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Geodynamics of oil-and-gas structures of the Western part of the Arctic shelf of Eurasia[1]

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Abstract. This paper reviews the questions of polyphasic development of the western part of the Arctic shelf of Eurasia. The existential interrelation of geodynamic processes has been considered and formation of conditions favorable for UV accumulation in sedimentary complexes of the shelf seas has been proved.

Аннотация. Рассмотрены вопросы полистадийного развития западной части арктического шельфа Евразии и обоснована пространственно-временная взаимосвязь геодинамических процессов и формирование обстановок, благоприятных для накопления УВ в осадочных комплексах шельфовых морей.

Key words: geodynamics, prognosis, oil-and-gas content, hydrocarbon accumulation

Ключевые слова: геодинамика, прогноз, нефтегазоносность, скопление углеводородов

1. Introduction

The European part of the Arctic shelf of Eurasia is well enough studied by geologic-geophysical methods; however laws of existential distribution UV in its limits and historical and genetic aspects of development of the region remain for today, they are in need of additional researches.

Northern and northwest (in modern points) extremities of the East European platform during the postarchaean time have been subject, as it is represented, to processes of split and a conflict joint with the North American lithospheric plate (*Khain*, 2001).

This is corroborated, in particular, by the affinity of the Svekofenian structural-lithological complexes on the Baltic Shield and in South Greenland's and Canada's Ketilides formed 1.9 to 1.8 BY ago at the time of the closing of the Svekofenian paleo-ocean in the process of the Megagea supercontinent formation.

Later, in Early and Middle Riphean (1,650-1,350 MMY ago) there are no reliable geologic data in that part of the platform. This may be interpreted as an indirect indication of the Japetus paleo-ocean opening processes (the paleo-ocean separated previously unified Canadian-Greenland continental formations and the similar structural-lithological Baltic Shield complexes). In the Peri-Timan area and in the Kandalaksha-Dvina basin, the structures of basement sagging and continental clastic sedimentation with some vulcanites developed during the 1,350 to 1,050 MMY time interval (*Khain*, 2001). Simultaneously, shelf and slope depositional complexes of the passive continental margin began forming in the northeastern Russian platform (*Negrutsa et al.*, 1993).

These events are well documented by the field data about Stille's Megagea supercontinent disintegration nearly 1.7 BY ago, which continued through Late Riphean (about 1 BY ago) when the next supercontinent, Mesogea (*Sorokhtin, Ushakov*, 1991) was formed. At that time, the Dalslandian folded area formed over the peripheral zone of the East-European Platform. The folded area is an extension of the Granville complex of Canada and Greenland. It marked the Japetus paleo-ocean closing zone.

Later Vendian (650 to 570 MMY ago), peneplanation processes led to the formation of a clastic continental depositional complex with the traces of tillites in the west (*Chumakov*, 1978) and near-shore marine formations in the north, in the Varanger Lake area (*Raaben et al.*, 1995). At the same time, the shelf and continental-slope formations continued to accumulate over the Russian Plate's northern and northeastern passive margin. West of it, the Dalslandian orogeny resulted in the formation of a number of regularly positioned rift systems in its northeastern areas. The tectonic environment of their formation had a clearly reflective nature. That resulted in the practically complete absence of the magmatic component in the rift sections and over the structural shoulders. The rare dolerite bodies and dykes associated with that time period are mapped only over the northern extremity of the Kola Peninsula and in the Sredny and Rybachy Peninsulas.

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A relative tectonic quiet in the eastern and northeastern Russian Plate during the extended time interval (about 780 MMY from 1,350 MMY through 570 MMY ago) is an indication of a possible accumulation of tremendous amounts of the potential oil and gas-bearing sediments over the continental slope and foot. During that epoch, the continent gradually migrated from the equatorial zone of Earth (where it was positioned during the Mesogea formation about 1.0 BY ago) to the high-latitude and polar areas (about 800-650 MY ago; *Sorokhtin, Ushakov*, 1991).

2. Discussion

Nowadays, the Riphean formations of the Russian Plate's passive margin are exposed in the Varanger Peninsula (northern Norway) and in the Sredny and Rybachy Peninsulas and the Kildin Island in the Kola Peninsula's northern extremity as well as in the Kanin Nos and the Timan salient of the Archangel Province.

These formations are identified as the Timan-Varanger Baikalid system (*Milanovsky*, 1996; *Simonov et al*., 1998). They are a monoclinal buildup of Middle-Late Riphean and Vendian metamorphosed sedimentary complexes that were upthrown, and sometimes overthrown onto the Archaean and Early Proterozoic formations of the Baltic Shield and Russian Plate (*Seismogeologic model…*, 1997).

The monoclinal surface dips at a low angle (2 to 5°) toward the South-Barents Sea depression; then, the dip increases to 5 to 10° (*Simonov et al*., 1998). The Middle Riphean sedimentary complexes are comprised of gray-colored polymictic conglobreccias, conglomerates and gravelites with siltstone and psammite interbeds. The middle section includes alternating gray argillites, siltstones, polymictic psammites and conglomerates with lenses and concretions of carbonate rocks. Late Riphean and Vendian formations are alternating variegated quartz, oligomictic and arkose psammites, siltstones, pelites and dolomites.

The section includes rare interbeds of polymictic conglobreccias with phosphorite and carbonate concretion fragments. The secondary alterations correspond with the metagenesis stage (initial metamorphosis; *Chikirev*, 1995). The geodynamic accumulation environment of the above complexes is compatible with a single lateral series of the shelf, continent-slope and continent-foot formations (*Negrutsa et al*., 1993). Phosphorite and carbonate concretions in the section indicate epicontinental marine environment over the lithospheric plate's northeastern portion and the presence of an upwelling zone.

The phosphorite formation in these zones is typical only of the tropical ocean areas, the Russian Plate migrated from the near-polar area into the lower latitudes only by Late Riphean and Vendian (*Sorokhtin*, 2007). Small phosphorite concentration exclusively in the upper section indicates the initial stage of their formation and the continental plate position in the moderate climate zone. The same concerns also carbonate concretions which can form due to carbonate salts evaporation in shallow water and under moderate, subtropical and arid climatic environment. Superimposed magmatism, metamorphism and folding are almost completely absent in this part of the Russian Plate. This testifies to the absence of any active continental margin indications during the evolution of the continental margin basin and thereafter.

In Late Vendian – Early Cambrian (nearly 620-540 MMY ago), the northern and northeastern extremities of the Russian Plate merged with the Barents-Pechora Plate. The latter subsequently separated into the Svalbard, North Kara and Pechora Plates (*Khain*, 2001). That was the period when the East European Platform structure similar to the present-day one was formed for the first time. At that time north of it was the Japetus Ocean formed after the Mesogea supercontinent disintegrated (*Sorokhtin, Ushakov*, 1991).

The East European Platform buildup process was proceeding with no intense folding or magmatism in the plate merger area. It is an indirect indication of the tangential shear-like merger or a single lithospheric plate, or a series of the echelon Pre-Cambrian island arcs. We believe that this process was evolving along a transform fault. It helped maintain the passive continental margin's structure-lithological complexes practically unchanged.

The Barents-Pechora Plate basement is nonuniform and includes adjacent areas of the continental (granite) and sub-oceanic types. This may indicate the formation of a young lithospheric plate due to the Late Proterozoic folding and juxtaposition of a number of the island arcs (Fig. 1).

The merger of the two lithospheric plates resulted in overthrowing of the Middle and Late Riphean and Vendian shelf and continental-slope formations over the Russian Plate's edge and in the formation of large dextral strike-slip and overthrust structures in the area of the Sredny and Rybachy Peninsulas.

It was shown (*Simonov et al*., 1998) that the Timan-Varanger suture zone formation was associated with a drastic decrease in the section thickness over the northwestern (Kola-Kanin) segment. At the same time, its multiple increase occurs in the southeast (Timan) segment. It should be added that the Riphean is missing from the section and is present only in the extreme southeast of the Timan-Varanger suture zone (*Khain*, 2001).

We believe that the described facts are associated with the dextral strike-slip (transform) joint of the two lithospheric plates when the separating oceanic basin closed without a significant subduction on the most of the plate merger area. In the process, the youngest fragments of the East-European Platform's shelf and continental section were partially upthrown over the plate's edge and partially cut away, moved and discharged in the southeastern direction. The older, Early-Riphean complexes (which composed the lower levels of the continental passive margin's slope and foot) were most likely buried within the lower portion of the formed suture zone.

These processes resulted in the increased folding and metamorphism, up to greenstone facies in the Timan and Kanin part of the section. They also led to contrast magmatism, from granite and granodiorite to gabbro-diabase. More to the south (in the Pre-Urals region) this zone changes to a convergent structure, the fact supported by island arc-type magmatic rocks penetrated by wells (*Khain*, 2001).

The Barents-Pechora Plate basement is exposed in the northeastern Spitzbergen, in the north of the Franz Joseph Land, on Taymyr and is penetrated in wells on the Franz Joseph Land and on the Pechora Plate. The section comprises gneisses and crystalline schists (multi-folded and metamorphosed in the epidote-amphibolite facies environment), biotite and dual-mica, coaly and graphitic, chlorite-sericite schists, quartzites, marbles, dolomites, calciphyres and conglomerates. These complexes are cut through by Riphean-Vendian granites. The basement age is 1.55 to 1.3 BY (*Khain*, 2001; *Wasserman*, 2001; *Explanatory memo…*, 1996). Age difference between an ancient Russian and a young Barents-Pechora Plates resulted in the constant sagging of the latter which is typical of young platforms. Besides, the areas with the suboceanic crust sagged faster than the granite ones (Fig. 1, 2).

The joint of lithospherical plates was accompanied by continental and surface formations on the suburb of the Russian Plate also generating large right-hand shift structures in the area of Sredny and Rybachy Peninsulas. It is noticed (*Simonov et al*., 1998) that processes of Timano-Varangersky sutural zone formation are interfaced to sharp reduction of capacity of the cut in northwest (Kolsko-Kaninsky) segment whereas its repeated increase is observed in southeast (Timansky).

Fig. 1. Schematic map of the Earth crust thickness over the Barents-Kara shelf with the geothermal measurement data (*Levashkevich*, 2005, with modification)

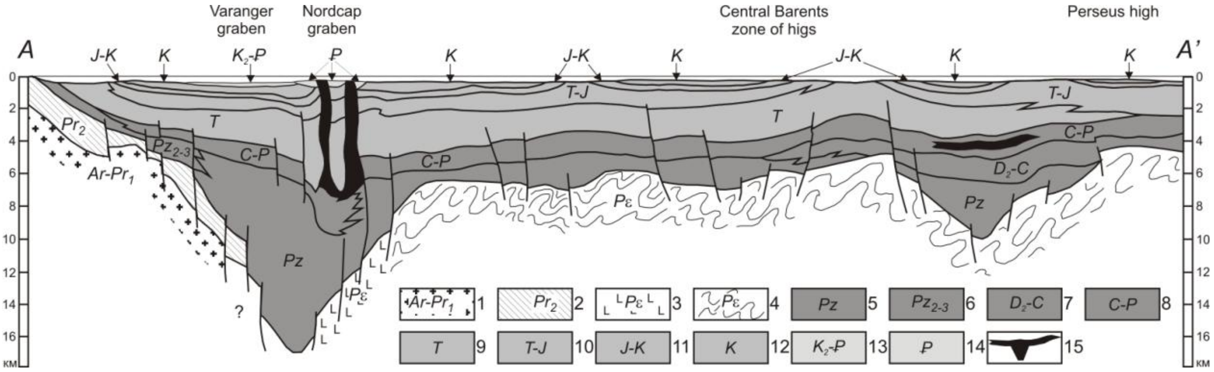

Fig. 2. Geologo-geophysical cross-section through the central Barents Sea shelf from the Varanger Peninsula to Perseus High (see Fig. 1) (*Explanatory memo…*, 1996)

1. Archaean basement of the Baltic Shield: multi-folded multi-metamorphed complexes of tonalite-trondhjemite composition, crystalline schists, amphibolites; 2. depositional Middle Riphean and Vendian complexes; alternating argillites, siltstones, oligomictic, arkose and polymictic psammites and conglomerates with carbonate lenses and interbeds of phosphorite-containing conglobreccias; 3. areas of Pre-Cambrian oceanic crust identified by geophysical techniques; 4. Pre-Cambrian metamorphed folded basement of the Svalbard and North-Kara Plates: gneisses and crystalline schists, marbles and calciphyres, quartzites, biotite and dual-mica schists, coaly and graphite schists; 5. unsubdivided Paleozoic complex: sandstones, clays, conglomerates, limestones and coaly interbeds; 6. unsubdivided Middle and Upper Paleozoic complex: sandstones and clays; 7. unsubdivided Middle Devonian – Carboniferous complex: sandstones, clays and coaly shales interbeds; 8. unsubdivided Carboniferous-Permian complex: sandstones with clay interbeds, conglomerates and limestones; 9. Triassic sedimentary complex: alternating sandstones and clays; 10. unsubdivided Triassic-Jurassic complex: sandstones with clay interbeds; 11. unsubdivided Jurassic-Cretaceous complex: sandstones with clay interbeds; 12. Cretaceous sedimentary complex: sandstones with rare clay interbeds; 13. unsubdivided Upper Cretaceous-Paleogene complex: sands; 14. Paleogene sedimentary complex: sands; 15. salt domes

The sediment cover on the Svalbard Plate begins with Cambrian-Silurian carbonates and clastics. This section is developed in the deeply-buried western parts of the plate (Fig. 2). It is overlain with a clear unconformity by Devonian-Carboniferous clastic rocks, which, in turn, are covered (also with an unconformity) by Permian and Triassic carbonates and evaporites (*Explanatory memo…*, 1996).

The identified Silurian – Early Devonian and Devonian – Carboniferous unconformities within the Svalbard Plate sediment cover are indications of a multi-stage nature of the Japetus Ocean closing west of the plate and a multi-stage nature of North-Atlantic Caledonides orogene complex formation (Fig. 3). At the early stage the Svalbard Plate grew from the west and the south-north (present-day direction) folded system formed. This is supported in particular by the structure-lithological affinity of the genetically connected complexes in Greenland and Spitzbergen (*Khain*, 2001). Besides, the folded formations in the Svalbard are cut by large sinistral strike-slip faults. That enables us to determine the lithospheric plates' motion vector relative one another. Also, glaucophane schists are identified in the Spitzbergen western block's lower section. This is an indication of the older North-American Plate subduction in that area underneath the Svalbard Plate.

Later, in Late Devonian (about 375 to 362 MMY ago) the Japetus Ocean finally closed and the Norwegian Caledonides folded system formed in the study area. Kinematics of the closing Japetus Ocean in that area had the nature of a frontal underthrust of the North-American Plate under the Baltic Shield and that of the formation of a characteristic collision suture on their boundary.

The Arctic Ocean closing in that epoch did not result in the formation of orogenic structures between the Lomonosov Ridge and Barents Sea Plate. This may be an indication of their unity that was later disrupted during the modern Arctic Ocean opening in Cenozoic. An indirect confirmation is the following: the Lomonosov Ridge has a block structure with indications of a pinchout, offset and sagging comparable with the paleogeodynamic reconstructions of the Barents Sea Paleozoic evolution (Fig. 3).

It should be noted in reviewing the Paleo-Urals Ocean closing processes that in the Svalbard Plate section the reflected events of the Hercynian stage tectonic activation resulted in the formation of the unconformable Triassic-Jurassic clastic-carbonate sequences over the Upper Paleozoic sediments (Fig. 2). The Urals folded system formation was accompanied by its multi-stage and non-uniform approach and subduction of the passive margin of East-European and Barents Sea Plate under the active margin of the young West-Siberian Platform.

This resulted in the formation [during the period from Early Carboniferous (about 350 MMY ago) in the south to Early Triassic (about 265 MMY ago) in the north] of an irregularly-shaped collision structure (*Milanovsky*, 1996). The North Kara Plate's passive margin was obducted over the Siberian craton and formed the Taymyr folded system. Based on that the shear structure connecting the Novaya Zemlya Island and Taymyr Peninsula folded formations should be considered a transform fault.

Total closing of the Paleo-Urals Ocean is marked by the intrusions of post-collision granites with the age of 264 MMY (*Explanatory memo…*, 1996). As a result, a suture orogenic structure (Polar Urals – Pay-Khoy – Novaya Zemlya – Taymyr) is formed between the East-European and West-Siberian platforms. The structure comprises vari-directional, sometimes arcuous, sometimes oxygonally-oriented folding zones. In some places, these zones include transform faults (Fig. 3). At the same time the Barents Sea – Pechora lithospheric plate was finally separated into the Svalbard (Barents Sea), Pechora and North Kara Plates.

The South Kara Plate is the offshore extension of the West-Siberian Plate. Its basement is composed of Pre-Cambrian folded formations and is structurally similar with the Svalbard Plate (Fig. 1). It is supported, in particular, by the presence of suboceanic type crust areas in its confines and by a stable subsidence style typical of relatively young platforms with a decreased lithosphere thickness. Such structures may occur at the merger of the island arcs. The present-time South Kara Plate is a large syncline filled up mostly with the Jurassic and Cretaceous deposits and affected by the superimposed structures of the sediment cover deformation.

The supercontinent of Pangaea is formed as a result of the Caledonian and Hercynian tectogeneses. Its northern portion is made up of collision-merged lithospheric plates of the North-American, East-European and Siberian ancient cratons. Between those are squeezed lithospheric plates with Grenville basement such as the West-Siberian and Barents Sea-Pechora platforms. Apparently, a large Eurasian oceanic depression was mostly formed at the same time. Its major part is occupied by the Canadian or Amerasian depression. It is possible that a weak axial spreading continued within it in Jurassic and Cretaceous but stopped later (*Khain*, 2001).

Such complex collision combination of vari-age lithospheric plates did not only form folded systems but also generated within them a system of regularly spaced faults and specific folding in their overlying sediment cover. Fig. 4 displays the conditions of regular formation of riftogenic structures and the large transform fault within the Barents Sea – Kara region. These conditions must have unavoidably occurred as a result of closing the Japetus and Paleo-Urals oceans. A characteristic angular configuration between the collision structures of the Greenland and South Kara, and joint East-European and Barents Sea Plates resulted in the formation of the orthogonal Norway-Mezen rift system. It was superimposed over (by that time) already existing aulacogens of the Grenville tectonic stage (Fig. 4). The intersection nodes of the largest lineaments, the axes and shoulders of rift structures are often marked by magmatic complexes and characterized by intense basement subsidence.

The ocean-floor topography over the northern extremity of the shelf in the subject region shows that the continental margin is composed of a number of subparallel wedge-shaped rifts (Fig. 3). The largest ones are the St. Anna and Voronin rifts in the east and the Franz-Victoria Trough between the Franz Joseph Land and Spitzbergen archipelagos.

The latter was most likely formed at the stage of the Novaya Zemlya folded zone evolution and is regularly positioned along the extension axis (Fig. 4). It makes it genetically affine with the described Norway-Mezen rift system.

We believe that the St. Anna and Voronin grabens have slightly different nature. Apparently, they are the North Kara Plate tear-off structures of the Svalbard Plate in the course of the oppositely directed offsets along the transform fault (Fig. 3). From our viewpoint, the tear-off and formation of the wedge-shaped rifts in that region were quite natural, because the Svalbard Plate subduction rate underneath the South Kara Plate was substantially lower than the obduction rate of the North Kara Plate over the Siberian Plate (Fig. 4).

The reasoning is as follows. The subduction and obduction of different areas on the same plate, at the equal tangential pressure of the lithospheric plates in the collision zone, could not occur at the equal rate as the energy expenditure in the former case is much higher than the parameters of the latter. It is no less natural that a characteristic magmatism occurred over the shoulders of these structures and in the intersection nodes of the largest lineaments of the Caledonian and Hercynian tectogeneses. For instance, the alkali-ultramafic and kimberlite magmatism of that time is very common over the Baltic Shield and the northern Russian Plate.

The sub-longitudinal and northeasterly dolerite dyke complex is encountered on the northern coast of the Kola Peninsula; its composition corresponds with oceanic basalts. Northeasterly trending lamprophyre dykes, picrite, mellilite and kimberlite diatremes are recorded on both shores of the Kandalaksha Bay. Based on geologic and geophysical information collected offshore Barents and Kara seas, several stages of sub-alkaline magmatism are identified there. It is represented by the Late Permian – Early Triassic as well as Jurassic – Cretaceous base composition sills and dykes and is localized within East Barents Sea and South Kara depressions and their frameworks. A younger Cenozoic magmatism is recorded in the Franz Joseph Land and

Spitzbergen. It comprises a complex of sub-parallel northwesterly dykes and base composition sheath volcanites as well as dolerite and dolerite-basalt sills. They invaded the Upper Triassic sediments and, most likely, marked the opening of the Arctic Ocean in Eocene (*Shipilov*, 1998).

Several magmatic stages manifested themselves in Phanerozoic in the Barents-Kara region. The earliest, Silurian one occurred during the time interval of 434 to 400 MMY (*Shipilov*, 1998). Magmatism occurred later in Late Devonian – Early Carboniferous (360-330 MMY), then Late Permian – Early Triassic (257-228 MMY) and Late Jurassic – Early Cretaceous (159-131 MMY). The magmatic activity ended in Paleogene – Quaternary (60-25 and about 1 MMY).

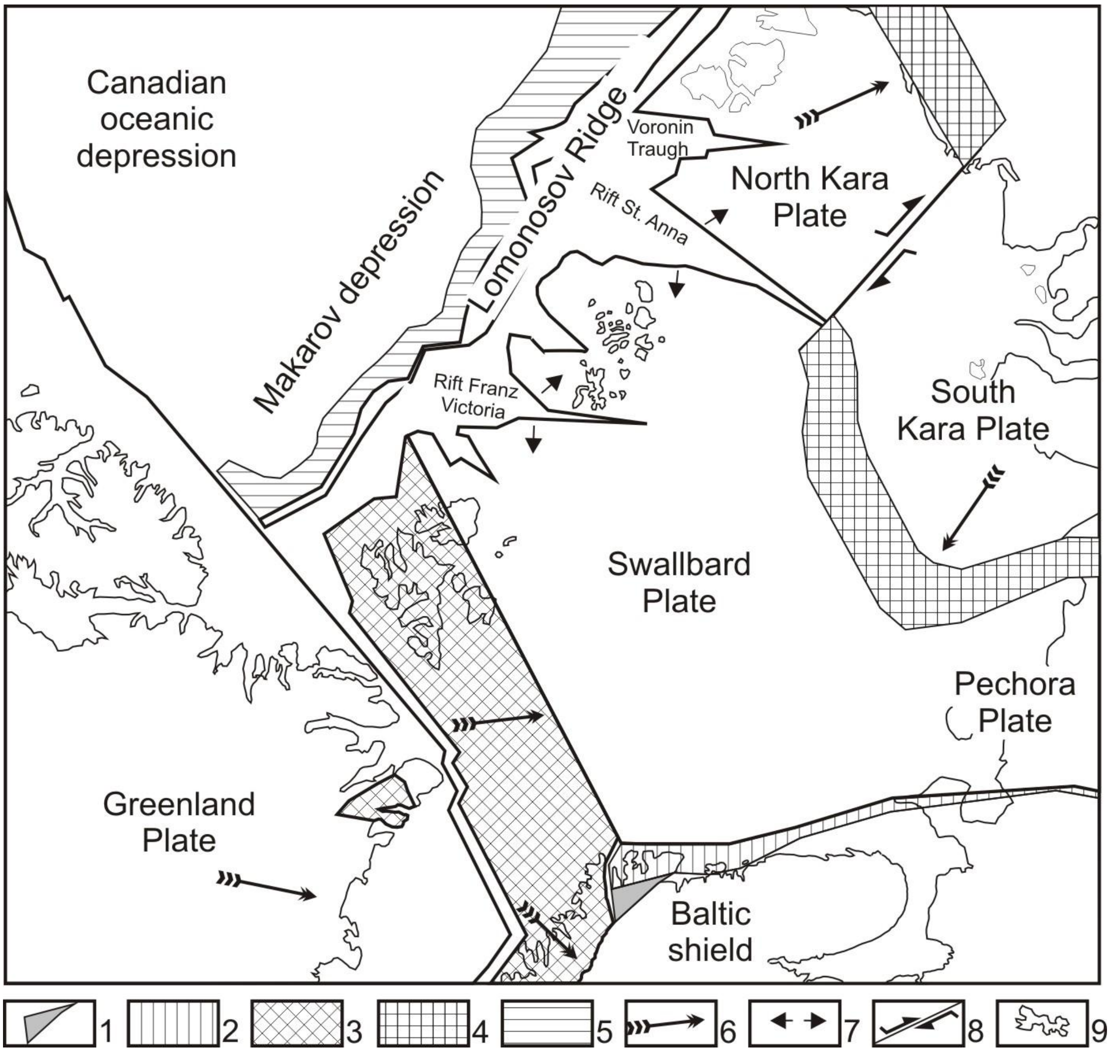

Fig. 3. Paleogeodynamic reconstruction of the northern East-European Plate and West-Siberian Platform and the adjacent Arctic basin in Paleozoic and Early Mesozoic (650-241 MMY).
1. Vendian continental clastic sediments (650-570 MMY); 2. Middle-Late-Riphean and Vendian sedimentary complexes of shelf and the continental slope of the northern Baltic Shield and Russian Plate; 3. Early-Ordovician – Late-Devonian (505-362 MMY) folded formations of the North-Atlantic Caledonides; 4. Polar Urals, Novaya Zemlya and Taymyr Peninsula folded formation in Early Permian – Early Triassic (290-241 MMY); 5. passive continental margin; 6. generalized direction of lithospheric plate migration; 7. vectors of the stress field in the continental lithosphere; 8. transform faults; 9. the present-day shore-line

The first and second magmatic stages were associated with the multi-stage formation of the North Atlantic Caledonides, and the third one was coincident with the closing of the Paleo-Urals Ocean and the end of Hercynian tectogenesis. The entire magmatism is often associated with the shoulders of the then forming rift system and corresponds compositionally with the normal alkalinity basalts. In our view, the following two magmatic stages were coincident with the removal processes of the tectonic stress in the post-collision evolution stretch of the Barents-Kara region. They are represented by the sub-alkaline series formations.

Beside the appearance in the Kara-Barents region of the extension structures, a regular system of troughs and highs was formed in the course of the Paleozoic tectonism. On the one hand, these troughs and highs are a reflection of a folding process on the lithospheric plate boundaries, and on the other, they are a result of the internal non-uniformity. For instance, geophysical data indicate the presence within the Svalbard Plate of the continental crust of various thickness but also some areas of the sub-oceanic type (Fig. 1). It is natural to expect the formation at the boundary of the media so different in their physicochemical parameters of contrasting sag structures and the accumulation of elevated sediment cover thicknesses. Two such structures are identified within the Svalbard Plate. One of them is associated with the East-Barents Trough, and another one with the Nordkap Graben. From our viewpoint, as opposed to the other identified linear structures these two were not formed due to the lithosphere extension.

The Nordkap Graben is believed to be positioned over the oceanic-type Pre-Cambrian crust. Fig. 2 shows that at the early stage the graben subsided faster than the adjacent Central Barents zone of highs. This process was going on relatively uniformly during the entire Paleozoic and Early Mesozoic (Triassic) and substantially slowed down thereafter. The subsidence is still continuing now.

As opposed to Nordkap, the Varanger Graben is associated with the axis of a rift extending along the Baltic Shield coast (Fig. 4). Its initiation dates back to the Riphean evolution stage although the most intense subsidence within its limits occurred in Paleozoic and Early Mesozoic. Later the subsidence rate also slowed down significantly (Fig. 2).

It is important that the subsidence rate in the Varanger graben during Paleozoic was much higher than in the Nordkap graben. The most likely reason is that the rift trough depth increases in time in proportion with the square root of its active evolution time. Should have the extension processes in the Varanger Graben been continuously evolving from its initiation time (Late Riphean), the low would have been about 28 km deep. In actuality, however, the depths are much smaller (16 to 18 km). This indicates a multi-stage and intermittent nature of its evolution. On the Sredny, Rybachy and Varanger Peninsulas within the Baltic shield, the riftogenesis was relatively short during Late Riphean – Vendian (possibly between 800 and 700 MMY ago). The subsequent evolution occurred during Caledonian and Hercynian epochs, in the time intervals 505-362 and 290-241 MMY, respectively. Therefore, the combined active evolution of this rift lasted 292 MMY, which must have resulted it its 17 km subsidence. This conclusion is well supported by geologo-geophysical information from the subject region (Fig. 2).

Apparently, the sag structures in the Barents-Kara region have diverse nature. Some of them are formed as a result of lithospheric extension, whereas others due to the evolutionary basement sagging. The former include Norway-Mezen rift system structures, the Voronin, St. Anna and Franz-Victoria grabens. The latter include the East Barents Sea trough, Nordkap Graben and the South-Kara depression. It is a regular pattern that the former structural type includes the normal alkalinity magmatism, whereas the latter is represented by sub-alkaline varieties.

The timing of the sub-alkaline magmatism is associated with the areas where drastic contrast in the basement composition and structure parameters is observed. Deep-seated faults – conduits for the mantle-type magmatite invasions – must have formed exactly on the contrasting media boundaries in the epochs of tectonic relaxation and destruction of the adjacent folded systems. The reason for that is that the isostatically leveling crust blocks of different composition, compaction and density undergo vertical motions at a different rate relative to one another. Their alkalinity depends on the lithosphere thickness which is always greater than in the actively evolving rift systems.

The formation of spatially localized hydrocarbon accumulations is closely associated with tectonophysics parameters of the process evolution on the lithospheric plate boundaries and with the overlying sediment cover.

Current data indicate that about 80 % of the world's oil and gas reserves are associated with the lithospheric plate subduction zones that existed in previous epochs (*Gavrilov*, 1986). The largest agglomerations emerge within the foredeeps that were formed when the island arcs or active continental margins obducted the passive margins (*Sorokhtin, Ushakov*, 1991).

The hydrocarbon amassing in such structures is due not only to the accumulation of dispersed organic matter but also to the hydrocarbon migration from the subduction zones. Most hydrocarbons migrate toward the subducting plate's passive margin perpendicular to the axis of the obducting allochthon, and some are squeezed in the opposite direction thereby enriching the back-arc areas (*Sorokhtin*, 2007).

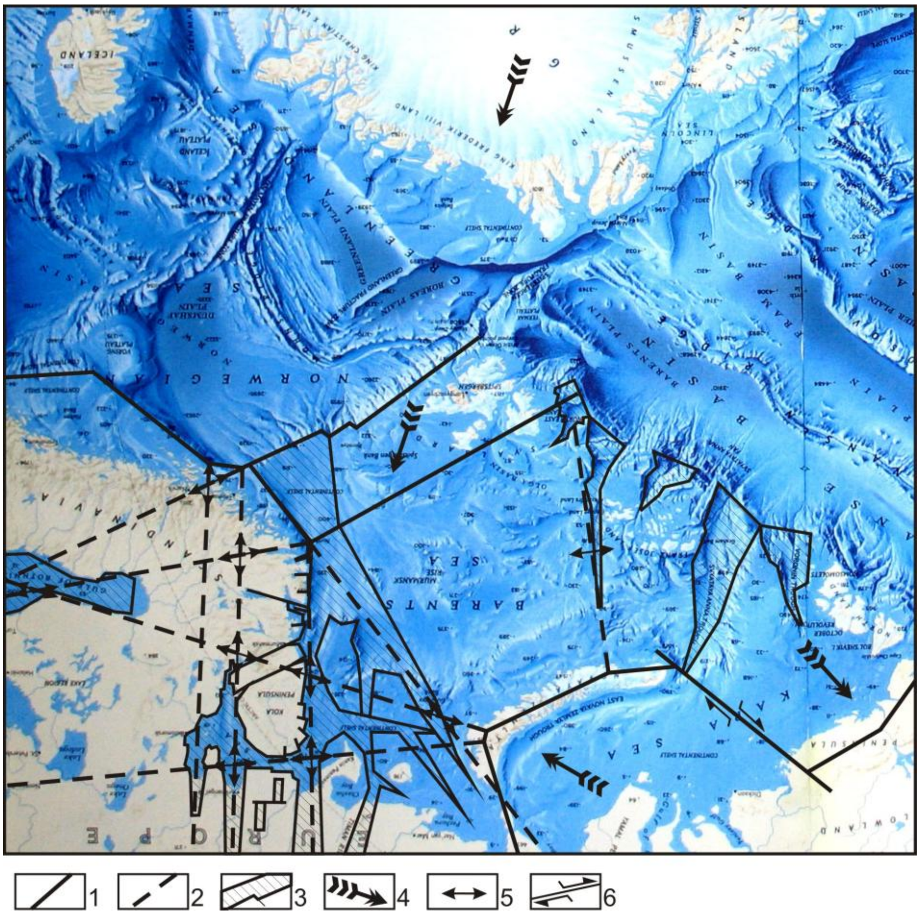

Fig. 4. Reconstruction of fault dislocations on the East-European, West-Siberian and Siberian platforms in Phanerozoic (650-241 MMY ago).

1. Lithospheric plate boundary along which closing down of paleo-ocean and collision occurred; 2. major lineaments forming in continental lithospheric plate; 3. rifts; 4. general direction of lithospheric plate migration; 5. stress field vectors in continental lithospheric plate; 6. transform fault

3. Conclusions

The oil and gas-generation processes evolve due to the overburden pressure, heating, dehydration within the sediment cover, and due to the effect of huge tangential action on this cover. The former causes generate the spatially dispersed hydrocarbon impregnations. As a result of the latter, they are mobilized, accumulated and squeezed from the higher pressure zones into the tectonic relaxation zones. This mechanism is responsible for the formation of large and super-large (unique) oil and gas fields in the sedimentary basins.

Significant oil and gas accumulation can occur also within the rift systems. Buried under thick sedimentary sequences, the dispersed hydrocarbons undergo the maturation due to a heavy overburden pressure and heating resulting from the elevated heat-flow from the mantle. These processes are particularly active under the conditions of hydration of the sedimentary complexes (at the emergence of rifts and aulacogens over the continental shelves) because due to this the water convection occurs in the rock sequences resulting in the gathering of oil, its migration and the formation of commercial accumulations.

Taking into consideration the aforementioned patterns in the geodynamic evolution of the Russia's western Arctic shelf, one can conclude that four oil-generating time intervals may be identified within this western Arctic shelf. Spatially, these generating processes are regularly distributed and reflect the continental crust and oceanic basins evolution specifics. The structural-lithological Riphean complexes within the merger area of the Russian Platform with the Timan-Pechora and Barents Sea lithospheric plates are the earliest potential oil and gas-bearing formations.

Potential oil and gas-bearing areas later occurred associated with the closing of the Japetus Ocean in Early Ordovician – Late Devonian (505-362 MMY). They were located over the western Barents Sea Plate and northward of the Baltic Shield Caledonides. Subsequently, oil and gas areas west and east of the Uralian folded system were formed along the Polar Urals – Pay-Khoy – Novaya Zemlya – Taymyr Peninsula trend, then in a result of closing of the Paleo-Urals Ocean in Early Permian – Early Triassic (290-241 MMY ago). The fourth and concluding stage in the formation of the region's oil and gas potential was associated with a Cenozoic (55-0 MMY) accumulation zone of biogenic and abiogenic (gas hydrate) hydrocarbons at the base of the continent slope over the continent's passive margin.

All these listed stages of hydrocarbon generation and accumulation in the sediment cover of the Russian Arctic shelf's continental crust resulted in the emergence of a number of large and regularly positioned oil and gas areas with the enormous combined potential.

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