Interpretation of surface structure on artisanal and small scale gold mining areas with geoelectric resistivity method of schlumberger configuration in Sekotong, West Lombok

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Abstract. West Nusa Tenggara (NTB) has a very diverse mineral content both metal and non-metal minerals. Sekotong Sub District in West Lombok Regency has mineral resources such as gold, copper, and silver. Artisanal and small scale gold mining activities are carried out without calculating how much potential mining materials are available and at what point and at what depth the minerals are located, the required cost, labor and time. Similarly, cases that occur in artisanal and small scale gold mining areas also occur in the Rambut Petung area, Sekotong Sub District. Therefore, special methods are required to determine the presence of excavated materials that settle beneath the surface of the earth. The method that is often used in identifying subsurface is the geophysical method. The utilization of geophysical methods must be under the nature of the materials to be examined. The data processing results indicate that there are layers consisting of breccias, lava, tuff with lens limestone. Based on the resistivity log, the resistivity value is 44.56 ohms, 3-11 m the resistivity value is 17.33 ohms, 11-89 the resistivity value is 42.39 ohms, and the value of 89-130 is 309.81 ohms.

1. Introduction

West Nusa Tenggara (NTB) is one of the provinces in the central part of Indonesia and is located on a volcano trajectory which is classified as still active. Consequently, NTB has a very diverse mineral content both metal minerals and non-metal minerals. Examples of non-metallic mineral resources such as silica, limestone, and pumice, while metal mineral resources such as silver, copper, lead, and gold. Sekotong area in the mining geology map has promising natural wealth potential such as gold, copper, and silver. The potential gold mine in Sekotong reaches 1,596 tons and can be mined for decades. The Sekotong area has an identified gold content, but it cannot be officially exploited because the NTB Provincial Government has issued Regional Regulation (Perda) number 11/2006 concerning the NTB Province's spatial plan (RTRW). Article 38 of the Regional Regulation No. 11/2006 limits mining approval issued by regents on Lombok Island so that residents are determined to carry out illegal mining activities in traditional ways [1].

For these artisanal miners, working as a gold miner in Sekotong is the same as a blessing, because they do not need a work permit and do not care about the presence or absence of identity. What is important for them is a high will with strong capital [2]. The equipment used is very simple and traditional such as crowbars, hammers, chisels and sacks (as a reservoir for rocks containing gold...
dust). An artisanal and small scale mining (ASM) is a subsistence miner who is not officially employed by a mining company, but works independently, mining various minerals or panning for gold using their resources. Small scale mining includes enterprises or individuals that employ workers for mining, but generally using manually-intensive methods, working with hand tools [3]. In exploiting excavated materials, information regarding the position or whereabouts of such materials must be known in advance, so that the exploitation carried out is not in vain, and the most important is to take into account the morphological order of the mining area. Therefore in the management of mineral resources, it is necessary to apply an appropriate mining system, both in terms of engineering and economics so that its acquisition can be optimized.

Mining activities are carried out without calculating how much mining materials potentials are available and at what point and at what depth the indicated minerals are located, the required costs, labor and time cases that are not much different that occur in people's mining areas in the area of Rambut Petung, Sekotong Sub-District, West Lombok Regency. People who conduct mining only rely on their hunches and surface geological structures, besides that they also pay less attention to the sustainability of the existence of minerals and the balance of the mining area ecosystem. In addition, people who have excavated a depth of several meters and do not allow the existence of the desired quarrying material, then the hole is left just like that, and this happens at several points, even many points with the type of minerals being mined in the form of gold metal. This reflects that people who conduct mining are only motivated by trial and error. Based on this, to determine the presence of excavated material that settles beneath the surface of the earth, special methods are needed to be able to find out. The method that is often used in identifying subsurface is the geophysical method [4][5]. Utilization of geophysical methods must be under the nature of the material to be examined so that according to the specifications of the equipment to be used so that in the end will get accurate information about the nature of the material to be investigated [6][7]. Geophysics is the science that studies the earth with a physics approach, in which geophysics is known for several methods, including the gravity method, the magnetic method, the electrical method, the seismic method [6][8]. Each method has advantages and disadvantages of each, and as a geologist, it is necessary to know how to read and process data, so that the results of the processed data can help exploration work [9][10]. The resistivity geoelectric method utilizes the rock's resistance to electricity, which is influenced by values such as metal and non-metal mineral content [11].

2. Method
This research was conducted by measuring the apparent resistivity value of rocks; the hope is that these values can describe the condition of subsurface structures in Sekotong. The method used in this study is the resistivity geoelectric method with a Schlumberger configuration. Geoelectrical resistivity is a geoelectric method that studies the electrical resistivity properties of rock layers in the earth[8][9]. In this method, an electric current is injected into the earth through two current electrodes, and a potential difference measurement is done through two potential electrodes [6]. From the results of measurements of currents and differences in electrical potential will be calculated variations in the price of resistivity in the earth's surface layer below the measuring point [7][12]. Electrode configuration that is often used in sounding techniques is the Schlumberger configuration (Figure 1).

![Schlumberger array: electrical resistivity methods](image-url)
Based on the existing geological map (Figure 2), the area around the planned drilling of a wellbore occupies a geomorphological unit of undulating hills. These undulating hills are the result of an overhaul of lithology which is included in the formation of scavengers (Tomp) with constituent rocks consisting of breccias, lava, tuffs with limestone lens lenses that contain sulfide minerals and quartz veins which are exposed in hills scattered on the edge of the Rambut Petung Region. The research points conducted at three locations are GL1, dan GL2 (Figure 3).

![Figure 2. Geological map of Sekotong](image)

![Figure 3. Geoelectric measurement point](image)

3. Result and Discussion
Geologically, the type of rocks in the study area is dominated by volcanic rocks. Rocks classified as volcanic rocks are tuff, sandy tufa, and lava. While the permeability value of the study area is
dominated by moderate to high permeability. Rocks with high permeability values are lava and tuff, while rocks that have low permeability are sandy tuff and soil [14]. The geological structure that developed in the study area is the N-15 Degree E Horizontal Directional Fault structure, making it possible for this area to have many joints that are the medium for water entering the soil. Besides these burly also store and drain groundwater, so it is called the type of fracture media aquifer or cracks.

For the surface structure below the surface in the study area, there are types of aquifers that generally develop in this area are aquifer or nest, small productive, local means. This aquifer type has a very low level of continuity, local shallow groundwater in limited quantities can be obtained from the rock-solid weathering zone [10][15].

The resistivity value obtained from the measurement result is not actual resistivity but apparent resistivity [6]. Pseudo resistivity is the resistivity value of the earth which is considered homogeneous, when, in fact, the earth is not homogeneous, so it needs to be done in inversion calculations [7][8]. This inversion process is carried out to eliminate the geometric effect in order to obtain the actual resistivity value. In this study, apparent resistivity was processed with IP2WIN and Progress software. The results of the study can be seen in Figure 4.
The results obtained in graph display and log sensitivity are due to soundly representing each datum point [7]. Interpretation of data processing results has been carried out. Each datum sounding point is interpreted by the types of layers to determine the lithology and aquifer characteristics. The depth of the study layer obtained at GL 1 was 130 m. From the data obtained in Figure 4, there are four layers of rock, where resistivity prices range from a few ohms to hundreds of ohms, while thickness ranges from a few meters to tens of meters. From the results of data processing, there are layers consisting of breccias, lava, tuff with lens limestone lenses. This is because tuff is a type of coating that has high porosity and low resistivity. Based on the log resistivity, the resistivity value is 44.56 ohms, 3-11 m the resistivity value is 17.33 ohms, 11-89 the resistivity value is 42.39 ohms, and the value of 89-130 is 309.81 ohms.

4. Conclusion
Interpretation of data processing results has been carried out. Each datum sounding point is interpreted by the types of layers to determine the lithology and aquifer characteristics. The depth of the study layer obtained at GL 1 was 130 m. There are four layers of rock, where resistivity prices range from a few ohms to hundreds of ohms, while thickness ranges from a few meters to tens of meters. From the results of data processing, there are layers consisting of breccias, lava, tuff with lens limestone lenses. Based on the log resistivity, the resistivity value is 44.56 ohms, 3-11 m the resistivity value is 17.33 ohms, 11-89 the resistivity value is 42.39 ohms, and the value of 89-130 is 309.81 ohms.

References
[1] Pemda, Perda Nomor 11 Tahun 2006 tentang Rencana Tata Ruang Wilayah Provinsi Nusa Tenggara Barat. Mataram: Pemda Nusa Tenggara Barat, 2006.
[2] I. Yuliadi, “Identification Of Subsurface Structure On Gold Manifest Area Using Magnetics Method At Loang Batu, Sub District Sekotong, District West Lombok,” Universitas Mataram, 2013.
[3] T. Hentschel, F. Hruschka, and P. Gmbh, Artisanal and Mining Challenges and Opportunities. 2003.
[4] M. Sutasoma, A. P. Azhari, and M. Arisalwadi, “Identifikasi Air Tanah Dengan Metode Geolistrik Resistivitas Konfigurasi Schlumberger Di Candikidul Dasa Provinsi Bali,” Konstan - J. Fis. Dan Pendidik. Fis., vol. 3, no. 2, pp. 58–65, 2018.
[5] A. Susilo, “Subsurface Mapping of Ground Water using Schlumberger Configuration in Upstream of Brantas River , Batu area , East Java , Indonesia,” Nat. B, vol. 2, no. 4, pp. 303–308, 2014.
[6] Telford, W. Murra, L. P. Geldart, and R. E. Sheriff, Applied geophysics, Second Edi. New York, USA: Cambridge university press, 1990.
[7] M. H. Loke, RES2DINV ver. 3.3 for Windows 3.1, 95 and NT; Rapid 2D Resistivity & IP Inversion Using The Least-squares Method (Wenner, dipole-dipole, inline pole-pole, poledipoe, equatorial dipole-dipole, Schlumberger) On land, Underwater and Cross-Borehole Surveys. Penang, Malaysia, 1999
[8] J. Reynolds, An Introduction to Applied and Environmental Geophysics. Chichester: John Wiley & Sons, 1997
[9] A. A. R. Zohdy, “A new method for the automatic interpretation of Schlumberger and Wenner sounding curves,” GEOPHYSICS, vol. 54, no. 2, pp. 245–253, Feb. 1989
[10] I. Muchingami, D. J. Hlatywayo, J. M. Nel, and C. Chuma, “Electrical resistivity survey for groundwater investigations and shallow subsurface evaluation of the basaltic-greenstone formation of the urban Bulawayo aquifer,” Phys. Chem. Earth, vol. 50–52, pp. 44–51, 2012.
[11] F. W. Schwartz and G. L. McClymont, “Applications of Surface Resistivity Methods,” Groundwater, vol. 15, no. 3, pp. 197–202, 1977.
[12] N. Janardhana Raju and T. V. K. Reddy, “Fracture pattern and electrical resistivity studies for groundwater exploration,” Environ. Geol., vol. 34, no. 2–3, pp. 175–182, May 1998.

[13] AGI USA, “www.agiusa.com”, 2019, [Online], Available: https://www.agiusa.com/schlumberger-array [Acessed 25 April 2019].

[14] D. S. Agustawijaya, “Influence of rock properties in estimating rock strength for shallow underground structures in Weak rocks,” Indones. J. Geosci., vol. 5, no. 2, pp. 93–105, 2018

[15] B. Pratap and H. Dev, “Electrical resistivity survey for groundwater investigation at sumbli of Jammu district (J&K),” in Management of Water, Energy and Bio-resources in the Era of Climate Change: Emerging Issues and Challenges, Springer International Publishing, 2015, pp. 127–139