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Cite as: AIP Conference Proceedings **2363**, 060002 (2021); https://doi.org/10.1063/5.0061476
Published Online: 23 November 2021

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Subsurface Identification as Preliminary Survey of Geo-Ecotourism Cave Development Using Electrical Tomography Resistivity (ERT) Method in Tritis Cave and Its Surroundings

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Abstract. Tritis Cave is a karst cave, located in the Gunungsewu Geopark area, Tanjungsari District, Gunungkidul Regency, DIY. This cave will be developed into a geo-ecotourism of the cave, which in practice requires an adequate supply of clean water. The availability of clean water in Tritis Cave and its surroundings is a major problem because it is influenced by the karst hydrogeological system which is characterized by the scarcity of surface water and the subsurface flow network. This makes it difficult to determine the location of groundwater sources. For this reason, it is necessary to investigate the subsurface using the dipole-dipole ERT method. ERT method acquisition with a = 20 m and n = 1 to 8 along 400 m has been carried out . The depth obtained from the 2D inversion of ERT data is 45 m. Interpretation is carried out on the results of 2D inversion of ERT data and is integrated with the results of surface geological mapping. The results obtained indicate the presence of a sedimentary basin at 100 m to 220 m, with a depth of 40 m. there is a crack in the bottom of the basin that connected to underground cave. The depth of the cave cannot be known from the results of the ERT which was carried out because it has a low penetration depth.

Keywords: ERT, Tritis Cave, Geo-Ecotourism

INTRODUCTION

Tanjungsari area is one of the district in Gunungkidul which is directly adjacent to the beach. This district has natural resources in the form of abundant tourist destinations. Noted there are several beaches in this district, including Krakal Beach, Sarangan Beach, Sepanjang Beach, Drini Beach, and Baron Beach. In addition to the beach, a tourist destination that attracts many tourists is the Cave tour. There are several caves that have been independently developed by the surrounding community as tourist destinations, namely Cabe Cave, Grengseng Cave, Tritis Cave, Pakubon Cave, and Bentar Cave. This research is the first step in assessing the carrying capacity of cave tourism development, especially clean water availability. The study focused on one of the caves in Tanjungsari district, Tritis Cave of Ngestirejo Sub-district (Figure 1).

The research location is in Ngestirejo Sub-district. There is a crack on the ground (Figure 2) in one area near the Tritis cave. according to information from the local community, these cracks are thought to be connected to subsurface caves that have dynamic water flow. This is because there are times when cracks give off steam. The research aims to determine the subsurface conditions of the area around the crack and provide a more detailed

3rd International Conference on Earth Science, Mineral, and Energy
AIP Conf. Proc. 2363, 060002-1–060002-8; https://doi.org/10.1063/5.0061476
Published by AIP Publishing. 978-0-7354-4154-5/$30.00

picture of the presence of cracks that emit water vapor in the study area. The results of the study are expected to provide information to the local community and related institutions to be followed up with drilling activities.

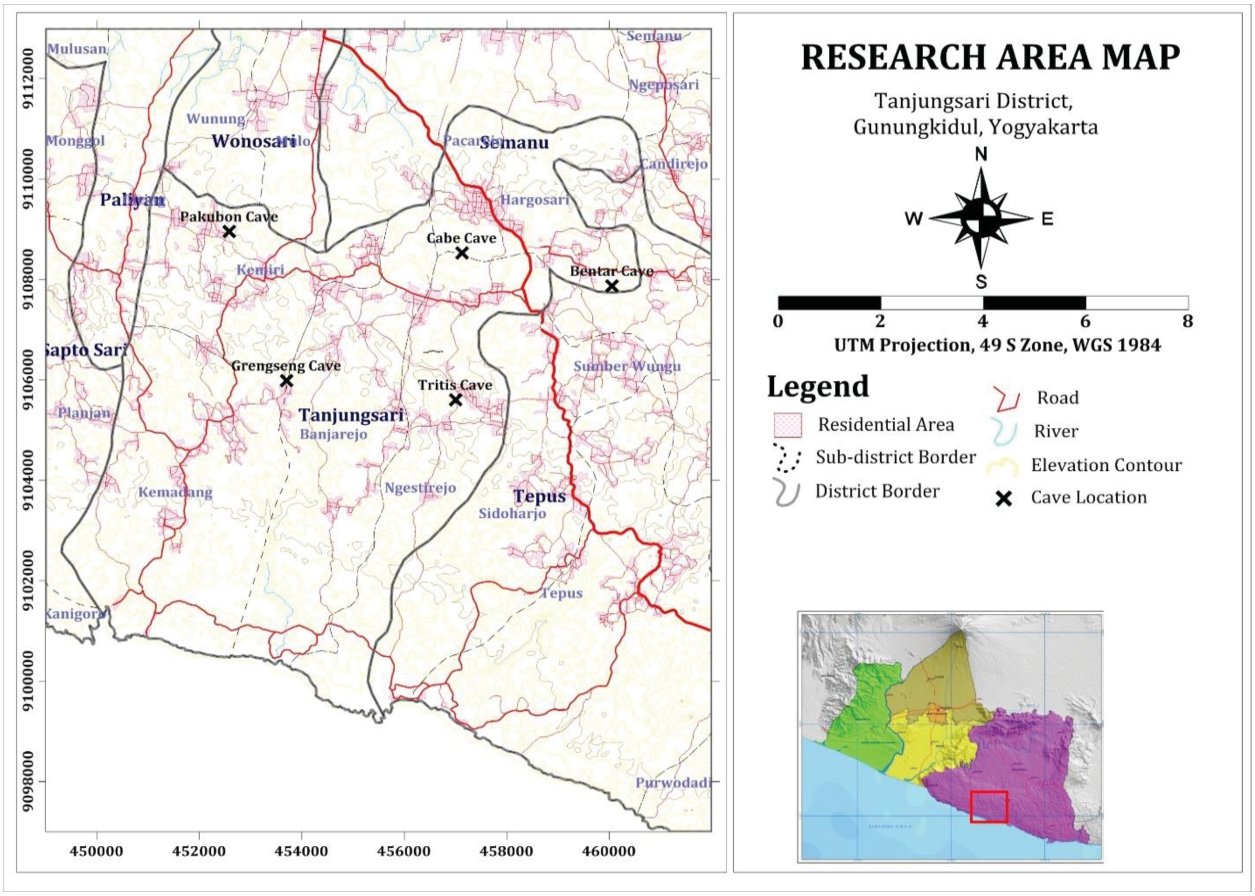

FIGURE 1. Research Area Map. The research located in around Tritis Cave, Ngestirejo Sub-District, Tanjungsari District, Gunungkidul, Yogyakarta

FIGURE 2. Location of the crack from local information. The area of the crack is on vast plain surrounded by cliff.

Geological Review of Gunungsewu Karst

The Gunungsewu area is physiographically located in the Southern Mountain Zone of Central Java - East Java[1]. The mountains are divided into 3 sub-zones by the Van Bemmelen sub-zone, namely the Baturagung - Panggung - Plopoh sub-zone in the north, Wonosari Plateau in the middle, and the Gunungsewu sub-zone in the south. The Baturagung sub-zone was built by a volcanic rock group called the Besole Group[2]. The Besole Group consists of the Kebo-Butak Formation, the Semilir Formation, and the Nglanggran Formation. The Wonosari Plato sub-zone is occupied by Kepat Formation carbonate rocks. Gunungsewu sub-zone is a karst hills with a relatively east-west axis, with a height difference of 10 m - 100 m, and hills with a diameter of 50 m - 300 m. The total area of the Gunungsewu sub-zone is approximately 1500 km^2, consisting of approximately 45,000 large and small hills[2].

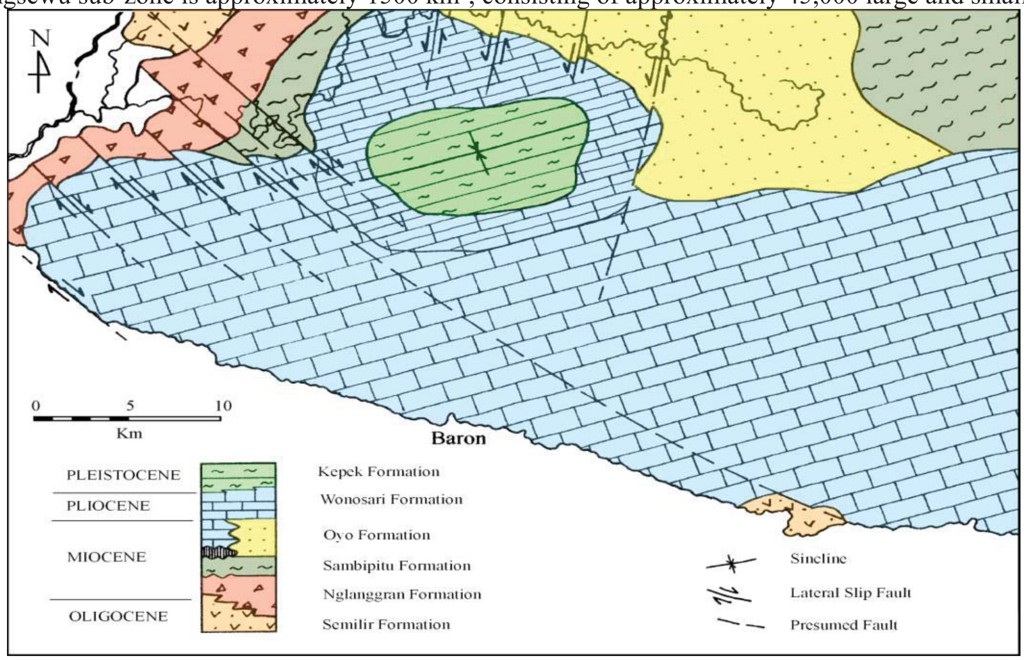

FIGURE 3. Geology Map of Research Area[2]

The main constituent limestone of Gunungsewu including the Wonosari Formation, can be divided into reef limestone consisting of boundstone and packstone, as well as layered bioclastic limestone in the form of wackestone, showing symptoms of carcification, and in some places showing calisification [2][3]. The Wonosari Formation is unconformably located on volcanic rocks consisting of tuffaceous sandstones, breccias, and lava Nglanggran Formation, which belongs to the Besole Group [2]. Besides the Nglanggran Formation as a base, in the eastern part of the Sambipitu Formation marlage, and in the western part there is a sandstone limestone of the Oyo Formation. Gunungsewu limestone is from middle Miocene to late Miocene[2].

The Wonosari plateau is geologically structured as a syncline, with an N75^{0}E - N255^{0}E axis orientation, and a slope of less than 10^0, while the Gunungsewu hills are generally homoclins tilted to the south, with the slope of the layer being between 5^0 to 15^0. Fault, muscular and fracture patterns in the Gunungsewu area indicate the general direction northwest-southeast and northeast-southwest[2].

Electrical Resistivity Tomography Method

ERT Method is included on Geoelectricity method as geophysical method that studies the nature of electric currents in the Earth and identify subsurface of the Earth. This method including the measurement of potential, current, and electromagnetic fields that occur, both naturally and due to injection of currents into the Earth. Therefore, the geoelectricity method has many kinds, including self-potential, telluric currents, magneto telluric, electromagnetic, induced polarization, and resistivity[4].

The method used is resistivity method. This method injects an electric current into the subsurface through two electrodes. The potential occurs from injection being measured by two electrodes as well (potential electrodes). The result of the measurement is potential differences (ΔV), current (I), and resistant (R). This result is calculated into resistivity by multiply resistant and factor configuration (K). Factor configuration is an electrode configuration which different in every measurement (Figure 4). Resistivity method itself can be separated into two kinds, vertical electrical sounding (VES) or 1D resistivity and Electrical Resistivity Tomography (ERT) or 2D electricity.

ERT measurement was using dipole-dipole configuration. The dipole-dipole electrode configuration has a configuration factor (K) $K = \pi an(n+1)(n+2)$ with a is electrode spacing and n is multiply factor. Measured resistivity data are plotted at points corresponding to the value of n (n = 1, 2, 3, 4, 5, 6,7,8) with the indicated depth is apparent depth level, so that the contour variation of the resistivity can be made laterally and vertically in the direction of pseudo depth.

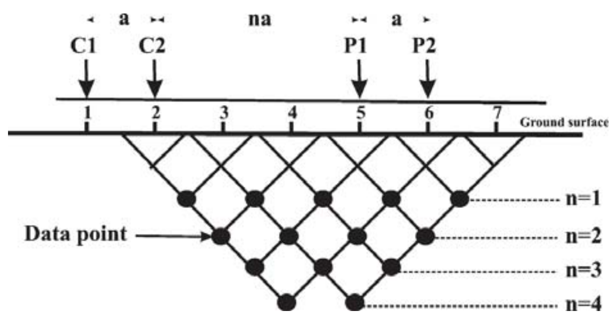

FIGURE 4. Dipole-dipole configuration and the data point get from the measurement.

METHOD

This research was conducted in 2 stages, surface geological mapping and Electric Resistivity Tomography (ERT) measurements. Field geological mapping is carried out around ERT line. Field Geological, apping uses rock sampling methods and outcrop descriptions. The ERT measurement was using Dipole-dipole ERT measurements with a = 20 and n 8 were carried out along the 400 m line. The line directed N 90 E (east-west). Field data obtained in the form of potential difference data (V), current (I), and resistance (R). The field data is calculated to get the apparent resistivity value (Rho App). This apparent resistivity value will be processed using Res2dInv software with the 2D Jacobian inversion method to get the true resistivity value (Rho). Interpretation is carried out on the cross section of the True resistivity value by interpreting the resistivity value into rock types and possible water content. Interpretation will be carried out in an integrated with analysis of rock outcrops from surface geology mapping.

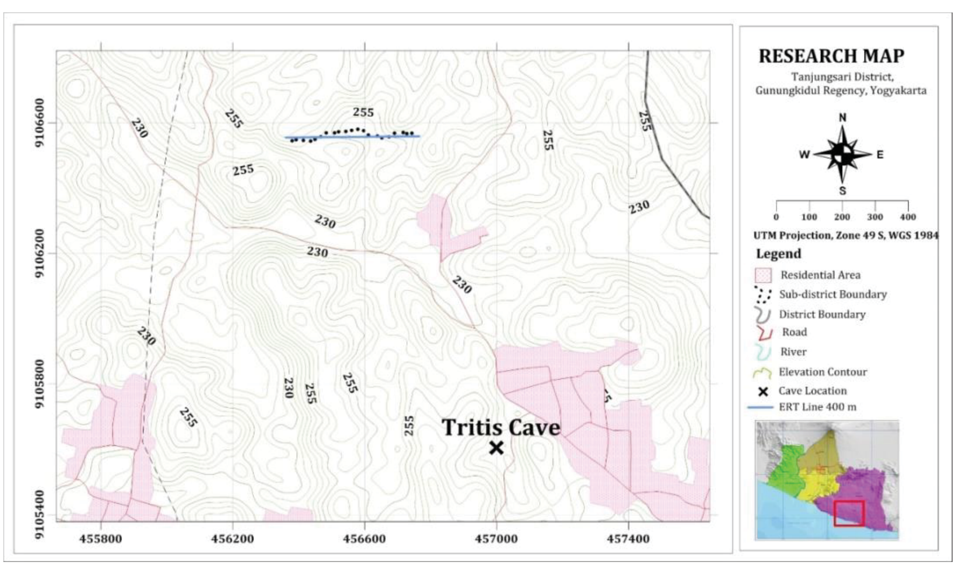

FIGURE 5. Location of ERT line show by blue line. the black dot is a location of the electrode of ERT measurement.

RESULT AND DISCUTION

Geological and Hydrogeological Condition

The research area is in Gunungsewu which is physiographically located in the Southern Mountains Zone of Central Java - East Java[1]. Gunungsewu is a relatively high-east porous karst hills, with a height difference of 10 m - 100 m, and hills with a diameter of 50 m - 300 m. The total area of Gunungsewu is approximately 1500 km2, consisting of approximately 45,000 large and small hills[2].

The research area is composed of the Wonosari Formation, consisting of reef limestone (boundstone) and and layered or bedded limestone in the form of packstone. Limestone in the study area has undergone karstivication (Figure 6). Wonosari formation limestones, geologically aged from Middle Miocene to late Miocene[2]. The distribution of the lithofacieses in the study area is shown in Figure 7.

Geological structure generally shows a homocline with a slope of less than 10^0, to the south, with the slope of the bedding is between 5^0 to 15^0. Fault, muscular and fracture patterns in the Gunungsewu area indicate the general direction northwest-southeast and northeast-southwest[2].

FIGURE 6. Reef limestone (boundstone) (left) and bedded limesttone (packstone) (right)

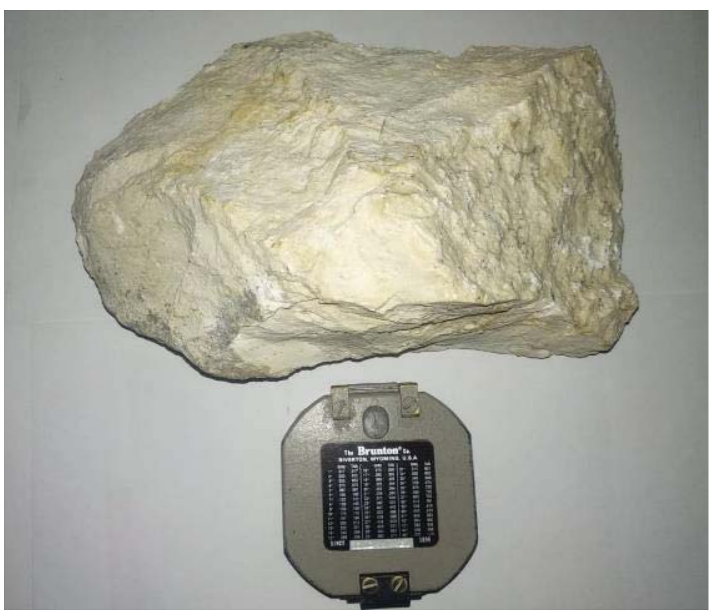

FIGURE 7. A hand speciment sample of pacstone taken from the study area.

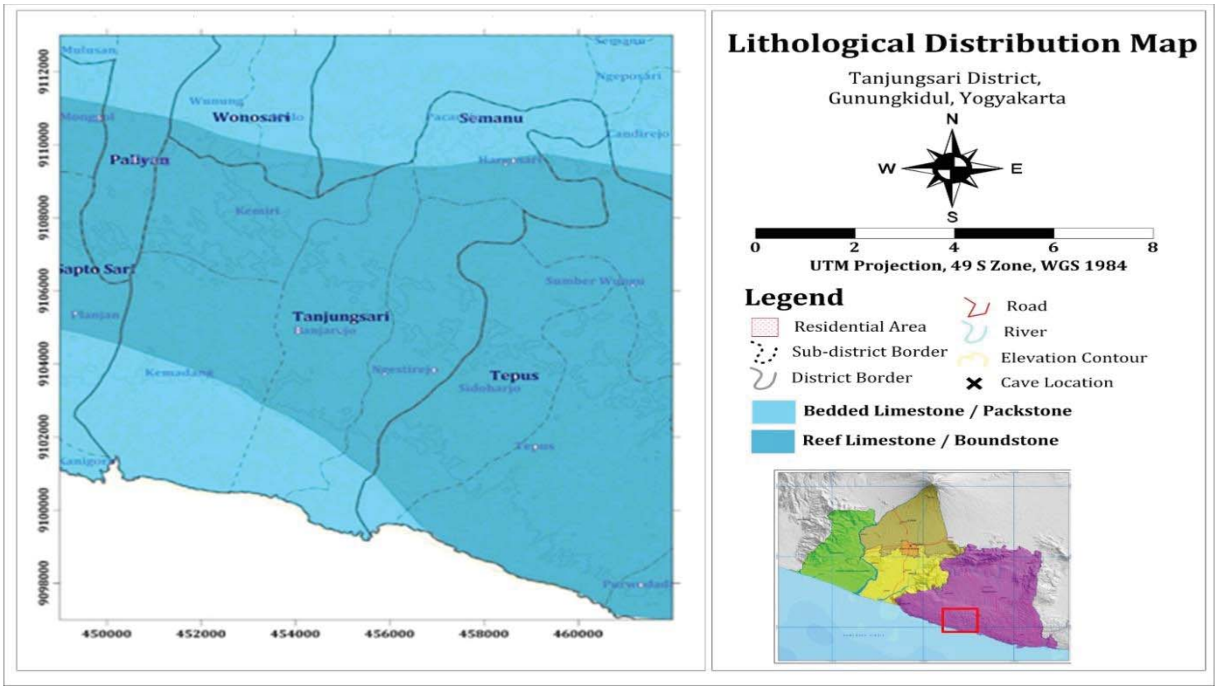

FIGURE 8. Lithological Distribution of Tanjungsari and Surrounding Aea

Hydrogeological research areas include the karst hydrogeological system, with limestone Wonosari Formation acting as an aquifer. In karst hydrogeological systems, groundwater flows occur in vessels, and large tunnels, or underground rivers. Its movement is influenced by gravity as an energy source, overflowing through karst springs called vocluse[2]. The subsurface water flow in the study area is included in the Bribin River Basin, which empties into the Baron[2][5]. The direction of the flow of the underground channel besides in accordance with the crack structure pattern, is also controlled by the slope direction of the limestone bed.

Cavity and Subsurface Waterflow

There are many karst caves in the research area, including Bentar Cave, Cabe Cave, Tritis Cave, Grengseng Cave, and Pakubon Cave. The caves have horizontal orientation and vertical. The caves in the karst area are generally associated with underground streams. Underground river flow patterns in the study area have a general direction relative northeast-southwest, and north-south. The main underground river flow in the study area, namely Kali Bribin which empties into the Indian Ocean in the Baron Bay[2]. Underground rivers in the Study Area are interpreted to form sub-rectangular-dendritic patterns, which are a combination of dendritic patterns with branching meetings that relatively form almost vertical angles[3]. With subsurface investigations, it is hoped that the existence of underground flow systems in the study area can be traced.

FIGURE 9. Cave Tritis and its surrounding situation

Sub-surface Identification

Geoelectric path is shown in the figure. The geoelectric cross section of the inversion results in the form of a cross section of subsurface resistivity distribution (Figure 10). The cross section of the resistivity value will be interpreted into the geological meaning of the type of rock. Rocks in the study area are dominated by the Wonosari formation which consist limestone. Limestone tends to have a high resistivity value. ERT line is heading east-west and has a length of 400 m.

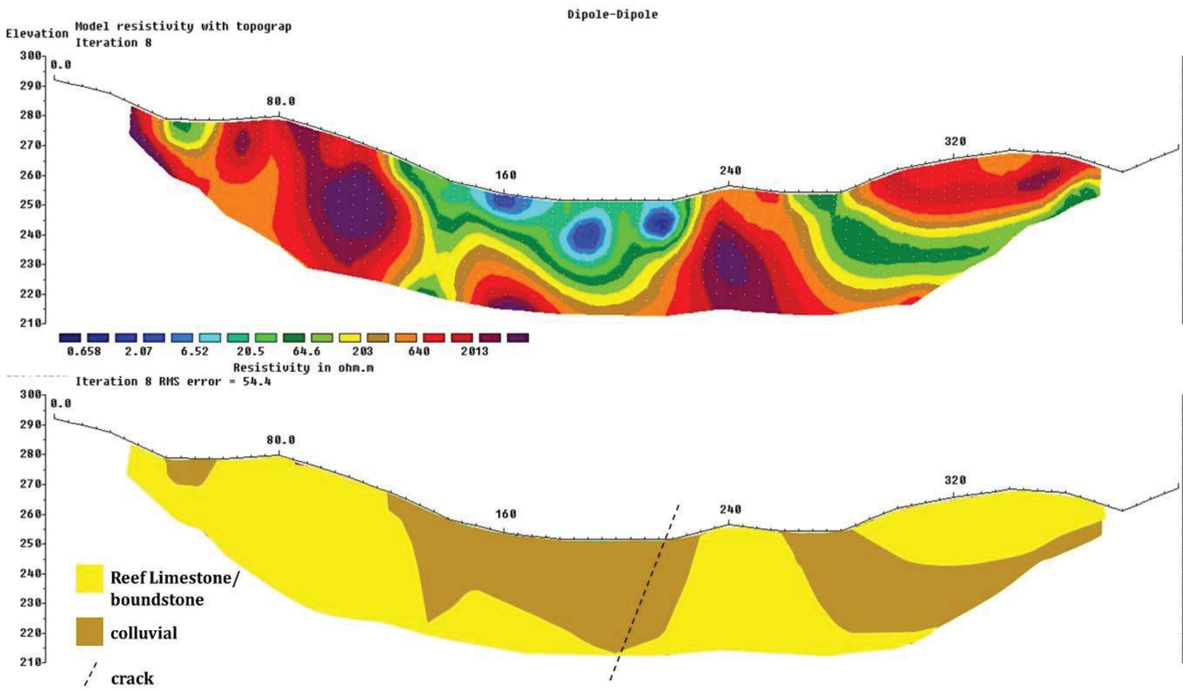

FIGURE 10. Result of ERT processing (up) and its interpretation (bellow)

The resistivity value on the ERT line is dominated by high resistivity (> 400 ohms) which is shown in orange to dark red / purple. This high resistivity value stretches from the beginning of the 0th meter line to the end of the 400th meter line. This high resistivity value is interpreted as limestone. Limestone in the ERT track has white characteristics, has a massive structure, an amorphous texture and with a mineral monomineralic carbonate ($CaCO3$) composition. Limestone in the study area is reef limestone or Boundstone.

The low resistivity value on the ERT line shown in blue to yellow color. This low resistivity shown in 100^{th} meter to 220^{th} meter, with the maximal depth is 40 m. This low resistivity value is interpreted as colluvium. Colluvium in research area has a characteristic such as reddish brown in color and composed of weathered sediment from the surrounding reef limestone cliffs.

Integrated Analysis

The analysis is carried out in an integrated manner from the results of geological mapping, ERT measurements, and information from the community. The cracks informed by the community are located at 200 meters on the ERT trajectory and are in colluvium rock units. Colluvium rocks have high porosity so that they pass water. From the ERT line results, the colonials rock unit is shaped like a basin with a limestone base. Limestone itself is an impermeable layer so it is impermeable to water. With the rock configuration as mention above, it allows water to be trapped in that place (basin). In fact, water does not collect in that place. This means that at the bottom of the basin there are cracks that allow the limestone to pass water. The crack is connected to the cave by a dynamic water flow. The depth of the cave cannot be known from the results of the ERT which was carried out because it has a low penetration depth.

CONCLUSIONS

1. Rocks in research area included into Reef Limestone (Boundstone).
2. There is a basin geometry of the colluvium from 100^{th} m to 220^{th} m with maximal depth 40 m.
3. There is a crack on the base of the basin that connected to cave with dynamic water flow on subsurface
4. The depth of the cave is unknown because of the low penetration depth of the method.
5. Other geophysical method are needed to get a better and deeper result.

ACKNOWLEDMENTS

This study was conducted by funding from the the Institute of Research and Community Service of Universitas Pembangunan Nasional Veteran Yogyakarta. In this occasion, the authors express a deep gratitude and high appreciation to the institution for the support in running this study.

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