Exploring of factors influencing the rocks resistivity value: comparative study of resistivity values in some areas

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Abstract. **Abstract**. Geophysics has been the success to solve environmental issues, engineering, and hydrogeology. One of the geophysical methods is electrical resistivity that has been used to survey near of surface. Electrical resistivity is a geophysical method that has a working principle by injecting DC (Direct Current) that has high voltage into the ground. The result can be used to obtain resistivity value that is passed by electrical current based on Ohm's Law. Factors that influence the rock resistivity value are included porosity, water content, and type of soil. The purposes of this study are to compare the rock resistivity values in some areas and to know the factors that influence the rock resistivity values in those areas. The method used in this study is to compare papers about some case studies using the electrical resistivity method.

1. Introduction

Geophysics is the study of the earth, oceans, atmosphere, and near-earth space by using physics applications. Geophysics has been the success to solve environmental issues, engineering, and hydrogeology. Some geophysical methods include seismic refraction, electrical resistivity, magnetic, gravity, and remote sensing. One of the geophysical methods is electrical resistivity that has been used to survey near of surface.

Electrical resistivity is a geophysical method that uses an electrical current into the rock to get resistivity value [1]. The function of electrical resistivity is to determine materials in the subsurface based on the resistivity value, it works based on measuring materials on the ground surface [2]. Electrical resistivity is used by injecting DC (Direct Current) that has high voltage into the ground. This electric current injection uses two current electrodes into the ground with a certain distance. The longer of both will make current can through a deeper layer. By using electrical current will create voltage into the ground [3]. The result can be used to know the resistivity value that is passed by electrical current based on Ohm's Law [4].

$$V = I \times R \tag{1}$$

Where V is voltage, the unit of voltage is volt (V), I iselectric current, the unit of current is ampere (A), and R is resistivity, the unit of resistivity is ohm (Ω).The functions of electrical resistivity are mapping subsurface hydrogeology, mapping saltwater intrusion, determine depth to bedrock, and determine depth to groundwater [5], detection of underground mine working [6], fracture zone exploration surveys, and stratigraphic surveys to explore oil and gas [7].

Factors that influence the rock resistivity value are includedporosity, water content, and type of soil [8]. The purposes of this study are to compare the rock resistivity values in some areas and to know the factors that influence the rock resistivity values in those areas. After that, the questions raised in this study is included 1) Is the same between the factors that influence the rocks resistivity value in some areas and the theory? 2) What are the conditions that influence the rocks resistivity value in each area? The method used in this study is to compare papers about some case studies using the electrical resistivity method.

2. Methods

The methodology in this paper uses five papers that told about some case studies such as landslide, groundwater circulation, and bedrock exploration by using electrical resistivity. Each paper told about each case study in some areas. Those papers showed the resistivity value of some materials from each case study. We use those resistivity value data to compare resistivity values in each area so that we will know the factors that influence the differences in resistivity values in some areas. We wrote the conclusion about the factors influencing resistivity value in each area.

3. Results and Discussion

We summarised some papers about some case studies by using electrical resistivity method. We focus on the rocks resistivity value and factors that influence it so that we can make a correlation between the rocks resistivity value and factors that influence it. In this paper, we use five papers from five areas: Norway [9], Italy [10], Spain [11], China [12], and Taiwan [13].

3.1 The rocks resistivity value in ESP, Trondheim, Norway

Summary from Solbergh et al. [9], they studied geophysical and geotechnical studies of geology and sediment propertiesat a quick-clay landslide site at Esp, Trondheim, Norway. The result of rocks resistivity value is shown in Table 1.

Table 1. The rocks resistivity value in ESP, Trondheim, Norway.

Materials	Resistivity value
Bedrock	192 - 462 ohm m
Leached clay	13.9 - 80 ohm m
Unleached clay	1 - 13.9 ohm m

According to Table 1, bedrock has resistivity value of 192 – 462 ohm m. It is highest resistivity value than other materials. Factors that make the bedrockhas high resistivity value are usually the condition of bedrock is fresh and hard, andbedrock is usually avoided from weathering process because of the position is deepest. Leached clay has resistivity value of 13.9 – 80 ohm m. It is higher resistivity value than unleached clay because it is the kind of clay but has occurred leaching process. Leaching process will make water will loose so that make higher resistivity value. Unleached clay has resistivity value of 1 – 13.9 ohm m. It is lowest resistivity value than other materials. It is the kind of clay that has water content inside. Unleached clay has lowest resistivity value than other materials because of the water content inside it makes the resistivity value becomes lower.

3.2 The rocks resistivity value in Riety Plain, Central Italy

Summary from Cardarelli and Donno [10], they studied multidimensional electrical resistivity survey for bedrock detection at theRieti Plain, Central Italy. The result of rocks resistivity value is shown in Table 2.

Table 2.The rocks resistivity value in Riety Plain, Central Italy.

Materials	Resistivity value
Silty sand	40 - 60 ohm m
Clayey silt	20 - 40 ohm m
Limestone	100 - 200 ohm m

According to Table 2., limestone has resistivity value of 100 – 200 ohm m. It is highest resistivity value than silty sand and clayey silt because limestone body is usually harder and more resistance than silty sand and clayey silt. Silty sand has resistivity value of 40 – 60 ohm m. It is higher resistivity value than clayey silt because the silty sand body is usually harder and more resistance than clayey silt. Clayey silt has resistivity value of 20 – 40 ohm m. It is lowest resistivity value than limestone and silty sand because it is usually softer and easier to erode than limestone and silty sand.

3.3 The rocks resistivity value in The Guadiana Basin, Southwest Spain

Summary from Tejero et al. [11], they studied electrical resistivity imaging of the shallow structures of an intraplate basin at The Guadiana Basin, Southwest Spain. The result of rocks resistivity value is shown in Table 3.

Table 3.The rocks resistivity value in The Guadiana Basin, Southwest Spain.

Materials	Resistivity value
Colluvium (gravel, sandstone, clay)	54.9 - 164.9 ohm m
Conglomerate, sandstone, clay	42.8 - 54.9 ohm m
Basement (igneous and metamorphic rock)	129 - 164.9 ohm m

According to Table 3., basement (igneous and metamorphic rock) has resistivity value of 129 – 164.9 ohm m. It is highest resistivity value than other materials because the condition of the basement is usually fresh and hard, and basement usually is avoided from weathering process because of the position is deepest. Colluvium (gravel, sandstone, clay) and conglomerate, sandstone, clay have resistivity value is almost similar because the compositions of their bodies are also almost similar.

3.4 The rocks resistivity value in Kualiangzi landslide, Southwest China

Summary from Ling et al. [12], they studied application of electrical resistivity tomography for investigating the internal structure of a translational landslide and characterising its groundwater circulation at Kualiangzi landslide, Southwest China. The result of rocks resistivity value is shown in Table 4.

Table 4.The rocks resistivity value in Kualiangzi landslide, Southwest China.

Materials	Resistivity value
Gravelly soil	23.6 - 49.0 ohm m
Clay layer	7.92 - 16.4 ohm m
Weathered sandstone and mudstone layer	7.92 - 16.4 ohm m
Sandstone	23.6 - 162 ohm m
Rock blocks	> 70.6 ohm m

According to Table 4, rock blocks have resistivity value of >70.6 ohm m. It is highest resistivity value than other materials because the condition of rock blocks are usually fresh and hard. Gravelly soil and sandstone have resistivity value are almost similar because the compositions of their bodies are also almost similar. They have resistivity value higher than clay layer and weathered sandstone and mudstone layer because they are usually harder and more resistance than clay layer and weathered sandstone and mudstone layer. Clay layer and weathered sandstone and mudstone layer have lowest resistivity value than other materials because they are usually softer and easier to erode than rock blocks and sandstone.

3.5 The rocks resistivity value in Southeastern part of Lishan landslide, Central Taiwan

Summary from Lee et al. [13], they studied the hydrogeological environment of the lishan landslide area using resistivity image profiling and borehole data at Southeastern part of Lishan landslide, Central Taiwan. The result of rocks resistivity value is shown in Table 5.

Table 5. The rocks resistivity value in Southeastern part of Lishan landslide, Central Taiwan.

Materials	Resistivity value
Colluvium and fractured slate	20 - 140 ohm m
Slate	100- 140 ohm m

According to Table 5, slate has resistivity value of 100 – 140 ohm m. It is higher resistivity value than colluvium and fractured slate because the position of slate is deeper than colluvium and fractured slate. It is avoided from the weathering process. The position of colluvium and fracture slate are on the surface. They will obtain some surface process such as weathering by wind and water so that makes their bodies are easier to eroded. In addition, if the water percolates in fractured slate, it will make resistivity value becomes lower.

In addition, we also compare between the same materials in the different areas. We compare the kinds of clay from each area: Unleached clay in Norway (1 – 13.9 ohm m), clayey silt in Italy (20 – 40 ohm m), clay mixed with conglomerate and sandstone in Spain (42.8 – 54.9 ohm m), and clay layer in China (7.92 – 16.4 ohm m). Although they are the same materials, they have different resistivity values. The factors influencing that resistivity values are: 1) the other materials contained in the clay bodies, such as in the unleached clay in Norway has lowest resistivity value than others because of inside that, a lot of water content. Clayey silt in Italy has higher resistivity value than unleached clay in Norway and clay layer in China because it is mixed with silt that has more resistance than clay. In addition, the condition of clay layer in China is weathered [12], it will make resistivity value becomes lower. The clay mixed with conglomerate and sandstone in Spain has highest resistivity value than others because in that clay mixes with conglomerate and sandstone. Because the conglomerate also has hard rock content and sandstone that have more resistance than clay, 2) the external factors such as between unleached clay in Norway and clay layer in China, in those areas are found groundwater area [9][12]. This condition will make resistivity values become lower because the materials contacted with water. In addition, water has also come from heavy rainfall, such as in China [12].

Another example is sandstone material. Comparison between sandstone that mixed with conglomerate and clay in Spain (42.8 – 54.9 ohm m) and weathered sandstone and mudstone layer in China (7.92 – 16.4 ohm m). Weathered sandstone and mudstone layer in China have lower resistivity value than sandstone that mixed with conglomerate and clay in Spain because of that condition is weathered.

4. Conclusion

From each study about the resistivity value, the factors influencing that resistivity values are : 1) The resistance of materials. Materials that have more resistance will have higher resistivity value, 2) Water content. Materials that have more water content inside their bodies will make lower resistivity value. Water content can come from groundwater and rainfall, 3) The mixture of other materials, such as sedimentary rock like clay has lower resistivity value than the sedimentary rock that mixed with igneous, metamorphic rock or other sedimentary rocks that have more resistance such as silt and sand, and 4) Weathering factors. The rocks condition in that area is weathered, it will make resistivity value will be lower.

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