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The scientific journal News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences has been indexed in the international abstract and citation database Scopus since 2016 and demonstrates stable bibliometric performance.

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«Қазақстан Республикасы Ұлттық ғылым академиясының Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналы 2016 жылдан бастап халықаралық реферативтік және ғылыметриялық Scopus дерекқорында индекстеледі және тұрақты библиометриялық көрсеткіштерді көрсетіп келеді.

Сонымен қатар журнал Web of Science платформасының (Clarivate Analytics, 2018) халықаралық реферативтік және наукометриялық дерекқоры Emerging Sources Citation Index (ESCI) тізіміне енгізілген.

ESCI дерекқорында индекстелуі журналдың халықаралық ғылыми рецензиялау талаптары мен редакциялық этика стандарттарына сәйкестігін растайды, сондай-ақ Clarivate Analytics компаниясы тарапынан басылымды Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI) және Arts & Humanities Citation Index (AHCI) дерекқорларына енгізу қарастырылуда.

Scopus және Web of Science дерекқорларында индекстелуі жарияланымдардың халықаралық деңгейде жоғары сұранысқа ие болуын қамтамасыз етеді, олардың дәйексөз алу көрсеткіштерінің артуына ықпал етеді және редакциялық алқаның геология мен техникалық ғылымдар саласындағы өзекті, бірегей және ғылыми тұрғыдан маңызды зерттеулерді жариялауға ұмтылысын айқындайды.

Научный журнал «News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences» с 2016 года индексируется в международной реферативной и наукометрической базе данных Scopus и демонстрирует стабильные библиометрические показатели.

Журнал также включён в международную реферативную и наукометрическую базу данных Emerging Sources Citation Index (ESCI) платформы Web of Science (Clarivate Analytics, 2018).

Индексирование в ESCI подтверждает соответствие журнала международным стандартам научного рецензирования и редакционной этики, а также рассматривается компанией Clarivate Analytics в рамках дальнейшего включения издания в Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI) и Arts & Humanities Citation Index (AHCI).

Индексирование в Scopus и Web of Science обеспечивает высокую международную востребованность публикаций, способствует росту цитируемости и подтверждает стремление редакционной коллегии публиковать актуальные, оригинальные и научно значимые исследования в области геологии и технических наук.

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EFFECTIVENESS OF MEASURES TO REGULATE THE DEVELOPMENT PROCESS AT ALIBEKMOLA FIELD

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Abstract. *Relevance.* Increasing oil production remains one of the most important challenges in the modern oil industry. Currently, a significant portion of proven oil reserves is concentrated in fields with complex geological and physical properties. Therefore, the use of enhanced oil recovery and reservoir stimulation technologies is particularly important for improving production efficiency, rational use of natural resources, and ensuring energy security. *Objective.* To evaluate the effectiveness of well rehabilitation and stimulation projects conducted at the Alibekmoli field and determine their impact on increasing the productivity of production wells and improving the operation of injection wells. *Methods.* The study is based on an analysis of annual well rehabilitation programs conducted at the field. To assess effectiveness, oil production and injection indicators before and

after interventions were compared. Particular attention was paid to acid fracturing operations. The treatments were carried out in stages, including acid wash, buffer stages, emulsified acid injection, and displacement stages. To determine the technological efficiency of the stimulation process, operational parameters such as fluid types, injection rates, and injected fluid volumes were analyzed. *Results and Conclusions.* The study demonstrated that acid fracturing significantly increases well productivity in carbonate formations and improves formation permeability. In practice, this technology enhances hydrodynamic connectivity between wells and enables the efficient development of previously underdeveloped areas. The study confirmed that acid fracturing is an effective and cost-effective method for enhancing oil recovery in mature carbonate fields. Furthermore, this approach significantly contributes to improving the efficiency of oil field development in Kazakhstan.

Keywords: oil recovery, reservoir, technology, research, hydrochloric acid, hydraulic fracturing, efficiency

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ӘЛІБЕКМОЛА КЕН ОРНЫНДА ИГЕРУ ПРОЦЕСІН РЕТТЕУ ЖӨНІНДЕГІ ІС-ШАРАЛАРДЫҢ ТИІМДІЛІГІ

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Аннотация. *Өзектілігі.* Мұнай өндірісін арттыру қазіргі мұнай өнеркәсібіндегі ең маңызды міндеттердің бірі болып қала береді. Қазіргі уақытта дәлелденген мұнай қорларының едәуір бөлігі күрделі геологиялық және физикалық қасиеттері бар кен орындарында шоғырланған. Осыған байланысты мұнай өндіруді қарқындату және қабатты ынталандыру технологияларын қолдану өндіріс тиімділігін арттыру, табиғи ресурстарды ұтымды пайдалану және энергетикалық қауіпсіздікті қамтамасыз ету үшін ерекше маңызға ие. *Мақсаты.* Әлібекмола кен орнында жүргізілетін ұңғымаларды жаңғырту және ынталандыру жобаларының тиімділігін бағалау, олардың өндірістік ұңғымалардың өнімділігін арттыруға және айдау ұңғымаларының жұмысын жақсартуға әсерін анықтау. *Әдістері.* Зерттеу кен орнында жыл сайын жүргізілетін ұңғымаларды жаңғырту бағдарламаларын талдауға негізделді. Тиімділікті бағалау үшін араласуларға дейінгі және кейінгі мұнай өндіру мен айдау көрсеткіштері салыстырылды. Қышқылмен жару операцияларына ерекше назар аударылды. Өңдеу жұмыстары кезең-кезеңмен жүргізіліп, оған қышқылмен жуу, буферлік сатылар, эмульсияланған қышқылды айдау және ығыстыру сатылары енгізілді. Ынталандыру үдерісінің технологиялық тиімділігін анықтау мақсатында сұйықтық түрлері, айдау жылдамдықтары және айдау сұйықтығының көлемдері сияқты пайдалану параметрлері талданды. *Нәтижелер мен қорытынды.* Зерттеу нәтижелері қышқылмен жару технологиясының карбонатты қабаттардағы ұңғымалар өнімділігін айтарлықтай арттыратынын және қабат өткізгіштігін жақсартатынын көрсетті. Практикалық тұрғыдан бұл технология ұңғымалар арасындағы гидродинамикалық байланысты күшейтіп, бұрын жеткіліксіз игерілген аймақтарды тиімді игеруге мүмкіндік береді. Зерттеу қышқылмен жарудың жетілген карбонатты кен орындарында мұнай қайтарымын арттырудың тиімді әрі экономикалық жағынан ұтымды әдісі екенін растады. Сонымен қатар, бұл тәсіл Қазақстандағы мұнай кен орындарын игеру тиімділігін арттыруға елеулі үлес қосады.

Түйін сөздер: мұнай өндіру, коллектор, технология, зерттеу, тұз қышқылы, гидравликалық жару, тиімділік

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ЭФФЕКТИВНОСТЬ МЕРОПРИЯТИЙ ПО РЕГУЛИРОВАНИЮ ПРОЦЕССА РАЗРАБОТКИ НА МЕСТОРОЖДЕНИИ АЛИБЕКМОЛА

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Аннотация. *Актуальность.* Увеличение добычи нефти остаётся одной из ключевых задач современной нефтяной промышленности. В настоящее время значительная часть доказанных запасов нефти сосредоточена в месторождениях со сложными геологическими и физическими характеристиками. В этой связи применение технологий повышения нефтеотдачи и стимуляции пласта приобретает особое значение для повышения эффективности добычи, рационального использования природных ресурсов и обеспечения энергетической безопасности. *Цель.* Оценить эффективность проектов по реабилитации и стимуляции скважин, реализуемых на Алибекмолинском месторождении, а также определить их влияние на продуктивность добывающих и эффективность работы нагнетательных скважин. *Методы.* Исследование основано на анализе ежегодных программ реабилитации скважин, проводимых на месторождении. Для оценки эффективности выполнялось сравнение показателей добычи и закачки нефти до и после проведения технологических мероприятий. Особое внимание уделялось операциям кислотного гидроразрыва пласта. Обработки осуществлялись поэтапно и включали кислотную промывку, буферные стадии, закачку эмульгированной кислоты и стадии вытеснения. Для оценки

технологической эффективности процессов стимуляции анализировались параметры эксплуатации, включая типы используемых жидкостей, скорости закачки и объёмы закачиваемых реагентов. *Результаты и выводы.* Установлено, что применение технологии кислотного гидроразрыва пласта способствует существенному повышению продуктивности скважин в карбонатных коллекторах и улучшению проницаемости пласта. На практике данная технология усиливает гидродинамическую связь между скважинами и позволяет эффективно вовлекать в разработку ранее слабо освоенные участки. Проведённое исследование подтвердило, что кислотный гидроразрыв пласта является эффективным и экономически целесообразным методом повышения нефтеотдачи на зрелых карбонатных месторождениях. Кроме того, его применение вносит значительный вклад в повышение эффективности разработки нефтяных месторождений Казахстана.

Ключевые слова: нефтеотдача, пласт, технология, исследования, соляная кислота, гидроразрыв пласта, эффективность

Introduction. Alibekmola field is one of the most important oil and gas fields in Kazakhstan (Kazenergy Association, 2023). The energy security and economic stability of the country directly depend on the efficient and environmentally responsible development of such strategic assets. Scientifically grounded regulation of the development process enables rational use of subsurface resources, reduction of production costs, mitigation of environmental impacts, and achievement of long-term production stability.

The choice of the topic is justified by several factors. First, Alibekmola is a production facility of regional and national importance. Second, the regulation of the development process affects not only production efficiency but also environmental safety and resource conservation, especially under mature-field conditions (Abibullaqyzy, 2025). Third, evaluating the consequences of applied technologies and management decisions at different stages of field development provides practical experience that can be transferred to other assets with similar geological and operational constraints (Han, 2025).

The oil and gas industry is currently undergoing a period of global transformation driven by tightening environmental requirements, energy-efficiency objectives, and the need to develop reserves without accelerated depletion (Beisembayev, 2025). These drivers increase the importance of optimizing field management and production regulation tools, including stimulation technologies, well interventions, and operational control (Pablo, 2016; Smith, 2015). The relevance of the topic is determined by a set of interrelated aspects: (i) technical and technological efficiency-improving the performance of methods used during field development is essential to sustain production and reduce costs (Zhanturin, 2024); (ii) environmental aspects—development planning must minimize negative environmental impacts and ensure compliance with subsurface-use standards; economic efficiency-

proper prioritization and regulation of interventions improves project profitability by reducing unit production costs; and (iv) the introduction of modern digital technologies enhancing automation and monitoring systems to support decision-making and reduce uncertainty in field operations (ARMA, 2024; Obzor metodov provedeniya kislotnogo gidravlicheskogo razryva plasta Materialy, 2020).

Problem statement. Despite the active use of geological and technical measures (GTM) at mature fields, the effect of these interventions is often highly variable across wells due to reservoir heterogeneity, changes in near-wellbore permeability, completion conditions, and operational constraints. As a result, it becomes difficult to (1) objectively compare the effectiveness of different GTM types, (2) select candidates with the highest probability of success, and (3) plan annual GTM programs that ensure stable production while meeting environmental and economic requirements. This challenge is particularly relevant for Alibekmola, where stimulation methods such as hydrochloric acid treatments and acid hydraulic fracturing are applied to carbonate intervals, but their effectiveness depends strongly on correct design, execution quality, and post-job operating strategy (Kultygina, 2019; Malyarenko, 2020).

Aim and approach. This study evaluates the effectiveness of development regulation measures at the Alibekmola field based on a unified assessment framework. The analysis covers producing and injection wells over the reporting period and includes major GTM categories (repair and insulation works, conversion to mechanized production, operating mode optimization, hydrochloric acid treatments, and acid hydraulic fracturing). Effectiveness in producing wells is assessed primarily through incremental oil production over the effect period, while injection well performance is evaluated via incremental injected volumes and injectivity response. The approach is supported by operational monitoring and, where applicable, technical and economic justification to ensure that conclusions are applicable to real field planning (ARMA, 2024; Smith, 2015).

A key intensification technology considered in this work is acid hydraulic fracturing. Its essence is to create bottom-hole pressure exceeding the minimum rock stress state, leading to fracture initiation and propagation when fluid is injected into the reservoir. After fracture creation, acid is pumped at pressures above fracture opening pressure to react with the carbonate rock at fracture surfaces, forming a rough, non-uniform etched texture. Due to this etching, conductive channels may remain open after pressure release, reducing the tendency for complete fracture closure. In carbonate formations represented by calcite and dolomite, which have sufficient strength, it is possible to form relatively stable etched channels. The resulting increase in permeability in the bottom-hole zone can exceed that of the undisturbed formation and may lead to improved well productivity and enhanced oil recovery due to expanded drainage area. However, acid hydraulic fracturing is technologically complex: insufficient knowledge of reservoir characteristics and suboptimal design may lead to low or even negative outcomes and unjustified

costs. Therefore, in many cases, a test job is performed prior to the main treatment to calibrate the design model and adjust operational parameters (Kultygina, 2019; Malyarenko, 2020).

The study demonstrates that systematic application of GTM can provide a measurable contribution to production stabilization and development regulation at Alibekmola. The analyzed interventions show that both stimulation actions (acid treatments and acid hydraulic fracturing) and operational measures (mechanization and operating mode optimization) can increase well performance when properly selected and implemented, while injection well treatments contribute to improved pressure maintenance through increased injected volumes (ARMA, 2024; Obzor metodov provedeniya kislotnogo gidravlicheskogo razryva plasta Materialy, 2020).

The practical value of the results lies in providing a structured basis for annual GTM planning and prioritization at Alibekmola and similar mature fields in Kazakhstan. The findings support evidence-based candidate selection for stimulation and mechanization, justify the continued use of acid-based interventions where near-wellbore limitations dominate, and emphasize the role of digital monitoring and standardized evaluation windows for isolating the effect of each measure. These outcomes can be used to reduce operational uncertainty, improve the economic efficiency of interventions, and ensure more environmentally responsible field management through optimized development regulation decisions (ARMA, 2024; Abibullaqyzy, 2025; Han, 2025).

Methods and definitions. The methodology of this study is based on the analysis of geological and technical measures (GTM) implemented at the Alibekmola oil field during the period 01.01.2022–01.07.2024. The objective of the methodological approach was to evaluate the effectiveness of different development regulation measures applied to producing and injection wells.

The study included the following types of GTM interventions: repair and insulation works, conversion of wells to mechanized production, acid hydraulic fracturing (acid HF), hydrochloric acid treatments of producing wells, HCl treatments of injection wells to improve near-wellbore permeability, sidetracking (drilling of a side track), additional perforation, and optimization of well operating regimes.

The acid hydraulic fracturing treatment was performed according to the optimized stage design, including acid washing, buffer pad stages, emulsified acid stages, and displacement/selling stages. The sequence of stages, fluids, pumping rates and volumes used during the operation are summarized in Table 1.

Table 1. Stages and materials for the process.

№	Stage	Liquid	Expenditure (m^3/min)	Stage volume (m^3)	Total volume (m^3)
1	Acid washing	HCL15	6.2	6.0	6.0
2	Buffer cushion	YF140	7.0	50.0	56.0
3	Emulsified acid	SXE28	5.0	50.0	106.0
4	Buffer cushion	YF140	5.0	50.0	156.0
5	Emulsified acid	SXE28	5.2	50.0	206.0
6	Buffer cushion	YF140	6.5	50.0	256.0
7	Emulsified acid	SXE28	4.5	46.3	302.3
8	Acid washing	HCL15	4.5	5.0	307.3
9	Selling	Oil	4.8	20.7	328.0
10	Selling	Oil	0.8	5.0	333.0
11	Selling	Water+ surfactants	5.8	21.4	354.4

For each well where a GTM operation was conducted, production or injection time-series data were analyzed for two periods: a baseline period before the operation and an effect period after the operation. The effectiveness of each measure was assessed using technical and production indicators.

For producing wells, the primary indicator of effectiveness was incremental oil production during the effect period. A GTM operation was considered effective if the stabilized production rate after the intervention remained higher than the pre-operation rate for a defined effect duration. Incremental oil production was calculated using the following expression:

$$Qadd = (qafter - qbefore) \times teffect$$

where qbefore is the well production rate before the intervention, qafter is the production rate after the intervention, and teffect is the duration of the effect.

For injection wells, effectiveness was determined by the increase in injected water volume and improvement of injectivity over the effect period.

Special attention was given to acid hydraulic fracturing operations. The treatment was carried out according to an optimized stage design consisting of acid washing, buffer stages, emulsified acid injection stages, and displacement stages. Prior to the operation, the wellbore was mechanically cleaned from paraffin deposits using a scraper. The fracturing process included the use of 15% hydrochloric acid and 2% potassium chloride solutions, emulsified acid systems, and gel stages. Perforation channels were isolated and activated using 20-mm balls together with gel to initiate controlled fracturing.

Before the acid HF operation, the wellbore was mechanically cleaned from paraffin deposits using a scraper. The treatment fluids included 15% HCl and 2%

KCl solutions; an emulsified acid stage (e.g., 28%) and gel stages were applied according to the job design. Perforation channels were isolated/activated using balls (≈20 mm) with gel to initiate and control fracturing stages. The process design included sequential stages (pad/buffer, acid stages, displacement/flush), and operational parameters (wellhead pressure and pumping rate) were monitored and adjusted according to the stage objectives (fracture initiation/propagation, acid etching, displacement).

The acid HF job used a standard high-pressure stimulation spread (e.g., Schlumberger), including multiple high-pressure pumping units, fluid tanks, centrifugal/annular pumps, additive supply system, wellhead protection, a control/data acquisition unit, and suction/discharge lines (see Figure 1). Stage composition and materials are summarized in Table 1.

Hydrochloric acid treatments were conducted in producing wells to improve near-wellbore permeability and restore productivity. Similar treatments were performed in injection wells to enhance injectivity. The effectiveness was assessed by comparing pre- and post-treatment rates (producing wells) and injected volumes (injection wells) over the defined effect period using the incremental calculation described above.

During the analyzed period, acid hydraulic fracturing was carried out in three wells. Before starting work, the well was cleaned of paraffin using a scraper. A 15% hydrochloric acid solution and a 2% potassium chloride solution were used as the acid. During the event, hydraulic fracturing of the perforation channels was carried out using balls with a diameter of 20 mm together with gel. The purpose of this material is to keep the created crack open after the liquid pressure is released. This creates a new, more spacious inflow channel. The channel combines existing natural cracks and creates additional well drainage area.

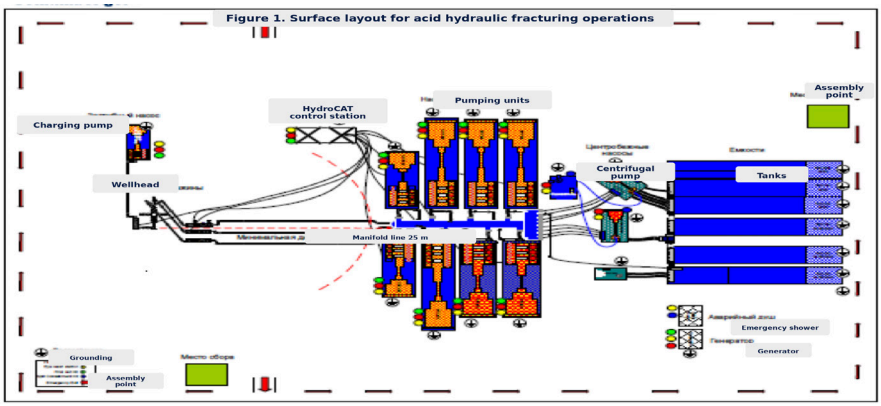

Figure 1. Location of equipment for acid hydraulic fracturing.

The operations were performed using a standard high-pressure stimulation spread consisting of pumping units, fluid tanks, centrifugal pumps, additive supply

systems, wellhead protection equipment, and a control station for monitoring pressure and pumping rates. The sequence of stages, fluids, pumping rates, and volumes used during the acid hydraulic fracturing operation is presented in Table 1, and the surface equipment layout is shown in Figure 1.

Statement of the problem. A significant portion of Kazakhstan's hydrocarbon reserves is associated with mature fields and reservoirs characterized by geological heterogeneity, complex fracture–pore systems, and progressive deterioration of near-wellbore permeability during long-term development. Under these conditions, the efficiency of primary and current recovery remains limited, and achieving planned production targets requires systematic regulation of the development process through geological and technical measures (GTM). In practice, field development regulation is implemented by a combination of interventions in producing wells (to restore or enhance productivity) and in injection wells (to improve injectivity and maintain reservoir pressure), including repair and insulation works, operating mode optimization, conversion to mechanized production, hydrochloric acid treatments, and acid hydraulic fracturing. However, the response to these measures is often non-uniform across wells due to variations in reservoir properties, completion conditions, and the degree of formation damage, which complicates the selection of candidates and the justification of annual GTM programs (ARMA, 2024; Dake, 1978).

At the Alibekmola field, carbonate intervals and mature development conditions make acid-based stimulation technologies particularly relevant. Acid hydraulic fracturing combines mechanical fracture creation with acid etching, potentially providing a more sustainable conductivity improvement compared to near-wellbore acidizing alone, while hydrochloric acid treatments can restore permeability and remove damage in the bottom-hole zone. At the same time, the economic effectiveness of these interventions must be confirmed by measurable incremental production in producing wells and incremental injection volumes in injection wells, because optimizing existing assets is typically more cost-efficient than greenfield development (Joshi, 1988; Cherepanov, 2015; Potapov, 2016).

Therefore, the core problem addressed in this study is the insufficiently quantified and systematized assessment of the effectiveness of development regulation measures at the Alibekmola field, including the comparative contribution of key GTM types to production stabilization and pressure support over a unified reporting period. The lack of a consistent effectiveness benchmark and a clear link between intervention type, operational response, and resulting production/injection gains limits the ability to prioritize measures, improve candidate selection, and increase overall recovery factor within the annual development program (ARMA, 2024; Larry, 1989; Majid, 2015).

In this context, the purpose of the work is to evaluate the effectiveness of GTM implemented at the Alibekmola field during 01.01.2022–01.07.2024 using unified criteria. The study aims to: (i) compile and compare results of GTM in producing

and injection wells; (ii) quantify incremental oil production and effect duration for producing wells and incremental injected volume for injection wells; (iii) identify the measures with the highest and most stable contribution to development regulation; and (iv) formulate practical implications for optimizing future GTM planning and candidate selection under mature reservoir conditions (ARMA, 2024; Dake, 1978; Joshi, 1988).

Results and discussions. The results and effectiveness of the geological and technical measures (GTM) implemented in producing and injection wells at the Alibekmola field for the reporting period 01.01.2022–01.07.2024 are summarized in Tables 2–3.

Table 2. Results of geological and technical measures in producing wells for the period 01.01.2022-01.07.2024.

Year	Type of measure	Well	Date	Increase in flow rate, t/day	Additional production, t
2022	Conversion to mechanized mining	A-314	04.09.2022	14.5	1187.6
2022	Conversion to mechanized mining	A-05B	07.10.2022	6.0	1549.0
2022	Acid hydraulic fracturing	A-300	14.06.2022	9.8	1982.1
2022	Drilling of the side shaft	A-106	17.06.2022	11.2	2337.5
2022	Additional perforation	A-20B	20.09.2022	11.0	1058.9
2022	Additional perforation	A-312	13.10.2022	13.8	981.4
2022	Hydrochloric acid treatment	A-109	02.03.2022	6.7	523.5
2023	Hydrochloric acid treatment	A-058	21.03.2023	44.5	6162
2023	Hydrochloric acid treatment	A-315	02.10.2023	58.1	5207
2023	Repair and insulation work	A-02A	24.04.2023	6.7	1182
2023	Conversion to mechanized mining	A-121	01.08.2023	7.3	1291
2024	Conversion to mechanized mining	A-134	05.06.2024	12.7	323

Table 3. Results of geological and technical measures in injection wells for the period 01.01.2022-01.07.2024.

Year	Well	Measure	Injection before, m^3/day	Injection after, m^3/day	Additional injection during effect, m^3
2022	201	Hydrochloric acid treatment	174.5	307.5	9192.7
2022	64	Hydrochloric acid treatment	43.4	478.4	5818.0
2022	108	Hydrochloric acid treatment	44.1	76.1	1995.5
2022	316	Hydrochloric acid treatment	24.7	402.0	58380.9
2023	A324	Hydrochloric acid treatment	61.0	363.38	2891.5

The assessment was performed using a unified approach: for producing wells, the primary criterion was incremental oil production during the effect period, determined from the difference between the pre- and post-operation rates multiplied by the duration of the sustained effect. In addition to the technological response, the interpretation of effectiveness also considered technical and economic feasibility, since development regulation measures at mature assets should provide stable production support while remaining cost-efficient relative to new drilling (ARMA, 2024; Yakovlev, 2019).

Repair and insulation interventions were applied to restore well integrity and to eliminate unwanted crossflows and water/gas breakthroughs that limit productivity. The results demonstrate heterogeneous outcomes: in the analyzed cases, one well did not show an observable effect over the considered period, while another well (№ 02A) exhibited a positive response. For well № 006, the liquid rate increased from 4 to 10.7 t/day with a gradual growth trend, and the incremental production during the effect period reached 1182 t. Such behavior indicates that repair and insulation measures can be effective when the dominant production limitation is related to completion integrity and near-wellbore flow restrictions; however, the variability across wells highlights the need for careful diagnostics and candidate selection (ARMA, 2024; Yakovlev, 2019).

Acidizing was one of the key stimulation techniques during the reporting period and was performed in 10 producing wells. A positive effect was observed in all treated wells, which suggests that near-wellbore permeability impairment and carbonate rock reactivity are important controllable factors at Alibekmola. The highest response was achieved at well № 315, where the rate increased by 58 t/day and the effect duration reached up to 150 days. The total incremental oil attributed to hydrochloric acid treatments in producing wells amounted to 24,977.3 tons. The representative well dynamics are illustrated in Figure 2 (ARMA, 2024; Joshi, 1988).

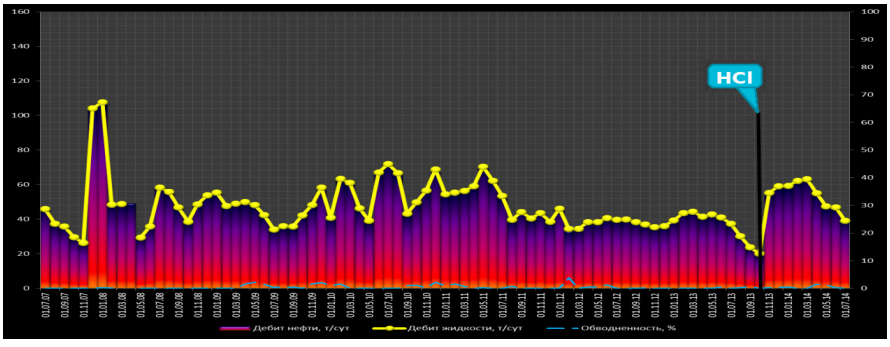

Figure 2. Dynamics of wells №. 315 operation before and after hydrochloric acid treatment.

From a development regulation perspective, this indicates that acidizing can serve as a relatively flexible tool for short- to mid-term production stabilization,

especially where flow is limited by near-wellbore damage and insufficient conductivity of the bottom-hole zone (ARMA, 2024; Joshi, 1988).

Among the methods used to intensify production, conversion to mechanized production was widely applied. In the reporting period, the selection criterion emphasized switching at approximately 30% water cut or at an oil rate of 5 t/day, which is consistent with a strategy aimed at avoiding rapid decline and maintaining controllable drawdown. Overall, an additional 6,751 tons of oil were produced due to this measure, while the average rate increase reached 18 t/day with an average effect duration of up to 120 days. At the same time, several wells (№№ 071, 02A, 010) did not demonstrate an effect, confirming that mechanization alone does not guarantee incremental production if reservoir constraints (high water cut, poor inflow, or completion limitations) dominate. A representative response is shown in Figure 3 (ARMA, 2024; Majid, 2015).

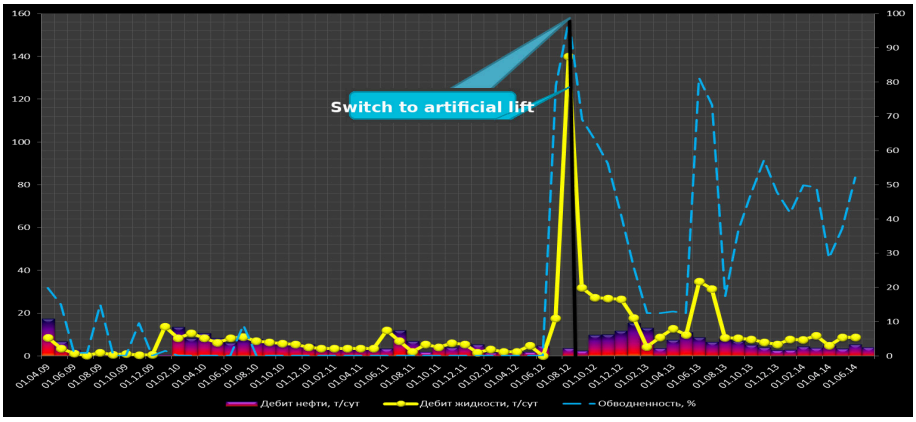

Figure 3. Dynamics of wells № 314 operation before and after the event.

In field-wide terms, mechanized production should be viewed as an operational regulation tool that is most effective when applied to wells with remaining inflow potential and appropriate fluid/energy conditions (ARMA, 2024; Majid, 2015).

Acid HF was carried out in three wells during the analyzed period. The operation combined mechanical fracture creation and acid etching, aiming to increase effective conductivity and connect natural fractures while extending drainage area. The job design included wellbore preparation (paraffin removal by scraper), staged pumping of acid systems (including 15% HCl and emulsified acid), and gel stages. The operational response during pumping was controlled through wellhead pressure and flow rate behavior; the recorded pressures reached high values, with a maximum wellhead injection pressure of up to 710 atm, indicating intensive fracture creation and/or significant friction and near-wellbore resistance during specific stages. The observed pressure trends during gel/acid replacement stages are consistent with changing friction losses and fracture conductivity evolution, while the need for operational adjustments (including short shutdown

due to seal leakage) illustrates typical field risks during high-pressure stimulation (Cherepanov, 2015; Potapov, 2016). A representative example of well performance response is shown in Figure 4 for well № 300.

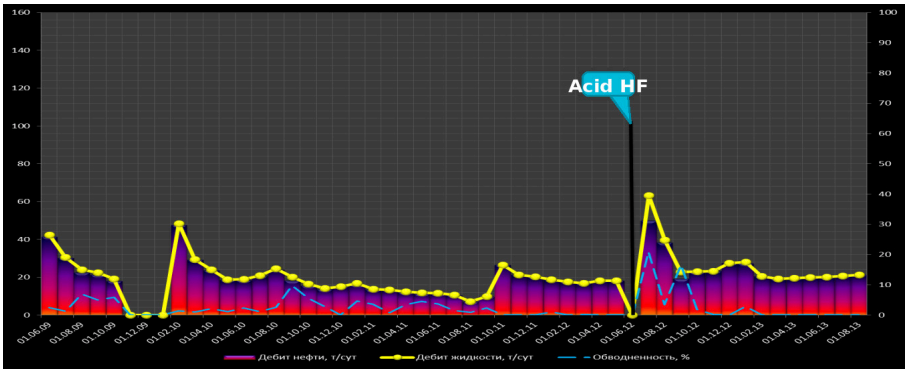

Figure 4. Dynamics of well № 300 operation before and after acid hydraulic fracturing.

From a development regulation standpoint, acid HF is particularly relevant when rate limitations cannot be overcome by near-wellbore treatments alone and when increasing drainage area and conductive pathways is required to achieve longer-term stabilization (Cherepanov, 2015; Potapov, 2016).

For injection wells, hydrochloric acid treatments were performed to improve permeability and reduce filtration resistance in the near-wellbore zone, thereby supporting the waterflood pressure maintenance system. The summarized outcomes (Table 3) show that the conducted treatments resulted in an additional injected volume of 102,790 m³ of water, indicating a tangible contribution to sweep efficiency and displacement energy. Nevertheless, the response was not uniform: in wells №№ 52, 210, 211, no effect was observed, while in wells № 64, 207, 215, the average effect duration was about 18 days, and the minimum effect duration was 9 days in well № 209. Such variability is typical for mature waterfloods where injectivity is influenced by heterogeneity, near-wellbore plugging, and varying connectivity; therefore, injection well acidizing should be applied selectively, supported by injectivity diagnostics and operational monitoring (Dake, 1978; Larry, 1989).

Overall, the results in Tables 2–3 confirm that GTM at the Alibekmola field function as a practical toolkit for regulating development in mature conditions by influencing two key controllable components: (i) well productivity in producing wells and (ii) injectivity/pressure support in injection wells. Measures such as HCl acidizing and acid HF primarily improve the inflow system through physicochemical and/or fracture-conductivity mechanisms, while mechanized production and operating-mode optimization act as operational regulators that can stabilize production when sufficient inflow potential remains. Repair and insulation works, although more selective in impact, remain important where integrity and

unwanted flows limit performance (ARMA, 2024; Yakovlev, 2019; Joshi, 1988; Cherepanov, 2015; Potapov, 2016; Dake, 1978; Larry, 1989; Majid, 2015).

The non-uniform effect observed across different wells indicates that the success of each measure depends on candidate selection, well condition, and reservoir heterogeneity. Therefore, the most effective regulation strategy for Alibekmola is not the isolated application of individual GTM, but an integrated approach that prioritizes (1) diagnosing the dominant limitation (near-wellbore damage vs. insufficient drainage vs. mechanical/operational constraints), (2) selecting the appropriate intervention (acidizing vs. acid HF vs. mechanization vs. repair/insulation), and (3) continuously monitoring the post-operation response to define the effect period and to plan follow-up actions in the annual GTM program (ARMA, 2024; Majid, 2015).

Recommendations. Based on the analysis of geological and technical measures (GTM) implemented at the Alibekmola field during the reporting period, the following recommendations are proposed to improve development regulation, stabilize production, and increase overall recovery.

Maintain and expand the GTM program as a key development regulation tool.

During the reporting period, the implementation of GTM provided an additional 156,088 tons of oil, confirming that systematic interventions in producing and injection wells are an economically justified mechanism for sustaining production at mature assets. It is recommended to preserve annual GTM planning as an integrated field management practice and to prioritize measures with the highest contribution and stability of effect (ARMA, 2024).

Prioritize conversion to mechanized production as the leading production-support measure, with refined candidate selection. The transfer to mechanized production proved to be one of the most effective measures and resulted in 617.53 tons of additional production, which corresponds to 39.6% of total additional production, while the flow rate increased by an average of 15 tons/day. To strengthen this impact, candidate selection should be based on:

– remaining inflow potential (stable reservoir pressure support and acceptable PI);

– manageable water cut trends (avoiding wells with rapidly increasing water cut where mechanization may mainly lift water);

– sufficient well integrity and completion condition to operate in a stable regime. It is recommended to implement a standardized screening workflow for mechanization candidates and to link the selected equipment type and operating parameters to expected drawdown and fluid rate targets to avoid premature decline after conversion (ARMA, 2024; Michael, 2014).

Continue hydrochloric acid treatment in producing wells and standardize the “problem–solution” matching. Hydrochloric acid treatments in producing wells yielded a consistent positive outcome: the oil rate increased by an average of 35 tons/day. This confirms the relevance of near-wellbore stimulation for the

Alibekmola reservoir conditions and supports continuing acidizing in wells with similar production limitations (ARMA, 2024).

To increase repeatability and reduce operational risks, it is recommended to:

– clearly define selection indicators (declining productivity index, evidence of near-wellbore damage, carbonate intervals, skin growth);

– standardize pre- and post-job well testing (baseline rate/pressure and post-treatment stabilization period);

– document acid system, volumes, and displacement strategy to build a local "best practice" database and improve future designs.

Use well operating mode optimization as a routine low-cost measure, but ensure comparability of evaluation. A significant effect was obtained from operating mode optimization, resulting in 38,752 tons of additional oil. Given the typically lower cost and faster execution of this measure compared to major interventions, it is recommended to treat operating mode optimization as a routine field management tool. At the same time, optimization should be performed under a controlled methodology: changes in choke settings, pump frequency, or drawdown should be planned and logged as a formal intervention with defined baseline and evaluation windows. This helps distinguish true incremental gains from short-term fluctuations.

Continue hydrochloric acid treatment in injection wells to support pressure maintenance and sweep efficiency. As a result of hydrochloric acid treatment in injection wells, a positive effect was obtained. Over the reporting period, 102,790 m^3 of water was additionally injected from this measure alone. Because injectivity improvement directly contributes to more stable pressure support and overall displacement efficiency, it is recommended to continue this type of intervention in injection wells.

To maximize field-scale benefit, it is advisable to prioritize injection wells that:

– show injectivity decline under stable surface conditions;

– have signs of near-wellbore plugging or permeability reduction;

– are located in areas critical for pressure support of high-potential producers.

Post-treatment monitoring should include injectivity index tracking and injected volume response over a defined effect period.

Strengthen "effect isolation": avoid changing well operating mode immediately after GTM to ensure correct effectiveness identification. Changes in operating regime after GTM create significant difficulties in identifying the effect of the intervention and may lead to over- or underestimation of incremental production. Therefore, it is recommended not to change the operating mode of the well during the GTM effect evaluation period, except for safety-critical cases. A standardized stabilization window and fixed evaluation procedure should be introduced for each GTM type (ARMA, 2024; Michael, 2014).

Practical implementation may include:

– locking operating parameters (pump frequency/choke/target drawdown) for a defined period after GTM;

– documenting any forced deviations and excluding affected intervals from effect calculation;

– using consistent pre- and post-intervention averaging windows for rate comparisons.

Conclusion. Acid hydraulic fracturing was performed at the Alibekmola field by Schlumberger as a single-stage stimulation treatment aimed at restoring well productivity under mature reservoir conditions. Prior to the operation, the well demonstrated extremely low productivity with a liquid rate of 0.033 t/day, indicating strong inflow limitations in the near-wellbore zone and/or insufficient effective conductivity of the productive interval. Immediately after the acid hydraulic fracturing treatment, a fountain inflow of 10 m^3/day was obtained, confirming that the intervention significantly improved the inflow conditions and created additional conductive pathways for fluid entry into the well.

Following the installation of an electric submersible pump (ESP) in August 2012, the well achieved a stable liquid production rate of 25–30 m^3/day. This production trajectory demonstrates the complementary effect of stimulation and artificial lift: acid hydraulic fracturing increased the well's inflow capacity, while mechanized lifting enabled the well to operate steadily and realize the improved productivity potential. The cumulative incremental oil production associated with the stimulation and the subsequent transition to mechanized production amounted to 1208.2 tons, indicating a positive operational and economic impact of the integrated approach.

Overall, the observed response confirms the positive effectiveness of acid hydraulic fracturing at Alibekmola, particularly when combined with mechanized lift, as a development regulation measure for mature carbonate reservoirs. The results support the inclusion of acid hydraulic fracturing in annual geological and technical measure (GTM) programs for wells with critically reduced productivity, especially in cases where near-wellbore acid treatments alone may be insufficient to deliver a sustainable rate increase. At the same time, to improve result predictability and ensure correct attribution of incremental production, future applications should emphasize standardized candidate selection, consistent pre-/post-treatment monitoring windows, and stable operating conditions during the effect-evaluation period.

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