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STRATIGRAPHY, CORRELATION, AND INDUSTRIAL-GEOPHYSICAL CHARACTERISTICS OF THE TRIASSIC DEPOSITS OF THE SEGHENDYK DEPRESSION (SOUTHERN MANGYSHLAK)

Purpose. To refine the stratigraphic subdivision, lithological composition, and sedimentation environments of the Upper Triassic deposits within the Seghendyk Depression (Southern Mangyshlak) using geophysical data and core materials from exploration wells.

Methodology. The study is based on an integrated analysis of geological and geophysical data, including gamma-ray logging, neutron-gamma logging, electrical resistivity logging, and spontaneous potential measurements, complemented by descriptions of core samples.

Findings. Stratigraphic correlation was conducted for the Saura-Seghendyk, Zhangeldy, and Northern Karagie areas, enabling the identification of lithostratigraphic subdivisions within the Triassic sequence. Within the Upper Triassic succession, two formations were identified: the North Rakushechnaya Formation and the Bokand Formation, which differ in lithological composition and geophysical characteristics. The North Rakushechnaya Formation is subdivided into four members: argillite-gravelite, argillite-sandstone, argillite, and carbonate-terrigenous, representing an incomplete third-order transgressive sedimentary cycle. The Bokand Formation comprises two members, argillite-sandstone and sandstone-argillite, forming another incomplete cycle. In the Seghendyk Depression, a regular increase in the thickness of the North Rakushechnaya Formation (up to 865 m) was observed, primarily due to the thickening of the lower gravelite member, which exceeds the values recorded in adjacent tectonic zones. Based on the interpretation of geophysical data, a correlation stratigraphic scheme was developed uniting the Saura-Seghendyk, Zhangeldy, and Northern Karagie areas.

Originality. For the first time, the internal structure of the Upper Triassic complex of the Seghendyk Depression has been detailed, identifying six lithostratigraphic members that reflect two incomplete sedimentation cycles. A refined stratigraphic framework is proposed, linking the Seghendyk Depression to the North Karagie Saddle and aligning it with the regional stratigraphic scale of Mangyshlak.

Practical value. The developed stratigraphic model enables more accurate correlation of the Triassic sections in Southern Mangyshlak, improving the prediction of reservoir horizons within the promising Saura-Seghendyk, Zhangeldy, and Karagie areas during oil and gas exploration.

Keywords: *Seghendyk depression, upper triassic, lithostratigraphic section, stratigraphic correlation, Southern Mangyshlak*

Introduction. Southern Mangyshlak, located in the southwestern part of Kazakhstan, is characterized by a complex and structurally heterogeneous geological development. The thickness of the Lower Mesozoic deposits in certain areas exceeds 3 km. The Triassic deposits of the region are subdivided into Lower, Middle, and Upper units: the Lower and Upper divisions are composed mainly of terrigenous rocks, whereas the Middle division consists of mixed terrigenous and carbonate sequences.

Stratigraphic and lithological studies of the Triassic deposits of Southern Mangyshlak, particularly within the Seghendyk Depression, remain limited. The available information is primarily based on generalized stratigraphic schemes, in which the Triassic is traditionally subdivided into Lower, Middle, and Upper Triassic sections. The Lower and Upper sections are composed predominantly of terrigenous formations, while the Middle section is represented by mixed terrigenous-carbonate strata [1].

Previous studies [2, 3] have significantly expanded the understanding of regional paleogeographic correlations and the provenance of clastic material. In particular, reference [2] demonstrated that biohermal structures within the Lower Permian and Triassic sequences of the northern part of the Buzachi Peninsula and the adjacent Caspian Sea shelf reflect the dynamics of sediment accumulation at the Permian-Triassic boundary and may serve as indicators of paleogeomorphological conditions and zones of enhanced reservoir capacity. The investigation presented in [3], using the example of the Simao Terrane (Southwestern China), demonstrated the universality of integrating sedimentary-section data with geochemical and mineralogical characteristics to reconstruct sources of terrigenous material and to analyze tectono-sedimentary settings. These methodological approaches are also relevant for correlating the Mesozoic complexes of Southern Mangyshlak.

A significant contribution to the study of the Triassic and Paleozoic complexes of the region was made in [4], which provided a detailed description of the lithological features of the Triassic-Paleozoic sequences of Southern Mangyshlak and their stratigraphic position. In [5], the authors substantiated the petroleum potential of the pre-Jurassic formations on the northern flank of the Buzachi Uplift, confirming the overall prospectivity of the Lower Mesozoic structures across the region. Later investigations revealed the lithological and stratigraphic characteristics of the Upper Permian and Triassic deposits of the Karachaganak field, enabling a clearer understanding of how reservoir properties are controlled by facies-related sedimentation environments [6].

Significant findings were also obtained in [7, 8], which showed that the pre-Jurassic petroleum-bearing complexes of Southern Mangyshlak possess a complex internal architecture, a zonal distribution of reservoirs, and substantial potential for further exploration. According to [9], the South Mangyshlak Depression is one of the key oil- and gas-bearing zones within the Kazakh sector of the Caspian Sea, where the formation of present-day petroleum systems is closely associated with the Triassic and Paleozoic sequences.

An essential contribution to the regional structural studies was made by works [10–12], which characterized the structural uplifts of the Zhazgurly and Seghendyk zones, refining their morphology, lateral extent, and relationship with the tectonic elements of Southern Mangyshlak. The researches presented in [13, 14] expanded the understanding of quantitative criteria for carbonate reservoirs within the Triassic deposits, which is essential for reassessing their hydrocarbon potential.

Recent studies have further developed specific aspects of geological and environmental analysis in the region. A comprehensive investigation of the Triassic deposits in the Caspian region was presented in [15], which described their structure, facies characteristics, and petroleum potential. Kozhagulova, et al. [16] proposed a preliminary assessment of the geothermal potential of the Mangyshlak Basin based on stratigraphic and temperature data, emphasizing the promise of deep horizons for sustainable energy development. Hofmann, et al. [17] developed quantitative criteria for evaluating the reservoir properties of Triassic formations of Southern Mangyshlak, while Nursaule, et al. [18] examined the hydrochemical characteristics of groundwater and wastewater within the Tengiz area, identifying anthropogenic alterations in the local ecosystem.

At the same time, recent Kazakhstani studies devoted to lithophysical and geodynamic aspects of sedimentation have provided valuable methodological insights. Works [19–21] demonstrated that variations in the lithophysical properties of productive horizons within the copper-bearing sandstones of Central Kazakhstan reflect consistent patterns of porosity and reservoir characteristics that are relevant to the surrounding rock sequences. Alzhigitova, et al. [22] emphasized the importance of analyzing the physico-mechanical parameters of cohesive soils when assessing the stability of deluvial-proluvial and alluvial deposits, which can be applied to predict the filtration and storage capacities of rocks. Baibatsha, et al. [23] integrated geophysical, geochemical, and cosmo-geological methods to reconstruct the geodynamics of the Shu-Ili ore zone, proposing a universal scheme of structural-tectonic analysis for Central Kazakhstan.

Parallel to these developments, research on mineralogical and geochemical systems has confirmed the multistage nature of sedimentation and metamorphism [24, 25]. At the same time, studies employing engineering-geological and remote sensing methods have advanced the prediction of geological structures [26–28]. Collectively, these directions underscore the increasing importance of interdisciplinary approaches in assessing the geological framework and subsurface potential of Kazakhstan.

Despite significant progress in the study of the structural and tectonic features of the region, comprehensive stratigraphic and lithofacies investigations of the Triassic sequences of Southern Mangyshlak remain underdeveloped. This highlights the need for further research to analyze their internal structure, refine stratigraphic differentiation, and assess the hydrocarbon potential of pre-Jurassic complexes.

The purpose of the present study is to identify the lithological and stratigraphic characteristics of the Triassic deposits within the Seghendyk Depression and to establish their comparative correlation with adjacent geological structures. This work aims to provide a scientific basis for evaluating the hydrocarbon potential of the studied area and to encourage the renewal of geological exploration and appraisal activities. Although active exploration in this region ceased more than fifty years ago, modern geological and drilling technologies create favorable conditions for the discovery of new, previously undetected oil and gas fields.

Study area. The southwestern part of Mangyshlak is subdivided into three tectonic zones that differ in structure and in the thickness of the Lower Mesozoic deposits. Relatively thin accumulations of Mesozoic strata characterize the northern and southern zones, whereas the central zone has a total thickness exceeding 3 km. The central uplifted zone includes the Karatau and Beke-Bashkuduk mega-anticlinoria, the Chakyrygan Depression, the East Mangyshlak Disjunctive Zone, as well as the Zhetybay-Uzen and Kukumbay plateaus. To the south lies the South Mangyshlak Depression, within which the Seghendyk and Zhazgurly depressions are distinguished, separated by the Karagie Saddle and the Sand-Shell Arch (Fig. 1).

The South Mangyshlak Depression represents the most downfolded structural unit of the Mangyshlak region, elongated in a northwest direction. In its eastern part lies the Zhazgurly Depression, while to the west is the Seghendyk Depression, bounded to the north by the Karagie Saddle.

Most of the Seghendyk Depression is submerged beneath the waters of the Caspian Sea, with only its eastern margin (approximately along the –3,400 m isohypse) emerging on land (Fig. 2). To the south, the depression

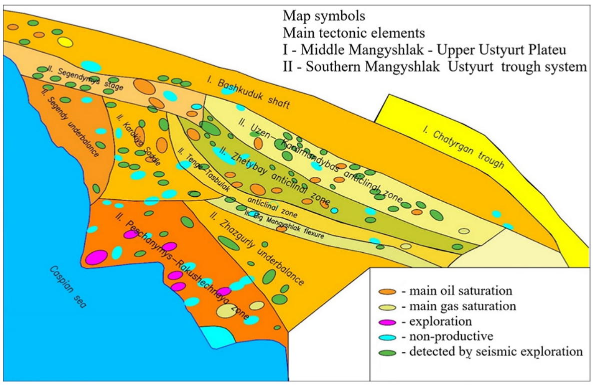

Fig. 1. Tectonic scheme of Southern Mangyshlak (based on geological and geophysical data of the region)

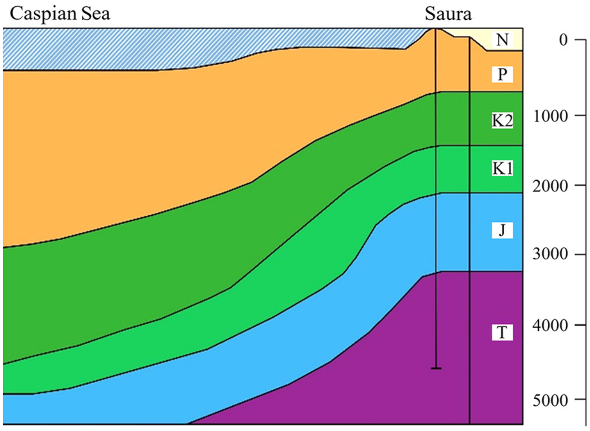

Fig. 2. Geological cross-section along the Saura-Caspian Sea line

is bounded by the Sand-Shell Arch, and to the east by the Karagie Saddle. The most excellent depth, exceeding 5.5 km, is associated with the central axis of the South Mangyshlak Depression.

The East Seghendyk Basin is located within the central subsided part of the Triassic sequence and covers an area of approximately 40 × 40 km. According to seismic exploration data, the V21 reflecting horizon, which marks the roof of the Middle Triassic carbonate complex, occurs at a depth of –5,100 m in the central part of the basin, –4,100 m in the southern segment, and –2,700 m in the north. The East Seghendyk Basin is structurally connected to the western extension of the South Mangyshlak Depression and continues westward into the Caspian Sea.

In many exploration wells of Southern Mangyshlak, Paleozoic basement rocks have been encountered. At the surface, in the areas of Oymashy, Zhylandy, Bukbash, Tamdy, Birbas, and South Alamuryn, granite-metamorphic complexes are exposed, represented mainly by quartz-muscovite and sericite-quartz schists. These metamorphosed sedimentary rocks are intruded by granitoid bodies, most extensively developed in the South Alamuryn, Tamdy, and Oymashy areas. Radiometric data indicate that the formation of the granitoids occurred between the Middle Devonian and Early Permian periods.

The Paleozoic strata underlying the Triassic deposits exhibit considerable lithological and facies diversity. In the North Rakushechnaya area (wells Nos. 15, 8, and 12), intensely metamorphosed sandstones, argillites, and siltstones were encountered. Similar rocks have been identified in South Zhetybay (well No. 4, interval 1,487–4,470 m), Zhetybay (well No. 25, 3,720–4,480 m), and Bekturly (well No. 100, 3,487–3,570 m). In the Saura and Saura-Seghendyk areas, the Paleozoic sequence is composed mainly of argillites with subordinate siltstone interbeds. In Northern Karagie, alternating schists and metamorphosed sandstones are present, whereas in the western part of Tasbulat (well No. 2, 4,060–4,200 m), dense, cemented sandstones and fine-grained, dolomitized limestones are widespread.

In the Temirbaba section (well No. 6, 3,650–4,050 m), tuff lavas and pyroclastic rocks have been identified, indicating volcanic activity during the Late Paleozoic. The upper horizons of the Paleozoic succession are most often represented by siltstones, siltstone-argillite, and argillite units, though their distribution across the region is irregular. The Triassic deposits rest upon the Paleozoic basement with a distinct stratigraphic unconformity.

The Triassic system of Southern Mangyshlak is subdivided into several formations. The Lower Triassic includes the Dolnapin Formation (Induan) and the Shetpin and Tyuryurpin formations (Olenekian). The South Zhetybay Formation represents the Middle Triassic, whereas the Upper Triassic comprises the Temirbaba Series, which includes the North Rakushechnaya and Zhazgurly formations. Collectively, these units form three lithostratigraphic complexes, each representing an independent second-order sedimentary cycle.

Seismo-geological zoning of the territory made it possible to distinguish four main areas, differing in their Triassic lithostratigraphic sequences:

I – Zhetybay-Uzen-Kukumbay zone (with southwestern and northeastern subzones).

II – Seghendyk-Zhazgurly zone.

III – Sand-Shell Arch.

IV – Aksu-Kendyrly zone.

The cyclic structure of lithostratigraphic complexes within the Zhetybay-Uzen-Kukumbay zone allowed the identification of three subdivisions in the Lower Triassic section. The basal deposits correspond to the Dolnapin Formation, the overlying transgressive unit represents the Shetpin Formation, and the upper carbonate-rich succession corresponds to the Tyuryurpin Formation.

Researchers have provided detailed lithological descriptions of the Triassic formations and associated faunal assemblages for all Lower Triassic zones, except for the Seghendyk-Zhazgurly zone. The most complete and thickest Lower Triassic section has been recorded within the Uzen-Karamandybas anticlinorium, whereas in the Zhetybay and Tenge-Tasbulat anticlinoria, facies variations and incomplete sections are observed. In the southern structural blocks of the region, particularly within the Sand-Shell Arch, the Olenekian succession is considerably reduced and composed mainly of coarse-grained clastic rocks. This pattern reflects substantial differences in sedimentation conditions across various parts of Southern Mangyshlak.

The Middle Triassic lithostratigraphic complex corresponds to the transgressive stage of the Triassic sedimentary cycle. Within this interval, the South Zhetybay

Formation is distinguished, comprising two well-defined subdivisions.

The lower subdivision consists of:

- a basal layer composed predominantly of carbonate rocks;
- an overlying horizon of argillite-carbonate facies.

The upper subdivision is represented by a lower carbonate-terrigenous horizon, overlain by a clay-rich horizon. Within the Sand-Shell structural zone, the South Zhetybay Formation is characterized by coarser clastic material and less stratigraphic differentiation, reflecting local variations in sedimentary environments.

In the Aksu-Kendyrly zone, the South Zhetybay Formation has been studied using data from wells Nos. 1, 5, and 6 in the Temirbaba area. These sections confirm the bipartite structure of the formation: the lower interval (well No. 1, 3,555–3,730 m) is composed of limestones, while the upper interval (3,400–3,555 m) consists of carbonate-terrigenous rocks. The total thickness of the formation in this area is approximately 330 m.

The Upper Triassic lithostratigraphic complex lies unconformably upon the Middle Triassic deposits, a relationship accompanied by the development of erosional surfaces, and is overlain by Lower Jurassic sequences. It represents a second-order sedimentary cycle and is composed predominantly of gray-colored terrigenous clastic rocks with a subordinate presence of red-bed facies.

Upper Triassic deposits are widely developed throughout Southern Mangyshlak and have been recorded in numerous wells — Northwestern Zhetybay (well No. 9), South Zhetybay (well No. 4), Western Tasbulat (well No. 2), Tenge (well No. 52), Oymashy (well No. 12), North Rakushechnaya (well No. 15), and others. The sections are characterized by an alternation of coarse-grained sandstones, gravelites, siltstones, and argillites, which in places are interbedded with tuffaceous rocks of variable thickness and composition.

In the lower part of the sequence, tuffaceous sandstones, siltstones, and argillites with gravelite interbeds predominate. Upsection, finer-grained sandstones and siltstones appear, accompanied by an increasing clay content.

It should be noted that Upper Triassic deposits are absent or significantly reduced in several structures of Southern Mangyshlak. Their thickness varies considerably from 100–300 m within the North Rakushechnaya zone (well No. 15) to 912–1,129 m in the Saura-Seghendyk and Bokand areas. According to seismic exploration data, even greater thicknesses may be expected in certain localities.

Methodology. This study focuses on the lithological and stratigraphic analysis and correlation of the Triassic deposits within the Seghendyk Depression, employing a combination of geophysical and petrophysical data, as well as core sample descriptions. The primary objective was to refine the internal structure of the Triassic succession and to delineate facies and reservoir zones within Southern Mangyshlak.

The initial dataset was obtained from geophysical surveys conducted in exploration and parametric wells drilled in the Saura-Seghendyk, Zhangeldy, and North Karagie areas. The study utilized data from gamma-ray logging (GR), spontaneous potential (SP), neutron-gamma logging (NGL), potential sounding (PS), and electrical resistivity logging (ER). The geophysical curves were normalized and depth-corrected to ensure scale consistency, allowing for interwell correlation of the stratigraphic sections.

Based on a comprehensive interpretation of the logging diagrams, six lithostratigraphic members were identified in the well sections, including well No. 3 (Saura-Seghendyk), wells Nos. 1 and 2 (Zhangeldy), and well No. 1 (North Karagie). These members are grouped into two main formations: the North Rakushechnaya Formation (comprising four members) and the Bokand Formation (comprising two members).

The geophysical parameters were used to evaluate the petrophysical properties of the rocks, primarily porosity, permeability, and saturation. Intervals characterized by low natural gamma activity and high electrical resistivity were interpreted as potential reservoir zones. In certain intervals with increased carbonate content, a diagnostic feature was a reduction in the neutron-gamma response.

The description of core material and its comparison with geophysical characteristics enabled the clarification of lithofacies variations within the Triassic sequence. Core samples were used for petrographic analysis and for visual characterization of texture, grain-size composition, and degree of cementation.

Based on the interpretation of well-logging and core data, detailed stratigraphic and correlation schemes were constructed for the study area. These schemes formed the basis for refining the boundaries of formations and lithostratigraphic members, as well as for determining the directions of facies transitions and predicting the distribution of reservoir horizons within the Seghendyk Depression.

Results and discussion. The pre-Jurassic deposits encountered in well No. 3 of the Saura-Seghendyk area, as well as in wells Nos. 1 and 2 of the Zhangeldy area, are represented by the upper part of the Triassic system and Paleozoic strata. This interpretation is supported by the results of microfaunal studies and lithological analysis (Fig. 3).

Paleozoic complex. In well No. 3 (Saura-Seghendyk area), the Upper Triassic deposits rest directly upon Paleozoic rocks. The Paleozoic sequence was penetrated within the interval 4,067–4,500 m and is represented by alternating layers of argillites and siltstones.

In well No. 2 of the Zhangeldy area, within the interval 4,654–5,000 m, rocks underlying the argillite-gravelite unit were encountered. Although these strata lack paleontological characterization, their lithological and geophysical features suggest an affiliation with the Paleozoic era. The section is composed of dark-gray and black argillites and siltstones with occasional sandstone interbeds. The rocks are structurally deformed, with bedding dip angles determined from core samples ranging from 30 to 40°.

According to well-logging data (geophysical surveys), the Paleozoic deposits are clearly distinguished from the overlying strata by the following characteristics: low acoustic log readings, moderate neutron-gamma values, high natural gamma activity, and an increased borehole diameter in the upper part of the interval. Based on the combined interpretation of geophysical data, the section was subdivided into two approximately equal parts.

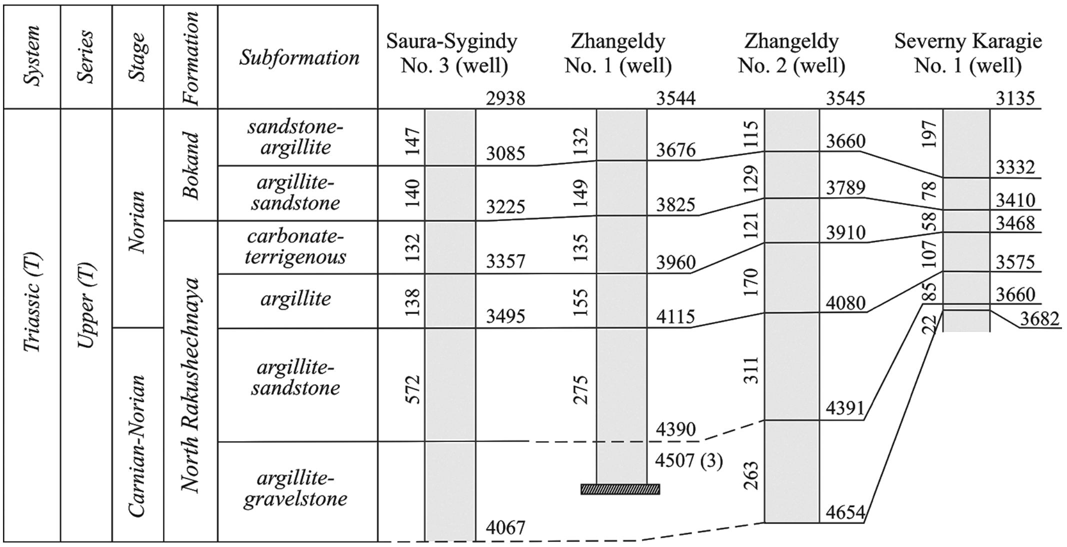

Fig. 3. Depth distribution scheme of Upper Triassic deposits in the exploration areas of Saura-Seghendyk, Zhangeldy, and North Karagie

Lower member. A single core sample from the lower part of the Paleozoic interval is represented by a dense, locally sandy, dark-gray siltstone with a porosity of 5.7 %. According to field geophysical data, this interval is characterized by frequent thin interbedding of argillites and siltstones. The sandstone and siltstone interlayers are distinguished by high electrical resistivity values (up to 20–25 Ω · m) and an enhanced neutron-gamma response, combined with low natural gamma activity. The acoustic log curve shows weak differentiation, indicating a homogeneous lithology. The borehole diameter remains close to nominal in sandstone interbeds, increasing slightly within clay-rich zones.

Upper member. The upper part of the Paleozoic section is composed mainly of argillites with inclusions of dense sandstones and siltstones. The thickness of the sandstone beds reaches 9.6 m. The argillites are dark green to black, exhibit a slaty fracture, and display slickensided surfaces. In the upper interval, rock deformation is observed, manifested by a siltstone-like texture and a chaotic microstructure.

The pelitic matrix consists primarily of hydromica, with admixtures of sericite and kaolinite. The silty fraction (25–30 %) is represented by quartz, feldspars, and rock fragments, among which quartz predominates. The mineral composition also includes muscovite (up to 3 %) and numerous microfractures ranging from 0.02 to 0.2 mm in width.

According to core analysis, the porosity of the rocks is low (4.9–6.8 %). The electrical resistivity of the reservoir interbeds increases to 35 Ω · m, corresponding to moderately compacted rocks with low filtration capacity. The natural gamma activity in the upper member is higher than in the lower one, by an average of 2 μR/h, indicating an increased content of clay minerals.

Paleozoic strata of the Saura-Seghendyk area. In well No. 3 (Saura-Seghendyk), the Paleozoic sequence has a total thickness of 433 m and is represented by alternating layers of sandstones and argillites. The sandstones are dark gray to black and exhibit a high degree of cementation. Their composition includes quartz grains, feldspars, and rock fragments of various sizes, embedded in a clay-cement matrix of basal-pore and film types. The grain size ranges from 0.04 to 0.6 mm (predominantly 0.1–0.2 mm). With depth, there is a decrease in quartz content (from 41 to 12 %) and feldspar content (from 16 to 13 %), accompanied by an increase in rock fragments (from 4 to 34 %). Accessory minerals include pyrite, leucoxene (up to 3 %), biotite, and muscovite (up to 2 %). Organic matter constitutes 2–3 % of the rock matrix, and in the interval 4,365–4,368 m, an accumulation of crystalline calcite (up to 14 %) was recorded. The cement is primarily composed of hydromica-kaolinite with a sericite admixture.

The argillites are dark gray to black, characterized by a coarse-pelitic structure and a discontinuous oriented microtexture. The pelitic matrix is composed primarily of hydromica, with minor sericite and kaolinite. The silty component (7–25 %) consists of well-rounded quartz grains and siliceous rock fragments up to 0.1 mm in size. The organic matter content reaches 10–15 %, resulting in thin, laminated interbeds. Pyrite and leucoxene occur in amounts up to 5 %.

According to well-logging data, the stratigraphic interval maintains a consistent thickness, while electrical resistivity (ER) and spontaneous potential (SP) values show only minor variations. The borehole diameter remains close to nominal, with slight enlargements (2–4 cm) near the top and bottom of the interval. Gamma-ray logging (GR) records zones of reduced radioactivity (down to 10 μR/h), indicating the presence of sandstone interbeds. Porous layers with thicknesses of 3–10 m are mainly confined to the upper 100 m of the section.

Triassic deposits. According to drilling data from the Saura-Seghendyk, Zhangeldy, and West Ketyk areas, Triassic deposits are recorded primarily in the upper part of the stratigraphic section (Fig. 4). In the correlation model along section line I–I, two formations can be confidently distinguished within the Upper Triassic succession: the North Rakushechnaya Formation and the Bokand Formation. Both geophysical indicators and the lithological characteristics of core samples confirm their continuity.

The North Rakushechnaya Formation is composed predominantly of dark gray and gray-green argillites and

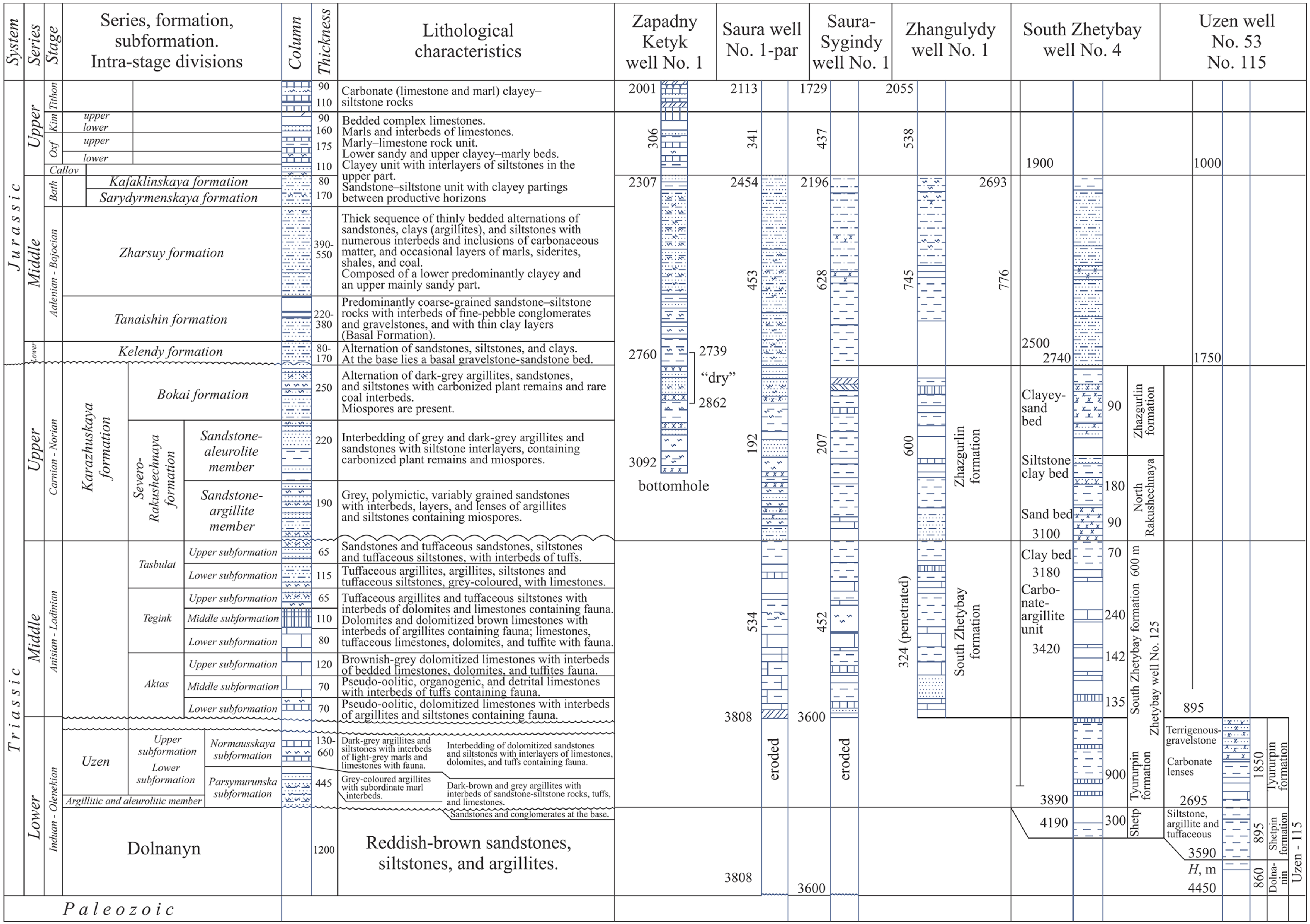

Fig. 4. Correlation scheme of Jurassic and Triassic deposits of Southern Mangyshlak (Seghendyk Depression)

siltstones with sandstone interbeds. In certain intervals, an increase in clastic material and the appearance of gravelites are observed, reflecting a transition to more active sedimentation conditions. In Well No. 2 of the Zhangeldy area, the formation is stratigraphically subdivided into four members, which differ in lithological composition and geophysical characteristics. In well No. 1 of the same area, the two upper members have thicknesses of 135 and 155 m, respectively, whereas the underlying deposits correspond to the middle member (392 m). In well No. 3 (Saura-Seghendyk area), the three lower members of the North Rakushechnaya Formation could not be identified due to the incompleteness of geophysical data.

Based on the combination of lithological and geophysical features, the Upper Triassic deposits are subdivided into six stratigraphic horizons. The North Rakushechnaya Formation includes four horizons:

I – argillite-gravelite horizon.
II – argillite-sandstone horizon.
III – argillite horizon.
IV – carbonate-terrigenous horizon.
V – argillite-sandstone horizon.
VI – sandstone–argillite horizon.

The two overlying horizons (V – argillite-sandstone horizon and VI – sandstone-argillite horizon) belong to the Bokand Formation.

Member I (argillite-gravelite member). The thickness of this member is approximately 263 m (Zhangeldy area, well No. 2). The section is composed predominantly of dark-gray, well-cemented gravelites with moderately rounded clasts, containing siliceous and clay fragments. In the upper part, interbedding with fine-grained dark-gray sandstones is observed, whereas the middle intervals consist mainly of siltstones and argillites. Coarse-grained sandstones dominate the upper horizons, with gravelites and argillites interbedded. The sandstones are polymictic, dark gray, and firmly cemented, often cut by vertical calcite-filled fractures.

The clastic fraction includes quartz (21–24 %), feldspars (17–34 %), rock fragments (16–25 %), and quartzites (up to 2 %). The grains are mostly angular to sub-angular, with moderate to poor sorting; their surfaces are covered with dusty inclusions, and fracturing is common. Rare glauconite grains are present. Feldspars are intensively sericitized and kaolinized. The matrix is primarily clayey, characterized by basal and film porosity.

Carbonized plant remains constitute 3–7 % of the rock. The argillites are dark gray to black, dense, exhibiting silty-pelitic and psammitic structures, irregular lamination, and a chaotic texture. They contain calcite veins and disseminations, as well as cleavage planes inclined at about 45° to the core axis. The pelitic matrix is composed of hydromica, while the clastic component (15–35 %) consists of quartz, feldspar, and rock fragments. The grains are poorly sorted, and some exhibit fracture features. The content of carbonized organic matter varies from 3 to 20 %, occurring as thin laminae up to 0.8–1 mm thick, which accentuate the bedding of the rock. Microcrystalline calcite (~2 %), biotite (~1 %), and occasional pyrite grains are also observed. The silty-pelitic rocks are black, exhibit high strength, an irregular fracture, and a local sandy texture with coal admixtures.

The threefold structure of the member is clearly distinguished on the apparent resistivity and neutron-gamma logging (NGL) curves. The denser intervals, composed of gravel and coarse-grained sandstones, display the highest apparent resistivity values ($\rho_n = 20–100\ \Omega \cdot m$) and secondary gamma radiation (J_n = up to 13,000 counts/min). These elevated readings are associated with the presence of siliceous clasts. The spontaneous potential (SP) curve is weakly expressed, and the borehole diameter remains close to nominal. Intervals of clean sand are characterized by minimal natural gamma activity.

During drilling of the upper part of the unit (depths 4,410–4,475 m, well No. 2, Zhangeldy area), gas shows were recorded with concentrations up to 13 %. Gas sampling using the OPN method revealed a composition consisting entirely of methane-series hydrocarbons. According to core data, rock porosity varies from 3.7 to 8.1 %, with porous intervals primarily confined to the lower and upper gravelly parts of the section.

In well No. 1 (Zhangeldy area), gamma-ray logging (GR) data identified five reservoir layers within the 4,390–4,490 m interval, characterized by resistivity values ($\rho_n = 6–26\ \Omega \cdot m$) and gamma activity ($J = 7–8\ \mu R/h$). The average porosity of these layers, as determined from logging data, is approximately 12 %.

Member II (argillite-sandstone member). This member is characterized by frequent interbedding of sandstones, argillites, and siltstones, with sandstones being the dominant lithology. Its thickness is approximately 311 m (well No. 2, Zhangeldy area).

The sandstones are gray to dark gray in color, polymictic, and contain carbonized plant material. The grain size ranges from coarse- to fine-grained, decreasing upward within the section, reflecting a gradual decline in depositional energy. The lower part of the section consists mainly of coarse- and very coarse-grained varieties, grading upward into medium- and fine-grained sandstones, and finally into dense dark-gray argillites with occasional siltstone interbeds. The member terminates with dark-gray, well-cemented gravelites.

The clastic fraction includes quartz, feldspars, rock fragments, and quartzites. The grains are mostly angular to slightly rounded and poorly sorted; some quartz grains exhibit cracks and inclusions. The content of carbonized organic matter varies from 5 to 15 %. The cement is clayey and calcitic (of film and basal-film types), imparting density and low permability to the rocks.

The argillites are dense, dark gray, with a splintery fracture and slickensided surfaces; they show a silty-pelitic structure and oriented microtexture. The groundmass is composed mainly of hydromica with minor sericite. The clastic component (10–30 %) consists of quartz, feldspars, and rock fragments, predominantly quartz, with an average grain size of about 0.05 mm.

The carbonized organic matter content reaches 5–35 %, occurring as thin laminae 0.04–0.1 mm thick and as rounded grains about 0.03 mm in diameter. The carbonate component is represented by calcite crystals (~0.05 mm) and pelitomorphic patches, amounting to 1–10 % of the rock. The siltstones are dark gray, compact, with an uneven fracture, and porous interbeds are evenly distributed throughout the section.

According to core analysis, porosity ranges from 3.0 to 3.4 % and from 5.2 to 8.2 %. Based on well-logging data (geophysical surveys), reservoir layers are identified on the gamma-ray log by minimum natural gamma activity. The electrical resistivity of the rocks varies between 8 and 35 Ω·m, while the porosity, as determined from logging data, ranges from 4.5 to 12 %.

Analysis of logging diagrams reveals a weak trend: the apparent resistivity (ER) and natural radioactivity (GR) curves shift to the right from the roof to the base, whereas the gamma-ray curve shifts to the left. The borehole diameter corresponds to nominal values. The member differs from the underlying one by its higher natural gamma radiation (10–12 μR/h) and slightly lower ER and NGL readings.

In well No. 1 (Zhangeldy area), during drilling of this member, gas readings increased more than fourfold above background levels. Below a depth of 4,160 m, the gas concentration reached 31 %. Testing of layers with the OPN method in the interval 4,117–4,155 m yielded a gas inflow volume of 7–30 L, confirming the gas-bearing potential of the rocks in this member.

Member III (argillite member). This member is represented predominantly by argillites with rare thin interbeds of sandstones and siltstones. At the top (well No. 2, Zhangeldy area), a thin limestone layer is recorded. According to geophysical data (characteristic section in well No. 1, Zhangeldy area), the member is distinguished by an increased borehole diameter, maximum gamma-ray (GR) values, and a positive increment in spontaneous potential (SP). The content of carbonized organic matter ranges from 10 to 20 %.

The thickness of the member varies from 138 m (well No. 3, Saura-Seghendyk area) to 170 m (well No. 2, Zhangeldy area). On well-logging diagrams, it is characterized by elevated GR readings (averaging 14 μR/h) and positive SP deflections. The number of sandstone interbeds decreases compared to the underlying members: one interbed is recorded in well No. 3 (Saura-Seghendyk) and well No. 1 (Zhangeldy), and up to four in well No. 2 (Zhangeldy).

The rocks consist of dense, dark-gray to nearly black argillites, locally slightly micaceous, with bedding dips of approximately 30°, and containing occasional thin layers of limestone and sandstone. The pelitic matrix is composed mainly of hydromica with minor sericite and occasional kaolinite; sericite commonly forms rims around detrital grains. The microtexture is oriented and orderly.

The clastic fraction (10–30 %) comprises quartz, feldspars, and rock fragments, with quartz being the predominant component. The average grain size ranges from 0.03 to 0.06 mm. The carbonized organic matter content ranges from 10 to 20 %, while the carbonate material varies from trace inclusions to 5–10 %, represented by calcite crystals (up to 0.05 mm) and pelitomorphic patches. Occasional platy muscovite grains occur (up to 3 %). The limestones are dense, dark gray, and sandy, with an irregular fracture pattern. The central mass consists of pelitomorphic calcite (66–80 %), while the clastic component (15–33 %) is composed of quartz and feldspars.

The sandstones are fine-grained, gray to dark-gray, and firmly cemented, containing carbonaceous inclusions. The sandstone layer penetrated in the interval 4,000–4,010 m (well No. 1, Zhangeldy area) is characterized by an electrical resistivity of $\rho_n = 35\ \Omega \cdot m$ and gamma activity of 6 μR/h. According to core data, porosity is 8.9 %, while well-logging data indicate 12 %. On caliper logs, a decrease in borehole diameter is observed within porous interbeds.

According to the results of field geophysical studies, Member III represents a predominantly clay-rich sequence with isolated sandy interbeds, a feature clearly reflected on the SP, GR, and ER curves.

Member IV (carbonate-terrigenous member). This member is composed of calcareous sandstones, siltstones, and argillites of gray to dark-gray tones, interbedded with limestone layers up to 5 m thick, which contain silty and sandy material. The carbonate content of the rocks increases from the Saura-Seghendyk area toward the Zhangeldy area (well No. 2), where core samples from two intervals consist of dark-gray limestones. The content of carbonized organic remains is 2–3 %.

On geophysical logging (well-logging) diagrams, the member is clearly distinguished by a sharp contrast in the neutron–gamma (NGL) and gamma-ray (GR) curves relative to the underlying strata. The spontaneous potential (SP) curve shifts downward and rightward along the section. The borehole diameters in wells Zhangeldy-1 and Zhangeldy-2 are close to the nominal value. The thickness of the member varies from 121 to 135 m.

The limestones are dark gray, dense, massive, and of sandy-silty composition, being firmly cemented. The carbonate component is primarily pelitomorphic calcite, with fine-grained calcite making up the remainder, comprising 70–85 % of the rock. The clastic material includes quartz grains and altered feldspars of sand- and silt-sized fractions. The grains are subrounded, well-sorted, and often corroded by calcite. The proportion of clastic material ranges from 7 to 25 %. Carbonized organic remains comprise 2–3 % of the rock and occur as rounded grains with diameters ranging from 0.1 to 0.16 mm.

The argillites are dense, calcareous, dark gray to nearly black, with a characteristic conchoidal fracture. The matrix is composed of hydromica particles up to 0.001 mm in size, while the silty component consists of quartz grains up to 0.16 mm (predominantly 0.04–0.05 mm). The grains are sub-rounded and poorly sorted. The sandstones are fine-grained, dark gray, and display a lenticular cross-bedded structure, occasionally showing heterogeneous cementation. For the North Rakushechnaya Formation as a whole, an increase in grain size with depth is observed, accompanied by an improvement in reservoir capacity. The middle (argillite) submember probably acts as a fluid seal for the underlying layers.

According to core analysis, porosity ranges from 5.9 to 7.9 %, with porous layers distributed relatively evenly throughout the section. The purest calcareous rocks, concentrated in the upper part of the section, are characterized by an electrical resistivity (ρ_n) of 35 Ω·m, secondary gamma radiation intensity of 0.9–2.5 conventional units, and a spontaneous potential (SP) of 5–15(–20) mV. According to the interpretation of the integrated well-logging data, no mud filtrate invasion was detected in the reservoir layers.

Member V (argillite-sandstone member). This member is composed mainly of gray and dark-gray sandstones, with less common siltstones, and interbeds of argillites ranging from dark gray to nearly black. Thin, gravelly interlayers are observed in core samples. The content of carbonized organic matter ranges from 3 to 5 %.

On well-logging diagrams (geophysical data), sand layers are distinctly identified by minimum gamma-ray (GR) values, negative anomalies of spontaneous potential (SP), and a reduction in borehole diameter. The thickness of the member varies from 78 m (North Karagie area, well No. 1) to 149 m (Zhangeldy area, well No. 1).

The sandstones exhibit bed thicknesses up to 14 m, well-defined SP differentiation, and increased apparent resistivity. Caliper logs record washouts up to 6–8 cm in clay interbeds, and up to 30–35 cm in well No. 1 (Karagie area). The sandstones are characterized by negative SP anomalies reaching –40 mV.

According to core data, the rocks consist of poorly sorted, polymictic, firmly cemented sandstones, with minor siltstones and argillites. Occasional thin gravelite interbeds of limited thickness are present. The clastic fraction comprises 60–90 % of the sediment, consisting of quartz, feldspars, and rock fragments. A consistent mineralogical trend with depth is observed: the feldspar content increases, while the proportion of quartz decreases. For instance, in the Zhangeldy area (well No. 1, 3,695–3,748 m), quartz content rises from 30 to 33 %, and feldspar content from 33 to 48 %; whereas in the Saura-Seghendyk area (well No. 3, 3,050–3,105 m), quartz content decreases from 41 to 21 %, and feldspar content increases from 10 to 34 %, likely reflecting a change in sediment provenance.

Quartz grains are predominantly angular and poorly sorted, with sizes ranging from 0.1 to 0.3 mm, and have clean surfaces with occasional microinclusions. Feldspars are represented by sericitized, and more rarely kaolinized, plagioclase and potassium feldspar. The cement consists of siliceous, carbonate-clayey, and clayey-carbonate material. The clay component is represented by sericite, the carbonate by fine-grained calcite, and the siliceous by opal. The cement types are pore-film, basal, and basal-film. Occasional split biotite and hematite grains occur (up to 1–2 %).

The argillite interbeds are dark gray to black, with a silty structure and dense texture. According to core data, the porosity of the rocks is low (4.8–5.5 %) (well No. 1, Zhangeldy area). Porous layers are distributed throughout the section, characterized by secondary gamma radiation of 2–3 conventional units and electrical resistivity of approximately 12 Ω·m. According to well-logging and hydrodynamic testing (KIP) data, the layers are water-saturated: formation testing (KII) indicated either “dry” intervals or drilling mud recovery with a clay film.

Member VI (sandstone-argillite member). This member is characterized by interbedding of silty clays and argillites with layers of sandstones of variable grain size. The content of carbonized organic matter ranges from 3 to 5 %. The thickness of the upper submember of the Bokand Formation ranges from 115 m (well No. 2, Zhangeldy area) to 197 m (well No. 1, Karagie area)..

According to geophysical data, the member is clearly separated from the overlying Jurassic deposits by a sharp increase in borehole diameter, positive deflections of the spontaneous potential (SP) curve, gamma-ray (GR) maxima, and minima of secondary gamma radiation. The Jurassic strata display inverse patterns of these parameters. The base of the member is distinctly identified on the SP, GR, and neutron-gamma logging (NGL) curves, showing a rightward shift and a decrease in secondary gamma intensity.

In well No. 1 (Zhangeldy area), core samples consist of argillite with bituminous films. The argillites are silty, gray to dark gray, and dense in texture. The clay matrix is composed mainly of oriented hydromica flakes, with a minor admixture of kaolinite. The clastic fraction (5–10 %) includes quartz grains and, less frequently, feldspars, measuring 0.07–0.08 mm in diameter. The carbonized organic matter content ranges from 3 to 5 %.

The sandstones are light to dark gray, medium-grained, dense, and polymictic. The grain size ranges from 0.2 to 0.3 mm; grains are sub-rounded and poorly sorted. The clastic material consists of quartz (47–59 %), sericitized and unaltered plagioclase (up to 20 %), and rock fragments (13–30 %). The cement is mainly clayey and siliceous, of the basal–film type. The amount of carbonized organic matter reaches 3–5 %.

In the interval 3,609–3,615 m (well No. 1, Zhangeldy area), the presence of tuffaceous sandstone was recorded. The central mass of this rock is composed of porphyritic andesite grains, while the cement consists of ferruginized volcanic glass.

According to core analysis, the porosity of rocks in well No. 1 (Zhangeldy area) varies between 5.9 and 7.4 %. Based on well-logging data, the porous layers are confined mainly to the lower part of the submember. They are characterized by an electrical resistivity (ρ_n) of 10–12 Ω · m, secondary gamma radiation ranging from 1.83 to 2.0 conventional units, and natural gamma activity equal to 8–12 μR/h.

General characteristics of the pre-jurassic deposits of the Seghendyk depression. Based on the results of exploration drilling, the following conclusions have been established:

1. Within the Seghendyk Depression, the Triassic system is represented exclusively by Upper Triassic deposits.
2. The thickness of the Upper Triassic succession, as well as of its constituent formations, is significantly greater than that in the adjacent Uzen-Zhetybay, North Rakushechnaya, and Aksu-Kendyrly zones.
3. The submembers distinguished within the North Rakushechnaya and Bokand formations exhibit well-defined lithological and geophysical characteristics, which allow for their confident differentiation in the sections of various wells.
4. The sequential succession of the North Rakushechnaya submembers the lower (argillite-gravelite), middle (argillite-sandstone), middle (argillite), and upper (carbonate-terrigenous) reflects the development of a transgressive sedimentation cycle, accompanied by a gradual transition of facies conditions from continental to nearshore-marine environments.
5. The most promising reservoir intervals are the lower (argillite-gravelite) member of the North Rakushechnaya Formation and the lower (argillite-sandstone) member of the Bokand Formation. These horizons are characterized by increased porosity and enhanced reservoir properties, making them the most probable oil and gas reservoirs within the Seghendyk Depression.

Stratigraphic and lithological characteristics of the Upper Triassic complex. The Upper Triassic lithostratigraphic complex of Southern Mangyshlak represents a second-order sedimentation cycle, composed predominantly of gray-colored terrigenous rocks, with less typical red-bed facies and minor limestone interbeds. Analysis of the lithological composition of rocks within the Upper Triassic section allows the identification of two lower-rank (third-order) sedimentation cycles.

The first cycle (the North Rakushechnaya Formation) is incomplete and corresponds to the transgressive stage of sedimentation. It begins with coarse-clastic rocks (Member I), passes upward into coarse-, medium-, and fine-grained sandstones and siltstones (Member II), followed by argillites (Member III), and terminates with terrigenous-carbonate rocks (Member IV).

The second cycle (the Bokand Formation) is also incomplete: its lower part consists mainly of sandy-silty rocks (Member V), while its upper part is composed of clayey-silty rocks (Member VI).

Paleontological data confirm the stratigraphic subdivision of the complex and its affiliation with the Upper Triassic Series. According to micropaleontological studies [2], the two lower stratigraphic units correspond to the Carnian-Norian age, whereas the four upper units belong to the Dorian age. The spore-pollen assemblage identified in well No. 3 (Saura-Seghendyk area, interval 3,005–3,010 m) [7, 8] reliably confirms the Upper Triassic age of this stratigraphic level.

Previous researchers have described the Upper Triassic lithostratigraphic complex as being most fully developed within the Zhetybay-Uzen-Kokumbay, Peschanymys-Rakushechnaya, and Aksu-Kendyrly structural-tectonic zones.

In earlier studies, the Upper Triassic deposits were subdivided into the North Rakushechnaya and Zhazgurlin formations. According to those authors, the most complete section of the Upper Triassic complex is observed within the Aksu-Kendyrly zone, where the North Rakushechnaya Formation is composed mainly of variegated sandy-silty rocks. Within its section, there is a consistent transition from gray and light-gray coarse- and medium-grained sandstones on quartz-carbonate cement to siltstones and tuffaceous sandstones with interbeds of argillites, tuffs, and tuffites. In the upper part of the section, a limestone interlayer is observed. The color of the sandstones ranges from brownish-red and reddish-brown to greenish-gray, and the formation thickness reaches 172 m.

The Zhazgurlin Formation is composed of gray-colored carbonate-terrigenous rocks. Sandy-silty varieties dominate the basal part, whereas upsection, the clay content increases, and carbonate interbeds appear. The argillites contain carbonized plant remains. The rocks are gray to dark gray, with a maximum thickness of up to 400 m.

In the Zhetybay-Uzen-Kokumbay zone, the Upper Triassic deposits are partially preserved after erosion and represented mainly by the North Rakushechnaya Formation, with fragmentary occurrences of the Zhazgurlin Formation. The entire section is composed of light-gray and grayish-brown terrigenous rocks. The argillites are dark gray to almost black, containing plant detritus, with a total thickness up to 270 m.

In the Peschanymys-Rakushechnaya zone, the preserved strata belong primarily to the North Rakushechnaya Formation, composed of light-gray, gray, and dark-brown coarse- and medium-grained sandstones, as well as light-gray polymictic siltstones containing thin coal streaks and lenses, and subordinate interbeds of dark-gray argillites with carbonized plant remains. The formation thickness varies from 100 to 280 m.

Within the Zhetybay-Uzen facies zone, the Bokand Formation (up to 900 m thick) has been identified; it correlates with the North Rakushechnaya Formation in adjacent areas. The latter differs from the Bokand Formation by a distinct alternation of sandstones, siltstones, and argillites, as well as by the presence of marine sediments containing foraminiferal shells, indicating the influence of a marine transgression during the formation of the Upper Triassic succession.

Studies conducted more than half a century ago raised questions about the existence of Upper Triassic deposits within the Aksu-Kendyrly zone. However, within the Peschanymys-Rakushechnaya zone, Popkov and Popkov [2] identified an argillite-sandstone sequence, confirmed by drilling on the North Karagii area (well No. 4, thickness 104 m), which they assigned to the Bokand Formation.

The section of Well No. 3 (Saura-Seghendyk area), belonging to the Peschanymys-Rakushechnaya zone, differs from the typical sections of this zone in that it has variable thicknesses of its constituent members. Researchers distinguished tuffaceous-terrigenous and sandy-argillite sequences, which, in the lithostratigraphic scheme, were correlated with the North Rakushechnaya and Zhazgurlin formations. The boundary between the Middle and Upper Triassic was proposed to be drawn along the base of the sand-gravel member, which marks the onset of a new sedimentation cycle.

Within the Upper Triassic deposits, the authors proposed distinguishing the Bokand Formation, which includes an argillite-sandstone sequence first encountered by drilling in the Bokand area (well No. 1, interval 3,618–3,868 m).

According to the Regional Stratigraphic Scheme of the Triassic Deposits of Mangyshlak, adopted at the Almaty Conference, the Upper Triassic deposits in the Zhetybay-Uzen zone are subdivided into:

- the North Rakushechnaya Formation, comprising two sequences – a sandsiltstone unit and a sandstone-argillite unit;
- the Bokand Formation, represented by alternating argillites, sandstones, and siltstones.

Both formations are grouped into the Karzhau Series. Within the Peschanymys-Rakushechnaya zone, the North Rakushechnaya Formation is distinguished, consisting of two members: a tuffaceous-terrigenous unit and a sand-argillite unit. Meanwhile, the upper Zhazgurlin Formation of the Aksu-Kendyrly zone is assigned to the Middle to Upper Triassic deposits.

Conclusions. The analysis of lithostratigraphic and geophysical data on the Upper Triassic deposits of Southern Mangyshlak has refined their internal structure, stratigraphic subdivision, and sedimentation history.

In the sections of wells No. 3 (Saura-Seghendyk area) and Nos. 1–2 (Zhangeldy area), two formations are confidently identified within the Upper Triassic succession: the North Rakushechnaya Formation and the Bokand Formation. These formations differ in lithological composition, facies characteristics, and geophysical parameters.

The North Rakushechnaya Formation comprises four lower lithological members that constitute an incomplete third-order transgressive sedimentation cycle. Its rocks were formed under conditions that evolved from continental to coastal-marine and predominantly marine environments, as evidenced by their mineral composition and the presence of foraminiferal shells.

The Bokand Formation consists of two upper members, forming a second incomplete sedimentation cycle. It is characterized by a gradual increase in the proportion of clayey and silty terrigenous material, accompanied by a decrease in marine influence upwards through the section.

Within the Seghendyk Depression, the North Rakushechnaya Formation ranges in thickness from 741 to 865 m, while the Bokand Formation varies from 244 to 287 m. The greater thickness of the North Rakushechnaya Formation compared with other areas of Southern Mangyshlak is primarily due to the thickening of the basal argillite-gravel member (up to 263 m in well No. 2, Zhangeldy area). In contrast, in adjacent zones, its thickness does not exceed 30–90 m.

Gray and dark-gray colors predominate in the Upper Triassic rocks, accompanied by the presence of carbonized plant remains and a high degree of cementation, which reflects the stability of sedimentation conditions and the dominance of terrigenous material in the depositional system.

The results confirm the distinctive and stratigraphically complete nature of the Upper Triassic complex of the Seghendyk Depression. The proposed stratigraphic scheme is preliminary; further lithostratigraphic and paleontological investigations will allow refinement of the Triassic stratigraphic framework and the final distinction between the Zhangeldy-type section of the North Rakushechnaya Formation and the Saura-type section of the Bokand Formation, both characterized by greater thickness and a pronounced cyclicity of sedimentation.

References.

1. Merekeyeva, E. K., Nurbayeva, F. K., Zhiyenbayeva, G. I., Sundetova, P. S., & Cherkeshova, S. M. (2024). Tectonics of the Zhazgurlinsky depression of Southern Mangyshlak. *News of the National Academy of Sciences of the Republic of Kazakhstan. Series of Geology and Technical Sciences*, (4), 95-106. https://doi.org/10.32014/2024.2518-170X.412

2. Popkov, V. I., & Popkov, I. V. (2021). Biohermal structures exploration of the pre-upper Permian sedimentary rocks of the northern part of the Buzachi Peninsula and the neighbouring shelf area of the Caspian Sea. *Neftegazovaya Geologiya: Teoriya i Praktika*, *16*(2). https://doi.org/10.17353/2070-5379/11_2021

3. Yang, L., Wang, C., Bagas, L., Du, B., & Zhang, D. (2019). Mesozoic–Cenozoic sedimentary rock records and applications for provenance of sediments and affiliation of the Simao Terrane, SW China. *International Geology Review*, *61*(18), 2291-2312. https://doi.org/10.1080/00206814.2019.1587671

4. Gurbanov, V. Sh. (2004). Lithostratigraphic Characteristic and Lithology of Triassic–Paleozoic Rocks of Southern Mangyshlak. *Lithology and Mineral Resources*, *39*(6), 541-554. https://doi.org/10.1023/b:limi.0000046957.60658.03

5. Pronin, A. P., Shestoperova, L. V., & Munara, A. (2021). Neftgazovyy potentsial doyurskikh otlozheniy severnogo sklona Buzachinskogo podnyatiya. *Neft i gaz*, *5*(125), 34-45. https://doi.org/10.37878/2708-0080/2021-5.02

6. Pronin, N. A., Pronin, A. P., Dzhumabaev, T. E., & Uteev, R. N. (2022). Lithological and stratigraphic characteristics of the Upper Permian and Triassic deposits of the Karachaganak oil and gas condensate field. *Kazakhstan Journal for Oil & Gas Industry*, *4*(3), 10-21. https://doi.org/10.54859/kjogi108582

7. Boranbayev, K. Kh., & Boranbayev, A. K. (2023). Prospects of the oil and gas potential of the pre-Jurassic deposits of Southern Mangistau, the direction of further prospecting and exploration, and some issues of the methodology of their implementation. *Kazakhstan Journal for Oil & Gas Industry*, *4*(4), 5-14. https://doi.org/10.54859/kjogi108601

8. Boranbayev, K. Kh., & Boranbayev, A. K. (2022). Oil and gas bearing complexes of the pre jurassic deposits of Southern Mangistau and their characteristics. *Kazakhstan Journal for Oil & Gas Industry*, *4*(3), 3-9. https://doi.org/10.54859/kjogi108579

9. Nurabayev, N. D. (2024). Geological structure and petroleum systems of the Kazakhstan sector of the Caspian Sea South Mangyshlak sedimentary basin. *Kazakhstan Journal for Oil & Gas Industry*, *6*(1), 5-17. https://doi.org/10.54859/kjogi108707

10. Merekeyeva, E. K., Kozhakhmet, K. A., Alekseyev, A. S., & Seydaliev, A. A. (2023). Characteristics of the structural elevations Mahat and Pribrezhnoye are localized within the Zhazgurli depression. *Neft i Gaz*, *3*, 68-81. https://doi.org/10.37878/2708-0080/2023-3.05

11. Kozhakhmet, K., Kushakov, A. R., Kushakov, F. A., Kurbonova, M. M., & Aripova, M. K. (2025). Stratigraphic subdivision of the Paleogene deposits of the Karakata depression of Kyzylkum. *News of the National Academy of Sciences of the Republic of Kazakhstan. Series of Geology and Technical Sciences*, (2), 137-151. https://doi.org/10.32014/2025.2518-170X.496

12. Merekeeva, E. K., & Qosarbai, Q. A. (2023). Characteristics of structural elevations Ulkendale, Tuchisken are localized within the Zhazgurli depression. *Neft i Gaz*, *1*, 7-16. https://doi.org/10.37878/2708-0080/2023-1.01

13. Tlepieva, J. M., & Shilanov, N. S. (2021). Estimation of quantitative criteria of carbonate reservoirs of triassic deposits. *Kazakhstan Journal for Oil & Gas Industry*, *3*(3), 87-100. https://doi.org/10.54859/kjogi88955

14. Ahmadi, H., Hussaini, M. R., Yousufi, A., Bekbotayeva, A., Baisalova, A., Amralinova, B., Mataibayeva, I., Rahmani, A. B., Pekkan, E., & Sahak, N. (2023). Geospatial Insights into Ophiolitic Complexes in the Cimmerian Realm of the Afghan Central Block (Middle Afghanistan). *Minerals*, *13*(11), 1453. https://doi.org/10.3390/min13111453

15. Antipov, M. P., Bykadorov, V. A., Volozh, Yu. A., Patina, I. S., Fomina, V. V., & Bars, F. M. (2024). Triassic Deposits in the Caspian Region: Structure, Tectonic Settings, Sedimentary Environments, and Oil-and-Gas Potential. *Lithology and Mineral Resources*, *59*(6), 638-659. https://doi.org/10.1134/s0024490224700743

16. Kozhagulova, A., Dillinger, A., Bayramov, E., Iltukov, R., Holbrook, J., & Fustic, M. (2023). Geothermal energy potential of the Mangyshlak Basin, western Kazakhstan: A preliminary assessment based on stratigraphy and temperature data. *Geothermics*, (109), 102655. https://doi.org/10.1016/j.geothermics.2023.102655

17. Hofmann, M., Al-Obaidi, S. H., & Chang, W. (2023). Evaluation of Quantitative Criteria for Triassic Reservoirs in the South Mangyshlak Basin. *Natural Science and Advanced Technology Education*, *32*(1), 7-24. https://doi.org/10.53656/nat2023-1.02

18. Nursaule, T., Yessenamanova, M., Kossarbay, K., Yessenamanova, Z., Tlepbergenova, A., Shamshedenova, S., Batyrbayeva, G., & Maden, S. (2022). Chemical Analysis of Groundwater and Wastewater in the Area of the Tengiz Deposit of the Atyrau Region of the Republic of Kazakhstan. *International Journal of Design & Nature and Ecodynamics*, *17*(5), 691-700. https://doi.org/10.18280/ijdne.170506

19. Istekova, S., Aidarbekov, Z., Togizov, K., Saurykov, Z., Sirazhev, A., Tolybayeva, D., & Temirkhanova, R. (2024). Lithophysical characteristics of productive strata of cupriferous sandstone within Zhezkazgan ore district in the Central Kazakhstan. *Mining of Mineral Deposits*, *18*(3), 9-17. https://doi.org/10.33271/mining18.03.009

20. Sirazhev, A., Istekova, S., Tolybaeva, D., Togizov, K., & Temirkhanova, R. (2025). Methodology and Results of Detailed 3D Seismic Exploration in the Zhezkazgan Ore District. *Applied Sciences*, *15*(2), 567. https://doi.org/10.3390/app15020567

21. Istekova, S., Makarov, A., Tolybaeva, D., Sirazhev, A., & Togizov, K. (2024). Determining the Boundaries of Overlying Strata Collapse Above Mined-Out Panels of Zhomart Mine Using Seismic Data. *Geosciences*, *14*(11), 310. https://doi.org/10.3390/geosciences14110310

22. Alzhigitova, M. M., Zapparov, M. R., Auelkhan, E. S., & Kuldeyeva, E. M. (2025). Investigation of the physico-mechanical properties of cohesive soils in deluvial-proluvial (QII-III) and alluvial (QIII-IV) deposits of the Alakol Depression. *Engineering Journal of Satbayev University*, *147*(1), 24-30. https://doi.org/10.51301/ejsu.2025.i1.04
23. Baibatsha, A. B., Kembayev, M. K., Rais, S. E., Yan, W., Amantayev, A. K., & Biyakyshev, Y. T. (2025). Geodynamics of the Shu-Ile ore zone: integration of geophysical, geochemical and cosmogeological methods. *Engineering Journal of Satbayev University*, *147*(4), 30-36. https://doi.org/10.51301/ejsu.2025.i4.05
24. Gornostayev, S. S., Crocket, J. H., Mochalov, A. G., & Laajoki, K. V. O. (2009). The platinum-group minerals of the Baimka placer deposits, Aluchin horst. *Canadian Mineralogist*, 37(5), 1117-1129.
25. Amralinova, B., Agaliyeva, B., Lozynskyi, V., Frolova, O., Rysbekov, K., Mataibaeva, I., & Mizernaya, M. (2023). Rare-Metal Mineralization in Salt Lakes and the Linkage with Composition of Granites: Evidence from Burabay Rock Mass (Eastern Kazakhstan). *Water*, *15*(7), 1386. https://doi.org/10.3390/w15071386
26. Sailygarayeva, M., Nurlan, A., Rysbekov, K., Soltabayeva, S., Amralinova, B., & Baygurin, Z. (2023). Predicting of vertical displacements of structures of engineering buildings and facilities. *Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu*, (2), 77-83. https://doi.org/10.33271/nvngu/2023-2/077
27. Mendygaliyev, A. A., Arshamov, Ya. K., Rysbekov, K. B., & Meirambek, G. M. (2025). Forecasting roll-front uranium provinces based on integrated geological and satellite remote sensing data. *Eurasian Mining*, 18-22. https://doi.org/10.17580/em.2025.01.03
28. Dubovenko, Y. I., Nazirova, A. B., & Abdoldina, F. N. (2022). Data-driven preprocessing of gravity data in oilfield GIS monitoring system in Kazakhstan. *International Conference Monitoring of Geological Processes and Ecological Condition of the Environment*, (1), 1-4. https://doi.org/10.3997/2214-4609.2022580267

Стратиграфія, кореляція та промислово-геофізична характеристика тріасових відкладів Сегендикської депресії (Південний Мангишлак)

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Мета. Уточнення стратиграфічного розчленування, літологічного складу й умов осадконакопичення верхньотріасових відкладів Сегендикської западини (Південний Мангишлак) із використанням геофізичних і кернових матеріалів розвідувальних свердловин.

Методика. Дослідження виконане на основі комплексного аналізу геолого-геофізичних даних, що включають гамма-каротаж, нейтронно-гамма-каротаж, каротаж електричного опору і самочинної поляризації, а також опис кернового матеріалу.

Результати. Проведена стратиграфічна кореляція розрізів площ Саура-Сегенди, Джангельди й Північне Карагіє із виділенням літолого-стратиграфічних підрозділів у межах тріасового розрізу. У межах верхнього тріасу виділені дві світи – Північноракушечна та Бокандська, що відрізняються за літологічним складом і геофізичними характеристиками. Північноракушечна світа розчленована на чотири пачки (аргілітово-гравелітову, аргілітово-піщану, аргілітову й карбонатно-теригенну), що утворюють неповний трансгресивний седиментаційний цикл третього порядку. Бокандська світа включає дві пачки (аргілітово-піщану й піщано-аргілітову), що формують другий неповний цикл. Для відкладів Сегендикської западини встановлене закономірне збільшення потужності Північноракушечної світи (до 865 м) за рахунок потовщення нижньої гравелітової товщі, що перевищує показники у сусідніх тектонічних зонах. На основі інтерпретації геофізичних даних розроблена кореляційна стратиграфічна схема, що об'єднує площі Саура-Сегенди, Джангельди та Північне Карагіє.

Наукова новизна. Уперше деталізована внутрішня структура верхньотріасового комплексу Сегендикської западини із виділенням шести літолого-стратиграфічних пачок, що відображають два неповних цикли осадконакопичення. Запропонована уточнена стратиграфічна схема, що пов'язує Сегендикську западину з Північно-Карагійським сідлом й узгоджується з регіональною стратиграфічною шкалою Мангишлаку.

Практична значимість. Розроблена стратиграфічна модель забезпечує точнішу кореляцію тріасових розрізів Південного Мангишлаку й сприяє прогнозуванню колекторських горизонтів у межах перспективних площ Саура-Сегенди, Джангельди та Карагіє під час пошуків нафти й газу.

Ключові слова: *Сегендикська западина, верхній тріас, літолого-стратиграфічний розріз, стратиграфічна кореляція, Південний Мангишлак*

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