Jurnal Geologi dan Sumberdaya Mineral Vol. 22 No. 2 Mei 2021 hal 89-98

Geo-Resources

Jurnal Geologi dan Sumberdaya Mineral
Journal of Geology and Mineral Resources
Center for Geological Survey, Geological Agency, Ministry of Energy and Mineral Resources
Journal homepage: http://jgsm.geologi.esdm.go.id
ISSN 0853 - 9634, e-ISSN 2549 - 4759

Interpretation of 1D-Resistivity Data to Describe the Aquifer Model in the Serayu Watershed Area of Somagede Village, Somagede District, Banyumas Regency

Interpretasi Data Resistivitas-1D untuk Menggambarkan Model Akuifer di Daerah Aliran Sungai Serayu Desa Somagede, Kecamatan Somagede, Kabupaten Banyumas

Sehah, Hartono, Zaroh Irayani, Urip Nurwijayanto Prabowo, Fajar Apriyanto, Desty Maharani Sagita, Dwi Purnamasari

Department of Physics, Jenderal Soedirman University,
Street of Dr. Suparno No.61 Karangwangkal Purwokerto Central Java, Indonesia,
e-mail: sehah@unsoed.ac.id

Naskah diterima : 31 Januari 2021, Revisi terakhir : 31 Mei 2021 Disetujui : 03 Juni 2021, Online : 03 Juni 2021
DOI: http://dx.doi.org/10.33332/jgsm.geologi.22.2.89-98p

Abstract-Acquisition of resistivity data using the Schlumberger configuration has been carried out in the Serayu watershed area of Somagede Village, Somagede District, Banyumas Regency. The purpose of this research was to describe a groundwater aquifer model based on the interpretation of 1D-resistivity data. The research results are resistivity logs of subsurface rock distributed over seven sounding points with resistivity values ?ranging from 2.24-192.78 m. The sounding points are located at positions of 7°31'28.55? and 109°19'8.65? (Sch-1) to 7°31'18.79? and 109°19'21.45? (Sch-7). The interpretation of the resistivity logs has resulted in a lithology log at each sounding point. Based on the interpretation, the lithology of the research area is composed of topsoil (42.85-85.13 m), sandy clay which partly slightly wet (7.08-17.18m), sandy clay inserted with gravel (22.44-31.70 m), sand, gravel, and pebble, with various consolidated (22.16-192.78m), sand inserted by gravel (6.77m), alternating sandstone and claystone, some of which are alternated with marl and tuff (8.71-21.99m), and sandstones with various porosity (3.25-8.76m). Shallow aquifers are interpreted to exist in sand inserted by gravel layer (13.23-27.67 m) at the sounding point of Sch-2 where the potential is quite good. While deep aquifers are estimated to be present in the sandstone layer with various porosity (> 46.67 m) at all sounding points with very good potential.

Keywords: 1D-resistivity, Serayu watershed, resistivity log, aquifer, Somagede Village.

***Abstrak**-Akuisisi data resistivitas menggunakan konfigurasi Schlumberger telah dilakukan di kawasan Daerah Aliran Sungai (DAS) Serayu Desa Somagede, Kecamatan Somagede, Kabupaten Banyumas. Tujuan penelitian ini adalah untuk menggambarkan model akuifer air tanah berdasarkan hasil interpretasi data resistivitas 1D. Hasil penelitian yang diperoleh adalah log resistivitas batuan yang tersebar di tujuh titik sounding dengan nilai resistivitas berkisar 2,24-192.78 m. Titik-titik sounding terletak pada posisi geografis 7°31'28.55? dan 109°19'8.65? (titik Sch-1) hingga 7°31'18.79? dan 109°19'21.45? (titik Sch-7). Interpretasi terhadap seluruh log resistivitas telah menghasilkan log litologi pada setiap titik sounding. Berdasarkan hasil interpretasi, litologi daerah penelitian terdiri atas tanah permukaan (42.85-85.13 m), lempung pasiran, sebagian agak basah (7.08-17.18 m), lempung pasiran bersisipan kerikil (22.44- 31.70 m); pasir, kerikil, dan kerakal dengan berbagai kemampatan (22.16-192.78 m), pasir bersisipan kerikil (6.77 m), perselingan batupasir, batulempung, dan sebagian berselingan dengan napal dan tuff (8.71-21.99 m), dan batupasir dengan variasi porositas (3.25-8.76m). Akuifer dangkal diperkirakan terdapat pada lapisan pasir bersisipan dengan kerikil (13.23-27.67 m) pada titik Sch-2 dimana potensinya diperkirakan cukup baik. Sementara itu, akuifer dalam diperkirakan terdapat di lapisan batupasir dengan variasi porositas (> 46.67 m) di seluruh titik sounding dengan potensi sangat baik.*

***Katakunci**: resistivitas-1D, DAS Serayu, log resistivitas, akuifer, Desa Somagede.*

INTRODUCTION

Background and Problems

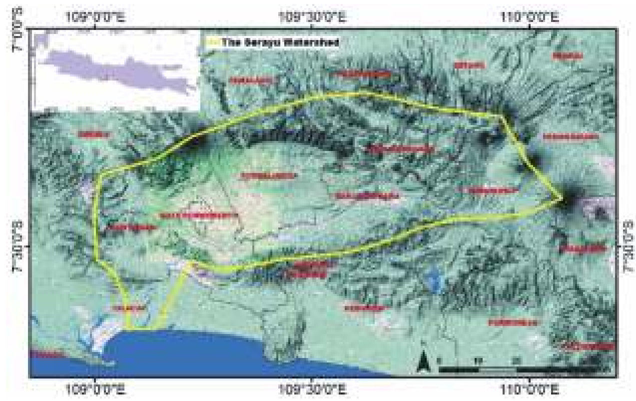
Serayu is the longest river in Central Java which flows about 250 kilometers away. The Serayu River flows from the Dieng Plateau of Wonosobo Regency to the west and turns south until it ends in Teluk Penyu, the Cilacap Regency as shown in Figure 1. This river flows through a fertile valley which is the basis for crops and an important food stuffs supplier in Central Java Province, even nationally. Along with its flow from upstream to downstream, the Serayu River gets a lot of water supply from several rivers originating from the Dieng Plateau, Sumbing and Sindoro Volcanoes, South Serayu Mountains, and Slamet Volcano (Anonymous, 2008). At the upstream area in the Banjarnegara, this river has water flow discharge of about 656 m³/sec. With increasing of water supply from several tributaries, the flow rate of Serayu has increased to 2,866 m³/sec in the Banyumas Regency area (Purnama, 2010). The large flow rate can trigger river water to fill the surrounding groundwater aquifer (Prasetya *et al.*, 2016). Hence the Serayu Watershed acts as a potential recharge zone for groundwater aquifers.

In 2019, the Banyumas Regency and its surrounding has experienced drought. Very low rainfall for a long time caused the recharge area of the South Serayu Mountains was not filled with rainwater, so the villages below experience water crisis. Based on data from the Regional Disaster Management Agency of Banyumas, the drought occurred in 48 villages spread across various districts in the Banyumas Regency, with the number of residents affected by the disaster have reached 12,904 families or 43,323 people (Zain, 2019). One of the villages in the Serayu watershed area that was drought was the Somagede Village. Geographically, the village is included in the Somagede District Banyumas Regency. Although Somagede Village is adjacent to the Serayu River, but most of the agricultural land in this village, especially rice fields, only relies on rainwater, so that the risk of crop failure during the planting period at the end of the rainy season.The view of the Serayu River that crosses Somagede Village area is shown in Figure 2.

One of the groundwater sources which has the potential to be explored as an effort to anticipate drought in Banyumas Regency is the aquifer of the Serayu watershed (Sehah and Hartono, 2016). The Serayu watershed aquifer is estimated can be used as good groundwater sources for domestic needs, agriculture, farm, industry, restaurant, and other needs. Based on the background and the problems occuring in the research area, exploration of groundwater sources in the Serayu watershed of Somagede Village needs to be done. This groundwater exploration can be carried out using the geoelectric method with Schlumberger configuration. The resistivity log data obtained can be interpreted into a lithology log. Then, the correlation between all lithologies logs will result in a hydrostratigraphical section model. Based on the model, the physical propertiesand potential of groundwater aquifer can be interpreted easily.

Research Purposes

This research purposeisto interpret the depth of the groundwater aquiferand its potential in the Serayu watershed area, especially the riverbanks of Serayuin the Village of Somagede, District of Somagede, Regency of Banyumas based on the resistivity data of the subsurface rocks.



Source: *http://mannusantara.blogspot.com*

Figure 1. The watershed of the Serayu river from the upstream in the Dieng Mountains Wonosobo to the downstream in Teluk Penyu Cilacap.

Source: Personal doc.

Figure 2. The view of the Serayu River that crosses Somagede Village area.

Literature Review

Groundwater is water that is stored naturally in the ground subsurface and its movement follows the laws of dynamical fluid. Its existence in the subsurface is highly dependent on the existence of rock layers which can store and flow water in large amounts, which is known as aquifer layer (Vaughn, 2015). Aquifer is a geology formation in the form of subsurface rock layers that have good porosity and permeability, allowing water to be stored and flow through it. Unconsolidated materials like gravel, sand, and even silt can form relatively good aquifers, such as sandstone. Other igneous rock can also be good aquifers if they were well fractured. Groundwater is stored in aquifer. The aquifer near the surface experiences lower pressure than that of the aquifer at greater depths. Hence, this type of aquifer tends to have more open space. Due to those reasons and cost factors, most groundwater is accessed to a depth of 100 m from the surfaceby individual users and communities (Earle, 2019).

Geologically, the surface of the research area is covered by the alluvium (Qa) that is composed of clay, silt, sand, gravel, and pebble. Below the alluvium there is the Undak Formation (Qt) that is composed of sand, gravel, and pebble; slightly consolidated which is the old sediment of the Serayu River. This deposit is exposed in the south of the research area in the Somagede District. Those two rock formations act as top soil and aquiclude. Aquiclude is a geological formation that cannot be passed by large amounts of water, but this formation still contains water. Based on the Geological Map of Banyumas sheet, under the Undak Formation, there are rocks from the Tapak Formation, but the rocks outcrops that appear in the south of the research area are the rocks of the Halang Formation that are actually ovelain by the Tapak Formation. This rock formation consists of an alternation of sandstones, claystones, marls, and tuffs with breccias intercalations under the influence of turbidity current and submarine slidings. Complete geological information can be seen in Figure 3 (Asikin and Handoyo, 1992).

To interpret the depth and potential of aquifers, a geoelectric survey can be applied. Geoelectric is one of the geophysical methods that can be used to understand the electrical properties of the rock layers in the subsurface by injecting an electrical current into the ground. The purpose of applying this method is to find the rock resistivity value. Resistivity is a physical parameter showing the value of an object's resistance to electric current. Rocks with having a large resistivity indicate that these rocks are difficult to pass by currents. This type of rock generally does not contain a lot of water, because water stored in rocks usually acts as a conducting medium (Akinlalu *et.al.*, 2016). Therefore rock formations containing water are characterized by small resistivity values, such as fine sands, clayey sands, sandy clays, and others.

The geoelectric method that is commonly used to explore groundwater sources in the subsurface is the resistivity method with the Vertical Electrical Sounding (VES) technique. The configuration of electrodesused when acquiring the datain this research is the Schlumberger. The VES technique is applied in this research since it has advantages; the depth of penetration is deep enough so that it is suitable for interpreting subsurface geological structures including the aquifer layer (Kumar and Swathi, 2014). According to Reynolds (2011), the measured resistivity during data acquisition can be expressed as:

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

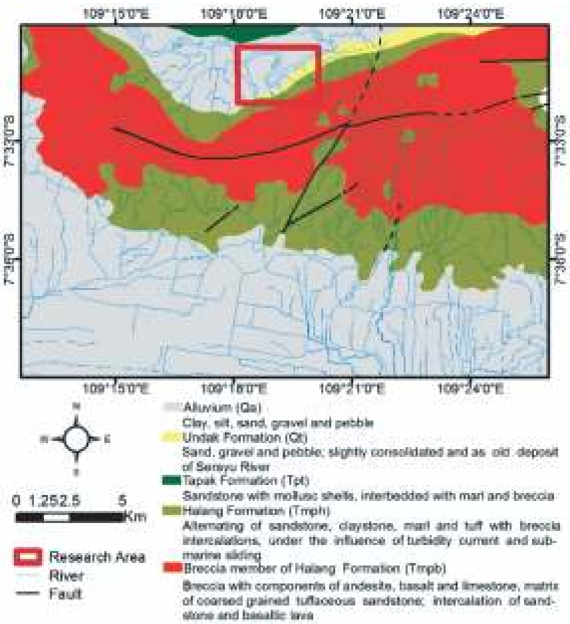
where ?$_a$ is the apparent resistivity (Ωm), ΔV is the potential difference or electrical voltage (V), *I* is the electrical current flowing through the rock medium (A), and *K* is the geometry factor of the electrode configuration used. Apparent resistivity is the measured electrical resistivity amid two points on the Earth's surface, which corresponds to the sensitivity the ground would have if it were homogeneous (Wightman *et.al.*, 2003). Thus, for the Schlumberger configuration, the value for the geometry factoris represented by the equation (Reynolds, 2011):

$$K = \pi\left(\frac{a^2 - b^2}{2b}\right) \qquad (2)$$

where *a* is the distance of ½C_1C_2 and *b* is the distance of P_1P_2 as shown in Figure 4.

The calculation of the penetration depth in the geoelectric method depends on the current electrode distance (2*a*). The greater the distance between the current electrodes, the deeper the electric current penetrates, so that the target of the subsurface investigation is also deeper. However, the greater the current electrode distance, the smaller the measured electric potential difference between two points on the surface. This is related to the change in potential measured on a surface depending on the intensity of the current flowing in the subsurface and as a distance function. The large fraction of electric currents that penetrate the surface can be expressed mathematically by the relationship (Telford *et.al.*, 1990):

$$\frac{I_z}{I} = 1 - \frac{2}{\pi}\tan^{-1}\frac{2z}{L} \qquad (3)$$



source: Asikin and Handoyo, (1992).

Figure 3. The geological map of the research area.

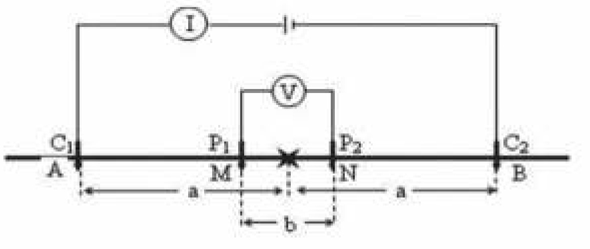


Figure 4. The Schlumberger electrode configuration in resistivity data acquisition.

I_z is the fraction of the electric current flowing at the depth $_z$ with the x axis direction, *I* isthe total current, $_z$ is the depth that can be penetrated by the electric current, and *L* is the distance between the current electrodes. Equation (3) indicates that the current which does not flow to a depth z in the subsurface is (Telford *et.al.*, 1990):

$$I - I_z = \frac{2}{\pi}\left(\tan^{-1}\frac{2z}{L}\right) \qquad (4)$$

If *L* = 2*z* then only half the current flows down to the depth *z*. Therefore, in a geoelectric method with a Schlumberger configuration, the depth of the investigation can be controlled by knowing half the current electrode distance (½AB) from the center of the investigation (sounding point).

RESEARCH METHOD

Location and Time of Research

Data acquisition in this research has been carried out in the Serayu watershed area of the Somagede Village, Somagede District, Banyumas Regency in July 2020. Data acquisition was carried out at sevensounding points as shown in Figure 5. The length of the current electrode for each sounding point is 200 m. Data processing, modeling, and interpretation have been done at the Laboratory of Electronics, Instrumentations, and Geophysics Jenderal Soedirman University, Purwokerto.

Research Equipment

The main equipment used is the Resistivitymeter of NANIURA type NRD-22S that is equipped with 2 x 200 m cable, 2 x 100 m cables, current and potential electrodes, 12V-DC battery, several software, and other supporting tools.

Research Procedure

The resistivity data acquisition in the geoelectric survey using the Schlumberger configuration can be done by changing the current and potential electrodes spacing from the smallest distance to gradually widening as shown in Figure 6. This spacing variation is done to obtain information on the geological structure and subsurface lithology based on rock resistivity values vertically (1D). This data acquisition technique is also called the Vertical Electrical Sounding (VES) technique, where the change in the spacing between the potential electrodes (P_1 and P_2) and the current electrodes (C_1 and C_2) is carried out according to a predetermined step of increasing the distance. The increase in the current electrodes spacing is proportional to the depth of the subsurface rock layer. The greater the current electrodes spacing, the deeper the rock layer is detected (Vasantrao *et.al.*, 2017). The rock resistivity contrast that is obtained can be used to interpret the 1D-vertical lithological variation in the subsurface.

The result of the resistivity data acquisition using the VES technique is anapparent resistivity curve (ρa) versus half current electrode spacing (½AB). The apparent resistivity curve is used as the basis for calculating the true resistivity value (ρt) of the subsurface rock layers by a modeling. The results obtained are the true resistivity curve versus the ½AB spacing and the resistivity log versus the depth of each rock layer. The interpretation was carried out on the resistivity log data based on the geological information of the study area, to obtain a lithological log that shows the various layers of subsurface rock and their depths. The correlation performed on lithological logs can be done to describe the hydrostratigraphic model of the research area including the aquifer which has the prospect of being exploited (Javid, 2013).

source: Google Earth.

Figure 5. The research location and position of sounding points of resistivity data acquisition.

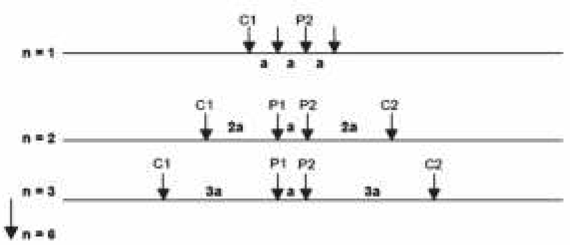


Figure 6. Changes in current and potential electrode spacing during resistivity data acquisition using the Schlumberger configuration.

RESULTS AND DISCUSSION

Research Results

Acquisition of resistivity data has been conducted in the Serayu watershed area in the Somagede Village with location of sounding points can be seen in Figure 5. The data obtained from the acquisition are current, potential difference, and spacing between some electrodes. As explained in the Research Method, these data are processed, so that the geometric factor (K) and the apparent resistivity (ρa) values can be acquired for each measured point. The apparent resistivity data are modeled using the software to get curves and logs of resistivity (Lubis, 2017). Figures 7 – 13 show the curves and logs of resistivity at the sounding points of Sch-1 to Sch 7. Whereas the results of the lithological interpretation of the resistivity log can be seen in Tables 1– 7. The interpretation is based on the geological map of the research area (Asikin and Handoyo, 1992) as explained in the Introduction Chapter.This mean thatthe interpretation of rock types is based on the lithological units of the geological map.

Based on the geological information, the top soil in the research area are alluvium deposits (Asikin and Handoyo, 1992). The results of interpretation have been adjusted to the geological information, where the topsoil layer is composed of sandy clays and silts inserted mostly by gravels. Under the top soil, there are also several layers of other rocks of the alluvium with different resistivity values. Due to variations of lithology units, the differences in the resistivity values of this layer is also estimated due to the water content variation and presence of other material piles (as soil, rocks, and others) due to human activities.

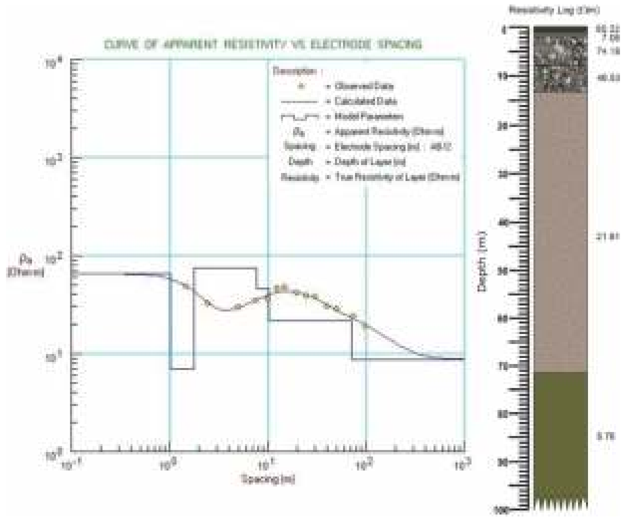


Figure 7. Resistivity curve and log at sounding pointSch-1.

Tabel 1. Interpretation results of resistivity log at sounding point Sch-1

Resistivity (Ωm)	Depth (m)	Lihological Interpretation
65.32	0.00 – 1.02	Top soil
7.08	1.02 – 1.75	Sandy clays (slightly wet)
74.18	1.75 – 7.73	Sands, gravels, pebbles (consolidated)
46.53	7.73 – 10.29	Sands, gravels, pebbles (slightly consolidated)
21.81	10.29 – 71.34	Alternatingsandstones, claystones,marls and tuffs
8.76	> 71.34	Mid porosity sandstones

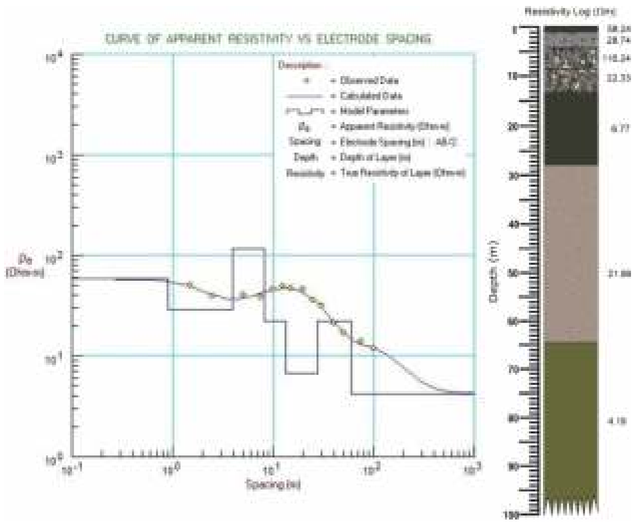


Figure 8. Resistivity curve and log at sounding point Sch-2.

Tabel 2. Interpretation results of resistivity log at sounding point Sch-2

Resistivity (Ωm)	Depth (m)	Lihological Interpretation
58.24	0.00 – 0.90	Top soil
28.74	0.90 – 3.92	Sandy claysinserted by gravels
116.24	3.92 – 8.27	Sands, gravels, pebbles (very consolidated)
22.33	8.27 – 13.23	Sands, gravels, pebbles (slightly consolidated)
6.77	13.23 – 27.67	Sandsinserted by gravels
21.99	27.67 – 60.44	Alternatingsandstones, claystones,marls and tuffs
4.19	> 60.44	High porosity sandstones

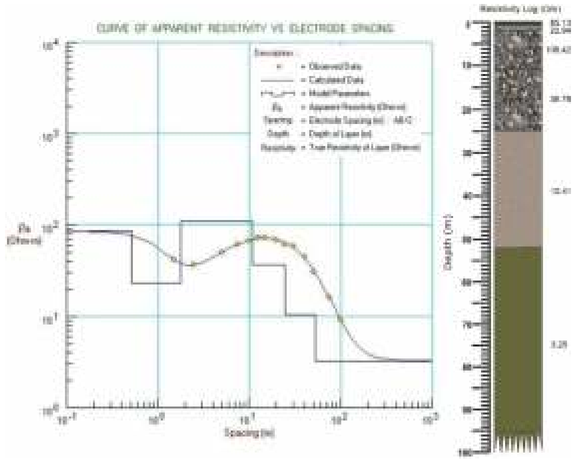


Figure 9. Resistivity curve and log at sounding point Sch-3.

Tabel 3. Interpretation results of resistivity log at sounding point Sch-3

Resistivity (Ωm)	Depth (m)	Lihological Interpretation
85.13	0.00 – 0.51	Top soil
22.94	0.51 – 1.79	Sandy claysinserted by gravels
108.42	1.79 – 10.83	Sands, gravels, pebbles (very consolidated)
36.78	10.83 – 24.87	Sands, gravels, pebbles (slightly consolidated)
10.41	24.87 – 52.07	Alternatingsandstones and claystones
3.25	> 52.07	High porosity sandstones

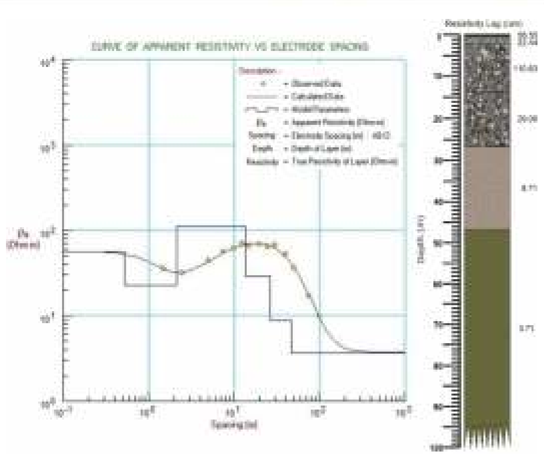


Figure 10. Resistivity curve and log at point Sch-4.

Tabel 4. Interpretation results of resistivity log at sounding point Sch-4

Resistivity (Ωm)	Depth (m)	Lihological Interpretation
56.55	0.00 – 0.53	Top soil
22.44	0.53 – 2.12	Sandy claysinserted by gravels
110.63	2.12 – 13.49	Sands, gravels, pebbles (very consolidated)
29.00	13.49 – 26.60	Sands, gravels, pebbles(slightly consolidated)
8.71	26.60 – 46.67	Alternatingsandstones and claystones
3.71	> 46.67	High porosity sandstones

Under the alluvium deposits, there is the Undak Formation which is composed of sands, gravels, and pebbles consolidated variably. Some of the rocks have a very high resistivity value, so that they are interpreted to be very consolidated. Whereas the rocks of the Undak Formation that have relatively low resistivity are estimated to be slightly consolidated and interpreted to contain water. Hence this layer can act as aquicludes. Aquiclude is a geological formation in the form of a subsurface rock layer that contains a limited of water and cannot be passed by groundwater flows (Putranto and Kuswoyo, 2008). The Undak Formation is thought to be the old deposit of the Serayu River (Asikin and Handoyo, 1992) which is Holocene in age (Munir, 2009). Therefore, the materials of thisformation are only distributed around the Serayu River.

Under the Undak Formation, there is a rock layer of the Halang Formation (Asikin and Handoyo, 1992). This formation is composed of alternating sandstones, claystone, marl, and tuff with inserts of breccias. The resistivity log obtained shows the varying resistivity values for this rock formation, ranging from 8.71 – 21.99 m. This variation in the resistivity value is influenced by slightly different lithological units in filling the layers of this rock formation. The relatively high resistivity value it is interpreted to consists of alternating sandstones and claystones with inserted by marls and tuffs. Whereas, the relatively low resistivity value is interpreted as composed by alternating between sandstones and claystone with some cracks and pores so that it can act as an aquitard. Aquitard is a geological formation in the form of water-saturated layers that can be passed by limited groundwater (Putranto and Rude, 2016). This rock layer often becomes the boundary between deep and shallow aquifers.

The next, all lithological units contructed from the interpretation process are correlated with one another, so that a 2D-hydrostratigraphical model can be obtained. This correlation is carried out by connecting the same or nearly same lithological units to form a certain rock layer. Based on the correlation results, eight rock layers are obtained as can be seen in Figure 14. The first layer is top soil composed of sandy clays and silts, most of which are inserted by gravels (42.85 - 85.13 m) at a depth of 0 -1.05 m. The second layer is sandy clays, that partly slightly wet (7.08 - 17.18 m) at a depth of 0.79 - 2.93 m. The third layer is sandy clays inserted by gravel (22.44 -31.70 m) with a depth of 0.51-3.92 m. All these rocks originated from the alluvium formation.

The fourth rock layer from the Undak Formation is composed of sands, gravels, and pebbles, which are consolidated variably (22.16 -192.78 m) at a depth of 1.75 - 26.60 m. The fifth rock layer is composed of sands inserted by gravels (6.77 m) at a depth of 13.23 – 27.67 m. This layer is also thought to be part of the Undak Formation. The sixth layer is composed of alternating sandstones and claystones, some of which are alternated with marls and tuffs (8.7 - 21.99 m) from the Halang Formation with a depth of 10.29 - 85.10 m. Then, the seventh rock layer is composed of sandstones with variations in porosity (3.25 - 8.76 m) with a depth ofmore than 46.6 m.This layer is thought to be a deep groundwater aquifer.

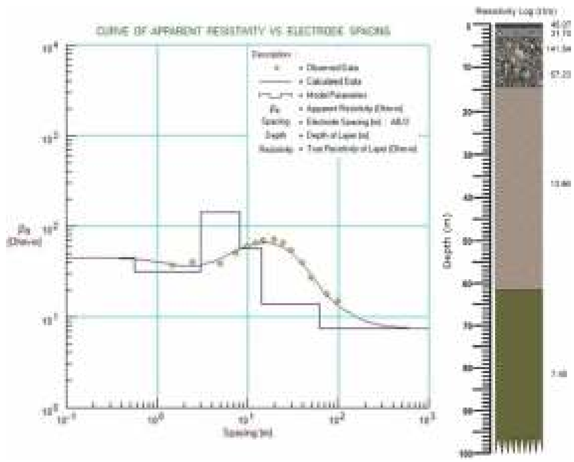


Figure 11. Resistivity curve and log at point Sch-5.

Tabel 5. Interpretation results of resistivity log at sounding point Sch-5

Resistivity (Ωm)	Depth (m)	Lihological Interpretation
45.07	0.00 – 0.56	Top soil
31.70	0.56 – 3.04	Sandy claysinserted by gravels
141.54	3.04 – 8.20	Sands, gravels, pebbles (very consolidated)
57.23	8.20 – 14.10	Sands, gravels, pebbles (slightly consolidated)
13.86	14.10 – 61.63	Alternatingsandstones and claystones
7.45	> 61.63	Mid porosity sandstones

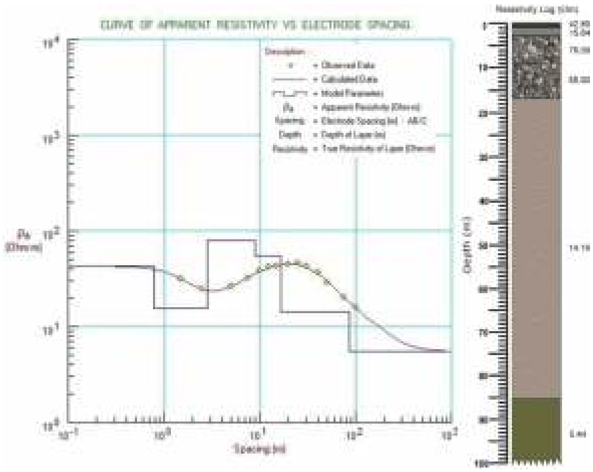


Figure 12. Resistivity curve and log at point Sch-6.

Tabel 6. Interpretation results of resistivity log at sounding point Sch-6

Resistivity (Ωm)	Depth (m)	Lihological Interpretation
42.85	0.00 – 0.79	Top soil
15.64	0.79 – 2.84	Sandy clays
79.59	2.84 – 8.92	Sands, gravels, pebbles (consolidated)
55.50	8.92 – 16.76	Sands, gravels, pebbles (slightly consolidated)
14.19	16.76 – 85.10	Alternatingsandstones and claystones
5.44	> 85.10	Mid porosity sandstones

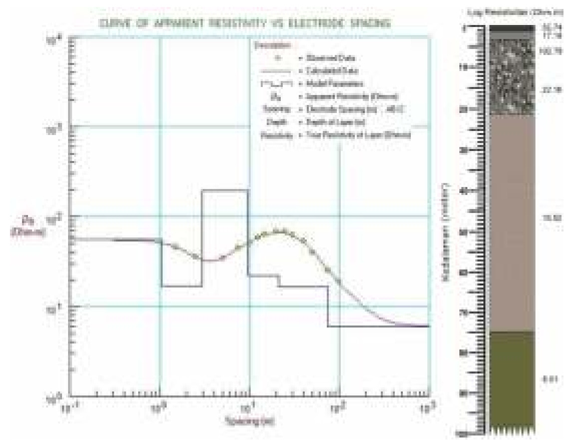


Figure 13. Resistivity curve and log at point of Sch-7.

Tabel 7. Interpretation results of resistivity log at sounding point Sch-7

Resistivity (Ωm)	Depth (m)	Lihological Interpretation
55.74	0.00 – 1.05	Top soil
17.18	1.05 – 2.93	Sandy clays
192.78	2.93 – 9.47	Sands, gravels, pebbles(very consolidated)
22.16	9.47 – 21.03	Sands, gravels, pebbles(slightly consolidated)
16.52	21.03 – 74.82	Alternatingsandstones and claystones
6.01	> 74.82	Mid porosity sandstones

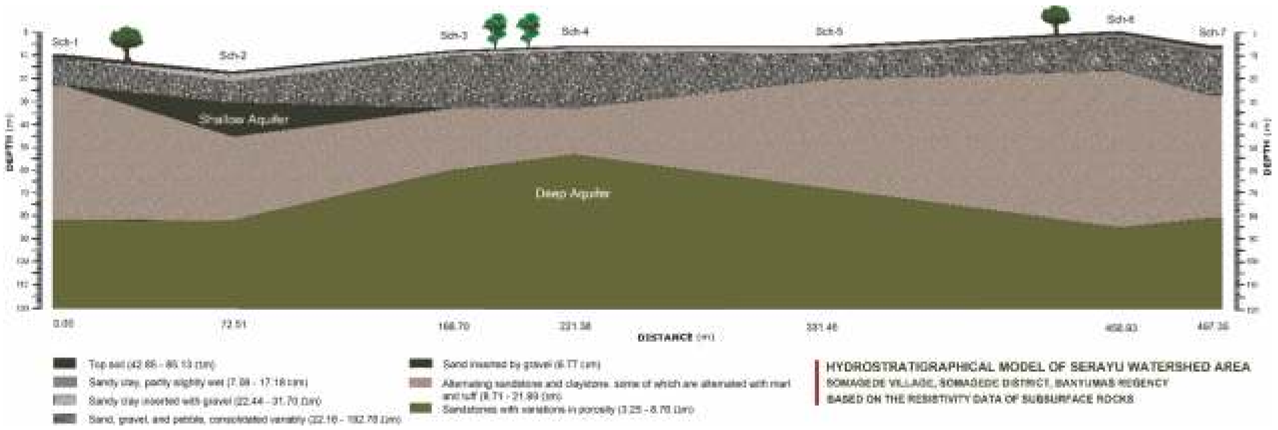


Figure 14. Hydrostratigraphical model of the Serayu watershed area of Somagede Village based on the interpretation and correlation of several resistivity logs.

DISCUSSION

The result of the interpretation and correlation of the resistivity logs in the research area is a model of hydrostratigraphic as can be seen in Figure 14. Based on this figure, the hydrological units which can be interpreted in the research area are aquifer, aquiclude, and aquitard. While the aquifuge could not be detected due to the limited distance of the current electrode spacing (only 200 m). Based on equation (4) as mentioned above, the maximum depth of modeling is only about 100 m. Aquifuge which is estimated to be more than 100 m deep is not modeled. The aquifuge is an impermeable rock formation that is neither porous nor permeable, that means it cannot store water in it and at the same time it cannot permit groundwater through it. Compact rock types is one of example of aquifuge (Devy, 2018). However, subsurface rocks layer under sandstones with variations in porosity as shown in Figure 14 is thought to be composed of breccias with andesite, basalt, and limestone components which is inserted by sandstone and basaltic lava. This rock layer is a breccia member of the Halang Formation and is estimated not to be an aquifug layer (Asikin and Handoyo, 1992).

Based on Figure 14, the shallow aquifer layer is only found at the sounding point of Sch-2 with a depth of 13.23 – 27.67 m. This rock layer has a resistivity value of 6.77 m which is interpreted as sands inserted by gravels and is thought to have relatively good groundwater potential. Although the shallow aquifer is not found at other points, this shallow aquifer may be connected with other aquifers in the south of the research area. In the south of this area to the South Serayu Mountains is dominated by rocks of the Halang Formation, it is assumed that many shallow aquifer layers are still found; because one of it's lithological unit is sandstone. Based on the landscape topography in the study area, the recharge area for this aquifer is estimated to be in the South Serayu Mountains as has been shown in Figure 1. The absence of shallow aquifers at most points in the study area is due to the dominance of the Undak Formation. (Asikin and Handoyo, 1992). The rock that fills this formation is variedly compressed, so that groundwater is relatively difficult to fill and flow in (Varalakshmi *et.al.*, 2012), as explained in the research results above.

Based on Figure 14, the deep aquifer layer of the research area is found in all sounding points with the upper depths ranging from 46.67 – 85.10 m. This rock layer has a resistivity value of 3.25 – 8.76 m, which is interpreted as a sandstone with variations in porosity from the Halang Formation. The higher resistivity indicates that the porosity of the rocks is lower (Hersir and Arnason, 2009), and vice versa. The groundwater in pores of rock can play a role in dissolving and reacting with minerals which can forms a salt solution (Kumar and Swathi, 2014). Dissolved salt has relatively low electrical resistivity, which means that the higher the mineral content of water the lower the resistivity (Corwin and Yemoto, 2017). Thus, the higher the porosity of the rock, the easier the current will flow through it; so that the resistivity value decreases (Ussher *et.al.*, 2000). This also shows that a large resistivity value indicates that the porosity is low, so the groundwater content in the rock is also small. However, the potential of groundwater in the deep aquifer is estimated to be quite good, because water can still be stored and flow in the pores and crevices of sandstones (Li and Wang, 2019).

The South Serayu Mountains, which are located south of the Serayu watershed become a potential recharge area during the rainy season. Some of the rainwaters which fall seeping through the pores, cavities, and gaps in the top soil and rock in the subsurface. The rainwater seeps up to a depth of several tens of meters and will continue to move until it reaches a certain layer. When it comes to the impermeable rock layers, water can no longer flow, so it ends up filling the cavities around or above it. The rock layers, where groundwater is stored and flows in the subsurface are referred to as aquifers, one of which is the Serayu watershed aquifer. For this reason, the Serayu watershed is thought to be a recharge area, where groundwater flows into wells, exits in the form of springs, and flows into the Serayu River. In the research area, the groundwater is estimated to enter the Serayu River through the shallow aquifer layer, i.e. at the sounding point of Sch-2 with a depth of 13.23 – 27.67 m.

CONCLUSIONS

Interpretation of 1D-resistivity data to describe the aquifer model in the Serayu watershed area of the Somagede Village Somagede District Banyumas Regency has been carried out, with the following results:

1. The 1D-resistivity data modeling has produced the resistivity logs of subsurface rock at seven sounding points with resistivity values ranging from 2.24 – 192.8m.

2. The interpretation of the all resistivity logs has resulted in a lithology log at each sounding point, and a correlation between all lithology logs has resulted in a lithological section of the research area including the shallow and deep groundwater aquifer models.

3. The lithological section shows that the research area consists of top soil (0 – 1.05 m), sandy clays partly slightly wet (0.79 – 2.93 m), sandy clays inserted by gravels (0.51 – 3.92 m); sands, gravels, pebbles consolidated variously (1.75 – 26.6 m), sands that inserted by gravels (13.23 – 27.67 m); alternating sandstones and claystones, several of which are alternated by marls and tuffs (10.29 – 85.10 m), and sandstones with various porosity (more than 46.6 m).

4. The aquifers models on the lithological section show that the shallow aquifer is interpreted as the sand layer inserted by gravels (13.23 – 27.67 m) at the sounding point of Sch-2 with 6.77 m in resistivity value. Whereas the deep aquifer is estimated as the sandstones layer with various porosity (more than 46.67 m) which is located at all sounding points with resistivity value is 3.25 – 8.76 m.

ACKNOWLEDGMENTS

The authors would like to thank the Rector and Chairman of Research and Community Service Institute of Jenderal Soedirman University for the research funding provided. We thank to the Head of Laboratory of Electronics, Instrumentation and Geophysics of the Jenderal Soedirman University for providing Resistivity meter and supporting tool. We would like to express gratitude to the member of the research teams of the Geophysical Interest Group of the Jenderal Soedirman University for the collaboration in the data acquisition process.

REFERENCES

Akinlalu, A.A., Adegbuyiro, A., and Obore, A.A., 2016. Application of Electrical Resistivity Method in Designing a Structural Model for a Proposed Filling Station Site, Akure, Southwestern Nigeria. *Global Journal of Science Frontier Research: A Physics and Space Science*, 16(6):ver. 1.0.

Anonymous, 2008. *Daerah Penyangga Serayu Mengkhawatirkan*. http://mannusantara.blogspot.com.

Asikin, S., dan Handoyo, A. 1992. *Peta Geologi Lembar Banyumas, Jawa, skala 1:100.000*. Pusat Penelitian dan Pengembangan Geologi, Bandung.

Corwin, D.L., and Yemoto, K., 2017. *Salinity: Electrical Conductivity and Total Dissolved Solids*. Methods of Soil Analysis, v. 2.

Devy, S.D., 2018. Hydrogeology of Karang Mumus Watershed in Samarinda, East Kalimantan Province, Indonesia. *Forum Geografi*, 32(1): 12 – 23.

Earle, S., 2019. *Physical Geology: Groundwater and Aquifers*. https://opentextbc.ca/geology/. BCcampus Open Textbooks,.

Hersir, G.P., and Arnason, K., 2009. *Resistivity of Rocks*. Presented at Short Course IV on Exploration for Geothermal Resources. Organized by UNU-GTP, KenGen and GDC, at Lake Naivasha, Kenya. November 1 – 22, 2009.

Javid, S., 2013. Petrography and Petrophysical Well Log Interpretation for Evaluation of Sandstone Reservoir Quality in The Skalle Well (Barents Sea). Thesis Ph.D. Norwegian University of Science and Technology.

Kumar, M.R.S.S., and Swathi, G., 2014. Vertical electrical sounding (VES) for subsurface geophysical investigation in Kanigiri area, Prakasam district, Andhra Pradesh, India. *Advances in Applied Science Research*, 5(5): 82 – 86.

Li, Y., and Wang, J., 2019. Effects of Porosity of Dry and Saturated Sandstone on the Energy Dissipation of Stress Wave. *Advances in Civil Engineering*, 2019: 1 – 10.

Lubis, G., 2017. Exploration of Groundwater Potential with Geoelectric Resistivity Method in Tanjung Kuba, Batu Bara Regency. *Journal of Applied Geology and Geophysics*, 5(1): 71 – 73.

Munir, A., 2009. *Characteristics of the Serayu Watershed Area, Central Java Province, Based on Physical, Social, and Economic Conditions*. Task of Watershed Management Subject. Department of Geography, University of Indonesia, Jakarta.

Prasetya, D.A., Waspodo, R.S.B., dan Saptomo, S.K., 2016. Prediksi Cadangan Air Tanah di Daerah Aliran Sungai Cisadane. *Jurnal Teknik Sipil dan Lingkungan*, 1(2): 59 – 68.

Purnama, S., 2010. Potensi Sumberdaya Air DAS Serayu. *Jurnal Rekayasa Lingkungan*, 6(3): 291 – 303.

Putranto, T.T., dan Kuswoyo, B., 2008. Zona Kerentanan Air Tanah terhadap Kontaminan dengan Metode Drastic. *Teknik*, 29(2): 110 – 120.

Putranto, T.T., and Rude, T.R., 2016. Hydrogeological Model of an Urban City in a Coastal Area, Case Study: Semarang, Indonesia. *Indonesian Journal on Geoscience*, 3(1): 17 – 27.

Reynolds, J.M. 2011. *An Introduction to Applied and Environmental Geophysics*. John Wiley & Sons Ltd, West Sussex: 681p.

Sehah dan Hartono, 2016. Pemanfaatan Metode Resistivitas untuk Mengidentifikasi Akuifer Air Tanah di Kawasan Lahan Kritis Daerah Aliran Sungai (DAS) Serayu Desa Karangsari dan Desa Penggalang Kecamatan Adipala Kabupaten Cilacap. *Simetri, Jurnal Ilmu Fisika Indonesia*, 2(2): 49 – 56.

Telford ,W.M., Gedaart, L.P., and Sheriff, R.E., 1990. *Applied Geophysics*. Cambridge. New York.

Ussher, G., Harvey, C., Johnstone, R., and Anderson, E., 2000. Understanding the Resistivities Observed in Geothermal Systems. *Proceedings World Geothermal Congress 2000 Kyushu - Tohoku, Japan*, May 28 - June 10, 2000: 1915 – 1920.

Vasantrao, B.M., Bhaskarrao, P.J., Mukund, B.A., Baburao, G.R., and Narayan, P.S., 2017. Comparative Study of Wenner and Schlumberger Electrical Resistivity Method for Groundwater Investigation: a Case Study from Dhule District (M.S.), India. *Applied Water Science*, 7: 4321–4340.

Varalakshmi, V., Venkateswara Rao, B., SuriNaidu, L., and Tejaswini, M., 2012. Groundwater Flow Modelling Of An Hard Rock Aquifer - A Case Study. J*ournal of Hydrologic Engineering*, 19(5): doi.org/10.1061/(ASCE)HE.1943-5584.0000627.

Vaughn, P., 2015. *A Basic Study In Groundwaterand The Hydrogeologic Characteristics Of Principal Aquifers In The United States*. Soil and Water Science. Master of Science Program. University of Florida, USA.

Wightman, W. E., Jalinoos, F., Sirles, P., and Hanna, K., 2003. *Application of Geophysical Methods to Highway Related Problems*. Federal Highway Administration. Central Federal Lands Highway Division, Lakewood, CO, Publication No. FHWA-IF-04-021.

Zain, 2019. *Kekeringan di Banyumas Meluas, Persediaan Bantuan Air Bersih Menipis*. Kompas.com, Edisi 06 September 2019. https://regional.kompas.com/read/2019/09/06/14051221/kekeringan-di-banyumas-meluas-persediaan-bantuan-air-bersih-menipis.