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The fault identification by gravity and seismology in West Lembang Segment

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Abstract. The Lembang fault considering vulnerable because of the site is near downtown Bandung. The west Lembang segment is the rural area of Cibodas. The two opinions is emerging, become normal fault or strike slip fault, based on recent earthquake (2010 onward). The geology data show the structure is observed by the outstanding topographic extended about 20 km, with volcanic rock very dominant. The seismology data is analysed for year 2011 in Mw less than 3, and classical fault plane solution is obtained. The gravity data is better acquired than 0.1 mGal, with elevation precision better than 60 cm. The upward Continuation, and second vertical derivative, is applied on data, as well as modelling 2.5D. The section is presenting in one section only, while data is getting in larger area. The seismology data show mostly for event is strike slip although in several parts having event normal. The gravity data is not ideal as graben like structure but rather locally low about 10 mGal amplitude. The combining the two methods suggested the slip zone or sag pond is more possible for the local anomaly. Besides, the Lembang fault is extended toward north rather to west or south.

1. Introduction

The fault identification is a key reason on further study of active tectonics in a region. The approach of identification in general is two, the morphology and Geophysical evidence such as imaging and earthquakes history in fault plane.

Unlike the most common method for fault plane interpretation, this paper is discussing about the possibility of gravity data representing the fault trace.

The west Lembang area is located 7 km to north Bandung. The area is covering majority by quaternary volcanic product [1]. Several investigations show the activity of this fault for seismology [2], paleoseismology [3], Bandung basin [4] and many others. Those discusses about this fault to the Cimandiri fault extending to west and south of cost of Java. The two fault is look like interconnection. From here, a group think the segment is fault connection to Cimandiri fault and continue to the east parts. The others is considering continue from south cost to north toward Purwakarta nearly coast of Java.

The study may contribute to environment and disaster because of fault lineament. It is located in dense population near the many resort and the downtown of Bandung.

2. The West Fault Segment

The Lembang fault is extending for 25 km from west to east. The west part of lineament is close to contact with Cimandiri fault. Morphologically the lineament is more subtle in east side with difference



elevation of 70 m vertical cliff, than the west one. In West side, the reliefs show undulation of hill occupied by agriculture and village-residence area.

The recent fault study shows the fault is bend [3], than the straight one based on resistivity imaging near the middle segment. The paleoseismology study of Eko [3] show the evidence for resulting earthquake history deposits or sag ponds in village of Tugu and near Graha Puspa, figure 1. Sag pond is a body of water collected in the lowest parts of a depression formed either near the head scarp of landslides or between two strands of an active strike-slip fault. This type of fault phenomena is found in San Andreas Fault.

The origin of fault is related to Sunda volcano graben [4]. And the other study think the dip slip in older one, and strike slip component. The resume show change of fault sense from normal fault into strike slip. These changes are related to different tectonic origin from volcano related into compression in south coast where Cimandiri fault existed. The Bandung Lake Basin is positioned in south part of the fault where now become a downtown. However the recent GPS study show moving 3-6 mm per year with slow creep [5].

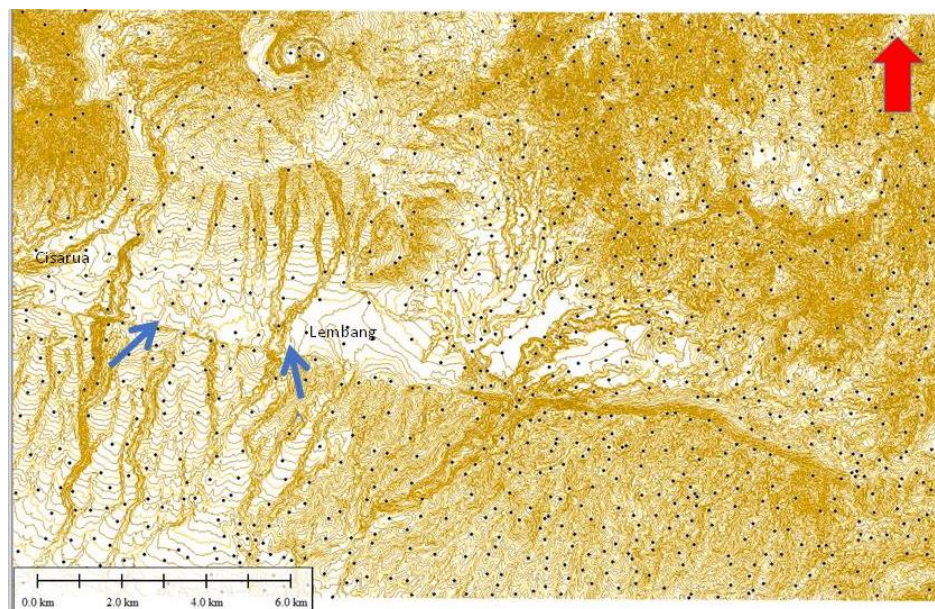


Figure 1. Lembang Fault Extending for 25 km. Morphology, and Sag pond location in west Segment. (Source: digital topography, BIG [6])

3. Methodology

The gravity is acquired to get the clear general picture for fault and subsurface lithology because of density contrast.

The gravity signal through the reduction process, is remaining obscure due to lithology heterogeneity in subsurface hence the structure. It becomes the small anomaly perturbing the visibility regional one, or the more general feature hiding the local anomaly.

The vertical derivative is apply for uncover the shallow part therefore the weak signal will emerging. Following the formula [7], or more recently [8]. The result of derivative d^2H/dz^2 , in general is come from the gravity point around in x-axis and y-axis through

$$\frac{d^2H}{dz^2} = \left(\frac{d^2H}{dx^2} + \frac{d^2H}{dy^2} \right) \quad (1)$$

The Upward continuation is apply for avoiding the local part that hiding the deeper lithology or structure. Therefore doing upward continuation, will improve the visibility.

The upward continuation [9], use frequency transformation and each other linked through gravity data $F(u,v)$, Upward continuation $G(u,v)$, and linier operator $K(u,v)$. The linier operator $K(u,v)$ is a function of exponential from level (going away from ground) desired. Finally, use inverse transform $G(u,v)$ become $g(x,y)$ in space domain. In practice the level is getting by multiple of grid size, and signal is getting on point around with weighting factor. The upward continuation could be describing as

$$G(u, v) = K(u, v) \cdot F(u, v) \quad (2)$$

4. The Fault Identification and interpretation

The resulting of Upward continuation is do for 330 meter cell, for 1650 meter above the ground. The trace of negative band on figure 2. It show bending in west part of fault segment. The part of upward continuation compare to Bouguer anomaly section is present in figure 3.

On the central part the low anomaly is close to fault line part of 25 km Lembang fault (see figure 1). At the beginning we suspected the change of negative amplitude anomaly is nearly ideal for the normal fault concept. But the west section show the spot negative anomaly is more subtle. Hence it is interesting to observe.

It is open to question, weather the mechanism effectively continuous or just single even. Where, it make such deep feature such as asperity and slip zone, or shear zone. The possible answered now is sediment deposits extensively flowing from northward become swarm area in the fault wall.

In case the Sag pond and related to gravity anomaly. It will be remain interest to interpret the fault and gravity data as a tool to fault identification. When it is examining, and combing with relief observation for interpreting fault lineament.

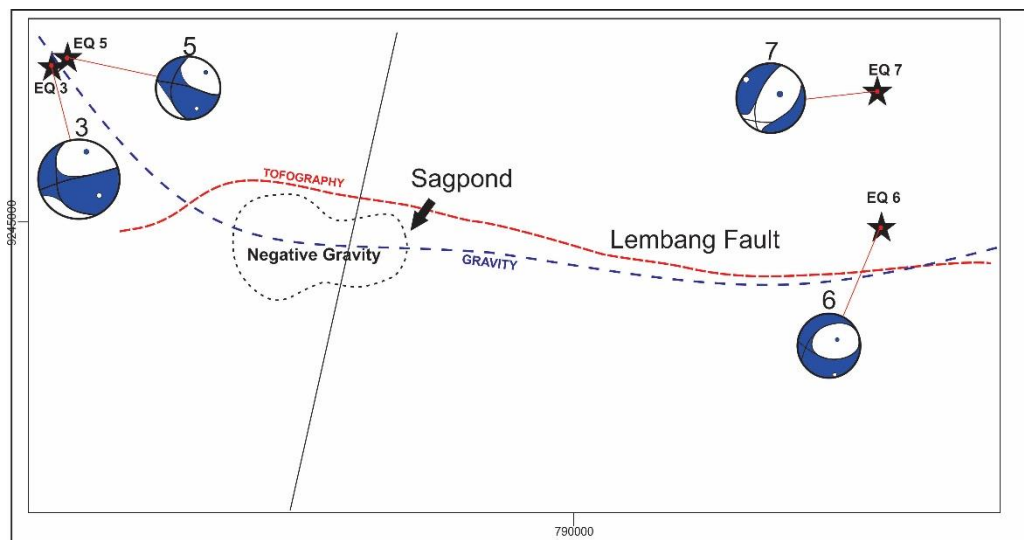


Figure 2. The Sketch of fault line, earthquake hypocenter and gravity section. The Arrow marks a Sag pond site, while the red dash line is trace of Fault based on Topography, Fault plan solution from [2].

The figure 2, shows the suspected Lembang fault by topography data (figure 1) and several identified fault by many author. The trace is mostly similar with the result upward continuation. Excepting on west side, it rather bend to Northwest than south west, nearly the hypocenter of EQ3 and EQ5.

This west part, is different with the idea of many author. The most idea is it connect to Cimandiri fault to south west, for example [10] by DEM data. It is different approach, where the DEM data is surface expression, while gravity data is subsurface expression. The two approach showing reconciliation is important to study comprehensively both surface and subsurface. Finally the evidence of other direct subsurface will proved it.

The fault plane solution observe by seismology, will not change by bending of west fault but maybe more reasonable. Nevertheless, the existence of fault lineament by topography, sag pond and low anomaly gravity of *upward continuation*, is coherence.

5. Gravity and Seismology

The gravity data is acquired on the area with accuracy better than 0.1 mGal and tie to gravity network. The total measurement of data is about 250 points although the whole data is for mapping, only a section of North-South displayed. The section contains about 30 points of measurement for 10 km. The issue of west segment of Lembang fault is closed to section. The data is subject to reduction process including terrain correction, and apply density 2.6 gr/cm³.

The elevation for reduction is measured in feet precision.

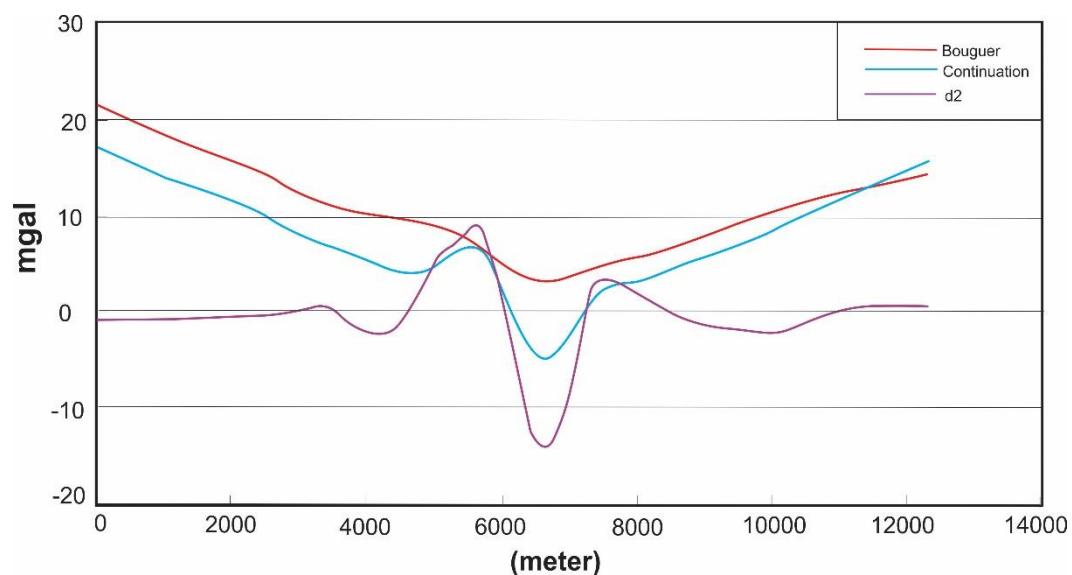


Figure 3. The Analyse segemen of section showing Bouguer Anomaly, upward continuation, and second derivative(D2). The upward Continuation is a reference to obtain the negative residual, while the derivative is enhanchment for fault and lithology heterogeneity arround.

On the gravity section figure 3, the upward continuation show the regional effect. The visibility is clear for negative anomaly nearly the suspected fault segment, and positive anomaly for suspected igneous rock.

The *second vertical derivative*, identify two features by the peak for igneous and valley for sedimentary deposited related to sag pond.

The gravity section figure 4, is getting near west segment of fault where the seismic data closed to figure 2, in adjacent area. It is separating about 5 km to west part of gravity section or 5 km to north of fault line. The section is length 10 km occupied by interpolating of 30 data, about 0.3 km interval. The negative anomaly of 10 mGal amplitude, is found around 16 square km in the surface. The step of limb shows the classic example of density contrast in subsurface.

The anomaly shows the large effect of body in subsurface. The model 2.5 D gravity [7] show depth about 0.75 km. Nevertheless, about 0.4 km shows the Sag pond. The best result will get soon after evaluating the whole section.

The seismicity of year 2010-2011, show the activity of earthquakes of Mw less than 2, strike-slip fault dominant. The recent seismology study near the west segment shows various fault plane attitudes with depth event about 15 km. The events of west segment fault are oblique-strike slip sense. While the east part is shallow (less than 2 km, the other is 10 km) and containing a normal sense.

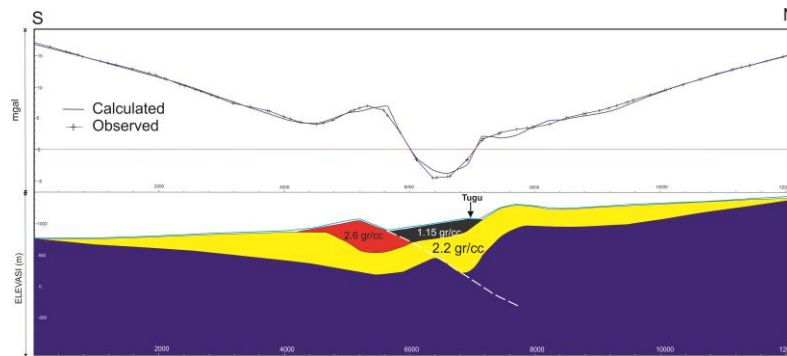


Figure 4. The gravity model of negative anomaly near west segment

According to Afnimar(2011), the hypocenter location of west segment is more to north from the actual surface fault line due to inclined plane different fault regime. But, the new indication of fault plane by gravity data, figure 2, it is much closer to and more steep indeed. Hence more fit with attitude of fault plane.

6. Conclusion

The upward continuation show the fault is similar to relief of topography, but on west segment is bending to North West than the others. Therefore, it probably separating to Cimandiri fault in south west if existed. The negative gravity anomaly reach amplitude 10 mGal, show a subtle anomaly and it is interpreting as a Sag pond. Hence this geophysics evidence and surface observation will reinforce and the indication for fault in the future.

Acknowledgment

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