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Subsurface Geological Structure and Geothermal System Modelling of Mount Bur Ni Telong, Indonesia, Based on Gravity Anomaly Interpretation

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Abstract

Mount Bur Ni Telong of Aceh, Indonesia, is a part of the Bukit Barisan volcanic arc region. It is located south of the young parasitic cone, Mount Bur Ni Geureudong. The Mount Bur Ni Telong area contains potential geothermal energy sources, as hot springs and fumaroles indicate. However, the information on Bur Ni Telong's geothermal prospect is still limited. Therefore, this study aims to develop a subsurface structural model of the geothermal system using gravity data. The subsurface geological structure was determined using density calculations based on residual gravity anomalies, calculated using the moving average method. The 2D modelling results showed that the system is controlled by normal faults associated with hot spring activity at the surface. This section indicated that water from Mount Bur Ni Telong in the western part of the study areas infiltrates the subsurface, where it is heated and then flows upward as hot springs that emerge at the surface. Using this interpretation as an initial model of the geothermal system, the best prospect for development is a reservoir likely located northeast of the northwest-southeast-trending normal fault.

Keywords: Gravity anomaly, Subsurface, Geological Structure, modelling Geothermal, Mount Bur Ni Telong,

1. Introduction

Indonesia has many potential energy sources, and various available energy sources are currently used to meet domestic and foreign energy needs. Some of the main energy sources in Indonesia are fossil energy, such as natural gas, oil, and coal [1], [2]. Fossil fuels are non-renewable resources that contribute to high carbon emissions, causing environmental degradation [3]. Therefore, most of these resources are only available in limited quantities in Indonesia. In anticipation of future fossil fuel limitations, finding renewable alternative energy reserves is necessary. Aceh province is a part of Sumatera Island in Indonesia, which has nearly 20 geothermal energy sources with four active volcanos [4, 5].

The Aceh province contains enormous energy potential that could be optimized to produce power for the needs of the region. The main energy sources in Aceh are clean and environmentally friendly sources, including hydropower and geothermal energy, which can

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potentially develop electrical future power plants [5, 6, 7]. Regarding previous research [8], Aceh has 17 locations with geothermal potential, with a total potential of 1,115 MWe (megawatts electric). As a renewable energy source that is also environmentally friendly, geothermal energy has the potential to be an alternative to nonrenewable fossil energy sources and to reduce environmental impacts in the form of CO₂ and other greenhouse gas emissions. Therefore, developing geothermal energy has a strategic value in reducing fossil energy use, which means that it can potentially reduce foreign exchange transactions for financing energy imports, especially fuel oil, and can reduce the environmental impacts from the exploitation of fossil energy.

The area within Aceh that contains geothermal energy sources is the Simpang Balik area, which is close to Mount Bur Ni Telong, Bener Meriah Regency, Aceh. Mount Bur Ni Telong is one of the many active volcanoes in Aceh, Indonesia, and is part of the Bukit Barisan volcanic mountain chain located approximately 50 km northeast of the Sumatra fault. Mount Bur Ni Telong is the youngest type A stratovolcano in an old volcanic complex consisting of Mount Salah Nama, Mount Geureudong, and Mount Papanji, which continues to display magmatic activity and produce geothermal energy, as evidenced by the presence of hot springs and fumaroles. A heat source at the depth of the area near the manifestation has been observed with a thermal anomaly with a high LST value, indicating conduction heat flow occurring below the geothermal surface [9]. However, Bur Ni Telong is one of the volcanoes in Aceh with no accumulated eruption intervals, so it does not have a fixed pattern that reflects the recurrence period of the eruption [10]. Bur Ni Telong in Aceh contains geothermal features with a potential of 100 MWe (megawatts electric) in speculative resources [8]. However, these geothermal resources have not been maximally utilized, and information regarding the geothermal system in Bur Ni Telong is very limited. Gravity surveys are a geophysical exploration tool used in geothermal prospecting to identify high-temperature geothermal reservoirs that contain fluid-trapping structures. This method can distinguish the density of a material from that of its surrounding environment, thus illustrating the subsurface structure. Gravity methods are highly suitable for studying subsurface geological structures in the Bur Ni Telong geothermal prospect area.



Figure 1: The location of the study area

Several geothermal exploration studies have been conducted in Bur Ni Telong, including magnetic methods applied to geothermal investigation [8], a study of how geological structures give rise to geothermal features in Bur Ni Telong based on geology and resistivity surveys [11], an analysis of the geothermal potential based around fault zones [12], a study using remote sensing techniques [9, 13, 14], interpretation of satellite gravity data to delineate structural features connected to geothermal resources [15], and mapping the fault structure surrounding the area by using high-resolution global gravity [16]. In this paper, we present the results of a gravity survey to develop a subsurface structural model of the geothermal system based on gravity data. A map of the study area is shown in Figure 1.

2. Geological Setting

The tectonic setting of Bener Meriah is part of the Sumatra tectonic regime, which consists of three tectonic systems: the Sumatra subduction system, the Mentawai fault system, and the Sumatra fault system (SFS). Thus, the structures developed in Bener Meriah display the same pattern as those found throughout Sumatra. The fault structure occurs as segments along with young Quaternary volcanic cones that lie along the fault line, one of which is the volcanic cone of Mount Bur Ni Telong [17, 18].

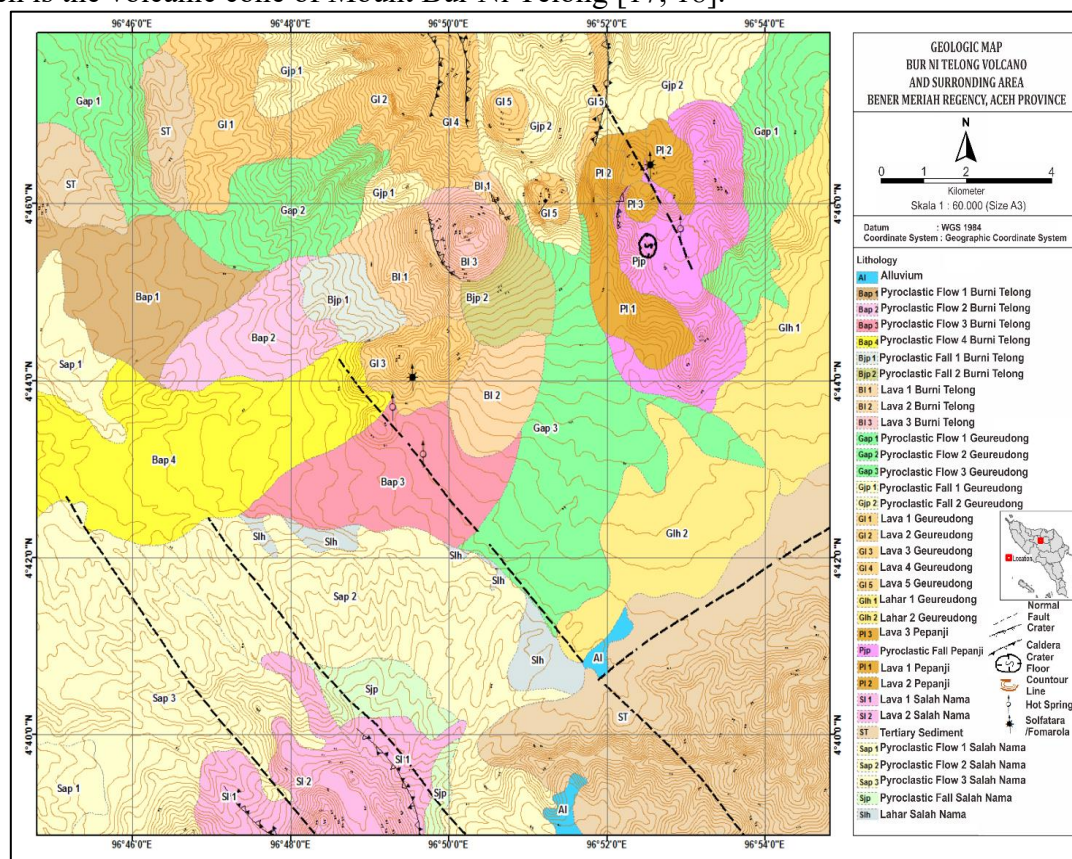


Figure 2: Geological map of Bur Ni Telong, Aceh, Indonesia

According to the research area (Figure - 2), a volcanic complex has several volcanic cones, such as the Burni Geureudong and Burni Telong volcanic cones. The geological structure of Bur Ni Telong consists of a caldera at the top of Mount Salah Nama and Mount Geureudong. A crater is located at the top of Mount Bur Ni Telong and Mount Papanji, and the faults in the Bur Ni Telong area are normal faults that formed after the host rock had fully cooled and solidified. The Geureudong geothermal field is also crossed by several faults,

including those near the geothermal manifestations. The fault is suspected to form a circulation of geothermal fluid that flows to the surface [15]. Generally, the faults in the study area are oriented northwest-southeast and northeast-southwest. According to DEM data and Rose Diagram analysis, they obtained more than 300 alignment structures known northwest-southeast as the dominant direction [14, 19]. This is further corroborated based on the high-quality seismicity distribution that the Burni Geureudong Fault strikes ENE-WSW, which is associated with the Lampahan Fault as a conjugate fault. In addition, the sinistral fault with the same strikes was known as the Burni Telong Fault, which is also indicated by the digital elevation model (DEM) [17].

The rocks found in the study area can be divided into rocks of volcanic and nonvolcanic origins. Volcanic rocks consist of pyroclastics, lava, and lahar deposits. In contrast, nonvolcanic rocks consist of old sedimentary rocks that have mostly been converted to quartzite, hornstone, and meta-limestone, constituting the basement rocks below the volcanic. Data from the corroborating wells suggest the sedimentary source of Bur Ni Telong has been deposited on the foreshore adjacent to the volcano, where magnetic material with black, rounded volcanic minerals has been identified [20]. The Bur Ni Telong volcanic morphology unit displays cone-shaped hills and slopes built by volcanic rocks in lava and pyroclastic material with pumice and igneous rocks of andesite–dacite compositions. The Bur Ni Telong unit contains the youngest rocks among the other Holocene-age volcanoes. Generally, the rivers here exhibit sub-dendritic flow patterns [21].

The geological analyses in Bur Ni Telong indicate that geothermal manifestations occur at the foot of Mount Bur Ni Telong due to the geological structures that cut through the area, including the fault structures and the geological fault plane [11]. The geothermal features in Bur Ni Telong include solfatara/fumaroles, kaipohan, and hot springs [8, 11, 22]. Outcrops of altered rock consist of manifestations (sulfur, skis mica, quartz, and sandy tuff), and kaipohan occurs where gas is discharged from Mount Bur Ni Telong, with no heat anomalies and a temperature of 22°C [11]. Furthermore, hot springs discharge from a basal surface at the foot of Mount Bur Ni Telong in two locations with different temperatures of 44°C–67°C [8] with pH ranging from 5.3 to 5.5, which is slightly acidic, indicating marginally more H⁺ than OH [11] and pH 6.5 to 7, which is nearly neutral and has total dissolved solids values ranging from 1500 to 2100 ppm (parts per million) [8]. According to [22], this solfata/fumarole field is located on a small hill in a coffee plantation area, which is seen from a distance in the form of whitish rock alteration marks. When seen up close, there are several points where thin white solfata smoke comes out, and as it approaches, there is a rumbling sound and a slight smell of sulfur.

The stratigraphic sequence in this volcanic complex from oldest to youngest is as follows [21, 23]:

- Sedimentary rocks (ST) are the oldest tertiary units, consisting of quartzite, hornstone, claystone, and meta-limestone.
- The Mount Salah Nama or Silih Nara (S) unit, in the Pleistocene Mount Silih Nara area, consists of pyroclastic flows and lava containing pumice, andesite and dacite, respectively.
- The Geureudong Unit (G) contains old rock produced by the volcano of the same name with the widest spatial distribution of all related volcanic units. This unit consists of pyroclastic flows and lava, with igneous andesite, dacite, and pumice. The age of this unit is Pleistocene.

- The Pepanji Unit (P) is Pleistocene in age and is located in Mount Pepanji, a volcanic complex that partially forms several lava cones and craters. The rock produced by this volcano consists of lava and pyroclastic falls with andesite lava.
- The Bur Ni Telong (B) unit, located in the Bur Ni Telong area, is the youngest rock among the volcanic units and is the Holocene. Various rock types resulted from several eruptions of lava and pyroclastic flows with pumice and rocks of andesite–dacite compositions. Corroborated by the results of MASW measurements that show Vs value data that varies from the surface to a depth of 30 meters, which has been identified as pyroclastic flow deposits.
- Alluvium (A) is in the form of river deposits still being deposited. This unit consists of loose chunks of igneous rock, sand, and mud [21, 23].

According to the three cross-sections of the conceptual model, the gravity method by [24], the andesite lava layer has a relatively low density compared to other layers; hence, this layer can be considered a rock layer that dominates the Burni Telong mountain geothermal reservoir. Conceptually, based on geology, low-density rocks tend to have high porosity values. Porosity is directly proportional to permeability. One of the causes of porosity and permeability is the detection of faults around the area. Near the crest of this volcano, there is a remnant of the crater wall in the center of which there are deposits of dacitic lava, while on the slopes and foothills of this mountain, pyroclastic deposits and andesitic lava are found, which partially cover the Salah Nama and Geureudong products. The distribution of these product deposits is generally towards the south and west because it is a relatively lower area compared to other places that are still slopes of the volcano [25].

3. Gravity Anomalies (Bouguer Anomaly)

Geophysical methods map subsurface structures and can be performed as an initial step in exploration surveying. Geophysical surveying does not eliminate the need for sampling and drilling [26]. However, geophysical prospecting can reduce the overall cost. It can still improve the quality of the investigation by targeting the anomalous areas with the properties being sought and providing data needed to support the interpolation of subsurface conditions and sample locations. It also has the advantage of surveying a large area quickly at an affordable cost [27].

Geothermal exploration uses geophysical surveys to map heat sources, reservoir areas, fluid movement zones, and available geothermal energy potential [27, 28]. Geophysical anomalies in a geothermal prospect area are usually generated by a contrast in the physical properties of the rock or fluid in the reservoir with the surrounding area. One such physical property is a contrast in subsurface density, which is a target in geophysical exploration using gravity methods. This method is generally used to provide information regarding subsurface structures in geothermal systems, such as detecting faults and rock intrusions, and it can help determine the geothermal sources. Then, the porosity and permeability of rocks are affected by the alteration process, which also changes the density of rocks in the alteration zone, affecting the gravity anomaly response [28, 29]. Typically, geothermal systems located in orogenic areas have a low gravity anomaly response, indicating low rock density; hence, the presence of geothermal reservoirs can be identified.

A gravity anomaly is the difference between the observed gravity (after tidal correction and drift correction) and theoretical gravity from the specified Earth model. Obtaining the value of the subsurface density variation alone requires eliminating all factors that are not related to the subsurface geological density distribution [27, 30]. After the data reduction process, the resulting value is the Bouguer anomaly (BA) map [31]. Lateral variations in subsurface

density relative to the topographic reference cause this anomaly. The BA map is obtained through the Eq. (1) below [27, 32, 33],

$$BA = g_{obs} - (g_N - FAC + BC - TC) \quad (1)$$

g_{obs} is the observed gravity value obtained from field measurements using a gravimeter. The calculation of the theoretical gravity value begins with the computation of normal gravity, denoted as g_N , on the reference ellipsoid using the GRS80 model. Subsequently, this ellipsoidal gravity model is projected to the surface through the free-air correction (FAC), which accounts for a reduction of gravity of 0.3086 mGal per meter above the surface. To incorporate the effect of subsurface rock mass into the theoretical model, a Bouguer correction ($BC = 0.04191\rho h$) is applied uniformly in an infinitely horizontal direction up to a topographic height h . Additionally, terrain correction (TC) is performed to remove excessive mass effects introduced by the Bouguer correction or to compensate for missing mass due to topographic variations. The subtraction of the theoretical gravity model from the observed gravity results in the gravity anomaly, representing the subsurface mass distribution without the influence of non-geological factors [27, 29, 30, 32, 33].

4. Gravity Data Analysis and Interpretation

4.1 Data feasibility analysis and calculation of complete Bouguer anomaly

The gravity method data collection was conducted using a Scintrex CG-5 gravimeter. The study involved a grid system comprising 66 measurement points (gravity observed station), with an average distance of 500 meters between each station, covering a research area of approximately 15 km². One way to evaluate the data quality is to observe the drift value, where good quality data will have a drift value of less than 30 μ Gal. Our calculated drift values in the study area showed that 30% of the field data have a drift value below 30 μ Gal. Furthermore, a data feasibility analysis compared the elevation values with the observed gravity anomaly values (g_{obs}).

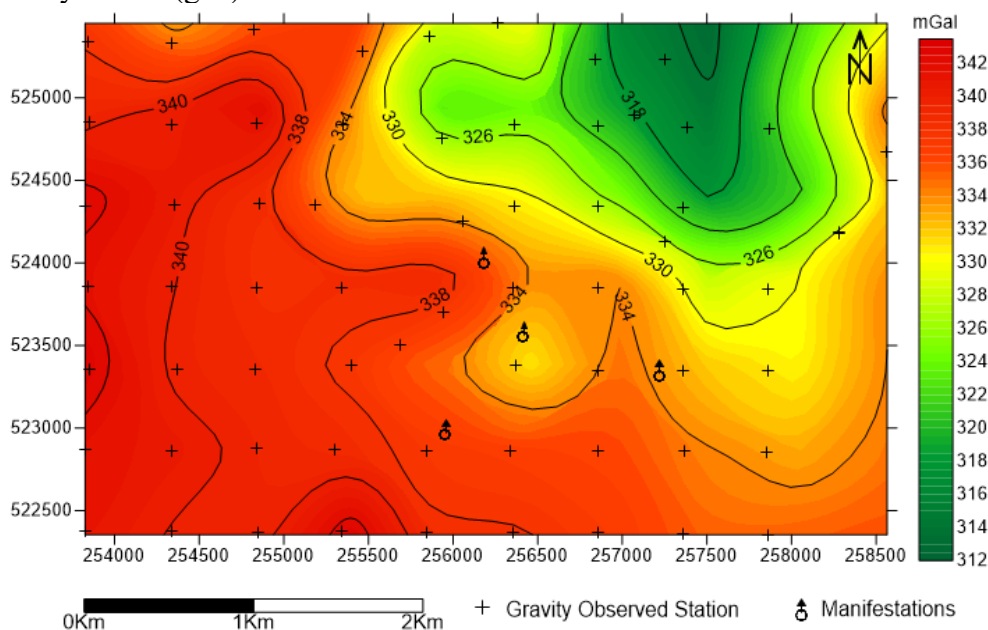


Figure 3: The Bouguer anomaly map of the Bur Ni Telong Area (density 2.7 gr/cm³)

To determine the BA, the gravity data were corrected (as shown in Figure 1). The corrections used in processing the Bur Ni Telong area data include drift, tide correction, latitude correction, free air correction, Bouguer correction, and TC.

The map of the BA in **Error! Reference source not found.** shows that the dominant structure has a northwest-southeast trend, which separates the region of low anomalies in the northeast from high anomalies in the southwest. The low anomaly values represent the presence of a low-density mass source, whereas the high ones represent the presence of a high-density mass source.

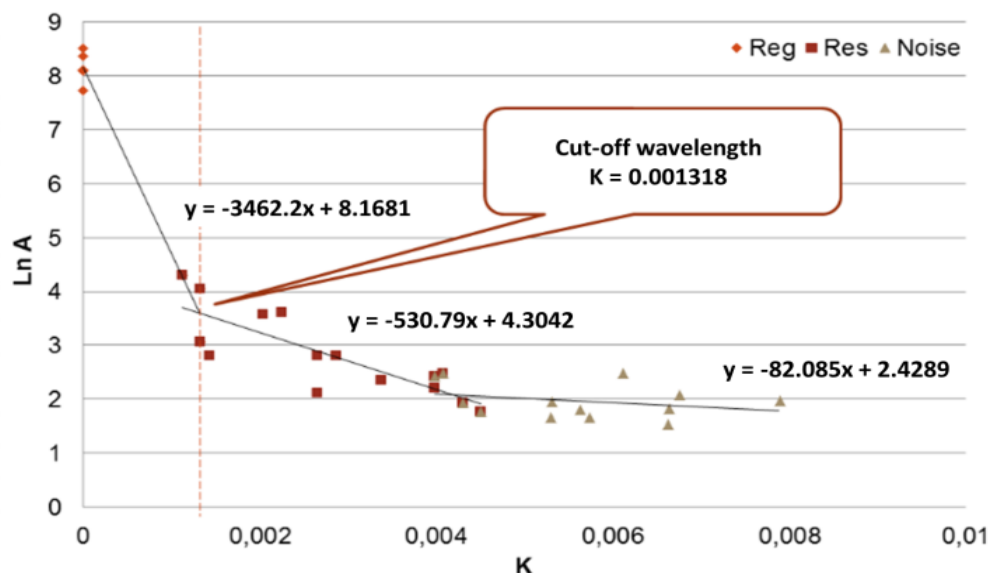


Figure 4: Relationship between amplitude (A) and wavenumber (k) based on spectral analysis.

4.2 Spectral analysis

The results of a spectral analysis of several lines from a scatterplot of wavenumber (k) and amplitude (A) are shown in **Error! Reference source not found.**. The curve of the amplitude (A) and wavenumber (k) plot (**Error! Reference source not found.**) shows how the cut-off wavenumber was obtained, which is the intersection of the regional and residual linear functions used to determine the width of the filter window in the gravity anomaly separation process. The gradient of the scatter curve was used to estimate the depths of the residual anomalies and regional anomalies.

4.3 Regional and residual anomaly separation

The moving average method was applied to determine the separation of regional and residual gravity anomalies. The regional anomaly map in Figure (a) displays a pattern of anomalies that trend in the northwest-southeast direction. Furthermore, the anomaly values are lower toward the northeast, near the top of Mount Bur Ni Telong. The residual anomaly map in Figure (b) shows low anomalies with negative values in the northeast and high positive anomalies outside that area.

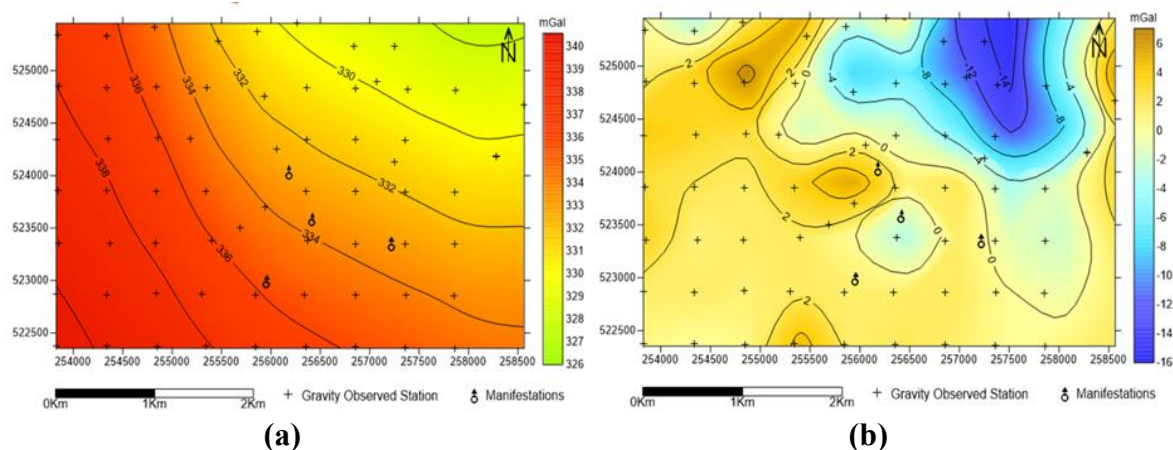


Figure 5: Anomaly separation: (a) regional and (b) residual gravity anomaly map of the study area.

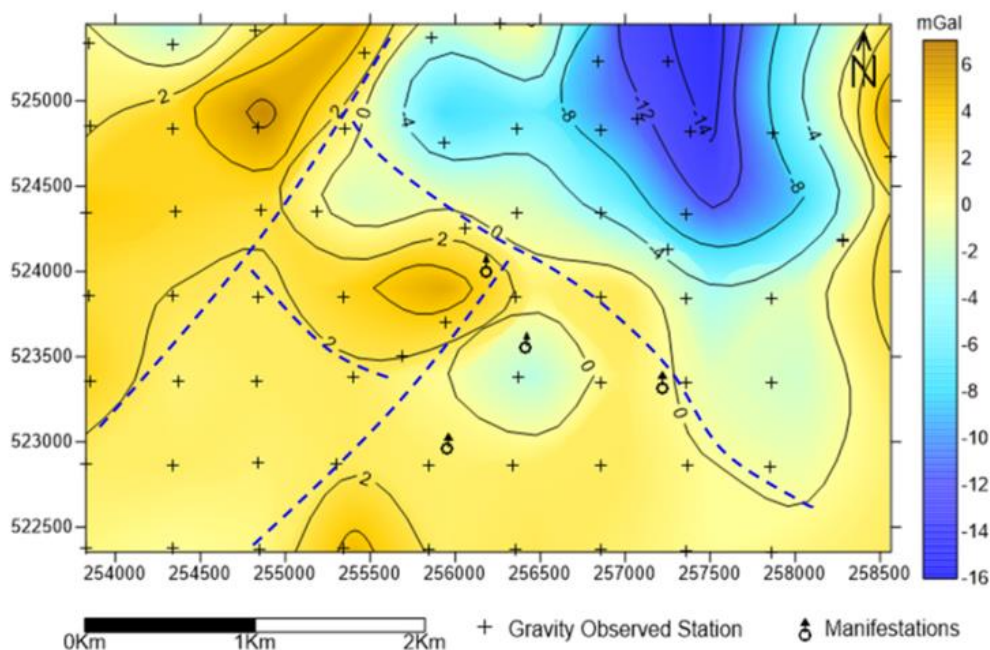


Figure 6: Interpretation of fault structures on a residual anomaly map

5. Structure Trend Analysis

Based on the residual anomaly map, the detection of fault structures was interpreted, as shown in Figure Error! Reference source not found.. The fault structures lie northwest-southeast and northeast-southwest. The northwest-southeast fault separates regions of positive and negative anomalies. Compared to the geological map of Mount Bur Ni Telong [14], a continuity with the Peparu faults can be seen. The pattern of the interpreted fault structures from the analysis of the residual anomaly map exhibits the same pattern as the structures that occur elsewhere in Sumatra, where the SFS has been influenced. The northwest-southeast trending fault structure is aligned with the trend of the Great Sumatra Fault, and the northeast-southwest trending fault is aligned with the maximum horizontal compression force in the Bur Ni Telong area.

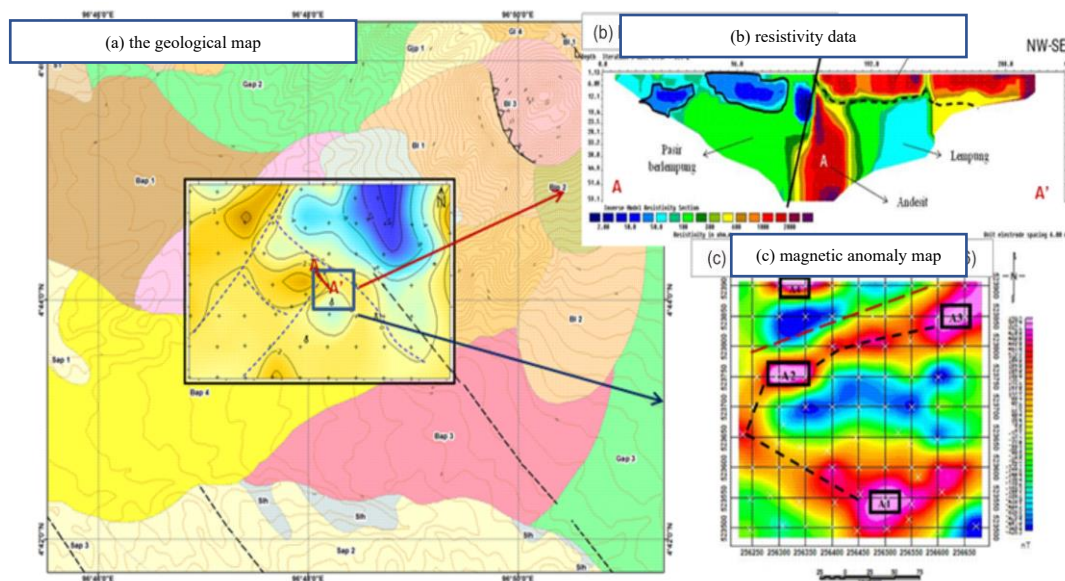


Figure 7: Comparison of gravity data in the study area with (a) the geological map [14], (b) resistivity data [11], and (c) magnetic anomaly map [34].

The faults found in the study area were normal fault [21]. The study area has geothermal features such as solfatar/fumarole, kaipohan, and hot springs. The appearance of these features is associated with a fault, indicating the presence of high-permeability reservoir rocks below the surface. A comparison of resistivity [11] and magnetic [34] data from the study area shows a linear trend controlled by the fault structure, which is also seen in the southwest-northeast trend of the gravity data. This is illustrated in Figure 7.

6. Modelling

Based on the analysis of the fault structures and geological map of Bur Ni Telong, lines 1, 2, and 3 cross the faults and three lithologies (Figure): B.jp.1, which is a pyroclastic fall, and B.ap.2 and B.ap.4, which are pyroclastic flows and are the main units of Bur Ni Telong. Generally, the study area contains igneous rocks in the form of andesite and basalt, which is known based on silica content analysis with a value range of 54-59.88wt% [35].

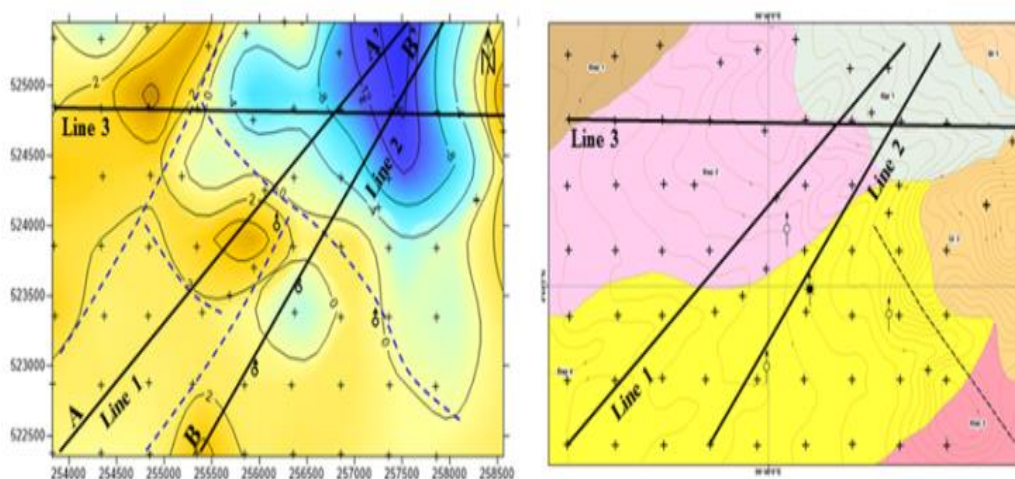


Figure 8” Cross-section line for forward modelling.

According to the interpretations of the forward modelling results (Figure , Figure 3, Figure 4, and Table 1), lines 1 and 2 contain the following four layers of [21]:

- B.jp.1: a thin layer of pyroclastic fall deposits having a density contrast of -0.82 gr/cm^3 . Stratigraphically, this pyroclastic fall is covered by B.ap.2 and consists of fine and coarse ash loops and lapilli-sized rock fragments.
- A thin layer of B.ap.4 has a density contrast of -0.34 gr/cm^3 and is a pyroclastic flow. The components of this rock include fragments of andesite, dacite, and sandstone rocks that partially cover the pyroclastic flows of B.ap.2. This rock outcrop is not easily identified because it has been strongly weathered in the southwest.
- The B.ap.2 layer is interpreted as a pyroclastic flow with a density contrast of -0.12 gr/cm^3 . Rocks in this layer consist of fragments of andesite, dacite, and pumice. Stratigraphically, this rock unit is covered by B.jp.1 in the northeast.
- Layer G.I belongs to the Geureudong unit and has a variable density contrast, which is approximately -1.08 gr/cm^3 (G.I-a) in the northeast on both lines with a density contrast of 0.25 gr/cm^3 (G.I-b) and -0.13 gr/cm^3 (G.I-c) in the southwest. The layers of the Geureudong unit are thicker than the other layers and are the oldest rocks found in the study area.

Table 1: Lithology based on interpretations of a forward model

Symbol	Lithology		$\Delta\rho \text{ (gr/cm}^3\text{)}$
B.jp.1	Bur Ni Telong unit	Pyroclastic fall of Bur Ni Telong 1	-0.82
B.ap.4		A pyroclastic flow of Bur Ni Telong 4	-0.34
B.ap.2		A pyroclastic flow of Bur Ni Telong 2	-0.12
G.I-a	Geureudong unit		-1.08
G.I-b			0.25
G.I-c			-0.13

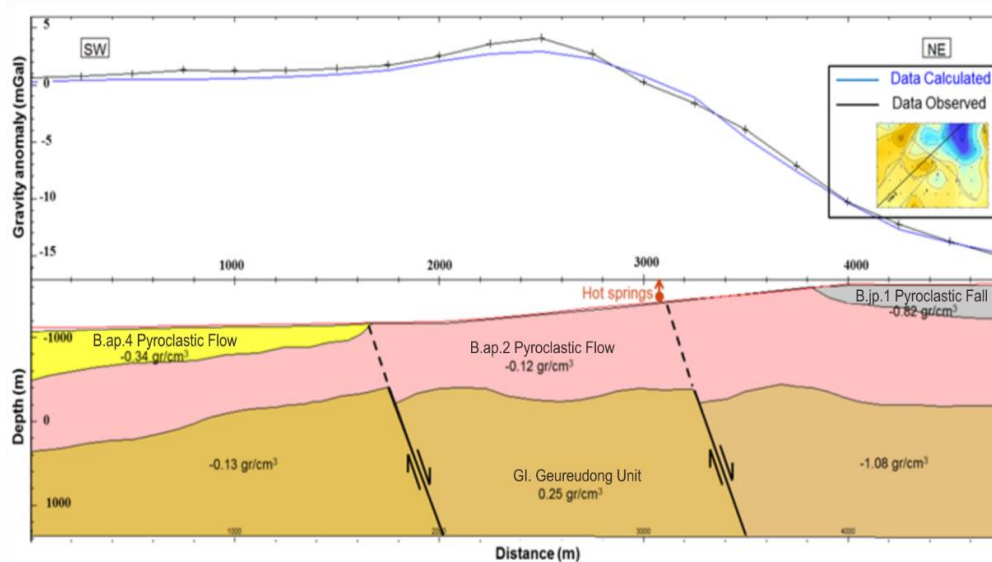


Figure 9: Geological cross-section of line 1 from A-A'.

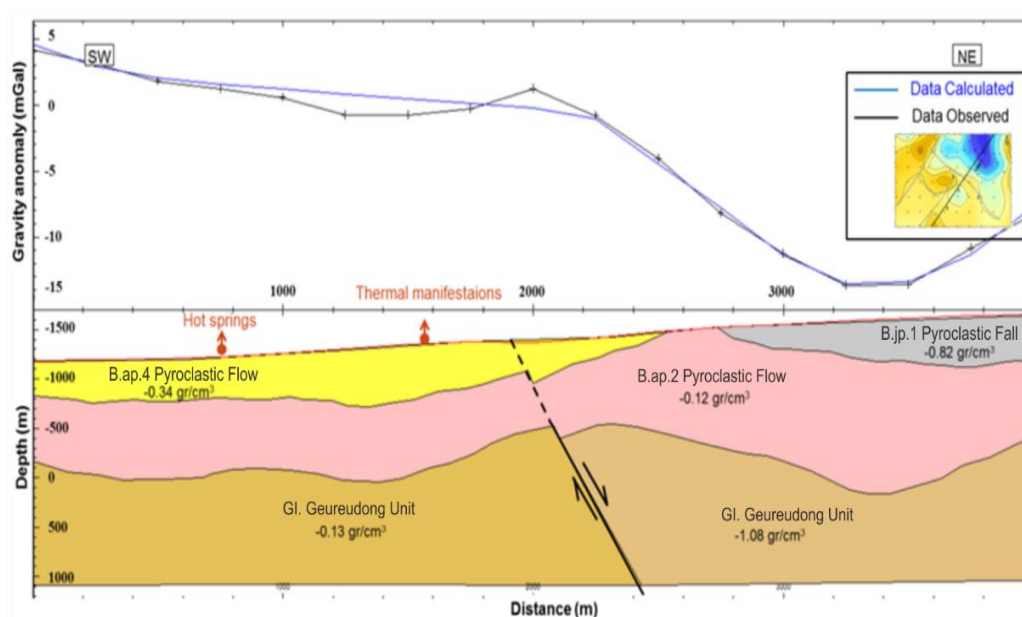


Figure 3: Geological cross-section of line 2 from B-B'.

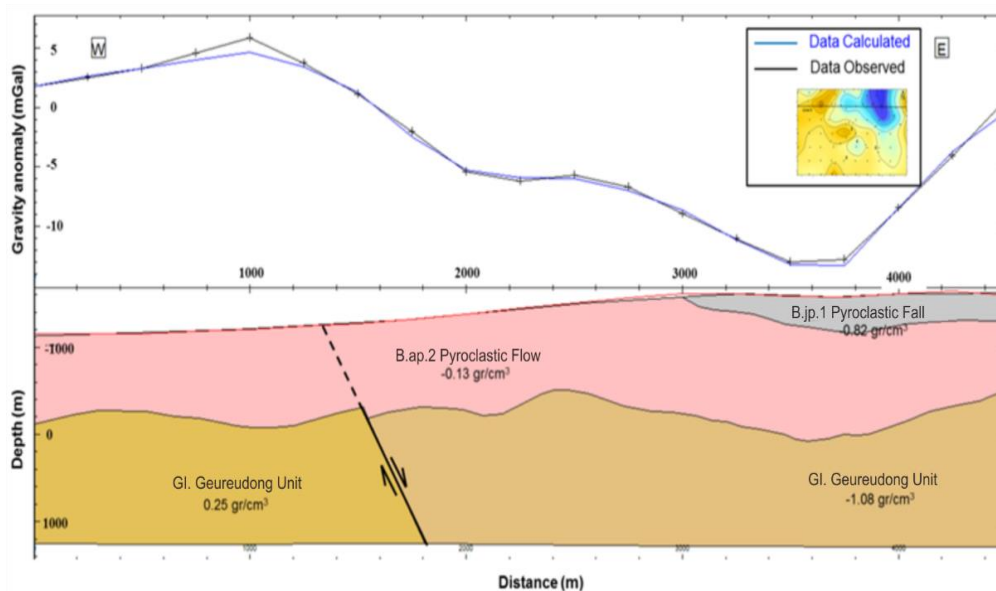


Figure 4: Geological cross-section of line 3 from C-C'.

Meanwhile, the line 3 subsurface density model only consists of 3 rock lithologies, namely B.jp.1, B.ap.2, and G.I. B.jp.1 lithology in the form of pyroclastic fall is deposited in the eastern part of the line and covers a small part of B.ap.2 lithology which is mostly visible on the surface. In addition, the G.I lithology, namely the Geureudong Unit, is the lowest layer of the subsurface model and is affected by normal faults that cause discontinuity of this lithology.

7. Analysis of Conceptual Geothermal System Model

An analysis of the three cross-sectional lines indicates a large anomaly that is assumed to represent the pyroclastic flow B.ap.2, which has a density contrast value of -0.12 gr/cm^3 on the surface and a density contrast value of 0.25 gr/cm^3 at bedrock, suspected to belong to the Bur Ni Geureudong unit. The low anomalies northeast of the study area were interpreted as the Geureudong unit with a low-density contrast of -1.08 gr/cm^3 . A low density in this area

was predicted because of faults or fracture structures and hydrothermal fluid flow, which increases porosity along with alteration processes, thereby decreasing the density of the original rock, as well as surface geothermal features.

The interpretation of the geothermal system in the study area (Figure, Figure , Figure) was constrained by a normal fault associated with hot spring activity at the surface. The low-density Geureudong unit is assumed to constitute part of the reservoir zone of the Bur Ni Telong geothermal field. This hydrothermal fluid-carrying layer is located in the northwest part of the normal fault. The reservoir fluid is assumed to flow upward in a zone near Mount Bur Ni Telong, and after being heated, the fluid exits through the fault, which acts as a high-permeability outflow zone. Furthermore, the B.ap.2 layer in the northwest is assumed to lie in the overburden zone of the Bur Ni Telong geothermal system.

This geothermal system (Figure) is characterized by fluid infiltration from Mount Bur Ni Telong in the southwest of the mountain that flows beneath the surface, is heated, and flows upward through the fault or fractures to form bicarbonate-type hot springs. This type of bicarbonate spring has a higher concentration of HCO_3 than chloride and sulfate. This is caused by the formation of CO_2 gas and fluids with relatively high temperatures, followed by condensation of water vapour into groundwater (steam-heated water) that becomes diluted by hot fluids that react with groundwater (meteoric water) and the surrounding rocks near the surface—the hot springs in the Bur Ni Telong area form in a shallow area with lateral fluid flow.

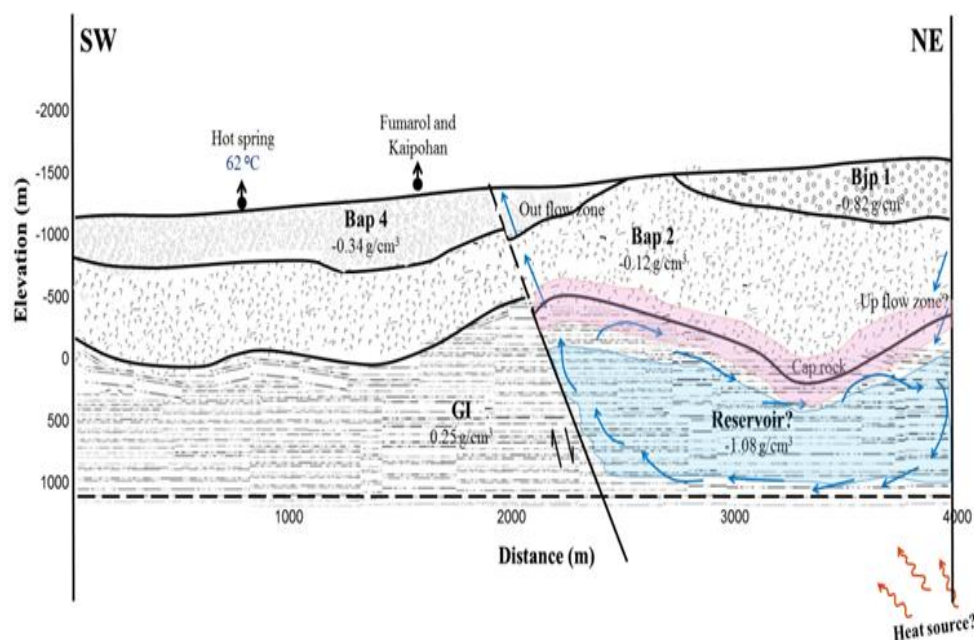


Figure 5: Initial conceptual model of the geothermal system along the line 1 profile

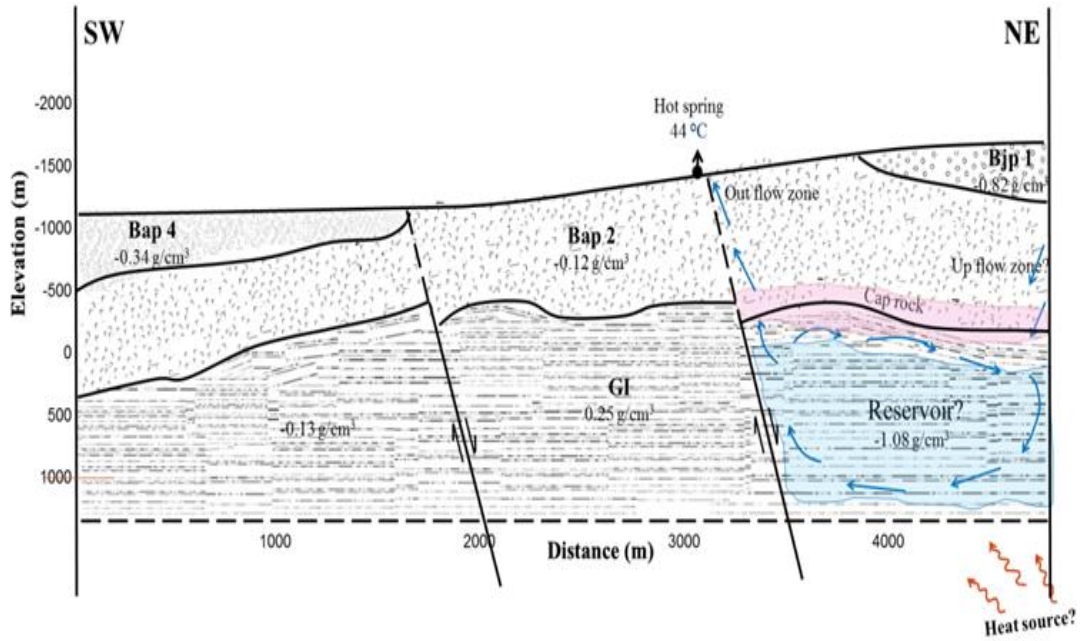


Figure 6: Initial conceptual model of the geothermal system along the line 2 profile

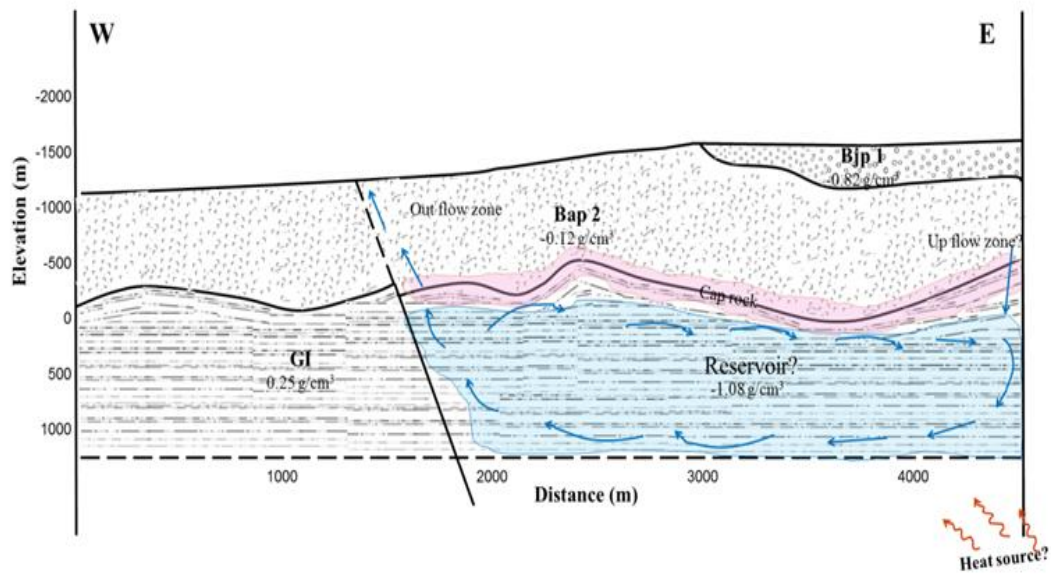


Figure 7: Initial conceptual model of the geothermal system along the line 3 profile

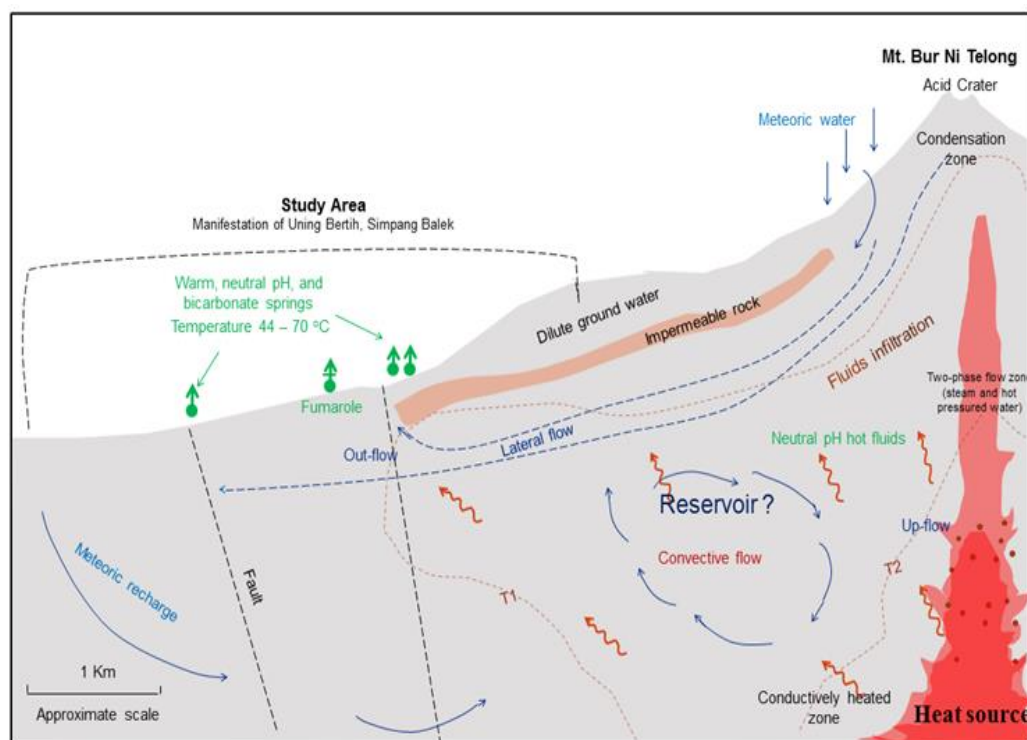


Figure 8: Schematic diagram of the Bur Ni Telong geothermal system relating the research area to the main heat source concerning the ideal model from [36, 37, 38, 39, 40]

The low-density Geureudong units were assumed to be part of the Bur Ni Telong geothermal reservoir zone in the northwest part of a normal fault oriented in a northwest-southeast direction with an estimated reservoir depth of approximately 1500 m below the surface. Furthermore, the area is considered an upward flow zone with high permeability for fluid and thermal outflow directly below the reservoir. B.ap.2 is assumed to form the cap rock for the reservoir beneath it.

The study area contains hot springs with a surface temperature of 44°C–67°C. These hot springs appear clear or white and do not exhibit a sulfurous smell. The pH of the water in the hot spring ranges from 6.5 to 7 [8, 11], which is nearly neutral, and has total dissolved solids values ranging from 1500 to 2100 ppm (parts per million). From these data, the hot springs in the Mount Bur Ni Telong area were found to have good water quality with low salinity, low chloride content, and little sulfur, and they are not corrosive to metallic objects. Based on the analysis of Bouguer data, it can be concluded the gravity method is effectively used to study the characteristics of the Bur Ni Telong volcano, which has the potential to be exploited for electrical energy. In addition, derivative analysis of gravity measurements covers all volcano areas, which can be done via ground and satellite surveys. It can map the distribution of faults associated with hydrothermal systems and their relation to the mechanism of volcano formation from regional fault tectonic activity [16, 41, 42, 43].

Still, because Bur Ni Telong is an active volcano in an area with high seismic activity due to its location on the Sumatra fault, it also has a high potential for natural hazards. This is an additional consideration for geothermal field development in the Bur Ni Telong area. Suggestions for research in the Bur Ni Telong area include the need for expanded geophysical studies using a wider coverage area and different methods. These methods should be capable of determining depth, delineating reservoir boundaries, and mapping heat sources. Furthermore, conducting a more detailed analysis of geochemical data, including measuring the subsurface temperature in the Bur Ni Telong geothermal area, is essential.

8. Conclusions

As a result of the above discussion, we conclude the following:

- a) According to the BA map, an anomaly value of 312 to 342 mGal followed a dominant structural trend in a northwest-southeast orientation. Values in regional anomaly maps range from 326 to 340 mGal, indicating a low-density mass source in the northeast and a high-density mass source in the southwest. The residual anomaly map suggests a range of values from -16 to 6 mGal, showing the detection of fault structures trending northwest-southeast and northeast-southwest.
- b) Forward modelling of the gravity data produced a subsurface model containing the Bur Ni Telong and Geureudong units.
 - The Holocene-age Bur Ni Telong unit consists of pyroclastic fall layer 1 Bur Ni Telong (B.jp.1) with a density contrast of -0.82 gr/cm^3 , pyroclastic flow layer 4 Bur Ni Telong (B.ap.4) with a density contrast of -0.34 gr/cm^3 , and pyroclastic flow layer 2 Bur Ni Telong (B.ap.2) with a density contrast of -0.12 gr/cm^3 .
 - The Pleistocene-age Geureudong unit (G.I), the oldest rock, has a variable density contrast of approximately -1.08 to 0.25 gr/cm^3 in the northeast and -0.13 gr/cm^3 in the southwest.
- c) The geothermal system in the study area is controlled by normal faults associated with surface hot spring activity. Fluid in this geothermal system infiltrates from Mount Bur Ni Telong in the west to the subsurface and then is heated and flows back up to the surface through faults or fractures as hot springs. It is assumed that the Bur Ni Telong geothermal system reservoir is located in the northeastern part of the normal fault oriented in the northwest-southeast direction.

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