ISSN 2518-170X (Online)
ISSN 2224-5278 (Print)

ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ

Satbayev University

ХАБАРЛАРЫ

ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ
НАУК РЕСПУБЛИКИ
КАЗАХСТАН
Satbayev University

NEWS

OF THE ACADEMY OF SCIENCES
OF THE REPUBLIC OF
KAZAKHSTAN
Satbayev University

SERIES

OF GEOLOGY AND TECHNICAL SCIENCES

6 (456)

NOVEMBER – DECEMBER 2022

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, NAS RK

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«ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Меншіктеуші: «Қазақстан Республикасының Ұлттық ғылым академиясы» РҚБ (Алматы қ.).

Қазақстан Республикасының Ақпарат және қоғамдық даму министрлігінің Ақпарат комитетінде 29.07.2020 ж. берілген **№ KZ39VPY00025420** мерзімдік басылым тіркеуіне қойылу туралы куәлік.

Тақырыптық бағыты: *геология, мұнай және газды өңдеудің химиялық технологиялары, мұнай химиясы, металдарды алу және олардың қосындыларының технологиясы.*

Мерзімділігі: жылына 6 рет.

Тиражы: 300 дана.

Редакцияның мекен-жайы: 050010, Алматы қ., Шевченко көш., 28, 219 бөл., тел.: 272-13-19
http://www.geolog-technical.kz/index.php/en/

Типографияның мекен-жайы: «Аруна» ЖК, Алматы қ., Мұратбаев көш., 75.

«Известия НАН РК. Серия геологии и технических наук».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Собственник: Республиканское общественное объединение «Национальная академия наук Республики Казахстан» (г. Алматы).

Свидетельство о постановке на учет периодического печатного издания в Комитете информации Министерства информации и общественного развития Республики Казахстан **№ KZ39VPY00025420,** выданное 29.07.2020 г.

Тематическая направленность: *геология, химические технологии переработки нефти и газа, нефтехимия, технологии извлечения металлов и их соеденений.*

Периодичность: 6 раз в год.

Тираж: 300 экземпляров.

Адрес редакции: 050010, г. Алматы, ул. Шевченко, 28, оф. 219, тел.: 272-13-19

http://www.geolog-technical.kz/index.php/en/

Адрес типографии: ИП «Аруна», г. Алматы, ул. Муратбаева, 75.

News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technology sciences.
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Owner: RPA «National Academy of Sciences of the Republic of Kazakhstan» (Almaty).
The certificate of registration of a periodical printed publication in the Committee of information of the Ministry of Information and Social Development of the Republic of Kazakhstan **No. KZ39VPY00025420,** issued 29.07.2020.
Thematic scope: *geology, chemical technologies for oil and gas processing, petrochemistry, technologies for extracting metals and their connections.*
Periodicity: 6 times a year.
Circulation: 300 copies.
Editorial address: 28, Shevchenko str., of. 219, Almaty, 050010, tel. 272-13-19
http://www.geolog-technical.kz/index.php/en/

Address of printing house: ST «Aruna», 75, Muratbayev str, Almaty.

***NEWS** of the National Academy of Sciences of the Republic of Kazakhstan*
SERIES OF GEOLOGY AND TECHNICAL SCIENCES
ISSN 2224-5278
Volume 6, Number 456 (2022), 247-260
https://doi.org/10.32014/2518-170X.253

UDC 553.982.2(575.146)

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ON SOME RESULTS OF STUDYING THE CAUSES OF ANOMALOUSLY HIGH FORMATION PRESSURE ON THE HYDROCARBONS DEPOSITS OF THE BASHKENT DEEP

Abstract. Based on the study of the mechanism of occurrence of abnormally high formation pressures (AHRP), more than 20 causes have been identified to date. At the same time, depending on the geological conditions of the oil and gas regions and the characteristics of each specific field, for the studied territories, mainly no more than 3–5 factors are distinguished that contribute to the occurrence of AHRP.

Based on the statistical generalization of the research results, it is shown that the occurrence of abnormally high reservoir pressure is associated with many geological and physical factors that are characteristic of each oil and gas region and a particular field. Using the example of hydrocarbon deposits in the Beshkent trough of the Bukhara-Khiva oil and gas region, an assessment was made of the degree of influence of geological and physical factors on the formation of abnormal reservoir pressure. To establish the geological and physical factors contributing to the occurrence of AHRP in the fields of the southeastern part of the Bukhara–Khiva region (BHR), the information content of these features was calculated using the Kullback measure. As a result, it was established that the magnitude of the vertical movement of the earth's surface has the greatest influence on the occurrence of AHRP in the hydrocarbon fields of the southeastern part of the BHR. The content of condensate in the gas, the difference in the densities of water and oil, and open porosity also have a significant effect.

It is shown that the occurrence of objects with abnormally high formation pressures in the study area is mainly associated with vertical movements of the earth's surface, the content of condensate in the formation gas, the difference in oil and water densities, as well as changes in the porosity of reservoir rocks. In this regard, when drilling prospecting and exploratory wells in new areas of the southeastern part of the BHR, the expected value of reservoir pressure should be justified taking into account the above factors, which are the main causes of AHRP.

Key words: region, oil and gas potential, field, horizon, pressure, temperature, density, porosity, tectonics, depth, informativeness, factor.

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БЕШКЕНТ ИІЛУ КӨМІРСУТЕГІ КЕН ОРЫНДАРЫНДА ҚАЛЫПТАН ТЫС ЖОҒАРЫ ҚАБАТ ҚЫСЫМЫНЫҢ ПАЙДА БОЛУ СЕБЕПТЕРІН ЗЕРТТЕУДІҢ КЕЙБІР НӘТИЖЕЛЕРІ

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О НЕКОТОРЫХ РЕЗУЛЬТАТАХ ИССЛЕДОВАНИЯ ПРИЧИН ВОЗНИКНОВЕНИЯ АНОМАЛЬНО ВЫСОКИХ ПЛАСТОВЫХ ДАВЛЕНИЙ НА ЗАЛЕЖАХ УГЛЕВОДОРОДОВ БЕШКЕНТСКОГО ПРОГИБА

Аннотация. На основе исследования механизма возникновения аномально высокого пластового давления (АВПД) к настоящему времени выявлено более 20 причин. При этом в зависимости от геологических условий нефтегазоносных регионов и особенностей каждого конкретного месторождения для изученных территорий выделяется, в основном, не более 3–5 факторов, способствующих возникновению АВПД.

На основе статистического обобщения результатов исследований показано, что возникновение аномально-высокого пластового давления связано со многими геолого-физическими факторами, характерными для каждого нефтегазоносного региона и конкретного месторождения. На примере месторождений углеводородов Бешкентского прогиба Бухаро-Хивинского нефтегазоносного региона проведена оценка степени влияния геолого-физических факторов на формирование аномального пластового давления. Для установления геолого-физических факторов, способствующих возникновению АВПД на месторождениях юго-восточной части Бухаро–Хивинского региона (БХР, вычислена информативность

этих признаков с применением меры Кульбака. В результате установлено, что на возникновение АВПД на месторождениях углеводородов юго-восточной части БХР наибольшее влияние оказывает величина вертикального движения земной поверхности. Значительное влияние также оказывает содержание конденсата в газе, разность плотностей воды и нефти и открытой пористости.

Показано, что возникновение объектов с аномально – высокими пластовыми давлениями на исследуемой территории связано, в основном, с вертикальными движениями земной поверхности, содержанием конденсата в пластовом газе, разностью плотностей нефти и воды, а также изменением пористости пород коллекторов. В связи с этим при бурении поисковых и разведочных скважин на новых площадях юго-восточной части БХР ожидаемая величина пластового давления должна быть обоснована с учетом вышеперечисленных факторов, являющихся основными причинами АВПД.

Ключевые слова: регион, нефтегазоносность, месторождение, горизонт, давление, температура, плотность, пористость, тектоника, глубина, информативность, фактор.

Introduction. One of the main problems in the oil and gas industry is the problem of abnormally high reservoir pressures (AHRP) due to complications in the process of drilling and developing oil and gas wells. Studies of the mechanism of occurrence of AHRP and its influence on the development of hydrocarbon deposits revealed positive and negative factors. The positive factors include the fact that objects with AHRP have higher porosity and reservoir properties and the energy potential of the reservoir, which leads to an increase in the specific gas reserves of the production rate and the life of wells, and also contributes to the formation of hydrocarbons (HC) in oil and gas bearing basins (Lin at all, 2014: 150; Makhmudov at all, 2022: 2432; Bekpolatov, at all, 2022: 2432).

Negative factors include a decrease in the strength properties of rocks represented by terrigenous deposits, which are the main cause of sand intrusion in wells, as well as an increase in the deformation properties of rocks in the form of carbonate deposits, which leads to a decrease in the porosity and permeability properties of reservoirs during field development as reservoir pressure drops (Bekpolatov at all, 2022: 2432; Liu at all, 2022: 2327; Hayitov at all, 2020: 2327; Nasirov at all, 2020: 2251).

Despite the rather long period of study of this problem, many different factors associated with mechanical, deformation, gravitational, physicochemical and other processes have been cited as the causes of AHRP so far. This is evidenced by the results of statistical processing of the causes of studying the occurrence of AHRP, given in more than 90 studies carried out in the period from 1995 to 2020.

Based on the analysis of the results of the study of the above works, it was established that, depending on the geological features of the oil and gas regions, as well as the geological and physical conditions of hydrocarbon deposits, there may be more than 20 reasons for the formation of AHRP. Systematizing the causes of AHRP, we combine them into the following groups:

Compaction of rocks in isolated reservoirs under the influence of geostatic pressure. It is shown that the absence or difficulty of hydrocarbon migration, high sedimentation rate, low reservoir permeability, high oil viscosity, high temperature and subsidence of the productive formation depth after the formation of hydrocarbon deposits increase the influence of this factor in the formation of AHRP. This factor in 26.5% of cases is given as the main cause of AHRP.

Tectonic stress and tectonic processes that cause compression and deformation of deep reservoirs. This factor in 19.4% of cases is given as the main cause of AHRP.

Entry of high-pressure fluids into a closed reservoir from deeper horizons along faults. This factor in 15.3% of cases is given as the cause of AHRP.

Physical and chemical properties of water, oil and gas (oil, gas and water saturation of reservoirs, physical and chemical changes in fluids associated with an increase in the volume of formation fluids during the transformation of high-molecular organic substances into lighter hydrocarbons, an increase in the difference in the densities of hydrocarbons and water, heat release during radioactive decay). This factor in 11.2% of cases is given as the cause of AHRP.

High height of sedimentary rocks (high height of hydrocarbon deposit, presence of thick rock salt in the section, presence of clayey strata in the section). This factor is cited as the cause of AHRP in 10.2% of cases.

Reducing the depth of the productive formation with the pressure remaining after the formation of the deposit. Osmotic phenomena. This factor is cited as the cause of AHRP in 5.1% of cases.

Phenomena after the formation of the reservoir. This factor is cited as the cause of AHRP in 5.1% of cases.

Artesian Conditions. Contribute to a significant excess of the exit of the formation to the surface above the wellhead. This factor is cited as the cause of AHRP in 4.1% of cases.

Diagenetic transition of montmorillonite to lite and gypsum to anhydrite. This factor in 3.1% of cases is given as the cause of AHRP.

It should be noted that such a large number of factors for the formation of AHRP, in addition to the features of the geological structure and geological and physical conditions of oil and gas regions and each hydrocarbon field, may also depend on other poorly understood processes.

Since hydrocarbon deposits with AHRP are discovered in the sedimentary cover of many oil and gas regions of the world, practically at all stratigraphic horizons, various depths and types of hydrocarbon deposits, there is a need for further study of this problem in order to increase the efficiency of geological exploration and field development.

Materials and methods. The object of study is the Beshkent trough of the Bukhara-Khiva region (BHR), which is the most promising for discovering new hydrocarbon deposits. Currently, more than half of the structures identified and prepared for exploratory drilling in the Bukhara-Khiva region are concentrated in the Beshkent trough, and the success rate of drilling exploratory and exploration wells is over 65%.

Some reasons for the occurrence of abnormally high formation pressures in the

fields of the Beshkent trough are considered in (Hayitov at all, 2018: 71; Abetov at all, 2021: 6). A common drawback of these studies is that they studied the influence on the formation of AHRP, basically, only one factor. For example, in the work of A.Kh.Nugmanov, the influence of hydrocarbon migration (Hayitov at all, 2018: 71), U.Abdazimov - the content of condensate in the reservoir gas (Abetov at all, 2021: 6), M.R. Khamidov the role of faults (Xayitov, 2022:46), O.G. Khayitov - modern tectonic movements of the earth's crust (Kozbagarov at all, 2021: 98), etc. In this regard, there is a need for a comprehensive assessment of the influence of geological and physical factors on the formation of AHRP. At present, to assess the influence of various geological and physical factors on the process indicator, the calculation of the information content of these features is widely used. We have assessed the degree of information content of geological and physical factors using the Kulboka measure according to the formula (Zhaparkulova at all, 2021; Khaitov at all, 2022: 253). The geological and physical parameters of the hydrocarbon deposits of the Beshkent trough used to assess their informative value are given in Tables 1 and 2.

Research results. It can be seen from the given data that the geological and physical conditions of hydrocarbon deposits vary greatly in terms of the geological structure and types of deposits, the parameters of productive horizons, and reservoir pressure anomalies.

Let there be groups of objects A and B and some feature common to them, in our case, the amount of subsidence of the earth's surface. If in the differentiable states of objects, A and B this feature is different for each group of objects, then it is informative, by this feature it is possible to distinguish the objects of group A from the objects of group B. If the feature is not informative, such a difference cannot be made on this feature.

It should be noted that the information content of features can also be used in the problem of pattern recognition as coefficients that determine the degree of influence of each factor.

All objects are divided into two groups - A and B. The first group A has an anomaly coefficient of formation pressure K_a = 1,40 greater than 1,40 and the second B with this coefficient less, then the differences in the signs for these two groups are determined.

Table 1

Geological and physical characteristics of deposits of the Beshkent trough of the Bukhara-Khiva region.

№	The name of the deposits.	Areas of oil and gas bearing, m^2	Total productive thickness, m	Oil and gas saturation thickness, m	Open porosity, fractions of units	Oil and gas saturation, shares of units	Density of oil and condensate, kg/m^3	Water density, kg/m^3	Reservoir temperature, ^0K	Content of condensate, $10\text{-}10^{-3} kg/m^3$	Absolute mark of water-oil and gas-water contacts, m
1	2	3	4	5	6	7	8	9	10	11	12
1.	Khanabad	4800	16	3,6	0,100	0,706	925	1075	395	5	2798
2.	Sovligar	9450	30	3,6	0,043	0,670	902	1059	395	7	3134
3.	Feruza	5580	140	17,54	0,112	0,810	898	1084	394,4	8	3039
4.	Garmiston	2167	61	8,6	0,110	0,899	932	1075	396	6	3020
5.	Mezon	8400	43,6	19,59	0,124	0,832	787	1050	393	106	2592
6.	Karatepa	4860	51	18,8	0,142	0,809	935	1075	386	117	2896
7.	Yangi Karatepa	4931	95	35,94	0,118	0,796	858	1085	391	185,2	3211
8.	Shakarbulak	3580	105	41,5	0,097	0,781	901	1120	394	172,5	3365
9.	Turtsari	9553	92	30,1	0,157	0,858	844	1071	381	232,9	3088
10.	Kumchuk	18550	193	28,4	0,068	0,720	873	1081	381	183,5	3383
11.	Northern Shurtan	10125	75	11	0,127	0,690	862	1067	402	85,2	3233
12.	Ilim	14625	86	6,97	0,088	0,870	915	1102	390	73,57	2766
13.	Darakhtli	5320	80	15	0,133	0,858	878	1065	387	59,57	3107
14.	Kamashi	10625	70	9,1	0,055	0,610	838	1068	390	166	2976
15.	Beshkent	16650	200	24,4	0,091	0,680	835	1063	391	209,7	2947
16.	Sherkent	2922	125	8,2	0,085	0,650	817	1084	405	250	3230
17.	Ruboyi	5400	85,5	8,2	0,084	0,770	806	1086	390	19,52	3249
18.	Aknazar	4590	43	9,97	0,120	0,820	9230	1630	370,9	74	2533

Continuation of table 1

1	2	3	4	5	6	7	8	9	10	11	12
19.	Northern Aknazar	17550	85	12,7	0,090	0,700	879	1055	130	209	3294
20.	Mirmiron	8670	37	9,3	0,079	0,760	932	977	104	117	2576
21.	Namazbay	15400	60	30	0,077	0,807	841	1066	76,4	56,26	2561
22.	Oydin	22825	331	17,3	0,074	0,822	791	1078	85,43	53,11	2261
23.	Chunagar	8820	280	29,5	0,064	0,830	830	1061	115	130,6	3040
24.	Shurtan	178200	550	117	0,100	0,850	835	1065	112,5	58	2628
25.	Akhirbulak	19520	160	71,4	0,110	0,713	822	1076	117,3	67,38	2819
26.	Buzakhur	16470	315	48,6	0,022	0,790	812	1071	114	62	2694
27.	Eastern Buzakhur	5880	173	20	0,097	0,770	755	1071	104	213	2283
28.	Tarnasoy	12800	240	2,5	0,080	0,780	793	1049	114	61,9	2683
29.	Тавакkал Tavakkal	10800	240	54,2	0,069	0,790	794	1061	120	44,79	2820
30.	Alachagikuduk	26400	120	18,1	0,080	0,750	795	1087	112,5	58	3095
31.	Zafar	5040	120	12,2	0,110	0,810	795	1091	103,7	51	3379
32.	Northern Nishan	9000	173	20	0,100	0,780	789	1110	132,5	55	3260
33.	Nishan	47635	150	90	0,100	0,880	811	1115	127,4	58	3400
34.	Northern Guzar	6900	73	21,8	0,092	0,779	785	1111	123	58	3244
35.	Marvarid	9085	189	12	0,096	0,800	780	1082	113	59	3224
36.	Topichaksoy	12800	195	27,2	0,069	0,630	793	1098	117	62	2650
37.	Girsan	7875	14,2	5,9	0,076	0,757	811	1076	120	35,46	2807
38.	Northern Girsan	8743	195	38,19	0,068	0,810	812	1065	128	56,6	3451
39.	Divkhana	3187	195	38,19	0.068	0,810	812	1065	128	56,6	3451
40.	Ernazar	5440	55	52,9	0,095	0,817	817	1065	128	36,7	3420
41.	Chigil	6303	29,6	16,6	0.068	0,810	812	1065	128	56,6	3451
42	Talimarjon	3287	192	38	0.069	0,812	814	1063	127	56,8	3452
43	Nazarkuduk	5640	58	52,8	0,096	0,819	818	1062	127	36,9	3421
44.	Kapali	6750	8	3,8	0,110	0,780	819	1074	117	6	2900

Table 2

Anomaly coefficient of formation pressure of hydrocarbon fields in the south-eastern part of the Bukhara-Khiva region (O.G. Khayitov, 2020).

№	Name of the field and type of deposits	Horizon	Depth, m	Reservoir pressure, MPa	Anomaly coefficient K_a	The magnitude of the vertical movements of the earth's surface, 10^{-3}m/year *
1.	Khanabad	XV-HP	2798	275	0,982	2
2.	Sovligar	XV-HP	3134	353	1.16	2
3.	Feruza	XV+XVa	3039	295	0,971	2
4.	Garministon	XV-HP	3020	296	0.98	2
5.	Mezon	XV-HP	2592	340,2	1,312	1,5
6.	Karatepa	XV-P+HP	2880	346,4	1,202	3
7.	Yangi Karatepa	XV+XV-ПР+XVa	3124	478	1,530	3,75
8.	Shakarbulak	XVa, XV-HP+P	3365	387	1,150	2
9.	Turtsari	XV-HP+P+ПР	2510	283	1,127	2
10.	Kumchuk	XV+XVa	1981	230	1,161	2
11.	Northern Shurtan	XV-HP+P	3233	387,8	1,199	2
12.	Ilim	XV+XVa	2766	372	1,344	3,75
13.	Darakhtli	XV- P	3107	621	1,998	4,5
14.	Kamashi	XV+XVa	2976	554	1,861	4
15.	Beshkent	XV+XVa	2947	553	1,976	3,75
16.	Sherkent	XV+XVa+XVI	3230	418,3	1,295	3,75
17.	Ruboyi	XV+XV-ПР+XVa	3249	471	1,449	3,75
18.	Aknazar	XV-HP+ P	3312	604	1,823	4,2
19.	North Aknazar	XV-ПР+ P	3294	603	1,830	4
20.	Mirmiron	XV-HP+ P	2576	296,3	1,162	2
21.	Namazbay	XV+XVa	2906	306	1,053	2
22.	Aydin	XV+XVa	2261	281	1,242	2
23.	Chunagar	XV+XVa	3165	319	0,938	2
24.	Shurtan	XV-HP+P+XV-ПР	2680	439	1,46	4
25.	Akhirbulak	XV-HP+XV-P	2819	338	1,199	3
26.	Buzakhur	XV+XVa+XVI	2965	353	1,190	3,75
27.	Eastern Buzakhur	XV+XVa+XVI	2283	336	1,471	3
28.	Tarnasoy	XV+XVa	2683	355	1,323	3,25
29.	Tavakkal	XV-HP+XV-P	2820	317	1,124	3,25
30.	Alachagikuduk	XV-HP+XV-P	3095	360	1,163	3,75
31.	Zafar	XV+XVa	2630	418	1,590	3,75
32.	Northern Nishan	XV+XVa+XVI	2850	533	1,870	3,75
33.	Nishan	XV+XVa+XVI	3224	533	1,653	4
34.	Northern Guzar	XV-HP+XV-P	2890	318	1,100	2,5
35.	Marvarid	XV	2650	353	1,332	3,75
36.	Topichaksoy	XV	2807	349	1,243	3
37.	Girsan	XV+XVa	3610	621	1,720	6,75
38.	Northern Girsan	XV+XVa	3610	618	1,711	6
39.	Divkhana	XV+XVa	3592	621	1,728	6
40.	Ernazar	XV+XVa	3420	621	1,815	6

41.	Chigil	XV+XVa	3471	621	1,789	6,75
42.	Talimarjon	XV+XVa	3299	621	1,882	5,4
43.	Nazarkuduk	XV+XVa	3550	621	1,749	4
44	Kapali	XV+XVa	3120	563	1,895	4

Note; * – According to the Institute of Seismology of the Academy of Sciences of the Republic of Uzbekistan (Yarmukhammedov A.A. and others)

Let's consider one of the signs - «oil-and-gas saturated thickness», which varies from 2,5 to 117 m. Let's break this ordered series into 12 intervals: from 0 to 10; 10 to 20, etc. (it is recommended to break it into 8-12 intervals). In the next two columns, we place data on the frequency of hitting deposits from groups A and B, in each interval.

In the following columns, we enter the values of the relative frequencies as a percentage, taking as 100% the sum of the frequencies, respectively, A and B in all ranges. For example, for the interval 0–10 in group B, we have (7/24) 100=29,2. In order to minimize the influence of the choice of interval boundaries on the results, we determine the weighted average (smoothed) frequencies in each interval by calculating the weighted moving average. In this case, we take into account the frequencies of this feature in four neighboring ranges.

In the next column, we enter the ratios of the smoothed frequencies $\bar{Y}_A/\bar{Y}_B$, as well as the diagnostic coefficient (DC), which is the logarithm of the ratios of the smoothed frequencies, multiplied by 10:

$$\mathbf{DC = 10lg \cdot \frac{\bar{y}_A}{\bar{y}_R}.} \qquad (1)$$

Expressing the smoothed frequencies in fictitious intervals (zero and minus one), the weighted average values $\bar{Y}_{19}\bar{Y}_0$ and $\bar{Y}_{-1}$ should be summarized and the resulting sum is considered the weighted average frequency $\bar{Y}$-$_1$ of this feature in the extreme range

$$\mathbf{DC = 10lg \cdot \frac{\bar{y}_A}{\bar{y}_R}} \qquad (2)$$

From here, for the indicator «oil-and-gas saturated thickness» in the first interval, we have

$$\frac{\bar{y}_{A1}}{\bar{y}_{B1}} = \frac{19,2}{17,29} = 1,11; \qquad \mathbf{DC = 10lg1,110 = 0,453.}$$

Then we enter the values of the information content of this feature in each interval. According to the Kullback formula, the information value of the í-th range of the j-th feature is equal to

$$\mathbf{J(x_j^i) = DC(x_j^i)\frac{1}{2}\left[P\left(\frac{x_j^i}{A}\right) - P\left(\frac{x_j^i}{B}\right)\right]}, \qquad (3)$$

where DC () is the diagnostic coefficient of the í-th range of the j-th sign; P () - probability (smoothed frequency) of getting into the group A_i -th range of the j -th feature, i.e., the one marked To compile a diagnostic table, it is necessary to calculate the information content of a feature in all intervals and then find the information content of the entire feature (), which is equal to the sum of the information content of its ranges.

$$\mathbf{J}(\mathbf{x_j}) = \sum_i \mathbf{J}\left(\mathbf{x_j^i}\right). \quad (4)$$

Let's calculate the informativeness of the «oil gas-saturated thickness» indicator in the first interval (0-50):

$$\mathbf{J} = \mathbf{0.45} \cdot \frac{\mathbf{1}}{\mathbf{2}} \cdot (\mathbf{0.192} - \mathbf{0.1729}) = \mathbf{0.004}, \quad (5)$$

in the second (50 - 100)

$$\mathbf{J} = \mathbf{0.257} \cdot \frac{\mathbf{1}}{\mathbf{2}} \cdot (\mathbf{0.2129} - \mathbf{0.2006}) = \mathbf{0.002} \quad (6)$$

and so on.

The information content of this feature as a whole is found by summing the values of information content in the intervals $J_h = 0.190$.

The informativity of the remaining nine features is determined in a similar way: the values of vertical movements of the earth's surface, the potential content of condensate in the reservoir gas, the difference in the densities of water and oil (condensate), open porosity, effective oil and gas saturation of the reservoir thickness, the depth of hydrocarbon separation - gas-water contact (GWC), water-oil contact (VNK), reservoir temperature, total thickness of the productive horizon, oil and gas saturation and its area.

The calculation results are summarized in Table. 3, which shows that the occurrence of anomalous reservoir pressure in the hydrocarbon deposits of the Beshkent trough of the Bukhara-Khiva region was most affected by the magnitude of the vertical movement of the earth's surface (56%). The influence of the potential content of condensate in the reservoir gas (9.8%), the difference in the densities of water and oil (condensate) and open porosity, respectively, are also significant, 8.24 and 7.8%. At the same time, the influence of the total and effective oil and gas saturation thickness of the horizon, the depth of hydrocarbon separation (GWC, WOC), the temperature of the reservoir, oil and gas saturation and the area of oil and gas content turned out to be insignificant.

Based on the study of the causes of AHRP by the method of assessing the information content of geological and physical factors, it can be concluded that anomalously high reservoir pressures in the hydrocarbon deposits of the southeastern part of the BCR were formed due to tectonic stresses and tectonic processes that cause compression and deformation of deep reservoirs, as well as due to physical chemical changes in reservoir hydrocarbons and compaction of rocks under the influence of geostatic pressure.

Taking into account these factors, we have compiled a map of the distribution of AHRP in the study area. Based on the general patterns' characteristic of each region, zones with varying degrees of their manifestation have been identified.

Table 3

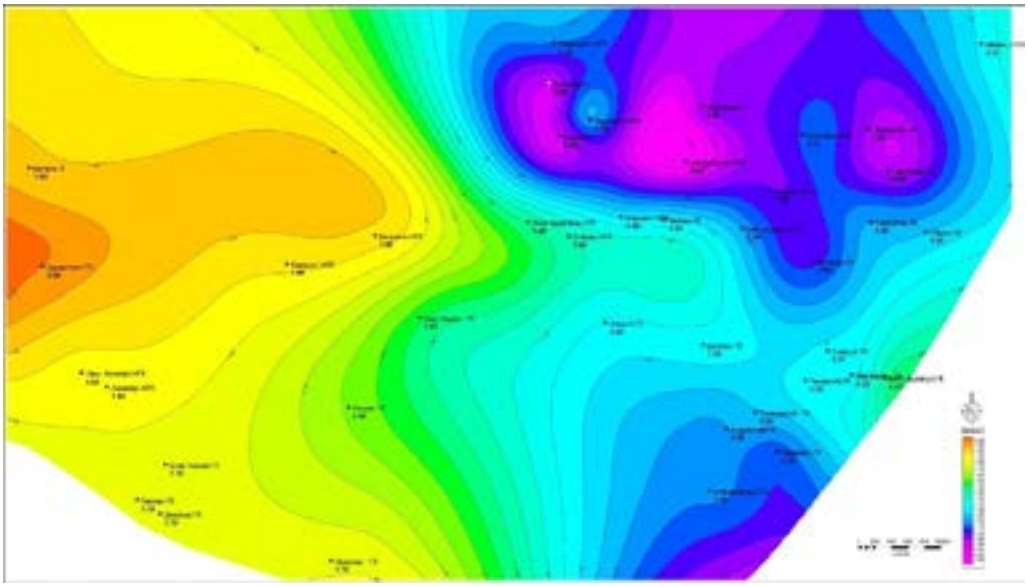
The results of assessing the information content of geological and physical parameters.

№	Parameters	Limits of change	Informative	Share in total informativeness	Note
1	The magnitude of the vertical movements of the earth's surface, 10^{-3}m / year	1,50–6,75	2,038	56,5	main factor
2	Potential content of condensate in reservoir gas, 10^{-3}kg/m³	5–250	0,354	9,80	Significant factor

3	Density difference between water and oil (condensate), кг/м³	252–518	0,298	8,24	Significant factor
4	Open porosity, %	2-20	0,283	7,80	Significant factor
5	Oil and gas pay thickness		0,190	5,26	Non-significant factor
6	Depth of hydrocarbon separation, m	2261-3461	0,166	4,68	Non-significant factor
7	Reservoir temperature, K	349,4-405,5	0,140	3,87	Non-significant factor
8	Total thickness of the productive horizon, m	8-550	0,106	2,93	Non-significant factor
9	Oil and gas saturation, shares of units	0,610-0,932	0,037	1,02	Non-significant factor
10	Area of oil and gas saturation, thousand m³	2167-178200	0,001	0,00	Non-significant factor

As can be seen from the figure, in the northeastern part of the study area, there are mainly oil fields with a formation pressure anomaly coefficient equal to K_a=1, in the middle part there are mainly gas condensate fields with a formation pressure anomaly coefficient within K_a=1, 2–1,6. In the southeastern part, gas fields were formed, in which the reservoir pressure anomaly coefficient reaches 2.

In this regard, when drilling exploratory and exploration wells in new areas, the expected value of reservoir pressure should be justified taking into account the above factors, which are the main causes of AHRP.



Map of reservoir pressure anomaly distribution in the Beshkent trough of the Bukhara-Khiva region

The discussion of the results. Based on the generalization of the results of the study of the causes of AHRP, it has been established that this process can be predetermined

associated with many geological and physical factors. Specific to a specific oil and gas region.

Using the method of assessing the information content of geological and physical factors, it was established that in the hydrocarbon deposits of the Beshkent trough of the Bukhara-Khiva region, the occurrence of AHRP is also associated with many factors. However, due to the different degree of influence of these factors, different zones of manifestation of AHRP are distinguished**.**

Thus, we can say the following, fields with abnormally high formation pressures are quite widespread in the sedimentary cover of the oil and gas regions of the world, in various stratigraphic horizons and depths, in various types of hydrocarbon deposits and their reserves. As a result of the analysis of the mechanism, more than 20 causes of AHRP have been identified. At the same time, depending on the geological conditions of the oil and gas regions and the characteristics of each specific field, no more than 3–5 factors are distinguished for the studied territories that contribute to the occurrence of AHRP.

2. Based on the systematization of the mechanism of occurrence of AHRP, the following groups of causes are identified, related to:

- compaction of rocks of isolated layers under the influence of geostatic pressure;
- tectonic direction and tectonic processes causing compression and deformation of deep reservoirs;
- the entry of high-pressure fluids into a closed reservoir from deeper horizons along faults;
- physical and chemical properties of water, oil and gas;
- high height of sedimentary rocks;
- a decrease in the depth of the productive horizon with the pressure remaining after the formation of the deposit;
- osmotic phenomena;
- a significant excess of the exit of the formation to the surface above the wellhead;
- diagenetic transition of montmorillonite to ilite and gypsum to anhydrite.

3. On the basis of statistical processing of data on initial reservoir pressures and potential condensate content in the produced gas of oil and gas condensate and gas condensate fields of the Beshkent trough, their close relationship was established with a correlation coefficient of 0.957. The revealed dependence shows that in the fields of the Beshkent trough, the presence of condensate content in gas can only be predicted in deposits with an initial formation pressure above 20 MPa.

4. To establish the geological and physical factors contributing to the occurrence of AHRP in the fields of the Beshkent trough, the information content of these signs was calculated using the Kullback measure. As a result, it was established that the magnitude of the vertical movement of the earth's surface has the greatest influence on the occurrence of AHRP in the hydrocarbon fields of the Beshkent trough. The content of condensate in the gas, the difference in the densities of water and oil, and open porosity also have a significant effect.

In this regard, when drilling exploratory and exploration wells in new areas of the

Beshkent trough, the expected value of reservoir pressure should be justified taking into account the above factors, which are the main causes of AHRP.

Conclusion. The geological and physical factors that are the main reasons for the occurrence of AHRP in the fields of the Beshkent trough have been determined. It is substantiated that in the study area, AHRPs were formed due to a complex of reasons associated with tectonic stresses and tectonic processes that cause compression and deformation of deep reservoirs, as well as physicochemical changes in reservoir hydrocarbons and rock compaction under the influence of geostatic pressure. A map of the distribution of AHRP was compiled for use in justifying the design of prospecting and exploration wells and methods for their development.

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ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Директор отдела издания научных журналов НАН РК *А. Ботанқызы*
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Редакторы: *М.С. Ахметова, Д.С. Аленов*
Верстка на компьютере *Г.Д. Жадыранова*

Подписано в печать 06.12.2022.
Формат 70x90$^{1}/_{16}$. Бумага офсетная. Печать – ризограф.
20,0 п.л. Тираж 300. Заказ 6.

Национальная академия наук РК
050010, Алматы, ул. Шевченко, 28, т. 272-13-19