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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

ENVIRONMENTAL CONDITION AND FACIAL QUALITY CONTROL OF MESOZOIC RESERVOIRS IN EASTERN PART OF CASPIAN SYNECLISE

Specialty:	2521.01 – Geology, prospecting and exploration of oil and gas fields
Field of science:	Earth sciences
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INTRODUCTION

Relevance of the topic and the degree of study of the topic

The study of environmental conditions and facies quality control of Mesozoic reservoirs in the southeastern part of the Caspian syneclise is an important task for the formation of a petrophysical model of the reservoir, clarification of the stratigraphic correlation between wells and the creation of a conceptual sedimentological model of the fields. The region under study is characterized by a unique geological structure and attracts the attention of many scientists and petroleum engineers. The study of the formation processes of Mesozoic hydrocarbon reservoirs, in particular Jurassic and Cretaceous age, is the starting point in the search and exploration of new fields and optimization of hydrocarbon production.

One of the main current problems considered in this study is a comprehensive analysis of sedimentation processes based on lithological and sedimentological analysis of cores from wells in the fields of the eastern part of the Caspian syneclise, which includes the study of the facies characteristics of sediments and the evolution of environmental conditions in the Mesozoic era, which are the basis to understand the genesis of reservoirs and their quality.

An important task is also to identify facies controls on the quality of reservoirs in the study area, which has not been done before. The analysis methods include a significant amount of standard core analysis together with geophysical data. The results obtained are aimed at identifying the textural and physical features of the rocks. Based on these data, were estimated permeability, saturation and other important parameters affecting the quality of reservoirs as well as their relationship with the conditions of sediment accumulation.

Understanding the spatial sedimentological model of the fields, which clearly represents the alternation of sedimentary facies both in the section and in space, in combination with petrophysical data from core studies, log interpretation and structural maps, serves as a basis for developing a high-quality digital geological facies-oriented 3D model of productive formations and host rocks, as well as reconstructing the geometry of formations and reservoir architecture. The obtained results are effective tools to make viable decisions in the process of field development, hydrocarbon production optimization, applying new technologies and improving hydrocarbon extraction methods, which also confirms the relevance of this study.

Thus, the results presented in this paper have both scientific and practical significance. They allow a more complete understanding of the formation history and quality of reservoirs in the region under study, as well as providing important information for geological and hydrodynamic modeling.

Object and subject of research:

The object of the study is the Jurassic and Cretaceous deposits of oil and gas fields in the south-eastern part of the Caspian syneclise, which are part of the Tengiz- Kashagan oil and gas region. These deposits are tectonically related to the Karaton- Tengiz system of uplifts, the Prorvinskaya uplifted zone and the depressed part located south of the Sagiz relatively uplifted zone.

The subject of the study was core material extracted from 21 wells located in nine fields, with a total volume of 1331.81 meters. This material was subjected to lithological-sedimentological macrodescription with subsequent interpretation taking into account the results of previously conducted standard core analyses and well geophysical survey (WGS) materials.

The purpose and objectives of the study:

The aim of the study is to conduct a comprehensive facies analysis and identify facies control over the quality of reservoirs of Jurassic-Cretaceous deposits in the eastern part of the Caspian syneclise. The results obtained during the comprehensive analysis will be used in constructing geological models of the deposits.

The objectives of the study include:

Study of the geological characteristics of the research area, including paleogeographic conditions;

Lithological and sedimentological analysis of cores of Jurassic and Cretaceous deposits with the study of traces of the life activity of organisms; construction of lithological and sedimentological columns and tablets;

Reconstruction of accumulation conditions of Jurassic and Cretaceous deposits; identification of variability of facies conditions over the area of the study region and over time;

The relationship between the lithological and mineralogical composition of sediments and the identified facies;

Characterization of the filtration and capacity properties of rocks, determination of the dependence of these properties on environmental conditions;

Determination of the influence of global eustatic variation on environmental conditions of the study area.

Methods of research of the set tasks:

To solve the problems, visual core description methods were used. Also was conducted reviewing of geological and geophysical materials and results of standard core and X-ray analysis.

Protecting provisions:

Environmental conditions of Jurassic-Cretaceous deposits in the eastern part of the Caspian syneclise.

Heterogeneity of Jurassic-Cretaceous reservoir architecture: its nature and impact on reservoir quality.

Scientific novelty:

- Based on the sedimentological analysis of core material, a detailed description of the environmental conditions of the Jurassic and Cretaceous deposits is presented;

- For the first time, a detailed analysis of ichnofossils in core material of Jurassic-Cretaceous deposits of the study area was carried out, which made it possible to clarify the paleogeographic reconstructions of the studied region;

- For the first time, facies zoning was carried out and paleogeographic conditions of the research area in the Jurassic period were clarified;

- Based on a comparison of the capacitive-filtration properties of Jurassic-Cretaceous deposits and the environments of their accumulation, the most favorable facies for the formation of reservoir rocks in the studied area were identified, including coastal environment, the inner, middle shelf, delta channels and the mouth-bar complex;

- Previously conducted modeling based on the reservoir-nonreservoir principle did not confirm the predicted reserves. The facies model we proposed led to an increase in reserves in the productive horizon of the S. Nurzhanov field.

- was revealed existence of a semi-enclosed reservoir, whose level’s frequent fluctuations led to multiple facies shifts, contributing to the formation of favorable conditions for the accumulation of reservoir rocks and dictated the architectural variability of the Jurassic-Cretaceous reservoirs in the study area.

Theoretical and practical significance of the results of the work:

Theoretical significance: lies in the fact that the obtained results make a significant contribution to understanding the paleogeographic history of the eastern part of the Caspian syneclise and the influence of paleogeographic factors on the formation of reservoir rocks and the quality of reservoirs.

Practical significance: consists in applying the obtained results in conducting geological, facies and hydrodynamic modeling of basins of a similar type.

Testing the work

The dissertation materials were presented and discussed at:

- The Fourth International Geological Conference "AtyrauGeo-2017" - Almaty, 2017;
- The Second International Forum on Geological Exploration « Kazakhstan Geology Forum: Oil&Gas 2018» Almaty, 2018;
- International scientific and practical conference "Methods of increasing oil recovery and intensifying oil production" - Aktau, 2018;
- International scientific and practical conference “Status and prospects for the exploitation of mature fields” - Aktau, 2019;
- Scientific and practical conference "Engineering solutions in the oil and gas industry of Kazakhstan" - Aktau, 2020;
- The Tenth (Anniversary) Annual SPE Caspian Technical Conference and Exhibition – Baku, 2023;

Based on the dissertation materials, 10 works were published, of which 10 articles, 4 articles were published in peer-reviewed journals approved by the Higher Attestation Commission of the Republic of Azerbaijan and Republic of Kazakhstan.

The author expresses deep gratitude to his scientific supervisor, Corresponding Member of the National Academy of Sciences of Azerbaijan, Doctor of Geological and Mineral Sciences E.G.- M. Aliyeva, as well as to the management of SOCAR Research Institute of Oil and Gas, where he has been a PhD candidate for the past 5 years.

Name of the organization where the dissertation work was carried out

The dissertation was completed at the Scientific Research Design Institute of Oil and Gas of SOCAR.

Structure and scope of work

The dissertation consists of an introduction (7765 characters), five chapters (Chapter 1 - 72342 characters; Chapter 2 -44844 characters; Chapter 3 - 35418 characters; Chapter 4 - 33922 characters; Chapter 5 -6678 characters), conclusion (3658 characters) and a list of references of 153 titles. The work is presented on 227 pages of machine text, contains 11 tables and 138 figures.

SUMMARY OF THE WORK

Introduction:

Introduction to the work, where the relevance and significance of the research conducted is substantiated, and the goal and objectives are formulated.

The scientific novelty and practical importance of the obtained results, which provide initial data for geological and hydrodynamic modeling, are emphasized.

Chapter 1. Geological characteristics of the research area:

The geological characteristics of the eastern part of the Caspian syneclise, including tectonics, stratigraphy and oil and gas potential of the research area, are considered in detail. The features of the geological structure and possible prospects for hydrocarbon deposits are highlighted.

Chapter 2. Sedimentological analysis and lithology of Jurassic-Cretaceous deposits:

The results of the lithologic description of sediment core and their interpretation are presented. This chapter also provides a comparison with geophysical well logging data and standard core analysis aimed at determining the environmental conditions of the Jurassic-Cretaceous deposits. The stratigraphy and lithological-mineralogical composition of the deposits are specified.

Chapter 3. Paleogeography of the eastern part of the Caspian syneclise in the Jurassic and Cretaceous periods:

The analysis of the available paleogeographic data and reconstruction of the accumulation conditions of Jurassic and Cretaceous deposits are carried out. In addition, the study of traces of the life activity of organisms and their remains, the allocation of ichnofacies and their correlation with the allocated facies are considered.

Chapter 4. Evaluation of filtration-capacitive properties of rocks of the identified facies:

Presentation of the results of characterization of filtration-capacitive properties of rocks, including assessment, construction of dependencies and maps of filtration-capacitive properties for deposits. Discussion of facies control over the quality of reservoirs.

Chapter 5. Fluctuations in the World Ocean level in the study area:

Results of data comparison on global eustatic variation at oil fields in the region.

CHAPTER 1. GEOLOGICAL CHARACTERISTICS OF THE RESEARCH AREA

The Caspian Lowland and the Caspian oil and gas province associated with it have been actively studied for over a hundred years. The study area has a complex tectonic structure, where three large sections of the section are distinguished in the sedimentary cover, reflecting different stages of tectonic development: subsalt, salt-bearing and presalt. Salt had a significant impact on the reservoirs formation, traps and fault systems[1]. The largest deposits are located near the study area, including presalt deposits of the Jurassic and Cretaceous age, which makes the search for new deposits promising. Development optimization and new data acquisition are becoming a priority task.

[1] Воцалевский, Э.С. Глубинное строение и минеральные ресурсы Казахстана / Э.С.Воцалевский, С.Ж.Даукеев, В.П.Коломиец, [и др.] // Нефть и газ. Том 3, - Алматы: Национальная АН Республики Казахстан, -2002 г., 248 с.

CHAPTER 2. SEDIMENTOLOGICAL ANALYSIS AND LITHOLOGY OF JURASSIC AND CRETACEOUS DEPOSITS

The results of sedimentological analysis of the core serve as the basis for the formation of a petrophysical model of the reservoir, clarification of the stratigraphic age and creation of a conceptual sedimentological model of the field. The stage of lithological studies begins with a brief description of the lithology of the full-size core and is clarified in detail using the results of instrumental analyses.

Sedimentological interpretation, including facies analysis and lithofacies analysis, is the reconstruction of sedimentation conditions. In the oil and gas industry, the need for sedimentological reconstructions is due to the use of geological methods facies-oriented 3D modeling of productive formations. The solution to the problem of constructing a facies model based on a comprehensive study of core material is of primary importance in geological modeling.

Reliable spatial modeling of reservoir geometry and properties requires detailed knowledge of the formation conditions. This includes factors such as whether productive deposits were formed in the deep sea, on the shelf, or in transition zones from the continent to the sea. Understanding the direction of shorelines, debris flow, and other aspects is vital as well.

The result of sedimentological interpretation is a spatial sedimentological model of the field, where the alternation of sedimentary facies in the section and in space is clearly traced. This model, together with the data of petrophysical studies of the core, quantitative interpretation of well logging and structural maps, serves as a basis for the development of a high-quality digital geological 3D model of the field.

The full-size core from the deposits within the study area, photographs and the results of standard and lithological studies were used as material for the sedimentological studies. The total volume of the studied core was 1331.81 meters, covering 21 wells from 9 deposits, such as: Karaton, Karasor, Akkuduk, Dosmukhambetovskoye, S.Nurzhanov, Tazhigali, Teren-Uzyuk, Baytubearal and Nurzhanov North-Eastern (NSV).

The main method used to construct sedimentological columns and subsequent interpretation is Gary Nichols method[2]. Figure 1 shows a fragment of the sedimentological column for one of the studied wells.

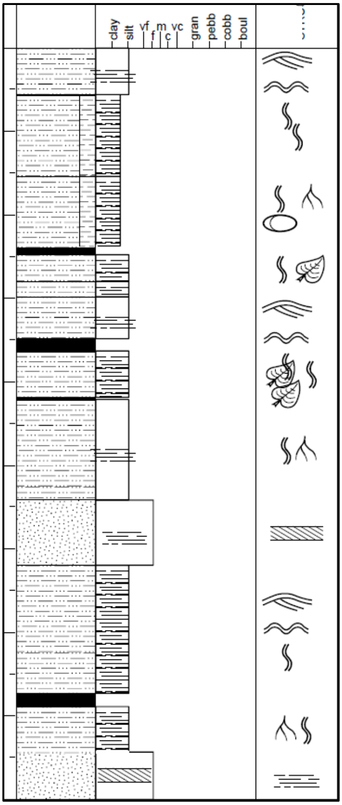


Figure 1. Fragment of the sedimentological column of the Akkuduk field, well No. 18, interval 1787.40-1796.40 m

Generalization of the information obtained as a result of sedimentological description of the core leads to the identification of several associations (Fig. 2) corresponding to four main environmental conditions: marine settings, marine carbonate settings, arid coasts and evaporites, and deltas. Each association includes its own set of facies characterized by lithological and textural features.

[2] Nichols, G. Sedimentology and stratigraphy // Second Edition. Wiley-Blackwell, - West Sussex: - 2009, - 432p.

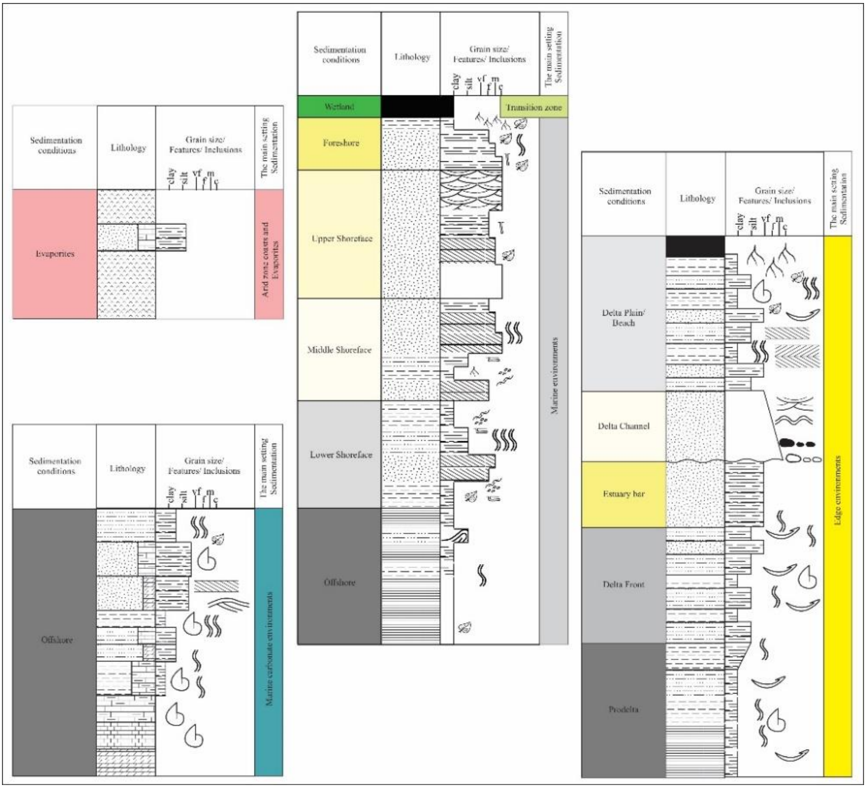


Figure 2. Identified associations and their relationship with the main sedimentation conditions, lithological and textural features.

In order to determine the environmental conditions and the corresponding facies during the core study, in addition to studying the lithology, structural and textural sedimentological features, methods based on studying traces of the life activity of organisms, identifying the remains of organisms and vegetation were used. All the obtained materials, together, allow us to determine the environmental conditions quite accurately and to divide them into facies.

The presence of traces of life, detritus and various remains of organisms indicate marine-shelf facies. The presence of carbonized remains indicates coastal settings close to continental, or a transition zone.

Marine environments:

Includes one transitional condition facies:

• **Wetlands** whose lithological section includes coal and carbonized plant remains in large quantities.

And five main facies of the marine environment:

• **Foreshore**, the lithological section is represented by clayey rock with inclusion of carbonized remains of root systems with a smooth transition to fine-medium-grained sandstone. The distinctive structure of the rock is weak bioturbation, burrows and horizontal stratification.

• **Upper shoreface** consists of sandstone deposits with distinctive layered textures. The layering appears as wavy, horizontal and oblique-horizontal bedding with inclusions of burrows and rare carbonized plant remains.

• **Middle shoreface** is lithologically represented by interbedding of fine-medium grained sandstone with clayey -silty interlayers. Horizontal and oblique-horizontal bedding, destroyed by a large number of traces of bioturbation. Remains of carbonized roots are also found in the interlayers of clayey rock.

• **Lower shoreface** consists of clayey- silty rock with layers of medium-fine-grained sandstone. The clayey rock predominates in the section. The structure and texture are horizontal and oblique-horizontal layering, destroyed by a large number of traces of bioturbation and silt-eater passages.

• **Offshore** is lithologically represented by argillite deposits interbedded with clay and siltstone. A layered texture is observed in the form of horizontal and convolute bedding. Traces of bioturbation and inclusions of detrital remains are rare.

Marine carbonate settings:

• **Deep-water shelf,** the basis of its lithological section are carbonate deposits in the form of limestones, clayish limestones, dolomites and fine-grained sandstones on carbonate cement. The texture and structure are represented by traces of bioturbation, horizontal, oblique, horizontal, rhythmic superimposed bedding and detrital remains of organism shells.

Coasts of arid zones and evaporites:

• **Evaporites,** lithological evaporites are represented by crystalline anhydrites, white in color, transparent. In the section there are also fine-grained sandstones on carbonate cement with horizontally layered texture.

Deltas

• **Delta plain, beach.** The lithological section is heterogeneous and is represented by interbedded terrigenous rocks in the form of clay, siltstone and sandstone. In most cases, the section begins with a carbonized layer that gradually turns into clayish rock with inclusions of carbonized root remains. Layered texture in the form of horizontal, oblique-horizontal and differently directed bedding is observed throughout the section. In places, the bedding is destroyed by bioturbation traces. Inclusions are detritus and fragments of pelecypods.

• **Delta channel** in lithological terms is represented by thick sandstones interlayers with an increase in the grain size of the rock towards the bottom of the section with inclusions of clasts. The sandstone has a layered texture in the form of wavy and wavy multidirectional bedding. The contact with the underlying layers is mainly gradational.

• **Mouth-bar complex** is represented by deposits of fine-grained sandstones with a layered texture in the form of horizontal bedding, which is partially destroyed by rare traces of bioturbation towards the bottom of the section.

• **Delta front** is lithological represented by interbedded siltstone with fine-grained sandstone and clay. The interval shows a horizontally layered texture, which is partially destroyed by traces of bioturbation. Inclusions are represented by detritus and fragments of pelecypod shells.

• **Prodelta** is lithological represented by interbedded clayey -silty rock with a gradual transition to argillite. The interval exhibits a horizontally layered texture, partially disrupted by traces of bioturbation, with inclusions of detritus and remains of pelecypod shells.

Taking into account the limitations in the length of the core sampled in some wells, which prevented a full interpretation and identification of facies, 15 wells from 5 fields were analyzed: Karaton, Karasor, Akkuduk, Dosmukhambetovskoye and S.Nurzhanova. An example of a tablet with the results of core analysis interpretation, identifying the environmental conditions of deposits of one of the studied fields is shown in Figure 3. Based on the results of the analysis of ichnofossils of the Jurassic deposits of the Akkuduk field, the predominance of marine environmental conditions is confirmed.

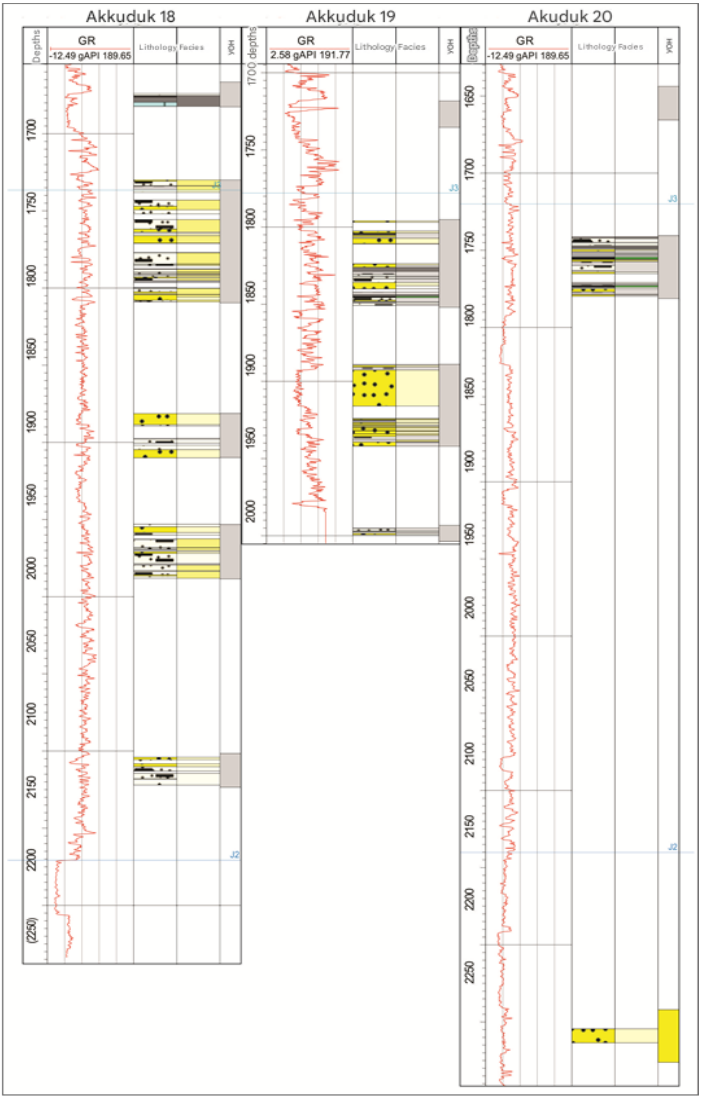
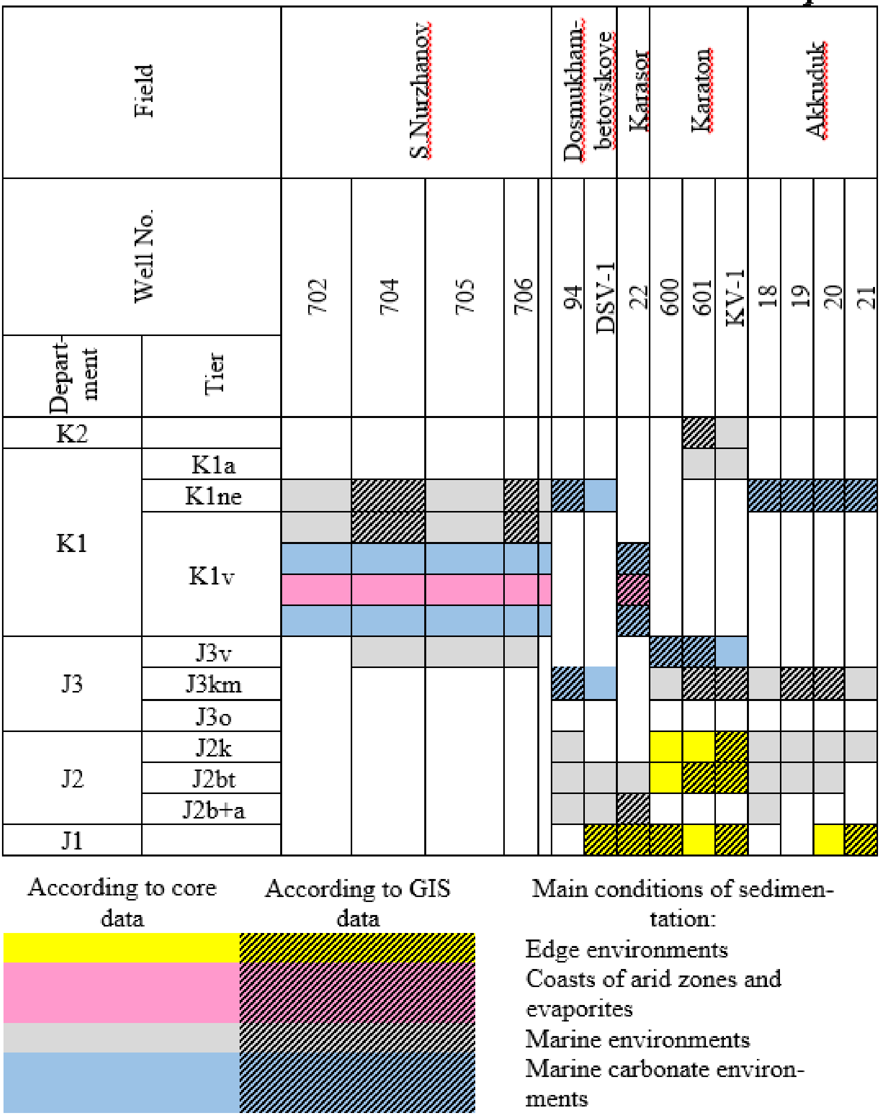


Figure 3. The results of sedimentological interpretation of the core, demonstrating a change in the sedimentation conditions of the Jurassic deposits of the Akkuduk field (alignment along the roof of the Jurassic)

A summary of the results of identifying environmental conditions for all studied deposits is presented in Table 1.

Table 1

Summary of identified sedimentation environments in the section of wells of the studied deposits



CHAPTER 3. PALEOGEOGRAPHY OF THE EASTERN PART OF THE CAPITAL SYNECLISE IN THE JURASSIC AND CRETACEOUS PERIODS

The main features of paleogeography, reconstructed on the basis of sedimentological analysis of core and well research data (GIM), indicate a variety of environmental conditions in the studied region of the Caspian lowland. Different parts of the section indicate different stages of tectonic development, the influence of salt tectogenesis, and the formation of various facies and reservoirs.

The main highlighted settings are:

- External shelf ;
- Inner shelf/shallow part of the shelf and coastal zone;
- Coastal plains (alluvial and marine);
- Lowland accumulative plain/Lowland, delta;
- Alluvial and lacustrine plains/Flat plains;
- Hilly plains, island dry land.

Middle - Late Triassic: The Kashagan-Tengiz zone predominates in the southeastern part of the Caspian lowland. It is necessary to highlight the conditions of the internal shoreface and the discharge zone from the supposed removal of sediments from the hilly plains in the east.

Early Jura: The paleogeography of this period is characterized by flat plains with major basins distributed in the central and southern parts of the region. Here, material is transported from the hilly plains of the northeast to the shallow inner shelf of the southwest.

Middle Jura: During this period, material continues to be carried away from the hilly plains of the northeast to the shallow inner shelf in the southwest. Lowlands, coastal plains, and land complexes of paleovalleys with deltas are distinguished.

Late Jura: The main sedimentation environment is the internal shoreface, which serves as a depocentre for sediments carried down from the hilly plains. Flat plains, lowlands, and coastal plains with deltas are noted.

Early Cretaceous: The depositional environment is similar to that in Late Jurassic, with no flat plains. The shallow internal shelf and the removal of material from the rolling plains predominate.

Late Cretaceous: The predominant sedimentation environment is the internal shoreface with basins of complex shape. Over deepened basin conditions appear in the west of the Kashagan-Tengiz zone.

Thus, the paleogeography of the Jurassic-Cretaceous deposits in the studied region of the Caspian Lowland represents a complex change in environmental conditions over the studied interval of geological time. The results of the conducted analyses and the available paleogeographic results, when compared, converge, with the exception of proposals for making adjustments to the paleogeographic reconstruction of the Middle Jurassic (Fig. 4).

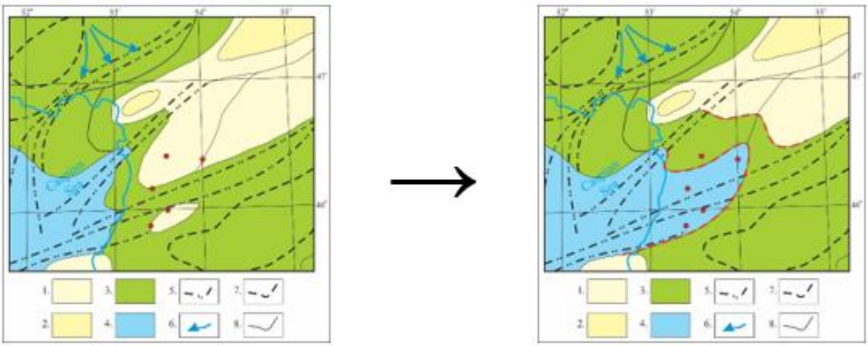


Figure 4. Extract from the paleographic map of the Northern Caspian[3] of the Middle Jurassic with proposed changes in the boundaries of environmental conditions based on the results of core studies. Sedimentation conditions: 1. Flat plains, 2. Shallow plains, 3. Lowlands, 4. Shallow shelf; Contour designations: 5. Proposed terrestrial and underwater contiguous complexes of valleys, deltas, cones of outflow and their paleodolines, 6. Probable directions of sediment removal, 7. Terraced ledges, 8. Contours of large paleomorphological provinces.

During the study of the core material of the deposits, an analysis of traces of bioturbation and ichnofossils was also carried out. The detected bioturbation can be classified by the degree of intensity. Lower

[3] Глумов, И.Ф. Региональная геология и нефтегазоносность Каспийского моря / И.Ф.Глумов, Я.П.Маловицкий, А.А.Новиков, [и др.] // - Москва.: ООО «Недра-Бизнес-центр», - 2004, - 342 с.

intense bioturbation is present in almost all sections of the studied wells. Bioturbation with increased intensity is observed in the terrigenous sections of Akkuduk, Dosmukhambetovskoye, Karaton, S.Nurzhanov and Karasor fields.

In the sections of the Jurassic deposits of Akkuduk field, one can identify many rocks in which are found abundant traces of life activity of organisms (Fig. 5). However, the traces are not characterized by high taxonomic diversity.

The sections of Dosmukhambetovskoye, Karaton and S.Nurzhanov fields are distinguished by a more limited diversity of ichnotaxa. In Dosmukhambetovskoye field, such ichnotaxa as Teichichnus, Palaeophycus, Planolites, Skolithos, Zoophycos were identified. In Karaton field, Planolites, Skolithos, Zoophycos are distinguished. In the section of S. Nurzhanov field only Planolites were found. It is emphasized that the isolated ichnofossils belong to certain species, and the presence of intervals with varying degrees of bioturbation does not exclude the presence of other species. The only difference in the sections of the Dosmukhambetovskoye and Karaton fields is the presence of ichnotax Zoophycos, whose ethological group indicates the presence of bathyal shelf conditions at the time of sediment accumulation.

CHAPTER 4. EVALUATION OF FILTRATION AND CAPACITY PROPERTIES OF ROCKS OF THE ALLOCATED FACIES

The most informative in terms of characterizing the filtration and capacity properties (FCP) were 15 wells located in 5 fields. For the FCP analysis, petrophysical research data collected between 2012 and 2021 were used.

The main parameters characterizing the reservoir properties were the values of porosity and absolute permeability. Standard analysis of core material demonstrated that the average porosity values for all fields are 18.95%, and permeability – 326.81 mD . The average values for the wells of each field are almost the same. The maximum average reservoir properties were obtained in Karaton field in well No. KV-1: porosity of 25.5% and permeability of 1474 mD. The minimum values of the average reservoir properties for porosity (10.32%) and permeability (4.6 mD) were recorded in wells No. 705 and No. 708 of S. Nurzhanov field, respectively.

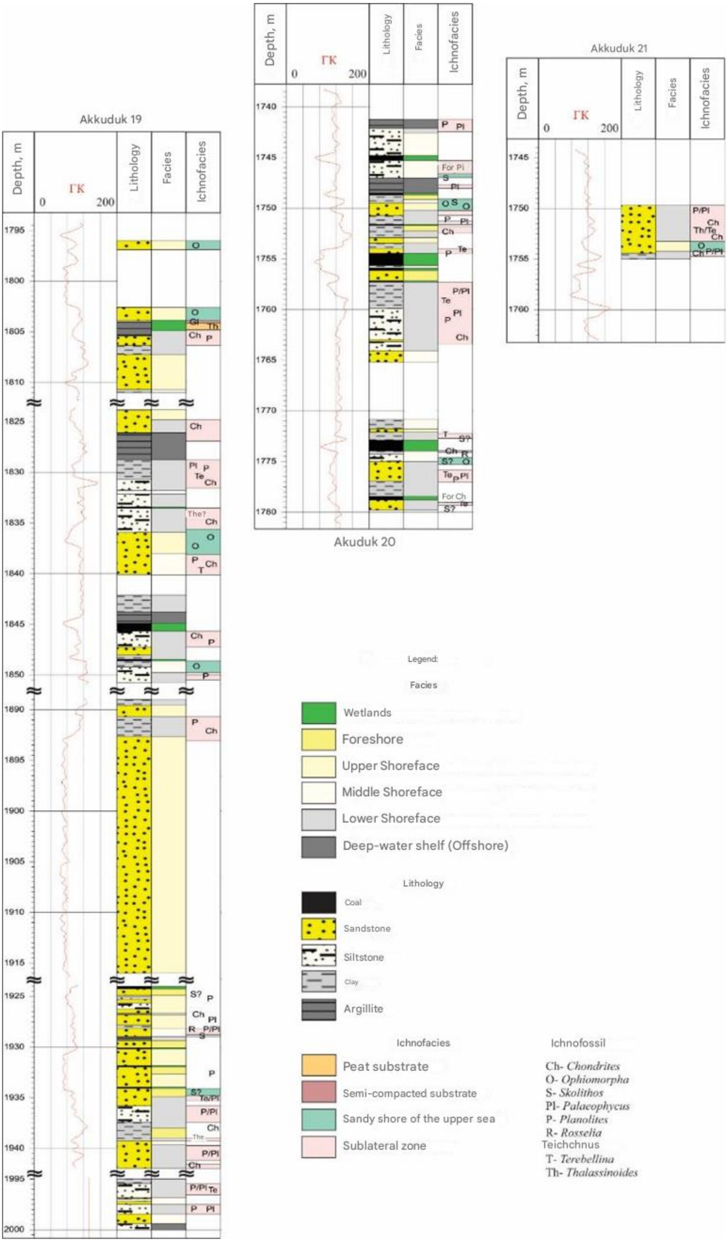


Figure 5. Lithological columns with highlighted facies of the Middle-Upper Jurassic deposits of Akkuduk field

All approximation reliability values for the exponential trend of permeability-porosity relationships exceed 0.5, which moderately approximates the data and makes them sufficiently reliable.

The porosity and permeability maps constructed for the S.Nurzhanova and Akkuduk fields, taking into account several wells for which there are results of standard core analysis, indicate that high porosity and permeability values are noted in the crest part of the structure. For S. Nurzhanov field, where the greatest amount of information is available and porosity and permeability maps have been made, it has been established that porosity and permeability values are distributed differently across the identified facies settings, such as marine carbonate sedimentation environment and evaporites.

For each group of porosity and permeability data, a binding to facies was made. Average indicators, minimum and maximum values, as well as the number of values for each well, field, lithology and facies were determined by means of consolidated calculations. Based on these data, porosity and permeability values were plotted. The lithology of rocks and the identified facies were colored in plots, which facilitated the allocation of cloud distributions and trends, and also allowed obtaining the corresponding conclusions regarding the establishment of dependencies between porosity and permeability of rocks and the identified facies.

The obtained correlations on permeability from porosity, taking into account the reference to facies, confirm, on the one hand, that the values facies of the coast, upper and middle parts of the shoreface, delta channel and mouth bar, occupy medium and high positions and tend to the right upper corner of the correlation plot and are mainly represented by sandstones and siltstones. On the other hand, rocks lithologically represented by clays, included in the facies of the deep-water shelf, delta plain, delta front and prodelta, occupy lower positions in the plot, tending to the left lower corner, and are most often below the limit value of 1 mD.

Table 2 presents the average values of reservoir property parameters for different facies.

Table 2

Average values of porosity and permeability by facies

		Wetlands	Shore	Upper shoreface	Middle shoreface	Shallow shoreface	Deep Sea Shelf	Evaporites	Deltaic plain	Delta Channel	Mouth bar	Delta Front	Prodelta
General	Por. avg. %	-	20.42	21.60	14.55	18.15	6.42	8.82	-	23.23	26.15	19.64	-
	Perm avg mD	-	462.49	541.56	59.75	22.74	0.12	0.4	-	276.37	1356.6	122.67	-
K1a	Por. avg. %	-	32.08	23.29	-	14.31	-	-	-	-	-	-	-
	Perm avg mD	-	2550.47	1774.23	-	21.27	-	-	-	-	-	-	-
K1v	Por. avg. %	-	18.36	16.80	14.23	17.23	6.42	8.82	-	-	-	-	-
	Perm avg mD	-	185.77	14.71	28.66	2.23	0.12	0.4	-	-	-	-	-
J3	Por. avg. %	-	14.77	21.00	-	-	-	-	-	-	-	-	-
	Perm avg mD	-	12.89	705.38	-	-	-	-	-	-	-	-	-
J2	Por. avg. %	-	20.17	22.52	16.32	19.38	-	-	-	25.41	26.15	19.64	-
	Perm avg mD	-	147.18	798.38	173.11	26.83	-	-	-	498.53	1356.6	122.67	-
J1	Por. avg. %	-	-	24.13	-	18.85	-	-	-	21.04	-	-	-
	Perm avg mD	-	-	339.32	-	28.87	-	-	-	54.2	-	-	-

Based on the tasks set in the dissertation, the obtained results were used to refine the geological model of the Valanginian productive horizons of the S. Nurzhanov field. The facies cube in the initial geological model was constructed using the collector- non-collector method (Fig. 6).

To take into account the obtained core data, discrete log diagrams were prepared, and the facies cube was constructed again (Fig. 7).

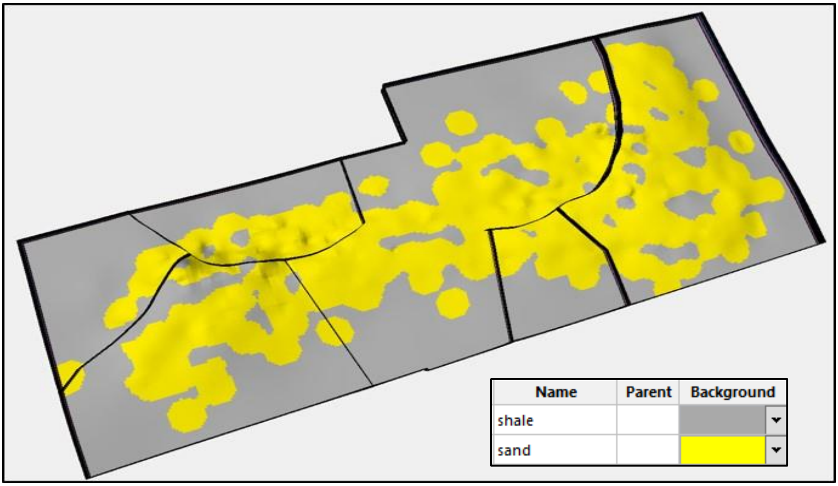


Figure 6. Slice of a facies cube for Valanginian productive horizon of S.Nurzhanov field, constructed using the collector-non-collector method

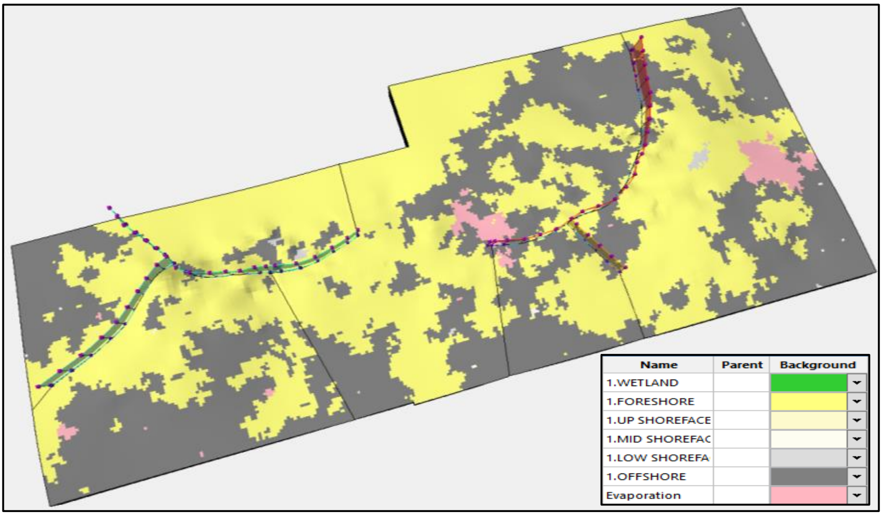


Figure 7. Slice of a facies cube for the Valanginian productive horizon of the S. Nurzhanov deposit, constructed taking into account the identified facies and environmental conditions according to the core.

Based on the newly obtained cube, taking into account the identified facies and sedimentation conditions, the saturation cube, lithology cube and reservoir properties were refined, fluid contact levels were revised and geological reserves were recalculated. The reservoir properties cube was built taking into account the distribution of porosity and permeability values by facies. Based on the constructions carried out, there was an increase in geological reserves of the Valanginian productive horizons of the S. Nurzhanov field by 2%.

CHAPTER 5. EUSTATIC VARIATION WITHIN THE RESEARCH AREA

Since the beginning of the Paleozoic, the tectonic factor (tectonoeustasy) has played a decisive role in changing the capacity of sea and ocean basins, as well as in changing the relief and structure of the ocean floor and adjacent continents. The main eustatic variations are apparently associated with the development of the system of mid-ocean ridges and the process of spreading of the sea floor - spreading. During periods of glacial flooding, when water accumulated on land in the form of ice sheets, the level of the World Ocean dropped by approximately 110-140 meters. After the glaciers melted, water again entered the World Ocean, raising its level by approximately 1/3 of the original. Changes in temperature and salinity affected the density of water, which led to differences in the level of the World Ocean between high latitudes and equatorial regions by several meters. These factors contributed to the formation of a lower terrace 3-5 meters high. Planetary factors such as changes in the speed of the Earth's rotation and pole shifts also had an effect during the process of eustasy.

The lithological and sedimentological studies we conducted on the core allow us to classify most facies in the study area as marine and deltaic. For a deeper understanding of sedimentation processes, determining their scale, and identifying the influence of the level of the World Ocean or regional-local water bodies on sedimentation as a whole, it is necessary to compare the available information on eustatic fluctuations and progradational – retrogradational sequences determined from core data and well logs.

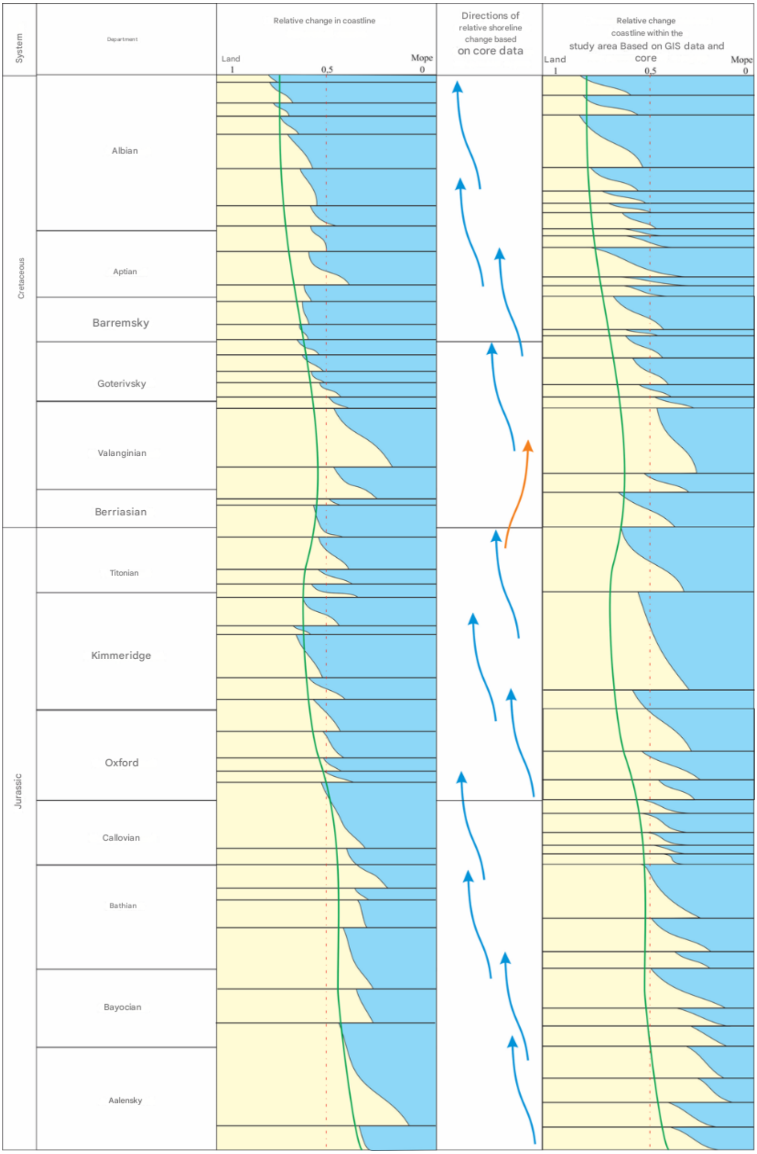


Figure 8. Correlation between global sea-level changes[4] (left side of the graph) and local basin dynamics in the study area (right side of the graph) during the Jurassic–Cretaceous periods.

[4] Haq, B. U. Mesozoic-Cenozoic Cycle Chart // Datapages, Incorporated, -1987.

Based on the identified dependencies, transgressive-regressive cycles and flooding surfaces are defined and generalized, which allows us to understand changes in sea level. The assumed zones of influence of local fluctuations in sea level led to aggradational cyclicity.

Comparison of the diagram data of the Mesozoic-Cenozoic cycle of eustatic variation with the fluctuations in the level of the reservoir that existed in the Caspian Depression in the Jurassic-Cretaceous periods (Fig. 8) allows us to assume that in the Jurassic time interval the dynamics of the development of these reservoirs differs. There is a more frequent change in the level of the reservoir of the Caspian Depression, the retreat of the coastline, which gives grounds to assume the presence of a shallow sea isolated from the World Ocean here.

The fact of a sharp retreat of the sea in the Valanginian, leading to the accumulation of evaporite deposits, deserves special attention.

CONCLUSIONS

1. The study of core material from Jurassic and Cretaceous deposits made it possible to identify facies and determine the main conditions of sedimentation, which creates the basis for facies modeling.
2. Four main sedimentation environments are identified in the sections of the studied wells: Marine environment; Marine carbonate environment; Coast of arid zones and evaporites; Edge environment.
3. The sections of the deposits contain numerous traces of the vital activity of organisms, which indicate the facies of the marine shelf. These data partially differ from paleogeographic reconstructions, which requires adjustments.
4. The best filtration and capacitance properties were found in the facies of the coast, the upper and middle parts of the chalk shelf, the delta channel and the estuary bar.
5. The identified environments include a number of facies related to wetlands, shallow and deep-water shelves, evaporites, delta plain, delta channels, delta front and delta extension. All the isolated facies are characterized by dependencies based on the lithological and textural features of the core.
6. The main mineralogical composition of sediments is represented by silicates (quartz, feldspar, clays) and carbonates (carbonate cement).

An increase in feldspar content in certain intervals indicates a change in the dynamics of sedimentation.

7. Reconstruction of sedimentation conditions has shown the influence of fluctuations in the level of the world ocean on the formation of sediments in the studied area.
8. In the Valanginian layer, exposed by the core of the S. Nurzhanov field there is a sharp departure of the sea, accompanied by the formation of thick layers of anhydrite, which is part of the evaporite facies.
9. The general characteristics of the results indicate a gradual flooding of the study area, with a transition from the continental delta environment in the Lower Jurassic to deep-sea environments with a high content of carbonate deposits in the Lower and Upper Cretaceous.
10. The facies modeling of the Valanginian horizon of the S.Nurzhanov field, based on the identified sedimentation conditions, provided an increase in reserves by 2-5%.
11. The need for sedimentological reconstructions is due to the use of methods of geological facially oriented 3D modeling of productive formations.
12. The construction of a facies model based on a comprehensive study of core material is a primary task in geological modeling.

The main content and results of the dissertation are published in the following works:

1.Пронин, Н.А. Подход к подбору точек отбора образцов на керновом материале для проведения стандартных и специальных лабораторных исследований // Перспективы нефтегазоносности Казахстана, проблемы, пути изучения и освоения трудноизвлекаемого нетрадиционного углеводородного сырья. Труды ОНГК, - Вып.6, - Алматы: - 2017. - с.367-372.

2.Пронин, Н.А. Лабораторный экспресс метод определения гранулометрического состава пород оптическим методом // Материалы международной научно-практической конференции «Методы увеличения нефтеотдачи и интенсификации добычи нефти» ТОО «КазНИПИмунайгаз», - Актау: - 2018. - с.351-360.

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