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REFLECTION OF THE GEODYNAMIC REGIME OF THE SHAMAKHI-ISMAYILLI SEISMOGENIC ZONE IN LOCAL ANOMALIES OF THE GEOMAGNETIC FIELD

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Introduction

The Shamakhi-Ismayilli earthquake of February 5, 2019 (ml = 5.2, h = 8km, φ = 40.78, λ = 48.46) is confined to the well-known Shamakhi-Ismayilli seismically active zone, the pleistoseist region of which is located within the south-east segment of the Greater Caucasus.

The zone is characterized by a complex step-block structure, complicated by a series of steeply dipping transverse and longitudinal faults. These faults, characteristic of the pre-Alpine base, transform into sloping upthrusts and thrusts during the transition to the Meso-Cenozoic complex (Ahmedbeyli et al., 2010).

In this article, on the basis of daily monitoring of the full vector of the geomagnetic field intensity, an attempt has been made to isolate violations of the course of the lunar-solar Sq variations of the T intensity of the geomagnetic field, the nature of the manifestation of the seismomagnetic effect and the spatio-temporal changes in the T gradient of the geomagnetic field before the tangible Shamakhi-Ismayilli earthquake 05.02.2019 (ml=5.2).

Seismo-tectonic characteristics of the Shamakhi-Ismayilli zone

The seismotectonic feature of the Shamakhi-Ismayilli seismogenic zone lies in the confinement of the main number of earthquakes to the Adjichay-Alyat and Germain upthrust-overlap. The West Caspian and North Ajinour strike-slip fault also have a great influence on the seismicity of the zone. The Zangi-Kozluchay, Goychay, Vandam and Dashgil-Mudrese upthrust-overlap structures located to the west of the West-Caspian Fault, confined to the Shamakhi-Ismayilli seismogenic zone, exert a rather high seismic activity within the Shamakhi-Ismayilli seismogenic zone (Shikhalibeyli et al., 1978). Deep penetration of the roots of the Adjichay-Alyat and Germain faults to depths of 15-25 km, i.e. before the Alpine base, forms their thrust structure. As for the source mechanisms within the zones of influence of the Adjichay-Alyat and Germain thrusts, the nodal planes of which are oriented in the NNW or NNE strike, i.e., perpendicular to the strike of the faults themselves and having a fault or strike-slip fault character, this can be explained by active dynamic influence of the West-Caspian fault in its close proximity to the Shamakhi-Ismayilli zone (Sherman S.I. et al., 1991).

The sources of earthquakes in the Shamakhi-Ismayilli zone are associated, as was shown in (Metaxas et al., 2011), both with overlaps-upthrusts of the NW-SE direction, as well as with the strike-slip fault movements along the West Caspian fault.

It should be noted that faults in the Shamakhi-Ismayilli seismogenic zone (both longitudinal and transverse) are in the stage of high activity characteristic of the preparation cycle of strong seismic events. At the same time, according to the degree of activity, the West Caspian and Adjichay-Alyat to the east of it can be considered the most active faults, then the Vandam thrust and less active - Dashgil-Mudrese and Germain thrusts (Metaxas et al., 2011).

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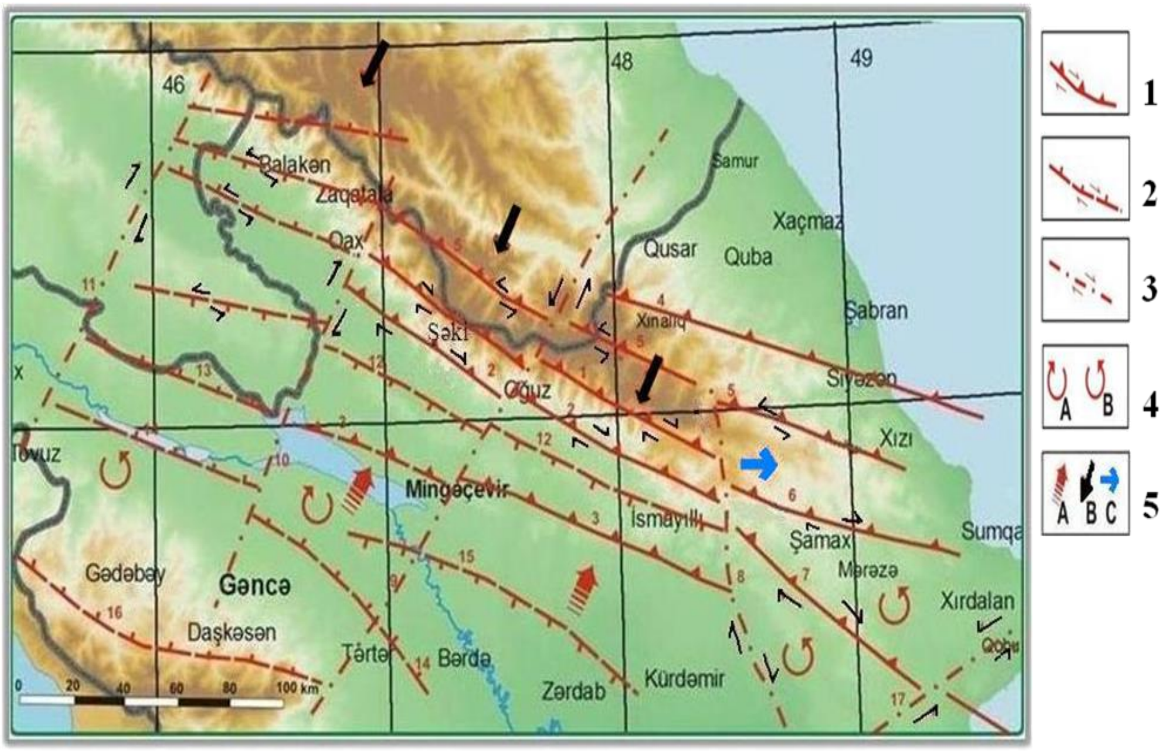

Figure 1. Scheme of the fault structure and features of the geodynamic regime of the southern slope and the southeast immersion of the Greater Caucasus

The main seismogenic faults that determine the features of the geodynamic regime of the Earth's crust: 1-upthrusts, 2-faults, 3-shifts (arrows indicate the direction of horizontal movements). Up thrusts: 1-Dashgil-Mudrese, 2-Vandam, 3-Geokchay, 4-Siyazan, 5-Zangi-Kozluchay, 6-Germain, 7-Adjichay-Alyat. Shifts: 8-West Caspian, 9-Arpa-Samur, 10-Ganjachay-Alazan, 11-Gazakh-Signakh. Faults: 12-North-Ajinour, 13-Ior, 14-Kura, 15-Mingachevir-Saatli, 16-Bashlybel, 17-Palmir-Absheron. Elements of geodynamics: 4- Torsion of blocks: A-clockwise, B-counterclockwise.5. Horizontal movements: A-under thrusts, B-thrust, C-shift.

Monitoring network of geomagnetic observations

The monitoring network of variations in the intensity of the geomagnetic field at the RSSC ANAS covers the zone of the south-eastern immersion of the Greater Caucasus, the middle and lower parts of the Kura depression, and the Near Talysh zone of the Lesser Caucasus (Fig.1). Actually, the Shamakhi-Ismayilli seismogenic zone is confined to the Sheki-Shamakhi geodynamic site.

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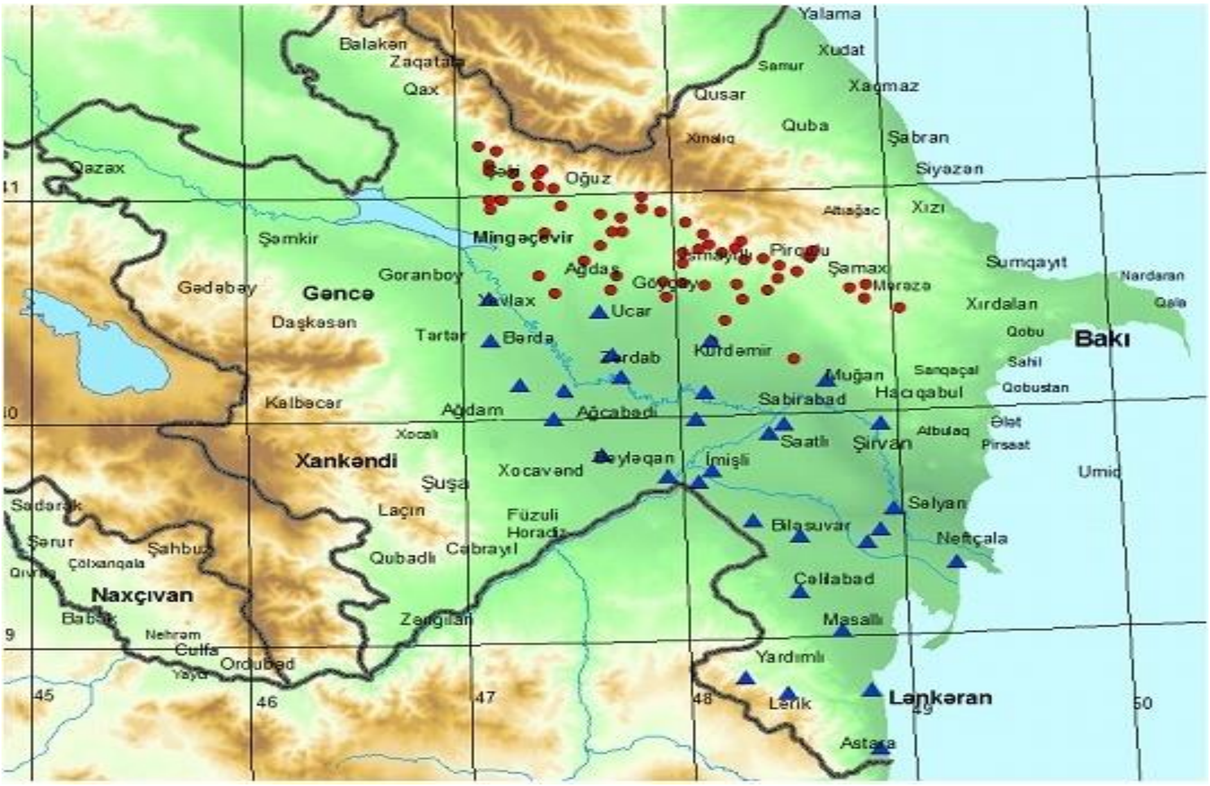

Magneto-variation stations

Magnetic points of repeated visits at the Sheki-Shamakhi prognostic site

Magnetic points of repeated visits on the Near-Talysh prognostic site

Figure 1. Map of location of magnetic variation stations and magnetic strong points of repeated visits at Sheki-Shamakhi and Near Talysh-Kura geodynamic sites.

In the framework of this work, magnetometric studies of the seismomagnetic effect (SME) and evaluation of the stress-deformed state of the earth's crust in seismogenic zones were carried out at the Sheki-Shamakhi geodynamic site in two directions:

1. Round-the-clock monitoring of variations in the total vector of the geomagnetic field strength T ~ f (t) (including daily solar Sq~f (t) variations).

2. Monitoring of spatio-temporal changes in the gradient of the geomagnetic field intensity on the area of the site (ΔT ~ f (t)).

The work was carried out on the basis of G-856 magnetic variation station (MVS) (Geometrics) in the amount of 8 MVS and 70 rigidly fixed points of repeated visits to the site area using the G-856 Geometrics hand-held proton magnetometer (Fig.1).

The discussion of the results

In order to establish the uniformity of the geomagnetic variations in the Shamakhi-Ismayilli zone, the daily solar diurnal Sq-variations due to the daily rotation of the Earth and almost motionless relative to the "Center of the Earth-Sun" line were analyzed. Most of the Sq-variations are due to external ionospheric factors and can be attributed to noise interference in the analysis of seismomagnetic effects in the magnetic layer of the earth's crust (Rasulov, 2007).

Figure 2 presents examples of time diagrams of Sq variations of Sq~f (t) at Ismailly, Pirgulu, Lankaran, Sheki, and Zagatala magneto variation stations.

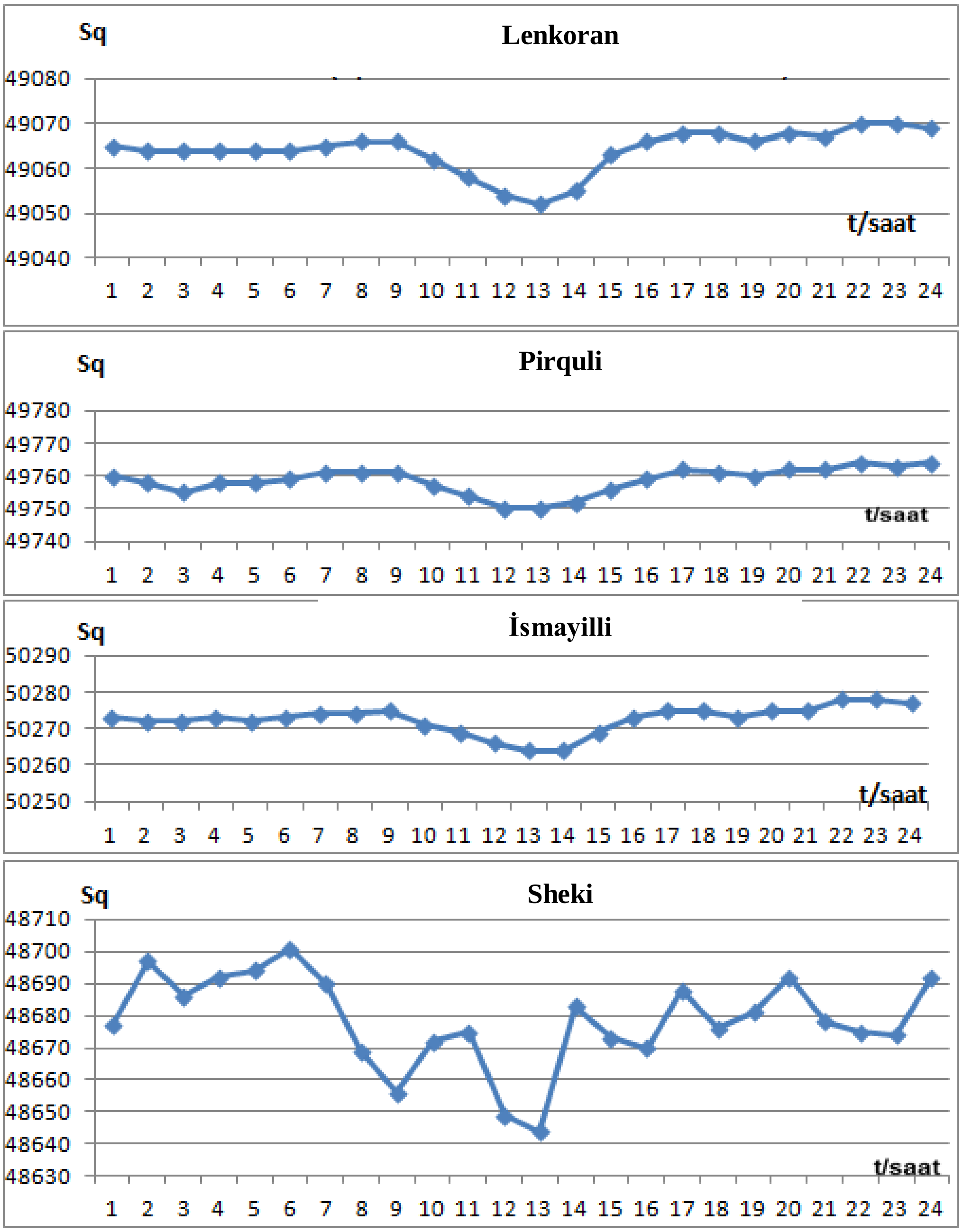

Figure 2. An example of the normal course of Sq variations in the Shamakhi-Ismayilli seismogenic zone and in the Near Talysh zone of the Lesser Caucasus

As can be seen from Fig.2, variations have a quasi-sinusoidal character with distinct local minima of tension in the period of 12-13 hours and long-period maxima of tension at night in the period from 22 hours to 08 hours of the morning.

The uniformity of the flow of Sq-variations over the entire observation area indicates the uniformity of the fall of the front of an external electromagnetic wave. Any visible disturbances in the ionosphere do not appear.

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A month before the earthquake of February 5 2019 (ml=5.2, h=8), there is a violation in the uniformity of the flow of solar-diurnal Sq-variations (Fig.3).

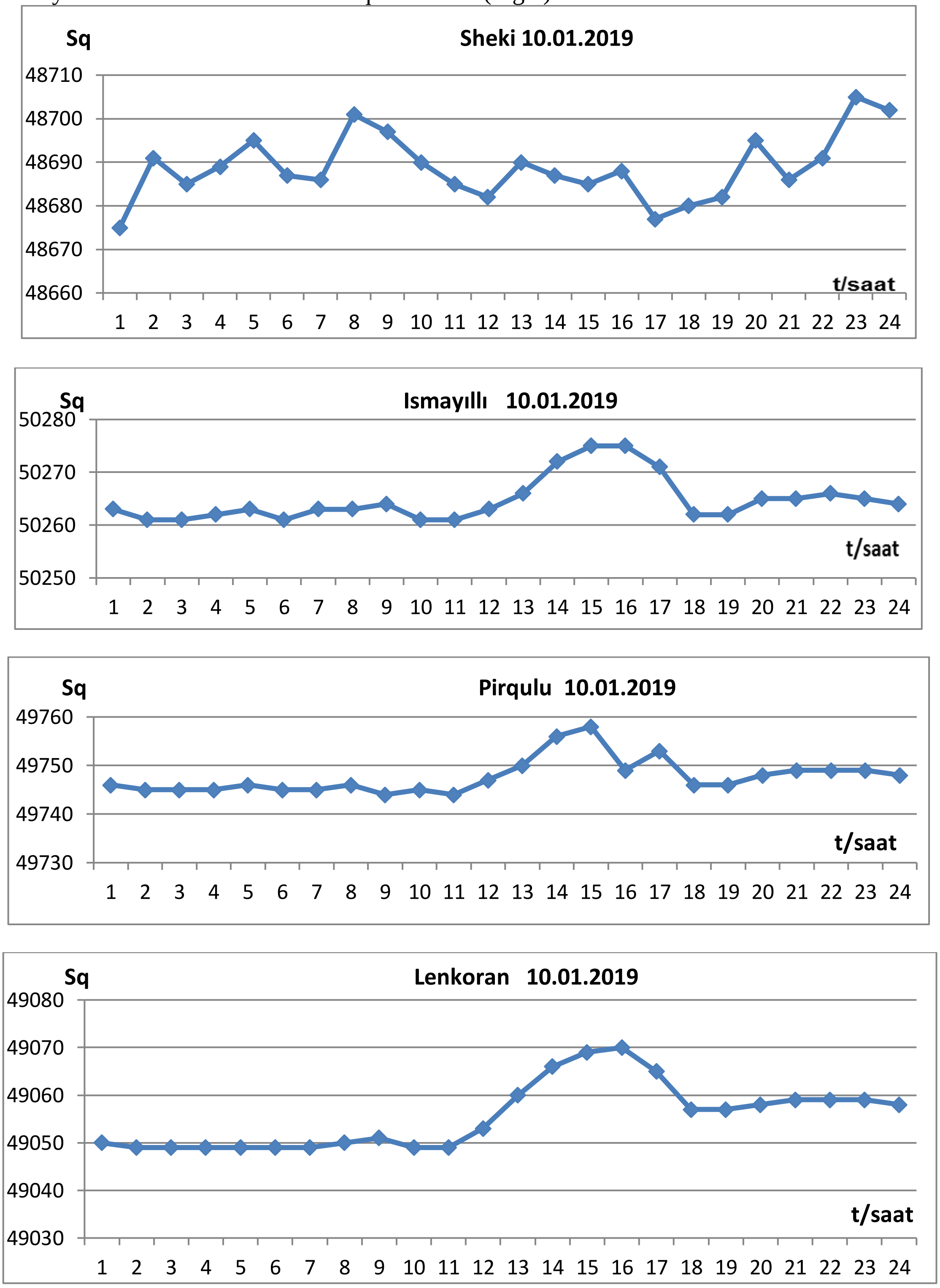

Figure 3. Disruption of the normal course of Sq - variations before the earthquake of February 5, 2019 (ml=5.2)

Taking into account the fact that Sq-variations are mainly caused by external causes, it can be noted that at the final stage of preparing the Shamakhi-Ismayilli earthquake source, there was an active emanation of electro-magnetic energy from the source to the atmosphere, which caused the ionospheric disturbance in the focal zone and, as a result, disturbances in the normal course of the external component of the Sq-variations.

In Fig.4 the time series of the ΔT ~ f (t) intensity values of the geomagnetic field normalized to synchronous field measurements at the Sheki base station is presented. The values of ΔT ~ f (t) are filtered from the influence of the ionospheric factor and are mainly determined by the geodynamic (seismotectonic) process in the earth's crust and the transformation of the residual magnetization of rocks in the earth's crust under their influence.

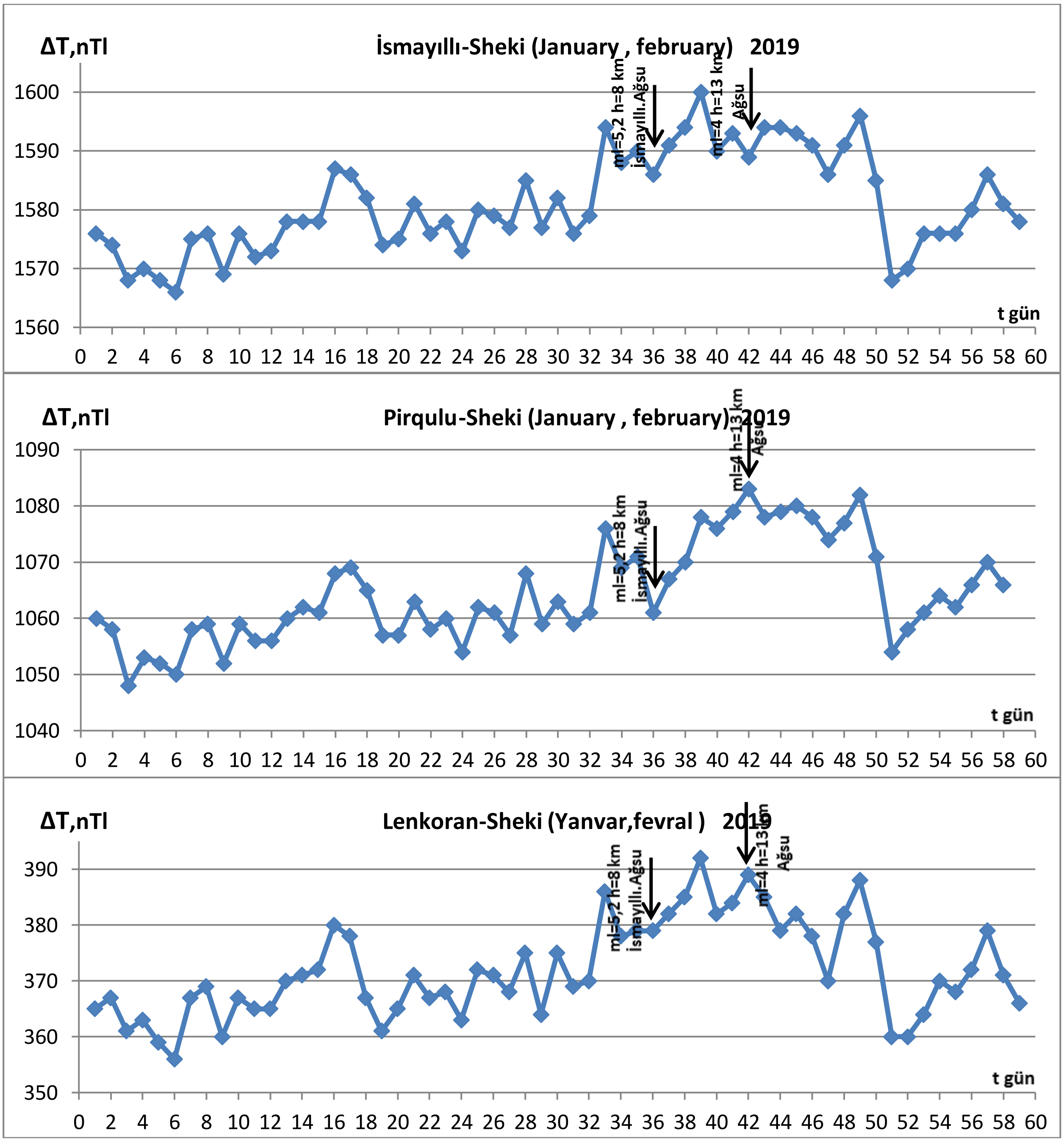

Figure 4. Magneto-variational curves of the increment of the geomagnetic field strength ΔT ~ f (t)

The seismic anomalous effect is clearly traced on the graphs, anticipating the main impetus of February 5, 2019. The amplitude of the precursor anomaly is about 20 nT. There is a positive increment in the intensity gradient of the geomagnetic field indicating the predominance of compressive stresses in the focus. Taking into account the location of the earthquake source in the geodynamic influence zone of the West Caspian right-sided shift fault and the Adjichay-Alyat right-sided up thrust fault, and also taking into account the nature of the increment of the geomagnetic field intensity gradient, it is possible to assert the formation of compressive elastic stresses in the source zone to the direction of the main geomagnetic field (N-NE) and shift right-sided stresses along the seismogenic fault line.

The formation of a long-period seismomagnetic maximum under the action of compression deformations observed after the main shock indicates that excessive stresses remain until the end of the implementation of the aftershock activity in the source zone, after which the background level of the geomagnetic field tension relaxes.

Analyzing the space-time changes in the geomagnetic field intensity gradient $\Delta T \sim f(t)$, we can come to the following conclusion. The accumulation of compression deformations occurred north-west of Shamakhi city, near the border of the Ismayilli region in the junction zone of the Adjichay-Alyat and West-Caspian faults. This is indicated by the maximum gradient of the intensity of the geomagnetic field in the vicinity of the city of Ismayilli (Fig.5).

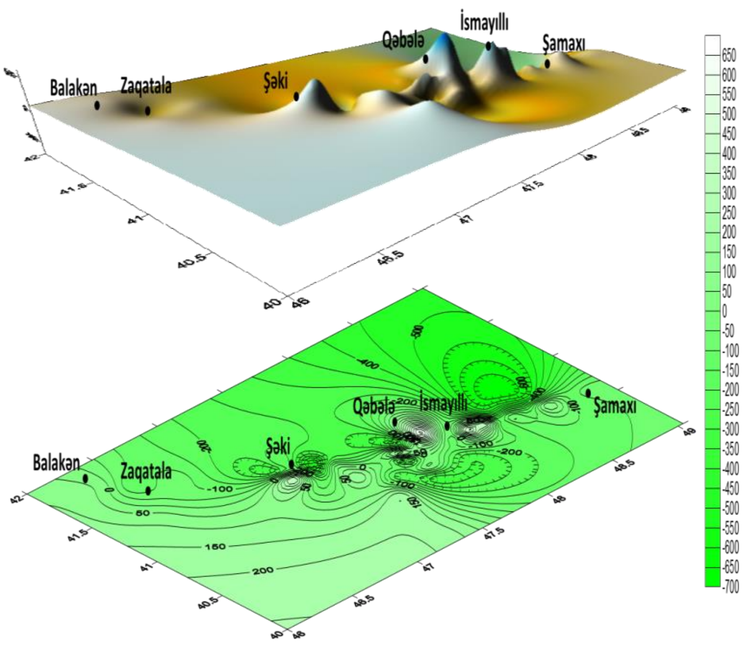

Figure 5. Stress-strain state of the geological environment during the preparation of the Shamakhi-Ismayilli earthquake of 05.02.2019 in 2D and 3D formats

In February 2019, after the Shamakhi-Ismayilli earthquake, elastic stresses near the town of Shamakhi (to the right of the West Caspian fault) are compensated (disappear). In this case, the compression deformation (the maximum of the intensity gradient ΔT) is redistributed to the zone of the Vandam offshore fault to the west of the West-Caspian fault-shift.

At the same time, no visible geodynamic activity is observed to the east of the West-Caspian fault in the vicinity of Shamakhi city (Fig.6).

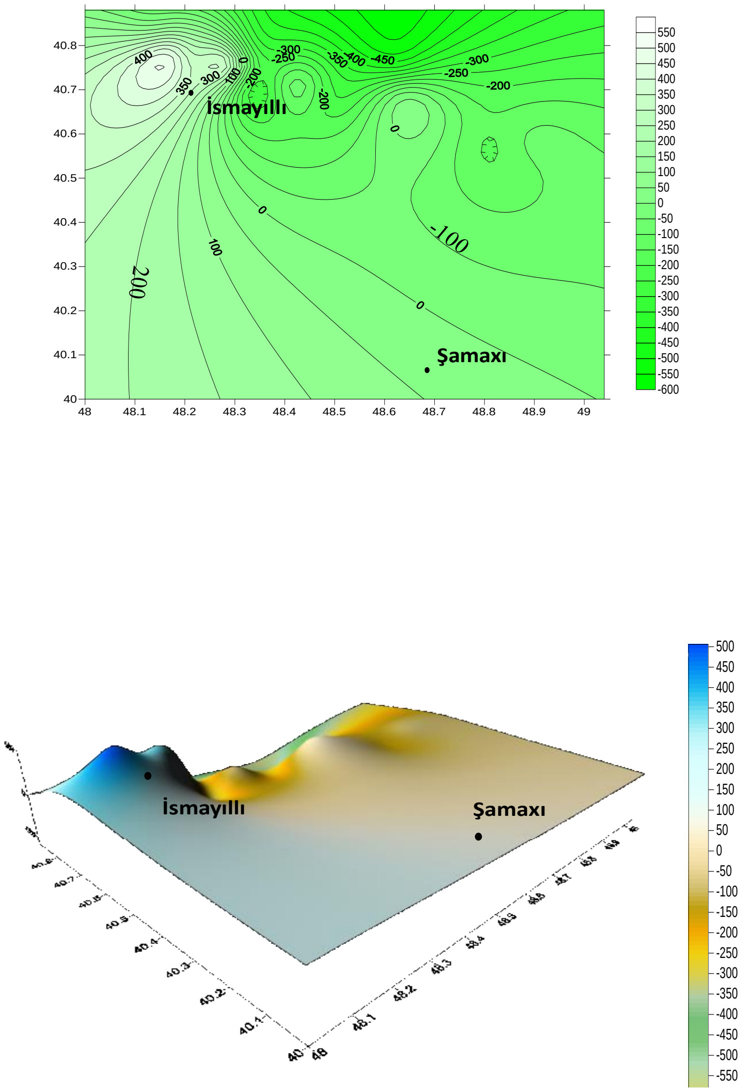

Figure 6. The stress-strain state of the geological environment of the Shamakhi-Ismayilli seismogenic zone in 2D and 3D formats (February 2019)

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This effect, namely the increased compression deformation in the Vandam Fault zone, is likely due to the intensification of translational movement of under thrust blocks of the Kura depression between the Arpa-Samur and Western Caspian faults under the upthrow-thrust structures of the south-eastern immersion of the Greater Caucasus, as was earlier stated in the work (5).

Conclusion

Based on the analysis of temporal and spatial-temporal features of the distribution of the full vector of the geomagnetic field strength in the Shamakhi-Ismayilli seismogenic zone, it was possible to simulate the features of the redistribution of stress deformations due to the geodynamic features of the crustal blocks and active faults developed both along the periphery and inside the Shamakhi-Ismailli seismogenic zone.

A picture of the connection of local geomagnetic anomalies with the stress-deformed state of the earth's crust in the Shamakhi-Ismayilli seismogenic zone is presented, namely, the geodynamic influence of the West-Caspian and Adjichay-Alyat faults on the formation mechanism of the Shamakhi-Ismayilli earthquake of February 5, 2019 (ml=5,2); the reflection of this influence in the features of local anomalies of the gradient of the increment of the intensity of the geomagnetic field.

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