Код МРНТИ 38.61.31

*D.S. Sapargaliyev[1, 2, 3], V.M. Mirlas[4], Y.Z. Murtazin[2], V.A. Smolyar[2]
[1]Satbayev University (Almaty, Kazakhstan),
[2]Institute of Hydrogeology and Geoecology named after U.M. Ahmedsafin, Satbayev University (Almaty, Kazakhstan),
[3]Kyrgyz State Technical University named after I. Razzakov (Bishkek, Kyrgyzstan),
[4]Department of Chemical Engineering and Materials & Biotechnology, Ariel University (Ariel, Israel)

HYDROGEOLOGICAL STUDY AND ASSESSMENT OF THE GROUNDWATER RESOURCES IN THE CRETACEOUS DEPOSITS OF THE ZHEM BASIN

Abstract. This article analyses the hydrogeological study and prospects of the Albian-Cenomanian aquifer complex confined to the second-order Zhem artesian basin. Data on calculating operational groundwater reserves for 77 groundwater well fields and sites associated with the Albian-Cenomanian aquifer complex were analysed. The description of the estimated resources included evaluations of the main hydrogeological parameters, long-term information on precipitation, flow rates, and water levels for seven main rivers of the Zhem basin area, summarised and analysed data on 8 meteorological and 12 hydrological stations, monitoring observations on groundwater levels at 13 hydrogeological sites, including 54 wells, were analysed. Conclusions have been drawn regarding the perspectives of Albian-Cenomanian aquifer complex use and further prospection.

Key words: *Albian-Cenomanian aquifer complex, groundwater resources, Zhem basin, Aktobe region, precipitation, river water flow, groundwater monitoring.*

Жем алабының бор шөгінділеріндегі жерасты сулары қорларының қалыптасу жағдайларын гидрогеологиялық зерттеу және бағалау

Аңдатпа. Мақалада Жем артезиан алабының бор шөгінділерінің альб-сеномандық сулы кешенінің гидрогеологиялық зерттелуіне және болашағына талдау жасалған. Аймақаралық басқармасындағы аумақтық бөлімшелері сынаған альб-сеноман сулы кешенін ашатын 77 кен орны мен учаскесі бойынша жерасты сularының пайдалану қорларын бағалаған мәліметтерге талдау жасалған. Жұмыс аймағында орналасқан 8 метеостанция мен 12 гидрологиялық посттың мәліметтері негізінде жауын-шашын, және де аумақтың 7 негізгі өзені бойынша ағынның жылдамдығы және су деңгейі туралы ағымдағы ақпарат жинақталып, талданған. Жерасты суларының мемлекеттік мониторингі желісінің 54 ұңғымаданы қамтитын 13 гидрогеологиялық пост бойынша жерасты суларының деңгейін бақылаудың деректері талданған. Жем артезиан алабының альб-сеноман шөгінділеріндегі жерасты суларын қолдану перспективалары туралы қорытындылар жасалған.

Түйінді сөздер: *альб-сеноман шөгінділері, жерасты суларының қорлары және ресурстары, Жем алабы, Ақтөбе облысы, жауын-шашын, өзен суының ағыны, бақылау.*

Гидрогеологическая изученность и оценка условий формирования ресурсов подземных вод меловых отложений Жемского бассейна

Аннотация. В статье приведен анализ перспектив использования водоносного альб-сеноманского комплекса меловых отложений Жемского артезианского бассейна. Проанализированы материалы подсчета эксплуатационных запасов подземных вод по 77 месторождениям и участкам, вскрывающих водоносный альб-сеноманский водоносный комплекс. Определены значения основных гидрогеологических параметров, характерных для описываемых отложений. Обобщены и проанализированы актуальные сведения об осадках, расходах и уровнях воды по 7-ми основным рекам региона по данным 8-ми метеорологических станций и 12-ти гидрологических постов, расположенных в районе работ. Проанализированы данные мониторинговых наблюдений за уровнем подземных вод по 13 гидрогеологическим постам, в том числе по 54 скважинам. Сделаны выводы о перспективах освоения подземных вод альб-сеноманских отложений Жемского артезианского бассейна.

Ключевые слова: *альб-сеноманские отложения, запасы и ресурсы подземных вод, Жемский бассейн, Актюбинская область, атмосферные осадки, расходы речной воды, мониторинг.*

Introduction

The Zhem (formerly Emba) artesian basin and its block-formation waters are classified as second-order basins and belong to the Caspian system of first-order artesian basins [1, 2]. The basin is located in the eastern part of the Caspian Depression and characterised by a ridged-hilly plain with elevations ranging from 50-75 to 300-420 m. Ravines and river valleys dissect the area. The Zhem basin shares borders with several other second-order basins: the South Pre-Ural to the northeast, the Dongystau-Predmugalzharsky to the east and south, the North Caspian to the southwest, and the Syrtovsky to the northwest. Its northern boundary is defined by the state border between the Republic of Kazakhstan and the Russian Federation (see Fig. 1). The Zhem basin is located in the Aktobe region of Western Kazakhstan, which lacks significant operational groundwater reserves included in the State balance evaluations [3]. The exploitable groundwater reserves of other administrative regions in Western Kazakhstan, such as Mangistau, West Kazakhstan, and Atyrau, are considerably less than those of the Aktobe region, respectively 4.8, 5.2, and 7.4 times smaller. By 2030, the demand for drinking water in the Aktobe region may double and reach 321,060 m^3/day [4]. This increase is attributed to the region's growing population as well as the development of industrial and agricultural areas [5].

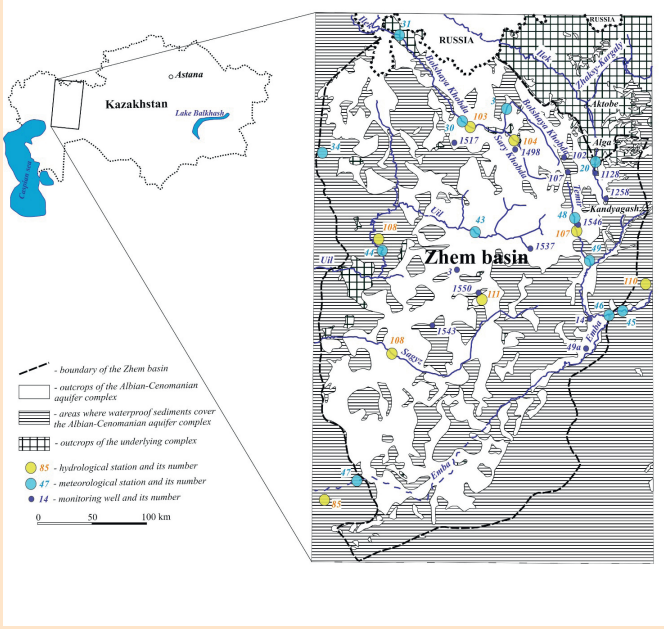

Figure 1. Zhem artesian basin.
Сурет 1. Жем артезиан алабы.
Рис. 1. Жемский артезианский бассейн.

As of November 2022, only 196 out of 315 rural settlements in the Aktobe region have access to centralised water supply services, according to the official data [3].

The most promising water supply source for the settlements and industrial facilities within the Zhem basin is the Cretaceous Albian-Cenomanian aquifer complex, which has a predominant mineralisation of up to 3 g/L.

Materials and Methods

Data from exploration work carried out during the search, assessment, and revaluation of operational groundwater reserves for 381 well fields and groundwater sites in the Aktobe region were used to characterise aquifer hydrogeological parameters. This included 77 well fields and sites confined to the Albian-Cenomanian aquifer complex. The State Commission has tested these data for the Mineral Reserves of the Republic of Kazakhstan or its territorial subdivision under the Interregional Department named «Zapkaznedra» (since 2018 – the State Commission for Subsoil Expertise or its subcommission under the Interregional Department «Zapkaznedra»). The sources used to compile the Cadastre of Groundwater Resources of the Republic of Kazakhstan as of 01/01/2021 include the Directory of Groundwater Well Fields of Kazakhstan, the Atlas of Hydrogeological Maps of the Republic of Kazakhstan, and several other sources [6-10].

To define changes in groundwater levels, groundwater monitoring results from 2007 to 2022 were collected and analysed at 13 observation stations that are part of the State groundwater monitoring system of the Republic of Kazakhstan. These stations characterise the Albian-Cenomanian aquifer complex and include 54 hydrogeological monitoring wells. From all stations, 13 representative wells were characterised by the maximum amplitude of groundwater level fluctuations. Water levels in wells were measured three to ten times per month using a standard hydrogeological tape measure, depending on the groundwater depth and the type of aquifer being characterised. The minimum number of measurements (three times per month) is carried out on confined groundwater resources, and the maximum is up to ten times per month on non-confined waters that have a hydraulic connection with surface watercourses.

Annual precipitation and streamflow data collected at meteorological and hydrological stations in the study area from 2007 to 2022 were collected and analysed. Direct observations were carried out by the National Hydrometeorological Service of the RSE «Kazhydromet»[1].

Water flow was measured daily at hydrological stations equipped with hydrometric meters or acoustic Doppler profilers (flow meters). Water level measurements at gauging stations are made daily using a water gauge.

Precipitation data are provided daily for each weather station for the period (hour): 00:00-03:00; 03:00-06:00; 06:00-09:00; 09:00-12:00; 12:00-15:00; 15:00-18:00; 18:00-21:00; 21:00-00:00.

Results

The Albian-Cenomanian aquifer complex is almost ubiquitous, except in some areas where underlying, more ancient sediments outcrop to the surface (Fig. 1). The water-bearing materials are quartz-glauconite sands of various grain sizes, which are clayey to varying degrees. The absence of continuous clayey horizons between the sandy Albian-Cenomanian strata forms a single aquifer complex. Within the Zhem basin, water-bearing sediments reach the surface or are covered by a thin layer of permeable Quaternary sediments. These areas are an area of intensive groundwater recharge, where the primary groundwater sources are formed by infiltration of atmospheric precipitation and surface watercourses. The groundwater flow moves southwesterly towards the Caspian Sea and, in certain areas, acquires a pressured character. Infiltration recharge by atmospheric precipitation and river runoff is essential in forming groundwater reserves. Eight meteorological stations (Fig. 1) are located in the Zhem basin. The observations of long-term annual precipitation for this stations are presented in Table 1.

The minimum mean annual precipitation is observed at the Kulsary weather station (149.18 mm). The maximum at the Novoalekseevka station (252.03 mm), the former in the southern and the latter in the northern part of the Zhem basin (Fig. 1). The mean annual precipitation in the area is equal to 217.32 mm, with minimum and maximum values of 114.68 and 402.68 mm, respectively.

Mean annual river water flow values for the study period (2007-2022) on 12 hydrological stations are given in (Table 2).

Table 2 shows that practically all major surface watercourses in the Zhem basin are covered by observations. The Bolshaya Khobda and Emba rivers have a natural regime, while the rest have been disturbed by hydraulic structures (dams). The table summarises data on the catchment area, mean annual flow and measured water levels. The mean annual discharge of the rivers varies from 0.5 m^3/s to 6.4 m^3/s and depends on the catchment area and the amount of precipitation. The mean annual groundwater levels of the Albian-Cenomanian aquifer complex are given in Table 3.

The mean annual groundwater levels of the Albian-Cenomanian aquifer complex are defined at depths of 2.33-14.23 m and 32.35-43.43 m. Their absolute heights range from 145.97-120.47 m and 147.65-113.17 m, respectively. The amplitude of fluctuation of the mean annual groundwater level varies from 0.55 m (well No. 1498) to 3.07 m (well No. 1258) and averages 1.64 m in the basin. The mean annual groundwater level in all monitoring wells fluctuates due to recharge changes from rainfall infiltration and surface runoff.

Data on 381 groundwater well fields and sites on reserves in the state balance of the Aktobe region were used. From this number, the groundwater reserves of 125 well fields and sites in the amount of 735,77 thous. m^3/day confined to the Albian-Cenomanian aquifer complex, including mineralisation up to 1 g/L – 566,22 thous. m^3/day for 110 well fields and sites; with mineralisation 1-3 g/L – 104,32 thous. m^3/day for nine well fields and sites. For six well fields and sites the reserves of 65.23 thous.m^3/day related to hydraulically connected water-bearing sediments of Quaternary and Albian-Cenomanian age were defined [3]. For detailed analysis, 77 well fields and sites were selected; their term of approval of the reserves has

[1] *Meteorological and hydrological databases of the RSE «Kazhydromet». URL: https://www.kazhydromet.kz/ru (date of the application: 26.09.2023).*

Table 1

Meteorological station precipitation information

Кесте 1

Метеостанциялар бойынша жауын-шашын туралы ақпарат

Таблица 1

Сведения об осадках по метеостанциям

No.	Station Number	Station Name	Elevation mark, abs.m	Total precipitation, mm		Mean annual precipitation, mm
				min (year)	max (year)	
1	103	Novoalekseevka (Khobda)	142	130.7 (2012)	493.1 (2016)	252.03
2	104	Ilyinsky	190	117.5 (2012)	335.5 (2007)	205.69
3	107	Temir	234	143 (2012)	469.1 (2016)	243.59
4	108	Uil	102	158.8 (2010)	403.7 (2016)	248.84
5	110	Emba	251.8	118.6 (2018)	355.5 (2016)	214.43
6	111	Karauylkeldi	227.2	129.2 (2018)	476.4 (2016)	243.27
7	81	Sagyz	55.2	70 (2012)	357.6 (2016)	181.49
8	85	Kulsary	-9.1	49.6 (2021)	331.2 (2016)	149.18
Average value				114.68	402.68	217.32

Table 2

Surface water flow rate and water level measured at gauging stations

Кесте 2

Жер үсті суларының ағындары және олардың өлшеу станцияларындағы деңгейлері туралы ақпарат

Таблица 2

Сведения о расходах поверхностных вод и их отметках по гидропостам

No.	Station Number	Station Name	River	River regulation	Watershed area, km^2	Mean annual value	
						Water flow rate, m^3/s	Water level mark, abs. m
1	30	Novoalekseevka (Khobda)	Bolshaya Khobda	Natural	8110	5.00	135.05
2	31	Kugala (Kogaly)			14200	6.21	95.37
3	32	Alpaisai	Karakhobda	Disturbed by dams	2240	2.33	175.60
4	34	Jigerlen	Kaldygaity		2510	1.49	73.52
5	43	Altykarasu	Uil		6997	1.88	124.965
6	44	Uil			17100	6.36	64.95
7	45	Zhagabulak	Emba	Natural	7730	2,94	196.46
8	46	Saga			16100	5.97	195.69
9	47	Akkiztogan			н.с.	3.75	-
10	48	Pokrovskoye (Sagashili)	Temir	Disturbed by dams	960	1.33	239.43
11	49	Leninsky			5310	3.84	198.28
12	20	Tamdy	Ilek		2371	0.47	245.92

not expired. Therefore, the reserves were evaluated from 2006 to 2022. These well fields and sites were grouped according to the value of the approved reserves. Their general characteristics are presented in Table 4.

Table 4 shows that most groundwater resources are developed with a demand of up to 1000 m^3/day using a single well. This indicates that the primary water users are rural settlements or villages with small water demands. The demand of 1000 to 10000 m^3/day is mainly devoted for the water supply of district centres and small towns. Well fields with reserves from 10000 to 50000 m^3/day have been prospected for the regional centre – Aktobe city, Kandyagash city, or for large water us-

Table 3

Monitoring well groundwater levels

Кесте 3

Мемлекеттік желінің бақылау ұңғымалары бойынша жерасты суларының деңгейі

Таблица 3

Уровень подземных вод по мониторинговым скважинам Государственной сети

No.	Station Number	Station Name	Well No.	Wellhead abs. elevation, m	Well, screen interval, m		Abs. elevation of average annual groundwater level, m		
					Top	Bottom	Min (year)	Max (year)	Average value
1	48	Oktyabrskiy water intake	1258	293.6	75	82	267.61 (2017)	270.68 (2020)	268.29
2	32	Kenkiyak	14	177	76	124	171.36 (2014)	173.3 (2022)	172.34
3	26	Sarybulak	107	328.7	119	156	289.41 (2010)	290.95 (2020)	290.10
4	28	West Kazakhstan effluent station	3	134.7	13	16	120.2 (2014)	121.15 (2021)	120.47
5	53	Kokzhide well field	49a	148.3	86	92	145.4 (2020)	146.56 (2007)	145.97
6	65	Nugaity	1543	156.6	56	59	112.56 (2020)	113.92 (2017)	113.17
7	66	Ilyinsky	1498	186	44	46	174.01 (2013)	174.56 (2008)	174.25
8	68	Shubarkuduk	1537	191.9	31	34	182.38 (2014)	184.93 (2018)	183.09
9	69	Khabalovka	1517	180	34	36	147.13 (2022)	148.07 (2011)	147.65
10	71	Znamensky	1546	252	8	12	248.24 (2019)	249.7 (2011)	249.40
11	72	Karaulkeldy	1550	208.6	63	68	174.96 (2021)	176.07 (2008)	175.44
12	23	Alginsky water intake	1128	250.95	31	36	242.72 (2011)	244.59 (2017)	243.65
13	37	Kundaktykyr	102	298.9	175	187	285.4 (2014)	288.18 (2012)	287.27

Table 4

General information on groundwater well fields and sites of the Albian-Cenomanian aquifer complex

Кесте 4

Альб-сеноман сулы кешеніндегі жерасты суларының кен орындары мен учаскелері туралы жалпы мәліметтер

Таблица 4

Общие сведения о месторождениях и участках подземных вод по водоносному альб-сеноманскому комплексу

No.	Approved reserves, m^3/day	Well fields and sites number	Total value of operational reserves, m^3/day	Type of water intake, units			The average depth of wells, m
				Single well	Linear water intake	Area water intake	
1	0-1 000	60	11,597	52	8	-	85
2	1 000-10 000	8	24,395	-	8	-	140
3	10 000-50 000	8	241,466	-	7	1	175
4	more 100 000	1	173,400	-	1	-	200
	TOTAL:	77	450,858	52	24	1	

ers with the purpose of domestic and drinking water supply of shift settlements or industrial and technical water supply of oil fields. The largest groundwater deposit, Kokzhide, with reserves of 173.4 thousand m^3/day, is being operated to supply water to the oil industry. This field is currently not operated.

At the same time, small water needs up to 1000 m^3/day can be met by individual wells, while for water withdrawals above 1000 m^3/day, a linear water withdrawal scheme is often used. The average depth of production wells correlates well with water abstraction capacity. For example, for sites with insignificant water demand, the average depth of wells is less than 100 m. For higher demands, well depths vary from 140 to 200 m.

Out of 77 well fields and sites, the Alga well field covers Albian-Cenomanian and alluvial Quaternary deposits of the Ilek River valley that are hydraulically interconnected.

Table 5

Main hydrogeological parameters of the Albian-Cenomanian aquifer complex within the Zhem basin

Кесте 5

Жем алабындағы альб-сеноман шөгінділерінің негізгі гидрогеологиялық көрсеткіштері

Таблица 5

Основные гидрогеологические параметры альб-сеноманских отложений в пределах Жемского бассейна

No.	Parameter	Units	Number of analyzed fields and sites, units	min	max	Average value	Values for the Alga well field, ***(Kal-s + aQ)***
1	Hydraulic conductivity	m/day	74	0.8	14.1	5.6	29.8
2	Effective capacity	m	76	4	200	43.1	51.7
3	Groundwater head	m	41	4	119.1	42.2	-
4	Transmissivity	m^2/day	15	111	1070	490	-
5	Conductivity ratio	m^2/day	46	173	6815	2127.6	4800
6	Piezoconductivity	m^2/day	32	7.7*103	2.6*106	2.8*105	-
7	Specific yield	Unit.	45	0.01	0.2	0.13	0.22
8	Specific storage	Unit.	36	1*10-5	6*10-2	8.7*10-3	-

The explored groundwater resources of the Aktobe region make up only 6% of the total republican forecast resources, including freshwater – 4.9%. At the same time, most groundwater well fields and sites are either not operated or operated not to their full capacity. The total amount of groundwater reserves reached only 4.8% of all reserves on the State Balance [3].

Table 5 shows the characteristic values of the main hydrogeological parameters used to estimate the operational reserves of groundwater well fields confined to the Albian-Cenomanian aquifer complex.

The Albian-Cenomanian aquifer complex's hydraulic conductivity varies from 0.8 to 14.1 m/day and averages 5.6 m/day. The hydraulic conductivity of groundwater well fields with reserves more significant than 2000 m^3/day ranges from 6.9 to 9.6 m/day, with an average of 8.2 m/day. This is due to the better hydrogeological study of the latter to classify the reserves in the national balance according to industrial categories – A and B [9]. In the Alga well field area, the hydraulic conductivity value, which was determined to be the $\boldsymbol{K_{al\text{-}s} + aQ}$ water-bearing complex, is much higher and reaches 29.8 m/day. The average values of conductivity ratio and specific yield were 2127 m^2/day and 0.13, respectively. For the confined groundwater flow, the average values of the piezoconductivity and specific storage defined equal to $2.8 \cdot 10^5$ m^2/day and $8.7 \cdot 10^{-3}$, respectively. The values of the main hydrogeological parameters for large well fields with operational reserves estimated at more than 2000 m^3/day are sometimes significantly different and are as follows: conductivity ratio reaches 4343 m^2/day; specific yield – 0.13; piezoconductivity – $4.5 \cdot 10^5$ m^2/day; specific storage – $3.7 \cdot 10^{-3}$; and transmissivity – 617 m^2/day. The average transmissivity value calculated for all well fields and sites is 490 m^2/day.

As already mentioned, the hydrogeological exploration of the Aktobe region is relatively low and makes up 6% of the total republican forecast reserves, including freshwater – 4.9%; at the same time, most of the well fields and sites are either not operated or not operated to their total capacity, reaching only 4.8% of the reserves from the State Balance [3].

Conclusion

Based on the materials mentioned above, it is possible to state the following:

- groundwater reserves of the Albian-Cenomanian aquifer complex within the Zhem basin are one of the primary sources of water supply for settlements and industrial facilities both in Aktobe and in the neighbouring water-scarce regions of Western Kazakhstan: Atyrau and Mangistau;

- the available database, obtained from the results of hydrogeological and exploration works for the evaluation of groundwater resources, meteorological and hydrological measurements, as well as from the observation of hydrogeological well monitoring data, serves as a reliable factual basis for further studies of groundwater resources related to the Albian-Cenomanian aquifer complex of the Cretaceous sediments in the Zhem Artesian Basin;

- the explored groundwater resources of the Aktobe region make up only 6% of the Republic's total projected resources, including freshwater – 4.9%. At the same time, most groundwater well fields and sites are either not operated or not operated to their total capacity;

- the research perspectives are related to the development of a regional geofiltration model for the long-term forecasting of changes in the hydrodynamic and water balance characteristics of the Albian-Cenomanian aquifer complex, as well as the assessment of groundwater resources for various options of their exploitation at explored groundwater well fields, allowing to meet the water needs of water-scarce regions of Western Kazakhstan [11, 12].

This research has been/was/is funded by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. BR 21882211)

REFERENCES

1. *Gidrogeologicheskaja karta Kazahstana. Masshtab 1:1 000 000. / B.S. Uzhkenov, D.A. Kasymbekov, T.K. Ajtuarov, Je.K. Kim, V.A. Smoljar, O.A. Fedorenko. Astana: Ministerstvo jenergetiki i mineral'nyh resursov. Komitet geologii i ohrany nedr, 2004 [Hydrogeological map of Kazakhstan. Scale 1:1,000,000. / B.S. Uzhkenov, D.A. Kasymbekov, T.K. Aituarov, E.K. Kim, V.A. Smolyar, O.A. Fedorenko. Astana: Ministry of Energy and Mineral Resources. Committee of Geology and Subsoil Protection, 2004] (in Russian)*
2. *Vodnye resursy Kazahstana (Poverhnostnye i podzemnye vody, sovremennoe sostojanie). / V.A. Smoljar, B.V. Burov, V.V. Veselov, T.T. Mahmutov, D.A. Kasymbekov. Almaty: NIC «FYLYM», 2002, 138-140 s. [Water resources of Kazakhstan (Surface and underground waters, current state). / V.A. Smolyar, B.V. Burov, V.V. Veselov, T.T. Makhmutov, D.A. Kasymbekov. Almaty: Scientific Research Center «Gylym», 2002, 138-140 p.] (in Russian)*
3. *Sapargaliev D.S. Perspektivy osvoenija presnyh podzemnyh vod melovyh otlozhenij Zhemskogo artezianskogo bassejna v Aktjubinskoj oblasti. / D.S. Sapargaliev, E.Zh. Murtazin, V.A. Smoljar, R.A. Nurpeisov. // Gornyj zhurnal Kazahstana. 2022. №11 (211). S. 22-28 [Sapargaliev D.S. Prospects for the development of fresh groundwater from the Cretaceous deposits of the Zhemsky artesian basin in the Aktobe region. / D.S. Sapargaliev, E.Z. Murtazin, V.A. Smolyar, R.A. Nurpeisov. // Mining Journal of Kazakhstan. 2022. No.11 (211). P. 22-28] (in Russian)*
4. *Smoljar V.A., Burov B.V., Mustafaev S.T. Vodnye resursy Kazahstana: ocenka, prognoz, upravlenie. Tom XIX. Podzemnye vody Kazahstana: obespechennost' i ispol'zovanie. Almaty: Institut geografii, 2012, S. 36-52 [Smolyar V.A., Burov B.V., Mustafaev S.T. Water resources of Kazakhstan: assessment, forecast, management. V. XIX. Groundwater in Kazakhstan: availability and use. Almaty: Institute of Geography, 2012, P. 36-52] (in Russian)*
5. *Jean Margat, Jac van der Gun. Groundwater around the World. A Geographic Synopsis. // CRC Press, A Balkema Book. 2013. P. 30-59 (in English)*
6. *Sapargaliev D.S., Zavalej V.A. Osobennosti razvedki mestorozhdenij podzemnyh vod v uslovijah nizkih znachenij fil'tracionnyh svojstv vodonosnogo gorizonta (na primere mestorozhdenija Severnaja Truva v Aktjubinskoj oblasti Respubliki Kazahstan). // Trudy XXIII Mezhdunarodnogo simpoziuma imeni akademika M.A. Usova studentov i molodyh uchenyh «Problemy geologii i osvoenija nedr». Tom 1: sb. nauch. st. Tomsk, 2019. – S. 390-392 [Sapargaliev D.S., Zavaley V.A. Features of exploration of groundwater deposits in conditions of low values of filtration properties of the aquifer (using the example of the Northern Truva deposit in the Aktobe region of the Republic of Kazakhstan). // Proceedings of the XXIII International Symposium named after academician M.A. Usov of students and young scientists «Problems of geology and subsoil development». V. 1: Sat. scientific Art. Tomsk, 2019. – P. 390-392] (in Russian)*
7. *Mestorozhdenija podzemnyh vod Kazahstana. Spravochnik. Tom I. Zapadnyj i Juzhnyj Kazahstan. Vtoroe izdanie. / B.K. Nurabaev, A.A. Nadyrbaev, M.K. Tulegenov, Zh.B. Tansykbaeva. Almaty, 2019. 40-91 s. [Groundwater deposits in Kazakhstan. Directory. V. I. Western and Southern Kazakhstan. Second edition. / B.K. Nurabaev, A.A. Nadyrbaev, M.K. Tulegenov, Zh.B. Tansykbaeva. Almaty, 2019. 40-91 p.] (in Russian)*
8. *Smoljar V.A. Kompleksnoe i racional'noe ispol'zovanie poverhnostnyh i podzemnyh vod – osnova vodnoj bezopasnosti Respubliki Kazahstan. / V.A. Smoljar, D.S. Sapargaliev, D.V. Kim. // Geologija i ohrana nedr. 2020. №1 (74). S. 59-71 [Smolyar V.A. Integrated and rational use of surface and groundwater – the basis of water security of the Republic of Kazakhstan. / V.A. Smolyar, D.S. Sapargaliev, D.V. Kim. // Geology and subsoil protection. 2020. No.1 (74). P. 59-71] (in Russian)*
9. *Absametov M.K. Podzemnye vody: sistema klassifikacii i upravlenija resursami. / M.K. Absametov, E.Zh. Murtazin, D.S. Sapargaliev, A.K. Isaev. // Nedropol'zovanie XXI vek. 2019. №6 (82). S. 20-25 [Absametov M.K. Groundwater: a system for classification and resource management. / M.K. Absametov, E.Zh. Murtazin, D.S. Sapargaliev, A.K. Isaev. // Subsoil use XXI century. 2019. No.6 (82). P. 20-25] (in Russian)*
10. *Sagin J. Underground water resources in Kazakhstan. / J. Sagin, D. Adenova, A. Tolepbayeva & V. Poryadin. // International Journal of Environmental Studies. 2017. Vol. 74. P. 386-398 (in English)*
11. *Mirlas V. An Integrated Aquifer Management Approach for Aridification-Affected Agricultural Area, Shengeldy-Kazakhstan / V. Mirlas, A. Makyzhanova, V. Kulagin, E. Kuldeev, Y. Anker/ // Water. 2021. №13 (17). P. 2357 (in English)*
12. *Mirlas V. MODFLOW and HYDRUS Modeling of Groundwater Supply Prospect Assessment for Distant Pastures in the Aksu River Middle Reaches. / V. Mirlas, V. Kulagin, A. Ismagulova, Y. Anker. // Sustainability. 2022. №14. P. 16783 (in English)*

ПАЙДАЛАНЫЛҒАН ӘДЕБИЕТТЕР ТІЗІМІ

1. *Қазақстанның гидрогеологиялық картасы. Масштаб 1: 1 000 000. / Б.С. Ужкенов, Д.А. Қасымбеков, Т.Қ. Айтуаров, Е.Қ. Ким, В.А. Смоляр, О.А. Федоренко. Астана: Энергетика және минералдық ресурстар министрлігі. Геология және жер қойнауын қорғау комитеті, 2004 (орыс тілінде)*
2. *Қазақстанның су ресурстары (жер үсті және жер асты сулары, қазіргі жағдайы). / В.А. Смоляр, Б.В. Буров, В.В. Веселов, Т.Т. Махмұтов, Д.А. Қасымбеков. Алматы: «Ғылым» ҒЗО, 2002, 138-140 б. (орыс тілінде)*
3. *Сапарғалиев Д.С. Ақтөбе облысындағы Жем артезиан алабының бор шөгінділерінен тұщы жер асты суларын игеру перспективалары. / Д.С. Сапарғалиев, Е.Ж. Мұртазин, В.А. Смоляр, Р.А. Нұрпеиісов. // Қазақстан тау-кен журналы. 2022. №11 (211). Б. 22-28 (орыс тілінде)*
4. *Смоляр В.А., Буров Б.В., Мұстафаев С.Т. Қазақстанның су ресурстары: бағалау, болжау, басқару. XIX том. Қазақстандағы жер асты сулары: болуы және пайдалануы. Алматы: География институты, 2012, Б. 36-52 (орыс тілінде)*
5. *Jean Margat, Jac van der Gun. Дүние жүзіндегі жерасты сулары. Географиялық конспект. // CRC Press: Балкема кітабы. 2013. Б. 30-59 (ағылшын тілінде)*
6. *Сапарғалиев Д.С., Завалей В.А. Сулы горизонттың фильтрациялық қасиеттерінің төмен мәндері жағдайында жерасты суларының кен орындарын барлау ерекшеліктері (Қазақстан Республикасының Ақтөбе облысындағы Солтүстік Трува кен орны мысалында). // «Геология және жер қойнауын игеру мәселелері» студенттер мен жас ғалымдарға арналған академик М.А.Усов атындағы XXIII халықаралық симпозиум материалдары. Том 1: ғылыми мақалалар жинағы. Томск, 2019. – Б. 390-392 (орыс тілінде)*
7. *Қазақстандағы жер асты суларының кен орындары. Каталог. I том. Батыс және Оңтүстік Қазақстан. Екінші басылым. / Б.Қ. Нұрабаев, А.А. Надырбаев, М.Қ. Төлегенов, Ж.Б. Таңсықбаева. Алматы, 2019, 40-91 б. (орыс тілінде)*
8. *Смоляр В.А. Жер үсті және жер асты суларын кешенді және ұтымды пайдалану – Қазақстан Республикасының су қауіпсіздігінің негізі. / В.А. Смоляр, Д.С. Сапарғалиев, Д.В. Ким. // Геология және жер қойнауын қорғау. 2020. №1 (74). Б. 59-71 (орыс тілінде)*
9. *Әбсаметов М.Қ. Жер асты сулары: жіктеу және ресурстарды басқару жүйесі. / М.Қ. Әбсаметов, Е.Ж. Муртазин, Д.С. Сапарғалиев, А.Қ. Исаев. // Жер қойнауын пайдалану XXI ғасыр. 2019. №6 (82). Б. 20-25 (орыс тілінде)*
10. *J. Sagin. Қазақстанның жер асты суларының ресурстары. / J. Sagin, D. Adenova, A. Tolepbayeva, V. Poryadin. // Қоршаған ортаны зерттеу халықаралық журналы. 2017. Т. 74. Б. 386-398 (ағылшын тілінде)*
11. *Mirlas V. Кептіруден зардап шеккен ауылшаруашылық аймақтарының сулы горизонттарын басқарудың кешенді тәсілі, Шеңгелді, Қазақстан. / V. Mirlas, A. Makyzhanova, V. Kulagin, E. Kuldeev, Y. Anker. // Су. 2021. №13 (17). Б. 2357 (ағылшын тілінде)*
12. *Mirlas V. Ақсу өзенінің орта ағысындағы шалғайдағы жайылымдарды жер асты суымен қамтамасыз ету перспективаларын бағалау үшін MODFLOW және HYDRUS модельдеу. / V. Mirlas, V. Kulagin, A. Ismagulova, Y. Anker. // Тұрақтылық. 2022. №14. Б. 16783 (ағылшын тілінде)*

СПИСОК ИСПОЛЬЗОВАННЫХ ИСТОЧНИКОВ

1. *Гидрогеологическая карта Казахстана. Масштаб 1:1 000 000. / Б.С. Ужкенов, Д.А. Касымбеков, Т.К. Айтуаров, Э.К. Ким, В.А. Смоляр, О.А. Федоренко. Астана: Министерство энергетики и минеральных ресурсов. Комитет геологии и охраны недр, 2004 (на русском языке)*
2. *Водные ресурсы Казахстана (Поверхностные и подземные воды, современное состояние). / В.А. Смоляр, Б.В. Буров, В.В. Веселов, Т.Т. Махмутов, Д.А. Касымбеков. Алматы: НИЦ «ГЫЛЫМ», 2002, 138-140 с. (на русском языке)*
3. *Сапаргалиев Д.С. Перспективы освоения пресных подземных вод меловых отложений Жемского артезианского бассейна в Актюбинской области / Д.С. Сапаргалиев, Е.Ж. Муртазин, В.А. Смоляр, Р.А. Нурпеисов. // Горный журнал Казахстана. 2022. №11 (211). С. 22-28 (на русском языке)*
4. *Смоляр В.А., Буров Б.В., Мустафаев С.Т. Водные ресурсы Казахстана: оценка, прогноз, управление. Том XIX. Подземные воды Казахстана: обеспеченность и использование. Алматы: Институт географии, 2012, С. 36-52 (на русском языке)*
5. *Jean Margat, Jac van der Gun. Подземные воды в мире. Географический синопсис. // CRC Press: Книга Балкема. 2013. С. 30-59 (на английском языке)*

6. *Сапаргалиев Д.С., Завалей В.А. Особенности разведки месторождений подземных вод в условиях низких значений фильтрационных свойств водоносного горизонта (на примере месторождения Северная Трува в Актюбинской области Республики Казахстан). // Труды XXIII Международного симпозиума имени академика М.А. Усова студентов и молодых ученых «Проблемы геологии и освоения недр». Том 1: сб. науч. ст. Томск, 2019. – С. 390-392 (на русском языке)*
7. *Месторождения подземных вод Казахстана. Справочник. Том I. Западный и Южный Казахстан. Второе издание. / Б.К. Нурабаев, А.А. Надырбаев, М.К. Тулегенов, Ж.Б. Тансыкбаева. Алматы, 2019, 40-91 с. (на русском языке)*
8. *Смоляр В.А. Комплексное и рациональное использование поверхностных и подземных вод – основа водной безопасности Республики Казахстан. / В.А. Смоляр, Д.С. Сапаргалиев, Д.В. Ким. // Геология и охрана недр. 2020. №1 (74). С. 59-71 (на русском языке)*
9. *Абсаметов М.К. Подземные воды: система классификации и управления ресурсами. / М.К. Абсаметов, Е.Ж. Муртазин, Д.С. Сапаргалиев, А.К. Исаев. // Недропользование XXI век. 2019. №6 (82). С. 20-25 (на русском языке)*
10. *Sagin J. Ресурсы подземных вод Казахстана / J. Sagin, D. Adenova, A. Tolepbayeva, V. Poryadin. // Международный журнал экологических исследований. 2017. Т. 74. С. 386-398 (на английском языке)*
11. *Mirlas V. Комплексный подход к управлению водоносными горизонтами для сельскохозяйственных территорий, пострадавших от засушивания, Шенгельды, Казахстан. / V. Mirlas, A. Makyzhanova, V. Kulagin, E. Kuldeev, Y. Anker. // Вода. 2021. №13 (17). С. 2357 (на английском языке)*
12. *Mirlas V. Моделирование MODFLOW и HYDRUS для оценки перспектив снабжения подземными водами отгонных пастбищ в Среднем течении реки Аксу. / V. Mirlas, V. Kulagin, A. Ismagulova, Y. Anker. // Устойчивое развитие. 2022. №14. С. 16783 (на английском языке)*

Information about the authors:
Sapargaliyev D.S., Doctoral Student at the Department «Hydrogeology, Engineering and Oil and Gas Geology» of the Satbayev University, Executive Secretary of the Innovation Council for the implementation of innovative projects and programs of the Institute of Hydrogeology and Geoecology named after U.M. Ahmedsafin Satbayev of the University (Almaty, Kazakhstan), Graduate student of the Kyrgyz State Technical University named after I. Razzakov (Bishkek, Kyrgyzstan), *sapargalievds@mail.ru;* https://orcid.org/0000-0002-3751-7738
Mirlas V.M., Ph.D., Candidate of Geological and Mineral Sciences, Senior Researcher, Department of Chemical Engineering, Ariel University (Ariel, Israel), *vladimirmster@gmail.com;* https://orcid.org/0000-0002-3117-0331
Murtazin Y.Z., Candidate of Geological and Mineral Sciences, Deputy Director of the Institute of Hydrogeology and Geoecology named after U.M. Ahmedsafin, Satbayev University (Almaty, Kazakhstan), *ye_murtazin@list.ru;* https://orcid.org/0000-0002-7404-4298
Smolyar V.A., Dr. Geol.-Mineral. Sciences, Chief Scientific Officer of the Laboratory of Regional Hydrogeology and Geoecology of the Institute of Hydrogeology and Geoecology named after U.M. Akhmedsafin, Satbayev University (Almaty, Kazakhstan), *v_smolyar@mail.ru;* https://orcid.org/0000-0001-9419-048X

Авторлар туралы мәліметтер:
Сапаргалиев Д.С., Satbayev University «Гидрогеология, инженерлік геология және мұнай-газ геологиясы» кафедрасының докторанты, Satbayev University, У.М. Ахмедсафин атындағы гидрогеология және геоэкология институтының инновациялық жобалар мен бағдарламаларды іске асыру жөніндегі инновациялық кеңестің жауапты хатшысы (Алматы қ., Қазақстан), И. Раззаков атындағы Қырғыз мемлекеттік техникалық университетінің аспиранты (Бішкек қ., Қырғызстан)
Мирлас В.М., техника ғылымдарының докторы, геология-минералогия ғылымдарының кандидаты, Ариэль университетінің химиялық инженерия бөлімінің аға ғылыми қызметкері (Ариэль қ., Израиль)
Муртазин Е.Ж., геология-минералогия ғылымдарының кандидаты, Satbayev University, У.М.Ахмедсафин атындағы гидрогеология және геоэкология институты директорының орынбасары (Алматы қ., Қазақстан)
Смоляр В.А., геология-минералогия ғылымдарының докторы, Satbayev University, У.М. Ахмедсафин атындағы гидрогеология және геоэкология институтының аймақтық гидрогеология және геоэкология зертханасының бас ғылыми қызметкері (Алматы қ., Қазақстан)

Сведения об авторах:
Сапаргалиев Д.С., докторант кафедры «Гидрогеология, инженерная геология и нефтегазовая геология» Satbayev University, ответственный секретарь Совета по инновациям по реализации инновационных проектов и программ Института гидрогеологии и геоэкологии им. У.М. Ахмедсафина, Satbayev University (г. Алматы, Казахстан), аспирант Кыргызского государственного технического университета имени И. Раззакова (г. Бишкек, Кыргызстан)
Мирлас В.М., доктор техн. наук, канд. геол.-минерал. наук, старший научный сотрудник Отдела химической инженерии Ариельского Университета Ariel University (г. Ариель, Израиль)
Муртазин Е.Ж., канд. геол.-минерал. наук, заместитель директора Института гидрогеологии и геоэкологии им. У.М. Ахмедсафина, Satbayev University (г. Алматы, Казахстан)
Смоляр В.А., д-р геол.-минерал. наук, главный научный сотрудник лаборатории региональной гидрогеологии и геоэкологии Института гидрогеологии и геоэкологии им. У.М. Ахмедсафина, Satbayev University (г. Алматы, Казахстан)