The Geophysics evidence for fault in Tertiary, Pre-Tertiary deposits rock of Lok Ulo central Java, revealed by Gravity data

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Abstract. Lok Ulo is a mayor river extended from north to South Kebumen. Area is famous pre-tertiary basement rock exposed to the surface. The evidence of fault directly is difficult due to in part by thick weathering surface, and second it could be hidden beneath the river. The gravity instrument of micro Gal precision is running to overcome the problem across the area where anticline valley is very subtle. Geology reconstruction is doing, but the geophysics evidence is giving another solution. The anomalous of 2.5 mGal is because of 1.5 km downthrown block. The reconciliation finally deducted, hence the fault is separating two block. Therefore, the thickness of sedimentary rock is becoming into two parts, the west and east. The throw of fault shows significant separating the mélange complex from the others. The gravity data is estimating the fault take deep seated origin. The thickness claystone of tertiary sedimentary is covering the mélange (the older one) and separating each other. By consequence, the sediments formation in east part is thicker than the west.

Keywords: Gravity anomaly, numeric modelling

1. Introduction

The basement rocks in Java Island are mostly deep seated origin [1]. Hence, the study of basement rock is relying upon deep seismic exploration data, where petroleum source rock in favor of object study. The origin and evolution of basement rock is important to study to related what is famous the present is key to the past meet confidence by observing in nature and measure indirectly by geophysics data.

The Area is famous for basement rock, accretion prism of fore arc origin exposed partially on the surface. This evidence has been discovered through geology data by observing the rock and morphology of area, such as [1][2]. Although they identify as fore arc region, but the geometry is not exposed. One the evidence is fault boundary between unit rock separating the mélange complex and the younger sedimentary infilling. The two units now is hidden each other due to the younger covering off in the form folding rock. The rock and geology reconstruction cannot make clear evidence, hence only geophysics data could resolve.

The geophysics gravity data is currently to make evidence that the fault or old morphology separating two rock units, the basement of mélange complex from the younger one. It will open to answered about the nature of fault either the normal, thrust, or strike slip origin. The further process such as modeling and anomaly separation technique will do more for the existence.
2. Methodology

Assuming that the thickness is similar to the horizontal direction under normal conditions, the measurement of the gravity field is mainly carried out along the direction. According to the Kampong path, the number of measurement points is about 154. Basic correction is doing through standard procedure [4].

Meanwhile, geology reconstruction will show up the continuation simple model for the basement to younger sedimentary origin. About disruption to a simple model will discover by gravity data whether as simple model or either old basement morphology or fault in the basement rock.

For fault existence will enhance by directional filter, or classical second vertical derivative [5]. Meanwhile the inversion gravity similar to [5][6][7] will reshape the subsurface model, and further by forward modeling.

3. Geology Area

Lok Ulo river in Kebumen is famous for its Pre-Tertiary formations exposed on the surface. The oldest rock is mélange complex consist of Upper cretaceous, meanwhile the younger is Paleocene age [1][2]. Pre-Tertiary rock (KTI, Kobc, Km, Kts) consist of native bloc of Greywacke, and exotic block lie of Chert, red Claystone, Schist, Limestone, and many rock of igneous origin. All rocks are deposited in fore arc origin.

Figure 1 Geology map overlay by Gravity contour. The thick Gravity contour is 85 mGal. Geologic map after [1]

Tertiary rock is exposed unconformable above the mélange complex. Three formation is exposed on this area, it is Karangsambung Formation (Teok) consisting Clay-shale, sometimes sandy, age Middle Miocene-upper Eocene. This formation is deposits in the Olisostrome environment. Subsequently, Totogan (Tont) Formation is deposited as claystone with fragment of clay, limestone, scheiss, and lava, the environments similar to Karanggambung Formation. Waturanda Formation (Tmw) is exceptional due to coarse elastic consisting of Breccia volcanic origin and sandstone, deposited in turbidity sequence. Its age is early to middle Miocene.
Recent deposits are alluvial (Qa), covering the younger formation. Many fragments of the older deposits are found along the river course. This area is known for structure valley anticline; it means an anticline has been morphologically mature in nature. Besides, Structurally the pre-Tertiary rock is encircling the area.

4. Reconstruction geology, geophysics inversion and enhancement

The map of Figure 1 show part of Anticline with strikes NW-SE. Map show apparently ideal layer where two formation rock of Waturanda and Karangsambung exposed widely. Geology dip is to north. From this we are do not know if it is event layer until basement. A priori if the subsequent layer of an anticline is really ideal, the horizon in subsurface parallel to strike will show a relatively homogenous elevation. This assumption will test through gravity observation.

Applying Gravity anomaly process, is introducing density 2.6 gr/cc. Its anomaly range range is about 10 mGal (the Complete Bouguer Anomaly, from about 81 mGal to 92 mGal). The most obvious anomaly (map, Figure 1) is beneath anticline body map repose the Tertiary sedimentary rock. It is separating the high and lower gravity anomaly. The west block is relatively higher than the east bloc. Meanwhile, around the area, the Pre-Tertiary rock exposed to the surface. Gravity data is subject to simple residual anomaly separation before doing the inversion process.

**Figure 2.** Inversion result. The assumption of lateral continuity basement rocks is disrupted by sediment layer (blue), hence the basement rock in east part is downthrown.
Gravity inversion is applying the concepts that subsurface model could be shaped based on data and an assumption model we introduced. We applied the density maximum concept, where the responsive anomaly based on variable density model. Running 500 iteration process is reaching until resulting RMS error below 5%.

Besides the inversion process, we apply the enhancement of second derivative to the anomaly hence the disruption of anomaly could be identified clearly (Figure 3). Resulting enhancement show two blocks is separating each other.

Based on Geophysics analysis, we predict that beneath the anticline structure where the Tertiary rock is exposed and covered the Mélange complex has different thickness from west to east (see illustration in Figure 4). This boundary remark the existence of old structure or morphology related to Pre-Tertiary basement rock, partially exposed closed to the area. This structure may extend to near surface where morphology shows the lineation, hence indicate a fault zone.

**Figure 3.** Bouguer and second derivative. The arrow indicates a discontinuity zone

**Figure 4.** The interpretation of two block beneath anticline. See result in Figure 2

**5. Conclusion**
An evidence of geophysics and analyse result show that inside the anticline body have subsurface morphology significance in separating two blocs due either subsurface melange tectonic or fault
bounded zone. Sedimentary thickness of Tertiary rock west block is very thin, while east bloc sediment is estimated less than one km, with density contrast -0.2 gr/cc.

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