SOI: 1.1/TAS DOI: 10.15863/TAS

International Scientific Journal

Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2024 **Issue:** 01 **Volume:** 129

Published: 04.01.2024 **http://T-Science.org**

Issue **Article**

Annaguly Rejepovich Deryaev

Scientific Research Institute of Natural Gas of the State Concern „Turkmengas",

Doctor of Technical Sciences, Principal researcher,

Corresponding Member of International Academy of

Theoretical and Applied Sciences,

Ashgabat, Turkmenistan

annagulyderyayew@gmail.com

ISOLATION AND EVALUATION OF CARBONATE RESERVOIRS ON THE EXAMPLE OF DEPOSITS IN TURKMENISTAN

***Abstract**: The isolation and evaluation of the industrial value of complex reservoirs in the sections of exploration and parametric wells in Turkmenistan is a rather difficult task and is currently not completely solved. To study carbonate reservoirs in domestic and foreign practice, various methods of complex interpretation of diagrams of geophysical well research methods are used, most of which are based on comparing the specific or relative resistance with the readings of acoustic and neutron gamma logging.*

The value of the carbonate deposits of Turkmenistan is associated with a wide variety of structural forms of their pore space, lithological heterogeneity, low-power formations, etc. As a result, the geophysical characteristics of carbonate rocks are ambiguous; the relationship established between different parameters for one lithological reservoir difference is often invalid for carbonate reservoirs of another lithology. Due to the low porosity of deep-lying reservoir rocks, the requirements for the accuracy of determining reservoir parameters from geophysical materials are significantly increasing.

***Key words**: porosity, corbonal rocks, resistivity, interpretation, cavernosity, saturation, logging, lithology.*

***Language**: English*

Citation: Deryaev, A. R. (2024). Isolation and evaluation of carbonate reservoirs on the example of deposits in Turkmenistan. *ISJ Theoretical & Applied Science, 01 (129),* 179-190.

Soi: http://s-o-i.org/1.1/TAS-01-129-11 ***Doi***: crossref https://dx.doi.org/10.15863/TAS.2024.01.129.11

***Scopus ASCC**: 2209.*

Introduction

The secondary porosity of carbonate rocks is associated with the presence of cavities and cracks or a different combination of them, depending on the predominance of a particular type of container. With an increase in the depth of carbonate rocks, the value of fractured porosity increases, since the permeability of reservoirs is associated with its magnitude.

Currently, various techniques have been developed to isolate fractured intervals in well sections: a method for determining fractured porosity according to lateral or microblock logging; a method for extreme values of block resistivity; a method for isolating fractured carbonate reservoirs by the value of critical resistance [1-4].

Let's consider the conditions of application of the latter method in the studied sections of Western and Central Turkmenistan. The deep-lying carbonate rocks of Western Turkmenistan (well No 23-Kara-Teke, interval 4000-5000 m) the Barem limestones are characterized by significant resistances reaching 1000 Ohms. The critical (limit) resistance $\rho_{l.f.}$ of the fractured collector, determined by the pallet (Fig. 1) at ρ_f = 0.16 Ohms, is 230 Ohms (the resistance of the rock block is 1000 Ohms).

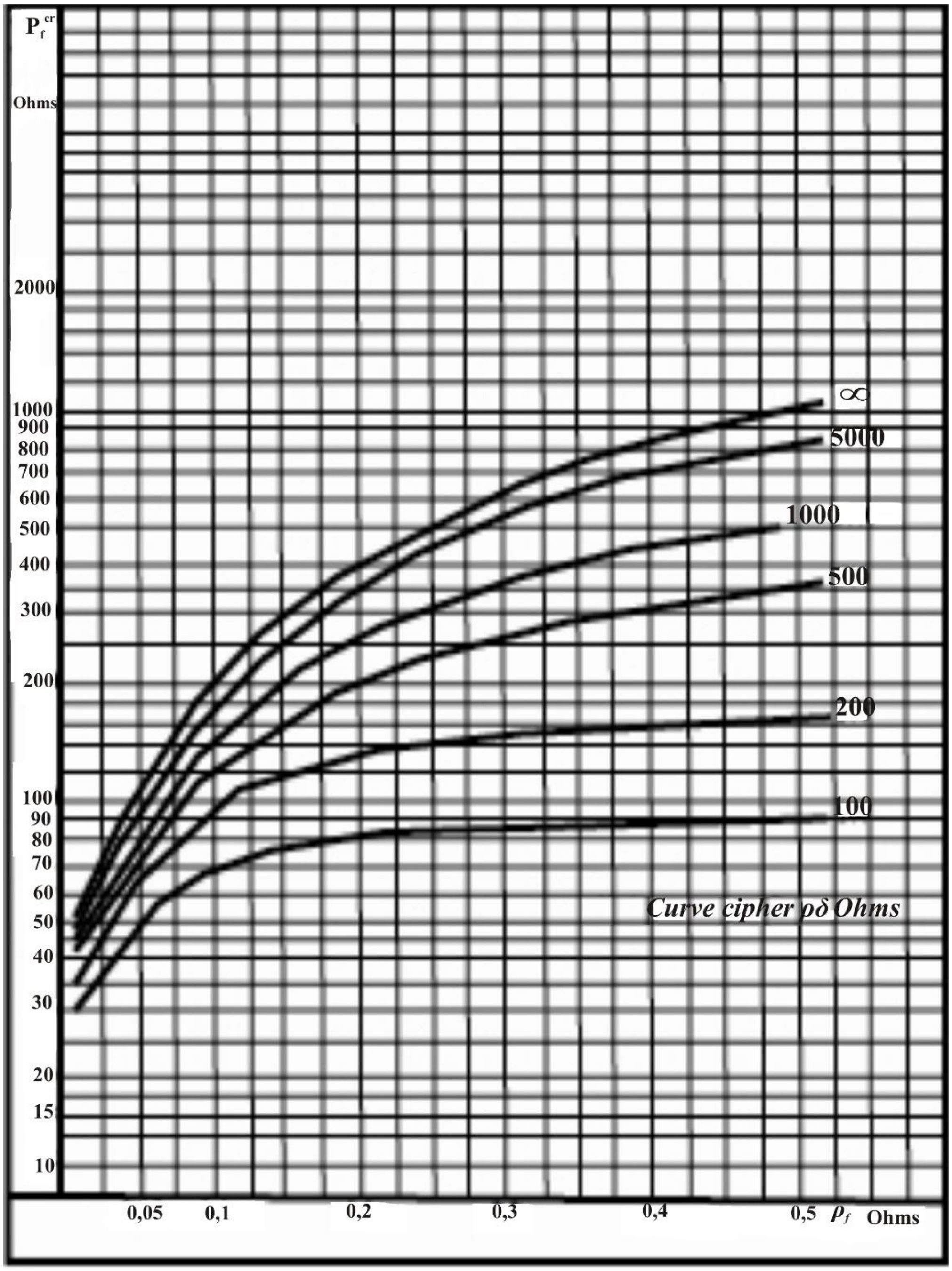

Fig. 1. A pallet for determining the critical resistance of a fractured collector

The maximum possible resistivity corresponding to the critical value of the flow fracture porosity equal to 0.05% is taken as the critical (limit) resistance of the fractured collector. [5, 6]

Using the nomogram (Fig. 2) for formations with a resistance of less than 230 Mm, the value of crack porosity is determined. According to this method, the $K_{p.f}$ varies between 0.04-03%. When using the approximate formula for calculating the $K_{p.f.}$ the values 0.04-0.5% were obtained.

$$K_{p.f.} = \rho_{f.} \frac{\rho_{l.r.} - \rho_{l.f.}}{\rho_{l.r.} \times \rho_{l.f.}} \qquad (1)$$

When testing the STT (a set of test tools) interval, an influx of gas and reservoir water was obtained [7, 8, 9].

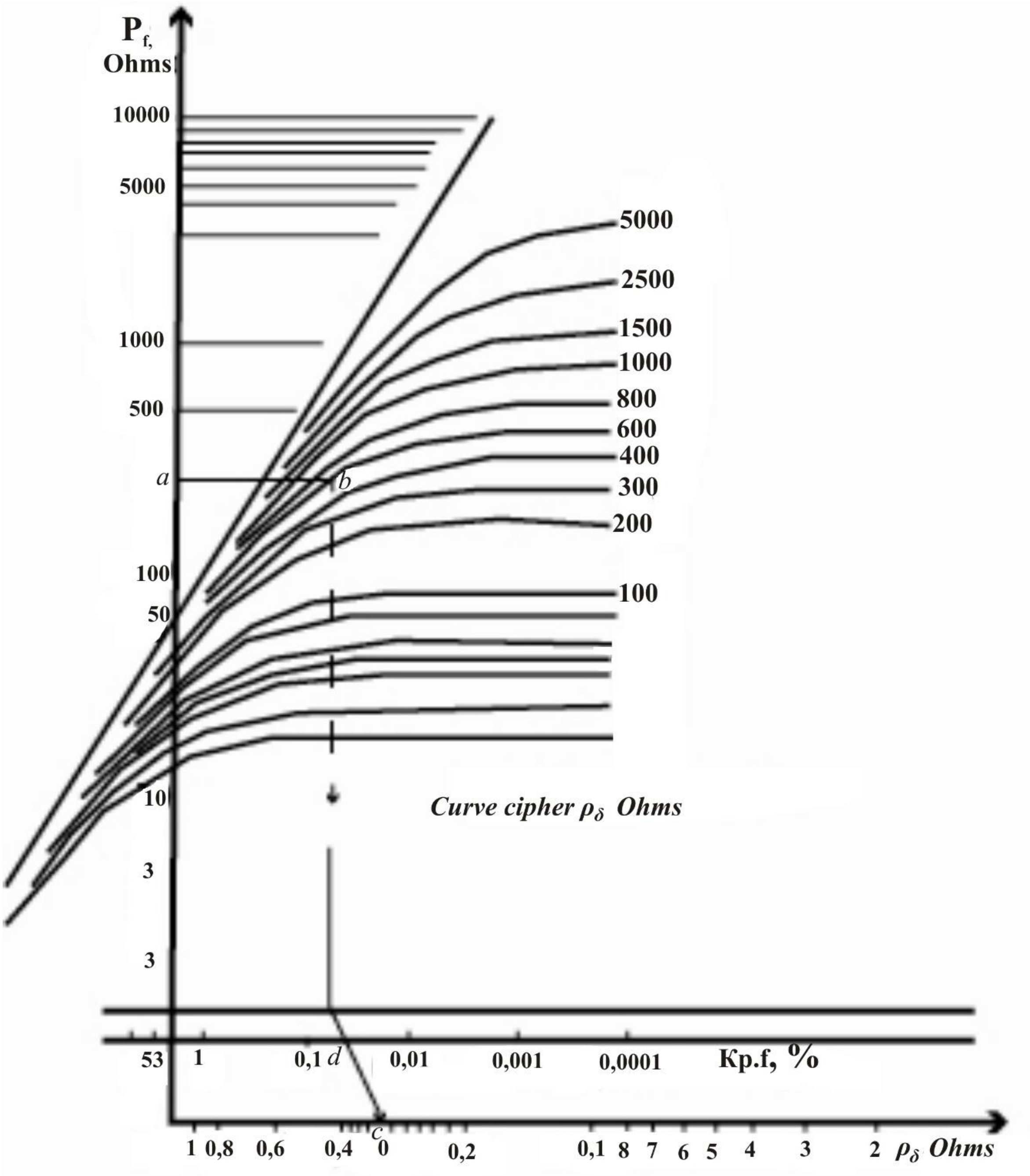

Fig. 2. Nomogram for determining fracture porosity

In conditions of highly mineralized drilling fluids in the exploration areas of Central Turkmenistan (ρ_f = 0.03 - 0.065 Ohms), the scope of application of the above pallet and nomogram is moved to the left. At the same time, there is a need for a differentiated approach to the choice of the value of the $\rho_{l.r.}$.

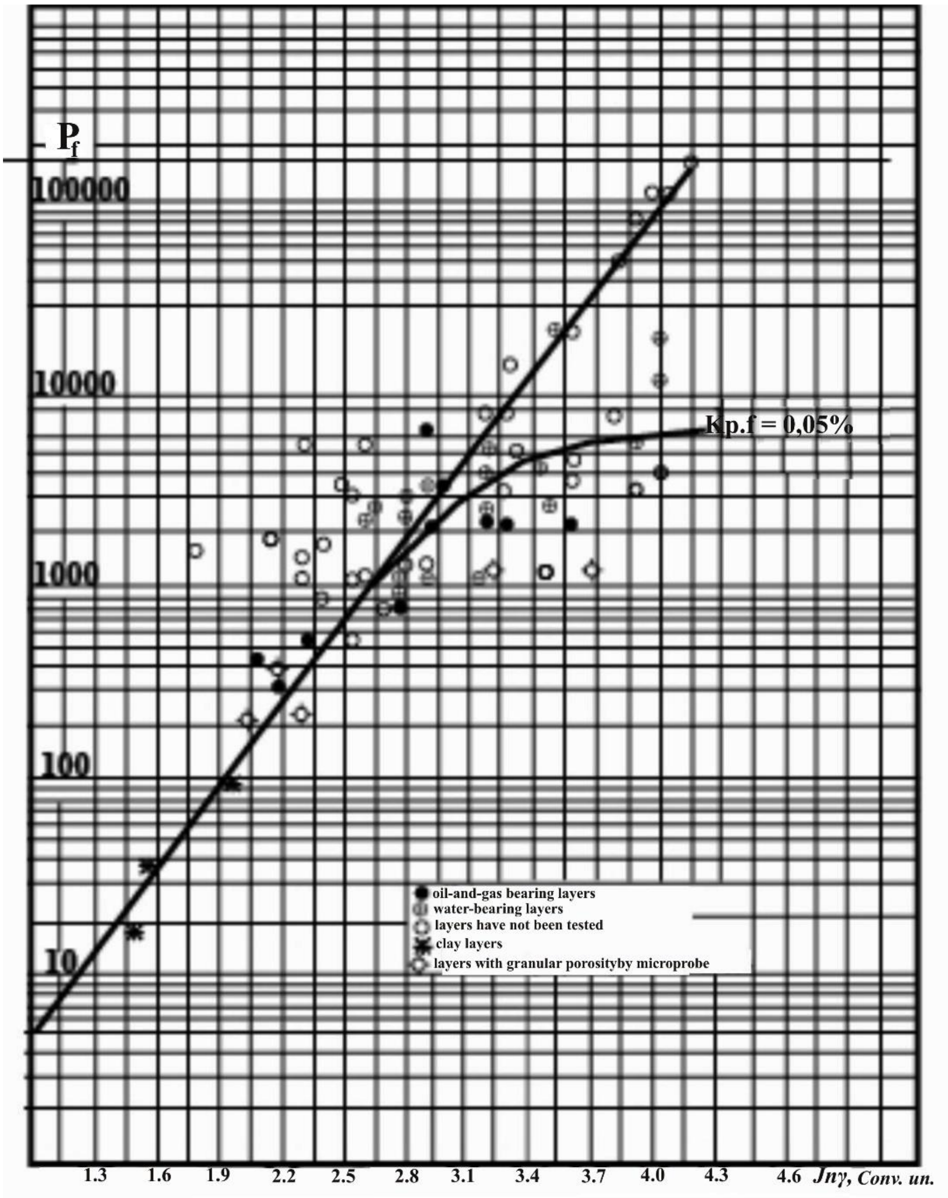

Fig. 3. Isolation of reservoirs with fractured porosity (well No 2-Sabur, interval 2644-2836m)

The determination of the magnitude of the fractured porosity of the $K_{l.f.}$ under such conditions is carried out as follows. The semi-logarithmic blank is marked with points whose coordinates correspond to the $P_{s.}$ and Jnγ of the selected layers (Fig. 3). A line of layers with granular porosity is drawn [10, 11].

The points located to the left of the line of granular rocks correspond to layers of dolomites or limestones with the presence of cavernous porosity; the points located below the line of granular rocks correspond to layers with fractured porosity.

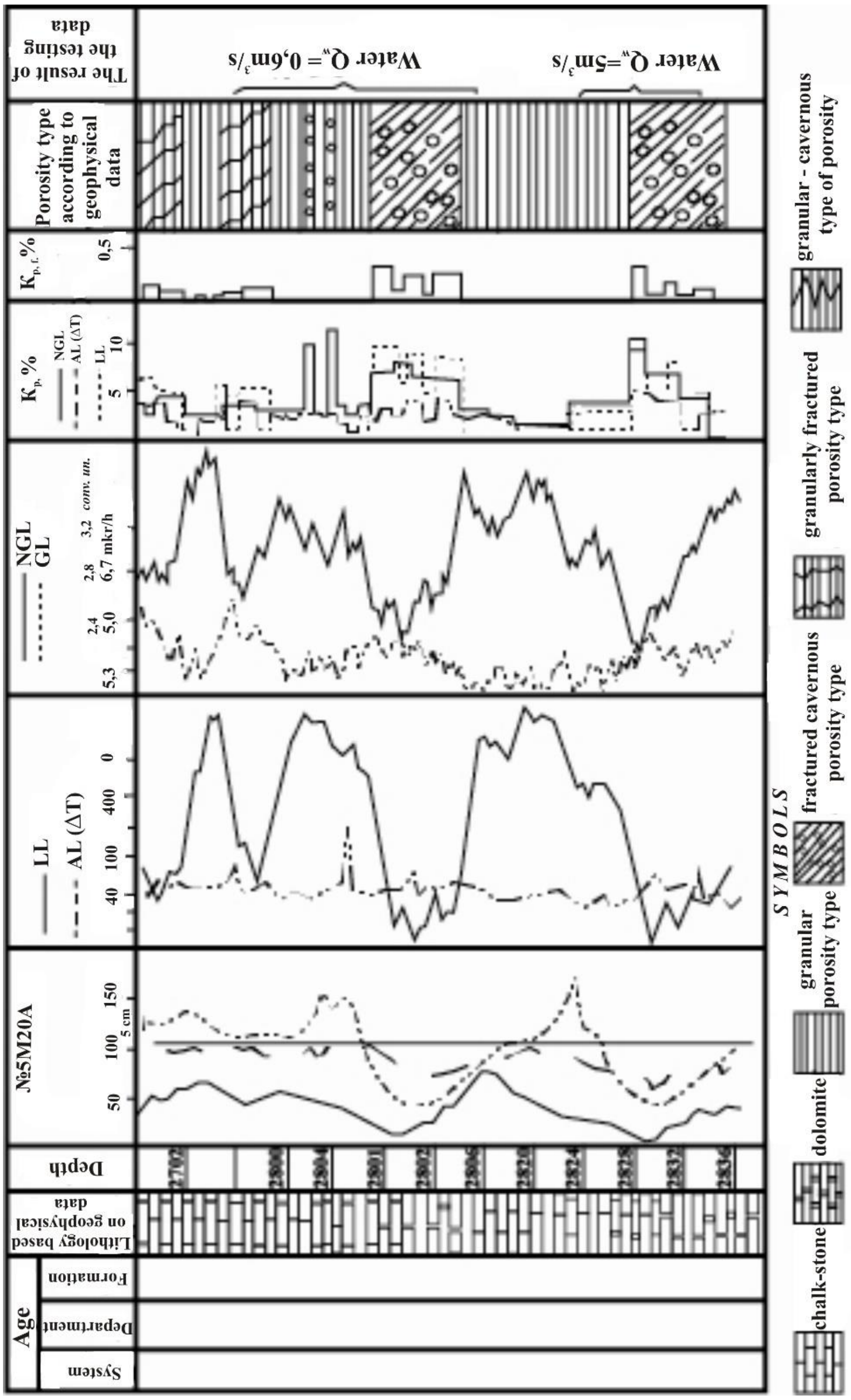

Fig. 4. Isolation and assessment of layers with a complex type of porosity (well No 2-Sabur).

According to the above formula (1), depending on the rpb, we calculate the boundary values of the $K_{l.f.}$ corresponding to 0.05%. Thus, layers with a $K_{l.f}$ of <0.05% will be located above the line, corresponding to $K_{l.f.}$ = 0.05%. These layers are not collectors and are excluded from further consideration.

Layers with a $K_{l.f.}$ of >0.05% will be located below the boundary value, for these layers the value of the fractured porosity of the $K_{l.f.}$ is determined by the nomogram in Fig. 3 or by formula (1).

As an example, consider the results of interpretation of gas dynamic studies (GDS) materials in the carbonate section of well No.2-Sabur (interval 2644-2836 m).

According to the method described above, a comprehensive quantitative interpretation was performed, $K_{p.}^{NGL}$, K_p^{AL}, K_p^{LL} were determined, taking into account which the rocks were divided according to the prevailing type of porosity (Fig.4). The magnitude of the fractured porosity varies within 0,05-0,9% [12, 13].

Isolation and evaluation of carbonate reservoirs with the presence of cavernous porosity. Cavernous rocks, the porosity of which is largely determined by cavities that have little effect on the overall electrical conductivity, have almost the same relative resistance as a rock with the same volume of intergranular porosity. Consequently, in cavernous rocks, the K_p^{LL} values will characterize the granular porosity. Cavernosity practically does not affect the results of determining porosity coefficients according to AL either. At the same time, the results of determining porosity by neutron gamma logging depend on the total porosity.

Thus, based on the well-known comparison of K_p^{LL}, K_p^{AL}, $K_{p.}^{NGL}$, it is possible to determine the type of reservoir and in some cases to separate fractured and cavernous rocks according to the K_p^{LL}, K_p^{AL}, $K_{p.}^{NGL}$ characteristic of fractured rocks and $K_{p.}^{NGL}$, K_p^{AL}, K_p^{LL} for cavernous rocks. The amount of cavernous porosity in this case is defined as the difference between $K_{p.}^{NGL}$ and K_p^{AL}, K_p^{LL} [14, 15].

One of the main tasks of interpreting GDS materials is to determine the nature of reservoir saturation. For this purpose, electrical methods or a set of methods are used, which necessarily includes an electrometric one.

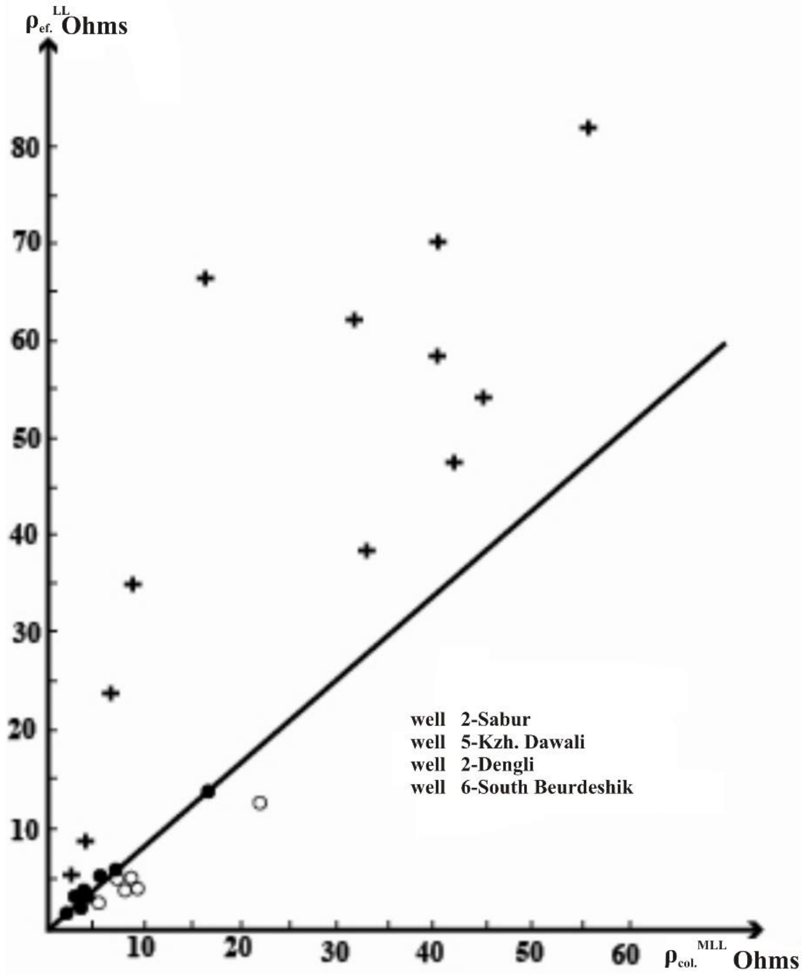

Fig. 5. Assessment of the saturation of carbonate reservoirs by the microlaterolog logging - lateral logging (MLL – LL) method

- not collectors;

♦ gas-saturated strata for testing;

o water-saturated layers for testing

<u>Determination of the saturation character according to the lateral logging sounding (LLS).</u> The use of LLS materials is based on the study of radial inhomogeneity in the resistance of the studied collector. A sufficient sign of reservoir oil and gas saturation is the production of a three-layer sounding curve characterizing the penetration of drilling mud filtrate, which reduces the resistance of the formation. However, the use of the method is possible in layers of sufficient power to obtain the right branch of the sounding curve.

As noted above, the productive deposits of the studied sections are characterized by layers of medium and low thickness (h≤4 m), therefore, the use of the method in most cases is not possible [16, 17].

<u>Determination of the saturation character by the</u>

MLL – LL method. The method is effective for determining the nature of saturation of collectors of any capacity. Figure 5 shows a comparison for the tested objects of the studied deposits. A clear separation of oil and gas saturated and water saturated reservoirs has been obtained. In this way, pore-cavernous and pore-fractured reservoirs are also separated according to the nature of saturation.

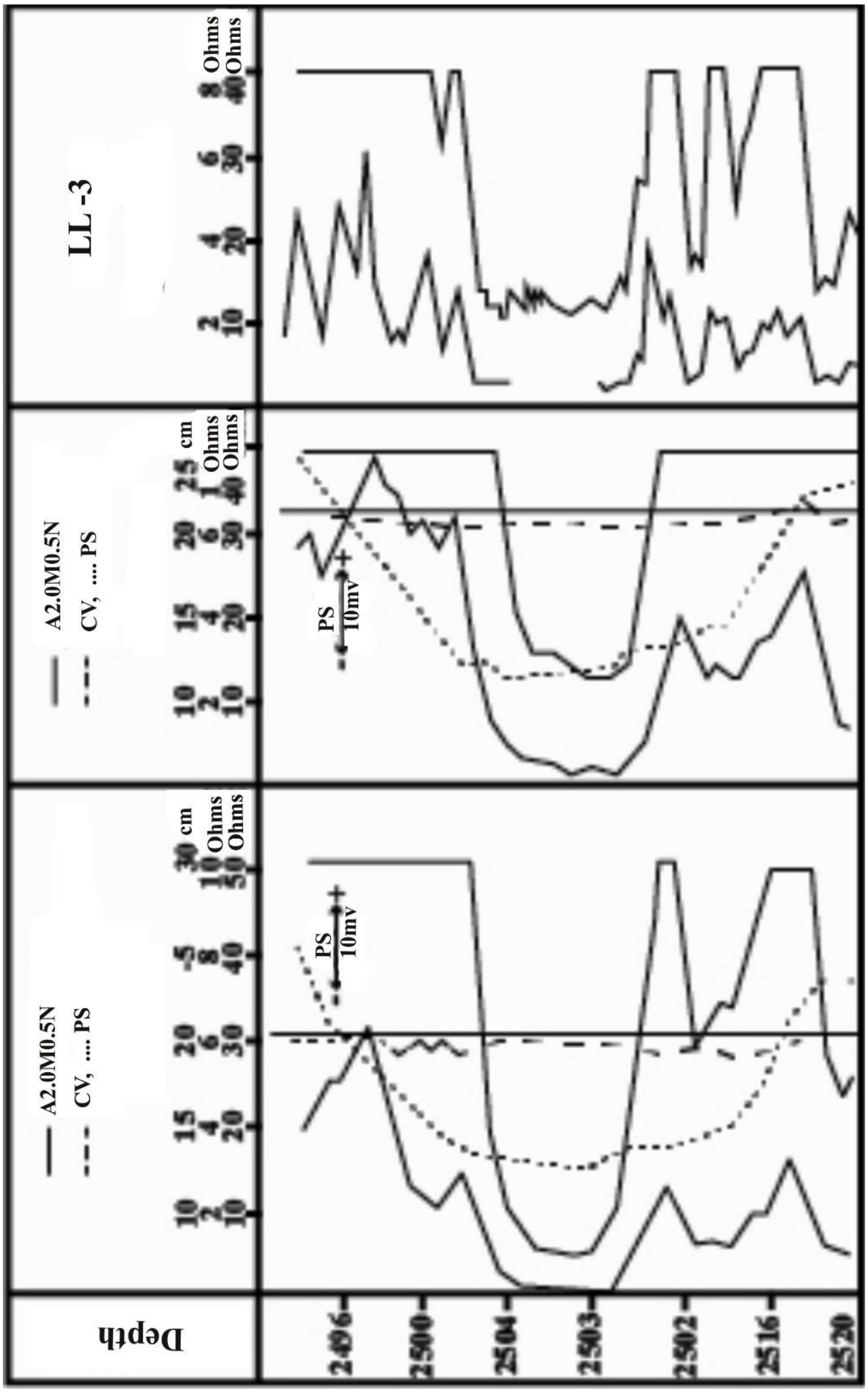

Fig. 6. The change in apparent resistivity (AR) on the curves of time measurements (well 5, Kzh. Dawali)

Determination of the saturation character based on temporary measurements of electrical logging.

The technique is applicable to assess the saturation pattern of reservoirs, both pore-type and complexly constructed. Figure 6 shows an example of the separation of a gas-saturated reservoir of the pore type. The effectiveness of the method depends on the time elapsed after opening the interval and the first measurement of the electrical logging. The shorter this time, the more effective the method is. The analysis showed that the time between opening the interval and the first measurement should not exceed 5 days [18, 19].

Determination of the saturation character according to LL and AL data. The method is based on the separation of reservoirs by critical resistance calculated from known porosity (AL) and reservoir water resistance (Fig. 7). The value of critical resistance $\rho\frac{LL}{KR} = 4P_s\rho_w$ is calculated for ρ_w = 0.012 0mm; 0.015 0mm; 0.018 0mm most characteristic of the conditions of the studied deposits and corresponds to K_w = 0.5.

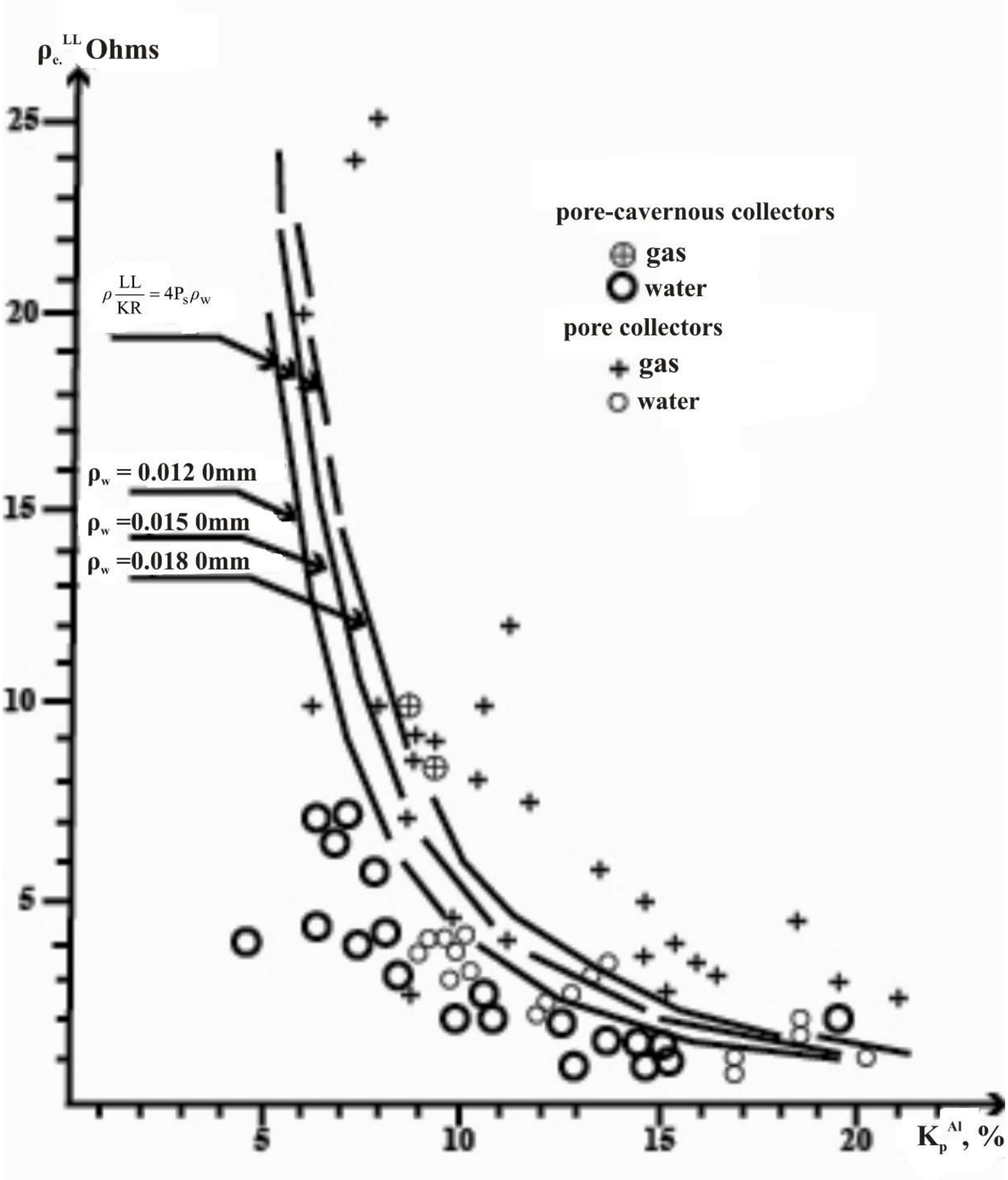

Fig. 7. Assessment of the nature of reservoir saturation according to BC w AK data

The lines $\rho = \frac{LL}{KR}$ separate the collectors tested through the production column by the nature of saturation with a confidence of 0.87.

Determination of the saturation character by the diagnostic coefficient (K_d). To assess the saturation pattern of the matrix and the type of collector based on the results of a comprehensive interpretation of the LL, NGL, AL data, it is proposed to use the diagnostic coefficient K_d:

$$K_d = \frac{K_p^{NGL} - K_p^{LL}}{K_p^{LL}} \qquad (2)$$

K_p^{NGL} is the total porosity of the formation, determined according to (neutron-gamma logging) NGL data.

K_p^{LL} is the block porosity of the formation, calculated by its specific resistance (with partial oil saturation of the intergranular space, K_p^{LL} is the water–saturated part of the lateral porosity, and K_p^{NGL} - K_p^{LL} is the crack-cavern porosity of K_{pfc}) [20-23].

Table 1 shows a comparison of diagnostic coefficients with the results of testing. Diagnostic coefficients are calculated separately for NGL-LL and AL-LL. As can be seen from the table, the coefficient values for AL-LL are slightly lower than for NGL-LL, which indicates the presence of cavernous porosity.

Table 1. Comparison of diagnostic coefficients with test results

Research interval	K_p^{NGL} %	K_p^{LL} %	K_p^{AL} %	$K_d = \frac{K_p^{NGL} - K_p^{LL}}{K_p^{LL}}$	$K_d = \frac{K_p^{AL} - K_p^{LL}}{K_p^{LL}}$	The results of the testing
Sabur square, well No. 1						
2882,0-2878,0	10,8	8,0	8,3	0,35	0,04	Q_w =15,8 m^3/s
2878,0-2875,0	3,0	3,3	2,0	-	-	
2875,0-2873,0	4,4	4,2	3,8	0,05	-	
2866,0-2864,0	5,3	4,0	3,9	0,32	-	
2864,0-2861,6	4,5	3,5	3,9	0,28	0,11	
2861,6-2859,2	1,7	2,0	1,9	-	-	
2855,0-2851,0	7,5	9,0	6,1	-	-	
2847,0-2841,6	4,5	4,1	3,4	0,1	-	
2841,6-2838,6	7,0	5,5	6,1	0,27	0,11	
2838,6-2835,0	1,2	1,5	1,9	-	0,26	
2799,6-2796,0	6,0	5,8	5,3	0,03	-	Q_w =0,5 m^3/s
2730,6-2727,6	6,0	5,3	3,5	0,13	-	Q_w =6,5 m^3/s
Chirli square, well No. 1						
3114,4-3118,0	14,0	11,0	10,8	0,27	-	Water - saturated
3315,0-3317,6	14,0	12,0	11,0	0,16	-	
3409,6-3415,2	16,5	13,0	16,5	0,27	0,27	Non-industrial gas inflow was received
3420,8-3422,8	6,1	7,0	4,9	-	-	
3424,0-3426,0	6,4	10,0	7,0	-	-	
3439,2-3443,2	12,0	10,8	11,1	0,11	0,03	
3580,8-3583,6	10,8	11,0	8,4	-	-	Water - saturated
3585,0-3588,6	14,8	4,8	2,2	1,25	-	
3588,6-3591,4	16,3	10,8	6,7	0,51	-	
3724,0-	0	1,2	0	-	-	

3728,8						
3740,2-3742,4	5,9	4,7	3,5	0,25	-	
Karadzaulak square, well No. 1						
4246,4-4249,6	5,3	6,2	3,6	-	-	
4336,6-4338,8	2,4	1,3	2,3	0,84	0,77	
4361,0-4365,6	14,0	7,0	11,3	1,0	0,61	Q_g=130 t m^3/s
4367,0-4370,4	12,5	8,0	10,8	0,56	0,35	Q_w=500 m^3/s
4374,0-4379,2	15,6	15,2	13,3	0,02	-	
Karadzaulak square, well No. 2						
3921,6-3925,6	3,2	3,0	2,6	0,06	-	Q_w =20 m^3/s
3929,8-3934,0	7,3	7,8	7,8	-	-	
3951,2-3954,0	1,8	2,4	2,4	-	0,25	Q_w =130 m^3/s
3955,2-3958,0	3,9	3,6	3,6	0,08	-	
North Halimergen square, well No. 1						
2806,0-2810,8	16,1	9,1	16,3	0,78	0,81	An influx of water and gas has been received Q_w =3.4 m^3/s Q_g =non-industrial.
2810,8-2815,2	11,2	12,0	10,8	-	-	
2819,0-2822,4	5,4	4,8	2,4	0,12	-	
2825,0-2829,6	10,4	11,5	10,1	-	-	
2829,6-2839,4	11,7	17,0	11,6	-	-	
3219,2-3224,0	2,5	3,6	1,9	-	-	The inflow has not been received
3259,0-3262,0	3,2	2,4	2,4	0,33	-	
3262,0-3268,0	2,3	1,8	1,5	0,27	-	
3281,0-3283,6	2,2	2,3	1,9	-	-	Traces of gas
3285,4-3288,2	1,2	2,7	1,9	-	-	During testing, a weak gas inflow was obtained
3289,6-3293,6	1,6	2,8	1,5	-	-	
3293,6-3296,0	2,1	4,2	2,2	-	-	
3322,6-3327,2	2,9	5,0	3,3	-	-	
3327,2-3330,0	2,2	3,0	1,9	-	-	
Sabur square, well No. 2						
2763,4-2765,2	5,6	2,8	5,2	1,0		Q_w =7,3 m^3/s Q_g =2, 4 thousand m^3/s
2773,0-2776,0	9,0	3,7	8,0	1,43		
2776,0-	11,0	7,7	10,5	0,43		

2777,6						
2777,6-2779,0	13,5	6,5	13,0	1,1		

The insufficient number of productive layers does not allow us to confidently determine the limit value of the K_d, which separates reservoir layers into water-saturated and productive ones. However, it can be assumed that at K_d <0.7 for NGL-LL (according to AL-LL <0.6), the layers are characterized as water-saturated, at K_d > 0.7 - as productive) [24, 25, 26].

In the presence of fractured porosity, the use of a diagnostic coefficient to assess the nature of reservoir saturation is impractical.

References:

1. Deryaev, A.R. (2022). *Sovremennoe sostoyanie izuchennosti bureniya napravlennyh i mnogozabojnyh skvazhin s razdel'noj ekspluataciej odnovremenno neskol'kih gorizontov (zarubezhnyj opyt).* Sbornik statej mezhdunarodnogo nauchno-issledovatel'skogo konkursa "Akademicheskaya nauka na sluzhbe obshchestvu". (pp.170-178). Petrozavodsk: Nauchnoe izdanie: MCNP "Novaya nauka".
2. Donkov, P.V., Leonov, V.A., Sorokin, A.V., & Sabanchin, I.I. (2003). *Razukrupnenie ob"ektov razrabotki dlya povysheniya ih nefteotdachi.* Intensifikaciya dobychi nefti i gaza: tr. Mezhdunarodnyj tekhnologicheskogo simpoziuma. – M.: Institut neftegazovogo biznesa.
3. Deryaev, A.R. (2022). Rekomendacii po kompleksnomu vnedreniyu s razdel'noj ekspluataciej odnovremenno neskol'kih gorizontov na gazovyh mestorozhdeniyah Turkmenistana. *Problemy nauki* №1 (69) – M: Izdatel'stvo "Problemy nauki", pp.16-21.
4. Donkov, P.V., Leonov, V.A., Sivokon', I.S., & Ahtyamova, E.N. (2003). *Preduprezhdenie otricatel'nogo tekhnogennogo vozdejstviya na prizabojnuyu zonu plasta.* Intensifikaciya dobychi nefti i gaza: tr. Mezhdunarodnyj tekhnologicheskogo simpoziuma. – M.: In-t neftegazovogo biznesa.
5. Garifov, K.M. (2010). Primenenie odnovremenno-razdel'noj ekspluatacii plastov v OAO "Tatneft'" K.M. Garifov, A.V. Gluhoded, N.G. Ibragimov, V.G. Fadeev, R.G. Zabbarov *Neftyanoe hozyajstvo*. №7, pp. 55-57.
6. Deryaev, A.R. (2022). Ohrana nedr i okruzhayushchej sredy pri razrabotke gazovyh mestorozhdenij metodom odnovremennoj razdel'noj ekspluatacii. *Nauchnyj zhurnal Metod Z* №2 (4) – Sankt-Peterburg: Izdatel'stvo: GNII «Nacrazvitie», pp.12-14.
7. Sahnov, R.V. (2011). Odnovremenno-razdel'naya ekspluataciya dvuh plastov s kontrolem depressii. R.V. Sahnov, I.V. Grekhov, O.S. Nikolaev. *Inzhenernaya praktika*. №3, pp. 20-23.
8. Deryaev, A.R., & Orazklychev, K. (2015) *Sposob odnovremenno-razdel'noj dobychi nefti i gaza iz mnogoplastovoj zalezhi odnoj skvazhinoj*. Patent № 644 ot 08.06.2015. (nomer zayavki 15/101320).
9. Deryaev, A.R., & Orazklychev, K. (2015) *Sposob odnovremenno-razdel'noj i sovmestnoj ekspluatacii neskol'kih produktivnyh gorizontov odnoj skvazhinoj i ustrojstvo dlya ego osushchestvleniya*. Patent № 643 ot 08.06.2015. (nomer zayavki 14/101317).
10. Semenov, V.N. (2010). Opyt razrabotki i osvoeniya tekhnologii ORRNEO mekhanizirovannym sposobom. V.N.Semenov. *Inzhenernaya praktika.* №1, pp. 85-89.
11. Osipov, M. G. (1957). Dobycha bezvodnoj nefti iz zalezhi s podoshvennoj vodoj. *Neftyanoe hozyajstvo.* №12, pp. 42-51.
12. Deryaev, A.R. (2022). Zadachi issledovaniya dlya metoda odnovremennoj razdel'noj ekspluatacii mnogoplastovyh mestorozhdenij. *Innovacionnye nauchnye issledovaniya* №2-2 (16) – Ufa: Nauchno-izdatel'skij centr "Vestnik nauki", pp. 43–51.
13. Parijchuk, N.I. (2011). Opyt vnedreniya tekhnologij OOO «SP-BARS» dlya sovmestnoj razrabotki neskol'kih gorizontov v neftedobyvayushchih kompaniyah Rossii N.I. Parijchuk *Inzhenernaya praktika*. №3, pp. 69-71.
14. Deryaev, A.R. (2022). *Osobennosti bureniya naklonno-napravlennyh skvazhin i tekhnologiya ih odnovremennoj razdel'noj ekspluatacii. "Fundamental'naya i prikladnaya nauka: sostoyanie i tendencii razvitiya".* Monografiya – (pp.76-96). Petrozavodsk: Nauchnoe izdanie: MCNP "Novaya nauka".
15. Belen'kij, V.I. (1964). *Razrabotka neftyanyh mestorozhdenij s primeneniem metoda*

odnovremennoj razdel'noj ekspluatacii dvuh plastov v odnoj skvazhine. Opyt odnovremennoj razdel'noj ekspluatacii neskol'kih plastov cherez odnu skvazhinu., Ser. Dobycha: nauch.-analit. i temat. obzory. (pp.31-77). M.: CNIITEneftegaz CNIITEneftegaz.

16. Deryayev, A.R. (2022). Treatment of drilling mud with “PACS-T” additive. “Innovative approaches in the modern science” Proceedings of CXV international scientific – practical conference. *International scientific journal* №7 (115) – M., pp. 74–77.
17. Diyashev, R.N., Musabirova, N.H., & Iktisanova, V.A. (1997). *Metodicheskoe rukovodstvo po opredeleniyu optimal'nyh plastovyh i zabojnyh davlenij*. (p.88). Bugul'ma: TatNIPIneft'.
18. Deryaev, A.R. (2022). *Rekomendacii po burovomu rastvoru dlya bureniya sekcii 295,3 mm otkrytogo stvola naklonno-napravlennoj skvazhiny*. Sbornik statej II Mezhdunarodnoj nauchno-prakticheskoj konferencii “Nauka, obshchestvo, tekhnologii: problemy i perspektivy vzaimodejstviya v sovremennom mire”. (pp.7-11). Petrozavodsk: Nauchnoe izdanie: MCNP “Novaya nauka”.
19. Deryaev, A.R. (2022). Provedenie promyslovyh ispytanij kompleksnoj ingibirovannoj dobavki KAIR-T na neftegazovyh ploshchadyah Turkmenistana. *Problemy sovremennoj nauki i obrazovaniya* №1(170) – M: Izdatel'stvo “Problemy nauki”, pp.11-17.
20. (1974). *Spravochnaya kniga po dobyche nefti.*, pod.red.SH.K. Gimatudinova. (p.704). M.: Nedra.
21. Deryaev, A.R. (2022). Osnovnye perspektivy razvitiya i inzhenernoe planirovanie burovyh rabot dlya rezul'tativnosti gorizontal'nogo bureniya. *Nauka, tekhnika i obrazovanie* №1 (84) – M: Izdatel'stvo “Problemy nauki”, pp.33-38.
22. Leonov, V.A., & Donkov, P.V. (2002). *Tekhnologiya nestacionarnogo vozdejstviya na gruppu plastov odnoj setkoj skvazhin. Povyshenie nefteotdachi plastov: tr.Mezhdunar. tekhnol. simpoziuma*. (p.173). M.: Institut neftegazovogo biznesa.
23. Geldimyradov, A. G., & Deryaev, A.R. (2022). *Razrabotka gazokondensatnyh mestorozhdenij metodom odnovremennoj razdel'noj ekspluatacii. «Instrumenty i mekhanizmy ustojchivogo innovacionnogo razvitiya»* Monografiya vypusk №67 (pp.22-37). Ufa: Nauchnoe izdanie: NIC “Aeterna”.
24. Deryaev, A.R. (2022). Metody opredeleniya tekhnologicheskih pokazatelej effektivnosti odnovremennoj razdel'noj ekspluatacii. *Nauchnyj zhurnal Metod Z* №1(3) – Sankt-Peterburg: Izdatel'stvo: GNII «Nacrazvitie», pp.8-10.
25. Deryaev, A.R. (2022). *Vskrytie produktivnyh gorizontov burovym rastvorom na uglevodorodnoj osnove dlya odnovremenno-razdel'noj ekspluatacii.* Sbornik statej Mezhdunarodnoj nauchno-prakticheskoj konferencii “Nauka v sovremennom obshchestve: zakonomernosti i tendencii razvitiya”. (pp.35-39). Ufa: Izdatel'stvo OOO “Omega sajns”.
26. Morev, A.V. (2011). Tekushchie rezul'taty vnedreniya ORE v OOO «Lukojl-Perm'» *Inzhenernaya praktika* №3, pp. 40-48 .