Tridimensional analysis of gravitational and magnetic fields of Terek-Caspian trough

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Abstract. The results of the tridimensional analysis of the gravitational and magnetic fields of the Terek-Caspian trough are presented in this article. Various transformations of the region's gravitational and magnetic fields (separation into components, calculation of higher derivatives, measurement of statistical characteristics, tracing of the anomaly axes, etc.) were performed. The morphology of the gravitational and magnetic fields was investigated, the characteristics of the anomalous geophysical fields were outlined and the relationship between various field characteristics and the features of the fault-block tectonics of the trough was analyzed.

1. Introduction

The gravitational field of the Terek-Caspian trough (TCT) is a system of anomalies of all sorts that differ in size, intensity, shape and origin. The gravitational field of the TCT [shown in Fig. 1 (a)] has a predominantly sublatitudinal strike of large anomalous zones, as well as a sublatitudinal and northwestern orientation. The block structure of the foundation is reflected through the distinctive strike of the anomalous gravitational field. The Terek-Caspian trough has a complex geological structure and bears the features of the folded structure, which includes folded areas and platforms in numerous parts. The though geology contains thick masses of rocks from the Precambrian to the Cenozoic periods. The foundation is defined by a complex fault-block structure with a step-down of blocks in the direction of the central part of the though [1].

Figure 1 (b) illustrates the magnetic field of TCT defined by the presence of a large Grozny regional maximum stretching in the latitudinal direction. An intrusive complex of rocks connected to a large deep fault determines the regional magnetic maximum.

The region of the negative magnetic field, located to the north, corresponds to a deep deposit of the Precambrian basement. On the meridian of Vladikavkaz, the Grozny maximum joins with a transverse magnetic maximum of, in all probability, the same nature. The southern part of TCT is characterized by a large number of small anomalies of both types. They are conditioned, apparently, by a magmatic activity in the zones of faults. The fault-block structure of the foundation played a decisive role in the formation of the structure of the sedimentary cover of the trough [2].
2. Materials and methods
The initial material base included the observed gravitational and magnetic fields of the Terek-Caspian trough. Interpretation and analysis of the geophysical fields of the investigation area will be carried out by applying the methods of the probability-statistical approach, focused on the identification of linear structural elements, which most often control the areas of tectonic dislocations.

The methods of the interpretational analysis used include procedures for evaluating the gradient and statistical characteristics of geophysical fields in moving ranges, and automatic separation of geophysical fields into constituent parts. To systematize and better represent the results of the processing of gravimetric and magnetic prospecting data, the algorithm of automatic geophysical field tracing will be applied using the probabilistic-statistical approach. This algorithm will allow identification of all main structural elements present in the components of geophysical fields in the form of tracer elements associated with the axes of anomalies and inflection points [3,4].

3. Results and Discussion
Based on the results of the analysis, a map of the total gradient of the gravitational field was created using the techniques discussed above and presented in Figure 2 (a). A strongly differentiated region in the southern part, as well as the structures of the northwestern strike in the central part of the investigation area, is clearly distinguished on the map. The full gradient allowed us to estimate the extent of the anomalies at each point of the initial observation network, while the transitions of contrast from the minimum values to the maximum values monitor the positions of the anomaly axes.

The study of the potential fields component made it possible to distinguish structural elements of different sizes and energy. Figure 2 (b) gives an evaluation of the regional component of the gravitational field, obtained by means of the automatic fields decomposition into components.

It has a gravitational minimum in the central part, which borders with a powerful gravitational maximum in the north, west and south.

The local component of the first-order gravitational field is shown in Fig. 3 (a), where large anomalous zones are presented with a strike from the northwest to the sublatitudinal zone. The nature of the field becomes more differentiated in the south; large anomalies are divided into a series of smaller anomalies, which made it possible to clarify the boundaries and shape of perturbing geological bodies. The field is calm and low-contrast in the northern part of the territory while the chains of linear anomalies are standing out in the central part, corresponding to the Tersky and Sunzha anticlinal zones and separating them from the Alkhanchurtskaya synclinal region. The emerging linear anomalies of different striking makes it possible to clarify the position of fault tectonics [5].

Two positive anomalies of latitudinal strike are clearly recorded in the central part of the territory observed. Those anomalies are located to the North and South of Grozny and control the zones of tectonic dislocations.

Figure 1. a - the initial gravitational field, b - the initial magnetic field.
Figure 2. a - the total gradient of the TCT gravitational field, b - the regional component of the gravitational field.

Figure 3 (a) presents the result of tracing the anomaly axes belonging to the regional component of the gravitational field. It clearly records all the trend structural elements that are reflected in the gravitational field. The position of the axes of the Tersky and Sunzha troughs is traced and specified. Let us emphasize the area of tectonic disturbance of the north-eastern strike, which runs north of the Vladikavkaz-Grozny line, and splits the main zone of latitudinal strike.

Figure 3 (b) shows the local component of the second-order gravitational field. The character of the second-order field of the local component reflects the distribution of the anomalous-forming objects in the upper part of the section. There is also a zone of latitudinal strike, which controls the regions of younger tectonic activity manifestations [6,7].

Figure 3. The local component of the gravitational field: a – first-order, b – second-order.

The trend component of the magnetic field is shown in Fig. 4 (a), where the main anomalous structure of latitudinal strike, which controls the main structural-tectonic element of the research area structure, is clearly recorded. It has to be noted that the positions of the structures that were marked out according to the local components of the gravitational field and the trend component of the magnetic field are identical, which, all in all, successfully agrees with the depth of the methods applied.

Figure 4 (b and c) shows the local components of the magnetic field, where a large number of smaller anomalies are outlined. Those anomalies are associated with the objects located at the top of the geological section, where a number of structural elements manifested in the gravitational field are presented as well.

Information about the structural-tectonic formation of the Terek-Caspian trough was obtained as a result of using the procedure of automatic tracing of gravitational and magnetic fields components.
Figure 4. Components of the magnetic field: a - regional component, b - local component of the first-order, c - local component of the second-order.

The results of the automatic tracing of the anomaly axes concerning the gravitational field regional component are shown in Fig. 5 (a). The figure clearly records all the trend structural elements that are reflected in the gravitational field [8].

Figure 5 (b) demonstrates the results of tracing the anomaly axes of the magnetic field trend component where the position of the anomaly is clearly recorded and that position controls the main zone of tectonic dislocations of latitudinal strike.

Figure 5. Results of the tracing the regional component anomaly axes: a - gravitational field, b - magnetic field

In addition to this zone, there are clearly traced anomalies of different strike, but less extensive. Here, along with linear structural elements, a lot of star-shaped structures are notable. It can be interpreted as intersections of tectonic dislocation of different strikes [9,10].
4. Conclusion

Based on the results of interpretation and analysis of geophysical fields such as separation into regional and local components, calculation of higher derivatives, tracing of the anomaly axes, etc., as well as spatial analysis of gravitational and magnetic fields of the Terek-Caspian trough, the following conclusions can be drawn.

The separation of potential fields into regional and local components makes it possible to mark out structural elements of different sizes and power and to clarify the boundaries and forms of perturbing geological bodies.

The main anomalous structure of the latitudinal strike, which controls the main structural-tectonic element of the region's structure, is clearly recorded in the trend components of the gravitational and magnetic fields. The results of axes tracing concerning the anomalies of the magnetic and gravitational fields clearly record the position of the anomaly that controls the main zone of tectonic dislocations.

Sublatitudinal chains of linear anomalies of the gravitational field of the first-order local component appear in the central part of the TCT and correspond to the Terskaya and Sunzhenskaya anticlinal zones. Local second-order components reflect the distribution of anomaly-developing objects in the upper part of the section.

The spatial position of the fault structures was specified according to a number of features (linear anomalies of horizontal gradients, zones of abrupt changes in the orientation of local anomalies and the morphology of anomalous fields, etc.).

Numerous star-shaped structures stand out in the anomalous geophysical fields of the TCT. Those structures can be interpreted as intersections of tectonic dislocations of different strike.

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