ANNOTATION

Of the dissertation for the degree of Doctor of Philosophy (PhD)
in the specialty: 8D07201 – *Geology and Exploration of Mineral Deposits*

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GEOLOGICAL AND GEOCHEMICAL CONDITIONSOF FORMATION OF HYDROCARBON GENERATION ZONES AND PETROLEUM ACCUMULATION IN THE ARYSKUM DEPRESSION OF THE SOUTH TORGAY SEDIMENTARY BASIN

Relevance. A key emphasis in the Address of the President of the Republic of Kazakhstan is placed on the high assessment of hydrocarbon reserves, which constitute the strategic foundation of the country's economic growth and energy security. It is noted that the rational development of the resource base requires the introduction of modern technologies, increased production efficiency, deeper geological exploration, and strengthening of scientific and technical potential.

In this context, particular importance is attached to studies aimed at refining the hydrocarbon generation potential of sedimentary basins, improving methods for evaluating source rocks, and forecasting new hydrocarbon accumulation zones (hereinafter – HAZ). Therefore, the study and justification of petroleum potential prospects of the Aryskum Depression, analysis of generation zones, and conditions for hydrocarbon (HC) accumulation are highly relevant and in demand for the development of the national oil and gas industry.

The Aryskum Depression is part of the South Torgay Basin (hereinafter – STB), which is the main oil and gas-bearing region in the south and southeast of Kazakhstan. More than 50 hydrocarbon fields have currently been discovered within the Aryskum Depression. The decline in geological exploration activities in recent years, mainly due to insufficient funding and a lack of prepared prospective areas, has resulted in unfavorable statistics for new field discoveries and a low replenishment rate of the hydrocarbon resource base. Consequently, a noticeable decline in oil and gas production levels in the STB region is currently observed.

In this regard, the scientific substantiation of new opportunities for expanding hydrocarbon potential, both regionally and with respect to the depth of prospective deposits, becomes a priority task for industry ministries and subsoil users. At the same time, a comprehensive task related to the expansion of the mineral resource base, conducting exploration activities, and studying the geochemical environment of hydrocarbon accumulation and formation remains highly relevant.

Accordingly, the main focus of this dissertation is defined as the study of hydrocarbon generation and accumulation zones, as well as the formation features of petroleum source rocks (hereinafter – PSR), which is of great importance for forecasting and assessing hydrocarbon potential and discovering new fields.

At the same time, issues related to the detailed study of elements of hydrocarbon systems, including the generation potential and geochemical characteristics of PSR, remain insufficiently investigated, which further determines the relevance of this dissertation.

The study area is administratively located within the Kyzylorda, Aktobe, and Kostanay regions.

State of the problem.

To characterize the level of study of this issue, the following key aspects should be noted:

1. Assessment of hydrocarbon generation potential within the regional section, study of HC generation zones in terrigenous and clay deposits, and justification of source rocks are especially important for forecasting new fields and increasing resource potential.

2. To optimize exploration activities, more detailed studies of the geochemical environment of sediment accumulation, characteristics of organic matter, and conditions of its transformation into liquid hydrocarbons are required. A more objective and high-quality assessment of petroleum potential helps reduce known geological risks.

3. Further progressive development of geological exploration and the oil and gas industry is directly linked to the identification of new prospective structures and fields. The implementation of this dissertation's directions is expected to contribute to attracting investments to the oil and gas sector and the regional economy.

4. Geochemical studies and investigation of oil and gas formation processes significantly contribute to the theoretical foundations of fundamental science in identifying global patterns of industrial hydrocarbon accumulation. Jurassic clay deposits play a key role due to their high sorption and generation capacity.

The aim of the study is to assess and justify favorable geochemical prerequisites and deep conditions for the formation of hydrocarbon generation and accumulation zones in the Aryskum Depression of the STB, and to identify the most promising areas for exploration activities.

To achieve this aim, the following objectives were addressed:

• refinement of the lithological and stratigraphic characteristics and internal structure of the Aryskum Depression based on new geological and geophysical data;
• analysis of geochemical characteristics and formation conditions of various lithological-stratigraphic complexes;
• analysis of regional and depth-related variations in oil and gas composition based on gas chromatography–mass spectrometry and gas-liquid chromatography data;
• justification of the main elements of the hydrocarbon system and its potential;
• refinement of petroleum potential prospects and justification of effective exploration directions.

Scientific novelty:

1. New data have been obtained determining the patterns of hydrocarbon generation in Middle and Upper Jurassic clay deposits of the Aryskum Depression based on integrated geological and geochemical analysis, and a petroleum geochemical model of the region has been substantiated.

2. Geochemical characteristics, genetic types of organic matter, levels of catagenetic maturity, and hydrocarbon potential of various LSC have been determined.

3. A forecast of hydrocarbon accumulation zones in Mesozoic deposits has been substantiated based on the interpretation of GC-MS and gas-liquid chromatography data.

4. Based on identified geochemical criteria, petroleum potential prospects have been assessed considering structural-tectonic development and lithological-facies features of the region.

The following scientific provisions are defended:

1. Thick Mesozoic deposits represented by terrigenous-clay formations of the Middle and Upper Jurassic within graben-syncline settings play a key role in the formation of hydrocarbon traps at contacts with horst-anticlines and in the development of a regional Jurassic–Cretaceous hydrocarbon accumulation belt.

2. Geodynamic and geochemical conditions of the Aryskum Depression determined the type of organic matter, its catagenetic maturity, and hydrocarbon potential of lithological-stratigraphic complexes. Sedimentation conditions, tectonic activity, and migration pathways played a decisive role.

3. Based on GC-MS and gas-liquid chromatography data, a forecast of hydrocarbon accumulation zones in Mesozoic deposits has been substantiated. The developed deep hydrodynamic model confirms favorable geochemical conditions for hydrocarbon generation and

accumulation.

4. According to geochemical criteria, structural-tectonic development, and lithological-facies features, the results confirm the key role of Lower and Middle Jurassic deposits in hydrocarbon generation and accumulation and expand the prospective reservoir interval.

Practical significance.

The obtained results improve methods for studying tectonic development, forecasting prospective local objects for exploration, and expand understanding of oil and gas reservoir models in the STB. The practical significance is also determined by new opportunities to improve the quality of forecasting new oil and gas accumulations, provide additional data for objective evaluation of hydrocarbon system elements, refine field development concepts, and ensure efficient exploitation.

Factual material.

The dissertation is based on previously conducted geological and geophysical studies and analysis results of Mesozoic and pre-Mesozoic oil samples from the Aksai and Ashisay horst-anticlines, as well as the Akshabulak and Bozingen graben- synclines of the Aryskum Depression. Five oil samples were collected from wells: No. 111 East Kumkol (1000–1005 m, horizon J-IV), No. 5014 South Kumkol (1005–1200 m, horizon J-III), No. 549 Konys (1255–1261 m, horizon J-0-I), No. 72 Aksai (1569–1572 m, horizon M-I), No. 107 Arys (1362–1369 m, horizon J-III). During 2023–2024, with the author's participation, pyrolytic and biomarker studies were conducted, allowing refinement of geochemical characteristics and generation potential of deposits and hydrocarbon system elements of the STB.

Research results from recent years (2020–2024) conducted by "Atyrau Branch of KMG Engineering" LLP were also used.

Approbation of the work.

The scientific provisions are based on new laboratory data, analysis of geological, geophysical, and geochemical information, and generalization of accumulated materials. The results were presented at international and national scientific conferences.

Publications.

The author has published 9 scientific papers on the dissertation topic, including 6 in peer-reviewed journals recommended by the Committee for Quality Assurance in Science and Higher Education of the Ministry of Education and Science of the Republic of Kazakhstan, and 3 in international indexed databases.

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Structure and volume of the dissertation.

The dissertation consists of an introduction, five chapters, and a conclusion. It comprises 108 pages of text, including 31 figures and 17 tables. The reference list includes 105 sources.