RESISTANCE ANALYSIS OF ROCK AND MINERAL UNDER SURFACE BY USING GEOELECTRIC METHOD IN THE VILLAGE OF DOLOK MARAWA SIMALUNGUN DISTRIC

by Abd Hakim Marausaha Simanjuntak

PS-015

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ABSTRACT

We have conducted the research to analyze the resistivity of rocks and minerals under the surface in the area Dolok Marawa Simalungun District. This research aims to determine the types of rocks and minerals under the surface based on the value of resistivity in the village of Dolok Marawa Simalungun Distrik. Determining the type of rocks and minerals under the surface by using geoelectric method were performed using an ARES geoelectric (Automatic Resistivity System) Schulumberger configuration three path tand length of path is 155 meter. Resistivity value of rocks and minerals below the surface is processed by using software Res2Dinv to obtain two dimensional cross-section. Research results obtained show that the geoelectric resistivity varies in the range of 0.327 Ωm which is groundwater up to 2200 Ωm which is a limestone. Type of Under surface mineral Dolok Marawa Village was the most dominating ground water with a resistivity value of less than 10 Ωm and predicted that in this research area is still ongoing volcanic activity. The rocks that make up the area is still ongoing volcanic activity. The rocks that make up the area are thought to be clay, silt, andesite, alluvium, sandstone and limestone.

***Keyword :** Geoelectric Method, Rock Resistivity*

INTRODUCTION

Indonesia has the abundant natural outcomes underthe earth's surface in the form of gold, silver, copper and rock. Rocks is the main constituent natural items and the earth collection of one or more minerals, organic matter and volcanic materials are much needed and used for human life. However the visible outcomes the abundant natural under the earth's surface cannot be observed directly. Information about the earth's subsurface conditions should be known as the type of rocks and minerals. Types of rocks and minerals can be seen by resistance type.

Marawa Dolok Village is one of the villages in the district Silau Kahean Simalungun of North Sumatra Province. Marawa village is a hilly area that has a geographical location 3°10'41" North Latitude and 98°51'53" East Longitude. In District Silau Kahean nature reserves that are high monarch nature reserve is a protected forest. Nature reserve area Dolok High King has a unique natural phenomenon that has hot water. Dolok Marawa a geothermal area that has

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spread widely enough hot water. According Henry and friend, (2010) Thehot springs are located in the area Dolok Marawa fault lies in the southeast sea with temperatures of 36.4 °C-66 °C. Based on the geological map of that type of rock found in the area Dolok Marawa is andesite, dacite, basal and piroklasita.

Every rock and mineral has a resistivity that is influenced by the composition of the constituent. Variation of earth resistivity material is shown in Table1.

Table 1. Variations of earth material type value detainees.

Type of Materials	Resistivity (Ωm)
Clay/Lempung	1-100
Silt/Lanau	10-200
Marls/Batu Lumpur	3-70
Alluvium (Aluvium)	10-800
Kuarsa	$10\text{-}2x10^8$
Sandstone/Batu Pasir	50-500
Limestone/Batu kapur	$50\text{-}4x10^2$
Slate	$6x10^2\text{-}4x10^7$
Gravel (Kerikil)	100-600
Masble	$10^2\text{-}2.5x10^8$
Lava	$100\text{-}5x10^4$
Air tanah	0,5-300
Air laut	0,2
Breksi	75-200
Andesit	100-200
Tufa vulkanik	20-100
Konglomerat	$2x10^3\text{-}10^4$
Dry Gravel (KerikilKering)	600-10000

Source :(Telford et al, 1982)

To determine theresistivityof rocks and mineralscontained in thesubsurfaceand measuringmethods are neededthatcan measurephysicalparametersassociatedwiththe presenceof rocks and mineralsunder the surface. In the estimation of the state ofthe earth'ssubsurfacegeophysicalneed a method. One of thegeophysicalmethodsthat can be usedto determine theresistivityof rocks and mineralsare thegeoelectricresistivitymethod. Geolistrikresistivitymethodis a method ofstudying the natureGeolistriktheelectricalresistivityofthe rock layersin the earthto a depth of300m. Resistivity valuelayer of rockunderthe soil surfaceby means ofan electric currentDC(Direct Current) into the ground. The goal isto estimatethe electrical properties ofthe mediumorthe rock formationsbelow the surface, especially its abilityto conductelectricityorinhibitconductivityorresistivity).

Geoelectric resistivity method is one of the most common methods used in geoelectric exploration. This methodis usedto describe thestate of thesubsurfaceby studying theelectrical resistivityofthe rock layersin the earth, where the earthis composed ofrocksthathaveelectrical conductivityvaries. Inthis method, an electric currentis passedinto thelayers of the earththrough twopotentialelectrodes. By knowing thecurrentpricecanbe determined, the potentialvalue ofthe resistivity. According to Loke (1995), the data obtainedin the fieldis the datavalue ofthe resistivity ofthe subsurface, Based on data frominversioncalculationis thenperformedin order to obtainthe variationof resistivityofacoating systemthat isassociatedwith thesoilunder the surface geological structures (Santoso, 2002).

Based on theresistivitystructure ofthe subsurfaceof the earth, we can know the typeof material in the layer. Geoelectric method can also be used on such hydrogeological investigation and determination ofaquifercontamination, mineralinvestigations, archaeological survey and detection Hot rocks on geothermal investigation (Reynolds, 1997). Geoelectricresistivitymethodis appliedby usingan artificialcurrent sourceinjectedinto the soilthroughthe ends of theelectrodes(Telford etal., 1990). Geoelectricresistivitymethodproduces a variety ofchanges inthe value ofresistivity(resistivity distribution), both horizontallyand vertically.Geoelectricresistivitymethod iseffectivewhen usedforshallowexploratorynature. Therefore,this methodis seldom used foroil exploration, but morewidely used inthe field of geologysuch asthe determination ofthe depth ofthe bedrock, the melting waterreservoir, alsoingeothermal explorationandenvironmentalgeophysics(Team AssistantGeophysics, 2004). Basedgeoelectricmeasurement techniques, there are twomeasurement techniquesis the methodof geoelectricresistivitymapping andsounding(drilling). Geoelectricresistivity mappingmethodis a methodthat aimsto study the sub surface resistivity variations in horisontal. Oleh Therefore, the method used electrodesspaceda fixeddistancetoall points ofthe soundings(very point) on the surfacegeoelectricresistivitysoundingbumi. Metodeaims tostudied thevariationof resistivityof rockunderthe earth's surfacevertically. Inthis method, measurementsat a pointsoundingsdone byvarying theelectrode spacing.Electrodedistancechangesmadefromthe smallelectrode spacinggraduallyenlarges. Electrode spacingisproportional to thedepth ofthe rocklayeris detected. The greater thedistance ofthe electrodes, the deeper layers of rockwere detected. In thefield measurements, the electrode spacingenlargementcan be doneifusing ageoelectricadequate. In this case,the toolshould be able toproducelarge currentsor currentthat is sensitive enoughto detectsmallpotential differencewithin the earth. Therefore, geoelectricgoodtoolis a tool thatcangeneratean electric currentis quite largeandhas ahigh sensitivity.

If thedistancebetween thetwoelectrodesis not located ina remote placeinfinitelikein Figure 1, the potential to be around the surface will be affected by the two electrodes.

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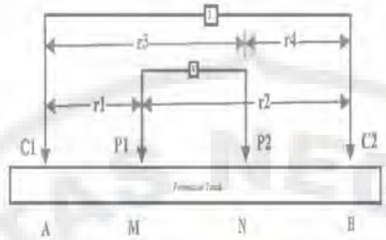

Figure1. Potential generated by two current electrodes on the surface of the earth (Telford et al, 1990)

Since the potential is a scalar quantity, so it applies the principle of superposition. So that the potential at a point can be obtained by summing the potential that comes from each electrode current to that point based on Figure 1.

$$\rho = K\frac{\Delta V}{I} (1)$$

with

$$K = 2\pi\left[\left(\frac{1}{AM}-\frac{1}{BM}\right)-\left(\frac{1}{AN}-\frac{1}{BN}\right)\right]^{-1} \quad (2)$$

Apparentresistivity valuedependson the geometryof theelectrode arrangementis used,which isdefinedbythe factor of geometryK, There are threemain types ofconfigurationseltroda(Reynoldds, 1997), and among theseinitiatorsisnamed afterFrankWennerandConradSchlumberger, while thethirdmethodisdipole-dipole.

Each methodandmannerelectrode configurationhas advantages, disadvantagesanda particularsensitivity. Factors ofeffectiveness andavailabilityspace forexplorationinto consideration inelection of typeconfiguration.These factorsintoconsiderationin the selectionandconfiguration typeinto considerationto layspanand effectivenessofeach method. Other factors are alsoimportanttonote is thelateralsensitivityof theirregularitiesandthe depth of penetration.

In Schulumberger configuration, has a current electrode spacing greater than the potential electrodes. Potential electrodes are placed in the middle ofthe electrode current. Current electrodes movable a distance corresponding to the result of the potential difference was considered small. Based on the measured physical quantities, Schlumberger electrode arrangement aims to determine the electrical potential gradient.

METHODS

The experiment was conducted in the village of Marawa Dolok district Silau Kahean Simelungun district, geographically in a 3°10'41'' North Latitude and 98°51'53'' East Longitude. In this study, the observed parameters are current (I), voltage(V), and the distance of the electrode, while the parameters are calculated apparent resistivity values (ρs). The stages are carried out in this study areas follows:

1. Preparation Phase

In the preparation phasethe researchersconducted a studyof literatureonthe theories thatsupport this research, a surveytocapture locationdata to determine thetrajectorymeasurements to beperformed. Moreover, at this stage theresearchers alsopreparethe tools and materialsneeded inthe study.

2. Planning Phase

Theauthorsdesigned thestagemeasurements to beperformedin the field. This studyselectedthreemeasurementtrajectoryasthe trajectorymeasurementarea. This determination is madeby considering theconditions ofthe study area.

3. Implementation Phase

Measurements using geoelectric method performed by injectingcurrent through currentelktroda. Arrangement of electrodes arranged according Schumberger configuration manually through ARES (Automatic Resistivity Meter). Path lengthmeasurementin this study is155metersto the distancebetweenthe electrodesis 5meters.

4. Data Processingand Data Analysis

Theauthors conducted aphaseof processingthe data obtainedusing statistical softwarev3.57Res2Dinvanddata analysis, with thehelp ofsurfer8in order to obtaina conclusion.

RESULTS

FirstPath

About 20yardsfromthe bluecraterat position 97^0 38' 6,65"EastLongitudeuntil 4 ^{0}18' 34,82" NorthLongitude and 97^0 38' 2,43" EastLongitude, at an altitude 435 meter from the surface of the sea ,with a path length is 155 meter (the distance between the electrodes5meters), as far north pole 470 from the line, has a value of pseudo resisitivitas (ρ_s) that

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variesthe0327Ωmto1053Ωm.Cross section images of subsurface resistivity contour first path can be seeninFigure2.

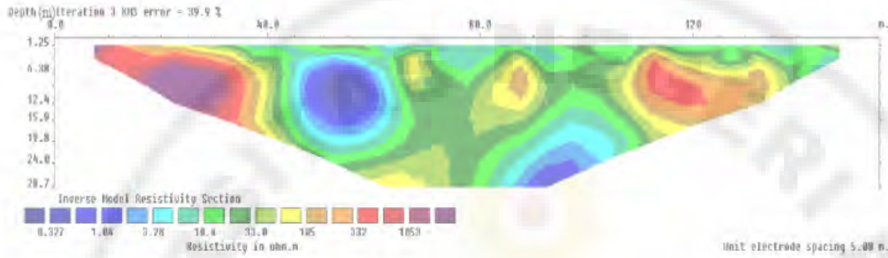

Figure 2. Cross-section contours of resistivity Path1

Basedoncross-sectionalresistivitycontourfirstpath(Figure 2) it can be seenthat thecross section ofthe subsurfacefirstpathcomposedof several typesof mineralswith aresistivity valuerespectively0.327Ωm, 1,04 Ωm, 3,28 Ωm, 10,4 Ωm, 33 Ωm, 105 Ωm, 332 Ωm, and 1053 Ωm are visualized by different color on each resistivity thus estimated as in Table 2.

Table2. Tabel type resistivity contour mineral based first path.

NO	Resistivity (Ωm)	Color	Depth (m)	Type of minerals
1	0,327		6,38-28,7	Ground Water
2	1,04		6,0-28,7	Ground Water
3	3,28		1,25-28,7	Ground Water
4	10,4		1,25-28,7	Lempung
5	33		1,25-28,7	Lanau
6	105		1,25-28,7	Andesit
7	332		1,25-16	Sandstone
8	1053		1,25-14	Limestone/Gamping

Second Path

About 15meters awayfrom the heat sourceat the position4 ^{0}18' 30,82" NorthLatitude and 97 ^{0}38' 5,49" EastLatitude until 4 ^{0} 18' 34,62" NorthLatitudeand 97 ^{0}38' 2,30" EastLatitude, At an altitude of428meters above sea level, with apath length155 meter (the distance between theelectrodes5meters), as farnorth pole700from the line, has a value ofpseudoresisitivitas(ρ_s) that variesthe1.89Ωmto1988Ωm. Cross-sectionimagesof subsurfaceresistivitycontours ofthe secondpathcan beseen in Figure 3.

Based oncross-sectionalcontour oftheresistivityof the path(Figure 3) it can be seenthat thecross section ofthe subsurfacethirdpathis composed ofseveraltypes of rockswithresistivityvaluesrespectively1.09Ωm, 5,11 Ωm, 13,8 Ωm, 37,3 Ωm, 101 Ωm, 272 Ωm, 736 Ωm and 1988 Ωm are visualizedbydifferent colorson eachresistivitythusestimatedas shown in Table3

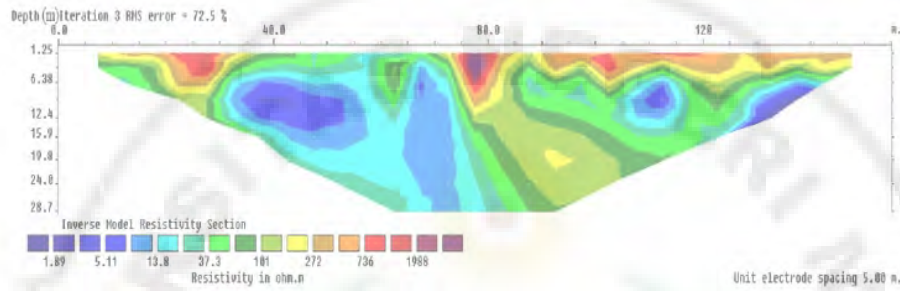

Figure 3. Cross-section contours of resistivity Path 2

Table 3. Mineral based.table type resistivity contours second path

No	Resistivity (Ωm)	Color	Depth (m)	Type of minerals
1	1,09		6,36-15,9	Ground Water
2	5,11		2,56-28,7	Ground Water
3	13,8		1,25-28,7	Lempung
4	37,3		1,25-28,7	Lanau
5	101		1,25-28,7	Andesit
6	272		1,25-28,7	Sandstone
7	736		1,25-16	Aluvium
8	1988		1,25-6,38	Limestone/Gamping

Third Path

About 15meters awayfrom the heat sourceat position4018'31.14 "Nand 97038' 3.93" E to 4018'35.64 "NorthLatitudeand 97038' 5.84" EastLatitude, at an altitude of431meters above sea level, with apath length of155meters(the distance between the electrodes5meters), as farnorth pole700ofthe line, has a value ofpseudoresisitivitas(ρ_s) that variesthe3.60Ωm to thecross-sectioncontourreisistivitas Ωm. Gambar 2200 under the track surface can be seen in Figure 4.

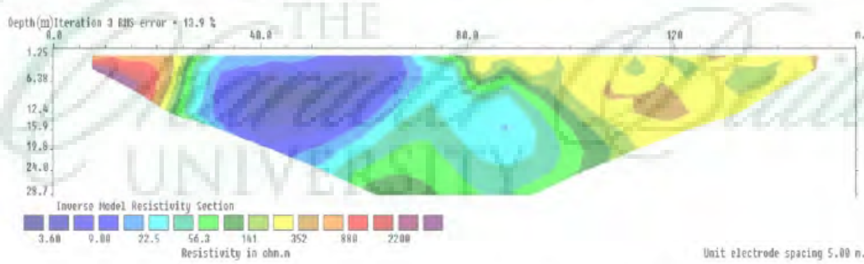

Figure 4. Cross-section contours of resistivity Path3.

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Basedoncross-sectionalresistivitycontourthirdpath(Figure 4) it can be seenthat thecross section ofthe subsurfacetersusunthirdpathof severaltypes of rockswith aresistivity valueof 3.60Ωmrespectively, 9.00Ωm, Ωm25.5, 56.3Ωm,141Ωm, Ωm352, 880Ωmand2200Ωmare visualizedbydifferent colorson eachprisonertypesthat can beestimatedas shown intable4. Thefollowing

Table 4. Type of mineral based on third path contour.

No	Resistivity (Ωm)	Color	Depth (m)	Type of minerals
1	3,60		3,76-15	Ground Water
2	9,00		1,25-22	Ground Water
3	25,5		1,25-24	Lempung
4	56,3		1,25-28,7	Lanau
5	141		1,25-28,7	Andesit
6	352		1,25-28,7	Sandstone
7	880		1,25-19,8	Limestone/Gamping
8	2200		3,8-9,3	Limestone/ Gamping

DISCUSSION

From the two-dimensional inversion results obtainedusingRes2Dinvverticalcross-sectionin the form ofsubsurfaceresistivityvalueberasoisasiwith the imagecolorswill vary dependingthe valueindicatedresisitivitasin Figure1, Figure 2 and Figure 3. In Figure2Dinversionresultsshowa resistivityvalueof eachrockas seen fromthe colorimage ofcross section ofthe structurethe surface layer. The distribution ofsubsurfaceresistivityvaluesindicated bythe colorimageonthe results ofdata processing.Todetermine the types oflayersof rocks and mineralsbelowthesurface ofis usedto matchreference tableTelfordresistivity valuein the canwithrocks andminerals areas shownin Table 2, Table 3 and Table 4.

Based on Table 2, Table 3 and Table 4 that the resistivity distribution depth of 1.25 m to 28.7 m depth in the field area of about 155 m2 with three path consisting of 8 layers with resistivity values ranging from 0.327-2200 Ωmas seen in Table 5.

Table 5. Resistivity and Type of minerals the third path

First Path			Second Path			Third Path		
Resistivity (Ωm)	Type of Minerals	Depth (m)	Resistivity (Ωm)	Type of Minerals	Depth (m)	Resisitivity (Ωm)	Type of Minerals	Depth (m)
0,327	Ground water	6,38-28,7	1,09	Ground water	6,36-15,9	3,60	Ground water	3,76-15
1,04	Ground water	6,0-28,7	5,11	Ground Water	2,56-28,7	9,00	Ground Water	1,25-22
3,28	Ground water	1,25-28,7	13,8	Lempung	1,25-28,7	25,5	Lempung	1,25-24
10,4	Lempung	1,25-28,7	37,3	Lanau	1,25-28,7	56,3	Lanau	1,25-28,7
33	Lanau	1,25-28,7	101	Andesit	1,25-28,7	141	Andesit	1,25-28,7
105	Andesit	1,25-28,7	272	Sandstone	1,25-28,7	352	Sandstone	1,25-28,7
332	Sandstone	1,25-16	736	Aluvium	1,25-16	880	Gamping	1,25-19,8

1053	Batu stone	1,25-14	1988	Gampingstone	1,25-6,38	2200	Gampinstone	3,8-9,3

The results of the retrieval and processing of data from the first to the third path can be found rock layers making up. Prediction of rock types in the area supported by measurements of resistivity values obtained results and geological conditions of the area. The data obtained will be analyzed using surfer 8 and will be taken by the depth to overall path measurements. Threemeasurement pointswhichcandescribe thepathrock typesinthe areaanddescribethe distribution of rockperdepth. The depththat will be displayedis thedepth5meters, 10 meters, 15 meters, 20meters, 25meters and28 metersfrom theresistivity(Ωm) whichwill be discussedin Figure 6.

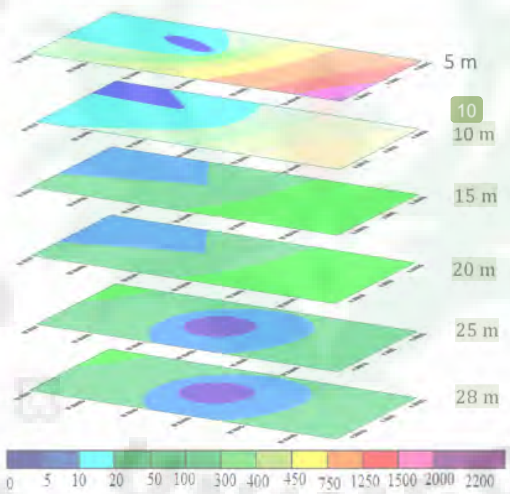

Figure 5. Results of contour depth of 5 meters to 28 meters.

Analysis of rocks and minerals below the surface of that are at depths of up to28.7metersaround thepathshownin Figure5. Themeasurementsthat showedthatmost of thetypesof mineralsfound inthe groundwaterbelow the surfaceisthe pick theresistivityvalues between0,327-10Ωm, wherevery lowresistivityvaluescan be foundto a depth of28.7meters. According Widartoin FaridM (2008), highly conductive zones will only be formed when there is afluid, especiallywater, in conditions ofhigh heat. AccordingLenat(1999) further increase the temperature of the lower resistivity ofthe rock. The presence ofhot waterand highporosityandhighpermeabilityrockswouldconstitutesome of the requirementsfor the lowvalue ofresistivityof rocks. As a sourceof heatforthe highly conductivezoneis predictedthat thevolcanicactivityis still ongoingunderpenelitian.Hasilareais supportedbythe presence ofa heat sourcein the form ofa craterappearedbluearoundthe sites.

CONCLUSION

From the results of the processing, analysis, and interpretation of the data in the study can be concluded as follows:

1. Based on the results obtained using geoelectric method resisitivitas varying prices ranging between 2200 Ωm to 0,327Ωm.
   - The firstPath, has a valuebetween0.327resisitivitasΩmto1053Ωm.
   - The secondPath, has a valuebetween1.89resisitivitasΩmto1988Ωm.
   - The thirdPath, has a valuebetween3.60resisitivitasΩmto2200Ωm.
2. The type of subsurface mineral marawa Dolok village was the most dominatinggroundwaterwithvalueslessresistivitydai10Ωmandpredictedthat inthisresearch areais still ongoingvolcanicactivity.
3. Based on the valuesobtainedresistivityrock typesfound inthe studyareaisclay, silt, andesite, alluvium, sandstoneand limestone.

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