Fractal method for determining the density of the stone tablet in Charak region (southern Iran)

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ABSTRACT: A prevalent method for determining the Bouguer density value as random and independent variable from topographic alternations has been introduced by Nettleton algorithm of which casually corrections for example in folded Zagros region may be accompanied with unexpected errors as a result of crustal thickening processes in southern regions of Iran. Sedimentary sequences in Charak-Namakin anticlines are known as important geological units which have been selected for prospecting oil related reservoirs by National Iranian Oil Company (NIOC) in 2002. Gravimetric datasets have been acquired by NIOC systematic land surveys in a total of 776 stations. The main target areas along Charak - Namakin salt domes are located between 54.00 - 54.30 and 27.00 - 28.45 geographic longitude and latitudes. Both Asmari (Oligocene) and Pabdeh - Gurpi formations (early Cenozoic) contain limestones with gray marls intercalations as potentially valuable facies for hosting of hydrocarbore reservoirs under ascending movements of the Paleozoic formations in diapiric systems. Hormoz series (Cambrian) including gypsum and other related evaporates play the main roles for oil trapping processes after emigrant volatiles arrive to permeable layers nearby brecciated structures. Determining of optimum Bouguer density that is only related to Charak geological impressions is an important procedure which associates number of gravimetric anomalies with probable oil trap locations. It means that, Bouguer anomalies are comfortable geophysical quantities for density estimations according to statistical techniques. Although a linear method such as Nettleton correction can be used to density estimations, some abnormal thickening of the crust may increases in topographic disturbances and subsequently causes to stochastic behaviors of the gravity values which cannot be interpreted by Euclidean geometry. Therefore, nonlinear analyses such as power law functions can be used to calculate the fractal dimensions as non-Euclid variables related to self similar peculiarities of the gravimetric values which theoretically assumed to have spatial independencies from crustal interactions with heavy masses of the lithosphere. According to Mark and Aronson (1982), a fractal based interpretation corresponding to gravimetric anomalous regions has been carried out by applying variance – distance logarithmic equation in Free Air and Bouguer georeferred datasets respectively. This research is an attempt to study of Brownian surfaces as unique area indicates to cumulative appearances of the gravimetric similarities above Charak sedimentary formations. Considering to iteration processes on the log-log plots, some Bouguer anomalies have been recognized to be independent from topographic alternations in ranges of 6.44-10.24 Km distances from backgrounds. As a result, an averaged density value equal with 2.4 g/cm^3 has been calculated for Charak lithological occurrences by stepwise fractal analysis of total density assumptions (1.8-2.4 g/cm^3). The fractal result subsequently compared with statistical conclusion that is considered ranges of 2.3-2.4 g/cm^3 as optimum density values for Hormozgan region after obtaining a new ratio of Bouguer regression versus Bouguer Poisson coefficient (R^2P) among estimation processes.

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1. Introduction

The selected area as a part of Zagros oil province, south of Iran in Hormozgan province is located in 54.00 to 54.30 east longitude and 27 to 28.45 north latitude, which is shown in figure1. This region is apt for development of hydro–carbon reservoirs in the carbonate country rocks due to suitable interior earth structure such as numerous dome-shaped facial occurrences resulting from the uprising of the Paleozoic evaporative sediments (Farmani, 2003). The apt areas in the prospecting oil field of Charak-Namakin consists of lime facies pertained to Aligoson (Asmari constituent) and the grey marns of early Cenozoic (Pabdeh - Gurpi constituents) and they are often situated in the lower part of the anticlinal summit of Namakin village (north-West of the map) and the Charak salt dome (in the center and east of the map). The host rock of oil reservoirs, in many cases, has been surrounded by evaporative covering rocks of Hormoz series (cambrian) and siltic – marly units pertained Aghajari constituent (Farmani, 2003). Based on the seisogram evidences (wide band and seismic trap), the depth average of Moho in the folded Zagros region is 45 kilometers (Kaviani, 2003 ; YaminiFard, 2008) and the adjustment of altitude difference resulting from structural ups and downs(sequenced anticline and syncline in Taphrogeny Cenozoic regime) is necessary for gravity corrections. Since the measurement of the gravity variations in the host and the evaporative covering rocks accompanying it is considered as a criterion for investigating the building traps and determining the spatial situation of prospecting oil reservoirs, the error increase in determining the situation of underneath facies makes the probable reservoirs un accessible. Therefore, the correction of the pattern of anomalies and estimating the density resulting from the variation of Bouguer slab for the preliminary up of the oil fields (using gravity measuring method) seems to be necessary.

In table1, the spatial position of obtained samples of gravity section or profiles accompanied with density variations related sediment facies of Charak has been included. Based on evidence available, regional surface and systematic surveys, paralled with discovered profiles L18 – L27, have been conducted recording the gravity variations in 776 stations (Farmani, 2003). After correcting gravity data, the maximum and minimum of Bouguer's anomaly have been calculated to be -24.311mgal and -50.367mgal respectively, which enjoys marly- carmnate (the maximum amount) and conglomerate formations (minimum amount) as far as relative spatial correspondence in concerned. In the majority of broken regions, cataclastic deformity is observed before bouguer's anomaly reduction. The relative density, in different sections of Asmari formation(as the host of hydrocarbon reservoirs) has increased compared with other sedimentary units and fluctuates remarkably neighboring salt domes and broken buildings surrounding the anticline. In the previous studies(Telford et al,1990) Nettleton method has been used to adjust the effect of Bouguer slab and the density of each section has been used in the equation of determining Bouguer anomaly at the same time as free air and latitude corrections have been recorded. Table1 shows that the averaged density value, regardless the coefficient of Bouguer slab in anticlinal ups of the region, is 2.21g/cm^3 that is not considered of as an exact index for investigating the gravity variations in the host stone of oil reservoirs although it relatively corresponds with obtained density from the lime-marly facies of Asmari formation(2.32 – 2.36). Similarly, regarding the building ups and downs in the underneath units of Charak region, applying Nettleton pattern to correct the effects of Bouguer slab is not useful(Mark & Aronson, 1984) and the remarkable thickness of the crust of this region of folded Zagros probably increases the error resulting from topographic considerations. Therefore, the operations of determining density and measuring the anomalies in the oil prospecting field of Charak require methods other than that of the variation of the crust thickness for the realization of which suggested method by Thorarinsson et al (1990) has been used to achieve fractal functions with the exponential distribution in the self-affinity quantities(gravity self-similarities).

2. Applicable methodology of fractal functions in gravimetric studies

2.1. Chaos theory and its application in fractal measurements

Theoretically, chaos theory based methods are applicable for evaluation of gravity variations in prone regions for hydrocarbon reservoirs. In this theory, by means of the recursive function concept, the distributive index of the quantities will compute, and then compare with the edge of chaotic environments. Then it will express in the form of fractal equations (Turcotte, 1997). In other words, variations of geophysical quantities that causes different anomalies which be formed in surface resulting from field measurements. The differences in the surface formations are self-similar components and this process is synchronous with quality variation of abnormal population from a similar linear process to a complex and chaotic one. Prediction of populations behavior via traditional (Euclidian) methods, in such a component, is very difficult and in some cases, impossible. Therefore, on base of Turcotte's suggestion (1997), it is possible to apply fractal relations to achieve Brownian Surface as a geometric index corresponding to chaotic environments and the pattern of nonlinear distribution of anomalies. Geophysical components such as gravity variations, magnetism, seismography and electromagnetic it is possible to use fractal relations. It will explain after calculating the coefficient of logarithmic functions as fractal dimension. The scale independencies of the anomaly, not differentiable density function and initial component or pattern of similar quantities are three properties of anomalies measurement such as gravity variations through many fractal methods.

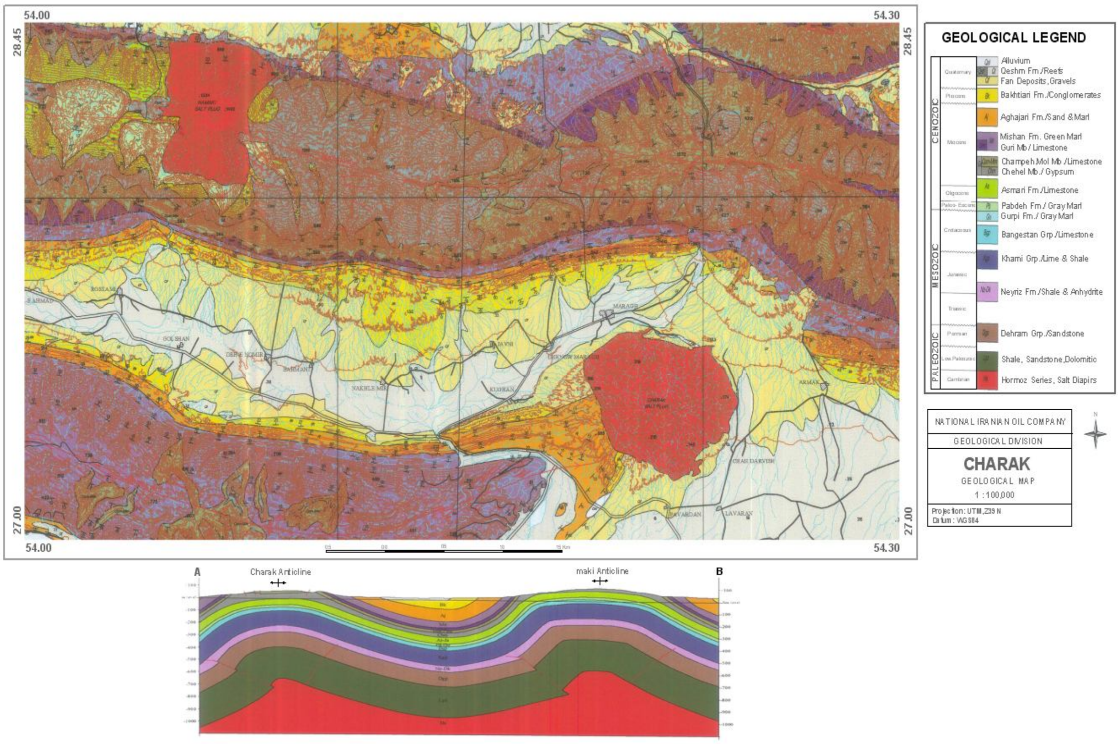

Figure1. Geological map of Charak-Namaki region located in Hormozgan province (Farmani, NIOC, 1982). Asmari limestone (Olig.) and Gurpi gray marls (Upper Cer.) are the main rock of oil reserves of folded Zagros oil province.

Table (1). Determined density by sampling and physical measurements in Charak region (reported by Farmani, NIOC, 2003)

Profiling No.	Coordinate (degree)		Stratum	Lithology	Density (g/cm3)
	Long.	Lat.			
L18	54°36′48.2″	26°31′48.6″	Bakhtiari Fm.	Conglomerates & Sandstone	1.87
L18					1.90
L18					1.90
L19					1.89
L19					1.86
L20	54°17′13.1″	26°47′46.0″	Mishan Fm.	Green Marl	2.14
L20					2.12
L21					2.13
L22					2.07
L22					2.14
L23	54°16′57.4″	26°48′05.9″	Aghajari Fm.	Sandstone & Marl	2.03
L24					2.02
L25					2.04
L26	53°38′17.8″	27°05′02.0″	Bangestan Grp.	Limestone	2.45
L26					2.39
L27					2.41
L28					2.45
L29					2.39
L30	53°38′18.6″	27°04′57.3″			2.44
L31					2.43
L32					2.43
L33					2.45
L34					2.44
L35	53°37′43.3″	27°04′18.3″	Asmari - Gurpi Fm.	Limestone - Gray Marl	2.36
L36					2.32
L37					2.32

For different spatial extension and undifferentiated function caused the similar formation populations, it is possible to make a scale-independent quantities to take pattern from geophysical variations. According to Feiffer & Obert (1889), changing in variables of linear process occurs by entering the chaotic status and simpler ones (lacking initial component) are replaced by iterative components. Practically, due to the complexity and ambiguity of the differential of chaotic functions, application of statistical parameters such as mean and standard deviation is not appropriate for self-similar population. In this state, the best way is to calculate the fractal dimension of self-affinity points to separate similar populations.

From Euclidian point of view, the appropriate dimensional equation for the surface variations of anomaly is constant. Based on fractal geometry, the appropriate coefficient angle of each surface for geometrical dimension is a number between 2 and 3. In other word, the variety and mechanism of data distribution, makes Brownian normal surface with possible maximum iterative quantities. Theoretically, the fractal functions, which have been, adopted from specific exponential law relationships. The logarithmic characteristic of independent quantities is used to determine to range of variables depending on distribution. By consideration of two given quantities A and C indicates the sets of domain and area of the intended function with the exponential coefficient FD, it is possible to write the equation1 as:

$A= C^{FD}$ (1)

The necessary component for converting FD to the angle coefficient of fractal line is the application of logarithmic coordinates in the equation2 as below:

Log A=FD Log C (2)

The density function plot of Log A Vs. Log C and the coefficient angle, resulting from linear observation of self-affinity points is shown in figure2. It is obvious that the variation of FD coefficient is the reason of different population separations from each other and the variety of coefficient (FD1, FD2) imply the behavioral change of the phenomenon during the chaotic occurrences.

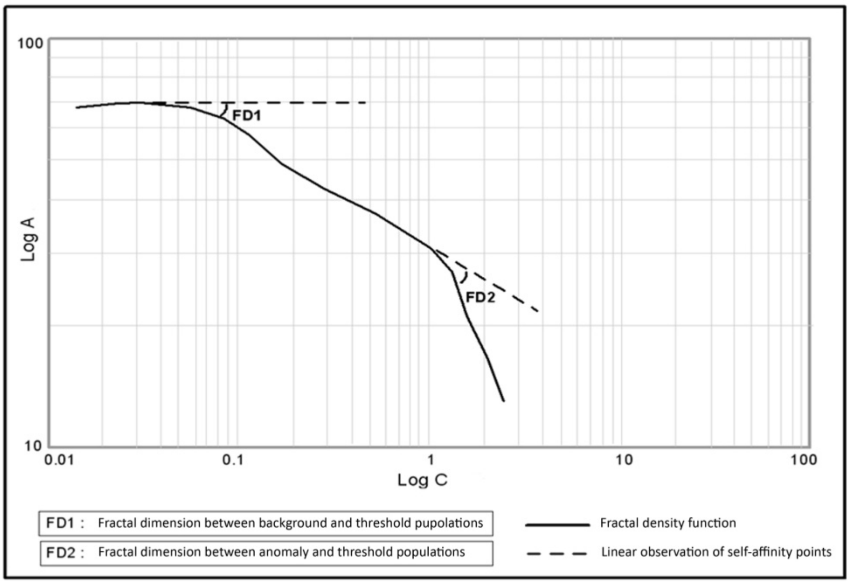

Figure2. Application of density function and variation of fractal line coefficient in population separations around the turbulent environment with respect to trend variation of fractal curve with FD1 and FD2 coefficient lines

2-2. The fractal measurement of surfaces anomalies via exponential function of distance-diffraction

To investigate the variations of surface anomalies in nonlinear methods relying on the variography principle of gravity data Mark and Aronson (1984) have introduced the following relation:

$E [(Z_p – Z_q)^2] = (d_{pq})^{2H}$ (3)

Z_p and Z_q are the gravity variations (mgal) in the points P and Q on the surface anomalies and d_{pq} is the horizontal distance (m) between the mentioned points. The mathematic expectation, E, suits distance dimension d_{pq} with an exponential function; so:

2H=3-FD (4)

By refer to classical statistics and random variables resulting from gravity variance corresponding to diffraction concepts in Z_p and Z_q, the mathematic expectation of $E [(Z_p – Z_q)^2]$, can be shown as:

$E [(Z_p – Z_q)^2] = \Sigma (Z_i – \bar{Z})^2 /N$ (5)

Where Z_i is the measurement of gravity component (mgal) and $\bar{Z}$ is the mean of gravity intensity (mgal) for N surveys different from surface anomalies. The obtained result of relations 3, 4 and 5 verify the relative-exponential relationship between diffraction resulting from gravity variations and the gravity distance of effect anomalies affection and 2H variable corresponds with FD fractal dimension. Application of geo statistical interpolations to establish continuity in exploration survey grid is essential component to achieve the values of relation 5. By use of logarithmic coordinates, the coefficient angle of FD line, which is known as diffraction distance fractal equation can, expressed as below:

$\text{Log } V_z = \text{FD Log } D_z$ (6)

Log V_z and Log D_z are the logarithms of diffraction and gravity distance from the center of anomaly. After drawing the function of Log V – Log D, the variations of fractal dimension (FD) indicate the population tendency to form self-affinity points and consequently the appearance of similar component in the unit of anomalous surface (Mark & Aronson, 1984). Therefore, for FD≤1, the surface similar components are less likely and indicate the linear process dominancy in the evolution process of the population (Turcotte, 1997). In case of 2>FD>1, we encounter to transitional status that some values could satisfy similar component, but due to shortage of spatial distribution of the initial component the maximum variations have been observed in the ground section and near to threshold of chaotic environment, they weaken (Turcotte, 1997). In such populations, the emergence of quasi fractal characteristics is common. That, in its turn, increases the probable achievement to self-similar patterns (Mandelbrot, 2002).

Thus, similar surface variations (Brownian surface) are necessary for ideal populations. Formation of this level is often accompanied by the dimension variations 3>FD>2 (Thorarinson & Magnusson, 1990). In other words, diffraction-distance equation is true for the set anomalies points whose fractal dimension is between 2 and 3. In such a continuous and definite domain of random variables such as FD= {2.01, 2.02,… 2.99}, the surface anomalous is desirable status and enjoys the maximum similar component.

Hence, the mentioned equation makes the evaluation of surface possible anomalous aiming at the recognition and separation of iteration patterns types of quasi fractal and chaotic distribution. Figure3 shows the locus of the Z_p and Z_q quantities in the distance d_{pq} on the supposed isograde curves. Based on the proposed methods by Mark and Aronson (1984), Thorarinson, and Magnusson (1990), the gravity variations between points p and q can be calculated by drawing concentric circles and their confluence at isograde surfaces. In this study, concerning the fractal measurement of gravity data, spatial analyst equipped with Arc View-GIS software has been used. To produce isograded maps an interpolation operations by use of geostatistic methods have been performed. The order of intended achieve quantities and their substitution in diffraction-distance logarithmic function (relation 6) are as follows:

1. The geostatistical interpolations through Kiriging method aiming at producing gridded maps.
2. Statistical reclassification to normalize the variables and extracting the required statistical parameters.
3. Producing random variable including quantitative values of surfaceanomalous (Km^2) and gravity intensity suiting each surface (mgal) as geometric and geophysical components related to the Z_p , Z_q , and d_{pq} values (relation3).
4. Processing and previous stage data completion to achieve included quantities in diffraction-distance equation.
5. Soloutin of diffraction-distance equation and drawing the diagram of logarithmic variations, $\text{Log } V_z$ versus $\text{Log } D_z$.
6. Determination the self-affinity points to recognize fractal populations from types of quasi fractal and linear.
7. Calculation of self-affinity points of fractal dimension to recognize the anomaly process and its comparison to similar quantities distribution in fractal population, quasi fractal, and linear.
8. Appropriate Brownian surface recognition for gravity distribution in terms of the variations of fractal dimension (3>FD>2).

Mark and Aronson (1984) showed that the self-affinity points, projected from free air anomaly, possess independent gravidity component from the effects of isostasy. The gravity distribution at the surface of similar quantities (Brownian surface) makes it possible to estimate Bouguer density in desirable component in lacking topographic effects. Therefore, diffraction-distance equation examines the locus of anomalies accurately regardless the altitude ups and downs and reduces the error of Bouguer slab corrections.

Similarly, achieving self-affinity points projected from Bouguer anomaly and solving the diffraction-distance equation for different densities, the diagram of the variations of fractal dimension versus density can be plotted and it is the turning point of the function indicating Bouguer density value with the minimum fractal dimension in the Brownian surface. To determine Bouguer anomaly corresponding with density variations, the following relation is used:

$$B_{new} = B_{old} + (\rho_{new} - \rho_{old}) (0.32562-0.0419h) \qquad (7)$$

B_{new} and B_{old} : known and unknown Bouguer anomaly (mgal), ρ_{old} and ρ_{new} : old and new densities (g/cm^3) based on the station altitude variations from the base surface of h (m).

3. Determination of Bouguer density in Charak area

According to Farmani (2003), after essential required corrections on 776 available systematic land surveys in Charak Geophysical Information System (CGIS) with a given average density (ρ = 2.3), the Bouguer anomaly values have been interpolated. The following relations have shown the calculation procedures of density concerning some gravimetric stations in Charak region:

S_{46} , S_{129} and S_{591}:

$$\rho s_{46} = (\text{Free Air } S_{46} - \text{Bouguer Anomaly } S_{46})/0.0419h = (-42.868 + 48.099)/2.274 = 2.3$$

$$\rho s_{129} = (\text{Free Air } S_{129} - \text{Bouguer Anomaly } S_{129})/0.0419h = (-41.367 + 44.942)/1.554 = 2.3$$

$$\rho s_{591} = (\text{Free Air } S_{591} - \text{Bouguer Anomaly } S_{591})/0.0419h = (-39.889 + 40.738)/0.369 = 2.3$$

Where ps_{46}, ps_{129}, and ps_{591} are the calculated density (gr/cm^3) in the gravimetric stations numbered 46, 129, and 591 respectively as it is observed, using tree quantities of free air, Bouguer anomaly (before topographic correction), and the altitude of gravimetric station, the averaged density obtained for the region under study is ρ =2.3 gr/cm^3 that is the very ρ_{old} in the relation (7). Replacing ρ_{old} by ρ_{new}, we can achieve a different pattern from the variation of Bouguer anomaly (B_{new}) in Charak-Namakin area. So, if we consider the interval of density variations originating from the variety of the formations to be from 1.80 to ρ =2.50, numerous quantitative concepts from the index of gravity variations can be inferred that, in turn, cause a lot of ambiguities in the interpretation of spatial situations of apt formations (containing oil reservoirs). Therefore, determination of the optimum density value by nonlinear methods and fractal equations to achieve independent gravity variations from the structure of ups and downs wills something unavoidable.

By attention to this point that the gravity variations of Charak region are related to various sedimentary units and the structure phenomena in the oil prospecting territory of Zagros, the error increase in calculating Bouguer density causes an inaccurate approximation of the anomalous status and consequently an unusual interpretation of the spatial situation of oil traps. In other words, the component of oil and probably gas reservoirs exploration in subsurface units of Charak anticline is the known Bouguer slab variation patterns. By separating it from the residual gravity remains known as apt formations (focusing on Asmari lime). On base of the fractal dimension variations, the mentioned method has been used to gain this important Bouguer correction.

3-1. The effect of Isostasy on the variations of free air gravity

Free air anomaly under the diffraction-distance equation is the first step of gravity data processing. It should be executed in a certain distance from similar distribution surface of gravity field, to recognize independent quantities from the mantle isostasy (Brownian surface). Based on figure4, gravity strain resulting from the projection of Cenozoic sediments distant from the Charak-Namakin domes behaves dually. A part of it has accompanied the emergence of the surface of similar variations (fractal population with the dimension of FD=2.08) and the other part has been influenced by the ups and downs of the region (chaotic population with dimension of FD≠2.08). In other words, the self-affinity points, resulting from free air variations, indicate the gravity distributions of similar characteristics and the iteration in gravity initial component will be independent from anomaly scale. That is, the points situated in 2.86 – 15.32 kilometer distance from background limits and the appearance similar quantities in Brownian surface simultaneously divide the variations of gravity field in Charak-Namakin area into two populations with nonlinear distribution patterns. Among these populations, only the self-affinity points with the line coefficient of 2.08 are pertained to Bouguer slab and are proposed to calculate Bouguer anomaly. The obtained results from testing the free air variations through diffraction-distance equation verify that:

1. Due to crust thickness and gravity essence variation, particularly when the distance is more than 15 and less than 2 kilometers, Nettleton's pattern is not allowable. It means that topographic corrections in Charak-Namakin area are necessary, because it causes diagonal increase in spatial situation of the anomalies estimation.
2. Exponential distribution of gravity and its relation to the appearance of similar components that enjoy field measuring scale independency of the quantities add to the priority of nonlinear methods such as fractal functions.
3. Density function resulting from diffraction-distance equation includes two populations, fractal (self-affinity points in the threshold of chaotic environment with the dimension of FD=2.08) and non fractal (scattered points with angle coefficient of FD≠2.08). regarding the number of similar quantities and the range of their effect in the surface of gravity distribution it is possible to use the self-similar characteristics of gravity field to achieve the pattern of Bouguer slab variations and decrease topographic effects.

3-2. Nonlinear distributive pattern originating from Bouguer anomaly

After conduction test of free air anomaly and recognizing independent gravity variations from station altitude effects, diffraction-distance equation has been used for Bouguer anomaly with the averaged density of ρ =2.3 which is shown in figure5. According to this figure, Bouguer threshold limit is accompanied by low self-affinity points (low correlation) in quasi fractal population with the line coefficient of FD<2, and similar quantities, by settling in the Brownian surface and keeping self-similar component (fractal dimension of FD=2.45) appear. The distance effect of self-affinity points has been estimated to be 6.44 – 10.24 kilometers from the anomaly threshold. In this distance the non diagonal approximation concerning density quantity, regardless the altitude effects and the variations due to the folding of Cenozoic sediments (the host of oil reservoirs in south Zagros) is possible. The iteration index of initial components is weakened and chaotic behavior (unpredictable) and will be observed in the variation pattern of Charak-Namakin Bouguer slab. It means a light correlation in the extreme points of the population (FD ≠ 2.45). Therefore, density determination through measuring of Bouguer slab variation is possible only in the limited distance of the gravity cointensity surfaces. So, to achieve reliable results, the calculation of Bouguer statistical parameters in terms of gravity variations of the region is necessary (ρ =1.80–2.50).

3-3. Density determination by classical statistics

To determine Bouguer slab density in the Charak area, common statistical methods (Manley, 2004) has been used to calculate measures of central tendency, diffraction and comparing statistical tests via relative variables, which is shown in table (2), which is obtained by combination of relation (7) with excel for 776 gravity data. The maximum and minimum of density are 2.5 and 1.8 g/cm^3 respectively. The given information in table (1), showed the obtained density 2.32 from Asmari's formation and 1.78 from those of Bakhtiari. The applied statistical procedures in this study include calculation of Pearson coefficient and determination of obtained skewness from Bouguer anomaly distribution against the altitude variation of gravity points and its true limits are $-1<p<1$. In the case that Pearson coefficient is zero, the distribution of variables is quite normal, but in the cases that Pearson Coefficient is not zero, its sign determines the skewness direction with positive for skewing to the right and negative for skewing to the left. Regarding the obtained variations for Pearson coefficient, the maximum skewness relates to the anomaly resulting from the density of 1.8 g/cm^3 and the minimum one does to the anomaly from the density of 2.5 g/cm^3. Also, by computing the correlation between the variations of Bouguer anomaly and the altitude of surveyed gravity points, the necessary values for the statistical measurement of geophysical component (gravity and density) have been obtained and compared with the geometric variables of the region (altitude and topographic variation). Hence, a new defined relative variable, R^2P in table (2), has been used to measure linear regression of data in terms of their Pearson coefficient variation.

R^2P is a relative variable with the continuous domain between 0-1 where $R^2P = 0$, $R^2P=0.5$ and $R^2P=1$ have different concepts in terms of the relationship between the quantities R^2 (data squared correlation) and P (Pearson coefficient). The proposed relation for calculating this quantity to examine Bouguer anomaly variation is as follows:

$$R^2P = [\text{Reg. } (B \text{ vs.} \Delta h)] / [\text{Pearson } (B \text{ vs.} \Delta h)] \quad (8)$$

Where R^2P represent the indented statistic (without unit) and the expressions Reg. (B vs ,Δh) and Pearson Coef. (B vs.Δh) have been included for the calculation of the correlation coefficient of regression and Pearson of Bouguer anomaly (B in terms of mgal) respectively versus the altitude variation (Δh in terms of meter) of the region under study. It is important to note that in the present study, the inferred concepts from R^2P variation have been interpreted merely to study gravity variation and its relationship with the Bouguer slab density of Charak area and the author does not assume any responsibility concerning the similar surveys of geophysical quantities.

As mentioned before, R^2P is determining the type and value of the correlation between R^2 and P that can be calculated in the forms of linear regression coefficient R^2 (R^2P). As shown in table (2), the anamoly correlation of Pearson coefficient and linear regression is 0.96 which indicates significant relationship between R^2 and P. It means that a direct relation between the anomaly skewness and Bouguer slab variation is available in studied area. In other word, increasing the anomaly skewness causes the increases on the same direction of the altitudes of gravity stations and the residual gravity field is affected by the structure ups and downs. Similarly, as the skewness of anomalies decreases, the direction of altitude variation towards the phenomena resulting from Bouguer slab variation weakens and the residual gravity will relatively be independent from topographic effects. Accordingly, R^2P estimates no diagonally due to the density variation of the studied region and R^2P =0.5 provides the best choice for determination of statistical procedure.

Considering R^2P =0.912 in table (2), the correlation between Bouguer slab variation and the altitude of investigated points is more than what has been expected and despite the acceptable skewness of gravity data, selecting density of 1.8 as an independent quantity from altitude effects of the region is not right. This is true for the densities 1.9 to 2.2, but R^2P =0.602 and R^2P =0.416 considering the approximation of the proportion 1.2, the suitable component for the separation of Bouguer slab variation from topographic variation is provided and following from this, the densities 2.3 and 2.4g/cm^3 are proposed as the desirable choices. The final quantity of table (2) is R^2P =0.159 that, despite the very low correlation between anomaly and altitude variation of the stations, lacks the necessary criteria for choosing the optimal density due to lowness of Pearson coefficient.

Although, statistically, the comparison of the density 2.3 with 2.4 is a suitable estimator to measure Bouguer slab variation in Charak area. Based on the proposed nonlinear method in this study the optimal density is selected and focusing on fractal functions. It is necessary to point that there are some considerations, regarding the measurement of initial components and knowing iteration patterns, which theoretically relate to scale independent quantities and enjoy enough accuracy in evaluating geophysical variables (Mandelbrot, 2006).

3-4. Density determination by fractal method

The assumption of using fractal method is the nonlinear distribution evaluation of gravity data within exponential functions (Torcutte, 1997) that previously has been referred as diffraction-distance equation (relation6). Due to sedimentary facies and density variation in apt formations of the region, Bouguer anomaly has been calculated (relation7) for different densities (1.8 to 2.5) and interpolated using kriging method. In this way the steps of achieving the Z_p ,Z_q , and d_{pq} variables (relation 5) have been iterated for each variation in the average density of the region and the results have been used to draw fractal functions. Figure6 shows the resulting diagrams from diffraction-distance fractal functions in different densities (1.8 – 2.5). Similar to figure5, the coexistence of similar quantities (self-affinity points) has caused different population to appear and fractal dimensions with the variation of Brownian surface ($2<FD<3$) have made it possible to recognize Bouguer anomaly while being independent from altitude variation of the region. As it is observed, the maximum fractal dimension pertained to Bouguer slab variation has been in the density of 1.9 g/cm^3 and its minimum belongs to the anomaly resulting from density of 2.4 g/cm^3. Based on proposed method by Mark and Aronson (1984), if we contrast fractal dimension variation with density variation, a second grade quasi function will be obtained over which the locus of optimum density will coincide yield the point of the function. Therefore, in the anticline of Charak region the density of 2.4 g/cm^3, because of FD min=2.11, has been selected as an independent quantity from the structure ups and downs Bouguer slab which is pointed in figure 7.

The comparison results of classical statistics with fractal method (table2) confirms the idea that the selection of 2.4 g/cm^3 density goes along with the simultaneous reduction of R^2 and P correlation coefficient and it creates a suitable situation for the independency of Bouguer slab density from the topographic variation of the region. So, assuming $0.4\leq R^2P \leq 0.5$ as a criterion for measuring the statistics that fit the optimized Bouguer anomaly, the relationship between statistical data and the results of fractal investigation is verified. Thus, using statistical methods, Bouguer slab density in the Charak area is approximately estimated to be between 2.3 and 2.4 g/cm^3 and achieving nonlinear distribution in the gravity field (fractal method), $\rho_{final}=2.40$ g/cm^3 is proposed as the optimized averaged density.

Conclusion

By Introducing statistical methods and application of diffraction-distance equation to determine Bouguer slab density in the Charak area, the present study investigated the results of each section and just the most important ones are reported as follows:

- Investigating fractal distribution of the gravity data aiming at evaluating Bouguer slab variation in the Charak-Namakin area, due to using similar quantities and focusing on self-similar features resulting from field measurement, makes it possible to estimate density, independent from structures ups and downs, enjoying accurate results based on the statistical parameters if compared Nettleton's correction pattern.
- In this study, Bouguer slab variation of Charak has been evaluated using classical statistics and fractal method separately and the results have been compared with the R^2P values, which $0.4\leq R^2P\leq 0.5$, as a suitable choice has been proposed to select the average density of the region.
- In the statistical measurement of the data, R^2P has been used as a criterion to evaluate Bouguer slab variation of Charak and after examining the assumed quantities of 1.8 to 2.5 g/cm^3, the regional average density of 2.3 g/cm^3 has been estimated by 0.1 approximations.
- In fractal method, using diffraction-distance equation, a new method was introduced to investigate gravity field variation. In this equation achieving the dimension of $FD\geq 2$ indicates the presence of similar components in the Brownian surface that, in their turn, are related to the appearance of the iteration patterns in the anomaly surface and indicate the gravity field variation in the threshold of chaotic environment.
- This study has made Mark and Aronson's proposed method (1984) possible to investigate Bouguer variation in terms of various densities and has used the results to obtain the Bouguer slab effects of the Charak region. Therefore, an optimized component to use the spatial analyst of Arc view GIS has been developed and increasing of the accuracy in the approximation of geostatic data consequently was experienced. The result of such a process is achieving the value of 2.4 g/cm^3 as Bouguer slab density in the Charak-Namakin area. It is also expected that Bouguer anomaly originates from the density of 2.4 independent from structure of ups and downs of Zagros and geometrically enjoys enough surface for self-similar gravity to appear.
- The exponential function resulting from free air variation (figure 4) verifies that the resultant of the gravity force in Charak-Namakin area has been in the distance of similar components (from 2.88 to 15.32 kilometers) independent from mantle isostasy and out of this distance it influenced by the structure of ups and downs of Zagros. Therefore, allocating the density of 2.3 or 2.4 g/cm^3 is of spatial limitation and unlike the common methods (Farmani, 2003), it requires fractal considerations to interpret the behavior of the gravity field.
- The exponential function resulting from the behavior of Bouguer anomaly (figure5), verifies that variation independent from structure of ups and downs in the Charak area has been observed only from 6.44 to 10.24 kilometers from the anomaly threshold and in other areas it has been affected by topographic factors. Similarly, using various densities (1.8 to 2.5 g/cm^{-3}) have caused numerous distances and consequently the appearance of some variations in process of anomaly distribution. This method, unlike the common ones (Farmani, 2003), requires using nonlinear pattern to determine Bouguer slab density by fractal method.

- Drawing the Bouguer vs variation of fractal dimension (figure7), implies that the proposed pattern by Mark and Aronson corresponds with the gravity findings in the Charak region. Accordingly, the quantity FD_{min}=2.11 lies at the yield point of the function and it will be the estimator of no diagonality from the average density of the region (ρ_{final} =2.4). Also, determining density by fractal method corresponds with the variation of $0.4 \leq R^2P \leq 0.5$ and the probability of achieving intended results, after the interpolation of gravity variation (via geostatistic methods), increases. Thus, if maximum and minimum of points of the anomaly are calculated using kriging method and taking into account that geometric index included in the survey grid of gravity data, the limits of anomalies correspond with the effect distance of free air variation and the residual gravity, in some sedimentary formations, will be independent from topographic effects. Such regions are recommended for further discovering activities aiming at achieving extended oil reservoirs in Charak-Namakin.

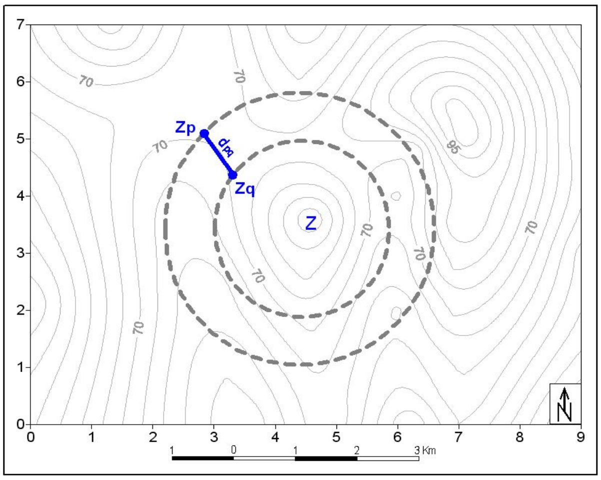

Figure3. Applied geometrical values of diffraction- distance fractal equation with 5 mgal Contour line difference (Thorarinsson & Magnusson, 1990)

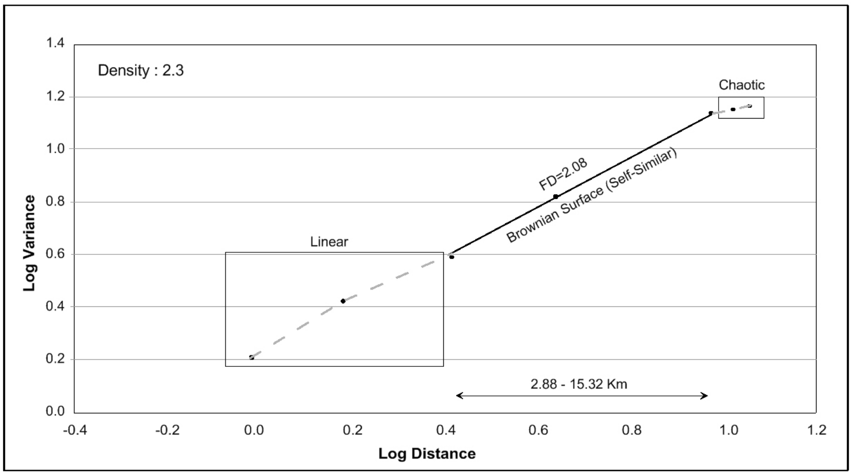

Figure4. Variation of diffraction- distance fractal equation for free air anomaly in Charak region

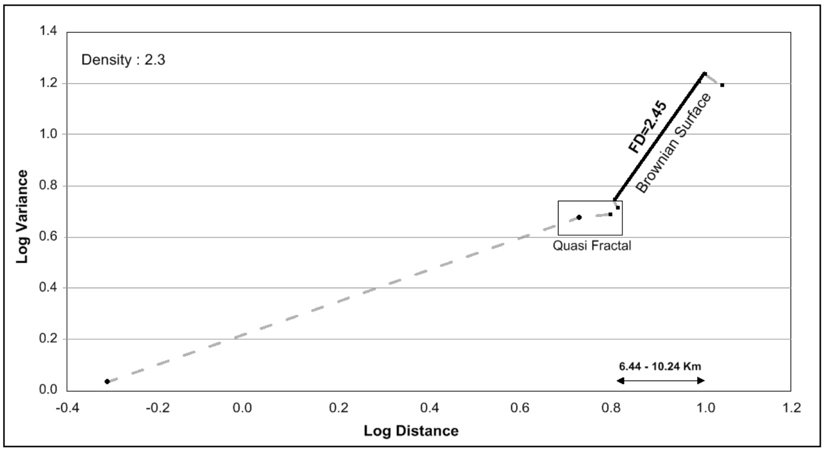

Figure5. Diffraction-distance fractal function for variation of anomaly in Charak-Namakin region (assumed density 2.3)

Table (2). Required statistical indices for comparison of Bouguer anomaly with different densities in Charak area

No	density (g/cm^3)	Bouguer Anomaly (mgal)				Bouguer Vs. Elevation		R2P Ratio
		Average	Min	Max	Stdev	Pearson Coef.	Regression (R2)	
1	1.8	-37.107	-50.441	-7.634	7.979	0.912	0.832	0.912280702
2	1.9	-37.998	-50.426	-11.104	7.111	0.888	0.789	0.888513514
3	2	-38.889	-50.411	-14.405	6.271	0.853	0.729	0.854630715
4	2.1	-39.779	-50.396	-17.707	5.472	0.802	0.644	0.802992519
5	2.2	-40.670	-50.381	-21.009	4.734	0.724	0.524	0.723756906
6	2.3	-41.561	-50.367	-24.311	4.090	0.602	0.363	0.602990033
7	2.4	-43.452	-50.352	-27.612	3.593	0.418	0.174	0.416267943
8	2.5	-43.342	-50.354	-30.914	3.308	0.163	0.026	0.159509202

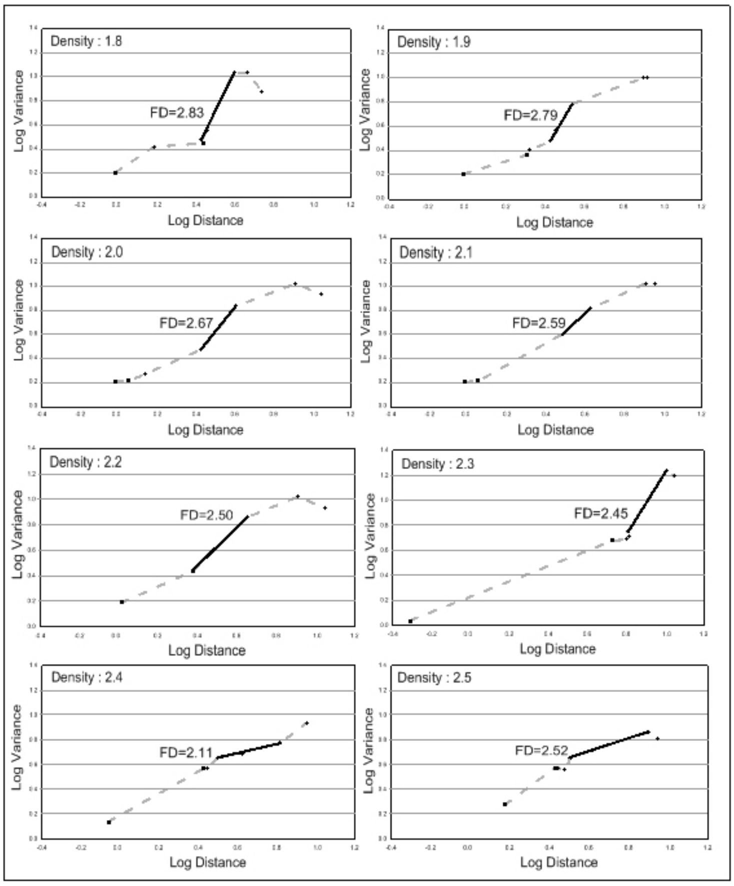

Figure6. Diffraction-distance fractal function for densities between 1.8 to 2.50 in Charak-Namakin region

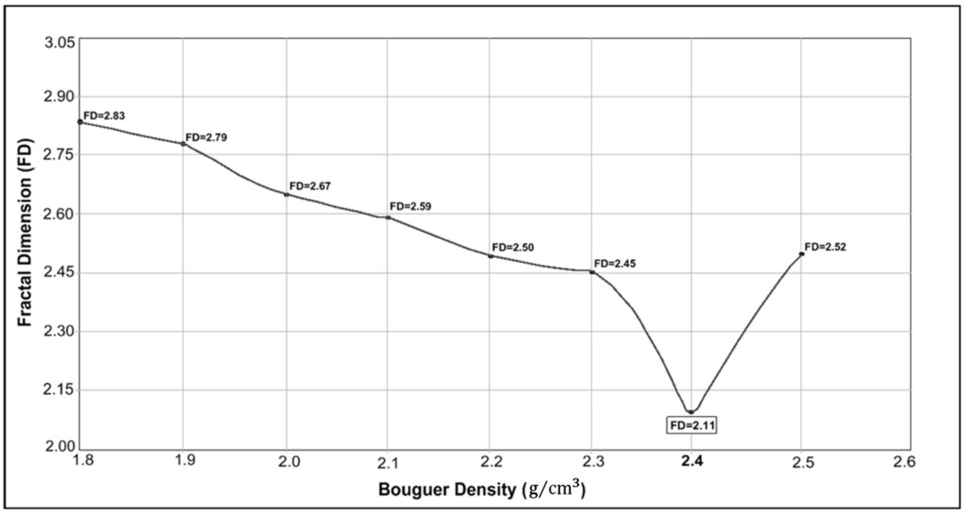

Figure7. Bouger anomaly vs. resulted fractally dimension from sedimentary formation densities in Charak-Namakin area

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