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Fault MapingInKlatenRegency AreaCentral Java Province Using Gravity Method

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Abstract: *The study was conducted to map the existence of faults in the study area using the gravity methodmethod. The research data usedissecondary data, The free air anomaly data obtainedfrom the website https://topex.ucsd.edu/cgi-bin/get_data.cgi. To map the fault, the free air anomaly data thencorectedbouguer and terrain correction to obtaincompletebougueranomaly (CBA) data. Complete bougueranomaly data thenanalysis by gradient, and euler de-convolution analysis. Gradient analysisincludes first horizontal gradient and second vertical derivative (SVD). Based on gradient analysis, and euler de-convolution, the results show thatthereisageological structure in the form of normal faultlocated in the southeast of researcharea. CBA data isthenmodeledinverselyusing Oasis Montaj software to getsub surface structure.The results of the 3D modeling obtained a normal fault indication at the UTM coordinates of the 49 S zone at Easting 453000 meters to 457000 meters and Northing around 9140000 m with a depth from about 1000 meters to 3000 meters*

Key Words : *gravitymethod, fault, gradient analysis, euler de-convolution, Klaten*

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I. Introduction

The gravity method is one of the geophysical methods based on the measurement of the gravitational field. This measurement can be done on the surface of the earth, in the sea or in the air. In this method, the study is a variation of the gravitational field due to variations in rock mass below the surface, so that the implementation investigated is the difference in the gravitational field from an observation point to another observation point [1]. One application of the gravity method is to map the subsurface structure in the form of a fault.

Fault or fault is shifting the broken rock from its original position. On the one hand, the presence of faults or faults can be of high economic value because it can be associated with a hydrocarbon trap or become a pathway for the release of magma to the surface which carries high economic value minerals. However, on the other hand it can bring losses caused by shifting faults or faults that will trigger tectonic earthquakes that can cause fatalities, material losses and landslides. [2].

One area that has experienced an earthquake is the area of Bantul Regency, GunungKidul Regency, Klaten Regency and its surroundings. The earthquake that occurred on May 27, 2006 in this area is likely to occur due to the presence of faults in the area. Some geologists concluded that the earthquake was due to the activation of the Opak Fault in the Bantul and Sleman areas, and the Jiwo Fault in Klaten District. In addition, the Yogyakarta Special Region is one of the provinces in the southern part of Java Island which is directly adjacent to the Eurasian and Indian-Australian plate subduction zones. This is what causes the physiographic conditions of Yogyakarta to be strongly influenced by the impact activity of the two plates [3]. Apart from being prone to earthquakes due to plate collision activities, Yogyakarta and Klaten are also prone to earthquakes caused by the activity of several local faults on land [3].

There are quite a number of local faults in Yogyakarta and surrounding areas (including Klaten), such as Opak Fault, SesarJiwo, Sesar Oyo, and SesarProgo. With the existence of a fault system or fault this will cause deformation in the rock which results in the emergence of new faults or minor faults [3].

The Opak-Oyo Fault activity is reflected in the distribution of epicenter and earthquake energy that occurs. On the seismicity map of the Opa-Oyo Fault region it shows more epicenter distribution in the East and Southeast Fault Pathways. The energy generated from the earthquake in the Opak-Oyo Fault region varies from 105.2 - 1012 Joules. Meanwhile, the energy associated with the existence of the Opak-Oyo Fault Line has a value ranging from 105.2 - 109.6 Joules with a hypocenter of 10 km - 20 km. The pattern of energy distribution has a pattern similar to the geological formation in the region [4].

In this study used satellite data in the form of free-air anomaly data obtained from gravimetric satellites, namely the satellite Topex/Poseidon and Jason. Gravimetric satellites are satellites whose duty is to provide accurate information from the earth's gravity field for a period of 5 years. Periodic temporal estimates of the earth's gravity field can be obtained along with the variations that occur [5].

Gravitational methods are used to identify or identify geological structures and subsurface geothermal systems based on rock density values. The existence of this geological structure can result in variations in the density of rocks that are below the surface. The decrease in subsurface structure is based on the relationship of Bouguer gravity anomaly which reflects variations in the density of the surface below the horizontal and geometry (shape) of anomalous objects. From this on this occasion a study was conducted to map faults in the area of Klaten Regency and its surroundings with the gravity method. The results of the study are expected to provide information on the presence of faults and a description of subsurface structures in the area of the study area.

II. Material And Methods

The gravitational field (gravitational acceleration) of an object with mass m caused by the pull of the earth mass M at distance r can be simply stated by [6]

$$g = G\frac{M}{r^2} = \frac{\vec{F}}{m} \quad (1)$$

where g is the gravitational acceleration (m/ s^2), M is the earth mass (kg), m is the mass of the object (kg), is the force of gravity (Newton), r is the distance of point to center of mass (m) and G is the universal gravitational constant, (6, 67 x 10^{-11} $m^3kg^{-1}s^{-2}$) [6].

Bouguer anomaly is an anomaly that is caused by variations in lateral density in rocks in the earth's crust that have been in the reference plane, namely the geoid field [7] [8]:

Gradient analysis is used to determine the boundary and to know the type of fault. To get this, the First Horizontal Derivative (FHD) and Second Vertical Derivative (SVD) are carried out from the path created in the Bouguer anomaly map or regional anomaly map or residual anomaly map which is then made cross section [9].

The First Horizontal gradient (FHG) or the first derivative has another name, namely Horizontal Gradient (HG). Horizontal gradients from gravity anomalies caused by a body tend to show the edges of the body. So the horizontal gradient method can be used to determine the location of the horizontal density contact limits of gravity data [10].

Second Vertical Derivative (SVD) is a High Pass Filter so that it can describe residual anomalies associated with shallow structures that can be used to identify the type of normal fault, reverse fault or horizontal fault [9]. Euler Deconvolution is a mathematical approach for estimating the depth of an object based on a three-way partial derivative (x, y, z) of a function. In general the euler equation can be formulated as follows [11].

This study used secondary data in the form of TOPEX satellite gravity data which is still free air data. Which is taken from the website https://topex.ucsd.edu/cgi-bin/get_data.cgi. This data has a distribution of 304 observation points with a distance between points of around 2000 meters.

The research flow chart can be seen in the diagram in Figure 1:

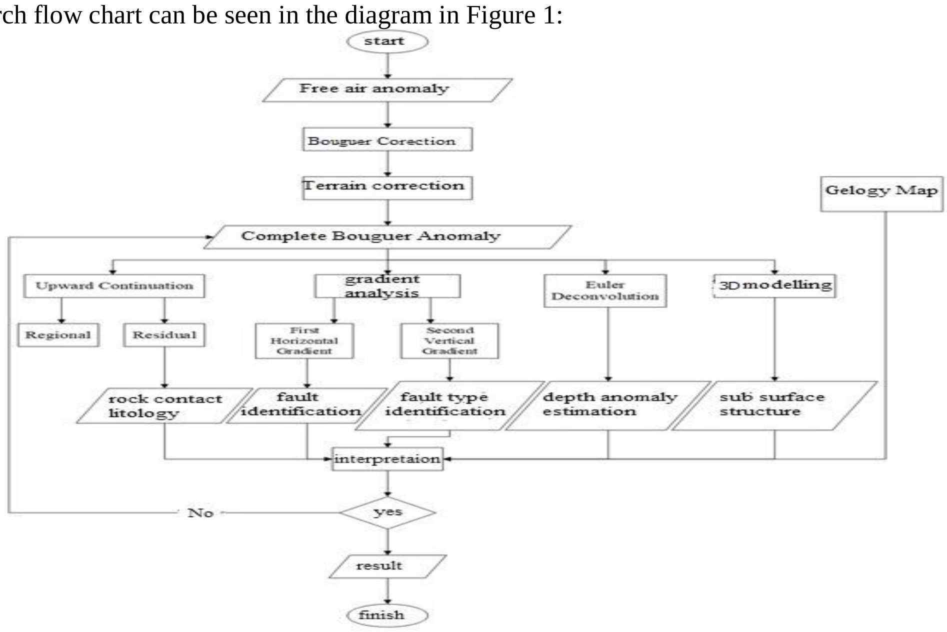


Figure 1. Research flow chart

III. Result

Complete bouguer anomaly is an anomaly value that is generated after the data used in this study is corrected in the form of bouguer correction and terrain correction. The complete bouguer anomaly value obtained is immediately processed by creating a grid and contour in the Oasis Montaj software to get an Anomaly Bouguer map. The results of bouguer anomaly contours can be seen in Figure 2.

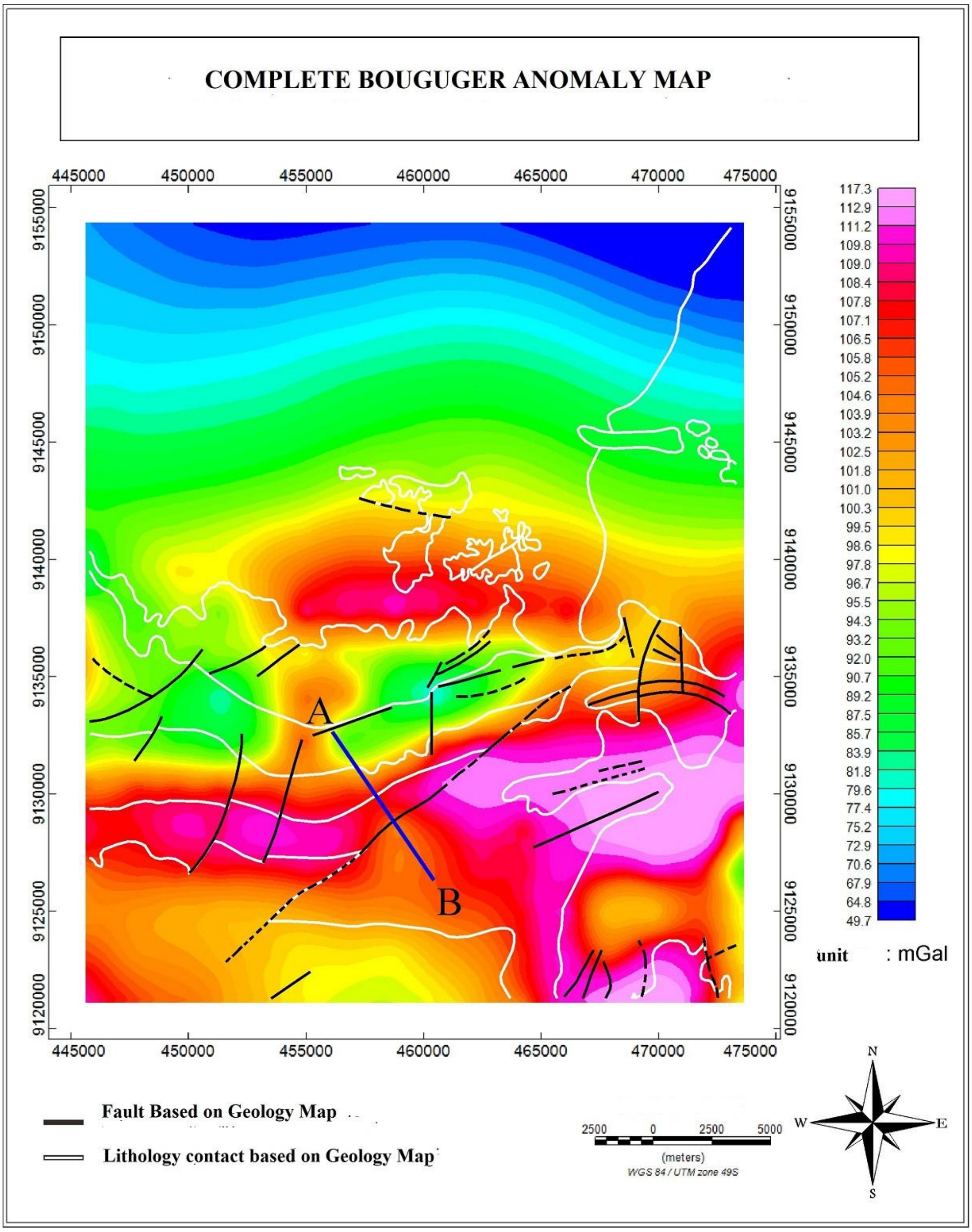


Figure 2. Complete Bouguer Anomaly (CBA) Map

Gradient analysis is done to determine the boundary and to know the type of fault. In this study two gradient analyzes were carried out, namely first horizontal gradient and second vertical gradient. In first horizontal gradient, when the maximum horizontal gradient value, it can be identified as a fault or rock contact [7] [8]. The maximum value on the horizontal gradient shows the lateral density in contrast identified as a fault. The results of the first horizontal gradient can be seen in Figure 3.

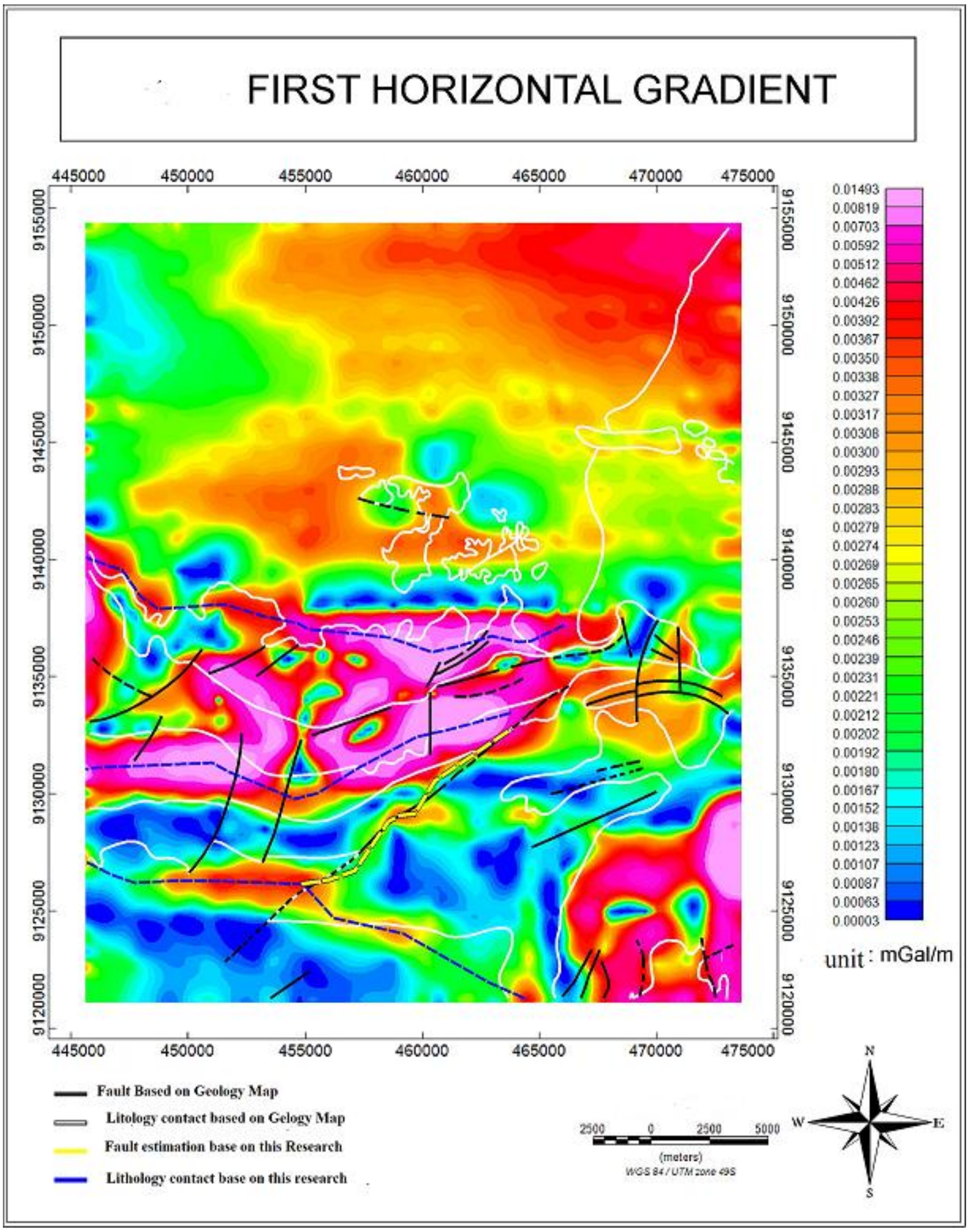


Figure 3First Horizontal Gradient Map

In second vertical gradient, when the second vertical gradient value is zero, it can be identified as rock contact or lithology boundary. Second Vertical Gradient emphasizes the shallow anomalies found in gravity data, this minimum value indicates lateral density in contrast identified as a fault. This research was conducted using the Elkins SVD filter. The results of the second vertical gradient can be seen in Figure 4.

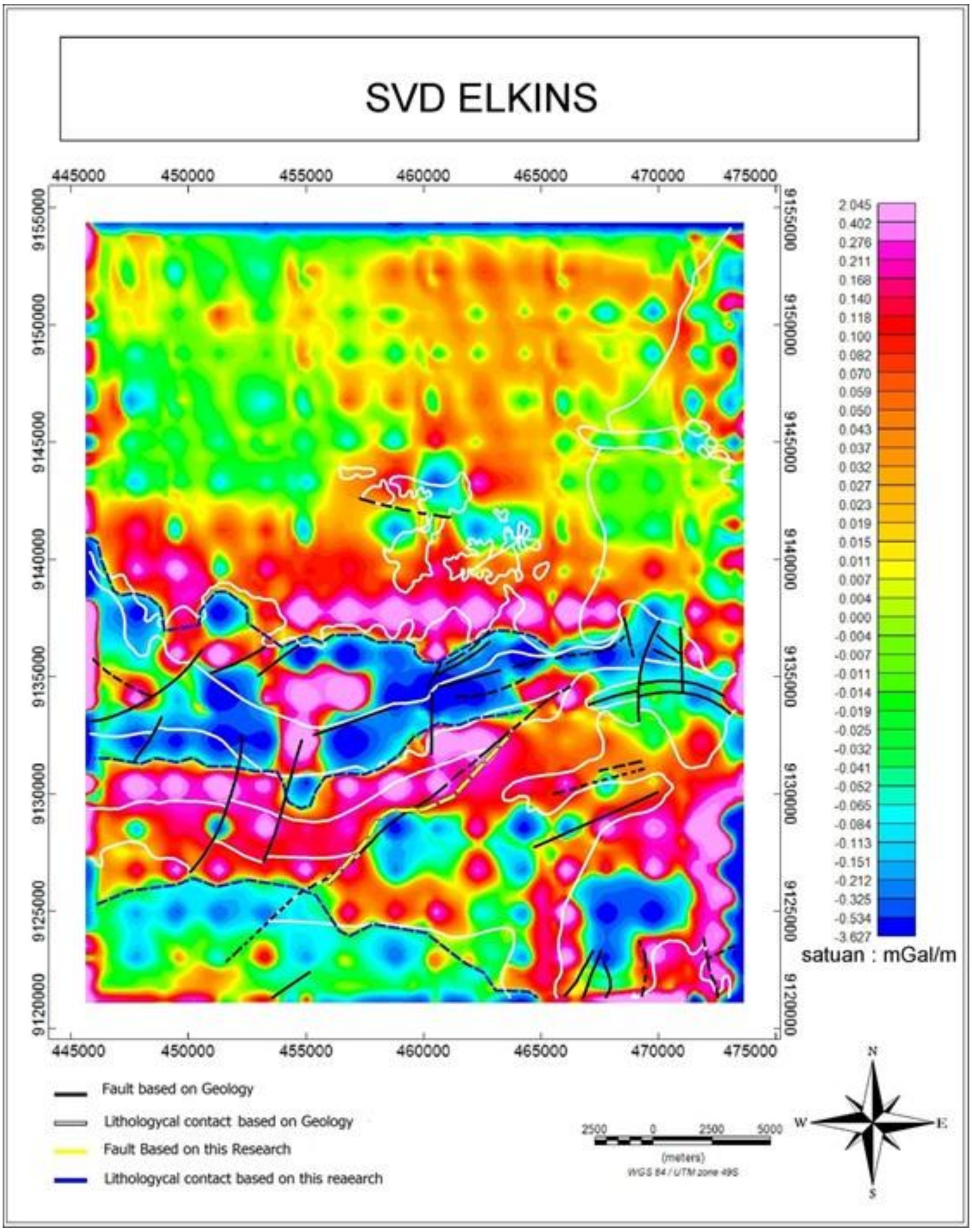


Figure 4Second Vertical Gradient Map

Euler de-convolution is one of the additional methods used to analyze subsurface structures. Euler de-convolution is used to estimate the position and depth of anomalous objects from a gravitational potential field. The results of Euler de-convolution are shown in Figure 5.

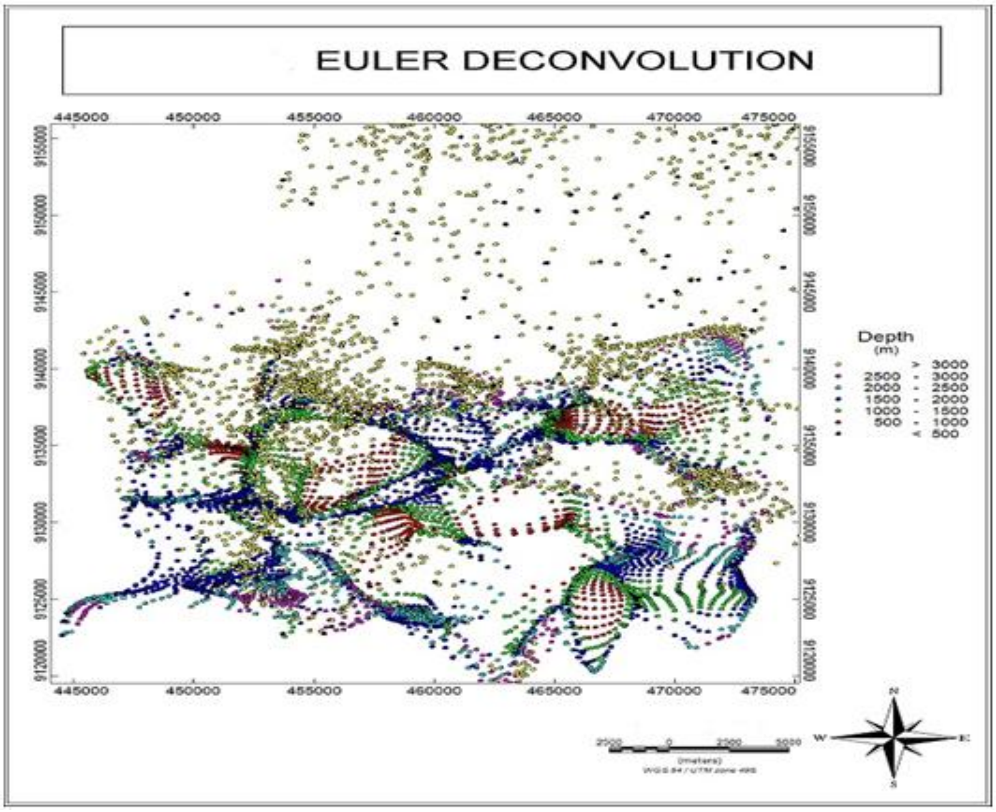
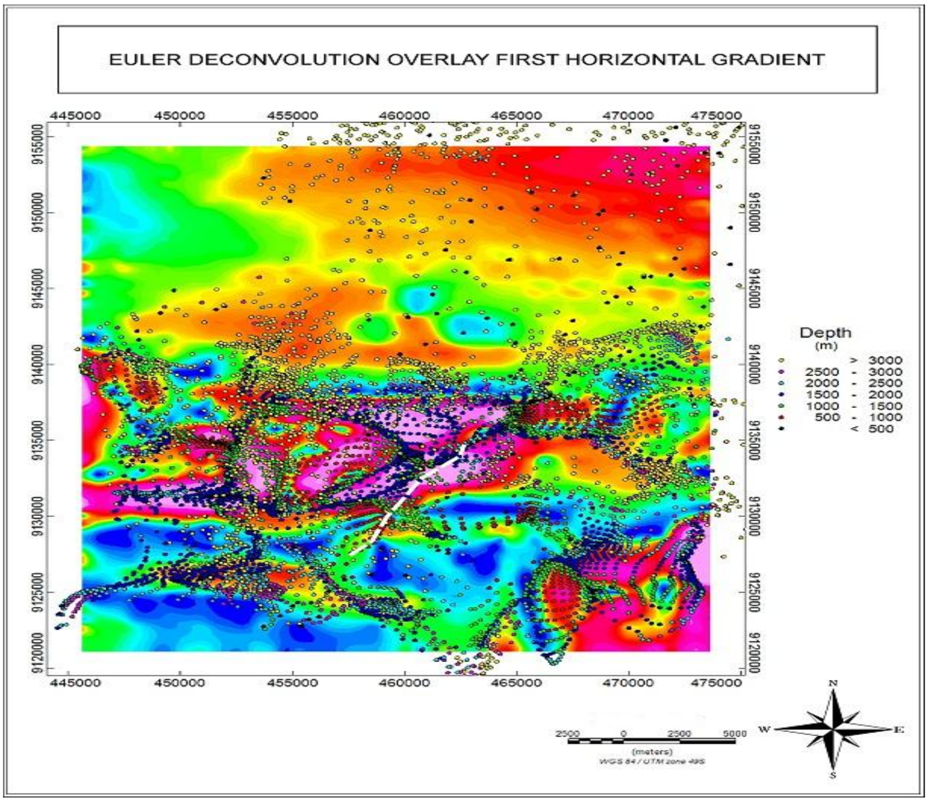


Figure 5.Euler De-convolution Result

The standard euler de-convolution results are then overlaid with maps resulting from analysis of first horizontal gradient to match the results of standard Euler de-convolution with results from first horizontal gradient. The standard Euler de-convolution overlay with first horizontal gradient is shown in Figure 6.



Gambar 6.Euler de-convolution Result which overlay with first horizontal gradient

3D modeling is carried out to assess the structure and layers of subsurface in the study area in 3D. Inversion modeling is done using montaj oasis software. The results of modeling in the north-south incision are shown in Figure 7, Figure 8 and Figure 9.

The north south incision at x (Easting = 454000) in the UTM coordinates shown in Figure 7.

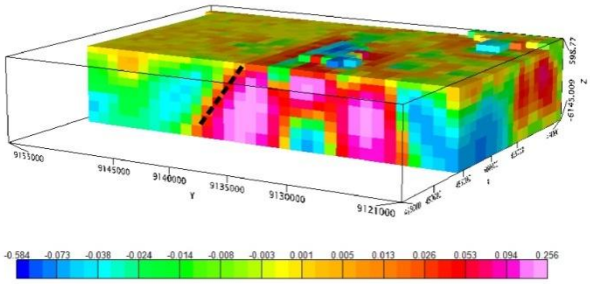


Figure 7 3D modelling x axis

Figure 7 is the result of subsurface modeling in the north-south incision at X = 454000 (in the UTM coordinates of zone 49 S). In this section the fault is shown to hear a black dotted line at arraound Y = 9140000 (in the UTM Coordinate zone 49 S).
The north south incision at x (Easting = 455900) in the UTM coordinates shown in Figure 8.

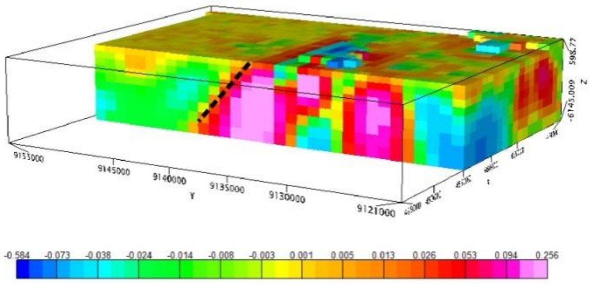


Figure 8. Second 3D modelling x axis

Figure 8 is the result of 3-D subsurface modeling on the incision at x (Easting = 455900). In the picture there is a fault indication indicated by a dashed black line. The fault indication is located at Y (Northing) around 9140000 meters in the UTM coordinate zone 49 S.
The north south incision at x (Easting = 456900) in the UTM coordinates shown in Figure 9.

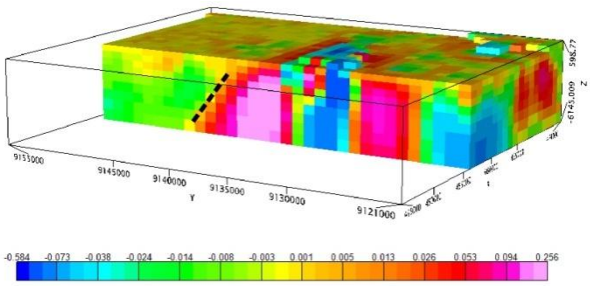


Figure 13. Third 3D modelling x axis

Figure 9 is the result of 3-D subsurface modeling on the x-axis incision (Easting = 456900). In the picture there is an indication of a fault indicated by a dashed black line. The fault indication is located around Y (easting 9140000) in the UTM coordinate zone 49 S.

IV. Conclusion

After a gradient analysis which includes first horizontal gradient, second vertical gradient and euler de-convolution analysis, there is an indication of a fault with the type of normal fault and east-southwest direction at UTM coordinates of 456595 easting and 9130741 northing to466017easting and 9134824 northing at research area with a depth of 1000 to 2500 meters.The results of the 3D modeling obtained a normal fault indication at the UTM coordinates of the 49 S zone at Easting 453000 meters to 457000 meters and Northing around 9140000 m with a depth from about 1000 meters to 3000 meters..

Acknowledgements

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