Hydrogeological Characteristics of Karst Maros: Case Study - Saleh Cave

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Abstract: Maros karst area known have a morphology similar a tower form, valley (doline, uvala) along cave with underground river. This research aims to analyse the hydrogeology behavior of Maros karst area so it will reveal existence of water potential. Method used in this research is geology survey there is fracture system measure for getting joint dominant direction related to cave system development and underground river, along with morphology identification to know the function as catchment area, aquifer and infiltration zone. Geoelectricity method used to presume limestone structure and cave system base on value of resistivity. The result reveal that the morphological of the research location implied in karst hill with macro type (eksokarst) positive form that is tower karst and negative form that is ponor, also many speleothem (endokarst). Analysis of fissure system orientation found two (2) common direction at Saleh Cave that is northeast to southwest direction it's about 65ºNE–245ºSW where the joint direction relatively having the same direction with dry channel and southeast to northwest direction it's about 140ºSE -320ºNW where the underground cave system have the same way. Geoelectricity interpretation indicate the cave system and underground river reside in about 18-45 meter below surface. Hydrogeology behavior of Maros karst at Saleh Cave very dependent by morphology condition, also development of fissure structure

1 INTRODUCTION

Karst is a landscape in carbonate rocks that are very typical form of hills, valleys, doline, uvala, polje, caves system and the existence of underground river network. Karst morphology is formed by tectonic and dissolving processes resulting in numerous fractures in limestone that have a role as vertical inlet and the development of underground rivers and concentrated solubilization (Haryono, et al., 2004). The formation of karst areas is influenced by climatic, tectonic and lithological factors. These three factors also play a role in establishing the Maros karst area. Based on the regional geological map (Sukamto, et al., 1982), the constituent rocks of the Maros karst area are the Tonasa formation carbonate rocks that were Eocene - Miocene (51 - 16 million years ago).

Maros karst area according to Daryanto, et al. (2009) is influenced by the geological structure due to the limberation (karstification) process of limestones so as to form various kinds of outer formation (eksokarst) such as upright hills, dolina valleys, resurgence, ponor or sinkhole, and formation in it (endokarst) that can be encountered such as stalactites, stalagmites, flowstones and underground river systems. Physically, the Maros karst area is dry and barren, so that the people living in the area suffer from water shortages, especially in the dry season (Setiawan, et al., 2008).

Imran (2006) mentions that underground rivers emerge as surface or springs streams which are further utilized by surrounding communities as a source of life both for household needs and for irrigation. According to Rachman (2010), the dynamics of water resources potential of Maros karst area shows a significant decrease indicator. This is thought to be due to changes in landscapes and karst cover areas that may result in the decline of karst area function as rain catchment and surface water absorption. Changes in landscapes and land cover conditions in the karst area also have an impact on climate change affecting karst aquifer function (Hao, et al., 2006).

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The karst landscape is an area with a potential water resource that flows beneath the surface as an underground river. With the identification and mapping of potential water resources in the karst area should be done as an effort in the preservation and management, in order to support the sustainability of the surrounding community life. Saleh cave in Pattunuangasue District Simbang District is included in Maros karst area which has underground river flow. The study entitled "Hydrogeological Characteristics of Karst Maros Area: a case study of Saleh Cave", aims to identify karst morphology in relation to subsurface water resources, estimation of Gua Saleh's system using geoelectric method and to analyze the influence of geological structure (fracture pattern) on underground river system at Saleh cave.

2 METHODS

The research location of Saleh Cave is located in Patunuangasue area, administratively located in Simbang District Maros Regency South Sulawesi Province, with geographic position 5° 2' 59,40" S and 119° 43' 17,16" E. Data collection in the form of geological structure measurement (random fracture pattern) in Saleh Cave, and measurement of the Wenner-Schlumberger configuration geoelectric method above the Saleh Cave (Figure 1), with a stretch of 160 meters, the distance of each 10 meter electrode so as to know the subsurface condition of Saleh Cave.

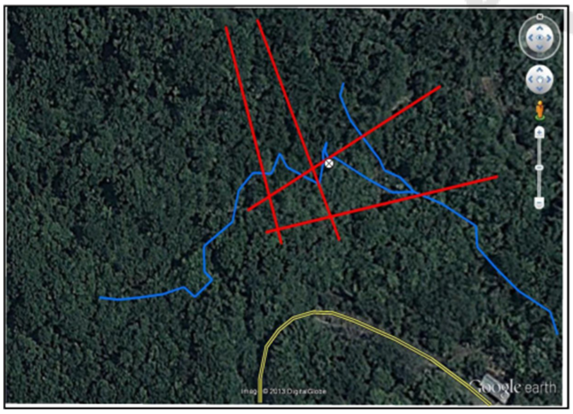

Figure 1. Geoelectric measurement scheme

The identification of karst morphology was analyzed based on its shape and function as rain catchment areas, aquifers and water absorption areas below the surface. Geoelectricity measurement data is processed by using Res2Dinv software then interpreted with reference to correlation between resistivity value and rock. The solid measurement data is processed by using Dips software so that the general direction (fracture pattern) in Saleh Cave is obtained.

3 RESULT

3.1 Geoelectric Methods Measurement

This method is based on the measurement of the electrical properties of the rock, ie the type resistance shown in the form of cross-section of 2D images. The image cross section is obtained after the measurement data is processed by using Res2Dinv software. Interpretation of the 2D cross-sectional image refers to the table of rock correlations and resistivity values (Telford, et al., 1990), to determine the subsurface condition of Saleh Cave. The result of the measurement inversion in the form of 2D cross-section shows the depth of geolistrik penetration about 30 meters below the surface with variation of resistance value of type around 2.0 Ωm to >4,718 Ωm.

Measurement of track 1 above Cave Saleh with coordinates 119° 43' 15.83" E - 5° 2' 56.9" S and 119° 43' 17.37" E - 5° 3' 0.74" S is at a surface height of about 150 - 167 above a sea level (asl) with northwest-southeast direction. The result of measurement on track 1 (Figure 2) can be interpreted that there is a resistivity value of 2.0 Ωm to 132 Ωm at a depth of 2 meters-25 meters (electrode 2-8) and a depth of 20 meters-25 meters (between electrode 11 - 14) is a layer of limestone that has a geological structure (stocky) that allows surface water to infiltrate (infiltration) through a fissure or crack system. This layer has good porosity with permeable properties that can serve as storage media and water infiltration (epicarstic aquifer). Resitivity values >132 Ωm to 1071 Ωm at depths of 2 meters-30 meters (electrode 6-15) indicate the presence of layers with geologic structures that are thought to be massive limestones with poor impermeable porosity. Higher resistivity values of >3,053 Ωm at depths of 2 meters to 20 meters (between 8-14 electrodes) and depths of 25 meters to 30 meters (electrode 10-13) are thought to be layers of limestone that have widened cavities as a result of a prolonged dissolution process to collapse and form a cave passage. The detected cave passage is estimated to be a new section of the roof at a depth of 30 meters (between 10-11 electrodes).

Measurement of track 2 above the Saleh Cave with coordinates 119° 43' 15.25" E - 5° 2' 57.05" S and 119° 43' 16.32" E - 5° 3' 0.79" S is at a surface level of about 150 asl-165 asl in the direction Northwest-southeast. The result of measurement on track 2 (Figure 3) can be interpreted that the accumulation of water in the limestone layer near the surface to a depth of 20 meters (between 2-8 electrodes) with a resistivity value of 4.06 Ωm to 89.4 Ωm. The limestone layer has good porosity with permeable properties allowing water to flow through the fissure or crack system and also become a water storage medium (epicarstic aquifer). Resitivity values >89.4 Ωm to 700 Ωm at depths of 2 meters-28 meters (electrode 5-14) show the presence of layers with geologic structures that are thought to be massive limestones with poor impermeable porosity. Higher resistivity values of about >1,958 Ωm at depths of 10 meters to 30 meters (between 7-13 electrodes) are thought to be layers of limestone that have wavelengths that have been dilated as a result of long-lasting dissolution processes until collapse, and formed a cave alley. The detected cave aisle is estimated to be a new section of the roof that is at a depth of 18 meters to 30 meters (between 9-13 electrodes).

Measurement of track 3 above the Saleh Cave with coordinates 119° 43'15.67"E - 5° 3'0.21"S and 119° 43'19.23 "E - 5° 2'58.05"S is at a surface level of about 140 asl - 162 asl with the West-West-East-Northeast direction. The result of measurement in track 3 (Figure 4) can be interpreted that there is accumulation of water in the limestone layer which has a geological structure (stack) from the surface to a depth of 25 meters, which is indicated by a resistivity value of 12.1 Ωm to 294 Ωm (between 5-14 electrodes). The limestone layer has porosity both with permeable properties, can serve as storage medium and epicarstic aquifer media through fissure or crack system. Resitivity values >294 Ωm to 1,447 Ωm on surface to a depth of 15 meters (between 2-7 electrodes) and a depth of 5 meters to 20 meters (between electrodes 6-12) indicate a layer with a geologic structure that is thought to be a massive limestone with bad porosity impermeable. Based on the results of the plot of the Saleh Cave and the 3 geo-electric track scheme, a resistivity value of about 3,211 Ωm at a depth of 10 meters (between 8-9 electrodes) is a proper Cave Saleh entry slot above the measuring site. Medium resitivity value >3211 Ωm at depth of 25 meter to 30 meter (electrode 10-13) allegedly is a layer of limestone forming cave passageway associated with Saleh Cave entry.

Measurement of track 4 above Cave Saleh with coordinates 119° 43'16" E - 5° 3'0.62" S and 119° 43'20.30" E - 5° 2'59.61" S is at a surface level of about 150 asl - 168 asl with the Southwest-East Northeast. The result of measurement on track 4 (Figure 5) can be interpreted that there is a resistivity value of 11.8 Ωm to 362 Ωm at depths of 10 meters to 15 meters (electrode 4-5) and a depth of 2 meters to 15 meters (between electrode 6 -14) is a layer of limestone that has a geological structure (stocky) that allows surface water to infiltrate (infiltration) through a fissure or crack system. This layer has good porosity with permeable properties that can serve as storage media and water infiltration (epicarstic aquifer). The resitivity value >362 Ωm to 2005 Ωm on the surface to a depth of 25 meters (between 2-13 electrodes) shows the presence of layers with geologic structures that are thought to be massive limestones with poor impermeable porosity. Medium higher resistivity value of >4718 Ωm at a depth of about 30 meters (between 5-7 electrodes) is thought to be a layer of limestone that has a cavity that has undergone widening as a result of a long dissolution process to collapse and form cave hallway.

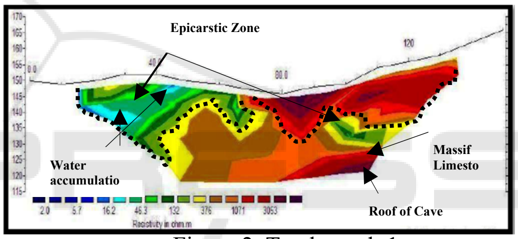

Figure 2. Track result 1

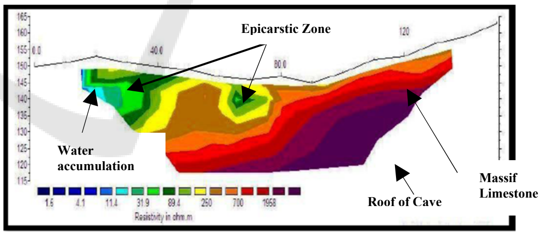

Figure 3. Track result 2

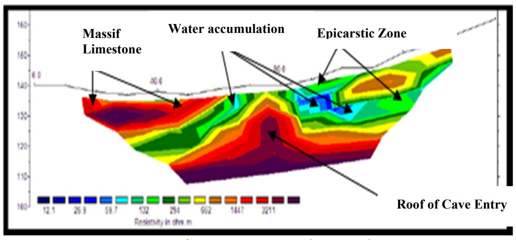

Figure 4. Track result 3

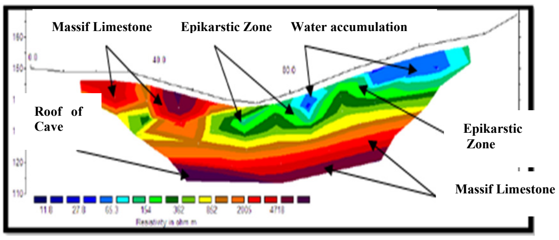

Figure 5. Track result 4

3.2 Fracture Patterns Measurement

The result of the solid measurement was obtained by the dominant direction of Northeast-Southwest about 65ºNE-245ºSW where the solid direction is relatively unidirectional with dry cave passages and North-West-trending alleys about 140ºSE -320ºNW where the solid direction is relatively unidirectional with underground river flow aisle (Figure 6). In addition to the solubility of rocks, thickness and degree of cohesiveness of rocks, the direction/pattern of general fracture is also one of the controlling factors for the formation of alleys and the availability of underground rivers at Saleh Cave. This fracture pattern system can be caused by tectonic influences which are then widened by the dissolution process due to climatic influences (rainfall). The relationship between the fracture pattern and the formation of cave and underground passageways is usually characterized by the dissolution of the upper part of the rock where the limestone surface is in an unsaturated state of CO^2 thus causing the flow of water to be dominated by vertical flow through rock crevices.

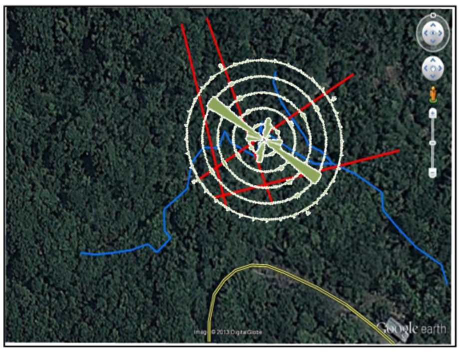

Figure 6. Fracture Patterns (Rosette plot)

4 CONCLUSION

Based on the results and discussions that have been described previously and refers to the objectives and problems of research, it can be concluded that the geomorphology at the study site included in the hills tower karst Maros. The phenomenon of karst morphology include (eksokarst): Tower karst, Sinkhole and Ponor/resurgence; and (endokarst): Stalactite, Stalagmite, Heliktit, Drypery, Flowstone, also the presence of underground river flow. The formation of karst morphology has an important role in the process of surface water drainage, storage and replenishment (storage and recharge) to infiltration through the fissure field to the subsurface which is ultimately channeled through the conduit as flow underground river. The geological structures have two general directions, the first relative to the northeast-southwest of about 65ºNE-245ºSW where the coarse direction is relatively unidirectional with the dry cave passage and the general direction of the second - necked Southeast-northwest direction around 140ºSE-320ºNW where the relative in the direction of the underground river basin. Interpretation of measurements of geoelectric method is known that the limestone layers below the surface of Saleh Cave have varying resistivity values ie low to high. Where a low resistivity value is interpreted as a limestone layer that has a geological (muscular) structure with porosity both permeable and high resistivity values are interpreted as a massive limestone coating with poor porosity is permeable.

It is suggested that there is further or continuous (comprehensive) research on hydrogeology in the Karst Maros Area in Pattunuangasue and in the surrounding karst areas, to reveal the availability of underground rivers as a potential groundwater. For the identification of underground systems and underground river networks in the karst area by geoelectric method should be measured (data retrieval) in sunny weather conditions and taking into account the distance of the path and electrode to obtain a more accurate subsurface description and can then be compiled with the results of the cave mapping.

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