Anatolian plate active faults character using potential fields data

Natalia Senchina1* and Emilia Ismagilova1

1 Geological Exploration Faculty, St. Petersburg Mining University of Empress Catherine II, 199106, 21st line, 2, St. Petersburg, 199106, Russian Federation

Abstract. The paper investigates the features of the manifestation in potential fields methods (gravity and magnetic exploration) of faults in the territory of modern Turkey and their relationship with earthquakes. The relevance of the work is determined by the significance of studying active faults as seismogenerating structures that directly affect the degree of seismic hazard of the territory of Turkey. The purpose of the work: based on geophysical and geodynamic data, to study the active faults of modern Turkey and adjacent territories, trace them to a depth and compare them with the foci of earthquakes that occurred in Turkey, including in February 2023. The study used original methods of data interpretation potential fields methods: complex analysis of maps of gravimetric and magnetic fields, tracing of lineaments, construction of transformation maps, solving the inverse problem using "tomography of potential fields" technology. For the entire selected territory, the inverse problem was solved for gravity and magnetic exploration data using the "tomography of potential fields" technique. A great potential has been identified in the data of gravity and magnetic exploration for the assessment of inhomogeneities in the structure of the Earth’s crust.

1 Introduction

Potential fields are called gravitational and magnetic fields, which characterize such properties of rocks as density and magnetic susceptibility (as well as magnetization, including remanent magnetization). Potential fields can be used as an auxiliary tool for fault mapping in low-studied regions with and weak manifestation of modern tectonics. The Anatolian plate is characterized by a well-study of active faults and high seismicity, which makes it possible to verify the deep elements of tectonics, visible in the ambiguous results of potential fields inversion and to confirm established fault dip.

The events in February 2023 forced to pay special attention to the region located on the Anatolian Plate, in this regard, we can highlight the problem of the urgent need to identify patterns of occurrence of earthquake focus.

* Corresponding author: n_senchina@inbox.ru

© The Authors, published by EDP Sciences. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/).
The Turkey region was chosen for the study because the Anatolian Plate, on which Turkey is located, is located on the border of the Eurasian and African plates, where many seismic events and faults occur (Fig. 1), one of the latest examples is the earthquake in February 2023.

Fig.1. Topographic map of Turkey, adjacent waters and territories, with active faults and earthquake epicenters (since 1900)

The Anatolian plate has a modern (Alpine orogeny) geodynamic activity: it is located at the junction of other plates, which makes it a geologically active zone. This is manifested in the presence of active faults and earthquakes. Intensive folding and uplift of this mountain belt were accompanied by strong volcanic activity, the introduction of magmatic intrusions, and the formation of faults. This process of the appearance of folded areas and faults is still ongoing, as the Turkish and Aegean plates, moving respectively to the west and southwest, continue to collide, and also, the Anatolian plate is moving counterclockwise relative to Eurasia. As a result, Turkey is the region most prone to earthquakes and volcanic eruptions [1, 2].

An active fault is considered to be a fault along which movement is possible, which can lead to seismic activity and natural disasters, such as earthquakes or tsunamis. Active faults are fundamental elements of tectonic systems and play an important role in the distribution of stresses and deformations in the Earth's crust. Based on this, there are several reasons for studying them: the study of geological processes for a general understanding of their origin and the creation of more accurate models, for more accurately earthquakes prediction using the connection of active faults with earthquakes.

Two regional faults are mapped within the study area:

1. The Northern Anatolian Fault is one of the most active and dangerous faults in the world. The fault extends for 1500 km and pierces the entire Anatolian plate from the western to the eastern border. The strongest earthquakes in the history of Turkey took place on its sites. The fault has been active for the last 10 million years and continues to develop to this day. The fault belongs to the type of right-sided shift [3, 5], which means that the two sides of the fault are horizontally displaced relative to each other. This movement causes strong earthquakes along the entire fault, which can have a magnitude of 6 to 7.
2. The East Anatolian Fault is another significant geological fault on the Anatolian Plate. The fault extends for 1300 km from the border with Georgia in the northeast to the Mediterranean Sea in the southwest. The fault belongs to the type of faults with a left-sides lateral shift [4]. The fault is currently active, and its movement causes earthquakes and seismic activity on the territory of Turkey. On February 6, 2023, a devastating earthquake of magnitude 7.8 occurred in the southeast of Turkey, followed by a number of aftershocks of several thousand. The hypocenter of the earthquake lies on the Eastern Anatolian Fault.

The emphasis in the work is on the eastern Anatolian fault.

2 Methods

Methods of studying the deep tectonic structure include the use of potential fields – gravitational and magnetic. Anomalies of these fields are associated with the distribution of mass (density of rocks) and magnetic properties inside the Earth and can be used to map structures and boundaries of various geological formations [7]. Geophysical data can help identify structures associated with faults and determine their size and depth [8, 9]. This can be especially useful in cases where faults are located in the deepest part of the crust and cannot be directly observed. In addition, potential fields can be used to evaluate the deformation mechanisms that can lead to earthquakes.

Fig. 2. Maps of the anomalous magnetic field and the vertical derivative of the gravitational field in the Bouguer reduction with tectonic elements and profiles
the vertical derivative of the gravitational field is demonstrated, since it better reflects the structures associated with the elements of tectonics than the map of the original gravitational field. It can be seen that large fault systems manifest themselves in the data of potential fields in the form of systems of sublinear anomalies or zones of change in the fields character.

Positive anomalies in the magnetic exploration data (blue color) are usually manifested in the distribution areas of rocks with increased magnetic properties, which include ultrabasic and basal rocks. Positive anomalies in the gravity survey data (brown) are manifested on a regional scale in the zones of thinning of the Earth's crust. So it can be seen that the territory of Turkey as a whole is characterized by negative anomalies, since the thickness of the earth's crust here is greater than in the adjacent areas. Anomalies of the medium-scale gravitational field are associated with material complexes of the upper part of the crust of different composition.

3 Results

For the entire territory of the plate, the inverse problem was solved for the data of gravity and magnetic exploration using the technique of "potential fields tomography" (author - M.B. Shtokalenko). An example of sections along profile 1–3 is shown in Fig. 3 with earthquake hypocenters applied. The epicenters are clearly grouped in conjunction with linear structures visible in sections of gravitational and magnetic fields.

Fig. 3: Graphs and sections along profile 1 (from top to bottom – a relief graph, a graph of the model and observed gravitational field, a section of the effective density, a graph of the model and observed magnetic field, a section of the effective magnetization and main proposed faults on section)
Fig. 4. Graphs and sections along profile 2 (from top to bottom – a relief graph, a graph of the model and observed gravitational field, a section of the effective density, a graph of the model and observed magnetic field, a section of the effective magnetization and main proposed faults on section)

Fig. 5. Graphs and sections along profile 3 (from top to bottom – a relief graph, a graph of the model and observed gravitational field, a section of the effective density, a graph of the model and observed magnetic field, a section of the effective magnetization and main proposed faults on section)
4 Conclusions

As can be seen, there is a great potential in the data of gravity and magnetic exploration for assessing inhomogeneities in the structure of the Earth's crust: faults and plate boundaries are manifested in the data of potential fields, earthquakes are confined to linear zones displayed on sections obtained from the results of inversion. This can help in understanding the processes taking place inside the Earth, and in the future in the development of more accurate models of its structure and evolution.

Thus, studies of active faults using potential fields are an important tool for understanding geological processes occurring inside the Earth and their impact on the environment and human activity. In general, studies of active faults using potential fields have a wide range of applications in various fields and can help in improving our understanding of the processes occurring inside the Earth and their impact on our lives and the environment.

References


7. A. Asoskov, Gravitational and magnetic anomalies generated by strike-slip structures in the upper part of the Earth's crust, Vestnik of Geosciences, 2(338), 3-9 (2023), DOI: 10.19110/geov.2023.2.1


https://doi.org/10.1051/e3sconf/202340212006