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# Indication of Intrusive Body in Wapsalit Geothermal Area, Buru Island, Indonesia

Yuanno Rezky and Ahmad Zarkasyi

Geological Agency, Soekarno Hatta No.444, Bandung 40254, Indonesia

yuanno@gmail.com, mga_habi@yahoo.com

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## ABSTRACT

Wapsalit geothermal area is a non-volcanic geothermal area. This area is covered by low to medium grade metamorphic rocks, Quarternary sediment and Quarternary surface deposits.

Gravity data show a high anomaly at the center and southwestern flank of the area, which is coincident with the thermal features. The anomaly is interpreted as an igneous minor intrusion (laccolith/sill?) which is possibly the heat source for the Wapsalit geothermal system.

Thermal features of the area have relatively high temperature ranging from 60.5 to 101.3°C, neutral pH, and total flow rate about 3 l/sec. Silica geothermometry shows a high enthalpy in the area. This indicates a possibility of magmatic activity beneath the area. No geological evidence for igneous rock is found on the surface, however gravity and geothermometry data indicate the existence of young minor intrusion as the heat source for the Wapsalit geothermal system.

## 1. INTRODUCTION

The Wapsalit area (Buru Island, Indonesia) has attracted attention because of the presence of geothermal manifestations. Various geological and geophysical studies have been carried out in the area, which have explained its surface geological structure; but have not yet clarified the actual in-depth situations. In order to improve our knowledge, a previous gravimetric survey carried out in the Wapsalit area has been reinterpreted.

The Bouguer anomaly, calculated with a constant density of 2.47 gm/cm$^3$ (Fig. 5) shows a gravity high already detected by previous studies (Sumardi et al., 2007) having values as high as 58 – 62 mgal in the Wapsalit area. Sumardi et al. (2007) concluded that this high can only in part be associated with metamorphic rock outcropping in the area, however a young volcanic or intrusive body is already detected as presumed.

Wapsalit geothermal area is situated at 126º47'40'' to 126º56'47'' longitude and -3º34'16'' to -3º26'09'' latitude or 9608000 - 9620000mU and 257000 – 271000 mT in UTM projection (Figure 1).

In this investigation, a partially melted intrusive body is hypothesized on the basis of the geothermal gradient in the area, and of the degree of thermometamorphism. The gravity interpretation shows rather superficial positive residual anomalies in areas of potential geothermal fields.

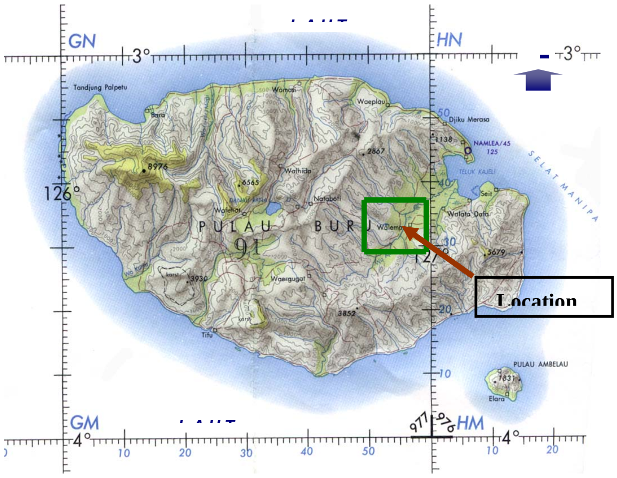


**Figure 1: Location map of Wapsalit geothermal area.**

## 2. REGIONAL GEOLOGY

Buru Island is a part of the inner Banda arc which has complex geology, as a consequence relative movement of the Australia and Asia plates (Figure 2). It is a non-volcanic area which is covered by four lithologic units, namely; metamorphic rock, claystone, terrace deposit, and alluvium. The alteration zone around the geothermal features is widely spread ± 35.000 m$^2$ as result of geothermal fluid effect over the metamorphic unit (Sundhoro, Nurhadi, 2007).

## 3. GRAVITY DATA

For the collection of the gravity data, LaCoste & Romberg (model D-114) gravimeters were used. The coordinates were obtained from a GPS Garmin 76c instrument of Garmin International, Inc., with an approximate horizontal error of 8 m.

Elevations in relation to sea level were obtained with a Wild (To) theodolite. Base-stations were defined using G-absolute of Pattimura Airport at Ambon to Grandeng village base. The spacing between stations varied from 250 to 500 meters, following the measurement line. The data were collected at 233 different points. All readings were corrected for tides due to the sun and to the moon, drift, and latitude, free-air, Bouguer corrections. The calculations of terrain corrections were done after Hammer (1939) using the Hammer chart. The map of Bouguer anomalies is presented in Figure 5. The Wapsalit basins are easily observed with positive gravity anomaly values.

A second-degree polynomial trend surface was removed from the gravity data using a regional-residual separation anomaly. The residual anomaly data was used to construct the residual anomaly map (Figure 6), for spectral analysis calculation and modelling.

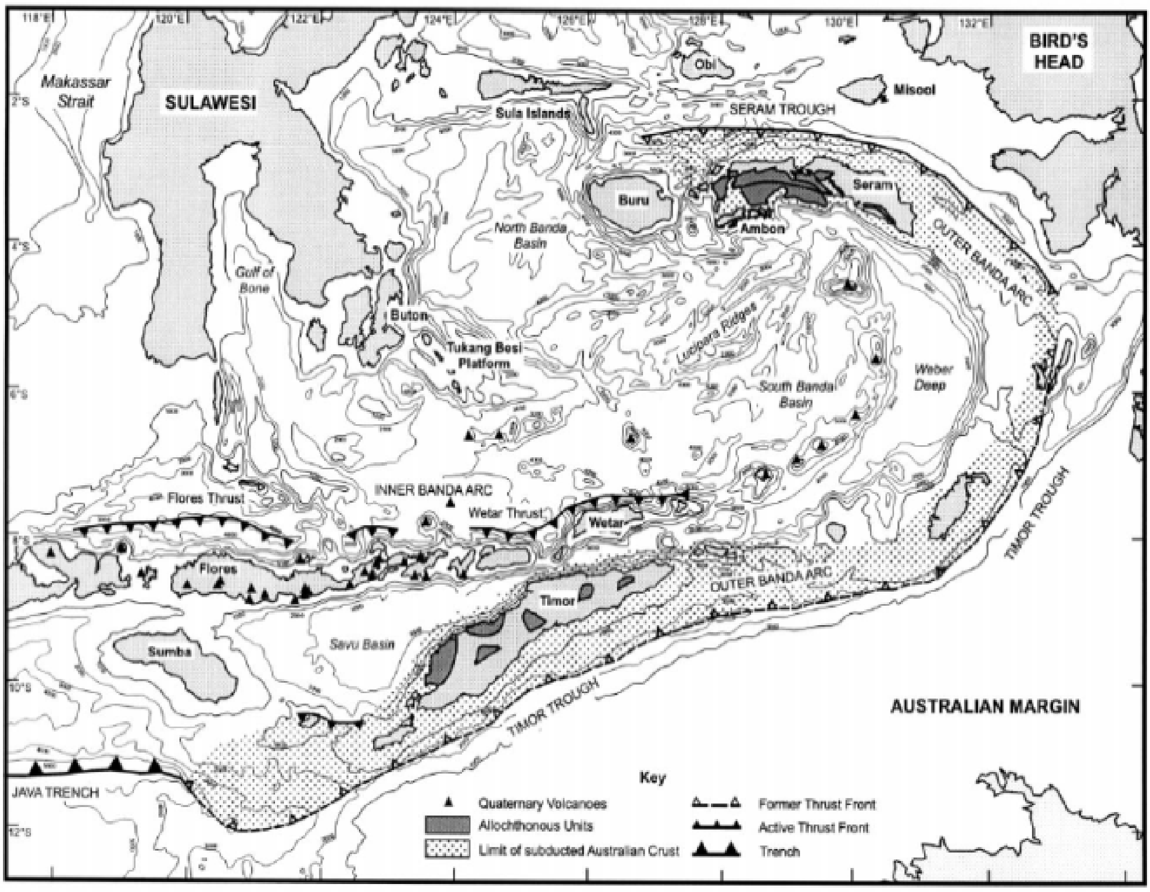


**Figure 2: Banda arc bathimetry zone map *Journal of Earth Science Asia* (R. Hall & M.E.J. Wilson, 2000).**

**Table 1: Analysis of rock density of Wapsalit.**

| Sample | Lithology | Density (g/ $cm^3$) | Location | |
|---|---|---|---|---|
| | | | **X** | **Y** |
| A3000 | Quartzite | 2.69 | 261561 | 9614016 |
| B2950 | Schist | 2.6 | 261469 | 9614058 |
| C3300 | Phylite | 2.51 | 262583 | 9613903 |
| C4000 | Phylite | 2.55 | 263156 | 9613496 |
| D4000 | Schist | 2.74 | 264113 | 9614141 |
| W1/G5250 | Clay | 1.78 | 266284 | 9615343 |

## 4. METHODS

We combined two methods: spectral analysis and 2.5D modelling. Spectral analysis has been widely used by several authors (Spector and Grant, 1970, Gerard and Debeglia, 1975; Bhattacharyya, 1978) for depths of magnetic or gravity anomalies. Energy spectral analysis provides a technique for quantitative studies of large and complex aeromagnetic or gravity data sets. The logarithm of the radial average of the energy spectrum (the square of the Fourier amplitude spectrum) is plotted versus the radial frequency. The slopes of the linear segments of the spectrum correspond to separate depth ensembles and provide parameters used for the design of numerous filters. The slope of each segment provides information about the depth to the top of an ensemble of magnetic or gravity bodies (Kivior and Boyd, 1998).

We have used the 2.5D modelling program of Grav2DC (G.R.J. Cooper, 1994-2003) to carry out models of the subsurface. The program is based on several algorithms (Talwani *et al*., 1959; Talwani and Heirtzler, 1964; Broom, 1986). It has constraints concerning the depth of investigation, the strike of the model and the density contrast between the anomaly which is responsible for the observed anomaly and the basement.

## 5. RESULT AND DISCUSSION

### 5.1 Spectral analysis

Two profiles B1 and B2 were selected in the area of survey. The first profile (B1) has a NW-SE direction, and crosses geothermal features of Wapsalit (Figure 3). The second (B2) has a NE-SW direction (Figure 4).

The energy spectrum for the intrusive body (Figure 3 and 4), shows two strong linear reflecting depths at 1.8 km and 2 km. These depths may be interpreted as the average depth of the top of intrusive body in each profile.

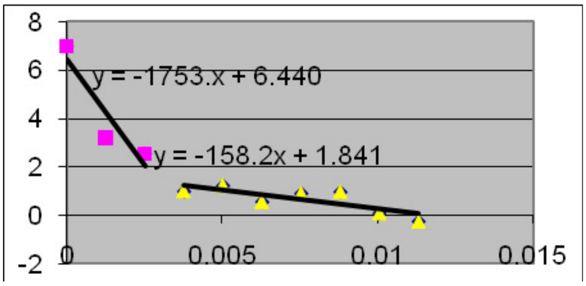


**Figure 3: Power spectrum of profiles from spectral analysis program for B1.**

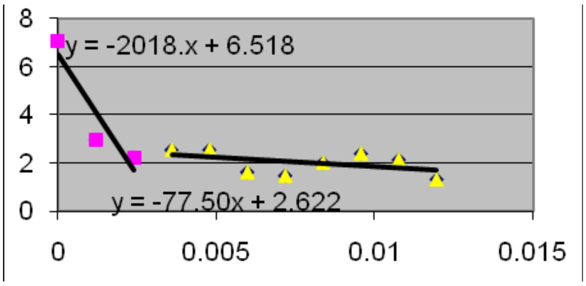


**Figure 4: Power spectrum of profiles from spectral analysis program for B2.**

### 5.2 2.5D modelling and interpretation

Negative anomalies have been attributed to materials lighter than the basement, because the topography in the region is nearly uniform. Positive anomalies are correlated with materials which are denser than the basement complex. Alteration zone are considered to justify the negative anomalies around Wapsalit geothermal features, whereas the positive anomalies can be justified by igneous rock, considered as intrusive body (Figure 5).

The density contrast between the average density of the suspected body and the basement complex are given in the Table 1. In general, model in Figure 7 has two principal layers. The layer with density 2.39 g/cm$^3$ are correlated to alteration zone that can reach 1.2 km deep, for the P1 and P2 profiles respectively. The layer with density 2.67 g/cm$^3$ are attributed to the metamorphic formation (phyllit, schist, gneiss). That with densitiy 2.85 is correlated to igneous rock or intrusive body. Moreover, a layer between low density at top and high density is interpreted as contact metamorphism in consequence of young igneous intrusion which is gradually altered (Figure 7).

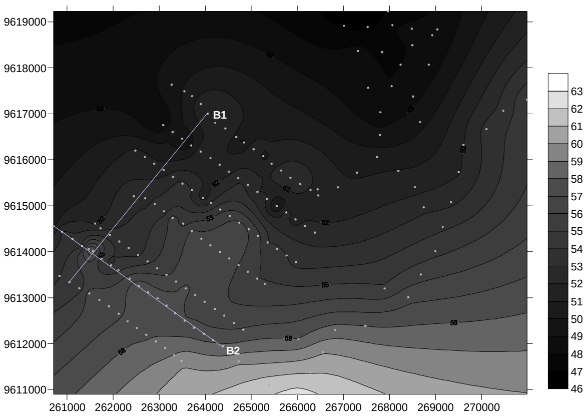


**Figure 5: Bouguer Anomaly map of Wapsalit**

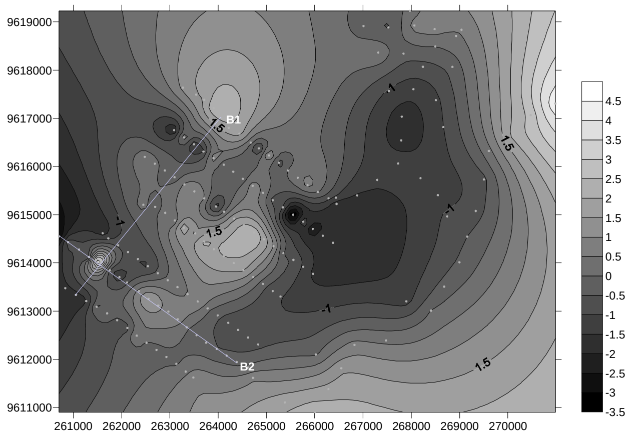


**Figure 6: Residual Anomaly map of Wapsalit**

### 6. CONCLUSION

Gravity modelling and spectral analysis have improved knowledge about this region of Wapsalit. The study suggests that the alteration zone is correlated with a sector of negative residual anomalies near Wapsalit geothermal features, while the metamorphic formation is separated by denser geological structures, interpreted as an intrusive body which correlates with positive residual anomalies zones. Therefore, the top of the intrusive body in Wapsalit could be 2 km deep, from mean sea level.

An intrusive and strong gravity high, which is not justified by outcropping rocks and an increase in heat flow can be explained if the presence at depth of a young intrusive body, which might be still partially melted, is assumed. This deep body may explain the thermal anomaly and part of the gravity low in the area which known as alteration zone, but the remaining lows cannot be attributed to it. This result indicates that the gravity method can give direct evidence of a geothermal field.

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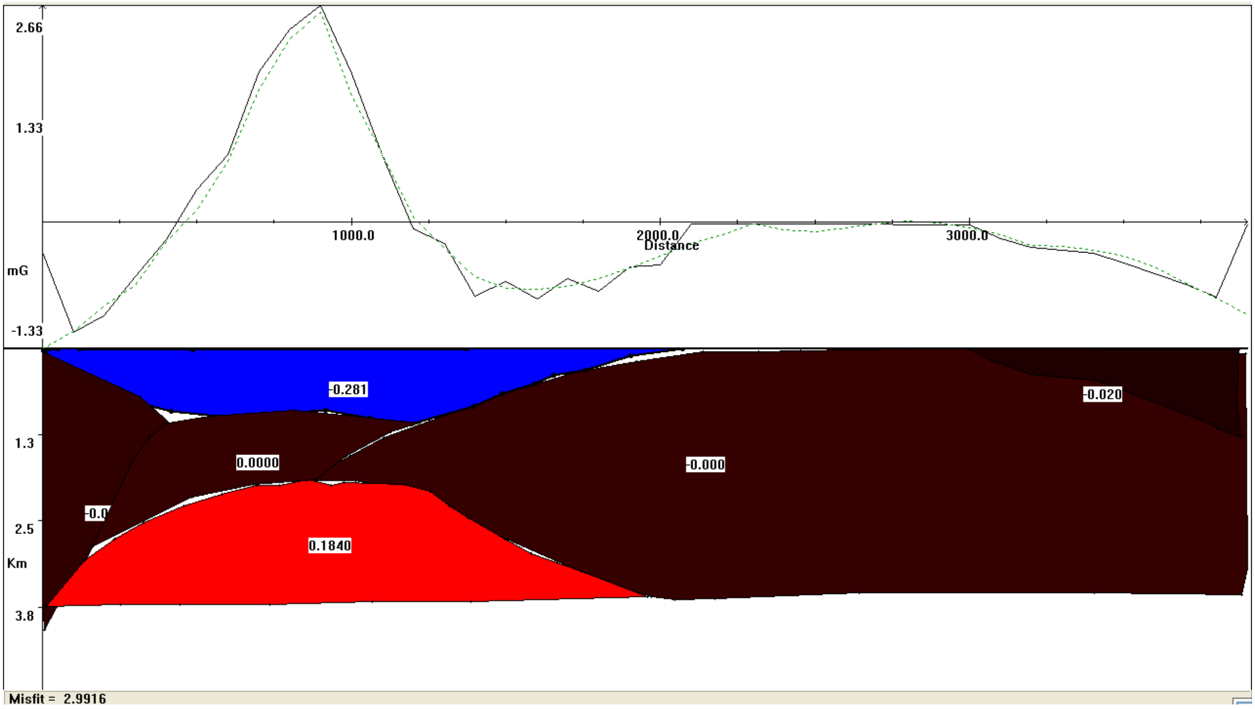


**Figure 7: Interpreted model from Grav2d.**