FEATURES OF GEOMAGNETIC EFFECTS OF SEISMOGEODYNAMIC CHANGES IN THE TERRITORY OF AZERBAIJAN

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Before the strong earthquakes in seismically active regions of the world, it has been identified that the geomagnetic field of the Earth's crust is changed abnormally and anomalous seismomagnetic effect of the geomagnetic field has been observed before Machusiro (1965-1967), Akita (1970), Zangazur (1968) earthquakes. The seismomagnetic effect has been observed before the earthquakes in the territory of Azerbaijan [1].

The formation of the geomagnetic field and the observed changes are mainly related to the physical and mechanical processes occurring in the layers of the magnetic flux formed in the Sun and the Earth: magnetosphere, ionosphere, atmosphere, tectonosphere. Many researchers believe that the seismicity caused by geodynamic stress is directly related to geomagnetic changes [2, 5, 6, 8, 9].

Observations show that electromagnetic and geomagnetic fields have been observed as anomalous seismomagnetic effects before the earthquake as one of the warning factors of the earthquake [2, 6, 10, 11, 12, 15].

So far, the regularity of the seismomagnetic effect and other warning factors, such as short-term, instantaneous forecast, has not been confirmed. Early warning of an earthquake is estimated: 1-long-term; 2-medium-term and 3-short-term. The long-term warning factor, based on geological studies, given the tectonic structure and seismicity of the area, suggests that there will be a strong earthquake during 10-100 years. Medium-term warning factor, based on data obtained by seismological, geophysical and geodetic devices, estimates that there will be a strong earthquake in 1-10 years on the basis of anomalous physical and mechanical changes observed over time. The short-term warning factor should be based on very accurate information. The coordinates of the earthquake source, the magnitude of the earthquake and the time range from several hours to a week should be prognosed. False prognoses have a devastating effect on people's psychological state and it causes economic damage.

As one of the warning factors, the signs of abnormal electromagnetic variation are considered more convincing than other predictive factors, and regular magnetometric regime observations are carried out in many seismically active regions of the world [7, 11, 13, 14].

Changes in the magnetic field over time have been studied in Azerbaijan since the 1980's. It is the detection of anomalous changes in the magnetic field - the seismomagnetic effect - under the influence of geodynamic energy accumulated in the epicenters of geodynamic processes, tectonic faults [2, 3, 5, 6, 7]. At present, magnetometric measurements are carried out by the magnetometry department of the Republican Seismic Survey Center of ANAS at the 6 permanent points and at Sheki-Shamakhi, Near Kura-Talysh prognostic sites once a month (Fig. 1).

During the studies, the variability of the geomagnetic field, the changing characteristics of the seismomagnetic effect are studied under the influence of earthquakes with magnitude of M ≥4. By analyzing the obtained data, the regularity of changes in the geomagnetic field due to earthquakes in geodynamic-stress zones is analyzed.

The purpose of the work is to monitor changes in the magnetic properties of rocks in the geological environment associated with the processes occurring in earthquake sources with modern devices and to analyze the variations of the magnetic field, to detect the seismoanomal effect and to determine the criteria for it.

Abnormal magnetic field changes caused by internal physical and mechanical processes and geodynamic stresses accumulated at the epicenter are studied as warning factors of earthquakes in time and space [3, 11]. Characteristic magnetic field changes are observed mainly before strong earthquakes. The researches have been carried out with proton-type magnetometers G-856,

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manufactured by the US Company Kinemetrics. The recording of the voltage T, which is the full vector of the magnetic field, is registered continuously (24 hours).

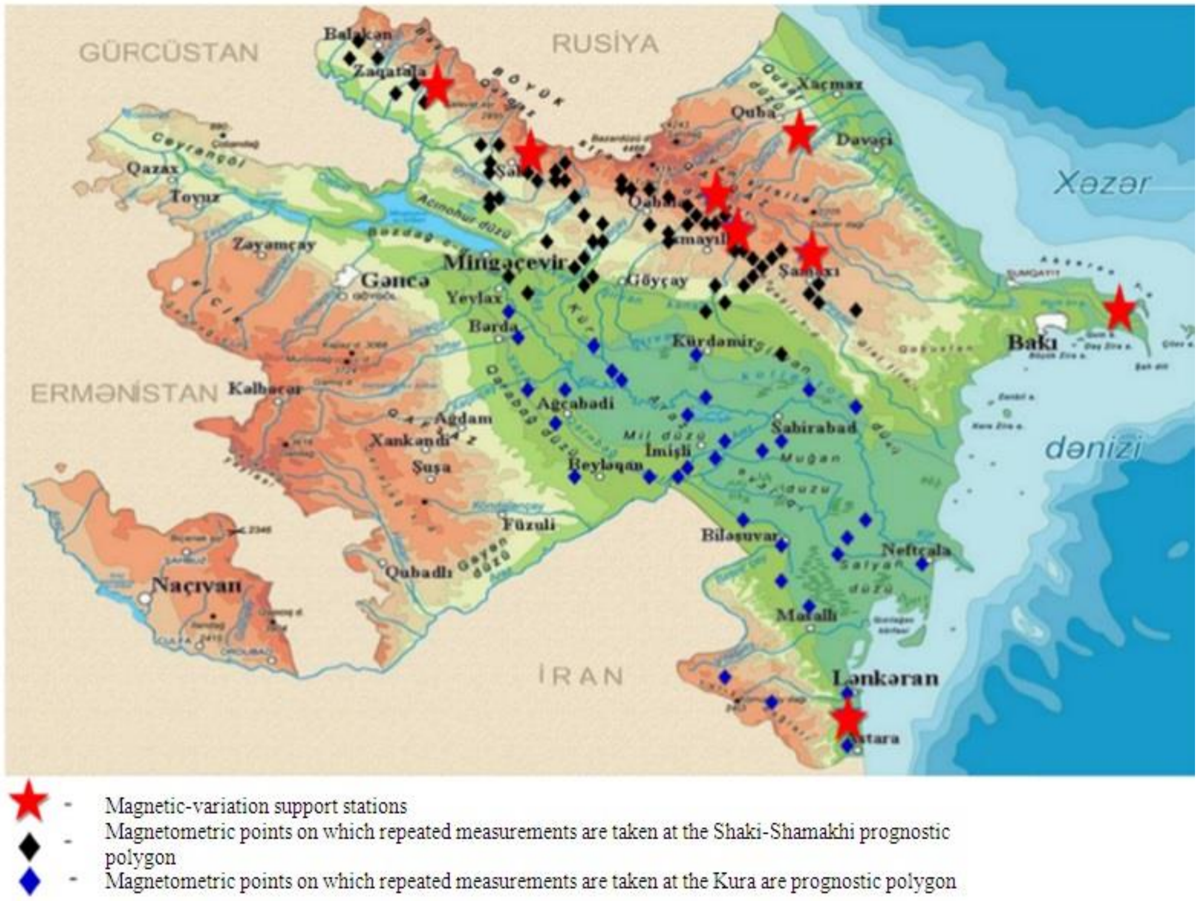


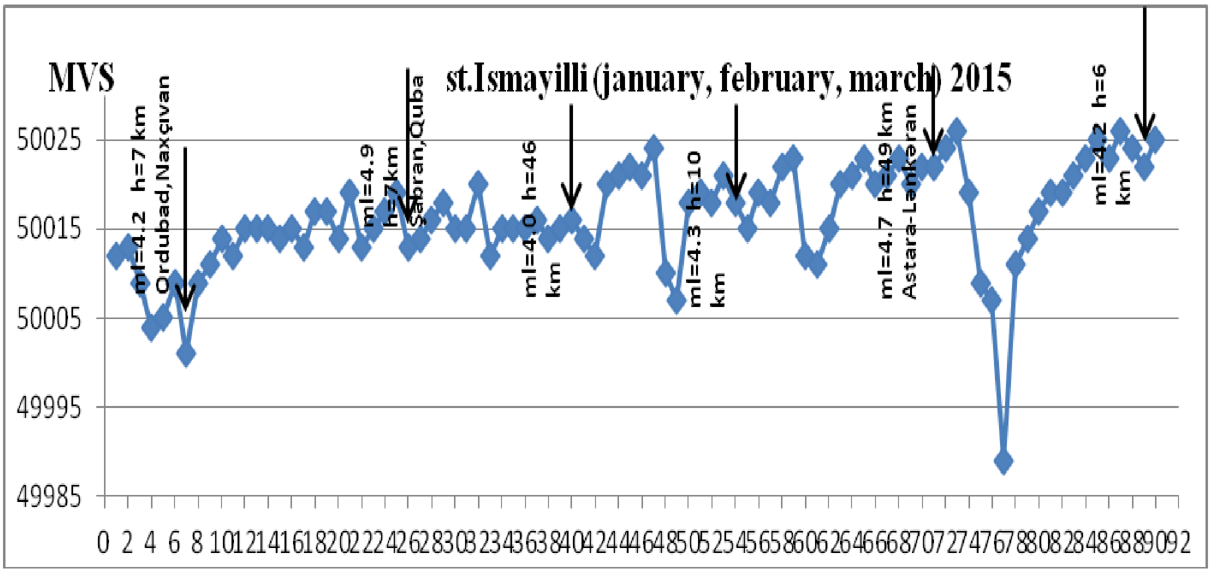
Figure 1. Scheme of magnetometric observation points where RSSC conducted studies in the territory of Azerbaijan

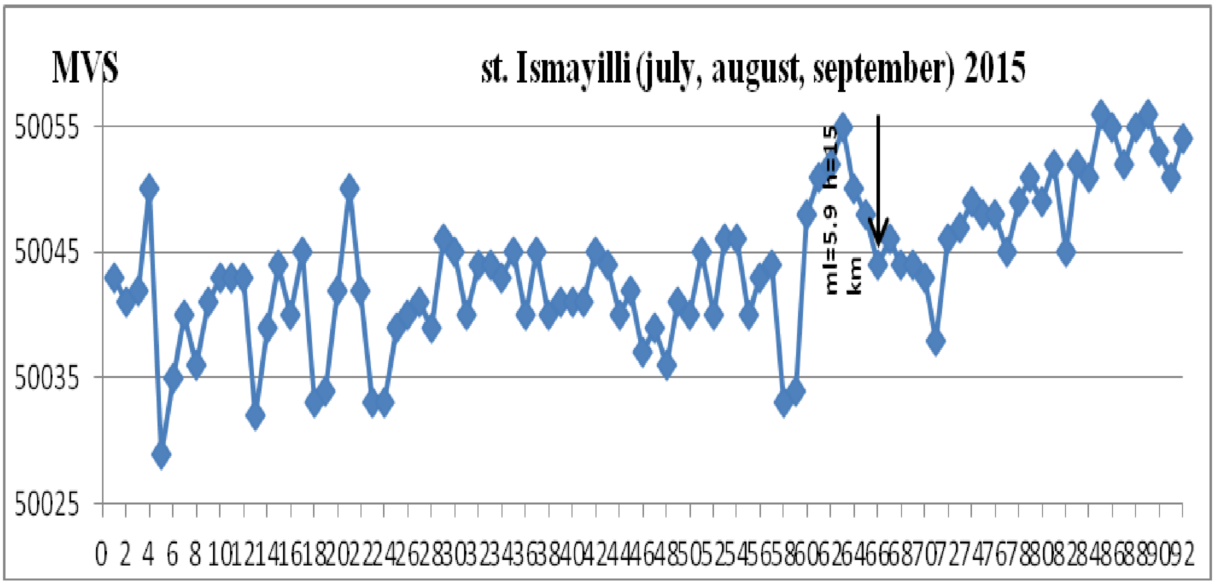
The experience of previous work and comparative analysis of data obtained at landfills in China, Uzbekistan, Russia, Kyrgyzstan and Tajikistan and other regions of the world, provide a basis for the prospects of magnetometric observation method as one of the warning factors of earthquakes. This method is used to study the anomalous seismomagnetic effect of the T-vector module by observing it simultaneously, both at the base station and at the measuring point. The essence of the method of comparative analysis is that the $\Delta T \sim f$ (t) dependency graphs are created on the geomagnetic field stress T observed synchronously. The ΔT obtained based on synchronous observations between the two points is recorded as an increase in the useful signal and stress field. Then the graphs of the series $\Delta T \sim f$ (t) are created during the year and the nature of the variations ΔT, the detection of the seismomagnetic effect and its regular variability are evaluated. During the study, seismic effects were selected at the measurement point and the effect formed by these earthquakes of the magnetic field variations has been studied [2, 6, 7].

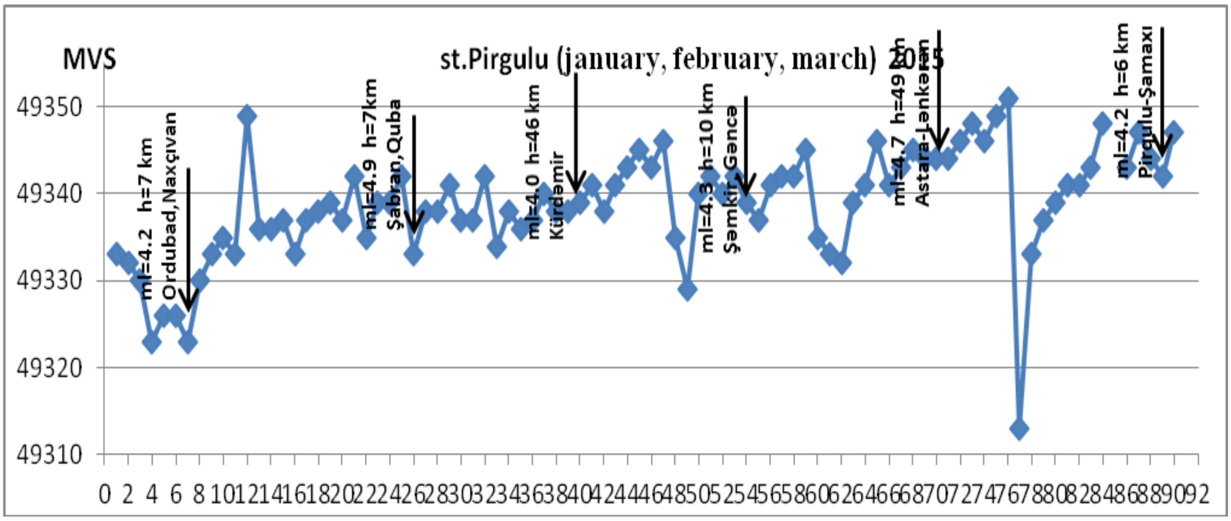
During the occurrence of earthquakes, the distribution area of the seismic magnetic effect has been calculated by the formula $R=10^{0.5M-1.27}$ km. The statistical quantity is $\rho=0.87$ in this area. This shows the cause-and-effect relationship between the seismomagnetic effect and earthquakes, and the relationship of seismomagnetic effects to the seismotectonic condition. It is accepted that the changes on T stress before earthquakes with magnitude of $M\geq 4$ are manifested in graphs, often in the form of bay-shaped. Such anomalous changes can be positive or negative, depending on the mechanism of the earthquake (compression, tension) [2, 4, 5, 7].

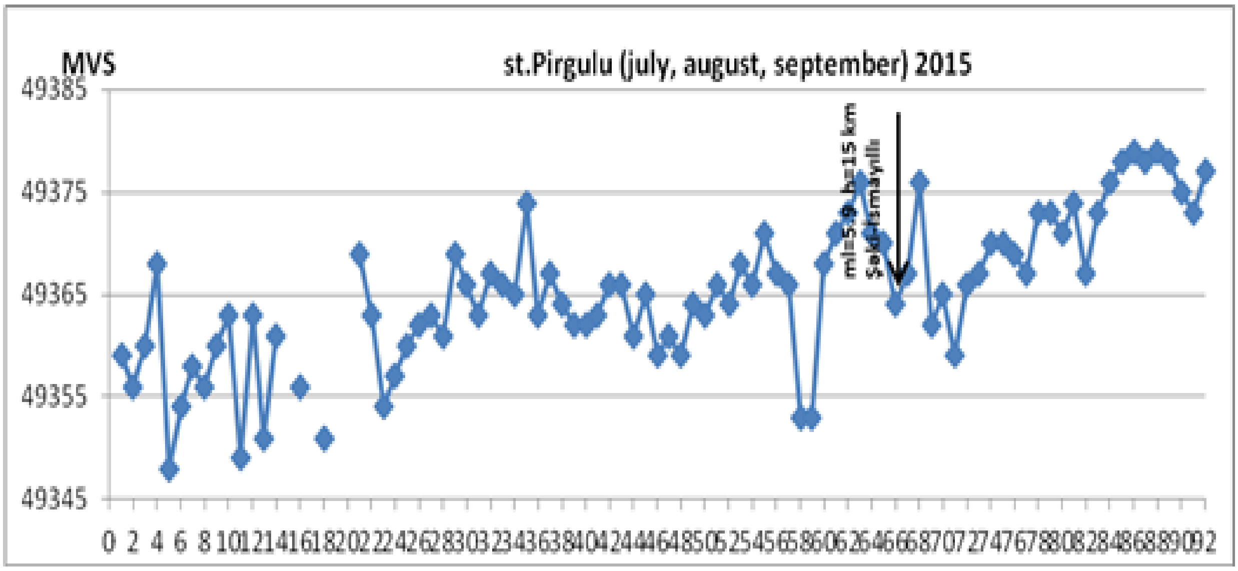
A comparative analysis method was performed to overcome ionospheric “barrier” factors and electromagnetic induction from observed T voltage field variations. As a result, $\Delta T(t) = Tm(t) - T_o(t)$, where Tm (t) -t at all stations and T_o (t) -t at the base station is taken as the value of the observed field stress [4, 6, 7]. Stationary geomagnetic observations have been carried out at Zagatala, Sheki, Ismayilli, Pirgulu, Lankaran and Absheron Peninsula-Nardaran Magnetometric Variation Stations (MVS) during the day since 2003 in registration regime. Based on these observations, T ~ f (t) graphs have been created and a comparative analysis of earthquakes has been conducted. During the analysis, earthquakes with magnitude of M≥4 were selected. Taking into account the epicenter distance of the selected earthquake from the observation point, the depth of the epicenter, the anomalous observation period of the seismomagnetic effect, the intensity of the magnetic change and its shape have been observed in the graph. For example, the graph of magnetometric observations in 2015 shows changes in the anomalous seismomagnetic effect of an earthquake (Fig.2).

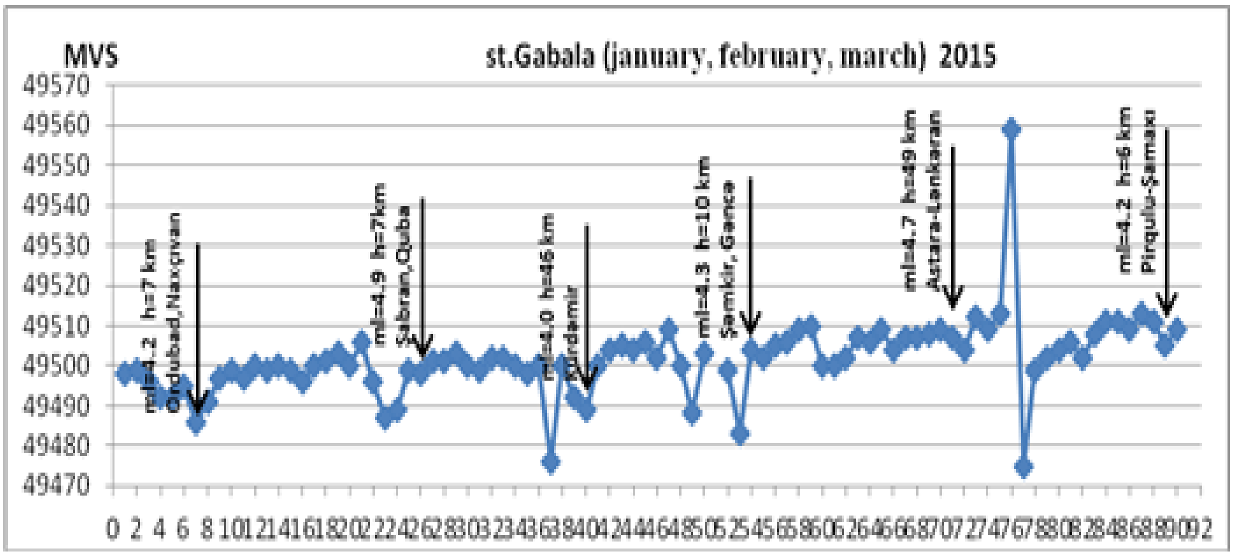
Abnormal magnetic changes, which are considered to be related to earthquakes, sometimes last from 2-3 days to 25-30 days. The large amplitude of anomalous magnetic changes is 30-40 nTl and sometimes more. As can be seen from the graph, anomalous changes in the geomagnetic field are sometimes observed even when no earthquakes is recorded. In our opinion, such cases are associated with other, unpredictable geodynamic processes occurring in the Earth's crust.

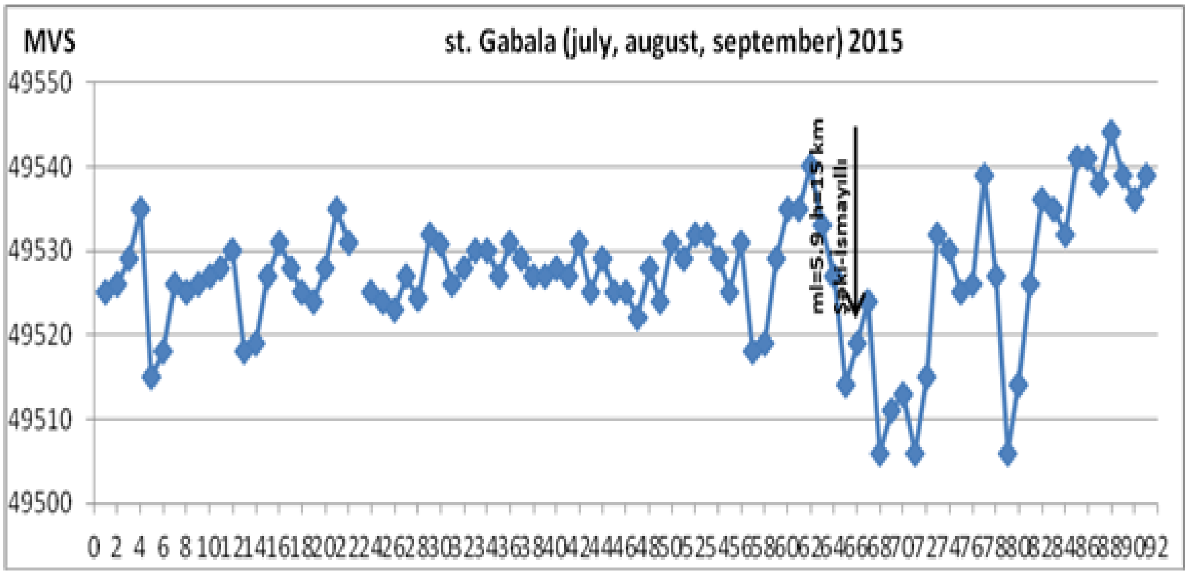


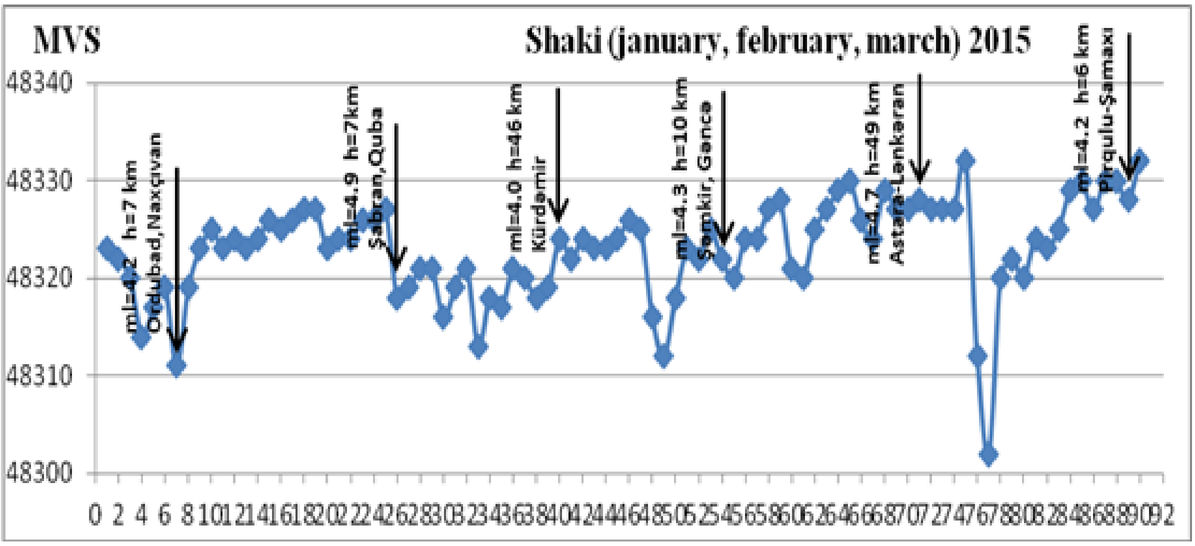


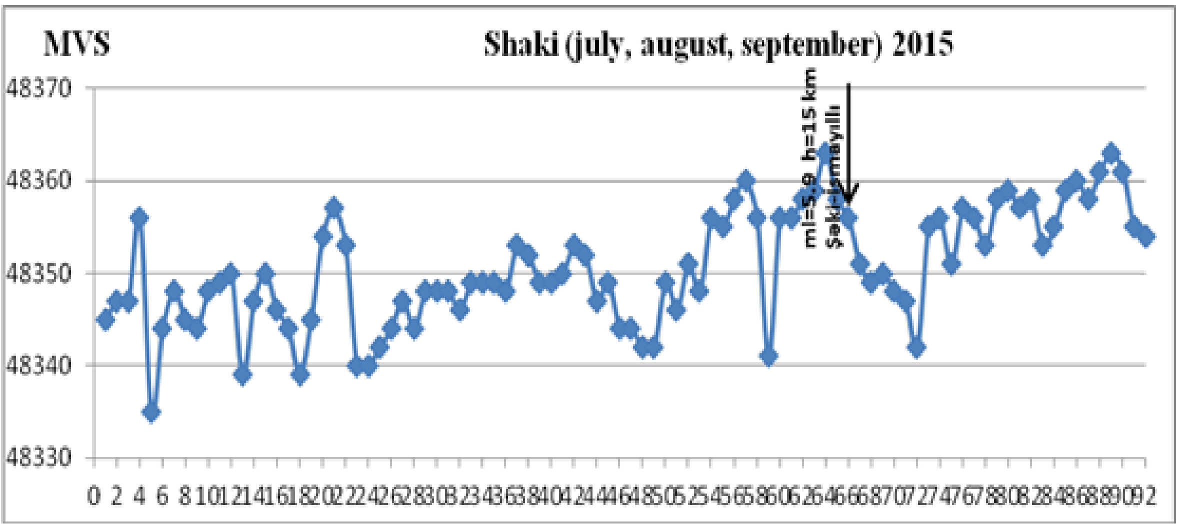

MVS
st.Pirgulu (january, february, march) 2015
49350
49340
49330
49320
49310
ml=4.2 h=7 km
Ordubad,Naxçıvan
ml=4.9 h=7km
Şabran,Quba
ml=4.0 h=46 km
Kürdəmir
ml=4.3 h=10 km
Şəmkir,Gəncə
ml=4.7 h=49 km
Astara-Lənkəran
ml=4.2 h=6 km
Pirqulu-Şamaxı


MVS
st.Pirgulu (july, august, september) 2015
49385
49375
49365
49355
49345
ml=5.9 h=15 km
Şəki-İsmayıllı


MVS
st.Gabala (january, february, march) 2015
49570
49560
49550
49540
49530
49520
49510
49500
49490
49480
49470
ml=4.2 h=7 km
Ordubad,Naxçıvan
ml=4.9 h=7km
Şabran,Quba
ml=4.0 h=46 km
Kürdəmir
ml=4.3 h=10 km
Şəmkir, Gəncə
ml=4.7 h=49 km
Astara-Lənkəran
ml=4.2 h=6 km
Pirqulu-Şamaxı


MVS
st. Gabala (july, august, september) 2015
49550
49540
49530
49520
49510
49500
ml=5.9 h=15 km
Şəki-İsmayıllı


MVS
Shaki (january, february, march) 2015
48340
48330
48320
48310
48300
ml=4.2 h=7 km
Ordubad,Naxçıvan
ml=4.9 h=7km
Şabran,Quba
ml=4.0 h=46 km
Kürdəmir
ml=4.3 h=10 km
Şəmkir, Gəncə
ml=4.7 h=49 km
Astara-Lənkəran
ml=4.2 h=6 km
Pirqulu-Şamaxı


MVS
Shaki (july, august, september) 2015
48370
48360
48350
48340
48330
ml=5.9 h=15 km
Şəki-İsmayıllı

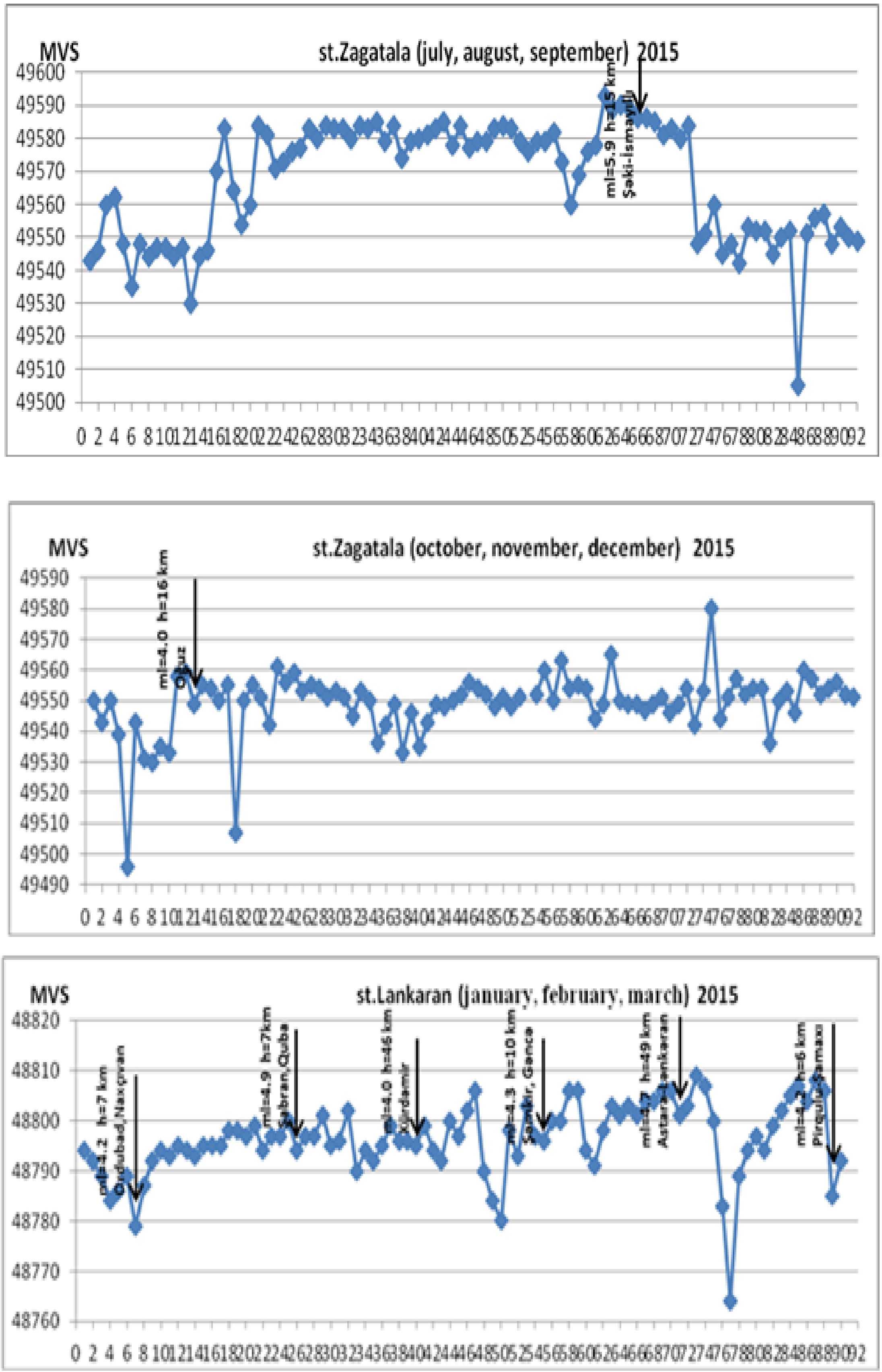


Figure 2. The graphs of magnetometric observations conducted in the territory of Azerbaijan in 2015 and changes in the anomalous seismomagnetic effect associated with earthquakes

In order to clarify the criterion for changing the seismomagnetic effect, we tried to explain the characteristics of the change in the seismomagnetic effect associated with earthquakes of M≥4.0 from the epicenter in the main layers of the Earth at different times. The hypocenters of earthquakes in the territory of Azerbaijan during 2003-2020 years have been observed 66% at a depth of 0-20 km, in the sedimentary layer; 21% at a depth of 20-35 km, in the granite layer, 12% at a depth of 35-60 km, in the basalt layer (Fig. 3). No earthquakes were recorded in the upper layers of the mantle, in the asthenosphere.

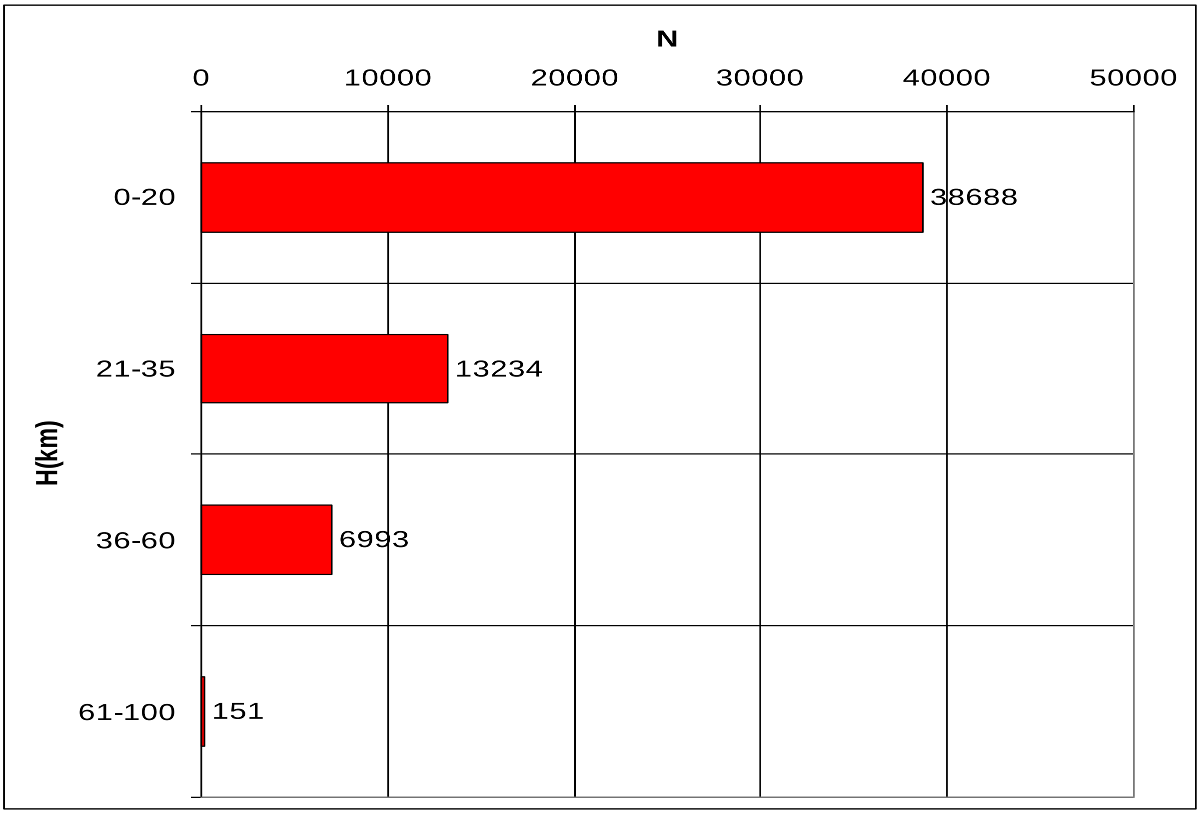


Figure 3. Graph of depth distribution of hypocenters in the South Caspian and onshore areas of Azerbaijan (Compiled by: H.O. Valiyev, S.E. Kazimova).

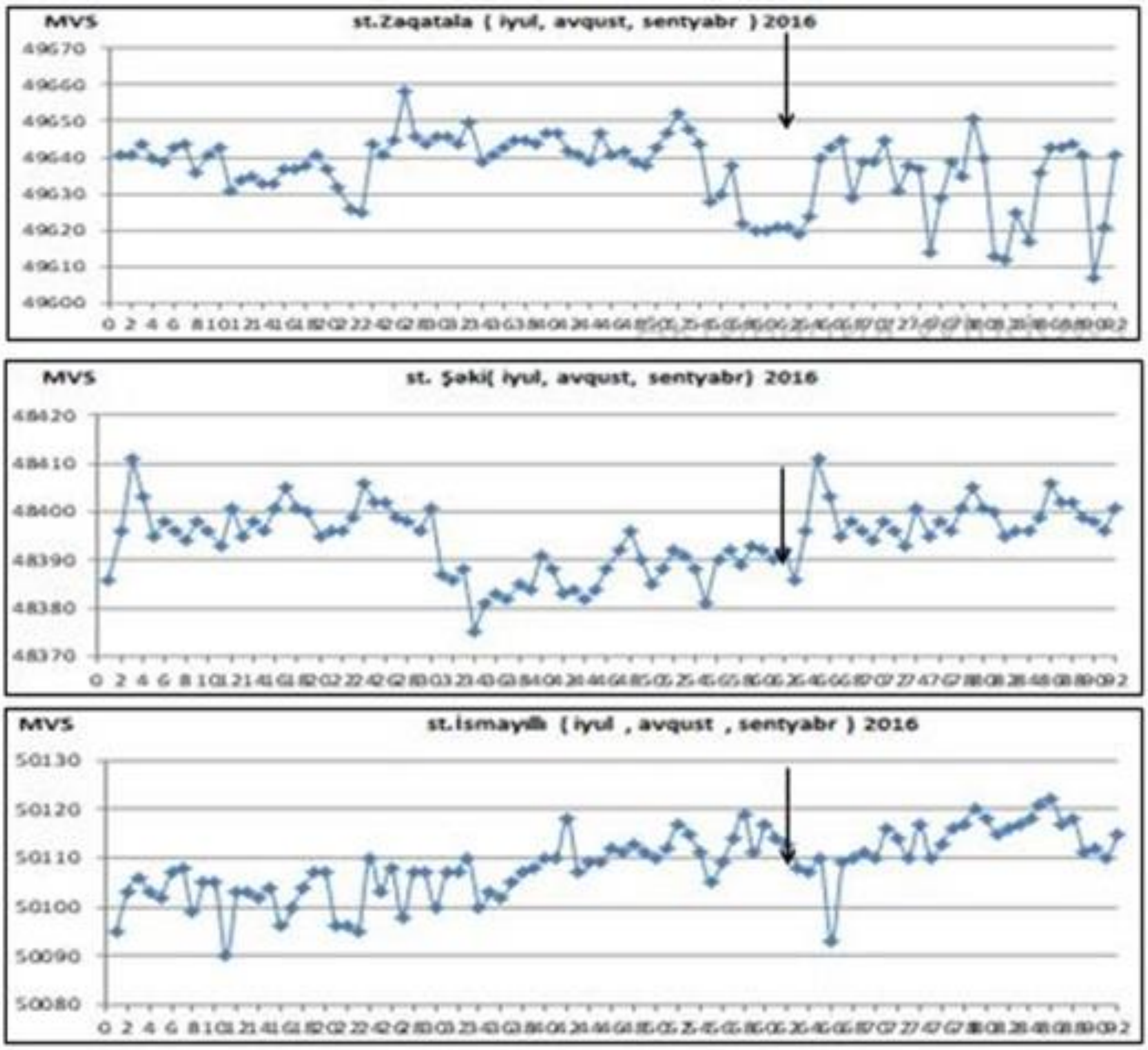
In the Caspian Sea basalt layer at a depth of 60-65 km, geodynamic activity is higher than in other areas. During the study, taking into account the depth of the epicenters and the presence of the epicenter in which layer of the Earth, it was observed how the geomagnetic field and seismomagnetic effect are formed at the magnetometric observation points (Fig. 4). The seismomagnetic effects of several earthquakes in the Earth's crust have been observed in the analyzed magnetometric data as follows.

In the Imishli zone, on 01.08.2016, the seismomagnetic effect of an earthquake with a magnitude of 5.6, the depth of the epicenter was in the granite layer and occurred at a depth of 28 km in Zagatala and Sheki points, began to form 8-10 days ago and was 20-30 with an bay-shaped minimum. It was extinguished 15 days after the earthquake. Seismomagnetic effect is observed in Ismayilli point, but it is not separated in a characteristic form.

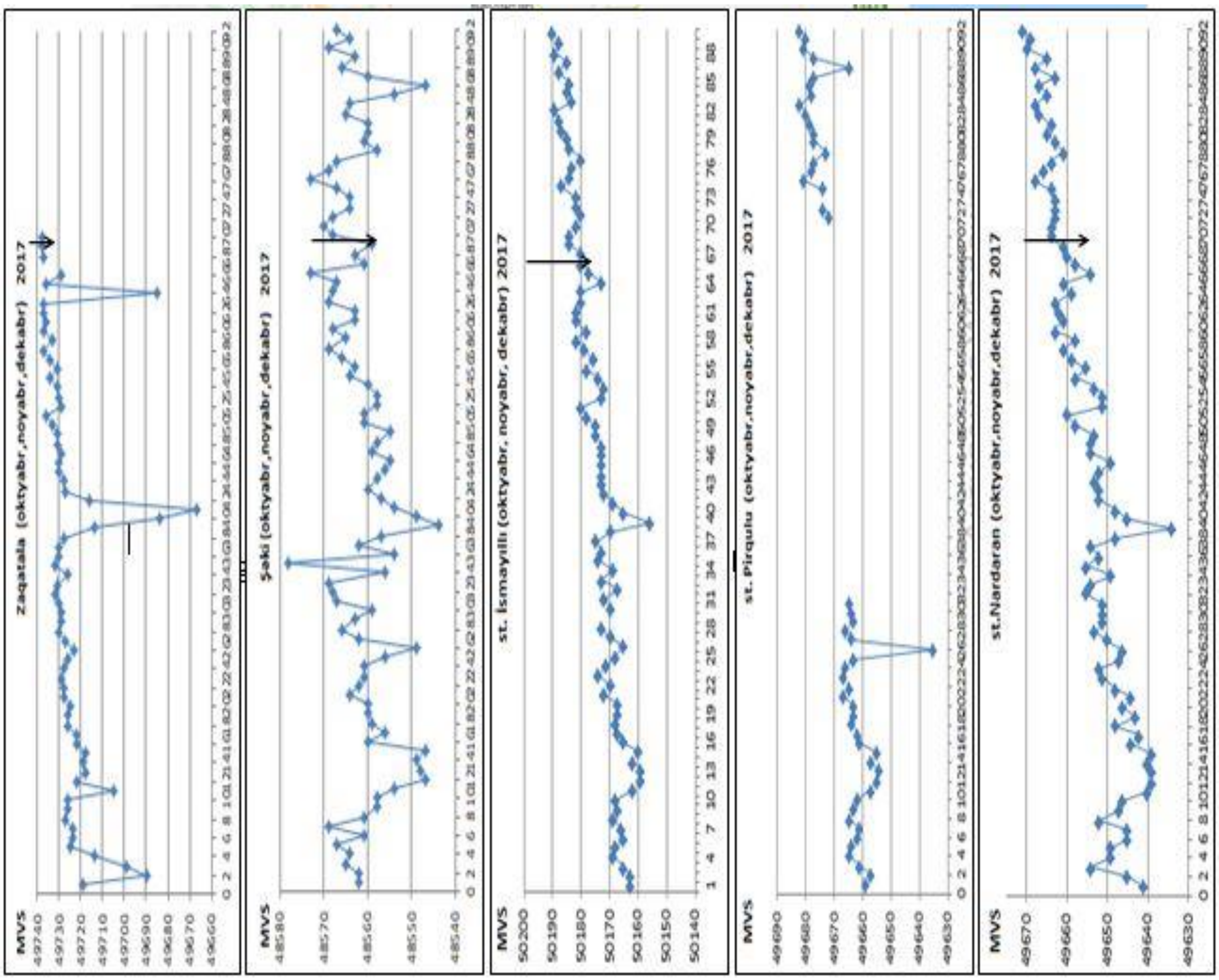
The depth of the source with the magnitude of 5.7 in **Barda-Agjabadi zone** on 15.11.2017, began to form 7 days ago with the seismomagnetic effect of 10-40 nT in Zagatala point of the earthquake occurring in the granite layer at depth of 25 km. There is seismomagnetic effect in Sheki, but in Ismayilli it is observed weakly.

In the Lankaran zone, on December 17, 2018, the depth of the epicenter with a magnitude of 4.7 in the basalt layer and at depth of 44 km in Sheki and Ismayilli points with seismomagnetic effect of 10-15 nT extinguished 9 days after the earthquake.


01.08.2016 04:46:35
39.91 47.85
ml=5.6h=28 (Qranitqat)
Azerbaijan


MVS
st.Zaqatala (iyul, avqust, sentyabr) 2016
49670
49660
49650
49640
49630
49620
49610
49600
MVS
st. Şəki(iyul, avqust, sentyabr) 2016
48420
48410
48400
48390
48380
48370
MVS
st.İsmayıllı (iyul , avqust , sentyabr) 2016
50130
50120
50110
50100
50090
50080


15.11.17 19:48:02
40.17 47.11
ml=5.7 h=25 (Qranitqat)
Azerbaijan
200,00 км
100,00 км


Zaqatala (oktyabr,noyabr,dekabr) 2017
Şeki (oktyabr,noyabr,dekabr) 2017
st. İsmayıllı (oktyabr, noyabr, dekabr) 2017
st. Pirqulu (oktyabr,noyabr,dekabr) 2017
st.Nardaran (oktyabr,noyabr,dekabr) 2017
MVS


05.06.18 18:40:27
41.50 46.67
ml=5.5 h=10 (Sediment layer)
200,00 км
100,00 км
Azerbaijan

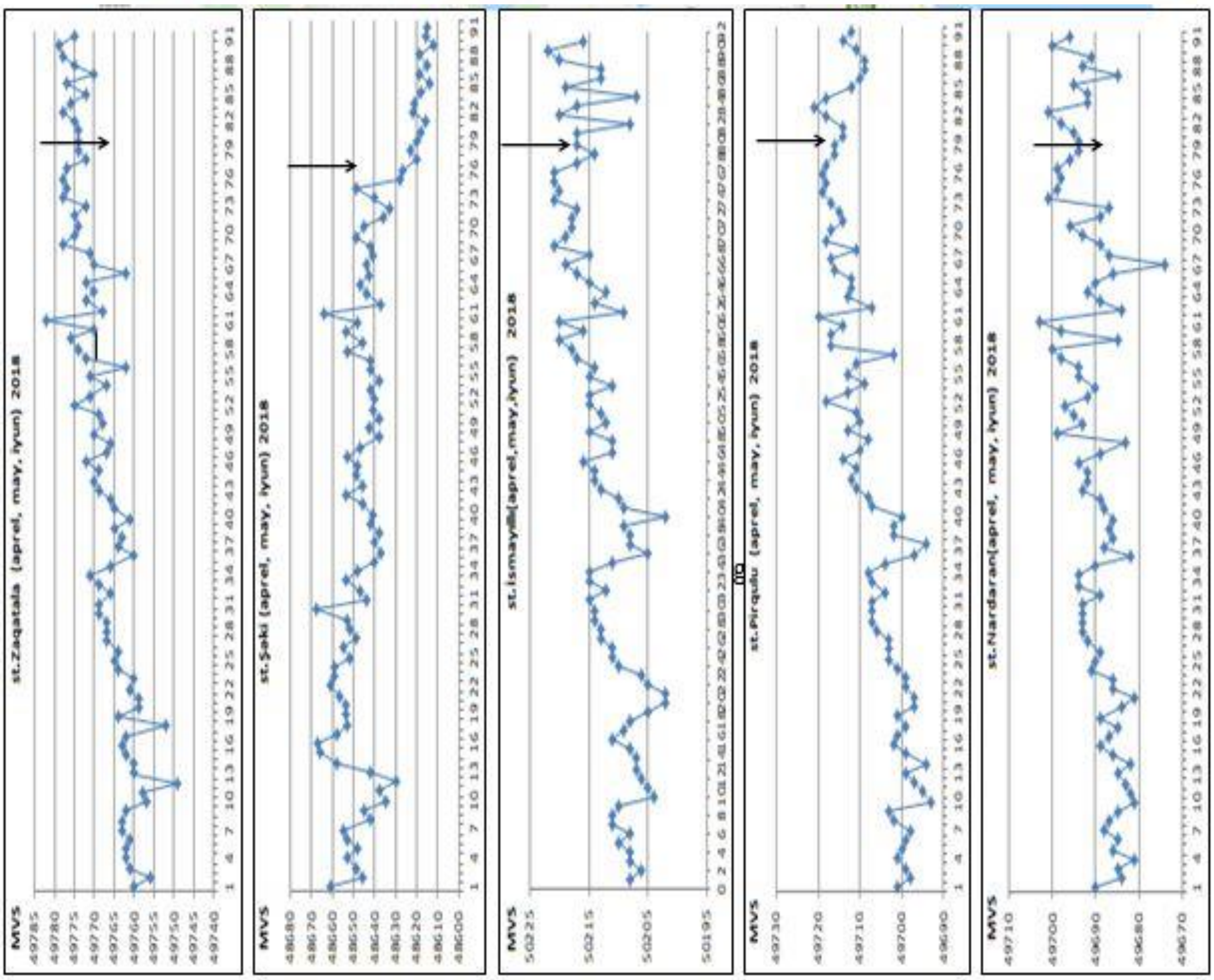

st.Zaqatala (aprel, may, iyun) 2018
st.Şaki (aprel, may, iyun) 2018
st.Ismayilli(aprel,may,iyun) 2018
st.Pirqulu (aprel, may, iyun) 2018
st.Nardaran(aprel, may, iyun) 2018
MVS

Figure 4. Graphs of seismomagnetic effect associated with earthquakes of magnitude M≥ 4.0 in the territory of Azerbaijan

In the Zagatala zone on 05.06.2019, the seismomagnetic effect began to form 5-6 days ago in all observation points of the earthquake with a magnitude of ml=5.5, the depth of the epicenter in the sedimentary layer h=10 km and it was observed being bay- shaped of 10-35 nT.

Measurement data of magnetometric regime observations in 6 permanent points of the Republican Seismic Survey Center of ANAS were analyzed in connection with earthquakes of M≥4.0 in the territory of Azerbaijan and features of epicenter-dependent change of seismomagnetic effect were investigated. It has been found that anomalous magnetic changes sometimes last from 2-3 days to 25-30 days, and the amplitude of the changes is 30-40 nTl and sometimes more. Features of the seismomagnetic effect associated with M≥4.0 earthquakes in the territory of Azerbaijan. For the first time, based on the analysis carried out taking into account the depth of the hypocenter of the earthquake and the stratum complex, it was determined that the seismomagnetic effect was observed in different forms.

Conclusion

1. The epicenter-dependent variability of the seismomagnetic effect associated the earthquakes with magnitude of M≥4.0 in Azerbaijan has been studied and it was determined that the anomalous magnetic changes sometimes lasted from 2-3 days to 25-30 days, the amplitude of the changes was 30-40 nTl and sometimes more.
2. It has been observed that in the absence of an earthquake, the magnetic field sometimes changes abnormally to a similar shape, and that such changes are thought to be due to other, unobservable geodynamic processes occurring in the Earth's crust.
3. It has been observed that magnetic fields sometimes have anomalous changes of a similar shape in the absence of earthquakes, and that such changes are thought to be related to other, unobservable geodynamic processes occurring in the Earth's crust.
4. The characteristics of the seismomagnetic effect depending on the epicenter distance were studied, taking into account the presence of the earthquake sources in the sedimentary layer, granite and basalt layers. Depending on the location of the observation point and the distance between the magnetometric observation point and the epicenter with physical-mechanical properties and magnetometric observation point and the composition of the medium in which the seismic magnetic effect spreads according to the layer in which the hypocenter is located, the observation and form of the observed anomalous seismomagnetic effect were different.
5. The seismomagnetic effect observed from the source in granite and basalt deposits is an bay-shaped form and is observed for about 20-25 days. This seismomagentic effect observed in sedimentary deposits is monitored with rhythmic changes and often in an uncharacteristic way for 40-50 days.
6. It has not been possible to determine the relationship between the depth of the layer where the epicenters are located and the physical and mechanical properties of the rocks formed by the environment in which the seismomagnetic effect is spread.

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