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ХАБАРЛАРЫ

ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ
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КАЗАХСТАН
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NEWS

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NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы «ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

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GEOLOGICAL AND HYDRODINAMIC MODELING OF AN OIL FIELD OF THE PRICASPIAN REGION OF THE REPUBLIC OF KAZAKHSTAN

Abstract. Application of field modeling methods in Kazakhstan has been going on for decades, in parallel with the discovery of new oil and gas fields in the Caspian basin. The purpose of this article is to provide the results of a comprehensive geological survey of an oil field in the west of the Republic of Kazakhstan and to introduce an application hydraulic fracturing technology. The methods used for modeling the field are considered in detail, namely: petrophysical interpretation of wells; seismic interpretation (analysis of seismic attributes for selected intervals); geological modeling (cross-well correlation and channel sediment identification, structural modeling, property modeling). As a result of the analysis of seismic attributes, potential development targets were delineated in the form of polygons, which were further involved in geological modeling. Following the completion of the aggregation phase, areas of possible associated channel sandstones / sand trends in each zone were mapped. When modeling properties for the final saturation model, predefined oil contacts were introduced, which made it possible to define the geometry of oil deposits by zones. Comparative experimental dynamic calculations of hydraulic fracturing modeling methods using the EasyFrac plugin and the HydroFrac well completion method were carried out. Under the same initial conditions, the Easy Frac plugin demonstrated a better possibility of liquid extraction, the pick-up rate of injection wells, an earlier water breakthrough into the producing well. Experimental calculations were carried out using the KINETIX hydraulic fracturing modeling technology, which demonstrated the possibility of creating a detailed design of the procedure for conducting a hydraulic fracturing operation, selecting the technology depending on the desired result.

Key words: Kazakhstan, modeling methods, hydraulic fracturing, geological exploration, oil field, Petrel, Pricaspian region.

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ҚАЗАҚСТАН РЕСПУБЛИКАСЫ КАСПИЙ МАҢЫ ӨҢІРІНІҢ МҰНАЙ КЕН ОРНЫН ГЕОЛОГИЯЛЫҚ ЖӘНЕ ГИДРОДИНАМИКАЛЫҚ МОДЕЛЬДЕУ

Аннотация. Қазақстанда кен орындарын модельдеу әдістерін қолдану Каспий бассейнінде жаңа мұнай және газ кен орындарының ашылуымен қатар бірнеше онжылдықтар бойы жалғасып келеді. Мақаланың мақсаты Қазақстан Республикасының батысындағы мұнай кен орнын кешенді геологиялық зерттеу нәтижелерін ұсыну және гидравликалық сынудың қолданбалы технологиясын енгізу. Кен орнын модельдеу үшін қолданылатын әдістер егжей-тегжейлі қарастырылады, атап айтқанда: ұңғымаларды петрофизикалық түсіндіру; сейсмикалық интерпретация (таңдалған интервалдар үшін сейсмикалық сипаттамаларды талдау); геологиялық модельдеу (ұңғымалар арасындағы корреляция және арналардағы шөгінділерді анықтау, құрылымдық модельдеу, қасиеттерді модельдеу). Сейсмикалық сипаттамаларды талдау нәтижесінде әлеуетті даму объектілері болашақта геологиялық модельдеуге қатысатын полигондар түрінде белгіленді. Агрегация кезеңі аяқталғаннан кейін әр аймақтағы ықтимал ілеспе арналық құмтастар/құм трендтерінің аймақтары картаға түсірілді. Қанықтылықтың соңғы моделіне арналған қасиеттерді модельдеу кезінде алдын-ала анықталған мұнай байланыстары енгізілді, бұл аймақтардағы мұнай кен орындарының геометриясын анықтауға мүмкіндік берді. Easyfrac плагинін және HydroFrac ұңғымасын аяқтау әдісін қолдана отырып, фрекингті модельдеу әдістерінің салыстырмалы эксперименттік динамикалық есептеулері жүргізілді. Дәл осындай бастапқы жағдайларда Easy frac плагині сұйықтықты алудың жақсы мүмкіндігін, айдау ұңғымаларын алу жылдамдығын, өндіруші ұңғымаға судың ертерек серпілуін көрсетті. Эксперименттік есептеулер KINETIX фрекингті модельдеу технологиясын қолдана отырып жүргізілді, бұл фрекинг операциясын жүргізу процедурасының егжей-тегжейлі жобасын құру, қажетті нәтижеге байланысты технологияны таңдау мүмкіндігін көрсетті

Түйін сөздер: Қазақстан, модельдеу әдістері, гидравликалық сыну, геологиялық барлау, мұнай кен орны, Petrel, Каспий маңы өңірі.

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ГЕОЛОГИЧЕСКОЕ И ГИДРОДИНАМИЧЕСКОЕ МОДЕЛИРОВАНИЕ НЕФТЯНОГО МЕСТОРОЖДЕНИЯ ПРИКАСПИЙСКОГО РЕГИОНА РЕСПУБЛИКИ КАЗАХСТАН

Аннотация. Применение методов моделирования месторождений в Казахстане продолжается уже несколько десятилетий, параллельно с открытием новых месторождений нефти и газа в Каспийском бассейне. Целью данной статьи является предоставление результатов комплексного геологического исследования нефтяного месторождения на западе Республики Казахстан и внедрение прикладной технологии гидроразрыва пласта. Подробно рассмотрены методы, используемые для моделирования месторождения, а именно: петрофизическая интерпретация скважин; сейсмическая интерпретация (анализ сейсмических характеристик для выбранных интервалов); геологическое моделирование (корреляция между скважинами и идентификация отложений в каналах, структурное моделирование, моделирование свойств). В результате анализа сейсмических характеристик потенциальные объекты разработки были очерчены в виде полигонов, которые в дальнейшем были задействованы в геологическом моделировании. После завершения этапа агрегации были нанесены на карту области возможных сопутствующих русловых песчаников/песчаных трендов в каждой зоне. При моделировании свойств для окончательной модели насыщения были введены предопределенные нефтяные контакты, что позволило определить геометрию нефтяных залежей по зонам. Были проведены сравнительные экспериментальные динамические расчеты методов моделирования гидроразрыва пласта с использованием плагина Easy Frac и метода завершения скважины HydroFrac. При тех же начальных условиях плагин Easy Frac продемонстрировал лучшую возможность извлечения жидкости, скорость отбора нагнетательных скважин, более ранний прорыв воды в добывающую скважину. Экспериментальные расчеты были проведены с использованием технологии моделирования гидроразрыва пласта KINETIX, которая продемонстрировала возможность создания детального проекта процедуры проведения операции гидроразрыва пласта, выбора технологии в зависимости от желаемого результата.

Ключевые слова: Казахстан, методы моделирования, гидроразрыв пласта, геологоразведка, нефтяное месторождение, Petrel, Прикаспийский регион.

Introduction. Oil and gas condensate fields of the Caspian Basin began to play an important role in the oil industry of the former USSR in the early 1980s after the discovery of the giant formations Astrakhan, Karachaganak, Tengiz. (Bedrikov et al., 1994).

The Ustyurt-Bozashinsky basin includes the Bozashinsky arch and the North Ustyurt system of deflections and elevations. The pool area is 130,903 sq km. About 60 local structures have been identified within the basin by geological and seismic methods over the years of study (Azhgaliev, 2020). The North-Ustyurt block has the shape of a wedge directed to the west, where it wedges out along converging faults in the Komsomolets Bay area (Leonov et al., 2010). The territory of the North-Ustyurt region has clearly expressed limitations in the form of large fault systems and extended antaclinal zones. (Daukeev, 2002).

Paleozoic deposits of the Ustyurt region are buried under the Mesozoic-Cenozoic sedimentary cover with a thickness from the first hundred meters to 6-8 km (Volozh et al, 2016). In the interior of the North Ustyurt Depression, on its northern and southern sides, under the Mesozoic-Cenozoic sedimentary cover, dislocated rock complexes of the Upper Paleozoic intermediate structural floor (Triassic, Permian, Carboniferous and Upper Devonian) lie to varying degrees (Niyazova., 2021) Differences in sedimentation conditions predetermined the different composition of hydrocarbons in the west (sea conditions) and in the east (lake-swamp conditions). (Abilkhasimov, 2019) From the position of the geothermal regime of the subsurface of the Caspian region at depths of 1-4 km, the central part of the Northern Ustyurt is characterized by the greatest heating (Glumov, 2004).

The field described in this manuscript is located in the northern part of the Ustyurt basin (Fig. A.1), where the productive Jurassic deposits of nearby fields play an important role. Permian and Lower Triassic deposits are widespread and have capacities up to 2 kilometers. Permian sediments are distinguished by their predominantly sandy composition, and Early Triassic organic matter (ostracods) has been found in Lower Triassic red-colored sandy-clay-siltstone rocks. (Volozh et al, 2015) Its structure is an anticline formed in the course of strike-slip and extensional tectonic regimes, where the plan shows the segmentation of a group of major and minor normal extensional faults with tracking of separation in geometry. Faults are also detected on logs in the form of cycles isolated from the section (in the general case), as well as duplicated ones. Previous interpretations of sedimentary environments in one way or another indicated a terrigenous fluvial, amenable to interpretation based on curves, cyclicity, mutual and spatial location of sandstones in wells and in the core, including the transition zone in the upper part of the section. The setting also correlates with the origin of hydrocarbons (lacustrine, fluvial, deltaic) established by geochemical analyzes.

Similar research results were published in the publication of S.M. Ozdoyev (Ozdoyev et al., 2017). The article presents the reservoirs of the field in the form of laterally and layer-by-layer heterogeneous in their reservoir properties and productivity factors, permeability, efficiency of oil-saturated capacities. Methods of using optimal technologies in increasing oil production from productive wells of the field have been selected.

The following sections of the article present the results for each method of computerized geological modeling of an oil field and assessment of the implementation of new technologies in the process of well design and completion.

Research material and methods. Oil field modeling methods. Petrophysical well interpretation. Quality control of logging curves of new wells was carried out. Log data in these wells was used as a reference for studying the well section. An example of a comparison is shown in Fig. B.1

As part of the quality control of the curves, graphical analysis tools were used in the Techlog software. For deep alignment of core data, spectrometric gamma-ray logging (GR) data were used. Structural and textural features, mineral composition of rocks, which are represented by detrital rocks of productive deposits, composed of grains of quartz, mica, feldspar, have been studied. According to granulometric analysis data, polymictic sandstones have different grain sizes (from small to large) and cementation degrees (from weak to densely cemented). Clay rocks are composed of the minerals chlorite, illite and kaolinite.

As a result of deep correlation «core description - logging», a model for calculating lithology was developed. Based on the analysis of core data, the separation of productive sandy rocks into two lithotypes was carried out - pure sandstones and dense clayey sandstones. Clean sandstones are characterized by GR values less than relatively dense clayey sandstones and large divergences of the GR-NPOR-DEN curves. This model also allows calculating the lithotypes of clay, limestone and coal based on the readings of the log curves. In Fig. B.2 presents an example of a comprehensive analysis of core and log data to study the degree of reservoir heterogeneity.

In Fig. B.3 shows the sums of the thicknesses of sandstone and clay in the previous and updated models. In the updated model, there is an increase in the thickness of sandstone (on average by 13%) and clay (on average by 2%).

The previous petrophysical model used a common «global» relationship between the permeability factor and the porosity factor. In Fig. B.4 shows the relationship «Permeability coefficient-Porosity coefficient» (Kpr-Kp) in the previous and updated models.

It is noted that the general dependence «Srw-Kp» has a high reliability (R2 = 0.89), but does not describe the sample in high Kp values, where the cloud of values "flattens out" at the level Srw = 27%. In this regard, an additional logarithmic dependence «Srw-Kp» was adopted, which describes samples with Kp more than 9%.

Productive deposits are represented by sandstones of various grain sizes and with varying degrees of cementation with the presence of finely dispersed clay minerals. This type of reservoir is capable of retaining a significant proportion of non-free water (clay- and capillary-bound). This is confirmed both by the results of core data analysis and by special logging studies. Dividing the type of sand reservoir into 2 subtypes allowed different permeability coefficient regressions to be applied.

In the previous model, general regression was used to predict Kpr. The updated model uses different Kpr-Kp relationships for sandstone lithotypes to predict permeability.

In this work, the Archie equation with the parameters of the existing petrophysical model was used to calculate Sw. The presence of residual water is confirmed by core data. Based on the analysis of core data, a dependence was obtained for calculating the Srw, according to which the minimum value is 27%.

Seismic interpretation. The seismic interpretation has been rebuilt, added velocity model building and seismic attribute analysis for all seismic horizons, followed by implementation in geological modeling.

The seismic interpretation was performed on the 3D seismic cube (177.1 km2), reprocessed in 2012.

The seismic interpretation workflow can be roughly divided into 2 parts: structural interpretation and seismic attribute analysis. The traditional structural interpretation approach has focused on the interpretation of faults and horizons, along with the construction of a velocity model for depth conversion. Seismic attribute analysis was aimed at visually highlighting and isolating promising objects like sand bodies. In seismic-attribute analysis, two techniques are involved: straightening the seismic volume to the horizon with its subsequent use as a source material for calculating seismic attributes Maximum Rated Sinusoidal (RMS amplitude), Sweetness and Envelop, the calculated attributes were analyzed as a single volume over time slices using Red Green Blue (RGB) color mixing; method of spectral decomposition followed by scanning along strato-sections in the form of a sample along the horizons.

The results of both methods were linked to well information to confidently delineate promising targets as polygons.

Interpreting horizons. According to the results of seismostratigraphic referencing and analysis of the wave field, more than 10 seismic horizons were identified and traced (Fig. C.1). Laterally sustained and well-connected seismic horizons (J-IV, JV, J-VI, J-VIII-A (FS2), J-IX-A, JXA (FS-1), J-XI (J2Base) are designated as reference and involved in the construction of the structural frame of the geological model. Each of the additional seismic horizons is characterized as a single lithological event in the wells between the reference horizons. All horizons are traced by a 10X10 grid in the ILN and XLN directions. For quality control purposes, the Anomaly identifier attribute was applied. Gray color of the attribute is identified. with zones of confident correlation for secant ILN / XLN, and red-blue gamma with residuals (Table A.1).

Table A.1

Horizons	Display Response	Pick Quality
J3_top	Blue Trough	Very Good
Carbonate_Top	Red Peak	Very Good
J-I (Shale Top)	Red Peak	Good
J-II (FS3)	Red Peak	Good
J-III	Red Peak	Fair - Good
J-IV	Red Peak	Good
J-V	Red Peak	Good
J-VI (Coal)	Red Peak	Good
J-VII-A	Blue Trough	Fair - Good
J-VII-B	Blue Trough	Fair - Good
J-VIII-A (FS2)	Blue Trough	Fair - Good
J-IX-A	Red Peak	Good
J-X-A (FS1)	Red Peak	Fair-Good
J-XI (J2Base)	Blue Trough	Poor-Good

3D seismic tracking of horizons was carried out taking into account the following criteria: lateral continuity of reflection; dynamic and frequency component of reflection; reflection geometry; number of reflections in a single package.

All horizons were traced in two stages. Initially, taking into account the lateral continuity with a 10X10 grid to determine the general structure and subsequent auto-tracking, taking into account the amplitude-phase characteristics of the reflection. The degree of auto-tracking is directly related to the original reflection quality.

Deterioration in the quality of seismic reflections with depth is observed, especially for the J-XI (J2Base) horizon, which may affect the ambiguity of the result. On the flank of the structure, deeper than the J-XI horizon (J2Base), there is an angular unconformity phenomenon.

Most of the horizons are characterized as confidently traced. Difficulties in tracing horizons are usually associated with fault zones and thin sandstone-clay interbedding.

The most confident are the J3 Top and Carbonate Top horizons. In general, the reflections in the interval of interest are sub-parallel with varying degrees of intensity. The lower part of the interval of interest can be characterized as low-intensity.

Reflections in the middle and upper sections of the section are sub-parallel and acoustically hard.

Seismic Attribute Analysis. There are more than 100 distinct seismic attributes calculated from seismic data and applied to the interpretation of geological structure, stratigraphy, and rock/pore fluid properties. (Adero et al., 2017) Seismic attribute analysis involves obtaining additional visually expressed information, which may be implicit in a traditional seismic field, and leads to improved geological and geophysical interpretation of the data.

In seismic attribute analysis, two techniques were used (Fig. D.1). Channel-type objects, as a rule, do not have a pronounced manifestation in the original seismic sections. Screening by slices of a mixed object of three attributes was applied. Initially, the attributes are calculated from the seismic volume straightened to the target horizon. This approach makes the visualization of stratigraphic features more obvious. The Sweetness, RMS amplitude, Envelop and eXchroma attributes were successfully applied to detect and highlight hidden objects by paleo-channel type. In an alternative approach to the analysis of seismic attributes, the spectral decomposition attribute was used, followed by its screening using horizontal samples.

RGB color mixing of seismic attributes works well for revealing structural and stratigraphic features. To confidently confirm the prospects, all objects were calibrated using well data, taking into account the geological concept of the region of work, the revealed thickness of the sandstone and the logging signature (a certain form of logging the logging curve) in each of the modeled intervals.

In Fig. D.2, Fig. D.3 shows an example of the described log calibration process. Unfortunately, the quality of the initial seismic survey and the thin-layered section did not allow the extraction of objects in the form of geological bodies. Potential development targets outlined in the form of polygons were involved in geological modeling.

Geological modeling. One of the most important tasks of the current stage of geological modeling is to revise the distribution of sandstones in the main production horizons, porosity, and saturation. Interpretation of seismic facies polygons in each zone has been performed, the position and number of polygons used in the interpretation of seismic facies has been changed. This, in turn, influenced the change in total net-to-gross and reservoir connectivity. Water saturation was modeled by spreading properties from wells using Gaussian Random Function Simulation (GRFS).

The geological interpretation process consisted of 4 stages. Quality control has been performed for the main marking horizons. Further, the secondary horizons were picked, controlled by the power of the subzones. The correlation of the horizons was complicated by the nature of channel sand incisions of different scales and tectonics, manifested by the isolation of cycles from the section - or by duplication. In order to better describe the behavior of the net-to-gross trend, at the preliminary stage, the concept of calculating the thicknesses of individual sandy interlayers (ICBT), which is most likely associated with river (channel) deposits, was applied. At the same time, the most probable lateral sandstone trends have been identified and integrated with core and seismic data. Due to the nature of the cyclic bedding of sandy channel bodies, there was a problem of unambiguous identification of their lateral prediction, which was solved by superimposing on the seismic trend - the isolation of seismic facies observed by sounding along a seismic cube (horizon probe). As a result of this aggregation, at the final stage, polygons of possible distribution of associated channel sandstones / sand trends in each zone were mapped.

Cross-well correlation and channel sediment allocation. More than 20 main and auxiliary correlation schemes were built in the wells before correlation and identification of individual channel sandstones.

Further, regional markers were identified and placed in all wells: the top of the Jurassic - the base of clayey, unconsolidated and low-resistivity Cretaceous rocks; roof of carbonates - the roof of a thick regional layer; clay roof - transition from carbonate thicknesses to pure regional clays; coal (VI or CBS) - a regional coal-seam that can be traced through the entire deposit; Jurassic base (base of horizon XI, fluvial, alluvial sandstones, with an unconformable adherence to Triassic rocks).

Some seismic horizons are associated with main skips, which in cross section represent maximum flood surfaces (MFS), or consistent horizons in area, such as coalified sequences. However, not all seismic horizons have been identified with geological horizons. In the model of the previous project, the upper horizon started from I, while in the 2020 model from IV.

To establish the spatial patterns of the distribution of sand bodies, ICBT logging was created, measuring the thickness of individual sandstones (logging thickness from 0 to 40 meters), which, based on a set of identification parameters, were identified in the section as channel ones. Not all sand bodies have been identified as channel bodies, but these sandstones were of interest for modeling. So, for example, the motive for the change in the GR curve for channel sandstones of a meandering river has a sharp lower contact and fining upwards, suggesting a mostly curvilinear geometry of sandy bodies, while the motive of a wandering river has a mainly cylindrical trend with sharp contacts, and in combination with a large fraction of sandstone in the basal part can easily be attributed to this type of bodies. The geometry of the wandering river trend suggests the development of linearly elongated sand bodies or trends (Fig. E.1). In horizon XI, the thickness of the mapped bodies exceeded 40-60 meters, which is not typical even for cyclic generations of river sandstones.

Speaking about the geometry of sandy bodies (Fig. E.2), it is worth noting that even being distinguishable by the generation mode (meanders, wanderings), lens sandstones and linearly elongated sandstones can have a cloak-like regional structure, the resulting thickness of which can be quite high, and the connectivity can be quite continuous in the case of repeated cyclicity of the sandstone formation process. For example, the thickness of the sandstone trend in zone IX_b is a good example.

Core data with photographs and descriptions were embedded in the correlation schemes. In addition, for a more accurate correlation in the core, a petrographic analysis was carried out for sandstones and clays and the results of structural and texture features were grouped: dimension, color, texture and structure, type of cement, inclusions and oil shows (Fig. E.3).

Structural modeling. In a previous project, the Corner point method was used to create a structural wireframe, in the present model, the method was replaced by the Structural Framework. All faults are built into the project, then «soldered». In the previous campaign, all faults were divided into 2 groups: primary and secondary, this time all faults are presented as 1 set (Fig. F.1). The Structural Framework (SF) method has an advantage over the classic Corner Point in terms of labor costs, but requires more machine time. All highlighted horizons and faults were embedded in the structural framework. The process of creating zones was controlled by pre-created skips and isochores.

After the structural frame was built, the 3D mesh was simulated with a rotation of 120 degrees in azimuth and dividing into layers, the number of layers coincided with the previous model. The grid resolution was 50 * 50m.

Property modeling. The next step was to upscale the interpreted logs onto the grid. For the discrete properties of facies, the Most of method was chosen, for continuous - several methods, among which arithmetic and harmonic were also used. The selection of methods was used to more accurately reproduce the values on the histogram with minimal data loss after scaling (Fig. G.1, Fig. G.2).

Next, a geostatistical analysis was performed for facies properties, porosity and saturation. In particular, for facies this is the selection of GSR (Fig. G.3), analysis of the fraction of facies, determination of the direction of anisotropy by zones, enumeration of variograms in three directions, etc. The Sequential Indicator Simulation method was used to propagate discrete properties, for the rest - Gaussian Random Function Simulation.

In addition, a geometric cube was built that defines the boundaries of the background and channel facies in space and a variable azimuth cube for the distribution of channel sandstones in directions in each zone (Fig. G.4).

The cubes of the background and channel facies, as well as the input logs from them, were modeled separately for data analysis. In reality, the “body” of the channel can be more than half covered with silt, fine-grained material, and the presence of the channel itself can only be evidenced by the coarse-grained material in its talweg part. This is especially true of meandering types of channels, in which sand is deposited in bends and, in the absence of cyclicity, represents isolated lenticular sealed bodies.

For quality control, for each zone, sandstone facies thickness maps were generated in the overall model and compared with the background.

After the facies model was built (Fig. G.5) the porosity and saturation properties were calculated by fitting variograms for each individual facies. Analogue databases were then used to derive a geological meaningful range of dimensions for the geometry of the respective sand bodies. (Kakayor et al., 2019)

Further, for the final saturation model, pre-defined oil contacts were introduced, which made it possible to set the geometry of oil deposits by zones.

Assessment of the implementation of technologies in the process of well design and completion. Design of completion of wells with hydraulic fracturing in various ways. To simulate hydraulic fracturing operations within the framework of the 2018-2019 project, Schlumberger used the Easy Frac plugin. To begin with, the main differences between these two modeling methods: Easy Frac plugin and Hydraulic Fracture (Hydro Frac) were analyzed.

Easy Frac creates an additional connection in the cells for wells with fractured hydraulic fracturing through which the crack passes. The calculation of the joint coefficient is based on the geometric parameters of the fracture, the permeability of the rock and proppant, as well as taking into account the effects of «choke restriction» (occurs when the inflow to the sides of the fracture far exceeds the possibility of transporting the fracture). In the case of «choke restriction», the outflow from the central cell should be much greater than the outflow from the cells at the end of the fracture sides; this is determined in terms of the opening coefficient CF in each cell. In addition, the plugin allows you to create and export ECLIPSE keywords that are responsible for reducing the productivity of the well over time (reducing the impact of hydraulic fracturing) or for increasing the injection capacity of injection wells if the bottom-hole pressure exceeds the hydraulic fracturing pressure (WINJMULT-automatic hydraulic fracturing in injection wells).

The Hydro Frac completion option simulates the effects of hydraulic fracturing by modifying the coupling coefficients for the model grid cells affected by the fracture and the permeability. Modified interblock conductivities are created for all grid cells affected by the fracture. This method of hydraulic fracturing modeling also has the option of using a correlation of matching with a small-scale resolution of a grid with local reduction in sizes, which changes the well productivity index and permeability using a negative skin factor. Thus, an approximation to the characteristics of a single-phase inflow occurs.

A simple model was created on which the sensitivity of different hydraulic fracturing modeling options to different crack characteristics was tested. Figure 1 shows a model with 4 producing wells located in the corners of the pit, each of which was taken into account in the calculations as a quarter of the producing well and one injection well. Thus, the ratio of production / injection is 1:1. The size of the grid cells in the x, y, z directions is 10m*10m*0.45 m. Number of cells - 58*58*31. The laterally homogeneous porosity increased with depth in order to reproduce the effect of porosity changes on the productivity of a well with hydraulic fracturing. The permeability was calculated from the porosity, the residual water saturation is constant and is equal to 0.4, approximately the average for the productive part of the field. The relative phase permeabilities, compressibility, and properties of oil, gas, and water are assumed to be the same as for the J-XI horizon.

Working conditions of wells: Bottom-hole pressures for producing wells are 80 atm; bottom-hole pressure of the injection well is 450 atm.

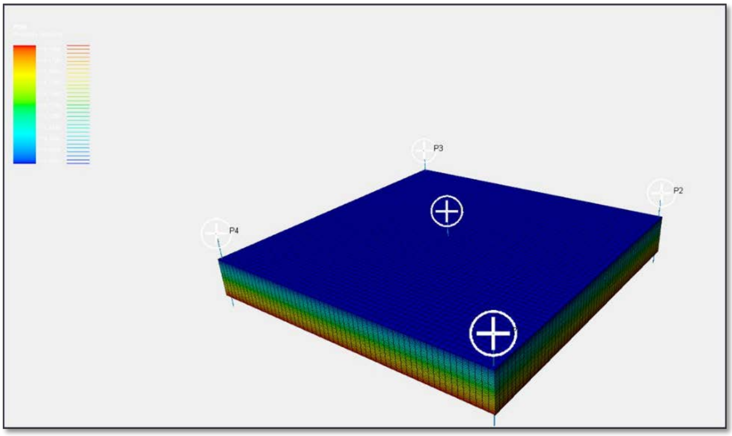


Figure 1. The model created for analyzing the sensitivity of hydraulic fracturing modeling

To analyze the sensitivity, 4 variations of the proppant permeability in a hydraulic fracturing crack were used: 100 D, 300 D, 500 D and 700 D. The direction of the azimuth of the fracture propagation is 0° and 90°. The calculations were performed with the Easy Frac plugin, the HydroFrac completion method, as well as using correlations that exist as an option in the HydroFrac completion. The parameters of fracture opening, height and half-length/length of the fracture are assumed to be the same for all variants. In this way, the sensitivity to the modeling method was investigated for different permeabilities of proppant.

Next (Fig. 3 - Fig. 5 and table A.2) the analysis of the results of calculations on the basis of which the following conclusions:

- Production fluid when using the plugin Easy Frac is much higher than the method of modeling the HydroFrac;
- Water extraction when using the plugin Easy Frac is much higher than the method of modeling the HydroFrac;
- Oil production using the Easy Frac plugin is much higher than with the HydroFrac modeling method;
- Well performance indicators using correlations and without them for the HydroFrac modeling method are almost the same;
- With an increase in the permeability of the proppant with the EasyFrac modeling method, the accumulated water production increases by 20%;
- With an increase in the permeability of the proppant with the HydroFrac modeling method, the accumulated oil production increases by 5%;
- With an increase in the permeability of the proppant, no changes occur in the HydroFrac modeling method with correlations.

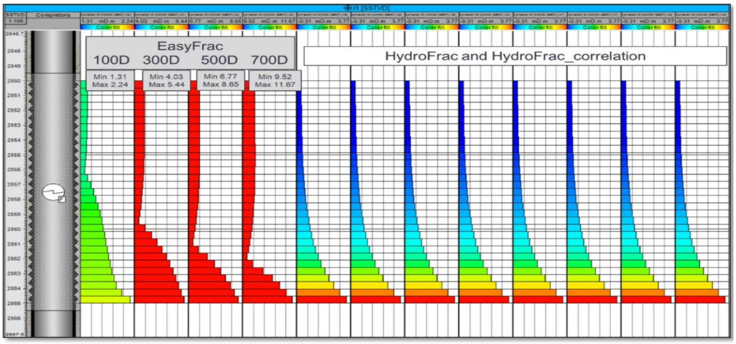


Figure 2. Changes in productivity by depth with different methods of hydraulic fracturing modeling

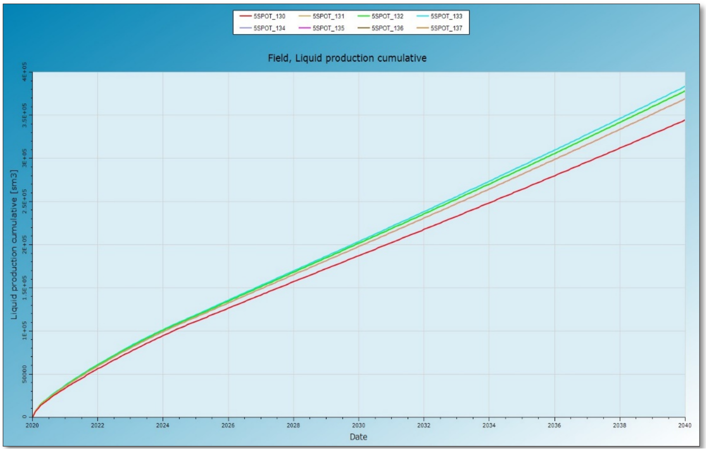


Figure 3. Accumulated production of liquids with different permeabilities of proppant for hydraulic fracturing modeling using the EasyFrac plugin

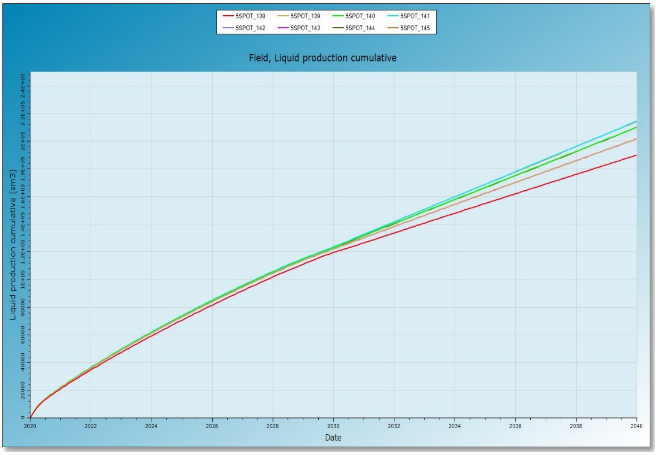
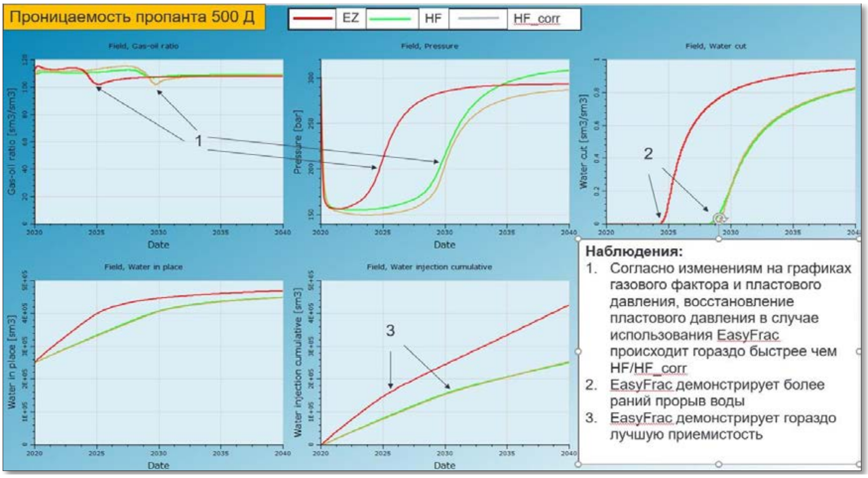


Figure 4. Accumulated production of liquids with different proppant permeabilities for hydraulic fracturing modeling using HydroFrac completion



Наблюдения:

1. Согласно изменениям на графиках газового фактора и пластового давления, восстановление пластового давления в случае использования EasyFrac происходит гораздо быстрее чем HF/HF_corr
2. EasyFrac демонстрирует более раний прорыв воды
3. EasyFrac демонстрирует гораздо лучшую приемистость

Figure 5. Analysis of changes in the parameters of well operation with various methods of hydraulic fracturing modeling

Table A.2 - Main results of calculations of hydraulic fracturing modeling methods for different propant permeabilities

Hydraulic fracturing modeling method	Proppant permeability	Accumulated liquid production	Accumulated oil production	Accumulated water production
EasyFrac	100 D	3.5e+05 m^3	1.7e+05 m^3	1.8e+05 m^3
	700 D	3.8e+05 m^3		2.2e+05 m^3
HydroFrac	100 D	1.9e+05 m^3	1.5e+05 m^3	0.4e+05 m^3
	700 D	2.1e+05 m^3	1.5e+05 m^3	0.6e+05 m^3
HydroFrac with correlations	All options	2.1e+05 m^3	1.5e+05 m^3	0.5e+05 m^3

An introduction of an application of technology for modeling the completion of wells with hydraulic fracturing

As a new technology for designing well completion, the plug-in of the company Schlumberger Kinetics (KINETIX) was used, which allows to optimize the design and technology of the hydraulic fracturing procedure as efficiently as possible. Calculations of the sensitivity of the well performance depending on the design of the hydraulic fracturing were carried out. Kinetix allows you to simulate hydraulic fracturing in detail. In real conditions at the field, hydraulic fracturing is performed in 2 stages: creating a crack and keeping this crack open using propane. To analyze the sensitivity of hydraulic fracturing, we use the following variable parameters:

1. Volume of injected water;
2. Water/propane injection rate.

In the future, for a more in-depth analysis, it is recommended to conduct a sensitivity analysis using a large number of parameters. The process contains several stages: choosing a sector model, well modeling, hydraulic fracturing modeling, creating scripts, analysis of the results.

Selecting a sector model. The part of the J-XI horizon model where there are no wells is selected as a sector model (Figure 6)

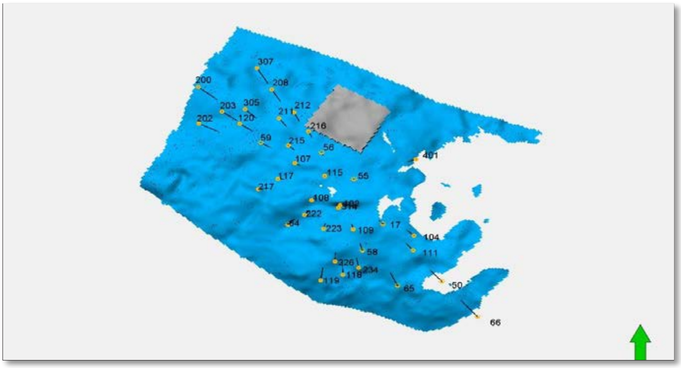


Figure 6. The part highlighted in gray is selected for creating a sector mod

Well modeling

Two wells were created: Production (hereinafter referred to as Well 2), Injection (hereinafter referred to as Well 1) (Figure 7).

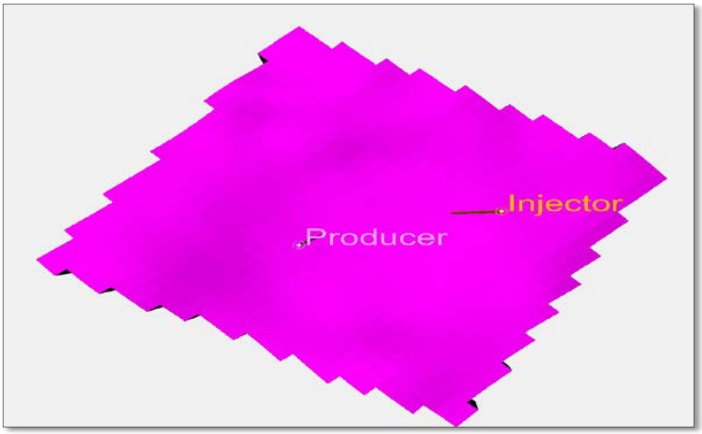


Figure 7. Production and injection wells on the sector model

The wells are perforated in a zone with non-zero porosity. On average, this region had better reservoir properties than the rest of the horizon, where the existing well stock is located. It is worth noting that the Arystanovskoye field is characterized by low reservoir connectivity, especially in the overlying horizons, which is one of the main reasons, along with the low permeability of the reservoir, for the need to use hydraulic fracturing operations. Therefore, we decided to worsen the properties in such a way that the properties are statistically similar to the most problematic parts of the horizon for mining. Using the active/inactive cell - ACTNUM properties, Figure 8 demonstrates the separation of the reservoir around the producing well. It is in such cases that hydraulic fracturing is a necessary procedure for obtaining production.

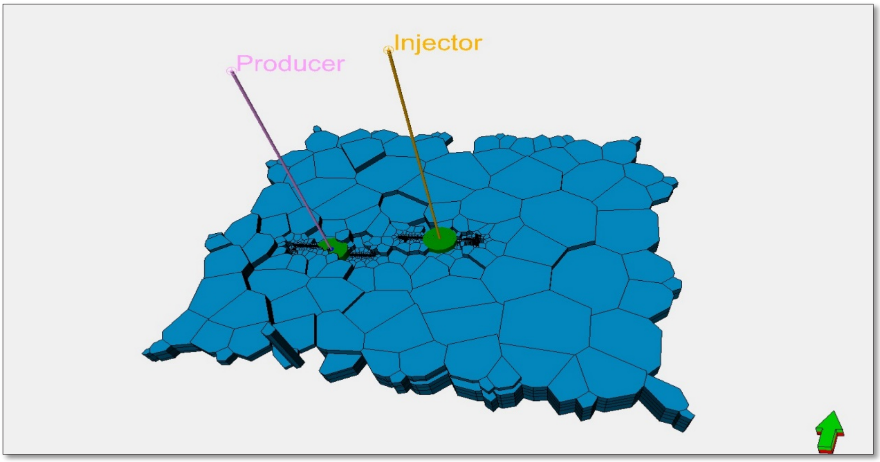


Figure 8. Active cells of the sector model near the Well 2

Using Kinetix, we can simulate all the stages of preparation for hydraulic fracturing. To start the simulation, we decided to use the design of the hydraulic fracturing well 223. Figure 9 shows an example of the design of modeling the stages of hydraulic fracturing.

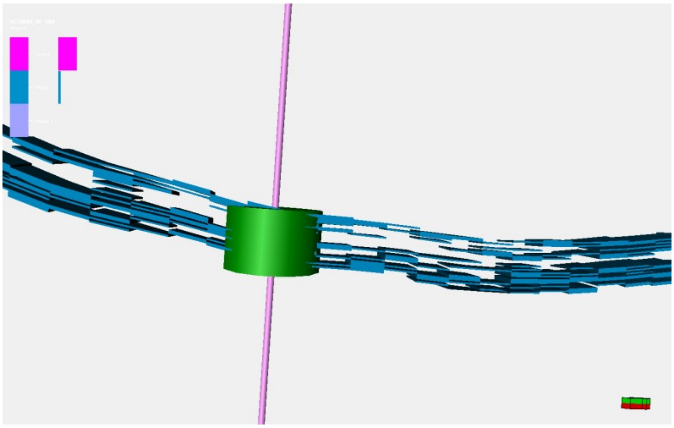
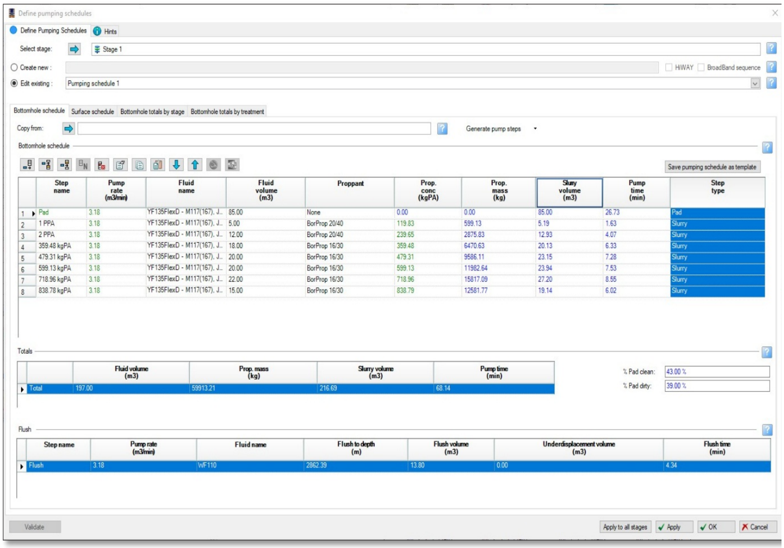


Figure 9. The stages of hydraulic fracturing of well 223, described using Kinetix

Kinetix models the fractured in a detailed way, as a result of which it automatically creates an unstructured grid that allows you to describe the geometry and properties of the crack as accurately as possible. Figure 10 shows an example of the created grid. Note that the crack is modeled by small cells to take into account the direction, shape and distribution of properties along it. The properties of the remaining cells are created by upscaling the properties of the sector model of a regular grid to an unstructured grid. It is important to remember that due to the sharp difference between the values of the property in the crack and the «matrix», there may be problems with the convergence of solutions of the equations during the simulation in INTERSECT(IX). And also, it is necessary to carefully consider the vertical resolution of the unstructured grid, because it depends on how successfully the properties from the reservoir model will be distributed to the unstructured grid.



Select stage: Stage 1

○ Create new :

● Edit existing : Pumping schedule 1

☐ HiWAY ☐ BroadBand sequence

	Step name	Pump rate (m3/min)	Fluid name	Fluid volume (m3)	Proppant	Prop. conc (kgPA)	Prop. mass (kg)	Slurry volume (m3)	Pump time (min)	Step type
1	Pad	3.18	YF135FlexD - M117(167), J...	85.00	None	0.00	0.00	85.00	26.73	Pad
2	1 PPA	3.18	YF135FlexD - M117(167), J...	5.00	BorProp 20/40	119.83	599.13	5.19	1.63	Slurry
3	2 PPA	3.18	YF135FlexD - M117(167), J...	12.00	BorProp 20/40	239.65	2875.83	12.93	4.07	Slurry
4	359.48 kgPA	3.18	YF135FlexD - M117(167), J...	18.00	BorProp 16/30	359.48	6470.63	20.13	6.33	Slurry
5	479.31 kgPA	3.18	YF135FlexD - M117(167), J...	20.00	BorProp 16/30	479.31	9586.11	23.15	7.28	Slurry
6	599.13 kgPA	3.18	YF135FlexD - M117(167), J...	20.00	BorProp 16/30	599.13	11982.64	23.94	7.53	Slurry
7	718.96 kgPA	3.18	YF135FlexD - M117(167), J...	22.00	BorProp 16/30	718.96	15817.09	27.20	8.55	Slurry
8	838.78 kgPA	3.18	YF135FlexD - M117(167), J...	15.00	BorProp 16/30	838.79	12581.77	19.14	6.02	Slurry

Totals

	Fluid volume (m3)	Prop. mass (kg)	Slurry volume (m3)	Pump time (min)
Total	197.00	59913.21	216.69	68.14

% Pad clean: 43.00 %

% Pad dirty: 39.00 %

Flush

Step name	Pump rate (m3/min)	Fluid name	Flush to depth (m)	Flush volume (m3)	Underdisplacement volume (m3)	Flush time (min)
Flush	3.18	WF110	2862.39	13.80	0.00	4.34

Figure 10. Unstructured grid automatically created by Kinetix

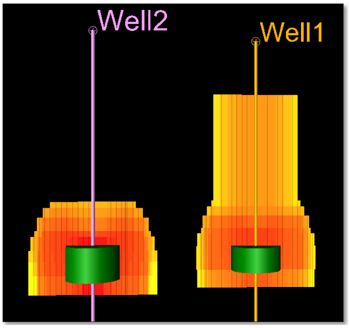


Figure 11. Example of created fractures

Creating scenarios

Working conditions of wells:

* Well 2 (producer):

Control: flow rate of liquid=20 m^3/day

Limit: downhole pressure=20 atm (minimum)

* Well 1(injection):

Control: water injection=20 m^3/day

Limit: downhole pressure=450 atm (maximum)

The table below shows 3 hydraulic fracturing scenarios, where the volume of injected water and the injection rate change:

Table 3 - Hydraulic fracturing scenarios

Scenario	Volume of initially injected water[m^3]	Water / propane injection rate [m^3 / min]
1 (Inj_1_2_7)	28	2.7
2 (Inj_1_3_2)	28	3.2
3 (Inj_2_2_7)	70	2.7

Results and discussion. Figure 12 shows the accumulated liquid and oil production under three water injection scenarios. The scenario with initially more injected water has the highest production in terms of liquid and oil. After it, scenarios 2 with a higher download speed and scenario 1, respectively, with a lower download speed, follow in order.

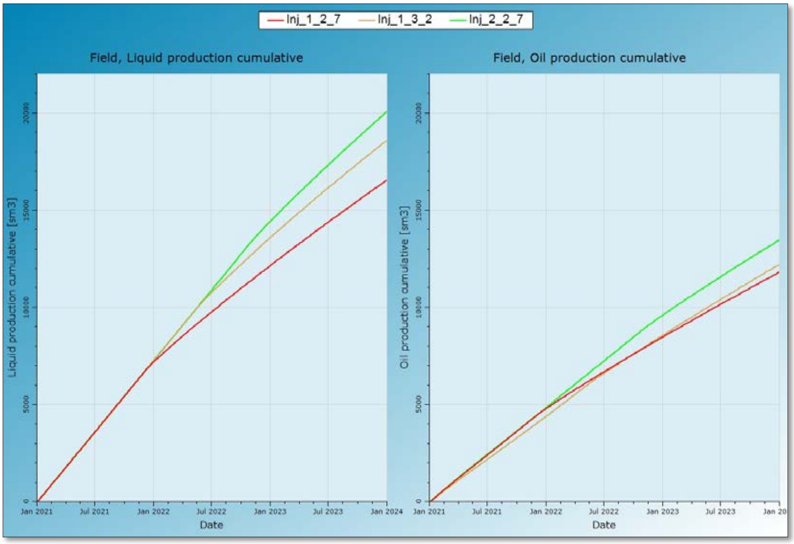


Figure 12. Accumulated liquid and oil production

Figure 13 shows that Scenario 3 keeps the liquid extraction longer than the other scenarios. An oscillation is visible on the oil flow chart, which is explained by the dissimilarity/instability of the calculations of the systems of equations. For this kind of dynamic calculations with a high resolution grid, especially unstructured, with a significant change in the volume and properties of adjacent cells, it is necessary to use powerful tools and software products such as INTERSECT (IX). It is recommended to pay special attention to checking the configuration of the model with a fracture, selecting the number of zones that they are used for upscaling, to conduct a preliminary series of calculations to obtain maximum stability.

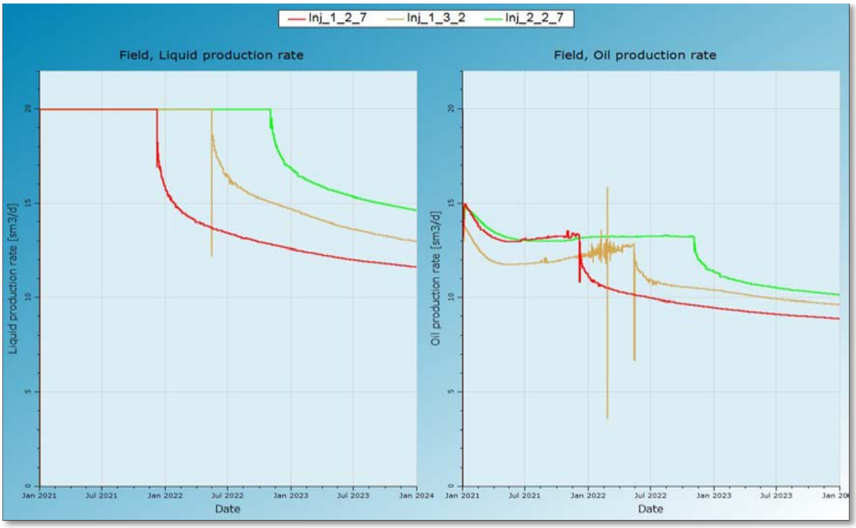


Figure 13. Flow rate of liquid and oil

In Fig. 14, the bottom-hole pressure is fully consistent with the fluid flow rate. Scenario 3 can keep the liquid extraction longer, respectively, the minimum downhole pressure of 60 atm is reached later. A similar explanation applies to other scenarios. For an injection well, the bottom-hole pressure increases more slowly if the reservoir properties allow it. This explains the slow increase in downhole pressure for scenario 3, compared to scenarios 1 and 2. In none of these scenarios it is possible to achieve the maximum permissible pressure at the bottom of 450 atm, respectively, all can pump 20 m^3/day of water.

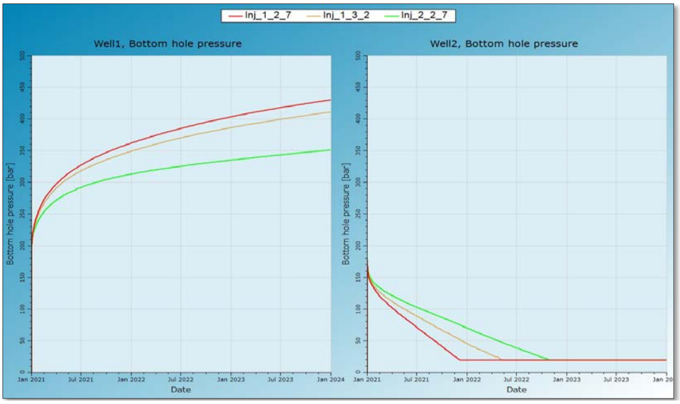


Figure 14. Bottom-hole pressure of the injection (left) and production (right) wells

Conclusion. This article is a compilation (Bealessio et al., 2020) of the results of geological and hydrodynamic modeling of an oil field in the west of the Republic of Kazakhstan.

Based on the results of a comprehensive study, a new geological model of an oil field in the west of the Republic of Kazakhstan was created. Its features are disclosed in this manuscript. The model takes into account data from new drilled wells in 2019-2020, updated petrophysical interpretation, refined seismic interpretation and attribute analysis, and updated vision of reservoir sand bodies identification. Numerical reservoir models quality can be significantly increased by wider usage of well-test and production-logging results for reservoir modeling. (Gulyaev et al., 2008)

Based on the analysis of the core data, a dependence was obtained for calculating Srw, according to which the minimum value is 27%. At the end of the seismic interpretation, the results of both methods were linked to well information in order to confidently delineate promising objects in the form of polygons. During the process of horizon interpretation, it was revealed that the J3 Top and Carbonate Top horizons can be attributed to the most confident. As a result of the analysis of seismic attributes, potential development targets were delineated in the form of polygons, which were further involved in geological modeling. Following the completion of the aggregation phase, areas of possible associated channel sandstones / sand trends in each zone were mapped. When modeling properties for the final saturation model, predefined oil contacts were introduced, which made it possible to define the geometry of oil deposits by zones.

Comparative experimental dynamic calculations of hydraulic fracturing modeling methods using the EasyFrac plugin and the HydroFrac well completion method were carried out.

Under the same initial conditions, the Easy Frac plugin demonstrated a better possibility of liquid extraction, the pick-up rate of injection wells, an earlier water breakthrough into the producing well.

Experimental calculations were carried out using the new KINETIX hydraulic fracturing modeling technology, which demonstrated the possibility of creating a detailed design of the procedure for conducting a hydraulic fracturing operation, selecting the technology depending on the desired result.

Nomenclature. CO2 carbon dioxide;
H2S hydrogen sulfide;
μo formation oil viscosity;
mcD displacement fluid viscosity;
ρo density of reservoir oil;
ρD displacement fluid density;
ICBT individual channel body thickness;
MFS maximum flooding surface;
Srw residual water saturation;
GRFS Gaussian Random Function Simulation.

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REFERENCES

Abilkhasimov Kh.B. (2003) Petroleum geology. [Geologiya nefti I gaza] 3: 25-30 (in Russ.).

Adero B., Masinde A., Osukuku G. Using Seismic Attributes for Reservoir Characterization. Date Views May 2017/ Conference: Oil, Gas & Mines Africa, Exhibition and Conference (OGMA).

Azhgaliyev D.K. Geological structure and new directions of oil and gas exploration in Paleozoic deposits of the Caspian basin and the western part of the Turan plate. (2020), 259 p.

Bealessio B.A., Blánquez Alonso N.A., Mendes N.J., Sande A.V. and Hascakir B. A review of enhanced oil recovery (EOR) methods applied in Kazakhstan. Date Views 03/16/2020. Petroleum Engineering Department, Texas A&M University, United States. Petroleum journal homepage. Mendeley Data, V1, doi: 10.1016/j.petlm.2020.03.003.

Bedrikov P.G. & Basniev K.S. 1994. Petroleum Engineering Challenges of the Development of Precaspian Depression Fields (Kazakhstan, Russia). World Petroleum Congress.

Daukeev S.Zh., Vocalevskiy E.S., Shlygin D.A., Pilifosov V.M. (2002) Petroleum Geology. [Neft I gaz] 3: 138 ISBN: 9965-13-760-9 (in Russ.).

Glumov I.F., Malovitskiy Ya.P., Novikov A.A., Senin B.V. (2004), Regional geology and oil and gas content of Caspian Sea. [Nedra-Businesscentr], 66p. ISBN: 5-8365-0184-X.

Gulyaev D., Chernoglazova N., Fedoseev M. Carbonate Reservoir Simulation Improvement on Base of Well-Test Data to Increase Forecast Reliability (Russian). SPE Russian Oil and Gas Technical Conference and Exhibition, 28-30 October 2008, Moscow, Russia. DOI; 10.2118/115351-ru.

Kakayor O.G. Reservoir Architecture as a Driver for Effective Field Development Planning in an Un-Appraised Field; Kz field, Kazakhstan as a Case Study. Society of Petroleum Engineers. (2019, August 5).

Leonov Yu.G., Volozh Yu.A., Antipov M.P., Bykadorov V.A., Kheraskova T.N. (2010) Consolidate Crust of Caspian Region. Moscow, GEOS. ISSN 0002-3272, p. 33.

Niyazova A.T. (2021) Geological structure and prospects of oil and gas potential of the Jurassic deposits of the North Ustyurt depression according to geological and geophysical data.

Oil and gas basins of Kazakhstan and prospects for their development. (2015), Association of petroleum geologists of Kazakhstan PA. ISBN: 978-601-06-3477-0, 342 p.

Ozdoyev S.M., Mashrapova M.A. Geological structure and methods of increasing oil recovery of the productive horizons of the Arystan deposit. Date Views 2017. News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences. 4 (424). P.270-275. Mendeley Data, V1.

Volozh Yu.A., Bykadorov V.A., Antipov M.P., Sapozhnikov R.B. (2016) Petroleum Geology. Theory and Practise. [Neftegazovaya geologiya. Teoriya I praktika] 11: 1-43 (in Russ.).

Volozh Yu.A., Bykadorov V.A., Antipov M.P., Parasyna V.S., Rybalchenko V.V. (2015) ISSN 2070-5379 [Neftegasovaâ geologiâ. Teoriâ i practika] (in Russ.) DOI: https://doi.org/10.17353/2070-5379/41_2016.

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