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# Analysis of the subsurface minerals of Bantimurung-Bulusaraung National Geopark: Leang Lonrong Cave in Maros-Pangkep regencies based on its characteristics of rainfall intensity

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**Abstract**. Leang Lonrong Cave with underground river flowing in it is located in Maros-Pangkep karst area known with a high level of annual rainfall. That condition affects the surrounding environment including water discharge and subsurface mineral types. This study aims at analyzing the impact of rainfall on sub-surface mineral types around the area of Leang Lonrong Cave. The data used are rainfall intensity of Tondong Tallasa, Bungoro and Ballocci stations in 2015-2019 which are analyzed using Oldeman and Schmidt-Ferguson methods to find out the characteristics of rainfall occuring in Pangkep Regency. As for water discharge in June 2020 and rock resistivity data, they are examined using geo-electric method by Wenner's through IP2Win and Res2DinV. The results of this study show that the area is dominated by wet months in November to April with rainfall intensity above 100mm per year and dry months which generally occurring in July to September where the others are considered as humid months with low water discharge flows in dry months. Moreover, the subsurface minerals are dominated by groundwater, clay and sand with resistivity extends from 0 to 27Ωm.

## 1. Introduction

South Sulawesi has large karst areas spread in each district [1]. It is characterized [2] by closed basins in various forms, no surface rivers along with a sub-surface drainage system. Bantimurung-Bulusaraung National Geopark: Leang Lonrong Cave in Maros-Pangkep area has a high content of limestone ($CaCo_3$) and spread over a large area [3]. One of the caves in the Karst Maros-Pangkep Area is Leang Lonrong Cave located in the Village Panaikang District Minasatene Pangkep Regency which is included in the cluster of National Parks (TN) Bantimurung Bulusaraung (Babul). This cave includes a horizontal cave with underground river flow in it. This cave has a water supply used by residents for irrigation and tourist attractions.

As an agricultural area, the availability of water throughout the year supports community activities. Rainfall intensity is the main factor influencing water availability. Rainfall in Karst Maros Area is highly varied, especially in the last 30 years. For 20 years only (1990-2010), rainfall in December and January (rainy season) is 600 mm / month, while in July, August and September (dry season) only

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about 10 mm / month. [4]. Rainfall is one of the factors that greatly affect the karstification process (karst area formation process) > 250 mm / year [5].

High rainfall intensity affects erosion occurring in soils on the slopes of karst areas [6]. Due to the slow rate of limestone formation while changes in rainfall intensity occur almost every year, soil erosion becomes faster than its formation [7]. Erosion results are generally carried away by rainwater and segmented. The high level of rainfall in the Maros-Pangkep Karst Region allows it to be one of the factors that influence the formation of sub-surface minerals.

## 2. Method

### *2.1. Data Observed*

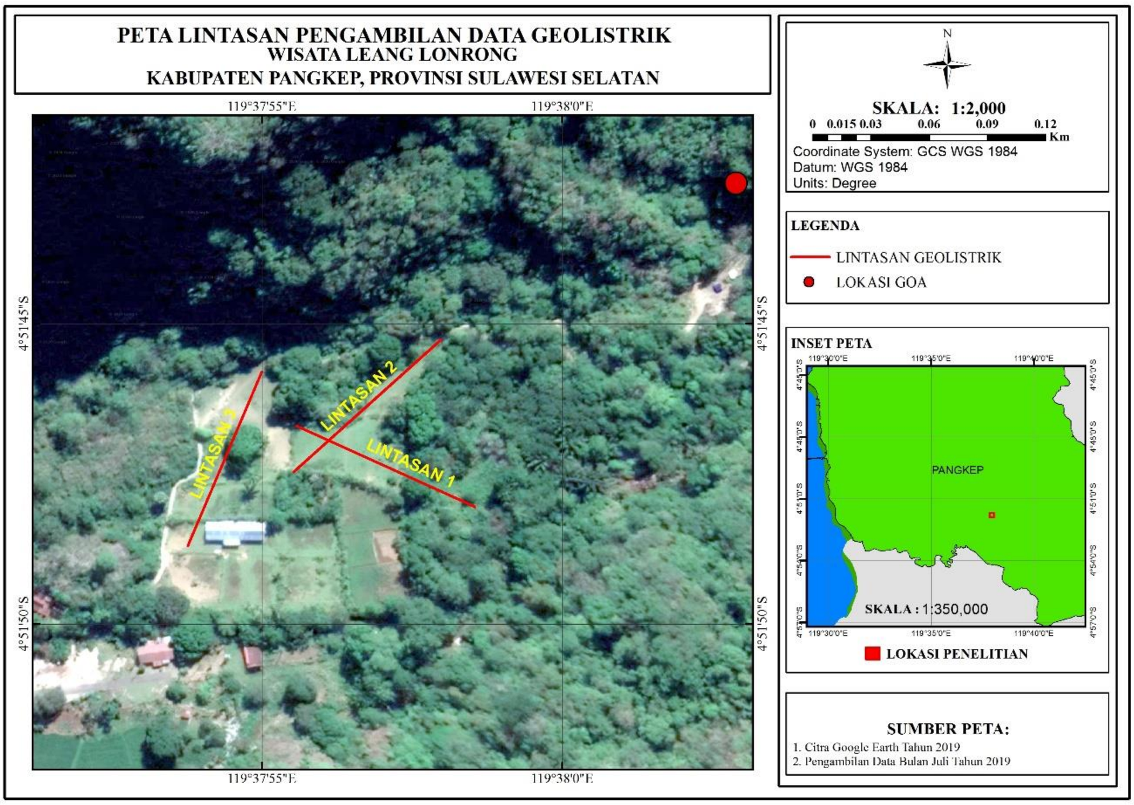


**Figure 1.** Location of Leang Lonrong Cave Karst Area.

This study took place in Leang Lonrong Cave Area. The data used in the form of 1) rainfall data from 3 Rainfall Stations (CH), namely: a) BALOCCI CH Station, b) Minasa Tene CH Station, and c) Tondong Tallasa CH Station with data starting from 2015-2019, 2) Water discharge data in June 2020, 3) Current data (I) and voltage (V) from measurements using geoelectric.

### *2.2. Data analysis*

*2.2.1.* Analysis of rainfall data is carried out with the following procedures [8]

$$P=\frac{P_1+P_2 \;\ldots\ldots\; +P_n}{n}$$

Description:

P = Average rainfall area

P1 = Rainfall Station 1

Pn = Nth station rainfall

n = Number of rainfall stations inresearch site

*2.2.2.* Determining the characteristics of rainfall types based on the Oldeman and Schmidt-Ferguson methods.

*2.2.3.* Sub-surface mineral profiling. To analyze sub-surface minerals, measurements are taken using geoelectric data. Processing acquisition data obtained by geoelectric is done using software Res2DinV and IP2Win modeled in 2-D using inversion programs with at least-square nonlinear optimization techniques.

## 3. Results and Discussions

### *3.1. Results*

*3.1.1 Characteristic of Rainfall in Bantimurung-Bulusaraung National Geopark: Leang Lonrong Cave in Maros-Pangkep Regencies*. The rainfall characteristics of Pangkep Regency were obtained from 3 stations namely, Ballocci Station, Bungoro Station and Tondong Tallasa Station for 2015-2019. The rainfall data obtained is illustrated in the form of graphs to see the pattern of rainfall on a yearly period.

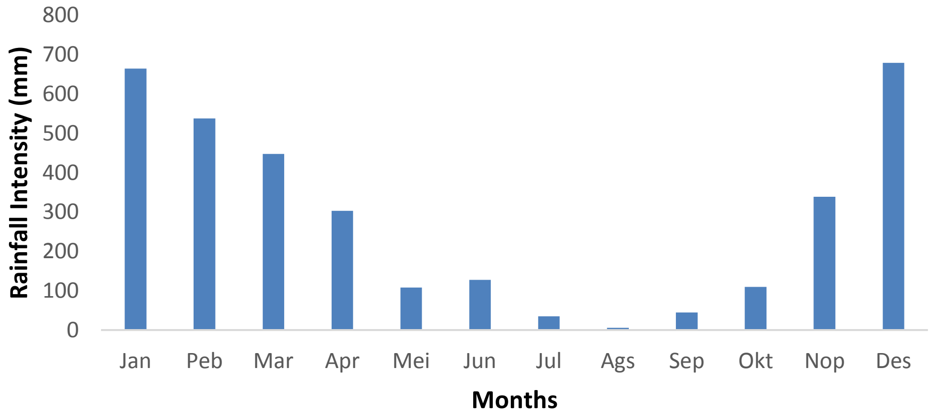


**Figure 2.** Patterns of Pangkep Regency's Annual Rainfall Intensity in 2015-2019

Figure 2 shows the rainfall patterns of Pangkep Regency from Ballocci Station, Bungoro Station and Tondong Tallasa Station. There are three months with rainfall below 100mm and the other nine months have rainfall above 100mm. The highest rainfall was in December while the lowest rainfall was in August.

**Table 1.** Characteristics of Rainfall in Leang Lonrong Pangkep Cave Area

| Months | Intensity | Characteristics |
|---|---|---|
| Jan | 664.2 | wet month |
| Feb | 537.5 | wet month |
| Mar | 447.4 | wet month |
| Apr | 302.9 | wet month |
| May | 108.7 | humid month |
| Jun | 127.5 | humid month |
| Jul | 35.1 | dry month |
| Aug | 6.1 | dry month |
| Sep | 45.3 | dry month |
| Oct | 109.6 | humid month |
| Nov | 338.6 | wet month |
| Dec | 678.6 | wet month |

Table 1 shows the rainfall characteristics of pangkep districts. There are three dry months in July, August, September, there are three humid months, namely May, June, October and there are 6 wet months in January, February, March, April, November and December.

*3.1.2Types of Subsurface Mineral in Bantimurung-Bulusaraung National Geopark: Leang Lonrong Cave in Maros-Pangkep Regencies.* As an effort to reveal the type of subsurface minerals in the cave area, it is analyzed through resistivity value using geoelectric configuration by Wenner's. There are three flow tracks with each track length around 100 meters with space between electrodes around five meters. The current value (I) and voltage (V) obtained were analyzed using two kind of softwares namely IP2Win and Res2DinV.

*3.1.2.1 FlowTrack 1*

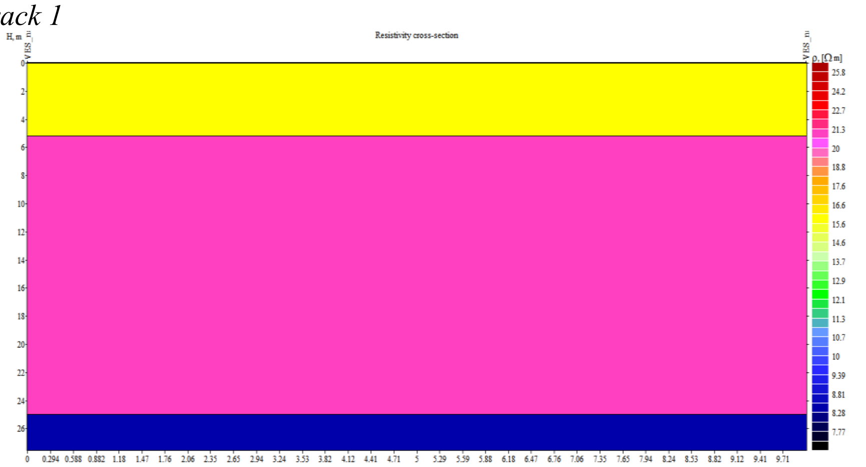


**Figure 3.**Visual Representation of Types of Subsurface Minerals through IP2Win Software

Figure 3 shows the type of mineral below the surface of the track 1, generally divided into three layers with a consecutive resistivity value of 15.5 Ωm with a type of mineral that is possible namely groundwater, clay and sand, 20-21.3 Ωm with possible mineral types namely groundwater, clay and slate, and 4.28-9.29Ωm with possible mineral types namely groundwater, clay and sand.

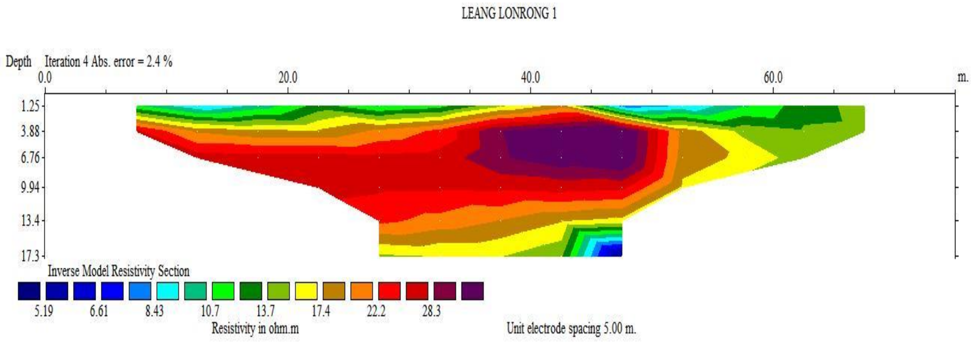


**Figure 4.** Visual Representation of Types of Subsurface Minerals through Res2DinV Software

Figure 4 shows the sub-surface mineral resistivity value is in the range of 5.19-28.3Ωm. The type of mineral indicated by the color dark blue to light blue with a resistivity value of 5.19-8.43Ωm is groundwater, clay and sand. The type of mineral indicated by the color green to brown with a resistivity value of 10.7-17.4Ωm is groundwater, clay and sand. The type of mineral shown in orange to purple with a resistivity value of 22.2-28.3Ωm is a type of mineral of groundwater, clay, sand and slate.

*3.1.2.2 .Flow Track 2*

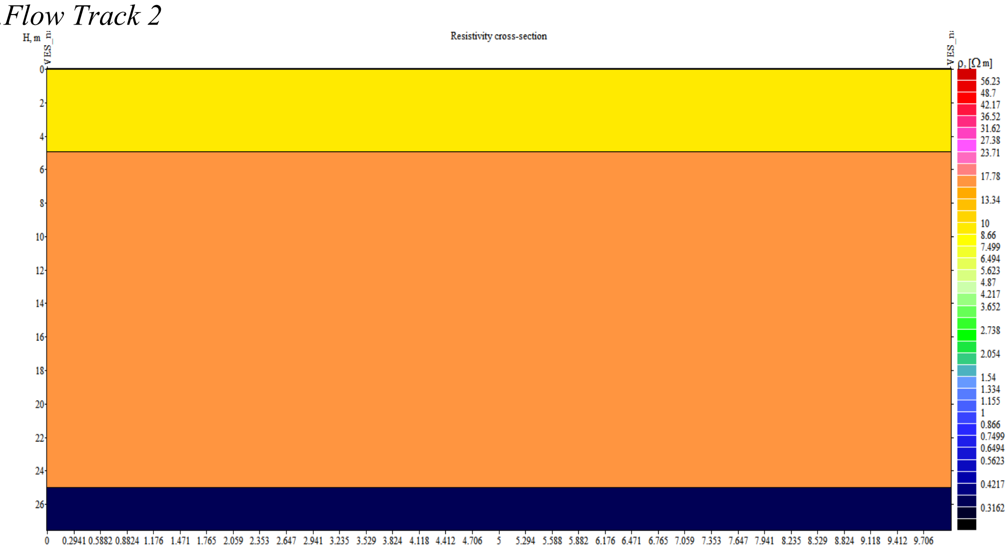


**Figure 5.** Visual Representation of Types of Subsurface Minerals through IP2Win Software.

Figure 5 shows the type of mineral below the surface of the track 2, generally divided into three layers with consecutive resistivity values, yellow color 7.49 Ωm with a type of mineral that is possible namely groundwater, clay, and sand, orange color 15.34 Ωm with a type of mineral that may be groundwater, clay and sand, and dark blue color 0.38 Ωm with a type of mineral that may be groundwater

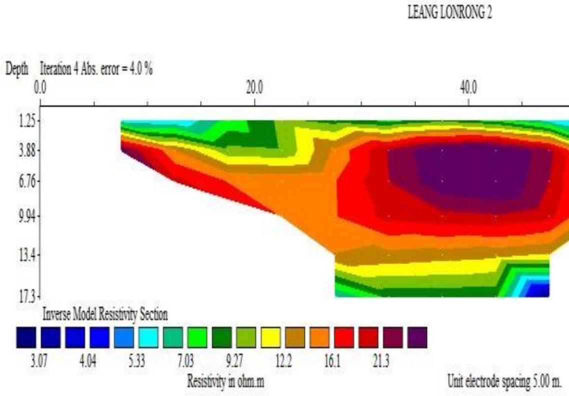


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**Figure 6**. Visual Representation of Types of Subsurface Minerals through Res2DinV Software

Figure 6 shows the type of sub-surface mineral with the resistivity value being in the range of 3.07-21.3Ωm at a depth of 1.25-17.3 meters. Mineral type indicated by dark blue to light blue color with resistivity value of 3.07-5.33Ωm is groundwater, clay and sand. The type of mineral is indicated by the color green to brown with a resistivity value of 7.08-12.2 Ωm is groundwater, clay and sand. Types of minerals indicated by orange to purple color with a resistivity value of 16.1-21.3Ωm is a type of minerals groundwater, clay, and sand.

*3.1.2.3 Flow Track 3*

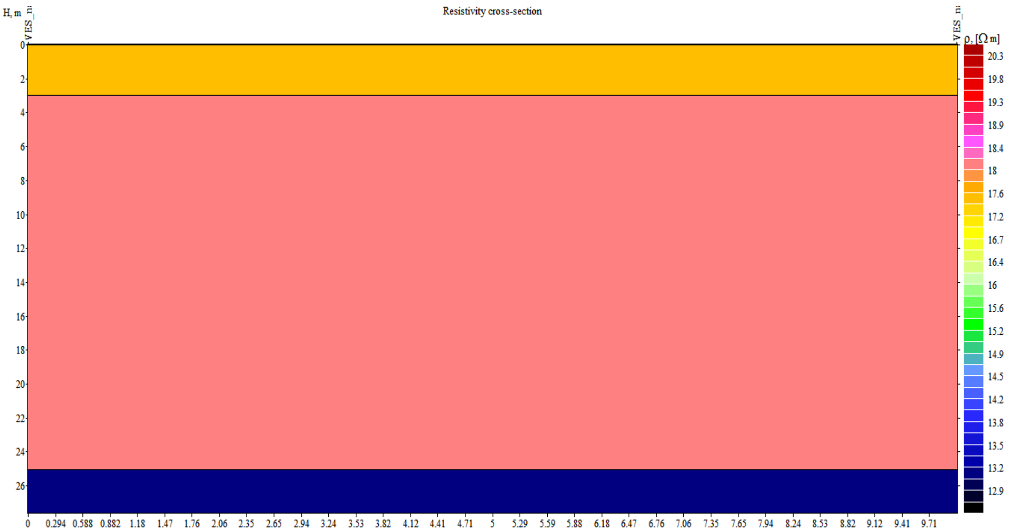


**Figure 7**. Visual Representation of Types of Subsurface Minerals through IP2Win Software

Figure 7 shows the type of mineral below the surface of the trajectory 3, generally divided into three layers with consecutive resistivity values, orange color 17.6 Ωm with a type of mineral that is possible namely groundwater, clay and sand, red color 18 Ωm with a type of mineral that may be groundwater, clay and sand and dark blue color 12.9 Ωm with a type of mineral that may be groundwater , clay, and sand.

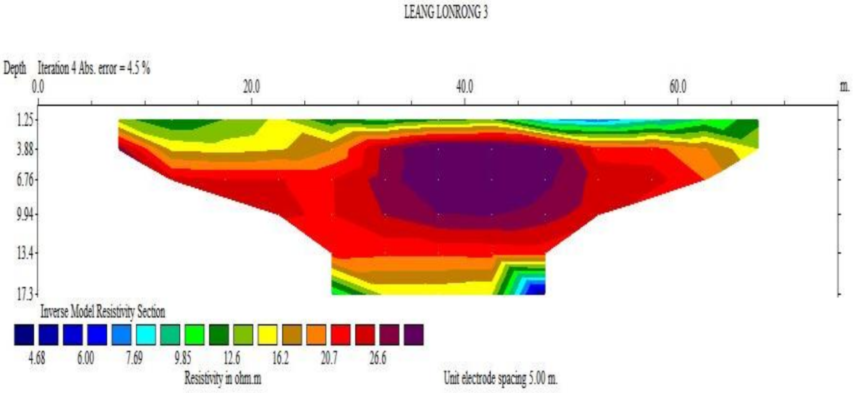


**Figure 8**. Visual Representation of Types of Subsurface Minerals through Res2DinV Software

Figure 8 shows sub-surface minerals with resistivity values in the range of 4.58-26.6 Ωm at a depth of 1.25-17.3 meters. Mineral type is indicated by dark blue to light blue color with resistivity value of 4.58-7.69 Ωm is groundwater, clay and sand. Mineral type is indicated by green to brown color with resistivity value of 9.83-16.2 is groundwater, sand and clay. The type of mineral indicated by orange to purple has a value of 20.7-26.6 Ωm is a type of mineral groundwater, clay, sand and slate.

### *3.2. Discussion*

The existence of karst area has many benefits for the surrounding community if utilized properly. Limestone can hold large amounts of water for use in everyday life as a spring. In addition, the potential of this area can be utilized for tourist attractions, archaeological sites, biodiversity and other unique landscapes.

The climatic condition of the karst area in Maros-Pangkep Regencies is classified as type C2 climate with two and three dry months and three dry months. Both of the conditions include wet months between 5-6 consecutive months of the year with average rainfall of 2,500-3,000 mm per year where the rest are humid months. This type is a rather wet type of climate. Humidity is in the range of 89 Rh-91Rh or an average air temperature of 27$^{o}$C. [9] stated that pangkep regency climate conditions in general is a type C1 and C2 climate with an average air temperature of 21$^{o}$-31$^{o}$ or an average of 26.4$^{o}$C.

High rainfall intensity is one of the main dynamic factors that cause the karstification process. This process causes minerals in the karst area to grow and develop. Low rainfall in dry months causes potential rock erosion in wet months with rainfall intensity of > 0.8 mm/min [10]. Changes in rainfall intensity have a subtansial effect on rock and soil erosion [11].

The karst area is formed from the dissolution of rocks such as limestone, dolomite and gypsum [12]. Arsyad, M [13] research suggests that the type of rock in the karst area of Leang Lonrong Cave is a dolomite limestone and modified limestone. A stable environment will trigger the process of weathering minerals, dissolution of carbonate materials and the formation of clay minerals, especially at the top and slopes of primary mineral hills, especially labradorite and mafik that are very easily weathered [14]. Minerals carried by rain each year are segmented below the surface. So in general, the type of sub-surface minerals in the Karst Region will be influenced by minerals carried by rainwater.

Deposition occurs because the fragments of rock carried by erosion cannot be carried away forever. The fragments of rock carried will be deposited. During the deposition process, the shards of rock will be deposited in layers where the heavy shards will be deposited first and then followed by lighter fractions and so on. Most sediments transported by fluid are eventually deposited, so the main feature of sedimentary rocks is layered. The boundary between one layer and the other layer is called layering field, layering field can occur due to differences: color, large grain, and or type of rock between two layers. Other sedimentary structures commonly found in rocks are layers of graded bedding and cross-bedding. The occurrence of these sediment structures is caused by deposition mechanisms and certain precipitation conditions and environments.

Geoelectric method is one of the methods that can be used to analyze the type of minerals that exist below the surface by utilizing the electrical properties of each mineral. Basically the value of resistivity obtained from all three paths by still being in the same value range. The result of sub-surface profiling analysis using geoelectric method of wenner configuration obtained resistivity value from 3 passes with a total track length of 300meter is in the range of 0-27 Ωm with possible mineral types are sand, clay and groundwater [15].Clay minerals become one of the dominant minerals due to the physical properties of karst area composed of limestone. During intensive rainfall water is transported very quickly to the underground channel network, while at times of low rainfall the water tends to accumulate before flowing slowly into underground karst [16]. The existence of shallow groundwater can be a solution for people when the dry moon arrives where the water discharge of Leang Lonrong Cave decreases drastically.

## 4. Conclusion

Characteristics of rainfall intensity in Bantimurung-Bulusaraung National Geopark: Leang Lonrong Cave in Maros-Pangkep Regency are classified by three dry months, three humid months and six wet months. Dry months start regularly from July to October, where wet months from November to April and the rest are humid months. High rainfall intensity causes karst rocks to become weathered in the dry months and eroded easily. Minerals ingested from karst rocks are carried away by rain and eventually settle below ground level. The calculated resistivity varies between 0-27 Ωm indicating that the type of minerals lies in the surface of Leang Lonrong Pangkep Cave Area are in the form of groundwater, clay and sand.

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