Beach sands deposite identification using very low frequency method in the Benteng Lubuk, Krueng Raya coastal area

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Abstract. The 2D subsurface identification work of iron sands in Benteng Lubuk, Krueng Raya was successfully studied using the very low frequency method based on resistivity mode (VLF-R). This study aims to identify iron sand deposits in coastal areas using electromagnetic inversion. The inversion process shows a conductivity zone of iron sand area, where the resistive layer is strongly covered by a conductive layer above it. High resistivity values were found at 80-100 m stations. This layer has a resistivity value between 20000 – 40000 m and the conductivity value tend to be low. It is estimated that at this point there will only be manifestations of iron sand or sea water intrusion, due to the location of the track close to the coastline.

1. Introduction
Aceh Province has abundant iron ore in the coastal area, especially iron sand. However, the minerals are still in raw form and most of them have not been discovered and the deposits are unknown [1]. The sand is rich in magnetic minerals which can be developed as industrial material [2,3], and also as a base material for permanent magnet industry [5-7].

Therefore, it is very important to have information about iron sand deposits. In this work, we introduce a simple method using the Very Low Frequency (VLF) technique [4] which apply electromagnetic fields sourced from low-frequency transmitters. This technique can supply a different electrical conductivity value in the sub-surface area.

In this study, an in-depth study of the iron sand sub-surface structure with the VLF method was conducted at Benteng Lubuk area, Lamreh, Aceh Besar, which aimed to predict the deposite mineral sands in supporting database for the local area.

2. Experimental procedures
In this work, the observation was carried out in 2 stages, measuring data at the location and data processing at laboratory. The measurement was carried out at Benteng Lubuk, Lamreh, Krueng Raya, Aceh Besar District.
Figure 1. Survey location at the coastal area of Benteng Lubuk, Lamreh, Aceh Besar

The T-VLF detector was used with supported equipment of a 1.5 volt battery, electrodes, GPS and 2 Layer Inversion Software (2LAYINV). After collecting data in the field, the data processing was carried out in the laboratory using software.

The measuring line was firstly made, with the first line 250 meters, the second line 120 meters and the third line 100 meters, and the distance between measurement points is 10 meters.

Then look at the position or direction indicated by the compass, this is done for the selection of a transmitter station that is in accordance with the location of the country adjacent to Indonesia. The T-VLF cable was attached to each unit by making sure the cables are connected properly. The T-VLF was turn on, then setting to choose spacing and line, then select the method to be used. In this research, resistivity method is used.

At each measurement point, the best value is observed which is indicated by the quality coefficient on the tool. The fine data quality is indicated by a high quality bar on the display. The measurement is repeated if the quality of the data produced is not good or there is an overload of the field during the measurement (this is indicated by the appearance of an SH mark on the display screen if there is an overload on the magnetic field or an SHE sign if there is an overload on the two fields). If the data quality is good, then the data can be saved and the measurement can be continued for the next measurement station.

3. Results and Discussion

3.1. Resistivity model on track 2 (frequency 15975 Hz and 22200 Hz).

The model obtained on second line using 15975 Hz (first frequency) after calculating the inversion is shown in Figure 2.

Figure 2 shows the model in the second line, uses a 120 m long track and has a depth of 50 m from the ground surface. In the model (Figure 1) using a frequency of 15975 Hz, the frequency on track 2 is the same as that used in track 1. The use of the same frequency on both tracks because the location of the frequency measurement can be well received. signal quality [8]. From the results of data inversion on track 2 which uses the first frequency, it produces a model with an RMS data error of 15.20% and an RMS error model of 0.30%. The value of the RMS data error and model error is large when compared
to the second frequency due to very large fluctuations in the phase value from one station to another. The measured phase value is not good so that the calculated phase cannot be matched.

The first layer in the model (Figure 2) at the measurement point of 20 – 70 m has a high resistivity value with a penetration depth of 0 – 10 m from the ground surface. At the measurement point (station) 40 – 60 past the fort foundation or measurement right around the fort. It is estimated that the resistivity value is large because around the 40-60 m measurement station there are igneous or metamorphic rocks.

The measured phase value is not good so that the calculated phase cannot be matched. Where the resistivity value obtained is not too much different, only the RMS is not too much different. The resistivity model at the second frequency is similar to the resistivity model at the first frequency. Where the resistivity value obtained is not too much different, only the depth of penetration is different because on this 2nd track the second frequency < the first frequency. In the model (Figure 3) using a frequency of 15975 Hz, the frequency on track 3 is the same as that used in lines 1 and 2. The use of the same frequency on all three tracks because at the measurement location the frequency can be

![Figure 2](image-url)

**Figure 2.** The second line of 15975 Hz (first frequency) model after calculating the inversion.

The second layer is inversely proportional to the first layer, at a certain measurement point the conductivity value is high, the resistivity value will be low and vice versa [9-11]. This is because the resistivity value is inversely proportional to the conductivity value. This second layer has a resistivity value between 20000 – 40000 m (in the figure shown on a logarithmic scale) and tends to have a low conductivity value. The high conductivity value at the 60 - 120 m measurement station, seen in the color scale generated by the inversion (Figure 1) shows a logarithmic scale which has a very high conductivity value. It is estimated that at this point it has manifestations of iron sand or just sea water intrusion, because the location of this 2nd track is close to the pond.

Figure 3 is an inversion model using the second frequency on track 2. The frequency used is 22200 Hz, which is higher than the first frequency on track 2. The model on this second frequency has a shallower penetration depth than the first frequency on track 2 [12]. The model on this second frequency has an RMS data error of 18.26% and an RMS model error of 0.26%. Compared to the first frequency RMS is not too much different. The resistivity model at the second frequency is similar to the resistivity model at the first frequency. Where the resistivity value obtained is not too much different, only the depth of penetration is different because on this 2nd track the second frequency < the first frequency. In the first layer, the resistivity value is the same as the resistivity value at the first frequency, which is between 10 - 30 m (in the figure shown on a logarithmic scale). In the second layer, the second frequency is the same as the first frequency, which is between 20000 - 40000 m.

**3.2. Resistivity model on track 3 (frequency 15975 Hz and 22200 Hz)**

The model obtained from the inversion calculation using 2layinv software on track 3 (Figure 4), uses a track measuring 100 m long and has a depth of 50 m from the ground surface. In the model (Figure 3) using a frequency of 15975 Hz, the frequency on track 3 is the same as that used in lines 1 and 2. The use of the same frequency on all three tracks because at the measurement location the frequency can be
received with good signal quality. From the results of data inversion on track 2 which uses the first frequency, it produces a model with an RMS error data of 16.68% and an RMS error model of 0.26%. The RMS data error value and model error is large, compared to the second frequency due to very large fluctuations in the phase value from one station to another [13-14]. The measured phase value is not good so that the calculated phase cannot be matched. The first layer in the model (Figure 3) at the measurement point 0 – 30 m has a high resistivity value with a penetration depth of 0 – 10 m from the ground surface.

**Figure 3.** The second line of 22200 Hz (second frequency) model after calculating the inversion

| Frequency | RMS d | RMS m |
|-----------|-------|-------|
| 22200 Hz  | 16.68%| 0.26% |

| Frequency | RMS d | RMS m |
|-----------|-------|-------|
| 15975 Hz  | 0.26% | 0.26% |

**Figure 4.** The model obtained after calculating the inversion on the 3. path with a frequency of 15975 Hz (first frequency).
At the measurement point (station) 80 - 100 also seen on the logarithmic color scale shown in the inversion model (Figure 3) has a high resistivity value as at the 0 - 30 m measurement station. The second layer is inversely proportional to the first layer, at a certain measurement point has a high conductivity value, then the resistivity value will be low and vice versa [15]. High resistivity values are seen at 80 - 100 m stations, seen on the logarithmic color scale of the inversion model. This second layer has a resistivity value between 20000 – 40000 m and tends to have a low conductivity value. It is estimated that at this point it has manifestations of iron sand or just sea water intrusion, because the location of the 3rd track is close to the shoreline. The selection of the measurement trajectory on the shoreline was carried out because around the shoreline there was a manifestation of iron sand [16-19]. The iron sand is visible on the surface mixed with sea sand.

4. Conclusion

From the results of this study, the resistivity model in the first highly conductive layer yield a resistivity value of 0 - 20 m. The model shows clearly that the coastal area (track 3) which is about 10 m from the beach has iron sand manifestations. However, it is hard to identify the resistivity values between iron sand intrusion and seawater in the model generated by the electromagnetic inversion method and modeling using the surfer program.

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References

[1] Jalil Z, Rahwanto A, Mustanir, Akhyar and Handoko E 2017 AIP Conference Proceedings 1862 030023
[2] Muhammad M, Fatmaliana A and Jalil Z 2019 IOP Conference Series: Earth and Environmental Science 348 012135
[3] Jalil Z, Rahwanto A, Mulana F and Handoko E 2019 AIP Conference Proceedings 2151 020041
[4] Handoko E, Sugihartono I, Budi S, Randa M, Jalil Z and Alaydrus M 2018 The effect of thickness on microwave absorbing properties of barium ferrite powder JPhCS 1080 012002
[5] Maulinda M, Zein I and Jalil Z 2019 Journal of Physics: Conference Series 1232 012054
[6] Arisandi R, Fathurrahman A, Fahrina A, Razi F, Jalil Z and Arahman N 2020 IOP Conference Series: Materials Science and Engineering 845 012018
[7] Premaratne W and Rowson N 2003 The processing of beach sand from Sri Lanka for the recovery of titanium using magnetic separation Physical Separation in Science and Engineering 12 13-22
[8] Hjelt S, Kaikkonen P and Pictilä R 1985 On the interpretation of VLF resistivity measurements Geoexploration 23 171-181
[9] Baranwal V C 2007 Ph.D. Thesis IIT Kharagpur
[10] Baranwal V C, Franke A, Börner R-U and Spitzer K 2011 Unstructured grid based 2-D inversion of VLF data for models including topography Journal of Applied Geophysics 75 363-372
[11] Sharma S and Baranwal V 2005 Delineation of groundwater-bearing fracture zones in a hard rock area integrating very low frequency electromagnetic and resistivity data Journal of Applied Geophysics 57 155-166
[12] Sismano M D E and Wahyuni L T 2019 Identification slip surface using resistivity and VLF-R mode in Goa Kiskendo Yogyakarta Indonesia International Journal 16 177-183
[13] Fischer G 1989 A strong topographic valley effect in AMT and VLF-R measurements Geophysical Journal International 96 469-475
[14] Oskooi B and Pedersen L B 2005 Comparison between VLF and RMT methods: a combined tool for mapping conductivity changes in the sedimentary cover Journal of Applied Geophysics 57 227-241

[15] Pirttijärvi M 2003 PhD thesis University of Oulu

[16] Ohwoghere-Asuma O, Chinyem I F, Aweto K E and Iserhien-Emekeme R 2020 The use of very low-frequency electromagnetic survey in the mapping of groundwater condition in Oporoza-Gbamaratu area of the Niger Delta Applied Water Science 10 1-14

[17] Ohwoghere-Asuma O, Aweto K E, Chinyem F I and Nwankwoala H O 2018 Assessing the protective capacity of aquifers using very-low-frequency electromagnetic survey. Geosciences 8 (5), 150.

[18] Rizwan, T., Kandi, O., Jalil, Z., Setiawan, I., Maulana, R., Ranti, D. M. V, Chaliluddin, M. A. 2021. The analysis of clean water need for fishing activities in Kutaraja Fishing Port, Aceh Indonesia. Australian Journal of Maritime & Ocean Affairs 13 (1), 1-11.

[19] Thaib Rizwan, Zulkarnain Jalil, Akhyar, Husaini. 2021. Oceanographic Factors as the Indicators for Shipyard Industry Development in Kutaraja Fishing Port: A Preliminary Study. Journal of Ecological Engineering 22 (9), 237–245.