GEOMAGNETIC VARIATION CHARACTERISTICS IN SEISMICALLY ACTIVE REGIONS AND THEIR RELATION TO SEISMICITY

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Annotation

Anomalous changes in the geomagnetic field intensity near earthquake sources are considered. It is shown that the nature of the seismomagnetic effect formation is determined by the geodynamic regime in the source. The spatio-temporal distribution of the geomagnetic field intensity gradient reflects the geodynamic regime of the studied territories. Schematic maps and graphs reflecting geomagnetic fields were constructed at the Sheki-Shamakhi-Balakan geodynamic test sites, and several local anomalies were identified. Several more intense anomalies were identified in the Jalilabad-Yardimly-Lerik areas.

Introduction

Changes in the magnetic field are observed primarily for two reasons:

- related to geodynamic processes occurring in the lithosphere;
- related to magnetic storms occurring in the ionosphere.

Magnetometric studies play an important role in studying geomagnetic field changes during strong earthquakes occurring in the lithospheric layer of the Earth's crust in seismically active regions of the republic. The integrated application of gravity magnetometric and engineering seismological methods in studying the dynamics of geodynamic processes, earthquakes, and landslides occurring in the Earth's internal structure yields effective results.

Based on magnetometric variations and discrete research data, patterns of changes in the geomagnetic field tension (ΔT) are continuously studied.

For the past twenty years, the Republican Seismic Survey Center has been conducting comprehensive seismological, geophysical, and geochemical studies in Azerbaijan, and a number of scientific results have been obtained. The geological and tectonic structure of Azerbaijan is complex. To study the geodynamic stress conditions and tectonic structure arising in the geomagnetic field, the most pressing contemporary challenges are the compiling of high-precision maps and monitoring of the dynamics of endogenous processes.

Objective of the study: To measure the main parameters of the geomagnetic field using modern geophysical instruments, and to redefine the locations and directions of tectonic blocks, local anomalies, and regional faults.

Study areas: Sheki-Shamakhi, Kura-South, Gandja-Gazakh, and Guba-Caspian geodynamic test sites.

Magnetometric Surveys

Maps based on magnetic field strength (ΔT) determine the location, direction, and depth of major tectonic fault zones, intense anomalies, gradient zones, complex tectonic fractures, and faults. Surveys conducted using magnetometers allow for the recording of all transformation processes occurring in the Earth's crust, reflecting the tectonic features of the geological section at depth.

Method. ΔT values of magnetic field strength are measured using modern geophysical instruments at specially selected points within geodynamic testing areas. Field observations are conducted using a reference network methodology with G-856 and more modern G-857 proton magnetometers manufactured by the American company Geometrics ***(Figure 1)***.

Connection between geomagnetic variations and seismicity

Magnetometric observations were continuously conducted in the geodynamic polygons of the aforementioned seismically active regions ***(Figure 2)***, both at discrete intervals and at points of constant variation. A 2D schematic map, a 3D model ***(Figure 3)*** and spatiotemporal variation graphs reflecting the stress-strain state of the region ***(Figure 5)*** were compiled. In recent

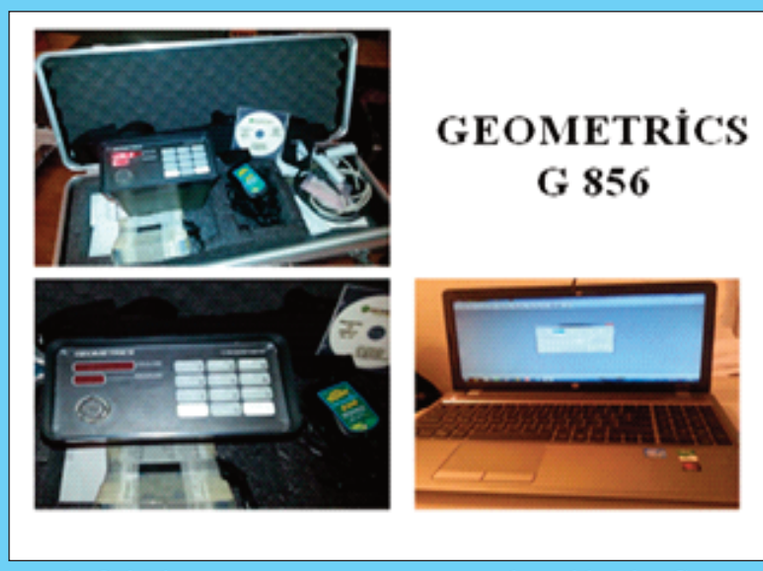

Figure 1. G-856 proton magnetometer produced by the Geometrics (the USA)

years, the geomagnetic field strength in the Ismayilli-Shamakhi zone has exceeded background levels, and intense geomagnetic anomalies have been observed in the Gabala-Ismayilli region [1].

Isoanomalies reflecting a geomagnetic field with values of -300 ÷ -600 nT are observed in the northeastern part of the Ismailli region. It should be particularly noted that the intense magnetic anomaly in this area is closed in the center of the Ismailli region, and the complex is slightly directed northwest of Shamakhi ***(Figure 3a)***. Intense anomalies discovered during the studies are also reflected on the seismic activity map ***(Figure 3c)*** [2].

In the Yardimly-Lerik zone, an anomalous magnetic maximum is observed, with isolines closed at 100 nT and oriented east-west ***(Figure 4)***. The gradient on the right and left sides of this anomaly changes sharply and is expressed by minima.

As can be seen from the map, a maximum-type magnetic anomaly with an intensity of 800 nT is ob-

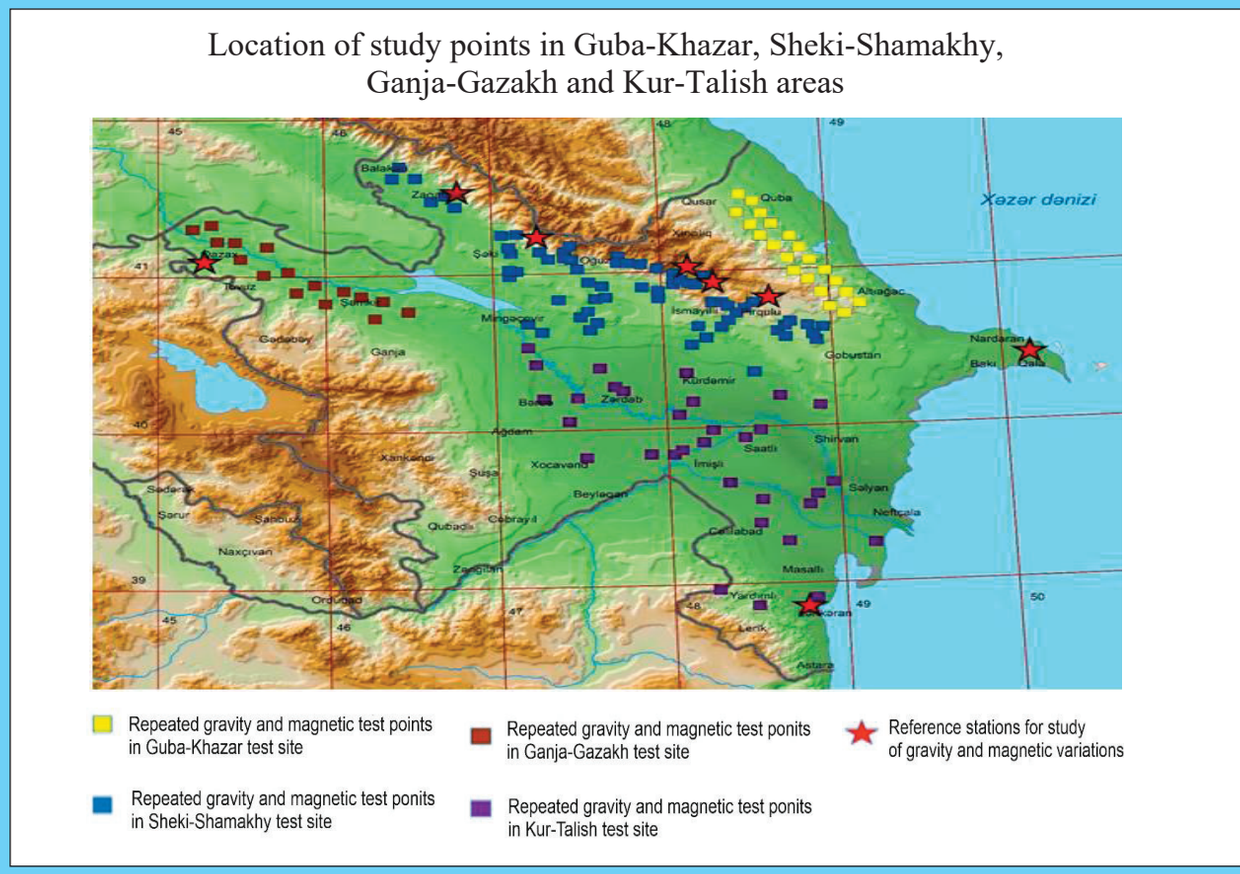

Figure 2. Layout of magnetometric observation points in Azerbaijan

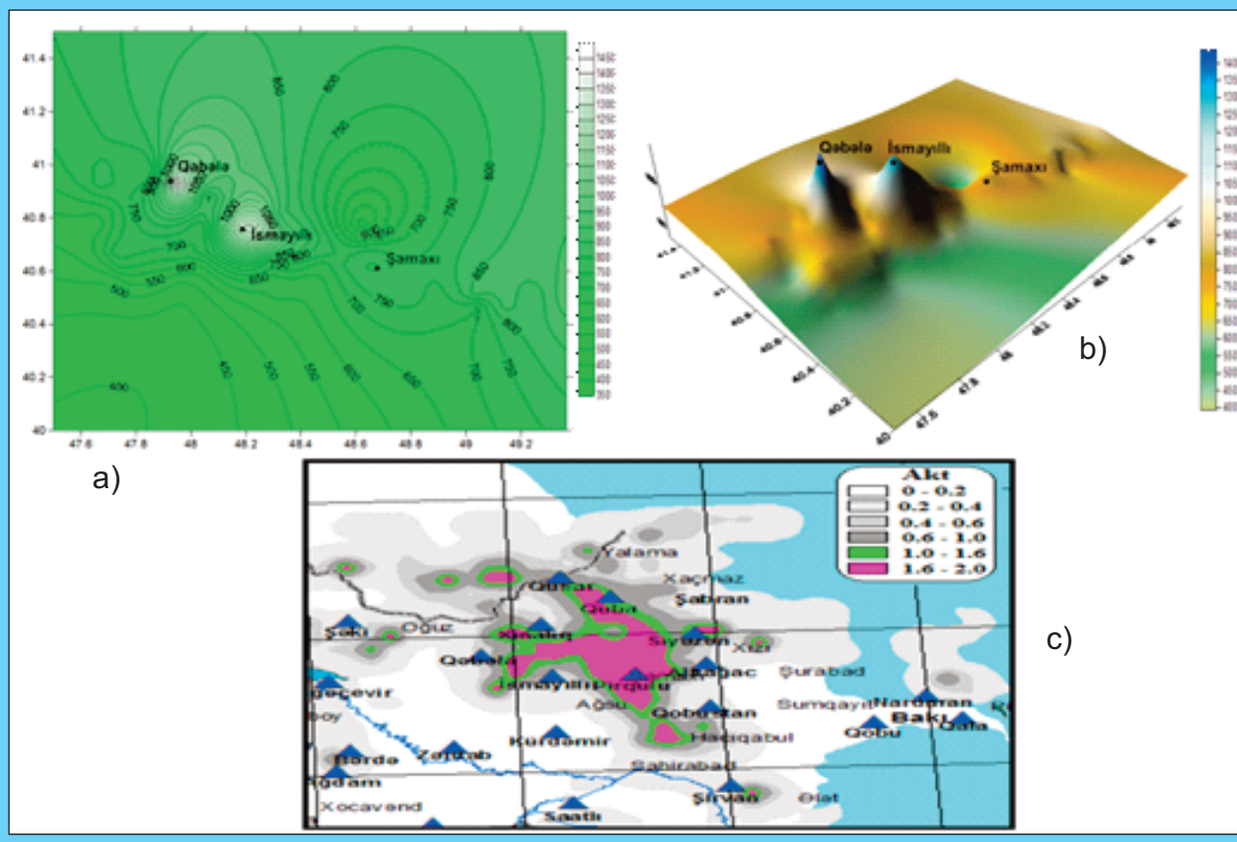

Figure 3. *Stress-strain state of the geological environment based on magnetic data in the Shamakhi-Gabala geodynamic test site in 2D format (a), 3D model (b), and seismic activity map (c)*

served in the south of the Jalilabad administrative district and north of Yardimly in a southwest-northeast direction. Another large-scale minimum-type magnetic anomaly was noted in the Lankaran region, with a relatively south-north direction and an elongated shape ***(Figure 4)***. Complex isoanomalies were primarily observed in this region. Such anomalous effects are associated with geodynamic processes occurring in deep layers [3].

On May 11, 2024, an earthquake with a magnitude of 5.3 occurred at a depth of 20 km in the Lankaran region. The source mechanism of the earthquake was of the nature of displacement-faults-subsidence of the ground (fault) [4]. As can be seen from the curve of the magnetometer installed at the Ismailly station versus time and space, the seismomagnetic effect formed in a decreasing direction with an intensity of 40 nT.

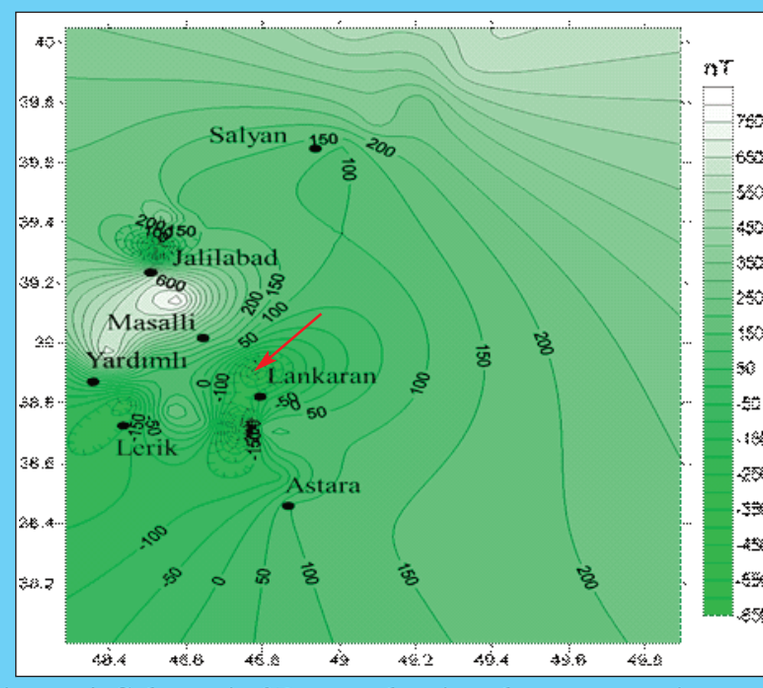

Figure 4. Schematic 2D map showing the stress-strain state of the geomagnetic field in the Southern Hemisphere

→ Complex fault zone. Intense magnetic minimum.

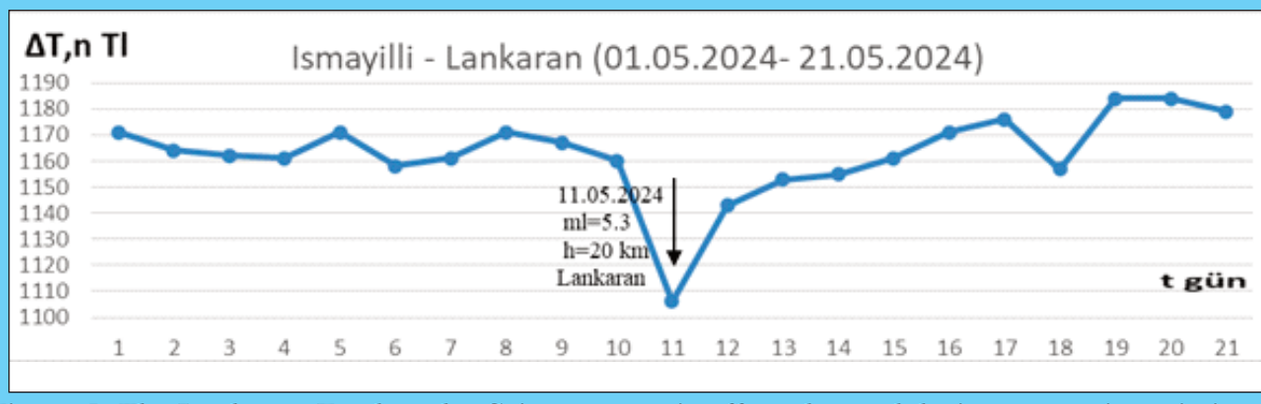

Figure 5. The Lankaran Earthquake. Seismomagnetic effect observed during magnetic variations at the Ismailly and Sheki stations

05/11/2024 Lat=38.80 Lon=48.65 H=20 ML=5.3 (Lankaran).

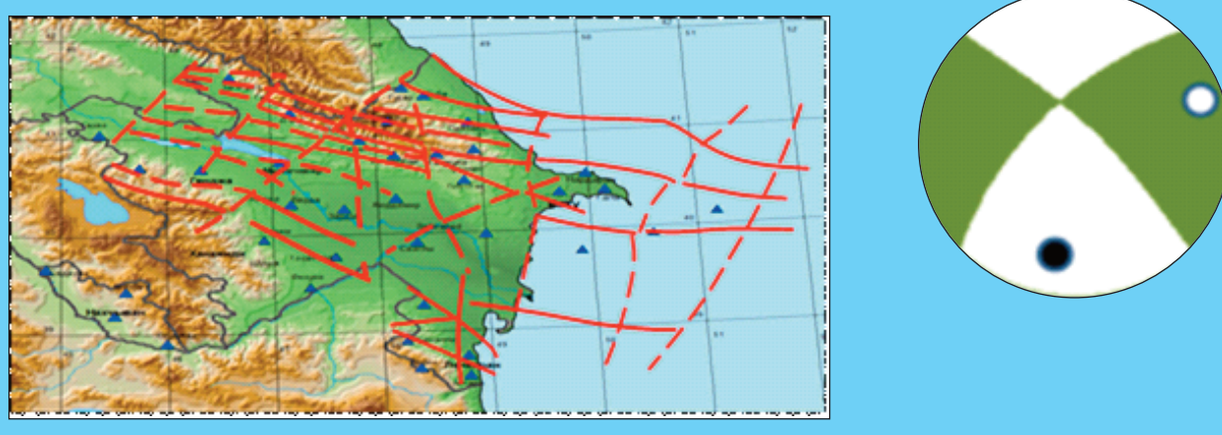

Figure 6. The mechanism of the Lankaran earthquake: displacements, faults and ground subsidence

This is twice as high as the theoretically calculated value (15-20 nT). A similar situation is observed at the Sheki station ***(Figures 5-6)*** [5, 6, 7, 8].

Recommendations

In the future, it is planned to continue similar studies in the Karabakh economic zone.

REFERENCES:

1. Yetirmishli G.J., Abdullayeva R.R., Ismayilova S.S., Kazimov I.E. Stress-strained state of the Earth's crust of Azerbaijan for.2004-2016 yy. seismoprognosis observations in the territory of Azerbaijan Seismoprogn. Observ.Territ.Azerb. V.13, №1, 2016, pp. 23-31.

2. Геология Азербайджана, том IV, Тектоника, Баку, Издательство "Nafta-Press", 2005, 506. Главные редакторы: академик В.Е.Хаин, академик Ак.А. Ализаде.

3. Зотов О. Д., Гульельми А.В., Собисевич А.Л. О магнитных предвестниках землетрясений. физика земли, 2013, № 6, с. 139-147.

4. Рзаев А.Г. и др., 2005, Геомагнитные предвестники землетрясений и их сейсмотектоническая обусловленность «Bilgi», «Техника», г.Баку. №1, с. 94-101.

5. Рзаев А.Г. и др., 2006, Связь аномальных изменений в напряженности геомагнитности геомагнитного поля с сейсмотектоническими процессами в литосфере Земли AMEA Xəbərlər, Yer Elmləri, №3, с.58-63.

6. Рзаев А.Г., Исаева М.И. 2006, Магнитные свойства, сейсмомагнитные эффекты горных пород Шеки-Шамахинской сейсмогенной зоны.

AMEA Xəbərlər. Yer Elmləri, №2. c. 38-41.

7. Рзаев А.Г., Етирмишли Г.Д., Казимова С.Э. 2013. Отражение геодинамического режима в вариациях напряженности геомагнитного поля. Xəbərlər. Yer Elmləri, N4, s. 3-15.

8. RSXM-nin Zəlzələlərin tədqiqatı bürosunun və maqnitometriya şöbəsinin hesabatları, 2022 - 2024-cü il.

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SEYSMOAKTİV BÖLGƏLƏRDƏ GEOMAQNİT VARİASİYALARIN DƏYİŞMƏ XÜSUSİYYƏTLƏRİ VƏ SEYSMİKLİKLƏ ƏLAQƏSİ

XÜLASƏ

Məqalədə zəlzələlər baş vermiş ərazilərdə geomaqnit sahə gərginliyinin anomal dəyişmələri haqqında məlumatlar verilir. Seysmomaqnit effektin yaranma xarakteri zəlzələ ocağında müşahidə olunan geomaqnit rejimlə təyin olunur. Geomaqnit sahəsinin gərginlik qradiyentinin məkan-zamana görə paylanması tədqiqat aparılmış ərazilərin geodinamik rejimini əks etdirir. Qəbələ-Şamaxı geodinamik poliqonunda geomaqnit sahəsinin dəyişməsini əks etdirən sxematik xəritə və qrafiklər tərtib olunmuşdur. İsmayıllının şimal şərq hissəsində müşahidə olunmuş anomaliya intruziv kütlənin effekti kimi qiymətləndirilir. Cəlilabad- Yardımlı-Lerik zonalarında maksimum və minimum tipli intensiv lokal anomal sahələr müşahidə olunur. Bu anomal effektlər dərin qatlarda baş verən geodinamik proseslərlə əlaqəlidir. Perspektivdə anoloji tədqiqatların Qarabağ iqtisadi zonasında davam etdirilməsi nəzərdə tutulur.

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ИЗМЕНЕНИЯ НАПРЯЖЕННОСТИ ГЕОМАГНИТНОГО ПОЛЯ В СЕЙСМОАКТИВНЫХ РАЙОНАХ И ИХ СВЯЗЬ С СЕЙСМИЧНОСТЬЮ

АННОТАЦИЯ

Рассмотрены аномальные изменения напряженности геомагнитного поля вблизи очагов землетрясений. Показано, что характер формирования сейсмомагнитного эффекта определяется геодинамическим режимом в очаге. Пространственно-временное распределение градиента напряженности геомагнитного поля отражает геодинамический режим исследуемых территорий. На геодинамических полигонах Габала-Шамахы были построены схематические карты и графики, отражающие геомагнитные поля, а также было выявлено несколько локальных аномалий. Еще несколько интенсивных аномалий было выявлено в Джалилабад -Ярдымлы-Лерикских площадях. В дальнейшем планируется продолжить аналогичные исследования в Карабахской экономической зоне.