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Z. A. Kuangaliev[1], M. M. Kursina[1], G. H. Aukhadieva[1], A. S. Zhakupov[2]

[1]Atyrau University of Oil and Gas, Atyrau, Kazakhstan;
[2]Atyrau Oil Refinery, LLP, Atyrau, Kazakhstan.
E-mail: z.kuangaliev5088-2@ubogazici.in, m.kursina5088-1@murdoch.in,
gaukha@tanu.pro, zhakupov5088-1@ubogazici.in

ANALYSIS OF RECOMMENDED MEASURES AIMED AT OPTIMISING AND IMPROVING THE DEVELOPMENT PROCESS AT THE PRORVA OIL DEPOSIT

Abstract. Determination of the optimal parameters of deposit development systems depending on the features of the geological structure and operating modes of the deposits, the main provisions of the regulation of control and regulation of the development process are considered as factors affecting the optimisation of the level of oil production. To increase the efficiency of deposit development and justify measures to control and regulate the development process, the design technological indicators are specified in this paper. The analysis determines the current state of development of the Zapadnaya Prorva deposit and its recoverable oil reservoirs, an assessment of the effectiveness of the implementation of previously approved design decisions, factoring in the existing understanding of the geological structure and new information obtained on the geological-field description of productive reservoirs, the current state of development, the study of the status and extent depletion of oil reserves from the reservoirs and issuing recommendations for monitoring and regulating the development process. This paper analyses geophysical, hydrodynamic studies of boreholes and reservoirs, the results of field studies, the current state of development. Initial data for assessing the development efficiency taking into consideration the history of borehole operation is determined, the effectiveness of the applied system for monitoring the development process and the state of the stock of producing wells is assessed, the effectiveness of measures to regulate the development process is analysed, and the effectiveness of the development process is assessed.

Key words: hydrodynamic studies, borehole, reservoir, the effectiveness of the system used.

Introduction. The progressive technical and technological lag in the domestic oil production complex with an increase in the production of hard-to-recover oil reserves (HTR reserves) is accompanied by a decrease in the profitability and competitiveness of oil companies. The final oil recovery, defined as the weighted average of the initial balance reserves, largely depends on the existing structure of reserves [1-3]. The structure of oil reserves only worsens over time, both due to the accelerated production of active oil reserves, and due to the deterioration of the conditions for their production during the flooding of reservoirs upon long-term development of oil deposits. As a result, part of the active oil reserves goes into the category of hardly recoverable. The application of the latest methods for increasing oil recovery should be designed in addition to the basic hydrodynamic methods as a single development system [4-6].

The relevance of the subject matter is conditioned by the fact that over 120 years have passed since the start of oil production in Kazakhstan. Currently, the oil and gas industry has become the basis of socio-economic reforms in the country. At the end of 2018, our oil and gas complex provided over a fifth of the country's GDP, two-thirds of revenues to the National Fund, about 62% of commodity exports, and half of foreign direct investment. With that, Kazakhstan is developing in the global space and with consideration of global processes [7]. In this regard, we shall investigate the latest history of the national industry

through the lens of key global tendencies. The main tendency in the global market constitutes the growing demand for hydrocarbons. Long-term forecasts of all the world's leading energy companies also demonstrate the continued role of oil and gas in the planet's energy structure in the foreseeable future [8]. The constant complication of mining and geological conditions for the development of oil deposits, the moral and physical aging of fixed assets, the low potential of existing technologies for increasing oil recovery create significant problems for the development of oil companies [9].

The leading approach to the study of this issue is the analysis of the need for production boreholes to systematically carry out field geophysical studies. In the future, it is recommended to continue monitoring the development of studies with the use of the GIS-control methods by INNK records, as well as PLT methods in production boreholes to monitor the current state of reservoir beds. It is confirmed by the application of approved methods, as well as by comparing the results with data obtained by other authors: "Supervision of the implementation of the revised project for the development of the Zapadnaya Prorva deposit", 2011. "Supplement to the revised project for the development of the Zapadnaya Prorva deposit", 2015 and other Funds Materials: Caspian Energy Research LLP. Oilgeoconsulting LLP. Scientific Research Institute "Caspiummunaigaz" LLP. A new technical solution is proposed to increase the efficiency of deposit development, as well as several conclusions and recommendations on geology and development based on increasing the efficiency of application at the Zapadnaya Prorva deposit.

Analysis of theoretical studies of the state of oil reserves from reservoirs and sections of the Western Prorva deposit. The materials of the paper on the experience of developing oil deposits, as well as theoretical and experimental studies based on field geophysical survey data of this deposit, can be useful for students, graduate students of oil universities and students of continuing education courses in the direction of "Development of oil and gas deposits".

The purpose of this paper is to summarise the accumulated experience of deposit development, to clarify the geological structure of the deposits, the properties of reservoir fluids and the properties of reservoirs, based on the results of drilling new wells and conducting relevant studies, identifying the causes of discrepancies between actual development indicators and design indicators, analysing the effectiveness of the implemented deposit development system, and issuing recommendations aimed at improving the development system and increasing its effectiveness based on new data on the geological structure of the deposit and current development characteristics.

Materials and methods. To monitor the development, condition, and operation of boreholes and borehole equipment at the Western Prorva deposit, it was proposed to conduct the following main types of research: field research; field-geophysical studies of boreholes and core samples; hydrodynamic studies of formations and boreholes; physico-chemical studies of the properties of oil and gas; physical and chemical studies of associated and injected water [10]. Studies were carried out at all developed facilities to control the development in accordance with mandatory research complexes that consider the specific geological and physical properties of the deposit and the features of the applied development system. With that, it was planned to carry out both systematic (periodic) and single (one-time) studies. Systematic studies were carried out in operating, producing, injection, and control boreholes with a specified frequency. One-time studies – in new boreholes that were taken out of drilling, as well as in boreholes where repeated perforation is provided, before and after the event.

Information about the well yields. The establishment of the frequency of flow rates (injectivity) measurements should be made differentially for low-rate wells (up to 5 t/day), medium-rate (5 to 25 t/day), and high-rate (more than 25 t/day). The determination of the water cut of production wells should be determined by one-time studies of all mastered wells after drilling or repair and systematically during operation. The determination is carried out by laboratory analysis of the selected product samples. The gas factor is determined by one-time studies of all producing wells new and after repair. The gas factor in wells that are operated at high bottomhole pressures and characterised by an initial gas factor is determined once a year.

The complex of hydrodynamic studies includes: the pressure transient test (PTS); repressuring method (RM); well interaction research method (well interference testing); bottomhole and reservoir pressure and temperature measurements. A study with the use of the steady-state selection method is carried out both on a one-time basis for all new wells, as well as for existing wells before and after geological and technical measures associated with a change in the bottom-hole zone, and systematically

for active producing wells at least once every two years. Well restoration by pressure restoration is carried out in the form of one-time studies for all new producing and injection wells, as well as wells that were abandoned for repair, and systematically for existing injection and producing wells at least once every two years.

In order to compare the current position of the contacts with the position existing at the time of the start of development, the movement of the oil water contact is controlled. The position of the oil and gas complex is determined by the methods of gamma-ray logging, lateral logging, induction logging and side-wall resistivity logging to reduce resistivity in special appraisal or still uncased production boreholes [11-14]. The criterion for the effectiveness of well intervention techniques in wells was the additional oil production during the effect. Those well intervention techniques were considered to be successful in the duration of the effect, after which the current yield is higher than the initial one (before the well intervention techniques) [15].

Results and discussion. To study the inflow profile, one-time studies are carried out on new producing boreholes, including boreholes before and after well intervention techniques which are related to impact on the bottom-hole zone. For each completed and commissioned borehole, it is necessary to carry out studies to determine the technical condition, tightness of the production string and cement quality.

In laboratory conditions, the following indicators are determined:

– physico-chemical properties of reservoir oil according to differential and contact degassing (pressure of oil saturation with gas, gas content, density, viscosity, volumetric coefficient and compressibility in reservoir conditions, shrinkage coefficient, etc.);

– physico-chemical properties of oil degassed to standard conditions (density, kinematic viscosity, molecular weight, boiling point and pour point, oil saturation temperature with paraffin, percentage of paraffins, asphaltenes, silica gel resins, sulphur, fractional, hydrocarbon and component compositions), the presence of salt and solids in oil;

– full chemical-physical analysis of produced water according to detail documentation.

A set of physical and chemical studies of oil and gas. Formation oil samples should be taken by in-depth samplers in the immediate vicinity of the inflow zone. The selection of boreholes for deep sampling is carried out by the geological service of the subsurface user and is coordinated with the company performing author's supervision over development [16]. To clarify the physicochemical properties and thermobaric conditions of productive horizons, it is further recommended that an analysis of deep oil samples and measurements of reservoir pressures be carried out in compliance with the required duration of well shutdown. A set of well research to control development is presented in table 1.

Table 1 – A set of studies to control the development process

No	Types of Research	Periodicity
1.	Measurement of yield and injectivity: – depleted wells; – medium- and high-rate wells.	One-time studies in all newly drilled wells and upon well intervention techniques: – 1 time in 15 days; – 1 time in 7 days.
2.	Determination of water cut in production wells: – waterless; – low and medium watered; – highly watered.	One-time studies in all newly drilled boreholes and upon well intervention techniques: – 1 time per month; – 1 time in 15 days; – 1 time in 7 days.
3.	Determination of the gas factor: – Rform>Psat; – Rform<Rsat.	One-time studies in all newly drilled wells and upon well intervention techniques: – 1 time per year; – 1 time per month.
4.	Determination of reservoir pressure	One-time studies in all newly drilled wells and upon well intervention techniques. Once every 6 months on a core network, an existing stock. Once a quarter for observation wells.
5.	Determination of bottomhole pressure	One-time studies in all newly drilled wells and upon well intervention techniques. 1 every 3 months for the existing stock.

Continuation of table 1

6.	Pressure recovery test	One-time studies in all newly drilled wells and upon well intervention techniques. Once every two years.
7.	Stationary behaviour study	One-time studies in all newly drilled wells and with well intervention techniques. Once every two years for the core network.
8.	Inflow profile study	One-time studies upon commissioning and upon well intervention techniques. Once a year for the production stock.
9.	Assessment of current oil saturation, control of the position of the oil water contact	One-time studies in all newly drilled wells and upon well intervention techniques. As required.
10.	Depth sampling for physico-chemical analysis of oil	At least three samples once every six months.
11.	Wellhead oil sampling to determine the basic properties of degassed oil	Once every six months at least five samples.
12.	Water sampling to determine composition and quality in production wells	One-time studies in all newly commissioned wells. In existing wells 1 time in 3 months.
13.	Preventive examination of the technical condition of combination strings	One-time studies in all newly drilled wells and upon well intervention techniques. As required (leakage, channelling, etc.).

The purpose of monitoring the development of deposit facilities is to assess the effectiveness of the applied development system at large, individual technological measures, or new technologies aimed at improving the process of reserves production. Development control measures provide information for planning work on regulating the development process and designing technologies for its improvement [17-19]. Table 2 compares the design and actual volumes of research.

Table 2 – Implementation of the development process control plan

Types of research	Frequency	
	Design	Actual
Dynamic well test		
Pressure transient test	One-time studies in all newly drilled wells. The current stock – once every 2 years, before and after repairs (well intervention techniques) associated with a change in the state of the engineering, procurement, and construction.	17 studies are being performed on 17 wells.
Pressure recovery test	One-time studies in all newly drilled wells. The current stock – once every 2 years, before and after repairs (well intervention techniques) associated with a change in the state of the engineering, procurement, and construction.	5 pressure build-up curve studies in 5 wells; 9 level build-up curve studies in 9 wells.
Yield measurements	One-time research on all new producing wells. Operating stock – monthly, with well intervention techniques, when their flow rate changes by over 40%.	Monthly.
Determination of bottomhole pressure	One-off studies in all newly drilled wells. Operating stock – once a quarter, upon well intervention techniques	650 measurements taken.
Determination of formation pressure	One-time studies in all newly drilled wells, on drifts – 1 time in 6 months, upon well intervention techniques.	214 measurements taken.
Determination of wellhead and casing pressure	For existing production (fountain) wells – 1 time in 3 days.	In progress.
The study of the physicochemical properties of oil		
Depth sampling for physico-chemical analysis of oil	One-time studies in gushing wells.	33 samples are taken in 21 wells.
Wellhead oil sampling to determine the basic properties of degassed oil	At least once a year from all operating production wells.	53 samples are taken for 37 wells.
Determination of the gas factor	One-off studies in all newly drilled wells. The current stock, when the formation pressure exceeds the saturation pressure – 1 time per year, upon a decrease in the formation pressure below the saturation pressure – on a quarterly basis.	Once a year.
Determination of water cut	For the entire operating maintenance stock, at least 1 time per month.	Once a month.

Continuation of table 2

Geophysical surveys		
Study of the inflow profile, determination of sources and water cut intervals	One-time studies upon commissioning a well from drilling. Fountain stock – once a year; upon conducting well intervention techniques.	Performed on 2 wells.
Inspection of the technical condition of production wells	One-time studies upon commissioning a well from drilling. The existing fund – as required (upon a sharp increase in water cut, a change in the operating mode of the well, in case of workover, upon commissioning idle or inactive wells).	Performed on 13 wells.
Monitoring the position of the oil water contact and assessing changes in oil saturation	The current stock – depending on changes in the composition of the incoming fluid (against non-perforated formations of the studied operation facility).	Performed on 13 wells.
Determination of formation temperature	One-time studies in all newly drilled wells. The existing stock – at least once a year.	In progress.

During the analysed periods, materials of geophysical well logging were interpreted from three wells (No 430, No 435, No 437) drilled after calculating reserves in 2013. Geophysical surveys in new wells were performed by Batysgeozertteu LLP. The complex of field-geophysical studies was carried out in open and closed boreholes. In open hole wells, designed to evaluate the reservoir properties of reservoirs in a productive section, a modern geophysical well logging complex was performed in the wells, including the following methods: self-potential logging, calliper logging, lateral logging, induction logging, micrologging, gamma-ray logging, neutron gamma-ray logging, acoustic logging, gamma-gamma density logging, high-frequency induction logging with isoparametric sounding, thermometry, and inclinometry. To assess the determination of the quality of cementing the columns, well cementation acoustic control was carried out, the methods of gamma-ray logging and collar locators were used to bind in depth to the section of the wellbore. For the period from 2014 to 2017, 13 wells were used to determine the current state of oil saturation of INNL (impulse neutron-neutron logging) with IGN-7, IGN-43-M1, and INGK-43 instruments. Monitoring of the technical condition of the production casing was also carried out in 13 wells [20].

The study of the physicochemical properties of oil, gas, and condensate in the Zapadnaya Prorva deposit began at the exploration stage. Over the entire period of deposit development, 48 deep and 61 surface oil samples, 6 condensate samples, 76 dissolved gas samples were studied. To control the development of the deposit, the following types of studies are carried out: registration of pressure changes in unsteady filtration modes (level build-up curve, pressure draw-down curve); well productivity studies in various operating modes (pressure transient test) [21-23].

During 2015-2017, hydrodynamic studies of wells were carried out at the deposit in transient modes (pressure build-up curve, level build-up curve), as well as measurements of static and dynamic fluid levels. Since the beginning of the implementation of the project document (DUPR-2015), the deposit has undergone 5 surveys of pressure build-up curve for 5 wells and 9 surveys of level build-up curve for 9 wells. Also, direct measurements of formation pressure and measurements of static fluid levels were used to analyse the energy state.

Conclusions. In the process of deposit development, it is necessary to carry out comprehensive research to assess the effectiveness of the adopted development system, to obtain the information necessary to optimise the ongoing development processes and design measures to improve them. The research work being carried out at the deposit to monitor the development of formations allows to evaluate the effectiveness of the adopted development system and to develop measures for its improvement.

An analysis of the measures taken at the deposit shows their high quantitative and qualitative characteristics. The analysis determines the current state of development of the Zapadnaya Prorva deposit and its recoverable oil reserves, an assessment of the effectiveness of the implementation of previously approved design decisions, taking into consideration the existing understanding of the geological structure and new information obtained on the geological and deposit characteristics of productive deposits, the current state of development, the study of the status and extent depletion of oil reserves from the reservoirs and issuing recommendations for monitoring and regulating the development process. The analysis of geophysical, hydrodynamic studies of wells and reservoirs, the results of deposit studies, the current state

of development. Initial data for assessing the development efficiency with consideration of the history of well operation are determined, the effectiveness of the applied system for monitoring the development process and the state of the stock of producing wells is assessed, the effectiveness of measures to regulate the development process is analysed, and the effectiveness of the development process is evaluated.

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З. А. Қуанғалиев[1], М. М. Курсина[1], Г. Х. Аухадиева[1], А. С. Жақұпов[2]

[1]Атырау мұнай және газ университеті, Атырау, Қазақстан;
[2]Атырау мұнай өңдеу зауыты, Атырау, Қазақстан

ӨНДІРІСТІК ЗЕРТТЕУЛЕРДІҢ ЖӘНЕ «ПРОРВА» КЕН ОРНЫНДАҒЫ ӘЗІРЛЕУ ҮРДІСІН ЖЕТІЛДІРУ МЕН ОҢТАЙЛАНДЫРУҒА БАҒЫТТАЛҒАН ӘЗІРЛЕУ ЖҰМЫСТАРЫНЫҢ АҒЫМДАҒЫ ЖАҒДАЙЫН ТАЛДАУ

Аннотация. Кен орны құрылымының күрделілігі бойынша дизъюнктивтік бұзу әрекеті орын алатын, қимасы және ауданы бойынша коллекторлардың жоғары әртектілігі байқалатын екінші топ объектісіне жатады. Көпқабаттық кен орны, Батыс Прорва ауданындағы барланған мұнай жатындары Юра және Триас дәуірінің шөгінділерімен байланысты. Геологиялық құрылым ерекшеліктері және мұнай жатындарымен жұмыс режиміне байланысты кен орындарын әзірлеу жүйесінің оңтайлы параметрлерін анықтау, әзірлеу үрдісін реттеу мен бақылау регламентінің негізгі қағидалары мұнай өндіру деңгейін оңтайландыруға әсер ететін факторлар ретінде қарастырылған.

Жұмыстың мақсаты – жаңа ұңғымаларды бұрғылау мен тиісті зерттеу жүргізудің нәтижелері бойынша мұнай жатындарының геологиялық құрылымын, қойнауқаттық флюидтер мен қойнауқаттың қасиеттерін зерттеу. Кен орнын әзірлеудің тиімділігін арттыру үшін және әзірлеу үрдісін реттеу мен бақылау бойынша шараларды негіздеу мақсатында берілген жұмыста жобалық технологиялық көрсеткіштер нақтыланған. Талдау арқылы Батыс Прорва кен орнын әзірлеудің заманауи күйі және ондағы өндірілетін мұнай қоры, өнімді жатындардың геологиялық-кәсіпшілік сипаттамасы туралы алынған жаңа деректер мен геологиялық құрылым туралы түсінікті ескере келе алдында мақұлданған жобалық шешімдердің жүзеге асырылу тиімділігінің бағасы, әзірлеу жұмыстарының ағымдағы жағдайы, қойнауқаттардан мұнай қоры өндірілуінің деңгейі мен күйін зерттеу және әзірлеу үрдісін реттеу мен бақылау бойынша ұсынымдардың берілуі анықталған.

Аталмыш мәселені зерттеудің басты тәсілі – далалық геофизикалық зерттеулерді жүйелі түрде жүргізу үшін қолданымдық ұңғымаға талдау жасау қажет. Кен орынды әзірлеудің тиімділігін арттыру үшін жаңа техникалық шешім ұсынылды, сонымен қатар Батыс Прорва кен орнында қолдану тиімділігін арттыруға негізделген геология мен әзірлеуге қатысты қорытынды жасалып, ұсыныстар берілген. Жобалық көрсеткіштер мен айғақты әзірлеу көрсеткіштерінің сай келмеу себептері анықталды. Сонымен қатар кен орнын әзірлеудің ендірілген жүйесінің тиімділігіне талдау жасалды. Зерттеу жұмысының соңында әзірлеудің ағымдағы сипаттамасы мен кен орнының геологиялық құрылымына қатысты жаңа деректер негізінде әзірлеу жүйесін жетілдіру мен оның тиімділігін арттыруға бағытталған ұсыныстар берілген.

Қойнауқат пен ұңғымалардың геофизикалық, гидродинамикалық зерттеулеріне, өндірістік зерттеу нәтижелеріне, әзірлеудің ағымдағы күйіне талдау жасалды. Ұңғымалардың қолдану тарихын ескере келе әзірлеу тиімділігін бағалауға арналған бастапқы деректер анықталды; өндіруші ұңғымалар қорының күйі мен қолданыстағы әзірлеу үрдісін бақылау жүйесінің тиімділігіне баға берілді; әзірлеу үрдісін реттеуге қатысты шаралар тиімділігіне талдау жасалды және әзірлеу үрдісінің тиімділігіне баға берілді. Мұнай кен орындарын әзірлеу тәжірибесі, аталмыш кен орнын далалық геофизикалық зерттеулер деректері негізінде теориялық және эксперименттік зерттеулер туралы мақала материалдары студенттер, мұнай және газ жоғары оқу орнында оқитын аспиранттар, сонымен қатар «Мұнай кен орындарын әзірлеу» бағытында біліктілігін арттыру курстарының тыңдармандары арасында кеңінен қолданыла алады.

Түйін сөздер: гидродинамикалық зерттеулер, ұңғыма, резервуар, қолданылатын жүйенің тиімділігі.

З. А. Куангалиев[1], М. М. Курсина[1], Г. Х. Аухадиева[1], А. С. Жакупов[2]

[1]Атырауский университет нефти и газа, Атырау, Казахстан;
[2]Атырауский нефтеперерабатывающий завод, Атырау, Казахстан

АНАЛИЗ ПРОМЫСЛОВЫХ ИССЛЕДОВАНИЙ И ТЕКУЩЕГО СОСТОЯНИЯ РАЗРАБОТКИ НАПРАВЛЕННОЙ НА ОПТИМИЗАЦИЮ И УСОВЕРШЕНСТВОВАНИЕ ПРОЦЕССА РАЗРАБОТКИ НА МЕСТОРОЖДЕНИИ «ПРОРВА»

Аннотация. Месторождение по сложности своего строения относится к объектам второй группы, для которых характерно наличие дизъюнктивных нарушений, высокая неоднородность коллекторов по площади и по разрезу. Месторождение многопластовое, разведанные залежи нефти на площади Западная Прорва связаны с юрскими и триасовыми отложениями. Определение оптимальных параметров систем разработки месторождений в зависимости от особенностей геологического строения и режимов работы залежей, основные положения регламента контроля и регулирования процесса разработки рассмотрены, как факторы, влияющие на оптимизацию уровня добычи нефти.

Целью данной работы является изучение геологического строения залежей, свойств пластовых флюидов и свойств пластов по результатам бурения новых скважин и проведения соответствующих исследований. Для повышения эффективности разработки месторождения и обоснования мероприятий по контролю и регулированию процесса разработки в настоящей работе уточнены проектные технологические показатели. Проведенный анализ определяет современное состояние разработки месторождения Западная Прорва и его извлекаемые запасы нефти, оценку эффективности реализации ранее утвержденных проектных решений, с учетом имеющегося представления о геологическом строении и полученных новых сведений о геолого-промысловой характеристике продуктивных залежей, текущем состоянии разработки, изучение состояния и степени выработанности запасов нефти из пластов и выдача рекомендаций по контролю и регулированию процесса разработки.

Ведущим подходом к изучению этого вопроса является анализ необходимости эксплуатационных скважин для систематического проведения полевых геофизических исследований. Предлагается новое техническое решение для повышения эффективности разработки месторождения, а также ряд выводов и рекомендаций по геологии и разработке, основанных на повышении эффективности применения на месторождении Западная Прорва. Выявлены причины несоответствия фактических показателей разработки и проектных показателей. Также проводился анализ эффективности внедренной системы разработки месторождения. По окончании исследования были даны рекомендации, направленные на совершенствование системы разработки и повышение ее эффективности на основе новых данных о геологическом строении месторождения и текущих характеристиках разработки.

Выполнен анализ геофизических, гидродинамических исследований скважин и пластов, результатов промысловых исследований, текущего состояния разработки. Определены исходные данные для оценки эффективности разработки с учетом истории эксплуатации скважин; проведена оценка эффективности применяемой системы контроля процессом разработки и состоянием фонда добывающих скважин; проанализирована эффективность мероприятий по регулированию процесса разработки и проведена оценка эффективности процесса разработки. Материалы статьи об опыте разработки нефтяных месторождений, а также теоретических и экспериментальных исследованиях на основе данных полевых геофизических исследований этого месторождения могут быть полезны студентам, аспирантам нефтяных вузов, а также слушателям курсов повышения квалификации в направлении «Разработка нефтегазовых месторождений».

Ключевые слова: гидродинамические исследования, скважина, пласт, эффективность применяемой системы.

Information about authors:

Kuangaliev Z.A., Professor in the Department of Oil and Gas Business, Atyrau University of Oil and Gas, Atyrau, Kazakhstan; z.kuangaliev5088-2@ubogazici.in; https://orcid.org/0000-0002-6029-2469

Kursina M.M., Professor in the Department of Oil and Gas Business, Atyrau University of Oil and Gas, Atyrau, Kazakhstan; m.kursina5088-1@murdoch.in; https://orcid.org/0000-0003-1749-5516

Aukhadieva G.H., Master in the Department of Oil and Gas Business, Atyrau University of Oil and Gas, Atyrau, Kazakhstan; gaukha@tanu.pro; https://orcid.org/0000-0001-8990-402X

Zhakupov A.S., Master in the Atyrau Oil Refinery, LLP, Atyrau, Kazakhstan; zhakupov5088-1@ubogazici.in; https://orcid.org/0000-0002-3894-2592

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