Identification of Potential Prospect Areas Based on Gravity Data Analysis for Danau Ranau Geothermal Working Area

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Abstract. Danau Ranau Geothermal Working Area (WKP) is geographically located in the southwestern part of the island of Sumatra, precisely in the border area between South Sumatra Province and Lampung Province. This area is influenced by the Great Sumatra Fault and is the intersection of the Komering Segment to the north and the Semangko Segment to the south. Danau Ranau Geothermal Field is one of the WKP that is still in the exploration phase and there are no drilling wells or temperature gradient wells. The main purpose of this study is seeking permeability that is related to the existence of geological structures, both faults and fractures filled with fluids that can be a media for heat energy transfer and are the target of this study. To obtain this information, this study was conducted using gravity data analysis with First Horizontal Derivative (FHD), and Euler Deconvolution analysis, to determine the structure below the surface to identify permeable zones, in order to help in the construction of geothermal system and the delineation of area prospects.

Keywords: *Danau Ranau, Euler Deconvolution, Gravity Analysis, FHD*

1 Introduction

WKP Danau Ranau is located in West Lampung Regency, Lampung Province and South OKU Regency, South Sumatra Province (Figure 1) with a WKP area of 8,561 Ha and an estimated estimated reserve of 210 MWe. This area is influenced by the Great Sumatra Fault and is intersected by the Komering Segment to the north and the Semangko Segment to the south. These two segments are thought to have considerable control over the geological structures found in the study area. In addition, the rectangular geometry of Lake Ranau is also interpreted as the effect of movement of the Great Sumatra Fault, as a result of an opening or stepover in the form of a pull-apart basin.

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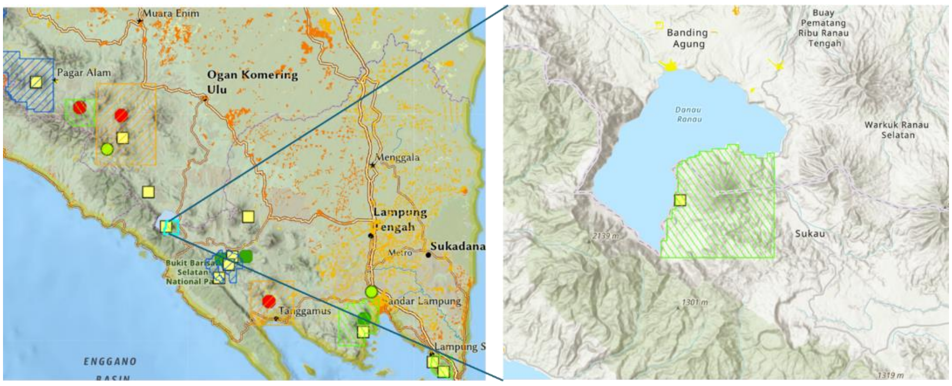

Figure 1 Danau Ranau Geothermal Working Area
(https://geoportal.esdm.go.id/ebtke)

Previous research related to gravity studies has been carried out by the Center of Study Geological Resources (PSDG) in 2004, where there are 286 measurement points (Figure 4). However, the gravity data which was used in the study, does not fully represent the research area. In 2023 PT PLN (Persero) as the owner of WKP acquired additional data at 105 measurement points which has better data distribution and can represent the research area.

In this study, both data PSDG and PT PLN (Persero) will be processed simultaneously, then further and specific analysis will be carried out related to the identification of geological structures through the First Horizontal Derivative and Euler Deconvolution methods.

2 Regional Geology

WKP Danau Ranau is located in the southwestern part of Sumatra Island, which is a contact between the Indo-Australian Plate in the east which subducts under the Eurasian Plate in the west (subduction). The implication of this subduction is the formation of the Great Sumatra Fault. The island of Sumatra is interpreted to be formed by collision and suture from microcontinents in the Late Pre-Tertiary Period (Pulunggono et al., 1992). As a result of the convergent movement of the Indo-Australian Plate which is subducted to the western part of the Eurasian Plate, a subduction zone is produced along the Sunda Trench. The subduction that occurred in the Paleogene resulted in the rotation of the island of Sumatra in the direction of clockwise movement (Barber et al., 2005). The change in the position of Sumatra, which was previously east-west to northwest-southeast, began in the Eocene-Oligocene. The rotation movement indicates an increase in the movement of the Sumatra Horizontal Fault. One of the geometries that can occur in a horizontal fault is an extensional stepover. The Sumatra Great Fault crosses

Danau Ranau area which is basically an extensional stepover along approximately 3 km next to Mount Seminung (Natawidjaja et al., 2017).

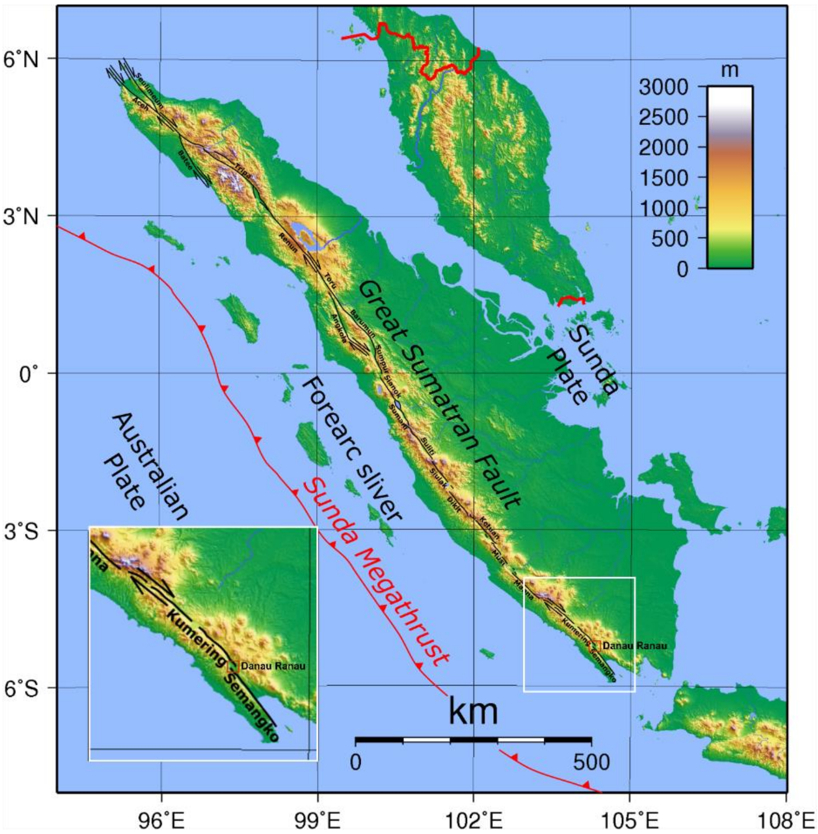

Figure 2 Pembagian segmen dari Sesar Besar Sumatera (Sieh dan Natawidjaja, 2000).

Volcanism on the island of Sumatra is directly influenced by subduction activities between plates accompanied by the movement of the Great Sumatra Fault which is a dextral strike-slip and segmented fault (Sieh and Natawidjaja, 2000). The Sumatra Great Fault is divided into 19 major segments (Figure 2), with the Seulimeum Segment in the northern part to the Semangko Segment in the southern part.

Danau Ranau area is a caldera of Mount Ranau of Pleistocene age that was formed in the Sumatran fault system. The formation of the caldera peaked at the eruption of Tuf Ranau about 0.55 million years ago. Then in the southeastern part of Lake Ranau formed Mount Seminung which is a post – caldera with strato vulkano type (International Association of Vulcanology and Chemistery of Earth’s Interior (IAVCEI, 1973).

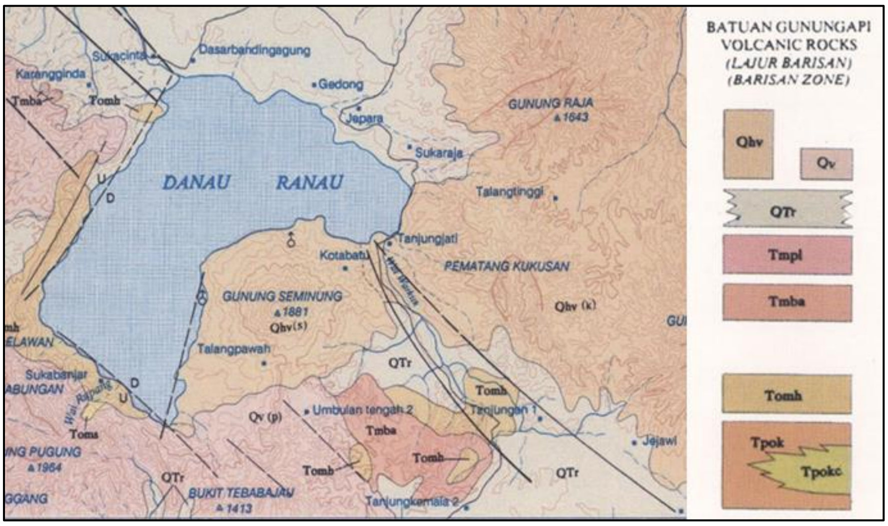

Figure 3 Regional Geological Map Study area (Gafoer et al., 1993)

Based on the Regional Geological Map of Baturaja and its surroundings (Figure 3), the main lithology in the Danau Ranau area is in the form of Volcanic Rocks of Mount Seminung which is located in the southeast of Danau Ranau. Mount Seminung Volcanic Rock is the youngest rock unit in the Danau Ranau area. It is suspected that this rock unit has an important role in controlling the the appearance of geothermal manifestations located around Mount Seminung. Just to the east of the Volcanic Rocks of Mount Seminung, there are Volcanic Rocks produced by Mount Kukusan. The Andesite-Basalt volcanic rocks of Mount Pugung are generally located in the southern and southwestern areas. Altered rocks of the Hulusimpang Formation are located in the western corner of Lake Ranau. The distribution of this formation has a straightness in the northwest-southeast and northeast-southwest directions in the western part of the lake. It is suspected that there is a structural role that controls the existence of this formation. The Ranau Formation is spread across the north, west and southeast of Danau Ranau.

3 Data and Method

In this study, the author processed 2 sets of gravity data that were acquired by 2 different agencies, as well as differences in the collection points and acquisition tools used. The first data is gravity data acquired by PSDG in 2004, where there are 286 measurement points using the La Coste & Romberg gravity meter type

G-802. The next data is data in 2023 which was acquired by PT PLN (Persero) as the owner of WKP to acquire additional data at 105 Measurement Points using the La Coste D-131 Gravity meter. The distribution of measurement points can be seen in figure 4.

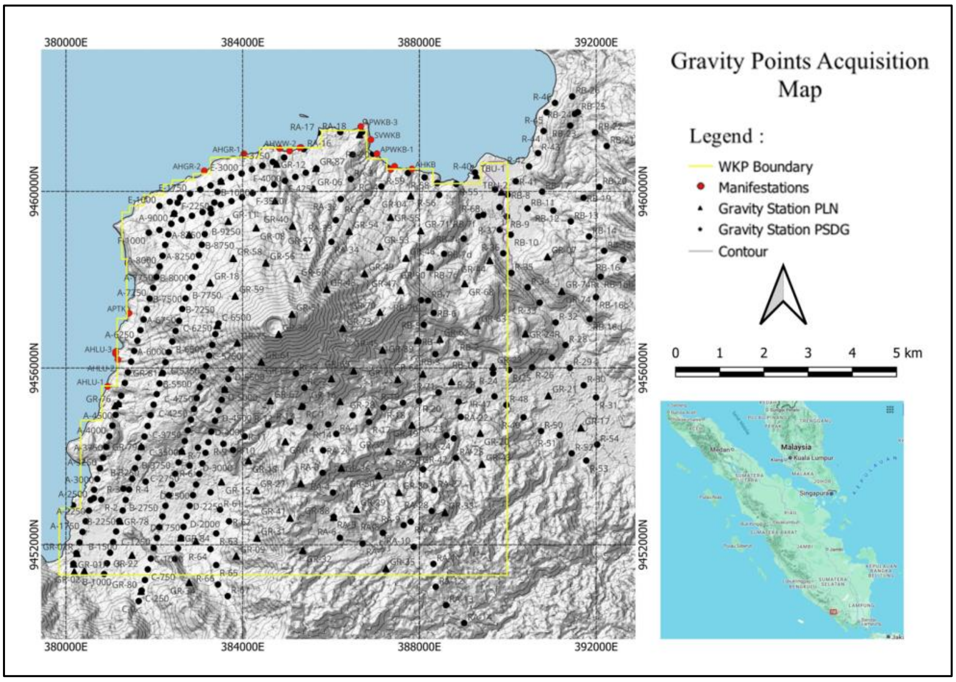

Figure 4 Gravity Point Acquisition Map

The results of gravity readings in the field were then processed by making several corrections, such as tidal correction, drift correction, latitude correction, terrain correction, and bouger correction until the Complete Bouguer Anomaly Value was obtained. After that, regional and residual anomalies are separated to determine shallow and deep anomalies.

In addition to the above data processing, further data processing was also carried out to identify the existence of geological structures under the surface using First Horizontal Derivative and Euler Deconvolution analysis.

However, before further data processing, the data quality is analyzed by the drift value. In this study, it is assumed that good data acquisition quality has a drift value that is relatively smaller than ±0.05 mGal. From PSDG gravity data, there are 59 data that had a drift value higher than ±0.05 mGal and from PLN gravity data there are 16 data that had a drift value higher than ±0.05 mGal.

4 Result and Discussion

The results of *the complete bouguer anomaly (CBA),* as seen in Figure 5, show that the pattern of high gravitational force anomalies is concentrated in the southern part of the study area corresponding with the undulating plateau and the distribution of older rocks. The same thing happened at the northeast end of the study area map. In addition, there is a very high heavy force value closure in the area (Lombok-Sukamaju). The boundary of the high gravitational force anomaly that appears on the CBA map is also very close to the lithological differences and is indicated to provide a conceptual description of the boundary of the Ranau Caldera wall which is estimated to surround the southern part of Mount Seminung. Meanwhile, the medium-low anomaly values corresponded with the distribution of pyroclastic rocks of Mount Seminung products as seen in the conical area of Mount Seminung, to the west and east.

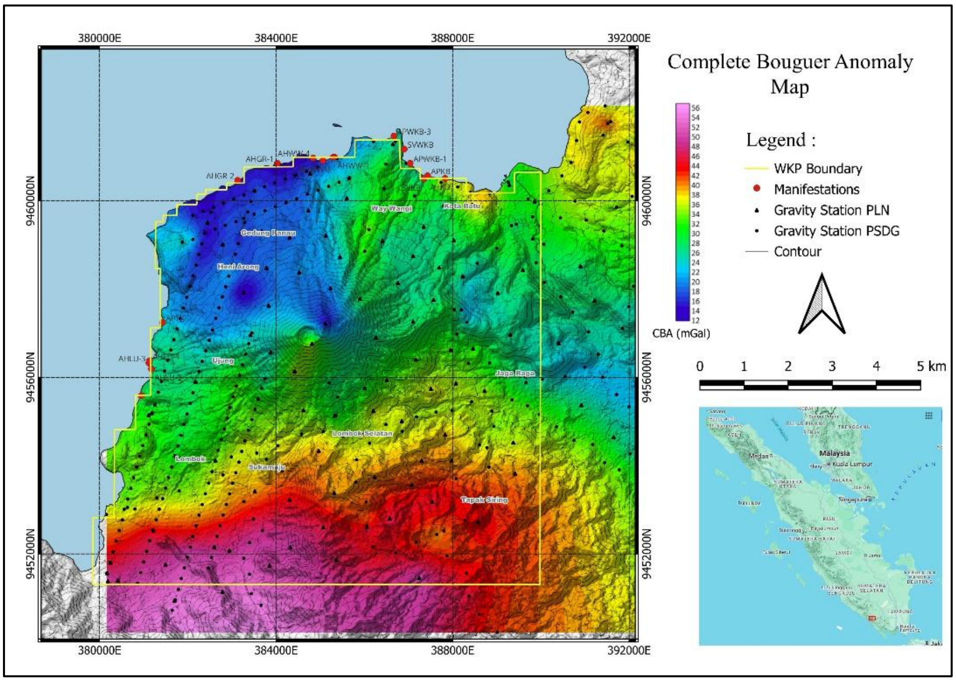

Figure 5 Complete Bouguer Anomaly Map

On the other hand, the regional gravity anomaly map (Figure 6) shows a simple pattern, namely a decrease in the value of the gravity anomaly from the south of the study area to Mount Seminung. The anomaly pattern can represent the source of the anomaly at a deeper depth that correlates with the geometry of the basement in the study area.

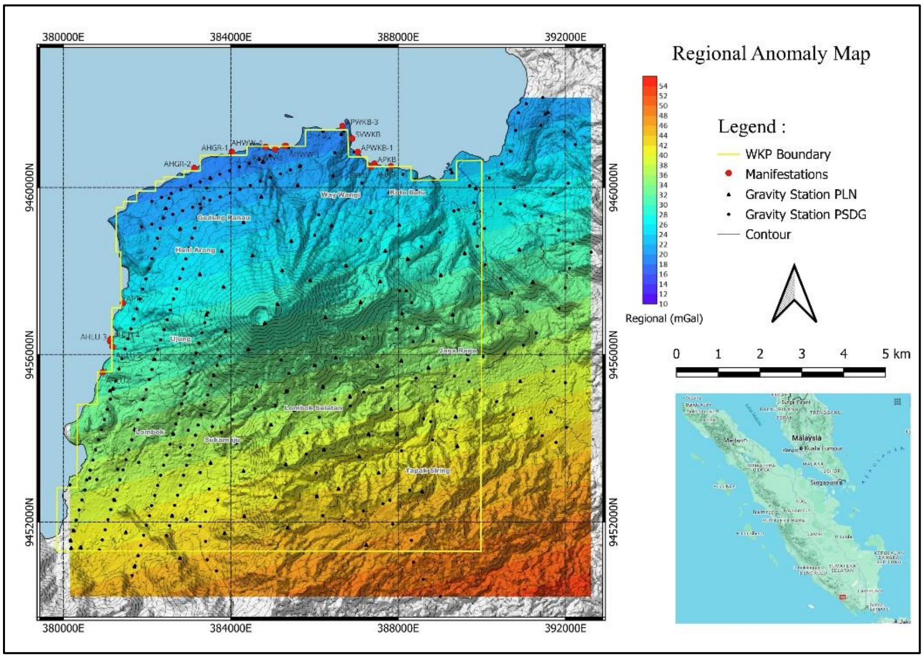

Figure 6 Regional Anomaly Map

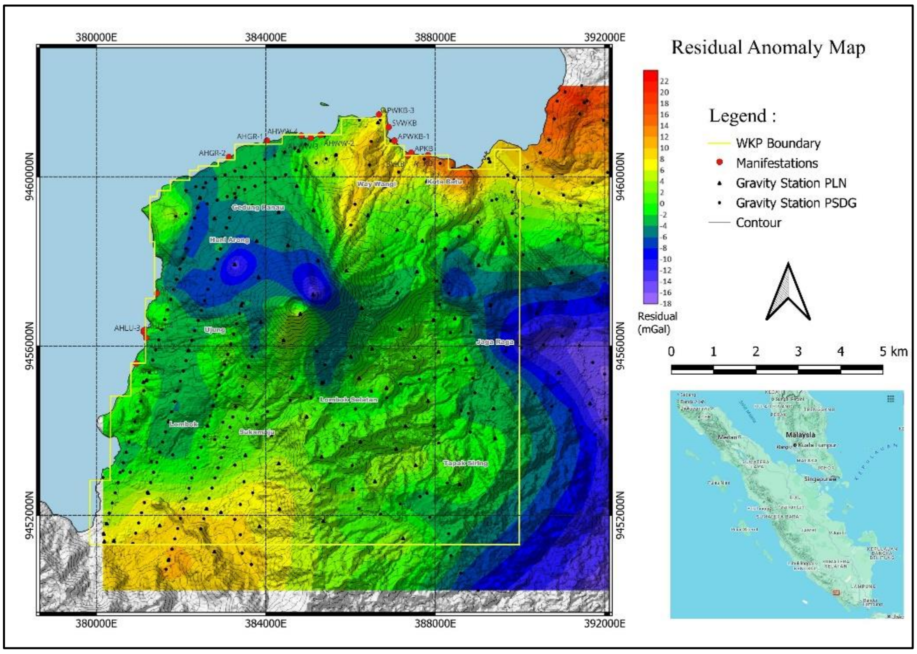

Figure 7 Residual Anomaly Map

The residual gravity anomaly map (Figure 7) appears to sharpen the anomaly pattern caused by shallow features such as the continuation of the high gravity anomaly pattern from Mount Seminung towards Kotabatu, and the low gravity anomaly pattern in the Heni Arong area. This is thought to be due to differences in the type of volcanic material such as the presence of pyroclastic flows or lava flow rock units. The low anomaly pattern appears consistently as in the CBA anomaly map, except in the east of the Tapak Siring area where the low anomaly sharpens. This can be correlated with the presence of depression areas, fault zones, or the distribution of alteration minerals in the area.

For further processing and sharpening of subsurface anomalies and subsurface geological structures, First Horizontal Derivative and Euler Deconvolution treatments are carried out, those map can be seen in Figure 8 and Figure 9.

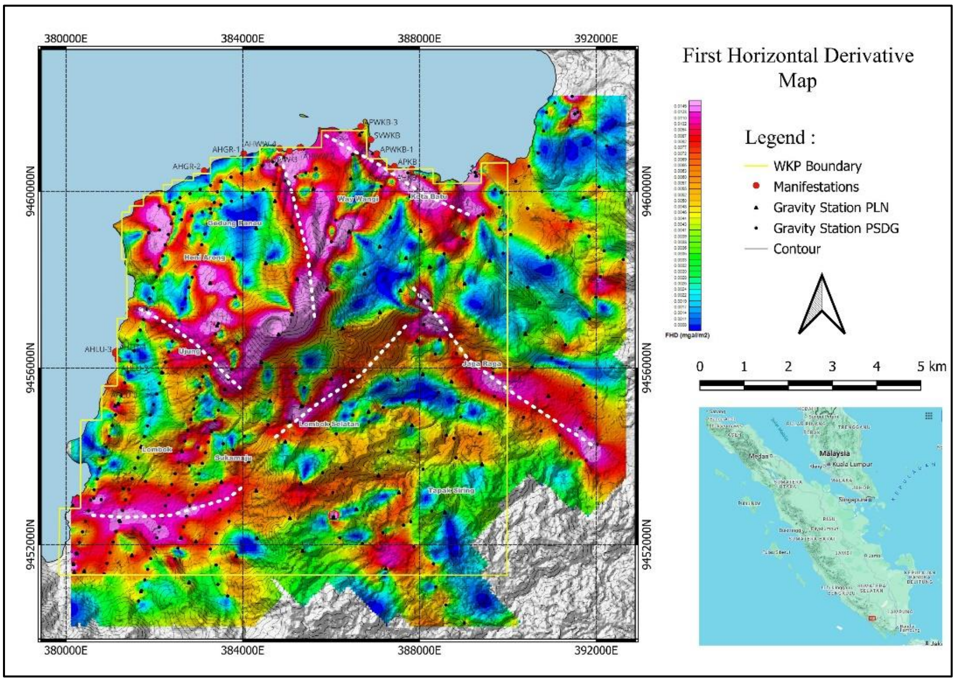

Figure 8 First Horizontal Derivative Map

The geometry of the anomalous bodies in the study area is also sharpened on the FHD anomaly map. In the First Horizontal Derivative Map above, it shows the contrast of density in several places that can be interpreted as a geological structure below the surface, on the map marked by a white dashed line. Some of the straightness seen on the FHD map has a trend in a direction similar to or close to the Sumatra Great Fault, namely NW-SE, especially in the eastern part of the study area where indeed the location is part of the Sumatra Great Fault segment. In some other straights there is a NE-SW direction where this direction is different from the regional fault in the study area. It is estimated that this fault is a fault that causes old rocks to appear on the surface.

In addition, to identify the depth of the geological structure, euler deconvolution analysis was carried out to identify the geometry of the geological structure based on gravity anomalies. The points that describe the source of the anomaly form a straight or curve pattern.

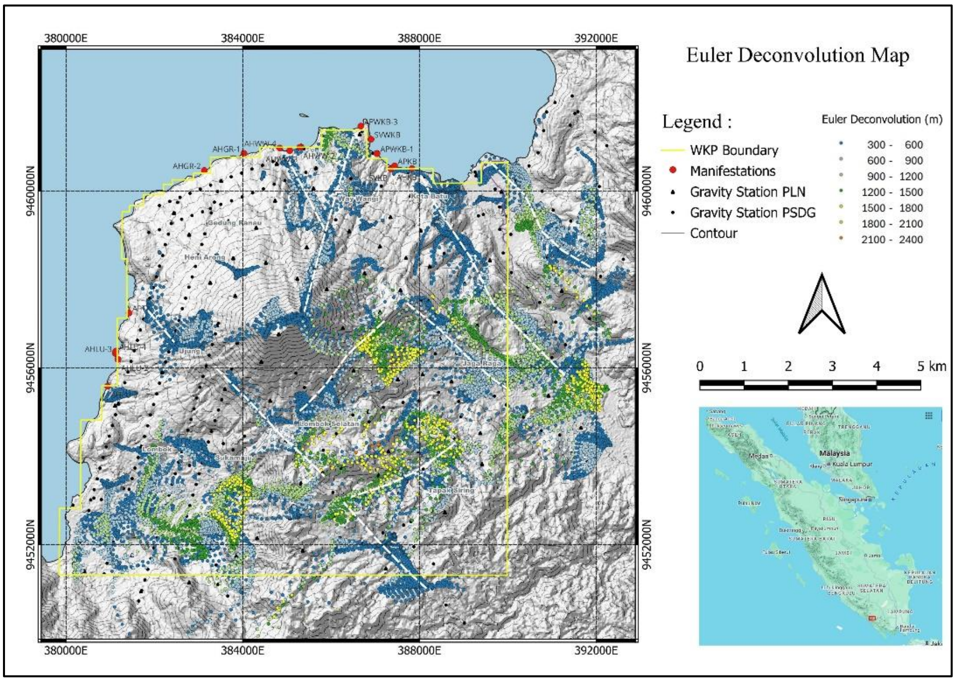

Figure 9 Euler Deconvolution Map

Then, from the distribution pattern of Euler deconvolution points, a lineament pattern is drawn which is interpreted as a fault below the surface. Almost the same as the lineaments in FHD, some of the lineament direction patterns in Euler deconvolution also have the same direction trend as the Great Sumatran Fault (NW-SE) and there are also lineaments with NE-SW direction. The results of the Euler deconvolution analysis can support the subsurface fault structure seen in the First Horizontal Derivative map and clarify the depth of the fault.

In addition, the manifestation in the Kota Batu and Way Wangi area is very correlated with the presence of FHD and Euler Deconvolution anomalies, so that it can be interpreted, these faults contribute to the presence of manifestations and have the permeability to be a media for fluids.

5 Conclusion

As discussed in the introduction, geothermal potential requires a heat source and a permeable zone in order to be further utilized, in this study the potential for a permeable zone has been identified based on gravity data processing in the Kota Batu and Way Wangi areas where there are several manifestations and there is a lineaments pattern that can be seen both on the FHD Map and Euler Deconvolution which is identified as geological fault. In addition, the interpretation of the faults that appear in the research area is also quite correlated with the regional tectonic conditions in the Danau Ranau WKP area.

As for ensuring the existence of the permeable zone, further studies can be carried out using surface geological structure and magnetotelluric (MT) data.

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