Magnetotelluric Analysis of the Bandung – Garut Basins

Analisa Magnetotelurik Cekungan Bandung – Garut

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ABSTRACT

Bandung and Garut Basins are part of Bandung Zone that is characterized by large basins surrounded by mountain ranges. Active volcanoes have distributed their material as pyroclastic deposit around the outer border and as lava flow deposit that become the boundary between the two basins. Bouguer gravity anomaly data also indicated the presence of several low anomaly closures at about the area of Bandung and Garut Basins surrounded by high gravity anomaly zones. Two magnetotelluric surveys were completed to acquire the subsurface model that might explain the tectonic evolution of study area. The subsurface resistivity models indicate the possibility of at least two stages tectonic evolution of the area. First stage that characterized by the presence of horst – graben structures might imply an extensional regime of the area. The next stage of evolution is indicated by horizontal layering that correlated to the relatively non-active tectonic. In addition, several most recent structures appeared near the surface, which suggests a possible extension force might be the current stage of the evolution.

Keywords: Bandung Basin, Garut Basin, Bandung zone, magnetotelluric, resistivity, subsurface model

INTRODUCTION

Java Island is an island arc produced by the subduction of Indian-Australian Plate beneath Sundaland Plate. General feature of the island is the present of volcanoes chain along the island. However, a closer observation shows that the tectonic of Western Java is not entirely similar to the rest of Java Island. The different characteristic is indicated mainly by the spreading of mountainous region. Figure 1 clearly shows the wide area of high elevation at the Western Java area (Southern Mountain), which is a remnant of ancient volcanoes (van Bemellen, 1949). While at the rest of the island,
general, the small circular high elevations spread sporadically along the middle of the island. This morphology feature alone may indicate possible variation in tectonic processes along the Java Island. Subsurface studies are essential to obtain more information of the tectonic of the region. The subsurface information is expected to give some new insights toward the tectonic evolution that accountable for current geological and morphological condition. In this research, we initiated the study in the Western Java region, by focusing at Bandung and Garut Basins. Magnetotelluric method was employed due to its ability to explore a wide and deep regional area.

**Regional Geology and Morphology**

Bandung and Garut Basins are two large adjacent depression zones that are actually main parts of the Bandung Zone (van Bemellen, 1949). These basins are intra-mountain depressions formed naturally between several active volcanoes. The hills and valleys of this area might indicate some strong tectonic force that formed great folds and faults (van Bemellen, 19496; Dam, 1994). The tectonic evolution might involve some extensional force that possibly formed pull-a-part basins as a product of at least two parallel strike slip faults (Handayani and Harjono, 2012).

The combination of the two basins forms a horse-shoe shape with the opening at the west. This horse-shoe configuration is outlined by pyroclastic deposits that cover mountains slopes (brown region in Figure 2). These pyroclastic mountainous ranges encircle Bandung and Garut Basins (blue region) with most volcanoes at this mountainous region are active. At the north, the basin is bordered by Burangrang – Tangkubanparahu – Bukittunggul - Manglayang volcanoes. At the east side, there are Cikuray – Talagabodas - Galunggung volcanoes. Papandayan, Malabar, and Cikuray volcanoes are three of several volcanoes chain bordered the southern boundary of the basin. Bandung Basin and Garut Basin are separated by a relatively younger Lava flow deposit (purple region in Figure 2) that covers a volcanic complex of Guntur-Kamojang volcanoes. Most of Bandung Zone is covered by young volcanic and alluvial deposits except at the western boundary of the area, where there are some tertiary sediment rocks (e.g. Rajamandala Formation).

The oldest volcanic rock that had been identified from Middle Paleocene was found at Cupunagara, Subang, north of Sunda Volcanic Complex (Kartadinata et al., 2002). At the same area also found some younger volcanic rocks from Oligo-Miocene to Quaternary (Indarto et al., 2006). The younger volcanic rocks (mostly Quaternary) are more common and found in most of the area, such as at Tangkubanparahu, Guntur, Malabar volcanoes (Bronto and Hartono, 2006; Dam, 1994; Koesoemadinata and Hartono, 1981).
Figure 3 shows the Bouguer gravity anomaly map with data from Untung and Sato (1978). The gravity anomaly map indicates the dense contours with high anomaly value frame both basins (orange region). Within those high anomalies areas, there are several low anomalies depressions, which most are coincident with the location of the basins.

We postulate that at least there are two main periods of geodynamic evolution of this area. At first period, there was a formation of the ‘outer ring’ that was characterized by pyroclastic sediment contained both Bandung and Garut Basins. Second period was represented by the formation of Guntur volcanoes complex, which its surrounding region are also covered by lava flow deposits. A subsurface study of the area by applying magnetotelluric method is expected to give further understandings in the geodynamical evolution of the Bandung-Garut Basins.

**Methods**

A subsurface modeling is necessary for further research of the Bandung Zone tectonics. The information of rock layers beneath the area might give some indications on events during a range of time, as the deeper the information obtained, the farther back in time we could identify the processes. In this research, a combination of magnetotelluric (MT) and audio-magnetotelluric (AMT) methods were employed due to its simplicity and cost effective to examine this substantially wide area. Furthermore, its ability to penetrate deeply make MT is a method of our choice for tectonic study.

Magnetotelluric (MT) method is a geophysical passive measurement of the natural magnetic and electricity contained in the earth, which has frequency between 10000 and 0.00001 Hz. Wide range of frequency allows this method for subsurface investigation from near surface (tenth of meters) to thousands of meters beneath the surface. Conductivity of subsurface information is obtained from the ratio of electric to magnetic fields. Ratio of a high frequency range gives information of shallow sub surface, while the lower frequency gives a deeper penetration. The ratio then is represented as MT-apparent resistivity with phase as the function of frequency.
Magnetotelluric soundings were conducted along two West–East lines located at the Great Garut Basin (see Figure 3). The first deployment worked along the southern line (SL) that consisted of 15 stations spaced about 4 km apart. Then, the second deployment ran through the northern line (NL) that consisted of 26 stations with about 2 km distance between each station. Magnetotelluric data were collected in two stations a day using two units of Magnetotelluric Instruments Phoenix MTU-5a with a 2 minutes sampling rate. During the second deployment, we also measured the AMT (Audio-Magnetotelluric) at each station of NL to obtain a near surface information.

**Result**

Data obtained from the surveys are apparent resistivities from each station from the two lines of surveys. Editing processes by MT-Editor were carried out to eliminate noises and to create smooth resistivity curve. Inversion processes were completed with the WinGLink software. Figure 4 and 5 are the resistivity section models for Northern and Southern Lines, respectively.

The Northern Line was extended at about 50 km from Cimonce (Soreang) to Leuwi Goong (Leles). The subsurface layering can be grouped into three groups of resistivity values: low (less than 100 Ohm.m), medium (between 100 and 1000 Ohm.m), and high (more than 1000 Ohm.m). The low resistivity appears on the surface between stations 41 and 40 (west end) and between stations 24 and 22. The medium resistivity exists across the line to the depth of about 2 km. And high resistivity appears to form two basins at the depth more than 2 km.

The Southern Line has a lower resolution model since the distances between stations are twice of those at the north. Nonetheless, the information generally much the same: there are three groups of resistivity layers. Three small area near surface have lowest resistivity. A layer of medium resistivity appears along the line to the depth about 2 km and
fills the basin shapes that formed by high resistivity layers. One feature that appears on both models is that the present of near surface low resistivity areas correspond to the top of the high resistivity parts beneath them.

**Discussion**

Bandung and Garut Basins are two depression zones surrounded by a chain of active volcanoes. Pyroclastic deposit covers almost all over around the basin, except some younger lava deposit that separate those two basins. Those pyroclastic areas are associated with the area of high Bouguer gravity anomaly and the younger lava and alluvial regions are correlated with the area of low Bouguer gravity anomaly (Figure 2 and 3). The low gravity Bouguer anomalies were usually associated to the basin filled with the low density rocks, which could be sediment or felsic igneous rocks (e.g. tuff). A preliminary data had indicates two possible stages of evolution of this study area. First stage was the one related to the older pyroclastic spreading, and second stage was the one
related to the basin structure and younger volcanic activity. Magnetotelluric measurement was executed in this area to further study of the tectonic evolution by mapping the deeper subsurface features. Magnetotelluric were measured along the two lines across Bandung-Garut Basin that crossed the two closures of low Bouguer gravity anomaly (Figure 3) and the model results are presented in Figure 4 and 5.

The low resistivity areas (less than 100 ohm.m or yellow to red areas in the figures) that appear at several places near the surface might be associated with the loose sediment (Dobrin and Savit, 1988). The intermediate resistivity rocks (100 to 1000 ohm.m or green areas in the figures) might be sediment deposit and/or felsic igneous rock (Dobrin and Savit, 1988). And the high resistivity rocks (more than 1000 ohm.m or blue-purple areas) might be hard sediment deposit or igneous rock (Dobrin and Savit, 1988). This highest resistivity layers (purple) might indicate the older igneous rock or basement.

The resistivity models above well correspond with the regional Bouguer gravity anomaly. The regions with low gravity anomalies are coincident with the region of the thickest blue layers (high resistivity). Low gravity anomalies indicate low density layers beneath the surface, which are only possibly explained by basins filled with sedimentary deposit rocks or felsic igneous rocks (tuff or rhyolite) (Dobrin and Savit, 1988).

Thus, the models indicate the existence of at least two stages of tectonic process in this area. First, there was an extension regime that produced the formation of horst and graben. Horsts were presented as high resistivity (blue-purple) mounds and grabens were presented as those basins that filled by lower resistivity deposit at. At second stage, the extension force ceased that made it possible for the formation of horizontal layering, which covered the area that continuous until most recently.

In addition, a narrow high resistivity features at the east end of Northern Line (Figure 4) indicates a disruption of rather a continuous pattern. This upset could be interpreted as a normal fault. Therefore, there is a possibility that the extension force has been reappeared recently and formed the normal fault as one of the consequences.

Unfortunately, these subsurface models acquired could not explain further in term of the wide area of Bandung Zone as expected. The two lines surveys are too little to cover the tectonic study of the area. Nevertheless, this new subsurface information of the area surveyed had sufficiently revealed some history of Bandung Zone’s tectonic.

Conclusions

Magnetotelluric surveys across the Bandung Zone (Bandung – Garut Basins) had confirmed the present of basins beneath the surface as indicated by Bouguer gravity anomaly previously. The resistivity subsurface modeling also indicates the possible of two stages tectonic processes of the region. First was the extension process that developed the basin. The second, was horizontal layering that indicates a stable regime of tectonic of the region. Currently, the extension regime appears to be re-activated due to the existence of one normal fault.

Reference


