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PROBLEMS AND PROSPECTS FOR THE DEVELOPMENT OF HYDROCARBON RESOURCES IN THE CONTEXT OF THE GLOBAL TRANSITION TO CLEAN ENERGY

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A b s t r a c t

Decarbonization of the world economy is one of the main trends in global development of the last decade. The beginning of the transition of the world economy to green energy poses new tasks and challenges for the geological exploration industry as well as for the fuel and energy complex. Currently, the most demanded energy-chemical resources are oil, natural gas and, to a lesser extent, coal. Their production has approached the maximum possible level and in the near future will inevitably begin to decline. However, due to large investments and highly efficient technologies, the process of switching to alternative energy sources may drag on for a long period, during which traditional hydrocarbons will remain the basis of the energy sector in many countries. The share of hard-to-recover reserves in the world is constantly growing; in Russia, it currently exceeds 65%. Hard-to-recover reserves include, in particular, reserves of high-viscosity oils and bitumen (with a viscosity of more than 30 mPa·s). The article discusses the prospects and possible ways of developing bitumen and coal deposits within the Volga-Ural oil and gas basin.

Keywords:

Decarbonization;
Natural bitumen;
Heavy oil;
Coal seams;
Thermal treatment.

The beginning of the world economy transition to green energy poses new tasks and challenges for the geological exploration industry as well as for the fuel and energy complex. Currently, the most demanded energy-chemical resources are oil, natural gas and, to a lesser extent, coal. Their production has approached the maximum possible level and in the near future will inevitably begin to decline. However, due to large investments and highly efficient technologies, the process of switching to alternative energy sources may drag on for a long period, during which traditional hydrocarbons will remain the basis of the energy sector in many countries. At the same time, significant problems are associated with the increased involvement in the development of additional resources of high-viscosity oil, natural bitumen and coals as unconventional sources of natural energy carriers and fuels within the long-term developed oil and gas basins. Their development is caused by the need to compensate for oil resources, which are at the stage of depletion. The resources of bitumen-containing rocks and coals within the oil and gas basins can reach billions of tons.

At the same time, the reservoir development of such types of caustobioliths, due to the peculiarities of their occurrence, leads to serious disturbances in both the natural geological environment and surface landscapes.

In this regard, one of the main tasks in the development of hydrocarbon resources in the foreseeable future will be the optimization of their development and refining with minimization of harmful (methane, carbon dioxide, etc.) products release into the atmosphere. The task can be solved by transferring the technological processes of the raw materials processing into the geological environment of their primary occurrence. At the same time, by-products of refining can be disposed of without being extracted to the surface, which will significantly reduce the environmental load on the development area.

This article discusses the prospects and possible ways of developing bitumen and coal deposits within the Volga-Ural oil and gas basin.

Extra-viscous oil and natural bitumen are produced, as a rule, using thermal methods as

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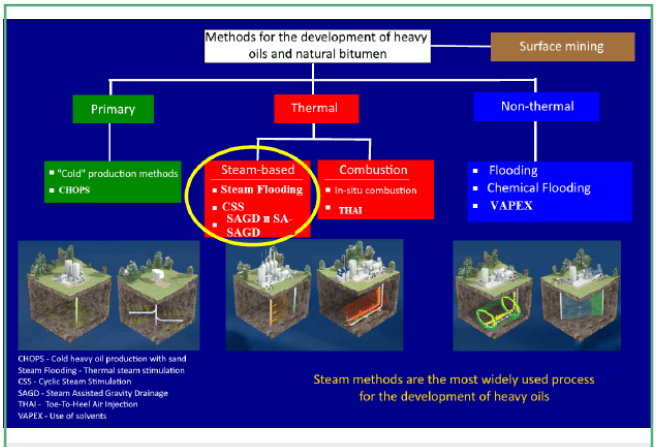

Fig. 1. Methods for the development of heavy oil and natural bitumen

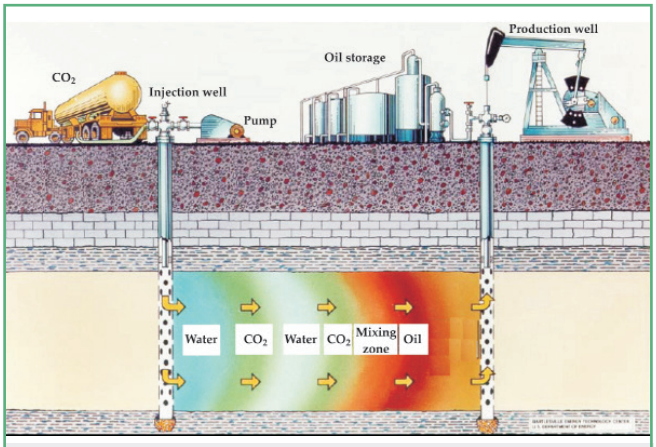

Fig. 2. Heavy oil displacement scheme using supercritical CO_2

injection of heat transfer agents into the reservoir or in-situ combustion (fig. 1). These processes are associated with significant energy costs both in the petroleum and in related industries. In such conditions, the negative environmental consequences of emissions of gases, flue gases of steam generators, heating boilers, oil heating furnaces and associated gas afterburning are obvious and lead to atmospheric pollution: thermal, carbon dioxide, hydrogen sulphide, sulfur oxides, nitrogen, etc.

It is possible to reduce the environmental load using fundamentally new highly efficient technologies for producing medium and low molecular weight hydrocarbons from the resinous-asphaltene part of oil and natural bitumen by oil reservoir thermal treatment and catalytic conversion of heavy hydrocarbons in the reservoir. The technical result of this process is the increase in production efficiency from the formation to the day surface as well as hydrocarbons quality improvement. The new innovative CAPRI catalyst technology provides oil cracking in reservoir conditions. At temperatures over 600°, the oil density can be reduced by 7° API compared to the in-situ combustion process [1]. The CAPRI method consists in adding a catalyst to a production horizontal well. As a result, it is possible to get a more stable and controlled process, a decrease in sensitivity to reservoir heterogeneity, maintain the process in the high-temperature oxidation mode, a decrease in the number of wells, as well as obtain oil of improved quality. Domestic and foreign research aimed at the underground refining of heavy hydrocarbon raw materials show their high efficiency in the development of technologies that provide thermo-oxidative conversion of heavy oil in the reservoir.

Another innovative technology is the technology of super-viscous oil (SVO) and natural bitumen (PB) displacement with the use of CO_2 in a supercritical state [2]. Given the significant depletion of conventional oil reserves, the technology of residual reserves SVO and PB displacement using supercritical CO_2, which is not currently used due to the lack of CO_2 sources, will be promising. This technology is based on supercritical fluid systems injection into the reservoir: CO_2-displacement, water-gas and steam-gas treatment (fig. 2).

The advantage of supercritical CO_2 displacement technologies is the possibility of their application in a wide range of geological and physico-chemical conditions, as well as the possibility of their application at any stage of field development. The effectiveness of their application based on the analysis of theoretical and experimental studies [3] and is determined by a decrease in viscosity and an increase in the mobility of viscous oil (dissolution of supercritical CO_2 in oil), dissolution of light oil fractions in supercritical CO_2, separation and washing of an oil film from the surface of rock particles, displacement of capillary trapped oil (high penetrating ability of supercritical CO_2). The technology of supercritical CO_2-displacement of hydrocarbons is aimed at the rational development of heavy oils and natural bitumen and allows the utilization of CO_2 during oilfield development.

At high-viscosity oilfields, supercritical CO_2-displacement technology can be used in combination with waterflooding, which makes it possible to ensure the displacement front uniformity due to equalizing the viscosities of water and oil and to increase the sweep efficiency. The technological and economic efficiency of the thermal steam treatment can also be significantly increased by adding insignificant amounts of carbon dioxide (about 2%) to the steam, which will increase the efficiency of high-viscosity oil and natural bitumen reservoirs development.

The technology of supercritical CO_2-displacement of hydrocarbons is aimed at solving the following problems:

- Rational development of heavy oils and natural bitumen
- Large-scale utilization of industrial CO_2 emissions

The unique combination of oil production, oil refining and petrochemical industries in the Zakamsky industrial region of the Republic of Tatarstan indicates the prospects of large-scale use of industrial CO_2 emissions in order to use them to increase oil recovery from hard-to-recover oil

reserves for tertiary oil production methods based on supercritical technologies. As a source of CO_2, it is possible to use industrial emissions of carbon dioxide at OAO Nizhnekamskneftekhim, which are fire and explosion proof, the volume of which exceeds 2 million tons per year. To displace oil only by CO_2 its high consumption is required for a tangible increase in oil recovery.

For the Volga-Ural oil and gas basin, which has entered the late stage of oilfields development, fossil coals can serve as an alternative to traditionally produced oil [1, 4-6]. The resources of fossil coal associated with the deposits of the Visean stage of the Lower Carboniferous exceed 3.5 billion tons in the territory of Tatarstan. On the territory of the republic, there have been identified 95 deposits, most of which are located in the licensed areas of PJSC TATNEFT within the northern and western slopes of the South Tatar Arch and the eastern side of the Melekess Depression (fig. 3).

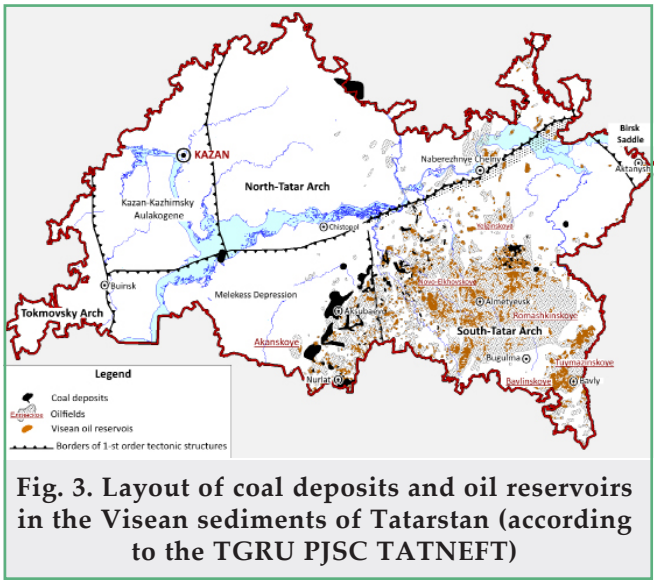

Fig. 3. Layout of coal deposits and oil reservoirs in the Visean sediments of Tatarstan (according to the TGRU PJSC TATNEFT)

Coal beds in Visean sediments are paragenetically related to hydrocarbon reservoirs. The thickness of coal deposits varies from 1 to 30 m. In terms of scale, they all belong to small and medium deposits, their resources range from the first to several hundred million tons.

Visean coals are characterized by a fairly high quality [4]. According to the grade composition, they are hardcoals of D grade, ash content is 15-26%, the yield of volatile substances is 41-48%, sulfur content is 3.1-4.2%, heat of combustion of 29.9-31.4 MJ/kg, content toxic elements is low. In terms of their quality, the coals are suitable for energy purposes, but the main obstacle to their development is the significant depth of the coal seams (900-1400 meters). In addition, coal deposits are characterized by low hardness of percarbonate rocks, gas accumulations, water saturation and are individual for each deposit [5]. For the above reasons, as well as in view of the saturation of the energy market with coal raw materials, their development by the mine method is inexpedient.

Despite the obvious unprofitability of coal mining, with a certain approach, the region's coal resources can be effectively used for the production needs of PJSC TATNEFT and business entities in the southeast of Tatarstan.

It should be borne in mind that coal deposits, as a rule, lie together with Visean oil reservoirs and are geographically close to the area of SVO deposits distribution. The joint occurrence of oil and coal deposits can be used in their development. Currently, there are a number of remote (drilling) technologies that allow mining deep-seated coal seams in the place of their bedding without extracting to the surface. Depending on the selected technology, it is possible to obtain, as independent types of fuel, combustible gas from underground gasification or coalbed methane, which can be used for the needs of PJSC TATNEFT, including for the operation of a local thermal power plant and steam generation in the development of extra-viscous oil (SVO) fields.

For the development of deep-seated coal seams, it is possible to use the method of underground coal gasification (UCG), which has been successfully tested at a number of coal deposits in the USSR at depths of up to 300 meters. Attempts to use it in Tatarstan were undertaken by TatNIPI (Bugulma) in 1962-63, but for a number of reasons the work begun was not brought to its logical conclusion. The accumulated information about the Visean coal deposits on the territory of Tatarstan allows us to conclude that the coals are suitable for the development of underground coal gasification (UCG) technologies in terms of quality and bedding conditions. A sufficiently detailed description of these technologies is given in the works of E.V. Kreinin and etc. [7]. It should be noted that all UCG activities in the USSR and Russia were carried out at depths of no more than 300 meters. However, there is every reason to believe that the depth of the Visean coals of Tatarstan is available for the latest technological approaches for underground gasification. Experimental studies abroad show that a large depth of coal seams is not an obstacle to the gasification process, but, on the contrary, contributes to an increase in its efficiency due to the activation of the methane formation reaction under conditions of increased pressure. In addition, from a depth of 600-700 m, clay and shale rocks under the influence of rock pressure become plastic and seal rock fractures. As a result of the increased hydrodynamic regime, gas leaks and the dispersion of coal processing ingredients are reduced, which in turn prevents groundwater pollution.

Large depths have a beneficial effect on the combustion process, the degree of its controllability, thus minimizing the harmful effect on the environment. The UCG unit generates a combustible energy gas of a complex composition, which can be used to enhance oil recovery at SVO fields. In the Visean sediments, the thermal field of the coal seam burned out during the UCG process can be used in areas with the combined position of coal deposits and oil reservoirs to enhance oil recovery

of a nearby reservoir. Such components of coal gas as carbon dioxide and nitrogen can be used for injection into oil reservoirs in order to maintain reservoir pressure (RPM) and oil displacement [4, 5, 8]. Thus, old oilfields can be restored.

Another promising area is the coal seams development by gas production with the extraction of methane and its homologues. Currently, developed countries are intensively working on the extraction of coalbed methane both abroad (USA, Canada, China, Australia, etc.) and in Russia (Gazprom Dobycha Kuznetsk) [9]. The development of coal seams is carried out by the method of gas production using directional drilling technologies. The produced gas is analogous to natural gas and can be used for household needs and for the operation of local thermal power plants. According to our estimates, the methane resource potential of Tatarstan's coals can reach 30-100 billion m^3. Visean coals occur at a depth of about 1 km, where high pressure and temperature prevail. Gas, coal and water in a coal seam are in a complex interaction.

Up to 70-75% of methane in coals is present in sorbed form [6, 7, 10], where its amount is adsorbed on the surface of coal particles, and the main task here is to break the stable physicochemical coal-methane bond. In situ coal thermal treatment leads to the destruction and desorption of coal [11]. Additional release of gas sorbed by coal can increase the methane content of the coal seam as a whole.

Experimental studies in this area are relevant, since they make it possible to identify patterns affecting the oil recovery factor, and to develop a feasibility study for new field development technologies, water-gas and steam-gas treatment. The success of the proposed technology commercialization is based on the experience accumulated in a number of countries.

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Перспективы освоения углеводородных ресурсов в условиях глобального перехода на экологически чистую энергетику

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Реферат

Декарбонизация мировой экономики – один из главных трендов глобального развития последнего десятилетия. Начавшийся переход мировой экономики на зеленую энергетику ставит новые задачи и вызовы перед геологоразведочной отраслью и топливно-энергетическим комплексом. В настоящее время наиболее востребованными энергохимическими ресурсами являются нефть, природный газ и, в меньшей степени, уголь. Добыча их приблизилась к максимально возможному уровню и в недалеком будущем неизбежно начнет снижаться. Однако, процесс перехода на альтернативные источники энергии из-за крупных капиталовложений и высокоэффективных технологий может затянуться на длительный период, в течение которого основой энергетики многих стран будут оставаться традиционные углеводороды. Доля трудноизвлекаемых запасов в мире постоянно растет, в России в настоящее время она превышает 65%. К трудноизвлекаемым относятся, в частности, запасы высоковязких нефтей и битумов (с вязкостью более 30 сП).

В статье рассматриваются перспективы и возможные пути освоения битумных и угольных месторождений в пределах Волго-Уральского нефтегазоносного бассейна.

Ключевые слова: декарбонизация; природные битумы; тяжелая нефть; угольные пласты; термическое воздействие.

Ekoloji təmiz energetikaya qlobal keçid şəraitində karbohidrogen ehtiyatlarının mənimsənilməsi perspektivləri

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Xülasə

Dünya iqtisadiyyatının dekarbonizasiyası son onilliyin qlobal inkişafının əsas trendlərindən biridir. Dünya iqtisadiyyatının yaşıl energetikaya keçidinin başlanması geoloji kəşfiyyat sahəsinin və yanacaq-energetika kompleksinin qarşısında yeni vəzifələr və məsələr qoyur. Halhazırda ən çox tələb olunan enerji-kimyəvi resurslar neft, təbii qaz və bir qədər də kömürdür. Onların hasilatı mümkün olan maksimum səviyyəyə yaxınlaşıb və yaxın gələcəkdə azalması qaçılmaz olacaqdır. Lakin iri kapital qoyuluşları və yüksək səmərəli texnologiyalar səbəbindən alternativ enerji mənbələrinə keçid prosesi uzana bilər ki, həmin müddət ərzində də bir çox ölkələrin energetikasını ənənəvi olaraq karbohidrogenlər təşkil edəcəkdir. Çətinçıxarılabilən ehtiyatların payı dünyada daim artmaqdadır, hal-hazırda bu, Rusiyada 65% -i ötür. Çətinçıxarılabilənlərə, xüsusən, yüksək özlülüklü neft və bitum ehtiyatları (özlülüyü 30 sP-dən yuxarı) aid edilir. Məqalədə Volqa-Ural neft-qaz hövzəsi hüdudlarında bitum və kömür yataqlarının mənimsənilməsinin mümkün yolları və perspektivləri nəzərdən keçirilir.

Açar sözlər: dekarbonizasiya; təbii bitum; ağır neft; kömür layları; termik təsir.