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METHODS OF FEASIBILITY STUDY OF EFFICIENCY OF WELL PLACEMENT OF HORIZONTAL DIRECTIONAL WELLS WITHIN OIL AND GAS RESERVOIR BED BOUNDARIES. JSC EMBAMUNAIGAS SUCCESS EXPERIENCE WERE TAKEN FOR ANALYSIS

Abstract. This article describes the positive experience of applying an integrated approach in planning and drilling horizontal wells with geosteering in the fields of Embamunaigas JSC (most of which have entered the late stage of development, with a steady increase in hard-to-recover hydrocarbon reserves) in order to achieve maximization of oil production. In this article we present a comprehensive horizontal well placement approach which comprises the following key elements: Interpretation of 3D seismic and the use of logs of nearby wells and a 3D static model for well trajectory planning; following a pre-agreed geosteering procedure while drilling, on-site analysis of cuttings and LWD data to adjust the well trajectory and, thereby, optimize well placement. The extent of field development drilling activity of the objects, production drilling of the main development object and the need of horizontal section well placement in the area of the existing element of the development of the object impose certain restrictions on the drilling of horizontal wells. Well placement is one of the best solution to increase production and extend of brawn field life.

Key words: drilling, geosteering (well placement), wells, LWD (Logging While Drilling), to adjust well trajectory.

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МҰНАЙ-ГАЗ ҚАБАТЫ ШЕКАРАСЫНДА КӨЛДЕНЕҢ-КӨЛБЕУ ҰҢҒЫМАЛАРДЫ ОРНАЛАСТЫРУ ТИІМДІЛІГІНІҢ ТЭН ӘДІСТЕМЕСІ. ЕМБІМҰНАЙГАЗ "АҚ-НЫҢ ТАБЫСТЫ ТӘЖІРИБЕСІ ТАЛДАНДЫ

Аңдатпа: Бұл мақалада мұнай өндіруді барынша арттыруға қол жеткізу мақсатында "Ембімұнайгаз" АҚ кен орындарында геонавигациясы бар көлденең ұңғымаларды жоспарлау және бұрғылау кезінде кешенді тәсілді қолданудың оң тәжірибесі сипатталады (олардың басым бөлігі игерілуі қиын көмірсутек қорларының ұдайы өсуімен игерудің кеш кезеңіне өткен). Бұл тәсіл геофизикалық деректерді пайдалануға (3D-сейсмикалық барлаудан бастап ұңғымаларды егжей-тегжейлі геофизикалық зерттеуге (ГАЖ) дейін, геологиялық модельдеу нәтижелері бойынша ұңғыманың траекториясын жобалауға, бұрғылау процесінде алынған ГАЖ, шлам және геонавигация деректерін ұңғыманың модельдерін нақтылау және траекториясын түзету үшін қолдануға, бұрғыланатын жыныстардың сүзу-сыйымдылық қасиеттерін нақты уақыт режимінде бағалауға негізделген.
Көлденең ұңғымаларды геонавигациялау-ескі мұнай кен орнының өндірісін ұлғайту және қызмет ету мерзімін ұзарту үшін ең жақсы шешімдердің бірі.

Түйінді сөздер: бұрғылау, геонавигация (мұнай және газ қабатының картасында көлденең ұңғыманы ораналастыру), ұңғымалар, бұрғылау кезіндегі LWD геофизикасы, ұңғыманың траекториясын түзету.

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МЕТОДИКА ТЭО ЭФФЕКТИВНОСТИ РАЗМЕЩЕНИЯ ГОРИЗОНТАЛЬНО-НАКЛОННЫХ СКВАЖИН В ГРАНИЦАХ НЕФТЕГАЗОВОГО ПЛАСТА. ПРОАНАЛИЗИРОВАН УСПЕШНЫЙ ОПЫТ АО «ЭМБАМУНАЙГАЗ»

Аннотация. В настоящей статье описывается положительный опыт применения комплексного подхода при планировании и бурении горизонтальных скважин с геонавигацией на месторождениях АО «Эмбамунайгаз» (большая часть которых вступила в позднюю стадию разработки с неуклонным ростом трудноизвлекаемых запасов углеводородов) в целях достижения максимизации добычи нефти. Этот подход основан на использовании геофизических данных (от 3D-сейсморазведки до детальных геофизических исследований скважин (ГИС), проектировании траектории скважины по результатам геологического моделирования, применении данных ГИС, шлама и геонавигации, полученных в процессе бурения для уточнения моделей и корректировки траектории скважины, оценки в режиме реального времени фильтрационно-емкостных свойств разбуриваемых пород. Комплекс сложностей: масштабы эксплуатационного бурения объектов, эксплуатационное бурение основного объекта разработки и необходимость размещения скважин горизонтального участка в районе существующего элемента разработки объекта накладывают определенные ограничения на бурение горизонтальных скважин, а также планирование объекта разработки за счет заложения сетки горизонтальных скважины с применением геонавигации в пределах картирования нефтяного пласта. Геонавигация горизонтальных скважин – одно из лучших решений для увеличения добычи и продления срока службы старого месторождения нефти.

Ключевые слова: бурение, геонавигация (расположение горизонтальной скважины внутри картирования нефтегазового пласта), скважины, LWD геофизика во время бурения, корректировка траектории скважины.

Introduction

Drilling of Directional Horizontal wells with Geosteering have obvious advantage of having much higher oil production rate compare to vertical wells. JSC Embamunaigas achieved one of the best results in efficiency of Drilling Horizontal wells with geosteering due to Engineering approach and Efficiency of Integrated team of Geologist, Petro physicist and Drilling department. In our article we will touch on the key aspects of a successful example of JSC Embamunaigas well placement of horizontal directional wells within oil and gas bed boundaries.

Main provisions

Production of JSC «Embamunaigas», Geography, Solving geological problems and reducing uncertainties, structural modeling, steps of well placement, software systems, implementation of the project, conclusion, references.

Materials and Methods

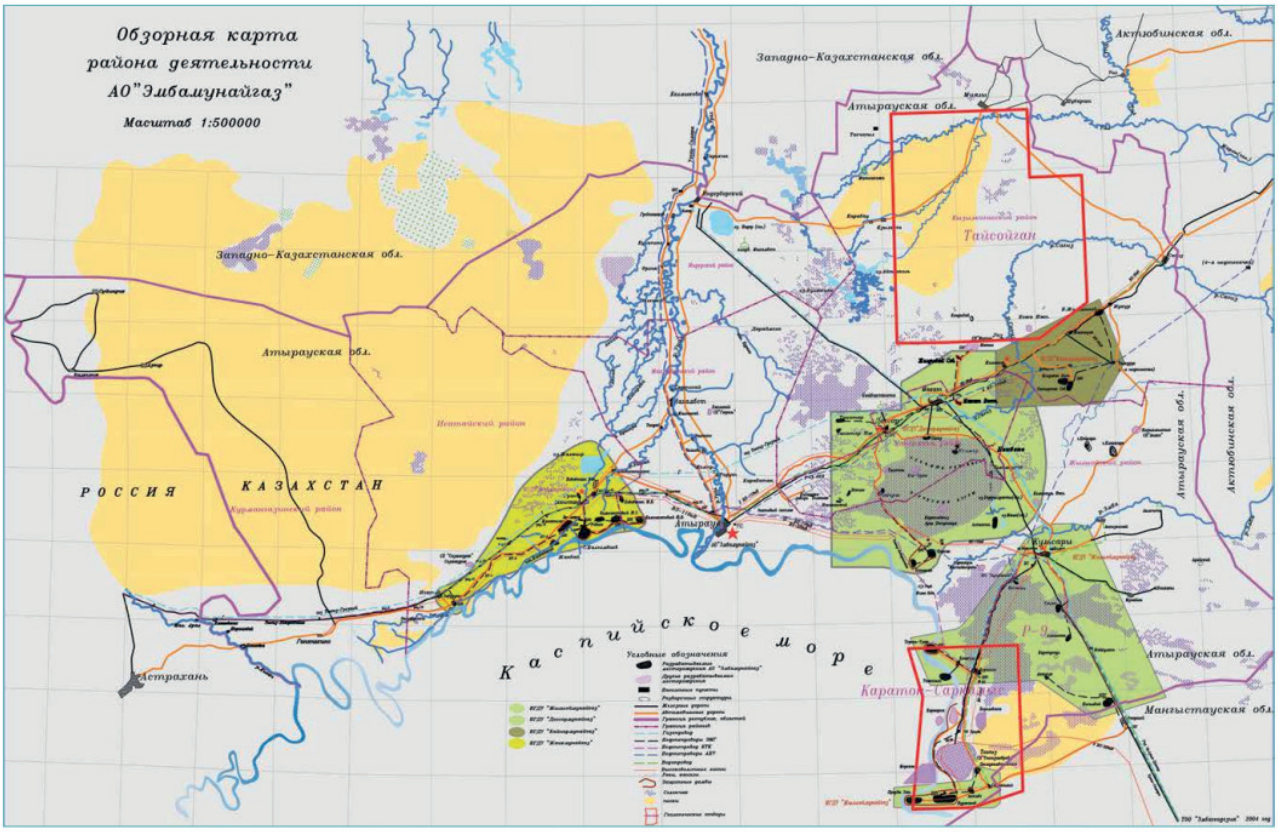
Basics of Well placement, JSC «Embamunaigas» data, three possible ways to study the change in lithology and properties of the rock during drilling.

Production of JSC «Embamunaigas».

The average annual production at JSC Embamunaigas is more than 2.6 million tons.

To date, JSC «Embamunaigas» is developing 36 fields. In the context of these fields, productive strata are characterized by different geological and physical properties of reservoirs and physicochemical properties of oil. Most of the oil fields of the industry have entered a late stage of development, the share of hard-to-recover reserves of fields is steadily growing. Stabilization of the level of oil production in recent years has been achieved through the application of a set of measures: drilling horizontal wells with well placement, drilling new wells, workover and current repair of wells, systematic work with the well stock, increasing oil recoverability factor, increasing the overhaul period, introducing advanced technologies and optimizing of the field development system.

Geography



The operational site is characterized by high dissection. In addition, there are lithological shielded isolated deposits in sand lenses bounded on all sides by fluid barriers. Thus, in the same field at the same hypsometric elevations there are strata with different saturations. Unfortunately, due to the low vertical resolution, seismic data does not allow to reliably identify individual, often isolated, objects in the clinaform post-salt complex of the southern side of the Caspian Depression, which significantly affects the choice of the system for the development and operation of the object.

The extent of field development drilling activity of the objects, production drilling of the main development object and the need of horizontal section well placement in the area of the existing element of the development of the object impose certain restrictions on the drilling of horizontal wells. The trajectory of wells is calculated taking into account minimizing the risk of crossing and anticollision risk between existed wells.

Solving geological problems and reducing uncertainties.

In the conditions of pilot sections drilling of the wells and the presence of geological uncertainties real time monitoring of the well trajectory and well placement of the well during drilling is required. In addition, due to the natural features of the reservoir while drilling through various lithological changes, additional control of the position of the wellbore is also necessary. The final result is affected by the following uncertainties.

– The uncertainties of the lithological structure and position of the oil-water contact, due to long horizontal section with length 0.5 – 1.1 km from vertical line, and low level of geological data availability of Triassic deposits and the complexity of the structure of the oil&gas deposits.

– Uncertainty associated with the dip formation angle of the reservoir bed: according to the results of the interpretation of seismic data and the actual results of drilling, the angle of incidence of the reservoir may differ from the planned one by +/- 1-5º.

– Uncertainty due to the thickness of the reservoir and the lithology of the rocks. According to the data obtained during drilling of the wells, the thickness of the main stratigraphic layers varies slightly. At the same time, a change in the lithological composition of the rocks can be traced from well to well. In addition to solving the main problems of field development, the wells allow further study of the geological structure of the object.

Geological support in real time (well placement) makes it possible to make operational decisions aimed at improving the efficiency of well placement in conditions of geological uncertainties in determining the spatial position of the wellbore relative to geological boundaries.

As part of the preliminary structural modeling, a complex of geological and geophysical data for the entire field is used, including the results of the interpretation of seismic exploration data, information of previously drilled wells (the results of the interpretation of wireline data, core and drilling cuttings analysis data).

The preliminary structural modeling stage includes a detailed correlation of the opened section with the wireline data obtained during the drilling of all wells. While drilling of intermediate section, the structural elements of the overlying strata are specified. The "landing" of the intermediate casing is carried out and the trajectory of the horizontal section in the target interval is adjusted.

The high stratification factor and lenticular nature of the target interval make it difficult to conclusively determine the position of the wellbore relative to the stratigraphic top and bottom of the formation, so the complex of geological and geophysical studies in the drilling process is planned in such a way as to obtain maximum information without carrying out additional descent tripping in/out operations.

The most important aspect of well placement is the timely decision to correct the trajectory of the well depending on the incoming data. Currently, there are three possible ways to study the change in lithology and properties of the rock during drilling.

1. Monitoring. This method does not involve active actions and changes in the trajectory of the well. Drilling is carried out according to a pre-planned program and excludes the possibility of influencing the position of the wellbore. This is a passive method, i.e. it involves only observation. In this case, it is appropriate to talk about the absence of well placement. An example is geometric drilling, in which the trajectory does not change depending on the properties of the formation. Incoming logging data is monitored, but no decisions are made based on these observations.

2. Comparison of types of well logging carried out by non-azimuthal devices. This is a well-established method of well placement. It does not require expensive images to work with; it can be effective even if there is one gamma ray logging curve (GR). The technique is "reactive": after drilling a certain interval, the resulting logging diagrams are processed, based on that decision will be made. This method includes four consecutive steps:

– Construction of a two-dimensional plane-parallel model of the reservoir;
– Calculation of synthetic logging data along the trajectory of the drilling well;
– Comparison of actual well logging during drilling with synthetic logging;
– Update of the model, forecast of the formation dip angle of the reservoir.

The result of the work is the determination of the stratigraphic position of the wellbore in the reservoir, as well as the forecast of the structure of the formation. A graphical representation of the methodology is shown in Figure 2.

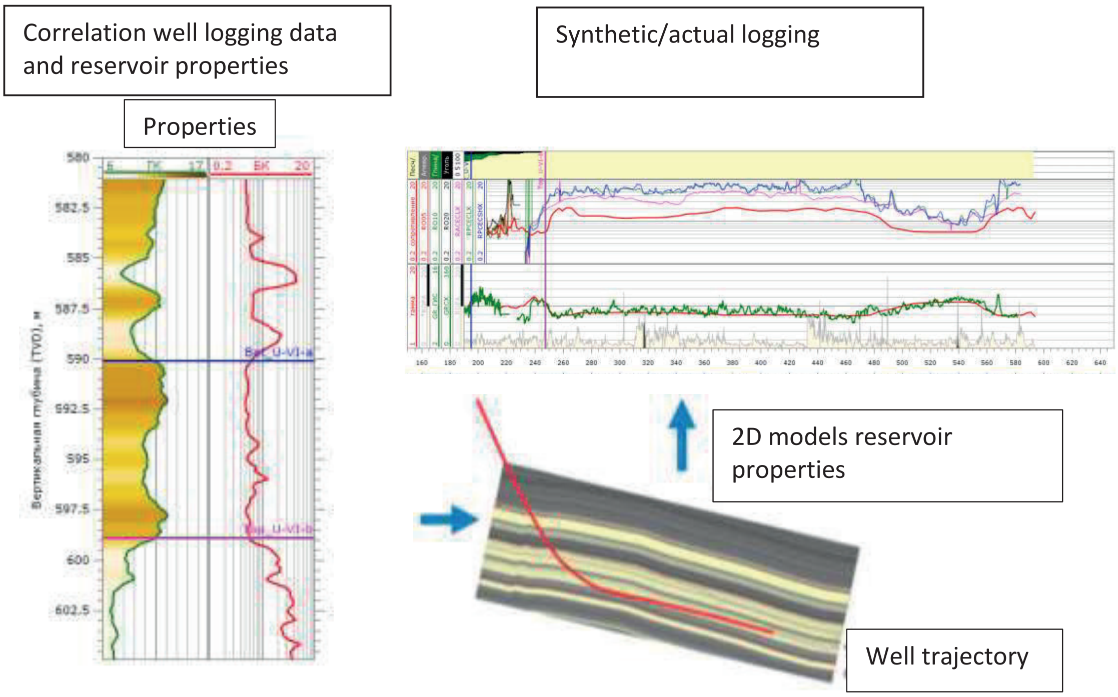


Figure 2 – Method of comparison of types of well logging data.

Synthetic logging is built on the basis of data from neighboring (reference) wells, which can be vertical or directional. Before drilling of a horizontal well, a reservoir model is created that takes into account the regional formation dip angle of the reservoir, obtained from the geological model of the field. Synthetic logging data built along the trajectory of the horizontal well based on the logging data of the reference well.

The actual logging of the horizontal well is compared with the synthetic logging of the model, after that the model is updated until the greatest coincidence of synthetic and actual logging data is obtained. Thus, the stratigraphic position of the wellbore in the reservoir is determined, and the change in the structure of the reservoir is predicted based on its formation dip angle and the selection of actual and synthetic logging. If necessary, the trajectory is adjusted during the drilling process. If necessary, the wellbore trajectory is adjusted during the drilling process of the horizontal well.

3. Determination of the formation dip angle of fall of the reservoir according to azimuth logging data. Azimuthal is the logging that obtains data from a specific sector (azimuth) of the wellbore. This method gives more information compared to the average value or logging for one sector, but is more expensive.

Curves of the upper and lower sectors are used to determine the formation dip angle of the reservoir along the well trajectory of the well. When crossing the wellbores of the rock down the layer, the lower sensor records the layer first, then it is recorded by the right and left side sensors and the last layer is recorded by the upper sensor. When crossing the layer up the layer along the logging tool, the order of padding by the sensors will be reversed. Using the distance between the logging curves of the upper and lower sensors, it is possible to calculate the formation dip angle of the layers in the section of the trajectory and thus determine the current position of the wellbore.

This method has the following advantages:

– Determination of the formation dip angle does not depend on lateral homogeneity and uniformity in the thickness of the formation;

– Direct determination of the position of the wellbore in the reservoir, which does not allow for a dual interpretation (for example, for the method of comparing logging, a situation may arise when two different sets of angles of formation dip of the reservoir give a same degree of correlation between actual and synthetic logging).

The disadvantages of the method include:

– The absence of lithological contrast when drilling in a lithological homogeneous layer - the method will not be able to define changes even when drilling is directed to the top or bottom of the lithological layers;

– The difficulty of determining the correspondences of the same layer on the logging of the upper and lower sensors at a low angle between the wellbore and the layer;

– High cost.

To achieve maximum efficiency of well placement, it is necessary to use a combination of the second and third methods. With this approach, the formation dip angle of the reservoir will be estimated by two independent methods and the accuracy of the assessment will increase significantly. In addition, during drilling, it is extremely important to obtain new logging data (conventional and azimuth) as quickly as possible. Therefore, transmitting of logging data is happening in real-time.

Therefore, software systems for geological support of well drilling have been developed and actively developed. Modern software solutions make it possible to combine the data of static geological models with the results of various methods of well placement. This allows geologists to significantly increase the efficiency of work to optimize the position of the wellbore.

Geological well placement using only traditional logging during drilling is difficult, since this method does not give an azimuthal direction of measurements in the well. Therefore, changes in lithology can be interpreted both drilling up and drilling down through the layers. In the case of azimuth logging, it is possible to determine from which azimuth sector (upper, lower, right or left) the lithology of the rock begins to change, which can show the direction of the trajectory of the well path in the reservoir (Figure 3).

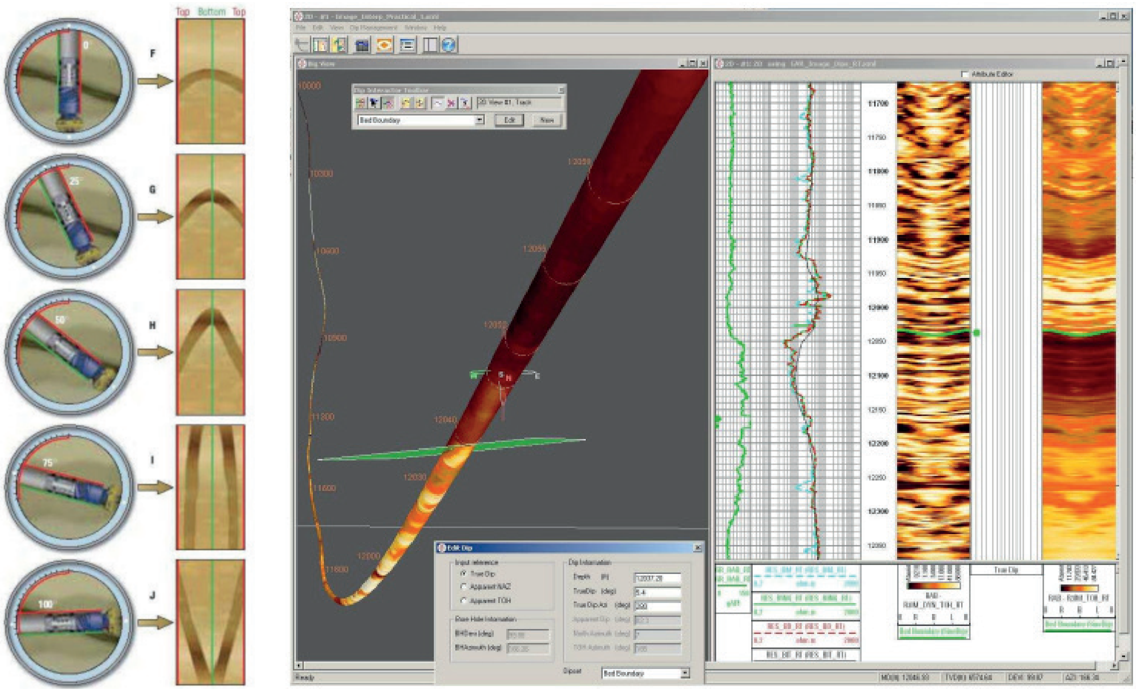


Figure 3 – Schematic of the position of the wellbore and wellbore image.

Results and discussions

Implementation of the pilot project

Before the start of drilling horizontal wells with well placement, a geological project for drilling was prepared on the basis of the approved draft document for the development of the field.

The geometry of the horizontal section can be characterized by: the point of installation of the shoe of the operational column - the beginning of the horizontal section; the point at which the set of the inclination up to 90°; the point of termination of the horizontal section is TD (Total Depth).

The main task of the geological service to support the drilling of wells is the location of points of horizontal section in the most favorable geological conditions (maximum capacity, permeability and oil saturation).

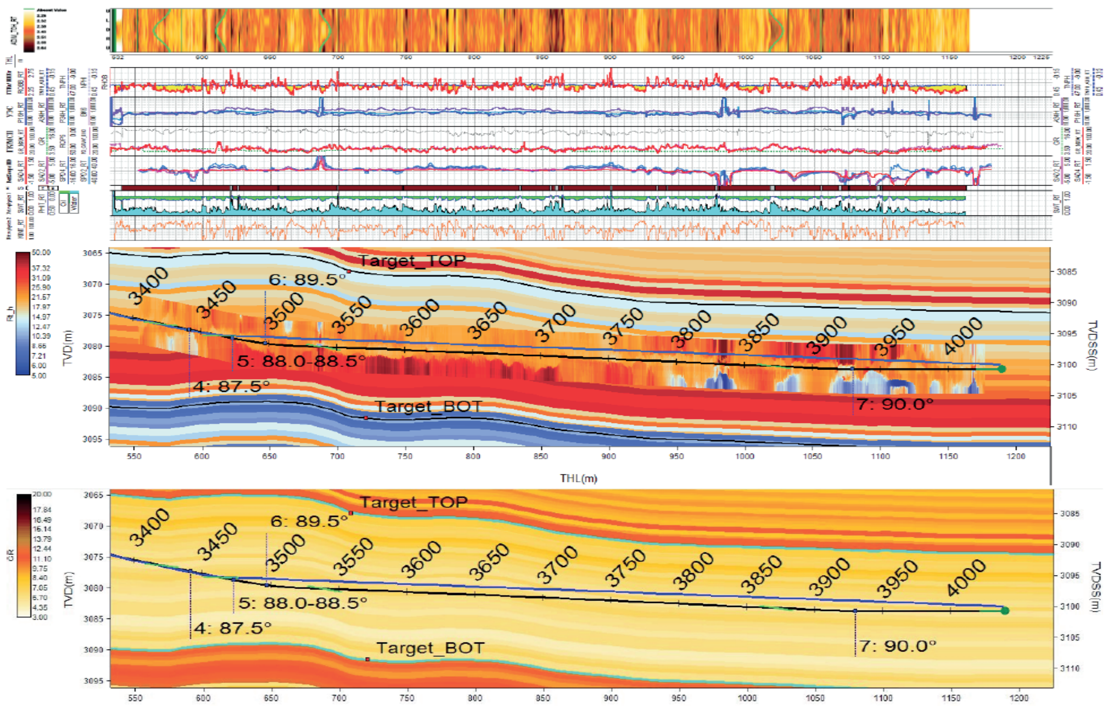
As part of the pilot project, the following set of geophysical studies in the drilling process was recorded in the horizontal section of production wells:

– Gamma Ray logging;
– Array resistivity logging (400 kHz and 2 MHz);
– Ultrasonic acoustic;
– Images of Gamma Ray logging (eight sectors);
– Images of Ultrasonic acoustic logging (eight sectors).

The geophysical equipment used in the process of drilling the horizontal section made it possible to obtain in real time multi-depth data of array electrical resistivity (Res) medium, GR - lower quadrant, ultrasonic acoustic, images of Gamma Ray and Ultrasonic acoustic logging based on the results of azimuthal measurements. The recording density along the length of the wellbore was at least three points per 1 m for all logging methods.

The formation dip angles and azimuths of the reservoirs obtained during the processing of azimuthal images corresponded to the values planned before drilling. The angles of impact of the reservoirs are consistent with the conceptual geological model of the field, structural constructions and are controlled by data on neighboring wells, including those obtained using the device of triaxial induction logging on a conditional reference well.

The depth of the GR is about 0.15 m, the azimuthal image allows you to assess the parameters of the environment in the study zone of a long electric logging probe (RES for attenuation of the amplitude of 2 MHz). In one of the examples (Fig. 4, adjustment), the shape of the image indicates an approach to the sole of the clay layer (fall of the structure), on the basis of which a decision is made to adjust the trajectory of the wellbore by reducing the angle of inclination of the well with a gradual flattening. Electric resistivity logging signals react poorly to boundaries due to the low contrast of media. After adjustment and prolonged drilling with a stable angle, the shape characteristic of drilling down the section and approaching the roof of the clay layer is fixed on the image of the GR.



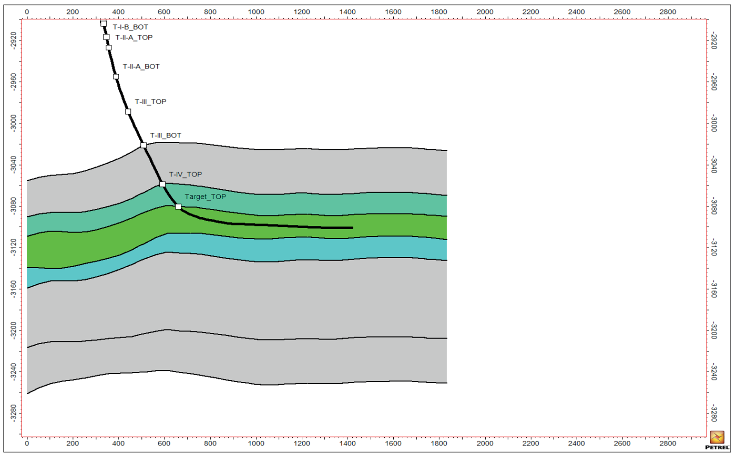


Figure 4 – North Nurzhanov, well 805

In the process of drilling the horizontal part of the wellbore, drilling cuttings were taken at intervals of 10 m. The main tasks were to describe the composition of the fractions: determine the amount of drilling cuttings and the shape of the grains, photographing in UV light. Combining the results of drilling cuttings analysis and wireline data makes it possible to obtain the most reliable picture by independent methods for decision-making in the drilling process.

As it mentioned at:

https://emba.kz/rus/press-centr/inform_soobshenie/?cid=0&rid=997

24/7 monitoring of the drilling process together with the analysis of all incoming geological and geophysical data allows you to make operational decisions on adjusting the drilling trajectory. In this case, it is possible to fully realize the potential of the production well, taking into account the maximum effective length of the horizontal section and well placement in the formation bed boundaries of the best reservoir properties. Interpretation of wireline data during drilling allows you to identify even minor changes in the characteristics of the section and make an operational decision to change the trajectory of the wellbore.

Conclusion

The process of well placement, implemented during drilling horizontal section of the five production wells of the suprasalt complex of the southern side of the Caspian Depression, made it possible to accumulate experience in the operational study of the properties of the section, to assess in practice the real capabilities of geophysical equipment and software. Such experience makes it possible to make process and methodology of planning future work most effectively, choose the most informative research methods and reduce the time of decision-making.

The results of drilling horizontal wells with well placement due to the opening of the productive reservoir of the horizontal section exceeded the productivity of vertical wells: for the Uaz Vostochny field by 8 times; for the East Moldabek field the J-VII horizon by 13.5 times and the J-VI-B horizon by 7.5 times; for the Severny Balgimbayev field , preliminarily by 5 times.

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The current situation in the commodity market, fluctuations in macroeconomic parameters and the presence of investment constraints necessitate the selection of optimal solutions at each stage of the implementation of oil and gas projects. The accumulated positive experience in using existing technologies in the field of geological and geophysical research in the construction of horizontal wells is important not only within the framework of the current project for the development of suprasalt complex of the southern side of the Caspian Basin, but also in general for projects with hard-to-recover reserves.

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