

ERT and Well Data Tie for Nickel Laterite Characterization

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Abstract. The need of ERT method in nickel laterites exploration can't be deny. This method have capability to make exploration more effective and efficient. In reality this method still remain ambiguity in its application, especially for geologist and mining expert. These ambiguity related with layer zone determination (limonite, saprolite and bedrock), the same resistivity values in the different zones and determination of bedrock. This paper try to expose interesting fact to overcome this ambiguity by using ERT data and drill data tie. This tie will show characteristic of nickel lateric based on resistivity value and the contribution of chemistry element for resistivity value. Data ERT was collected by using gradient configuration and well data consist of mayor element and minor element. Tie result showed difference resistivity value in limonite layer influence by Fe, H₂O and Ni, where resistivity value from saprolite layer influenced by Fe, H₂O, SiO₂, MgO, Al, Cr, and Ni in certain accumulation. In bedrock layer, almost all drill data did not reach bedrock but only reached the boulder alone, it is supported by the value of the resistivity of rock unserpentinized peridotite which should show a relatively large resistivity value

1. Introduction

Nickel laterites deposit is a product of chemical weathering of ultramafic rocks that Ni-silicate carrier, generally found in areas with tropical climates up to subtropical. Significant laterite deposits range in age from Palaeozoic to Recent and most deposits in the current tropical belts. The most common ways to exploit this deposit by using drill data and test pit, beside to get economic layer also to extract subsurface information. In early stage exploration usually explorationist used sparse drill data to get regional view related with economic distribution of nickel laterites. Before exploitation stages, they will drill more extensively with small distance between one drill hole to others. The more small distance between the drill data the more reliable information they will get, but unfortunately in the same time it needs more time and cost.

The limitation of these two data are narrow coverage area and only show vertically layer variation. Horizontally distribution in 2 and 3 dimension related with continuity done by correlation and geostatistical analysis. Another problem encountered is identification boundary between saprolite and bedrock. Generally this boundary is determined based on drill data, in this case there is a provision that



required, for example, if it is assumed to have reached a thickness of 5 meters of fresh rock, the drilling was stopped and the bedrock is assumed to have been obtained. In fact, the characteristic of saprolite layer in west block consist of boulder that has thickness more than 5 meters, it means an error happen in determining the bedrock. This error will impact on the exploitation techniques and calculation of reserves.

Therefore we need another approach that can be used as guidance not only to see horizontal distribution of nickel laterite layer but also can be used for making drilling spacing and how deep drilling must be done. One approach that can be done is by geophysical approach, in this case using the method of geoelectric resistivity. Some results of the research showed satisfactory results using the method of geoelectric resistivity to identify sediment laterite (Robain et al., 1996; Ritz et al., 1999; Beauvais et al., 1999). Especially for the identification of lateritic nickel deposit has been made by Savin et al., (2003) and Robineau et al. (2007). ERT for the correlation between the data and the drill data in the same area but different field have done Aswad et al (2014) even further Aswad et al (2015) have used the data ERT as primary data to determine the location and number of drill point.

This method is done by injecting electricity into the earth, and analyze the response of subsurface materials. This response in resistivity form of rocks subsurface (Telford, 1990). By knowing the subsurface resistivity distribution can make it easier to interpret the material beneath the surface and determine the boundary of the zone from nickel laterite profile.

Results ERT cross-section that has a horizontal resolution either tied with drill data (chemical elements), which has a good vertical resolution. The combination of this data used to make Characteristic of laterite nickel contained in the measurement line.

2. Data and Methodology

The area of research lies in the area of mining concession area of PT. Vale Indonesia, which is administratively located in Luwu Timur. Research area was conducted in an area that includes the area west block. The data used in this study consisted of one line of data ERT (Electrical Resistivity Tomography) and 13 drill point. The line length is 441 meters and the space between the drill points is 25 meters. Configuration used in this study is the gradient configuration. In addition to use of the gradient configuration Wenner configuration has also been used to identify sediment laterite (Ritz et al., 1999; Beauvais et al., 1999; Savin et al., 2003; Robineau et al., 2007). Schlumberger configuration combined with the Wenner configuration has also been used to identify lateritic nickel deposit (Robain et al., 1996).

Configuration gradient is used because it allows generating vast amounts of data with various combinations of electrode potential and current electrodes. This gradient configuration provides better imaging resolution because it is a combination of configuration Characteristic pole-dipole, Wenner and Schlumberger (Dahlin and Zhou, 2006)

3. Result and Discussion

3.1. Preliminary Interpretation

Based on resistivity cross section (Figure 1) trajectory R can be divided into 3 layers buy seeing trend resistivity value and the initial information about the distribution of nickel laterite profile, there are limonite, saprolite and bedrock (bedrock). Limonite layer with resistivity values of 50-800 Ωm . Characteristic in this layer has different between the eastern and western parts of the foregoing. The

eastern part has a resistivity value is relatively much larger than the western part, this shows that the factors that support the eastern part laterisation different from those in the east. Saprolite with 25-450 Ωm resistivity values. In this layer of Ni element is expected enrich. This layer based on preliminary information have characteristic of nickel laterite profile West Block contains many boulder and this can be seen from the cross section of the resistivity (closed curve dotted line). This layer has a low resistivity value relatively small because the water saturation zone, has a small grain size, unless there is a boulder in it. Boulder is very influential in the calculation of reserves. The last layer is a layer of bedrock with resistivity values of more than 400 Ωm . This layer is indicated as a zone of bedrock that has the permeability and porosity is very low. Based on the value of resistivity of this layer belong to ultramafic igneous rock which contains olivine and piroksin (peridotite). A question mark at the beginning of the interpretation of this layer still raises the question whether the error in data collection, data processing, or beneath the surface of this reality is what it is. To answer these questions required additional data is data drill data.

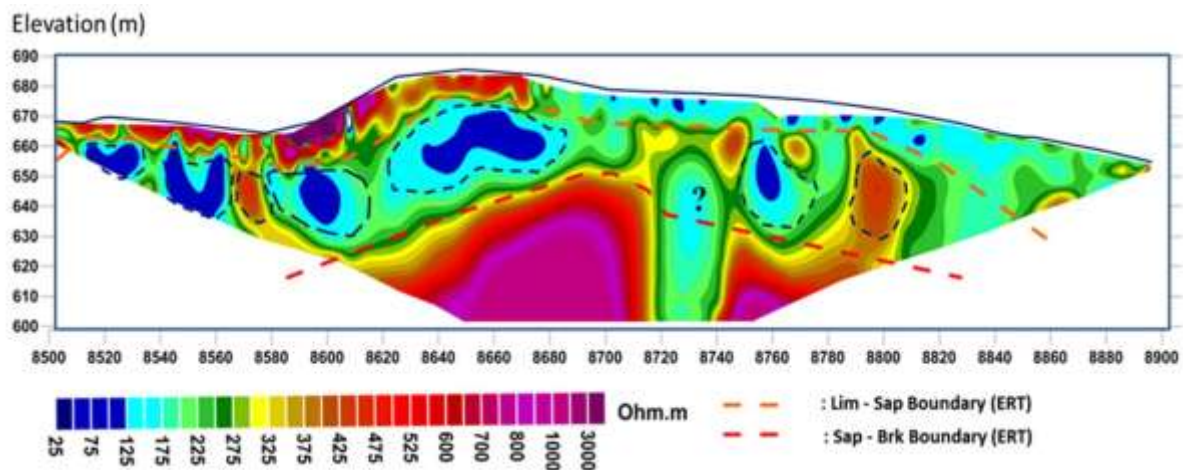


Fig. 1 Resistivity cross section of line R

3.2. Nickel Laterite Profile Based on Drill Data

This cross-section is based on data drill spacing of 25 meters (Figure 2), except for the western part of the drill spacing between R03 and R04 because the topography is very steep. The drilling will be stopped after 5 meters gained massive rock (fresh rock) and annotated have reached bedrock (bed rock). Any data retrieved drill core drilling conducted geological description and examination of the chemical element. From the analysis of chemical elements along with certain criteria determining the limits (cut off) obtained by the boundary zone of limonite-saprolite and saprolite-bedrock boundary for each point of the drill. The entire drill data on the track then correlated to form a cross-section shown in Figure 2. The divisions own profile in accordance with that proposed by Waheed (2009). It was clear enough distinction western and eastern parts of the foregoing. The western part there is a layer of limonite, saprolite and bedrock, while the eastern part is only there is a layer of limonite and immediately met with bedrock without saprolite

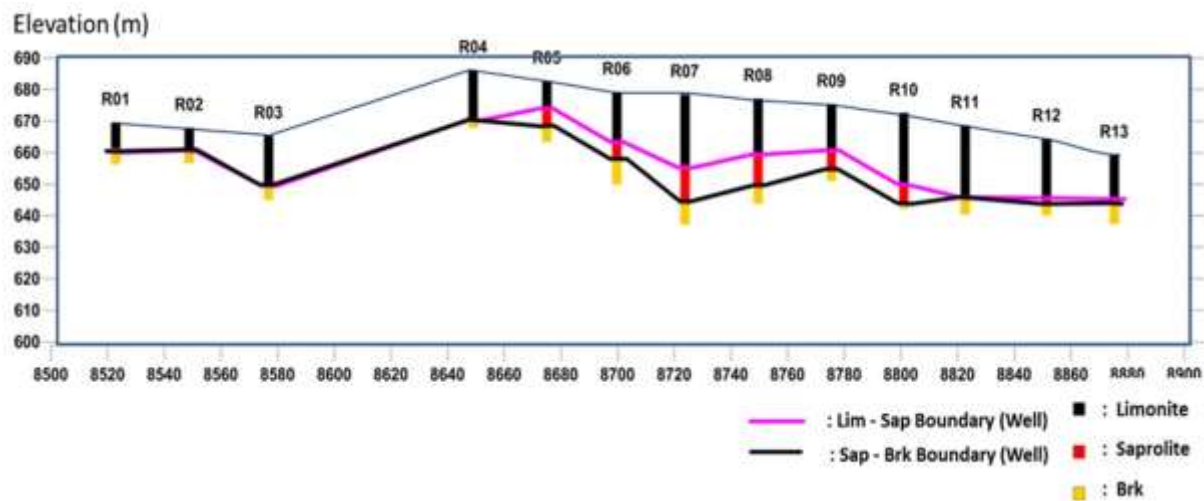


Fig. 2 Nickel laterite Distribution Based on Drill data

3.3. Chemical Mobility of Element

In the ultramafic rocks occur geochemical mobility. Mobility is the ability of an element to be dispersed into the surrounding matrix of another material. Mobility affects the response element to the process disperse. The main factors affecting the mobility geochemistry geochemistry is the chemical stability of the elements (Waheed, 2009).

The mobility of an element that is found in ultramafic rocks or associated with laterite can be classified as follows:

1. Elements that are highly soluble and highly mobile, Easily washed / swept up in the weathering profile and is highly soluble in groundwater flow slightly acidic tropical regions, such as Mg, Si, Ca, Na and K (Figure 3)
2. Elements that are not soluble and unmobile dissolve in ground water at ordinary pH / Eh conditions, these elements make up the bulk or residual soil, such as Fe^{3+} (ferric), Al^{3+} , Cr^{3+} , Ti and Mn^{3+} (Figure 4)
3. Elements with limited solubility and limited mobility (Figure 5), such as: Ni^{2+} , Co^{2+} and Mn^{2+} . Partially soluble in acidic ground water, and insoluble when there are more soluble elements (Si, Mg)
4. ground water, and insoluble when there are more soluble elements (Si, Mg)

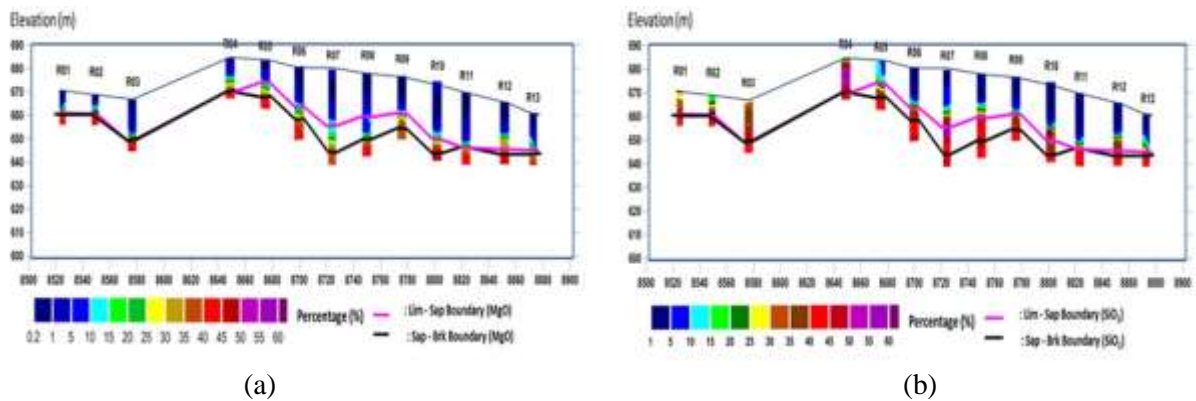


Fig. 3 Elements that are highly soluble and highly mobile consist of (a) MgO dan b) SiO_2

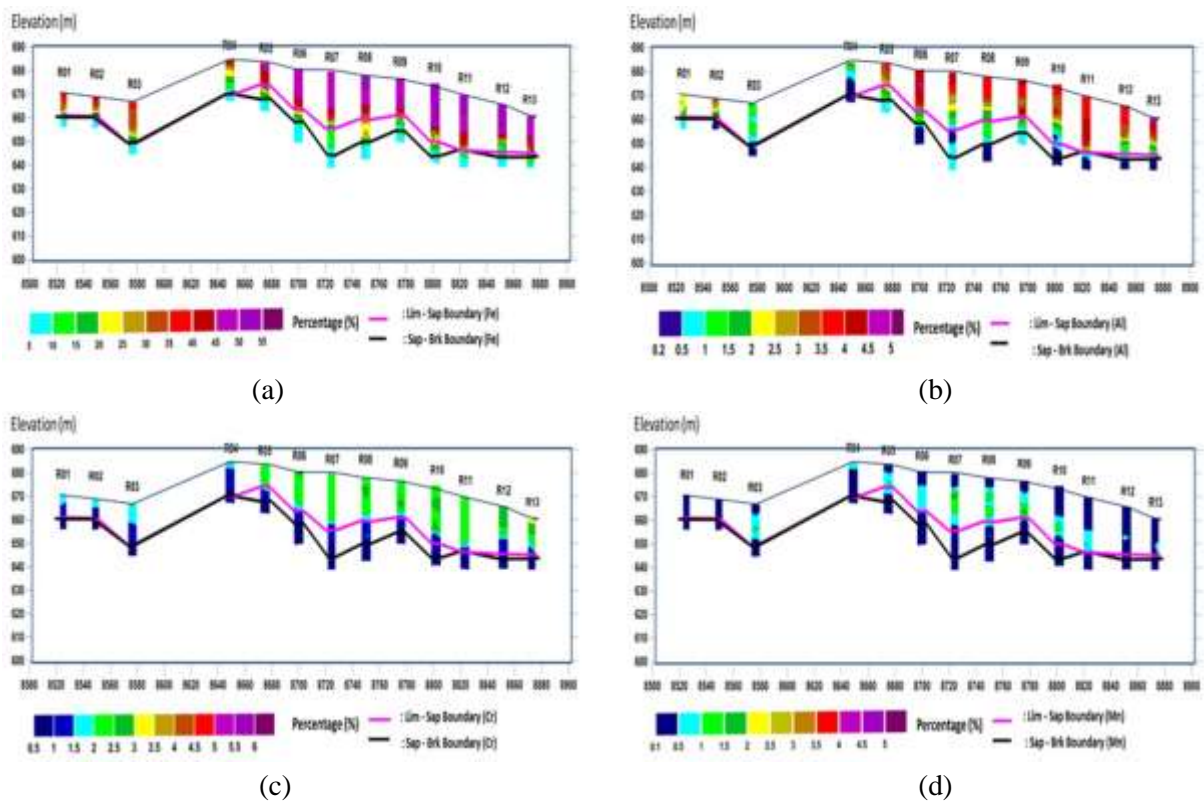


Fig. 4 Elements that are not soluble and unmobile a) Fe, b) Al, c) Cr dan d) Mn

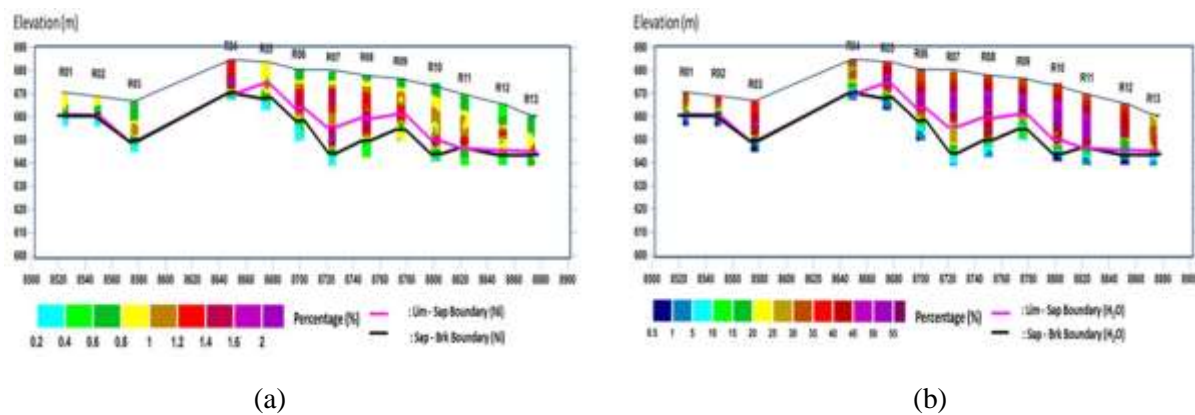


Fig. 5 Elements with limited solubility and limited mobility Ni (a) and water contain core sample (b)

3.4. ERT and Drill Data Tie

Can be clearly seen the difference between the drill data and resistivity data in determining the upper limit and lower limit of each layer of laterite, especially those boundary of the base layer (bed rock). This has implications for the determination of the difference thickness of the saprolite and ultimately affect the calculation of reserves. The lower limit of the drill data saprolite, in this case the boundary between the saprolite and the bedrock / bed rock is at an average depth of 21.5 meters \pm . ERT Data show different things, the depth of the lower limit of saprolite resistivity values are based on average depth of \pm 43 meters. This is due to the assumption of the drill data that says after 5 meters found the massive rock (fresh rock) mistakenly based on data ERT. The ERT data showed that the rock still mostly boulder in a large size, which under the bolder they are expected to have a saprolite nickel content which is great. Results from data tie showed limonite zone resistivity difference was more influenced by the content of Fe, Ni whereas H_2O and saprolite resistivity values are influenced by Fe, H_2O , SiO_2 , MgO , Al, Cr, and Ni with a specific accumulation.

The problem with question marks in initial interpretation from data analysis can be done by comparing anomaly with data vicinity. To strengthen the analysis of geochemical data can be used, particularly by comparing the drill data R06. From the geochemical data that is H_2O , MgO and Al looks a distinct pattern with drill R06. H_2O from R07 possible for smaller if drilled deeper, it is also supported by data MgO were also relatively large. Water as transport will bring the mobile element in this regard MgO deeper. It can be concluded that in this area there is a structure activity, could be fault or fracture).

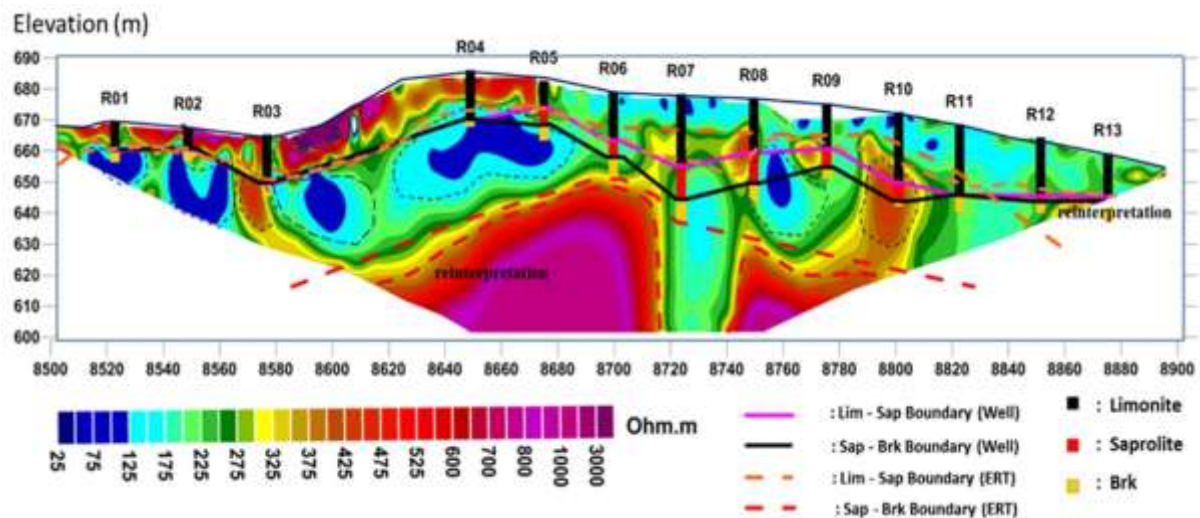


Fig. 6 Reinterpretation using combination ERT and Drill data

4. Conclusion

Interpretation in determination boundary of limonite, saprolite and bedrock would be much better using combination drill data and data ERT, it is seen by the ability of both these data to determine the boundary layers and identify the boulder. Especially for bedrock can be seen clearly in the data ERT with large resistivity values, it is supported by the fact rock bedrock consisting of peridotite unserpentinised. Merging this data also helps in identifying the structures associated with local faults or fractures.

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