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Satbayev University

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ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ
НАУК РЕСПУБЛИКИ
КАЗАХСТАН
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HYDROGEOSEISMOLOGICAL PRECURSORS SUSAMYR EARTHQUAKE 1992

Abstract. On August 19, 1992, in the central spurs of the Northern Tien-Shan in the Susamyr ridge, one of the strongest earthquakes in Central Asia in the last century occurred, which value M=7.5 in magnitude. The Susamyr earthquake, named after the place of origin, was preceded by anomalies in the seismic regime, geophysical, hydrogeological and geochemical fields, were noted in the Tashkent, Fergana, Bishkek, Almaty, Issyk-Kul, Dzhungar and Urumchi seismic prognostic fields.As a result of synchronization of the anomaly occurrence time for this event for all polygons, it was possible to note that the earliest anomalies in the hydrogeodynamic, hydrogeochemical and gas composition of groundwater were recorded 2-2.5 months before. The greatest interest is caused by the development of the anomaly in the far zones in the Tashkent geodynamic test site. This paper presents the results of routine observations of the seismohydrogeological parameters of groundwater in seismically active zones of Uzbekistan. The research period covers the time of preparation and implementation of the strongest earthquake over the last century. Hydrogeochemical, hydrogeodynamic, geophysical conditions of manifestation and seismotectonic conditions of localization of the source and location of observation water points relative to the epicenter of this earthquake on the territory of the Republic of Uzbekistan are considered. A complete review of all materials shows that anomalies of destructive earthquakes arise mainly as a result of renewal of large, global faults that limit multidirectional tectonic

structures, which affected the spread of anomalous precursor phenomena over a vast territory.

Key words: precursor, magnitude, tectonic conditions, anomaly, variation, background value, hydrogeoseismology, seismogenic zones, gas concentration, isotopic composition.

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1992 ЖЫЛҒЫ СУСАМЫР ЖЕРСІЛКІНІСІНІҢ ГИДРОГЕОСЕЙСМОЛОГИЯЛЫҚ БЕЛГІЛЕРІ

Аннотация. 1992 жылы 19 тамызда Солтүстік Тянь-Шаньның орталық сілемдерінде Сусамыр жотасында өткен ғасырдағы Орталық Азиядағы ең күшті жер сілкіністерінің бірі болып, магнитудасы М=7,5-ке жетті. Сусамыр жер сілкінісі пайда болған жердің атымен аталған, оның алдында сейсмикалық режимдегі, геофизикалық, гидрогеологиялық және геохимиялық өрістердегі ауытқулар байқалды және олар Ташкент, Ферғана, Бішкек, Алматы, Ыстықкөл, Жоңғар және Үрімші сейсмикалық болжамдық бақылау полигондарында орын алды. Барлық полигондар үшін аномалиялардың пайда болу уақытын синхрондау нәтижесінде жер асты суларының гидрогеодинамикалық, гидрогеохимиялық және газдық құрамындағы ең ерте ауытқулар осыдан 2-2,5 ай бұрын тіркелгенін атап өтуге болады. Ең үлкен қызығушылық Ташкент геодинамикалық полигонындағы алыс аймақтардағы аномалия дамуымен байланысты. Бұл мақалада Өзбекстанның сейсмикалық белсенді аймақтарындағы жер асты суларының сейсмогидрогеологиялық параметрлерін жоспарлы бақылау нәтижелері берілген. Зерттеу кезеңі өткен ғасырдағы ең мықты жер сілкінісінің дайындық және жүзеге асқан уақытын қамтиды. Өзбекстан Республикасы аумағындағы осы жер сілкінісінің эпицентріне қатысты бақыланатын су нүктелерінің көзі мен орналасуының гидрогеохимиялық, гидрогеодинамикалық, геофизикалық көріністері мен сейсмотектоникалық жағдайлары қарастырылады. Барлық материалдарды толық шолу жойқын жер сілкіністерінің аномалиялары негізінен кең аумақта аномальды прекурсорлық құбылыстардың таралуына әсер еткен көп бағытты тектоникалық құрылымдарды шектейтін ірі, ғаламдық жарықшақтардың жаңаруы нәтижесінде туындайтынын көрсетеді.

Түйін сөздер: алдын ала болжау, магнитуда, тектоникалық жағдайлары, ауытқуы, вариациясы, фондық мәні, гидрогеосейсмология, сейсмогендік аймақтар, газ концентрациясы, изотоптық құрам.

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ГИДРОГЕОСЕЙСМОЛОГИЧЕСКИЕ ПРЕДВЕСТНИКИ СУСАМЫРСКОГО ЗЕМЛЕТРЯСЕНИЯ 1992 ГОДА

Аннотация. 19 августа 1992 года в центральных отрогах Северного Тянь-Шаня в хребте Сусамыр произошло одно из самых сильных за последние столетие в Средней Азии землетрясение, которое достигло по магнитуде М=7,5. Названное по месту возникновения Сусамырское землетрясение предварялось аномалиями в сейсмическом режиме, геофизических, гидрогеологических и геохимических полях, отмечались на Ташкентском, Ферганском, Бишкекском, Алматинском, Иссык-Кульском, Джунгарском и Урумчинском сейсмопрогностических полях. В результате синхронизации времени возникновения аномалии по данному событию по всем полигонам удалось отметить, что наиболее ранние аномалии в гидрогеодинамическом, гидрогеохимическом и газовом составе подземных вод зафиксировано за 2-2,5 месяца. Наибольший интерес вызван развитием аномалии в дальних зонах в Ташкентском геодинамическом полигоне. В данной работе приведены результаты режимных наблюдений за сейсмогидрогеологическими параметрами подземных вод сейсмоактивных зон Узбекистана. Период исследований охватывает время подготовки и реализации сильнейшего землетрясения за последнее столетие. Рассматриваются гидрогеохимические, гидрогеодинамические, геофизические условия проявления и сейсмотектонические условия локализации очага и нахождения, наблюдательных водопунктов относительно эпицентра этого землетрясения на территории Республики Узбекистан. Полное рассмотрение всех материалов показывает, что аномалии разрушительного землетрясения возникают в основном в результате обновлений крупных, глобальных разломов, ограничивающих разнонаправленные тектонические структуры, что и отразилось на распространение аномальных явлений – предвестников на огромной территории.

Ключевые слова: предвестник, магнитуда, тектонические условия, аномалия, вариация, фоновое значение, гидрогеосейсмология, сейсмогенные зоны, газовая концентрация, изотопный состав.

Introduction. The main characteristics of the Susamyr earthquake. One of the strongest earthquakes in Central Asia over the past century - the Susamyr earthquake occurred on August 19, 1992 with M=7.4, at a depth of 25 km (coordinates 42.07N, 73.63E) on the territory of Northern Kyrgyzstan in the Northern spurs of the Northern Tien-Shan. This earthquake affected a large territory of Central Asia, including all seismogenic zones in Kazakhstan, Kyrgyzstan and Uzbekistan (Abdullaev, 2002). In view of the large amount of data, this article presents the materials received on the territory of Uzbekistan.

The focal mechanism of the Susamyr earthquake is reverse fault with a small shear component; both possible planes have a sublatitudinal position, which is confirmed by the sublatitudinal strike of two sections of the rupture that emerged to the surface. The position of the compression axis is submeridional and near-horizontal, the tension axis is near-vertical (Sultankhodzhaev et al, 1983), (Kuchay et al, 2002).

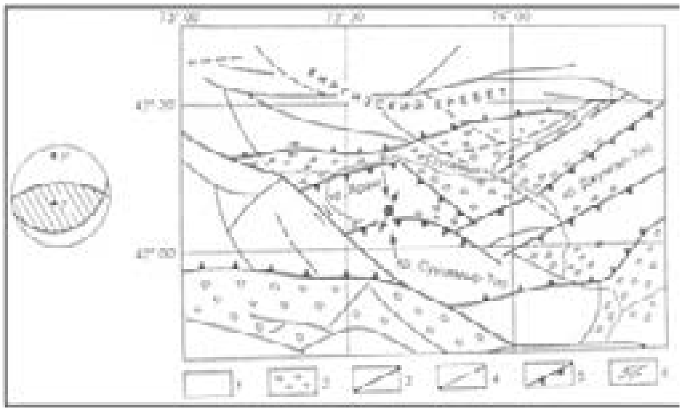

Fig. 1. Geological and tectonic scheme of the area of the Susamyr earthquake (Bagachkin et al., 1993).
1-Pre-Cenozoic sediment, 2-Cenozoic sediment, 3-major marginal faults, 4-predicted faults, 5-thrusts and thrusts, 6-strike-slip faults. The arrows show the compression and extension axes at the epicenter of the Susamyr earthquake. To the left of the main figure is a diagram of the source mechanism of the main earthquake according to the Harvard CMT catalog (upper hemisphere).

According to the seismological study, the source of the Susamyr earthquake was located in the disjunctive node of the intersection of faults of the nearlatitudinal Tien-Shan (Aramsuupthrust) and Northwest Talas-Fergana (Ichkeletau-Susamyr) orientations (Bagachkin et al., 1993).

The Susamyr earthquake occurred in the zone of seismic calm, which was considered characteristic of the inner part of the Tien Shan, at M = 7.4 it was felt in the epicentral area with an intensity of 9-10 points. It was accompanied by a large number of aftershocks that lasted for several years. Taking into account that the aftershock with M = 6.7 lags slightly behind the main shock both in time (after 1 hour and 8 minutes) and in magnitude (by 0.7 units), in the case of the Susamyr earthquake we can speak of a conjugate double shock (Kalmetyeva et al., 2009).

Materials and methods of research. Hydrogeodynamic and hydrogeochemical observations at geodynamic test sites. Abnormal displays of hydrogeoseismological and geophysical parameters were observed at many seismic forecast stations in Uzbekistan. The layout of the forecasting stations is shown in Fig. 2. The Susamyr earthquake affected the vast territory of Central Asia (Sultankhodzhaev et al, 1983), which can be confirmed by anomalous displays in the wells of Chartak (180 km), Khodjabad (190 km), Chimion (268 km), Tashkent (370 km), Khavatag (480 km), Shurchi (650 km) and Bukhara (850 km). At all stations, the M/LgR value was greater than 2.5 (where M is the magnitude and R is the epicentral distance of earthquakes). For convention, this value will be denoted by M/ LgR = I. The value of I is used as a parameter characterizing the intensity of earthquake preparation processes, taking into account the remoteness of the corresponding sources from the center of the polygon (Serafimova & Kopylova. 2010).

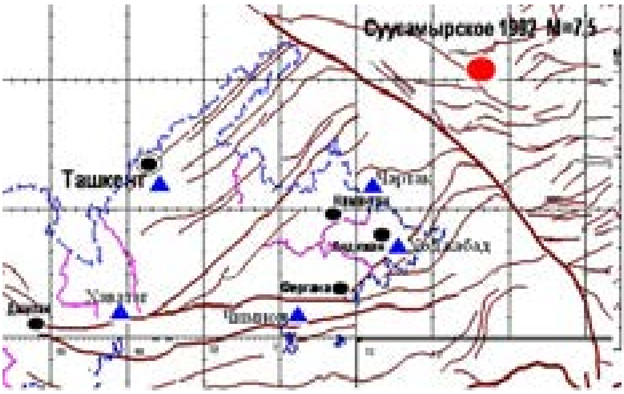

Fig. 2. Schematic map of the location of the HGH and HGD water points for observations of the epicenter of the Susamyr earthquake.

- the epicenter of the earthquake;
- city names;
- GGS forecast stations

For Central Asia, as practice shows, earthquakes with values of the sensitivity zone of the parameter - I is greater than or equal to 2.5, can be considered as included in the sensitivity zone of the HGS observations (Nurmatov et al., 2016).

Table 1

	M	Tash-kent		Chartak		Andijan		Jimyeon		Hawa-tagh		Zhuma-bazaar		Shurchi		Bukhara		Zhan-geldi	
		R, km	I	R, km	I	R, km	I	R, km	I	R, km	I	R, km	I	R, km	I	R, km	I	R, km	I
19. 08. 1992	7,5	380	2. 90	180	3. 25	180	3.32	270	3.08	470	2.80	610	2. 69	670	2. 65	820	2.57	870	2. 55

Apparently, as seen in Table 1, the anomalous displays of HGSP before the Susamyr earthquake reflect displays of the stress-strain state of seismotectonic structures of different ranks in the region, i.e. vast territory of Central Asia (Abdullaev, 2002).

The Susamyr earthquake on August 19, 1992, affected a large territory of Central Asia, i.e., in all seismogenic zones of Uzbekistan, for all forecast stations the value of I (M/ℓgR) was more than 2.5. Despite the anisotropy of the environment and the separation of the earth's crust space between the earthquake source and observation points by breaks, all these stations (water points) reacted to the preparation and implementation of the Susamyr earthquake with displays of anomalous changes in various indicators of groundwater.

In the generalizing works (Abdullaev & Yusupov, 2020), (Kopylova & Voropaev, 2006) the most well-known data on hydrogeochemical precursors are given and it is shown that these data allow one to estimate the general regularities of these anomalies with future earthquakes and the characteristic times and lead times of their manifestation. Obtaining such estimates is a primary task in providing a scientific basis for the use of hydrogeoseismologycal (HGS) methods for predicting earthquakes.

The following materials were used in the work: the time series of observation data for the GGS parameters of groundwater at the forecasting stations of Uzbekistan (artesian basins of the Pritashkent and Fergana, the Khavatag, Zhumabazar and Shurchi fields, at the Bukhara well) obtained for 1991-1992. Seismic Prognostic Monitoring Center of the Ministry of Emergency Situations of the Republic of Uzbekistan.

The traditional method of hydrogeochemical observations is continuous monitoring of water-gas systems of groundwater at self-flowing wells and springs, followed by gas-chemical analysis of water composition in laboratory conditions. The frequency of hydrogeochemical observations ranges from weekly to several times a week.

This method of searching for earthquake precursors is based on the sensitivity of the underground hydrosphere to changes in the stress-strain state of the earth's crust at the stages of earthquake preparation (Sultankhodzhaev et.al, 1983), (Abdullaev, 2002). It is a system of hydrogeodynamic (water level, flow rate of sources and wells, reservoir pressure), hydrogeochemical (composition of water, gases and isotopes) and temperature indicators.

Research results. Let us consider for all water points individual parameters that appeared during the preparation and implementation of the Susamyr earthquake.

Carbondioxide. Carbon dioxide is one of the most active and informative earthquake precursors for our region. It showed itself as a harbinger before such earthquakes as Tavaksay, Nazarbek, Izbaskan, Uchkurgan and other earthquakes.

In parallel with the study of the concentration of carbon dioxide in groundwater, the isotopic composition of carbon $\delta^{13}C$ in CO_2 dissolved in groundwater in the Tashkent geodynamic test site and partially at the wells of the Chartak forecasting station was measured. Isotopic studies have shown that anomalous displays of carbon dioxide are associated with stress-strain processes in the carbonate gas-water-rock system, and δ13C acts as an indicator.

As you can see, one of the most active and informative HGSPs, CO_2, manifested itself in almost all water points in all seismically active regions of Uzbekistan. One of the visible features of this precursor is that the closer the observation post is to the epicenter, the anomaly manifests itself before the earthquake and the further from the epicenter it manifests itself during or after the earthquakes. Abnormal displays of carbon dioxide in groundwater are mainly explained by imbalance in the carbonate system (gas-water-rock) of groundwater and cracking in water-bearing rocks during changes in the stress-strain states of the earth's crust (Nurmatov et al., 2016).

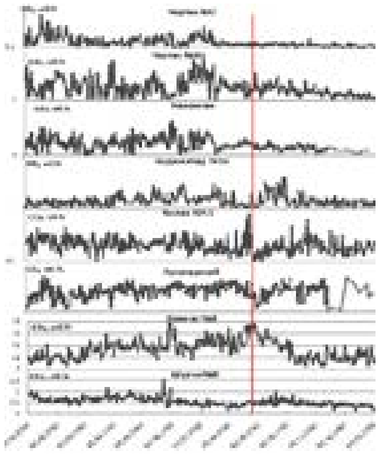

Fig. 3. Abnormal CO_2 variations in groundwater in Uzbekistan during Susamyr earthquake.

Changes in the organic components of the gas composition can also be attributed to anomalous displays, i.e. content of methane (CH_4) in groundwater (Fig. 4).

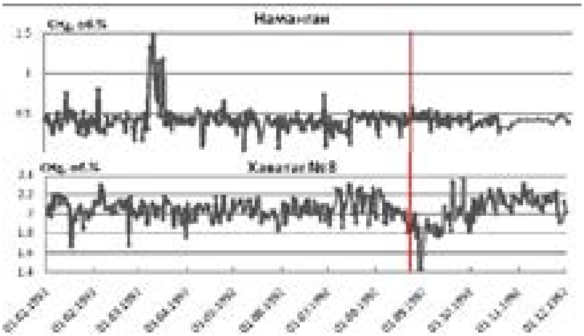

Fig. 4. Anomalous variations in CH_4 temperature in groundwater in seismically active regions of Uzbekistan during the Susamyr earthquake.

It can be seen from Fig. 4 that, at the nearest station, a positive organic gas anomaly manifests itself before the earthquake (at the beginning of March, 5 months ahead), and at the distant station, i.e. in Hawatagh manifested itself during the events (negative anomaly).

In terms of temperature, there were anomalies in all wells in the groundwater. Basically, an increase in temperature (Chartak, Khodjabad, Khavatag) before the earthquake, and in Tashkent wells, anomalies were observed during earthquakes (Fig. 5).

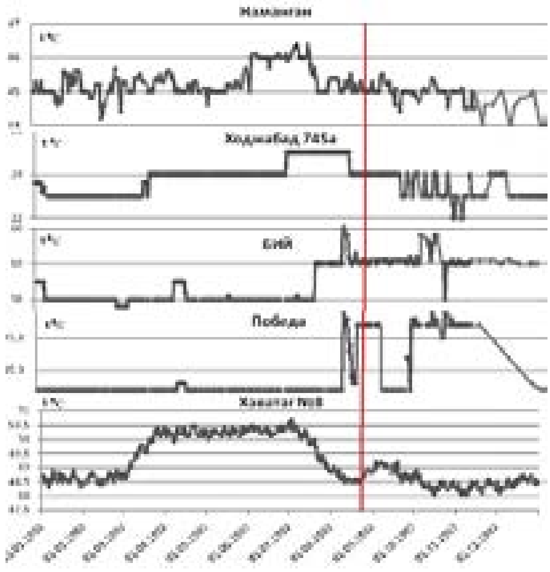

Fig. 5. Abnormal temperature variations (t^0C) in groundwater during the Susamyr earthquake.

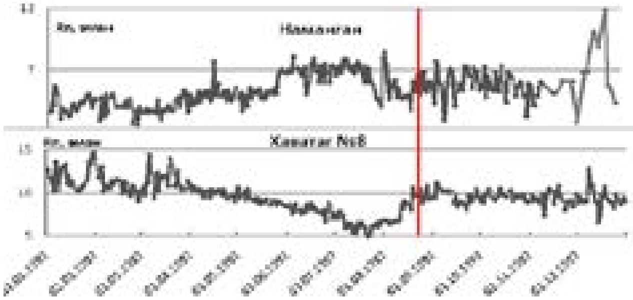

Fig. 6. Abnormal variations in Rn content in groundwater during the Susamyr earthquake.

Dissolved gas - radon also manifested itself at the nearest station (well Namangan) before the earthquake with a positive anomaly and at the distant station (Khavatag), also before the earthquake, but with a negative anomaly. Apparently, the processes of compression (Namangan) and extension (Khavatag) of mountain water-bearing layers played a role here.

The indicators of the groundwater environment (pH-Eh) experienced anomalous variations during the implementation of the Susamyr earthquake (see Fig. 7).

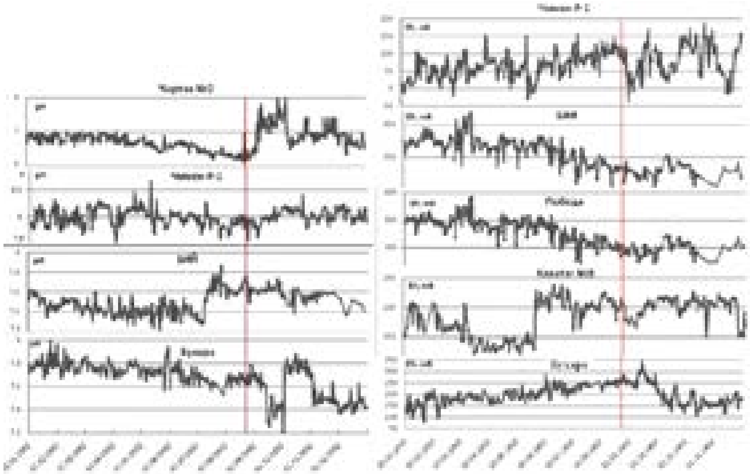

Fig. 7. Anomalous variations in pH and Eh in groundwater of the Susamyr earthquake.

Thus, in the manifestation of earthquakes and associated precursors, a special place is occupied by the spatial position of tectonic blocks and seismogenic faults limiting them. In the manifestation of precursors over long distances, the decisive role is played by the scales of tectonic blocks, along the boundaries of which the impulse of tectonic stresses propagates.

The degree of «sensitivity» of individual points, the nature, intensity and time of manifestation of precursor anomalies are primarily due to the generality or difference in the structural-geological and seismotectonic conditions of the location of earthquake foci and observation points, as well as the power (strength) of the impending earthquake. The ambiguous behavior of the precursor parameters, even when the earthquake source is located relatively close to the observation point, indicates that there are other factors that control the displays of precursor deformation at different scale levels (ranks). Until now, the mechanism of transmission of the precursor disturbance over long distances has not been established.

Conclusion. The main reason for all displays of earthquake precursors, apparently, is due to a change in the stress-strain state of the earth's crust of the entire region.

Table 2 shows us the general tendency of the stress-strain state of the earth's crust on a regional scale and, as a result, changes in the gas-chemical composition in groundwater act as indicators of the degree of the deformed state of the earth's crust in a given region. For clarity, in the table, all the parameters that manifested themselves in pre-seismic activation were marked in green, the parameters that manifested themselves in co-seismic activation were marked in yellow, and the parameters that were manifested already post-seismic were marked in red.

Table 2

Station	Wells	R, km	M/LgR	Doseismic. parameters	Koseimich. parameters	Postseism. parameters	Note
Chartak	Well 2	180	3,25	CO_2, He, °t, Eh, H		P	
	Well 6			CO_2, He			
	Well. Namangan			CO_2, He, ° t CH_4	Eh		
Khojab.		180	3,32		° t	CO_2, Cl^-, P, HCO_3^-	
Chimion	Well R-1	210	3,08	° t, pH, Eh, Si_2O			
	Sq. HP-1			CO_2,			
Tashkent	BIIT	380	2,90		CO_2 ° t, Eh		
	Victory				° t. Rn, Eh		
Hawatag		410	2,89	Rn, °t, , CH_4	CO_2, Eh		
Shurchi		670	2,65			CO_2,	
Bukhara		820	2,57			Eh, pH	

The precursors of the Susamyr earthquake manifested themselves mainly at close distances, i.e. closer to the epicenter of earthquakes. The farther from the epicenter, the less the predictive abilities of the HGH parameters were manifested. On the other hand, these anomalies are directly proportional to the energy of earthquakes, which can be seen from the example of the Susamyr earthquake.

This indicates to us that, regardless of the geological and tectonic conditions for strong earthquakes, like Susamyr (M = 7.4), the propagation of the deformation field goes far beyond the limits of one polygon, covers large territories (thousands of km_2).

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