Proceedings World Geothermal Congress 2015
Melbourne, Australia, 19-25 April 2015

Volcanic Neck of Mount Iyang Argopuro Revealed From Gravity Study

Sotarduga S. Nainggolan, RM. Tofan Sastranegara, Imam B. Raharjo

Mailing address, PT Pertamina Geothermal Energy, Skyline Building 15th Floor, Jl. MH Thamrin 9th Jakarta, Indonesia 10340

E-mail address, ssj.nainggolan@pertamina.com

Keywords: Geothermal, Gravity, 2D inversions, Volcanic Neck

ABSTRACT

Mount Iyang Argopuro is a volcanic complex which has geothermal prospect located in the eastern part of Java Island. The prospect itself is still in exploration stage. The gravity survey has already conducted in 2013 with total 200 number of stations which covering 50 x 50 km of Mount Iyang Argopuro area. Scintrex CG-5 was used to measure the gravity data in each station and High Precission GPS to measure the elevation to collect high quality of gravity data. 2D inversion model within conjugate gradient scheme with rectangular mesh forward operator was used to reconstruct the subsurface density distribution.The length of line for 2D inversion is 50 km crossing the Mount Iyang Argopuro from the low land to the overlaying volcano. The model shows an interesting vertical dense body having a density contrast up to 0.35 gr/cm^3 from average rock density. The dimension of the dense body is 5 km width x 4 km height located near the top of the volcano. The dense body is interpreted as the volcanic neck of the old Iyang Argopuro volcano which currently known as Mount Tengah. However, this dense body will be eliminated from consideration of geothermal prospect since the geological dan geochemical data showed no indication of the presence of geothermal activity. Furthermore, the low residual gravity anomaly in the crater of Mount Iyang Argopuro, after integreted with other geoscientific data is concluded as the most prospective region for geothermal exploitation.

1. INTRODUCTION

Mount Iyang Argopuro is located in the administrative area of East Java Province which is one of the Mining Concession Area of PT. Pertamina Geothermal Energy (PGE) as shown in figure 1.

Figure 1: Map location of Iyang Argopuro geothermal prospect area.

Mount Iyang Argopuro is categorized into Volcanic Complex which has a geothermal potential. As a new geothermal concession area of PGE, we have conducted several geological and geochemical studies to analyse and deliniate the most prospective area. Gravity study is one of the studies that has been conducted in this area. The presence of geothermal prospect will be shown as a distribution of low and high bouger gravity anomaly in this study area.

2. GEOLOGICAL SETTING

Mount Iyang Argopuro complex is a product of subduction of the oceanic Indo-Australian Plate with the southeastern part of Eurasian continental plate (Katili, 1975) which formed the Sunda Arc Magmatic or Sundanese Orogeny and tectonically this area belongs to the transition zone (Hamilton, 1979). Volcanic activity began in the Late Miocene time until the Quaternary or Resen (Soeria-Atmaja & Noeradi, 2005). The lithology which is found in the Mount Iyang Argopuro can be grouped into two lithologies, Old Argopuro deposition and Young Argopuro deposition (figure 2).

Old Argopuro deposition grouped into seven rock units, from old to young, namely: Lava and Pyroclastic Unit Mount Gilap (Qlpg), Lava and Pyroclastic Unit Cemorokandang (Qlpck), Lava and Pyroclastic Unit Mount Gendeng (Qlpgd), Lava and Pyroclastic Unit Mount Patrol (Qlpp), Lava and pyroclastic Unit Mount Malang (Qlpm), Lava and pyroclastic Unit Mount Siluman (Qlps) and Lava and pyroclastic Unit Mount Berhala (Qlpb). This unit is mainly exposed to the east and south of the study area dominated by basaltic andesite lava composing and the volcanic breccia. Andesite lava comes more dominant than the volcanic breccia, except at

Lava and Pyroclastic Unit Mount Malang (Qlpm) are dominated by breccia tuffs (volcanic breccia).Young Argopuro deposition grouped into three rock units, from old to young, namely: Lava Pyroclastic Unit Taman Hidup (Qlpth), Lava and Pyroclastic Unit Jambangan (Qlpj) and lava and pyroclastic unitArgopuro-dominant Rengganis (Qlpar). All three of these units can be equal with Post - Caldera Iyang / Argopuro group.

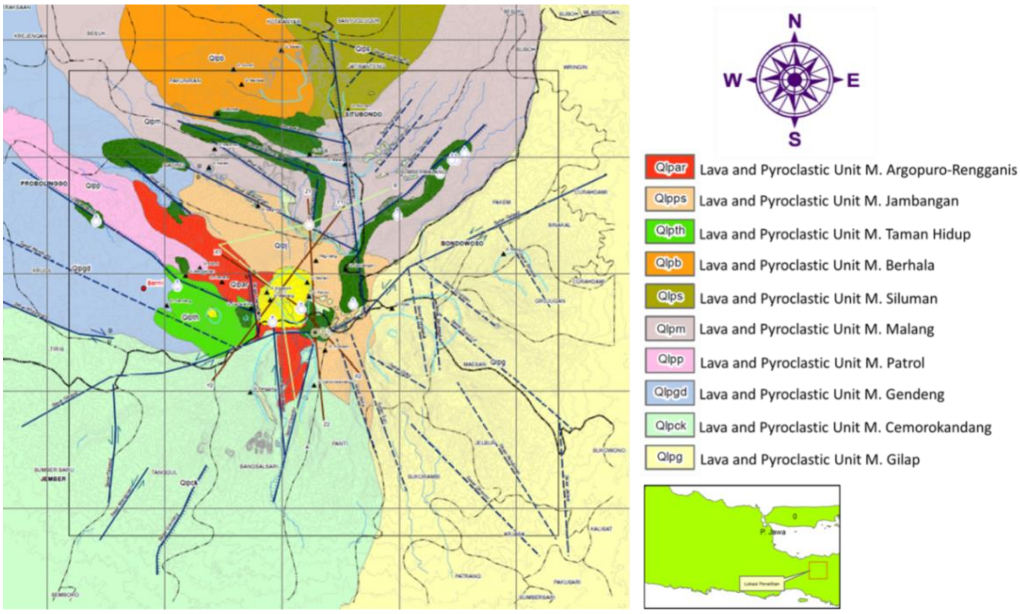

Figure 2: Simplified geological map of Iyang Argopuro.

3. GRAVITY DATA AND METHOD

A gravity survey covering the Iyang Argopuro area using Scintrex CG-5 relative gravimeter has been carried out in 2013 by University of Indonesia under the contract with PGE. Total number of gravity station was 200 divided into 3 lines. Each line consist of 60 and 70 gravity station with the distance of each station is 500 mup to 2 km. Parasnis method was used to estimate the average subsurface density (2.6 g/cm^3) to yield the Complete Bouger Anomaly (CBA) Map (figure 3). The CBA map has a blank region due to the distribution of the gravity station is not covering the whole area evenly.

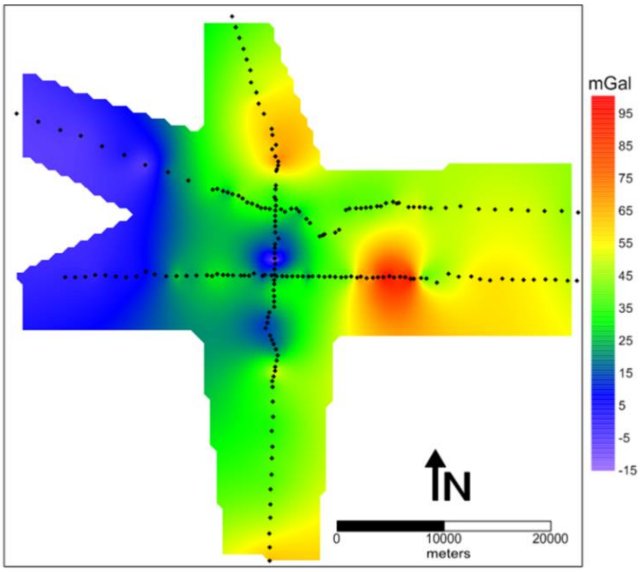

Figure 3: Complete Bouger Anomaly (CBA) map of Iyang Argopuro geothermal prospect area (ρ=2.60 g/cm^3).

There is several method to separate regional-residual gravity anomaly from complete bouger anomaly data. In this paper, polynomial fitting was used to separate regional and residual anomaly. This is a purely analytical method, in which matcing of the regional by a polynomial surface of low order exposes the residual features as random errors (Telford et al, 1974). Second order polynomial regression was used in this paper to eliminate regional gravity anomaly from the compleate bouger anomaly data (figure 4). In this regard, the bouger anomaly data were first digitized from CBA map and displayed as a graph between distance and its gravity anomaly response. Second order polynomial regression was selected as the regional trend because it well corelated with the regional gravity data of eastern Java where the gravity anomlay trends is low in the western side, higher in the surrounding area of the volcano and becomes low again towards the eastern side (Nainggolan et al, 1995).

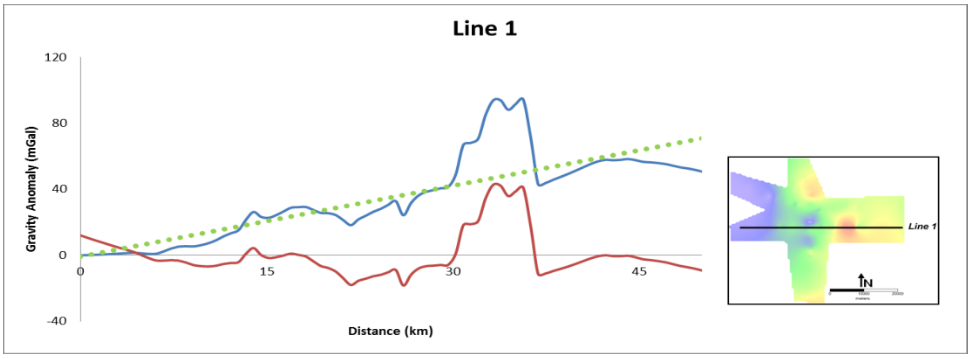

Figure 4: Regionalgravity anomaly (red) extracted from CBA's trend (blue) using polynomial 2nd order approach (green).

The residual map (figure 5) shows two high anomalies region, in the eastern part of line 1 (Mount Tengah) and in the northern part of line 3 (Mount Rabunan) which might be an indication of volcanick neck or rock intrusion. Unlike Mount tengah and Mount Rabunan, Mount Iyang Argopuro located in the low gravity anomaly region which may indicate fracture or high porosity-permeability zone (alterated rock). Mount Iyang Argopuro also located in the agrilic zone and has geothermal manifestation in the surface which indicate a geothermal activity.

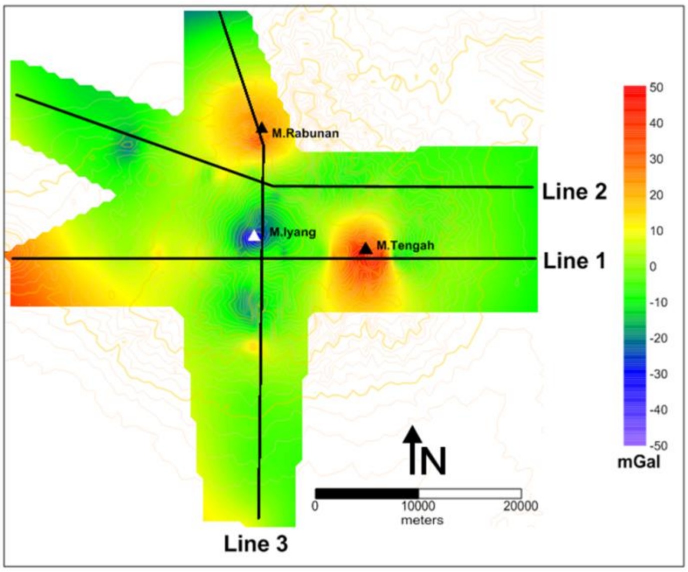

Figure 5: Residual gravity anomaly map overlayed with contour map and gravity line measurement.

4. MODELLING

In this paper we try to make a 2D model from line 1 which crossing Mount Tengah which has higher residual gravity anomaly and Mount Iyang Argopuro which has lower residual gravity anomaly. This 2D model used rectangular grid and conjugate gradient scheme as the parameter of the inversion. We used Matlab sofware to run the program without using any prior data to inverse the gravity data or in other words this model is a blind inversion model (figure 6). The model shows an interesting vertical dense body. The huge dense body as we interpret as volcanick neck has gravity anomaly response 45 mGal located below Mount Tengah with density contrastup to 350 kg/m^3 related to 2.600kg/m^3 as the average rock density.

If we compare the dimension of the dense body from the gravity model to the surface appearence condition of Mount Tengah, we could not see any indication of this volcanic neck because it totally covered by lava and pyroclastic rock unit from Mount Gilap nearby. The low density body bellow Mount Iyang Argopuro's crater has a density contrast up to -500kg/m^3 related to 2.600 kg/m^3 with gravity anomaly response -10 mGal located at depth 1-3 km from the surface. Detailed studies are highly recommended to understand the geothermal potentialities for the areas associated with these anomalies. The model shown bellow depth 4 km from the surface, has a uniform density of rock (0 kg/m^3 of density contrast) and we interpreted as the basement of this area.

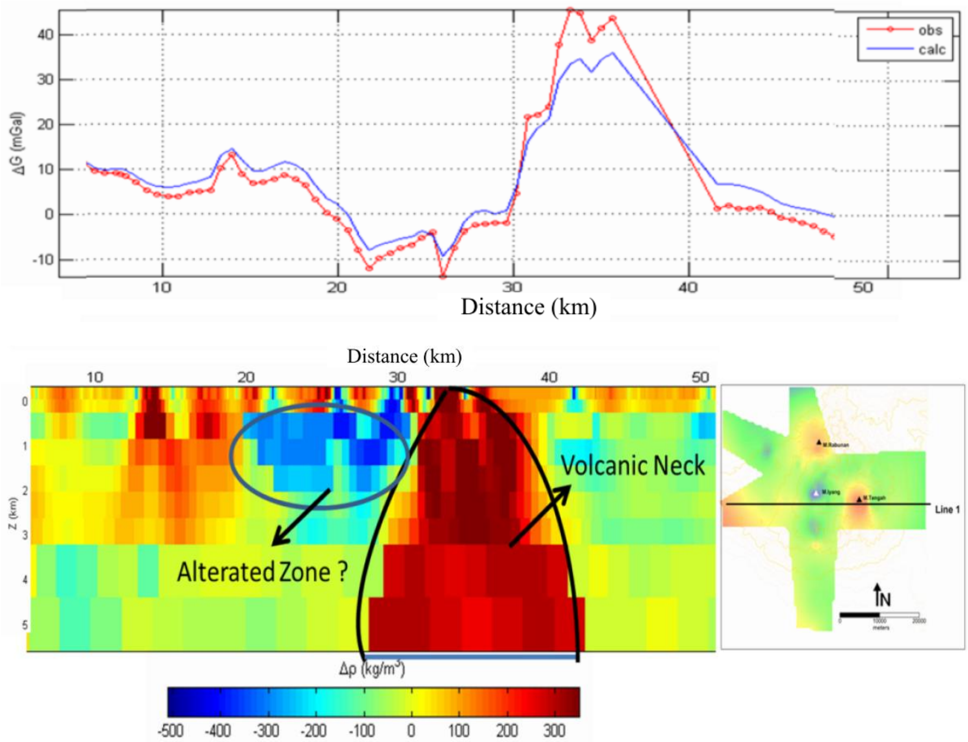

Figure 6: 2D model of line 1 based on gravity data inversion.

5. CONCLUSION

Amid limitation of geophysical data in this study area, Gravity study has been able to reconstruct an initial subsurface model of Mount Iyang Argopuro's geothermal system. The vertical dense body (figure 6) signifies a volcanik neck of Mount Iyang Argopuro which might be an indication of geothermal system, however since there is no surface indication such as altered rock or geothermal manifestation, we can conclude that this is the old Mount Iyang Argopuro's volcanic neck, which does not has geothermal potential anymore. Low residual gravity anomaly in the crater of Mount Mount Iyang Argopuro, has a correlation with the geological and geochemical data where altered rock and geothermal manifestation able to be found in the surface. After integrating the existing geoscientific data, we made a tentative conclusion that Mount Iyang Argopuro region is the most prospective region for geothermal exploitation.

REFERENCES

Hamilton, W.B.: Tectonic of The Indonesian Region, United States Geological Survey, (1979).

Katili, J.A.: Volcanism and Plate Tectonics in the IndonesianIsland, *Tectonophysics*, **26**, (1975), 165-188.

Nainggolan, D.A., and Mirnanda.: Bouger Anomaly Map of Besuki Quadrangle Java, *Geological Research and Development Centre*, Bandung, (1995).

Pertamina, G.E.: Geological Survey Report, *Unpublished*, Jakarta, (2013).

Soeria-Atmadja, R., and Noeradi, D.: Distribution of early Tertiary volcanic rocks in South Sumatra and West Java, *Island Arc*, **14**, (2005), 679-686.

Telford, W.M. et al.: Applied Geophysics, *Cambridge University Press*, Cambridge, (1974).