

Determining The Optimal Density Of Bouguer Anomaly And Topography Modeling Of The Bedrock In The Charak Area (South Of Hormozgan .IRAN)

Samadi.H.R^{1*}, Salehi.M.H²

¹PH D of geophysics Ardestan Branch, Islamic Azad University, Ardestan, Iran, ²Ardestan Branch, Islamic Azad University, Ardestan, Iran

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ABSTRACT

In exploration geophysics the main and initial aim is to determine density of under-research goals which have certain density difference with the host rock. Therefore, we state a method in this paper to determine the density of bouguer plate, the so-called variogram method based on fractal geometry. This method is based on minimizing surface roughness of bouguer anomaly. The fractal dimension of surface has been used as surface roughness of bouguer anomaly. Using this method, the optimal density of Charak area insouth of Hormozgan province can be determined which is $2/7 \text{ g/cm}^3$ for the under-research area. Geometry and topography of the bedrock of the area can be recognized by the difference between optimal density and the density of the bedrock, in which all of the calculation for determining the topography of the bedrock are performed in the Fourier area. In fact, all of the obtained results are approximately good in geology and the drilled exploratory in determining both optimal density by Fractal method and topography of the area's bedrock

KEYWORDS: fractal dimension, Anomaly bouguer, optimal density, topography of the bedrock, Fourier area.

1. INTRODUCTION

The word fractal is derived from the Latin word 'fructus' which means an irregularly broken and ground rock. It was brought up in 1975 for the first time by Benoit B. Mandelbrot. In recent years, Mandelbrot's brownian fractional surfaces have attracted a lot of attention because of their noticeable similarity to topography (Mandelbrot, 1975, Good Child, 1980, 1982, Fournier, 1982). Observing shapes in the nature, it is concluded that Euclidean geometry is not able to state and

explain natural complex and apparently irregular shapes. In Euclidean geometry dimension is an integer such as one, two and three. As a consequence, Euclidean geometry is able to explain one, two, three and higher dimensional phenomena According to Chotia's theorem(Chotia ,2001), for determining the geometry of the bedrock, first, we should extract the remaining gravity that is representing of the signal of the topography of the bedrock, and then the remaining gravity is used to invert the topography of the bedrock and its density. The upward continuation formula (Jacobson, 1987) is chosen to extract the remaining field. For inverting the topography of the bedrock according to (Parker,1973and Oldenburg,1974) equations in Fourier domain, the bedrock is modeled like an infinite flat plan with the even bottom and upper wavy surface. This algorithm supposes the constant density difference between bedrock and the materials that are on their surface based on the geological information, which is able to identify the three dimensional topography of the bedrock in the whole of the region. For inverting the density according to equations (Last and kubik,1983) and equations (Bulenger and chotia,2001), the sub-surfaces are divided into n cells in which every cell has constant density. Inversion considers a density for each of cells and finally presents us the three-dimensional picture of the density.

Geology of area

The considered area lies between longitudes 53° and $54'$ to 54° and $24'$ east and latitude 26° and $43'$ to 26° and $56'$ north. This area is spread out to Lavaran from the east, to Dehno Maragh and Bahmani from the north, Kalat and Mazra'e Jobran from the west and to Persian Gulf from the south. From a geological point of view and considering partitioning Iran, this under-research area is in Zagros area covering north parts of Bandar Abas to the west of Lenge port . Districts in this area belong to the end of mountains in south west of Zagros which is made up of two sub-areas of high Zagros and jagged Zagros. The main difference between these two sub-areas in the related part of Hormozgan province is mostly of structural differences, but taking sequences of stones into account, they do not differ.

*Corresponding Author: Hamid Reza Samadi, PH.D of geophysics and the member of Young Researchers Club, Ardestan Branch, Islamic Azad e-mail: samadi@iauh.ac.ir, (phone: +98-09132180636)

METHODOLOGY

Calculations on the data of complete bouguer anomaly of the studied area made by surface Variogram method are as follows. Firstly, a point in the area with identified longitude and latitude is considered as center and a circle, centered at this point with the largest possible radius to draw, is drawn to include data as much as possible. This maximum distance is divided to 30 equal groups. Then, variance of bouguer data difference for each group is calculated and its logarithm is drawn with respect to logarithm of each group differences (Aronson, 1984). After investigating the graph, points which are supported by Earth's rigid crust and show fractal feature are selected and then we fit the regression line of least squares with them. The slope of this straight line which satisfies the formula $y=mx+b$ demonstrates fractal dimension of line,

$$E \{(Z_p - Z_q)^2\} = K(d_{pq})^{2H} \tag{1}$$

where Z_p and Z_q are surface values in the points q and p , d_{pq} horizontal difference among the points and H is equal to $(3-D)$. Drawing logarithm of variance of differences caused by local complications of the surface with respect to logarithm of distance among the points results in a graph which the existence of a linear relation along the domain implies self-similarity along that domain, and its fractal dimension is gained by slope b of a drawn line in domain point. $D=3-b/2$.

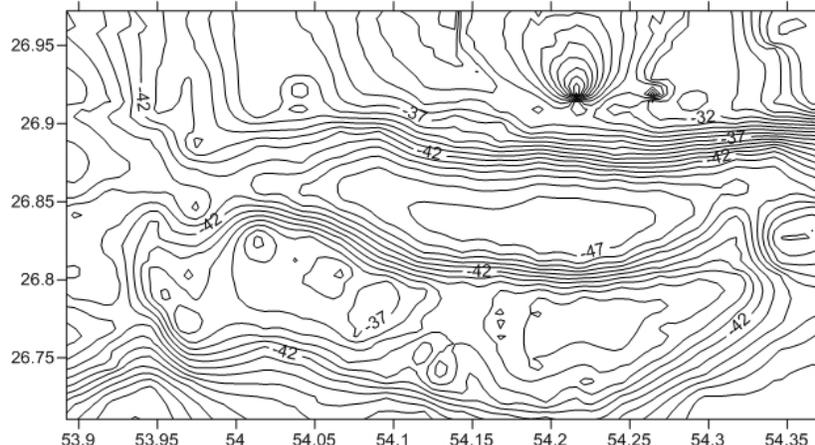


Figure (1): Contour map of complete bouguer anomaly with density $(2.3)g/cm^3$ and level line differences of 1 (m gal)

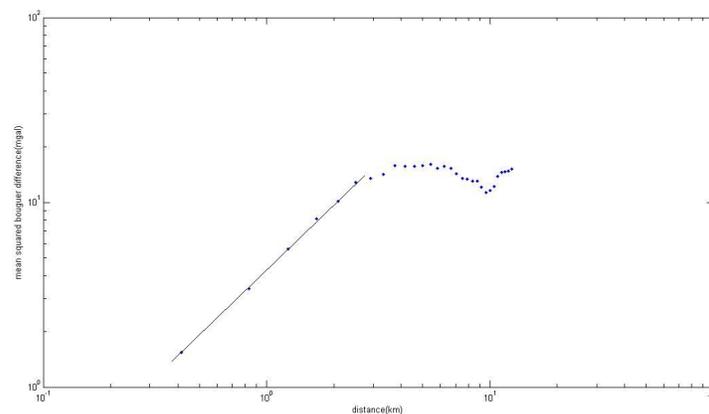


Figure (2): Complete regression line of bouguer anomaly of the area with fractal dimension (2.42)

Identification scheme of optimal density in the area:

In this section, to reduce the dimension of surface roughness of bouguer anomaly, optimal density is determined, and to achieve this goal, firstly, complete data of bouguer anomaly of the area with different density should be calculated. Then, fractal dimension of each new obtained data series is calculated using mentioned method and draw the results with respect to their density (Thorarinsson, 1988). In the obtained graph, the minimum shown dimension has the best density which is $(2/7g/cm^3)$ for the under-research area

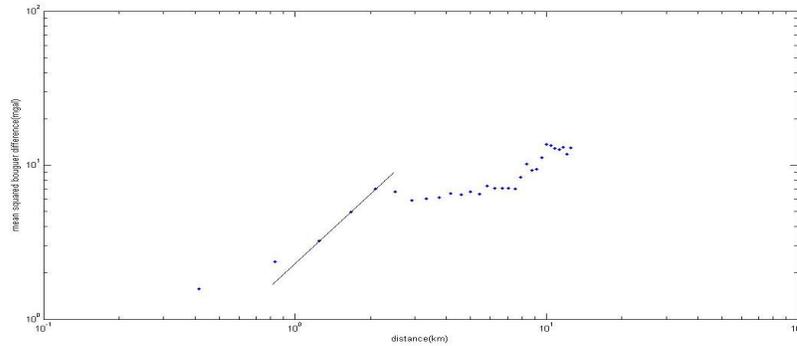


Figure (3): Complete regression line of bouguer anomaly of the area with optimal density (2.7g/cm³) with fractal dimension (2.24)

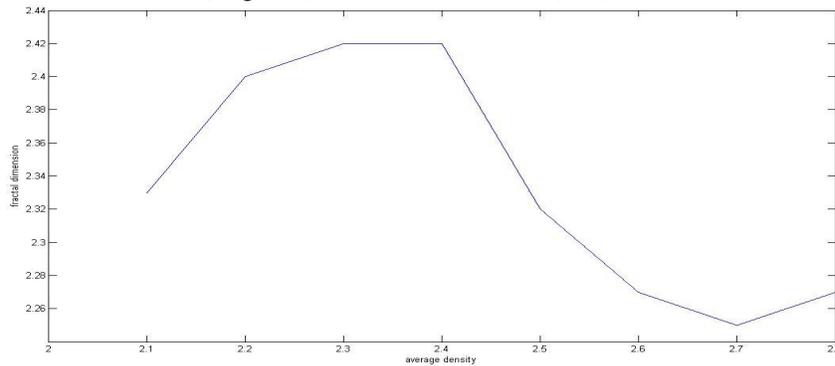


Figure (4): Illustrating determination of optimal density of the area

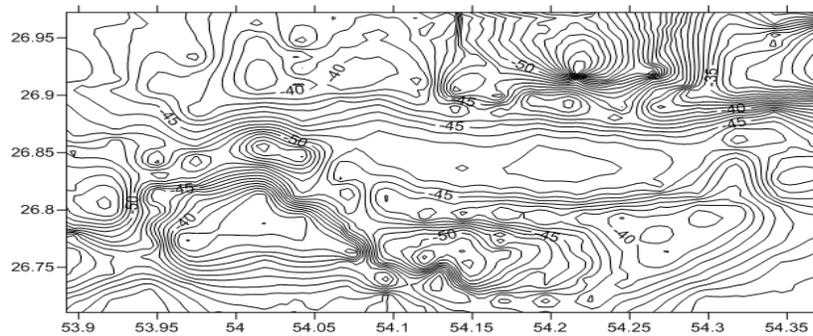


Figure (5): Contour map of complete bouguer anomaly with density (2.7)g/cm³ and level line differences of 1 (m gal)

Determining the topography of the bedrock of the region

Applying upward continuation to separate local field from regional

For several decades, it has been a vital subject in gravity and magnet to separate the regional and remaining fields. A proven process for separating the regional and remaining fields is by convolving with the so-called separation filter. In other words, for the observed field (f_0) equals the addition of regional field (f_{reg}), remaining (f_{rem}), and noisy (f_{noise}) together i.e.

$$F_0(r) = f_{reg}(r) + f_{res}(r) + f_{noise}(r) \quad (2)$$

Sandwich source distribution structure

We consider a sandwichconstitutingof N narrow layers with a small vertical space Δz in which all of the layers have the energetic spectral $s(k)$. Since we do not consider any correlation among the density distribution in distinct layers, external energy among them will tends to zero, so we conclude that the spectral energy of the whole of the sandwich source will be as bellow:

$$P(k) = \sum s(k) \exp [-2k(z, + n\Delta z)] \quad (3)$$

Where z_t shows the depth to top of the sandwich, also $z_b = z_t + n\Delta z$ shows the depth to bottom. The sum of the third equation is calculated as the sum of quotient and is about to $-\exp(-2k\Delta z)$ or $2k\Delta z$, so:

$$P(k) = s_0(k)[\exp(-2k\Delta z) - \exp(-2kz_b)] \quad (4)$$

$$s_0(k) = s(k)/(2k\Delta z) \quad (5)$$

This model in any depth, between z_t and z_b can be divided into two uncorrelated models, both of which have the spectral energy as the third equation

Separating filters with optimized dispersal for sandwich source

Suppose that a dispersal of a sandwich source consists of half of the total land space according to $z_t = 0$ and $z_b \rightarrow \infty$ in the fourth equation. Consider the remaining field as a field which is originated from an upper level of a position z_0 and the regional field is considered in a way that is derived from the under of the position z_0 (kubik,1938), so:

$$P_{reg}(k) = S_0(k)\exp(-2kz_0) \quad (6)$$

And the optimal filter for extracting the regional field is as follow:

$$H_{reg}(k) = \exp(2kz_0) \quad (7)$$

It shows that the value of wave for upward continuation to a height of $2z_0$ in the above of measurement level is independent from $S_0(k)$. In all filter for extracting field from a layer or an interval between z_0 and z_0' has the form as follows: (Jacobson,1987)

$$H_{slab}(k) = \exp(-2kz_0) - \exp(-2kz_0') \quad (8)$$

This is the answer of wave number for evaluating the difference between upward continuation fields.

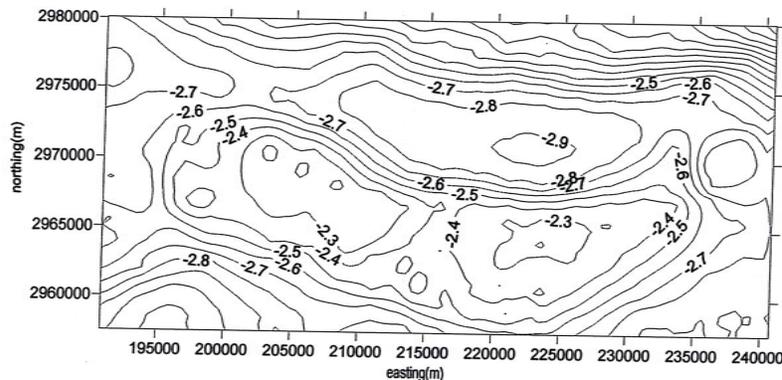
It is necessary to be mentioned that an optimal filter for estimating a field which is originated under the position z_0 and is measured in the depth z_0 is presented as bellow: (Jacobson,1987).

$$H_{regz_0}(k) = \exp(kz_0) H_{reg}(k) = \exp(-kz_0) \quad (9)$$

In fact, it is an upward continuation and the result is completely constant.

At first, the regional buge anomaly which, in fact, represents the regional field is obtained, then by using the upward continuation, the rest anomaly that denotes the local field is extracted (Figure (6)) with respect to the fifth relation.

Where, $S_0(k)$ is the buge anomaly, k is the wave number, and z_0 is the extended distance to the upward continuation (parker ,1973 and arnaud,1989). The most significant character in upward continuation is identifying the extended distance, in which how distance should be used until the rest anomaly completely represents the topography of the bedrock. For do this, take a profile of the region , and then apply all of the distinct extended distances on it, and compare the two dimensional picture of each of the rest anomaly with the buge anomaly of that profile. Each of the extended distances which makes the most similarities to the buge anomaly is our suitable extended distances and should be used to evaluate the rest anomaly in all of the other points.



Figure(6): The contour map of the rest anomaly of the picked area

Inverting the three dimensional topography of the bedrock

First, we consider the Parker's method for evaluating the gravitational of an uneven two-dimensional layer of material with a constant density. In a Cartesian coordinate $x-z$, the gravitational anomaly is represented by $\Delta g(x)$, and the upper and lower ranges of the chaotic layer is represented by $z=0$ and

$z=h(x)$ respectively. The total mass of the chaotic layer should lie under the horizontal line on which observation will be done. Since our profile has a limited length and for preventing from convergent problems, we suppose that the layers out of the range and limited to d tends to zero. For instance, if $x \notin C$, then $h(x)=0$. In practical, $h(x)$ is measured with respect to some of the balanced reference layers with a distance z_0 under the level. We define the one-dimensional Fourier transformation of a function $h(x)$ as follow:

$$F[h(x)] = \int h(x) e^{ikx} dx \quad (10)$$

Where, k is the wave number of the transformed function. Here, we obtain the Fourier transformation of the gravitational anomaly by converting the Parker's two dimensional formula into an one –dimensional formula(Parker's, 1973)

$$F[\Delta g(x)] = -2g\pi\rho e^{-kz_0} \sum \frac{k^{n-1}}{n!F[h^n(x)]} \quad (11)$$

Where, ρ is the density difference between the bedrock and its upper material, and G is the universal constant of gravitation. We are able to obtain following formula by converting $n=1$ from infinite summation and by rearranging (Oldenburg,1974):

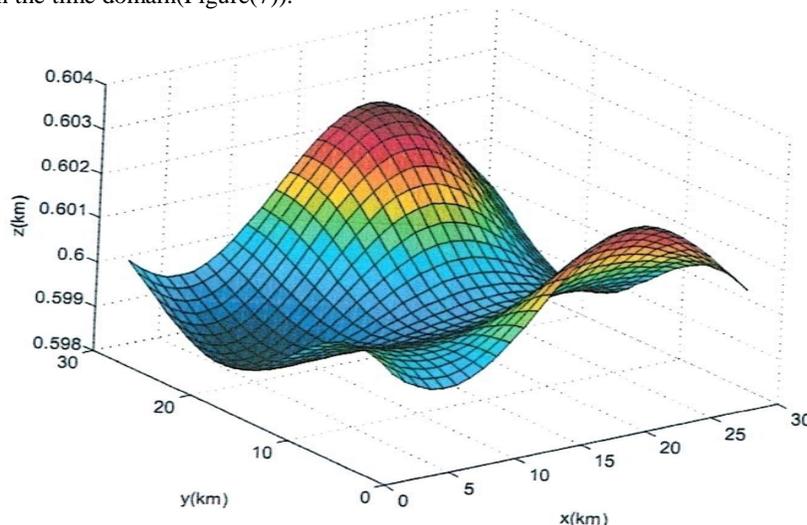
$$F[h(x)] = F[\Delta g(x)]e^{kz_0}/2g\pi\rho - \sum \frac{k^{n-1}}{n!F[h^n(x)]} \quad (12)$$

When, ρ and z_0 are known (or are supposed). This approach can repeatedly be used for evaluating the $H(x)$ as follows: The newest $h(x)$ (for the first step, $h(x)=0$ or choosing a suitable random value will satisfy) will be used for calculating the right side of the equation (12). Then the inverse of the Fourier transformation gives a new value for the topography. Pursue this repetition procedure until we face to a kind of convergence value, or we reach to the maximum repetition number. Note that evaluating $h(x)$ in the equation (12) consists of almost the same calculations' steps relative to the straight solution algorithm, so every repeat can rapidly be done.

For inverting the data of the study area, the first necessary parameter that should be studied is the density difference between the bedrock and its upper sediments. Based on the geological mapping and drilling, the bedrock's and its upper sediment's density is estimated $3.5 \frac{g}{cm^3}$, $2.7 \frac{g}{cm^3}$ respectively, so the density difference which is used in calculations is $0.8 \frac{g}{cm^3}$.

In this procedure, we, first, depict the three-dimensional map of the rest anomaly of the study area based on the distance in a square net, then the quick Fourier transformation will be used for evaluating a matrix with a given amplitude spectrum. The first approximation of the topography of the bedrock is used for calculating the second sentence of equation (12).

Where, ρ is the density difference between the bedrock and its upper material, and G is the universal constant of gravitation. The second sentence will be filtered again, and after using the quick inverse Fourier transformation, the standard deviation between the new and the old topography will be calculated. With starting the repetition process that is applied for evaluating the right side of the equation (12), the first sentence of the series will be obtained by the equation (11), and the acquired topography will be filtered by a low-pass filter, then by using the quick inverse Fourier transformation, the topography is calculated in the time domain(Figure(7)).



Figure(7): The three dimensional map of topography of bedrock in the picked area

Acknowledgements

Usage of small and large amount of bouguer density in the bouguer plate and topography correction makes extra effect of topography on the results of bouguer anomaly. Supposing that gravitational field has usually less roughness in comparison with topography, we determine bouguer density with minimizing surface roughness of bouguer anomaly. The amount of this roughness has been determined by dimension of surface fractal.

- In the west of the area (about 53.92, 26.81) the anomaly caused by salty dome in contour map with density of 2.7 is determines more clearly and more definite

- In the north of the area (54.10, 26.95) the salty dome in contour with density of 2.7 with respect to contour map with density of 2.3 is more clearly distinguishable

- Windows in Mishan formation (about 54.03, 26.86) which because of erosion caused displacement of Asmari limestone and is distinguishable in the contour map of topography of the area, in the contour map of bouguer anomaly with density of 2.7 is well-represented more clearly

- In the center inclined to the west (54.03, 26.86) in the contour map with density of 2.7 a special anomaly can be seen that is likely caused by Barund's fault performance of north east-south west which made formations break and move and made waterway in the valley that cannot be seen in the contour map with density of 2.3

Nowadays, determining both the geometry of the bedrock and the layers with the density contrast in different depths is one of the crucial aims in much work. Sincethere alwaysexists a density contrast between the bedrock and the upper layers, the gravity survey method which examines the changes in density will help to determine the bedrock. The written program by the real data of gravity survey in the south of Hormozgan province has been shown a good agreement with the local geology, thus this procedure for determining the three-dimensional topography of the bedrock is an appropriate method.

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