RESEARCH ARTICLE   OPEN ACCESS

Subsurface Determination Of Cavities In Limestone Rock Area By Geoelectric Method In Tinapan Village Todanan Blora District Central Java Indonesia

Agus Santoso[1,2], Sismanto[3], Ari Setiawan[4], Subagyo Pramumijoyo[5]
Indriati Retno Palupi[2]

[1]*Ph.D. Student, Physics Department, GadjahMada University, Indonesia*
[2]*Geophysical Engineering, UPN "Veteran" University, Yogyakarta, Indonesia*
[3]*Physics Department, FMIPA GadjahMada University, Indonesia*
[4]*Physics Department, FMIPA GadjahMada University, Indonesia Geology engineering GadjahMada University, Indonesia*
Corresponding author: agussantoso1953@gmail.com

ABSTRACT
Two Dimensional of geoelectric method can be used to find out the conductive formation in the earth surface. The purpose of this research is to give the description about the geological subsurface formation, that the high resistivity value is indicate the potential area of cave and void in the limestone rocks.

The dipole dipolegeoelectric method is used in this research with the path of lines is 250 m with 10 m electrode spacing. The total lines is 7 and the azimuth is from east to west. Resistivity method is started with inject the electrical current into the earth by current electrode, then potential difference will arise and measured by potential electrode. Variation value of resistance for each layer rock can calculated by divided potential defference with current value.

The existence of the cavity is known by the resistivity value is more than 2500 ohm-m, while the cracks have a resistivity of 1500 to 2500 ohm-m.

Keywords: Geoelectric, resistivity, dipole-dipole, ohm-m, Cavities.

I. INTRODUCTION

Geoelectric method is a geophysical method that learn about the flow of electricity in the subsurface and detect it in the surface of the earth. In this method there are several parameters needed, they are potential measurements, currents and electromagnetic fields. There are many kinds of geoelectricmethod, they are self potential, telluric current, magneto-teluric, electromagnetic, induced polarization and resistivity.

In resistivity method, the current is injected into subsurface by the current electrode, then potential difference will arise and measured by potential electrode. The variation of spacing of the electrode can reduce the variation value of resistivity in each type of barrier layer below the measuring point.

II. BASIC THEORY

The basic principle of geoelectric method is Ohm's Law, where the resistance is obtained by measuring the potential difference and current in the subsurface :

$$R = \frac{V}{I} \qquad (1)$$

where R is the resistance (Ω), V is potential difference (Volt) and I is current (Ampere).

Because the medium in the subsurface is very heterogeneous, so there are variety in the resistance value. It can be measured by configuration factor (K) in addition to read potential and current value.

$$\rho = K\text{R} \qquad (2)$$

whereρ is apparent resistivity. The implementation of resistivity method is inject the current into subsurface to potential electrode. The space of current and potential electrode is varied to get the resistivity value at any distance between them. By plotting resistivity versus electrode space, it can obtained the curve that describe functional relationship.
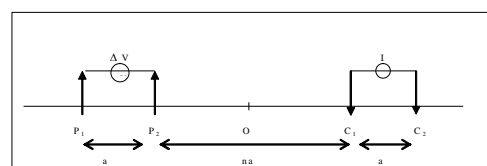
Figure 1. Geoelectric dipole-dipole arrangement

$C_1P_1 = a+na = a(n+1)$; $C_1P_2 = na$
$C_2P_1 = a+na+a = a(n+2)$
$C_2P_2 = na+a = a(n+1)$

$$k_d = 2\pi \left[\frac{1}{a(n+1)} - \frac{1}{a(n+2)} - \frac{1}{na} + \frac{1}{a(n+1)} \right]^{-1}$$

$$k_d = 2\pi \left[\frac{2}{a(n+1)} - \frac{1}{a(n+2)} - \frac{1}{na} \right]^{-1}$$

$$k_d = 2\pi \left[\frac{2(n)(n+2) - (n)(n+1) - (n+1)(n+2)}{a(n)(n+1)(n+2)} \right]^{-1}$$

$$k_d = -\pi a(n)(n+1)(n+2) \quad (3)$$

and apparent resistivity is :

$$\rho = -\pi a(n)(n+1)(n+2) \frac{\Delta V}{I} \qquad (4)$$

Geoelectric equipment
The equipment used in this research are :
1. ARESdigitalresistivity meter
2. Cable 4rollswith a length ofover 300m
3. Twocurrentelectrodesand2(two) potentialelectrode
4. 12 voltbatteriesandsomedry batterytype
5. GPS(Global PositioningSystem)
6. Compassgeologyandgeologicalhammer
7. Distance measuring tool andmultimeter
8. Topographic mapsscale 1: 5000.

III. DATA ACQUISITION

Dipole-dipole method is used to measure the rock resistivity. Principally, injecting electrical current into subsurface it will be obtained the potential difference in the medium that contains information about rock resistivity. Current usedis preferably direct current, but to avoid the influence of the capacitance and the polarization (the tendency of rock store charge) thenusedan alternating currentof low frequency.This currentflowsinto subsurface throughtwo electrodescalled thecontactelectrodecurrent,then resultingpotential distributionthrough thepotential electrode. By knowing the current flow that caused the great potential, it can be calculated the rock resistant in the subsurface, the distance of each current and potential electrode. Figure 1 describe about the configuration of current (C1 and C2) and potential (P1 and P2) electrode.

Tabel. Coordinates from : line 01 - 07

LINE	Azimuth	COORDINATES (UTM)	
		Starting Point	**Endpoint**
Line-01	N 90°E	x : 0522342 y : 9227950	x : 0522590 y : 9227950
Line-02	N 90°E	x : 0522338 y : 9227856	x : 0522590 y : 9227853
Line-03	N 90°E	x : 0522259 y : 9227775	x : 0522495 y : 9227772
Line-04	N 90°E	x : 0522243 y : 9227714	x : 0522481 y : 9227714
Line-05	N 0°E	x : 0522607 y : 9227969	x : 0522607 y : 9227727
Line-06	N 90°E	x : 0522342 y : 9227889	x : 0522590 y : 9227885
Line-07	N 90°E	x : 0522371 y : 9227820	x : 0522624 y : 9227821

IV. GENERAL GEOLOGY

1. Geomorphology
The geomorphology of the research area is include to the Rembang-Madura antiklinorium. This area can be divided into two kinds of morphological units, the first isdenudasional sloping hills and the second is steep hills structural units of anticline. In general, the research area is located in the hills with lush vegetation and the relief is not so high. The topography of this area is caused by the presence of either clastic limestone or limestone reef (reef) that located in thetop of the Bulu Formation. This area is a karst topography, there are many rivers and underground cavities in limestone reef.

2. Lithology (rock composition)
Based on it's regional stratigraphic, it is include four kinds of rock units, from the oldest to the youngest, the massive limestone unit, quartz sandstone unit, unit of organic lime stones and sandy limestones with sandstones glauconit inserts. From the regional of geology, the structure found in the area arelimestone stocky, regional fault structure that crosses the village Tinapan.Historical geological mapping of the area began in the Middle Miocene and Late Miocene ended, beginning with the deposition of limestone (Tawun Formation), followed by precipitation of quartz sandstone (Ngrayong Formation), organic lime stones (Bulu Formation), last sandy lime stones (Ledok Formation). While geological disasters that can happen is a mass movement in the form of creep and avalanches result from mining.

Lithology or rock-forming region is a limestone reef formations that are widespread throughout the Bulu Formation in Blora that located at the top of Pati carbonate composition, both clastic and non-clastic, the clastic rocks are well layered, with a thickness of 2 cm - 50 cm whereas a non clastic reef (coral reefs) with a circular shape - the circumference to form a morphological karst topography.The shape of this reef rock often forming cavity - small to large cavities that occur due to the leaching process due to groundwater or rainwater, these rocks have vug porosity, so the porosity is large enough. Besides this karst area formed the river - underground river which flows from north to south through the dams (small dams) were watery during the year.

V. DATA PROCESSING AND ANALYSIS

Based on the final result of this research that proseccing with Res2dinv software, it can be analized that the depth resistivitycorrelate with themagnitude ofthe real("True resistivity") of therockis dividedinto a number ofrock unitsas follows:

1.The cover layer(Soil).
Resistivityranging from 50 tomorethan 1000Ω meters, consisting ofloose sand, marl, silt, gravelandgravel.

2.UnitClay/Marl
Resistivityless than 10Ω meters,consisting ofmarl. Generally permeable

3.CalcareousSandUnit
Resistivity value is ranging from 10 to 100Ω meters, whichcomprisescalcareoussandstonelimestoneclasticsedimentsis generally aresultof eruption ofvolcanoes. Is agoodaquifer, highly permeable, andcontainsplenty ofwaterdischarge.

4.SandyLimestoneunit.
Resistivity value is ranging from 100 to 200Ω meters, consisting ofa mixture oflimestonewithorfine sandsizeupa bit rude.

5.LimestoneUnit
Resistivity value is ranging from200 to 500Ω meter, limestone with fragments oflimestonebouldersthe size of5-10 mm, matrixof sandandcarbonatecement.

6.Limestonecompactunit
Resistivity value is ranging from 500 to 1500Ω meters. Very compactsometimes withfragments oflimestoneboulders5-10 cm, matrixcalcareoussands, carbonatecement.

7. Cracks in limestone that have resistivity value that ranging grom 1500 to 2500 Ω meters
8. Cavitiesinlimestone.

Resisitivity value is larger than 2500 Ω meter, the greaterthevalueresistivitybethe greater thecavitiesinthe rock.

Figure 2. Line 01

Description: Line 01
There is no limestone cavities in rocks, here there are only rocks cracked, form a small cavity diameter less than 5 cm. Cracks located at 85-95 m, 130-135 m and 160-165 m.

Figure 3. Line 02

Description: Line 02
There is nolimestonecavitiesin rocks,herethere are onlyrocks crackedat50-60m, at the depth of3-16mand80-195mat the depth more than30 m. cracksformsmallcavitieswithdiameterless than 5cm.

Figure 4. Line 03

Description: Line 03
Cavity (> 2500 Ω meters) is located on 55-60 m, 82-85 m, 103-112 m and 125-128 m in diameter 3-10 m,at the depth of 2-6 m. At the bottom there are cavities in the limestone surrounded by sandy Bulu Formation limestone, forming limestone reefs.

Figure 5. Line 04

Description: Line 04
Cavity (> 2500 ohm-m) is located on 95-105 m with the depth of 15 m until more than 31 m. found on the surface152-154 m, at a depth of 1.5 - 4 m.At the bottom there are cavities in the limestone surrounded by sandy Limestone.

Figure 6. Line 05

Description: Line 05
There is nolimestonecavitiesin rocks,there are onlyrocks crackedforma smallcavitydiameterlessthan 6cm. at65-70mat the depth of9 mto 25m. On the surface.these cracksfound in55-57m, 67-74m, 81-83m, (at 155-167mdepth12m) and227-233mwith a depthup to 5m.

Figure 7. Line 06

Description: Line 06
There is nolimestonecavitiesin rocks,there are onlyrocks cracked forma smallcavitydiameterlessthan5 cm. crackslocated at86-92m, at the depthsmore than 8 m. this area isstable enoughbecause theyonly slightcrackswithoutcavity.

Figure 8. Line 07

Description: 07
Cavity (> 2500 Ω meters) arequite largeat97-150mwith the depth of29 muntil more than34 m. The top of cavity is found in142-145m, at a depth of5-7m and the bottom ofare includedrock sedimentarysandstone orclayofTawun Formation

Fig 9. Location Map ofcavitiesandcracks

VI. CONCLUSION

Interpretation of cavity

Line - 01: There is no existing cavity is formed crack rock crevices with a small hole diameter 2-5 cm. Cracks found in 85-95 m, 130-135 m and 160-165 m to more than 30 m.

Line - 02:. Cracks found on the meters to 50-60 m at the depth of 3-16 m, and, on the surface of the meter to 80-195 m, at a depth that more than 30 m. Basically rock strong enough.

Line - 03: no cavities - cavities in four places on the meters to 55-60 m, 82-85 m, 103-112 m, and 125-128 m, a depth of 2-6 m, to form limestone reefs / coral reefs.

Line - 04: no cavities in two places on the 95-105 m, which is enough to more than 30 m somewhat enlarged. On the surface there is a small cavity at 152-154 m with a depth of 2-4 m

Line - 05:. No existing cavity is formed cracks rock crevices with a small hole diameter 2-5 cm. the meters to 65-70 m at a depth of 9 m and, on the surface at the meters to 57-67 m, at a depth of 5 m. There are also cracks in the 155-165 m at the depth of 15 m.

Line - 06: forming little cracks with small hole diameter 2-5 cm. the meters to 86-92 m at depths more than 8 m and, basically strong and stable rock, the rock is not hollow and little cracks only.

Line - 07:. There cavity - the cavity in two places at meters to 97-150 m, which is quite large and in up to more than 30 m somewhat enlarged. On the surface there is a small cavity at 142-145 m with a depth of 5-7 m. In this trajectory limestone reefs in the middle of the track are covered by limestone lined the edge of a path.