International Journal of Computational and Experimental Science and ENgineering (IJCESEN)

Vol. 10-No.1 (2024) pp. 11-14
http://www.ijcesen.com

ISSN: 2149-9144

Research Article

Gravity Field Numerical Analysis and Depth Structure of the South-Eastren Caucasus

Gunel SADIGOVA[1]*, Aynur ZAMANOVA[2]

[1]Institute of Geology and Geophysics of the Ministry of Science and Education of Azerbaijan Republic / Modern geodynamics and space geodesy Department, Baku, Azerbaijan
***Corresponding Email:** gsadigova@yahoo.com - **ORCID:** https://orcid.org/0009-0006-7394-571X

[2]Institute of Geology and Geophysics of the Ministry of Science and Education of Azerbaijan Republic / Modern geodynamics and space geodesy Department, Baku, Azerbaijan
Email: aynur-zamanova@rambler.ru - **ORCID:** https://orcid.org/0009-0009-3651-2714

Article Info:

DOI: 10.22399/ijcesen.6
Received : 08 August 2023
Accepted : 08 February 2024

Keywords

gravity anomaly
sedimentary basin
oil and gas fields

Abstract:

In this paper, the gravity anomalies of the Bouguer of the Absheron, Shamakhi-Gobustan and Pricaspian-Guba oil- and gas-bearing regions are interpreted by the 3D prism method. According to this model, a part of the earth's crust covering the crystalline basement is considered as a set of many prisms located nearby. The depth of the surface of the crystalline basement is calculated taking into account the change in density at the bottom of the low velocity zones of the upper part of the earth's crust and the dependence of the density difference on depth according to a quadratic law.
For interpretation of the gravity anomalies in the Absheron, Shamakhy-Gobustan and Pricaspian-Guba regions, a sedimentary basin viewed as, a number of prisms placed in juxtaposition. The decrease of density contrast in sedimentary basins approximated by, a quadratic function. The contour map is sampled at 1160 equispaced points with 5 km interval. The depths to the interface separating sedimentary were calculated using a generalized computer program GR3DSTR for 3-D inversion of gravity data either for a constant density contrast or for a variable density contrast with depth.
From 3D gravity model of the sedimentary layer, it was found that the maximum depth is in the areas of Gyuzdek and Meraza (11 km), and the minimum is in the areas of Gonakkend, Gilazi, Garabulag, Dubrar (4 km).
The depth of the sedimentary layer around the Agzibirchala well varies within 6 km. The correlation of the distribution of the thickness of the sedimentary layer on the site with the seismic section and well sections was determined.

1. Introduction

I.O. Tsimmelzon and R.M.Gadjiyev were mainly engaged in the study of the surface crystalline basement depth of the Azerbaijan territory, which was carried out using the interpretation of the gravity field. The scheme of the surface crystalline basement depth of the Azerbaijan territory, compiled according to the available data from deep drilling materials, geological and geophysical studies, is given in the works of I.V. Kirillova, Rastvorov, A.A. Sorsky, V.E. Khain, B.K. Balavadze, G.Sh. Shengelaya, G.Sh. Shengelaya, G.A. Akhmedov, M.M. Radjabov, R.M. Gadjiyev, E.Sh Shikhalibeyli., O.B. Babazade., G.O. Veliyev and F.A.Kadirov [1,2,3,4].

In this work, the depth of the sedimentary layer is studied: a) taking into account the change in density at the bottom of the low velocity zone, reaching 0.3-0.4 g/cm3 and b) with the dependence of the density difference on depth according to a quadratic law.

2. Material and Methods

Gravity anomalies of the study area in Bouguer reductions are shown in Fig.1. Within the Absheron Peninsula and Gobustan, a pronounced East Azerbaijan minimum is observed. It is distinguished by anomalies down to -140mGal, which are quite unusual for low regions of the earth's crust. From the south-west this minimum is

limited by the Azerbaijan maximum. The Caspian-Guba region covers the zone of the Caspian - Guba gravitational minimum and part of the East Azerbaijan minimum. It is distinguished by anomalies up to -135 mGal. The main results of the study of gravitational anomalies are covered in the works [1,5,6].

2.1. Gravity field of the study area.

In order to study gravity anomalies, the map of the Bouguer anomalies of Azerbaijan was previously divided into a square grid with a step of 5 km, and the values of the Bouguer anomalies were determined at the nodal points. The origin of the coordinate system is located in the southwest corner of the study area. The X axis is directed to the East, and the Y axis is directed to the North. The number of elements on the X-axis (Nx) and on the Y-axis (Ny) was chosen as N_x=29 və N_y=40.

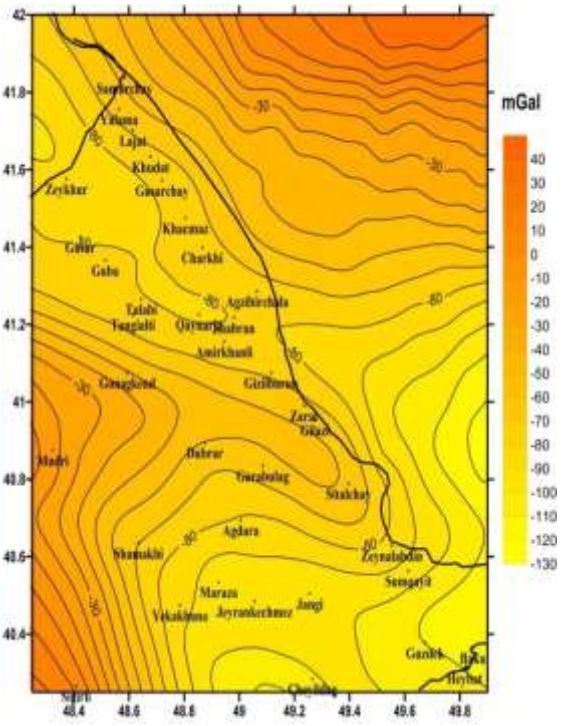

Figure. 1. *Bouguer gravity map for the study area. Contour interval is 5 mGal.*

2.2. Three-dimensional modeling of gravity anomalies.

The rock density difference in the part of the earth's crust covering the crystalline basement can be approximated by a quadratic function [7] of depth:

$$\Delta\rho(z)=a_0+a_1z+a_2z^2 \quad (1)$$

where the Z axis is directed downward, a_0 represents the extrapolated value of the density difference on the surface, a_1 and a_2 are constants of a quadratic function. For 3D modeling of gravity anomalies, a part of the earth's crust covering the crystalline basement can be considered as a set of many prisms located nearby.

The equation for the gravity anomaly of a prism with a quadratic change in density with depth is defined in [8] and is expressed by the formula:

$$\Delta g(x,y)=\gamma a_0\left|z\arctan\frac{xy}{zR}+\frac{x}{2}\ln\frac{R-y}{R+y}+\frac{y}{2}\ln\frac{R-x}{R+x}\right|_{x=X_1}^{X_2}\Bigg|_{y=Y_1}^{Y_2}\Bigg|_{z=Z_1}^{Z_2}$$

$$+\gamma a_1\left|\frac{z^2}{2}\arctan\frac{xy}{zR}-\frac{x^2}{2}\arctan\frac{yz}{xR}-\frac{y^2}{2}\arctan\frac{xz}{yR}\right.$$

$$+xy\ln(2R+2z)\Big|_{x=X_1}^{X_2}\Big|_{y=Y_1}^{Y_2}\Big|_{z=Z_1}^{Z_2}+\gamma a_2\left|\frac{z^3}{3}\arctan\frac{xy}{zR}\right.$$

$$\left.-\frac{x^3}{3}\ln\frac{R-y}{R+y}-\frac{y^3}{6}\ln\frac{R-x}{R+x}+\frac{2}{3}xyR\right|_{x=X_1}^{X_2}\Big|_{y=Y_1}^{Y_2}\Big|_{z=Z_1}^{Z_2} \quad (2)$$

here X_1=x+T, X_2 = x-T, Y_1=y + W, Y_2= y - W, $R=\sqrt{X^2+Y^2+Z^2}$ and γ is the gravity constant, T and W are half the length and width of the bottom of the prism, respectively. The computer program GR3DSTR for 3D modeling of gravity anomalies in FORTRAN-77, in the case of density variation with depth, was prepared by Bhaskara Rao and Ramesh Babu [8].

3. Results and Discussions

Application of the GR3DSTR program for modeling gravity anomalies in the study area: Absheron and Shamakhi-Gobustan regions are characterized by a four-layer structure of the earth's crust: 1-layer Cenozoic deposits with a density of ρ=2.2-2.4 g/cm^3, 2-layer Mesozoic deposits, ρ=2.6-2.72g/cm^3, 3-layer, consisting of metamorphic strata and granites, ρ = 2.66-2.85 g/cm^3 and 4-basalt layer, ρ = 2.9 g/cm^3 [5]. The thickness of these layers undergoes significant changes, and the total thickness averages about 42 km. Taking the thickness of the Cenozoic and Mesozoic layers equal to 5 and 10 km, with a density difference at the Cenozoic-Mesozoic boundary of 0.27 g/cm3 and at the boundary of the crystalline basement of 0.15 g/cm3, a quadratic dependence of the density difference on depth was determined.

The zone of low speeds in the Pricaspian-Guba region has a thickness of 5–10 m, and the wave speed in it is 430–620 m/s [9]. Taking into account the results of borehole, laboratory and seismic studies, a general density model for the region was compiled. In this model, five petro-density levels are distinguished with an average density increasing from top to bottom: Quaternary 1.95

g/cm^3; Paleogene-Neogene 2.23 g/cm^3, Cretaceous 2.48 g/cm^3; Bajocian-Upper Jurassic 2.62 g/cm^3 and Lower Jurassic-Aalenian 2.72 g/cm^3 [5,10,11,12]. Accordingly, the density differences at the contacts are 0.28; 0.25; 0.14. 0.1 g/cm^3. The thicknesses of the layers are respectively taken to be 0.2; 5.8; 2; 2; 5 km. The density difference between the Mesozoic complex and the crystalline base is 0.1 g/cm3. When determining the quadratic dependence of Δρ (density difference) on depth, at the bottom of the low velocity zone, the density difference was taken equal to -0.4 g/cm^3.

In fig. 2 shows the change in density difference with depth. Coefficients of quadratic functions a_0= −0.4090, a_1 = 0.03041, a_2=− 0.00092. Subtracting from the gravimetric field data the influence (20 mGal) associated with the approach of heavy masses to the surface we get a new map of anomalies. The data of this card is used as the source field. In fig. 3 shows the depth of the sedimentary layer of the Absheron, Shamakhi-Gobustan and Pricaspian-Guba regions, calculated by the GR3DSTR program after ten iterations. In fig. 4 shows the gravity effect of the depth of the sedimentary layer of the Absheron, Shamakhi-Gobustan and Pricaspian-Guba regions. Comparison of the map of Bouguer anomalies and the gravity effect of the depth of the sedimentary layer, taking into account the correction (20mGal), shows a satisfactory agreement.

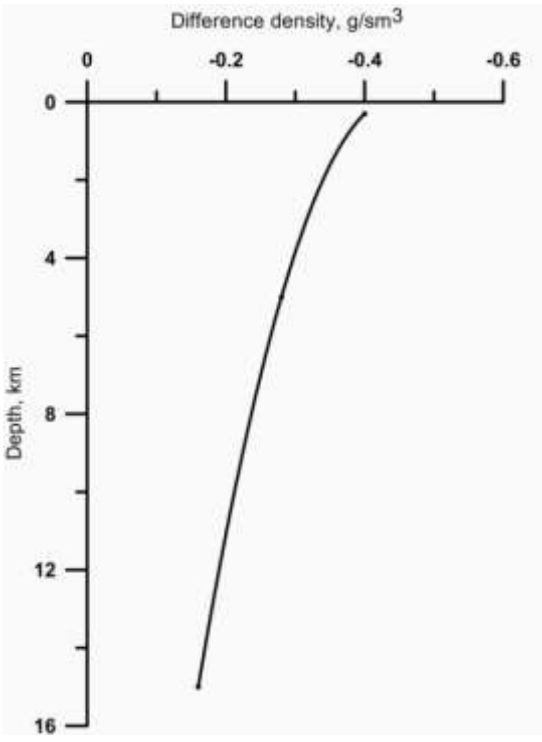

Figure. 2. *Approximation of density difference -vs.-depth data for the study area by a quadratic function.*

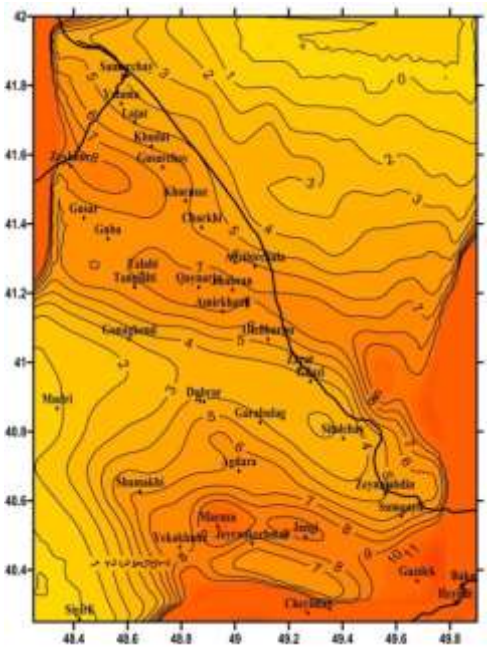

Figure. 3. *The sedimentary layer depth contour map of the study area derived from 3-D modelling of gravity anomalies using a quadratic density function. Contour interval is 1 km.*

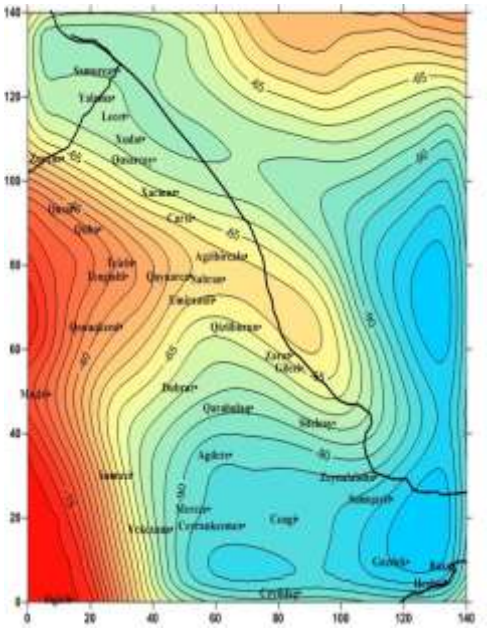

Figure. 4. *The calculated gravity anomalies of the sedimentary basin with the 3-D prism program. Contour interval is 5 mGal.*

4. Conclusions

From the depth map of the sedimentary layer, it can be seen that great depths have been reached on the Absheron Peninsula. The average depth of the sedimentary layer on the Absheron Peninsula is 11 km. In the Guzdak region of the Absheron Peninsula, a relative deepening is visible. Another zone with the same average depth is observed near Maraza.

In the zone around the districts of Gonakkend, Gilesi, Garabulag and Dubrar, a rise in the sedimentary layer was observed. The average depth of the sedimentary layer was 4 km in the areas of Gonakkend, Gilesi, Garabulag and Dubrar.

The depth of the sedimentary layer between the regions of Guba, Gusar, Khachmaz, Agzybirchala is 6 km. The average depth of the sedimentary layer was 7 km in the area covering Shabran, Talabi, Amirkhanli, Gaynarja and 8 km in Zeykhur. In Gusar-Shabran basin, the depth of the sedimentary layer varies around 8 km. The obtained values of the depth of the sedimentary layer in the study area are consistent with previously known data [13,14,15,16].

The gravity model of the sedimentary layer shows that the thickness of the sedimentary layer around the Agzibirchala well is 6 km. The depth of the sedimentary layer around Gaynarja is calculated to be 7 km. This depth is close to the results obtained from geophysical and geological data [15].

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.
- **Acknowledgement:** The authors declare that they have nobody or no-company to acknowledge.
- **Author contributions:** The authors declare that they have equal right on this paper.
- **Funding information:** The authors declare that there is no funding to be acknowledged.
- **Data availability statement:** The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

References

[1]Kadirov, F.A. (2000). *Gravitational field and models of the deep structure of Azerbaijan*. Baku: Edition of the Institute of Geology of the Azerbaijan Academy of Sciences

[2]Kadirov Fakhraddin. (1999). Interpretation of gravity anomalies in the Absheron and Shamakhino-Gobustan regions using the 3D prism method. *Proceedings. The sciences of Earth*.(1):85-89.

[3]Kadirov Fakhraddin. (2000). Application of the Hartley transform for interpretation of gravity anomalies in the Shamakhy–Gobustan and Absheron oil- and gas-bearing regions Azerbaijan. *Journal of Applied Geophysics*. 45(1):49–61. DOI:10.1016/S0926-9851(00)00018-5

[4] Kadirov Fakhraddin. (1999). Filtering gravity data of the PreCaspian-Guba region. *Proceedings. The sciences of Earth*. (1):90-95.

[5]Akhundov, A.B., Veremeenko, O.B., & Shekinskiy, E.M. (1996). *Regional studies. In: Geophysical exploration in Azerbaijan.* Baku: Sharg-Garb.

[6]Gasanov, A.G. (2001). *Deep structure and seismicity of Azerbaijan in connection with the forecast of oil and gas potential.* Baku: Elm.

[7]Bhaskara Roa. (1986). Modelling of sedimentary basins from gravity anomalies with variable density contrast. *Geophysical Journal International*. 84(1):207-212. DOI:10.1111/j.1365-246X.1986.tb04353.x

[8]Bhaskara Rao, Ramesh Babu. (1991). A fortran-77 computer program for three-dimensional analysis of gravity anomalies with variable density contrast. *Computer and Geosciences.* 17(5):655-667 DOI:10.1016/0098-3004(91)90037-E

[9]Khain, V. E., Alizade, Ak. A. (Eds.). (2005). *Geology of Azerbaijan, Vol. IV. Tectonics.* Baku: Nafta Press.

[10]Safarov, I. B., (2011). *Petrophysical models of lithospheric plates of continents and oceans*. Baku: Elm.

[11]Balakishibeyli, Sh.A. (1992). *Petrophysical models of the earth's crust of Azerbaijan*. Baku: Abstract of dissertation for the degree of Doctor of Geological and Mineralogical Sciences.

[12]Balakishibeyli, Sh.A., Salekhli T.M., Hasanov A.B., Kuliyev R.D. (1996). *Results of petrophysical researches In book: Geophysical researches in Azerbaijan (Ed.: Kerimov K.M.).* Baku: Sharg-Garb.

.

[13]Huseynov, B.B., Salmanov, A.M., Maharramov, B.I. (2019). *Oil-gas-geological zoning in the land area of Azerbaijan (monograph).* Baku: "Mars Print" publishing house.

[14]Salmanov, A.M. Suleymanov, A.M., Maharramov, B.I. (2015). *Paleogeology of oil and gas regions of Azerbaijan (monograph).* Baku: "Mars Print" publishing house.

[15]Yusifov, Kh.M., Suleymanov, A.M. (2015). *Geological basis of oil and gas exploration in Mesozoic sediments in Azerbaijan.* Baku: "Mars Print" NPF.

[16]Yusifov, Kh.M., Aslanov, B.S. (2018). *Oil and gas basins of Azerbaijan.* Baku: "Mars Print" NPF.