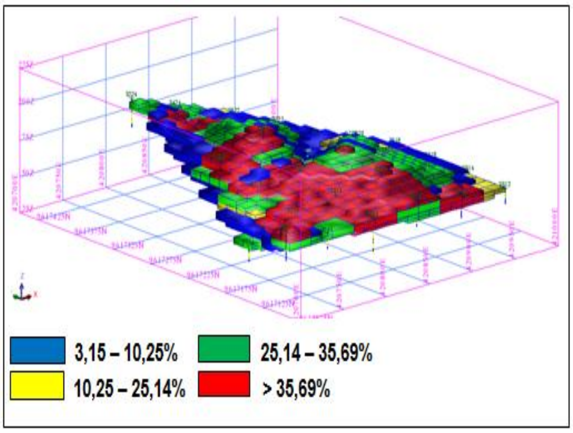

Figure 2: Blok Model of Fe Distribution

Block Model of MgO Distribution

The red color is a block model of MgO grade range from 0.25 to 10%. The blue color is a block model of of MgO grade range from 10-20%. The yellow color is a block models of MgO grade range from 20-30%. The green color is a block models of MgO grade range from >30%. Block models of MgO describes the conditions of the element distribution under the surface based on drilling data and chemical analysis in the study area. Block models of MgO form the block size of 25 meters, which describes the block distribution of MgO based on the grade, thickness of elements distribution, and following the drilling depth and topographical patterns in the study area. Block models with high grade of MgO form block at a relatively low elevation while the element with low grade of MgO form blocks with relatively high elevation. (Figure 3)

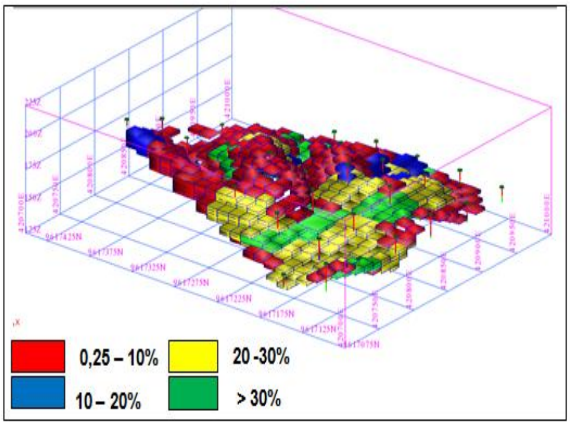

Figure 3: Block Model of MgO Distribution

Block Model of Co Distribution

Co grade range from 0 to 0.1% form a block model with a yellow color. Co grade range from 0.1 to 0.2% form a block model with a green color. Co grade range from 0.2 to 0.3% form the block models with red color. Co grade range > 0.3% form the model blocks in blue. Block model of the elements distribution is one of the reconstruction methods from drilling data and chemical analysis data that will show how the subsurface conditions of the Co distribution. Block model of Co distribution in the study areas formed block patterns based on the grade with the block size of 25 meters and 12.5 meters of sub-blocks. Block models pattern follow the thickness of elements, depth of the drilling, and drilling point elevation. Block model of low grade Co concentrated at relatively high elevations and block model of high grade Co concentrated in a relatively low elevation. (Figure 4)

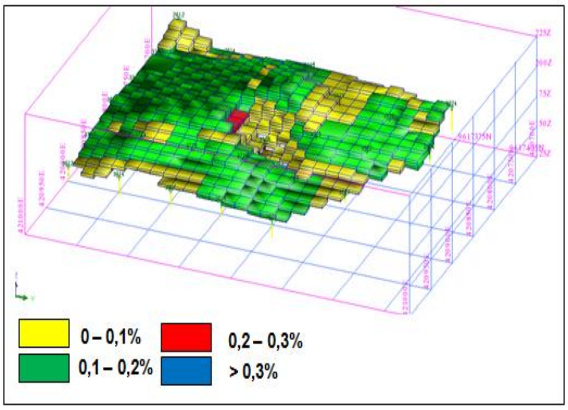

Figure 4: Blok Model of Co Distribution

Blocks Model of Sio$_2$ Distribution

Block models generally described in color and blocks according to limits of element. The red color is a description of blocks model of SiO2 grade range from 1-15%. The green color is is a description of blocks model of SiO2 grade range from 15-30%. The yellow color is is a description of blocks model of SiO2 grade range from 30-45%. The blue color is a is a description of blocks model of SiO2 grade range > 45%. Block models generally formed a description of distribution of subsurface elements, where in the study area, blocks model of SiO_2 described the distribution od subsurface conditions based on drilling data and chemical analysis data, SiO_2 formed block of 25 meters and 12.5 meters of sub block.

From the results of elements distribution modeling can describe the pattern of elements distribution in the form of block based on grade classification, high and low grade SiO_2 can form in according to the elemenys thickness of drilling point, depth of drilling, and drilling point elevation. Block models of high grade SiO_2 elements concentrated in a relatively low elevation and block model of low grade SiO_2 are concentrated in high elevations. Block model of SiO2 distribution can be seen in (Figure 5).

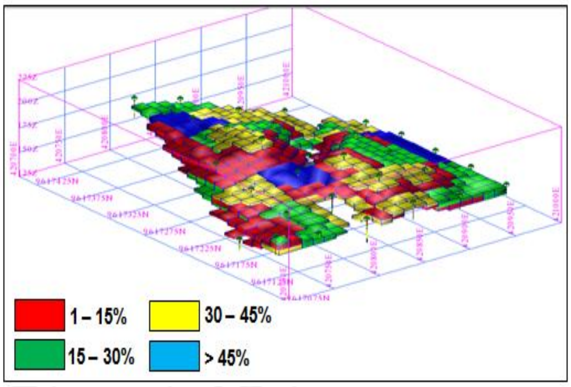

Figure 5: Block Model of SiO_2 Distribution

4. Conclusion

From this study, it can be concluded that the distribution of elements vertically shows the degree of elements distribution variation and element mobility difference. Elements Ni, MgO and SiO2 tends to be concentrated in the saprolite zone while the element Fe and Co tend to be concentrated in the limonite zone.

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