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GROUND-SPACE METHODS FOR FORECASTING DEEP OIL-PERSPECTIVE HORIZONS

Abstract. The search for hydrocarbon deposits is a multifactorial task, which at present cannot be successfully solved on the basis of data from only one method. And for its solution, as a rule, a set of data is obtained, obtained both by ground means and remote, providing an objective picture of the structure of the sedimentary cover based on high information density without significant time and financial costs

The paper considers modern methodological approaches used in the practice of prospecting for oil and gas, which give an objective idea of the criteria on the basis of which a geostructural image of a section of the geological environment is created.

The resulting complex of terrestrial and remote data is aimed at clarifying the structure of the zones of possible oil and gas accumulation and identifying the most promising hydrocarbon traps within them. The main attention is paid to the identification of local structures of various types and discontinuous disturbances. It is the structural aspect, that is, the identification of discontinuous faults of various ranks and the determination of their parameters – strike, direction of fall and kinematics – that is most significant for determining the directions and choosing the methodology for oil and gas prospecting works in each specific area.

The use of thermal range images with the construction of maps of surface temperatures and thermal anomalies based on them, taking into account the influence of the atmosphere, weather conditions, and geological features of the region under study, makes it possible to more efficiently identify productive structures and the most active faults at the present stage. Isolation of such objects makes it possible to concentrate on them seismic exploration and drilling, and thereby reduce the cost and significantly increase the reliability of forecasting and search operations carried out by traditional methods (geology, geophysics, geochemistry).

Among them, in particular, is deep seismic exploration using the common depth point method, which allows to identify migration channels and fluid supports - structural elements that indicate the possible productivity of certain horizons. Nevertheless, despite the leading role of seismic exploration, interpretation of its data at great depths should be approached with some caution due to the high percentage of “dry” wells and the high cost of drilling itself.

.Along with the existing ones, it is proposed and justified the use of the method of parametric 3D modeling of a geological section, which allows creating a visual spatial image of the distribution of oil prospective horizons. The method is verified on data from known deposits and showed good convergence of results.

The results obtained are of interest to subsoil users and organizations planning to search for deposits in oil-spitting regions.

Keywords: density inhomogeneities, hydrocarbons, fluid dynamics.

Despite the successes in the development of technologies for the development of new, practically inexhaustible, energy sources, currently traditional energy sources are at the peak of their demand.

According to experts, by 2040 a 30% increase in demand for energy is predicted, which significantly exceeds current consumption [1].

At the 66-th session of the UN General Assembly in 2011, the President of Kazakhstan, N.A. Nazarbayev, in his report emphasized the need to develop scenario forecasts and a global energy-ecological strategy for the future, which is objectively understandable. Indeed, even without taking into account population growth, the size of the global economy should increase by at least 2 times by 2040, which in turn will require affordable and reliable sources of energy.

And although Kazakhstan belongs to the states with excess energy resources, and it is able to export oil, gas, coal, uranium, without prejudice to its domestic needs, but nevertheless, it also needs to plan to increase natural energy sources, which include hydrocarbons.

Today, Kazakhstan is one of the key exporters of hydrocarbons for the global economy. As of 2013, according to BP Statistical Review of World Energy 2013, Kazakhstan ranked twelfth in the world in terms of proven oil reserves. A significant part of them is located in the Caspian oil and gas basin. However, their additional exploration and further industrial development are complicated[1]:

• low geological exploration of the subsoil;

• the location of a significant part of resources in subsalt horizons located at depths of the order of 5 and more than thousand meters, which increases the capital costs of investors by an order of magnitude.

So, from 202 open oil and gas fields, with estimated recoverable resources of oil in the amount of 7.8 billion tons, and natural gas - 7.1 trillion cubic meters, the vast majority of them are associated with subsalt horizons [2]. This circumstance, against the background of increasing growth rates of production volumes, negatively affected the level of growth in the balance of hydrocarbon reserves. Already, beginning in mid-1995, there was a deficit in replenishment of balance sheet resources, which in the future may pose a real threat to the economic security of Kazakhstan [2].

Therefore, at the KAZENERGY forum held in 2013, Kazakhstan presented a project to create the Eurasia international oil consortium, which is aimed at exploring the deep deposits of the Caspian Depression. According to foreign geologists, the main hydrocarbon reserves, amounting to about 40-50 billion tons of standard fuel, are in the Caspian basin, with 90% of them located at depths of more than 7 km. According to the President of the Society of Petroleum Geologists B.M. According to the results of the work, Kuandykova "will identify new promising areas and objects for exploration, which will make it possible by 2030–2050 to double the existing recoverable reserves of hydrocarbons (hydrocarbons) [3].

According to Akhmet Timurziev, one of the supporters of the concept of the inorganic origin of oil and the author of the Deep Oil project, turning the country's heat and energy complex (FEC) to deep hydrocarbon resources will minimize the cost of replenishing the resource base and stabilize the growth of oil production, including due to its extraction in the territories of the "old regions", which undoubtedly is a cost-effective alternative to the development of new territories.

Forecasting methods for deep oil-bearing horizons.

The search for hydrocarbon deposits both in Kazakhstan and abroad is, as a rule, a traditional set of methods and technologies that allows for a comprehensive analysis of the results obtained using data from geological and geophysical surveys and ending with recommendations for drilling exploratory wells.

Among the geophysical methods, as a rule, gravity and seismic exploration dominate. The implementation of the traditional research complex is a very time-consuming and cost-intensive process, the payback of which is justified "under the conditions of exploration of large and medium anticline oil and gas bearing structures located at shallow depths" [4]. This is explained by a rather high percentage of "dry" wells with a high cost of drilling itself. Therefore, the use of a well-known set of methods when searching for deposits located at great depths should be approached with some caution.

At the same time, deep seismic exploration using the common depth point method (MOGT) allows us to obtain new data on the structure of the earth's crust, indicating its connection with the structure and oil content of the sedimentary cover. These data, obtained along the Tatsays geotraverse, which crossed the entire Volga-Ural province, allowed V.A. Trofimov set "new criteria for the interpretation of seismic data, which, combined with the results of other methods, make it possible to assess the prospects of large tectonic elements, small sections and local objects, as well as to purposefully determine the prospects for deep-seated horizons" [7, 8, 9]. Apparently, the identification of migration channels and possible fluid backlash, which together can serve as a search sign of a reservoir provided that fluids come from below, up to the level of the upper mantle, are among these "criteria". Another search feature is the presence of dynamic anomalies under each of the known studied deposits - "subvertical or steeply inclined disturbed zones, which probably display the desired oil supply channels, or, more correctly, oil and gas supply channels". In the works of R.M. Bembel et al. [10], they are called subvertical zones of destruction, having linear dimensions with a width of several hundred meters to several kilometers. Interestingly, no such "dry" wells were identified in the area of such zones.

Thus, based on regional seismic studies, it was found that each hydrocarbon field has its own main fluid supply channel displayed on the seismic sections in the form of a subvertical disturbed zone and, possibly, secondary channels.

The implemented approach to the interpretation of seismic data allowed the author to identify a gigantic positive structure at levels of 7–11 km, which, according to search criteria already established, suggests the presence of a large hydrocarbon field at this depth and recommends drilling of a parametric well [7].

Along with methods based on ground-based observations, in recent years, the emphasis on prospecting for mineral deposits (MPI) and, in particular, hydrocarbons has shifted towards methods using data from remote sensing of the Earth's surface (ERS).

The attractiveness of remote sensing methods in the study of oil and gas regions is due to the possibility of obtaining an objective picture of the structure of sedimentary cover without significant time and material costs. The geospatial information obtained in this way allows us to establish the spectral images of objects due to the deep migration of hydrocarbon fluids and heat and mass transfer of deep matter, leading to changes in soils, soils, and vegetation located on the surface of the study area. The integral effect of these factors is expressed in anomalies associated with both a change in the stress-strain state of the earth's crust and fluid-geodynamic processes, which are detected in space images [11, 12].

Thus, the remote sensing methods at the search stage make it possible to identify promising geological structures and thereby specify the directions of ground research.

In the analysis of space images, much attention is paid to structural and morphological methods. Among the latter, there is a large group of geomorphological methods that use maps and spectrozonal satellite imagery data of various scales, aimed at identifying possible search features - features of the phototone of the soil and vegetation, the presence of ring structures, lineaments, and other features of the relief and landscape as a whole. Unfortunately, the results of applying these methods do not allow us to draw unambiguous conclusions even for predicting shallow structures.

Against this background, the method is distinguished, which is called the structural method, focused not so much on identifying direct deciphering signs as on detecting indirect ones, which make it possible to establish some quantitative characteristics of the desired deposits, regardless of the depth of their occurrence. The method is implemented in the form of a software complex that has "no analogues in world practice", which, according to its authors, allows one to conduct scientific analysis, predict the location and establish various parameters of oil and gas deposits and other objects of the geological environment, including those located at great depths, right down to up to 20-25 km "[4, 5].

It is based on the discovery [6], which allowed its author to solve the inverse problem of determining the depth and localization of a buried deposit up to determining its thickness with an accuracy comparable to the accuracy of seismic methods. The error of definitions on average is 3-5% of the depth of the analyzed surface, and "the success of exploratory drilling exceeds 75%." At the same time, the cost of forecasting work in relation to the traditional technology of searches is (0.3-0.4)% [Structometric analysis and search of minerals, http://www.magnolia.com.ru/files/anomalies.gif].

The final product of the application of this technology is the recommendations for well placement provided in the form of cartographic materials, as well as 3D and 2D probabilistic models of the geological section. Obviously, the use of this technology due to its "limited" verification and practical use is not indisputable, but from the point of view of cost and timelines it can be very attractive.

The method of geospatial modeling of the section of the geological environment.

Unfortunately, direct search methods for ground-space observations are not a source of complete and unconditional geospatial information about the presence and location of possible hydrocarbon deposits in the geological section. And to fill this gap, reducing the ambiguity of the results obtained, is largely succeeded by the method of mechanical-mathematical modeling of the geological environment [13, 14].

Using the data on the distribution of the elastic characteristics of the geological environment, borrowed from the results of seismic observations, the method allows you to develop spatial parametric models of the distribution of density inhomogeneities and values of the parameters of the stress-strain state in the geological half-space of the study area, regardless of the depth of the proposed reservoir.

In solving this problem, the following stages can be distinguished:

Stage 1. Creation of spatial models for the distribution of zones of decompression.

The construction of such models can be used at the search stage, since they allow us to identify, in the context of the studied structure, the areas of decompression, which may be associated with the actual spatial position and morphology of possible reservoirs, as well as those elements of the deep structure that can serve as supply channels, migration channels or areas of potential hydrocarbon accumulation.

Stage 2. Construction of a spatial model of the geological section in the parameters of the SSS.

The mechanical and mathematical modeling of the geological environment involves the calculation of a set of parameters of the stress-strain state (SSS) with spatial reference of the calculated values. The distribution of the latter in the geological space can be used in solving a wide range of applied problems. Including when performing geodynamic zoning of territories and determining areas of latent energy concentration, identifying areas of increased permeability and assessing the directions of possible fluid movement, etc.

Stage 3. Development of complex parametric models.

The construction of complex models is aimed at identifying the degree of correspondence of the distribution of decompression zones with the distribution of the values of the SSS parameters in the studied block of the earth's crust. In particular, the identification of areas of reduced pressure is one of the main conditions for the movement of fluids in the geological environment. Therefore, it seems important to establish their spatial position and link with the distribution of decompression zones, which, by definition, can be collectors, as well as serve as channels for their migration.

An analysis of the distributions of density inhomogeneities and the anomalous values of the SSS parameters in the volume of the geological environment allows you to:

1. Get a visual spatial representation of the properties of the geological environment and identify new structural forms.

2. To give a visual representation of the morphology of productive horizons, which is the basis for the design of wells and allows you to draw conclusions about the possible location of new deposits.

The proposed methodology can be used as one of the stages of the search and exploration of hydrocarbon deposits in the projected areas in order to identify productive horizons in the context of the earth's crust.

The developed method was verified on the materials of several fields of the Northern Caspian and showed good convergence with the data of downhole observations in terms of the correspondence of the levels allocated and the actual productive horizons [15].

The method allows to establish the presence of hydrocarbon migration channels and to study their spatial structure. Thus, in the presence of information on possible fluid backings, it is possible to draw predictive conclusions about the location of the reservoir.

As a general conclusion, we can say that the presentation of seismic data in decompression parameters reinforced by the SSS parameters allows to obtain a clear spatial image of the geological environment section and thereby increase the efficiency of geophysical studies both at the search stage and at the stage of exploitation of hydrocarbon deposits.

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ЖЕРДІҢ ТЕРЕҢ ҚАБАТТАРЫНДАҒЫ МҰНАЙ-ПЕРСПЕКТИВТІ АЙМАҚТАРДЫ АНЫҚТАУҒА АРНАЛҒАН ЖЕР-ҒАРЫШТЫҚ ӘДІСТЕРІ

Аннотация. Көмірсутек шикізатын іздеу - көп факторлы міндет, қазіргі уақытта оны тек бір әдіс негізінде ғана сәтті шешу мүмкін емес. Оны шешу үшін, әдетте, уақыттың және қаржылық шығындарсыз ақпараттың жоғары тығыздығына негізделген шөгінді жамылғының құрылымының объективті көрінісін беретін жер үсті және қашықтықтан алынған мәліметтер жиынтығы алынады.

Мақалада мұнай мен газды барлау тәжірибесінде қолданылатын қазіргі заманғы әдіснамалық тәсілдер қарастырылған, олардың негізінде геологиялық орта бөлігінің геоструктуралық бейнесі жасалынған өлшемдер туралы объективті түсінік берілген.

Алынған жер үсті және қашықтағы мәліметтер кешені мұнай мен газдың ықтимал жинақталу аймақтарының құрылымын анықтауға және олардың ішіндегі ең перспективті көмірсутек тұзақтарын анықтауға бағытталған. Негізгі назар әр түрлі типтегі және тоқтаусыз бұзылулардағы жергілікті құрылымдарды анықтауға аударылады. Бұл құрылымдық аспект, яғни әр түрлі қатардағы тоқтаусыз ақауларды анықтау және олардың параметрлерін анықтау - соққы, құлау бағыты мен кинематика бағыттарды анықтау және әр нақты ауданда мұнай мен газды барлау әдістемесін таңдау үшін маңызды болып табылады.

Зерттелетін аймақтың атмосферасын, ауа-райының жағдайын және геологиялық ерекшеліктерін ескере отырып, жер бетіндегі температура карталарын және оларға негізделген жылу аномалияларының карталарын салумен жылу диапазонының суреттерін пайдалану өндірістік құрылымдарды және қазіргі кезеңдегі ең белсенді кемшіліктерді тиімді анықтауға мүмкіндік береді. Мұндай объектілерді оқшаулау оларға сейсмикалық барлау мен бұрғылауға шоғырлануға мүмкіндік береді, осылайша өзіндік құнын төмендетеді және дәстүрлі әдістермен (геология, геофизика, геохимия) жүргізілетін болжау және іздеу жұмыстарының сенімділігін айтарлықтай арттырады.

Олардың ішінде, атап айтқанда, көші-қон каналдары мен сұйықтық тіректерін - белгілі горизонттардың мүмкін өнімділігін көрсететін құрылымдық элементтерді анықтауға мүмкіндік беретін тереңдіктің жалпы әдісін қолдана отырып, терең сейсмикалық барлау бар. Сейсмикалық барлаудың жетекші рөліне қарамастан, оның деректерін үлкен тереңдікте түсіндіруге «құрғақ» ұңғымалардың жоғары пайызы және бұрғылаудың өзіндік құны жоғары болғандықтан өте сақтықпен қарау керек.Мақалада іздеу көмірсутегі кен орындарының орналасқан үлкен тереңдікте. Сонымен қатар, қолданыстағы шешімдерімен ұсынылады және негізделеді әдісін қолдану, параметрлік 3D-модельдеу геологиялық қимасын, мүмкіндік беретін жасау көрнекі кеңістіктік бейнесі бөлу нефтеперспективных горизонттардың. Әдісі верифицирован осы атақты кен орындарын және жақсы жинақталуы нәтижелері. Алынған нәтижелер қызығушылық үшін жер қойнауын пайдаланушылар мен тол.

Түйін сөздер: біртекті емес тығыздық, көмірсутектер, флюидодинамика.

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НАЗЕМНО-КОСМИЧЕСКИЕ МЕТОДЫ ПРОГНОЗИРОВАНИЯ ГЛУБОКОЗАЛЕГАЮЩИХ НЕФТЕПЕРСПЕКТИВНЫХ ГОРИЗОНТОВ

Аннотация. Поиск месторождений углеводородов - это многофакторная задача, которая в настоящее время не может быть успешно решена на основе данных исключительно одного метода. И для её решения, как правило, используется набор данных, полученных как наземными средствами, так и дистанционными, обеспечивающими получение объективной картины строения осадочного чехла на основе высокой плотности информации без значительных временных и финансовых затрат.

В работе рассмотрены современные методические подходы, используемые в практике поисковых работ на нефть и газ, дающие объективное представление о критериях, на основании которых и создаётся геоструктурный образ разреза геологической среды.

Получаемый в результате комплекс наземных и дистанционных данных направлен на уточнение строения зон возможного нефтегазонакопления и выделения в их пределах наиболее перспективных ловушек углеводородов. Основное внимание уделяется выявлению локальных структур различного типа и разрывных нарушений. Именно структурный аспект, то есть выделение разрывных нарушений различного ранга и определение их параметров – простирания, направление падения и кинематики является наиболее весомым для определения направлений и выбора методики нефтегазопоисковых работ на каждом конкретном участке.

Использование снимков теплового диапазона с построением по ним карт температур поверхности и тепловых аномалий с учетом влияния атмосферы, погодных условий и геологических особенностей исследуемого региона позволяет с большей эффективностью выявлять продуктивные структуры и наиболее активные на современном этапе разрывные нарушения. Выделение подобных объектов позволяет сосредоточить на них сейсморазведочные работы и бурение, а этим сократить стоимость и значительно повысить достоверность прогнозно-поисковых работ, проводимых традиционными методами (геология, геофизика, геохимия).

К их числу, в частности, относится глубинная сейсморазведка методом общей глубинной точки, позволяющая выявлять миграционные каналы и флюидоупоры, - элементы строения, указывающие на возможную продуктивность тех или иных горизонтов. Тем не менее, несмотря на ведущую роль сейсморазведки, к интерпретации её данных на больших глубинах следует подходить с известной осторожностью из-за высокого процента «сухих» скважин и высокой стоимости собственно бурения.

Наряду с существующими решениями, предлагается и обосновывается использование метода параметрического 3D моделирования геологического разреза, позволяющего создать наглядный пространственный

образ распределения нефтеперспективных горизонтов. Метод верифицирован на данных известных месторождений и показал хорошую сходимость результатов.

Полученные результаты представляют интерес для недропользователей и организаций планирующих поиски месторождений в нефтеперспективных регионах.

Ключевые слова: плотностные неоднородности, углеводороды, флюидодинамика.

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