Identify the Distribution of Galena using Induced Polarization and Resistivity Methods in central of Lombok, West Nusa Tenggara

Asnur Azis¹, Muh. Adimaher Zamhuri¹, Muh. Iqbal Rais¹, Syamsuddin¹, Sabrianto Aswad¹, Obed Patiung², Yanto Sudianto³
¹Geophysics Department, Hasanuddin University, South Sulawesi. Indonesia
²Geological Engineering Department, Hasanuddin University, South Sulawesi. Indonesia
³Agency for the Assessment and Application of Technology - Center for Mineral Resource Technology

asnurazis10@gmail.com

Abstract. This study aims to identify the distribution of galena in central of Lombok, West Nusa Tenggara. On the surface of the area Silicified Rock shows the shape of quartz veins, which are formed as fillers in volcanic breccia, tuff and igneous andesitic rocks. Quartz veins generally have a relative direction following the main stress, with a vein thickness of 0.5 cm - 3 cm (stockwork of vein), while the main vein has a thickness ranging from 22 cm - 2.5 m. Mineralization conditions are very strong in quartz vein outcrops indicated by the presence of pyrite mineralization, chalcopyrite and galena. One of the geophysical exploration methods used to detect the presence of galena is the geoelectric method. The geoelectric method used in this study is the resistivity method and the induced polarization method (time domain). The resistivity method is used to detect the distribution of rocks associated with galena, while the induced polarization method detects the effect of the capacitor on subsurface metal minerals. This research has 3 line, the length of each line is 235 meters and one line is used as a reference for measuring 24 meters in length using the Wenner schlumberger configuration. Interpretation results obtained galena distribution is in all line with chargeability value 35.0-45.7msec

Keywords: Resistivity, Induced Polarization, Wenner Schlumberger, Galena

1. Introduction
Along with good industrial activities, both at home and abroad there will be a need for raw materials or black wood (PbS), especially China. So many activities are carried out to find areas that have the potential to contain black ingredients. Correspondingly, the government has included the private sector in an effort to find and develop the potential for lead (Rosana, 2007).

From several previous investigations, especially metal minerals, it is known on the island of Lombok that there are sulphide minerals in the rocks of Pengulung Formation (Gunradi, 2005). Preliminary exploration carried out by the Directorate of Mineral Resources (1997) in the regions of West Lombok and Central Lombok, shows that there are several prospect areas of metal mineralization in this area (Gunradi, 2005).

One of the appropriate methods to detect the distribution of the presence of ore deposits below the surface is to use geoelectric methods. The geoelectric method itself is defined as a geophysical method
that studies the nature of electricity in the earth. A good geoelectric method used for metal mineral exploration is a method of Induction Polarization. (Telford, et. al , 1990).

Induced polarization Method (IP) is a relatively new method of geophysics and has been used in the field of basic metal exploration. This method is widely used in exploration of base metals because of the polarization phenomenon that occurs to a rock medium. The polarization phenomenon indicates the presence of metal below the surface that is not detected properly if it only uses the resistivity geoelectric method (Telford , et . al , 1990 ).

2. Resistivity Method

The flow of electric current in rocks and minerals can occur if rocks or minerals have many free electrons so that the electric current is flowed in rocks or minerals by the free electrons. This electric flow is also influenced by the nature or characteristics of each rock that passes through it. One of the characteristics or characteristics of the rock is resistivity. Resistivity or commonly called types resistance is a parameter that shows the inhibitory power of a medium in flowing electric current.

In the isotropic homogeneous earth model (figure 1), an electrode C inside the earth is coupled with other electrodes on the surface at a considerable distance. Electrode C can be seen as a source point that emits electrical currents in all directions within the earth with type resistance. When the distance between 2 current electrodes is determined, the magnitude of the potential for point P1 is due to current sources C1 and C2 (Telford , et . al , 1990):

\[ V_1 = \frac{I \rho}{2\pi} \left( \frac{1}{r_1} - \frac{1}{r_2} \right) \]  

(1)

With the same rules, the potential for point P2 due to current sources C1 and C2 is:

\[ V_2 = \frac{I \rho}{2\pi} \left( \frac{1}{r_3} - \frac{1}{r_4} \right) \]  

(2)

So that the potential difference between points P1 and P2 is as follows:

\[ \Delta V = \frac{I \rho}{2\pi} \left[ \left( \frac{1}{r_1} - \frac{1}{r_2} \right) - \left( \frac{1}{r_3} - \frac{1}{r_4} \right) \right] \]  

(3)

\[ \Delta V \] = potential difference between P1 and P2 (Volt),
\[ I \] = current strength through current C1 C2 (Ampere) electrode,
\[ r_1 \] = distance between C1 and P1 (meters),
\[ r_2 \] = distance between C2 and P1 (meters),
\[ r_3 \] = distance between C1 and P2 (meters),
\[ r_4 \] = distance between C2 and P2 (meters)

![Figure 1. Electricity Potential by Two Current Sources in the Earth (Kearaey, et., al, 2002).](image)
Based on the arrangement of measurement electrode placement there are various types of configurations including Wenner Alpha configuration, Wenner Beta, Wenner Gamma, Pole-Pole, Dipole-Dipole, Pole-Dipole, Wenner-Schlumberger, and Equatorial Dipole-Dipole.

Figure 2. Electrode Configuration and Geometry Factors (Loke, 2004).

Figure 2 shows each configuration has its own characteristics, so that each configuration has advantages and disadvantages. Each configuration produces different geometry factors. Where the geometry factor is a quantity that changes into the distance apart (space) of the electrode and depends on the arrangement of the electrodes that is formulated (Loke, 2004).

\[ K = \frac{2\pi}{r_1 + \frac{1}{r_2 + \frac{1}{r_3 + \frac{1}{r_4}}}} \]  

(4)

K is a geometry factor that depends on the arrangement of 4 electrodes. Substituting the geometry factor of all resistivity equations can be simplified to:

\[ \rho = K \frac{\Delta V}{I} \]  

(5)

\( \rho \) is an apparent resistivity with Ohm. Meter

A problem is better done with one type of electrode configuration, but it is not certain that the problem can be solved if another type of configuration is used. Therefore, before making a measurement, the goal must be clearly known so that it can choose which type of configuration to use (William, 2003).

3. Induced Polarization Method

The induced polarization method is part of the geophysical method that utilizes polarization properties due to the presence of electric currents passed in the medium. This method arises because of the limitations of the Geoelectric method, one of the techniques for measuring this method is in the time zone, therefore it is called Time Domain Induced Polarization (TDIP) (Yatini, et al., 2014).

The effect of induced polarization (IP) can be illustrated by using a four-electrode configuration in a resistivity measurement as in figure 1. When the current flow at the current
electrode are stopped, the potential difference value of the two potential electrodes is not directly zero but decreases slowly until worth zero.

The same phenomenon occurs when an electric current is turned on. In the initial state, the value of the potential difference increases slowly over a certain time interval to a constant value. The medium that experiences the effect is called a medium that can be polarized. The IP effect is shown during the time interval decrease in potential difference as shown in figure 3.

**Figure 3.** Phenomenon of Induced polarization (Kearey, et.al, 2002).

### 3.1 Measurement Principles

Induced polarization method uses the Wenner Schlumberger configuration when taking measurements of the field as illustrated with Figure 1. Data acquisition method of polarization induction can be done in two ways, time domain measurement and frequency domain measurement.

Measurements of the frequency domain are carried out by flowing electric current into the ground in two different frequencies of a certain time interval. The use of these two different frequencies is because each material has a different response for certain types of currents with the same frequency.

The measurement of the IP time domain is used to measure the potential difference after the current is stopped. One measurement parameter is chargeability M, which is defined as an area under a decrease curve over a certain time interval $(t_1-t_2)$ which is normalized by a potential difference $\Delta V_C$. Chargeability is measured from a certain time interval when the current is stopped (Kearey, et., al, 2002).

$$M = \frac{1}{\Delta V_C} \int_{t_1}^{t_2} v(t) dt$$

M has a time dimension with second or millisecond units

**Figure 4.** Residual potential for time (Kearey, et., al, 2002).
4. Result and Discussion

In this study the interpretation is based on several things where each parameter used is the result of literature studies and field parameters that are used as reference measurements. Where in this reference has a quartz vein whose relative direction follows the main stress with a vein thickness of 0.5 cm - 3 cm (stock work of vein), while the main vein have a thickness ranging from 22 cm - 2.5 m. Mineralization conditions are very strong in quartz vein outcrops indicated by the presence of pyrite mineralization, chalcopyrite and galena. Galena are found to be associated with tuff (figure 5).

![Figure 5. Reference measurements in the field. a). Resistivity inversion results, b). Chargeability inversion results.](image)

The inversion result from figure 5 shows the range of resistivity values between 8.59 - 152.93Ωm and the chargeability value between 2.69-83.41msec. Galena has a chargeability response > 35.0 - 45.7msec with a low resistivity value. The reference distance parameter aims to obtain the model parameter values to obtain theoretical data that matches the observation data. If there is a response to a model that matches the observation data, the model used to obtain the response can be considered to represent the subsurface conditions where the data is measured.

4.1 Analysis of Measurement Results

The processed data generates resistivity values and chargeability values then are converted in Res2Dinv which is then displayed in the Surfer section of each path to facilitate interpretation.
Figure 6. a). Resistivity inversion results, b). Chargeability inversion results

Figure 6 Shows the resistivity response to a high resistance anomaly with a resistivity value of 58.8 - 86.4 μm which is thought to be the origin rock. Chargeability response to a value of 35.0 - 45.7 msec shows the mineral prospects of galena which are locally related, indicated by a black line indicated where the accumulation of galena is, with a thickness of ± 20 m at a distance of 80-120 with a depth of 20-45m.

Figure 7. a). Resistivity inversion results, b). Chargeability inversion results

Figure 7. Chargeability response to a value of 35.0 - 45.7 msec shows the prospect of galena marked with a black line indicated where the mineral accumulation of galena is accumulated, with a thickness of ± 20m at a distance of 60-100m with a depth of 20-45m. Resistivity response shows the dominance of low in medium resistivity values with a range of values of 27.3-40 Ωm, but at a distance of 80-100m there is a weak zone anomaly that has a lower resistivity value than its surroundings.
5. Discussion
Interpretation is done by combining resistivity and chargeability sections. This is to strengthen the assumption of the results of the analysis in determining the distribution of rocks containing galena from each measuring path. From the resistivity section and the chargeability section of the inversion results which are associated with the geological conditions of the study area, obtained estimates of the chargeability and resistivity values of rock containing galena based on observations can be seen in Table 1.

| Resistivity (Ωm) | Rock Lithology                                      |
|------------------|-----------------------------------------------------|
| 40.0-127         | Breccia rock is composed of polymict fragments consisting of andesite, diabase and basalt |
| 8.59-27.3        | Tuffaceous rocks have experienced physical weathering due to exogenous and endogenous influences (hydrothermal processes). |

Galena have a low chargeability value <3.7 msec (Kearey, 2002). The presence of galena associated with the surrounding environment causes the presence of galena will be indicated by a greater chargeability value, which is between 35.0 - 83.41 msec.

Figure 8. Overlay resistivity section and chargeability section

The data processing results of this path shows the chargeability response which is locality with a chargeability value of ≥35.0 msec, can be seen in Figure 8 is the result of overlaying resistivity section and chargeability section can be seen shaded zones at distances between 80-120m, in this zone the prospects of mineralization galena is quite large with a thickness of ± 20m, a high resistivity value ≥58.6 Ωm looks like a large chunk. This can be interpreted as bedrock associated with galena mineral, then linked to the geological conditions of the study area, then this value is considered as breccia intrusion rock beneath the surface.
The data processing results in this path show the chargeability response in the similarity of the model on the line_1 path (figure 7.b). It is assumed that the continuity of galena on the line_1 and line_2 paths. Figure 9 is the result of overlaying the resistivity section and chargeability section can be seen shaded zones at a distance between 60-100m is the mineral prospect of galena. At this layer it is assumed that there is a weak zone at a distance of 80-100m which has a lower resistivity value than its surroundings which is thought to be composed of alteration rocks consisting of sericite rocks (interlaced tuffs) where these rock units have high porosity and permeability.

6. Conclusion

On each line, the prospect of galena is indicated on the line 1 and 2, line 1 is associated with breccia rock, while line 2 is associated with sericite rocks (altered tuffs).

Excellent prospects for mineralization are on lines 1 and 2. The continuation of rocks in the form of breccia and tuff which is the accumulation of galena.

References

[1] Gunradi, R. 2005. Evaluasi Sumber Daya/Cadangan Bahan Galian Untuk Pertambangan Sekala Kecil, Daerah Pulau Lombok, Provinsi Nusa Tenggara Barat.
[2] Kearey, P.,Michael, B., Ian., H . 2002. An Introduction to Geophysical Exploration. Blackwell Science Ltd. London.
[3] Loke, M.H. 2004. Rapid 2D Resistivitas & IP Inversion using the least-square method, Geotomo Software. Malaysia.
[4] Rosana F,M. 2007. Keterdapatian Bahan Galian Galena di daerah Ceigemblong, Kabupaten Lebak, Propinsi Banten. Jurusan Geologi. FMIPA. Universitas Padjadjaran.
[5] Telford, W.M., Geldart, L.P., Sheriff, R.E. 1990. Applied Geophysics. Cambridge Univ. Press. Cambridge.
[6] William J.J. 2003 Application Geoelectric Resistivitas method for detectionof underground Mine Working, Geophysical Technology for detecting underground Coal.
[7] Yatini, S. D., Laesanpura, A., 2013, Physical Modelling studies of the Time Domain Induced Polarization (TDIP) Response, Case : Homogeneous Isotropic Medium, Proceedings, 3rd Annual Basic Scien.