



IDENTIFICATION OF GEOTHERMAL DISTRIBUTION IN THE BANYU BIRU HOT WATER SOURCE USING THE MAGNETIC METHOD

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ABSTRACT

The geothermal phenomenon in Banyu Biru hot springs in Gondangwetan Village, Jatikalen District, Nganjuk Regency, has the potential to be developed into a tourist spot and an alternative renewable energy source that is environmentally friendly; for example, a geothermal power plant. So it is necessary to know the distribution of geothermal reservoirs and how much potential energy is contained. This research aims to determine the distribution of geothermal energy in the research area and its geological structure. This study used the Magnetic Method for secondary data obtained from NOAA satellite data. Data acquisition with an area of 2000 meters x 2000 meters obtained 100 data with a spacing of 200 meters. Based on research results, geothermal bursts have a low anomaly value of -50 nT to 25 nT. The low anomaly distribution can be used to determine the geothermal distribution in the area, assuming that areas with the same anomaly value indicate the presence of geothermal energy. The geology of the study area has five layers, namely: Topsoil (soil) has a susceptibility value of 0.0000377 SI, Alluvium has a susceptibility value of 0.00144513 SI, Tufan Clay has a susceptibility value of 0.00692407 SI, Limestone Tuff has a susceptibility value of 0.125713399 SI and Breccia (Andesite and Basalt) has a susceptibility value 0.0126292 SI. The depth of the geothermal source in the study area is ± 250 meters below the surface.

Keywords: Geothermal Distribution; Banyu Biru Hot Water; Magnetic Method

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INTRODUCTION

Indonesia is a country along the ring of fire^[1], so several volcanoes generate large amounts of geothermal energy potential^[2]. Indonesia is a country that has enormous geothermal potential^[3]. Around 40% or 29.000 MW of the world's total geothermal energy is in Indonesia^[4]. East Java has a geothermal potential of 1206.5 MW^[5].

One of the geothermal sources in Nganjuk Regency. Located on the national artery road in the middle lane of East Java province, which is an agricultural area between the slopes of Mount Wilis and Mount Pandan, it is possible that it has something to do with the volcanic activity of the volcano^[6]. Geothermal phenomena in the Banyu Biru hot springs, Gondangwetan Village, Jatikalen District, Nganjuk Regency, found that after drilling a well to irrigate the rice fields, hot water has a temperature of approximately 37°C with a good depth of 250-300 meters. The existence of this manifestation indicates the existence of a geothermal reservoir below the surface^[7-8]. This geothermal source has the potential to be developed into a tourist spot^[9]. An environmentally friendly renewable alternative energy

source^[10-13] can even be used as a power plant with binary technology with a minimum temperature of 70° C, so it is necessary to know the distribution of geothermal reservoirs and how much potential energy is contained. So research is needed to find out the distribution of geothermal heat so that it can be known whether or not geothermal potential is used as a tourist spot and an alternative energy source^[14-15]. The research results are also useful as a reference for geothermal development in the area.

Based on the existing phenomenon, it is necessary to carry out geothermal research, which is carried out by the magnetic Method. This method can be used to determine fault patterns and geological structures that develop and are sensitive to minerals that have magnetic susceptibility^[16]. Using this Method is expected to determine the distribution of geothermal in the study area and its geological structure^[17].

This Method also uses a contour that describes the distribution of rock susceptibility below the surface in a horizontal direction. From the susceptibility value, it can be localized or separated rocks that contain magnetic properties and those that do not.

METHOD

Research Locations

This research was conducted around the Banyu Biru hot spring located in Gondangwetan Village, Jatikalen District, Nganjuk Regency, at coordinates 7°52'02"LS 112°10'8.58"BT E to 7°50'65"LS 112°12'19"BT East with an area of the study area of 2000 meters × 2000 meters which aims to determine the subsurface structure in the area (Figure 1).

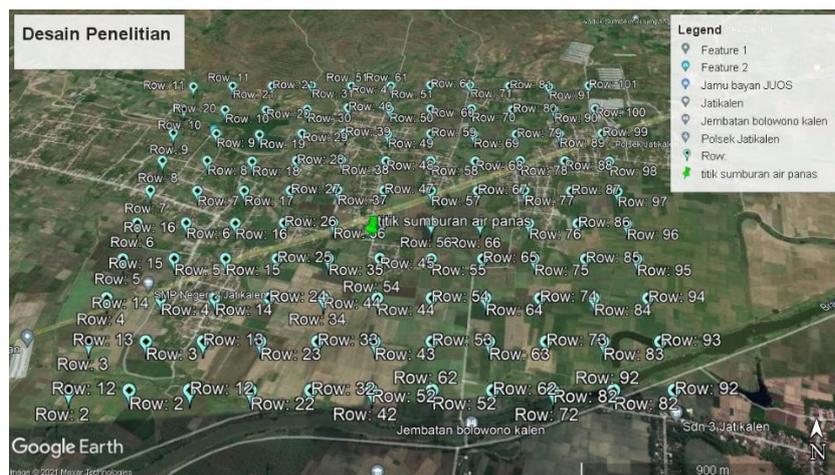


Figure 1. Acquisition Design

The research location is located in a land morphological unit in the main watersheds: Konto River, Widas River, Brantas River, Bangsal River, and Brangkal River, with branching, woven, meandering, and semi-linear flow patterns.

Research Tools

PC or Laptop, Microsoft Excel 2019, Surfer Version 2013, Magpick Oasis Montaj, Matlab.

Types of Data and Research Methods

In this study, secondary data, namely NOAA (National Oceanic and Atmospheric Administration) magnetic data with satellite measurements, can be obtained and accessed via <http://ngdc.noaa.gov/geomag/calculators/magcalc.shtml>. The data obtained is in the form of total magnetic field intensity values. The research method is described in a flowchart.

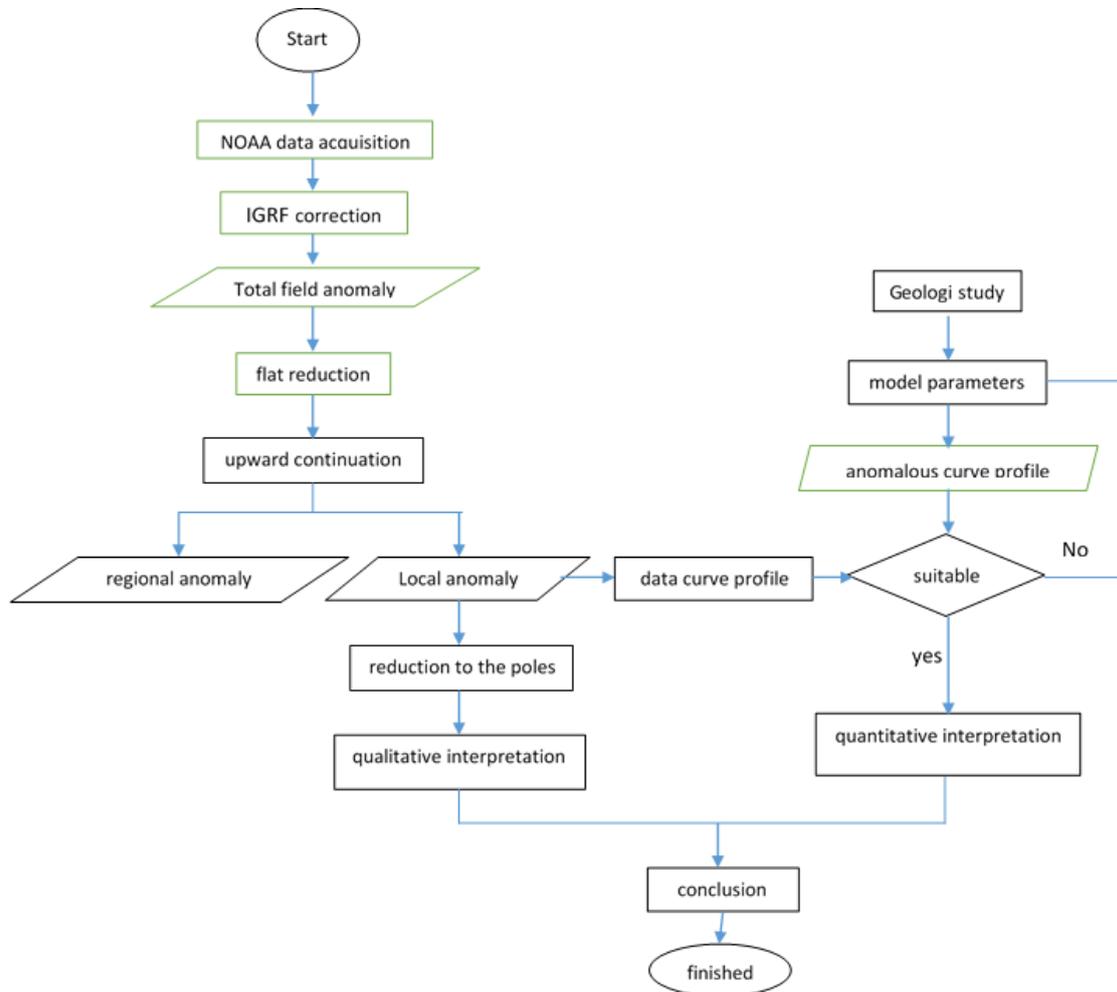


Figure 2. Research Flowchart

The steps of this research are data acquisition using NOAA after which initial processing is carried out, namely IGRF Correction, this correction is made to eliminate the effect of the external magnetic field value and the main magnetik field (IGRF Value) which will later obtain total field anomaly data (Figure 2). However, the total field anomaly data is still affected by the height factor, so a flat plane reduction is done first. In the flat plane reduction process there is still a local value effect from shallow sources caused by magnetic objects, so an upward continuation process is carried out which will produce two anomalies, namely regional anomalies and local anomalies.

In general, the interpretation of magnetic data is divided into two, namely qualitative and quantitative interpretations. Qualitative interpretation is based on the magnetic field anomaly contour patterns originating from the distribution of magnetized objects or subsurface geological structures. Furthermore, the resulting magnetic field anomaly patterns are interpreted based on local geological information in the form of the distribution of

magnetic objects or geological structures^[18], which are used as the basis for predictions of the actual geological conditions^[19]. Qualitative interpretation will interpret the analysis on the local anomaly contour map. In contrast, quantitative interpretation is carried out with the help of Oasis Montaj Software to model the conditions below the surface and with information from geological maps to determine the contrast value of rock susceptibility (k) and layer thickness (h).

RESULTS AND DISCUSSION

Total Magnetic Field Anomaly.

Stratigraphically the study area includes the Alluvium (Qa) formation composed of gravel, gravel, sand, clay, silt, and plant remains. The Notopuro Formation (Qp_{nv}) comprises breccia, tuffaceous sandstone, tufa stone, silt sandstone, and limestone. The Pucangan Formation (Qp_p) comprises breccias, sandstone, clay inserts, and conglomerates. In contrast, the last one is the Kabuh Formation (Qp_k), composed of sandstone, conglomerate inserts, tuff, and claystone. 5 The contours of the total magnetic anomaly based on the research results are as follows.

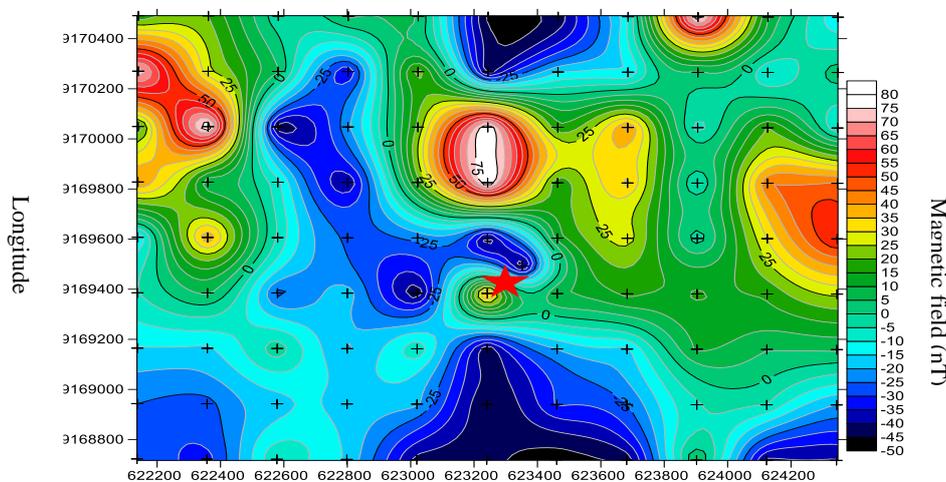


Figure 3. Total Magnetic Field Anomaly Contours and Measurement Points Latitude

Figure 3 is the total magnetic field anomaly resulting from the IGRF (International Geomagnetic Reference Field) correction. These results indicate that the total magnetic field anomaly value in the study area ranges from -50 nT to 80 nT which is 5 nT away with three different anomaly patterns. Blue to green colors are low anomalies that spread around the study area with anomaly values of -50 nT to 25 nT, where low anomalies can be said to be areas with the potential for hot springs or geothermal. The medium anomaly with a yellow to orange color is located in the northwest and east with an anomaly value of 30 nT to 45 nT. The high anomaly with red to white colors is located in the northwest and north, and east, with an anomaly value of 50 nT to 80 nT. The red asterisk is a geothermal well that is visible from the surface, as a manifestation of geothermal heat. So the magnitude of the field represented by the same color as the red star is considered geothermal distribution.

Qualitative Interpretation

Flat Plane Reduction

Plane reduction is carried out with the aim of reducing or bringing the total magnetic field anomaly that is still scattered in the topography to a flat field^[20]

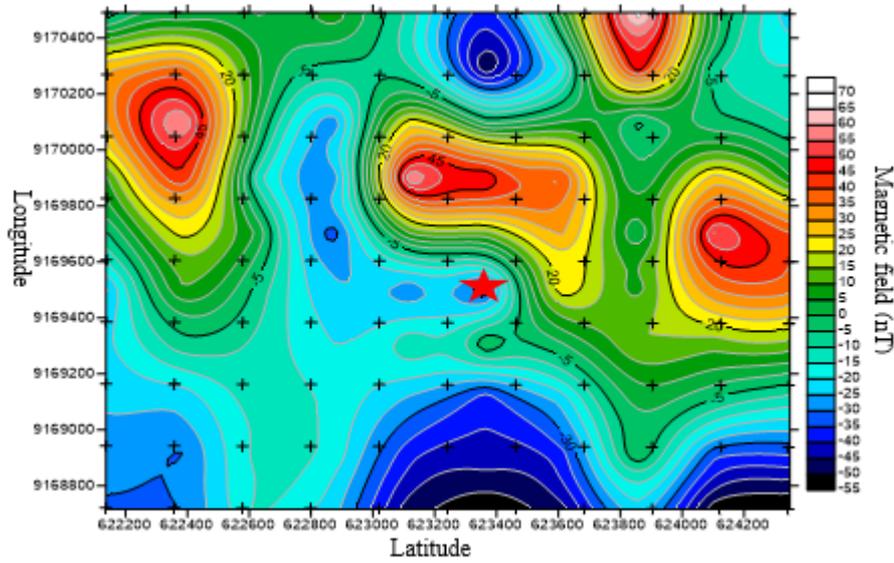


Figure 4. Total Magnetic Field Anomaly Contours After Flat Plane Reduction and Measurement Points

Based on the contours of the total magnetic field anomaly in Figure 4, which has been reduced to a flat plane, it can be seen that the anomaly values range from -55 nT to 70 nT which is 5 nT away, where the hot spring burst point is included in the low anomaly of -40 nT. The contours resulting from flat field reduction resemble contours that are similar to the total magnetic field anomaly and have an anomaly value that is slightly lower than the total magnetic field anomaly before the plane reduction is carried out. Based on Figure 4, geothermal distribution is in the electric field range of 25nT-35nT.

Upward Continuation

The continuity above is carried out to separate local and regional anomalies^[21-22]. The regional anomaly results from the upward continuation are as follows.

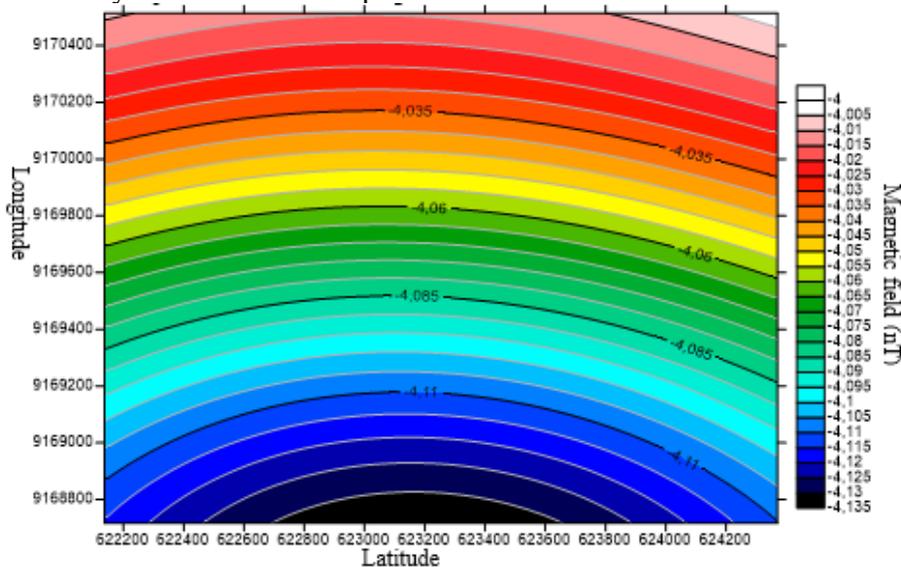


Figure 5. Regional Anomaly Contours Result of Upward Continuation with an Altitude of 4000 Meters

Based on the picture of the regional anomaly resulting from upward continuation with a lift of 4000 meters, the regional anomaly in the study area ranges from -4.135 nT to -4 nT with an anomaly value difference of 0.005 nT.

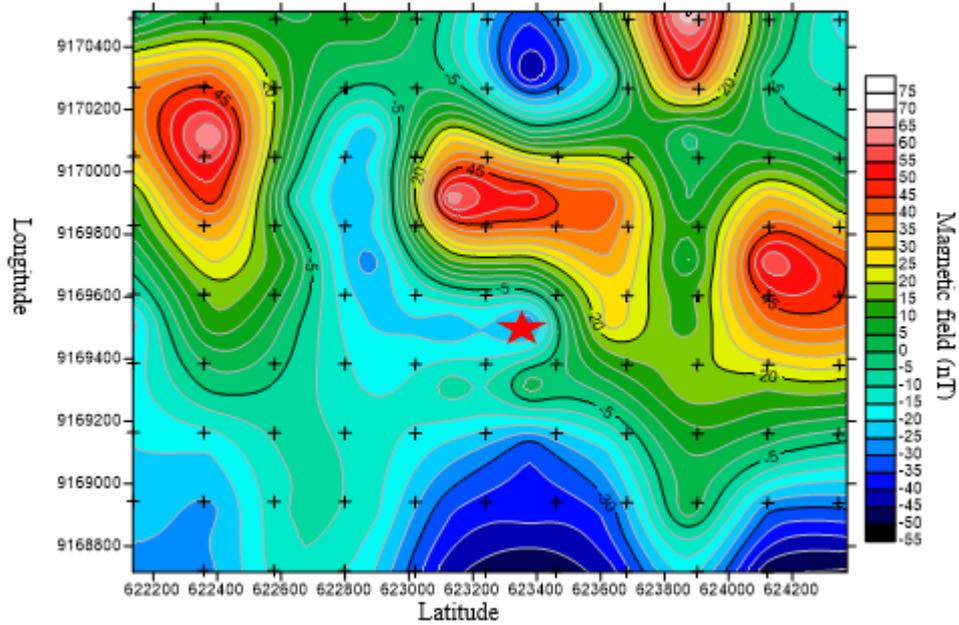


Figure 6. Local Anomaly Contour Result of Upward Continuation with an Altitude of 4000 Meters

The local anomaly results from an upward continuation at 4000 meters which has a local anomaly value ranging from -55 nT to 75 nT. Qualitatively, the local anomaly contour pattern in the study area is divided into 3, namely low anomaly, moderate anomaly, and high anomaly. And from the contour pattern of the local magnetic field anomaly, it can be seen that the rock or lithology in the study area is disorganized or very varied. It is based on low or high anomaly values that are influenced by rock type, rock depth or position, and rock volume. Based on Figure 5, geothermal distribution is in the electric field range of 25nT-35nT.

Reduction to the Poles

The polar reduction process is needed to localize the presence of anomaly sources in the study area^[23].

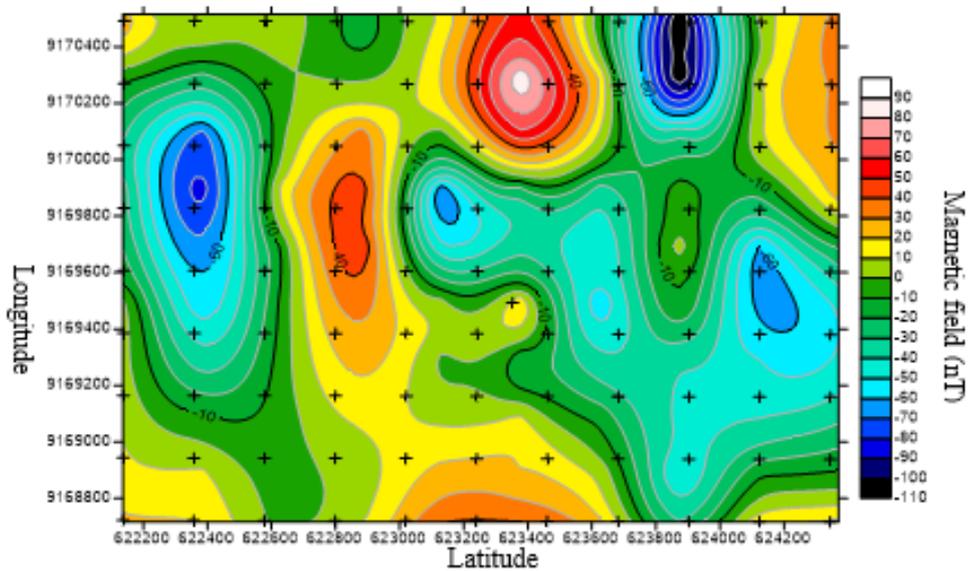


Figure 7. Local Anomaly Contour Results of Reduction to Poles and Measurement Points

The local anomaly contour image resulting from the reduction to the poles, where it can be seen that there are differences in anomaly values, is very influential when the reduction to the poles transformation has been carried out after the reduction to the poles transformation process, the anomaly value becomes higher. This is due to the anomalous value of the magnetic field at the local anomaly being strengthened when it has been reduced to the poles, which can be demonstrated by the presence of a high anomaly contour pattern and a low anomaly with a value of -110 nT to 90 nT, it can be determined that the rock causing the anomaly is located below the closure pattern.

Quantitative Interpretation

Quantitative interpretation is carried out by analyzing local anomaly cross-sections on the slice profile to determine the target or location's depth and subsurface models that show the geological structure of subsurface measurements.

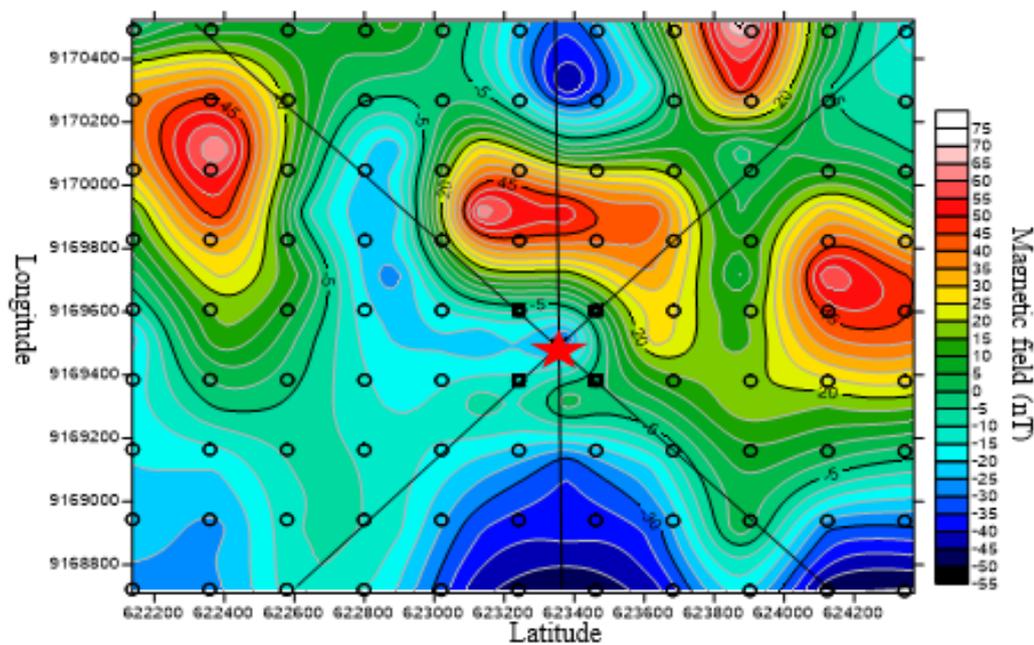


Figure 8. Slice A-A', B-B,' and C-C' on Local Anomaly Contours and Measurement Points

Quantitative interpretation is carried out based on Figure 8, a local anomaly contour pattern is sliced with reference to the point of hot springs. This interpretation uses three cross sections, A-A', B-B,' and C-C,' to show subsurface rock formations around the study area.

Based on Figure 9, the arrows indicate where the geothermal wells appear on the surface. Intersects the point of the hot water spout with a path length of 2556 meters by setting the depth at 300 meters. In the subsurface modeling of the slice, section A-A', B-B,' and C-C' consists of 5 layers with an error value of 0.939%. The first layer is light blue as the top layer, which can be interpreted as topsoil (soil). The second layer is yellow, interpreted as Alluvium in gravel, gravel, sand, clay, silt, and plant debris. The third layer is green, which can be interpreted as tuffaceous clay, and the fourth layer is dark brown, which can be interpreted as a light tuff. And the last layer is the fifth, red, which can be interpreted as a breccia with andesite and basalt components.

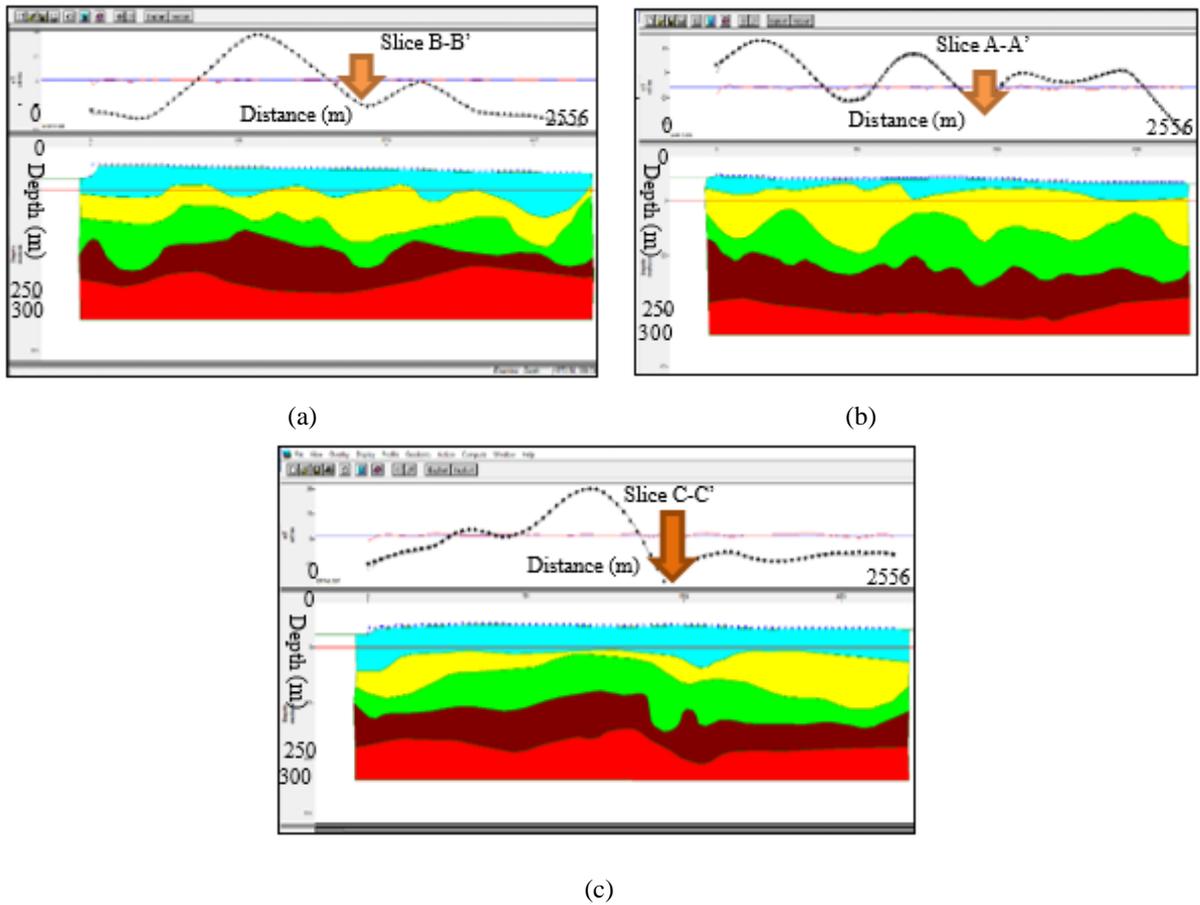


Figure 9. Subsurface 2D Model in (a). Slice A-A'(b). Slice B-B' (c). Slice C-C'

Quantitative Interpretation of A-A' Slice Sections

Table 1. Slice A-A'

Layer	Depth (m)	Susceptibility (SI)
1	3-22	0,0000377
2	11-19	0,00144513
3	2-17	0,00692407
4	3-10	0,12571399
5	7-9	0,0126292

Table 2. Slice B-B'

Layer	Depth (m)	Susceptibility (SI)
1	5-7	0,0000377
2	6-10	0,00144513
3	7-10	0,00692407
4	14-61	0,12571399
5	5-17	0,0126292

Tabel 3. Slice C-C'

Layer	Depth (m)	Suceptibilitas (SI)
1	7-12	0,0000377
2	3-17	0,00144513
3	5-9	0,00692407
4	2-12	0,12571399
5	7-16	0,0126292

According to the existing Kediri Geological Sheet map, the reservoir rock is suspected to be in the second layer, which means that the Alluvium consists of gravel, gravel, sand, clay, silt, and plant remains. This rock has the characteristic of being hollow, so it has high porosity. Cap rock, which is in the third layer, namely tuffaceous clay, which has plastic properties and is composed of fine-grained clay minerals, can hold water in Alluvium. Hot water that is in the earth's crust can change the minerals from the rock so that it becomes clay rock (Argillic Alteration) which can form a waterproof cap (caprock), so the caprock (caprock) can prevent geothermal originating from the reservoir from being come out to the surface. Meanwhile, tuff rock has a wild nature and high permeability value. The tuff also contains chlorite, which can help improve the quality of the reservoir rock. In the last layer, breccia which has andesite and basalt components, the heat source is thought to come from andesite rock which can propagate in the inner layer, where andesite rock convects very easily because it has very high porosity. So it can be expected that water can be trapped in high pores, which can allow for a heating process when in contact with hot rocks, which is called hydrothermal.

So that in this study, it can also be interpreted that geothermal potential has the same composition, namely clay rock and breccia rock. Breccia rocks originating from volcanoes are thought to be reservoir rocks. Meanwhile, the caprock, the hot fluid retaining layer from the reservoir, is thought to be tuffaceous clay rock with impermeable properties. Therefore volcanic breccia rock is thought to be a fluid storage rock heated by hot rock and tuffaceous clay rock as rock. Cover (caprock) of the manifestation of the geothermal system in the form of hot springs in the Nganjuk blue river.

CONCLUSION

In the initial survey results, geothermal burst points as geothermal manifestations are marked with research center points or burst points. Based on research results, geothermal bursts have a low anomaly value of -50 nT to 25 nT. The low anomaly distribution can be used to determine the geothermal distribution in the area, assuming that areas with the same anomaly value indicate the presence of geothermal energy. The geology of the study area has five layers, namely: Topsoil (soil) has a susceptibility value of 0.0000377 SI, Alluvium has a susceptibility value of 0.00144513 SI, Tufan Clay has a susceptibility value of 0.00692407 SI, Limestone Tuff has a susceptibility value of 0.12571399 SI and Breccia (Andesite and Basalt) has a susceptibility value 0.0126292 SI. The depth of the geothermal source in the study area is ± 250 meters below the surface.

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