



## **Anomalous Dynamics Of Hydrogeochemical Parameters (Cl<sup>-</sup>, Co<sub>2</sub>, Eh, Ph, T) Of The Chimyan Np-1 Well Associated With The M=5.7 Earthquake**

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### **Abstract**

Hydrogeochemical changes associated with earthquakes are considered as a potential tool for detecting earthquake signals. The article presents the results of scientific analysis of seismological monitoring data conducted by the Republican Center for Seismological Monitoring of the Ministry of Emergency Situations of the Republic of Uzbekistan at the Institute of Seismology, which analyzed the changes in the hydrogeochemical parameters Cl<sup>-</sup>, CO<sub>2</sub>, EH, PH, T° in the “Chimyon NP1” well in the Fergana geodynamic polygon during the preparatory phase of the earthquakes that occurred in 2025. As a result of the analysis, graphs were drawn and anomalous periods of each parameter were determined. These results prove that hydrogeochemical monitoring can be very effective for seismic monitoring.

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## Introduction

Earthquake prediction remains one of the most challenging tasks in geosciences, and there is still no reliable methodology for short-term prediction. Traditional approaches have focused mainly on seismic activity, fault kinematics, and stress accumulation to assess earthquake hazard and risk at regional scales; however, these methods often suffer from inconsistencies and limitations due to the complex and nonlinear nature of fault mechanics and regional geology. Hydrogeochemical anomalies in groundwater systems have received considerable attention since the 1970s (Rikitake, 1979, Dobrovolsky et al., 1979, Wakita, 1996), as changes in groundwater chemistry are often associated with crustal stress redistribution, fluid-rock interactions, and deep fluid migration. Active fault zones disrupt the hydrogeochemical balance of the subsurface through the dynamic interaction of rocks and water, which causes diagnostic anomalies in the chemistry of groundwater, which can serve as potential seismic detectors.

Determining the regional role of the hydrogeoseismological method in earthquake forecasting. Currently, there are several methods for forecasting earthquakes, and the hydrogeoseismological method is considered one of the effective methods for detecting short- and medium-term earthquake detectors.

Hydrogeoseismological studies in Uzbekistan have been systematically organized since 1966, and since that time a comprehensive approach to detecting earthquake detectors based on hydrogeochemical, gas-geochemical and isotopic analyses has been developed.

Main part: The territories of the Republic of Uzbekistan are divided into seismic polygons and monitoring work is carried out. The "Chimyon NP1" complex prognostic station (KPS) is a comprehensive prognostic station located in the Fergana geodynamic polygon, in the South Fergana deep fault zone. Analyzing seismicity in the Fergana Valley and taking into account the features of tectonic development, R.N. Ibragimov (1970) distinguishes several seismotectonic zones in the region: Northern - Fergana, Central - Fergana and Southern - Fergana. Each zone has its own earthquake sources [1,2].

**Table 1.** Geological and hydrogeological characteristics of the hydrogeoseismological observation point

Structural arrangement	Observation points	Seismotectonic conditions	The depth interval of the aquifer and its stratigraphic assignment	Lithological composition of aquifer rocks	Hydrochemical composition of groundwater (Kurlov formula))
Fergana Geodynamic Polygon of the Orogenic Region	Chimyon-NP-1	Southern Fergana Deep Fault Zone	N-Q 220-295m	Conglomerate, Sandstone	$M 0.63 \frac{SO_4 48 Cl 12 HCO_3}{(Mg44Na29) Ca2}$

The most active of the identified seismotectonic zones is the South-Fergana fault and the South-Fergana flexural-fault zone isolated around this fault [3,4]

On 06.10.2025, an earthquake with a magnitude of  $R=188$ ,  $lgR=2.5$  was observed at the Fergana geodynamic polygon ( $M>5.7$ , earthquake). The epicenter of the earthquake is Jalalabad, Kyrgyz Republic. We selected this earthquake using the Dobrovolsky coefficient [4]:

$$R=100.43 \cdot M \quad (5)$$

where: R is the stress (related to the Dobrovolsky number), M is the magnitude (Mb), 0.43 is the empirical coefficient (obtained based on experience).

Also, the calculated deformation values calculated according to the formula [4] are presented (Table 2).

$$D=(R/100.413 \cdot M - 2.66) - 3 \quad (6)$$

Earthquake information

**Table 2**

Date	Latitude	Longitude	Depth, km	M	Borehole R (km)	Coefficient	$V_{max}$	D	Deformation magnitude $\epsilon D$
06.10.2025	41,94 N	71,43	10	5.7	188	2.69462E-11	410.5821	1.1064E-08	1.81897E-08

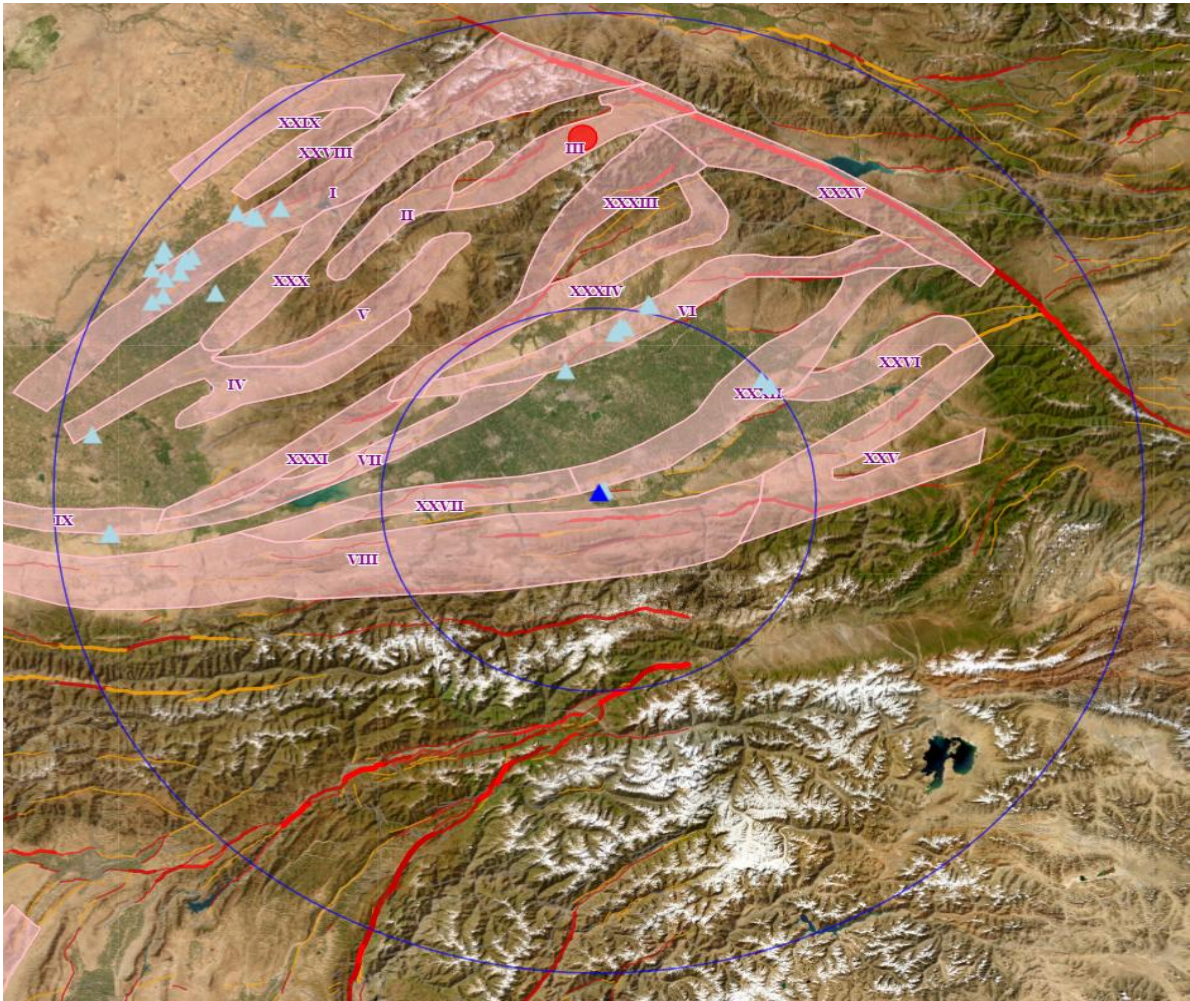


Fig. 1. Map of seismogenic zones of Uzbekistan and neighboring regions

**Observation point**

**Earthquake focus**

**IX - seismogenic zones**

The blue circles indicate the area of influence of the earthquake focus, i.e. a radius of 50 -100 km

**Table 3.** The frequency of earthquakes with a magnitude of M-4 or higher in 2024-2025

Date	Time	Latitude	Longitude	Depth	Mb	Ml	Epicenter
19.06.2024	12:09:43	41,59	71,23	14	4,3	4,4	Kyrgyzstan
10.08.2024	05:26:37	42,28	72,16	15	4,3	4,4	Kyrgyzstan
23.08.2024	20:32:58	39,71	71,35	9	4,8	5	Kyrgyzstan
04.09.2024	10:43:15	39,57	72,79	14	4,1	4,3	Kyrgyzstan
20.10.2024	17:44:48	39,49	73,69	6	4,2	4,2	Kyrgyzstan
19.11.2024	22:53:19	39,92	70,01	29	4,6	4,6	Kyrgyzstan
20.11.2024	15:46:41	39,31	67,65	10	4	4	Tajikistan
23.11.2024	08:33:01	39,4	71,63	5	5,2	5,6	Tajikistan
12.03.2025	03:11:21	40,55	72,8	11	4,3	4,4	Kyrgyzstan
13.04.2025	04:24:01	39,02	70,8	28	5,8	5,8	Tajikistan
13.04.2025	14:34:25	38,91	70,75	15	4,8	4,8	Tajikistan
14.04.2025	00:44:55	38,93	70,6	15	4,1	4,2	Tajikistan
06.05.2025	08:08:25	39,44	73,43	5	4	4,3	Tajikistan
02.08.2025	06:27:37	39,35	71,82	14	4	4,1	Kyrgyzstan
05.08.2025	13:44:10	41,3	72,7	5	5,3	5,3	Kyrgyzstan

08.08.2025	03:58:49	40,55	72,27	23	4,3	4,4	Uzbekistan, Andijan Region, Marhamat District
25.08.2025	17:59:49	39,69	72,94	15	4,5	4,6	Kyrgyzstan
26.08.2025	10:31:18	39,5	72,06	6	4,4	4,3	Kyrgyzstan
06.10.2025	20:28:59	42,16	71,34	18	5,3	5,7	Kyrgyzstan
05.11.2025	05:58:24	40,07	69,1	20	4,1	4,4	Tajikistan
11.11.2025	17:32:33	41,18	71,53	16	4	4	Uzbekistan, Namangan Region, Kosonsoy District.
05.12.2025	21:04:12	40,88	70,76	17	4,4	4,5	Uzbekistan, Namangan Region, Pop District

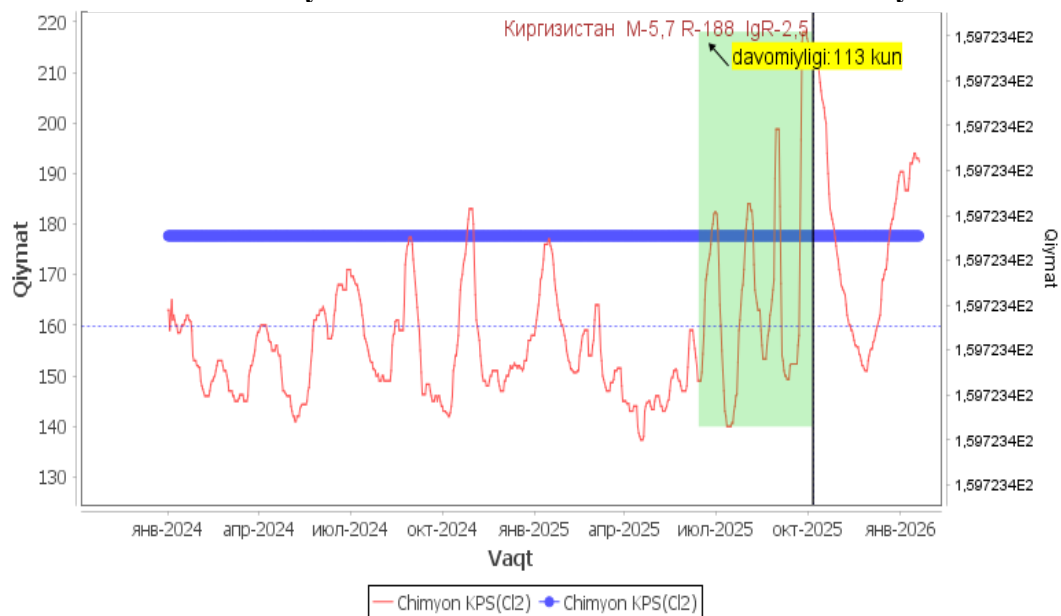
The table shows the frequency of earthquakes with a magnitude of  $M=4$  or higher in 2024-2025. The magnitude, time, and depth of the earthquake epicenter are shown in this table.

The Fergana geodynamic polygon is located in a seismically active area and is affected by seismic processes in neighboring Kyrgyzstan, Tajikistan, and other border regions.

When the parameters of the "ChimyonNP1" well  $Cl^-$ ,  $CO_2$ , EH, PH, To, were studied during this earthquake, a significant anomaly was observed in this parameter.

Hydrochemical analysis has been conducted in the "ChimyonNP1" well for many years. One of them is the determination of chlorine ions. This analysis is carried out by the titration method. The obtained water sample is titrated through a silver nitrate solution. Graph 1 shows the amount of chlorine ions from January 2024 to January 2026. As a result of monitoring, an increase in the amount of chlorine in the sample was observed starting from July 2025, and this increased to a peak for 113 days, when an earthquake was observed on October 6, after which the amount of chlorine returned to its normal level.

**Well Chimyon NP-1 CI 06.10.2025 M-5.7 Median 7 days**

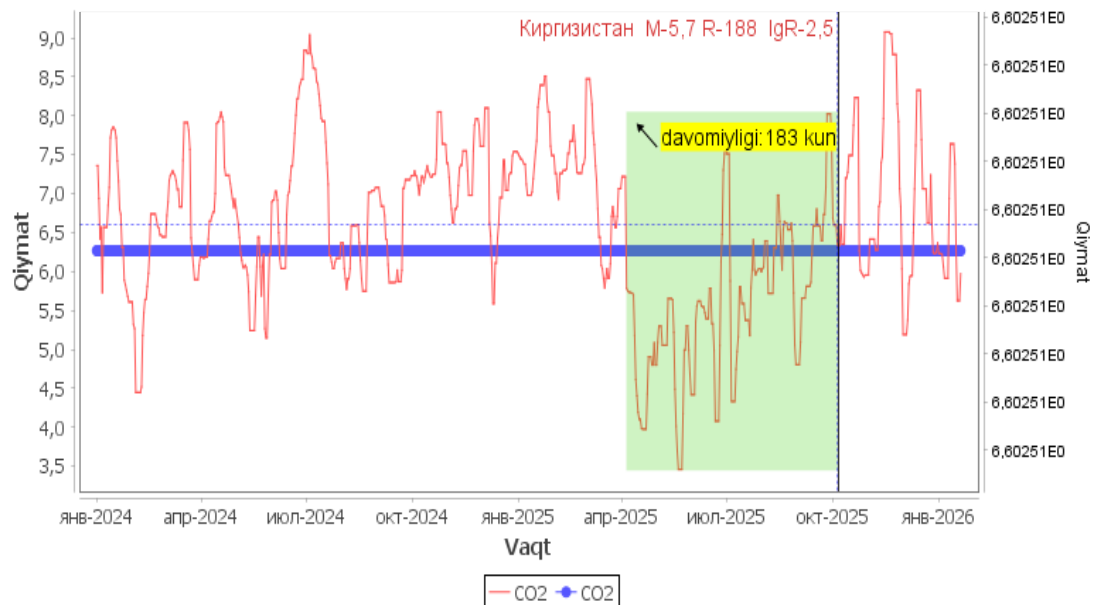


**Graph 1** shows the amount of chlorine ions in a sample taken from the ChimyonNP-1 well

Seismic forecasting significance: Continuous monitoring of chlorine concentration can be used in seismic monitoring systems to detect pre-earthquake anomalies, correlate with other parameters (radon, helium, pH, Eh), and use it in seismic monitoring systems. For example, some observations have shown a 10–30% change in  $Cl^-$  a few days or weeks before an earthquake. In this study, we investigated the possible causes of regional earthquake signals, such as  $CO_2$  release and groundwater mixing. This is due to regional geological structure, lithology, water and surface reactions, and high-speed GPS field characteristics. Signals resulting from  $CO_2$  release are usually short-lived, lasting about two months. However, groundwater mixing associated with earthquakes has been detected 4–5 months before the events. Another change in the monitoring process is the change in  $CO_2$  gas.  $CO_2$  Gas Chromatograph "Kristallux

4000m" is used to measure gases dissolved in water (hydrogen, helium, nitrogen, oxygen, carbon dioxide). Graph 2 shows the amount of carbon dioxide from January 2024 to January 2026 on a graphical basis. As a result of monitoring, a decrease in the amount of carbon dioxide in the sample was observed starting from July 2025, which lasted for 183 days. An earthquake was observed on October 6, after which the amount of carbon dioxide returned to its normal level.

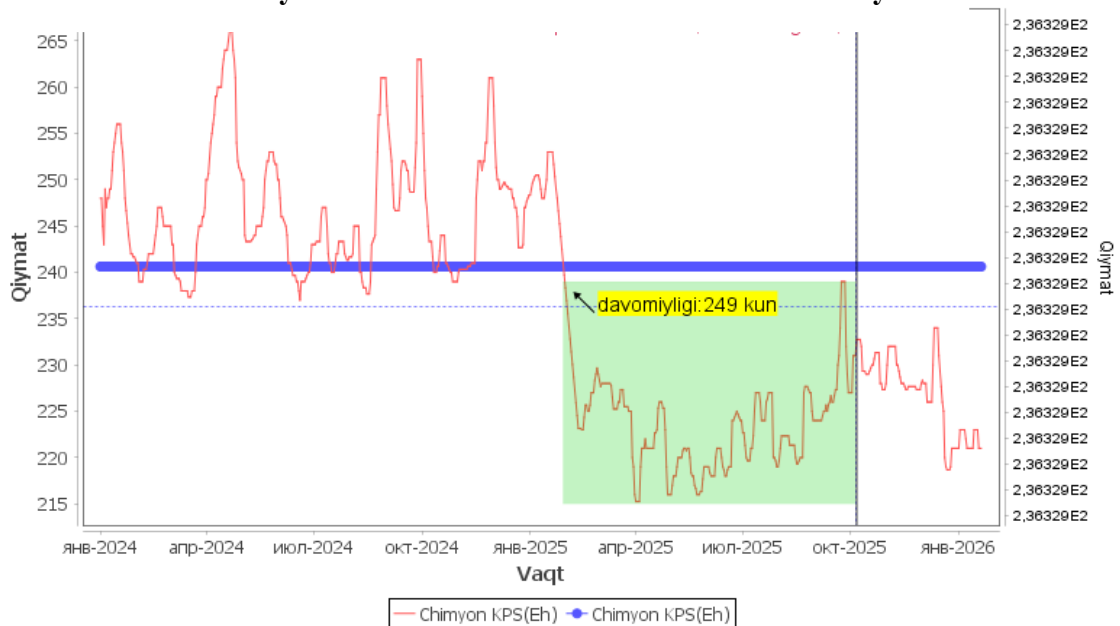
### Well Chimyon NP-1 CO<sub>2</sub> 06.10.2025 M-5.7 Median 7 days



**In the graph 2,** the amount of CO<sub>2</sub> in the sample taken from the ChimyonNP-1 well

In seismic forecasting, Eh is used as an indicator of the geochemical response of groundwater. As a result of increased stress in the earth's crust before an earthquake, cracks open, gases are released, and water-rock interaction increases. These processes can lead to anomalous changes in Eh. In the pre-earthquake stage: Microcracks expand, reducing gases such as CH<sub>4</sub>, H<sub>2</sub>, CO<sub>2</sub> are released, the reaction of groundwater with rocks accelerates, and the activity of microorganisms changes. As a result: Increase in reducing gases → Eh decreases (towards – mV). Oxygen ingress or mixing → Eh increases (+ towards + mV). Changes are observed.

### Well Chimyon NP-1 Eh 06.10.2025 M-5.7 Median 7 days



**Graph 3** shows the amount of Eh in a sample taken from the ChimyonNP-1 well.

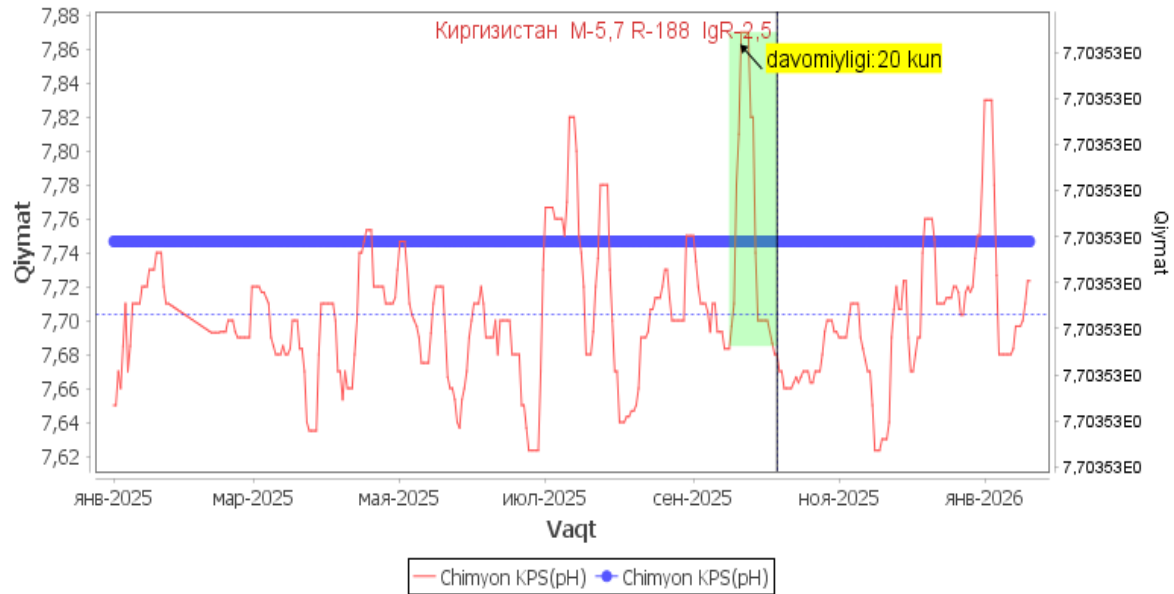
In graph 3, the Eh value decreased from 255-260 mV to 218-220 mV. The anomaly lasted for 249 days. Eh is a sensitive parameter reflecting the redox state of groundwater, which can indirectly indicate stress accumulation processes. It represents gas migration and water mixing. It has a predictive value in complex monitoring. The pH of

groundwater can change under the influence of geochemical processes in the pre-earthquake and post-earthquake periods. These changes are associated with increased stress in rocks, the formation of cracks and the release of gases. In seismic monitoring, pH usually changes as follows: a decrease of 0.2 - 1.0 units (most often observed) an increase of 0.1 - 0.5 units can be observed. In seismic monitoring, pH is analyzed along with the following indicators: Cl<sup>-</sup> may increase CO<sub>2</sub> increases sharply Eh often decreases Temperature Increases slightly

CO<sub>2</sub> ↑ → pH ↓

Eh ↓ → reducing environment increases

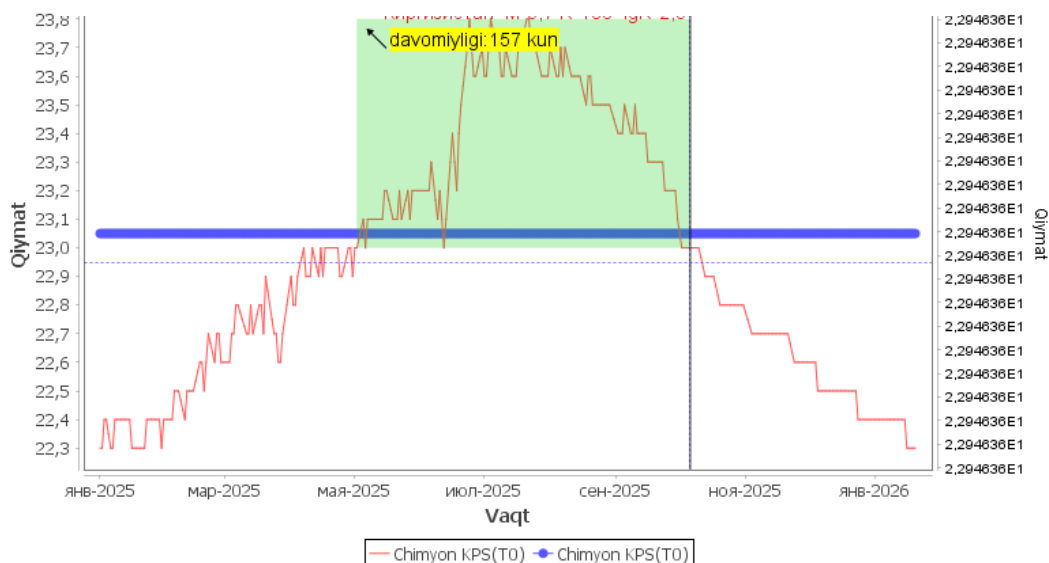
**Well Chimyon NP-1 pH 06.10.2025 M-5.7 Median 7 days**



**Graph 4** shows the pH content of a sample taken from the ChimyonNP-1 well

Before an earthquake, pH often decreases due to CO<sub>2</sub> release, but it can also increase under certain hydrogeological conditions. Therefore, pH is always analyzed in a complex manner with Eh, CO<sub>2</sub>, Cl<sup>-</sup>, radon and temperature. pH changes can indicate: enrichment of groundwater with gas, opening of new cracks, mixing of deep waters. Therefore, pH is one of the indicators of seismic forecasting. The temperature of groundwater can change before, during and after an earthquake. These changes are associated with geodynamic stress, opening of cracks, and migration of deep waters. Before an earthquake, the tension in the earth's crust increases and microcracks appear. As a result, hot waters in deep layers rise up, gases (CO<sub>2</sub>, CH<sub>4</sub>, H<sub>2</sub>) are released, and the water cycle accelerates. As a result, the temperature usually increases slightly (0.1 – 2 °C). In some cases, the temperature may also decrease due to the mixing of cold water.

**Well Chimyon NP-1 T0 06.10.2025 M-5.7 Median 7 days**



The content of T0 in the sample taken from the ChimyonNP-1 well

The differences in hydrogeoseismological parameters that are manifested as a result of earthquakes can be caused by various factors. Earthquakes with large magnitude and depth ( $M \leq 7$ ) affect a large area of the earth's crust, therefore, changes in chemical parameters are also more noticeable. Deep earthquakes come into contact with groundwater and minerals for a longer time, as a result of which chemical changes can be more complex.

## Conclusion

Hydrogeological indicators in earthquakes are divided into long-term, medium-term and short-term indicators. In hydrochemical forecasting of earthquakes, one of the most effective methods is currently to determine the isotope composition of elements such as oxygen, hydrogen, helium, argon, since oxygen and hydrogen elements in the mantle are transferred to groundwater during deformation. According to many studies, in earthquake forecasting, multiparameter monitoring helps to identify prognostic anomalies and understand the origin of hydrological changes. In particular, accurate information can be obtained if groundwater levels, gas composition, ion composition, pH, Eh values, and deformation data are analyzed together. An increase in chlorine ( $\text{Cl}^-$ ) concentration, a decrease in carbon tetraoxide ( $\text{CO}_2$ ) concentration, a decrease in the Eh redox value, changes in the environmental indicator pH and temperature. A comprehensive analysis of these parameters is important in identifying earthquake indicators. Analysis of multiparameter hydrogeochemical monitoring data together with seismic and deformation data can further increase the possibilities of earthquake forecasting in the future.

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