MINISTRY OF SCIENCE AND HIGHER EDUCATION OF THE REPUBLIC OF KAZAKHSTAN

K. I. Satpayev Kazakh National Research Technical University

K. Turysov Institute of Geology, Oil and Mining

Department of Hydrogeology, Engineering and Petroleum Geology

Azinur D. Bakytkereyeva

THESIS

Topic: **Geological structure and lithological and stratigraphic characteristics of the Eastern geoblock of the Caspian depression, oil and gas potential of the Kenkiyak field**

6B07202 – Geology and exploration of mineral deposits

Almaty 2023

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ASSIGNMENT
For the graduate work

Student: Azinur D. Bakytkereyeva
Topic: «Geological structure and lithological and stratigraphic characteristics of the Eastern geoblock of the Caspian depression, oil and gas potential of the Kenkiyak field»
Approved by order of the Rector of the University *"23" November 2022 year* #408
Completed Work Delivery Date *"30" May 2023 year*
Initial data for the thesis: materials obtained during field practice, geological literature, reporting data.
Short content of the thesis: this study focuses on analyzing the geological features and understanding the lithological and stratigraphic variations, oil and gas occurrence within the Eastern geoblock,with a specific emphasis on the Kenkiyak oil field.
List of issues considered in the diploma work

a) *Features of the geological structure*
b) *Lithology and tectonics*
c) *Oil and gas potential of Kenkiyak field*
d) *Characterization of reservoir properties of productive horizons.*

The schematic materials are listed in the slide 22
Number of references 12

To preparation of diploma work
TABLE

Title of list	Date of delivery to research supervisor and commissions	Remarks
General information about the Eastern geoblock of Precaspian basin	26.03.2023	Done
Overview of oil and gas field	18.04.2023	Done
Oil and gas potential of Kenkiyak	03.05.2023	Done

Signatures
of the comission of departments of the thesis and the controller of norm for completed work

Title of list	**Commissions, name,patronymic, surname (degree, position.**	**Signature date**	**Signature**
General information about the Eastern geoblock of Precaspian basin	T.S. Jarassova PhD, senior-lecturer	26.03.2023	
Overview of oil and gas field	T.S. Jarassova PhD, senior-lecturer	18.04.2023	
Oil and gas potential of Kenkiyak	T.S. Jarassova PhD, senior-lecturer	03.05.2023	
Standart control	M.E. Sanatbekov Master, assistant	19.05.2023	[signature]

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Date «2» 06 2022

АҢДАТПА

Каспий маңы ойпатындағы Шығыс геоблоктың геологиялық құрылымы, литологиялық құрамы және стратиграфиялық сипаттамалары аймақтың мұнай-газ әлеуеті үшін үлкен маңызға ие. Бұл зерттеу Кеңқияқ кен орнына ерекше назар аудара отырып, геологиялық ерекшеліктерді талдауға және Шығыс геоблоктағы литологиялық және стратиграфиялық өзгерістерді түсінуге бағытталған.

Шығыс геоблок шегінде орналасқан Кеңқияқ кен орны өзінің келешегі бар мұнай-газ әлеуетімен ерекше назар аударады.Бұл кен орнының геологиялық құрылымын және литологиялық және стратиграфиялық сипаттамаларын түсіну ресурстарды тиімді бағалау және игеру үшін өте маңызды. Деректерді талдай отырып, бұл зерттеу Кеңқияқ кен орнының көмірсутектік әлеуетін жан-жақты шолуды, оның қабатының сипаттамаларын ашып көрсетуді және болашақта барлау мен өндіру үшін құнды мәліметтерді ұсынуды мақсат етеді.

Негізгі сөздер: геологиялық құрылымы, литологиялық құрамы, стратиграфиялық сипаттамасы, Шығыс геоблок, Каспий маңы ойпаты, мұнай-газ әлеуеті, геологиялық қорлар, Кеңқияқ кен орны.

Дипломдық жұмыс аннотациядан,мазмұнынан, кіріспеден, үш бөлімнен, қорытындыдан, пайдаланылған әдебиеттер тізімінен тұрады. Дипломдық жұмыс ішінде 28 сурет және 6 кесте бар.

АННОТАЦИЯ

Геологическое строение, литологический состав и стратиграфические характеристики Восточного геоблока в Прикаспийской низменности имеют большое значение для нефтегазового потенциала региона. Это исследование направлено на анализ геологических особенностей и понимание литологических и стратиграфических вариаций в пределах Восточного геоблока с особым акцентом на месторождении Кенкияк.

Месторождение Кенкияк, расположенное в пределах Восточного геоблока, привлекает большое внимание в связи с его перспективным нефтегазоносным потенциалом Анализируя данные, это исследование направлено на то, чтобы предоставить всесторонний обзор углеводородного потенциала месторождения Кенкияк изучить характеристики его коллектора, нефтеносности и предложить ценную информацию для будущих исследований и добычи.

Ключевые слова: геологическое строение, литологический состав, стратиграфическая характеристика, Восточный геоблок, Прикаспийская впадина, нефтегазоносность, геологические запасы, месторождение Кенкияк.

Дипломная работа состоит из аннотации, содержания диссертации, введения, трех частей, заключения, списка литературы. Дипломная работа содержит 28 рисунков и 6 таблиц

ABSTRACT

The geological structure, lithological composition, and stratigraphic characteristics of the Eastern geoblock in the Caspian depression hold significant implications for the region's oil and gas potential. This study focuses on analyzing the geological features and understanding the lithological and stratigraphic variations within the Eastern geoblock, with a specific emphasis on the Kenkiyak field.

The Kenkiyak field, located within the Eastern geoblock, has attracted considerable attention due to its promising oil and gas potential. Understanding the geological structure and lithological and stratigraphic characteristics specific to this field is crucial for effective resource evaluation and development. By analyzing available data, this study aims to provide a comprehensive overview of the Kenkiyak field's hydrocarbon potential, shedding light on its reservoir characteristics, and offering valuable insights for future exploration and production endeavors.

Keywords: geological structure, lithological composition, stratigraphic characteristics, Eastern geoblock, Caspian depression, oil and gas potential, geological reserves, Kenkiyak field.

The thesis consists of an annotation, content of the thesis, introduction, three parts, conclusion, list of references. The thesis contains 28 figures and 6 tables.

CONTENT

INTRODUCTION

The exploration and exploitation of hydrocarbon resources play a vital role in meeting the ever-increasing global energy demand. One of the most promising regions for hydrocarbon reserves is the Caspian Depression, an expansive geological basin located between the Caspian Sea and the Ural Mountains. Within this vast depression, the Eastern geoblock stands out as a significant area of interest due to its geological structure and potential oil and gas reserves.

This thesis provides a comprehensive analysis of the geological structure and lithological and stratigraphic characteristics of the Eastern geoblock of the Caspian Depression, with a specific focus on the Kenkiyak field.The Kenkiyak field, situated within this geoblock, has been recognized as a key hydrocarbon reservoir, making it an ideal case study to understand the broader oil and gas potential of the region.

To achieve this objective, a multidisciplinary approach will be employed, combining geological, geophysical, and stratigraphic data. The research will involve a thorough examination of existing geological maps and profiles, structural maps, reservoir properties, and other relevant geological data sources. Additionally, field surveys and laboratory analyses will be conducted to gather new data and refine the understanding of the subsurface formations in the Eastern geoblock.

The study will begin with an overview of the geological setting of the Caspian Depression, providing a contextual framework for the subsequent analysis. Special attention will be given to the tectonic evolution, lithology and structural features that have shaped the region. Furthermore, a comprehensive literature review will be conducted to consolidate existing knowledge and identify research gaps related to the geological understanding of the Eastern geoblock and the Kenkiyak field.

This thesis aims to contribute to the scientific understanding of the geological structure and lithological and stratigraphic characteristics of the Eastern geoblock of the Caspian Depression, with a specific focus on the Kenkiyak field. Special emphasis will be placed on the rock formations and reservoir properties that contribute to the oil and gas potential of the Kenkiyak field. The findings of this study will not only provide valuable insights into the potential hydrocarbon reserves in the region but also serve as a foundation for future exploration and development activities.

The thesis is compiled in accordance with the assignment issued by Department of Hydrogeology, Engineering and Petroleum Geology and according to the «Guidelines for diploma design for students of the specialty 6B07202 – Geology and exploration of mineral deposits of specialization «Petroleum Geology».

1 General information about Eastern geoblock of the Caspian Basin

Caspian oil and gas basin is one of the largest in terms of hydrocarbon reserves in the world. Within its boundaries, giant deposits have been discovered, such as Kashagan, Tengiz on the southern side, and Karashyganak on the northern side. On the eastern side of the basin, large deposits of Zhanazhol, Kenkiyak, Alibekmola, Kozhasai and others have been discovered and are being developed (Figure 1).

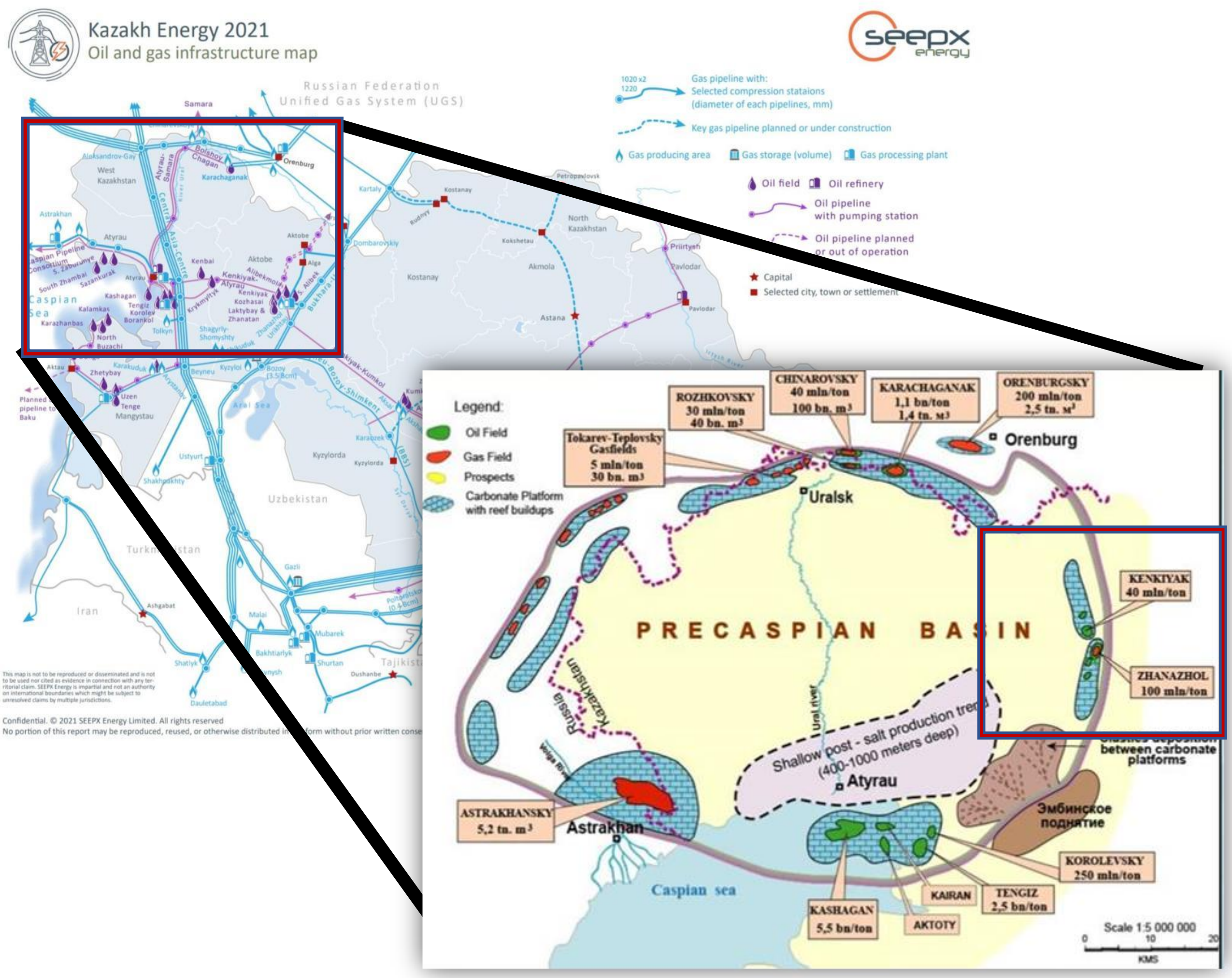


Figure 1 - Overview map of the Caspian Basin and its eastern side [5,7]

Within the eastern side of the Caspian syneclise, regional seismic surveys began in the 1950s in conjunction with reference drilling. Since 1957, there has been an intensification of these works.

Until the 70s of the last century, the exploitation of the deposits of the Caspian depression was associated with the post-salt rock complex, where the oil and gas potential of the geological section from the Upper Permian deposits to the Neogene deposits was established. The preparation of prospective targets for deep drilling was carried out mainly by the CDP method, which made it possible to increase the depth of research. Industrial oil and gas potential of pre-salt deposits of the eastern side is proved by the discovery of a group of fields: Zhanazhol, Kenkiyak and Northern Truva.

Vostochnobortovaya oil and gas region (East Emba, Kenkiyak-Zhanazholskaya, Zharkamys-Temirskaya)—oil and gas region is located in the southwest part of Aktobe region in Kazakhstan, in the middle and lower reaches of the river Emba. One of the oil and gas fields in Precaspian oil and gas province. The depth of occurrence varies widely, from 200 to 6500 m. The age of this area is Paleozoic. Vostochnobortovaya oil and gas area before the discovery of the field Zhanazhol was part of the Emba oil and gas region, in the 1990s it became an independent region.

The resources of this area are estimated at 0.8–2 billion tons of oil and 0.5–1.5 trillion m^3 of gas.

1.1 Geological knowledge of the basin

The main attention in the structure of the Caspian basin is attracted by the presence of a huge thickness of the salt column, peculiar salt-dome structures and deposits subordinate to them, contained in the salt-bearing complex itself, as well as in post-salt deposits.

The productive section of the deposits of the eastern wall consists of carbonate and terrigenous rocks belonging to the strata KT-III, KT-II,MKT and KT-I.

The main productive strata of the eastern side of the Caspian syneclises - KT-I and KT-II are well studied.

The thickness of the KT-I sequence in the east is 400–500 m and decreases in the north to 140–180 m (South Mortuk structure), and in the south 140–160 m on the South Tuskum and East Tortkol structures. The rocks that make up the carbonate-terrigenous sequence of the study area are diverse in origin, mainly organogenic limestones, some of which are transformed into dolomites.

The carbonate sequence (KT-II) covers a wide time interval, from the Upper Visean substage of the lower section to the lower Podolian stage of the middle section of the Carboniferous system C1v2al2–C2m1–C2m2pd1. It is distributed almost throughout the study area.

The recoverable hydrocarbon reserves of these strata have been calculated and approved, which cannot be said about the promising carbonate stratum KT-III, while its productivity is almost proven by drilling a deep well in the Urikhtau field. At the moment, the KT-III stratum has been penetrated by a small number of wells and is poorly studied, since its study is difficult due to the large depth of occurrence.

1.2 Lithological and stratigraphic characteristics

In order to study the deep structure and trace productive oil and gas bearing horizons within the eastern onboard zone, a significant number of deep, parametric, structural-exploratory, exploration wells were drilled with an average depth of 200 to

5500 meters, the deepest are Kozhasai PGS-1 (6031 m) and Baktygaryn G-1(6212 m).

The stratigraphic sequence, the thickness of the deposits, and their genetic features make it possible to distinguish several lithofacies zones in the subsalt deposits of the east of the Caspian depression: Aktobe, Ostansuk-Dzhurun, Temir, Zhanazhol-Tortkol, Tuskum-Kozhasai, Borzher-Akzhar and Teresken zones.

Aktobe zone is characterized by a single lithological sequence of Upper Carboniferous-Lower Permian gray-colored sandy-argillaceous deposits.

Ostansuk-Jurun zone is composed of a thick sequence of weakly deformed deposits of the Lower Permian (2361 m) and Upper Carboniferous (259 m).

Temir zone covers the areas of Kenkiyak, Aransay, Bozoba, Akkum, Baktygaryn, etc.

The Zhanazhol-Tortkol zone stands out between the Early Permian carbonate scarp and the line where the carbonate sequence KT-I pinches out (or is eroded by erosion)..

Tuskum-Kozhasai zone. It is characterized by the presence of only the lower (KT-II) part of the carbonate platform, the slope of which is far (up to 15 km) advanced to the west compared to the distribution line of the carbonate stratum of KT-I.

Teresken zone. The Teresken zone corresponds to the trough of the same name, located southeast of the Mynsyulmas-Teresken ledge of the Devonian-Early Carboniferous deposits of the South Emba uplift.

The **Devonian-Lower Visean (D-D1v)** Lithological-Stratigraphic Complex (LSC) consists of sedimentary deposits from the Devonian period (as shown in Figure 2). These deposits encompass the lower, middle, and upper sections and primarily consist of marine formations.

During the *Eifelian stage*, the sedimentary rocks are predominantly gray and dark gray in color. They are a mixture of organic and detrital materials, with some areas showing partial crystallization. Terrigenous rocks are also interspersed within these layers.

In the *Givetian stage*, the lithology comprises dark gray and brownish gray limestones, which are mainly composed of organic coral and detrital materials.

In the *Frasnian stage*, which is concealed within the Temir zone in wells G-1 Baktygaryn, G-4 Kumsai, and G-9 Bozoba, the limestones exhibit brown-gray and light gray colors.

In the **Carboniferous deposits (C)** section, there are four distinct layers that successively replace each other from bottom to top:

1. The lower terrigenous sequence (TT-II)
2. The lower carbonate (KT-II)
3. The upper terrigenous TT-I (or intercarbonate, MKT)
4. The upper carbonate (KT-I)

The *Tournaisian Stage and Lower Visean Substage (C1t-v)* primarily consist of sediments from the lower terrigenous sequence (TT-II), as mentioned earlier.

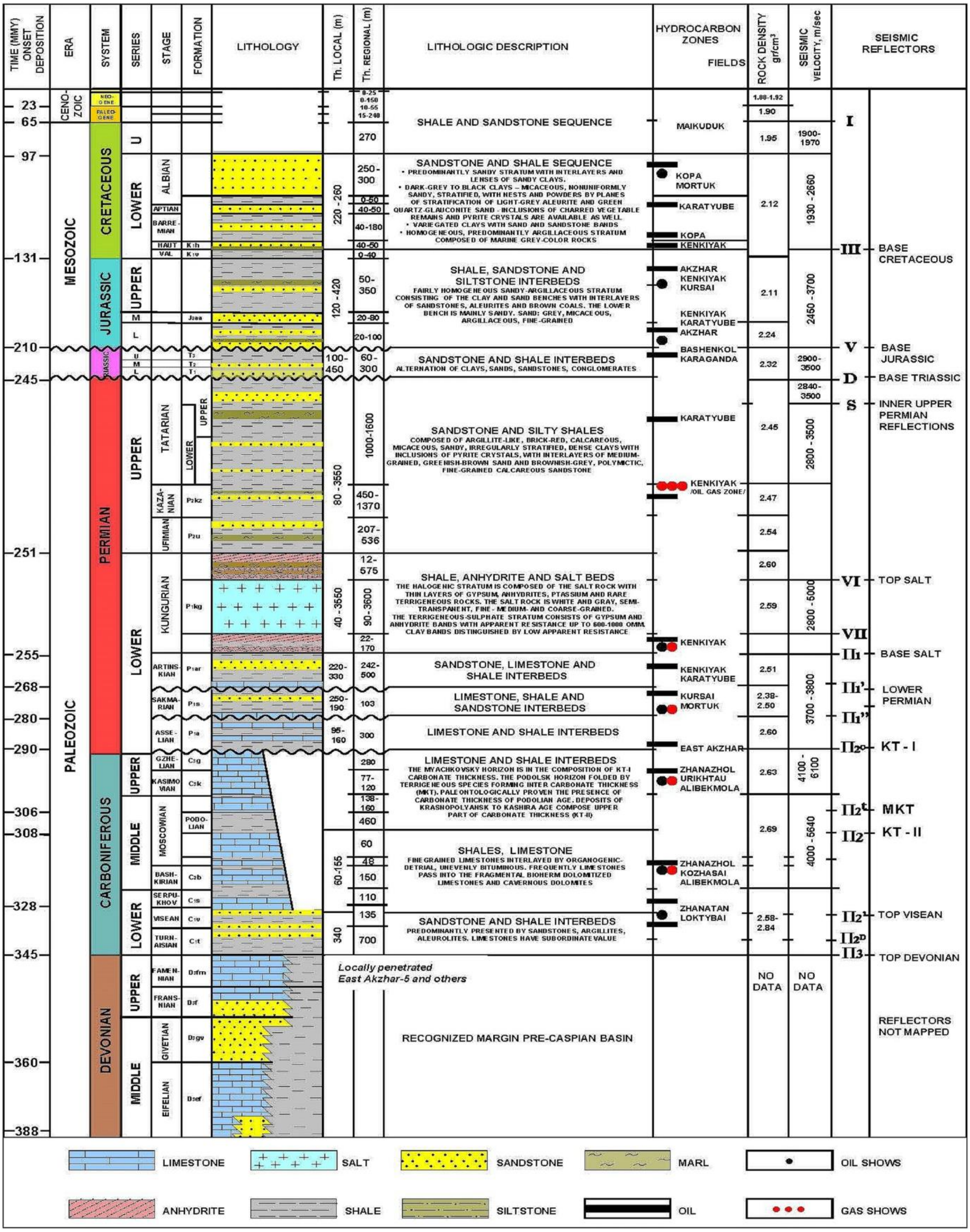


Figure 2 - Stratigraphic column of the eastern edge of the Pre-Caspian sedimentary basin [3]

During the *Visean stage,* both the lower and upper substages are characterized by terrigenous and carbonate facies.

In the *Serpukhovian stage,* the deposits consist of lenticular interbedding of gray and dark gray sandstones, mudstones, and siltstones.

The *Bashkirian stage* exhibits varying stratigraphic volumes in its deposits.

The *Moscow tier* is composed of gray, dark gray to black limestones with an organogenic-clotty, platy texture. Interlayers of black cherts, siltstones, and mudstones containing a complex of foraminifers can also be found.

The *Kasimovian stage* is composed of light gray to brown biomorphic and biohermal algal limestones.

Deposits from the *Gzhelian stage* primarily consist of carbonate formations, including bioherms, fusulinide, and other shallow-water limestone lithotypes.

In the **Permian deposits (P),** there are two distinct sections. They can be subdivided based on their lithological composition into subsalt, salt-bearing, and post-salt parts.

The *Asselian stage* is characterized by biohermal, bluish-gray limestones that contain bryozoans, blue-green algae, and attached foraminifera.

The *Sakmarian stage* conformably overlays the deposits from the upper zone of the Asselian tier. The rocks in this stage are predominantly gray in color.

The Artinian tier consists of terrigenous rocks and can be divided into two lithological units: the lower coarse clastic unit and the upper predominantly argillite unit.

During the Kungurian stage, deposits with different lithological volumes have been discovered through numerous wells.

The Ufa stage is characterized by Ufa deposits, which have a total thickness ranging from 267 meters (in the Shengelshiy area) to 525 meters (in the Kumsai area) on the eastern side of the Caspian depression.

In the Kazanian stage, there is a gradual increase in the sand content from west to east within the section. Additionally, the rocks tend to exhibit increased anhydritization when approaching the salt massifs of domes.

Deposits from the Tatarian stage overlay the underlying rocks with erosional unconformity. In most sections, the presence of deposits from the Lower Tatarian substage is supported by faunal evidence.

Triassic deposits (T) are widely distributed in the considered territory of the Caspian syneclise. Based on paleontological data, the Lower Triassic deposits can be subdivided into the Indus and Olenek stages.

The *Baskunchak series* or Akzhar Formation, identified by G.Z. Zholtaev (1966), is lithologically composed of alternating sands, sandstones, and clays.

On the eastern side, the *Middle Triassic deposit*s are represented by the Tashshi Formation, identified by P.Y. Avrov (1966).

Jurassic system deposits (J) are widespread in the eastern part of the Caspian basin, and many indications of oil have been identified within them.

During the *Aalenian Stage*, deposits from the Aalenian stage have been observed in many areas. They rest with erosional unconformity on rocks from the Lower Jurassic, including the Kungur stage.

Bajocian rocks, from the Bajocian stage, have been encountered in boreholes within many structures and are exposed on the Aschesai dome.

The *Callovian stage* is represented by gray and greenish-gray clay deposits at the top, which are dense. In some areas, there are sandy layers at the base, with frequent interlayers of sands, sandstones, marls, and layers of brown coal.

The *Volgian stage* is locally distributed within the Kenkiyak, Zhanazhol, and western and southwestern dome structures.

Cretaceous Lithological-Stratigraphic Complex (LSC) deposits are widespread in the eastern part of the area and have been mapped through numerous wells, structural prospecting, and deep drilling under various structural conditions.

The *Valanginian stage* has not been fully established yet but is present on the Aschesai and Zhaksymai domes and on the right bank of the river.

During the *Hauterivian stag*e, marine sediments transgressively overlie Jurassic sediments.

The *Barremian stage* is exposed through numerous wells and has outcrops in various locations.

Aptian stage marine deposits, which erode the Barremian deposits, are widespread. They can be divided into two layers based on lithological features: a lower sandy layer and an upper clayey layer, identified as substages.

The *Albian stage* is represented by light gray clay deposits with occasional interlayers of sands and a small amount of sandstones.

1.3 Tectonics

The Caspian syneclise, with an area of more than 500,000 km2, occupies a marginal position within the southeastern part of the East European Platform (Figure 3).

The western and northern boundaries of the syneclise are drawn along the Lower Permian tectonic-sedimentary carbonate ledge, which separates it from the Volga-Ural province and the Volga monocline. In the east, the Caspian basin is framed by the folded structures of the Urals and Mugodzhar, in the southwest it is separated by the Donetsk-Astrakhan marginal suture from the Scythian plate. From the west and north, the Caspian syneclise is limited by areas of shallow basement (3-6 km), the surface of which increases towards its central part to depths of 15-22 km.

In the sedimentary complex of the eastern wall, the main structural constructions are made on the following reflecting horizons:

Pre-salt sediment complex:

- П – foundation surface,
- П3 – the surface of the Lower-Middle Devonian,
- П2 – the surface of the carbonate deposits of the Visean-Bashkirian age
- П1 – the surface of pre-salt deposits

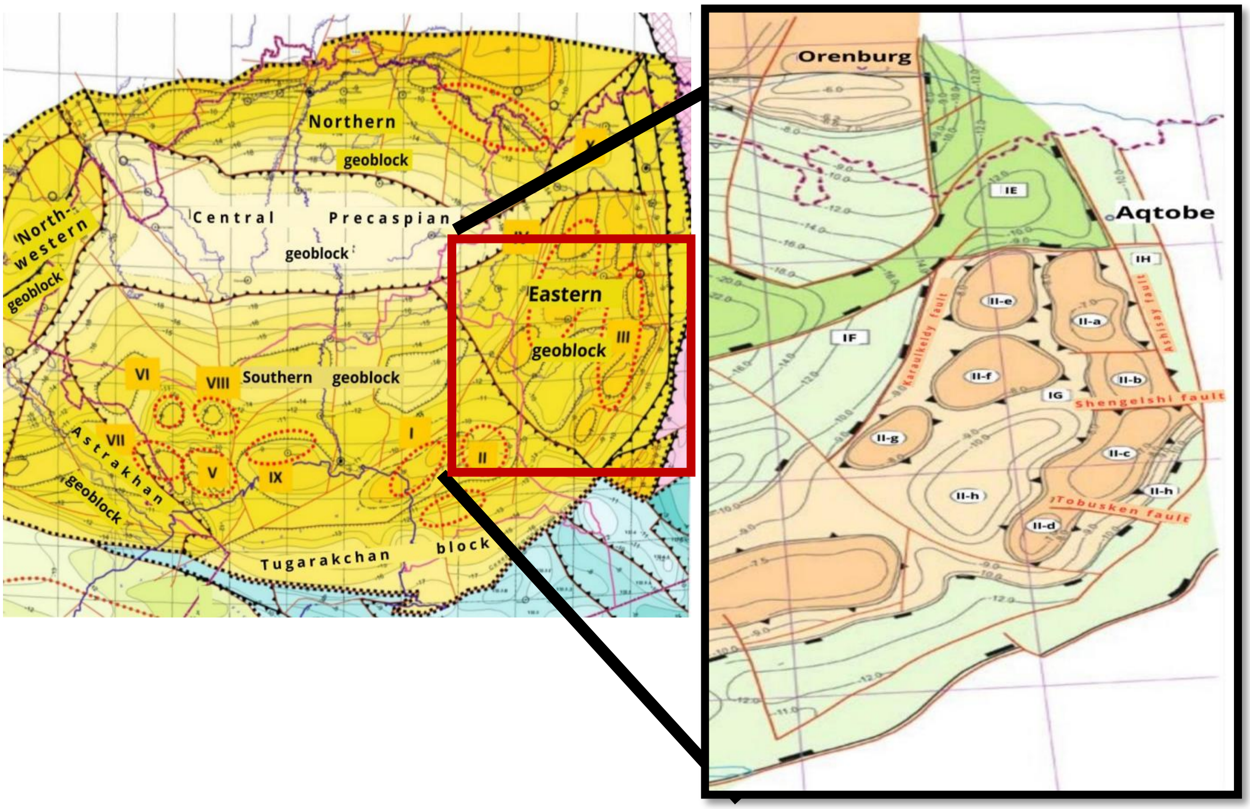


Figure 3 - Tectonic scheme of Eastern geoblock [4]

Post-salt sediment complex:

- VI – surface of saline deposits,
- D – bottom of the Triassic deposits,
- V – bottom of the Jurassic deposits,
- III – the bottom of the Cretaceous deposits.

The structure of the basement of the eastern side (Figure 3) of the Caspian syneclise has a pronounced block character, contrastingly traced in the regional plan, and is reflected in the structural plan of the Paleozoic and Mesozoic deposits. This suggests that the crystalline basement played a primary role in the formation of the structures of the platform Paleozoic cover.

The basement surface, complicated by local forms of positive and negative signs (raised and lowered blocks), has a general regional tendency to sink towards the center of the basin.

Based on the analysis of geological and geophysical data within the eastern side of the Caspian syneclise, deep faults were identified and traced. Systems of deep faults, both submeridional and sublatitudinal, were inherited from the time when the separation of the Caspian syneclise began in the southeastern part of the East European Platform.

П1- the surface of pre-salt deposits. The horizon is confined to the roof of the Lower Permian Asselian-Sakmarian and Artinian formations.

П2– stratigraphically tied to the top of carbonate deposits Visean-Bashkir age.

Horizon Π_3 most difficult to interpretion (Figure 4), because located at depths of more than 6 km. Tectonic data structure sediments indicates the preservation of the largest structural elements identified on the surface of the foundation.

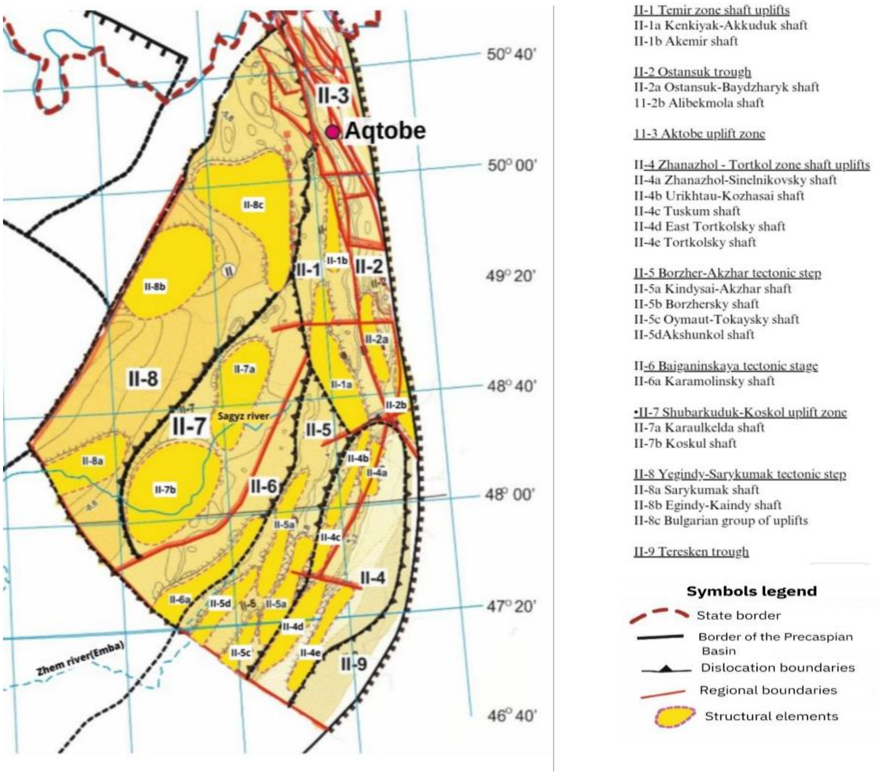


Figure 4 - Tectonic map along horizon Π_3 [4]

1.4 Oil and gas potential

In the section of the sedimentary cover of the eastern marginal zone of the Caspian syneclise, oil and gas fields have been discovered, the commercial productivity of which is determined in a wide stratigraphic range from Devonian to Neogene deposits inclusive.

In the pre-salt complex of sediments in the eastern part of the Caspian depression, oil and oil and gas condensate fields Alibekmola, Zhanazhol, Zhanatan, Kenkiyak (pre-salt-post-salt), Kozhasai, Urikhtau and others have been discovered.

Along the section, hydrocarbon deposits are found both in terrigenous (East Akzhar, Zhanatan, Kenkiyak, Loktybay) and carbonate rocks (Alibekmola, Zhanazhol, Kenkiyak, Kozhasai, South Mortuk and East Mortuk, Sinelnikovskoye, Urikhtau) (Figure 5-6)

The area is divided into 3 main oil and gas regions , two of them cover the territory of the field in the pre-salt complex and all three are shown in the post-salt complex.

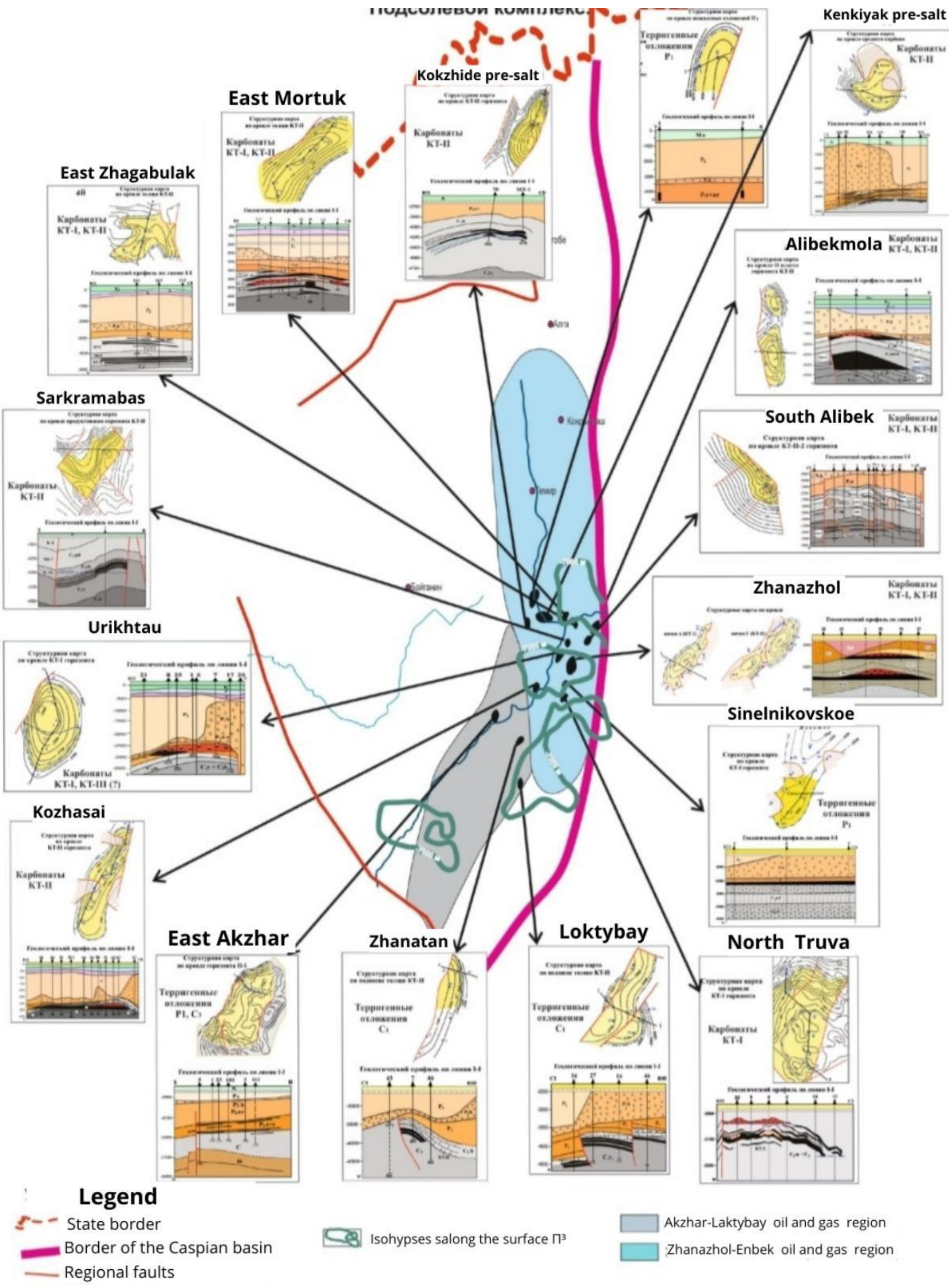


Figure 5 – Oil and gas zoning scheme of the pre-salt complex of the eastern side of the Precaspian syneclise [4]

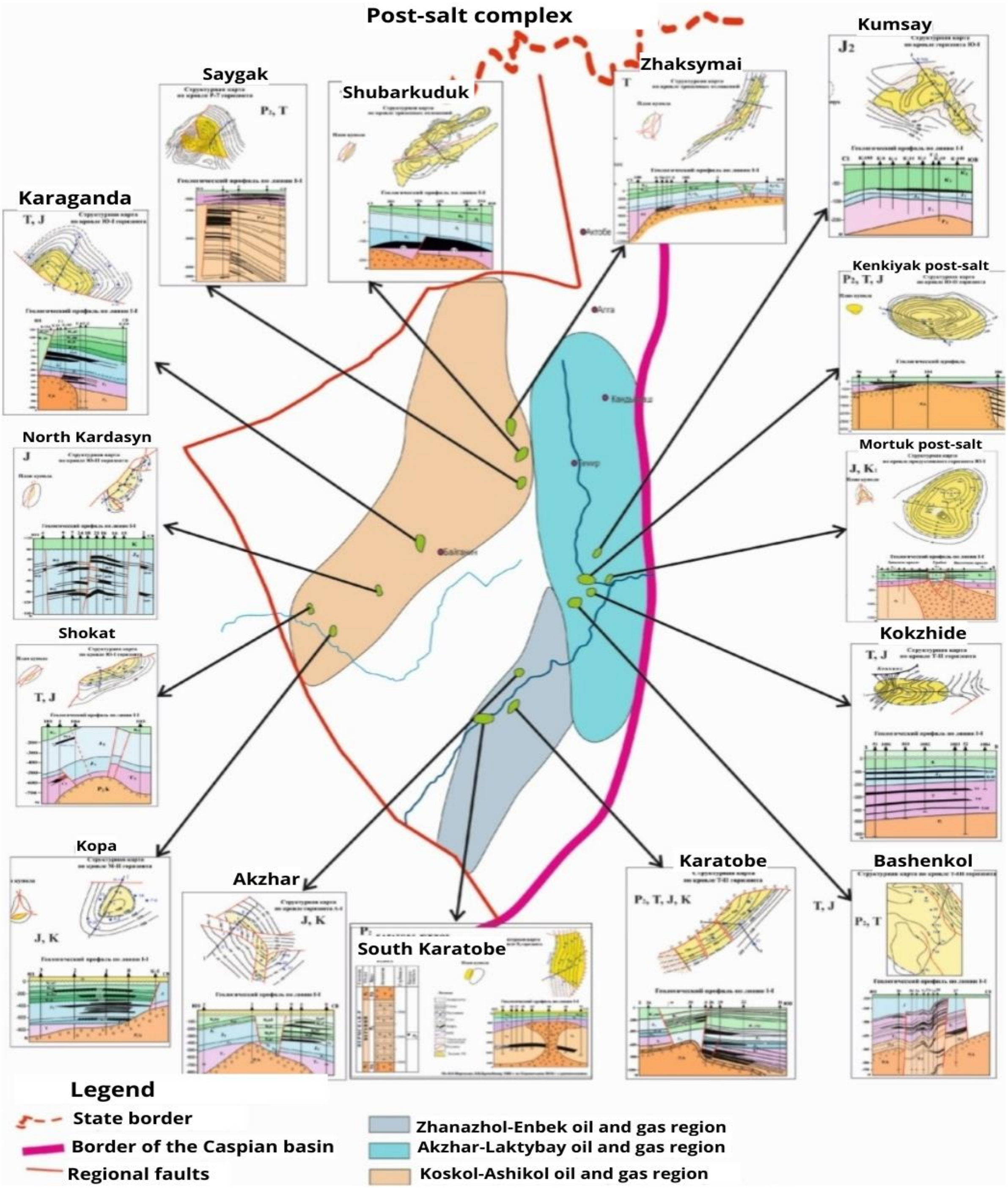


Figure 6 - Oil and gas zoning scheme of the post-salt complex of the eastern side of the Precaspian syneclise [4]

In the studied part of the section, 9 oil and gas bearing complexes (OGCs) were identified, five of them in the pre-salt section, 4 in the post-salt part.

- Middle-Upper Devonian - Lower Carboniferous prospective oil and gas complex D2-C1 (KT-III)
- Visean-Middle Carboniferous oil and gas complex C1v2 - C2s-C2b-C2m1 (KT-II)

- Lower-Middle Carboniferous terrigenous OGK C2m2pd1 (MKT)
- Middle-Upper Carboniferous oil and gas complex C2m2pd3 – C3g(KT-I)
- Lower Permian oil and gas terrigenous complex (P1a-as)
- Upper Permian terrigenous oil and gas complex (P2.)
- Triassic terrigenous oil and gas complex (T)
- Jurassic oil and gas complex (J)
- Lower Cretaceous terrigenous oil and gas complex (K)

*Middle-Upper Devonian promising oil and gas complex.*Devonian deposits in the territory of the eastern part of the Caspian depression are poorly studied due to the small number of wells that have exposed rocks of this age. At the East Akzhar site, in well No. G-5 at a depth of 5673 m, Lower Devonian limestone deposits of dense, clayey, breccia-like, brownish-gray and gray colors are distinguished. The total thickness of the Devonian in this well is 90 m, attributable to KT-III according to seismic data. There was a strong smell of hydrocarbons on the core in a fresh fracture, and traces of oil were noted along the cracks.

*Lower Permian oil and gas terrigenous complex (P1a-as)*It is represented by unevenly interbedded sandy-silty and clayey rocks. When testing well No. 1 from the interval 4325-4370m, an oil inflow was obtained with a flow rate of 40 barrels / day. The reservoirs are carbonate sandstones with low reservoir properties: porosity is in the range of 5.0-12%, and permeability is 0.1-4.0 mD.

Kungur oil and gas complex. Signs of oil and sandstones and anhydrites of the lower sulfate-terrigenous unit were found in well 7 of the Zhilansaid area. At the Kenkiyak dome, abundant oil was noted in the anhydrites and argillites of keprok in wells 12 and 20, and drip-liquid oil was observed in a number of wells in salt.

Jurassic oil and gas complex (J) is one of the main oil and gas bearing complexes of post-salt deposits of the Caspian syneclises. Initial oil production rates reached 74m3/day. Oil deposits have an elastic-water-driven regime and are arched, tectonically screened, and lithological in type. The reservoir properties of productive deposits are characterized by full porosity reaching 22.5-44.1%, open porosity from 21.2 to 38% with a permeability of 105.4-5600 mln and oil saturation of 72-80%.

2. General information about the Kenkiyak field

2.1 General review of the Kenkiyak oil field

The Kenkiyak field is located on the eastern side of the Caspian depression, on the territory of the Aktobe region of the Republic of Kazakhstan (Figure 7), 220 km from the city of Aktobe and 70 km from the city of Temir. The settlements of Kenkiyak and Sarkol are located near the field. The territory of the mine is crossed by the Temir River. An oil pipeline with a length of 115 km was laid from the Kenkiyak mine to the Russian city of Orsk. Located 110 km to the North-West. In orthographic terms, the area is a slightly hilly area.

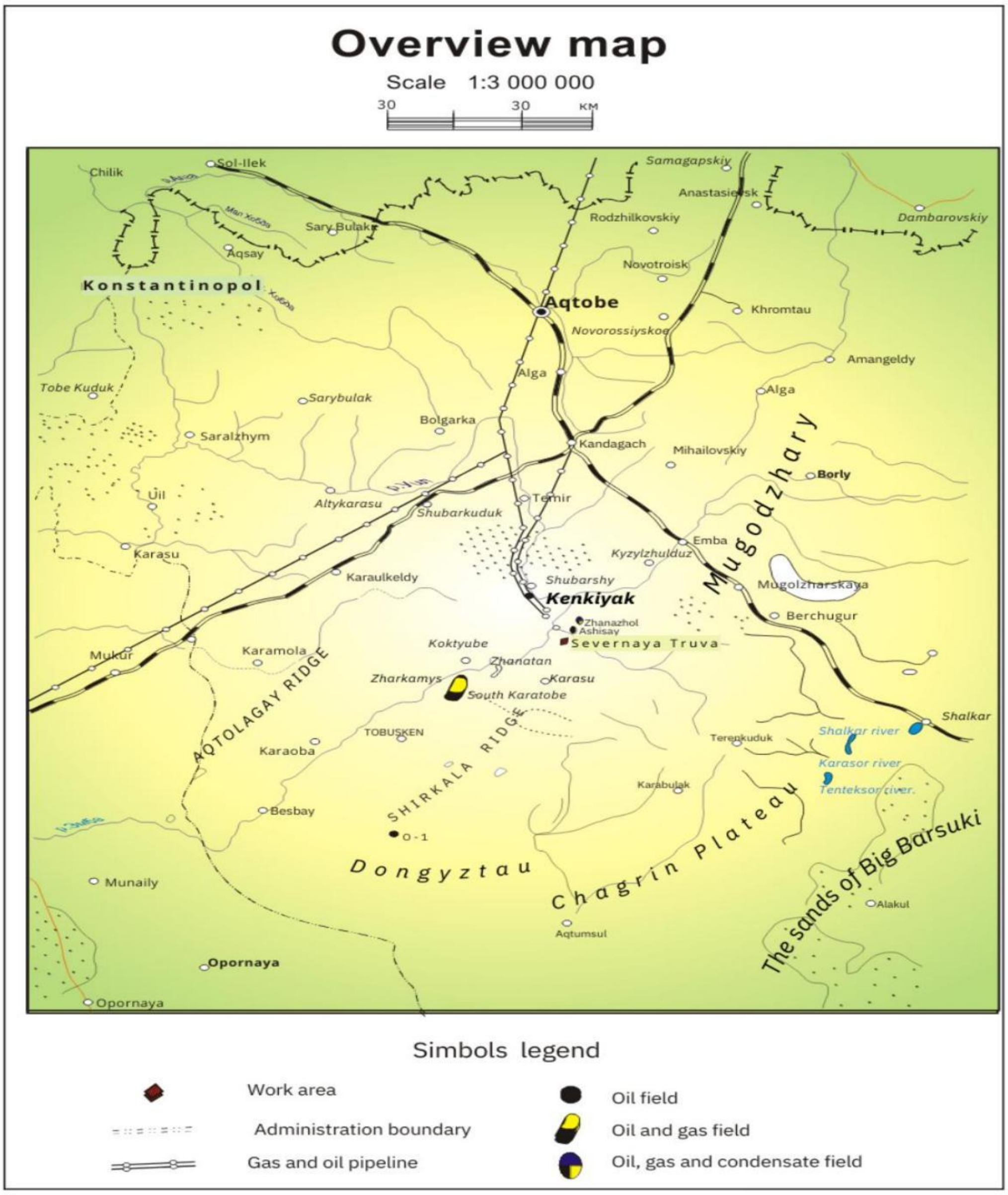


Figure 7 - Overview map of the Kenkiyak field[1]

The geographical position is flat, semi-desert region. The relief is 170-230 m above sea level, flat. The weather is strictly continental, the average summer temperature is +34 - 400C, the average winter temperature is -35 - 400C. The main wind directions are from the east, from the southeast to the west. Average speed 5-6 m/s, strong wind up to 28 m/s in places. In winter, the average snow thickness is 17 cm, the frost thickness is 1.8 m. The annual amount of moisture is 250 mm.

2.2 Geological knowledge

The sedimentary deposits of the Paleozoic - Permian, Mesozoic - Triassic, Jurassic, Cretaceous, Cenozoic-Quaternary age take part in the geological structure of the deposit.

The post-salt deposits of the Kenkiyak field are divided into two sections according to the distribution conditions: the Main area and the Steep slope. In general, the area of the post-salt oil complex of the field is 2673.8 ha (27.27 km^2)

As a result of drilling and testing of wells, the following productive horizons have been established in the Main Area: Barremsky, Gotherivsky - in the Lower Cretaceous deposits, J_2-I, J_2-II, J_2-III - in the Middle Jurassic deposits, T_1-I and T_1-II - in the Lower Triassic deposits, P_2t - Upper Permian deposits.

In the Steep Slope area, there is a conglomerate horizon (in the Lower Triassic deposits) and horizons III-XI in the Upper Permian deposits.

Exploration work on the Kenkiyak suite, discovered in 1932, began in 1956, the first oil inflow was obtained in 1959 from two structural exploration wells of the Lower Triassic (well K-34) and the Middle Jurassic (well No. K-17). From that year to 1961, exploratory drilling was carried out, including a total of 42 exploration, 1 parametric and 21 structural research wells. As a result, oil deposits were discovered in the Upper Permian, Lower Triassic, Middle Jurassic and Cretaceous sedimentary strata.

In October 1956, structural and exploratory drilling began on the Kenkiyak uplift. When drilling wells K-17, K-27, K-34, sands and sandstones of the Jurassic and Lower Triassic age were raised, saturated with oil. In subsequent years, as a result of exploratory drilling, it was proved that not only the post-salt complex, but also deep-lying sub-salt deposits are oil-bearing.

According to the results of drilling the cuttings, the oil reserves of the field were calculated, and later in 1962 the same calculations were approved by the State Reserves Committee of the USSR in the amount of 110.9 million tons in categories A + B + C1 + C2.

In 1966, by the order of “Embaneft”, the NPU “Kenkiyakneft” was organized.

Since 1997, shares in the amount of 60% of the Chinese National Company CNPC were sold, after which it became known as CNPC-Aktobemunaigas JSC.

2.3 Lithological and stratigraphic characteristics

Paleozoic group (PZ)

The exposed part of the Paleozoic is represented by Devonian rocks, the lower and middle Carboniferous, as well as better studied sediments of the lower and upper sections of the Permian system(Figure 8)

Lower Permian deposits (P1) (Figure 10) are represented by the Kungurian Stage (P1k). These include halogen hydrochemical sediments and a comparatively thin terrigenous-sulfate stratum overlying them everywhere.

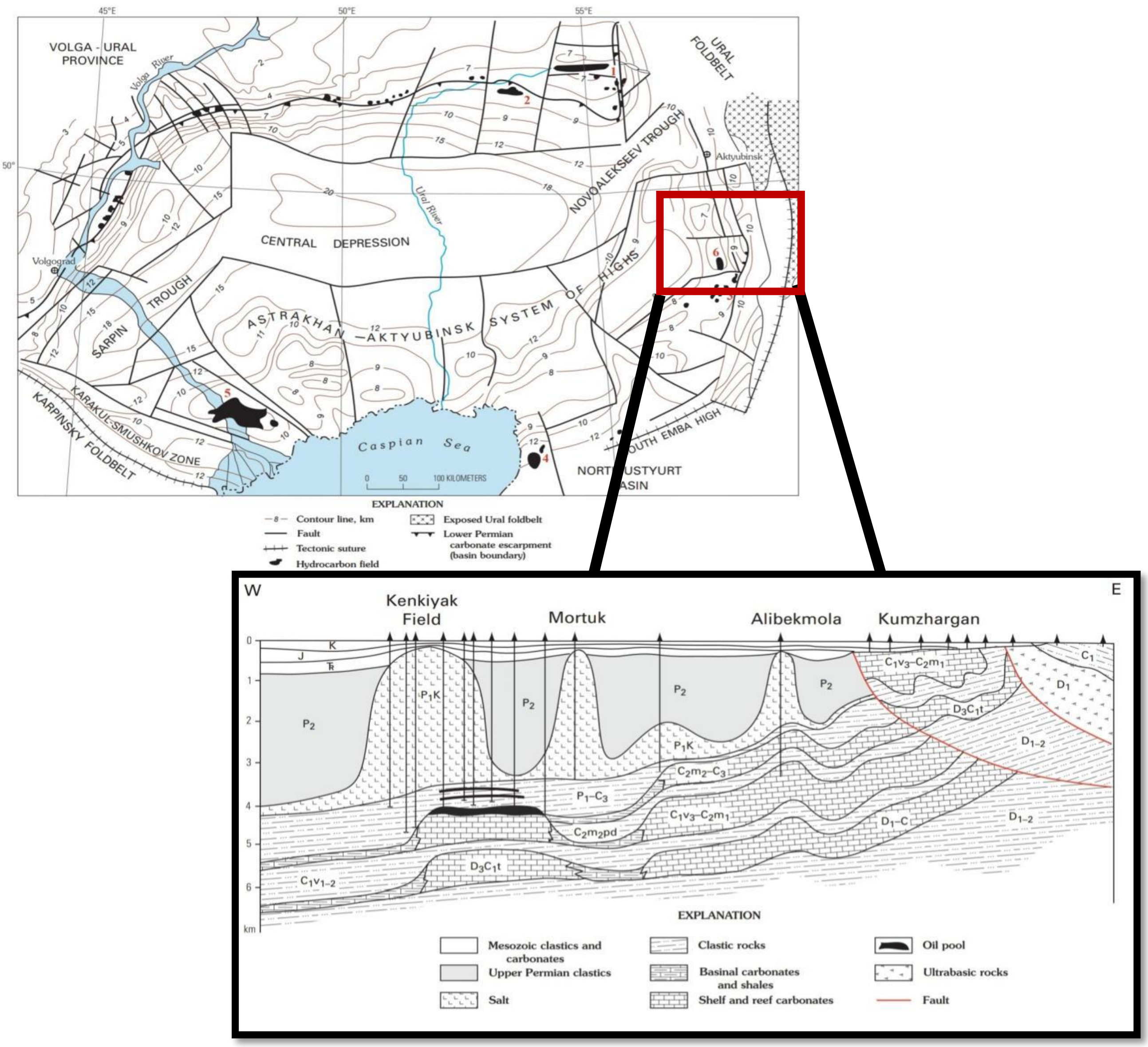


Figure 8 - Structural map of Precaspian basin and Geological profile of Kenkiyak field and near fields [6]

In the section of the Lower Permian deposits, there are 6 productive horizons: P_1k, PI, P-II, P-III, P-IV, PV, separated by well-visible clay sections and Kungur, Artin, Sakmara and stratigraphically combined with Assel deposits.

Kungurian stage. At the Kenkiyak dome, abundant oil was noted in the anhydrites and argillites of keprok in wells 12 and 20, and drip-liquid oil was observed in a number of wells in salt.

Upper Permian (P_2)lie on the eroded surface of the terrigenous-sulfate sequence of the Kungurian stage.

Lithologically , the section of Upper Permian is composed of sandy-siltstone-clayey rocks predominantly of grayish-brown, dark brick-red color, less often clayey-carbonate sediments with subordinate interlayers of sandstones, siltstones, and dolomites. The maximum stripped thickness is 134 m.

Mesozoic group (MZ)

The exposed part of the Mesozoic is represented by sediments of the Triassic; deposits of the lower section (T_1) are mainly distinguished in the volume of the Vetlugian (T_1vt), Baskunchak (T_1bs) series and, to a much lesser extent, the upper section (T_3).

The maximum thickness of the Lower Triassic that has been discovered is 390 m. Two productive oil horizons (I and II) composed of sands and sandstones are distinguished in the Lower Triassic.

The Upper Triassic at the deposit is poorly developed and not studied.

Jurassic system (J)

The deposits of the Jurassic system are represented by two divisions - lower and middle. The sediments of the Upper Jurassic in the area of the deposit are eroded (Figure 11,12).

Lower Jurassic Division (J_1). The sediments of the Lower Jurassic occur unevenly and non-universally on the eroded surface of the Triassic.

Lithologically, they are composed of slightly compacted, sometimes cross-bedded sands and sandstones, light-colored, medium-grained with a content of semi-octane gravel, 2-5 mm in size.

The clays are gray with a slight brownish tinge, layered, silty with charred small plant remains.

Middle Jurassic (J_2) It is represented by lagoonal-continental sandy-siltstone-argillaceous sediments of charred plant detritus, interlayers of brown coal from 3-5 to 40-50 cm thick. The color of the rocks is predominantly gray, brownish-gray, dark gray, less often with a greenish tinge. Fine-grained sandstones on clay-carbonate cement. Silts are present in most cases in the form of thin interlayers and even plaques on the planes of stratification of clays and sandstones. The exposed thickness is 100-140 m. (from top to bottom), where the main oil reserves of the field are concentrated.

Upper Jurassic (J_3)was not isolated at the deposit. The Upper Jurassic deposits were probably completely eroded(Figure-9). The microfaunal complex found in individual rock samples from the base of the Hauterivian Stage characterizes both the

Upper Jurassic and Valanginian age of these rocks, which indicates their redeposition.

Cretaceous system (K)

In the Lower Cretaceous section of the Kenkiyak deposit, sediments of the Gauterivian, Barremian, Aptian, and Albian stages are distinguished.

*Gautherivian Stage (K1g).*Lithologically, Hauterivian sediments are predominantly represented by clays of marine origin with interlayers of sandstones, siltstones, less often marls and limestones, the number of which noticeably increases in the lower part of the section.

The exposed thickness of the Hauterivian is from 30 to 60 m.

Barremian (K1br). Lithologically they are composed variegated clays with subordinate interlayers of siltstones, sandstones, compacted sands, rarely limestones.

The thickness of the Barremian deposits varies from 40 to 85 m.

There is a sandy horizon at the base of the Barremian section. In the crest of the field, this horizon is oil-bearing.

*Aptian Stage (K_1a).*In general, the section of the Aptian deposits is composed mainly of dense clays, dark gray to black, viscous. The clays are often layered with thin interlayers and deposits of light gray silt along the layering planes. The thickness of the Aptian rocks in an area of 30-70 m.

Albian Stage (K_1al). Lithologically, the Albian stage is composed of coastal-marine and continental sandy-argillaceous rocks; the lower part of the section is composed of clays; sand content increases higher. Clays are gray, silty, non-carbonate, layered with ODP. Sands and sandstones have lighter shades of gray color, fine-grained. The largest exposed Albian thickness in the area is 165 m.

Upper section (K_2)represented by the Santonian and Campanian stages.

*Santonian Stage (K_2st)*layer deposits with a break lie on the Upper Albian sands and have at their base a phosphorite layer 0.2-0.3 m thick, consisting of nodules, in some places forming a continuous slab. Above the phosphorite layer lie yellowish-gray, fine-grained, clayey, calcareous sands, with interlayers of gray, sandy clays, loose sandstones. The thickness of the layer is 0.15-0.30 m.

Campanian(K2km) is represented by a stratum of clays of greenish-gray and gray color, gypsum-bearing, carbonate, dense, thin-layered, banded. Thickness up to 60-80 m.

Cenozoic group (КZ)

Paleogene system (P) the deposits of the system have a boundary distribution and are represented by the middle and lower parts of the Upper Eocene, clays, flasks with phosphorite concretions at the base.

*Neogene system (N)*enjoys limited distribution. Small areas are blocked by them in the southwestern part of the region.

Quaternary system (Q) represented by four divisions. These are deposits of floodplain terraces, floodplains, watershed spaces, pebbles, sands, sandy loams, loams, clays, eolian sands.

Table 1 – Lithological scheme of Kenkiyak oil field

System(series)	Stage	Productive horizon	Characteristics
Quaternary (Q)		-	sandy loam,loam,sands
Cretaceous (K)	Barremian (K1br) Hauterivian (K1ht)	I (K1br; K1ht)	Sandstones, mudstones, siltstones
Upper Jurassic (J) Middle Jurassic(J2)	Tithonian(Volgian) (J3t)	II (J2-I) III (J2-II; J2-III)	sandstones, clays
Lower Triassic (T1)	Olenekian(T1o) Indian(T1i)	IV(T1-I, T1-II)	sandstones, clays
Upper Permian (P2)	Tatarian(P2t)	V	Sandstones, clays, mudstones, siltstones
Lower Permian (P1)	Kungurian (P1K)	P1k	Sulfate-terrigenous rocks
	Artinskian (P1ar)	P1-I	Sandstones, mudstones with separate layers of gravelstones and conglomerates
		P1-II	
		P1-III	
	Sakmarian (P1S)	P1-IV	sandy-clay rocks
	Asselian (P1a)	P1-V	Sandy-argillaceous rocks with limestone interlayers and inclusions of gravel-pebble material
Middle carboniferous	Lower Bashkirian (C2b1)	KT-II	Organogenic-detrital, organic-terrigenous, oolitic limestones
Lower Carboniferous (C1)	Serpukhov (C1S)		Limestones with clay interlayers
	Visean (C1V)		Limestones, dolomites
Devonian (D)			Carbonate rocks with clay interlayers

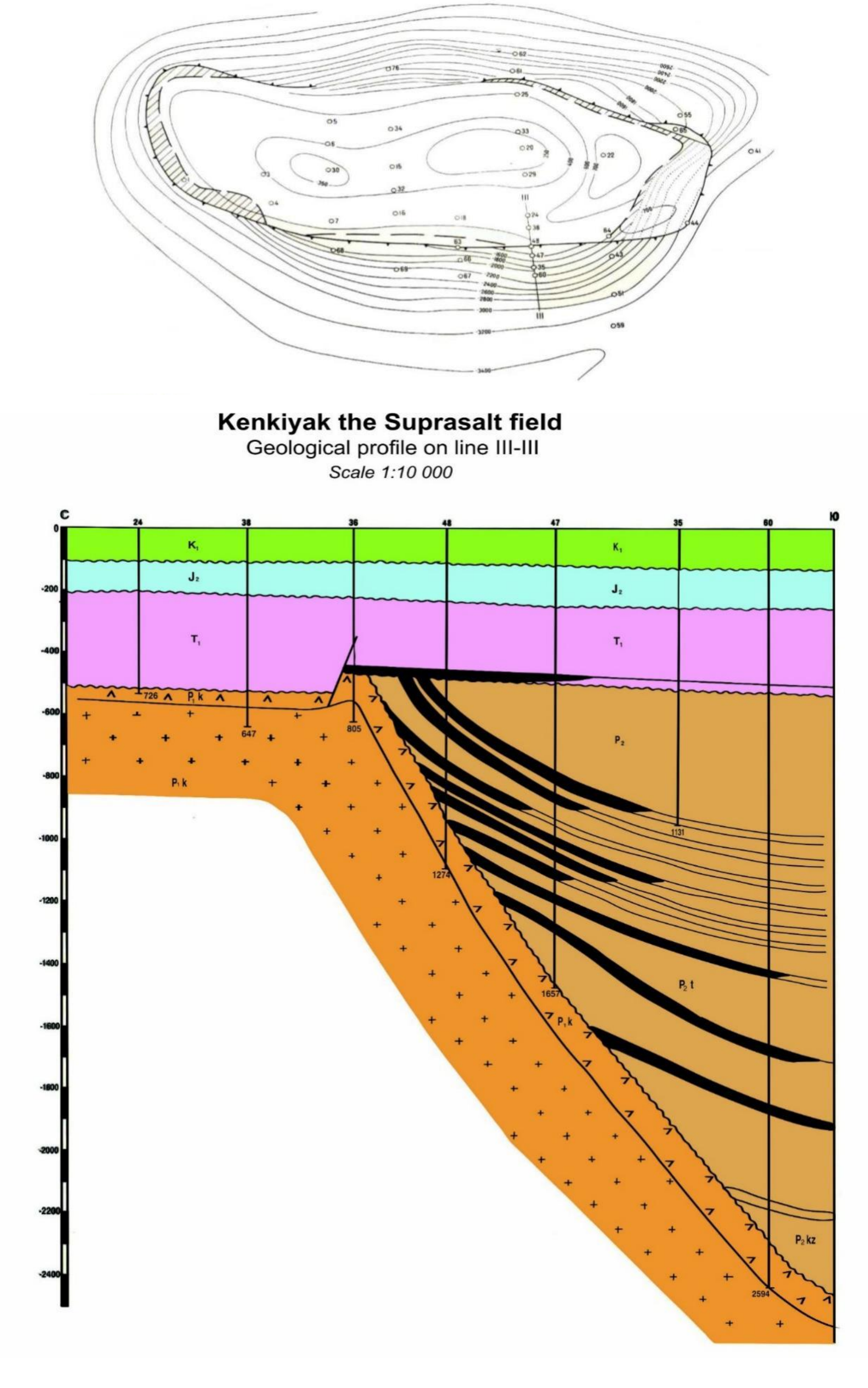


Figure 9 - Structural map of post-salt complex and geological profile III-III, digitized by Bakytkereyeva A. [8]

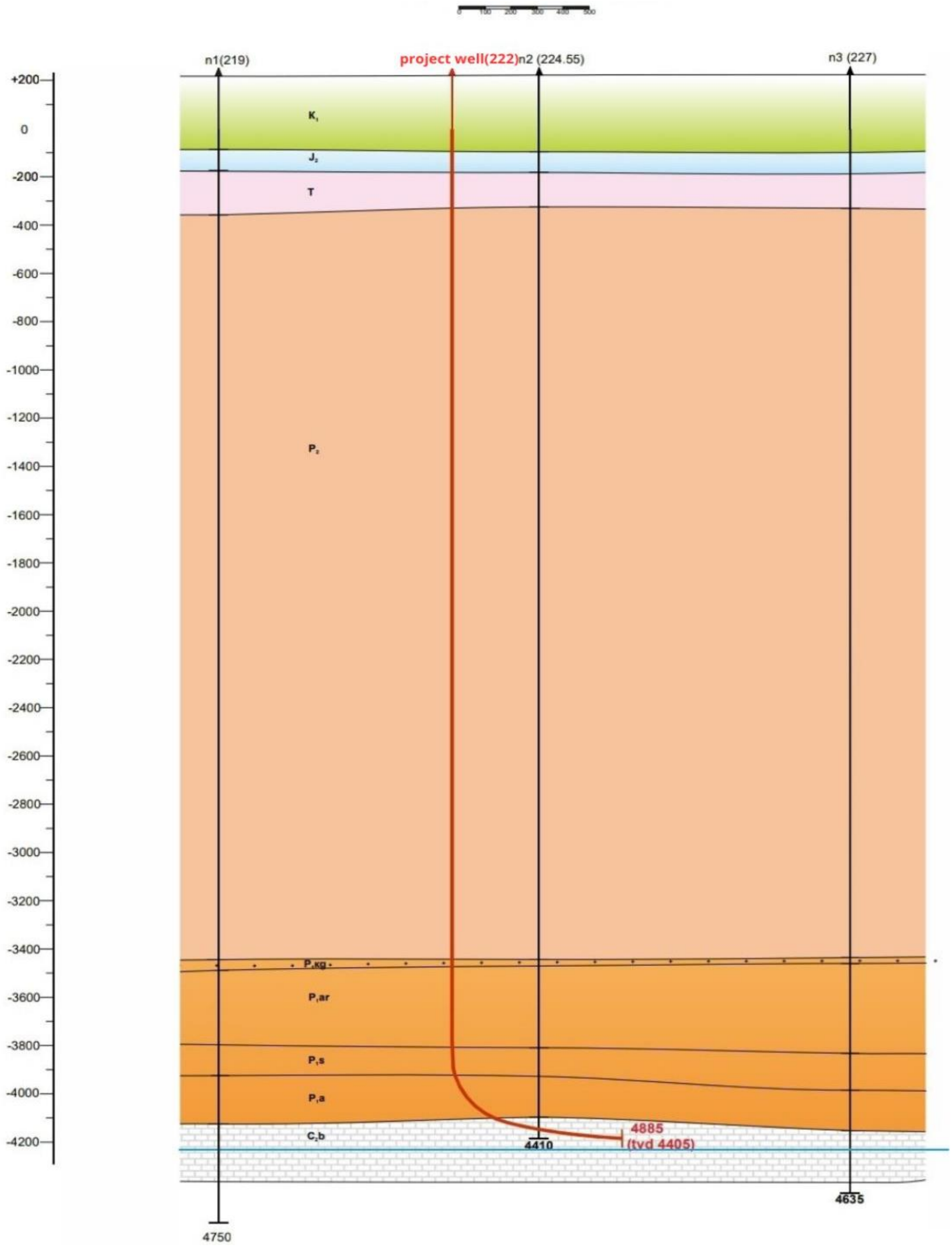


Figure 10 - Geological profile of Kenkiyak pre-salt field, digitized by Bakytkereyeva A. [11]

2.4 Tectonics

In tectonic terms the region is a junction zone between the Caspian depression and the Mugodzhar folded system. According to the structural-tectonic zoning of the Mesozoic complex, the Kenkiyak deposit is located in the Zhanazhol uplift zone (Figure 11).

In the complex of post-salt deposits, two structural stages are distinguished – lower and upper, differing from each other in the conditions of occurrence, the intensity of tectonic movements, the presence of angular and stratigraphic unconformity at the contact between them.

The lower structural series combines deposits of the Upper Permian and Lower Triassic sections. The upper structural series is separated by a stratigraphically unconformable surface of Jurassic and Cretaceous deposits. The unconformity between the series is characterized by the occurrence on different slopes of the Lower Jurassic and Middle Jurassic sections.

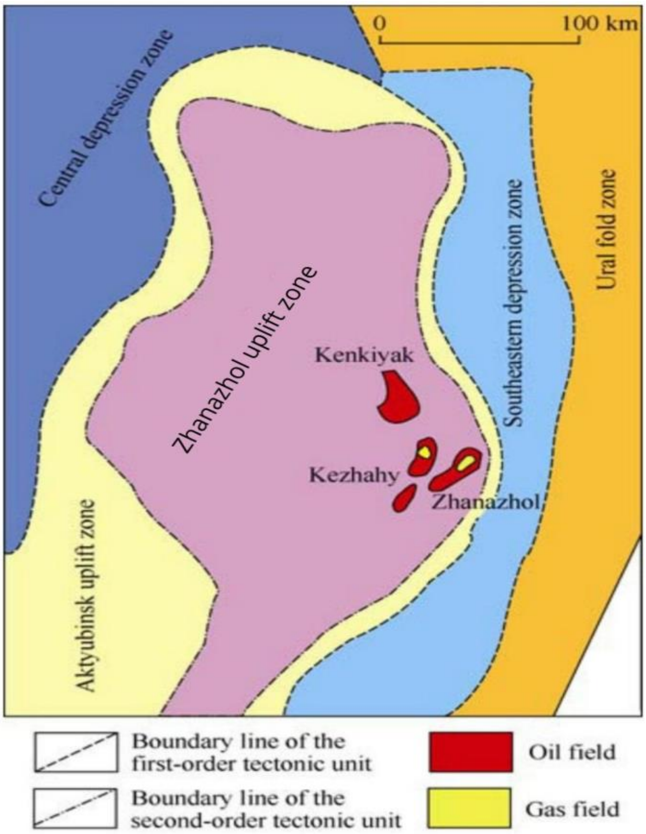


Figure 11 - Tectonic map of the Kenkiyak field [9]

The upper structural series has a very complex geological structure. This is explained by the presence of long-eroded surfaces, significant changes in the thickness of stratigraphic slopes during tectonic disturbance. Compared to the lower row, the upper structural row is characterized by a much smoother rock bed and a slight angular incompatibility.

According to geological formations and structural maps compiled on three Jurassic slopes, the post-salt deposits in the Kenkiyak field are divided into northern and southern wings by a field distribution graben.

The northern flank of the structure is characterized by a very steep brachyanticlinal fold bounded by the main strike of the graben from the south. The fault dips to the south at an angle of 60-65°, and its amplitude decreases by 20-25° along the Aptian deposits.

3 Main part

This part presents the results of the analysis of the characteristics of productive horizons, such as oil and gas potential and oil saturation of the reservoirs in accordance with the reservoir features of the rocks, based on core samples, and also a comparison of the geological reserves of the field.

3.1 Oil and gas content

In 1959 when testing the structural exploration well K-17, an oil inflow was obtained with overflow through the mouth from the second Middle Jurassic horizon.

It should be noted that signs of oil on the Kenkiyak dome were observed in brecciated anhydrites and argillites of Kungur caprock in well 12 interval 470-488m and in well 20 interval 520-527m. Up the section, the commercial oil and gas potential of the Upper Permian deposits has been proven.

Barremian productive horizon. The horizon is opened by all drilled wells. The total thickness of the horizon varies from 10.1 m to 41.8 m. The effective oil-saturated thickness varies from 0.6 to 37.3 m. For the period 2018-2019, 189 wells were drilled and tested, where good oil inflows were obtained from 3.2 to 21 m3 / day

Hauterivian productive horizon. The Hauterivian horizon is the reference reference horizon for the correlation. The horizon thickness varies from 15.8m (well No. 61105) to 29.3m (well No. 61047). The effective oil-saturated thickness varies from 0.4 to 8.9 m.

Productive horizon J2-I. For the first time, the first Middle Jurassic productive horizon was identified on the basis of field geophysical materials in the structural exploration wells K-27, K-41, K-40, K-77, etc.

The horizon is characterized by reservoir-arched tectonically and lithologically shielded oil deposits(Figure-12). The horizon was tested for the first time in the G-34 well together with the J2-II horizon, where oil was obtained with flow rates of 0.4 and 0.5 m3/day.

Productive horizon J_2-II. This horizon contains 66% of the geological reserves of the entire field, and it is the main development target.

The reservoir is reservoir-arched, tectonically and lithologically limited. Horizon thickness ranges from 25 m to 108.8 m, effective oil pay thickness ranges from 1.6 m to 57.3 m

Productive horizon J_2-III. The section between the J2-II and J2-III horizons is a clayey formation, well traceable over the area of the deposit, with a thickness of 7.3 (well 1265) to 20.7 m (well 139).

The horizon was first tested in 1960. Exploration well G-12, which gave a free flow of oil. The reservoir is reservoir-arched, tectonically and lithologically shielded.

First Lower Triassic productive horizon (T_1-I). The oil deposit of the T1-I horizon is stratigraphically and tectonically shielded. Effective oil pay thickness varies from 4.5m (well K-34) to 17.5m (well G-10)

Second Lower Triassic productive horizon (T_1-II). The oil content was first established in 1959 in the K-34 structural exploration well. The identified oil deposit is stratigraphically and tectonically shielded.

Upper Permian (conglomerate) horizon. The oil content of the Upper Permian horizon has been established only on the northern and southeastern wings of the eastern part of the area.

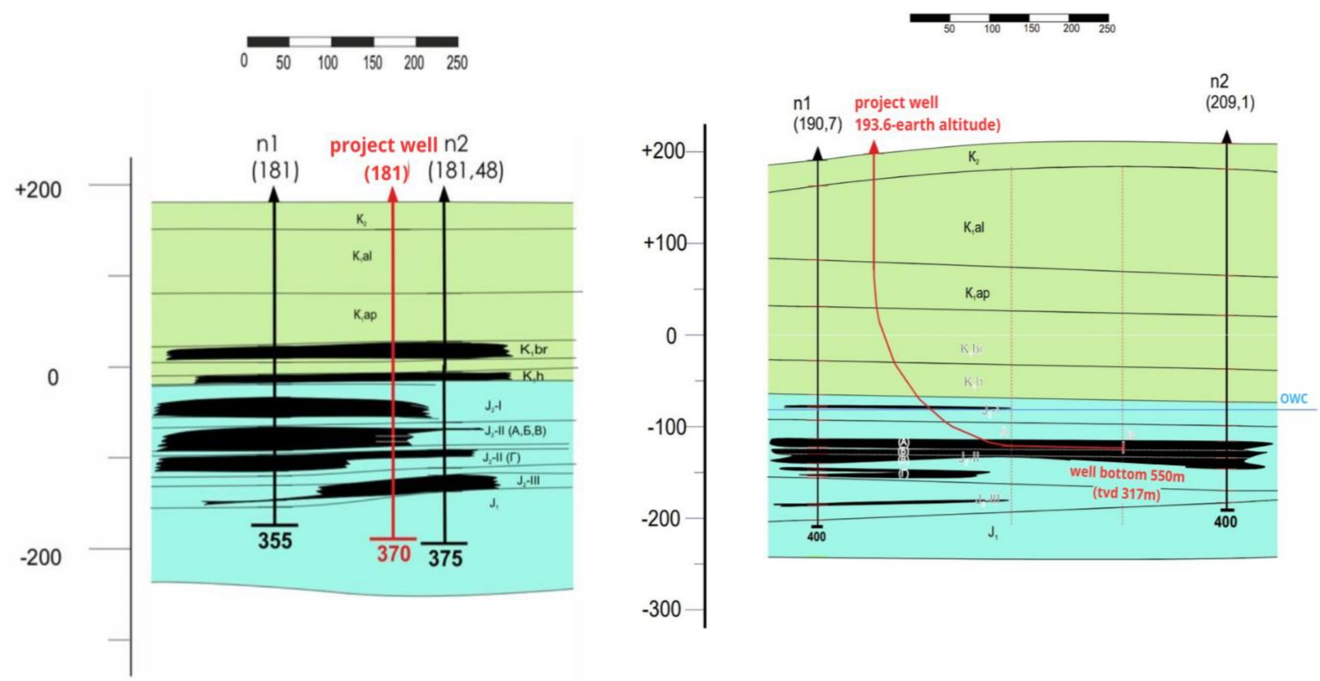


Figure 12– Geological profiles along wells n1-project-n2 of Kenkiyak post-salt field, digitized by Bakytkereyeva A.[12]

Lower Permian productive strata. The identified pay horizons are lenticular types of deposits that do not obey the structural position and possibly represent secondary accumulations formed during vertical migration from the underlying carbonate reservoir. Due to the very strong lithological variability of the constituent rocks, the distribution zones of productive reservoirs were limited to the middle distance between wells in areas illuminated by a large number of wells , and in areas of lesser knowledge, the well drainage radius was taken beyond the productivity boundary according to the approved well grid.

In the pre-salt complex, as a result of detailed reservoir correlation involving the results of well testing in the section of terrigenous Lower Permian deposits, 6 productive horizons P1k, P-I, P-II, P-III, P-IV, PV were established (Figure 13).

Productive horizon P_1k. The basis for the selection of this horizon was the receipt in well 96 from the interval of 3575-3620 m (terrigenous-sulfate deposits of kungur) of an open fountain of oil. At the testing stage, the oil flow rate was 1068.9 m3/day at a 50 mm choke, the associated gas flow rate was 241.5 thousand m3/day. From April 14 to June 15, 1976, the well was in trial operation with an oil flow rate of 504 m3/day per 25 mm. fitting.

Productive horizon P-I stratigraphically confined to the Artinskian stage of the Lower Permian. The horizon is a lithologically shielded reservoir. The horizon thickness ranges from 20 m (well 106) to 130 m (well 7-K), the effective oil-saturated thickness varies from 1.2 m (well H8101) to 10.6 m (well 231). The number of reservoir interlayers varies from 1 to 8, averaging 3, the net-to-gross ratio varies from 0.09 to 1, averaging 0.6.

Productive horizon P-II confined to the middle part of the Artinian Stage of the Lower Permian. The total thickness of the horizon ranges from 87 m (well 8039) to 227.7 m (well 4-K).

The oil deposit discovered here is lithologically limited by a vast clay zone and areas with water-saturated reservoirs located at the same or hypsometrically higher elevations. The productivity of the P-II horizon was proven by the results of testing thirteen wells (G-88, G-90, G-93, G-96, G-108, G-109 and G-104, G-113, G-115, 119, G -231, G-232, G-233) with oil flow rates from 0.25 m3/day per 3 mm. choke (well G-119, depth 3863-3888 m) up to 1068.9 m3/day per 50 mm. fitting.

Productive horizon P-III. Stratigraphically confined to the lower part of the Artinskian. In this horizon, according to the data of drilled wells, there is a deposit lithologically shielded by a vast zone of the absence of reservoirs, among which 7 areas with oil-saturated and water-saturated thicknesses have developed.

The productivity of the P-III horizon was proven by testing twelve wells (G-86, G-91, G-93, G-104, G-115, G-116, 7001, 7016, 7024, 7049, 8054, 7-K) with flow rates from 0.62 m3/day (well G-91, depth 4099.4-4109.9 m; 4117.6-4127.1 m) to 250 m3/day (at 50 mm choke well G-116).

Productive horizon P-IV. Stratigraphically, it is confined to the Sakmarian stage and has a deposit lithologically shielded from all sides. The productivity of the P-IV horizon was proven by testing nineteen wells with flow rates from 0.53 m3/day (well G-113, int. 4026-4032 m, 4044-4052 m) to 124 m3/day with a 10 mm choke (well G-119, depth 4119-4150 m), of which wells G-115, 7001, 7010, 7037, 7049, 8001, 8004, 8005, H8018A, 8031 and 8054 were or are in the production well.

Productive horizon P-V. It is confined to the Asselian stage of the Lower Permian and has an oil deposit lithologically screened by a vast zone of development of impermeable rocks.

The productivity of the P-V horizon has been proven by testing wells G-92, G-104, 7001, 7016, 8007, H8024, 8031 and 8072 with flow rates from 1.08 m3/day.

Carbonate productive stratum (KT-II). The productive horizon is a massive reservoir oil deposit. The full section of the KT-II carbonate structure was penetrated by two wells 3K and G-235, the total thickness of which is 703 m and 718.3 m, respectively(Table 2).

During the development period, the productivity of KT-II was confirmed by testing production wells with initial flow rates from 10 t/day to 687 t/day.

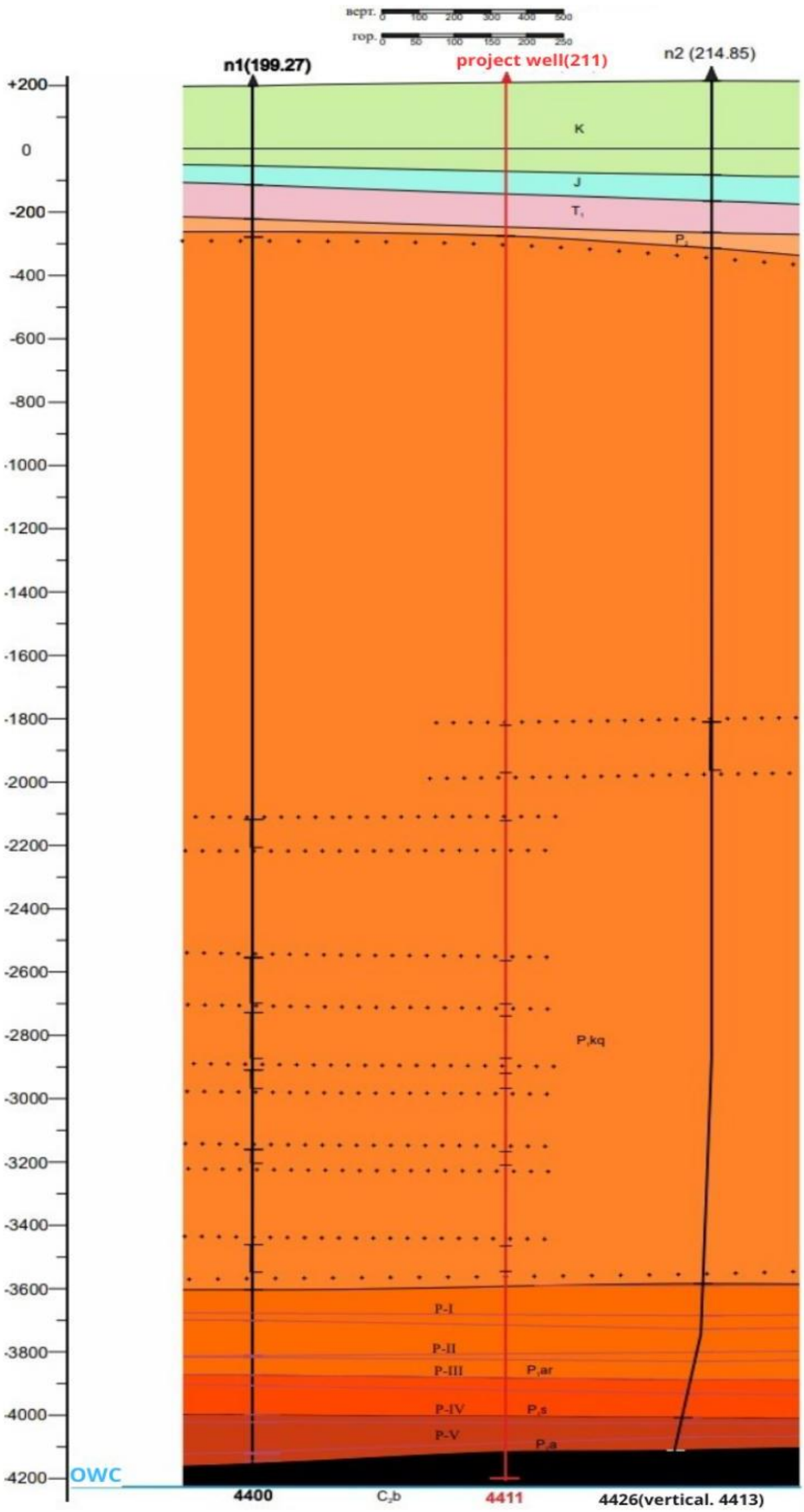


Figure 13 - Geological profile of Kenkiyak pre-salt field, digitized by Bakytkereyeva A.[11]

Table 2 - Characteristics of fluid-saturated thicknesses[11]

Thickness	Name	Objects	
		II (Lower Permian)	I (KT-II)
Total	Average, m	118.6	85
	Coefficient of variation, shares of units.	0.46	0.91
	Change interval, m	0.6-268.8	1.7-526.7
oil-saturated	Average, m	14.3	36.4
	Coefficient of variation, shares of units.	0.56	0.59
	Change interval, m	0.6-63.8	0.8-120
water-saturated	Average, m	8.7	48
	Coefficient of variation, shares of units.	0.7	0.9
	Change interval, m	0.9-41.5	11.2-169.2
Effective	Average, m	18.2	41.1
	Coefficient of variation, shares of units.	0.61	0.75
	Change interval, m	0.6-83	0.8-202.6

3.2 Properties of reservoir rocks of productive horizons according to core sample.

The oil field primarily consists of a dominant pre-salt Carboniferous reservoir (as shown in Figure 14), characterized by an oil zone located below 4,180 meters. The reservoir mainly comprises bioclastic limestone, oolitic limestone, and a small amount of dolomite from the Middle-Lower Carboniferous period. It exhibits low porosity (11.5%) and extremely low permeability ($0.82 \times 10{-}3\ \mu m^2$), with a formation pressure reaching up to 80 Mpa and a pressure coefficient of 1.84. The Permian formation above the reservoir contains substantial salt domes, with a maximum thickness of 3,800 meters.

In terms of oil production, the highest daily output per well exceeds 1,000 tons. However, there is significant lateral variation, as the lowest daily production per well is only 38 tons. The fractures present in the reservoir are a result of overpressure and include various types of fractures. In favorable reservoir locations, these fractures intersect and form a network, leading to the development of highly productive layers.

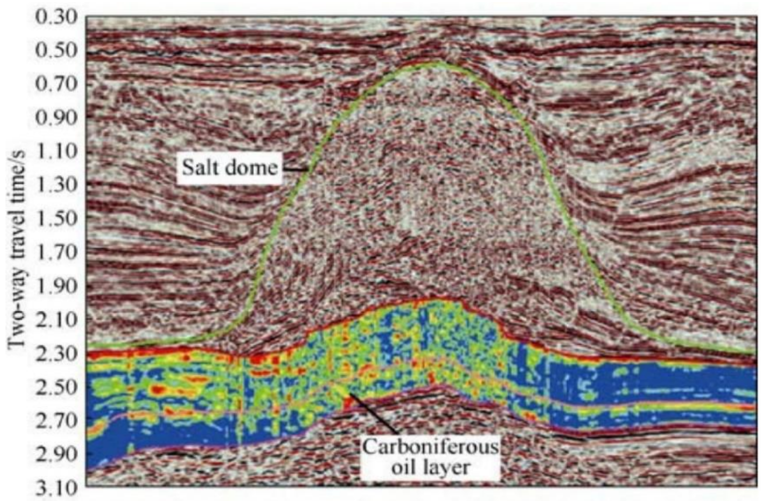


Figure 14 – Seismic section of Kenkiyak oil field[9]

To establish a reference for the porosity and permeability of artificial cores, data on the porosity and permeability of organic cores were initially collected. These core samples were obtained from the carbonate reservoirs of three coring wells in the Kenkiyak Pre-salt oil field (Table 3). The cores display low porosity and ultra-low permeability(Figure 15,16), with an average porosity of 6.99% and an average permeability measurement of 0.67×10−3 μm².

Table 3 – Porosity and permeability of cores in the reservoir of the Kenkiyak pre-salt oil field

Well №	**Core №**	**Porosity %**	**Permeability,10^{-3}μm²**
7001	no.6-8	4,07	0,214
	no.7-21	5,19	0,017
	no.7-29	5,54	0,017
	no.6-33	3,25	0,178
8001	no.218	6,96	0,079
	no.302	7,3	0,009
	no.362	7,71	0,047
8016	no.683	12,29	0,012
	no.484	7,91	0,975
	no.676	9,73	0,089

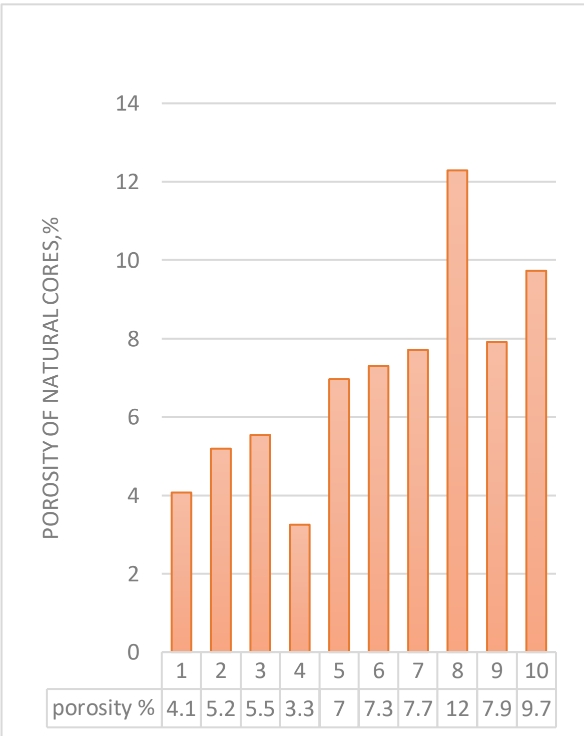


Figure 15 – Porosity of carbonate reservoir core

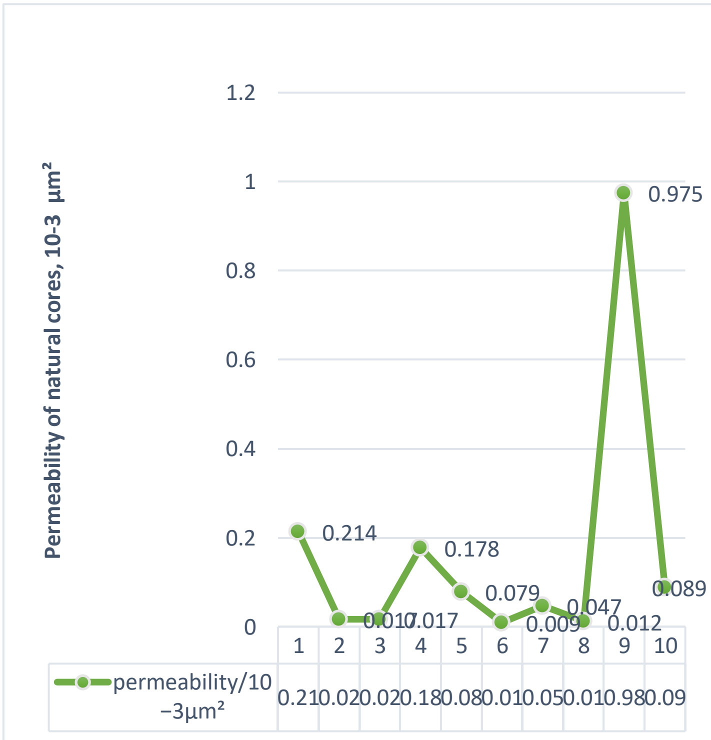


Figure 16 – Permeability of carbonate reservoir core

The process began by compacting various-sized quartz sands with natural carbonate rock powder in specific proportions. The mixture was then cemented with calcium carbonate and dried in a thermotank at 90°C. Once cooled, these mixtures formed artificial cores with a specific pore structure, representing matrix cores of a porous reservoir without fractures(Figure-17). Subsequently, fractures were introduced into the artificial cores to simulate unpacked, semi-packed, and fully packed scenarios. The porosity and permeability of these artificial cores are detailed in Table 4.

Table 4 – General data of artificial cores

Core No.	Matrix		Unpacked		Semi-packed		Fully packed	
	Porosity/%	Permeability/ 10^{-3} μm^2	Porosity/%	Permeability/ 10^{-3} μm^2	Porosity/%	Permeability/ 10^{-3} μm^2	Porosity/%	Permeability/ 10^{-3} μm^2
3-8	11.36	9.09	11.82	29.03	17.52	37.73	16.58	27.44
3-9	7.85	16.67	10.69	40.22	12.18	24.34	11.10	17.15
3-10	6.73	0.04	7.64	514.33	7.33	13.43	3.07	0.01
3-11	5.93	2.39	6.85	115.66	7.95	977.56	9.39	1.66
3-12	11.83	6.77	12.92	137.80	12.37	59.97	10.89	4.75
3-13	5.88	0.35	6.71	1.16	6.53	0.74	6.84	0.08
3-14	21.43	10.0	22.44	44.98	15.43	19.24	15.06	7.62
3-15	8.48	0.05	11.79	31.61	15.70	61.31	11.89	23.63
3-16	18.62	0.05	17.62	15.80	12.71	23.84	12.20	0.03
3-17	10.46	0.08	10.93	25.65	10.46	27.68	10.16	33.80
3-18	16.07	0.81	16.35	1.19	16.61	0.20	16.49	0.14

The analysis of stress sensitivity experiments were managed on the 11 artificial cores (Table 4) and no.676 natural core. The results of experiment with these 12 cores are similar.

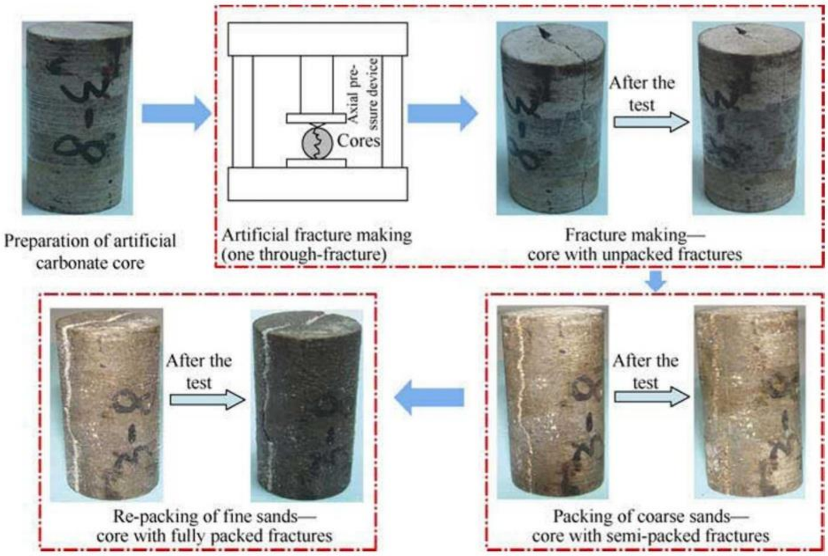


Figure 17 – Conducting experiments on artificial cores. [5]

Regarding the matrix cores, the porosity only experienced a slight decrease (around 2%) with increasing confining pressure. Upon pressure reduction, the recovery rate of porosity and permeability was high, reaching 99.0% and 95.7% respectively. However, complete recovery was not achieved, indicating elastoplastic characteristics.

In cores with unpacked fractures, (Figure-18) the fractures were devoid of fillers. When the pressure decreased, the recovery rate of permeability was low, measuring only 31.4%, demonstrating plastic features.

For cores with semi-packed fractures, the presence of supporting materials within the fractures resulted in a relatively small recovery rate of permeability, which stood at 48.5% during pressure reduction.

The cores with fully packed fractures exhibited a high degree of filling in the fractures. After pressure decrease, the recovery rates of porosity and permeability reached as high as 98.5% and 93.0% respectively.

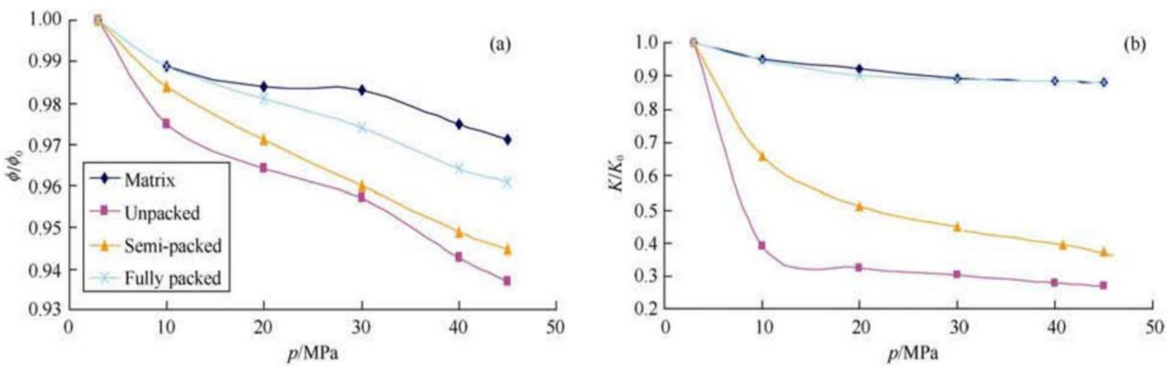


Figure 18– Comparative curves illustrating the changes in porosity and permeability of cores with varying packing degrees.(samples 3-8 in fig.17) [5]

The stress sensitivity of reservoirs is enhanced because of the existence of fractures. The packing degree of fractures has a large impact on the stress sensitivity of reservoirs. With the decrease of the packing degree of fractures, the stress sensitivity of rocks is enhanced. With the increase of confining pressure, the variation of porosity and permeability shows good exponential variation regularity.

Reducing the pore pressure in the reservoir, generally, will increase the effective stress, and cause the rock mass that is the reservoir to strain. It also will control the exchange of fluids between the intact rock and the fractures.

The fractures in the Kenkiyak pre-salt reservoir can be categorized into macro fractures and micro fractures based on their scale and size. Macro fractures are visible in the core samples and are approximately 0.01 to 10 millimeters wide and 0.4 to 1.6 meters long.

Figure 19 – Fractures arise due to tectonic stresses [9]

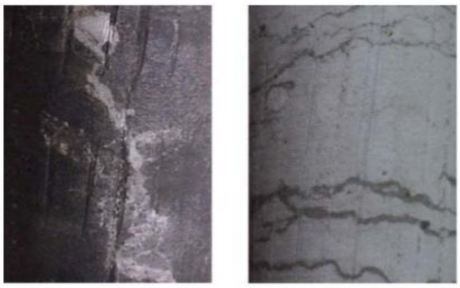


Figure 20 – Fractures form as a result of diagenesis [9]

In terms of fracture genesis, fractures in the Carboniferous carbonate reservoir can be classified as tectonic fractures, dissolution fractures, stylolites, and hydraulic fractures(Figure 19,20). From the cores obtained from four wells, the following characteristics and origins of fractures can be observed:

Tectonic fractures encompassing regional tectonic fractures and tectonically deformed fractures. In the case of regional tectonic fractures, shear fractures initially form in the rocks, followed by the development of zigzag tension fractures under regional compressional stress. This occurs when the shear strength of the rock is lower than its tensile strength.

The plane shear fractures and tension fractures were generated from the late Carboniferous to the early Permian period. The attitude of these fractures is characterized by two groups of plane shear fractures oriented in the NE-SW and NW-SE directions, respectively (as shown in Figure 19a). These fractures are conjugate, with an included angle of approximately 50 degrees and an aperture of 0.01 to 0.05 millimeters. Additionally, tension fractures are distributed in an east-west direction.

Sectional shear fractures:

These fractures are characterized by four groups of small-scale, unfilled, and oil-bearing fractures that occur mainly in the upper tight rocks. They exhibit a dip of 45 degrees and 90 degrees (as shown in Figure 19a) with an included angle of 20 degrees and 50 degrees, respectively.

Dissolution fractures: Dissolution fractures are formed as a result of denudation, where various early fractures undergo further expansion instead of compaction(as shown in Figure 19c).

Stylolites: Stylolites form when rocks are unevenly dissolved and compressed by underground water in different fissures and intergranular pores under the influence of static pressure(as shown in Figure 20).

Hydraulic fractures: In the Kenkiyak sub-salt reservoir, hydraulic fractures often resemble the shape of early fractures. These fractures have larger aperture under overpressure and form a network with irregular fracture walls. Both walls of the fractures can connect without being completely filled. Both macro fractures and micro fractures exist, but the micro fractures are more prevalent. Core observations and thin section analysis reveal distinct characteristics of hydraulic fractures (as shown in Figure 21).

(a) Brecciated limestone (b) Calcite vein (c) Microscopic characteristics of hydraulic fractures (×50)

Figure 21 - The features of hydraulic fractures caused by overpressure in the Carboniferous reservoirs of the Kenkiyak pre-salt formation.

Calcite veins are a typical feature of hydraulic fractures. Core samples display calcite veins that are 5 to 40 millimeters wide, consisting of macroscopic automorphic crystal calcite (Figure 21b), which is colorless and transparent. Microscopic examination reveals that hydraulic fractures exhibit a radial distribution along the pore (Figure 21c).

The formation of hydraulic fractures is closely linked to abnormally high pore fluid pressure. The mechanism behind the overpressure in the Carboniferous is complex. It involves the expulsion of compaction water from Permian and Carboniferous source rocks into adjacent Carboniferous pores during compaction, as well as the expulsion of hydrocarbon fluid into the Carboniferous after the hydrocarbon generation stage, leading to increased pore fluid volume.

Additionally, under-compaction of source rocks during burial conveys overpressure to the Carboniferous pores, and distinct under-compaction zones have been observed in the Permian mudstone above the Carboniferous. Stresses on the Carboniferous resulting from salt dome activity in two stages (mid-late Triassic and early Tertiary) and matrix uplift also contribute to the formation of overpressure (Figure 22). In summary, the interaction of these factors generates overpressure in the Carboniferous, with pore fluid pressure reaching up to 80 Mpa and a formation pressure coefficient of 1.84.

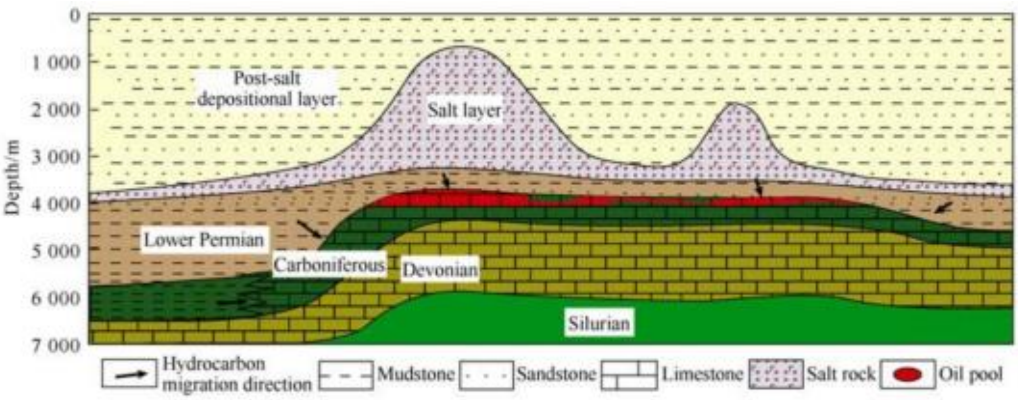


Figure 22 - Schematic diagram of overpressure generation in pore fluid and HC migration in the Kenkiyak Pre-salt Carboniferous formation

3.3 Geological reserves of oil and gas.

According to the approved project document, six development objects have been allocated at the post-salt field:

- I development object - Barremsky and Hauterivian horizons;
- II development object - I Middle Jurassic horizon J2-I;
- III development object - Middle Jurassic deposits with horizons
- J2-II and J2-III;
- IV development object - Triassic horizons T1-I and T1-II;
- V object of development - Upper Permian horizon P2;
- VI object of development - Lower Triassic "conglamerate" and III-XI Upper Permian horizons of a steep slope.

Table 5 - Parameters for calculating oil and gas reserves for the post-salt complex

Horizon	Category	Oil-bearing area, 10^3 m^2 (S)	Thickness, m (H)	Coefficient, fr.of unit			Oil density, g/cm^3	**Initial geological oil reserves, 10^3 t**	Oil recovery factor	Recoverable oil reserves, 10^3 t
				open porosity	oil saturation	conversion rate				
Main area										
I Object (K1br+ K1ht)	B+C1	6020,1	12,9	0,32	0,53	0,995	0,92	**12132,24**	0,18	3113,545
	C2	1953,1	2,8	0,32	0,49	0,993	0,908	**780,2**	0,06	46,8
II object(J2-I)	B+C1	4158,2	9	0,29	0,52	0,995	0,915	**6401,22**	0,119	761,8
	C2	1707,4	3,1	0,32	0,52	0,995	0,915	**858,94**	0,059	50,5
III object (J2-II +	B+C1	33618	15,2	0,32	0,51	0,994	0,914	**75811,6**	0,22	21085,5

J2-III)										
IV object (T1-I+T1-II)	C1	1012,8	5,1	0,26	0,72	0,978	0,885	**850,5**	0,297	234,4
P2 (object V)	C1	554,8	6,2	0,24	0,5	0,98	0,869	**350,4**	0,102	35,7
	C2	229,9	2,6	0,24	0,5	0,98	0,869	**62**	0,051	3,2
Steep slope area										
Steep slope area	B+C1							**5776,9**		2190,5
	C2							**1387,2**		266,7
Total (post-salt)	B+C1							**101322,9**		27421,5
	C2							**3087,9**		367,2

Table 6 – Parameters for calculating oil and gas reserves for the pre-salt complex

Horizon	Category	Oil-bearing area, 10^3 m^2 (S)	Thickness, m	Coefficient, fr. of unit			Oil density, g/cm^3	**Initial geological oil reserves, 10^3 t (Q)**	Oil recovery factor	Recoverable oil reserves, 10^3 t
				open porosity (K)	oil saturation (S)	conversion rate (B)				
P1k	C1	1160	8,8	0,19	0,77	0,578	0,803	780	0.160	19.0
	C2	1510	1,15	0,19	0,77	0,578	0,803	**235**	0.120	125
P-I	B+C1	3558	6,1	0,13	0,64	0,578	0,803	**838**	0,123	103
	C2	4975	1,9	0,13	0,64	0,578	0,803	**374**	0,092	35
P-II	B+C1	9552,5	4,3	0,13	0,6	0,578	0,803	**1495**	0,123	183
	C2	12990	3	0,13	0,6	0,578	0,803	**1433**	0,092	132
P-III	B+C1	14847,5	5,1	0,14	0,65	0,578	0,803	**3207**	0,123	395
	C2	10043	3,4	0,14	0,65	0,578	0,803	**1445**	0,092	133
P-IV	B+C1	22106	6,3	0,13	0,66	0,578	0,803	**5535**	0,123	681
	C2	26007,5	3,9	0,13	0,66	0,578	0,803	**3998**	0,092	369
P-V	C1	9069,9	4,3	0,12	0,68	0,578	0,803	**1482**	0,123	182
	C2	10720,5	4,1	0,12	0.68	0,578	0,803	**1657**	0,092	153
KT-II	B+C1	78119	33,7	0,1	0,77	0,552	0,818	**93645**	0,397	34908
	C2	5651	220,4	0,09	0,76	0,437	0,826	43114	0,281	15851
Total	B+C1							**105028**		36401
	C2							**13521**		2081

Estimation of geological reserves of oil in the Kenkiyak field was carried out using the volumetric method:

$$Q = So \times H \times К \times Ss \times Bc \times \rho \qquad (1)$$

Q – Geological oil reserves, thousand tons;
So – Oil-bearing area, thousand km²
H – Average effective oil-saturated thickness, m;;
К – Porosity coefficient, fractions of units
Ss – Oil saturation factor, fractions of units;
Bc – Conversion factor, fractions of units;
ρ – Oil density, g/cm³

The development of reserves is carried out at a low pace. The main volume of initial geological and recoverable oil reserves is concentrated within the boundaries of object III. The state of oil reserves development for post-salt objects and the field as a whole is presented in Table 5-6, Figures 23-24 show the inventory distribution schedule.

In general, the cumulative oil production for the field is 19650.3 thousand tons, the field is at the last stage of development, the extraction of recoverable reserves is not carried out at a high rate, the peak of production falls on 2011. The value of oil recovery factor was reached at the level of 0.194 shares of units. The value of the remaining recoverable oil reserves is 7771.1 thousand tons, while the availability of reserves at the current level of oil production in 2020. (476.6 thousand tons) is 16 years.

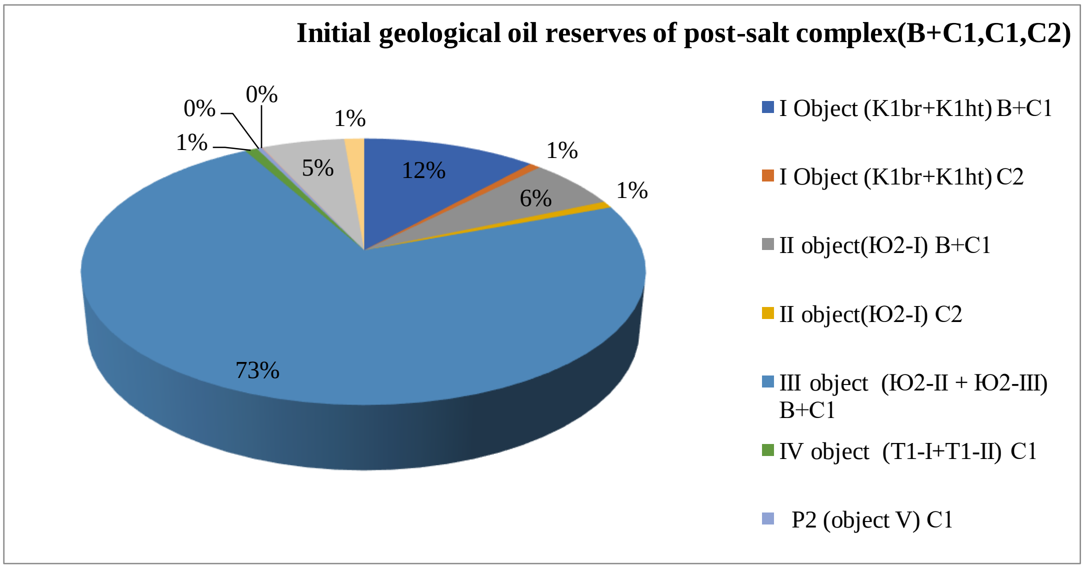


Figure 23 – Pie chart of the distribution of geological reserves of the objects of development of post-salt deposits at the Kenkiyak field

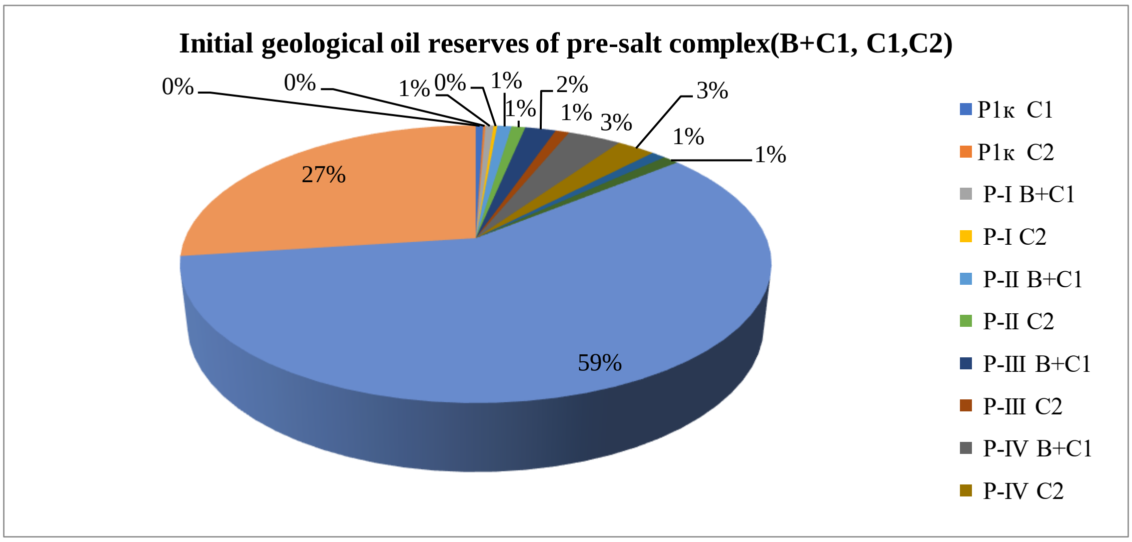
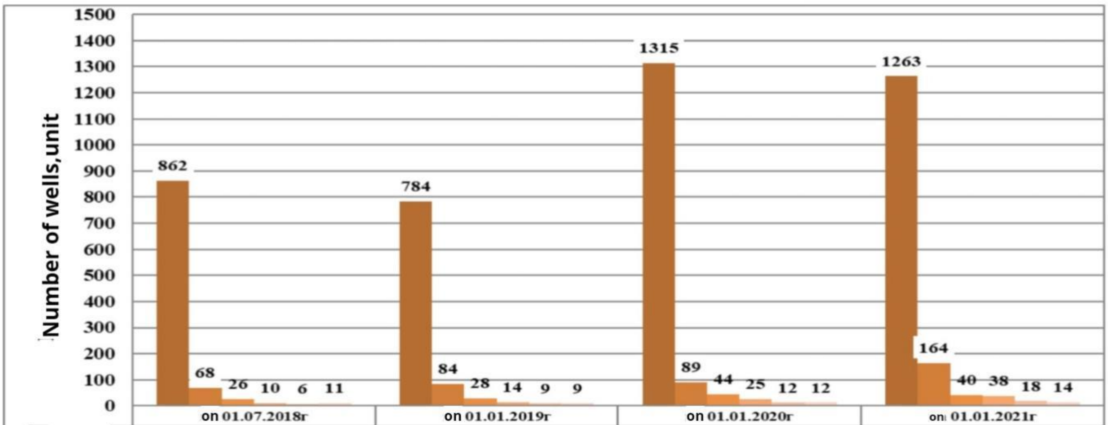


Figure 24 – Pie chart of the distribution of geological reserves of the objects of development of pre-salt deposits at the Kenkiyak field

3.4 Analysis of oil production of the field.

The distribution of the well stock, producing production by oil flow rate, is shown in Figure 25. In relation to 2019, there is a decrease in the number of operating wells with flow rates up to 2 tons / day by 52 units and in the range of 4-6 tons / day by 4 wells.

In other ranges, there is an increase in the number of operating wells, with flow rates from 2 to 4 tons / day by 75 units, in the range of 6-8 tons / day by 13 units, from 8 to 10 tons / day by 6 units, in the group with flow rates over 10 tons/day, there is an increase in wells by 2 units.



	on 01.07.2018г	on 01.01.2019г	on 01.01.2020г	on 01.01.2021г
<2t/day	862	784	1315	1263
2-4 t/day	68	84	89	164
4-6 t/day	26	28	44	40
6-8 t/day	10	14	25	38
8-10 t/day	6	9	12	18
>=10t/day	11	9	12	14

Figure 25 - Distribution of the stock of producing wells of the by oil flow rate

New wells drilled in 2020 are characterized by an average oil production rate of 7.7 t/day, liquid 14.1 t/day, and a water cut of 45.3%. The average annual flow rates of oil and liquid of the operating fund as a whole for the field for 2020 amounted to 2.1 t/day and 14.0 t/day, respectively, the water flooding of the production as of the date of the report was 85.1%. The distribution of oil production in general for the field is shown in Figure 26.

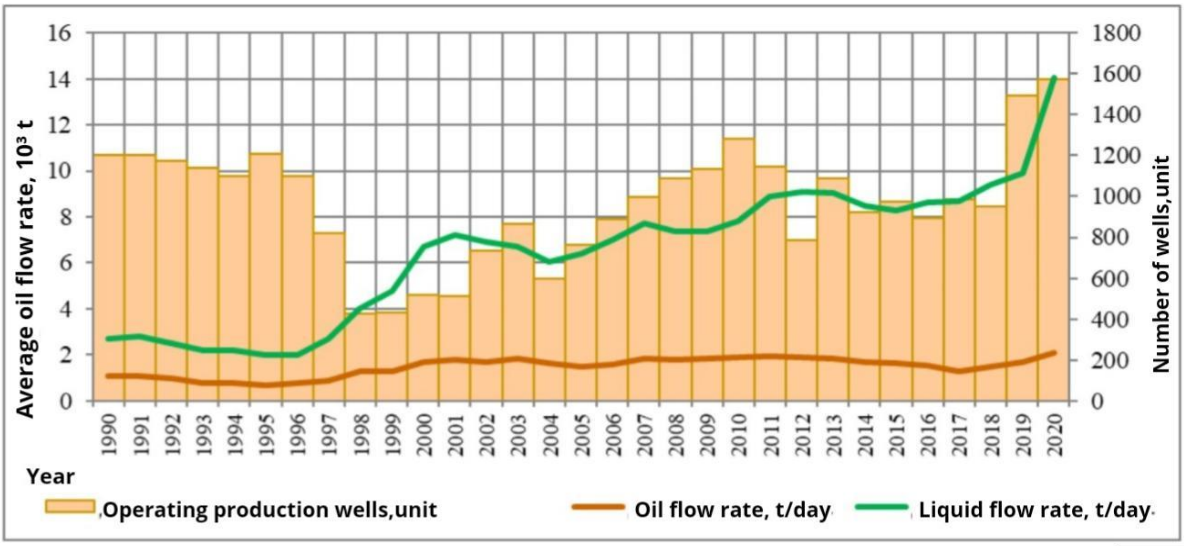


Figure 26 - Dynamics of the operating production well stock and average annual oil and liquid production rates for the whole field

The share of oil produced in 2020(Figure 27-28) from object III amounted to 227.4 thousand tons (or 47.7%) relative to the total volume of oil produced, the second most important is the I development object, which accounts for 182.4 thousand tons (or 38 .3%), the third most important is the VI object, it accounts for 53.49 thousand tons (11.2%). The total contribution to oil production of objects II, IV and V is estimated at about 2.8%.

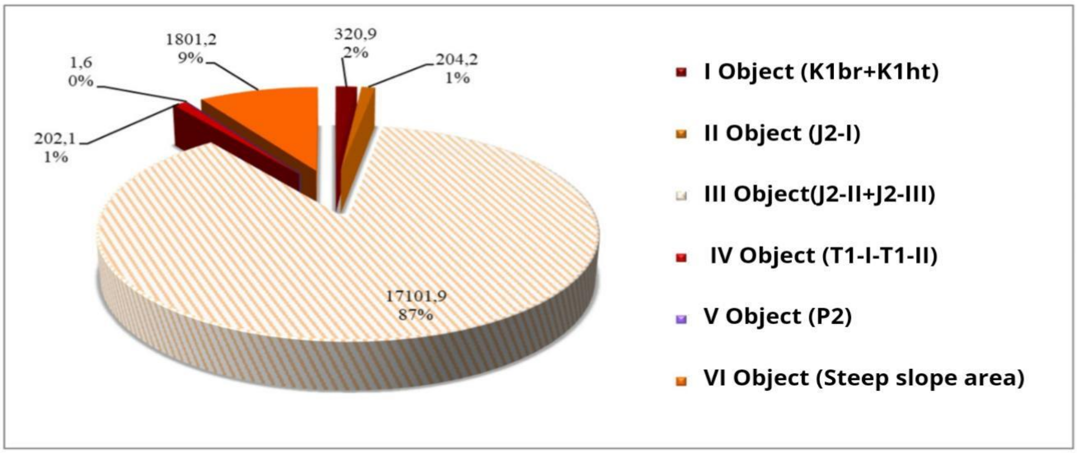


Figure 30 - Pie chart of general oil flow rate by development objects in the period 1990-2020 y

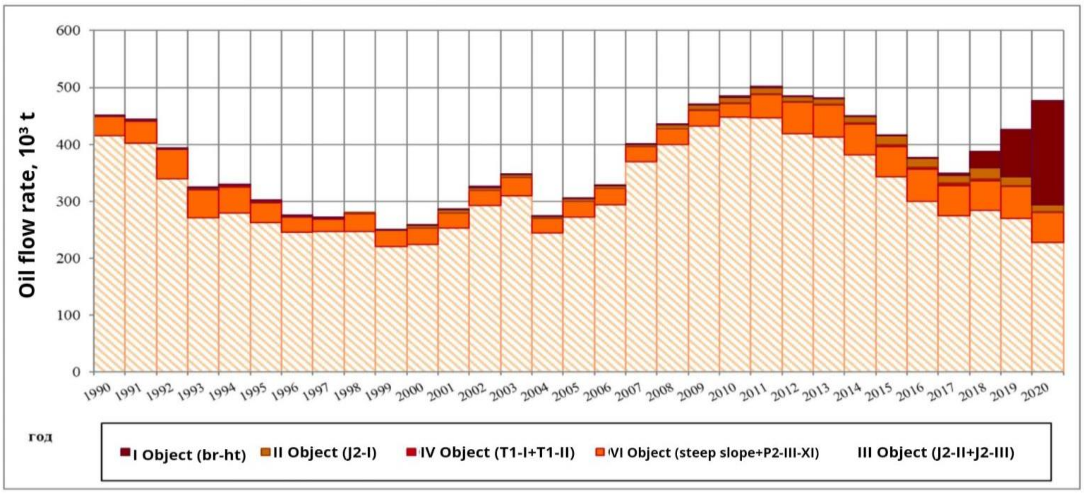


Figure 30 – Dynamics of general oil flow rate by development objects in the period 1990-2020 y.

Table 6 – Characteristics of new wells drilled in the period from 2018 to 2021

Well No.	Horizon	Entry date	Current performance		
			Oil flow rate, t/day	Water flow rate, t/day	Waterflooding, %
1	2	3	7	8	9
68084	K1br	01.12.2020	0.2	12.7	98.4
68085	K1br	01.12.2020	0.1	8.9	98.9
68086	K1br	01.12.2020	0.1	4.8	98.0
68101	K1br	01.12.2020	0.1	9.4	98.9
68102	K1br	01.12.2020	0.1	8.3	98.8
68103	K1br	01.12.2020	0.4	10.2	96.2
68116	K1br	01.12.2020	0.1	8.9	98.9
68117	K1br	01.12.2020	0.1	8.0	98.8
68118	K1br	01.12.2020	0.6	8.0	93.0
68297	K1br	01.12.2020	0.1	4.9	98.0

This table shows wells located in the Barremian horizon (K1br) of the post-salt complex. It can be seen that the water flooding in many wells is 98%, which may mean high permeability of the formation, as well as a large volume of injected water.

Operation with a water flooding of more than 98% can be allowed only in some cases, with a combination of favorable geological and organizational conditions that make the continuation of their work economically feasible. As can be seen in the table, oil production in new wells is still carried out, despite the low flow rate of 0.1-0.6 tons / day.

Well water flooding, along with productivity, is one of the most important indicators that determine the amount of direct production costs.

CONCLUSION

Kenkiyak is a large oil and gas field, geological structure, which is complex, indicating the heterogeneity of the reservoir an feature of the fluid system. To quantifyreserves, you need to understand the overall geology of the basin under study and it building structure. The study of the uniqueness of the geological structure,prospects for oil and gas potential made it possible to clearly understand this terrain, as well as about its exploration and production. Formation of stratigraphic and structural models that give an idea of the type of reservoir fluids are key, solutions for greater productivity of assimilation of complex carbonate structures.

Final results of the work: based on the obtained information data for the time that he passed pre-diploma practice,also published in the public domain literature and other sources,an analysis of the available material was made and a thesis was compiled.

The results of the work: in this thesis work were the features of the geological structure of the Kenkiyak deposit were studied, description stratigraphies and lithologies of the productive horizon, a calculation was made reserves of hydrocarbon raw materials, the nature of reservoir fluids and prospects for oil and gas potential, the main features were identified geological structure of this field:

After analyzing this region, I came to the conclusion that the area productive and it is associated with two productive complexes. In the first oil and gas bearing strata are represented by 6 objects: these are I(K1br+K1ht),II(J2-I),III(J2-II+J2-III), IV(T1-I+T1-II), V(P2) and steep slope area.The second oil and gas bearing strata in pre-salt complex are demonstrated by 6 productive horizons P1k,P1k,P-II,P-III,P-IV,P-V).

Recommendations

1 Continue taking deep and surface reservoir fluid samples, especially for poorly explored productive horizons/blocks;
2 Continue the selection and study of core material to clarify the porosity and reservoir properties of the reservoir;
3 In wells whose operation is characterized by a high level of watering, it is necessary to conduct studies to determine the source of watering (determination of intervals and composition of the inflow);

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Протокол

о проверке на наличие неавторизованных заимствований (плагиата)

Автор: Бакыткереева Азинур Дархановна

Соавтор (если имеется):

Тип работы: Дипломная работа

Название работы: 2023_БАК_Бакыткереева Азинур Дархановна.docx

Научный руководитель: Толганай Джарасова

Коэффициент Подобия 1: 1.7

Коэффициент Подобия 2: 0

Микропробелы: 9

Знаки из здругих алфавитов: 7

Интервалы: 0

Белые Знаки: 0

После проверки Отчета Подобия было сделано следующее заключение:

☑ Заимствования, выявленные в работе, является законным и не является плагиатом. Уровень подобия не превышает допустимого предела. Таким образом работа независима и принимается.

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Дата *Заведующий кафедрой*

Протокол

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☐ Обоснование:

Дата

проверяющий эксперт

31.05.23 [signature]

МИНИСТЕРСТВО НАУКИ И ВЫСШЕГО ОБРАЗОВАНИЯ РЕСПУБЛИКИ КАЗАХСТАН

Казахский национальный иследовательский технический университет имени К. И. Сатпаева
Институт геологии и нефтегазового дела им.К.Турысова
Кафедра гидрогеологии, инженерной и нефтегазовой геологии

РЕЦЕНЗИЯ
на дипломную работу

Студент: Бакыткереева Азинур Дархановна

Специальность: 6В07202 – «Геология и разведка месторождений полезных ископаемых»

Тема дипломной работы: «Геологическое строение и литолого-стратиграфическая характеристика Восточного геоблока Прикаспийской впадины, нефтегазоносность месторождения Кенкияк»

Дипломная работа представляет собой общее описание восточной части Прикаспийской синеклизы, а также геологическое строение, литолого-стратиграфическая характеристика, тектонические особенности и нефтегазоносное районирование данного региона, уделяя большое внимание. Практическая часть дипломной работы посвящена изучению нефтегазоносных особенностей Кенкиякского месторождения, бурение наклонно-направленной скважины в среднеюрские отложения надсолевого комплекса, а также подсчитаны запасы объёмным методом в нефтегазоносных горизонтах месторождения.

Автором даны рекомендации по отбору глубинных и пластовых флюидов, изучение керного материала, а также проведение профиля притока высоко обводнённых скважинах фонда месторождения.

Дипломной работа, выполненная Бакыткереевой Азинур Дархановна на тему «Геологическое строение и литолого-стратиграфическая характеристика Восточного геоблока Прикаспийской впадины, нефтегазоносность месторождения Кенкияк» соответствует требованиям, предьявляемым к дипломным работам, а автор рекомендуется к защите и оценивается на 100 баллов.

Рецензент
АО «Кристал Менеджмент»
Главный геолог ____________ Темирхасов А.М

«2» 06 2023 г.

МИНИСТЕРСТВО НАУКИ И ВЫСШЕГО ОБРАЗОВАНИЯ РЕСПУБЛИКИ КАЗАХСТАН

Казахский национальный исследовательский технический университет имени К. И. Сатпаева

Институт геологии и нефтегазового дела им.К.Турысова

Кафедра гидрогеологии, инженерной и нефтегазовой геологии

ОТЗЫВ НАУЧНОГО РУКОВОДИТЕЛЯ

на дипломную работу

Дипломная работа выполнена по полученным материалам в период преддипломной практики и направлена на изучение и уточнение особенности геологического строения и нефтегазоносности месторождения Кенкияк.

В геологической части приведены общие сведения о теоретической изученности восточного борта Прикаспийского бассейна и расположенным на нем Кенкиякском месторождении, включая такие разделы как литология, стратиграфия, тектоника и нефтегазоносность.

Специальная глава охватывает данные касательно коллекторских особенностей нефтенасыщенных пород , определению свойств коллекторских пород по проведенным в лаборотории анализам, также продемонстрированы результаты подсчет запасов углеводородного сырья продуктивных горизонтов.

В целом, тема дипломной работы раскрыта полностью и соответствует всем требованиям.

Дипломная работа Бакыткереевой Азинур может быть рекомендован к защите с присвоением ему академической степени бакалавра техники и технологии по специальности 6B07202 – Геология и разведка месторождений полезных ископаемых.

Научный руководитель
PhD, старший преподаватель

_________________________ Джарасова Т.С
Подпись

«2» ____06_____ 2023 жыл

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Дата отчета 5/31/2023

Дата редактирования ---

Отчет не был оценен.

Метаданные

Название

2023_БАК_Бакыткереева Азинур Дархановна.docx

Автор

Бакыткереева Азинур Дархановна

Научный руководитель / Эксперт

Толганай Джарасова

Подразделение

ИГиНГД

Оповещения

В этом разделе вы найдете информацию, касающуюся текстовых искажений. Эти искажения в тексте могут говорить о ВОЗМОЖНЫХ манипуляциях в тексте. Искажения в тексте могут носить преднамеренный характер, но чаще, характер технических ошибок при конвертации документа и его сохранении, поэтому мы рекомендуем вам подходить к анализу этого модуля со всей долей ответственности. В случае возникновения вопросов, просим обращаться в нашу службу поддержки.

Замена букв	ß	7
Интервалы	A→	0
Микропробелы	·	9
Белые знаки	ß	0
Парафразы (SmartMarks)	a	12

Объем найденных подобий

Обратите внимание!Высокие значения коэффициентов не означают плагиат. Отчет должен быть проанализирован экспертом.

КП1	КП2	КЦ
1.75%	0.00%	0.20%

25 Длина фразы для коэффициента подобия 2

9157 Количество слов

55684 Количество символов

Подобия по списку источников

Просмотрите список и проанализируйте, в особенности, те фрагменты, которые превышают КП №2 (выделенные жирным шрифтом). Используйте ссылку «Обозначить фрагмент» и обратите внимание на то, являются ли выделенные фрагменты повторяющимися короткими фразами, разбросанными в документе (совпадающие сходства), многочисленными короткими фразами расположенные рядом друг с другом (парафразирование) или обширными фрагментами без указания источника ("криптоцитаты").

10 самых длинных фраз

Цвет текста

ПОРЯДКОВЫЙ НОМЕР	НАЗВАНИЕ И АДРЕС ИСТОЧНИКА URL (НАЗВАНИЕ БАЗЫ)	КОЛИЧЕСТВО ИДЕНТИЧНЫХ СЛОВ (ФРАГМЕНТОВ)	
1	https://www.sciencedirect.com/science/article/pii/S1876380413600245	13	0.14 %
2	'Barriers-to-change' in a governmental service delivery type organisation CJH Coetzee, Karel J Stanz;	13	0.14 %
3	Каспий маңы бассейнінің оңтүстік-шығысындағы тұз үсті шөгінділердің тектоникасы, мұнайгаздылығы және Шығыс Мақат кенорны бойынша қосымша барлау жобасы.docx [redacted] 4/26/2018 Satbayev University (ИГиНГД)	13	0.14 %
4	https://www.sciencedirect.com/science/article/pii/S1876380413600245	11	0.12 %

5	Каспий маңы бассейнінің оңтүстік-шығысындағы тұз үсті шөгінділердің тектоникасы, мұнайгаздылығы және Шығыс Мақат кенорны бойынша қосымша барлау жобасы.docx [redacted] 4/26/2018 Satbayev University (ИГиНГД)	10	0.11 %
6	Диплом Увакова Сауле.doc [redacted] 5/17/2020 Satbayev University (ИГиНГД)	9	0.10 %
7	https://www.sciencedirect.com/science/article/pii/S1876380413600245	8	0.09 %
8	Palaeontology, taxonomic revision and variability of some species of the genus Gassendiceras Bert et al., 2006 (Ammonitina, Upper Barremian) from southeastern France L. Canut, S. Bersac,D. Bert, G. Delanoy;	8	0.09 %
9	https://pubs.usgs.gov/bul/2201/B/b2201-b.pdf	7	0.08 %
10	Каспий маңы бассейнінің оңтүстік-шығысындағы тұз үсті шөгінділердің тектоникасы, мұнайгаздылығы және Шығыс Мақат кенорны бойынша қосымша барлау жобасы.docx [redacted] 4/26/2018 Satbayev University (ИГиНГД)	7	0.08 %

из базы данных RefBooks (0.43 %)

ПОРЯДКОВЫЙ НОМЕР	НАЗВАНИЕ	КОЛИЧЕСТВО ИДЕНТИЧНЫХ СЛОВ (ФРАГМЕНТОВ)	
Источник: Paperity			
1	Palaeontology, taxonomic revision and variability of some species of the genus Gassendiceras Bert et al., 2006 (Ammonitina, Upper Barremian) from southeastern France L. Canut, S. Bersac,D. Bert, G. Delanoy;	14 (2)	0.15 %
2	'Barriers-to-change' in a governmental service delivery type organisation CJH Coetzee, Karel J Stanz;	13 (1)	0.14 %
3	THE ROLE OF THE PALEONTOLOGICAL ASPECTS TO DETERMINE THE HYDROCARBON POTENTIAL OF THE NORTH-WESTERN CASPIAN POST-SALT COMPLEX T. S. Smirnova,I. V. Bystrova, D. A. Bychkova, M. S. Melikhov;	12 (2)	0.13 %

из домашней базы данных (0.78 %)

ПОРЯДКОВЫЙ НОМЕР	НАЗВАНИЕ	КОЛИЧЕСТВО ИДЕНТИЧНЫХ СЛОВ (ФРАГМЕНТОВ)	
1	Каспий маңы бассейнінің оңтүстік-шығысындағы тұз үсті шөгінділердің тектоникасы, мұнайгаздылығы және Шығыс Мақат кенорны бойынша қосымша барлау жобасы.docx [redacted] 4/26/2018 Satbayev University (ИГиНГД)	56 (8)	0.61 %
2	Диплом Увакова Сауле.doc [redacted] 5/17/2020 Satbayev University (ИГиНГД)	9 (1)	0.10 %
3	Тектоническое строение, нефтегазоносность и анализ физико-химических свойств и состава нефти и газа место-рождения Кара Арна [redacted] 5/19/2020 Satbayev University (ИГиНГД)	6 (1)	0.07 %

из программы обмена базами данных (0.00 %)

ПОРЯДКОВЫЙ НОМЕР	НАЗВАНИЕ	КОЛИЧЕСТВО ИДЕНТИЧНЫХ СЛОВ (ФРАГМЕНТОВ)

из интернета (0.55 %)

ПОРЯДКОВЫЙ НОМЕР	ИСТОЧНИК URL	КОЛИЧЕСТВО ИДЕНТИЧНЫХ СЛОВ (ФРАГМЕНТОВ)	
1	https://www.sciencedirect.com/science/article/pii/S1876380413600245	37 (4)	0.40 %
2	https://pubs.usgs.gov/bul/2201/B/b2201-b.pdf	13 (2)	0.14 %

Список принятых фрагментов (нет принятых фрагментов)

ПОРЯДКОВЫЙ НОМЕР	СОДЕРЖАНИЕ	КОЛИЧЕСТВО ИДЕНТИЧНЫХ СЛОВ (ФРАГМЕНТОВ)