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A Model of the Geological Structure and the Oil and Gas Prospects of Neocomian (Berriasian–Lower Aptian) Sediments of the West Siberia Arctic Regions and the Kara Sea Shelf

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Abstract—The paper presents a model of the geologic structure of Neocomian (Berriasian–lower Aptian) sediments in the Arctic regions of West Siberia and on the shelf of the Kara Sea. The southern part of the Kara Sea is the northern end of the West Siberian sedimentary basin and is identified as the South Kara regional depression of the West Siberian oil and gas province (OGP). Structural and tectonic analysis was performed, and 97 oil- and gas-promising anticlinal objects (structures of ranks III–IV) were identified in the Neocomian megacomplex relief, including 61 on the continent and 36 on the shelf. In the Yamal and Gydan oil and gas areas (OGA), the Neocomian complex of sediments has a structure typical of West Siberia. The megacomplex includes clinoform and shelf complexes. Clinoforms resulted from the ablation of terrigenous material from the eastern and southeastern edges of the plate and are tilted in the northwestern direction; the depocenter within which the eastern and western clinoforms converge is located in the Urals zone, west of the Nurmin megaswell. In the South Kara regional depression, the Berriasian–lower Aptian megacomplex is also represented by clinoform and shelf complexes. On the Kara Sea shelf, Neocomian clinoforms are tilted in the southern, western, and eastern directions; they resulted from the ablation of sediments from the Novaya Zemlya Archipelago and the Siberian Sill. Throughout most of the South Kara regional depression, clinoforms have a typical structure and contain shelf and Achim sandstones that can concentrate significant volumes of hydrocarbons; in the northeast, in the pre-sill zone, clinoform deposits will be represented by poorly sorted “dump” sandstones.

Keywords: shelf; seismic cross section; reflecting horizon; megacomplex; complex; clinoform; Achim member; shelf formations; structure; oil- and gas-promising object; Arctic regions of West Siberia; Kara Sea

INTRODUCTION

The southern part of the Kara Sea, located to the south of the Novaya Zemlya Archipelago, is the northern end of the West Siberian sedimentary basin and is distinguished as part of the superorder tectonic element – the South Kara regional depression (Suprunenko et al., 2009; Kontorovich et al., 2010, 2013, 2017; Stupakova, 2011).

In tectonic terms, the South Kara regional depression includes the same-name megasyneclise and the monoclises of the Inner Region and the Outer Belt of the plate surrounding it. From the west, north and east, the sedimentary sub-basin located in the shelf area is limited by folded framing structures: in the south-west by the Ugra Peninsula and Vaigach island, in the northwest and north by the Novaya Zemlya Archipelago, in the northeast by the Siberian Sill, in the east by the Taimyr Peninsula (Fig. 1).

In the southern part of the Kara Sea, the Mesozoic-Cenozoic deposits have the same geological structure as on the continental margin of Western Siberia on the Yamal and Gydan peninsulas. In the Mesozoic–Cenozoic deposits of these regions, six regionally developed sedimentary and seismogeological megacomplexes are identified: Triassic, Jurassic, Neocomian (Berriasian–lower Aptian), Aptian–Albian–Cenomanian, Turonian–Maastrichtian, and Cenozoic (Bochkarev, 2010; Kontorovich et al., 2017). All sedimentary megacomplexes at the top are controlled by regionally developed acoustically abnormal transgressive clay packs, on which major seismic horizons are formed that control seismogeological megacomplexes (Fig. 2; Table 1).

In terms of oil and gas, the southern part of the Kara Sea is identified as a part of the South Kara oil and gas area (OGA) of the West Siberian oil and gas province (OGP) (Fig. 1).

The northern and arctic regions of Western Siberia are traditionally predominantly gas-bearing and free gas, concentrated mainly in Aptian–Albian–Cenomanian sediments, accounts for more than 90% of the total recoverable hydro-

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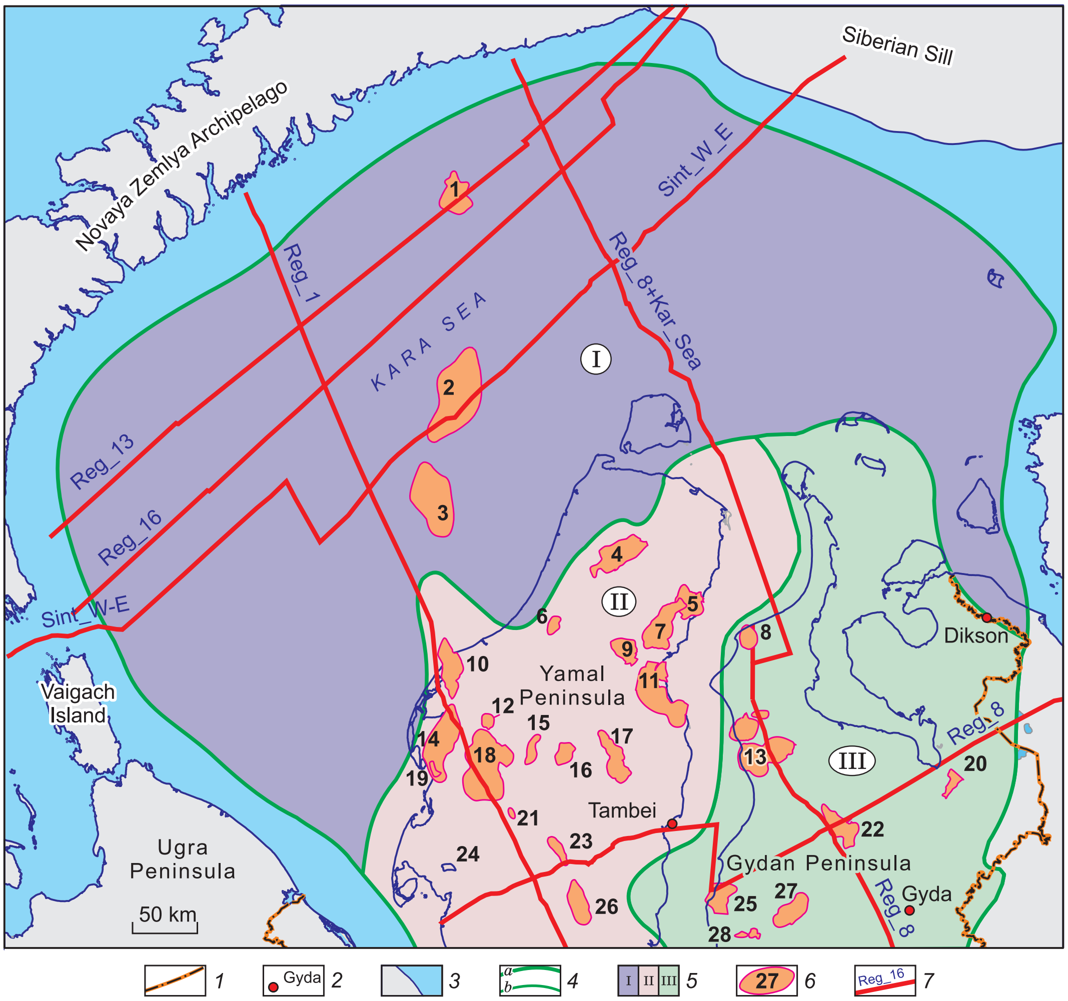


Fig. 1. Review map of the Kara-Yamal region. *1*, administrative borders, *2*, large settlements, *3*, the sea–land border, *4*, the borders of the West Siberian OGP (a) and OGA (b), *5*, oil and gas areas (I, South Kara, II, Yamal, III, Gydan), *6*, fields, *7*, regional seismic profiles. Fields: 1, Pobeda, 2, Rusanovskoe, 3, Leningradskoe, 4, Malyginskoe, 5, Tasiiskoe, 6, Syadorskoe, 7, Severo-Tambeiskoe, 8, Shtormovoe, 9, Zapadno-Tambeiskoe, 10, Kharasaveiskoe, 11, Yuzhno-Tambeiskoe, 12, Severo-Bovanenkovskoe, 13, Salmanovskoe, 14, Kruzenshternskoe, 15, Vostochno-Bovanenkovskoe, 16, Verkhnetiuteiskoe, 17, Zapadno-Seyakhinskoe, 18, Bovanenkovskoe, 19, Yuzhno-Kruzenshternskoe, 20, Ladertoiskoe, 21, Nerstinskoe, 22, Gydanskoe, 23, Neitinskoe, 24, Baidaratskoe, 25, Geofizicheskoe, 26, Arkticheskoe, 27, Soletskoe + Hanaveiskoe, 28, Vostochno-Bugornoe.

carbon (HC) reserves. At the same time, numerous oil fields associated with Jurassic and Lower Cretaceous reservoirs were discovered in this territory. In the Yamal and Gydan OGAs located on the Kara Sea coast, industrial oil inflows were obtained at the Geophysicheskoe, Salmanovskoe, Messoyakhskoe, Tambeyskoe, Rostovtsevskoe, Novoportovskoe and other fields. In general, as of January 1, 2020, in the Yamal and Gydan OGAs, industrial oil reservoirs were discovered in 15 fields and in these regions liquid hydrocarbons account for 4% of recoverable and 12% of geological hydrocarbon reserves. Moreover, more than 40% of the oil reserves of the Yamal and Gydan OGAs are concentrated in Neocomian (Berriasian–lower Aptian) sandstone formations. According to a quantitative assessment performed at the IPGG SB RAS, the differentiation of hydrocarbons by fluid types and sedimentary complexes in the South Kara OGA has a similar distribution (Kontorovich et al., 2013).

At present, directly in the Kara Sea, unique Aptian–Albian–Cenomanian gas reservoirs have been discovered at the Leningradskoe and Rusanovskoe fields. In 2013, Rosneft Oil Company discovered the Pobeda field in the immediate vicinity of the Novaya Zemlya Archipelago, where industrial oil inflows were obtained from the Lower–Middle Jurassic sandstone formations; gas reservoirs are concentrated in the upper Aptian and Cenomanian sediments. Also partly on the Yamal Peninsula, partly in the Kara Sea, are the Kharasaveyskoe and Kruzenshternskoe fields, the productivity of which is also associated with Cretaceous deposits.

This work is devoted to the analysis of the geological structure and the oil and gas potential of the Neocomian (Berriasian-lower Aptian) sediments of the South Kara OGA.

Table 1. Stratification of major reflecting horizons

Indexing reflecting horizons	Stratigraphic confinement (Western Siberia)
F	Basement top
A	Terrigenous Triassic bottom/top of Paleozoic platform sediments/top of the Paleozoic megacomplex
T	Jurassic bottom/Triassic top/Triassic megacomplex top
B	Top of the Bazhenov (Golchikhin) Formation, Upper Jurassic, Volgian/top of the Jurassic megacomplex
M	Top of of the Koshay (Neytin) pack, Lower Cretaceous, the lower part of the Aptian/top of the Neocomian (Berriasian-Lower Aptian) megacomplex
G	Bottom of the Kuznetsov Formation, Upper Cretaceous, Cenomanian top/Aptian-Albian-Cenomanian megacomplex top
C	Top of the Gan'kino Formation, Cretaceous top/top of the Turonian-Maastrichtian complex

The term "Neocomian" was introduced by Thurmann in 1835 and is included in the stratigraphic scheme of d'Orbigny as the lower stage of the Cretaceous system. In the modern interpretation, Neocom includes the Berriasian, Valanginian, Hauterivian and Barremian stages. In the practice of oil and gas exploration in Western Siberia, the Neocomian oil and gas complex is traditionally understood as the sequence of sediments lying between the Bazhenov Formation and the Koshay (in the north Neytin) member, which are confined to the top of the Jurassic and the upper part of the lower Aptian, and are regional seismogeological marker horizons. In the present work, the Neocomian megacomplex refers to this section interval.

In Western Siberia, the Neocomian sedimentary complex is the most promising in terms of oil content and more than 80% of the province's oil reserves are concentrated in it

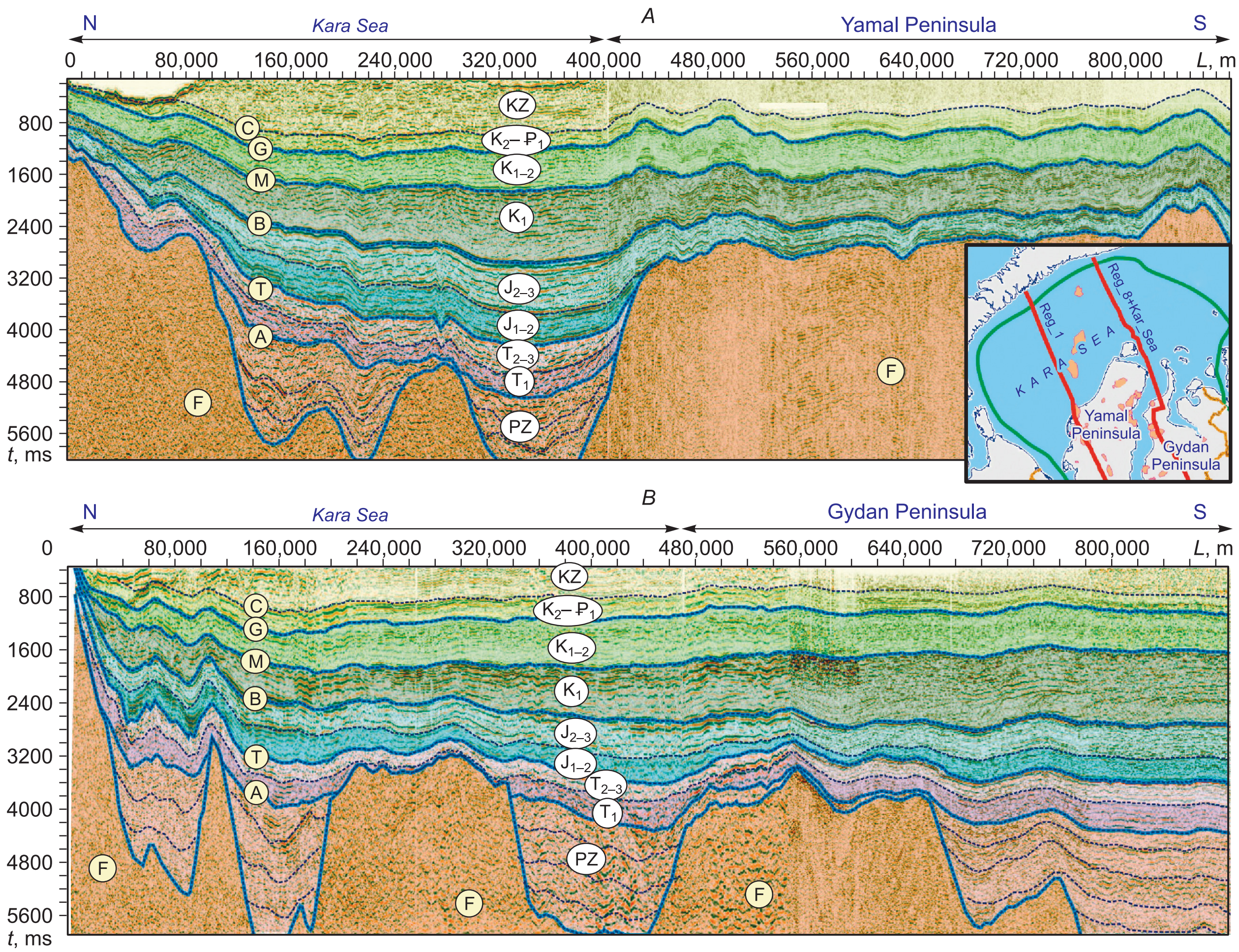


Fig. 2. Seismogeological sections along the composite regional profiles Reg_1 (A) and Reg_8 + Car_Sea (B).

(Kazarinov, 1963; Kontorovich et al., 1975). In the Kara Sea, these deposits were practically not studied by drilling; oil inflow from the Hauterivian sandstones was obtained in one well drilled on Beliy Island.

GEOLOGICAL STRUCTURE AND FORMATION CONDITIONS OF NEOCOMIAN DEPOSITS IN WESTERN SIBERIA

A feature of the geological structure of the Neocomian (Berriasian–lower Aptian) sediments of Western Siberia is the clinoform (regionally cross-stratified) section structure.

The term “clinoform” was proposed by J. Rich in 1951 to refer to the facies sedimentation conditions in the region of the accumulative slope. Currently, this term is interpreted more broadly and by clinoforms we mean the entire thickness of sediments of the same age, which formed under conditions of filling a deep-sea basin through lateral build-up of the paleoslope. At the same time, coastal-marine, slope, and deep-water deposits – undatema, clinotema, and fondotema – are distinguished as clinoforms.

The first fundamental models of the regional cross-stratified structure of Neocomian deposits in Western Siberia were developed and published by A.L. Naumov, T.M. Onischuk, M.M. Binshtokom, L.A. Wexler and others at the end of the 1970s (Naumov et al., 1977; Onishchuk et al., 1977; Binshtok, 1980). Subsequently, the model of the Neocomian clinoform structure was developed, refined and detailed in the works of V.S. Bochkarev, Yu.V. Braduchan, V.N. Borodkin, G.N. Gogonenkov, V.Ya. Gidion, L.Sh. Girshgorn, F.G. Gurari, S.V. Ershov, Yu.N. Karogodin, Yu.A. Mikhailov, A.A. Nezhdanov, O.M. Mkrtchyan, M.Ya. Rudkevich, L.Ya. Trushkova, I.L. Tsibulin, V.I. Shpilman, S.S. Elmanovich, G.S. Yasovich and many others.

During the Volgian stage in Western Siberia there was a sharp plunge of the basin central part and the sea formed in this territory, which was the deepest in the whole Mesozoic development history of the West Siberian basin; maximum depths were about 500 m (Trushkova, 1969; Kipriyanova, 1971; Bulynnikova et al., 1978; Bochkarev, 1999; Zakharov, 2006; Vazhenina, 2009; Kontorovich et al., 2014a,b; Ershov, 2016).

The resulting uncompensated depression gradually filled from the periphery to the axial part of the paleobasin through lateral build-up of the paleoslope. Under these conditions, S-shaped geological bodies – clinoforms – formed.

The construction and then the detail of the regional cross-stratified model of the Neocomian of Western Siberia was based on the integration of seismic exploration and drilling data. On seismic sections, clinoform deposits are displayed by a series of cross-stratified reflecting horizons, successively approaching horizon B, confined to the Jurassic top.

In most of the West Siberian basin, Neocomian clinoforms are inclined in the western and northwestern directions. Counter clinoforms plunging eastward have a limited distribution and are mainly represented by clay varieties. In this case, the axial zone, within which the clinoforms of the western and eastern fall “meet”, is substantially shifted westward relative to the modern axial part of the basin and is located near the Ural Mountains (Fig. 3).

The asymmetric structure of the Neocomian complex of Western Siberia indicates that the southeastern and eastern framing of Western Siberia in the Berriassian–Barremian significantly elevated above the Urals and the bulk of the terrigenous material was carried off from the Altai-Sayan Folded Area and the Siberian Platform.

The structure of the clinoform complex of Western Siberia was significantly influenced by eustatic fluctuations in sea level. At the transgressive stages and associated pauses

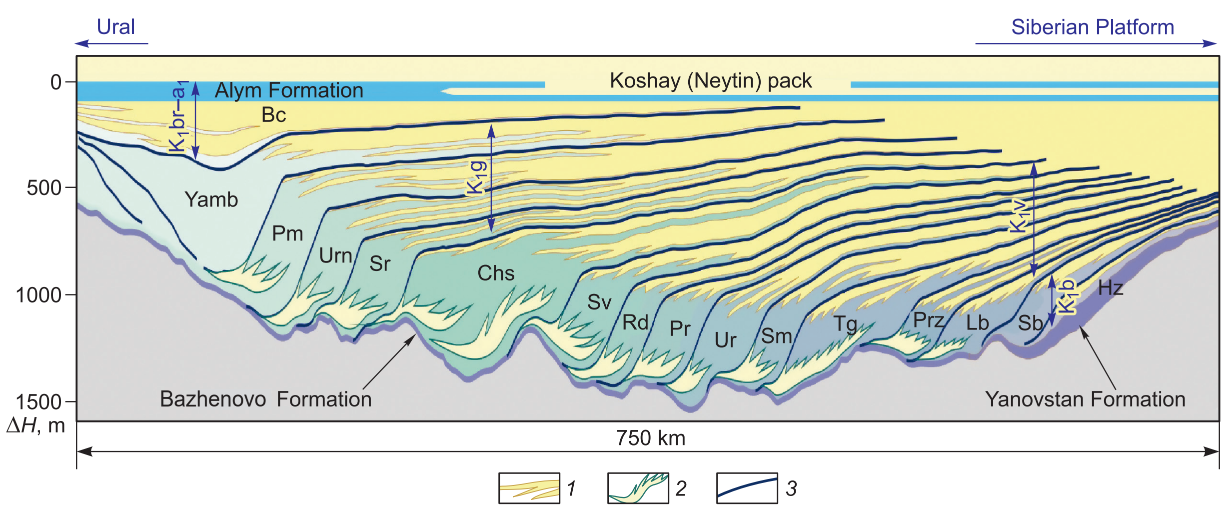


Fig. 3. The fundamental model of the Neocomian productive complex clinoform structure in the northern regions of Western Siberia (Ershov et al., 2009). *1*, shallow-water sandy deposits, *2*, deep-sea sandy-silt deposits of the Achim member, *3*, boundaries of regional clinoforms: Bs, Bystrinskaya, Yamb, Yamburgskaya, Pm, Pimskaya, Urn, Urengoiskaya, Sr, Sarmanovskaya, Chs, Cheuskinskaya, Sv, Savuiskaya, Rd, Rodnikovaya, Pr, Pyreinaya, Ur, Ur’evskaya, Sm, Samotlorskaya, Tg, Tagrinskaya, Prz, Priozernaya, Lb, Labaznaya, Sb, Sabunskaya, Nz, Nazinskaya.

in the lateral introduction of terrigenous material, the formation of regional cross-stratified clay packs took place. The formation of these strata is associated with the vertical deposition of a thin suspension, which was not controlled by the paleorelief.

Geological bodies enclosed between regional transgressive clay packs are represented by sandstones, siltstones and mudstones and formed at the regressive stages of development, when there was an intensive process of lateral introduction of terrigenous material and active lateral build-up of paleoslopes.

A feature of the Neocomian clinoforms of Western Siberia is the presence of two regional levels of the same age, but fundamentally different in terms of the genesis of sandstone bodies – reservoirs (Fig. 3) (Kazanenkov et al., 2014; Ershov, 2018). At the regressive stages of development in the zones corresponding to the upper parts of the clinoforms, coastal-marine sedimentation conditions existed and shelf sandstone formations formed; in the area of the accumulative slope, characterized by relatively large (1.5–3.0º) tilt angles, mainly clay differences accumulated; in the deep-water zone, the sandstones of the Achim member associated with the deep-water cones. Lenticular sandstone reservoirs could also form on terraces complicating the slope parts of clinoforms.

As the basin filled with precipitation and the clinoforms advanced from the framing structures to the depocenter of depression, the paleorelief of the bottom leveled off, and already by the end of the Hauterivian in most of Western Siberia, the uncompensated depression was filled with sediments. The upper part of the Neocomian megacomplex was formed according to the classical scheme for Western Siberia and the Barremian–lower Aptian part of the section is composed of subparallel strata. In the north of the basin, in particular, in the Kara Sea, compensation for depression probably occurred a little later, already in the Barremian (Kontorovich et al., 2014a; Ershov, 2016).

The Neocomian sedimentation stage ended with the early Aptian transgression, when a Koshay (in the north Neytin) clay pack was formed in most of Western Siberia, which is regionally distributed and developed in most of the basin.

In accordance with the conditions for the formation of sediments, the Neocomian megacomplex distinguishes the Berriassian–Hauterivian (Berriassian–early Barremian) clinoform and Barremian–lower Aptian shelf complexes. There is no reliable geological reference point separating clinoform and shelf complexes, and this boundary itself is non-isochronous, moving.

Oil and gas potential objects. The subparallel deposits of the Barremian–lower Aptian complex, which lie in the upper part of the Neocomian section, are represented by interbedded sand and clay blocks that formed, respectively, at the regressive and transgressive stages of the territory's development. The Koshay (Neytin) clay pack lying in the top of the Barremian–lower Aptian complex is a regional seismogeological marker horizon and serves as a regional impermeable rock for Neocomian hydrocarbon reservoirs.

The shelf sandstone horizons of the Berriassian-Hauterivian clinoform complex, formed in the undaform parts of clinoforms, also have coastal and shallow-marine genesis and are widespread. In this case, from east to west, older shelf sandstone horizons "grow" laterally with younger ones. This process can be accompanied by the formation of lithological screens between them, and can lead to the formation of hydrodynamically-connected "scaly" reservoirs.

The wide distribution of sandstone beds of the Barremian-lower Aptian complex and shelf layers of the clinoform complex predetermined that the hydrocarbon reservoirs concentrated in them are usually controlled by post-sedimentary anticline structures. At the same time, lithological screens can be developed within the objects, and the reservoir properties of the beds can vary significantly both in section and in lateral.

The deep-water sandstones of the Achim member and sandstones formed on terraces that complicate the slope parts of clinoforms, by contrast, are lenticular, and most of the associated oil and gas prospective objects are complex lithological and structural-lithological non-anticlinal traps.

Seismogeological characteristics. On the seismic sections, the Neocomian megacomplex is controlled by reflecting horizon B in the bottom and horizon M in the top (Fig. 2).

The reflecting horizon B (the Upper Jurassic, the Volgian stage) is confined to the top of the Jurassic and is formed on the Bazhenov Formation and its analogues. Due to the abnormality of acoustic properties, the consistency of the formation thickness in large areas and its wide distribution, this horizon is the most reliable seismic marker horizon in the West Siberian oil and gas province.

The reflecting horizon M (Early Cretaceous, the Aptian) in most of Western Siberia is formed on a clay Koshay (Neytin) pack dating from the early Aptian. The horizon has variable intensity and dynamic expressiveness, and its unambiguous phase correlation is difficult due to the redistribution of seismic recording energy between the individual phases of seismic wavetrain. At the same time, regionally, this stratigraphic level is fairly reliably mapped from seismic data.

As noted earlier, the Neocomian megacomplex distinguishes the Berriassian–Hauterivian clinoform and the Barremian–lower Aptian shelf complexes.

On the seismic sections, the shelf complex is displayed in a series of reflections subparallel to the horizon M, which, as a rule, have low intensity and energy expressiveness; the clinoform part of the Neocomian is represented by a series of cross-stratified reflecting horizons successively approaching horizon B.

An analysis of the lithological and acoustic characteristics of the sediments that form the Berriasian–lower Aptian deposits allows us to conclude that the most dynamically expressed and traceable at relatively large distances cross-stratified reflecting horizons of the clinoform complex are formed on transgressive clay packs that have abnormally low acoustic wave velocities.

In the shelf zone (undatema), reflecting horizons confined to the tops and bottoms of clinoforms are traced subparallel to the reflecting horizon M, while the ΔT values between these horizons and horizon M monotonously and slightly increase in the direction of the clinoforms fall.

The internal structure of clinoforms is characterized on seismic sections by various patterns of seismic recording – seismic facies and the distribution of the amplitude and frequency characteristics of wave fields.

The task of mapping reservoir distribution zones in the clinoform part of the section, in particular, in the Achim member is by no means trivial and in each specific case must be solved individually with the use of all available geological and geophysical information. At the same time, there are a number of patterns that many researchers pay attention to.

An analysis of geological and geophysical materials showed that the lithological composition of the rocks which form clinoform formations of the Neocomian is characterized by the angles of inclination of the reflecting horizons. The bodies most enriched in sandy material have gentle slopes of the reflecting surfaces, mainly clay deposits – steep.

It was noted above that a feature of Neocomian clinoforms is the presence of two regional levels of same-age sand bodies associated with shallow-sea and deep-water zones. As early as the 1970s, experts noted that the boundaries of clay zones of shelf and Achim members of the clinoform complex, as a rule, coincide with the points of sharp inflections of reflecting seismic horizons. At the same time, shelf sandstone beds developed in the upper parts of clinoforms and Achim sandstones formed at the foot of the accumulative slope are replaced by impermeable differences, respectively, in the zones of transition of undatema and fondotema to the slope part of clinoforms.

Considering that post-sedimentary tectonic processes have left marks on the modern relief of Neocomian horizons, it is most correct to use ΔT or ΔH maps between clinoform reflecting horizons and horizon M. To construct two-dimensional models of the clinoform complex, paleosections aligned with the M horizon are also used. The correctness of this approach is determined by the fact that the Koshay (Neytin) clay pack was formed in relatively deep water conditions at the transgressive stage of development, has sustained thickness and is developed in the huge territory of the West Siberian basin. This allows us to consider it as a regional quasi-isochronous leveling surface and use it in paleoreconstructions. The $\Delta T/\Delta H$ maps and paleosections, to a first approximation, restore the paleorelief of the territory that took place at the time of the formation of clinoform deposits. On paleo-maps, on the slope of the clinoforms, there is a contour zone of contouring of contours, which is even more clearly and unambiguously identified on isopach gradients maps of clinoform seismic complexes. Terraces that complicate the slope parts of clinoforms on which sandstone lenses can accumulate are also clearly distinguished on gradient maps.

STRUCTURAL-TECTONIC CHARACTERISTICS

It was noted above that the oil and gas potential objects of the Barremian-lower Aptian complex and shelf layers of the clinoform complex are largely associated with anticlinal traps. Let us dwell on analysis of the tectonic structure of Neocomian sediments and characterization of positive structures of the III–IV orders – potential traps for hydrocarbon (Fig. 4).

In the Arctic regions of West Siberia and on the Kara Sea shelf, the true vertical depth subsea (TVDSS) of the Neocomian megacomplex top (reflector M) varies from –3200 m in the most submerged part of the South Kara regional depression to –300 m on its wings, in the fringe zone of these deposits on frame structures.

South Kara megasyneclise. The largest structure in the area is the South Kara megasyneclise, which geographically covers the southern part of the Kara Sea and the northern part of the Yamal Peninsula. Syneclise has an isometric shape and is controlled by level line –2320 m. The South Kara megasyneclise includes in its structure by the same name syneclise, the Northern megasaddle and the Predtaimyrskaya depression. The area of the South Kara megasyneclise is 154,000 km^2, and its amplitude is 735 m.

In the most submerged part of the South Kara megasyneclise there is the Central Kara megadepression controlled by level line –2900 m; the area of megadepression is 31,000 km^2, the amplitude is 175 m. The megadepression is complicated by a number of the II–IV orders depressions, one III-order positive structure and five local uplifts. In the M reflector topography the largest Skuratov dome-shaped uplift (21) is elongated northward and is complicated by two domes. The structure is contoured by level line –2910 m, its area is 1840 km^2 and an amplitude is 60 m. There are Yarnatuyahinskoe (20), Schubertovskoe (22), Polyarnoe (23) local uplifts to the east of Skuratov uplift; and there are West Skuratovskoe (26), Nyarmeyskoe (32) and Severo-Malyginskoe (37) local uplifts to the west and south-west. The areas of these structures range from 85 to 195 km^2, the amplitudes are 10–25 m.

To the west and north-west of the Central Kara megadepression, there is a regional decrease in the depth of Neocomian sediments towards the Novaya Zemlya Archipelago. At first, the rising of the horizons occurs quite smoothly, and then the gradient of the relief increases sharply. The relatively submerged and calm northern and northeastern wings of the South Kara megasyneclise are complicated by a series of terraces, to which positive structures of the III–IV orders are confined.

In the northern part of the South Kara syneclise there is a semi-closed positive structure of the second order submerging eastward – the Kropotkinsky mesoledge. Its area is

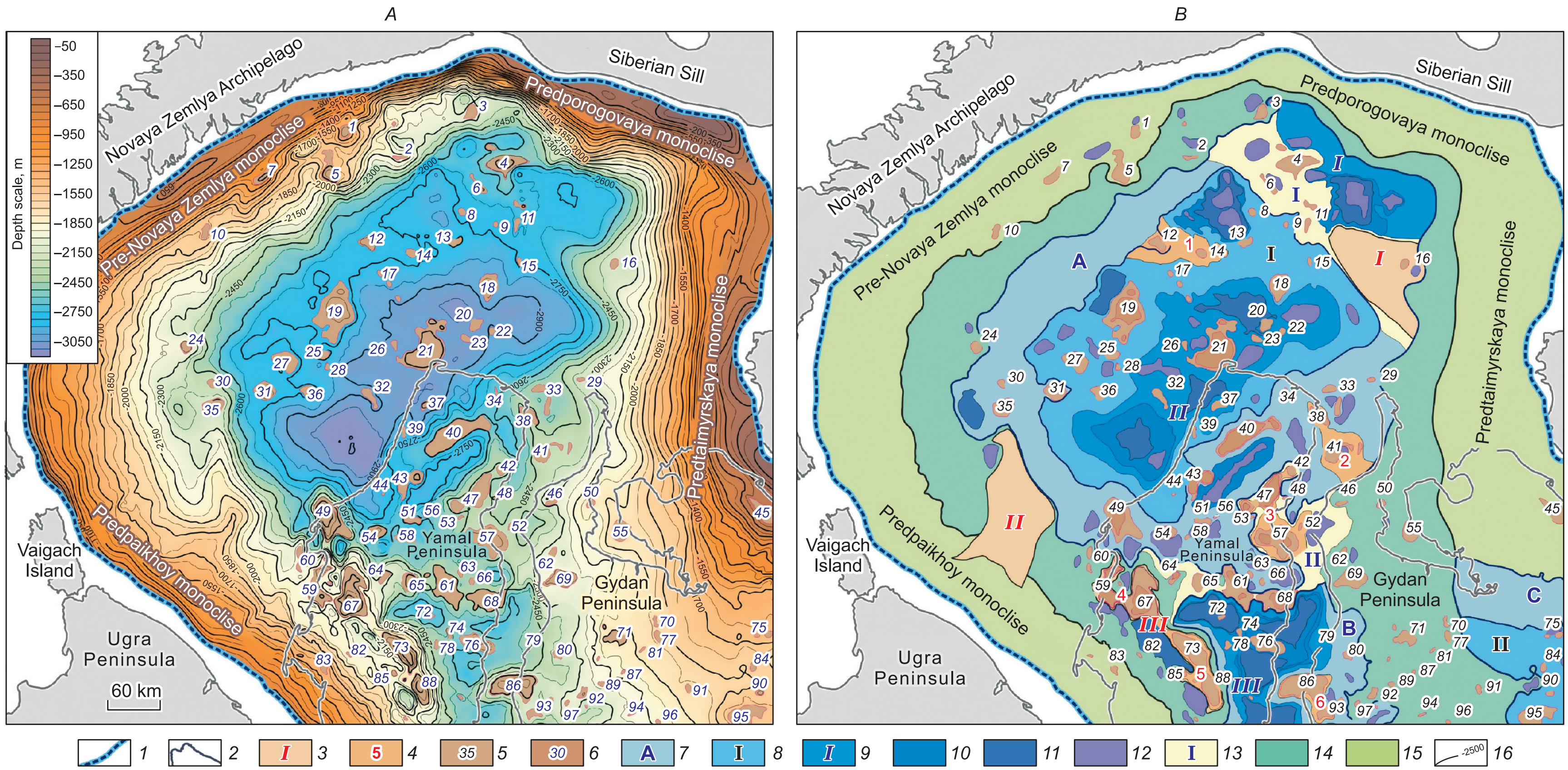


Fig. 4. Structural (A) and tectonic (B) maps on the top of the Neocomian (Beriassian–lower Aptian) megacomplex (Arctic regions of Western Siberia and the Kara Sea shelf). *1*, basin boundaries, *2*, coastline; positive structures: *3*, I order, *4*, II order, *5*, III order, *6*, IV order; negative structures: *7*, superorder, *8*, 0 order, *9*, I order, *10*, II order, *11*, III order, *12*, IV order; intermediate structures: *13*, mesosaddle, *14*, monoclises of the Inner region, *15*, monoclises of the Outer belt, *16*, isohypses of the Neocomian megacomplex top (m).

Tectonic elements: Superorder structures: A, South Kara megasyneclise, B, Antipayutinsko-Tadebeyakhinskaya megasyneclise, C, Yenisei-Khatanga regional trough; 0 order: I, South Kara syneclise; Positive structures of the I order: I, North Taimyr megaledge, II, Baidaraga megaledge, III, Nurmin megaswell. Negative structures of the II order: I, Predporogovaya megadepression, II, Central Kara megadepression, III, Tadebeyakhinskaya megadepression. Positive structures of the II order: 1, Kropotkinskii mesoledge, II, North Gydan mesoledge, 3, Tambei mesoswell, 4, Bovanenkovo mesoswell, 5, Kruzenshternskii mesoswell, 6, Geophysical mesoswell. Megasaddles: I, Northern, II, Yamal-Gydan. Positive structures of the III–IV order: 1, Vlas'evskoe, 2, Nansen, 3, Severnoe, 4, Rogozinskoe, 5, Universitetskoe, 6, Kop'evoe, 7, Vikulovskoe, 8, Zapadno-Shchitovoe, 9, Shchitovoe, 10, Tatarinovskoe, 11, North Taimyr, 12, Matusevich, 13, Kropotkinskoe, 14, Zapadno-Kropotkinskoe, 15, Taimyr, 16, Vilkitskogo, 17, Yuzhno-Kropotkinskoe, 18, Central Kara, 19, Rusanovskoe, 20, Yarnatuyakhinskoe, 21, Skuratovskoe, 22, Shubertovskoe, 23, Polar, 24, Mininskoe, 25, Yuzhno-Rusanovskoe, 26, Zapadno-Skuratovskoe, 27, Severo-Leningradskoe, 28, Yuzhno-Rusanovskoe-2, 29, Neupokoevskoe, 30, Severo-Obruchevskoe, 31, Zapadno-Matochkinskoe, 32, Nyarmeiskoe, 33, Khalyanginskoe, 34, Drovyanoe, 35, Obruchevskoe, 36, Leningradskoe, 37, Severo-Malyginskoe, 38, Preobrazhenskoe, 39, Tarminskoe, 40, Malyginskoe, 41, Yuzhno-Preobrazhenskoe, 42, Tasiiskoe, 43, Pyaseidaiskoe, 44, Severo-Kharasaveiskoe, 45, Mokhovoe, 46, Shtormovoe, 47, Tambeiskoe, 48, Yuzhno-Tasiiskoe, 49, Kharasaveiskoe, 50, Vostochno-Zelenomysskoe, 51, Zapadno-Khariusnoe, 52, Khortyakhskoe, 53, Malotambeiskoe, 54, Vostochno-Kharasaveiskoe, 55, Yernikovoe, 56, Lokal'noe–2, 57, Yuzhno-Tambeiskoe, 58, Lokal'noe–3, 59, Kruzenshternskoe, 61, Zapadno-Kruzenshternskoe, 61, Zapadno-Seyakhinskoe, 62, Severo-Utrennee, 63, Tomboitosskoe, 64, Khondeyakhskoe, 65, Verkhnetiuteiskoe, 66, Khusyakhskoe, 67, Bovanenkovskoe, 68, Severo-Seyakhinskoe, 69, Utrennee, 70, Malogydanskoe, 71, Gydanskoe, 72, Verkhneyasaveiyakhskoe, 73, Neitinskoe, 74, Nilivoyakhskoe, 75, Nadoyakhskoe, 76, Seyahinskoe, 77, Ventoiskoe, 78, Vostochno-Neitinskoe, 79, Novolunnoe, 80, Bystritskinskoe, 81, Amposyakhskoe, 82, Nerutoyachskoe, 83, Baidaratskoe, 84, Salpadayakhskoe, 85, Yasawaeiskoe, 86, Zentral'no-Geofizicheskoe, 87, Vostochno-Yungiyakhskoe, 88, Arkticheskoe, 89, Yungiyakhskoe, 90, Laduketskoe, 91, Yuzhno-Gydanskoe, 92, Hanaveiskoe, 93, Trekhbugornoe, 94, Nerosedayakhskoe, 95, Pagodskoe, 96, Tyngevapaetayakhskoe, 97, Soletskoe.

3195 km^2, its amplitude is 95 m and mesoledge is complicated by two local uplifts.

There is the West Kropotkin uplift (14) in the southeastern part of the Kropotkinsky mesoledge. In the top of Berriasian–lower Aptian megacomplex topography it is contoured by isogypsum –2720, has an area of 100 km^2 and an amplitude of 10 m. To the northeast there is the Matusevich uplift (12), wich contoured by isogypsum –2680 m and have an area of 199 km^2 with an amplitude of 25 m.

In the northwestern part of the Central Kara syneclise, northwest of Skuratovskoe structure, the Rusanovskoe domed uplift is located (19), which is associated with a unique gas condensate field. The Rusanovskoe structure in the M reflector topography is elongated in the northeast direction and is complicated by three domes; it is controlled by isogypsum –2720 m, has an area of 1840 km^2 and an amplitude of 100 m.

To the southeast of Rusanovskoe structure, on the eastern wing of the South Kara syneclise and megasyneclise there is a number of isometric positive structures of the III–IV orders. The largest Severo-Leningradskoe (27), Zapadno-Matochkinskoe (31) and Obruchevskoe (35) dome-shaped uplifts have areas of 390–475 km^2, amplitudes of 45–70 m. The areas of the Yuzhno-Rusanovskoe (25, 28), Leningradskoe (36) and Severo-Obruchevskoe (30) structures are 30–150 km^2, amplitudes – 10–65 m.

In the northeastern part of the South Kara megasyneclise, there is the Northern megasaddle, which separating the South Kara syneclise and the Predporogovaya megadepression. The megasaddle has an area of 19,000 km^2, is elongated in the northeastern direction, parallel to the Siberian sill and is complicated by the North Taimyr megaledge and three local uplifts.

The North Taimyr megaledge is located in the southeastern part of the megasaddle and has an area of 7240 km^2. The structure of the I order is limited by an isogypsum of –680 m on the west, north and east sides, in the south it adjoins the Predtaimyrskaya megamonocline, within which the roof of the Berriasian–lower Aptian megacomplex rises regionally in the Taimyr Peninsula direction.

There are Rogozinskoe (4), Kopyevoe (6) and North Taimyr (11) uplifts in the northeastern part of the Northern megasaddle. The Rogozinskoe uplift is elongated in the latitudinal direction, contoured by level line 2530 m, has an area of 658 km^2 and an amplitude of 107 m. The areas of the Kopyevoe and North Taimyr structures are 125 and 80 km^2, and the amplitudes are 25 and 15 m.

Predporogovaya megadepression (area is 11,000 km^2) is located to the northeast of the Northern megasaddle.

The southern gently sloping wing of the South Kara megasyneclise, which is geographically located in the northern part of the Yamal Peninsula, is complicated by a series of depressions, the North-Gydan mesoledge, and a large number of positive structures of the III–IV orders.

The North-Gydan mesoledge is controlled by an isogypsum of –2750 m in the southeast, north and northwest, and it adjoins the Predtaimyrskaya monoclise in the south. The mesoledge is complicated by Preobrazhenskoe (38) and Yuzhno-Preobrazhenskoe (41) dome-shaped uplifts, the areas of which are 259 and 230 km^2, and the amplitudes are 35 and 15 m.

The Malyginskoe swell (40), Kharasaveyskoe dome-shaped uplift (49), Neupokoevskoe (29), Khalyanginskoe (33), Drovyanoe (34), Pyaseidaiskoe (43), Zapadno-Khariusnoe (51), Malotambeiskoe (53), Vostochno-Kharasaveiskoe (54), Tomboytoskoe (63), Khusyakhskoe (66) uplifts are located on the south and southeast wings of the South Kara megasyneclise in the Neocomian top.

The largest Malyginskoe swell and the Kharasaveiskoe dome-shaped uplift have areas of 1320 and 1230 km^2. The Malyginskoe swell is elongated in northeast direction and is complicated by two local positive structures. In the M reflector topography the swell is contoured by level line 2600 m and has an amplitude of 80 m.

The Kharasaveiskoe dome-shaped uplift is located in the southwest of the megasyneclise: partly on the continent, partly in the Kara Sea. The structure controlled by the –2380 m isogypsum is extremely contrasted and has an amplitude of 305 m in the top of the Neocomian complex.

The areas of the remaining uplifts located on the southern side of the South Kara megasyneclise lie in the range of 50–406 km^2, the amplitudes are 10–250 m.

Monoclises. It was noted above that the South Kara regional depression includes the megasyneclise of the same name and monoclises encircling it from the east, north, and west.

The northeastern and eastern wings of the South Kara regional depression are very scarp and are not complicated by either negative or positive tectonic structures. Within the wings there are Predtaimyrskaya and Predporogovaya monoclises, which are the conjunction zone of the South Kara megasyneclise with the Siberian Sill and the Taimyr Peninsula.

The western side of the regional depression is also scarp and complicated by one semi-closed structure of the first order – the Baidaraga megaledge, the area of which is 8760 km^2 with an amplitude of 625 m. The megaledge is elongated to the north and from the west, north and east is controlled by level line –2300 m, in the south it adjoins the Predpaikhoy monoclise.

The Universitetskoe (5) and Vikulovskoe (7) dome-shaped uplifts and Vlas'ev (1), Nansen (2), Severnoe (3) and Tatarinov (10) local uplifts are allocated on the northern wing of the South Kara regional depression, within the area of the Pre-Novaya Zemlya monoclise. The Pobeda field, where hydrocarbon are concentrated in Jurassic and Cretaceous reservoirs, is associated with the Universitetskoe structure located in the immediate area of the Novaya Zemlya Archipelago. In the Neocomian top, the Universitetskoe structure is elongated northward, is contoured with isogypsum –1730 m, has an area of 440 km^2 and an amplitude of 180 m. To the east of Universiteteskoe structure there is Vikulovskoe dome uplift, which is controlled by an isogypsum –1300 m, the area of the structure is 405 km^2, the amplitude is 70 m.

The local structures areas of the Pre-Novaya Zemlya monoclise range from 65 to 140 km^2, the amplitudes are 15–65 m, the contouring isohypses are range from 1500 to 230 m.

Let us look more closely at the Tatarinskoe structure, which has an area of 110 km^2 with an amplitude of 25 m in the Neocomian megacomplex top. In the north of Western Siberia, Aptian-Albian gas reservoirs are displayed on seismic sections with a sharp increase in the amplitudes of the seismic record, creating the effect of a "bright spot" (Kontorovich et al., 2018, 2019). For instance, this type of seismic recording we can see in the Leningradskoe and Rusanovskoe fields (Fig. 5) located in the Kara Sea. An analysis of the wave fields in the sections crossing the Tatarinov uplift allows us to identify two seismic "bright spot" anomalies in

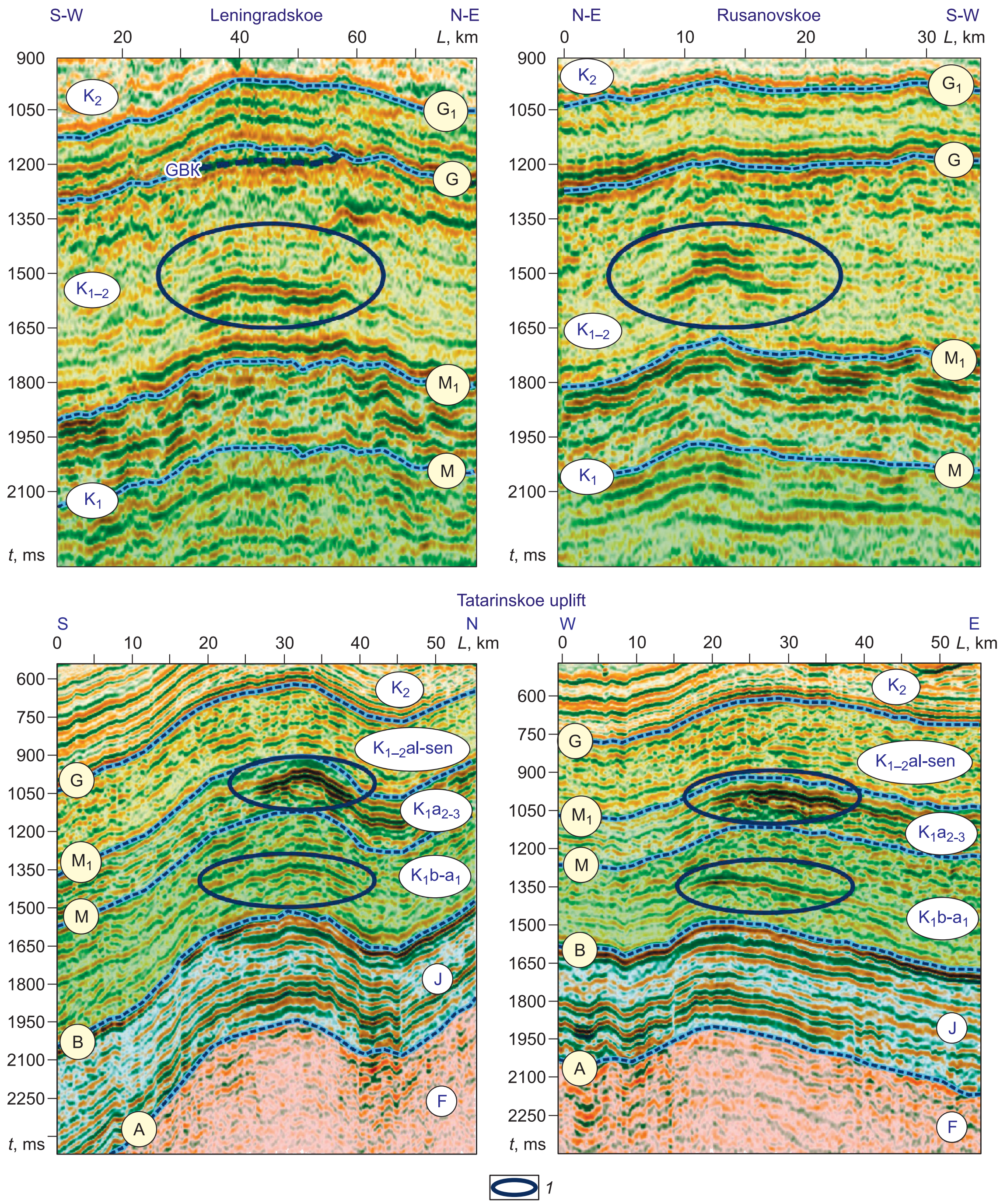


Fig. 5. Seismic anomalies of the "bright spot" on the Albian gas reservoir of the Leningradskoe and Rusanovskoe fields; in the Middle–Upper Aptian and Neocomian complexes of the Tatarinskoe uplift (Kara Sea).

this object, which make it possible to predict gas reservoirs with a high degree of probability. The upper anomaly is associated with a gas reservoir of the TP beds of the Middle–Upper Aptian megacomplex, and the lower anomaly is associated with a gas reservoir in the Neocomian sandstones (Fig. 5).

Yamal–Gydan megasaddle, which separates South Kara regional depression from the Antipayutinsko-Tadebeyakhinsky megasyneclise, is situated to the south of the South Kara regional depression.

The Yamal–Gydan megasaddle has an area of 12,600 km^2, it is elongated in the eastern and northeastern directions, in the west and east it adjoins the monoclises of the Inner Region of the plate.

In the Neocomian top, the megasaddle is complicated by one positive structure of the II order – the Tambei mesoswell and three uplifts of the III–IV orders. The Tambei mesoswell is elongated northward, has an area of 1105 km^2 with an amplitude of 75 m and is contoured by level line –2440 m. The mesoswell is complicated by the Tambei swell (47), the Yuzhno-Tambeiskoe dome-shaped uplift (57) and two local structures – Tassiiskoe (42) and Khortyakhskoe (52). In the top of the Berriasian–lower Aptian megacomplex Tambei swell and the South-Tambei dome-shaped uplift are controlled by level line –2430 and –2400 m, have areas of 826 and 1128 km^2 and amplitudes of 50 and 65 m. Structures of the third order are complicated by local uplifts.

There are the Zapadno-Seyakhinskoe (61), Verkhnetiuteiskoe (65) and Severo-Seyakhinskoe (68) dome-shaped uplifts in the southern part of the Yamal–Gydan megasaddle. The largest Severo-Seyakhinskoe and Zapadno-Seyakhinskoe structures are contoured by level line –2450 m, have areas of 800 and 950 km^2 and amplitudes of 55 and 70 m. The Verkhnetiuteiskoe dome-shaped uplift is located hypsometrically higher, controlled by an isogypsum of –2350 m, has an area of 286 km^2 and an amplitude of 105 m.

The Antipayutinsko-Tadebeyakhinskaya megasyneclise is located to the south of the Yamal–Gydan megasaddle. In the northern part, megasyneclise is complicated by the Tadebeyakhinskaya megadepression, which is contoured by level line –2460 m, has an area of 15,965 km^2 and an amplitude of 250 m in the Neocomian complex top. In conjunction zone of the depressions, which are located within the Tadebeyakhinskaya megadepression, there are Seyakhinskoe (76) dome-shaped uplift and Nilivoyakhskoe (74), Vostochno-Neytinskoe (78) local uplifts, and in the eastern part of the Tadebeyakhinskaya megadepression there is Novolunnoe (79) uplift.

The Seyakhinskoe dome-shaped uplift is located in a submerged zone in the center of the North-Tadebeyakhinskoe mesodepression, is elongated in a northwestern direction, it is contoured at the level of –2550 m, has an area of 580 km^2 and an amplitude of 55 m. The areas and amplitudes of local structures complicating the megadepression range from 35 to 75 km^2, amplitudes are 10–20 m.

In the eastern part of the Antipayutinsko-Tadebeyakhinskaya megasyneclise, to the east of the Tadebeyakhinskaya megadepression, there is the Geophysical mesoswell complicated by the Zentralno-Geofizicheskii swell (86) and Trekhbugornoe local uplift (93). The Geophysical mesoswell is pear-shaped contoured with –2350 m isogypsum, It has an area of 1900 km^2, amplitude 200 m in the Neocomian complex top. The Zentralno-Geofizicheskii swell (86), which controls the reservoirs of the Geofizicheskoe field, and the Trekhbugornoe local uplift (93) are outlined at –2320 m, the areas of the structures are 1140 and 125 km^2, and the amplitudes are 170 and 15 m in the M reflector relief.

To the west of the Antipayutinsko-Tadebeyakhinskaya megasyneclise, within the Ural monoclise there is the Nurmin megaswell – the only closed positive structure of the first order to the north of the Messoyakha ridge. The megaswell is extremely relief and elongated in a northwest direction parallel to the Paikhoy bordering of the West Siberian plate. There is a chain of elongated north-west depressions and troughs to the west of the megaswell, which forms a linear depression zone separating the megaswell from the regional gradient slope.

In the Neocomian complex top, the Nurmin megaswell is controlled by an isogypsum of –2125 m, has an area of 5900 km^2, an amplitude of 360 m, and is complicated by two positive structures of the second order. Bovanenkovo mesoswell and the Neitin mesoswell, which are located in the northern and southern parts of the megaswell, were contoured by level line –2085 m, the areas of the structures are 2180 and 2360 km^2, and the amplitudes are 325 and 310 m.

The Bovanenkovo mesoswell is U-shaped and complicated by the Kruzenshternskoe (59) and Bovanenkovskoe (67) dome-shaped uplifts, which are controlled by –2090 m isohypses, the areas are 635 and 1455 km^2, and the amplitudes are 130 and 320 m in the M reflector topography.

The Neitinskoe (73) and Arctic (88) swells are contoured by level line –2010 m within the northward-elongated Neitin mesoswell. The areas of swells are 870 and 460 km^2, and the amplitudes are 230 and 190 m.

The Pre-Yenisei monoclise is located to the east of the Yamal–Gydan megasaddle and the northern part of the Antipayutinsko-Tadebeyakhinskaya megasyneclise. The monoclise acts as a conjunction zone of these structures with the Yenisei–Khatanga regional trough. There are 4 structures of the third order Gydanskoe (71), Yernikovoe (55), Mokhovoe (45) and Utrennee (69) dome-shaped uplifts and 10 local structures: Shtormovoe (46), Vostochno-Zelenomysskoe (50), Severo-Utrennee (62), Malogydanskoe (70), Ventoiskoe (77), Amposyahskoe (81), Vostochno-Yungiyahskoe (87), Yungiyakhskoe (89), Yuzhno-Gydanskoe (91), Nerosedayakhskoe (94) and Tyngevapaetayakhskoe uplifts in this zone.

The Utrennee dome-shaped uplift, to which the Salmanovskoe gas condensate field is confined, is controlled by an isogypsum of –2230 m, the area of the uplift is 535 km^2, and the amplitude is 255 m in the M reflector relief.

The Gydan uplift, which associated to the gas field, is located to the southeast of Utrennee uplift. It's contoured by level line –2000 m, has an area of 280 km^2 and an amplitude of 30 m. To the east of the fields there are Yernikovskoe and Mokhovoe dome-shaped uplifts, outlined at absolute levels of –1950 and –540 m. The areas of the structures are 385 and 575 km^2; the amplitudes are 30 and 55 m. The areas of local uplifts in this zone range from 20 to 80 km^2, and the amplitudes vary from 10 to 25 m.

In the southeastern part of the study area, the western end of the Yenisei–Khatanga regional trough is located, within which the Nadoyakhskoe (75), Salpadayakhskoe (84), Laduketskoe (90) and Pagodskoe (95) positive structures of the III–IV orders are distinguished. Pagodskoe dome-shaped uplift is the largest in this zone, it is contoured at –1750 m, has an area of 745 km^2 and an amplitude of 55 m.

In summing up the structural and tectonic characteristics of the South Kara regional depression and the Arctic regions of Western Siberia, we conclude:

1. Most of the study area is occupied by large depression zones: South Kara and Antipayutinsko-Tadebeyakhinskaya megasyneclises and framing their monoclise.

2. Eight structures of the first order: 3 negative – Central Kara, Predporogovaya and Tadebeyakhinskaya megadepressions; 2 intermediate – Predtaimyrskaya and Yamal–Gydan megasaddles and 3 positive – North Taimyr and Baidara megaledges and the Nurmin megaswell were identified in the Neocomian top. Only the Nurmin megaswell is a closed tectonic element.

3. In the topography of the Neocomian top 97 positive structures of III–IV orders, which could act as anticline oil and gas prospective objects – anticlinal traps for hydrocarbon reservoirs in Neocomian sandstons. There are 32 uplifts of the III order with areas 205–1850 km^2, 65 uplifts of the IV order with areas of 15–200 km^2 including on the continent: 22 structures of the III order, 39 structures of the IV order; in the shelf area: 10 structures of the III order, 26 structures of the IV order.

NEOCOMIAN COMPLEX OF THE KARA SEA

It was noted above that Neocomian clinoform sediments of West Siberia were formed mainly due to the removal of terrigenous material from the southeast and east bordering of the plate. The clinoforms dip northwest direction in the basin. The Neocomian complex has a similar structure in the far north of West Siberia. Figure 6 shows paleo-sections along profiles crossing the northern parts of the Yamal and Gydan Peninsulas in latitudinal and meridional directions.

The paleosections are leveled off the M_1 reflector, confined to the top of the Aptian and forming on the bottom of the Yarong clay member regionally spread in the north of West Siberia. The Yarong clay member overlain the Tanopchin formation and being a regional impermeable bed for hydrocarbon reservoirs for the Middle–Upper Aptian deposits. According to the analysis of the profile Reg_3, seismic record seven regional clinoforms falling eastward and a clinoform of the western dip in the Neocomian part of the section are distinguished. At the same time, the depocenter, within which western and eastern clinoforms converge, is located near the western bordering of the plate to the west of the Nurmin megaswell, which complicates the Predpaikhoy monoclise. Clinoforms dip northward in the time section along the regional profile Reg_8, which in the north reaches the coastline.

Analysis of seismic sections by regional profiles of the South Kara regional depression allows us to conclude that in the Kara Sea the Neocomian complex has a two-part structure, traditional for West Siberia. The Upper Barremian–lower Aptian part of the section is composed of beds lying subparallel to the reflector M. The Lower Berriasian–Hauterivian complex has a clinoform structure. At the same time, there is a number of fundamental differences.

Figure 7 shows composite regional paleo-sections along Reg_1and Reg_2 profiles, passing along the line "sea-continent" and crossing the Yamal Peninsula and the Kara Sea. Clinoforms plunging in the northern and southern directions are clearly distinguished in these sections in the Neocomian complex. In this case, the axis, within which the clinoforms, formed due to terrigenous material migration from the south and north, from the Siberian platform and Novaya Zemlya, converge, passes near the coastline. These materials allow us to conclude that in most of the South Kara regional depression, the Neocomian clinoform complex was formed due to the supply of material from the north, from the islands of the Novaya Zemlya archipelago and from the Siberian sill.

In time sections along the Reg_13 and Reg_16 profiles, crossing the Kara Sea in the latitudinal direction and oriented parallel to Novaya Zemlya, clinoforms, dipping in the western and eastern directions, are distinguished in the Neocomian part of the section (Fig. 7). In contrast to Western Siberia, in the shelf area, the clinoforms of the western dip are located further from the rock ledge of the plate and the zone where the western and eastern clinoforms converge is located in the central part of the depression.

There are clinoforms of the southern, western, and eastern fall on the shelf of the Kara Sea. Here the Neocomian clinoform complex formation was due to the terrigenous material input from the north, west, and east – from Vaigach Island, Novaya Zemlya Archipelago and the Siberian Sill, which at this stage of tectonic evolution were significantly above sea level and acted as provenance area.

Paleostructural characteristics. Let us focus on the paleostructural framework that took place in the South Kara regional depression in the Berriasian–early Aptian (Fig. 8).

An analysis of the isopach map of the Berriasian-lower Aptian sediments indicates that in the southern part of the Kara Sea, the thickness of the Neocomian megacomplex varies from 0 to 1800 m. At this stage of tectonic evolution, two contrasting depressions existed in the South Kara re-

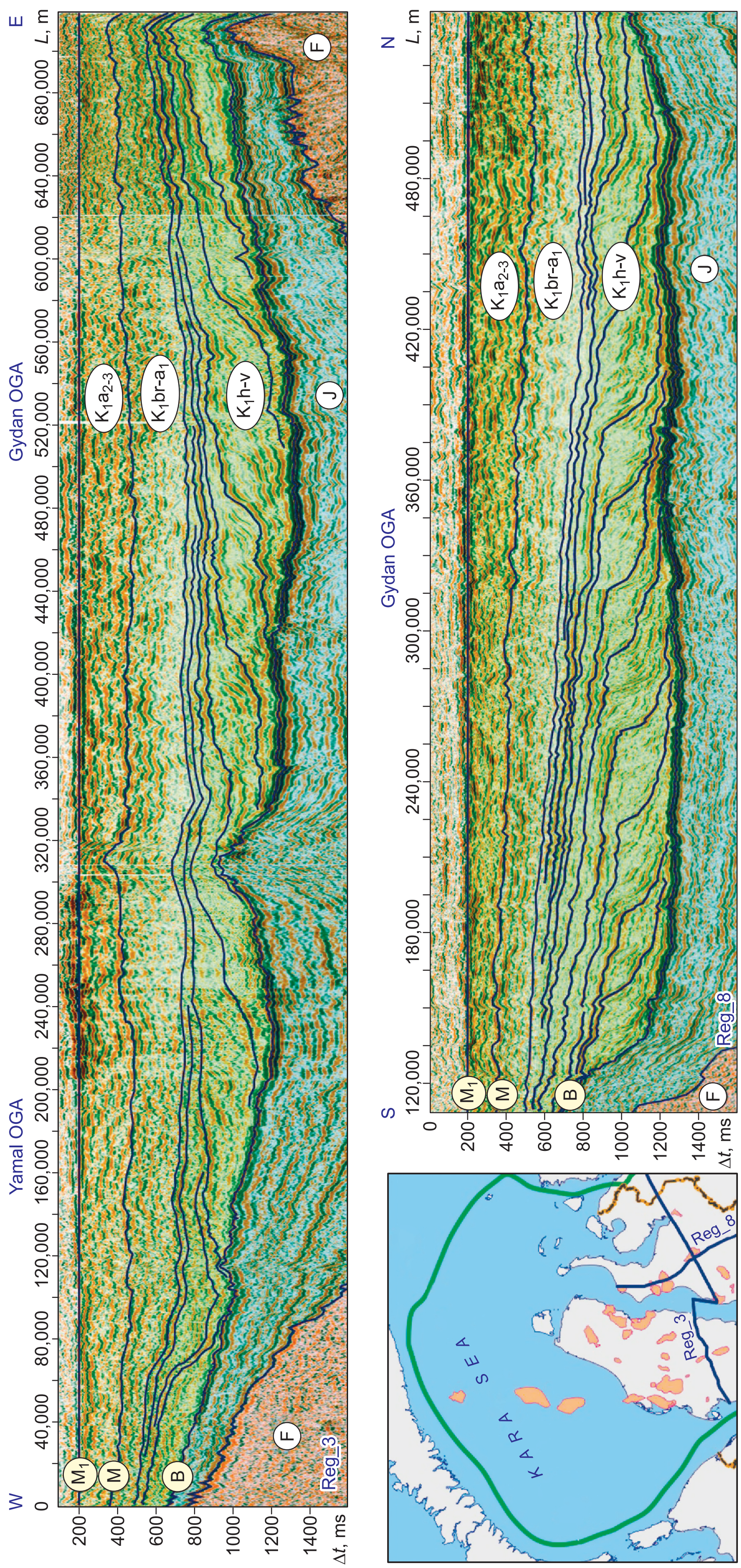
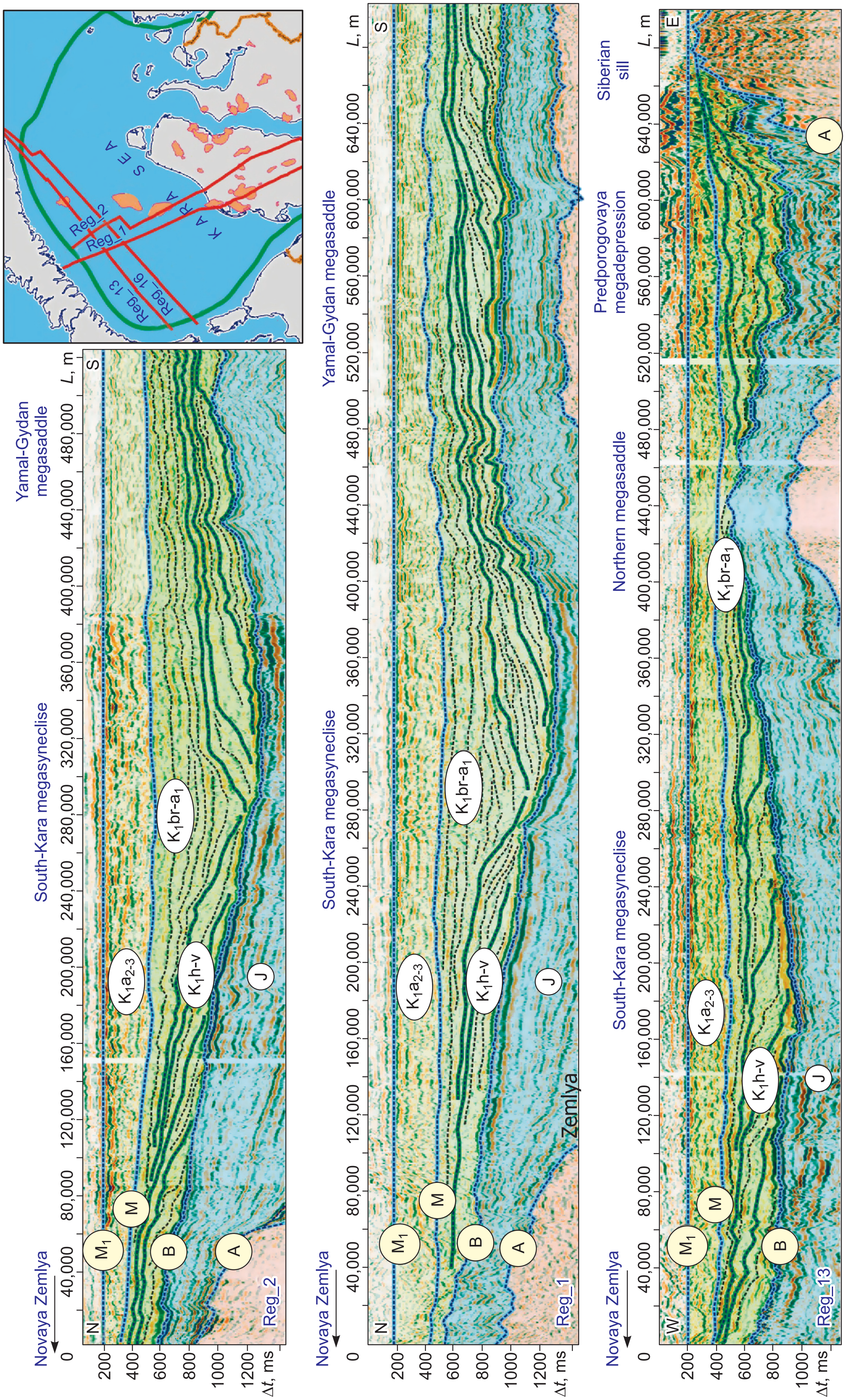


Fig. 6. Seismogeological characteristics of the Berriasian–Aptian sediments of the Yamal and Gydan OGA (seismic and geological paleo-sections of the Reg_3, Reg_8 profiles).



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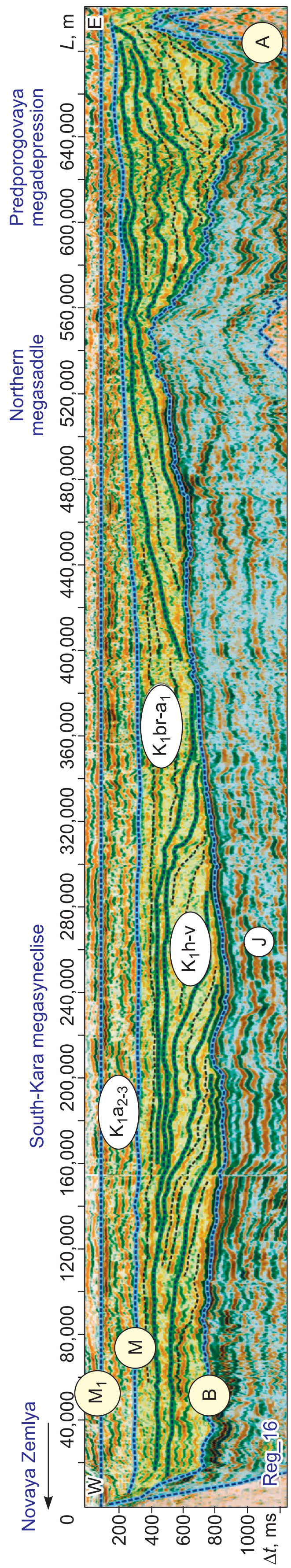

Fig. 7. Seismogeological characteristics of the Lower Cretaceous sediments of the West Siberian Arctic regions and the Kara Sea shelf (seismogeological paleo-sections along the meridional profiles Reg_1, Reg_2 and latitudinal profiles Reg_13, Reg_16).

gional depression. The deep depression zone, within which the thickness of the Berriasian-lower Aptian sediments reaches 1200 m, was located in the northeast of the study area – in the area of the modern Predporogovaya megadepression.

The Central Kara depression, in which the thickness of the Neocomian megacomplex reaches 1400 m, was more contrasting and larger than the South Kara depression, and was located in the southeastern part of the Kara Sea, to the northwest of the Yamal Peninsula.

These depressions were separated by the Northern megasaddle, which lied northeast from the Taimyr Peninsula to Novaya Zemlya Archipelago. Within the saddle, the thickness of the Neocomian sediments is significantly reduced to 400–500 m in the north and 800–900 m in the south.

During most of the Neocomian, these paleodepression zones were isolated areas of sedimentation that were not connected to each other.

The analysis of geological and geophysical materials allows us to note that the Predporogovaya depression in the Neocomian was filled exclusively due to terrigenous material migration from the northeast from Northern Island, which is located in the eastern part of the Novaya Zemlya Archipelago, and from the Siberian Sill. This process was probably extremely intense. The Neocomian complex has a cross-stratified structure in this zone in seismic time sections. At the same time, classical clinoforms with deep-sea, slope, and shelf parts are not distinguished here. In the Predporogovaya depression, steeply dipping reflectors are recorded in seismic sections. These reflectors originate on the rock ledge of the plate, Northern Island and Siberian Platform and sequentially “slice into” the paleo-sandbank, which was located within the Northern megasaddle (Fig. 9).

First, the most submerged and contrasting part of the depression was filled. As the relief is leveled, the reflectors angles decrease, and their length increases. The migration of terrigenous material into the Predporogovaya paleodepression took place extremely intensively, and, probably, by the end of the Berriasian depression was filled with sediments. In general, the seismic record, the absence of a clearly identified shelf part within the cross-stratified reflectors, as well as the proximity of the terrigenous material source suggest that in the Predporogovaya megadepression, most of the clinoform complex will be represented by poorly sorted sandstones, and there will be no reliable impermeable beds in this part of the section. Sediments laying in the upper part of the clinoform complex was formed in other conditions. By the nature of the seismic record in this part of the section, classical West Siberian clinoforms are distinguished, the shelf (unformal) parts of which bend around the Northern saddle and go west, where they meet clinoforms dipping eastward (Fig. 7).

Neocomian sediments have a classic appearance to the west of the Northern megasaddle. Here there is a series (4–5) of clinoforms, which build up each other laterally and dip eastward. Within clinoforms the undatema, fondotema and

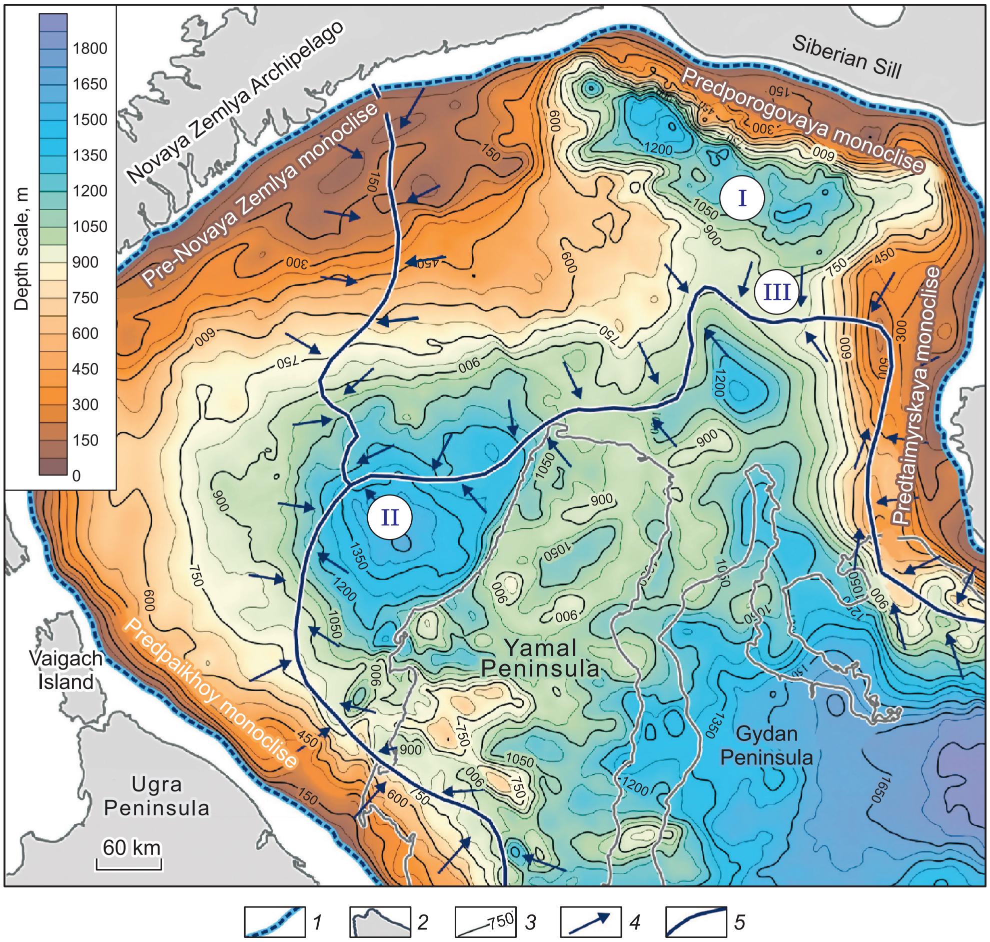

Fig. 8. Isopach map of the Neocomian clinoformic megacomplex (Arctic regions of West Siberia and the Kara Sea shelf). I, Central Kara paleodepression, II, Pre-Porogovaya paleodepression, III, Northern megasaddle. *1*, boundary of the basin, *2*, coastline, *3*, isopachs of the Neocomian megacomplex, *4,* direction of the clinoforms fall, *5*, depocenters, within which clinoforms of the north-south and west-east falls converge.

accumulative slope are clearly distinguished. In this zone, the formation of shelf sandstone beds and sandstones of the Achim member is entirely possible and, as a result, formation of classic Neocomian traps and hydrocarbon reservoirs.

Depocenters where clinoforms converge, which subside in the western and eastern, northern and southern directions are shown in Fig. 9.

Figure 10 shows a seismic paleo-section along the Sin_W-E profile, which crosses the Kara Sea in the latitudinal direction, and the result of its interpretation, which characterizes the fundamental model of the geological structure of the Berriasian–Aptian sediments of the South Kara regional depression.

CONCLUSIONS

This work is devoted to the analysis of the geological structure and assessment of the oil and gas prospects of Neocomian (Berriassian–lower Aptian) sediments in the Arctic regions of Western Siberia and on the shelf of the Kara Sea. Based on the results of the studies, the following main conclusions are made:

1. The southern part of the Kara Sea, located south of the Novaya Zemlya Archipelago, is the northern end of the West Siberian sedimentary basin and is identified as the South Kara regional depression.

2. In tectonic terms, the South Kara regional depression includes the same-name megasineclise and monoclise framing it of the Inner Region and the Outer Belt of the plate. From the west, north, and east, the South Kara regional depression is limited by folded framing structures: the Ugra Peninsula and Vaigach Island, in the north-west and north of the Novaya Zemlya, Archipelago in the northeast the Siberian Sill, in the east of the Taimyr Peninsula; in terms of oil and gas geological zoning, the southern part of the Kara Sea is allocated as part of the South Kara oil and gas area of the West Siberian oil and gas province.

3. Most of the study area is occupied by large depression zones: South Kara and Antipayutinsko-Tadebeyakhinskaya megasyneclises and framing their monoclise.

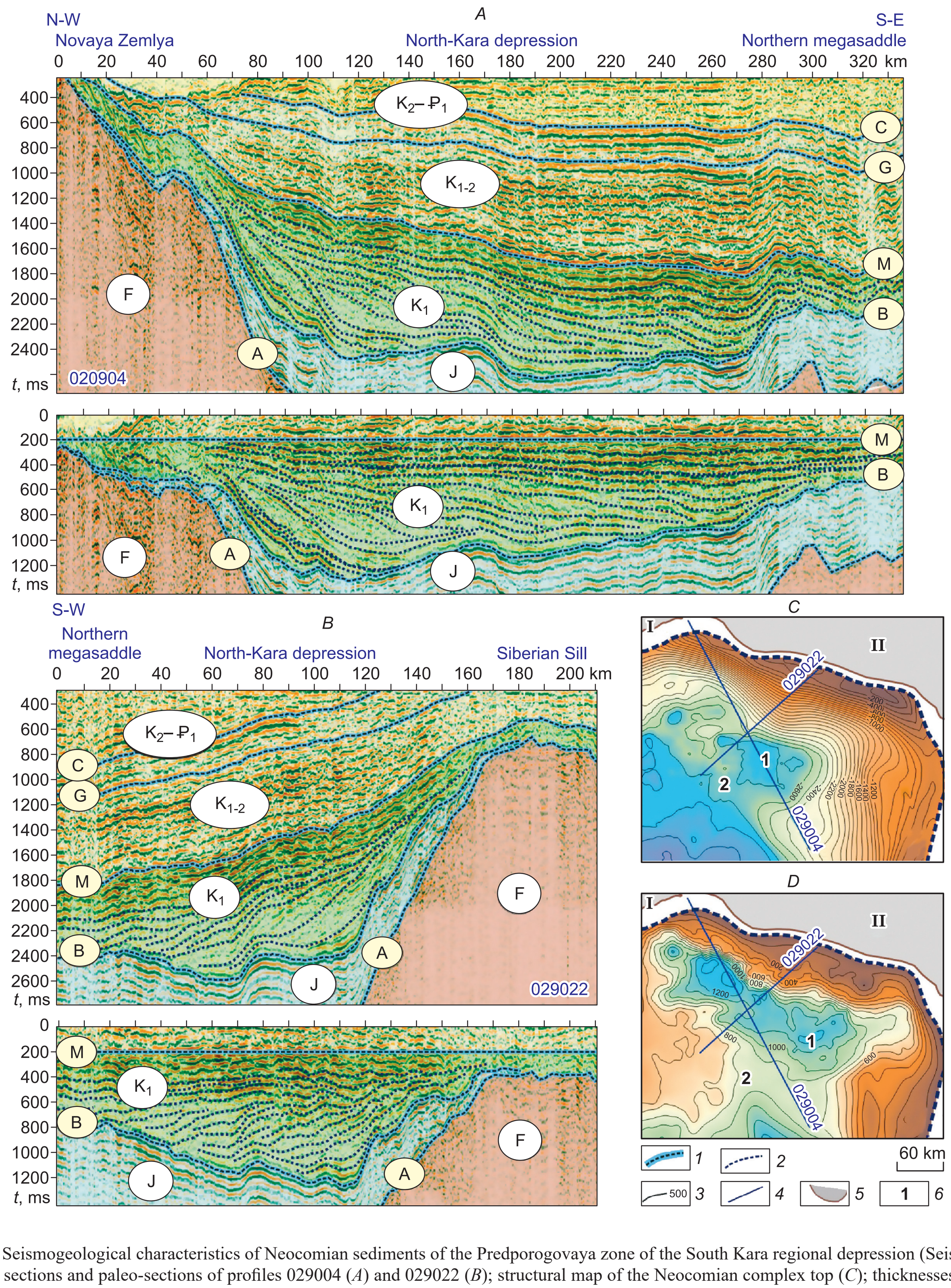

Fig. 9. Seismogeological characteristics of Neocomian sediments of the Predporogovaya zone of the South Kara regional depression (Seismogeological sections and paleo-sections of profiles 029004 (*A*) and 029022 (*B*); structural map of the Neocomian complex top (*C*); thicknesses map of Neocomian complex (*D*)). *1*, seismic marker reflectors, *2*, reflectors of the clinoform complex, *3*, isohypses (isopachites); *4*, seismic profiles CDP, *5*, basement highs (I, Novaya Zemlya, II, Siberian Sill).

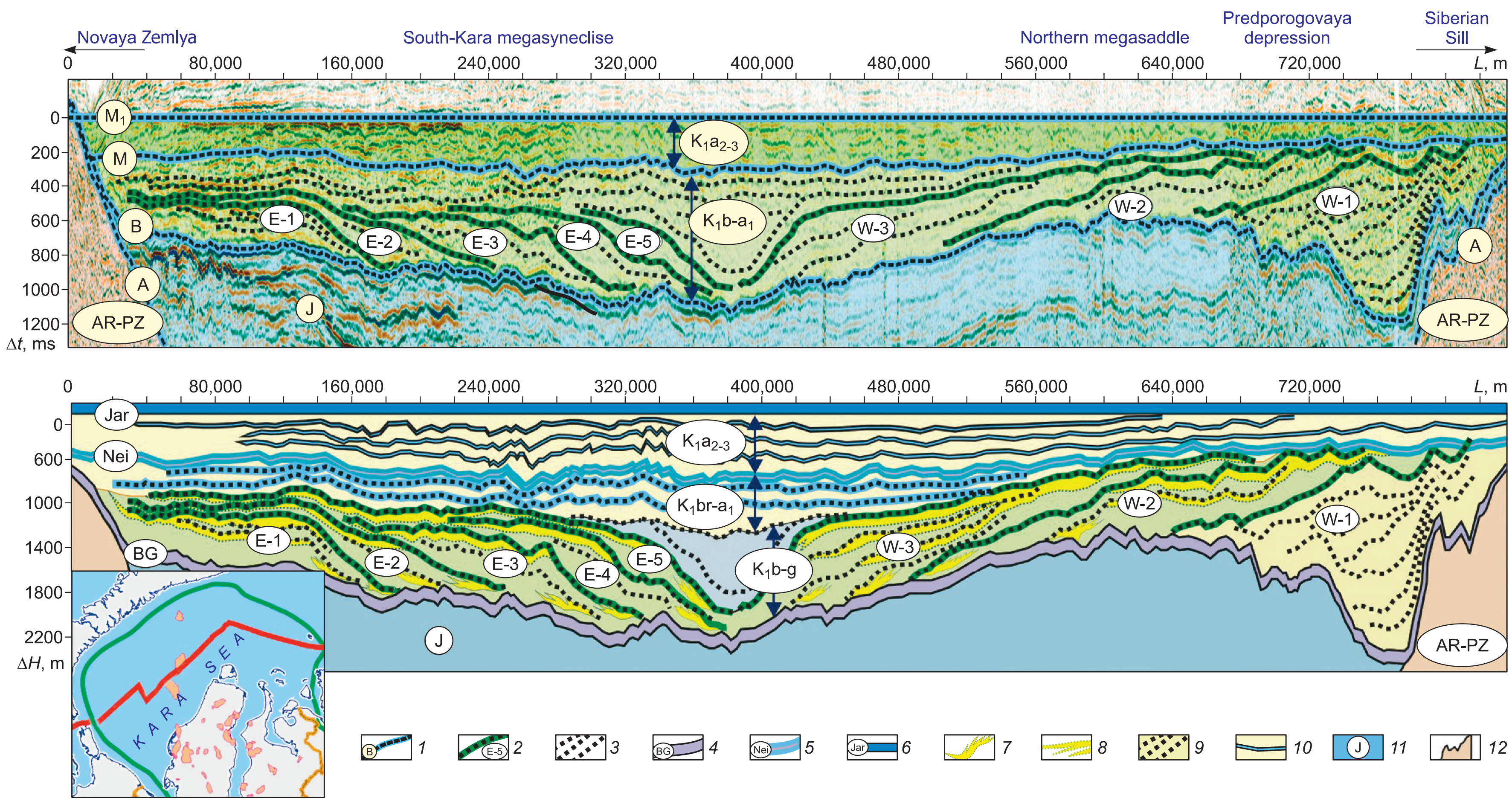

Fig. 10. Geological structure model of the Berriasian–Aptian deposits in the South Kara regional depression (time and geological sections along the Sin_W-E profile). *1*, seismic marker reflectors, *2*, reflectors of the regional clinoforms, *3*, reflectors inside the regional clinoforms, *4*, Bazhenov Formation and its analogues, *5*, Neitin member, *6*, Yarong Formation, *7*, Achim sandstones, *8*, shelf sandstones of the clinoform complex, *9*, “dumped” sandstones, *10*, interbedding of sandstones and clay beds of the shelf complex and the Middle–Upper Aptian megacomplex, *11*, Jurassic sediments, *12*, basement highs.

4. In the Arctic regions of Western Siberia and on the shelf of the Kara Sea, the Berriassian–lower Aptian sediments have a two-membered structure. The section of the Neocomian megacomplex is represented by the Berriassian–Hauterivian clinoform and Barremian–lower Aptian shelf complexes.

5. In the northern parts of the Yamal and Gydan, seven regional clinoforms are distinguished, plunging in the western and north-western directions, which were formed due to the precipitation from the Siberian platform and one counter eastern Ural clinoform. The depocenter, within which western and eastern clinoforms converge, is located in the Ural zone, to the west of the Nurmin megaswell, which complicates the Predpaikhoy monoclise.

6. On the shelf of the Kara Sea, clinoforms of the southern, western, and eastern falls are distinguished, the formation of which was due to the receipt of terrigenous material from. Vaigach Island, Novaya Zemlya Archipelago and the Siberian Sill, which at this stage of development significantly rose above sea level and acted as sources area. Clinoforms plunging in the northern and southern directions converge near the coastline, western and eastern clinoforms converge at the longitude of the Rusanovskoe and Kharasaeyskoe fields.

8. Located in the northeast of the South Kara regional depression, the Predporogovaya megadepression was filled exclusively by the destruction of terrigenous material from the northeast, from the Northern Island, located in the eastern part of Novaya Zemlya Archipelago and from the Siberian Sill. The transport of terrigenous material into the Predporogovaya paleodepression was extremely intense, and, probably, by the end of the Berriasian, depression was filled with sediments. The nature of the seismic record, the absence of a pronounced shelf part within the cross-stratified reflecting horizons, as well as the proximity of the drift source suggest that in this depression most of the clinoform complex will be represented by poorly sorted “dump” sandstones and there will be no reliable fluid supports in this part of the section.

9. The widespread occurrence of sandstone beds of the Barremian–lower Aptian complex and shelf beds of the clinoform complex predetermined that the concentrated hydrocarbon reservoirs in them are usually controlled by post-sedimentary anticline structures. At the same time, lithological screens can be developed within the objects, and the reservoir properties of the layers can significantly change both in section and in lateral. The deep-water sandstones of the Achim member and sandstones formed on terraces that complicate the slope parts of clinoforms are lenticular, and most of the associated oil and gas objects are complex lithological and structural-lithological non-anticlinal traps.

10. According to the results of structural-tectonic analysis, 97 positive structures of III–IV orders – anticline oil and gas prospective objects – were identified in the Neocomian top of the study area; 32 uplifts of the III order, the areas of which lie in the range 205–1850 km^2 and 65 uplifts of the IV order with areas of 15–200 km^2: on the continent: 22 structures of the III order, 39 structures of the IV order, in the water area: 10 structures of the III order, 26 structures of the IV order.

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