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Geoelectric Method-based Survey on the Existence of Iron Sand Layers at Jolosutro Beach, Blitar Regency, East Java Province, Indonesia

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Abstract— *This study was conducted at Jolosutro Coastal Coast, Blitar, Indonesia. It aimed to find out the presence of a thickness layer of iron sand. Data acquisition was performed using geoelectric resistivity method with dipole-dipole navigation on a trajectory length of 200 meters and a distance between points of 10 meters. Measurement was made in three areas along the coast consisting of two passes for each. The resistivity value at the research area was around 7-357 Ωm with the following details: 1) The resistivity value of 7-60 Ωm was assumed to be an iron sand layer; 2) The resistivity value of 157 Ωm was assumed to be sand mixed with clay; and 3) The resistivity value of 210-357 Ωm was assumed to be bedrock. The visual observation shows that the first area on line one and two had brownish sand, line three and four had brownish-black sand, and line five and six had grayish-black sand, but they turned to be solid black when the condition was moist. Based on the interpretation of geoelectric data and the results of visual observation, it shows that there were iron sand layers with a resistivity value about 7-60 µm at each point of the measured trajectories which dominated each point with a layer thickness about 13-15 meters from the surface.*

Keywords— *Geoelectric resistivity method with dipole-dipole navigation, iron sand, Jolosutro Beach.*

I. INTRODUCTION

Indonesia is one of the countries with natural resources that are mostly used as industrial raw materials in the form of minerals containing a lot of substances, such as iron, titanium, and so on. One of the raw materials that has economic value is iron sand mineral [1] and [2]. Iron sand (placer precipitate) is defined as mechanically concentrated surface mineral precipitate, that is, the separation of natural specific gravity from heavy minerals from light minerals by water or air as the media which, by their nature or mineral behavior, is collected in a precipitate [3]. Based on data from the Ministry of Energy and Mineral Resources of the Republic of Indonesia, the potential for iron sand is shared by several regions, such as the west coast of Sumatra, the south coast of Java and Bali, the beaches of Sulawesi, East Nusa Tenggara, Maluku, and the coast of Papua. The potential of iron sand in the Java is generally socialized with the coastal landscape, which provides the potential for additional natural resources in the form of tourism objects [4] and [5]. Most of the iron sand in Indonesia is spread in the coastal zone, thus the study of identification on coastal iron sand will provide a deeper understanding on the presence of iron sand. Java island is known to have a lot of iron sand in the south [6] and [7].

One of the beaches in the southern part of Java is Jolosutro, which takes place in South Blitar, East Java Province. It has the potential for natural resources in the form of iron sand precipitate. Iron sand precipitate in the area is weathered beach sediments and bedrocks as the origin rocks which are accommodated by rivers and deposited along the coast. However, the presence of these minerals still does not have in-depth information and therefore, it needs to be investigated using earth science methods.

The geoelectric method is a geophysical method that observes the nature of electric flow in the earth. The parameters used in geoelectric measurements include potential, current, and electromagnetic fields, both in natural way and injection of flow in the earth. Geoelectric methods are grouped into several methods; resistivity method, induced polarization (IP) method, self-potential (SP) method, magnetotellurics (MT) method, and so on. The working principle of this method is that the flow is injected into the earth through two current electrodes. The potential difference is measured through two pieces of potential electrodes. Based on the results of current measurements and potential differences for each different electrode distance, it can then be derived for variations in the value of the type of resistance of each layer below the measured point. This method is used for mineral exploration, water reservoirs, geothermal, biogenic gas, bedrock depth, and so on [8], [9], and [10]. Geoelectric method is one of the choices of efficient method to be used in this study, which aims to find out the presence of a thickness layer of iron sand along the Jolosutro Beach.

II. METHOD AND MATERIALS

Data acquisition was carried out at Jolosutro Beach, Blitar Regency, Indonesia. Data acquisition using geoelectric resistivity method with dipole-dipole configuration was carried out in three areas of Jolosutro Beach, each area consisting of two lines. The measurement was performed with a length of 200 meters, electrode spacing of 10 meters, and visual observation (Figure 1) which is a research survey design. The geological map of Blitar Regency [11] is presented in (Figure 2). The study area had a geological formation, namely the Tuff Member of Mandalika and

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Aluvium Formation, the formation of these rocks which is the process of forming iron sand, such as volcanic breccia rocks which have undergone a mineralization process so as to contain iron oxidation minerals, such as magnetic and herman minerals. This study used several tools to support the process of data collection and interpretation.

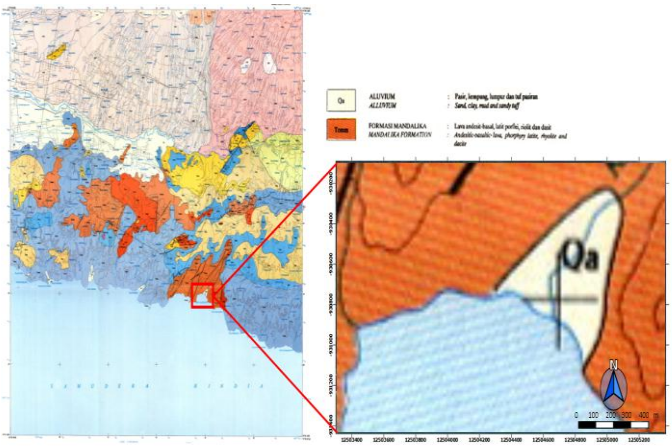

Fig. 1. Blitar Geological map sheet [11]

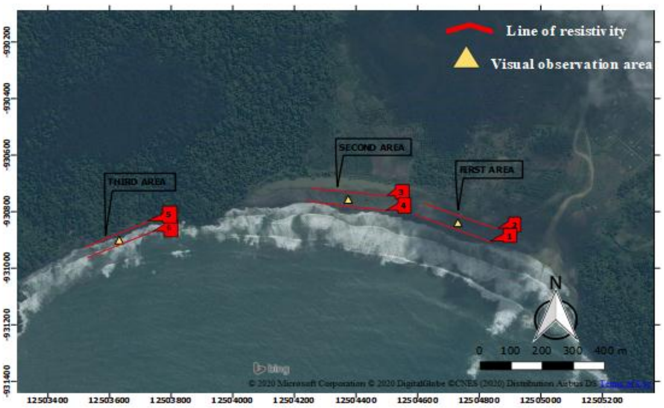

Fig. 2. Geoelectrical resistivity and visual observation area research survey design

a. Resistivity Method

The instrument was OYO McOhm Resistivity meter as shown in (Figure 3). The principle of resistivity method is to inject an electric precipitate to the earth through two electrode precipitate, then the difference in potential is measured by two potential electrodes, so the resistivity value can be calculated as shown in Figure 4. Field data was obtained in the form potential value, flow, precipitate and potential electrode position and the coordinates of research point. Furthermore, data processing, which aimed to obtain resistivity value, was then carried out in the inversion process using RES2DINV software [12].

The resistivity value of dipole-dipole configuration is indicated by the following formula:

$$P = \prod na\,(n + 1)\,(n + 2)\,\Delta V / 1. \quad (1)$$

P is apparent resistivity (Ωm), n is an integer, $\Delta V\ /\ 1$ is resistance (R, ohm), and I is flow (Ampere) [13]. a is the distance between C1 C2 and P1 P2 electrodes and na is the distance between C1 C2 and P1 P2 electrodes, because P1 P2 electrodes move to the right up to the maximum line.

Fig. 3. OYO McOhm

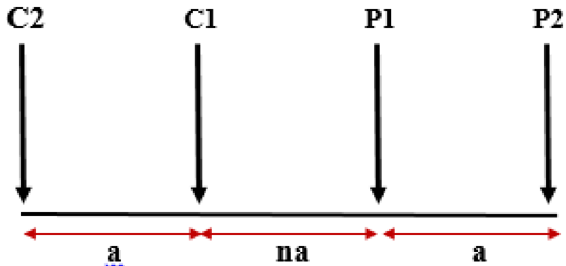

Fig. 4. Konfigurasi dipole-dipole [13]

The measurement using dipole-dipole configuration was performed by moving the potential electrode (P1-P2) with the distance n to the right up to the maximum line and the flow electrode at the initial position. The electrode (C2-C1) was then driven by distance n followed by the displacement of the potential electrode and so on, as the first step up to the measurement of the electrode flow at the maximum line [14].

III. Results and Discussion

Field data were obtained from the measurement results in the form of potential value, flow, flow electrode position (I), potential difference (V), and coordinates of the research point. Geometry factor (K) and apparent resistivity (ρa) in each sheet could be calculated based on the data. Furthermore, data processing was carried out, which aimed to obtain resistivity value, and the inversion process was carried out using RES2DINV software to obtain an illustration in the form of subsurface contours for each path as shown in (5.6.7.8.9.10.)

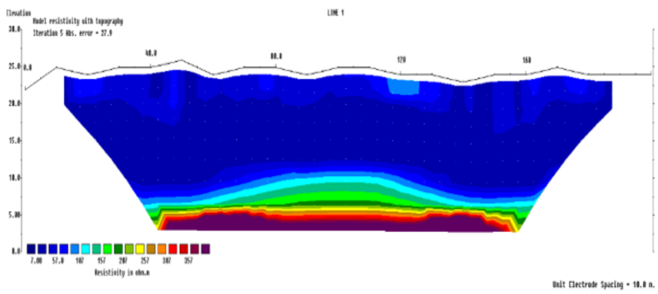

Fig. 5. Subsurface resistivity 2D cross-section of line 1

Interpretation of the results of the 2-dimensional cross section of (Figure 5) shows the presence of iron sand which had a content (fluid) at a depth of 0-15 meters with a thickness around 15 meters and a resistivity value around 7-60 Ωm. The resistivity value at 157 µm was interpreted as a layer of sand mixed with clay at a depth of 15-20 meters with a thickness of ± 3 meters. The sensitivity value was 210-357 Ωm located in the lowest layer which was interpreted as bedrock from the process of iron sand formation in the area.

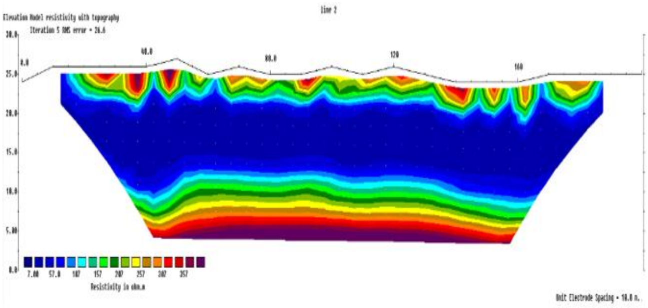

Fig. 6. Subsurface resistivity 2D cross-section of line 2

Interpretation of the results of the 2-dimensional cross section of (Figure 6) at a depth of 0-3 meters was interpreted as hard rocks on the surface, as well as the influence of vegetation in the measurement area, which had varying resistivity values. Whereas iron sand was found at a depth of 3-15 meters with a layer thickness of around 12 meters. The resistivity value of 157 µm was interpreted as layer of sand mixed with clay at a depth of 15-17 meters with a thickness of around 2 meters. The sensitivity value was 210-357 Ωm located in the lowest layer which was interpreted as bedrock from the process of iron sand formation in the area.

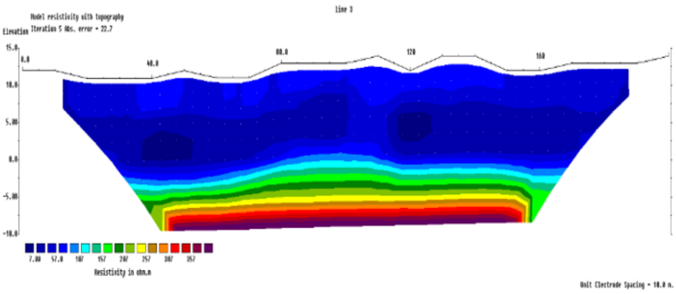

Fig. 7. Subsurface resistivity 2D cross-section of line 3

Interpretation of the results of the 2-dimensional cross section of (Figure 7) shows the presence of iron sand which had a content (fluid) at a depth of 0-15 meters with a thickness around 15 meters and a resistivity value around 7-60 µm. The resistivity values of 157 µm was interpreted as a layer of sand mixed with clay at a depth of 15-20 meters with a thickness of ± 3 meters. The sensitivity value was 210-357 Ωm located in the lowest layer which was interpreted as bedrock from the process of iron sand formation in the area.

Interpretation of the results of the 2-dimensional cross section of (Figure 8) shows the presence of iron sand at a depth of 0-10 meters with a thickness around 10 meters and a resistivity value around 7-60 Ωm. The resistivity value of 157 µm was interpreted as a layer of sand mixed with clay which was found at a depth of 10-15 meters with a thickness around 3 meters. The sensitivity value was 210-357 Ωm located in the lowest layer which was interpreted as bedrock from the process of iron sand formation in the area.

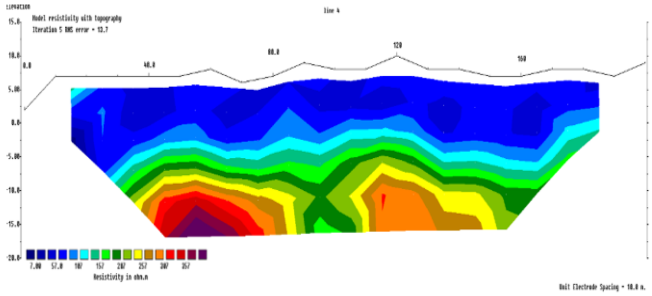

Fig. 8. Subsurface resistivity 2D cross-section of line 4

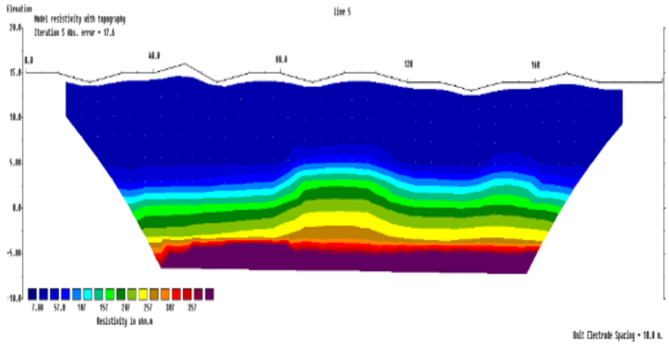

Fig. 9. Subsurface resistivity 2D cross-section of line 5

Interpretation of the results of the 2-dimensional cross section of (Figure 9) shows the presence of iron sand which had a content (fluid) at a depth of 0-15 meters with a thickness around 15 meters and a resistivity value around 7-60 µm. The resistivity value of 157 µm was interpreted as a layer of sand mixed with clay at a depth of 15-19 meters with a thickness of around 4 meters. The sensitivity value was 210-357 Ωm located in the lowest layer which was interpreted as bedrock from the process of iron sand formation in the area.

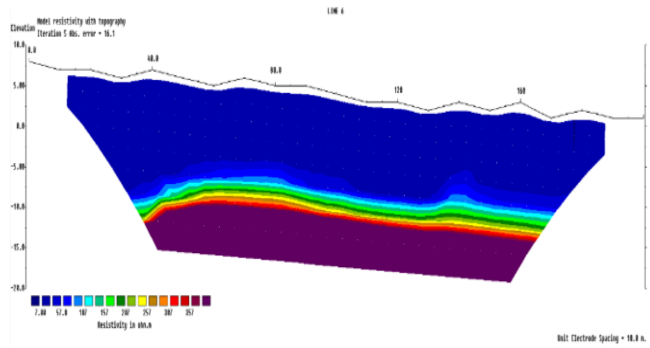

Fig. 10. Subsurface resistivity 2D cross-section of line 6

Interpretation of the results of a 2-dimensional cross section of (Figure 10) shows the presence of iron sand which had a content (fluid) at a depth of 0-15 meters with a thickness around 15 meters and a resistivity value around 7-60 µm. The resistivity values of 157 µm was interpreted as a layer of sand mixed with clay at a depth of 15-17 meters with a thickness of ± 2 meters. The sensitivity value was 210-357 Ωm located in the lowest layer which was interpreted as bedrock from the process of iron sand formation in the area.

(a) (b) (c)

Fig. 11. Visual observation area

Based on the visual observations (Figure 11), the first area on line 1 and 2 shows the following description of sand: brownish color composed of fragments of marine animals (shells), coral, magnetic hematite, organic material, and poor sorting. The second area on line 3 and 4 shows the following description of sand: brownish black with white spots composed of marine animal fragments (shells), magnetic hematite, and bad sorting. The third area on line 5 and 6 shows the following description of sand: grayish-black, solid black when moist, composed of marine animal fragments (shells), magnetic hematite, and good sorting.

IV. CONCLUSION

The measurement results of the geoelectric method with resistivity values in the study area were found in around 7-357 Ωm. The 2-dimensional image in the form of subsurface contours shows the presence of iron sand layers found at each line of the measurement point with resistivity value around 7-60 Ωm. The line with iron sand layer containing fluid (wet layer) was one that is closer to the shoreline. The estimated thickness of the iron sand layers from each area along the coast was around 13-15 meters from the surface. The results of geoelectric data were then correlated with visual observations showing the sand color in the first area (e.g. brownish sand) and assumed to have a low iron (Fe) content. The second area had brownish-black sand and assumed to have a moderate iron (Fe) content. The third area had grayish-black sand. The color turned to be solid black when the condition was moist and assumed to have high iron (Fe) content. Based on the above results, it reveals that the iron sand mineral in Jolosutro Beach has considerable potential with different iron (Fe) content presentation in each area along the coast.

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