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СРАВНИТЕЛЬНАЯ ХАРАКТЕРИСТИКА НЕФТЕЙ ЮЖНО-КАСПИЙСКОГО И ЧЕРНОМОРСКОГО БАССЕЙНОВ

COMPARATIVE FEATURES OF OILS IN THE SOUTH CASPIAN AND BLACK SEA BASINS

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Аннотация. В статье приводятся сравнительные характеристики нефтей Южно-Каспийского и Черноморского нефтегазоносных бассейнов. Нефти из Южно-Каспийского бассейна обычно демонстрируют более высокую термическую зрелость, что приводит к большей тенденции к более легкому углеводородному составу. С другой стороны, нефти из Черноморского бассейна, как правило, менее зрелые, что часто приводит к более тяжелым составам. Нефти обоих бассейнов демонстрируют признаки морского влияния. Что касается биомаркеров, южно-каспийские нефти обычно имеют большую концентрацию стеранов и гопанов, что указывает на сильное морское влияние. Черноморские нефти демонстрируют большую изменчивость, причем некоторые показывают повышенный приток наземной органики. Майкопская (олигоцен-миоценовая) формация служит важной материнской породой для обоих бассейнов, однако полученные из нее нефти демонстрируют различные характеристики, на которые влияют региональные геологические условия. Хотя углеводороды из майкопских отложений обнаружены в обоих регионах, различия в их геохимических свойствах, включая молекулярный состав, наличие биомаркеров и общее содержание углеводородов, обусловлены различиями в термической зрелости, условиях осадконакопления и условиях сохранности.

Ключевые слова: oils, biomarkers, isotopes, Maykop source rocks, geochemistry.

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Annotation. The article gives the comparative features of oils from the South Caspian and Black Sea hydrocarbon basins. Oils from South Caspian Basin generally exhibit higher thermal maturity, resulting in a greater tendency toward lighter hydrocarbon compositions. On the other hand, oils from the Black Sea Basin tend to be less mature, often leading to heavier compositions. Both basins exhibit signs of marine influence. Regarding biomarkers, South Caspian oils usually have a greater concentration of steranes and hopanes, signifying a strong marine influence. Black Sea oils demonstrate more variability, with some showing increased terrestrial organic input. The Maykop (oligocene-miocene) formation serves as an important source rock for both basins, yet the oils derived from it exhibit distinct characteristics influenced by regional geological conditions. While hydrocarbons from the Maykop sediments are found in both areas, variations in their geochemical properties-including molecular composition, biomarker presence, and overall hydrocarbon content-are shaped by differences in thermal maturity, depositional settings, and preservation conditions.

Keywords: oils, biomarkers, isotopes, Maykop source rocks, geochemistry.

Introduction

The South Caspian and Black Sea basins are two of the most strategically important hydrocarbon-rich regions. These basins hold significant reserves of oil and natural gas, attracting major global and regional energy players. Their geologic characteristics, production potential, and geopolitical significance make them critical to energy markets.

The South Caspian Basin is known for its deep-water formations, thick sedimentary layers, and high-pressure reservoirs. It features a combination of Mesozoic and Cenozoic formations with prolific hydrocarbon systems. The basin has complex tectonics with subsidence leading to significant hydrocarbon traps.

The Black Sea Basin is structurally diverse, with shallow-water and deep-water prospects. It contains a mix of Mesozoic and Cenozoic sediments, but exploration is more recent compared to the Caspian. The basin has both carbonate and clastic reservoirs, with oil seeps indicating hydrocarbon potential.

South Caspian Basin is a home to some of the world's largest offshore oil fields, including Azerbaijan's Azeri-Chirag-Gunashli (ACG) field. Estimated oil reserves are up to 7–10 billion barrels. Major production sites include offshore Azerbaijan and Turkmenistan.

Black Sea Basin is considered underexplored compared to the Caspian basin, but with increasing discoveries. Major reserves found in Romania, Bulgaria, and Turkish waters. Estimated reserves are 1–2 billion barrels (with potential for more discoveries). Turkey's Sakarya gas field is a major recent offshore discovery, boosting interest in deep-water exploration.

Comparison of composition and properties of oils in the South Caspian and Black Sea Basins

The South Caspian and Black Sea basins contain oil resources with differing compositions and properties due to variations in reservoir rock age, thermal maturity, and geological characteristics. These differences affect their quality, refining potential, and commercial value.

The younger sediments in the South Caspian Basin have undergone relatively low thermal maturity, which preserves lighter hydrocarbons and results in lower sulfur content. The basin's geological setting features deep subsidence, overpressured reservoirs, and thick sedimentary sequences, all of which contribute to the production of high-quality oil.

The Black Sea Basin has a mix of Mesozoic (Jurassic, Cretaceous) and Cenozoic (Eocene, Miocene) formations. Older Jurassic and Cretaceous sediments have been exposed to greater thermal maturity, leading to heavier crude oil with higher sulfur content.

The composition of crude oils in the South Caspian and Black Sea basins varies significantly due to differences in geological history, source rock characteristics, and depositional environments.

Oils from the South Caspian Basin generally has an API gravity of 30–45°, categorizing it as light to medium crude. The crude oils are characterized by low sulfur content (0,1–0,5 %), which makes it easier to process and transport. The wax content in Caspian oil is moderate (around 5–10 %), and the asphaltene content is relatively low (0,5–2 %), ensuring good flow properties and minimal refining challenges. The crude oils also have a relatively low viscosity, making it suitable for pipeline transportation without extensive heating or dilution.

Oils from the Black Sea region, on the other hand, tends to be heavier, with an API gravity of 20–40°. It often contains higher sulfur levels (0,5–2,5 %), making it a «sour» crude oil that requires additional refining steps, such as hydrotreating, to meet market standards. The wax content is higher (8–15 %), increasing the risk of solidification in cold temperatures, which can complicate transportation. Additionally, the asphaltene content in Black Sea oils are higher (2–5 %), leading to increased viscosity and the need for special refining techniques.

In the South Caspian and Black Sea basins, biomarker distribution highlights significant differences in organic matter contribution and thermal maturity. Oils from the South Caspian Basin are characterized by a dominance of C27 steranes and C30 hopanes, indicating an organic matter source primarily composed of marine planktonic and algal material [1]. These biomarkers suggest that petroleum in this basin originated from deep marine shales deposited in an anoxic environment. The low to moderate pristane/phytane (Pr/Ph) ratio (ranging from 0,7 to 1,2) further supports deposition under reducing conditions, which is consistent with the deepwater settings of the South Caspian Basin.

Oils from the Black Sea Basin show a greater proportion of C29 steranes and C29 hopanes, indicative of a stronger terrestrial plant-derived contribution. These oils were likely sourced from deltaic or coal-rich sediments. The pristane/phytane ratio in Black Sea oils is significantly higher (1,5 to 3,0), suggesting that the depositional environment was more oxic compared to the South Caspian. The presence of tricyclic terpanes in moderate concentrations also points to mixed marine and terrestrial organic matter input.

Additionally, polycyclic aromatic hydrocarbons (PAHs) are more prevalent in Black Sea oils, suggesting a greater degree of thermal maturity or contribution from coaly source rocks. In contrast, South Caspian oils show lower PAH concentrations, indicating that they have undergone less thermal alteration and biodegradation. The presence of tricyclic terpanes and the higher Pr/Ph ratios suggest that oils from this basin were generated under more oxic conditions compared to the South Caspian.

The carbon isotopic composition ($\delta^{13}C$) of saturated hydrocarbons in the South Caspian Basin, ranges from –27‰ to –29‰, which is typical of marine planktonic organic matter. Similarly, the $\delta^{13}C$ of aromatic hydrocarbons falls within the range of –25‰ to –28‰, further confirming a marine depositional setting. The hydrogen isotopic composition (δD) of these oils ranges from –120‰ to –140‰, indicating that the organic matter was deposited in an anoxic, deepwater marine environment. Based on isotope-geochemical studies, differences were identified in oils of Cretaceous-Eocene (isotopically heavy) and Miocene (isotopically light) origin [1–3].

In the Black Sea Basin, the $\delta^{13}C$ of saturated hydrocarbons is relatively heavier, ranging from –24‰ to –26‰, reflecting a greater terrestrial influence. The $\delta^{13}C$ of aromatic hydrocarbons is also less negative, ranging from –22‰ to –25‰, which aligns with the presence of higher plant-derived organic matter in the source rocks. The δD values for Black Sea oils range from –90‰ to –110‰, further supporting the idea that these oils contain a mix of marine and terrestrial organic matter.

The differences in biomarker and isotopic compositions can be linked to the age and depositional history of the reservoirs in these basins.

Both basins have oils derived from the Maykop sediments, but differences in their geochemical signatures, such as hydrocarbon content, molecular composition, and biomarkers, reflect regional depositional environments, thermal maturation, and other geochemical factors.

Oils from Azerbaijan, Turkmenistan and Iran sectors demonstrate biomarker signatures of the Maykop group to varying degrees. High pristane/phytane ratios of about 1.1–1.9 correspond to suboxic and anoxic marine sedimentary conditions [3].

Key locations of Maykop-derived oils (Oligocene-Lower Miocene) in the Black Sea Basin include Domino Field (Western Black Sea, Romania), characterized by light, paraffinic oils. Tuna-1 is a large deepwater oil discovery sourced from Maykop shales in Turkish sector of the Black Sea basin. Shah Deniz analogues in Eastern Black Sea, Georgia and Turkey are Maykop-sourced oils with moderate sulfur content.

In the western Black Sea (Bulgaria, Romania), oil was formed from Oligocene and Lower Miocene source rocks (Maykop group). Evidence for this is the high oleanane index (>0.3), elevated 24-norcholestane and 24-nordiacholestane NCR and NDR (> 0.6), and isotopic similarity to Oligocene and Lower Miocene source rocks [5]. Oil in this sub-basin is mainly derived from the Maykop shales, which contain type II kerogen deposited in anoxic environments [4].

Oil generation from Oligocene Maykop shales along with the Middle Eocene Kuma Formation is reported within the East Black Sea sub-basin, the Georgian-Russian shelf area. Biomarker and isotope analyses indicate a mixed contribution of marine and terrestrial organic matter [5]. For example, oil in the Rioni Basin (Georgia) is a mixed oil derived primarily from the Middle Eocene Kuma Formation with additional contribution from the Oligocene Maykop deposits [6].

Within the Turkish sector, exploration has been limited to offshore areas. Oil generation is also associated with thermally mature Oligocene-Miocene source rocks [7]. In the eastern part, a number of seeps of low-maturity, biodegraded oils have linked the oils of the Maykop oil group, based on oleanane results [7]. Upper Oligocene and lower Miocene oils (Maykop series) were discovered within the Romanian and Bulgarian shelves of the West Black Sea sub-basin. They belong to the transition phase with a combination of oil and gas accumulations. The balanced composition of steranes (C27:C28:C29 ~ 35:32:33) indicates a mixed marine and land inflow. The Pr/Ph ratio ~ 1–1.5 confirmed the alternation of oxic and anoxic conditions during the formation of oils [8]. In the central part of the West Kuban trough, oil comes from the deposits of the middle and upper Maykop suites at a depth of 4000–4500 m [9].

Conclusions

Oils from the South Caspian Basin are typically associated with higher thermal maturity, leading to more gas-prone oils with lighter hydrocarbon compositions. In contrast, oils from the Black Sea Basin might be less mature, leading to more waxy or heavier oils.

The Black Sea oils tend to have higher sulfur content compared to those from the South Caspian Basin, reflecting different depositional environments.

Oils from the South Caspian generally show a higher abundance of steranes and hopanes, indicating a marine origin. Black Sea oils may show more variability, with some oils having more terrestrial biomarkers due to varying organic input.

While both basins show marine influence, oils from the South Caspian typically have lighter isotopic signatures compared to those from the Black Sea.

The Maykop suite is a significant source rock in the South Caspian and Black Sea Basins, with distinct oil compositions based on the region's geological characteristics. Both basins have oils derived from the Maykop sediments, but differences in their geochemical signatures, such as hydrocarbon content, molecular composition, and biomarkers, reflect regional depositional environments, thermal maturation, and other geochemical factors. SCB oils show slightly higher maturity (Pr/Ph ratio), indicating better preservation and a longer burial history.

Список литературы:

1. Гулиев И.С. Нефтегазоносность Каспийского региона / И.С. Гулиев, Д.Л. Федоров, С.И. Кулаков. Баку : «Nafta-Press», 2009. – 409 с.

2. Гулиев И.С. Изотопный состав углерода нефтей Южно-Каспийской мегавпадины / И.С. Гулиев, А.А. Фейзуллаев, Д.А. Гусейнов // Азербайджанское нефтяное хозяйство. – 1999. – № 6. – С. 3–13.

3. Гусейнов Д.А. Изотопно-геохимические особенности нефтей месторождений восточного борта Южно-Каспийского бассейна (Западный Туркменистан. ANAS Transactions, Earth Sciences 2 / Д.А. Гусейнов, А.А. Фейзуллаев. – 2019. – С. 3–11.

4. Georgiev G. Geology and hydrocarbon systems in the Western Black Sea // Turkish Journal of Earth Sciences. – 2012. – № 21. – 723 p.

5. Petroleum charge and migration in the Black Sea: insights from oil and source rock geochemistry / J. Mayer [et al.] // Journal of Petroleum Geology. – № 41(3). – P. 337–350.

6. Sweda M. Compound-specific carbon isotope analysis of n-alkanes from source rocks and oils from the Paratethyan realm. MSc thesis. Montanuniversitaet Leoben. – 2018. – 126 p.

7. Exploration plays in the Turkish Black Sea / C. Menlikli [et al.] // The Leading Edge. – 2009. – P. 1066-1075.

8. Надежкин Д.В. Нефтематеринские свойства майкопских отложений и их роль в формировании нефте газоносности восточной части Черного моря : дис. … на соиск. уч. ст. канд. геол.-мин. наук. – М. : МГУ, 2011. – 176 с.

9. Генетические типы нефтей восточной части Крымско-Кавказского региона. Геохимия / Н.В. Обласов [и др.] // ФГБУ «Издательство Наука». – М., 2020. – Т. 65. – № 11. – С. 1129–1150.

List of references:

1. Guliyev I.S. Oil and gas content of the Caspian region / I.S. Guliyev, D.L. Fedorov, S.I. Kulakov. Baku : «Nafta-Press», 2009. – 409 c.
2. Guliyev, I.S. Carbon isotope composition of oils of the South Caspian megavalley / I.S. Guliyev, A.A. Feyzullayev, D.A. Huseynov // Azerbaijan Oil Economy. – 1999. – № 6. – C. 3–13.
3. Huseynov D.A. Isotope-geochemical features of oils from the fields of the eastern side of the South Caspian basin (Western Turkmenistan. ANAS Transactions, Earth Sciences 2 / D.A. Huseynov, A.A. Feizullaev. – 2019. – P. 3–11.
4. Georgiev G. Geology and hydrocarbon systems in the Western Black Sea // Turkish Journal of Earth Sciences. – 2012. – № 21. – 723 p.
5. Petroleum charge and migration in the Black Sea: insights from oil and source rock geochemistry / J. Mayer [et al.] // Journal of Petroleum Geology. – № 41(3). – P. 337–350.
6. Sweda M. Compound-specific carbon isotope analysis of n-alkanes from source rocks and oils from the Paratethyan realm. MSc thesis. Montanuniversitaet Leoben. – 2018. – 126 p.
7. Exploration plays in the Turkish Black Sea / C. Menlikli [et al.] // The Leading Edge. – 2009. – P. 1066-1075.
8. Nadezhkin D.V. Oil-maternal properties of the Maikop sediments and their role in the formation of oil and gas bearing capacity of the eastern part of the Black Sea : cand. candidate of geol.-min. of sciences. – Moscow state university, 2011. – 176 c.
9. Genetic types of oils of the eastern part of the Crimean-Caucasian region. Geochemistry / N.V. Oblasov [et al.] // FGBU «Publishing House Nauka». – M., 2020. – Vol. 65. – № 11. – P. 1129–1150.