Identification of Fault Poso Earthquake Causes 2017 Mw 6.6 with Gradient Vertical Gravity Satellite Imagery

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Abstract. May 29, 2017 a devastating earthquake occurred in the district of Poso, Central Sulawesi. This earthquake can be affected significantly by the people. Based on the analysis of the source mechanism, an earthquake caused by a normal fault around the graben zone of Palopo. The purpose of this research is to identify Earthquake-causing fault of Poso 2017 Mw 6,6 by using Second Vertical Derivative (SVD) analysis of gravity. The result of profiles line that bypass the alleged fault orientation indicates the existence of normal fault structure indicating the absolute value of the minimum SVD anomaly is relatively smaller than the maximum SVD anomaly value in the epicenter zone of the earthquake.

Keywords: earthquake, SCD, Poso

1. Introduction

On May 29, 2017 at 21:35 pm there was a tectonic earthquake arround of Central Poso District with the power of Mw 6.6. The earthquake occurred at the coordinates S 1.28^o, E 120.48^o at a depth of 10 km. The epicenter on 38 km Northwest Poso, Central Sulawesi. Based on the results of the shock level shakemap analysis, BMKG indicates that this earthquake is potentially felt on the scale of II SIG-BMKG or III-V MMI in Poso, Loeo, Palu, Kasongan, and Toli-Toli. This is in corresponding with the people report that this earthquake is felt on the intensity scale II SIG-BMKG or V MMI in Poso and Torue, Palu and Sigi (III-IV MMI). People in Toli-toli, Pasang Kayu and Tana Toraja also felt on the III MMI scale. Likewise, people in Gorontalo, Boalemo, Pohuwato and Bone Bolango feel the earthquake on the scale of II SIG-BMKG (III MMI). People in Palopo, Masamba, and Balikpapan also feel this earthquake on the scale I SIG-BMKG (II MMI).

The purpose of this research is to identify Earthquake-causing fault of Poso 2017 M 6,6 by using Second Vertical Derivative (SVD) analysis of gravity. Previously, there has been no identification of the fault structure in the Graben Palopo region using gravity anomaly data. Hartati (2012) [1]has previously conducted cesarean identification research using gravity method but did not focus in Central Sulawesi. Hartati (2012)[1] had previously conducted a fault identification study using gravity methods but did not focus on Central Sulawesi.

2. Data and method

The data used in this research are satellite gravity anomaly data obtained from CryoSat-2 and Jason-1 satellite observations [2]. This data is a global data with grid every 1 minute degree. Downloaded data in the form of free air anomaly data (FAA). Data downloaded for coordinate constraints S 0.28$_{o}$ - 2.28$_{o}$, and E 119.48$_{o}$ - 121.48$_{o}$. Furthermore, bouguer correction was done to obtain a simple bouguer anomaly of the study area. This study is limited by not doing terrain correction. After obtaining the bouguer anomaly value, separation of regional anomalies and residual anomalies was performed. The method of separating anomalies in this study is to use a digital screening approach to separate anomalies that have long wavelengths associated with regional anomalies (Deep effect) and anomalies with shorter wavelengths associated with target structural causes of shallow earthquakes. In this research, we selected separation method using second vertical derivative filter (SVD). SVD is done by performing a convolution between bouguer anomalies and the SVD filter matrix. In this research the SVD filter matrix used is the matrix of Elkins (1951)[3]. The vertical derivative profile of these two gravity anomalies can be used to aid the interpretation of the types of earthquake-causing structures.

3. Result

After correcting the bouguer, a simple bouguer anomaly was obtained. Map of this bouguer anomaly can be seen in Figure 1. In the study area of two-degree times two degrees or about 12,392.14 km$_2$ (assuming one degree in the equator = 111.32 km) there are 21,901 observation points. It means there is one observation point in every 1.77 km^2. The Poso earthquake with the magnitude of Mw 6.6 empirically calculated using the Wells and Coppersmith equations (1994)[4] is generated by a normal fault (down) with dimensions about 29.34 x 16.34 km. By the length and width of the fault so that the dimensions of the source of the earthquake will be identified by the gravity anomaly analysis performed in this research.

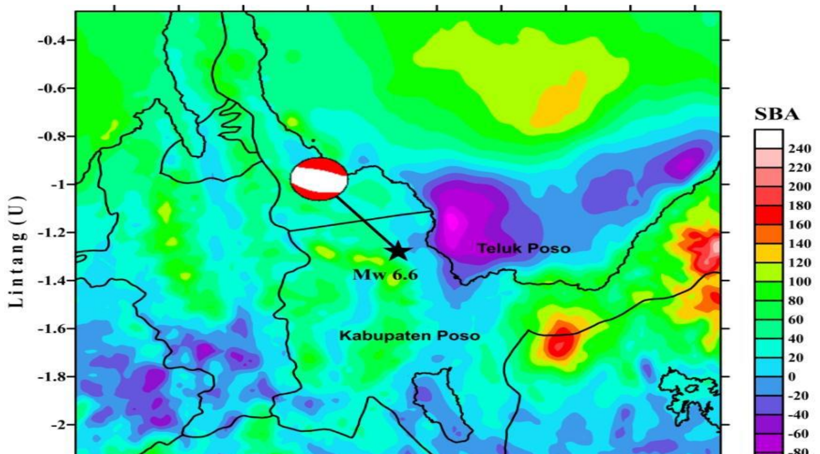

Figure 1. Map of the simple bouguer anomaly of Poso District and surrounding areas.

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The smallest bouguer anomaly in the study area (Figure 1) has a value of -108.19 mGal located in Poso Bay or southeast of the epicenter of the earthquake. The largest bouguer anomaly in the study area has a value of 243.12 mGal on land in eastern bay of Poso. While in the southwest of the epicenter zone there is also an earthquake bouguer anomaly is quite high which is about 80-120 mGal. From the mapping of the bouguer anomaly, it can be seen that the epicenter location of Poso Mw 6.6 earthquake is in the southwest of the low (negative) anomaly in Poso Bay and northeast of the positive anomaly contour. Judging from the geological map, the epicenter area of Poso Mw 6.6 earthquake is located in Graben Palolo zone [5]. The fault orientation of the Poso Mw 6.6 earthquake can be seen through the source mechanism parameters of GCMT which is a fault with northwest-southeast straightness.

If using Poso earthquake epicenter data from BMKG analysis (E 120,48, N -1,28), the position of this earthquake is in zone with anomaly value close to zero (about 5 mGal). The Poso earthquake epicenter zone is flanked by two opposite anomalies. The northeast of the epicenter location tends to have a negative anomaly, while the southwest tend to have a positive anomaly pattern. Earthquakes tend to occur at the border between two different anomalies. A low (negative) anomaly value indicates a region with a low subsurface density while a high (positive) anomaly value indicates otherwise.

Result of mapping of residual anomaly from screening result using SVD method can be seen in Figure 2. There was a significant difference between the contours of bouguer anomaly and its residual anomalies. This suggests that the contour of bouguer anomaly is dominated by inner effects (regional anomalies). From the results of the residual anomaly mapping (shallow effect), it can be seen clearly that the location of the epicenter is in a zone with residual anomalies of about 5-10 mGal. While in the southwest near this epicentral zone, there is a high residual anomaly with a value of about 90-120 mGal. To further deepen the interpretation of this residual anomaly, a four-lane profile is made of paths A-A ', B-B', C-C 'and D-D' as shown in Fig. 2.

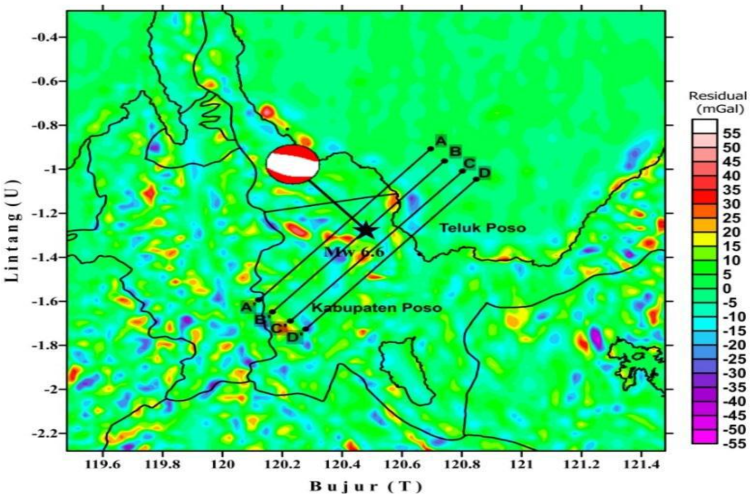

Figure 2. Map of gravity residual anomalies showing the shallow effect of filtration by a second vertical derivative method.

The slicing created in the northeast-southwest orientation crosses the orientation direction of the caustic fault of GCMT modeling results. The purpose of making this slicing is to see the SVD profile of each track in order to help interpretation the structure in accordance with the theory obtained from previous studies.

The profile of the four trajectories can be seen in Figure 3. Figures are presented in sequential SVD profiles from A-A' to D-D' paths. Broadly speaking, if we assume the use of epicenter data from BMKG, then the location of the epicenter is at a distance of about 40-60 km from the starting point of the track. The location of the epicenter looks after a positive anomaly and before the anomaly is negative when viewed from the starting point of the track (points A, B, C and D). The B-B' slicing cuts right at the epicenter of the BMKG earthquake and the red star in Figure 3 illustrates the position of the epicenter of Poso Mw 6.6 earthquake on the profile.

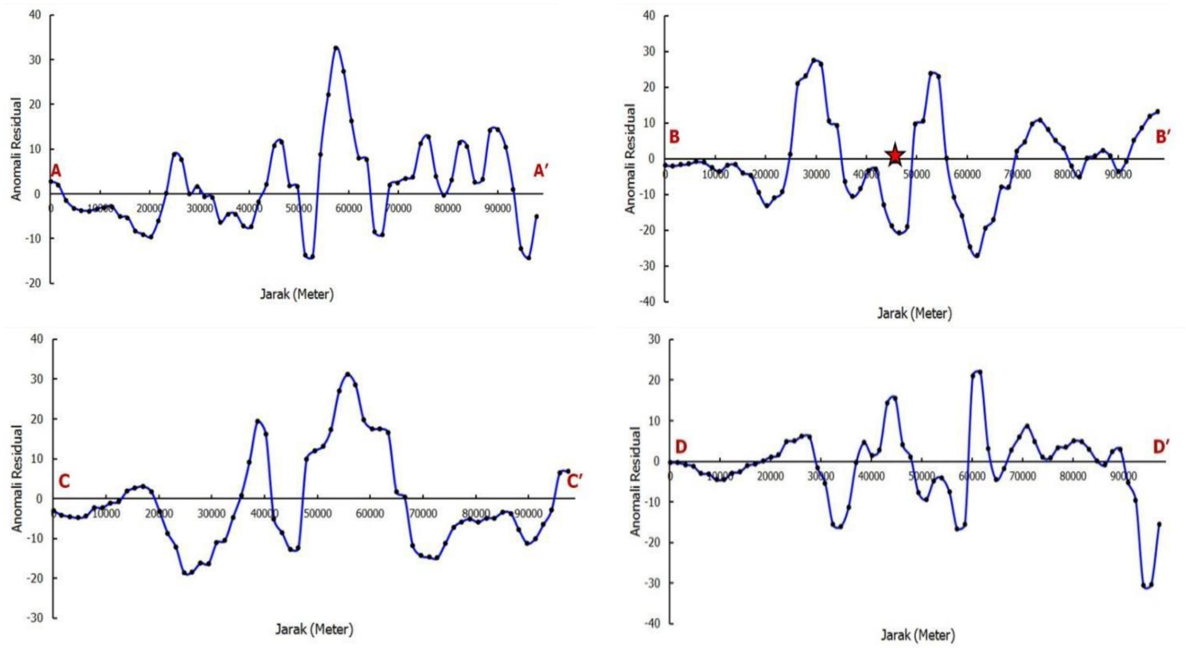

Figure 3. Profile residual anomaly (mGal) on the A-A ', B-B', C-C 'and D-D' track respectively

From the residual anomaly profile of the B-B path and supported by the third profile of the other paths, it can be seen that the absolute value of the SVD price is at least less than the absolute value of the maximum SVD. The absolute minimum SVD value in the northeast of the epicenter is 20.8 mGal while the absolute maximum SVD value to the northeast is 23.8 mGal. This reinforces the notion that the Erthquke Poso May 29 2017 Mw 6.6 is caused by the fault structure that is experiencing a downward movement (normal fault). Reynolds (1997) [6]states that the criteria for determining the type of structure of the fault are as follows: normal fault (decreasing) indicates the absolute value of the minimum SVD anomaly is relatively smaller than the maximum SVD anomaly value while for the reverse upward fault.In gravity data, the anomalous values will change vertically as a result of the uneven distribution of mass uniformly vertically, then the derivatives of both will show the magnitude of the gravity effect of the wider structures and lie deeper. Therefore small / local and vague structures can be clarified or more sharpened by curve form rather than regional structures that are more widespread in shape.

4. Conclusion

Based on the analysis on the vertical derived profiles of the two vertical gravity images of the satellite in the epicentral zone, it can be concluded that the Poso earthquake of 29 May 2017 with the power of Mw 6.6 is caused by normal fault (decreasing) in the grid zones of Palolo. This norml fault can be shown with the absolute value of the minimum SVD anomaly relatively smaller than the maximum SVD anomaly value in the epicenter zone of the earthquake.

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