Morphology of geophysical fields of Terek-Caspian trough and placement patterns of oil and gas structures

E A Abubakarova¹,²

¹ Department of problems of the fuel and energy complex, Integrated Research Institute named after H.I. Ibragimov of the Russian Academy of Sciences, Grozny, Russia
² Department of Applied Geophysics and Geoinformatics, Grozny State Oil Technical University named after academician M.D. Millionshchikov, Grozny, Russia

E-mail: eliza_ggni@mail.ru

Abstract. The paper considers the characteristic morphological features of geophysical fields caused by fault tectonics of the Tersko-Caspian trough. The results of the interpretation of the gravitational and magnetic fields of the region using the Cascade 3D spectral-correlation analysis of data are presented. Computer technology made it possible to analyze three-dimensional digital geophysical information using the methods of a probabilistic-statistical approach. Linear positive anomalies of geophysical fields are identified that extend in the fault zones. A comparative analysis of the maps of transformants of the gravitational and magnetic fields and maps of oil and gas structures. Based on the results of comparative analysis, a dependence was established that characterizes the confinement of the known oil and gas deposits in the region to the zones of positive linear anomalies of geophysical fields of a sub-latitudinal strike.

1. Introduction

In geological terms, the Tersko-Caspian trough has a complex structure; the foundation is characterized by a fault-block structure with the chaotic immersion of blocks. Fault tectonics of the study area is essential in the oil and gas and geological zonality of the region, which determines the migration paths of hydrocarbons [1, 3, 6, 10]. Known oil and gas-bearing structures are mainly located in the sub-latitudinal strike of the study area, which is shown in the diagram of the oil fields and oil and gas prospective areas of the Tersko-Caspian trough (Fig. 1).

A regional description of the geophysical fields of the studied territory of the North Caucasus is given in many works [5, 7]. Materials of detailed gravimetric surveys and their geological interpretations were processed on the territory of the study area. The analysis of gravimetric maps on a scale of 1: 200000 within the described territory made it possible to identify many features of the gravity field. The region’s gravitational field (Fig. 2) is characterized predominantly by the sub-latitudinal strike of the iso-anomalies. The entire studied area is characterized by large anomalous zones of sub-latitudinal and northwestern orientations. In the north of the described territory, a zone of smooth decrease in the gravitational field is distinguished. In the northern zone, the gravitational field is gradually expanding from west to east.
Figure 1. The layout of oil fields and promising areas (Designation: a – deposits under development; b – deposits located in exploration; c – perspective areas).

**Oil fields:**
1 – Bragunskoye; 2 – Goit-Kortovskoye; 3 – Goryacheistochnenskoye; 4 – Gudermesskoye (with Petropavlovskim); 5 – Zamankul'skoye; 6 – Karabulak-Achalukskoye (with Sernovodskim); 7 – Malgobek-Gorskoye; 8 – Oktyabr'skoye; 9 – Pravoberezhnoye; 10 – Starogroznenskoye; 11 – Khayan-Kortovskoye; 12 – El'darovskoye; 13 – Andreyevskoye; 14 – Benoyskoye; 15 – Mineral'noye; 16 – Severo-Mineral'noye; 17 – Severo-Malgobekskskoye; 18 – Severo-Bragunskoye; 19 – Cherylennoye; 20 – Khankal'skoye; 21 – Akhlovskoye; 22 – Mesketinskoye; 23 – Alkhanurtskaya; 24 – Severo-Dzhalkinskaya; 25 – Datykhskoye; 26 – Arak-Dalaterekskoye; 27 – Kharbizhinskoye; 28 – Lesnoye;

**Exploration area:**
29 – Belorechenskaya; 30 – Koshkel'dinskaya; 31 – Kurpskaya; 32 – Groznenskaya; 33 – Terskaya; 34 – Il'inskoye; 35 – Nozhay-Yurtovskaya; 36 – Magistral'naya; 37 – Suvorovskaya; 38 – Rodnikovaya; 39 – Yuzhno-Kharbizhinskaya; 40 – Zandakskaya; 41 – Groznenskaya; 42 – Priterechnaya; 43 – Yuzhno-Gudermesskaya; 44 – Severo-Sayasanovskaya.

In the central part, near the Nadterechny and Chervlensky lows, the described zone is the narrowest. In the eastern part, the Pereterennaya zone axis of minima is shifted to the south in a rock-like fashion. The large and complex Khasavyurt minimum has a sub-latitudinal orientation and is complicated in the east by the Kizilyurt local minimum. In the extreme western part, the Mozdok minimum of the gravity field has vague contours. It passes into the zone of a gradual increase in the gravitational field in the direction of the Mineralovodsky ledge. The described zone of minima corresponds to the submerged sections of the Paleozoic basement of the deflection.

Further south, the Terek zone of linear minima stands out, which corresponds to the Tersk anticline zone. Within the Tersky zone, the Arak-Dalatarek, Malgobek-Voznesensky, Eldarovskoye, Aliyurt-Orlinny, Khayan-Kortovsky, Bragunsky and Guderme maximums are distinguished. The Arak-Dalatarek maximum, complicated by three local maximums, stretches from the southwest to the
southeast from Prokhladny to Urusheva. It is due to the eponymous anticlinal uplift. The maxima located east of Malgobek-Voznesensky, Eldarovsky, and Aliyurt-Orliny represent a narrow strip complicated by local maxima of various intensities, bounded from the north and south by highly gradient zones. The described maxima correspond to the largest anticlinal within the Terek anticlinal zone of the Malgobek-Voznesenskaya-Aliyurt-Gorsky anticline, which stretches for 75 km and has a width of 4 km.

To the east, there is a Kalausky complex-built minimum corresponding to the depression of the same name. The maximum allocated to the east of the Khayan-Kortovsky maximum also represents a narrow strip 40 km long, limited from the north and south by highly gradient zones. In the extreme east, the anomaly is complicated by a sizeable local maximum in the area of Yastrebinaya. With the maximum of Mount Yastrebinaya in the east, the Bragunsky linear maximum articulates articulately. The anomaly is clearly expressed and corresponds to the anticlinal uplift of the same name. The Bragunian anomaly in the southeast passes into the Guderme maximum, which has a southeast direction. The Guderme anomaly corresponds to the anticlinal uplift of the same name, within which the Tersk anticlinal zone merges with the Myatli ledge of the Montenegro monoclinic zone. To the south, the Alkhanchurt linear minimum zone is noted, separating the Tersky and Sunzhensky maximum zones, and corresponding to the synclinal zone of the same name.

The Sunzha linear maximum zone includes the Zamankul, Sunzhen, and Starogroznensky maxima. It corresponds to the anticlinal zone of the same name, within which the Zamankul, Karabulak – Achalukskoye, Sernovodskoye, Oktyabrskoe, and Starogroznenskoye uplifts are distinguished. The Zamankul maximum with a length of 50 km and a width of 7–9 km has a sub-latitudinal strike in the central part and southwest in the west. In the far west (Zmeyskaya station), the maximum again changes its orientation to sub-latitudinal and smoothly passes into the Argudansky maximum. The Zamankul anomaly is complex and limited by highly gradient zones from the north and south.

In the western part, the Zamankul maximum is divided into Harbizhinsky and Malokabardinsky branches. Sophisticated Sunzhensky maximum stretches from Achaluki to Zakanurt for more than 50 km, is complicated by local anomalies and is limited from the north and south by highly gradient zones. The articulation of the Zamankul and Sunzhen maxima is rocky. The Starogroznensky maximum, stretching east to the city of Grozny in the form of a narrow strip, is characterized by a limited gradient zone from the north and a less gradient zone from the south.

Analysis of the density characteristics of the section indicates the presence of several density boundaries. Still, the most contrasting are the roof of the Upper Cretaceous deposits and the pre-Jurassic base.

![Figure 2. Anomalous gravitational field of the Tersko-Caspian trough Anomalous magnetic field ∆Tα of the Tersko-Caspian trough.](image-url)
The block structure of the basement and the faulty, folded structures of the sedimentary cover (mainly of the Upper Cretaceous deposits) determine the nature of the anomalous gravitational field of the studied area. The zones of development of saline sediments of the Upper Jurassic also have a significant effect on the character of the gravitational field of the studied region. When analyzing the dominant nature of the indicated gravitational boundaries, it is necessary to take into account that other factors (intrusive and effusive magmatism, inhomogeneities of the upper part of the section, and lateral density changes) may dominate in some areas.

A characteristic feature of the gravitational field of the region is the presence of highly gradient zones due to fault-block tectonics. The anomalous gravitational field of the studied region has a complex morphology. It is characterized by the presence of zones of maxima and minima of various energies corresponding to the corresponding tectonic elements.

The TKP magnetic field is characterized by the presence of a broad Grozny regional maximum, stretching in the Caucasus direction (Fig. 3). The depth of magnetoactive masses varies in the range from 10 to 18 km. The regional magnetic maximum is determined by the intrusive complex of rocks associated with a significant grave fault. The area of the negative magnetic field located in the north corresponds to the critical occurrence of the Precambrian basement.

On the meridian of Vladikavkaz, the Grozny maximum is articulated with a transverse magnetic maximum, apparently of the same nature. The region southwest is characterized by a large number of small anomalies of both signs, most due to magmatism in the fault zones.

![Figure 3. Anomalous magnetic field ∆Ta of the Tersko-Caspian deflection.](image)

2. Methods and materials
The study aims to establish an interdependent relationship between the anomalies of geophysical fields and the oil and gas potential of the studied region. The solution to the problem posed is based on one of the methods for interpreting digital geophysical information of the Cascade 3D software for spectral correlation analysis of data – tracing the axes of anomalies.

3. Results
A comparative analysis of the transformant of the gravitational field obtained using the above method and the location scheme of oil and gas structures was carried out (Fig. 4). According to the results of the comparative analysis, we can observe the relationship, i.e., confinement of most hydrocarbon deposits to linear maxima of gravity. Comparing the axes of the anomalies in the local component of the gravitational field and the deposits of oil fields, they are confined to the local maxima of gravity [2].

Compared with the transform of the gravitational field, the result of the interpretation of the magnetic field is displayed less informatively. In this connection, the following processing algorithm was used – filtering the results of tracing by the initial magnetic field. The software module that
implements this stage of processing made it possible to isolate the estimates of the shape of weak anomalies, the amplitude of which is commensurate with the level of interference. The analysis of the compared transform obtained from the results of the final interpretation and the location scheme of the oil fields of the studied region is carried out. As a result of the analysis, it was found that Oil and gas-bearing structures can be traced in the sub-latitudinal tracing zone of positive anomalies of different magnetic field energies (Fig. 5) [4, 8, 9].

4. Conclusion
The analysis of the transformants of the gravitational and magnetic fields obtained by the interpretation of digital geophysical information using modern computer technology. This analysis shows that basically, the maxima of the gravitational and magnetic fields coincide.

A comprehensive interpretation of the regional digital geophysical materials of the studied area was made. The similar scheme of oil and gas structures of the Tersko-Caspian trough with transformants of gravitational and magnetic fields is analyzed. This study allowed establishing a relationship characterizing the confinement of known oil and gas deposits in the region to the zones of positive linear anomalies of geophysical fields of the sub-latitudinal strike.

Figure 4. The result of tracing the axes of anomalies on the local component of the gravitational field and the placement of oil and gas bearing structures
Figure 5. Filtering the results of tracing the axes of anomalies in the initial magnetic field and the placement of oil and gas structures

References

[1] Daukaev A A, Bachaeva T Kh, Abubakarova E A et al 2018 Deep Structure, and Oil and Gas Content of Submerged Zones of Western Part of Terek-Caspian Trough, Series: Advances in engineering research Engineering and Earth Sciences: Applied and Fundamental Research Proc. of the Int. Symp. (ISEES 2018) Retrieved from: https://doi.org/10.2991/isees-18.2018.85

[2] Volodarsky R F and Landa T I 1970 Geological interpretation of gravitational and magnetic fields using a computer (Moscow: Nedra) 200 p

[3] Gavrilov V P 2008 Possible mechanisms for the natural replenishment of reserves in oil and gas fields The geol. of Oil and gas 1 56–64

[4] Demura G V, Zinovkin S V and Petrov A V 2013 New opportunities and prospects for magnetic exploration – computer technologies for volume modeling and filtering the results of high-frequency fruitful surveys Subsoil use of the XXI century 4(41) 20–6

[5] Kerimov I A 1990 Prediction of structural features of the deeply submerged horizons of the Tersko-Caspian trough according to the data of gravity and seismic surveys Univer. Proc. Proc. Oil and gas 11 24–30

[6] Kerimov I A, Daukaev A A and Bachaeva T Kh 2011 Natural oil yields in Chechnya and Ingushetia Bull. of the Acad. of Sci. of the Chechen Republic 1(14) 74–9

[7] Kerimov I A 2011 The F-approximation method for solving problems of gravimetry and magnetometry (Moscow: Fizmatlit) 264 p

[8] Petrov A V and Trusov A A 2000 Computer technology for statistical and spectral-correlation analysis of three-dimensional geoinformation, Geophysics no 4 (Moscow: EAGO) pp 29–33

[9] Strakhov V N, Kerimov I A and Stepanova I E 2009 Development of the theory and computer technology for constructing linear analytical approximations of gravitational and magnetic fields (Moscow: IFZ RAS) 254 p

[10] Sudarikov Yu A, Serkerov S A, Kholina I et al 1976 Use of geological and geophysical data to study regional tectonics of Oil and gas-bearing areas (Moscow: Subsoil) 165 p