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Gravity Method Used in Identifying the Northern Part of Seulimeum Fault, Krueng Raya, Aceh Besar, Indonesia

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ABSTRACT

Gravity method can be used to identify any fault system by utilizing the difference of density exhibit from different materials in the earth. This study is to identify the Seulimeum fault system in Krueng Raya, Aceh Besar (Indonesia) using gravity method and correlate the result with the geological map and also to identify and understand the trend patterns or characteristics of the fault system based on the contrast of the bouguer anomaly contour map. A base station is fixed at one place and the reading is taken at the beginning and at the end of each survey to reduce the observed gravity value. The study area of 2.3 km × 1.7 km is divided into 2 boxes of approximately same size. Every station has interval of 200 m to 500 m randomly in the study area. The data is processed using the Microsoft Office Excel and Surfer8 software is used to map the bouguer anomaly contour map. The contour map shows that the lowest value of -33.5 mGal is in the northwest and the highest value of -21.5 mGal is in the southeast part of the area. Geological map of the area and the bouguer anomaly contour map is correlated and the Seulimeum fault system can be detected

successfully using gravity method. The Seulimeum fault system stretches from the northwest to southeast at the upper part of the area and bends towards southeast at the latitude of 5.583 of the Krueng Raya area. The fault has characteristic of low, intermediate and high bouguer anomaly contrast on the contour map.

KEYWORDS: Gravity, Seulimeum fault, Krueng Raya, Aceh Besar

INTRODUCTION

Fault is an extended break in a rock formation that is indicated by relative displacement and discontinuity of strata on either side of particular plane. A displacement of fault may involve few to several hundreds of kilometers which usually resulted from earth movement or an earthquake. There are several types of fault that experience different earth movement and have different structure. The three main types of fault are the normal fault, the reverse fault and the strike-slip fault. Normal fault occur when the hanging wall moves downward and the foot wall moves upward while the reverse fault moves in opposite direction. Strike-slip fault moves in different direction compare to the normal and reverse fault. The earth block moves side by side horizontally and there is no vertical movement of the earth blocks. The combination of normal or reverse fault with strike-slip fault will occur in real life which is more complex to explain.

GRAVITY THEORY

Gravity is a type of force that attracts one object to the other or towards the centre of the Earth. It is a force that acts at a distance or in other words, it is a potential field (Mariita, 2007). The gravity method basically investigates the variations of the Earth's gravitational field due to the difference in the densities between subsurface rocks. It uses the concept of causative body. Causative body means a rock unit of different density from its surrounding. The rock unit that causes perturbation in gravitational field is called gravity anomaly. Different type of rock will have different density. Igneous rocks tend to have bigger density due to its mineral content of primarily silica and also the porosity of the rock. Generally, sedimentary rocks have lower density values due to its porosity. The variation of densities is higher in sedimentary rock than igneous rock because of several factors. The factors are mineral composition, cementation, porosity, and pore fluid type. It is necessary to do all the gravity reductions to the data before the data is interpreted. The corrections are done to all variations of the Earth's gravitational field which do not result from the differences of density of the underlying rocks. The process is known as gravity reduction. The gravity readings have to be corrected for influence of Earth tides and instrumental drift, latitude, elevation and if significant topographic exists, a topographic correction is also should be considered (Mariita, 2007).

GEOLOGY AREA

Krueng Raya is part of the Krueng Aceh Valley facing the Andaman Sea. The area is the northern part of the Barisan Mountain range which is of the Cretaceous age. The oldest rocks in the area are of pre-quaternary rocks which are limestone, slates and phyllites (Culshaw et al., 1979) as shown in Figure 1. The Seulimeum Fault is the minor fault that originated from the Sumatran Fault System in Aceh. The Seulimeum Fault has cut through Plio-pleistocene sediments and volcanic products. The volcanic products came from the active Seulawai Agam volcano that ends with hot springs at its southern part. Krueng Raya has lithology that is dominated by Lam Teuba volcanic which composed of pumiceous breccias, tuffs, andesitic to dacitic volcanic, agglomerate ash flows. Lam Teuba

volcanic intrude the Seulimeum formation that composed of conglomerates, calcareous sandstones, tuffaceous and minor mudstones (Bennett et al., 1981).

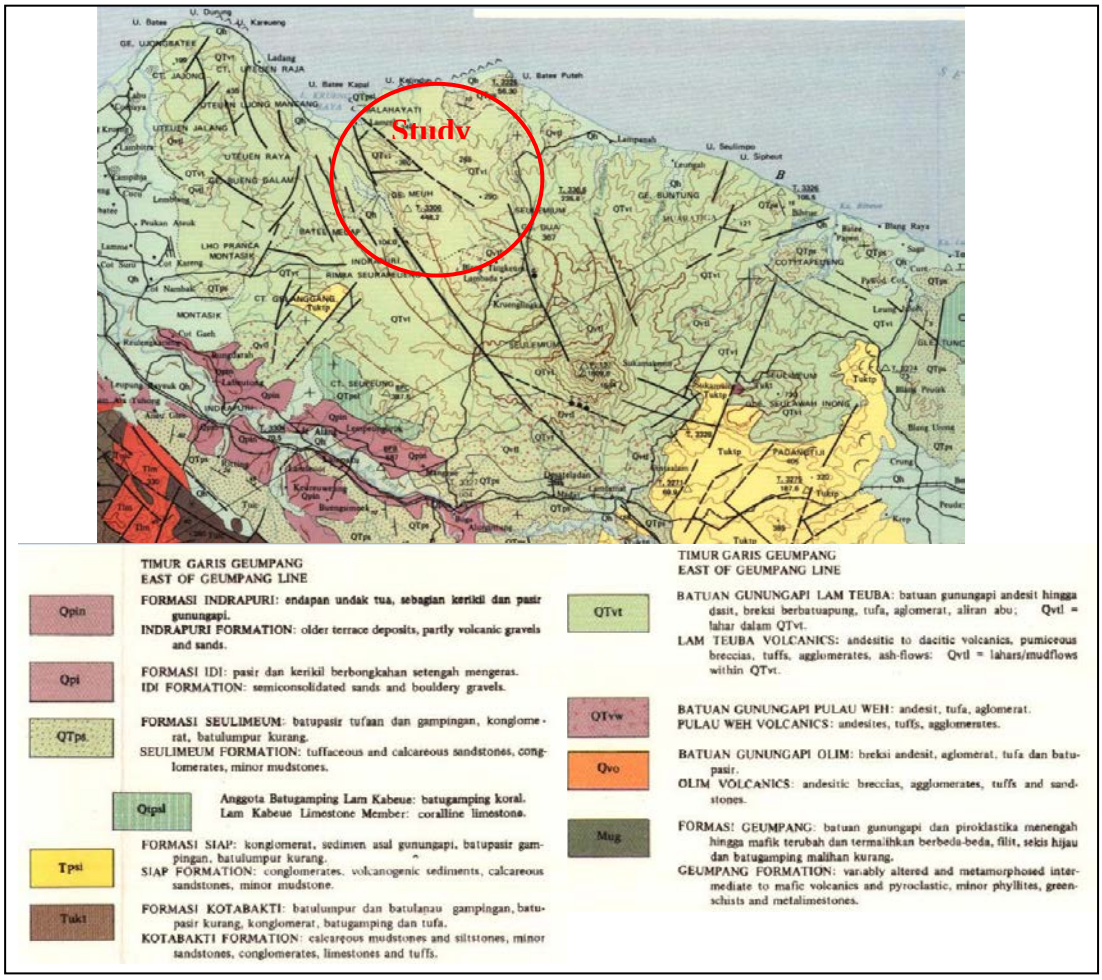

Figure 1: The geological map of Krueng Raya, Aceh Besar (Bennett et al., 1981).

STUDY AREA

The study area is in the northern part of Krueng Raya, Aceh Besar (Indonesia) with an area of 2.3 km × 1.7 km. The area is hilly with widespread of vegetations where some having thick woods and others are just green field. The study area is divided into 2 boxes of approximately equal size (Figure 2). Box 1 is near to the coastline that is mostly flat which consists of residential and oil refinery area. Box 2 is mostly dominated by hills with vegetations and also residential area. The stations have interval of 200 m to 500 m randomly. Figure 3 shows the stations of gravity reading in the study area.

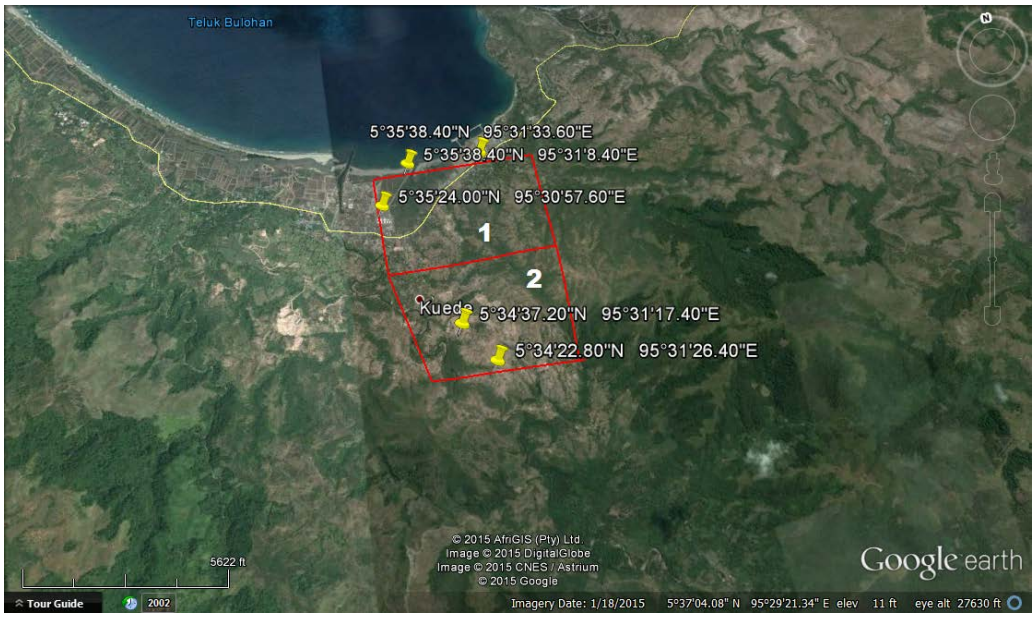

Figure 2: Study area at Krueng Raya, Aceh Besar (Google earth, 2014).

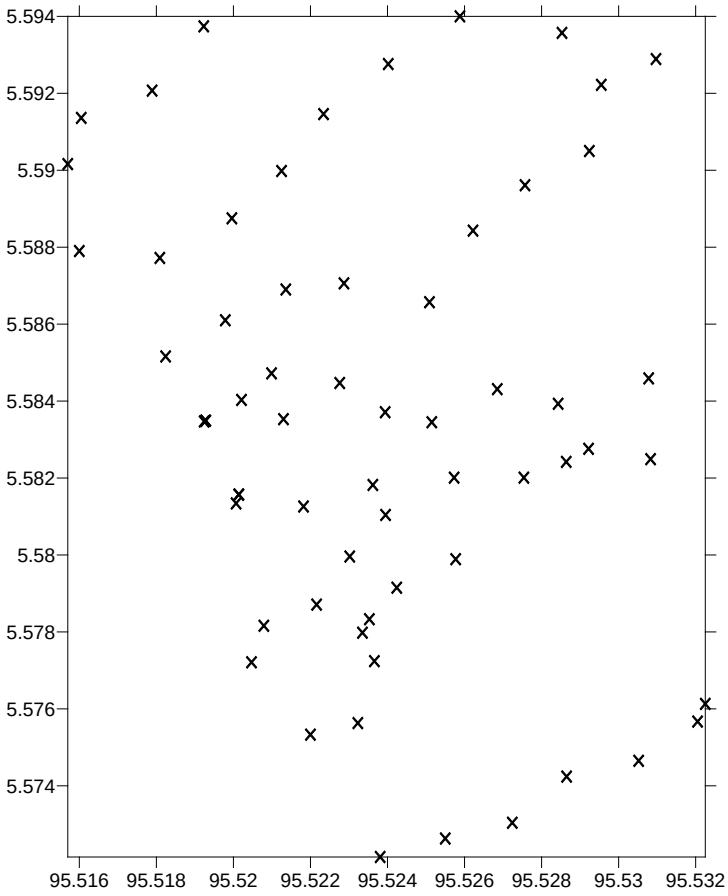

Figure 3: The stations in the northern part of Krueng Raya.

METHODOLOGY

One local base station is fixed for each box and the gravity value at the base station is taken repeatedly. It is taken for correction due to the instrument drift and the effect by the Earth tides. It is important for the base station to be placed at a quiet environment which is far from noise and strong vibrations and has an easy access. Box 1 and 2 has two gravity values at the base station that was taken in the morning and in the afternoon after the survey is finished. The stations have interval of 200 m to 500 m randomly. The station interval is selected by considering the depth and size of the anomaly sought. GPS is used to record the latitude, longitude, elevation of all stations and for providing the direction to proceed to the next station. The tripod height between the base of the gravity meter and the ground surface is measured using the measuring tape up to one decimal point and it is read at eye level to avoid any parallax error. 4 gravity values are taken for each station. The lowest standard deviation, gravity value with lowest standard deviation, tripod height, time and station number are then recorded on the data sheet for reference.

The raw data from the gravity meter is in the format of Text Document (.txt). and the raw data is opened in Microsoft Office Excel to be processed. Since the raw data has 4 gravity values for each station, only the gravity value with the lowest standard deviation is taken for further process. All the corrections are made in the Microsoft Office Excel to get the readings of anomaly bouguer. Surfer 8 is used to plot the gravity values in the form of contour and the coordinates for the stations are positioned on the contour.

RESULTS AND DISCUSSION

The Seulimeum formation composed of tuffaceous and calcareous sandstones, conglomerates and minor mudstones (Bennet et al., 1981). The bouguer anomaly contour map shows that the gravity value has a range from -33.5 mGal to -21.5 mGal. The bouguer anomaly contour map of northern part of Krueng Raya is represented in Figure 4. The low gravity value is represented in blue color and the high value is in red in color. The northwest part of the study area shows low gravity values, the high values are in the southeast part of the area while the rest of the area has intermediate gravity values. The contour map also shows that in box 1, low gravity values are distributed at the west side and the middle to the east of box 1 has intermediate gravity values. The contrast is more noticeable in box 2 as it shows that the lowest gravity value of -33.5 mGal in the west side of the area.

Based on the geological map, the gravity readings are taken across and randomly along the fault system to get a well distributed gravity readings that can verify the fault. A vertical fault can be identified when there is a minimum and maximum bouguer anomaly around the fault and the position of the fault is in the middle of the maximum and minimum (Toushmalani, 2010). The fault formation can be seen clearly from the contour map of the study area due to the contrast of low (northwest) and high (southeast) gravity values. The Seulimeum fault system stretches from the northwest to southeast at the upper part of the area and bend towards southeast at the latitude of 5.583 of the Krueng Raya area.

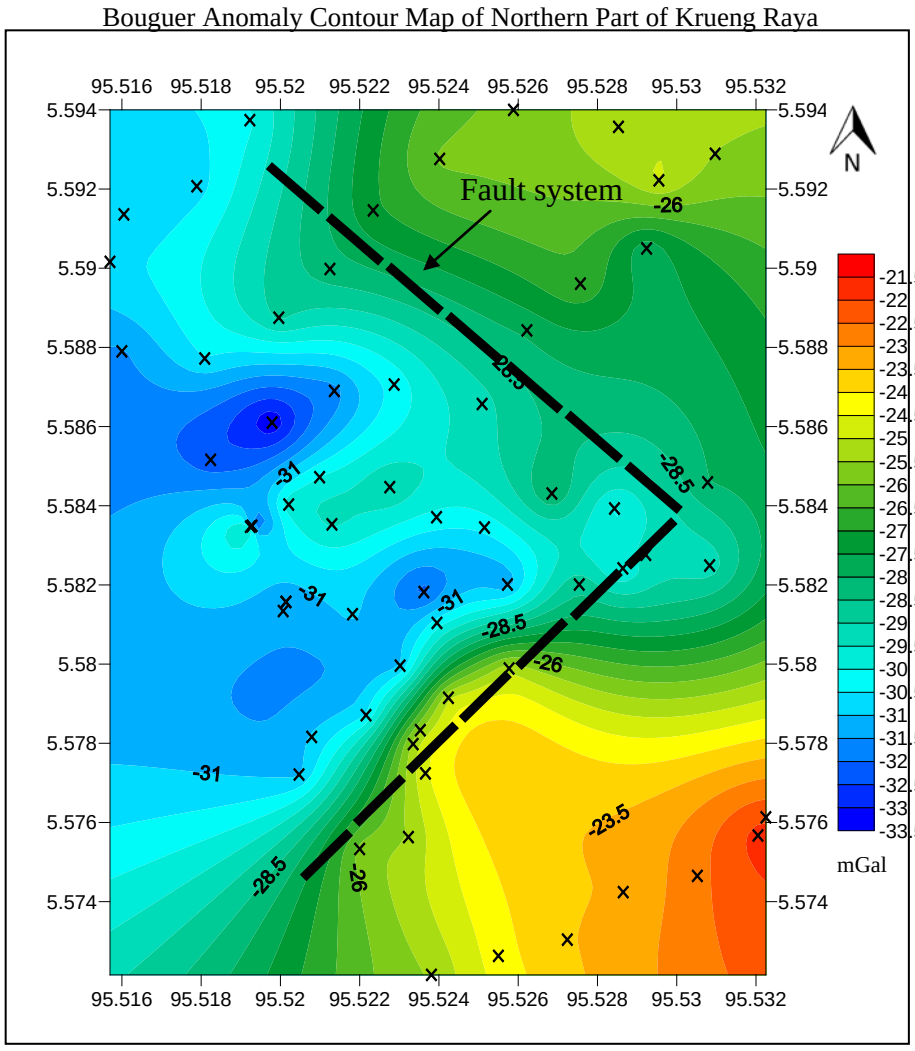

Figure 4: The bouguer anomaly contour map of study area.

CONCLUSSION

The correlation between the bouguer anomaly contour map and the geological map conclude that the Seulimeum fault can be identified in the area. The result interpreted shows that the study area consists of minimum, intermediate and maximum bouguer anomaly values. The lowest value is -33.5 mGal which situated in the northwest part of the map while the highest value is -21 mGal that is in the southeast. The northeast and southwest of the area composed of intermediate value of bouguer anomaly. Differences in rock types and density between the surrounding area and the fault formation resulted in the bouguer anomaly contrast. The position of the bouguer anomaly on the contour map shows that the fault is in the middle of the maximum and minimum values. The Seulimeum fault that is shown on the geological map can be correlated with the result of the study. The Seulimeum fault can be detected successfully in the study area by using the gravity method. The Seulimeum fault system stretches from the northwest to southeast at the upper part of the area and bend towards

southeast at the latitude of 5.583 of the Krueng Raya area. The fault has a characteristic of low, intermediate and high bouguer anomaly contrast on the contour map.

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