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Criteria for Predicting the Hydrocarbon Potential of Riphean-Vendian Deposits in the Mezen Syneclise

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Abstract: The East European Platform is one of the most extensively studied regions of Russia in terms of geological exploration. However, certain areas remain relatively underexplored from a geological and geophysical perspective. One such region in the European part of Russia is the Mezen syneclise and the adjacent shelf of the White Sea. This area is characterized by complex and poorly studied geological structures. No hydrocarbon inflows have been obtained from the sedimentary cover deposits of the Mezen syneclise. The oil and gas potential of the region can only be inferred from hydrocarbon shows and elevated hydrocarbon concentrations detected in the underground waters of the Riphean and Vendian formations during drilling. Based on a conceptual geological model and an evolutionary-genetic analysis of the region's development, an assessment of the specific resource density of the Precambrian section of the sedimentary cover was conducted. A key factor that influenced the region's hydrocarbon potential was the Vendian collision of the East European Craton with the Pechora Plate. The prospects for discovering oil and gas accumulations are associated with the platform slopes of the most subsided structures, including the Safonovsky, East Safonovsky, and Leshukonsky depressions. The primary exploration targets are structural-lithological hydrocarbon traps located along these slopes, which have been minimally affected by tectonic transformations and may have preserved their hydrocarbon potential.

Keywords: Riphean and Vendian sediments, Mezen-Belomor tectonic-sedimentary element, oil and gas content forecast, hydrocarbon resources, marginal systems.

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Introduction

The modern energy landscape is shaped by the increasing role of alternative energy sources [*Golubev et al.*, 2021], significant redistribution of traditional sales markets, and the high cost of geological exploration [*Kirsanova et al.*, 2024]. These factors are particularly relevant in the context of mineral resource extraction in the Arctic regions of the Russian Federation [*Babyr et al.*, 2024; *Romasheva and Dmitrieva*, 2021; *Zhukovskiy et al.*, 2024] and the adjacent shelf [*Gusev*, 2022; *Prischepa et al.*, 2021], as well as in the development of deeply buried horizons of the sedimentary cover [*Dvoynikov et al.*, 2022; *Prischepa et al.*, 2023; *Prischepa and Xu*, 2025; *Serikova and Allanazarova*, 2023]. These challenges necessitate the development of new approaches to studying, processing, and interpreting geophysical fields [*Mingaleva et al.*, 2022; *Olneva et al.*, 2024; *Putikov et al.*, 2020; *Yakovleva et al.*, 2023], including the use of advanced software packages [*Nefedov et al.*, 2024]. Moreover, they require a reassessment of previously obtained results in regions with developed infrastructure or more accessible geographic locations.

In traditional oil and gas production areas, new research directions are focused on complex clinoform-type formations [*Dovgan et al.*, 2024; *Zharkov*, 2016], "shale" and low-permeability reservoirs [*Dorhjie et al.*, 2023; *Prishchepa et al.*, 2024], as well as the study of ancient sedimentary sequences, deeply buried horizons, and the basement of the sedimentary cover [*Prischepa and Sinitsa*, 2025]. The trend of increasing extraction

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depths is observed not only in the oil and gas sector but also in other industries related to mineral resource extraction [*Malozyomov et al.*, 2024]. This phenomenon is driven by both the depletion of near-surface and shallow deposits and technological advancements in the mining industry, which have made the development of deeper horizons economically viable.

In the northeastern part of the East European Platform, one of the least studied deeply buried structures is the Mezen syneclise, where the crystalline basement surface lies at depths of up to 7 km. This structure shares a unified rift-related geological framework with the Belomorian region [*Baluev et al.*, 2009]. Along with the significant area of the syneclise located within the modern landmass, the marginal northeastern and northwestern parts of the Mezen syneclise continue under the White Sea, which allows us to consider them as a single tectonic segment with similar geological structure and a common history of development.

To the northwest, the territory is bounded by the Baltic Shield. The eastern boundary is defined by the Timan folded structure. To the southeast, the syneclise is limited by the slopes of the Sysol Uplift, which is part of the Volga-Ural Anteclise. The southwestern boundary is drawn along the outer contour of the Kandalaksha-Dvina Trough.

Over more than 80 years of geological exploration of the Mezen syneclise, a significant amount of geological, geophysical, and geochemical data has been accumulated. Its favorable geographical location and the proximity of two major oil and gas production centers – the Volga-Ural and Timan-Pechora petroleum provinces – have repeatedly prompted the resumption of geological exploration within the Mezen syneclise.

Despite a relatively thick sedimentary cover, a long history of geological exploration, and identified hydrocarbon shows, no commercially significant hydrocarbon discoveries have been made to date. The oldest stratigraphic units mapped in the study area belong to the Middle Riphean, overlain by Upper Riphean, Vendian, Silurian (identified only in the Pesha depression [*Shilovskaya and Shilovskiy*, 2007]), Devonian, Carboniferous, Permian, Triassic, Jurassic, and Quaternary deposits.

The greatest hydrocarbon potential of the region is associated with ancient (Riphean) sedimentary complexes filling riftogenic structures. Discovered hydrocarbon accumulations within Precambrian sedimentary sequences are well known across ancient platforms [*Sitar et al.*, 2022]. The most significant discoveries have been made in the southern part of the Siberian Platform [*Frolov et al.*, 2011; *Kelly et al.*, 2011] and are associated with the regional pinch-out of basal sandstones [*Zharkov et al.*, 2024].

The Problem of Oil and Gas Bearing Capacity of Precambrian Complexes of East European and Other Platforms

The discovery at the end of the 20th century of a group of oil and gas condensate fields (Khukhrinskoye, Yulievskoye, Chernetchinskoye, Gashinovskoye, etc.) in the Precambrian (Archean-Lower Proterozoic) basement on the northern side of the Dnieper-Donets depression [*Chebanenko et al.*, 2004] large oil deposits in Upper Proterozoic carbonates of the Yurubcheno-Tokhom zone (Yurubcheno, Kuyumbinskoye and Terskoye) of Eastern Siberia [*Melnikov et al.*, 2011] allow us to consider the study of oil and gas content of Precambrian sedimentary complexes of ancient platforms as one of the important directions of oil and gas geology of the 21st century. In fact, we are talking about two independent, but closely interrelated problems of great theoretical and practical importance, and necessitates an integrated approach based on geological and geophysical, geochemical and petrophysical studies.

The problem of hydrocarbon potential in the Precambrian basement is an integral part of a broader issue related to assessing the prospects of crystalline basements of different ages within the stratified sphere – specifically, the granite layer of the Earth's crust – as a new hydrocarbon-bearing domain in the lithosphere [*Areshev et al.*, 1998; *Shnip*, 2000]. The significance of this issue is underscored by the discovery, at the end of the last century, of more than a dozen oil fields in the Mesozoic crystalline basement of the Vietnam shelf

(Cuu Long Basin). Among these, the large White Tiger field produced over 10 million tons of oil annually from the basement, with initial well flow rates reaching 2000 m^3/d [*Khalimov*, 2012].

The study of the hydrocarbon potential of Precambrian (Upper Proterozoic) sedimentary formations is fundamental for understanding the patterns of hydrocarbon accumulation in ancient sedimentary basins and addressing the most debated issues related to the theory of petroleum generation, historical geology, and evolutionary paleontology [*Gatiyatullin*, 2004].

The interrelation of these issues is determined by two main factors: the commercial hydrocarbon potential of the Baikal crystalline basement (and its structural and age analogs – the Grenville basement of North America, the Rifean of Central Sahara, and the Proterozoic of Australia); and the significant role of the disintegration products of the Precambrian basement (coarse-clastic sandstones, arkoses, and other taphrogenic molassoids) in the composition of the Riphean complexes.

The multifaceted nature of the problem of Precambrian hydrocarbon potential is emphasized by its deep connection with the questions of oil and gas origin. On the one hand, the modern concept of petroleum generation must somehow explain the patterns of hydrocarbon occurrence in pre-Paleozoic sedimentary formations (including the appearance of the Riphean-Vendian maximum on the global cyclicity scale of hydrocarbon formation). On the other hand, understanding Precambrian hydrocarbon potential without clear insights into the sources (generation centers) of hydrocarbons, their migration pathways, and the regularities of trap filling makes it impossible to conduct targeted exploration for hydrocarbon accumulations in ancient deposits.

Many domestic and the vast majority of foreign petroleum geologists believe that the prediction of hydrocarbon potential in ancient strata should be based on the sedimentary-migrational theory (SMT), just as it is for traditional sedimentary formations.

Having practically displaced all other "biogenic" variants, the SMT interprets petroleum generation and hydrocarbon accumulation as the result of the catagenesis of organic matter within sedimentary sequences, which are continuously subjected to thermobaric influences under conditions of elisional (diagenesis–mesocatagenesis) and exfiltrational (boundaries between individual stages of meso-apocatagenesis and metagenesis) hydrogeological regimes, with predominant tectonic subsidence.

In the context of the SMT, the hydrocarbon potential of a basin does not exclude the role of endogenous factors in petroleum generation processes. Since the initial stage of basin formation, according to widely accepted views, is driven by the emergence of a mantle plume, its subsequent evolution is inextricably linked to the development of regional catagenetic zonation and the basin's geothermobaric history.

Consequently, the observed correlation between areas of commercial hydrocarbon accumulations and the "uplift" of the Moho surface [*Zhang et al.*, 2023], as well as other "seismic markers" of the lithosphere [*Bulin et al.*, 1999], along with the association of hydrocarbon accumulation zones with deep faults, riftogenesis, and subduction, should not be regarded as indisputable evidence supporting a mantle-abiogenic origin of hydrocarbons.

This statement also applies to other formal indicators of a connection between petroleum and gas reservoir formation and endogenous factors, such as the paragenesis of hydrocarbon accumulation and hydrothermal ore mineralization, anomalous mercury concentrations in certain oil and gas fields [*Yan et al.*, 2017], and geothermobaric anomalies characteristic of many large oil deposits [*Meyer and McGee*, 1985].

Materials and Methods

The study employed seismic survey data, detailed core-description records, lithological subdivision of wells, and the results of geochemical and petrographic investigations – totaling 570 samples – conducted by the VNIGRI and IG URO RAS. The drilling outcomes of Well Ust-Nyaftinskaya-1 were analyzed in depth. In examining the lithological and stratigraphic characteristics of the Mezen syneclise deposits, we drew upon the publications and archival materials of I. A. Shchukin, B. A. Pimenov, G. D. Udot, V. A. Dedeev, N. A. Malyshev, O. I. Timoshenko, O. M. Veltistov, T. A. Mikhailov, E. P. Dokhsanyants, A. G. Kuznetsov, L. S. Kossovoy, G. F. Budanov, V. A. Rudavskaya, and numerous other researchers.

When modeling the evolution of marginal (mobile) zones, it is necessary to reconstruct not only the geological history of the sedimentary cover but also the nature of its interaction with adjacent tectonic structures, as this ultimately influences the formation, accumulation, and preservation of hydrocarbon deposits.

Each sedimentary basin was formed under specific geodynamic regimes and underwent a long geological evolution. At certain stages of basin development, favorable geological, geochemical, and geothermobaric conditions emerged, determining the processes of oil and gas formation and their redistribution among various complexes composing these paleobasins, as well as the processes of partial or complete destruction of hydrocarbon accumulations [*Egorov et al.*, 2021].

In assessing the hydrocarbon potential of the marginal part of the East European Platform, an evolutionary-genetic approach was used, focused on a comprehensive study of the origin and development history of the Mezen syneclise and the identification of relationships between geotectonic processes affecting the hydrocarbon potential of the sedimentary cover.

The study of the present-day tectonic structure plays a key role in reconstructing the geological history of the region and assessing its hydrocarbon potential. Modern geostructural elements reflect the complex evolution of tectonic processes that have occurred over hundreds of millions of years. Sedimentary basins and structures such as rifts, uplifts, horsts, grabens, and thrusts are the result of interactions between various geodynamic factors. The primary tool of this methodology is the identification of the mechanisms behind the formation of geological structures, which enables a more complete reflection of the relationship between the hydrocarbon potential of the sedimentary cover and the ongoing tectonic processes in the lithosphere, particularly in the context of basin modeling.

Tectonic Structure

Seismic exploration has revealed significant depths of crystalline basement subsidence and the presence of a series of rifts (avlacogens) of Riphean age. The thickness of the sedimentary cover within the rift structures ranges from 3 to 5 km and is composed, based on well sections and natural outcrops, of sedimentary rocks from the Middle–Upper Riphean and Vendian–Cambrian. The sedimentary fill of the rifts consists of three tectonosedimentary elements: synrift, postrift, and plate (Figure 1).

The uplifted areas are separated by rift zones, which form a subsidence region in the central part of the Mezen syneclise (Figure 2). A general subsidence is observed across all major structural surfaces toward the Timan structure [*Baluev*, 2013], which has been thrust onto the edge of the East European Platform. The Safonovskaya and Peshskaya rift zones, extending along the Timan ridge, descend stepwise beneath the fold structures of Timan. The amplitude of discharges on the western side does not exceed a few hundred metres, while the eastern side is subducted under a series of scales of the Timan structure with a total amplitude of more than 5 km [*Gavrilov et al.*, 1998]. Thus, this part of the syneclise is the most submerged element of the syneclise.

The second largest deflection zone encompasses the Leshukonsky rift, which has a V-shape in the north, and the adjacent Pinezhsky rift, which continues this zone southwards through a small saddle.

The Leshukonsky rift (Figure 3) extends from the White Sea in the north to the mouth of the Vashka River over a distance of more than 200 km. Within its limits, the basement surface is submerged to a depth of 4.0–4.5 km. The northern part of the rift zone is complicated by the large Kuloisky basement uplift, which divides the northern section of the rift into the Leshukonsky and Azopolsky branches. Their relative subsidence amplitude along the bounding faults is 1.5–2 km.

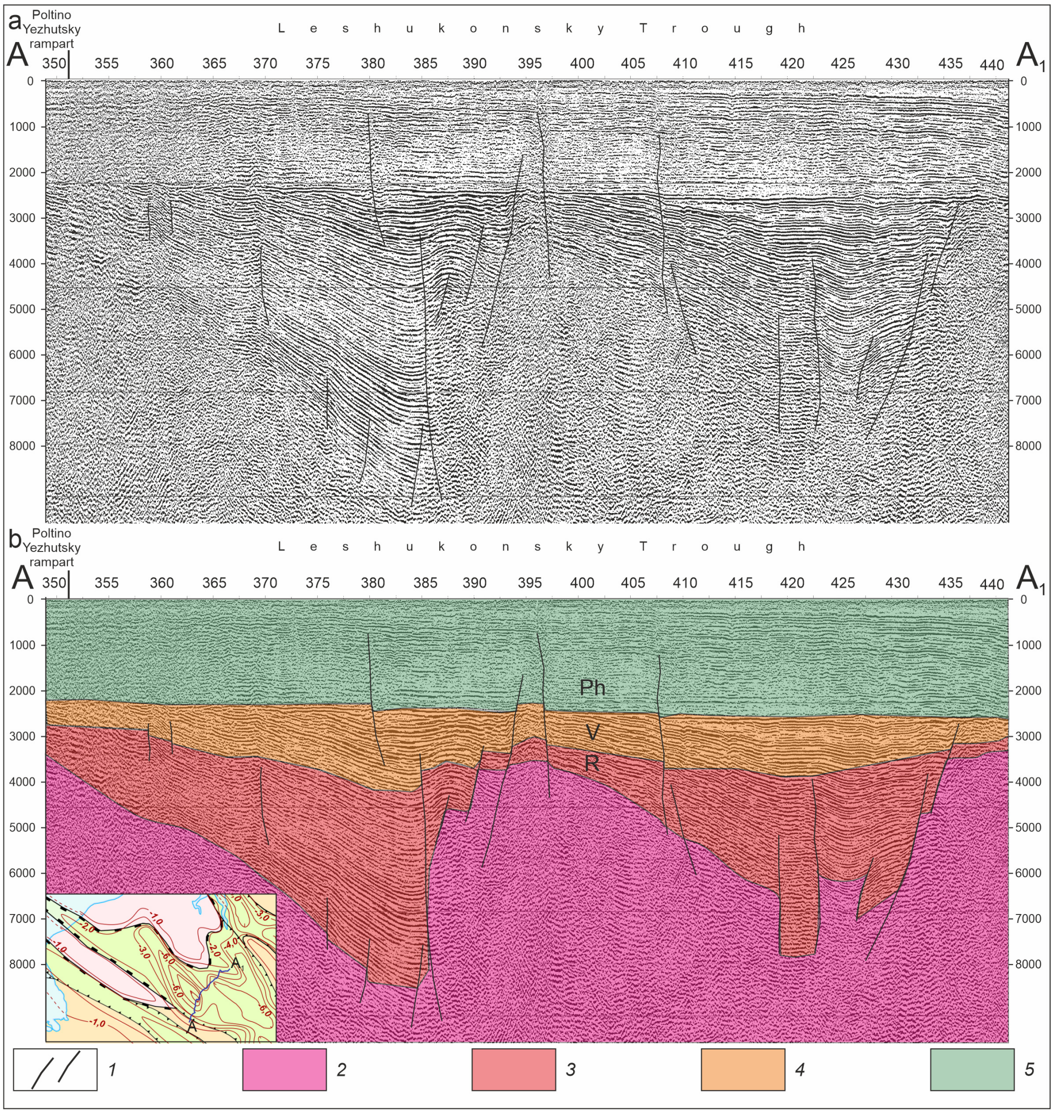

Figure 1. Fragment of regional profile A-A_1 (authors' interpretation, Spetsgeofizika materials) (a – uninterpreted; b – interpreted). 1 – discontinuities; 2 – basement rocks; 3 – synrift complex; 4 – postrift complex; 5 – plate complex.

To the west of the Leshukonsky rift lies the Keretskaya step, which complicates the Arkhangelsk horst from the east. The basement depth within this step ranges from 3.0 to 3.5 km. In the eastern marginal part of the step, the large Poltinskoye and Yezhugskoye basement uplifts are distinguished, with summit depths of approximately 2.5 km.

The southern end of the Arkhangelsk horst descends to depths of 3.0–3.5 km. This part is complicated by numerous tectonic faults, which have formed relatively large uplifts: Yulskoye, Yuraskoye, Uftyugskoye, and Karpogorskoye. These uplifts exhibit significant size and amplitude on the basement surface.

The Vychegda Trough [*Botalov and Alekseeva*, 2021], located south of the study area, extends along the Timan ridge and shares a similar genesis with the Peshskaya and Safonovskaya depressions. Their formation is associated not only with rifting processes but also with additional influences that intensified subsidence due to the thrusting of the Timan structure onto the edge of the East European Platform.

History of Geological Evolution

The geological history of the Mezen-White Sea tectonic segment includes several key stages. In the Neoarchean, the early granitoid crust of the Kola and Karelian massifs [*Sharov et al.*, 2020] was formed, along with metamorphic belts. During the Paleoproterozoic stage, the development of a mobile belt and the formation of the Karelides took place.

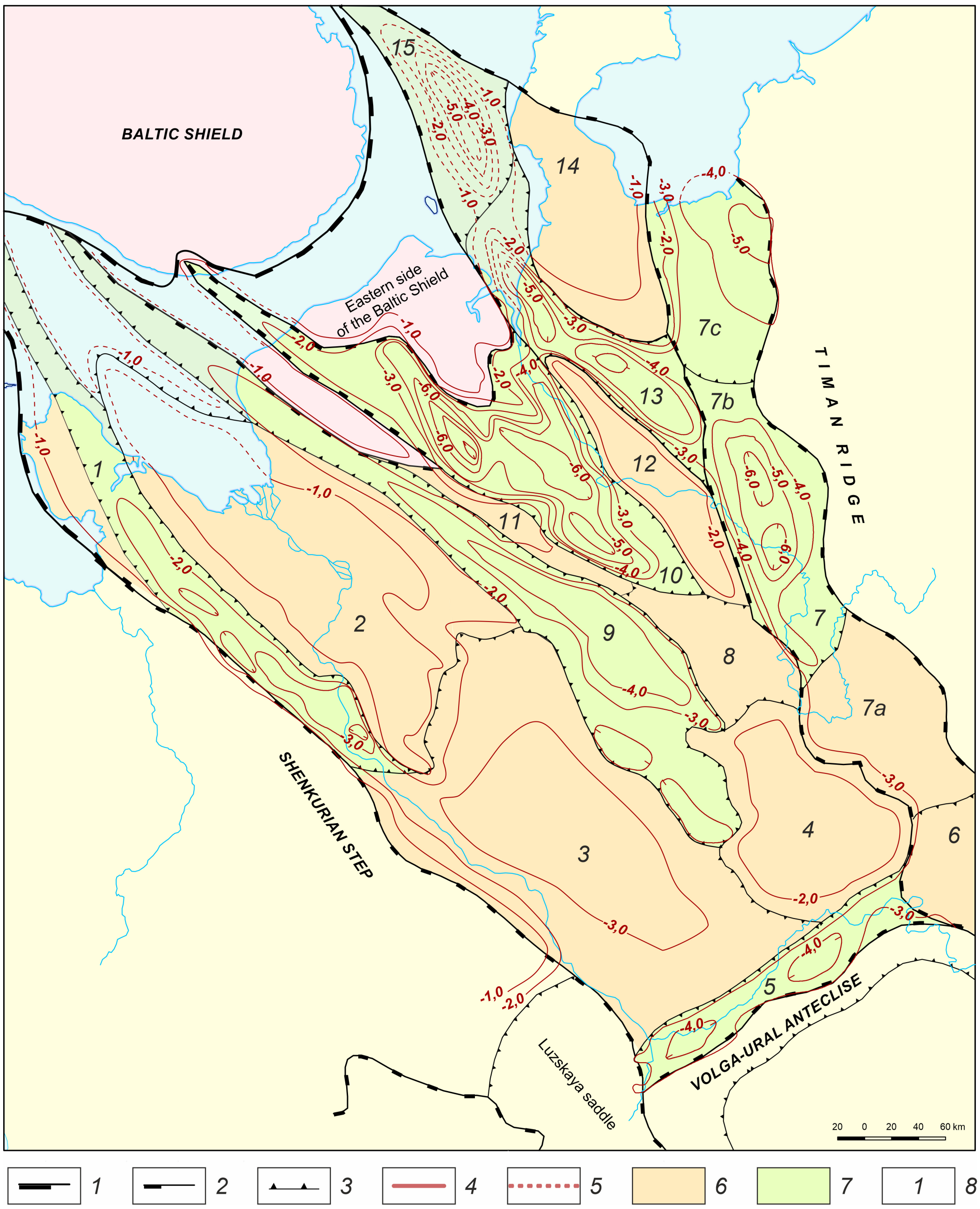

Figure 2. Structural map of the basement of the Riphean complex [*Peskov et al.*, 2024]. 1 – tectonic boundaries of supra-order structures; 2 – tectonic boundaries of first-order structures; 3 – tectonic boundaries of second-order structures; 4 – isohypses of Riphean sediments on land; 5 – isohypses of Riphean sediments at sea; 6 – uplifts; 7 – depressions 8 – signatures of structures (1 – Kandalaksha-Dvinsky linear trough; 2 – Arkhangelsky bulge; 3 – Pinezhskaya saddle; 4 – Vashkinsky arch; 5 – Kotlassky linear trough; 6 – Vychegodsky trough 7 – Predtimansky trough (7a – Vymskaya trough; 7b – Vostochno-Safonovsky trough; 7c – Peshskaya trough); 8 – Mezensko-Vashkinsky saddle; 9 – Keretsko-Pinezhsky trough; 10 – Leshukonsky trough; 11 – Poltinsko-Ezhutsky rampart; 12 – Mezensky rampart; 13 – Safonovsky trough; 14 – Nessko-Tylugsky ledge; 15 – Panoisky basin).

During the Middle–Late Riphean stage, continental rifting was actively expressed (Figure 4b, c), driven by the breakup of the supercontinent Paleopangea [*Asming et al.*, 2022] and the formation of the eastern passive continental margin of the East European Platform [*Baluev et al.*, 2012]. This stage was characterized by the gradual thinning of the Earth's crust and sediment accumulation in a transgressive marine basin environment.

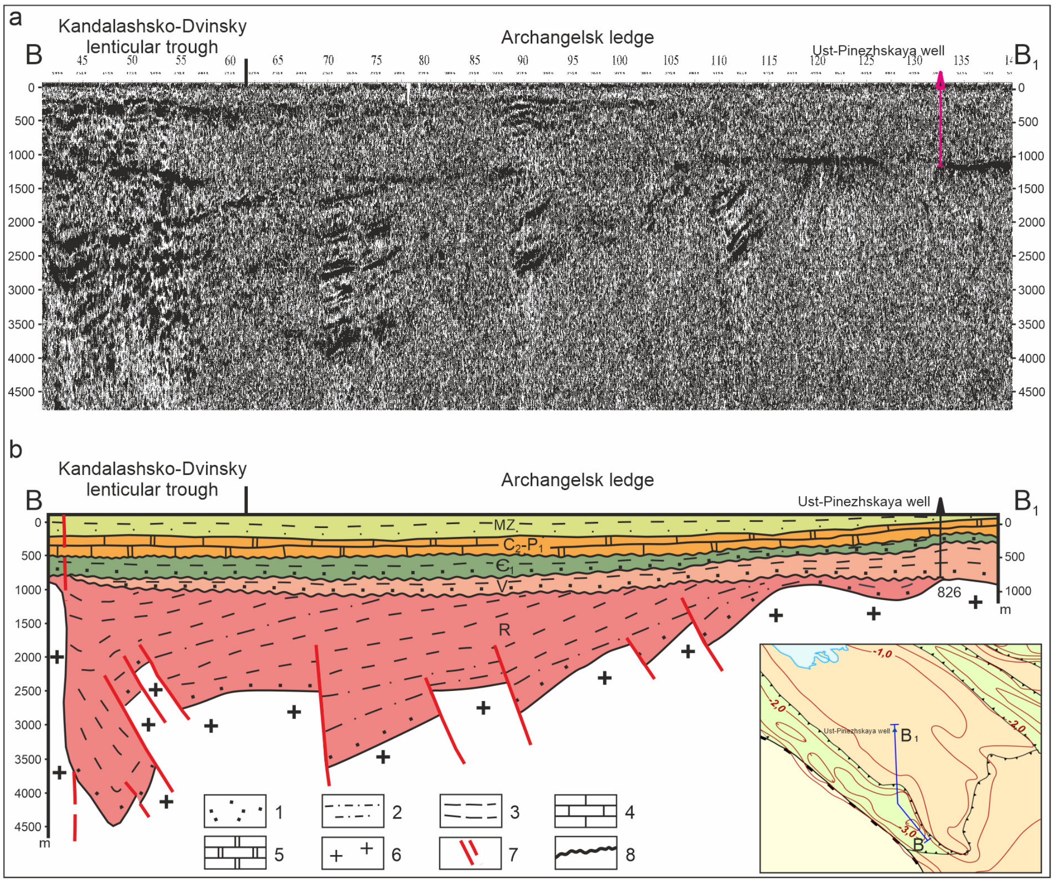

Figure 3. Deep seismic section along line B-B_1 (a – uninterpreted; b – interpreted). 1 – sandstones; 2 – siltstones; 3 – mudstones; 4 – limestones; 5 – dolomites; 6 – basement rocks; 7 – tectonic faults; 8 – stratigraphic unconformities.

The breakup of the supercontinent was reflected not only within the Timan marginal system. Similar rift structures in terms of structure, shape, timing, and sedimentary fill are observed in the marginal parts of the Siberian Platform, such as the Sette-Daban marginal system, which includes the Ust-Maya rift zone.

The Kandalaksha-Dvinsky (Figure 3) and Kotlas rift systems caused accelerated deflection of the basement block bounded by them and thus ensured the formation of the Mezenskaya syneclise. The ocean level probably reached the peneplainenised surface of this depression area in the Middle Riphean, flooding it. As a result, a shallow shelf marine basin with weak hydrodynamics was formed, as we observe in the sections of Riphean sediments penetrated by wells, characterised by predominantly clayey sediment composition.

In the Lower Vendian, the craton likely experienced some uplift, or global sea levels dropped, resulting in the absence of sedimentary deposits of this age in the region. At this stage, a collision between the East European and Pechora plates likely occurred (Figure 4d). In the area of the Baltic Shield and the Volga-Ural Anteclise, the advancing Pechora Plate encountered rigid obstacles. In these regions, the West Timan Fault coincides with the Central Timan Fault. Where the crystalline basement was less rigid, the Pechora Plate was thrust onto the Russian Plate, with a thrust amplitude reaching up to 70 km.

The Timan structure should be considered a zone of a Precambrian orogen that developed on the former northeastern passive continental margin of the East European Platform as a result of its collision with the active margin of the Pechora Plate. Riphean deposits, which accumulated in shelf, continental slope, and continental rise environments, were deformed and partially underwent metamorphic changes due to the thrusting of a volcanic arc onto the passive margin. These deposits were displaced toward the East

European Platform along newly formed low-angle thrust faults [*Gavrilov et al.*, 2000]. The modern structure of the Timan orogen includes a series of thrust tectonic slices, partially overlapping the marginal depressions of the Mezen syneclise.

Under the influence of the thrust Pechora Plate sedimentary mass, the collision zone corresponding to the territory of the Mezen syneclise bends sharply. It is important to note that this segment was separated from the main craton by rift zones, which reduced its elastic properties. Due to this bending, several tectonic wedges (horsts) were displaced, among which the Mezen and Poltinsko-Yezhugsky horsts stand out with the greatest uplift amplitude. This is confirmed by drilling data from the Ust-Nyaftinskaya and Sredne-Nyaftinskaya wells, located in close proximity to the Mezen Uplift. In these wells, Riphean-age sediments are predominantly clayey, with no indications of a local source of sediment transport. If the Mezen Uplift had formed during the Riphean, it should have acted as such a source (Figure 4c, d).

The uplifted areas underwent intense erosion. The formation of sandstones of the Uftyug Formation, characterized by a high quartz content as the most resistant mineral to weathering, occurred under conditions of erosion and reworking of the underlying deposits. Meanwhile, the pelitic fraction of the eroded sediments was largely transported beyond the studied area.

The question of whether and to what extent the roof of the Riphean deposits was eroded during the plate collision can be addressed by analyzing the density difference between Riphean and Vendian deposits. Well data from various, widely spaced locations indicate that the Riphean deposits have a uniform density of 2.7 g/cm^3, both in the Leshukonskaya depression (Ust-Nyafta-1 well) and in the Vychegda Trough (Seregovo-1 well). This suggests that sediment removal occurred uniformly across the entire study area (as a planar erosion process). The density difference between the Vendian (2.5 g/cm^3) and Riphean (2.7 g/cm^3) deposits is 0.2 g/cm^3, which is a significant discrepancy. Based on the density variations of Vendian deposits upward in the section, it can be inferred that more than 1 km of sediments was eroded.

Further sedimentation of Vendian sediments occurs in the conditions of periodically dried shallow sea. The sources of sediment transport were likely external positive structures, as evidenced by the presence of variegated rocks. During this time, intraformational erosional events took place. The most significant erosion is associated with the base of the Mezen Formation and the roof of the Vendian deposits.

In the Cambrian, sediments were likely deposited in localized areas, which were later eroded by subsequent transgressions. During the Ordovician period, the platform likely occupied an elevated position above sea level. Sedimentation resumed in the Devonian due to the reactivation of rifting processes [*Baluev et al.*, 2018], with a predominantly continental sedimentation regime [*Malov*, 2003].

In the Carboniferous, a significant transgression occurred, covering the entire platform. Sedimentation took place in calm, moderately deep-water conditions, leading to the formation of substantial carbonate deposits. During the Kungurian period, the marine basin experienced maximum shallowing, as evidenced by evaporite deposits such as anhydrite and halite. Certain areas of the region were likely affected by hypergenic processes. Subsequently, until the end of the Permian period, marine transgressions continued, accompanied by the emergence of new external sources of terrigenous material, resulting in a terrigenous-carbonate sedimentation regime. During this time (Late Carboniferous–Late Permian, Kazanian stage) [*Tsyganov*, 2006], mafic dikes and sills were intruded.

In the Triassic, the region experienced uplift, leading to the accumulation of a regressive sequence of deposits. This period was marked by tectonic reactivation [*Brusilovskiy and Bush*, 2015], accompanied by the manifestation of trap magmatism (Late Permian–Early Triassic).

In the Jurassic period, marine sedimentation was replaced by continental deposition. In the subsequent period, the region underwent extensive erosion by numerous rivers, maintaining an elevated position above global sea level.

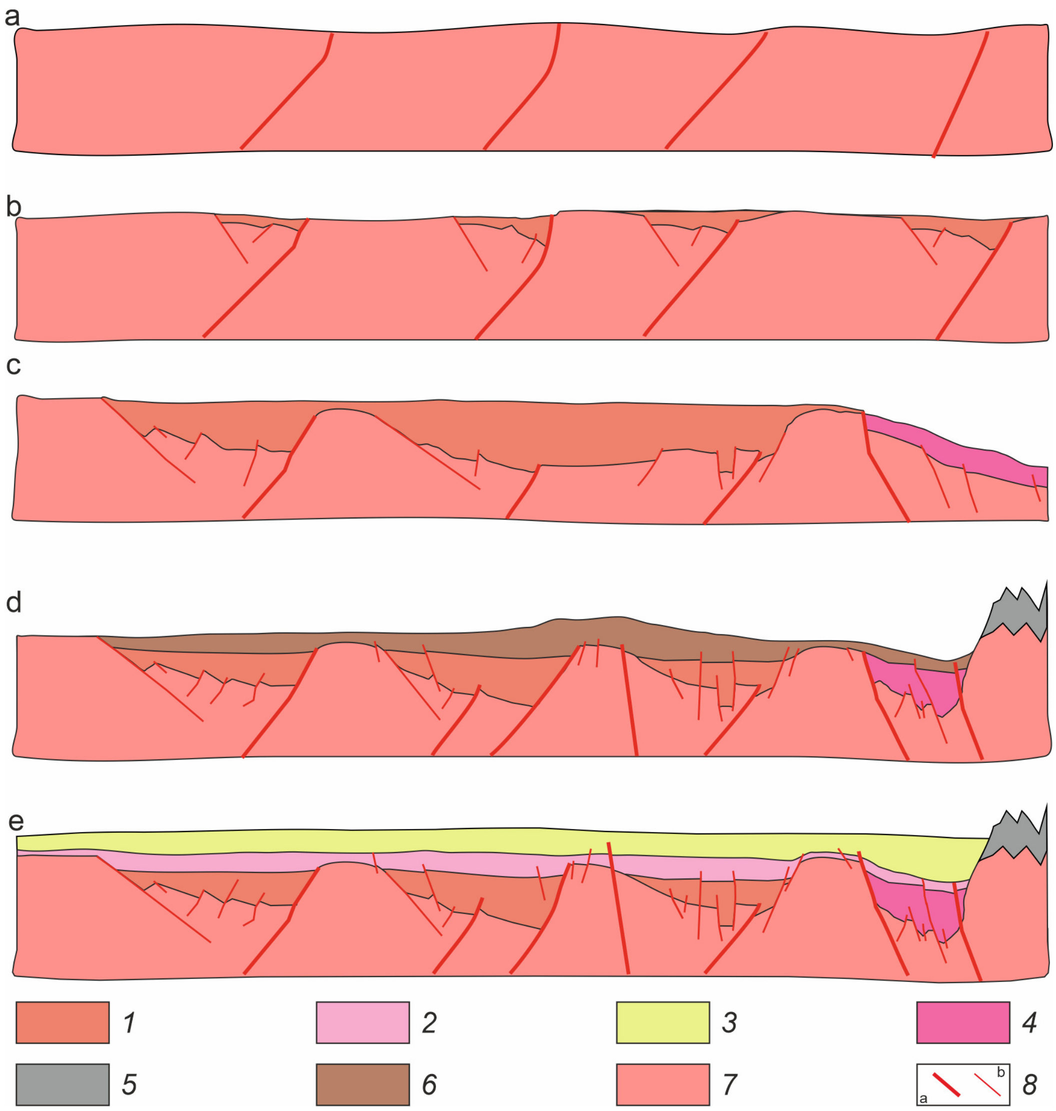

Figure 4. Scheme of evolution of the north-eastern margin of the East European Platform evolution (a – early Riphean; b – beginning of middle Riphean; c – late Riphean; d – early Vendian; e – end Mesozoic). 1 – synrift complex; 2 – postrift complex; 3 – plate complex; 4 – passive continental margin complex; 5 – Timan folded structure; 6 – eroded sediments; 7 – basement rocks; 8 – discontinuities (a – major; b – minor).

Characteristics of Potential Reservoirs

The perspectiveUpper Proterozoic deposits are represented by terrigenous and carbonate-terrigenous sequences of the Riphean and terrigenous deposits of the Vendian. Collectors are predominantly of the porous type; however, in Riphean strata, the development of fractured and fractured-porous collectors can also be expected.

Sandstones and siltstones predominantly have an oligomictic composition, consisting of approximately 75–90% quartz, 11–18% feldspar, and 3–15% rock fragments and mica. Quartz monomineralic sandstones account for about 30% of the total sandstones within the Upper Proterozoic complex. The sandstone cement is mainly clayey, with less frequent occurrences of carbonate and quartz (regenerated-quartz) cement.

In the Riphean, clay cement with chlorite predominates cement predominates, while in the Vendian, kaolinite cement develops, with an increasing iron enrichment process upward in the section. Analytical data on the physical properties of Riphean rocks indicate poor reservoir quality, with virtually no porous reservoir present. The average porosity values of rocks in the Omenskaya well range from 0.87% to 4.9%.

In the Vendian, reservoir properties improve compared to the Riphean deposits. In the lower Vendian (Uftyug Formation), VI–V class reservoir rocks are present (classified as low and very low reservoirs based on intergranular permeability), but pore-fracture type reservoirs can be expected here. In the upper Vendian (Mezen and Padun formations), III–IV–V class reservoir rocks are encountered. Porosity values range from 6.85% to 10.05%.

The Padun and Mezen formations have the highest storage and filtration potential (II–III class reservoirs) in the areas of the Ust-Nyaftinskaya and Koynasskaya wells. The maximum values of effective porosity do not exceed 20.89%.

Assessment of Inferred Oil and Gas Resources

The assessment of hydrocarbon potential has been reflected in both official reports and numerous independent evaluations [*Aplonov et al.*, 2006; *Peskov et al.*, 2024; *Pimenov*, 1994; *Zhuravlev et al.*, 2012]. Overall, the resource potential is considered relatively low. According to the latest assessment based on basin modeling, the geological resources of liquid hydrocarbons amount to 1888.6 million tons, with 50.6 billion cubic meters of gas [*Peskov et al.*, 2024], which is considered quite low for an area of 110 km^2.

The collision between the East European Platform and the Pechora Plate formed a "frontal" contact type, characterized by thrust-fault structures. The fault inclinations are directed away from the contact zone. The collision occurred during a period of active hydrocarbon generation and migration, leading to the drainage of the marginal zone. The consequence of such an early collision is the removal of hydrocarbons to the upper horizons of the sedimentary cover and beyond due to numerous disturbances.

A negative factor was the erosion of the Riphean deposits that accompanied this process. This is confirmed by the transformation of organic matter. In the Riphean deposits, organic matter exhibits high catagenesis values that do not correspond to the current burial depths. In the roof of the Safonovskaya Series R_3 (depth 1880 m), catagenesis of grade MK_3 has been determined, which, according to the shortened catagenesis scale, corresponds to a burial depth of 3.5–3.6 km. At the same time, samples from the Ust-Pinezha Formation V_2 (depth 1.5 km) exhibit an early stage of mesocatagenesis (MK_1), indicating a pronounced catagenetic unconformity typical of Riphean inverted aulacogens of ancient platforms [*Bazhenova*, 2008]. Similar catagenetic unconformities are observed in many structures of the Siberian Platform, as well as in the Middle Russian Avlacogen of the East European Platform and other regions. This fact suggests that rocks that underwent such catagenesis were buried at significantly greater depths during the Riphean period than they are at present.

The greatest interest in terms of petroleum potential is represented by the Vostochno-Safonovsky, Safonovsky, and Leshukonsky depressions (Figure 5), which are considered the most favorable for hydrocarbon generation and accumulation.

In the Paleozoic and Mesozoic complexes, under conditions of an infiltration regime of water exchange and in the absence of their own generative potential [*Malov*, 2004], and with the peak generation of the Precambrian section already achieved in the Riphean time, there are no prospects for identifying even minor hydrocarbon deposits.

Conclusions

The geological history model of the region has been refined, serving as the basis for resource density assessment. The Mezen syneclise is part of the marginal zone of the East European Platform, whose formation is associated with the breakup of Paleopangea. When predicting the hydrocarbon potential of the marginal parts of ancient platforms, it is essential to consider not only the geological evolution of the sedimentary basin but also to reconstruct the geodynamic processes occurring both within the platform and in the contact zone with adjacent plates.

The contact between the East European Platform and the Pechora Plate during the active phase of hydrocarbon migration and accumulation, along with significant erosion,

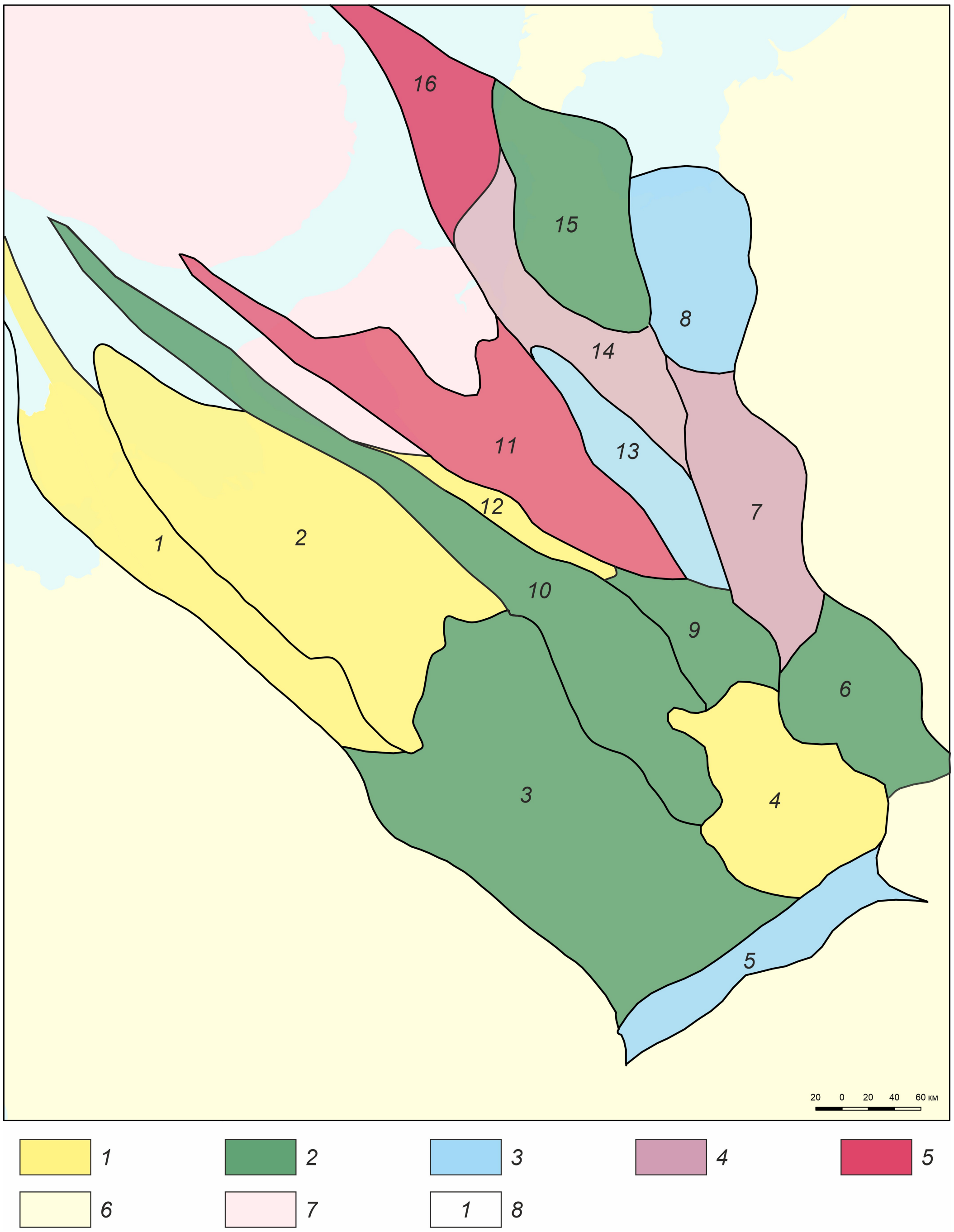

Figure 5. Scheme of oil and gas geological zoning of the Mezen syneclise. 1 – less than 1 thousand t/km^2; 2 – 1–5 thousand t/km^2; 3 – 5–15 thousand t/km^2; 4 – 15–30 thousand t/km^2; 5 – more than 30 thousand t/km^2; 6 – adjacent territories; 7 – Baltic Shield; 8 – prospective oil and gas areas (1 – Kandalaksha-Dvina PNA; 2 – Arkhangelsk PNA; 3 – Pinega PNA; 4 – Vashka PNA; 5 – Kotlas PNA; 6 – Vym PNA; 7 – East-Safonov PNA; 8 – Pesha PNA; 9 – Mezen-Vashka PNA; 10 – Kerets-Pinega PNA; 11 – Leshukonskoye PNA; 12 – Poltino-Yezhug PNA; 13 – Mezen PNA; 14 – Safonov PNA; 15 – Nesso-Tylug PNA; 16 – Panoy PNA).

largely determined the region's hydrocarbon potential. As a result, the marginal part of the platform lost its hydrocarbon potential. Along tectonic fault zones, hydrocarbons migrated into the upper horizons of the sedimentary cover, dispersing and oxidizing along the way.

The prospects for discovering hydrocarbon accumulations are associated with the deepest depressions, where the thickness of the sedimentary cover exceeds 3 km, and the average weighted resource density is 12 thousand tons per km^2. The predicted traps are of a non-anticlinal type, while the reservoir properties of the most promising Riphean complex are characterized by moderate filtration and storage capacity.

Potential traps are associated with sandstone lenses formed in the upper parts of the slope, creating lithological and structural-lithological hydrocarbon traps that have been significantly less affected by destructive factors and structural rearrangements.

Thus, the proposed approach can be used for further planning of geological exploration not only within the studied region but also in other areas, such as the marginal parts of the Siberian Platform, where similar geological and geophysical conditions are observed, and hydrocarbon potential remains largely uncertain.

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