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Integrated of Gravity and Magnetic Data to Modeling Structure Subsurface In Bora Geothermal Field Central Sulawesi

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Abstract. This field research is located in a geothermal area expressed by the existence of hot springs. A complex geological structure has shown that the area was in the Palu-Koro fault. The purpose of the study is to achieve a model of subsurface of the area using data collected over gravity data and magnetic data. The two Data were compared in order to validate the models. Furthermore 2-dimensional modeling was performed using two gravity and magnetic lines by means of geo-sys software from Geosoft. The results of the models have a bit difference response by means of the existence of residual indicator that expected as a geothermal reservoir due to fault activity

Keywords: *gravity, magnetic, fault and geothermal reservoir*

1. Introduction

Bora village, district of Sigi is an area that has a complex geological structure and is an active fault line of Koro-Palu so that this area is a zone of depression. These conditions make this area a prospect for a geothermal field. In this area also found hot springs with temperatures around 90.1 ° C, hot ground (100.6 ° C) and altered rocks. The rock structure of this area consists of Quaternary sediment, Tertiary plutonic intrusive rocks and Pre-Tertiary metamorphic rocks. The terrain is characterized by extensive faulting forming almost the N-S trending ridges and fault scarps [1].

The application of geomagnetic and gravity methods has been carried out by various researchers, for example [1] conducting exploration research using gravity and geomagnetic methods that model volcanic magma in the Brazilian region. [2] have conducted research by combining magnetic and gravity data to describe subsurface structures in sedimentary basins in the Sinai Peninsula region. [3] conducted a numerical study on the interpretation of magnetic and gravity anomalies in the Thuringian Basin, Germany. [4] using magnetic and gravity data to describe the characteristics of subsurface structures in the complex basin in Egyptian Central Sinai. [5] conducted a study using magnetic and gravity data to draw geological structures in Cairo Egypt



Particularly in the study area by [1] integrated measurement of geophysics (gravity, gravity, magneto telluric) and the results in the form of qualitative interpretations which indicate the existence of gravity anomalies that are positive and negative and geomagnetic measurements indicate the presence of Bora depression zone with negative anomaly characteristics while positive magnetic anomaly indicates intrusion. The magneto telluric results show that the Bora geothermal field has a variation of resistivity from 0 to 200 ohms to a depth of 1000 meters. In this study modeling is done using magnetic and gravity data that has been measured by [1]. The aim is to describe the structure model under the surface in the study area using integrated magnetic and gravity data.

2. Geology setting

Geothermal manifestations in Bora Village appear to be caused by the Palu-Koro Fault. This fault is found in the South Arm of Sulawesi trending north-west to south-southeast. This fault is called the Palu-Koro Fault because it passes through Palu City and Koro River. On land, this fault is characterized by the presence of a fault canyon that is flat at its base, with a width reaching 5 km around Palu, and its wall reaches a height of 1,500-2,000 m above the valley floor, while in the sea it is characterized by lineaments of the bath, namely basic slope straightness the sea is steep and ends at the Poso normal fault.

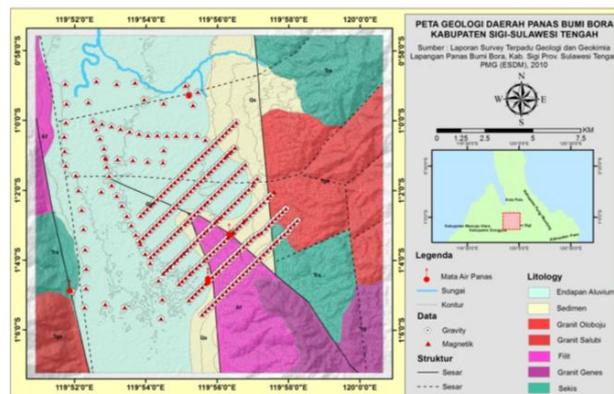


Figure 1. Geological maps and gravity and magnetic measurement points [1]

Stratigraphy of constituent rocks in the research location of Bora Village and its surroundings are sequentially from the youngest to the oldest rocks consisting of: Alluvium (Qal), Sediment (Qs), Oloboju Granite (Tgo), Granite salubi (Tgs), Filite (Kf), Granite genes (Trg) and Sesis (Trs) as shown in Figure 1.

3. Geophysical Data

In this study the gravity and magnetic data used were obtained from the Bandung Geology Agency (Center for Geology Resource Indonesia Geology Agency). The results of the corrections made to the gravity data are Bouguer anomalies and corrections to the magnetic data are total magnetic intensity as shown in Figures (2) and (3) below.

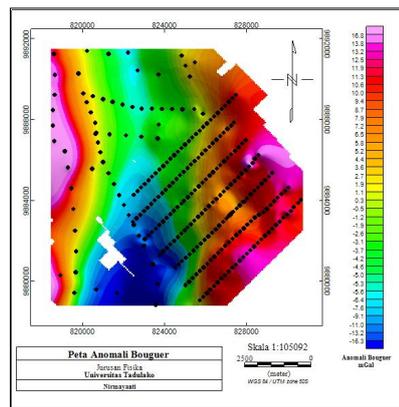


Figure 2. Map of Bouguer Anomaly distribution and gravity data measurement point

It can be seen in Figure (2) that the distribution of Bouguer anomalies in the study location is the response of the subsurface density distribution. The distribution of Bouguer anomalies below the surface varies between -17 mGal to 17 mGal. This anomaly is divided into low and high anomalies. Low anomalies as shown in dark blue to light green ranging from -17 mGal to 0.3 mGal. High anomalies as shown in yellow to pink range from 1.1 mGal to 17 mGal.

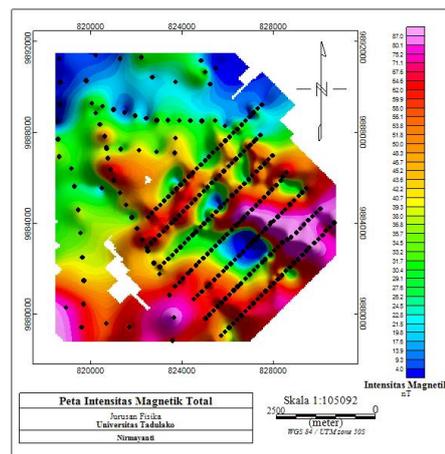


Figure 3. Map of total magnetic intensity distribution and gravity data measurement point

Figure 3 shows that the distribution of magnetic intensity values ranges from 4.0 nT to 90 nT. The value of magnetic intensity varies greatly due to the unevenness of the rock below the surface, resulting in a low and high magnetic intensity value. Relatively low magnetic intensity is in the north and magnetic intensity is high relative to the south. Based on magnetic intensity distribution (Figure 3), there is a low magnetic intensity whose magnetic intensity around it has a relatively higher magnetic intensity. This anomaly is located in the location of Bora hot water manifestations which can be seen on the geological map (Figure 1). This low anomaly is suspected because the heated rock will have a low level of magnetization and indicated manifestations that appear on the surface perpendicular to the reservoir.

4. Gravity and Magnetic modeling

In this study modeling was carried out using GM-SYS 2D software from Geosoft. The model is built by integrating gravity data and magnetic data to draw subsurface structures carrying surfaces. Furthermore, to obtain a subsurface picture of the study site, two trajectories were made on the gravity and magnetic contour maps (Figure 4). One track is made across the springs (BB track) with relatively North-South direction / N 45 ° E. The length of the track between B-point to B' point is 7.44 km. The

second track is the FF path 'relatively North-South direction N 45 ° E. The distance from point F to point F' is 8.33 km

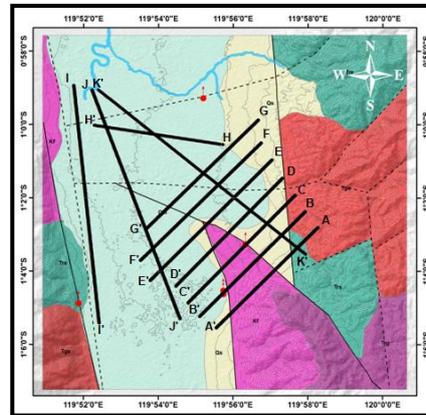


Figure 4. Profile of overpass trajectory with geological maps [1]

Modeling is done through several iterations until a match between the gravity and magnetic data model matches with the response of the measurement data with presentation errors of less than 5%. Two-dimensional model (2D) rock coating distribution built up to 5 km. The modeling results on the BB 'and DD' paths can be seen in Figures 5 and 6. The BB trajectory modeling results' obtained by 3 layers of rock distribution. The surface layer has a susceptibility (k) of 0.0002 SI and a density (ρ) of 1.960 kg/m³ with a thickness of 0.8 km extending from positions 5.79 to 7.44 km allegedly alluvium rocks. In the middle rock layer obtained susceptibility (k) of 0.0088 SI and density (ρ) of 2,500 kg/m³. This layer has a model that is suspected of sedimentary rock. The third layer shown in pink has susceptibility (k) of 0.0015 SI and density (ρ) of 2.770 kg/m³ extends to 7.44 km. These rocks are found in depths varying from 0.18 to 3.60 km with different layer thicknesses from 0.18 to 3.28 km thought to be phyllite rocks.

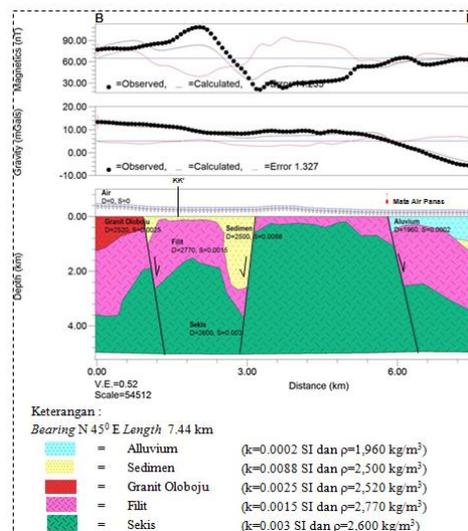


Figure 5. Model of the track BB 'subsurface structure.

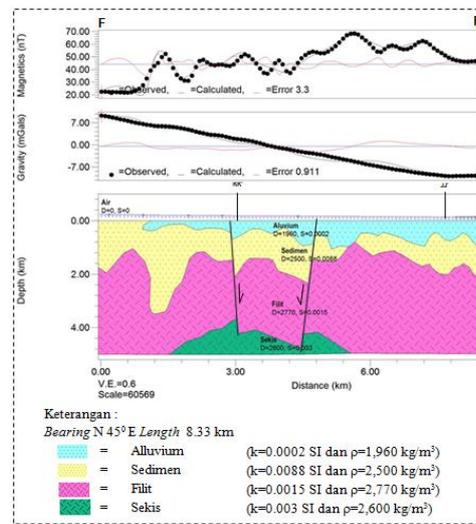


Figure 6. Model of track FF' subsurface structure

Figure 6 shows a rock distribution model that has varying density and susceptibility values. The first layer is shown in blue with the susceptibility value (k) of 0.0002 SI and the density (ρ) of 1.960 kg/m³. The rock has a depth of 0.12 to 0.98 km and extends to 8.33 km and is thought to be alluvium. The second layer is shown in yellow with susceptibility (k) of 0.0088 SI and density (ρ) of 2,500 kg/m³ with depths varying between 1.11 to 3.49 km extending to 8.33 km and thought to be sedimentary rocks. The third layer is indicated by color pink has a susceptibility (k) of 0.0015 SI and density (ρ) of 2.770 kg/m³. Extending to 8.33 km with a depth between 1.03 and 5 km is thought to be phyllite rock. The fourth layer shown in green is interpreted with a susceptibility of (k) 0.003 SI and a density of (ρ) 2.600 kg/m³, extending from 1.50 to 5.56 km at depths of up to 5 km and thicknesses varying from 0.24 to 1.34 km and thought to be schist.

The geological structure in the form of a fault appears on the two tracks that cut rock layers. There are 3 faults which are thought to be normal faults. The appearance of the water which is a manifestation of geothermal energy at the study site is likely to be caused by these faults. The two rock layer distribution models carrying surfaces show that geothermal reservoirs are interpreted in schist rocks with susceptibility values (k) of 0.003 SI and density (ρ) of 2.600 kg / m³ which averages from 0.48 to 7.61 km with thicknesses varying between 0.65 km to 3.55 km.

5. Conclusion

The purpose of this study is to model the subsurface structure by integrating gravity data and magnetic data simultaneously in the area of the geothermal field. Some important conclusions reached in this study are.

- Modeling of rock structures carrying surfaces using data gravity integration with magnetic data simultaneously can reduce ambiguity.
- The subsurface model obtained shows that there are several faults that cross the study area.
- Rocks that behave as reservoirs are metamorphic (schist) rocks that have undergone fractures.

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