The mapping of potential ground water using geoelectrical measurement of Schlumberger configuration method in Malata Village, Tana Righu Sub-District, West Sumba District, East Nusa Tenggara Province

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Abstract. This study aims to analyze rock units containing aquifers in the location of investigation using geoelectrical measurements with Schlumberger configuration method of the MC OHM 2115 Resistivity Meter. The estimation was carried out in 12 measurement points with the length of each path was 150 m. The data analysis of the measurement was implemented using IP2WIN software and Corel Draw X6 software. The results of the interpretation of the 12 measurement points indicated that there were 5 rock units, namely the resistivity $0 \leq 2$ Ohm m which is interpreted as clay. Resistivity $2, 5 \leq 10$ Ohm m as marl. Species resistivity $10.5 \leq 20$ Ohm m as marl limestone, while resistivity $\geq 20.5$ Ohm m as reef limestone. The aquifer belongs in the reef limestone unit with a specific resistance of $20.5 \leq 100$ Ohm m which ends with an impermeable layer such as clay or semi impermeable such as marl. Based on the interpretation, it is concluded that along the measurement area there are aquifers with varying depths which can be optimized by means of drilling at points 01, 03, 04, 06, and 09. The location that has the thickest aquifer is point 04 (± 29.3 m) and 09 (± 38 m).

1. Introduction

1.1. Background

Water is one of the basic necessities for any living creature either for humans, animals or plants. Without water, the ecosystem of life in the world would be disrupted. Water is generally categorized into surface water and underground water. Ground water is water trapped in the soil that comes from rain and surface water. In a certain geological condition, an area has absolutely no surface water but indicates a sufficient groundwater reserve.

East Nusa Tenggara Province is one of the semi-framed areas of the archipelago/dry land area and one of which is Malata Village, West Sumba Regency. In light of the aforementioned problem, as a Mining Engineering student at the Faculty of Science and Engineering, University of Nusa Cendana, I undertook a research to map the potential for groundwater in the area of my investigation. This objective aligns with the vision of the Mining Engineering Department, which is to become a center of excellence in the Tridharma of the university in the semi-framed area of the archipelago.
1.2. Formulation of the problem
Based on the background above, the problems discussed in this research are:
• What are the rocks found in the investigation area?
• What is the geoelectrical measurement result of the Schlumberger configuration resistivity method in the investigation area?
• What is the potential for groundwater in the investigation area?
• Is there any geoelectrical measurement point that could potentially be followed up with drilling?

1.3. Research purposes
The objectives of this research are:
• Analyzing rock units in Malata Village, TanaRighu District, West Sumba Regency.
• Analyzing the resistivity value of rock types in Malata Village, TanaRighu District, West Sumba Regency.
• Analyze the potential for groundwater distribution in Malata Village, TanaRighu District, West Sumba Regency.
• Analyzing the geoelectrical measurement points that could potentially be followed up with drilling.

1.4. Scope of problem
In order to facilitate the discussion, the following problem boundaries are given:
• Interpretation of rock units and rock unit boundaries is carried out based on regional geological maps at a scale of 1: 250,000 from the mapping of A. C. Effendi and T. Apandi [1].
• The surface geological mapping is implemented through observations of outcrops along rivers, wells, deserted wells, boreholes, and other outcrops on the surface.
• The geoelectrical method applied is the Schlumberger method using the Mc OHM measuring instrument. 2115
• No discussion of the specifications of the Mc OHM measuring instrument. 2115
• Data processing and modeling of geoelectrical measurement results utilizing IPI2WIN and Corel Draw X.6 software
• The interpretation of rock types and groundwater potential are carried out based on the results of the mapping of outcrops and resistivity values.

1.5. Benefits of the research
1.5.1. For students
• Fulfilling the Semester Credit Unit that must be taken as an academic requirement in the Mining Engineering Department, Faculty of Science and Engineering, Nusa Cendana University.
• Contributing insights and knowledge in the field of groundwater exploration and geophysical mapping with geoelectrical methods.

1.5.2. For the alma mater
• As a form of concrete application of the Vision and Mission of the Mining Engineering Department, Faculty of Science and Engineering, University of Nusa Cendana.
• This research is expected to be a necessary input and reference for further research.
1.5.3. For the government
This research aims to provide information to the government as the reference on the provision of clean water assistance to areas in need, in this case the field of groundwater exploration in the form of groundwater drilling.

1.5.4. Place and time of research
The research took place in Malata Village, Tana Righu District, West Sumba Regency. The research was conducted directly at the location of the investigation in order to obtain primary data from direct measurements at the research site. The study was carried out for 4 weeks from 01 March 2019 - 01 April 2019. The schedule of the research is provided in the following table 1.

| Table 1. The schedule of research. |
|-----------------------------------|
| No | Activities               | Weeks |
|----|--------------------------|-------|
| 1  | Field orientation        | 1     |
| 2  | Literary study           | 2     |
| 3  | Implementation of the activity | 3   |
| 4  | Data collection         | 4     |
| 5  | Data analysis            |       |

![Research flowchart](Figure 1)
1.6. General review

1.6.1. Need for clean water
Malata Village, Tana Righu District, Sumba Baat Regency has a population of ± 1547 people with an area of 17.96 km2 (BPS, 2018). This is not proportional to the availability of water sources which is only 6 wells and 1 drilled well.

1.6.2. Geological conditions
The research area is in the Waikabubak formation rock units (Tmpw) which consists of reef limestone, marl limestone, marl, sandy marl and clay. Aquifers are located in high porosity rock units, namely reef limestone which ends with a watertight layer such as marl.

2. Theoretical basis
Geoelectrical method, known as the resistivity measurement, is a geophysical method that can be used in hydrogeological research. The basis technique of this geoelectrical method is to flow the electric current into the earth through the current electrode and measuring its potential on the earth's surface using the potential electrode. This method is carried out by using a direct electric current that is injected through two current electrodes into the earth, then observing the potential that is formed through two potential electrodes located elsewhere [2]. In order to determine the deep subsurface structure, the distance of each current electrode and potential electrode is increased gradually. The greater the spacing of the electrodes, the deeper the effect of the current penetration is. The relationship between the resistivity value of the rock with the potential difference and the electric current injected into the soil is as follows:

\[ \rho_a = \frac{dV}{I} \times K \]

\( \rho_a \) = Apparent resistivity value (ΩM)
\( dV \) = Voltage resulting from the current injection (V)
\( I \) = Current injected (A)
\( K \) = geometric factor depending on the distance (AB / 2)
\[ = \pi \frac{AB^2 - MN^2}{4MN} \]

2.1. The Schlumberger configuration method
The use of the Schlumberger method was first carried out by Conrad Schlumberger in 1912. The advantage of this configuration is the ability to detect non-homogeneity of rock layers on the surface by comparing the apparent resistivity value when there is a potential electrode distance (MN / 2) and is very suitable for sounding measurements which is the investigation of subsurface resistivity to the vertical direction. Such measurement is carried out by means of changing the current and voltage electrode distances at a fixed size point. In addition, among these four methods the Schlumberger method is the most efficient and easy to implement in the field and is very suitable as a measuring instrument used in this research which is Mc OHM. 2115 with high accuracy and can display voltage at least 2 digits after the commas.

The principle of the Schlumberger method is to flow an electric current into the ground with a low frequency (0.1 - 1.0 Hz) through a pair of electrodes A and B, then the potential difference is measured at a pair of potential electrodes M and N that are symmetrical to A and B.
2.2. List of resistivity values
Based on research conducted previously by Telford et al. in 1976. Afterwards, there was further research conducted by M. H Loke in 2000 and it was then that the resistivity of several rocks was classified into the following table:

| Material   | Resistivity (Ω m) |
|------------|-------------------|
| Clay       | 0.1 - 50          |
| Marls      | 2 - 50            |
| Limestone  | 20 – 4 x 10^2     |
| Granite    | 5 x 10^3 – 10^4   |
| Quartz     | 10^2 – 2 x 10^6   |
| Sandstone  | 8 – 100           |

(taken from: Ditjen Sumber daya Air [3])

3. Results and discussion

3.1. Data analysis

3.1.1. Regional Geology: Based on the results of the study from the Geological map, it can be inferred that the research site is located in two rock formations, namely the Waikabubak Formation (Tmpw) and the Kaliangga Formation (Qpk). Concerning the regional geological map and associated with the possibility of aquifers, which is when viewed from the side of the rocks found in the Malata Village area, such as limestone, coral limestone, marl limestone. Those are the rocks that have a high enough porosity so that they can function properly as a place to absorb groundwater due to its permeable characteristic and has high porosity causing it to be very likely to find aquifers along the investigation site. It is also suspected that this permeable rock layer also ends with impermeable layers such as marl and clay.

3.1.2. Interpretation of rock units: Reef limestone generally have a higher resistivity value than ordinary limestone. The inserts of marl are frequently found along the investigation site as well as marl limestone and marl within the limestone unit. The results of the interpretation of these rock units further strengthen the assumption of the presence of aquifers that has been carried out in the interpretation of regional geological maps. The presence of aquifers is usually in rocks with high porosity, in this case limestone / reef limestone, which then ends with an impermeable or semi-impermeable layer.

3.2. Results of the interpretation of resistivity values
In the research site, the resistivity that is suspected to contain aquifer is the resistivity in the range of 20 - 500 ohm m, and the rocks are coral limestone. The aquifer in the investigation location is interpreted to be in the limestone layer of the reef which immediately ends with impermeable layers such as clays and marl. Resistivity in the research site is classified into several types of rock, namely:

1. The resistivity value 0 ≤ 2 Ohm m is classified as a clay rock unit.
2. The resistivity value of 2.5 ≤ 10 Ohm m is classified as a unit of marl, marl.
3. The resistivity value of 10.5 ≤ 20 Ohm m is classified as marl limestone unit.
4. The resistivity value of 20.5 ≤ 500 Ohm m is grouped as a unit of reef limestone.
3.3. Aquifer interpretation

3.3.1. Spot 01

Figure 2. The aquifer is at a depth of ± 30.92 m – 55.8 m.

3.3.2. Spot 02

Figure 3. The aquifer is at a depth of ± 22 m – 28.5 m.

3.3.3. Spot 03

Figure 4. The aquifer is at a depth of ± 29.59 m – 41.59 m.

3.3.4. Spot 04

Figure 5. The aquifer is at a depth of ± 22.47 m – 51.78 m.
3.3.5. Spot 05

Figure 6. The aquifer is at a depth of ± 38.29 m – 47.11 m.

3.3.6. Spot 06

Figure 7. The aquifer is at a depth of ± 55.79 m – 74.99 m.

3.3.7. Spot 07

Figure 8. The aquifer is at a depth of ± 20.42 m – 46.52 m.

3.3.8. Spot 08

Figure 9. The aquifer is at a depth of ± 30.2 m – 55.1 m.
3.3.9. Spot 09

Figure 10. The aquifer is at a depth of ± 28 m – 66 m.

3.3.10. Spot 10

Figure 11. The aquifer is at a depth of ± 24 m – 36 m.

3.3.11. Spot 11

Figure 12. The aquifer is at a depth of ± 11.09 m – 28.83 m.

3.3.12. Spot 12

Figure 13. The aquifer is at a depth of ± 9.28 m – 39.10 m.
3.4. Cross-sectional correlation cut

3.4.5. Spot 01 - 02 - 03 - 07

3.4.6. Spot 05 - 06 - 01 - 02

3.4.7. Spot 04 - 07 - 08 - 09

3.4.8. Spot 09 - 10 - 12 - 11

Figure 14. Spot 01 - 02 - 03 - 07.

Figure 15. Spot 05 - 06 - 01 - 02

Figure 16. Spot 04 - 07 - 08 - 09

Figure 17. Spot 09 - 10 - 12 - 11.

4. Conclusion

• Based on the interpretation of regional geological maps and observations in the field, the rock units in the study area are reef limestone, marl limestone, marl, and clay.
• Based on the results of geoelectrical measurements in the field, the researchers interpreted the resistivity values of the measurements as follows:
  a. The resistivity value $0 \leq 2$ Ohm m is classified as a clay rock unit.
  b. The resistivity value of $2.5 \leq 10$ Ohm m is classified as marl marble rock units.
  c. The resistivity value of $10.5 \leq 20$ Ohm m is classified as marl limestone unit.
d. The resistivity value ≥ 20.5 Ohm m is classified as a reef limestone unit.

- Based on the results of the interpretation of groundwater potential derived from the data of wells, boreholes, and also the results of geoelectrical measurements of the Schlumberger configuration method, the researcher concludes that along the geoelectrical measurement area there are aquifers with varying thickness and depth which can be followed up with drilling.

- The results of the interpretation of geoelectrical measurement data indicate that all measurement points contain aquifers with varying depths. However, what can be followed up with drilling is at points 01, 03, 04, 06, 08, and 09. The locations that have the thickest aquifers are points 04 (± 29.3 m) and 09 (± 38 m). While points 02, 05, 07, 11 and 12 can be optimized with dug wells because the aquifers are quite shallow.

5. Suggestion

- This research is expected to be followed up with drilling activities in order to optimize the potential for groundwater in the research area.

- Future research can perform geoelectrical measurements with different configurations in order to obtain more accurate results

Reference

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