ANNOTATION

dissertation work of Bekeshova Zhanna on the topic: «Refinement of the geological structure and assessment of the oil and gas potential of the Kosbulak Depression using new geological and geophysical data», submitted for the degree of Doctor of Philosophy (PhD) in the specialty 8D07208-Geology and exploration of mineral deposits

Assessment of the current state of the solved scientific or scientific - technological problem. The Northern Ustyurt is a region with high hydrocarbon potential; however, its geological structure remains insufficiently studied, which complicates the effective planning of exploration and prospecting activities. Modern research indicates that Paleogene clinoform complexes and Paleozoic carbonate massifs may contain significant hydrocarbon reserves, yet their spatial distribution and tectonic features require further clarification.

In recent years, amidst global climate changes and rising energy consumption, the demand for higher accuracy in geological and geophysical studies and the optimization of drilling technologies has increased. To meet these demands, modern seismic exploration methods, 3D modeling, and dynamic analysis are employed, allowing for a more detailed characterization of hydrocarbon-bearing complexes.

Significant contributions to the study of this region have been made by both domestic and international scientists and industry experts, including Bulekbaev Z.E., Garetzky R.G., Kartseva O.A., Borodyaev B.G., Volozh Yu.A., Lipatova V.V., Votsalevsky E.S., Popkov V.I., Voskoboy V.A., Nurmanov A.M., Bykadorov V.A., Antipov M.P., Parasyna V.S., Rybalchenko V.V., Sapozhnikov R.B., Maslov V.V., Goryunova L.F., Gibshman N.B., Ivanov S.A., Kuznetsov A.V., Utkelbaev A.B., Yuldashev K.M., Zaitsev V.N., Karimov B.T., and many others.

Their research has significantly advanced the understanding of the oil and gas **potential** of the Northern Ustyurt. However, to fully substantiate the prospective zones, further studies of deep structures, the development of new geological and geophysical analysis methodologies, and the implementation of advanced exploration drilling technologies are required.

Relevance of the topic. In recent years, against the backdrop of a decline in oil and gas exploration activities, there has been a significant decrease in scientific research related to the stratigraphy and oil and gas potential of Meso-Cenozoic and Paleozoic sedimentary complexes. This process is particularly evident in the Northern Ustyurt region, where unresolved issues remain regarding the assessment of hydrocarbon accumulation prospects and the refinement of stratigraphic models.

One of the key problems requiring urgent attention is the absence of a unified stratigraphic concept for the region. Different zones are characterized by sedimentary complexes of varying ages, making their correlation challenging. This, in turn, affects the study of depositional environments, lithology, and reservoir properties, which directly influences the prediction of oil and gas potential in individual stratigraphic units.

The situation has changed with the resumption of oil and gas exploration activities, increasing the need for a detailed study of the geological structure of Mesozoic-Cenozoic and Paleozoic deposits in Northern Ustyurt. Under these conditions, the study of Paleogene clinoform complexes and Paleozoic carbonate massifs has gained particular significance as key targets for hydrocarbon exploration.

Thus, a comprehensive analysis of geological and geophysical data aimed at identifying new stratigraphic hydrocarbon traps is not only relevant but also essential for the successful planning of exploration activities in the region.

Research on the stratigraphy and oil and gas potential of Northern Ustyurt has a long history, dating back to 1959, when the first geological exploration works were conducted on Mesozoic-Cenozoic deposits. However, many existing models have become outdated and require updating in light of new geophysical data. One of the significant areas of study is the Samsko-Kosbulak Depression, located in the Uzbek sector of Northern Ustyurt. The research of Yuldasheva M.G. includes an analysis of the geological section of this depression, based on the interpretation of deep drilling data. These studies serve as an important foundation for further research on similar structures in the Kazakh sector of Northern Ustyurt.

The studies of Abdullayev G.S. and Bogdanov A.N., dedicated to reefal carbonate massifs of the Paleozoic, have played an important role in shaping new understandings of the region's hydrocarbon potential. In particular, industrial gas and condensate inflows have been obtained from reefal carbonate massifs of Paleozoic age at the Kokchalak and Karachanalak fields, located in the Uzbek part of Northern Ustyurt.

Nevertheless, despite the accumulated data, unresolved issues remain concerning Paleogene clinoform complexes, the stratigraphic affiliation of sedimentary sequences, and the depositional environments in which they were formed.

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Research aim and objectives. The aim of this research is to refine the geological structure and assess the oil and gas potential of the Kosbulak Depression based on modern geological and geophysical methods, including 3D seismic modeling, dynamic analysis, and geochemical studies.

To achieve this aim, the following research objectives were addressed in the dissertation:

1. Conducting a lithological-stratigraphic analysis of the region and developing facies zoning schemes for the sedimentary cover.
2. Studying the tectonic structure of the Kosbulak Depression, identifying fault zones and structural traps.
3. Performing a seismofacies analysis of Paleogene clinoform complexes and substantiating their hydrocarbon accumulation potential (for the first time).
4. Evaluating the reservoir properties of Paleozoic carbonate massifs and determining their role in hydrocarbon accumulation.
5. Developing an integrated geological and geophysical model of the Kosbulak Depression, incorporating drilling, seismic exploration, and geochemical data.
6. Proposing recommendations for exploration and prospecting activities, including the selection of promising drilling sites.

Research objects. The research objects include the hydrocarbon-bearing complexes of Northern Ustyurt, including clinoform complexes and carbonate

massifs, which form hydrocarbon accumulations. The study analyzes geological structures, lithological-facies characteristics, and the filtration-capacity properties of reservoirs. It also examines stratigraphic and tectonic elements that influence the formation of traps and the distribution of accumulations. The research utilizes drilling data, geophysical studies, and seismic data (2D and 3D high-resolution seismic surveys - MOGT) for a comprehensive assessment of the region's hydrocarbon potential.

Subject of the study. The study identifies patterns in the formation and spatial distribution of hydrocarbon-bearing complexes in Northern Ustyurt, including clinoform complexes and carbonate massifs. The lithological-facies characteristics of productive horizons, seismostratigraphic structure, and structural-tectonic factors affecting hydrocarbon accumulation processes have been determined. The efficiency of geophysical analysis methods for detecting potential hydrocarbon accumulation zones has been evaluated. Seismic data interpretation has been conducted, stratigraphic correlation of well sections has been performed, and the boundaries of productive deposits have been refined. Particular attention has been paid to improving data processing and interpretation methodologies to enhance the accuracy of predicting promising hydrocarbon-bearing zones.

Research tools. The study employed specialized software packages, including Schlumberger Petrel, GeoGraphix, Techlog, RMS, and Surfer, for processing and modeling geological and geophysical data. Additionally, cluster analysis methods and machine learning were applied to assess hydrocarbon potential.

Research methodology. The research is based on a comprehensive analysis of geological and geophysical data from Northern Ustyurt. The study applied seismostratigraphic analysis, lithological-facies examination of rocks, tectonic analysis, and interpretation of drilling and well logging (GIS) data. The research utilized 2D and 3D high-resolution seismic exploration data (MOGT), petrophysical core analysis results, and geochemical studies. Special attention was given to the integration of geological and geophysical data, analysis of structural and stratigraphic features of clinoform complexes and carbonate massifs, correlation of well sections, evaluation of reservoir filtration-capacity properties, and assessment of hydrocarbon prospectivity.

The conclusions were substantiated through a comparative analysis of Northern Ustyurt data with analogous hydrocarbon-bearing regions. The study aims to increase the reliability of data interpretation and refine the boundaries of productive deposits.

Research tasks.

1. Refinement of the lithological-stratigraphic characteristics of the region and analysis of sedimentary complexes, allowing for the determination of the stratigraphic affiliation of hydrocarbon-bearing complexes, including Paleogene clinoform structures and reef carbonate massifs of the Paleozoic.
2. Identification of fault zones and hydrocarbon structural traps within the Kosbulak Depression, which enabled a more detailed analysis of the tectonic structure and its influence on hydrocarbon accumulation processes.

3. Conducting a detailed seismofacies analysis of Paleogene clinoform complexes, based on which promising hydrocarbon accumulation zones were identified and their geological significance refined.

4. Determination of hydrocarbon accumulation zones in Paleozoic carbonate massifs, which allowed for their preliminary evaluation and justified the need for further study.

5. Development of an integrated geological-geophysical model of the Kosbulak Depression, incorporating drilling, seismic exploration, and geochemical research data, which enabled the refinement of productive deposit boundaries.

6. Formulation of recommendations for exploration and prospecting activities, aimed at increasing the efficiency of exploration drilling and selecting promising areas, ensuring more accurate prediction of productive zones.

The research results contribute to the optimization of geological exploration activities, reduction of financial and environmental risks, and provide a scientifically grounded approach to the development of the oil and gas potential of the Kosbulak Depression.

Scientific novelty

As a result of the study:

- Prospective gas traps in Paleogene clinoform structures were identified based on a detailed analysis of geological and geophysical data.
- Hydrocarbon accumulation zones in Paleozoic carbonate massifs were identified and their reservoir characteristics analyzed.
- An integrated geological and geophysical model of the Kosbulak Depression was developed, incorporating drilling, seismic exploration, and geochemical research data.
- A new methodology for 3D geological section modeling of the region was proposed, allowing for the increased efficiency of exploration and prospecting activities.

The obtained results make a significant contribution to refining the geological structure of the Kosbulak Depression and allow for the optimization of future hydrocarbon exploration strategies in the region.

Practical significance of the study. The practical significance of this study lies in the fact that its results contribute to enhancing the efficiency of geological exploration in the Kosbulak Depression, while also minimizing financial and environmental risks associated with field development. Refining oil and gas potential models and applying modern methods (3D seismic exploration (MOGT-3D), dynamic analysis, and geochemical studies) enable more accurate predictions of productive zones. The identified carbonate massifs and clinoform structures define promising drilling directions, contribute to the optimization of exploration activities, and expand the resource base of the region.

Reliability of the obtained data. The reliability of the obtained data and conclusions is ensured by a comprehensive approach to analyzing the hydrocarbon-bearing complexes of the Kosbulak Depression and the application of modern methods for processing and interpreting geological and geophysical information. The main factors confirming the reliability of the materials include:

1. Application of modern geological and geophysical analysis methods, including:

- 2D and 3D seismic exploration, ensuring detailed structural and seismostratigraphic interpretation of the sedimentary cover.
- Dynamic analysis and geochemical studies, allowing for a more precise understanding of hydrocarbon accumulation conditions.
- Lithological-facies analysis, aimed at determining the reservoir properties of rocks.

2. Utilization of specialized software, such as Schlumberger Petrel, GeoGraphix, Techlog, RMS, and Surfer, which enabled the creation of accurate digital models of the region's geological structure.

3. Comparison of data from various sources, including: drilling research, core analysis, well logging (GIS), and seismic exploration results, which ensured a high degree of correlation in geological sections.

4. Comparative analysis with analogous hydrocarbon-bearing basins, including the Uzbek sector of Northern Ustyurt, where productive hydrocarbon fields (such as Kokchalak and Karachanalak) have previously been discovered. This confirms the prospectivity of the identified structures in the Kazakh sector of the region.

Thus, the reliability of the obtained materials and conclusions is confirmed by the application of modern analytical methods, the high correlation of various data sources, and the alignment of research results with practical discoveries in analogous hydrocarbon-bearing regions.

Author's personal contribution.

- Collection, systematization, and digitization of historical geological and geophysical data on Northern Ustyurt, including well logging diagrams, testing reports, laboratory analyses of reservoir fluids, core, and cuttings, as well as historical 2D seismic data stored in the state geological archives of MD «Zapkaznedra» and JSC «National Geological Service».

- Analysis, synthesis, and structuring of archival geological and geophysical materials from the Soviet period to enable their comprehensive integration into modern research.

- Development of attribute maps and seismofacies analysis based on geophysical survey data from drilled wells.

- Interpretation of reflecting horizons, tectonic faults, and the predicted Paleozoic carbonate massif using seismic cross-sections.

Scientific propositions submitted for defense.

1. High hydrocarbon generation rates contributed to the formation of «oil windows» on the eastern flank of the Kosbulak Depression, which refines forecasting models of oil and gas potential and allows for the differentiation between productive and non-productive structures.

2. The application of modern methods, including 3D seismic exploration (MOGT-3D), dynamic analysis, and geochemical studies, enhances the accuracy of oil and gas potential assessment and reduces environmental and economic risks in field development.

3. The presence of a promising Upper Permian carbonate massif in the Kosbulak Depression has been substantiated, requiring further study to confirm its oil and gas potential and assess its productive capacity.

4. Paleogene gas-bearing clinoform structures in the Kosbulak Depression have been identified based on comprehensive geological and geophysical analysis, which substantiates their study for oil and gas potential confirmation and productivity assessment.

Connection with Programmatic Scientific Research. The dissertation was prepared within the framework of the «Zhas Galym» grant project for young scientists (№AR22686978), implemented with the support of the Ministry of Science and Higher Education of the Republic of Kazakhstan for the period 2024–2026. The study of Northern Ustyurt's oil and gas potential and the identification of new hydrocarbon accumulations based on geophysical data is a part of this project, aligning with the dissertation's research focus. The study of this region has been ongoing since the author's doctoral studies in 2020. As part of the grant implementation, geological and geophysical studies were conducted, forming the foundation of this dissertation.

Validation of research results and publications.

The main scientific propositions of the dissertation were presented at:

- The International Scientific and Practical Conference «Scientific Modernization: Legacy of a Personality», dedicated to the 95th anniversary of Academician Sh. Yesenov (Aktau, October 2022).
- The International Geological Conference «The Oil and Gas Future of Mangystau» (Aktau, April 2024).

From June 1 to June 27, 2023, a scientific internship was conducted at the National University of Uzbekistan named after Mirzo Ulugbek (Tashkent, Republic of Uzbekistan) under the supervision of PhD, Associate Professor, and Head of the Geology Department I.S. Togaev. Based on the internship results, a joint article with Uzbek colleagues was published in the journal «Oil and Gas» (№2 (140), 2024) on the topic «Paleozoic sediments are oil and gas exploration reserve of Uzbekistan».

The main findings of the dissertation research have been published in six scientific papers, including:

- Two articles in journals indexed in the Scopus database.
- Two articles in publications recommended by the Committee for Quality Assurance in Education and Science (KKSON) of the Ministry of Science and Higher Education of the Republic of Kazakhstan.
- Two articles in conference proceedings.

At an extended meeting of the «Ecology and Geology» Department of the Caspian State University of Technology and Engineering named after Sh. Yesenov, the study «Refinement of the geological structure and assessment of the oil and gas potential of the Kosbulak Depression using new geological and geophysical data» was presented and reviewed.

Structure and volume of the dissertation. The dissertation consists of 128 pages of typed text, including an introduction, four chapters, a conclusion, and a list of 123 references. The work is illustrated with 38 figures.

Factual basis. The factual basis of the dissertation research is built upon:

- The author's own research materials.
- Published articles and monographs in domestic and international journals (123 sources in total).
- Archived reports related to the dissertation topic.