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HYDROGEOSEISMOLOGICAL MONITORING OF WATER LEVEL AND GAS CHANGES DURING EARTHQUAKES

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Abstract. Recent studies have shown that variations in hydrochemical parameters, especially dissolved gases in groundwater, may act as precursors to earthquakes. This research investigates anomalies in helium and hydrogen gas concentrations in groundwater before and after seismic events in Uzbekistan, focusing on data from well No. 1 located in the Karzhantau fault zone, Tashkent. Measurements were carried out from October 2023 to November 2024 using a “Kristallyuks 4000M” gas chromatograph and ionomeric methods for pH and Eh. Helium concentrations rose from background levels (0.001–0.004%) to peaks of 0.006–0.022% prior to earthquakes with magnitudes between M=3.2–3.7. Hydrogen levels also increased from 0.001–0.002% to up to 0.014%. These anomalies were typically observed 10–30 days before seismic events and declined after the earthquakes, though in

some cases remained above background. Groundwater levels in surrounding wells (EOCC 2, 3, 4) also exhibited notable fluctuations before earthquakes. The spatial correlation between gas anomalies and seismic activity was analyzed using Dobrovolskiy's formula to define precursor influence radii. The results suggest a strong relationship between increased gas emissions and crustal stress accumulation. While not all earthquakes show identical gas behavior, the consistent pre-seismic anomalies in helium and hydrogen indicate the potential for gas monitoring as part of a multi-parameter earthquake forecasting system in seismically active regions of Uzbekistan.

Keywords: earthquake, helium, hydrogen, groundwater, water level, anomaly

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ЖЕР СІЛКІНІСІ КЕЗІНДЕГІ СУ МЕН ГАЗ ДЕҢГЕЙІНІҢ ӨЗГЕРУІН ГИДРОГЕОСЕЙСМОЛОГИЯЛЫҚ БАҚЫЛАУ

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Аннотация. Соңғы зерттеулер жер асты суларындағы гидрохимиялық параметрлердің, әсіресе еріген газдардың өзгерістері жер сілкіністерінің алдын ала белгілері болуы мүмкін екенін көрсетті. Бұл зерттеуде Өзбекстандағы сейсмикалық оқиғаларға дейін және кейін жер асты суларындағы гелий мен сутегі газы концентрацияларының аномалиялары қарастырылды. Зерттеу Ташкенттегі Каржантау жарылыс аймағында орналасқан №1 ұңғыма мәліметтеріне негізделген. Өлшеулер 2023 жылғы қазаннан 2024 жылғы қарашаға дейін "Kristallyuks 4000M" газдық хроматографы және pH пен Eh анықтауға арналған ионометриялық әдістер арқылы жүргізілді. Гелий концентрациясы фондық деңгейден (0.001–0.004%) жер сілкінісі алдында 0.006–0.022%-ке дейін артты (магнитудасы M=3.2–3.7 аралығында). Сутегі де 0.001–0.002%-тен 0.014%-ке дейін көбейді. Бұл аномалиялар әдетте жер сілкінісінен 10–30 күн бұрын байқалып, кейін төмендеді, дегенмен кейбір жағдайларда фондық деңгейден жоғары қалды. Жақын маңдағы ұңғымаларда (EOCC 2, 3, 4) да сейсмикалық оқиғалар алдында жер асты суының деңгейі айтарлықтай өзгерді. Газ аномалиялары мен сейсмикалық белсенділік арасындағы кеңістіктік байланыс Добровольский формуласы арқылы талданды. Зерттеу нәтижелері газ шығарылымының артуы мен жер қыртысындағы кернеудің жиналуы арасында күшті байланыс бар екенін көрсетеді. Барлық жер сілкіністері бірдей газдық реакция көрсетпегенімен, гелий мен сутегінің тұрақты алдын ала аномалиялары газ мониторингінің Өзбекстанның сейсмикалық белсенді аймақтарында көп параметрлі болжау жүйесінің бір бөлігі ретінде маңыздылығын дәлелдейді.

Түйін сөздер: жер сілкінісі, гелий, сутегі, жер асты сулары, су деңгейі, аномалия

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ГИДРОГЕОСЕЙСМОЛОГИЧЕСКИЙ МОНИТОРИНГ ИЗМЕНЕНИЙ УРОВНЯ ВОДЫ И ГАЗА ВО ВРЕМЯ ЗЕМЛЕТРЯСЕНИЙ

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Аннотация. Недавние исследования показали, что изменения гидрохимических параметров, особенно концентрации растворённых газов в подземных водах, могут служить предвестниками землетрясений. В данной работе анализируются аномалии концентраций гелия и водорода в подземных водах до и после сейсмических событий в Узбекистане, с акцентом на данные из скважины № 1, расположенной в зоне разлома Каржантау (г. Ташкент). Измерения проводились с октября 2023 года по ноябрь 2024 года с использованием газового хроматографа «Кристаллюкс 4000М» и ионометрических методов для определения pH и Eh. Концентрация гелия увеличивалась от фоновых значений (0,001–0,004 %) до пиковых (0,006–0,022 %) перед землетрясениями магнитудой M = 3,2–3,7. Уровень водорода также возрастал от 0,001–0,002 % до 0,014 %. Эти аномалии наблюдались за 10–30 дней до землетрясений и снижались после событий, хотя в некоторых случаях оставались выше фонового уровня. Уровень подземных вод в соседних скважинах (EOCC 2, 3, 4) также демонстрировал заметные колебания перед сейсмическими событиями. Пространственная корреляция между газовыми аномалиями и сейсмической активностью была проанализирована с использованием формулы Добровольского для определения радиуса действия предвестников. Полученные результаты указывают на тесную связь между повышением газовыделения и накоплением напряжений в земной коре. Хотя не все землетрясения сопровождаются одинаковыми газовыми изменениями, устойчивые предсейсмические аномалии гелия и водорода подтверждают перспективность газового мониторинга как части многопараметрической системы прогнозирования землетрясений в сейсмоактивных регионах Узбекистана.

Ключевые слова: землетрясение, гелий, водород, подземные воды, уровень воды, аномалия

Introduction. To date, research conducted by scientists worldwide has recorded anomalies in more than forty hydrochemical parameters in groundwater in relation to numerous earthquakes. The most frequently observed anomalies are primarily seen in radon, helium, carbon dioxide, groundwater level, oxygen, and hydrogen isotopes. Radon, a radioactive element, can change its concentration in the earth, water, and atmosphere before, during, and after an earthquake. Radon is produced by the decay of uranium and thorium in rocks, soil, and groundwater. Typically, high concentrations of these radioactive elements are found in areas with granite

formations or uranium-rich rocks. Helium is a colorless, odorless, and inert gas present in small amounts in the Earth's crust (0.003 mg of helium in 1 kg of Earth material). It is primarily produced through the radioactive decay of heavy elements such as uranium and thorium. This process generates two isotopes of helium: helium-4 (4He) and helium-3 (3He). The majority of helium on Earth is in the form of 4He, but the rarer 3He can be found in trace amounts in some geological formations and natural gas fields. Due to helium's light and inert properties, it rarely reacts with other elements, making it a useful tracer for studying fluid movements in the Earth's crust. Detecting an unusual increase in helium levels near fault lines may indicate some seismic activity before an earthquake. According to the observations of in the Altai Republic region, it was reported that the concentration of helium in groundwater near faults is higher than in groundwater located far from faults, suggesting that helium could be used as a precursor to earthquakes (Sultankhodzhaev et al, 1967; Sultankhodzhaev et al, 1982; Dutova et al, 2020; Wang 2004; Yan 1996; Zhou et al, 2021; Zhu et al, 2024).

The increase in helium gas levels before an earthquake has been recorded in numerous observations and scientific studies. This change is primarily related to tectonic pressure and geodynamic forces in the Earth's crust. Before an earthquake occurs, underground gases, including helium, may escape through fractures. As stress increases in the Earth's crust, the release of gases also rises. These processes are especially significant before large-magnitude earthquakes.

Anomalies have been observed before several earthquakes, including the 1975 China Haicheng earthquake, where a significant increase in helium gas was noted before the 7.4 magnitude event. This situation indicates that helium gas is released due to underground stress and geodynamic forces (Wuyep et al, 2021; Zhang et al, 2022; Zhao et al, 2021).

The rapid increase in helium gas during an earthquake. When an earthquake occurs, the opening of fractures and cavities in the Earth's crust accelerates the release of helium gas. This change is often dependent on the magnitude of the earthquake and the geological characteristics of the region. During large-magnitude earthquakes, the release of helium gas is more noticeable. For instance, during the 1995 Japan Kobe earthquake, the release of helium gas accelerated. The displacement of the Earth's crust and the opening of fractures led to an increased release of gases.

The decrease in helium gas after an earthquake. After an earthquake, fractures and cavities in the Earth's crust may quickly close. As a result, the release of gases ceases or decreases. Once the earthquake has passed and geological structures have recovered, the concentration of gases decreases. For example, during the 2008 China Sichuan earthquake, there was a sharp reduction in helium gas levels in the final phase. This is related to the closing of the Earth's crust and the cessation of gas release (Barkat et al, 2018; Woith 2015; Umeda et al, 2013; Sano et al, 1998; Das et al, 2009)

In the study of the gas-chemical impact of the Nazarbek earthquake in Uzbekistan in 1994, observed in the Lunacharskoye well, anomalies were recorded in the helium and carbon dioxide gas concentrations in groundwater.

Methods and procedures. In this study, the hydrochemical data of well No. 1 observed from October 2023 to November 2024 are presented. The amount of dissolved gases in groundwater was measured throughout the year using the "Kristallyuks 4000M" Chromatograph device. Only the graphs of the parameters where changes were observed are presented in this paper (Figures 6, 7, 8), while the remaining graphs are not provided due to the absence of anomalies.

The pH (hydrogen ion concentration) and Eh (oxidation-reduction potential) levels in groundwater were determined using the Ionomer I-160MI device. Measurements were carried out throughout the year.

The concentrations of cations and anions in groundwater were determined using titration methods.

The above experiments were only conducted for well No. 1, while groundwater levels in other wells were measured throughout the year.

In this work, we used the formula by (Dobrovolsky 1991), which is typically used to evaluate the selection range of seismic precursors, expressed as follows:

$$R = 10^{0.43\,M}$$

Where R is the radius of the effective precursor manifestation depending on the earthquake magnitude. According to this formula, the epicentral distance radii of earthquakes with M = 4, 4.5, 3.2, 3.6, and 3.7 can reach 52.5, 86.1, 23.8, 35.32, and 39 km, respectively. Table 2 provides information about the observed earthquakes.

Geological and geographical characteristics. Uzbekistan is located on the southern border of the Eurasian tectonic plate, which is one of the most complex geological and tectonic structures on the Asian continent. The geological structure of the region falls within the Alpine-Himalayan tectonic belt, where the plates interact with each other, resulting in high seismic activity. The main tectonic plates and zones of Uzbekistan: Eurasian plate: Most of Uzbekistan is located within the Eurasian tectonic plate. This plate covers a large part of the Northern Hemisphere and is relatively stable. However, along the southern borders, friction between the plates causes seismic activity. Indian plate: The Indian plate, moving from the south, moves against the Eurasian plate. This collision process creates enormous compressive forces in the Pamir and Hindu Kush mountain systems, which increases the risk of earthquakes in the southern and eastern parts of Uzbekistan. Pamir-Tian-Shan mountain system: The eastern and southeastern parts of Uzbekistan are located in the seismically active zones of the Shan and Pamir mountain systems. These mountains were formed as a result of the pressure of the Indian Plate on the Eurasian Plate (Yusupov et al, 2024; Yusupov et al, 2024; Yusupov et al, 2025; Yusupov et al, 2025).

Characteristics of tectonic movements: Convergence zones: In the Pamir and Tien Shan mountains, tectonic plates form compression zones, where mountain uplift and strong earthquakes occur.

Plate faults and faults: There are several tectonic faults (for example, the Talas-Fergana fault) located on the territory of Uzbekistan, along which tremors and earthquakes occur.

Seismic activity: Southern Uzbekistan (Kashkadarya, Surkhandarya) and eastern regions (Fergana Valley, Tashkent, Namangan) are considered seismically active zones.

The tectonic location of Uzbekistan makes it one of the seismically dangerous regions. The country is part of the Alpine-Himalayan tectonic belt, where complex movements occur between the Eurasian and Indian plates. Therefore, great attention is paid to building standards and safety measures, taking into account seismic hazards.

The city of Tashkent, the Fergana Valley, and the Andijan, Namangan, Bukhara, and Samarkand regions are among the most dangerous zones. In particular, Tashkent and the Fergana Valley are characterized by greater seismic activity.

The geological structure of Tashkent is complex, which is associated with the tectonic activity and historical development of the region. The city is located in the Tashkent oasis, in the Chirchik River valley and in the surrounding foothills.

Tectonic structure. Tashkent is located in a tectonic region of high seismic activity. There are small and large faults in the earth's crust in the region. The Talas-Fergana fault and other geological dislocations pass near Tashkent, which causes earthquakes.

Groundwater resources. The Tashkent Valley is rich in groundwater resources. These aquifers are located in alluvial rocks and are an important source of water supply for the city. However, high groundwater levels sometimes reduce the strength of the soil and affect the safety of construction.

Seismic risk factors. The presence of soft and water-saturated alluvial rocks in the Tashkent region can amplify seismic waves and increase the damage from earthquakes. Therefore, much attention is paid to earthquake-resistant construction in the city. Figure 1 shows the wells located at the Tashkent landfill.

Wells No. 1, 2, 3, 4 on the territory of the Institute of Seismology of the Academy of Sciences of the Republic of Uzbekistan were established for seismic monitoring and earthquake forecasting (Figure 1). These wells are located in the Karzhantau fault zone. The depth of well No. 1 is 60 m, the drilling diameter is 244 mm, the diameter of the pipe body is 159 mm, and the filter is 10 m. The lithology of the aquifer consists of gravel and sandstone (Figure 2). The gas composition, ionic composition, groundwater level, temperature, pH and Eh values of this well are constantly monitored (Table 1). In the remaining 3 wells, only the water level is measured from April 2021 to November 2024. Information about these wells is presented in Table 1.

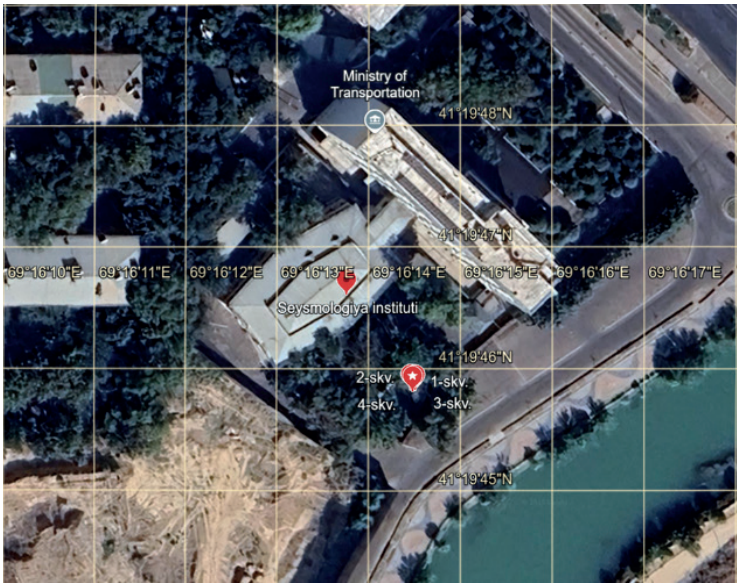

Figure 1. Area where the Swajinas are located.

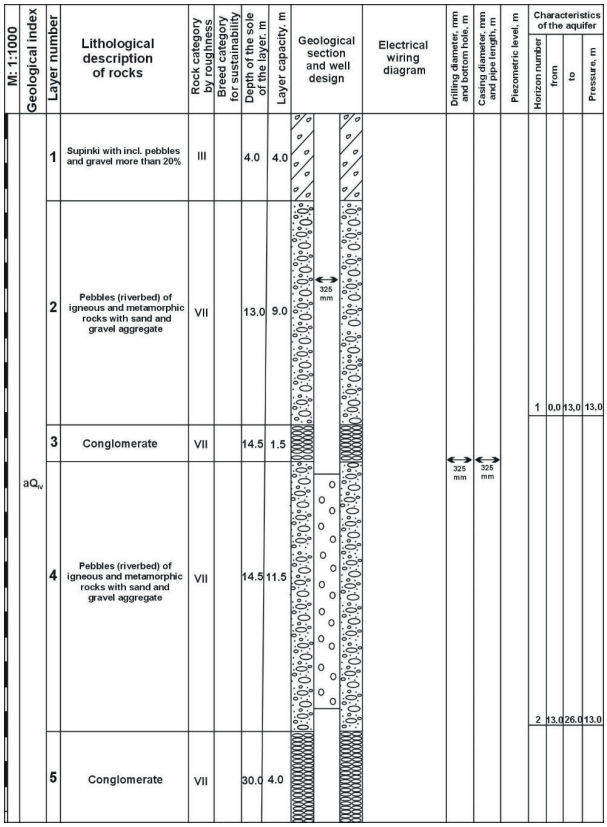

Figure 2. Lithological structure of well No. 1

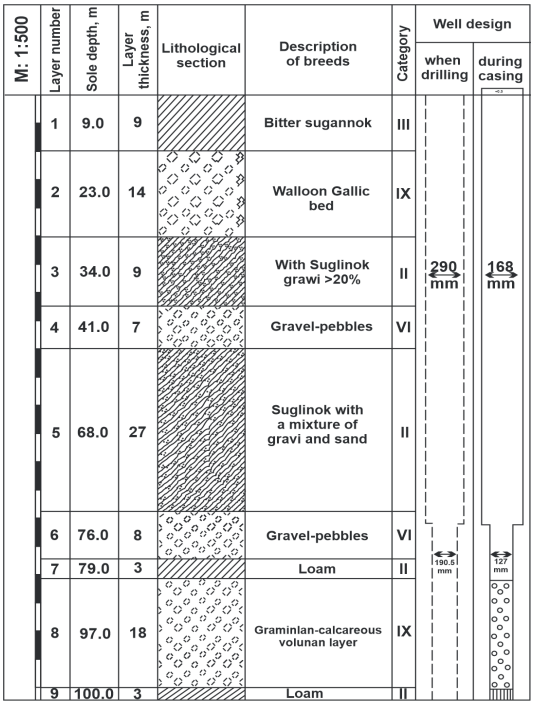

Figure 3. Lithological structure of well No. 2

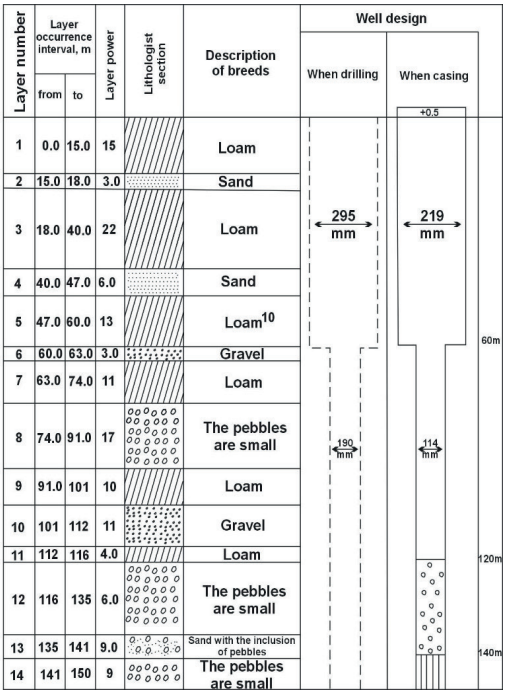

Figure 4. Lithological structure of well No. 3

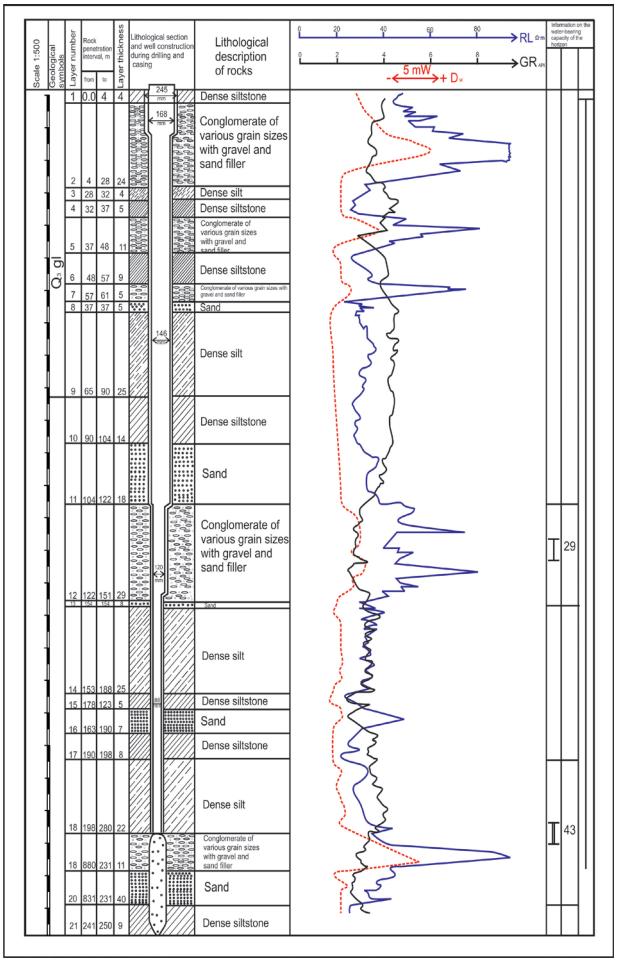

Figure 5. Lithological structure of well No. 4

Table 1. Lithological compositions of the studied wells and monitored parameters

Observation point	Seismotectonic conditions	Depth	Lithological composition of groundwater
Institute of Seismology No. 1 well	Karjantau deep fault	Q_{IV}, 60 m	Sand and gravel
Institute of Seismology No. 2 well	Karjantau deep fault	Q_{IV}, 100 m	Sand, gravel, and conglomerate
Institute of Seismology No. 3 well	Karjantau deep fault	Q_{IV}, 150 m	Sand, gravel, igneous and metamorphic rocks, and conglomerate
Institute of Seismology No. 4 well	Karjantau deep fault	Q_{IV}, 250-300 m	Sand, gravel, igneous and metamorphic rocks, and conglomerate

Table 2. Earthquakes that occurred during the GGS monitoring period

№	Date	Location	M	northern latitude	east longitude	depth km	Epicentral distance (km),
1	11.09.2021	Kazakhstan	3.6	41,55	69,12	15	32
2	05.11.2022	Kazakhstan	4.5	41,56	68,93	15	46
3	26.07.2023	Kazakhstan	4	41,43	68,98	10	27
4	05.04.2024	Kazakhstan	3.2	41,36	69.02	20	13
5	09.09.2024	Uzbekistan Tashkent sh.	3.6	41,33	69,38	5	9
6	19.10.2024	Uzbekistan Middle Chirchiq	3.7	41,03	69,39	10	34

Results and discussion. During the one-year observation period, the helium and hydrogen gases in the groundwater changed in small ranges. However, in the periods before and after the earthquakes, the composition of these gases showed clear changes. Before the earthquake, the pressure of tectonic plates increases, which creates small cracks in the Earth's crust. As a result, it becomes easier for underground gases, including helium and hydrogen gases, to escape to the surface. Helium is formed as a result of the decay of geological rocks, especially uranium. When tectonic activity increases, these rocks crack, and the release of helium into the atmosphere increases. The concentration of helium gas increased from the background value of approximately 0.001% to 0.006% before the earthquake on 05.04.2024 (M=3.2, R=13 km). The anomaly began at the end of March. After the anomaly began, the amount of helium gas increased and decreased after the earthquake. The anomaly, in which the helium content increased from a background value of approximately 0.002% to a maximum value of 0.015% before the earthquake on 09.09.2024 (M=3.6, R=9 km), began in July. After the anomaly began, the gas content gradually increased and reached a maximum value before the earthquake. The background value increased from approximately 0.004% to 0.022% before the earthquake on 09.09.2024 (M=3.6, R=9 km). After the anomaly began in late August, the helium content increased, and after the earthquake it decreased, but was still above the background level (Figure 6).

The hydrogen gas concentration increased from approximately 0.001% to 0.006% of the background value before the earthquake on 05.04.2024 (M=3.2, R=13 km). The gas content increased from the beginning of the anomaly in late March (approximately 28.03.2024). After the increase, the hydrogen content decreased after the earthquake. The background value increased sharply from approximately 0.002% to 0.012% before the earthquake on 09.09.2024 (M=3.6, R=9 km). A significant increase was observed from the beginning of the anomaly in late August (approximately 27.08.2024). After the earthquake, the hydrogen content decreased, but still remained at a high level. The hydrogen concentration reached its highest value in the earthquake of 18.10.2024 (M=3.7, R=34 km),

reaching 0.014%. The gas content increased since the beginning of the anomaly (approximately 05.10.2024). After the earthquake, the gas content decreased, but remained at a stable high level (Figure 7).

Significant changes in the groundwater level were observed in each earthquake. In the 1st earthquake, a decrease in the water level was observed in wells EOCC 2 and EOCC 3. In well EOCC 4, there was a slight change, but a significant decrease. The anomaly began to decrease the water level since August 2021. Before the 2nd earthquake, i.e. since December 2022, the water level in the EOCC 2 well, which began to rise, rose from -12.3 m to -11.8 m, and in the EOCC 3 well, it rose sharply from -12.4 m to -11.7 m. During the 3rd earthquake, a rise in the water level was also observed in the EOCC 2 and 3 wells, from -12.4 m to -12 m and from -12.3 m to -11.9 m, respectively, while no change was observed in the EOCC 4 well. Before the 4th earthquake, i.e. since July 2024, the water level in all three wells began to rise. Uplift anomalies were also observed in the fifth and sixth earthquakes, but only in the sixth earthquake, no change was observed in the EOCC 2 well.

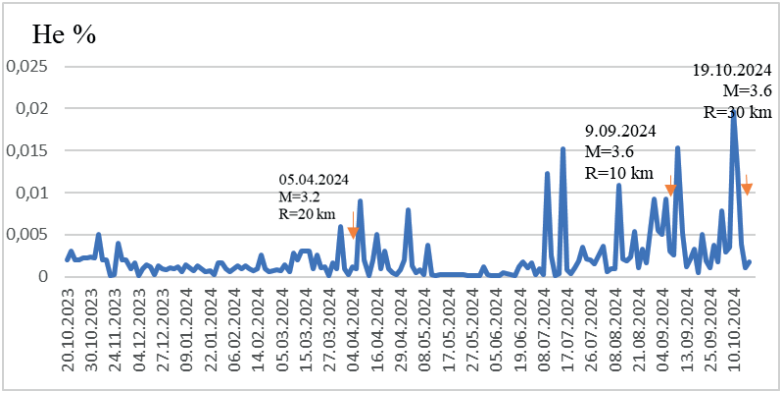

Figure 6: Graph of helium gas changes in well No. 1 on the territory of the Institute of Seismology

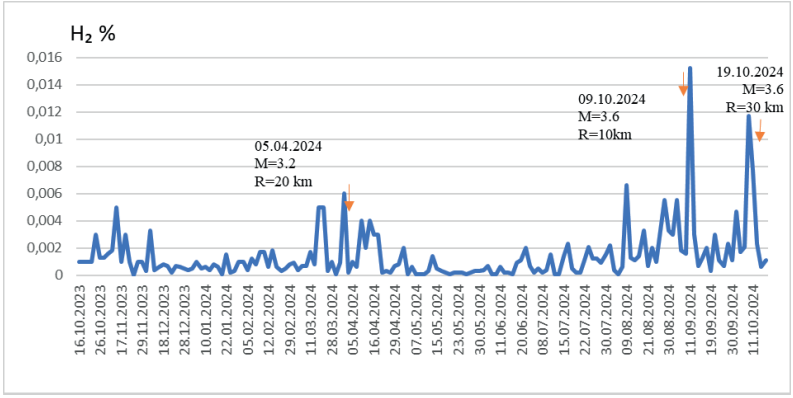

Figure 7. Graph of hydrogen gas changes in well No. 1 on the territory of the Institute of Seismology

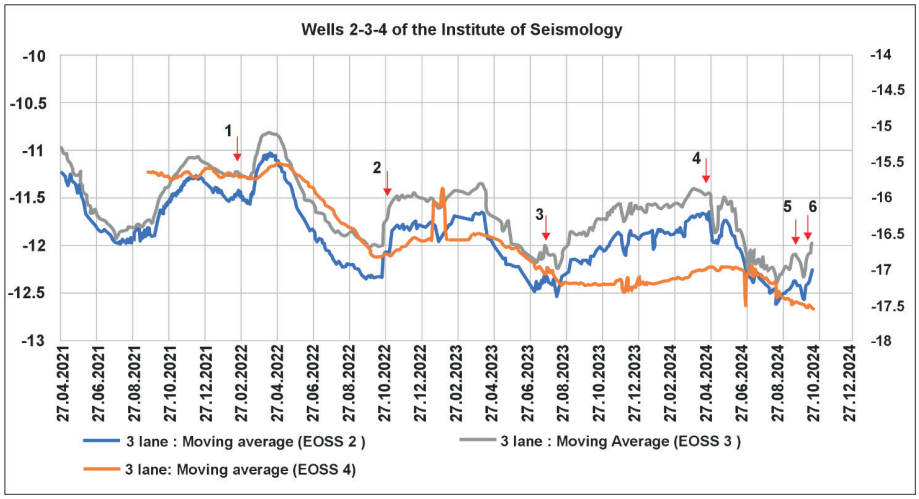

Figure 8. Graph of groundwater level changes in wells No. 2,3,4 on the territory of the Institute of Seismology

Conclusion. The helium gas anomaly began 10-30 days before each earthquake, that is, the amount of helium gas gradually increased. The longest-lasting anomaly was observed before the earthquake on 09.09.2024 (the gas content increased for 25 days). After the earthquake, the amount of helium gas decreased, but in some cases remained above the background level. The amount of helium increased sharply before each earthquake, which indicates an increase in the release of gas from the underground in preparation for earthquakes.

These results may confirm that the increase in helium gas is associated with seismic activity, and indicate the importance of helium monitoring for earthquake forecasting. However, these results may not be repeated in some earthquakes. Therefore, it is worthwhile to confirm these results with many studies.

A sharp increase in the concentration of hydrogen gas was observed several days or weeks before each earthquake. For stronger earthquakes (M=3.6, 3.7), the hydrogen content was relatively higher. After the earthquake, the gas content decreased, but in some cases remained high. The largest was observed before the earthquakes of 05.04.2024 and 09.09.2024.

Usually, the water level decreases or increases before an earthquake, and then returns to its previous state after the earthquake. These changes can be useful for predicting earthquakes in advance. Of the three wells above, EOCC 4 well has the largest changes since the earthquakes, which indicates that deeper aquifers are sensitive to seismic activity.

References

Sultankhodzhaev A.N., Latipov S.U., Zigan F.G., et al. (1967) Gidrogeosejsmologicheskie predvestniki zemletryasenij. Pod redakciej akademika G.A. Mavlyanova [Hydrogeoseismological Precursors of Earthquakes. Edited by Academician G.A. Mavlyanov]. Tashkent: FAN Publishing. — 136 p. (in Russ).

Sultankhodzhaev A.N., et al. (1982) Gidrogeosejsmologicheskie sistemy tektonicheskih razlomov. V razdele: Fizicheskie processy v ochagah zemletryasenij [Hydrogeoseismological Systems of Tectonic Faults. In: Physical Processes in Earthquake Foci]. Moscow: Nauka. — P. 82–98. (in Russ).

Dutova E.M., Kats V.E., Shitov A.V., Surnin A.I., Molokov V.A. (2020) Helium in groundwaters of the Altai Republic. Geodinamika i tektonofizika, 11. — P. 651–663. DOI:10.5800/GT-2020-11-3-0497 (in English).

Wang R., Woith H., Milkereit C., Zschau J. (2004) Modelling of hydrogeochemical anomalies induced by distant earthquakes. Geophysical Journal International, 157. — P. 717–726. DOI:10.1111/j.1365-246X.2004.02240.x (in English).

Yan X., Shi Z., Wang G., Zhang H., Bi E. (2021) Detection of possible hydrological precursor anomalies using long short-term memory: A case study of the 1996 Lijiang earthquake. Journal of Hydrology, 599, 126369. DOI:10.1016/j.jhydrol.2021.126369 (in English).

Zhou Z., Zhong J., Zhao J., Yan R., Tian L., Fu H. (2021) Two Mechanisms of Earthquake-Induced Hydrochemical Variations in an Observation Well. Water, 13. — P. 2385. DOI:10.3390/w13172385 (in English).

Zhu R., Yang F., Zhou X., Tian J., Zhang Y., He M., Li J., Dong J., Li Y. (2024) Anomaly Detection Using Machine Learning in Hydrochemical Data From Hot Springs: Implications for Earthquake Prediction. Water Resources Research, 60, e2023WR034748. DOI:10.1029/2023WR034748 (in English).

Wuyep L.C., Kadiri U.A., Monday I.A., Nansak N.E., Zakka L., Thomas H.Y., Ogugua E.P. (2021) Geo-Chemical Techniques for Earthquake Forecasting in Nigeria. African Journal of Geoscience Research (AJGR). — P. 29–45. DOI:10.9734/ajgr/2021/v4i394 (in English).

Zhang S., Shi Z., Wang G., Yan R., Zhang Z. (2022) Application of the extreme gradient boosting method to quantitatively analyze the mechanism of radon anomalous change in Banglazhang hot spring before the Lijiang Mw 7.0 earthquake. Journal of Hydrology, 612, 128249. DOI:10.1016/j.jhydrol.2022.128249 (in English).

Zhao Y., Liu Z., Li Y., Hu L., Chen Z., Sun F., Lu C. (2021) A case study of 10 years groundwater radon monitoring along the eastern margin of the Tibetan Plateau and in its adjacent regions: Implications for earthquake surveillance. Applied Geochemistry, 131, 105014. DOI:10.1016/j.apgeochem.2021.105014 (in English).

Barkat A., Ali A., Hayat U., Crowley Q.G., Rehman K., Siddique N., Haidar T., Iqbal T. (2018) Time series analysis of soil radon in Northern Pakistan: Implications for earthquake forecasting. Applied Geochemistry, 97. — P. 197–208. DOI:10.1016/j.apgeochem.2018.08.016 (in English).

Woith H. (2015) Radon earthquake precursor: A short review. European Physical Journal Special Topics, 224. — P. 611–627. DOI:10.1140/epjst/e2015-02395-9 (in English).

Umeda K., Asamori K., Kusano T. (2013) Release of mantle and crustal helium from a fault following an inland earthquake. Applied Geochemistry, 37. — P. 134–141. DOI:10.1016/j.apgeochem.2013.07.018 (in English).

Sano Y., Takahata N., Igarashi G., Koizumi N., Sturchio N.C. (1998) Helium degassing related to the Kobe earthquake. Chemical Geology, 150. — P. 171–179. DOI:10.1016/S0009-2541(98)00055-2 (in English).

Das N., Bhandari R., Ghose D., Sen P., Sinha B. (2009) Significant anomalies of helium, radon and gamma ahead of 7.9 M China earthquake. Acta Geodaetica et Geophysica Hungarica, 44. — P. 357–365. DOI:10.1556/AGeod.44.2009.3.7 (in Eng.).

Dobrovol'skiy I.P. (1991) Teoriya podgotovki tektonicheskogo zemletryaseniya [Theory of Tectonic Earthquake Preparation]. Moscow: Institute of Physics of the Earth, USSR Academy of Sciences, 224 p. (in Russ).

Yusupov V.R., Sattorova N.A., Nazarov S.X., Nabiyev S.N., Shaxriyev B.B., Hakimov E.N. (2024) Analysis of hydrogeoseismological anomalies observed in groundwater during earthquakes. Earthquake, 2(2). DOI:10.59429/ear.v2i2.7045 (in English).

Yusupov V.R., Sattorova N.A., Sagdullayeva K.A., Nazarov S., Khakimov E., Shakhriyev

B.B. (2024) Statistical Analysis of the Manifestation of Precursors of Strong Earthquakes in Hydrogeoseismological Parameters. In: Science and Innovation: Proceedings of the International Scientific Conference of Young Scientists. Tashkent: Center for Advanced Technologies, November 15. — P. 215–217. (in Uzb).

Yusupov V., Kayumov B. (2025) Hydrogeoseismological variations in groundwater parameters in the Bukhara region and their correlation with seismic activity. Journal of Geosciences Insights, 3(2). — P. 1–7. DOI:10.61577/jgi.2025.100006 (in English).

Yusupov V.R., Sattorova N.A., Muminov G.Z., Begmatov Kh.U., Qayumov B.R. (2025) Hydrogeoseismological Monitoring: Observing the Relationship Between Water Level and Gas Components with Earthquakes. In: Topical Issues of Engineering Seismology and Seismic Risk Assessment – TASECO-2025: Proceedings of the Scientific-Practical Conference, Tashkent, June 10–11. — P. 179–182. (in Uzb).

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