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THE ENORMOUS EARTH'S CRUST TENSION AND HYDROCARBON PIPELINE EXPLORATION IN THE SOUTH CAUCASUS – EASTERN MEDITERRANEAN

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Summary. The latest catastrophic earthquakes in eastern Turkey require their geodynamic understanding. The two most decisive events (with magnitude (M) = 7.8 and 7.5) were observed with an interval of 9 hours on February 06, 2023, followed by a whole series of aftershocks (four with M ≥6, about twenty-five with M ≥5 and above, and more than two hundred with M ≥4). These tragic events led to about 50 thousand deaths and enormous property damage. The above values indicate the colossal tension created in the Earth's crust. Besides the conventional geodynamic parameters, such giant tension can be caused by the influence of the giant mantle quasi-ring counterclockwise rotating structure. The existence of this structure has been detected by 11 independent geological-geophysical factors (residual satellite gravity, GPS, paleomagnetic data, geoid isolines, seismic tomography, paleobiogeographical data, coincidence of the center of the structure with the critical latitude of the Earth, a series of tectonic-structural data, etc.). The position of the western part of the Baku-Tbilisi-Ceyhan pipeline is shown on the Easternmost Mediterranean map of the satellite-derived gravity gradient field accompanied with the essential tectonic parameters. The map of the above and other pipelines of Azerbaijan is combined with the projection of the deep rotating structure on the Earth's surface. The impact of this rotation effect should be considered when laying and operating regional underground oil and gas pipelines.

Introduction

The region where these strongest earthquakes occurred is located in a tectonically very complex junction zone of four tectonic plates: Eurasian, Arabian, African and Anatolian (e.g., Tatar et al., 2004; Kadirov et al., 2012; Faccenna et al., 2014; Uzel et al., 2015; Eppelbaum et al., 2018). The joint movement of these plates (consisting, in turn, of tectonic elements of different ages) occurs at an average rate of 6-15 mm per year (e.g., Rellinger et al., 2006). However, after two marked powerful shocks on 06.02.2023, the Anatolian plate shifted to the southwest by more than 3 meters at once. Many buildings and engineering constructions were destroyed.

Applied Methods

It was found that the most crucial element of the zone of the junction of the Eurasian and Gondwana platforms is the zone of collision of the Mesozoic terrane belt (MTB) (composed of massifs of thinned

continental and oceanic crust) (Eppelbaum and Katz, 2015) and the Alpine-Himalayan orogenic belt (formed of a highly variegated complex of blocks of continental bark and numerous ophiolites). The most complex section of this junction zone corresponds to the distal protrusion of the MTB, which intrudes into the Alpine-Himalayan belt in the eastern area of wedging out of the tectonically most complex part of the Anatolian plate (Figures 1 and 2). Based on the positions of deep geophysics, two planetary geodynamic zones are developed in this junction zone: the sublatitudinal critical parallel of the Earth 35° (Veronnet, 1912) and the submeridional geoid anomaly belt, where the Ural-African step of the transition from positive to negative geoid anomalies is developed (Eppelbaum et al., 2018). Near the intersection of these two planetary zones, the distal protrusion of the MTB is located.

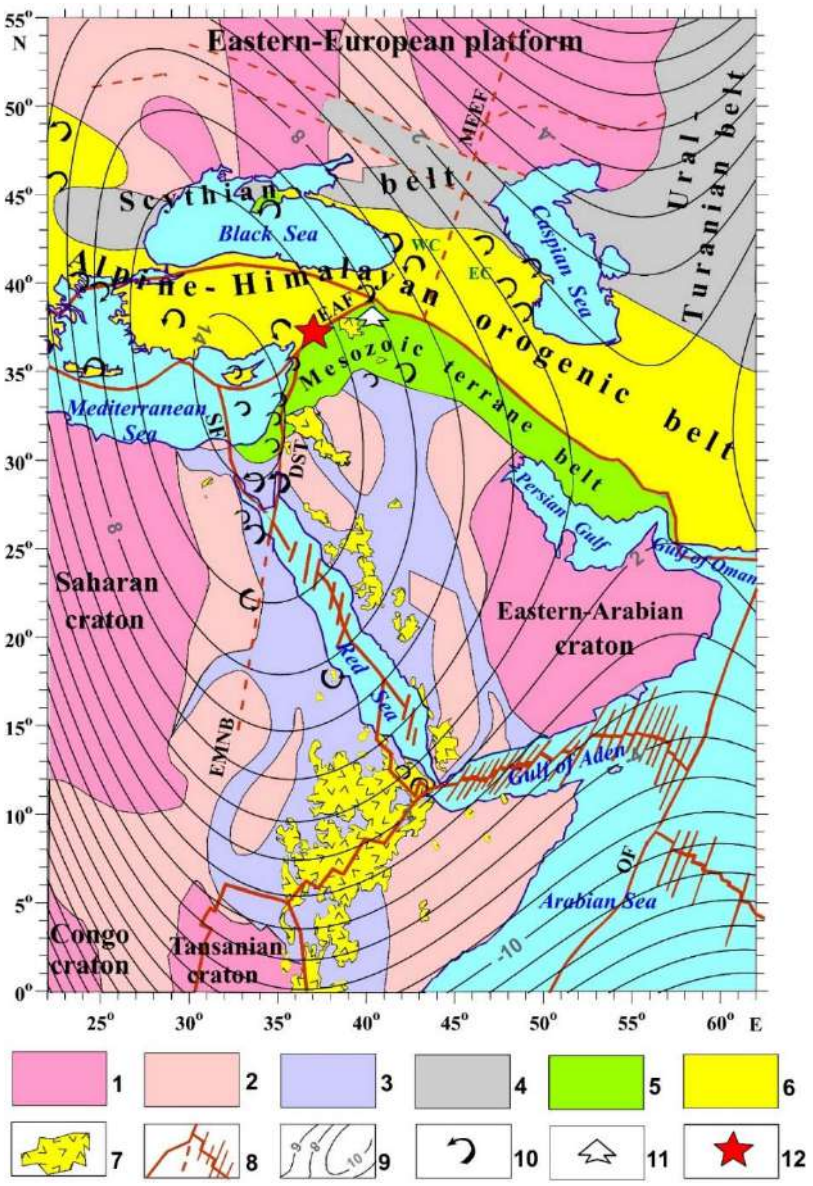

Fig. 1. Tectonic-geophysical scheme of the studied region overlaid on the gravity residual anomaly.
(1) Archean cratons, (2-4) folded belts: (2) Paleo-Middleproterozoic, (3) Neoproterozoic, (4) Late Paleozoic (Herzynian), (5) Mesozoic terrane belt, (6) Alpine-Himalayan orogenic belt, (7) Cenozoic traps of the African-Arabian rift belt, (8) main fault systems, (9) isolines of polynomial obtained regional gravity trend, (10) rotational geodynamic elements derived from paleomagnetic (major) and tectonic (minor) data (after Eppelbaum et al., 2021, with supplements), (11) distal part of the Mesozoic terrane belt, (12) high magnitude seismogenic zone in Eastern Turkey (February 06-07, 2023).
SF, Sinai Fault, DST, Dead Sea Transform, MEEF, Main Eastern European Fault, EMNB, Eastern Mediterranean Nubian Belt, OF, Owen Fault, WC, Western Caucasus, EC, Eastern Caucasus, EAF, Eastern Anatolian Fault

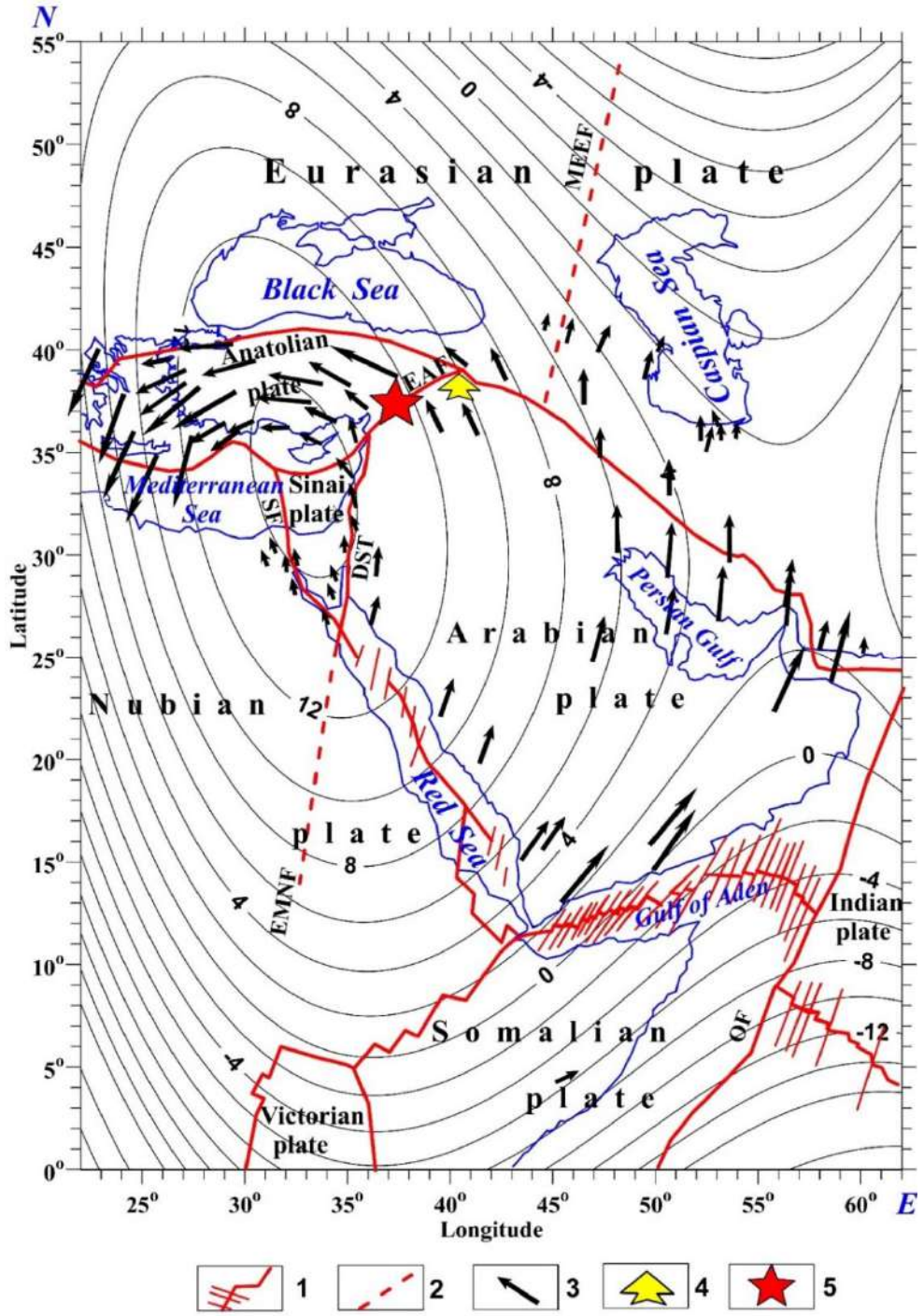

Fig. 2. Integrated scheme of geodynamic indicators distribution of the region under study (overlaid by the residual gravity anomalies) (after Eppelbaum, 2021, modified and supplemented).
(1) isolines of gravitational trend, (2) main interplate faults, (3) main intraplate faults, (4) vectors of the GPS monitoring (after Reilinger et al., 2006)

The structural analysis describes the most significant features of the Earth's crust's regional deformation with a sublatitudinal Alpine belt and a submeridional Neoproterozoic belt with an arcuate protrusion of the MTB in the zone of their junction. The combination of structural and paleomagnetic data shows (Figure 1) that deep diagonal faults are developed approximately in this zone, near which the rotation of tectonic blocks in the counterclockwise direction dominates in the west, and in the east, in the clockwise direction. The zone of catastrophic earthquakes under consideration is developed west of the arcuate ledge.

In the developed Easternmost Mediterranean satellite-derived gravity gradient map (with the main tectonic elements), the western part of the Baku – Tbilisi – Ceyhan pipeline was countered (Figure 3). It can be seen that the pipeline line passes near several tectonically active areas. At the same time, it is located to the west of the most dangerous area.

Geophysical-geodynamic mapping (Figures 1-2) using tectonic modeling, GPS data analysis (Reilinger et al., 2006), calculation of a residual satellite gravity anomaly (data were taken from the World Gravity DataBase as retracked from different missions, e.g., Sandwell and Smith (2009)) together with the analysis of numerous paleomagnetic (Figure 1), structural-tectonic, petrological, biogeographical and other data only recently made it possible to obtain a reliable explanation of the geodynamic features and history of the development of the region under consideration (Eppelbaum et al., 2020, 2021). A deep mantle structure was revealed, rotating in a counter-clockwise direction. This phenomenon significantly influenced all geodynamic regional processes in this most complex region of the development of spreading and collision processes in the tectonosphere. Figure 1 shows that the most active deformations and geodynamic processes up to the growth of mantle diapirs are developed in the apical part of the deep structure. The Sinai plate with intense seismic activity is also developed here. In the contact zone of the most active faults (Dead Sea Transform and Eastern Anatolian Fault), deep stresses are discharged in the distal part of the northward-moving Arabian lithospheric plate with the deviation of the focal zones of high-magnitude earthquakes to the south-west, in the direction of movement of the blocks counterclockwise (Figure 1). Therefore, the Anatolian plate was shifted in this direction towards the Mediterranean Sea.

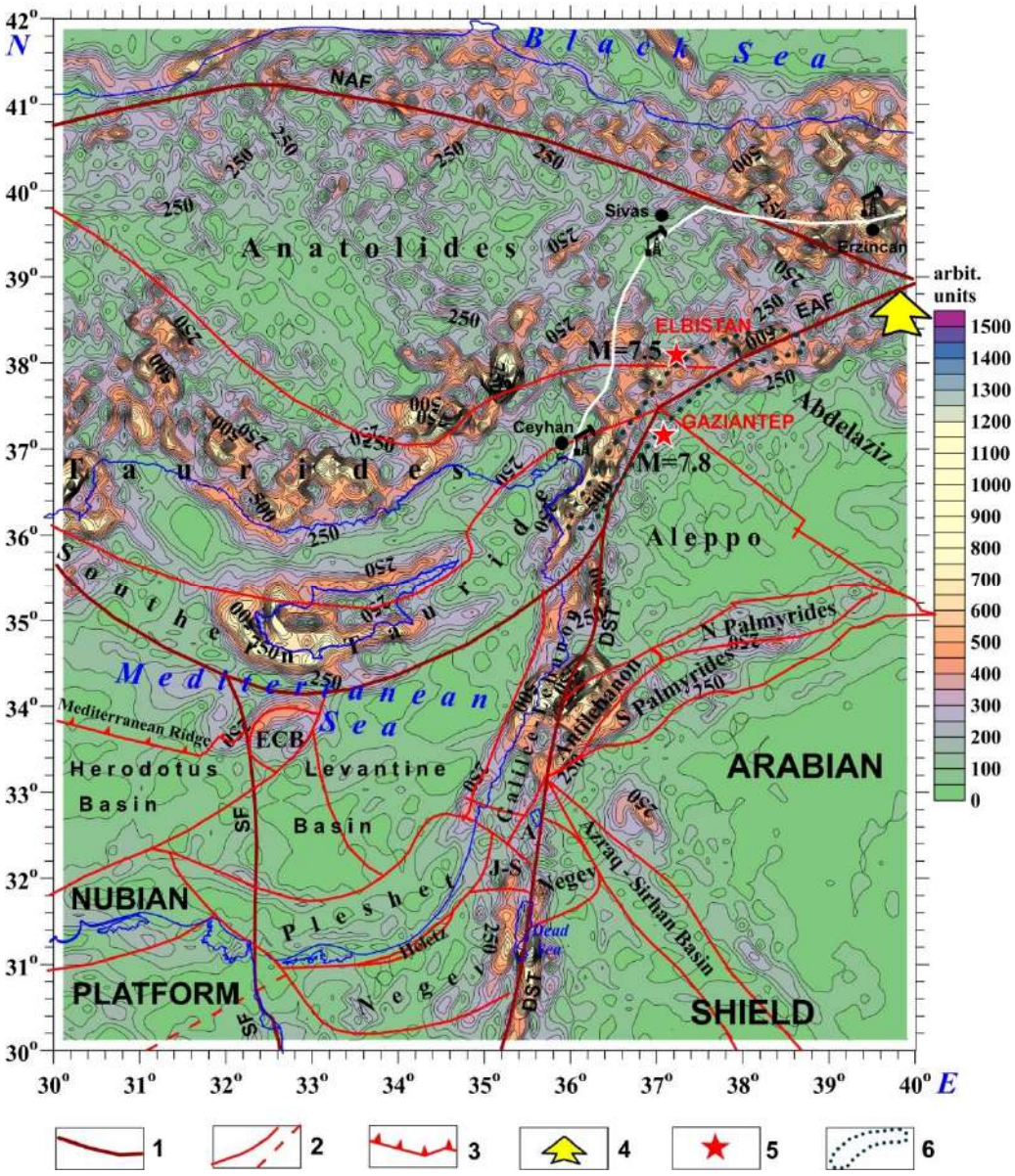

Fig. 3. Satellite-derived gravity gradient map with the main tectonic elements and seismological features in eastern Turkey (1) main fault systems, (2) interplate and intraplate faults, (3) Mediterranean Ridge, (4) distal part of the Mesozoic terrane belt, (5) epicenters of two main catastrophic earthquakes in eastern Turkey, (6) dangerous seismogenic zone (after Hancilar et al.,2023). ECB, Eratosthenes Continental Block, DST, Dead Sea Transform, SF, Sinai Fault, J-S, Judea-Samaria, A, Antilebanon, NAF, Northern Anatolian Fault, EAF, Eastern Anatolian Fault. The western part of the Baku – Tbilisi – Ceyhan pipeline is white-contoured

Figure 4 displays the position of four Azerbaijan pipelines: (1) Baku – Novorossisk, (2) Baku – Supsa, (3) Baku – Tbilisi – Ceyhan, and (4) South gas corridor. It can be observed that the pipeline Baku – Tbilisi – Ceyhan is under the most geodynamic danger. It is necessary to note that the significance of the geodynamic monitoring of hydrocarbon pipelines was underlined earlier in Alizadeh et al. (2017).

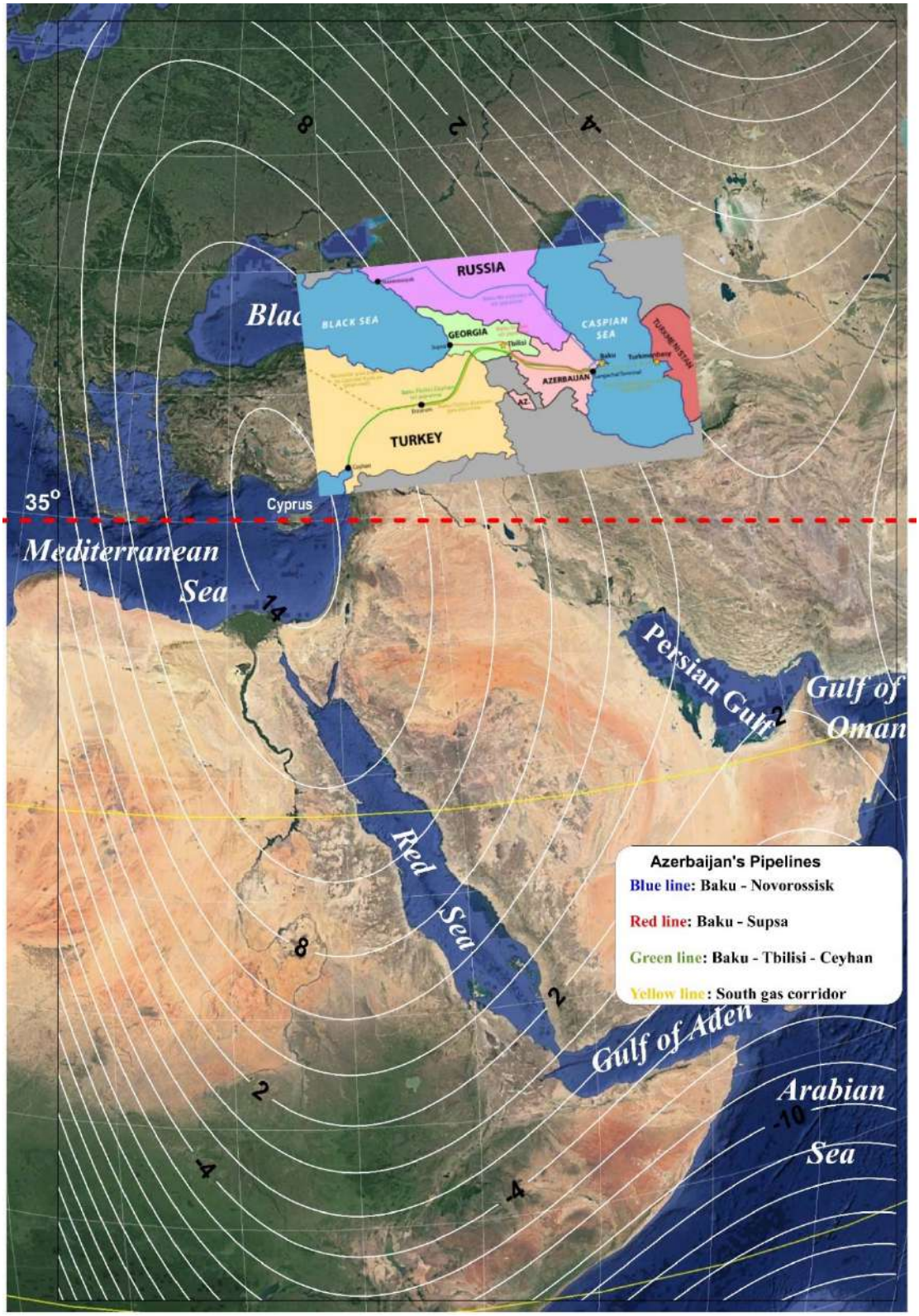

Fig. 4. Correlation between the projection of the deep mantle rotating structure (white lines, after Eppelbaum et al., 2020) and the pipelines of Azerbaijan (https://en.wikipedia.org/wiki/Pipelines_in_Azerbaijan). The background map is obtained from Google Earth

Results and discussion

Thus, the created map (Figure 1) explains the main features of catastrophic earthquakes in eastern Turkey and can serve as a basis for upcoming research in seismological engineering. The data (together with Figures 2-4) can be used for future regional underground pipeline development and monitoring.

Conclusions

The presented data unambiguously indicates the existence of a giant rotating structure that influences all four plates involved in the complex tectonic-geodynamic interaction. Considering this effect, the future projection and exploitation of the underground hydrocarbon pipelines should be realized under the control of multifactor tectonic-geodynamic analysis and engineering geodynamics.

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