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ESTIMATED OF METAL MINERAL DISTRIBUTION USING INDUCED POLARIZATION (IP) GEOLISTRIC IN MALALAK WEST SUMATERA INDONESIA

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ABSTRACT

The Malalak area in West Sumatra Indonesia area located around the volcano and generally rich in economically valuable metal minerals, however, the presence of minerals in nature is not easy to find. The existence of economically valuable minerals around volcanoes, such as Mount Singgalang has not been widely revealed. Based on the above, a study aimed to estimate the distribution of metal minerals in Malalak Subdistrict, Agam Regency when viewed by the Geoelectric Induced Polarization (IP) method was conducted. Research is needed as reference data to predict mineral potential in the study area so that it can be used by the Malalak community. The exploration method used in this research is the Geoelectric Induced Polarization (IP) method. Data obtained by measuring using the ARES measuring instrument. Data processing uses Res2Dinv software to obtain 2D cross-sections and the data is interpreted using Smoothness-Constraint Least-Square inversion. Based on the estimates made to determine the distribution of minerals in the Malalak District, the types of minerals are Bornite in Line 1 with Chargeability of 6.93 msec and mineral Galena in Line 2 with Chargeability of 4.30 msec. The rock types found in Malalak District, consist of Sandstone, Limestone, and Granite. Track 1 has a type of rock with a resistivity value, namely Sandstone with a value of 58.4 Ωm - 295 Ωm, Limestone with a value of 296 Ωm - 1,501 Ωm and Granite with a value of 1,502 Ωm - 38,768.04 Ωm. Track 2 has a rock type with a resistivity value, namely Sandstone with a value of 58.5 Ωm - 287 Ωm, Limestone with a value of 288 Ωm - 1,412 Ωm and Granite with a value of 1,413 Ωm - 34,179.12 Ωm.

Keywords: Induced Polarization (IP) method, Dipole-dipole configuration, Malalak.

I. INTRODUCTION

Indonesia is an archipelago that is located on a volcanic route that forms a ring of fire due to the submergence of the Indian Ocean-Australian crust plate moving northward, plunging the southern part of the Eurasian continental plate and forming a series of volcanoes [1]. One of the areas located close to the volcanic route is the Malalak District, West Sumatra. Malalak District is a residential area located in the area of three mountains, namely Singgalang, Tandikek, and Marapi. The existence of this volcanic path characterizes the tectonic framework of the western part of Indonesia which has the potential to form mineral resources.

Minerals are generally defined as inorganic compounds that occur in nature, have certain physical and chemical properties, and have an orderly crystal arrangement. A combination of one or more types of minerals, either in loose or solid form, is called rock. Thus, mineral resources are defined as valuable mineral deposits or deposits found in an area, whether the amount of reserves is known or those that are still potential [2]. Mineral resources consist of metal minerals and non-metal minerals as well as associated minerals and disturbing minerals. Metals are chemical elements that conduct electricity and heat well. Metallic minerals are mineral commodities whose main component consists of metal elements.

Non-metal minerals are mineral commodities whose main component consists of non-metal elements. Accessory minerals are minerals that form rock from magma crystallization. Minerals of this type are present in relatively small amounts (<5%). The presence or absence of these minerals in the rock does not affect determining the name of the rock, for example, apatite, zircon, and rutile. Nuisance minerals are minerals that are not valuable in the ore [2].

Marginal resources are mineral resources, rock, and coal as well as associated minerals from mining products which at that time still did not receive attention to be utilized for human life. Natural resources have not received attention from interested parties because their potential, both in terms of quality and quantity, is relatively low. Also, there has been no study of an economic process technology so that it is considered a worthless mineral [3].

Whereas there are 3 (three) main commodities in mining potential, namely Iron ore, Manganese, and Sulfur [4]. One area that has the potential for mining minerals is in the Malalak District area. Malalak District is estimated to have mining potential because it is located around the foot of Mount Singgalang, Marapi, and Tandikek. The mineral potential in this area needs to be known as initial information to carry out mineral exploration activities. However, whether there are any mineral sources, especially metal minerals in Malalak District has not been published yet. So, the presence of metallic minerals in Malalak District needs exploration.

One of the methods used in mineral exploration is the Geoelectric method. The Geoelectric method is a geophysical method that studies the nature of current flow in the earth and how to detect it on the earth's surface. The Geoelectric method is divided into several parts based on the parameters measured, including the Self-Potential (SP) method, the Magneto-Telluric (MT) method, the Induced Polarization (IP) method, the Control Source Audio Magneto-Telluric (CSAMT) method, and the Resistivity method (prisoner of sex). The geoelectric method that is usually used for metal mineral exploration is the Induced Polarization (IP) method.

The IP method is a method that detects the occurrence of electrical polarization on the surface of metal minerals below the earth's surface. The cause of polarization is due to the reaction between electrolyte ions and metal minerals caused by inductive currents. This method can detect the presence of a very small number of resistivity anomalies, which are not detected by other methods. . The IP method can also be used to detect mineral types and depths. The advantage of the IP method compared to other methods is that it can detect sulfide minerals that are scattered and irregular. Thus, this method is very suitable to be used to map and obtain Sulfide resources associated with Gold ore, and other metal ores that are scattered under the surface.

Based on the description described above, the researcher conducted a study entitled Estimation of Metal Mineral Distribution using the Geoelectric Induced Polarization (IP) Method in Malalak District. Researchers hope that this research can provide information about the potential of minerals contained in Malalak District that can be utilized by the local community.

II. METHOD

This type of research is descriptive basic research. This study describes the results of the interpretation of the distribution of metal minerals in Malalak District using the Geoelectric Induced Polarization (IP) method based on the chargeability value. Measuring data during the survey using the ARES Multielectrode. Research parameters consist of measured parameters (current strength and potential difference) and calculated parameters (apparent resistivity and apparent chargeability). The research procedure is divided into 3 stages and data processing techniques, namely:

1. Preparation stage

The preparation stage includes several things. First, literature review of the theories that support research. Second, a survey to the measurement area in determining the trajectory and knowing the geological conditions of the measurement area. Third, prepare tools and materials.

2. Data Collection Stage

The data used in this research is secondary data. Secondary data is data obtained without conducting direct research. This stage is done by downloading the data that has been obtained on the ARES tool.

3. Data Processing Techniques

This research is a Geophysical survey. The survey method used is the Geoelectric Induced Polarization (IP) method. The measurement data is in the form of electric current (I) and potential difference (V). The apparent chargeability value is calculated using Equation (1) and the apparent resistivity Equation (4). The data that has been processed is then interpreted using the Smoothness-Constraint Least Squares inversion method to obtain a 2D model cross-section below the earth's surface based on the resistivity and chargeability values.

The apparent resistivity and apparent chargeability obtained at the time of measurement do not directly indicate the resistivity and chargeability values of a medium but reflect the distribution of the resistivity and chargeability values of the medium. The data interpretation process is carried out with the help of Res2dinv software. The next step to take is to estimate the rock types that make up the study area based on the actual resistivity value compared to the rock density table and the geological conditions of the study area. Content analysis.

The minerals contained in the rock that make up the study area can be estimated based on the actual chargeability value which is matched with the Chargeability value in Table 3.Based on the resistivity and chargeability values, it can be seen that the rock making up the research area and the types of minerals contained in the rocks in the study area

1. Analysis Technique

This research was conducted using the Geoelectric Resistivity method of Induced Polarization configuration. The data obtained from the research are current strength, potential difference, and electrode spacing. The electrode spacing is used to calculate the geometric factor for the Induced Polarization configuration. The apparent resistivity value of the rock is known by entering the geometry factor, current strength, and potential difference. Data analysis was carried out by first knowing the apparent resistivity value. The apparent resistivity obtained at the time of measurement does not directly indicate the resistivity value of a medium but reflects the distribution of the resistivity value of the medium. The apparent resistivity value and apparent chargeability are interpreted using the inversion method to obtain the actual resistivity value and actual chargeability.

2. Interpretation techniques

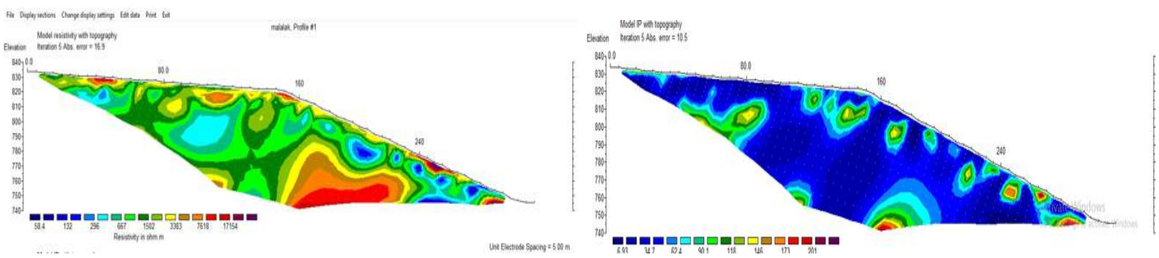
The interpretation technique is a way of processing data to determine the actual type and depth of rock. Data processing in this study used Smoothness-Constrain Least-Squares inversion with Res2dinv software. This aims to simplify the data processing and get better results. Data interpretation using Res2dinv software produces true resistivity values and depths in the form of 2D subsurface cross-sectional models. The data that has been processed using Res2dinv software is then estimated to obtain rock types in the study area.

3. Estimation Techniques

Data that has been analyzed and interpreted, then the data can be estimated. The data is estimated by comparing the actual chargeability with the Chargeability table and the geological conditions of the study area. After comparing the actual chargeability with the chargeability table, it is concluded that the depth and thickness of the rock and mineral species in the study area are obtained.

III. RESULTS AND DISCUSSION

The length of track line 1 is 315 m with an electrode spacing of 5 m. Figure 1 shows a 2D cross-section below the earth's surface using the inversion Smoothness-Constraint Least Squares.



(a) (b)

Fig. 1. (a). Cross-section of 2D model resistivity with passage topography 1 (b). Cross section of 2D chargeability model with track topography 1

Based on Figure 1, track 1 has a resistivity value range of around 58.4 Ωm - 38,768.04 Ωm. The maximum depth that can be measured on track 1 is 71 meters. The error percentage of 16.9% was obtained in the 5th iteration. The results of data processing on line 1 indicate that the accuracy of the research results is about 83.1% of the measurement error rate.

Based on the resistivity value on line 1 with the cross-section of the 2D model it is analyzed that line 1 has 3 types of subsurface constituent rocks. The resistivity value from the value range of 58.4 Ωm - 295 Ωm is estimated as a Sandstone. This is following the resistivity value of the rock resistivity value table, where the resistivity value range is 1 Ωm - 6.4x108 Ωm. The resistivity value with a value range of 296 Ωm - 1,501 Ωm is estimated to be Limestone. This is following the resistivity value in the rock resistivity value table, where Limestone has a resistivity value range of 50 Ωm - 107 Ωm. The resistivity value with a value range of 1,502 Ωm - 38,768.04 Ωm is estimated to be Granite. Following the table of the resistivity value of the rock.

Granite resistivity value ranges from 3x102 Ωm (wet) - 105 Ωm (dry). Analysis of rock types, depths, and thicknesses of each type of rock and mineral on track 1 at the Sounding point can be seen in Table 1.

Table 1. Interpretation Results of 2D Model of Land Type and Chargeability of Passes 1.

color code	resistivity (Ωm)	point 1		point 2		point 3		rock type
		depth (m)	**thickness (m)**	**depth (m)**	**thickness (m)**	**depth (m)**	**thickness (m)**	
	58,4 – 295							*Sandstone*
	296 -1.501	9 – 37	28	7 – 37	30	3-29	26	*Limestone*
	1.502 -38.768,04	surface – 9	9	surface - 7 and 37 – 71	7 dan 34	surface - 3	3	*Granite*
color code	**chargeability (msec)**	**point 1**		**point 2**		**point 3**		**mineral**
		depth (m)	**thickness (m)**	**depth (m)**	**thickness (m)**	**depth (m)**	**thickness (m)**	
	6,93	surface – 10	10	surface – 55	55	surface - 33	33	*Bornite*

Based on Table 1, it is known that there are 3 soundings to identify the type and depth of rocks on track 1. Sounding 1 is at a distance of 80 m, this point is identified as having 2 types of rock layers, namely Limestone and Granite. The Limestone layer is located at a depth of 9 m to 37 m so that it has a thickness of 28 m. The Granite layer is on the surface to a depth of 9 m so that it has a thickness of 9 m.

Sounding 2 is at a distance of 160 m from the starting point of the measurement. This point was identified as having 2 types of rock layers, namely Limestone and Granite. The Limestone layer is located at a depth of 7 m to a depth of 37 m so that it has a thickness of 30 m. Granite layers exist on the surface to a depth of 7 m and at a depth of 37 m to a depth of 71 m so that it has a thickness of 7 m and 34 m.

Sounding 3 which is at a distance of 240 m is identified as having 2 types of rock, namely Limestone and Granite. The limestone layer is found on the surface to a depth of 3 m to a depth of 29 m so that it has a thickness of 26 m. The granite layer is found on the surface to a depth of 3 m so that it has a thickness of 3 m.

Minerals contained in the rock making up Passage 1 are Bornite minerals with a Chargeability value of 6.93 msec. Bornite mineral is contained in almost every rock making up Path 1. This can be seen from the presence of Bornite minerals at three measurement points, namely 80 m, 160 m, and 240 m with a depth of each surface - 10 m, surface - 55 m, and surface - 33 m so that depth respectively, namely 10 m, 55 m, and 33 m.

The length of track 2 is about 315 m with an electrode spacing of 5 m. A cross-section of 2D results using the Smoothness-Constraint Least Squares inversion can be seen in Figure 2.

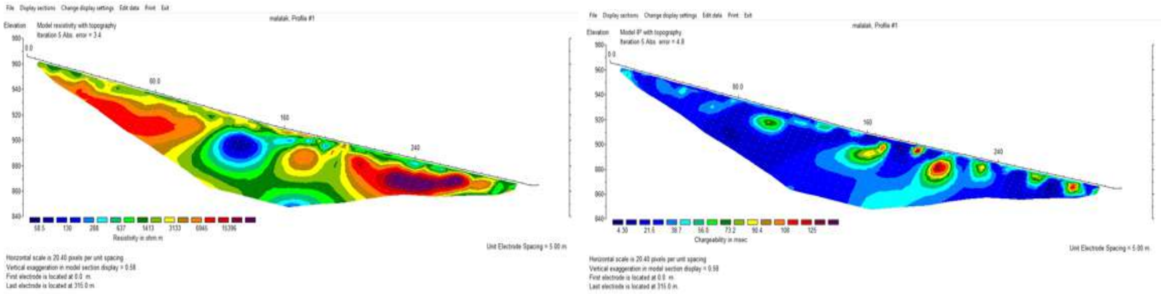


Fig. 2. (a) Sections of 2D model resistivity with line topography 2 (b) Cross section of 2D chargeability model with line topography 2.

Based on Figure 2, track 2 has a resistivity value range of around 58.5 Ωm - 34,179.12 Ωm. The maximum depth that can be measured on track 2 is 55 meters. The error percentage is 3,4% in the 5th iteration. The results of data processing on line 2 indicate that the accuracy of the research results is around 96.6% of the measurement error rate.

Based on the resistivity value on line 2 with the cross-section of the 2D model it is analyzed that line 2 has 3 types of subsurface constituent rocks. The resistivity value from the value range 58.5 Ωm - 287 Ωm is estimated as Sandstone. This is following the resistivity value of the rock resistivity value table, where Sandstone has a resistance value range of 1 Ωm - 6.4x108 Ωm. The resistivity value with a value range of 288 Ωm - 1,412 Ωm is estimated to be Limestone. This is following the resistivity value in the rock resistivity value table, where Limestone has a resistance value range of 50 Ωm - 107Ωm. The resistivity value with a value range of 1,413 Ωm - 34,179.12 Ωm is estimated as Granite. This is following the resistivity value in the rock resistivity value table, where the Granite resistivity value has a value range of 3x102 Ωm (wet) - 105 Ωm (dry). Analysis of rock types, depth, and thickness of each type of rock and mineral Track 2 at the sounding point can be seen in Table 6.

Table 2. Cross-sectional Interpretation Results of 2D Model Resistivity and Line Chargebility 2.

Color code	Resistivity (Ωm)	Point 1		Point 2		Point 3		Rock type
		depth (m)	thickness (m)	depth (m)	thickness (m)	depth (m)	thickness (m)	
	58,5 – 287							*Sandstone*
	288 -1.412	Surface-3	3	5- 55	50	Surface – 10	10	*Limestone*
	1.413 – 34.179,12	3 – 41	38	surface – 5	5	10 - 21	11	*Granite*
Color code	***Chargeability* (msec)**	**Point 1**		**Point 2**		**Point 3**		**Mineral**
		depth (m)	**thickness (m)**	**depth (m)**	**thickness (m)**	**depth (m)**	**thickness (m)**	
	4,30	4 – 40	36	Surface – 10	10	Surface – 28	28	*Galena*

Based on Table 2, it is known that there are 3 soundings to identify the type and depth of rocks on Track 2. Sounding 1 is at a distance of 80 m, this point is identified as having 2 types of rock layers, namely Limestone and Granite. The limestone layer is found on the surface to a depth of 3 m so that it has a thickness of 3 m. The Granite layer is found at a depth of 3 m to a depth of 41 m so that it has a thickness of 38 m.

Sounding 2 is at a distance of 160 m from the starting point of the measurement. This point was identified as having 2 types of rock layers, namely Limestone and Granite. The Limestone layer is at a depth of 5 m to a depth of 55 m so that it has a thickness of 50 m. Granite layers are found on the surface to a depth of 5 m so that it has a thickness of 5 m.

Sounding 3 which is at a distance of 240 m is identified as having 2 types of rock, namely Limestone and Granite. The limestone layer is found on the surface to a depth of 10 m so that it has a thickness of 10 m. Granite layers are found at a depth of 10 m to 21 m so that it has a thickness of 11 m.

Minerals contained in the rock making up Passage 1 are Galena minerals with a chargeability value of 4.30 msec. Galena minerals are contained in almost every rock that makes up Track 2. This can be seen from the presence of Galena minerals at three measurement points, namely 80 m, 160 m, and 240 m with a depth of 4 - 40 m each, surface - 10 m and surface - 28 m so that the depths are 36 m, 10 m and 28 m respectively.

The mineral formation is closely related to magmatic processes. Metallic minerals can usually be found in volcanic rock. The rocks that make up the area of Malalak District are rocks from hydrothermal deposits of Mount Tandikek and Mount Singgalang. Geologically, the constituent rocks of Malalak District, are pumice, Andesite, and Granite. After researching Malalak District using the Geoelectric Induced Polarization (IP) method, the data were analyzed and interpreted using the Smoothness-Constraint Least-Squares inversion method. The next step is to estimate the rock types that make up the study area based on the resistivity value. Rock is a material that is formed from one or several minerals in solid form so that further analysis to find out what types of minerals are present in the rock in the study area are estimated based on the Chargeability value.

The cross-section of the 2D model of resistivity on Track 1 is interpreted as having 3 types of rock, namely Sandstone, Limestone, and Granite. Based on the cross-sectional chargeability value of the 2D Chargeability Path 1 model, it is known that the mineral that makes up the rock of Pass 1 is Bornite with a Chargeability of 6.93 msec. According to Telford (1990: 584), Bornite has a charge ability value of 6.3 msec. bornite is a copper iron sulfide mineral with a chemical composition of Cu_5FeS_4. Based on the rock estimates/materials that make up the research area that has been carried out, the Bornite mineral-bearing rocks are granite, metamorphic, and sedimentary igneous rocks.

Track 1 displays the distribution of Bornite minerals throughout the measurement path. Figure 10 (b) shows quite a lot of Bornite mineral content in the rock making up Passage 1. The mineral Bornite in Figure 10 (b) is depicted in blue. Based on the cross-section of the 2D Chargeability model. Track 1 shows that the Bornite mineral is a mineral that is scattered in almost every measurement point with varying thicknesses. The point measuring 80 m is found to be 10 m thick. The measuring point of 160 m is found with a thickness of 55 m, and the measuring point of 240 m is found with a thickness of 33 m.

The cross-section of the 2D model of resistivity in Track 2 is interpreted as having 3 types of rock, namely Sandstone, Limestone, and Granite. Based on the cross-sectional chargeability value of the 2D Chargeability Line 1 model, it can be seen that the mineral constituent of the Passage 1 rock is Galena with a chargeability value of 4.30 msec. According to Telford (1990: 584), Galena has a chargeability value of 3.7 msec. Galena is a naturally occurring mineral of lead (II) sulfide (PbS). Galena is found mostly in frozen and metamorphic rocks.

Line 2 shows the distribution of Galena minerals throughout the entire measurement path. Figure 10 (b) shows quite a lot of Galena mineral content in the rock making up Passage 1. The mineral Galena in Figure 10 (b) is described in blue. Based on the cross-section of the 2D Chargeability Line model 1, it can be seen that Galena is a mineral that is spread almost at every measurement point with varying thicknesses. The point measuring 80 m is found to be 36 m thick. A measuring point of 160 m is found with a thickness of 10 m, and a measuring point of 240 m is found with a thickness of 28 m.

The results of mineral investigations in the Malalak Subdistrict, Agam Regency, identified that in this study area copper sulfide minerals were scattered. This can be seen from the discovery of minerals containing copper in the form of Bornite and Galena. Based on the estimation that has been done, it is found that the research area has a large enough copper mineral potential.

CONCLUSION

Based on the results obtained from this study, it can be concluded that:

1. The area of Malalak District, is thought to be dominated by metal minerals in the form of Bornite and Galena.
2. Mineral Bornite was found with varying thicknesses, namely 10 m, 55 m, and 33 m. Meanwhile, Galena minerals were found with thicknesses of 36 m, 10 m, and 28 m

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