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Study On Mineralization Zone Of Blitar District By Means Of Simple Bouguer Anomaly

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Abstract: ***Study on mineralization zone of Blitar district by means of simple Bouguer anomaly has been done. Gravity and position data acquisition were acquired 224 data respectively by using gravitymeter and GPS distributed in all of Blitar district included 22 sub-district. Data distributed in geographic coordinates (112.43952°BT; 7.91870 °LS) and (111.96268°BT; 8.33120 °LS). Gravity data processing has been done by some corrections i.e tide, drift, base station, tie, normal gravity, free air, and Bouguer to obtain the simple Bouguer anomaly. From this data processing has been obtained the simple Bouguer anomaly value in range from -10mGal until 115mGal that distributed in all of sub-district. By means of gravity data processing has been obtained that the high relatively of simple Bouguer anomaly with the value more than 80mGal and more than 110mGal for free air anomaly is located in the sub districts of Bakung, Kademangan, Wonotirto, Sutojayan, Panggungrejo, Binangun, and Wates. All of these sub-districts are located at southern mountains, i.e. at the south side of Blitar district. Otherwise, that the negative value of Bouguer anomaly located at Kelut Volcano and surrounding, i.e. at the north side of Blitar district. From these research could shown that the simple Bouguer anomaly has relationship with the mineralization zones at the Blitar district. Whereas the mineralization zone in this area indicate by the presence of some out crop in this area, i.e.: kaolin, limestone, bentonite, manganese, feldspar, iron sand, copper, ball clay, onyx, calcites, zeolites, volcanic rocks, sand, trass, gold, piropilit, chalcedony, and other ore minerals.***

Key Words: **Simple Bouguer Anomaly, Blitar District, Gravity, Mineralization Zone.**

I. INTRODUCTION

Administratively, the district Blitar lies between Kediri district in the northern, Malang regency in the eastern, Indian Ocean in the southern, and Tulungagung district in the western part. While geographically, Blitar district has located between geographical coordinates 111°40' - 112°10' in east longitude and 7° 9'51" in south latitude or have an area about 1588.79 km^2. Blitar located at an altitude of 167+ meter above sea level. Brantas River divides the Blitar district into two parts, namely north Blitar region has an area of 898.94 km^2 and south Blitar with an area of 689.85 km^2. Southern Blitar region has infertile soil because the soil tend to contain limestone, while northern Blitar region has fertile soil because in this area there are Kelut volcano is still active with eruption and volcanic ash as an adequate number of river streams. Blitar has 22 districts with 7 districts located in southern Blitar and 15 districts located in North Blitar. In Physiographic, southern Blitar region is part of the southern mountains [1]. Southern mountains extend from Wonosari area, also known as mountain Sewu in Central Java to Blambangan peninsula in East Java is flanked by Yogyakarta depression zones in the west side and Pasirian depression zone or Lumajang in the east. In the northern of this mountains is lined Quartenary volcanoes on Solo zone, while in the southern of this mountains is the Indian Ocean. southern Blitar region itself constrained by Tulungagung district in the west side, the Kediri district in the north side, Malang district in the east side, and the Indian Ocean in the south side. In general, these mountains have Tertiary age (Oligocene, Miocene, Pliocene up) and Quaternary, several formations intruded by dacite, quartz diorite and tonalite [2]. As a result of the intrusion, the rock surrounding suffered hydrothermal alteration and make propilitisation and mineralization. Due later in the area there are many mineralized zones likes kaolin, limestone, bentonite, manganese, feldspar, iron sand, copper, ball clay, onyx, calcites, zeolites, volcanic rocks, sand, trass, gold, piropilit, chalcedony, and other ore minerals. Some mineral or mineral resources resulting from the above process are often found in southern Blitar. Metallic minerals in general are safe products as a result of a process of differentiation and crystallization of magma that occurred during the formation of igneous activity will end. This process begins with the initial break through hydrothermal solution of high concentration in rocks older age. When the solution in through cracks and / or fractures, there was a process of alteration in these rocks. The process of alteration occurs at high temperature and pressure, followed by changes in the mineral composition of the rock, due to the inclusion of hydrothermal solution. Alteration processes can be classified into 3 types [3], i.e:

- *Argilitisation* : Alteration that changes the mineral feldspar into clay minerals in rocks intruded.
- *Silisication* : Alteration that resulting silica mineral, can be as fine-grained mineral quartz, chalcedon or other types of silicate compounds.
- *Propilitisation* : Alteration that resulting the mineral group.

At the cooling took place, along with the chemical and physical reactions, precipitates newly formed minerals. This mineral kinds depending on the type hydrothermal solution, kind of rock that intruded, and the rate of cooling process that occurs in the rocks themselves. Diverse rock mineral content will produce some kind of newly formed minerals. The end result of this process, it will accumulate in the pores of rocks, fractures/faults and / or perlapisan rock. Meanwhile, the area's main characteristic alteration is the formation of CO_2 which is the product of the alteration process. The existence and amount of CO_2 depends on the type of metal, magnesium and / or potassium rocks intruded. In this case the alteration process followed by the formation of pyrite (FeS_2). This event usually found around bodies of sulphide minerals. Another possible sulphide minerals such as chalcopyrite formed (CuS_2) and galena (PbS)[4]. Physically, in the alteration zone has lower value in density, susceptibility, and resistivity than the similar parameters in fresh rock (not experienced alteration) in the surrounding. This happens because of the alteration zone which is the accumulation of metallic minerals would have a value of low resistivity or high conductivity values compared with non-metallic minerals. The existence of contrasting physical values which led to the application of integrated geophysical methods can be used to determine the distribution of the subsurface mineral [5]. Therefore, efforts to optimize the real potential of this district should continue to be done, both the identification, inventory, and design management. Based on the above, the research will be conducted to determine the cause of the spread of various types of rock mineral or mineralized zones contained in Blitar district, especially the southern part Blitar using gravity. The use of gravity methods in this study on the grounds that the mineralized zone generally will have a significant density contrasts with the surroundings. In addition, the gravity data acquisition can be performed by the method of stop and go, so it can be done quickly and does not require a measurement for extensive configuration. However, because the gravity method is one geophysical method that is relatively so that the measurements need to be tied to a known point value. In this paper will be delivered piece or part of research that has been done, i.e. the Simple Bouguer Anomaly for mineralized zones located in the Blitar district.

II. METHODS

The study was conducted through a series of activities which include data acquisition, processing and interpretation. Gravity data acquisition is distributed across Blitar district and lies between the geographical coordinates (112.43952^{o}in east longitude; 7.91870^{o}in south latitude) and (111.96268^{o}in east longitude; 8.33120^{o}in south latitude) with the points number of measuring data 224. The data is distributed along the roads that can be passed either by vehicle or by foot. Data is also focused on the discovery outcrop locations and locations of mining that has been operating at the study site. The main equipment that used in this study is the Gravity meter La Coste and Romberg in miliGal accuracy rate. The distance between the measuring point to measuring point the other is approximately between 1km to 2km. Data acquisition is done by looping daily to the base station which is located in the Department of Physics Faculty of Mathematics and Natural Sciences University of Brawijaya Malang. The base station is the result of the calculating from tie point is located in the Juanda Airport, Surabaya, East Java with reference to a Regional Gravity Base Station Network for Indonesia [6]. The distributions of the gravity data is shown in Figure 1. Contour of gravity before processing the data from acquisition is shown in Figure 2. Data processing is performed by applying tide correction, drift correction, base station correction, free air correction, and Bouguer correction [7]. Data interpretation is done using simple Bouguer anomaly with many considerations from data outcrop, and the potential of the locally mineral mining.

III. RESULT AND DISCUSSION

Gravity method works based on the nature of the rocks making up the Earth, namely that between one type of rock to another rock has different density. If there are anomalies in the subsurface, then the measured value of the gravitational field at that location will deviate from the normal state of the gravitational field. If the deviations are in the form of adding value, then it is called positive anomalies (density anomaly greater than the density of the surrounding area). Conversely, if the deviations in the form of a reduction in value, it is called a negative anomaly (density anomaly is smaller than the density of the surrounding area). Because these parameters are sensitive to changes in gravitational tides due to rotation of the earth and the moon, the advantages and disadvantages of mass due to the topography of the earth, and the difference in reference to the reference calculation, the data measured in the field necessary corrections to eliminate these influences

*A. **Tidal Correction***

Earth is in the sun solar system. Earth surrounded by sky objects very much. There's the sun, the stars, the moon and meteorites. All the celestial bodies affects the gravitational acceleration recorded by the gravimeter. But the moon and the sun have the greatest influence than the other heavenly bodies, because of the mass and the distance from the earth, so that the influence of other celestial bodies is negligible.

To eliminate the change in value of the gravitational acceleration due to the influence of the heavenly bodies particularly the sun and the moon, the data presented should be tide correction (TDC). The magnitude of this correction was: [8]

$$\mathrm{Tdc} = \frac{3\gamma r}{2}\left\{\frac{2M}{3d^2}(\sin^2 p - 1) + \frac{Mr}{d^4}(5\cos^3 p - 3\cos p) + \frac{2S}{3D^3}(3\cos^2 q - 1)\right\} \quad (3.1)$$

with: p is moon zenith angle, q is solar zenith angle, M is moon mass, S is sun mass, d is distance between the center of the earth and the moon, D is distance between the center of the earth and the sun, γ is value of Newtonian gravity constant, and r is distance measurement from the center of the earth.

B. Drift Correction

Due to frequent shocks during the measurement data in the field or during transport, resulting in a shift in the reading of the zero point on the instrument (especially on instrument that do not clamped so gravimeter spring still work). This is called drift that have magnitude as a function of time. This correction is done by making a closed path or closed loop at points of measurement, which is by way of repeated measurements at the initial station (point base station each loop). The magnitude of this drift correction is:

$$Kd(ti)=\{(t_i - t_{aw})/(t_{ak} - t_{aw})\} x\ (G_{ak} - G_{aw}) \quad (3.2)$$

with: Kd (t_i) is drift correction at readings time at the i-th point, t_i is time reading at i-th point, t_{aw} is time reading time at the start point, t_{ak} is time reading at the end point, G_{aw} is gravimater reading at the starting point, G_{ak} is gravimeter reading at the end point [9].

C. Normal Gravity Correction

Earth's rotation causes the earth is an ellipsoid. So the radius of the earth varies for different latitudes. Centrifugal acceleration causes the maximum rotation of the earth at the equator and zero at the poles, it is contrary to the acceleration of gravity greater at the poles than at the equator [10]. It should be made a form formulation g_θ as a function of latitude position, which was then called the theoretical gravity correction or correction of normal gravity ($g_n(\theta)$). For several years the formulation of normal gravity value is improved. One of the formulation according to the Geodetic Reference System which refers to the shape of the earth theoretically is using the formula of the IAG (International Association of Geodessy) that is GRS (Geodetic Reference System) of 1980 on the WGS84 (World Geodetic System 1984), is:

$$g_n = 9.7803267714 \left(\frac{1+0.0019385138639 \sin^2\theta}{\sqrt{1-0.00669437999013 \sin^2\theta}} \right) \qquad (3.3)$$

with: g_n in m.sec^{-2} and θ is the angle of latitude [7].

D. Free Air Correction

For the measurement of gravity at sea can be directly compared with the normal value of gravity (g_n) because geoid field corresponding to sea level. Gravity measurements on land had to be corrected due to altitude that is below or above sea level [7].

Free air correction based on the fact that the gravity of the earth as a whole can be considered the same as if the mass is concentrated at its center. If the height gravitimeter changed, then the distance from the center of the earth changes with the same value [11].

If the distance from the surface of the spheroids into the center of the earth is r and height measurements of gravity at the point of observation from the field of spheroids is h (where h << r), if g (r) represents the gravity field or geoid normal gravity, the free air correction is:

$$g(r+h)-g(r) = \frac{2g(r)}{r}h = g_{fa} = -\ 0.3086\text{x}10^{-5}h \qquad (3.4)$$

with: h is the height at above sea level. Equation [3.4] according to SI units (g_{fa} in m.sec^{-2}, h in m) and the cgs unit (g_{fa} in Gal, h in cm) for the g_{fa}/h unit is sec^{-2} [7].

Free air correction value is added if the observation point above the datum plane and subtracted if it is below the datum.

E. Bouguer Correction

In free air correction and normal gravity, the mass of rock between the observation point and the datum plane be ignored. In the actual conditions of course the mass below the point of measurement must be taken into account. So Bouguer correction depends on the height of the observation point and the datum plane density rock that lies between the observation point and the datum plane. Bouguer correction value as opposed to the free air correction, deductible if the observation point above the datum plane and added when the observation point is below the datum. The value of Bouguer correction is [12]:

$$\begin{aligned} Bc &= 0{,}04193\ \rho\ h \text{ mgal/m} \quad \text{or} \\ &= 0{,}01273\ \rho\ h \text{ mgal/ft} \end{aligned} \qquad (3.5)$$

with: ρ is Bouguer density, h is height of the measurement point to the plane of spheroids.

The formulation above is valid under the assumption that the field Bouguer an infinite flat plate.By applying the data processing or data correction as mentioned in above to eliminate the influence of tidal effect due to the rotation of the earth and the moon, drift correction to eliminate the influence of drift effect, basestation correction to equate the value of inter-loop gravity in the acquisition activity, tie correction to get the value of gravity on the actual measuring point [6], and normal gravity G using the formula of the IAG (International Association of Geodessy) that is GRS (Geodetic Reference System) of 1980 on the WGS84 (World Geodetic System 1984) to compare the value of gravity measurements with ellipsoida or sferoida reference, then obtained free air anomaly as in Figure 3. Contour of simple Bouguer anomaly is shown in Figure 4.

From this last correction, the data which was originally located on the sferoida reference was taken to the topography. From the free air correction is already a rough idea can be seen in spatial location of an anomaly to be searched, which tends to sub-districts Bakung, Kademangan, Wonotirto, Sutojayan, Panggung rejo, Binangun, and Wates, a shown in Figure 3.

The gravity method works based on the density contrast from the rock of the earth. If there is an anomaly under the surface, then the value of the gravitational field will deviate from the normal measured. If the deviation is the adding of the value, called a positive anomaly (anomaly density > density of the surrounding area). Conversely, if the deviation is reduction of the value, called a negative anomaly (anomaly density < density of the surrounding area) [13], [14].

Bouguer anomaly data, as shown in Figure 4 is a rock that caused the mineralization process. Based on the Bouguer anomaly data, the potential for mineral mining, especially for the primary potential can be localized. Red contour is a mineralized zone, in contrast blue-white contour is not mineralized zones. Based on Bouguer anomaly contour as in Figure 4, then that is mineralized zones are sub-districts: Bakung, Kademangan, Wonotirto, Sutojayan, Panggungrejo, Binangun, and Wates. The mineralization zone showing by high relatively value of Bouguer anomaly i.e. more than 80mGal (with red colour) and more than 110mGal from free air anomaly. The negative anomaly (with blue colour) places at around of Kelut volcano showing the existency or presence of Kelut volcano magma chamber. These results are similar with the result from free air anomaly. These sub-districts are the center of the mineralization zone which places the formation of minerals and mining or commonly called the primary potential in the Blitar zone. This means that from the total Blitar about 158,879.0 hectares, it is 59,579.6 hectares or 37.5% is a mineralized zone. The mineralized zone is located in the southern Blitar, where Blitar south itself has an area of approximately 68,985.0 hectares or about 43.42% of total district Blitar. As we know, that Blitar district has about 16 mines and mineral potential, either as a primary or secondary potential, i.e: kaolin, limestone, bentonite, manganese, feldspar, iron sand, copper, ball clay, onyx, calcites, zeolites, volcanic rocks, sand, trass, gold, piropilit, chalcedony, and other ore minerals. The geochemical test or samples test results from some outcrop rocks in the mineralized zones and mining areas are as in Table.1. The result of this research is to estimate the anomaly causes mineralized zones only. For future enhancement and further development should use the near-surface geophysical methods.

IV. CONCLUSION

Based on Bouguer anomaly that is mineralization zones are located in the sub-districts: Bakung, Kademangan, Wonotirto, Sutojayan, Panggungrejo, Binangun, and Wates. The mineralization zone showing by high relatively value of Bouguer anomaly i.e. more than 80mGal and more than 110mGal from free air anomaly. The negative anomaly located at around of Kelut volcano showing the presence of Kelut volcano magma chamber. These sub-districts are the center of the mineralization zone which places the formation of minerals and mining or commonly called the primary potential in the Blitar zone. This means that from the total Blitar area about 158,879.0 hectares, it is 59,579.6 hectares or 37.5% is a mineralized zone. The mineralized zone is located in the southern Blitar, where Blitar south itself has an area of approximately 68,985.0 hectares or about 43.42% of total district Blitar. From some outcrop rocks in the mineralized zones and mining areas, there are about 16 mines and mineral potential, either as a primary or secondary potential, i.e: kaolin, limestone, bentonite, manganese, feldspar, iron sand, copper, ball clay, onyx, calcites, zeolites, volcanic rocks, sand, trass, gold, piropilit, chalcedony, and other ore minerals, some kinds as shown in the geochemical test result from some samples.

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AUTHOR PROFILE:

Sunaryo is a Lecturer and Researcher in Geophysics Study Program of Physics Department of Sciences Faculty at University of Brawijaya (UB) Malang-Indonesia since 1995. He completed S-1 degree in 1993 at UB Malang Indonesia. S-2 degree was completed in 2001 at University of Gadjahmada (UGM) Yogyakarta Indonesia. Mean while the S-3 degree was completed in 2007 at UGM Yogyakarta Indonesia. Until now, he has done at least 66 researchs in the field of mining and minerals, groundwater/geohidrology, volcanoes and geothermal, natural disasters and mitigation, and geotechnical. He has about 31 publications in the form of proceedings, national journals, and international journals.

Now, he was a Chairman of the Geophysical Study Program of Physics Department of Sciences Faculty at University of Brawijaya and as a Chairman of the Indonesian Association of Geophysicists for Malang East Java Indonesia Area.

APPENDIX

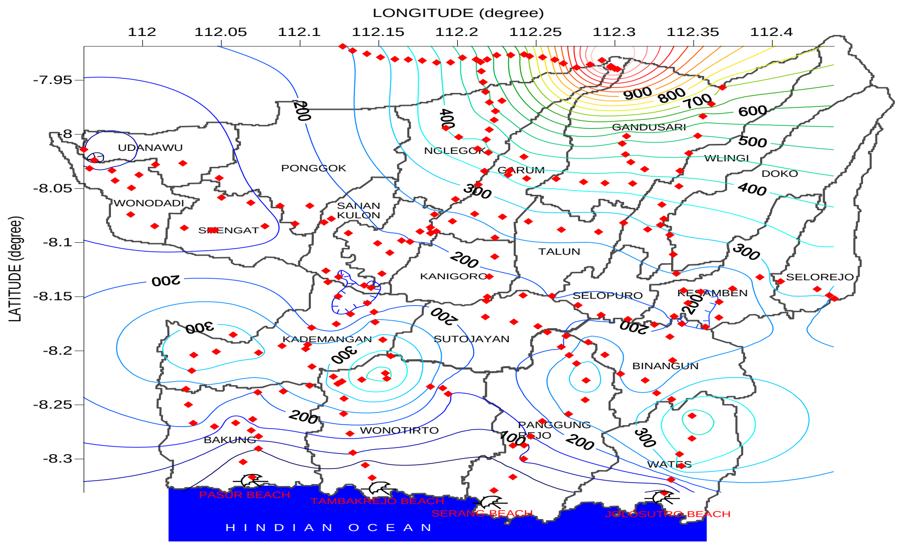

Fig 1. Topography Contour And Distributions Of Gravity Observations Points Overlapping On Administration Map.

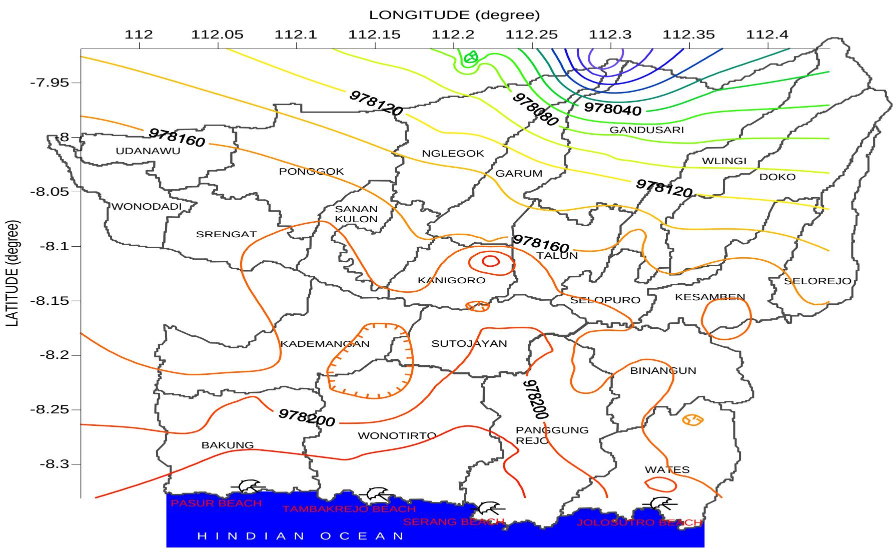

Fig 2. Contour Of Gravity Observations Data Overlapping On Administration Map.

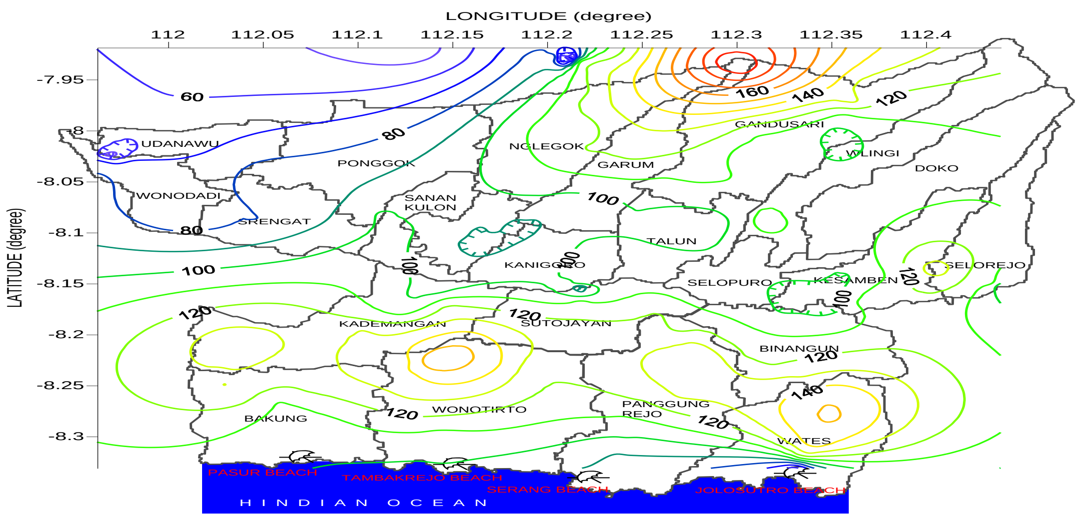

Fig 3. Contour of Gravity Free Air Anomaly Overlapping On Administration Map.

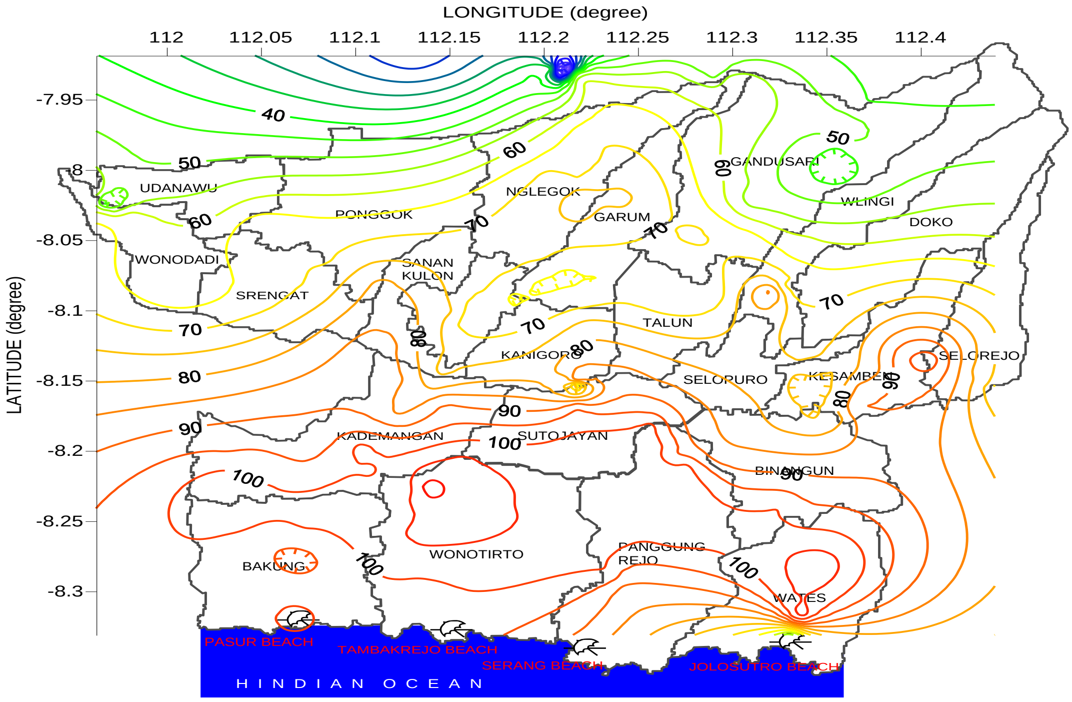

Fig 4. Contour Of Gravity Simple Bouguer Anomaly Overlapping On Administration Map.

Table 1. The Geochemical Or Samples Test Results From Some Out Croped Rocks In The Mineralized Zones And Mining Areas.

NO	SAMPLE NAME	CODE SAMPLE	PARAMETERS	TEST RESULTS		REAGENTS	METHODS
				CONTENTS	UNITS		
1	WATES	Gold	Au	9.1540±0.2019	ppm	aquaregia	AAS
2	WONOTIRTO	Manganese	Mn	1.88±0.00	%	$NaIO_4$	Spectrofotometry
3		Copper	Cu	278.63±0.75	ppm	HNO_3	AAS
4		Sulphur	S	18.3703±0.0302	%	$Mg(NO_3)2\text{-}BaCl_2$	Spectrofotometry
5		Piropilit	Fe	967.319±0.617	ppm	HNO_3	AAS
6		Kaolin	Si	36.53±0.04	%	Aquaregia	Gravimetri
7		Limestone	Ca	8651.145±298.473	ppm	HNO_3	AAS