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# SCIENTIFIC AND METHODICAL APPROACHES TO INCREASE PROSPECTING EFFICIENCY OF THE RUSSIAN ARCTIC SHELF STATE GEOLOGICAL MAPPING

**Aleksey S. EGOROV[1], Ilya Yu. VINOKUROV[2], Alexander N. TELEGIN[1]**
[1] *Saint-Petersburg Mining University, Saint-Petersburg, Russia*
[2] *A.P.Karpinsky Russian Geological Research Institute (VSEGEI), Saint-Petersburg, Russia*

A rationale for the set of theoretical and methodological techniques of mapping and deep modeling in the Russian Arctic shelf and adjacent sedimentary basins in continental Russia is based on the materials for the Barents and Kara Seas region. This article provides the factual basis of the research and shows how to apply zonal-block model of the crust and generalized models of geodynamic settings in terms of the different geophysical data inconsistency. The necessity and approach for global and regional paleo-reconstructions are also discussed.

It is shown that localization of the principal structural and compositional units of the lithosphere being a consequence of geodynamic processes at the boundaries of lithospheric plates, form at the basis of sedimentary cover and crystalline basement layered maps as well as cross-sections of the continental crust. The identified parameters of the deep structure and milestones of the regional tectonic history open new opportunities to explore the regularities of ore deposits distribution. The shown example of the forecast and metallogeny problems solution within Western Siberia and Khatanga-Vilyui petroleum provinces is made using the parameters of known industrial oil and gas fields for training the pattern recognition system.

***Key words*:** Arctic shelf; methods of geological and geophysical modeling; zonal-block model of the Earth's crust

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**Introduction.** Joint investigations of the St. Petersburg Mining University, A.P.Karpinsky Russian Geological Research Institute (VSEGEI) and Sevmorgeo state enterprise scientific teams aimed at the *deep structure*, *tectonics, and geodynamics studies of the Russian Arctic western sector and adjacent areas of the Eurasian continent* facilitated the development of methodical techniques that significantly increase the detail level and reliability of deep structures in the Arctic shelf and adjacent sedimentary basins of continental Russia [9].

Materials of gravity and magnetic surveys, bathymetry data, seismic common depth point (CDP), profiling, deep seismic sounding (DSS), seismic refraction data, and seismic acoustic profiling served as a basis for this study. In addition seismotomography, geothermal, magnetotelluric, geological mapping, deep-sea drilling, and other surveys data were used [3].

**Statement of the problem.** In the process of a comprehensive interpretation of the diverse data, researchers are forced to solve a wide range of scientific, theoretical, and methodological problems. The following problems should be primary mentioned:

1. The incompatibility of data obtained from various geophysical fields, often reflecting different objects of research or different properties of a single object. This apparent incompatibility leads to an ambiguous geotectonic interpretation of the geophysical field anomalies that do not provide recognition and modeling of structures formed in different geodynamic settings.

2. The multivariance of the interpretation, even in sections of geophysical calibration profiles, provided with the maximum amount of actual information, is caused by the ambiguity in solving of the inverse geophysical problems, as well as the complexity and diversity of structural and petrophysical parameters of different geotectonic structures.

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3. The need to study the regional history which increases the reliability of deep geotectonic constructions and opens up opportunities for assessing the spatial regularities of deposits localization.

4. Sharp differences in the structures of platform cover and crystalline basement, which lead to the too sophisticated geotectonic maps, simultaneously reflecting the cover and basement structures.

5. The study of the mineral deposits localization features using the identified parameters of the regional deep structure and tectonic history ensures the implementation of scientific developments in the solution of prospecting and exploration questions.

**Research methodology.** The solution to the problem of *incompatibility of data obtained from various geophysical data* was found in application of *the Earth's crust zonal-block model* [4]. In the framework of this approach, modeling of blocks and interblock zones of different within the area under the investigation and in sections of reference geophysical profiles: *blocks* are identified as *stationarity areas* of the calculated geophysical parameters; *interblock zones* are distinguished as *gradient zones* or zones of a radical change in the geophysical field infrastruc-

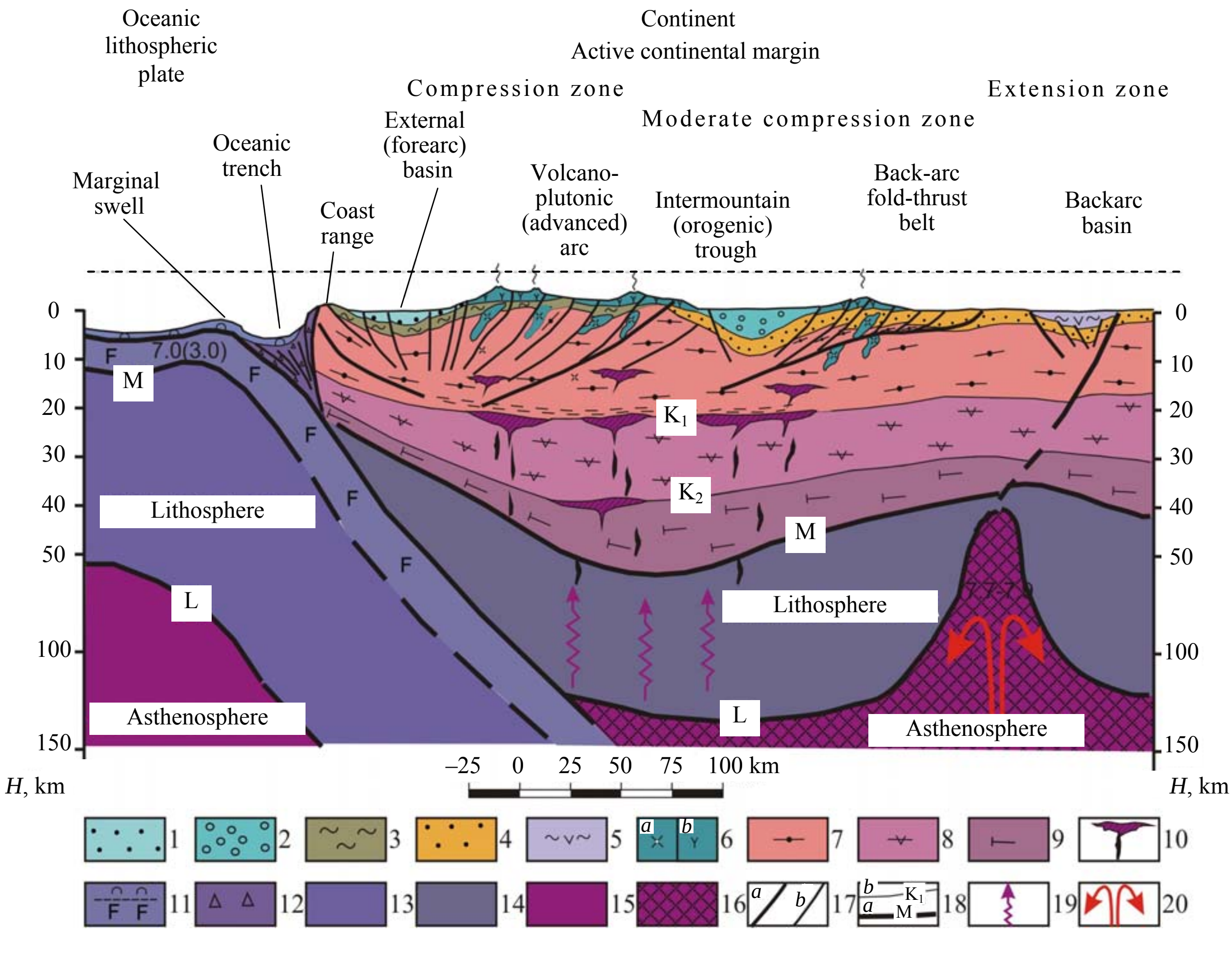


Fig.1. Generalized crust section of the Andean-type active continental margin

1-16 – structural and compositional units (SCU) of the crust and upper mantle: 1 – forearc basin sediments, 2 – intermountain (orogenic) trough molasse, 3 – ancient passive margin sediments, 4 – intracontinental sediments, 5 – volcanogenic-sedimentary riftogenic complexes, 6 – igneous complexes of volcano-plutonic arc (*a* – intrusive, *b* – volcanic), 7 – the upper crust granitic layer, 8 – middle crustlayer, 9 – lower crust layer, 10 – crust-mantle and crust magma chambers, 11 – oceanic crust, 12 – accretionary prism complexes, 13, 14 – lithospheric mantle (13 – oceanic, 14 – continental); 15, 16 – asthenosphere (15 – oceanic, 16 – continental); 17 – faults (*a* – principal, *b* – minor); 18 – boundaries of the lithosphere radial stratification (*a* – the principal, including crust (M ) and the lithospheric (L) bottoms, *b* – minor, including upper ($K_1$) and middle crust ($K_2$) bottoms); 19 – zones of heat and mass transfer, initiated by the interaction of water-saturated sediments of the sinking oceanic lithosphere with the asthenosphere of the continental plate; 20 – back-arc mantle plume

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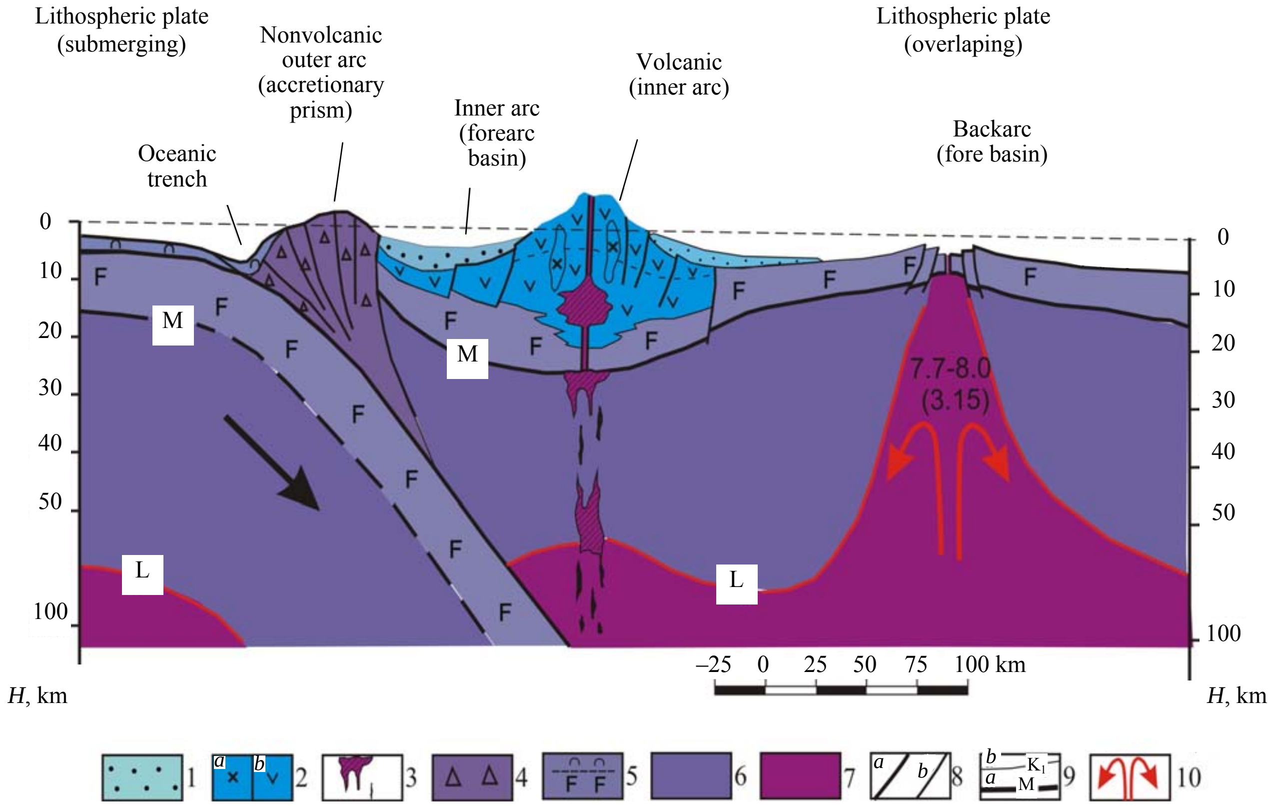


Fig.2. Generalized crust section of the ensimatic island arc

1-7 – structural and compositional units (SCU) of the crust and upper mantle: 1 – forearc basin sediments, 2 – igneous complexes of volcano-plutonic arc (*a* – intrusive, *b* – volcanic), 3 – crust-mantle and crust magma chambers, 4 – accretionary prism complexes, 5 – oceanic crust, 6 – lithospheric mantle, 7 – oceanic asthenosphere; 8 – faults (*a* – principal, *b* – minor); 9 – boundaries of the lithosphere radial stratification (*a* – the principal ones, including crust (M) and the lithospheric (L) bottoms, *b* – minor, including upper ($K_1$) and middle crust ($K_2$) bottoms); 10 – back-arc mantle plume

ture. The blocks on the resulting tectonic models usually correspond to the continental parts of lithospheric paleo plates and microplates or their autonomous segments; interblock zones correspond to tectonic structures formed under conditions of tension (rifts), compression (collision orogen sutures) or shift faults [5].

Thus, even at an early stage of qualitative interpretation of geophysical fields, the approach allows comparing and summarizing heterogeneous geophysical and a priori geological information and performing preliminary geotectonic typing of distinguished physical and geological heterogeneities.

The solution of modeling challenge in the lack of geological and geophysical information and, accordingly, the *multivariance of interpretation models* is performed by recognizing the geodynamic conditions of structure formation by indirect geophysical features. Taking into consideration the theoretical concepts, a natural analog is selected and their properties are applied in the study of relatively less studied structures. Thus, the deciphering of the structures, which are studied by geological and geophysical investigations, is based on generalized models of geostructures formed in various geodynamic settings [4]. Modeling of the geological objects under study is performed with a high level of generalization: the section reflects only principal structural and compositional inhomogeneities, such as the block boundaries and interblock zones, deep faults, tectonic dislocations of sedimentary stratas, intrusive massifs and other high-contrast petrophysical features, etc. Generalized sections of structures formed in convergent geodynamic settings are given as an example (Fig.1-3).

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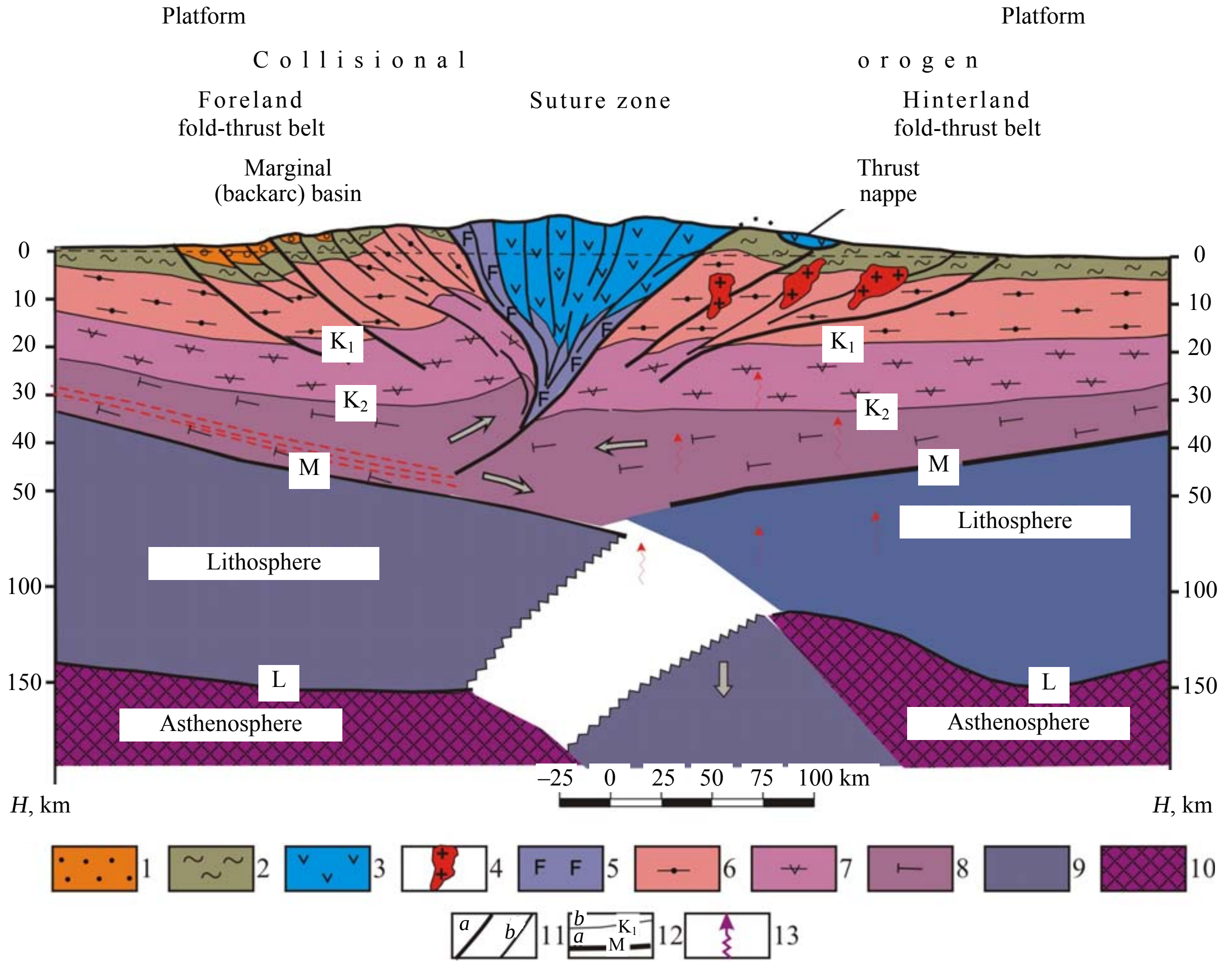


Fig.3. Generalized crust section of the Urals-type collisional orogen

1-10 – structural and compositional units (SCU) of the crust and upper mantle: 1 – forearc basin molasse, 2 – ancient passive margin sediments, 3 – igneous complexes of ancient island arc, 4 – collisional granites, 5 – ophiolites, 6 – the upper crust granitic layer, 7 – middle crust layer, 8 – lower crust layer, 9 – lithospheric mantle, 10 – asthenosphere; 11 – faults (*a* – principal, *b* – minor); 12 –boundaries of the lithosphere radial stratification (*a* – the principal ones, including crust (M) and the lithosphere (L) bottoms, *b* – minor, including upper ($K_1$) and middle crust ($K_2$) bottoms); 13 – zones of heat and mass transfer, initiated by the interaction of water-saturated sediments of the submerging oceanic lithosphere with the asthenosphere of the continental plate

The application of the geodynamic models in depth constructions finally confirms the geotectonic approach to the comprehensive geological interpretation of geophysical data. It is quite clear that maps and sections of the deep structure should be regarded as tectonics models. Only in this case the appeal to the generalized models of geodynamic settings and to the properties of well-studied analogs can be considered as correct one.

*The study of the regional geological history* is successfully carried out by linking the author's geotectonic constructions, performed within the framework of the «*radial-zonal model of the Earth's crust*», with more generalized reconstructions based on paleomagnetic data. Thus, our regional palinspastic reconstructions were based on the Arne Bjorlykke's models [11], according to which the Proterozoic evolution of the Earth ends with the formation of a whole group of Archean-Early Proterozoic cratons located in the equatorial zone.

The reconstruction of the Baikalian tectonic epoch (700-670 Ma) characterizes the end time of the accretion of the Svalbard part of the Laurentia paleo plate with the Bolshezemelskaya paleo plate and the Baltic. The result of accretion is the formation of the Timan-Pechora orogen on their borders. The sediments denudation and accumulation at this time occur from the central part of

Svalbard and, probably, from the axial zone of the Timan-Pechora orogen to the periphery areas of Svalbard. The Yenisei and Taimyr folded regions are formed along the margins of the Siberian paleo plate as a result of the joining of the Nyadoyakh and Kara paleo plates. The Taimyr folded region is the source of sedimentary material incoming the Kara basin (Fig.4, *a*).

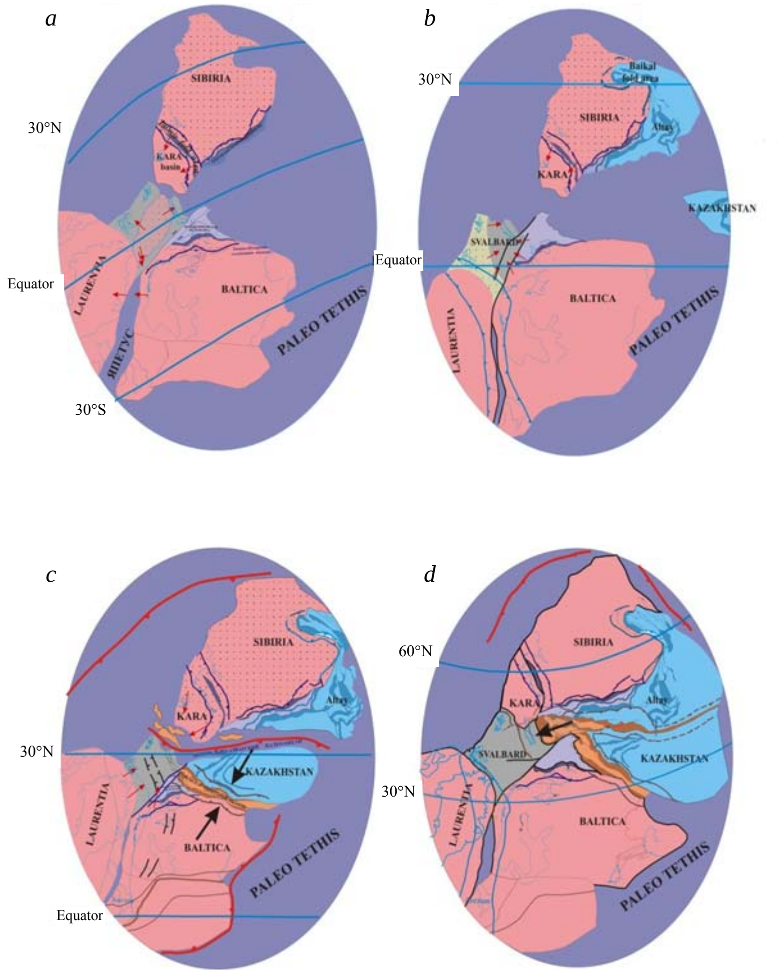


Fig.4. Regional palinspastic reconstructions for the main Paleozoic epochs carried out by assembling the elements of the author's model of depth tectonic regionalization of Northern Eurasia with paleomagnetic reconstructions by Arne Bjorlykke [11].
The orogeny: *a* – Baikalian (700-670 Ma), *b* – Caledonian (560 Ma), *c* – Hercynian (290 Ma), *d* – Cimmerian (195 Ma)

The reconstruction for a period of 420 million years shows the closure of the Iapetus Ocean as a result of the accretion of Laurentia paleo plate with the Baltic and Svalbard during the Caledonian tectonic epoch. The result of accretion is the formation of an extensive fold belt, which includes the western flank of Spitsbergen, the Norwegian periphery of Europe, the territory of modern Britain, the periphery of Greenland and North America. Sedimentary material accumulated in the southwestern part of the Svalbard paleo plate. The territories of the northwestern part of Svalbard and the Bolshezemelskaya margin of the Baltic served as the source of sedimentary material. The Siberian paleocontinent at that time had been increased by the folded structures of the Altai-Sayan and Baikalian folded regions (Fig.4, *b*).

During the Hercynian epoch in the conditions of the Baltic paleo plates (Laurentia's margin), Kazakhstan, and Siberia accretion, the Urals (290 Ma) and the Central West Siberian folded regions (250 Ma) were formed. The accumulation of sedimentary material from the surrounding orogens continued within Svalbard and Kara basins (Fig.4, *c*).

At the beginning of the Mesozoic Era (195 Ma), we assumed a high-amplitude strike-slip movement of the Siberian paleocontinent and the Central West Siberian orogen relative to other segments of the Pangea and of the Pay-Khoy and Novaya Zemlya folded belt formation in the area of their accretion with the Svalbard margin. The beginning of the Mesozoic Era is associated with the rift structures formation, which led to the intensive sedimentation within the West Siberian syneclise, the Kara and Barents basins.

Palinspastic reconstructions are designed to clarify the logistics of the development of multi-age folded belts and the formation of uneven age sedimentary paleo basins of the Barents and Kara seas regions. The reconstructions are aimed at linking the distinct geodynamic regimes occurred during the pre-Mesozoic evolution in different parts of the region and adjacent structures of the West Siberian, Yenisei-Khatanga and Pechora sedimentary basins.

These supporting materials increase the validity of the geotectonic interpretation of geological and geophysical data and modeling of structures formed in different geodynamic environments. The materials also serve as a basis to create the tectonic framework of the area of interest. *Under these conditions, the Earth's crust maps and sections* present localization of the main structural and compositional units of the continental crust and upper mantle *as consequences of geodynamic processes at the boundaries of the lithospheric plates*. The maps of the platform areas, in addition, provide the spatial ratios of the consolidated crust and the platform cover units. These studies open the way for the research in the field of sedimentary basins geodynamics and new opportunities for the multiple metallogenic forecasts.

The challenge of mapping and modeling *of platform cover and a crystalline basement, as well as the informational overload of the compiled deep structure maps*, is solved by compiling layered maps of the Earth's crust deep structure and deep sections using a unified system of symbols. This approach is illustrated by the Barents and Kara seas region materials.

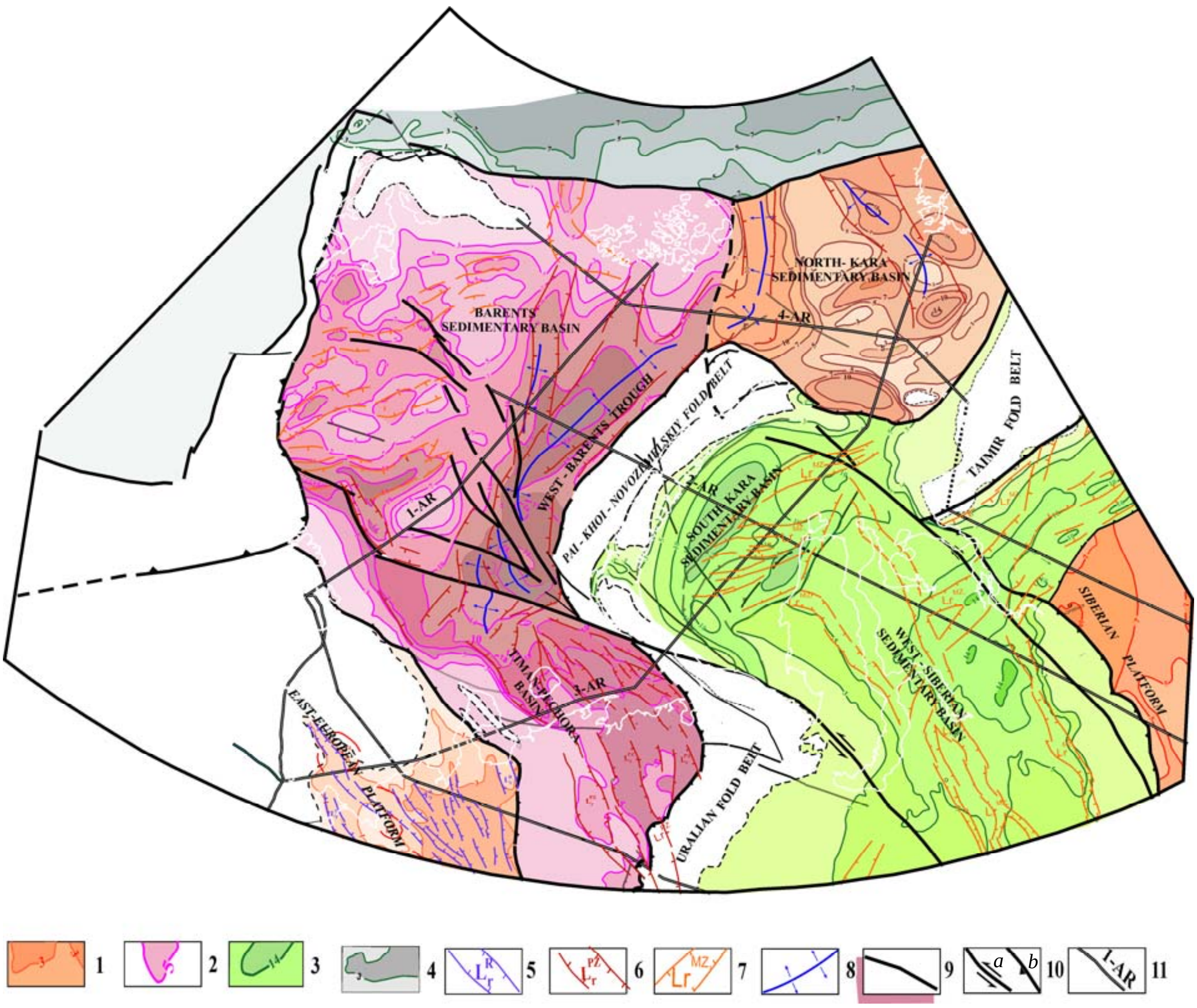


Fig.5. The deep structure map of the sedimentary cover of the Barents and Kara Seas shelf and adjacent regions of the Eurasian continent (with simplifications)

1-4 – **i**sohypses of the platform cover bottom: 1 – the ancient East European, Siberian platforms and the Kara plate, 2 – the Timan-Pechora and Barents Sea Paleozoic sedimentary basins, 3 – the Mesozoic West Siberian and South Kara sedimentary basins, 4 – the oceanic crust sediments of the Arctic basin; 5-7 – rift structures of the basal parts of sedimentary basins: 5 – Riphean; 6 – Paleozoic, 7 – Early Mesozoic; 8 – axes of rift troughs; 9, 10 – principal faults (including strike-slips (10a) and thrusts (10b)); 11 – reference geotraverses of the Barents and Kara Seas regions and related continental geotraverses

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*The sedimentary cover map* of the Barents and Kara Seas shelf and the adjacent parts of the Eurasian continent characterizes the deep structure of sedimentary basins of various ages, sizes, and morphology. According to the map legend, the color corresponds to the age interval of cover formation; color intensity characterizes cover thickness (Fig.5).

Within the study area following geostructures can be identified:

– the northern flanks of the *East European and Siberian cratons*, which sedimentary covers are mainly presented by Vendian-Paleozoic sediments with an average thickness of 2-3 km; the Riphean aulacogens with a thickness of up to 8 km are underlying;

– *North Kara basin,* composed of the Riphean, Paleozoic, and Mesozoic sediments with a thickness varying from the first to 16 km (within the East Barents depression);

– *Timan-Pechora basin,* which is characterized by a variable thickness of the Paleozoic-Mesozoic sedimentary strata from zero (Timan ridge and Canin-North Timan zone) up to 8 km in the Urals and 16-18 km on the southern flank of the South Barents basin. This sedimentary basin had been developed from the Early Paleozoic in the settings of passive continental margin. Its structure has been greatly influenced by intraplate shear-fault and shear-thrust deformations initiated by the Late Paleozoic orogenic processes of the Ural Fold Region;

– *The Barents Sea sedimentary basin,* composed of Paleozoic and Mesozoic sediments with a thickness varying from zero (Spitsbergen Island) to 20 km within the North Barents Basin. The sedimentary basins structure was greatly affected by the following processes: Early-Middle Paleozoic and Late Paleozoic-Early Mesozoic rifting, epi-Caledonian orogenic processes in adjacent Svalbard folded region and Early Mesozoic orogenic processes of the Pay-Khoy and Novaya Zemlya folded region [2, 7];

– *West Siberian sedimentary basin,* laid on the uneven crystalline basement, including the Ural, Central West Siberian, Kazakhstan, Altai-Sayan, and Yenisei fold regions [10]. The thickness of the sedimentary strata changed dramatically and reached maximum values (14 km) in its northern and eastern parts [1]. The morphology of the basin is greatly influenced by the Early Mesozoic rifting areas and transregional Tom-Kolyvan-Novaya Zemlya shear-thrust zone;

– *Khatanga trough,* formed on the northern flank of the Siberian platform. This basin is composed of Vendian-Paleozoic and Mesozoic sediments with a total thickness of up to 10 km;

– The southern flank of the *South Kara sedimentary basin*, which is considered to be continuation of the West Siberian sedimentary basin. The northern flank of the basin laid on an epi-Cimmerian folded basement; the most submerged part of the basin is localized on the oceanic crust (residual ocean basin).

On the *deep structure map* of the Barents and Kara Seas shelf and adjacent areas of the Eurasian continent crystalline basement, the color reflects the Earth's crust consolidation age of the of the principal geostructures of the region under study: ancient cratons, orogens of Grenville, Baikalian, Caledonian, Hercynian, and Cimmerian epochs (Fig.6).

The outlines of geological complexes, classified by the geodynamic settings of their formation, as well as the faults of various morphology and kinematics carry important additional information. Within the study area can be identified following geostructures:

– ancient cratons (*Eastern European and Siberian platforms*), which basement contains blocks of the Archean continental crust, separatedt by the Early Proterozoic rift and suture zones;

– *The Severozemelsky block*, which is considered to be a segment of the Siberian paleocontinent, re-attached to its northern (in modern coordinates) margin at the final stage of the Baikalian orogenic cycle;

– *The Barents folded area is* classified as a structure, formed during the Grenville epoch;

– *The Timan-Pechora fold system*, formed along the Baltic paleo plate border during the Baikalian orogenic cycle, which includes its passive margin, the Upper Pechora suture zone, and the Bolshezemelsky mega-block (paleo plate) with the continental crust;

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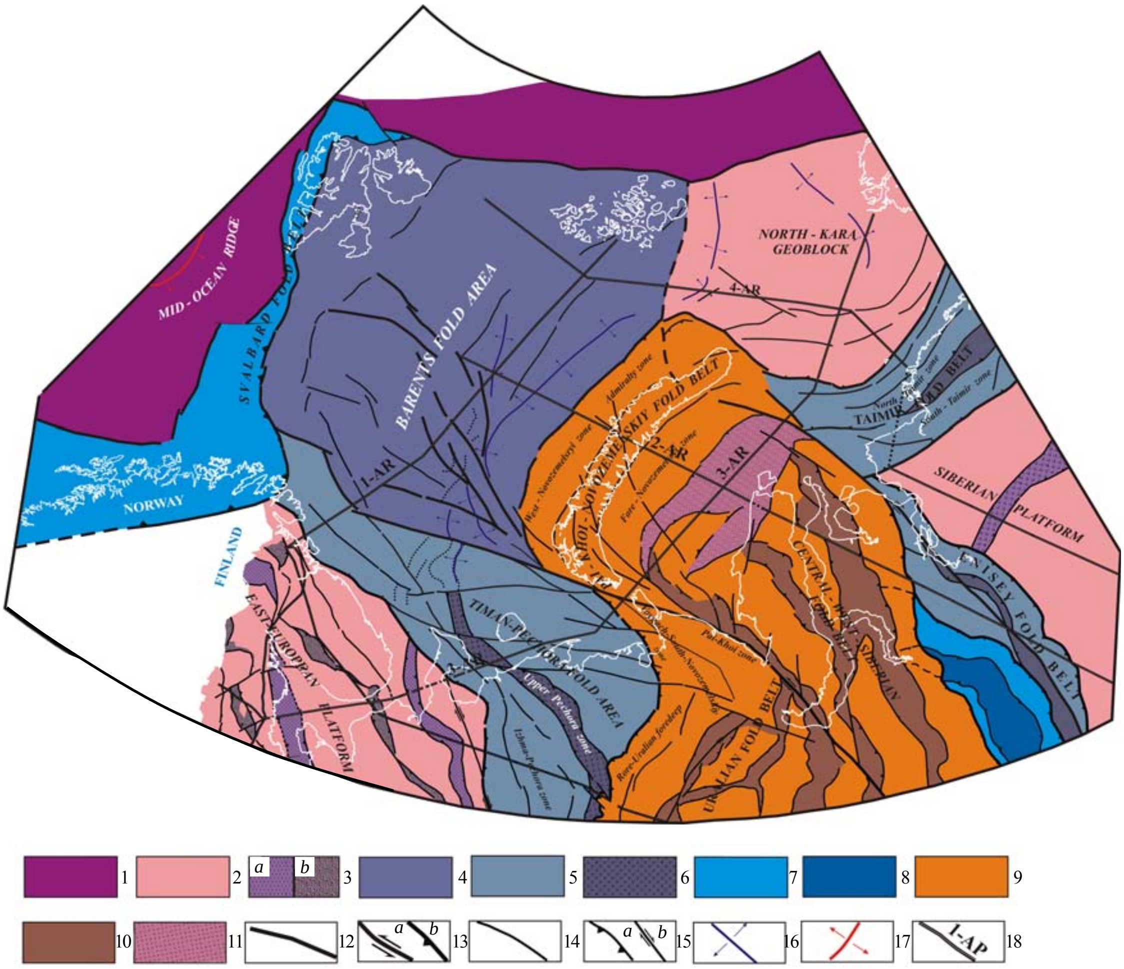


Fig.6. Map of the crystalline basement of the Barents and Kara Seas shelf and adjacent parts of the Eurasian continent (with simplifications).

1-11 – structural and compositional units (SCU) of the lithosphere: 1 – oceanic lithosphere, 2, 3 – ancient platforms (2 – blocks, 3 – interblock suture (*a*) and rift (*b*) zones), 4 – blocks of the Grenville orogen, 5, 6 – Baikal folded areas (5 – blocks, 6 – interblock suture zones), 7, 8 – Caledonian orogen (7 – blocks, 8 – interblock suture zones), 9, 10 – undifferentiated Hercynian and Cimmerian orogens (9 – blocks, 10 – interblock suture zones), 11 – remnant oceanic basin; 12-15 – faults: 12 – principal deep faults, including strike-slips (13*a*) and thrusts (13*b*); 14, 15 – second-rank faults (including the thrust boundaries of the suture zones (15*a*) and shifts (15*b*); 16 – axes of rift troughs; 17 – mid-oceanic ridge 18 – geotraverse of the Barents and Kara Seas region and related continental geotraverse

– *The Ural and Central West Siberian folded regions* are considered to be collisional orogens formed in the process of the Baltic, Kazakhstan and Siberian paleocontinents accretion at the end of the Hercynian orogenic cycle;

– *Pay-Khoy and Novaya Zemlya folded areas*, formed at the final stage of the Paleo-Asian ocean's northern branch closure at the beginning of the Mesozoic era;

– structures of the northern flank of the *Altai-Sayan and Yenisei fold areas*, which are, respectively, form the epi-Caledonian and epi-Baikalian folded frames of the Siberian paleocontinent and represented by paleo microplates, suture zones and deformed margins of this paleocontinent;

– *Taimyr fold area,* formed in the epi-Baikalian tectonic epoch; Late Paleozoic shear and fold-thrust dislocations are considered to be intraplate ones.

The integral Earth's crust map reflects the cover and basement structures. The main purpose of this map, overloaded with information, is to compare the parameters of sedimentary cover and crystalline basement.

*The sections of the Earth's crust along the reference geophysical profiles* (*geotraverses*) reflect the principal features of the platforms and fold regions geostructures [3, 9]. In the water areas of the Barents and Kara Seas, such sections were constructed along the lines of four reference geophysical profiles AP-1, AP-2, AP-3, and AP-4. The central fragment of the AR-2 profile reflects the features of the deep structure of the Pay-Khoy and Novaya Zemlya fold areas, as well as the framing structures. Detailed reflection seismic data provided basic information on the fold-thrust dislocations of Pay-Khoy and Novaya Zemlya fold areas. Geological reinterpretation of these data in combination with seismic tomography and potential fields data allowed not only to substantiate the general structure of thrust deformations but also to estimate the shift along the main fault planes.

This data indicates that the sedimentary strata of the eastern flank of the North-Barents basin and the western flank of the Pay-Khoy and Novaya Zemlya folded areas have similar sequences and thicknesses of layers, which indicates their long-term development under uniform conditions. Differences in their structure are associated with the Early Mesozoic accretionary processes at the final stage of the Paleo-Asian ocean's closure, which led to intense deformations and emergence of the depression's eastern flank, which is now included in the Pay-Khoy and Novaya Zemlya folded areas. It is noteworthy that the intensity of deformations within the folded area decreases from the Admiralty and Central Novaya Zemlya zones in the direction of the South Kara basin.

Folded-thrust deformations are not distinguished in the section of the Forenovozemelsky block. In this case, only rifting processes are modeled (Fig. 7).

Within the Kara basin's area, under the Mesozoic and Cenozoic sediments of the South Kara basin, we have distinguished the Kara residual basin with the oceanic crust [1]. Parameters of a seismic tomography section were used in modeling of the oceanic crust 's inhomogeneities.

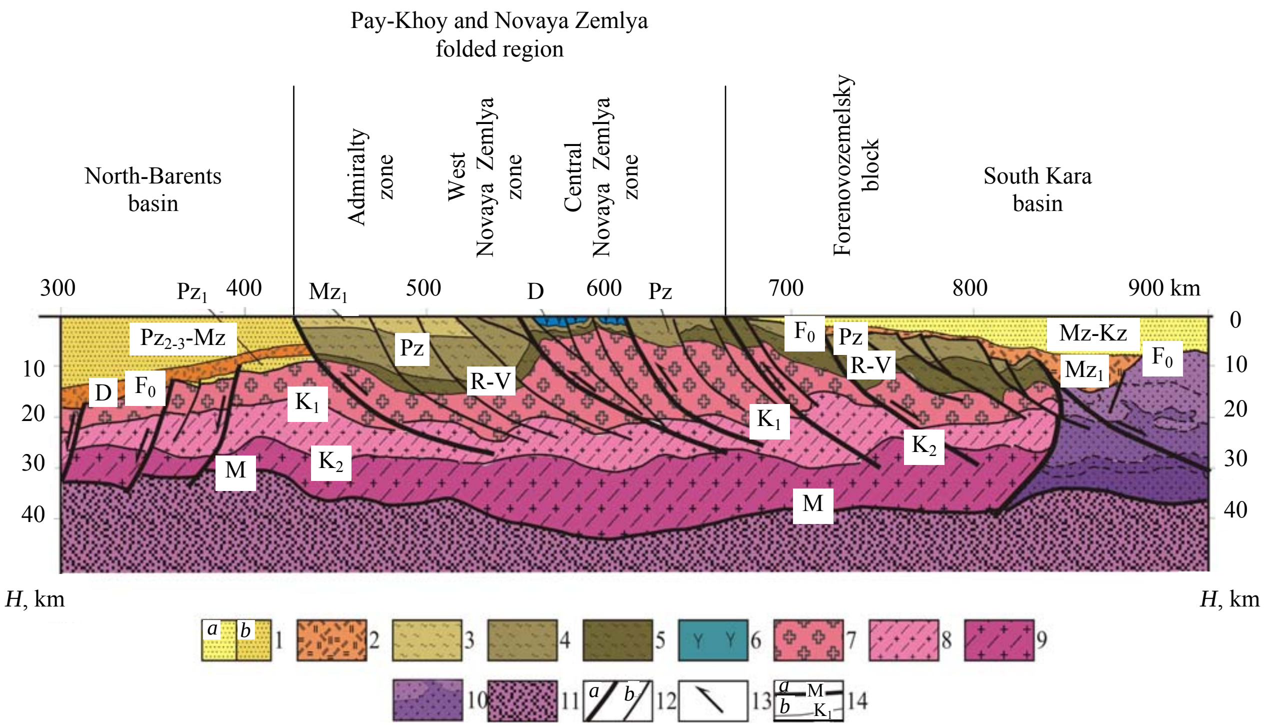


Fig.7. The deep section of the Pay-Khoy and Novaya Zemlya folded region and adjacent structures along the eastern fragment of the major geophysical profile 2-AP

1-10 – structural and compositional units (SCU) of the Earth's crust: 1 – sediments of intraplate basins (*a* – Mesozoic and Cenozoic, *b* – Paleozoic and Mesozoic), 2 – rifting complexes, 3-5 – sediments of ancient passive continental margins and micro-plates' covers of Mesozoic (3), Paleozoic (4) and Riphean (5) ages, 6 – volcanogenic and sedimentary formations of ancient active continental margins, 7-9 – crystalline crust layers, distinguished by the P-wave velocity values $V_P$: 7 – the upper crust granitic layer, $V_P$ = 6,0÷6,4 km/s, 8 – middle crust, $V_P$ = 6,5÷6,8 km/s, 9 – lower crust, $V_P$ = 6,8÷7,2 km/s, 10 – oceanic crust of the South Kara basin, differentiated according to seismic tomography modeling (isolines – velocities of the P-waves in km/s); 11 – upper mantle; 12 – faults of the Earth's crust (*a* – principal, *b* – minor); 13 – trends of crustal blocks movements along the faults; 14 – principal (*a*) boundaries of the Earth's crust the radial stratification ($F_0$ – base of the volcanogenic sedimentary poorly lithified layer, M – the Earth's crust bottom (the Moho discontinuity)), and other (*b*) the boundaries of the earth's crust radial stratification (including $K_1$ – the upper crust bottom, $K_2$ – the middle crust bottom)

Drawing up maps of the deep structure and deep geological and geophysical sections, which are interconnected and compiled with a unified legend, allows you to get fundamentally new information about the features of the structure, tectonics, and geodynamics of the studied regions. The obtained cartographic documents are considered to be tectonic models, which contain information about the structure of the platform cover and the crystalline basement.

The scientific and methodological approach to assessing the prospects for the oil and gas potential of the continental shelf based on the study of the mineral deposits localization features, using the identified deep structure parameters and the tectonic history of the region, allows us to identify new factors (criteria) of the predicting of oil and gas presence and set them into metallogenic forecasting models using pattern identification algorithms.

The analysis of all geological and geophysical data for the Barents and Kara Seas region allowed us to identify three groups of the most significant criteria (factors) of oil and gas presence: lithologic/stratigraphic, geochemical, and tectonic.

The *lithologic/stratigraphic* criteria are best recorded on paleogeographic reconstructions made as a set of lithologic and paleogeographic maps reflecting the main stages of structural rearrangements and the formation of a sedimentary cover at different stages of evolution. The maps also show the sources of detrital material's denudation and sedimentation conditions, including reef formation.

A set of *geochemical criteria*, especially data on the catagenetic transformation of organic matter in rocks, allows us to draw conclusions about the distribution of oil and gas source suites and their potential. Of particular importance for a qualitative forecast is the mapping of the expected

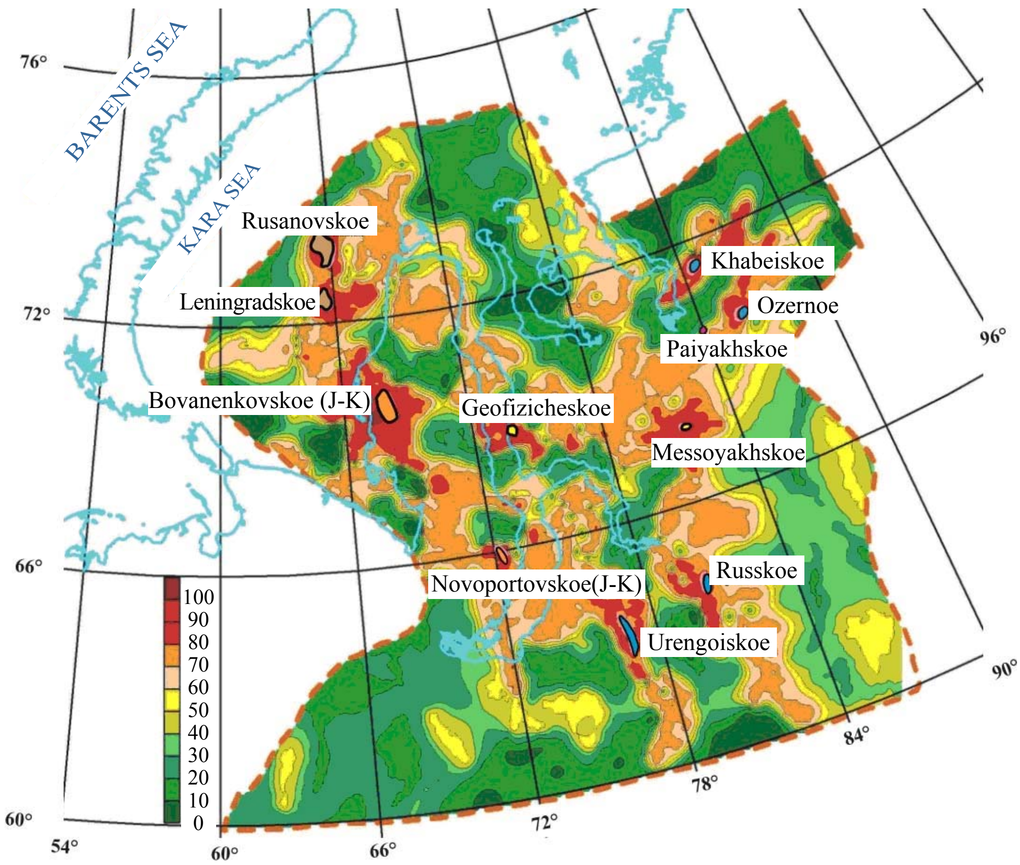


Fig.8. The integrated predictive solution of the pattern identification of the West Siberian and Khatanga-Vilyui oil and gas provinces using 11 industrial deposits as objects of learning (the color scale represents the probability of detecting objects identical to the reference sample)

distribution areas of bituminous rocks in the late Devonian (also in the in the Early Devonian in case of the Severnaya Zemlya archipelago), Permian, Middle Triassic, and Late Jurassic relatively deep-water terrigenous and terrigenous-carbonate strata with the thickness of first hundreds of meters, which under the conditions of catagenesis are in the «oil window». The exception is the thermally immature Late Jurassic suite, as well as the Late Devonian and Permian strata, which form the centers of liquid hydrocarbons formation only in the south-western regions of the Barents sea. We have confirmed this with the schemes of catagenesis for the Upper Paleozoic, Triassic, Jurassic, and Cretaceous rocks.

The *tectonic criteria* for petroleum potential are highly informative especially in the formation history of the sedimentary basin. As mentioned above, the integration of various methods (CDP, DSS, etc.) and the use of modern computer data processing technologies make it possible to create a volumetric seismic geological model of the entire region's structure. It also gives an opportunity to identify structural complexes in the so-called coilogenic Meso-Cenozoic intermediate syn-rift complex of sedimentary cover. Tracing seismic boundaries in the lower part of the crust also allows determining the nature and thickness of this crust and identify blocks with an anomalously high thickness of the sedimentary cover [8].

The analog method, traditionally applied in metallogenic forecasting, has been actively used in recent decades in solving multi-factor forecasting issues using pattern identification algorithms [6]. Reference objects with a known position in a given classification are specified as «objects of learning». A rule is based on reference objects at the training stage. Using this rule, at the recognition stage, a forecast is given for the remaining objects, namely, the values of some functions characterizing the proximity of each object to each reference sample are estimated.

Based on the type of the hydrocarbon deposits within the West Siberian oil and gas province and their localization relative to the crystalline basement and the platform cover structures, we outlined seven fields that were considered as learning objects. In addition, similar constructions were made for four objects located in the western flank of the Khatanga Trough, Khatanga-Vilyui oil and gas province (Fig.8).

The resulting solution for the northern part of the West Siberian oil and gas province indicates a wide range of distribution of sedimentary basin's promising areas.

**Conclusion.** Investigations of the deep structure of the Earth's crust in the regions of the Russian Arctic and the Eurasian continent are recommended to be carried out taking into account the following principles:

– the algorithm for processing and geological interpretation of the geophysical data includes various field transformations, methods for solving direct and inverse problems, statistical methods, a technology of referencess classification and pattern identification used for digital data on area, vertical sections, and three-dimensional geological space;

– maps and sections of the deep structures are considered to be documents of tectonic content; their construction is performed according to a single theoretical methodology using a unified system of symbols; all the maps and sections are linked by semantic and formal parameters;

– a layered approach, providing a separate cartographic display of the platform cover and the crystalline basement structural features, is implemented in the generation of the deep structure maps;

– layered maps of the deep structure are considered to be components of a three-dimensional geotectonic model of the region of research;

– an essential component of this research is the development of scientific knowledge about the history of the Earth's interior formation, represented in the form of palinspastic and paleogeographic schemes and sections, genetic models, etc.

Taking into account the methodological experience of the performed work, it can be said that the construction of maps and sections of the deep crustal structure, planned by the state geological mapping programs of 1:1 000 000 and 1:200 000 scales requires the compilation and analysis of a huge amount of diverse geological information, processing of geophysical fields with the use of dis-

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tinct modern software and presence of excellent skills in tectonics and geodynamics. Within the framework of a separate geological assignment, this is impossible at a high professional level and the results obtained by different groups of authors will not be comparable.

The solution to this problem is a development of the «Deep structure (geotectonic) map, accompanied by a set of reference sections (geotraverse)» in monitoring mode which is updated online with new data from the State geological map's sheets of 1:1 000 000 and 1:200 000 scales and, in its turn, provides these sheets with necessary maps and sections. This ensures connection between the structural and compositional parameters of adjacent sheets.

The collaborative scientific research, carried out by VSEGEI and the Mining University will contribute to reviving the tradition of close cooperation between these oldest geological organizations and the development of a common school of cartography, created by G.P.Helmersen, A.P.Karpinsky, I.V.Mushketov and other prominent geologists.

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***Authors*: Aleksey S. Egorov,** *Doctor of Geological and Mineralogical Sciences*, *Head of Department*, *asegorov@spmi.ru* (*Saint-Petersburg Mining University*, *Saint-Petersburg*, *Russia*), **Ilya Yu. Vinokurov,** *Candidate of Geological and Mineralogical Sciences*, *Deputy Head of Department*, *ilya_vinokurov@vsegei.ru* (*A.P.Karpinsky Russian Geological Research Institute* (*VSEGEI*), *Saint-Petersburg*, *Russia*), **Alexander N. Telegin**, *Doctor of Geological and Mineralogical Sciences*, *Professor*, *telegin@spmi.ru* (*Saint-Petersburg Mining University*, *Saint-Petersburg*, *Russia*).

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