International Journal of Multidisciplinary Research and Development
www.allsubjectjournal.com
ISSN Online: 2349-4182 ISSN Print: 2349-5979
Received: 04-10-2022, Accepted: 20-11-2022, Published: 06-12-2022
Volume 9, Issue 12, 2022, Page No. 6-9

Applications moving average and horizontal derivative on GGMplus satellite data in Bojonegoro

Agus Setyawan*, Ivena Christie, Muhammad Irham Nurwidyanto, Jatmiko Endro Suseno
Department of Physics, Faculty of Science dan Mathematics, Universitas Diponegoro, Semarang, Indonesia

Abstract
The research was conducted in Bojonegoro Regency which by UTM coordinates is located at 569187.51 until 618964.78 and 9226764.44 until 9183751.81. The geophysical method used is gravity method by looking for the distribution of the density. The data used is gravity disturbance data downloaded from the official website of Global Gravity Model Plus (GGMplus 2013) and Earth Residual Terrain Model (ERTM2160). We applied the moving average and horizontal gradient derivative. The aims of study area to separate the regional and local anomaly and to detect the structural geology or contact lithology in Bojonegoro area. Results of research are Lithology of Bojonegoro area is not only influences by local but regional as well. Horizontal Derivative could detected the fault structure in Kendeng Hills, Anticlines in Kawengan and several fault souronding Khayangan Api Abadi area.

Keywords: gravity method, GGMplus satellite data, moving avarege, horizontal gradient, Bojonegoro regency

Introduction

The research area is in Bojonegoro Regency, which is included in the East Java Province with an area of 1,992 km2. Ecologically, Bojonegoro Regency is included in the Kendeng Zone which has a geological appearance in the form of anticline or karst hills [1, 2, 3]. Based on previous research this region has oil and gas potentials (hydrocarbons) in it, for example in the Gondang Regency area [4]. Geologically, the area of Bojonegoro Regency has many interesting geological potentials so that it is choosen as a research area. The Northwest Region of Bojonegoro Regency is dominated by the presence of limestone/karst mountains (part of the Kendeng Zone) follows by the Undak Bengawan Solo (part of the Bengawan Solo River in Ngasem District). There are several mountains in Bojonegoro Regency, starting from Mount Pegat in the Anggota Dander area of the Lidah Formation and Mount Watu. Several other geological features include the existance of the old well of Wonocolo in the Northwest, Khayangan Api Abadi in the Southwest, the Kedung Maor waterfall in the south, the warm springs potential of Banyukuning and Selo Gajah, the down-fault of Goa Jepang, and the Dung Lantung river in the North [4, 5]. The geological structures that dominate the Bojonegoro Regency area are folds, faults and lineaments [4, 5]. Normal and joint fault structures in the direction of West-East and North-South were found in the Kalibeng Formation, Kerek Formation and Mundu Formation. The up-fault structure rises in the East region as the Banyukuning fault and a number of upfaults in the West (Kalibeng Formation and Kerek Formation). Topographically, the Bojonegoro Regency area is dominated by a relative low slope with a low level of ground level[5]. Currently, the existing research is still limited to the description of the subsurface structure of Bojonegoro Regency separately for each manifestation in its sub-district. Based on this, the study aims separate the regional and local anomaly and to detect the structural geology or contact lithology in Bojonegoro area which is expected to be useful as a reference for further research related to the exploration of manifestations found in the research area.

Gravity Satellite Data

The gravity method is a method based on measuring variations in the gravitational field on the earth's surface, there are many researcher has applied the gravity method [6, 7, 8]. In the current era, a complete method for measuring gravitational field data from satellites has been developed, including data on the geographic location of measuring points on the earth's surface [9, 10, 11]. The satellite image data used in this study is the 2013 GGMplus satellite data which has a distance between points of up to 200 m. GGMplus gravity satellite image data obtained in the form of gravity disturbance data in the form of FAA (Free Air Anomaly) data which is the corrected gravity anomaly value to the Free Air Correction (FAC) stage. FAC (Free Air Correction) itself is a correction stage for the gravity method which is carried out due to the influence of altitude when measurements are made at an observation point [8]. The secondary data used is in the form of satellite gravity data, so that the area that able to be covered can be wider than the field measurements during the same research period. Initially, satellites were used to record the wavelength component of the earth as a measurement correction on the surface which was later developed, satellites were made specifically to study potential by increasing the accuracy and spectrum of the waves [12]. The gravity data anomaly that will be used in the research is downloaded from the official website of GGMplus 2013 via the link https://bgi.obs-mip.fr/dataproducts/grids-and-models/modele-global ggmplus 2013. The data provided by GGMplus is in the form of gravity disturbance data which will be used to obtain the Complete Bouguer Anomaly (CBA) value by performing a topographic correction process. The topographic correction itself consist of the bouguer correction and terrain correction [13].

Method

Moving Average

Separation of anomalies is done because of the complete Bouguer anomaly (CBA) obtained are still affected by regional anomalies and residual anomalies. Both of those anomaly value is still interact and causing the anomalies are overlapping [14]. Subsurface anomalies that are measured before the anomaly separation is carried out are still in the form of a superposition of various detected anomaly sources, while the target in subsurface exploration using the gravity method is a residual anomaly that can provide information on the subsurface structure because it is an anomaly value caused by high-frequency shallow anomalies and short wavelength [15]. The anomaly separation method used in this study is the moving average method. The moving average method is done by taking the average anomaly value which further will be considered as the regional anomaly value. While the residual anomaly value is obtained from subtracting the value of the gravity measurement with the regional anomaly value obtained. Mathematically, the calculation of the moving average method is expressed by equation 1 and 2.

$$\Delta Treg(i,j) = \frac{(\Delta T(i-n,j-n)+\cdots+\Delta T(i,j)+\cdots+\Delta T(i+n,j+n)}{N} \quad (1)$$

$$\Delta Tres = \Delta T - \Delta Treg \quad (2)$$

With n = (N-1)/2, N is an odd number, Treg is a regional anomaly, Tres is a residual anomaly, and T is a bouguer anomaly [16].

First Horizontal Derivative (FHD)

Horizontal derivative in gravity is a change in the gravitational anomaly from one point to another at a certain distance. Horizontal derivative is a gravitational anomaly as a result of a body that can show the edge of a body, so that this method is suitable for determining the location of the density contact limit from a horizontal gravity data [17, 18]. The derivative analysis method that will be used in this study is the First Horizontal Derivative (FHD) method.

Result Analysis

Complete Bouguer Anomaly

Complete Bouguer Anomaly (CBA) was obtained after conducting through several correction processes in the gravity method described in the previous chapter. Figure 1 is the appearance of the CBA contour map based on the processing results through the Geosoft Oasis Montaj software which shows the anomaly value range between -15.55 mGal to 101.15 mGal. Based on the range of anomaly values, it can be said that the research area is predominantly classified as an area with medium anomalies marked in green to orange areas with range of values between 27.11 mGal to 35.98 mGal.

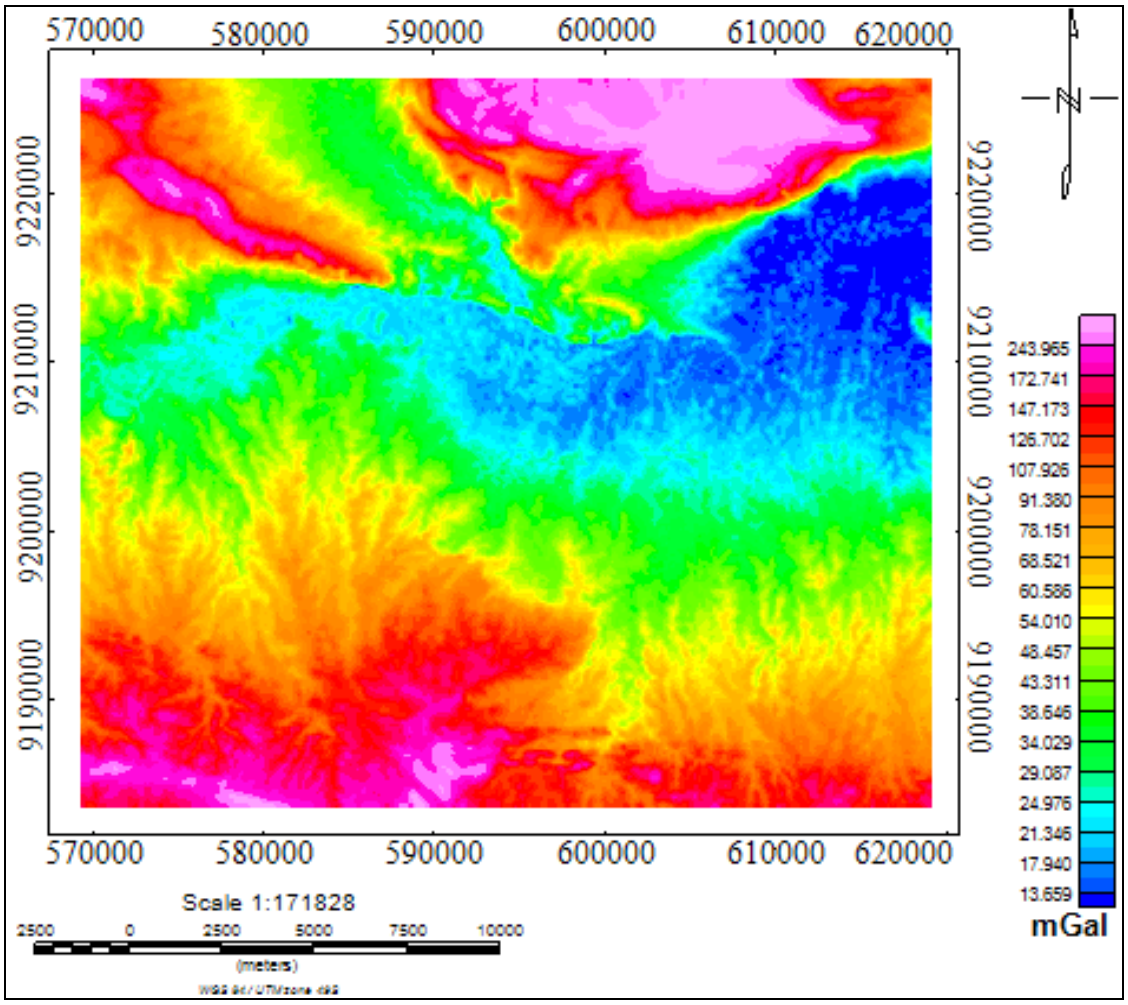
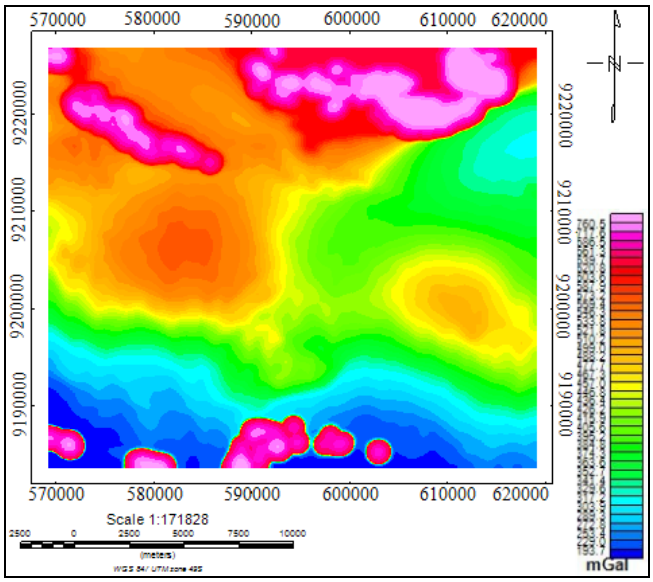


Fig 1: Complete Bouguer Anomaly Contour Map

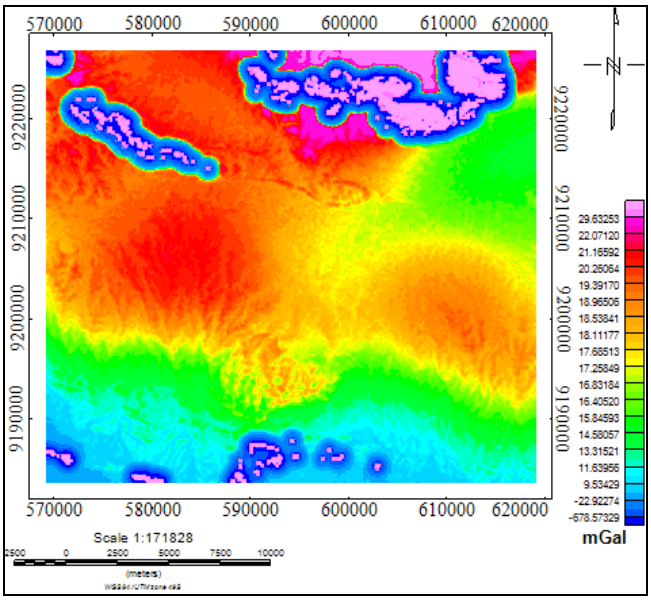
Based on Figure 1, low anomaly with anomaly range of -15.55 mGal to 24.83 mGal is indicated by a dark blue to light blue map areas that stretches to the south, below the medium anomaly areas. This low anomaly area is indicated as a research area that has a distribution of low rock density. There are predominance of clay rocks, water areas where the Bengawan Solo River flows. Medium anomaly with an anomaly range of 27.18 mGal to 35.98 mGal marked with green to orange colour spread lengthwise in the East, West and Southwest of the research area with indications of the presence of geological features, namely the Goa Japan and Goa Sendang Gong as a place that discover a lot of bentonite in the area (on Lidah Formation research area). Meanwhile, the high anomaly in the study area is marked with red to purple color with anomaly values ranging from 37.04 mGal to 101.15 mGal which are spread over the northern area of the research area and stretch in the direction of West to East. This high anomaly area is indicated as an area with a relatively high density or rock mass density compared to its surroundings (the hilly land area included in the Kendeng Mountains and Kawengan Field). High anomalies also appear in the southern and southwestern parts of the research area which are indicated as areas of Khayangan Api Abadi. Many manifestations are formed in the northern and southern parts of the study area with geological structures that dominate the study area, which is fault structures, folds, anticlines, synclines, and hilly structures to the appearance of former river areas. Bojonegoro Regency as a whole is an area consisting of several geological formations. The Kalibeng Formation and the Kerek Formation (in the southern part with a west-to-east direction) are parts that indicate the presence of the Banyukuning upfault structure and normal faults at its sorroundings. The Kalibeng Formation in the Northwest as an indication of the appearance of hilly soil part of the Kendeng Mountains where geological structures such as faults and folds are found. Until the Kerek Formation where the appearance of the Immortal Flame Heaven was found in the Southwest part of the research area. The Mundu Formation and the Lidah Formation in the northern part of the research area are locations indicating the presence of the Kawengan Field which shows an anticline structure. The Lidah Formation itself is a formation where terraced fault structures are found, bentonite, and the appearance of the Goa Japan and Goa Sendang Gong. While the Alluvium Formation is a formation where low anomalous appearances are found in the research area which indicates the former area of the Bengawan Solo River flow.

Moving Average

Complete Bouguer Anomaly (CBA) is an anomaly value that is still influenced by regional and residual anomalies so that an anomaly separation process is required. The input used in the anomaly separation process in this study is CBA data. The method used in the process of separating regional and residual anomalies is the moving average method. The moving average method is a method of separating regional and residual anomalies by averaging the gravity anomaly data. The moving average is done through Geosoft Oasis Montaj software with the help of a 5x5 MVA file filter. Figures 2 show anomalous contour maps using the moving average method and obtain regional anomaly values of 193.7 mGal to 760.5 mGal (Figure 2a) and residual anomaly values of -578.57 mGal to 29.53 mGal (Figure 2b). Based on the figure, it can be seen that the regional anomaly contour map based on the moving average method has anomaly appearance that resembles the CBA contour map with a smoother appearance.



(a)



(b)

Fig 2: (a) Regional anomaly map, (b) Residual anomaly map

First Horizontal Derivative

The steps of derivative analysis are carried out to determine the lithological boundaries and subsurface structures formed in an area. The derivative analysis stage carried out in this research is the first horizontal derivative in order to determine the lithological boundary or rock contact that will be identified as the appearance of the subsurface structure in an area. The derivative analysis process was carried out based on the residual contour map resulting from the separation of anomalies using the moving average method. The horizontal derivative will be used as a step to emphasize the high anomaly contained in the gravity data to show the density in the contrast which is further interpreted as a fault. Horizontal derivative can be interpreted as a fault and rock contact from an area when the horizontal gradient value has a maximum value. The results of first horizontal

gradient are shown in Figure 3 with a value range of 0.48 x 10^{-4} mGal to 6.52 mGal.

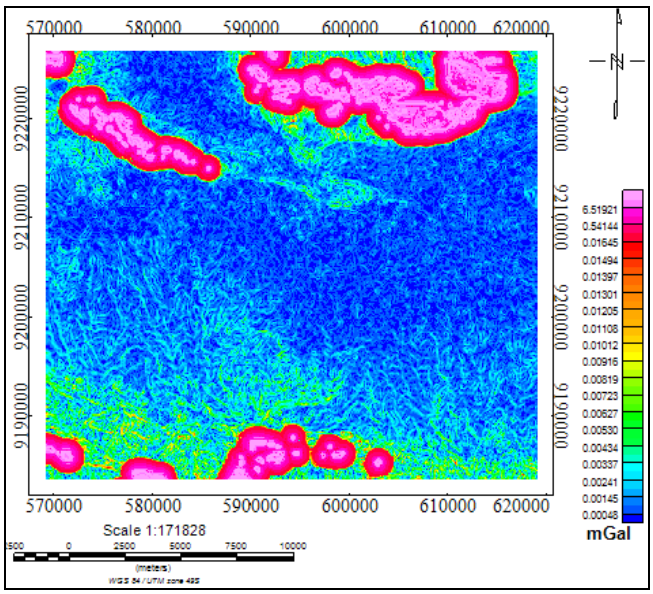


Fig 3: First horizontal derivative map of research area

The results of the first horizontal derivative analysis show the maximum value in the red to light purple areas with a value range of 0.54 mGal to 6.52 mGal. Medium values in the green to orange sections with a range of values of 0.434 x 10^{-3} mGal to 0.54 mGal and low values (minimum) in the dark blue to light blue areas with a value range of 0.48 x 10^{-4} mGal to 0,34 x 10^{-3} mGal. FHD analysis in research can be used to interpret geological structures, where there are several identified structures, including fault structures in the Northwest part of the study, namely in Kendeng Hills area, as well as anticlines in the Kawengan Field area (located below the Kendeng Hills fault), as well as several structures, up-faults and faults in the southern part of the study area, namely around Khayangan Api Abadi area.

Conclusions

The regional anomaly contour map based on the moving average method has anomaly appearance that resembles the complete bouguer anomaly contour map with a smoother appearance. Lithology of Bojonegoro area is not only influences by local but regional as well. Horizontal Derivative could detected the fault structure in Kendeng Hills, Anticlines in Kawengan and several fault souronding Khayangan Api Abadi area.

References

1. Bemmelen VRW. The Geology of Indonesia v. I.A., Government Printing Office, 1949.
2. Gupta H, dan Ray S. An Outline of the Geology of Indonesian, IAGA Jakarta, 2007, 11-36.
3. De Genevraye P, Samuel dan Luki. Geology of the Kendeng Zone (Central and East Java). Indonesia: Indonesian Petroleum Association, 1972.
4. Setiawan Jatmiko. The Geology Role in The Development of Natural Resources and Disaster Management, Proceeding of 3rd National Seminar of Geology Department Faculty Engineering Universitas Padjadjaran, 2016.
5. Hasyim Rizal Arief. Geology of the Surrounding Papringan Temayang Bojonegoro East Java, 2016, 1(1).
6. Setyawan A, Ehara S, Fujimitsu Y, Nishijima J, Saibi H, Aboud E. The Gravity Anomaly of Ungaran volcano Indonesia, J. Geotherm Res. Soc. Japan,2009:31:107-116.
7. Saibi H, Aboud E, Setyawan A, Ehara S, Nishijima. Gravity data Analysis of Ungaran Volcano, Arabian Journal of Geosciences,2012:5:1047-1054.
8. Nishijima J, Naritomi K. Interpretation of gravity data to delineate underground structure in the Beppu geothermal field, central Kyushu, Japan. J. Hydrol. Reg. Stud,2017:11:84-95.
9. Anderson OB, Knudsen P. DNSC08 Mean Sea Surface and Mean Dynamic Topography Models, Journal of Geophysical Research Atmosphere, 2009, 114.
10. Tscherning CC, Anderson OB, Knudsen P. Improvement of gravity prediction from satellite altimetry in coastal areas using data on land, 2008.
11. Setyawan A, Khusna LM, Suseno JE, Rina DI, Yulianto T, Aribowo Y. Detecting Hot Spring Manifestations based on Gravity Data Sattelite on Mountain Lawu, Journal of Physics, 2021. 012034 IOP Publishing doi:10.1088/1742-6596/1943/1/012034
12. Kurniawan FA Sehah. Utilization of Geosar Imagery Gravity Anomaly Data and ERS-1 Satellite to Modelling the Geological Stucture of The Bentasari Basin Brebes, Indonesia Journal of Applied Physics,2012:2(2):184-195.
13. Hinze W, VonFrese RRB, Saad AH, Gravity and Magnetic Explorations, Priciple Practice and Applications, Cambridge University Press, 2013.
14. Telford WM, Geldart LP, dan Sheriff RE. Applied Geophysics 2nd ed. Cambridge University Press: Cambridge, 1990.
15. Hinze W, VonFrese RRB, Saad AH. Gravity and Magnetic Explorations, Priciple Practice and Applications, Cambridge University Press, 2013.
16. Lowrie William. Fundamentals of Geophysics, New York: Cambridge University Press, 2007.
17. Blakely Richard J. Potential Theory in Gravity and Magnetic Application, New York: Cambridge University Press, 1995.
18. Cordell L. Gravimetric Expression of Graben Faulting in Santa Fe Country and the Espanola Basin, New Mexico. In: Ingersoll, R.V., Ed., Guidebook to Santa Fe Country, New Mexico Geological Society, Socorro, 1979, 59-64.