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Geological and Geodynamic Reconstruction of the East Barents Megabasin from Analysis of the 4-AR Regional Seismic Profile

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Abstract—The article considers problems related to the geological structure and geodynamic history of sedimentary basins of the Barents Sea. We analyze new seismic survey data obtained in 2005–2016 to refine the geological structure model for the study area and to render it in more detail. Based on the data of geological surveys in adjacent land (Novaya Zemlya, Franz Josef Land, and Kolguev Island), drilling, and seismic survey, we identified the following geodynamic stages of formation of the East Barents megabasin: Late Devonian rifting, the onset of postrift sinking and formation of the deep basin in Carboniferous–Permian, unique (in terms of extent) and very rapid sedimentation in the Early Triassic, continued thermal sinking with episodes of inversion vertical movements in the Middle Triassic–Early Cretaceous, folded pressure deformations that formed gently sloping anticlines in the Late Cretaceous–Cenozoic, and glacial erosion in the Quaternary. We performed paleoreconstructions for key episodes in evolution of the East Barents megabasin based on the 4-AR regional profile. From the geometric modeling results, we estimated the value of total crustal extension caused by Late Devonian rifting for the existing crustal model.

Keywords: East Barents megabasin, rifting, teectonostratigraphy, crustal model, paleoreconstructions
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INTRODUCTION

Investigations of the Barents Sea region began in the 14th–15th centuries, whereas the first special geological works were carried out in 1921 at a floating marine institute headed by Ya.V. Samoilov [6]. Since then, the factual data necessary for understanding the regional geological structure and evolution have been being collected and analyzed. In the adjacent land, areal and traversing geological mapping of different scales was performed, as well as gravimetric and aeromagnetic works. Intensive geological and geophysical investigations in the water areas of the Barents and Kara seas began in the 1960s–1970s; various studies were performed by such organizations as the All-Russia Research Institute of Geology and Mineral Resources of the World Ocean (VNIIOkeangeologiya), Karpinsky All-Russia Geological Research Institute (VSEGEI), the All-Union Research Institute of Marine Geophysics (VNIIMORGEO), R&D Enterprise for Marine Geological Survey of the North (Sevmorgeo), All-Russia Research Institute for Geophysical Survey Methods (VNIIGeofizika), R&D Organization Marine Arctic Geological Exploration Company (MAGE), Marine Petroleum Geophysical Exploration Enterprise (Sevmorneftegeofizika, or SMNG), Enterprise for Arctic Marine Oil and Gas Exploration (Arktikmorneftegazrazvedka, or AMNGR), and Arctic Marine Engineering Geological Expeditions [8]. In the 1970s–1980s, AMNGR drilled several tens of boreholes in the Barents Sea and on adjacent islands (Kolguev, Franz Josef Land, and Novaya Zemlya). In recent years, offshore drilling in the Barents Sea has been performed by the Gazflot Company. The obtained factual data have been studied and systematized by such researchers as I.S. Gramberg, Yu.E. Pogrebitskii, N.V. Sharov, M.L. Verba, V.E. Khain, E.V. Shipilov, S.I. Shkarubo, S.V. Aplonov, A.V. Stupakova, N.M. Ivanova, and many others [1–4, 16, 18, 21, 25, 32]. Their studies laid the foundation for contemporary ideas about the geological structure and evolution of the region. With respect to the fact that geological setting of the Barents Sea region is hardly accessible for direct investigations, many details of the regional structure and evolution still remain topics of debate. There are different viewpoints on the onset of the formation of the East Barents megabasin: some researchers think it had been developing since the Vendian–Cambrian [3, 18]; another group of authors have it occurring since the Late Devonian [11, 12, 21, 22]; finally, a third group argues that the onset took place in the Permian–Trias-

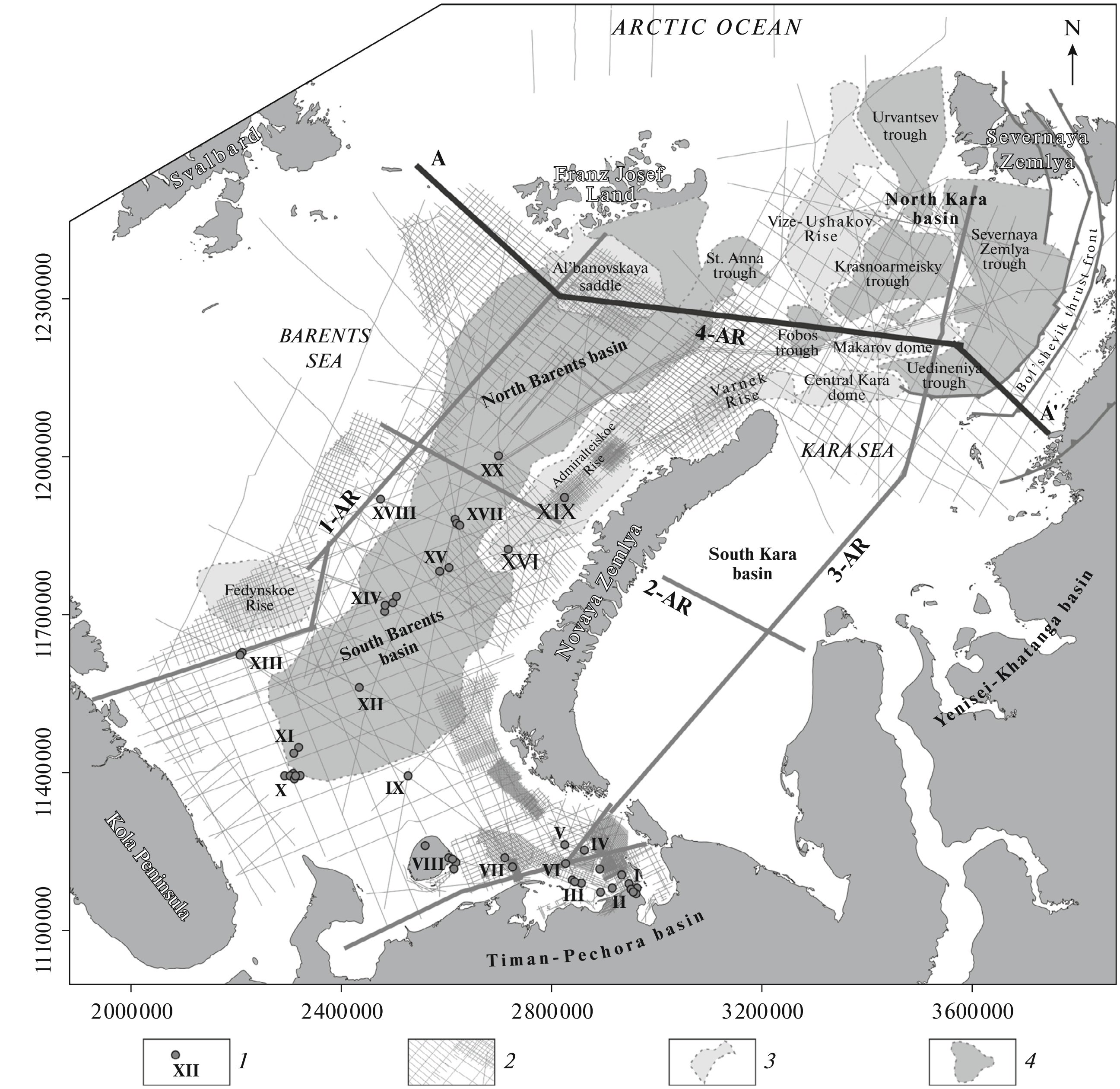


Fig. 1. Tectonic scheme of East Barents megabasin (Lambert azimuthal equal-area projection). (*1*) Holes; (*2*) SRM–CDP profiles made in different years; (*3*) rises; (*4*) basins and troughs. Drilling areas: I, Medyn'-More; II, Varandei-More; III, Pakhancheskaya; IV, South Dolginskaya; V, North-Dolginskaya; VI, North Gulyaevskaya; VII, Pomorskaya; VIII, Peschanoozerskaya; IX, Kurentsovskaya; X, Murmansk; XI, North Murmansk; XII, Arkticheskaya; XIII, North-Kil'din; XIV, Shtokmanovskaya; XV, Ledovaya; XVI, Krestovaya; XVII, Ludlovskaya; XVIII, Fersmanovskaya; XIX, Admiralteiskaya; XX, Luninskaya.

sic [5, 7]. Some problems of stratigraphic subdivision of the sedimentary sequence, Paleozoic–Mesozoic history, and tectonic evolution have also not been completely solved.

In recent years, such organizations as MAGE, SMNG, Sevmorgeo, and Geology without Limits have obtained new high-quality seismic survey data that can significantly supplement and refine the earlier geological models. This study is based on interpretation of new seismic profiles and synthesis of all available data to reconstruct the geological history of the East Barents megabasin. From here on, let us understand the East Barents megabasin as a system of deep basins divided from each other by narrow submarine elevations (saddles) and located west of Novaya Zemlya, in the Russian sector of the Barents Sea [22]: South Barents, North Barents, and St. Anna (Fig. 1).

MATERIALS AND METODS

When creating the geological model of the East Barents megabasin, we used the following factual data (see Fig. 1).

(1) Seismic survey profiles, including those obtained in 2000–2016 by such organizations as MAGE, SMNG, Sevmorgeo, and Geology without Limits, and those obtained during the implementation of a program aimed at creating a state network of geological ad geophysical reference profiles (1-AR, 2-AR, 3-AR, and 4-AR).

(2) Deep boreholes in the water areas of seas. Boundaries of Paleozoic seismic sequences, beginning from Carboniferous deposits, were correlated to sequences of holes drilled in the North Gulyaevskaya, Pakhancheskaya, and Admiralteiskaya oil areas. The boundaries of Mesozoic sediments in seismic profiles were referred to sequences from boreholes at the Arkticheskaya, Kurentsovskaya, Murmanskaya, North Kil'dinskaya, Ludlovskaya, and Shtokmanovskaya oil areas. The horizons were referred on the entire network of seismic survey profiles, and the results of this work were later plotted in the 4-AR model profile.

(3) A crustal model along the 4-AR profile, constructed by Sevmorgeo specialists based on analysis of wide-angle deep seismic profiling data and data from multichannel seismic studies [26].

In addition, the geological model of the East Barents megabasin took into consideration data on structure and composition of sedimentary strata of different ages investigated on Novaya Zemlya and Franz Josef Land. Some of the authors of this work participated in field works on such archipelagoes as Novaya Zemlya, Franz Josef Land, and Svalbard, as well as in the Polar Urals.

Bearing in mind the insufficient knowledge of regional deep structure from drilling, deep seismic survey data attain great value. To analyze these data, we used tectonostratigraphy and sequence stratigraphy. We traced unconformity surfaces in the sedimentary section over the entire network of seismic survey profiles, and these unconformities were then compared to the borehole-based stratigraphic levels. Seismic profiles were interpreted on a time scale, whereas reference to borehole-based levels was done by applying velocity laws calculated from vertical seismic profiling data.

GEOLOGICAL STRUCTURE MODEL OF THE EAST BARENTS MEGABASIN

The 4-AR profile was interpreted geologically on a time scale during areal correlation over the entire network of seismic profiles. These results are presented in Fig. 2.

The geological interpretation was later drawn in the same profile (obtained by Sevmorgeo) on a depth scale (Fig. 3). Note that our interpretation differs slightly from the geological model proposed earlier [26], but this can at least be explained by the large volume of new data.

From west to east, the 4-AR profile runs across the northern East Barents megabasin and the North Kara basin. Identification of tectonostratigraphic units and the basin evolution in the North Kara part of the cross section are described in [11, 14, 17, 29]. Detailed descriptions are given in these our previous publications, so we provide no special discussion of this basin here.

In the East Barents megabasin, the following tectonostratigraphic units and respective boundaries are distinguished.

At the surface of the acoustic basement in the eastern part of the East Barents megabasin, a system of grabenlike depressions up to 30 km wide or more filled with deposits 1.5 to 3 km thick (in Fig. 4 these deposits are indicated as D_3) has been identified. Rock complexes in these depressions are interpreted as synrift complexes. The system of basins, which are separated from each other, which is clearly traced in the vicinity of Novaya Zemlya, gradually disappears towards the central East Barents megabasin. This can be explained by the following reasons: first, the resolving power of seismic survey may be insufficient at depths of 12–15 km to study the structure of the basement; second, the observed system of basins may be a domino-type structure, where extension is achieved through rotation of basement blocks, so in the central part of the megabasin, where extension was maximum, the basement blocks rotated at larger angle to reach a subhorizontal position. Sediments of the synrift complex have not been recovered by drilling anywhere on the shelf, while those recovered elsewhere are dated to the Late Devonian proceeding from the following [22, 29–31]. There is a well-known pre-Frasnian angular and erosional unconformity in rock outcrops on the islands of Novaya Zemlya. Above the surface of this unconformity, the Frasnian synrift complex occurs, represented by various detrital facies and volcanites [8, 9, 15, 23]. Upsection, Upper Paleozoic deposits rest conformably on Frasnian synrift deposits. Few seismic profiles in the Barents Sea are located closely to the shoreline, to the mentioned natural outcrops on the islands of Novaya Zemlya. Therefore, we can logically assume that the rift complexes observed in the seismic profiles are of Frasnian age. It is seen in the same profiles that synrift rock complexes gradually change to postrift units upsection. Synrift deposits on Novaya Zemlya are Early Frasnian in age [8, 23], so we can consider that the time of manifestation of rifting within the East Barents megabasin could have been longer, spanning, e.g., the Frasnian–Famennian interval. In the East Barents megabasin, pre-Frasnian deposits of the Early Paleozoic may be present, but they have already been incorporated into the rock complex making up the acoustic basement of the megabasin and have been deformed to different degrees [22, 30, 31]. The pre-

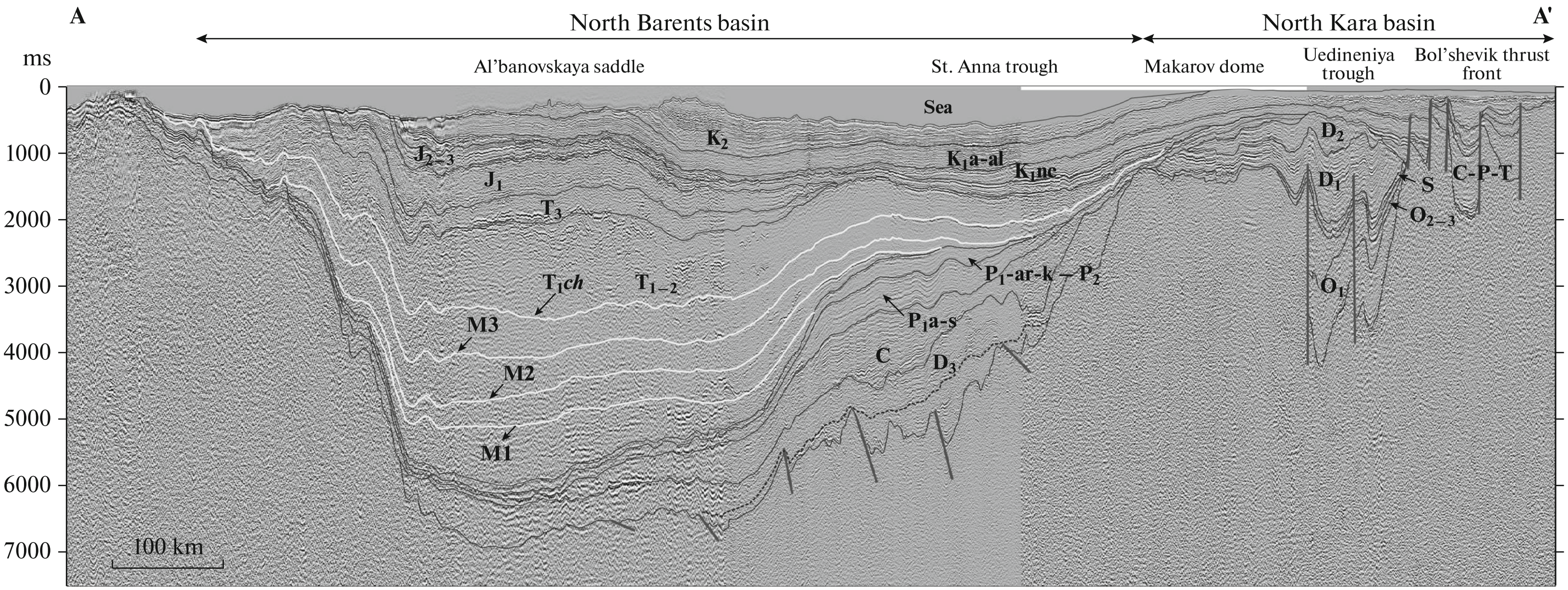


Fig. 2. Interpretation of 4-AR profile on time scale. A–A' is 4-AR profile (see Fig. 1). M1, M2, and M3 are identified maximum flooding surfaces traced for entire region without stratigraphic references.

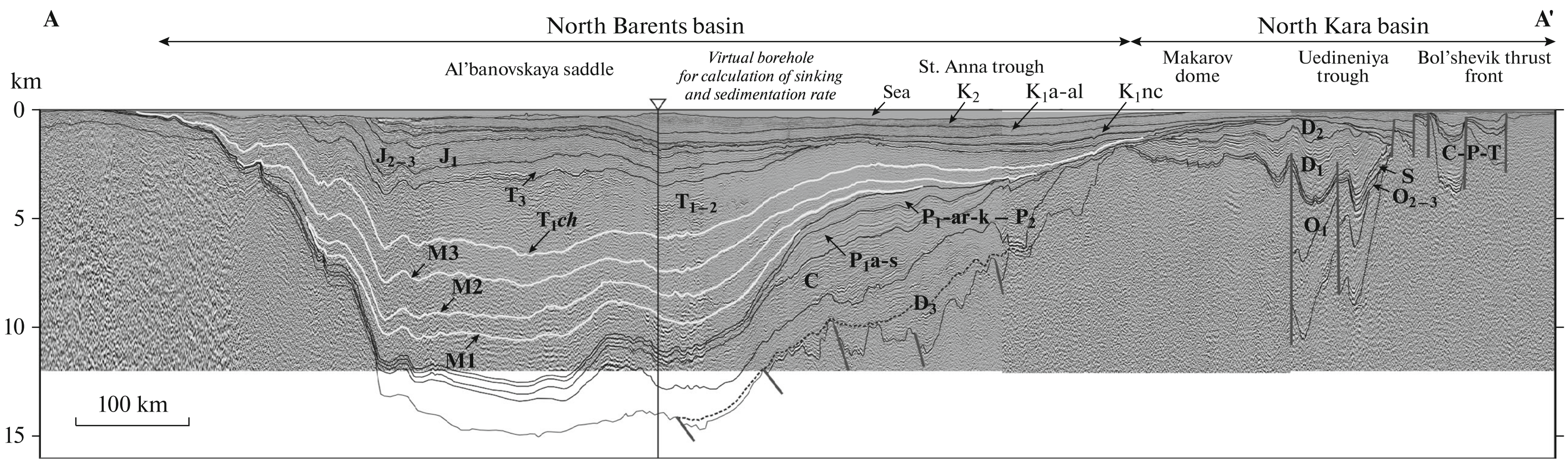


Fig. 3. Interpretation of 4-AR profile on depth scale. A–A' is 4-AR profile (see Fig. 1). M1, M2, and M3 are identified maximum flooding surfaces traced for entire region without stratigraphic references.

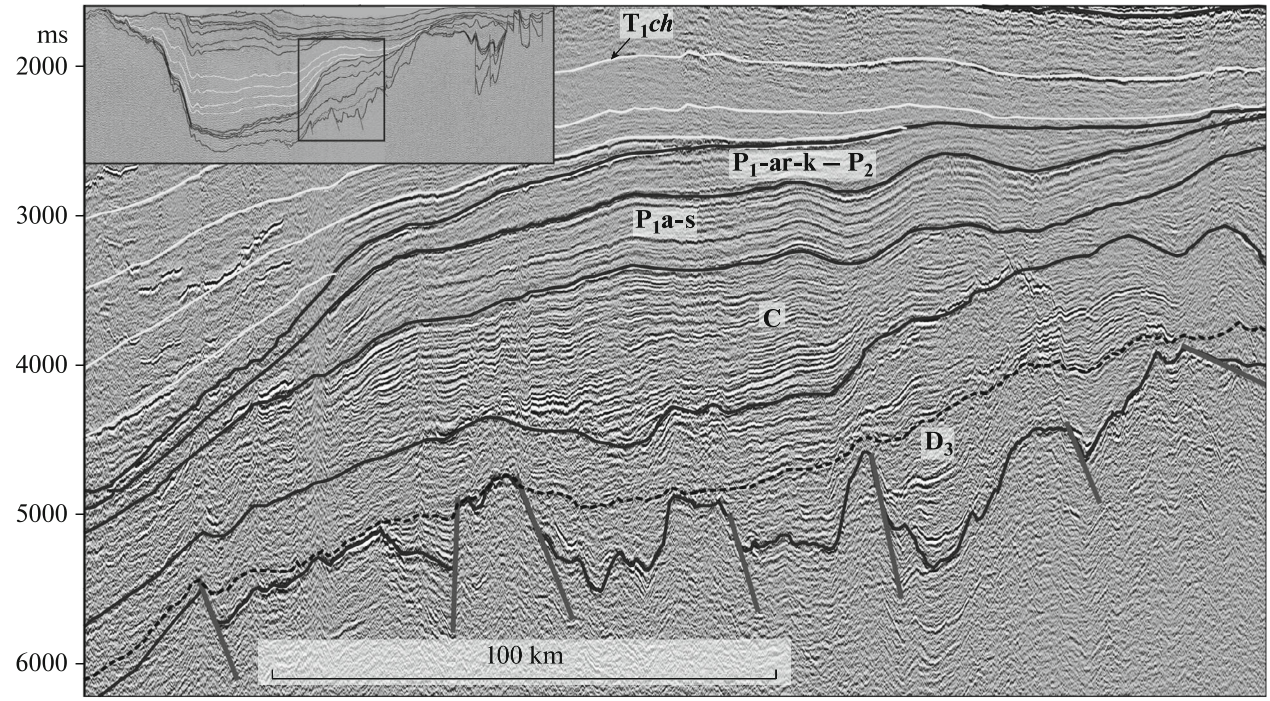


Fig. 4. Synrift and postrift complexes in 4-AR profile. In inset, rectangle shows location in 4-AR profile.

Frasnian unconformity is also documented in the sections of the Timan–Pechora basin [19].

The next complex (indicated as C in Fig. 4) is identified above deposits of the synrift complex and characterized by transition from local sedimentation in depressions to the formation of the regional sedimentary cover. We interpret such a transition as the onset of postrift stage of downwarping in the region under consideration. The unconformity at the base of the postrift complex in the North Kara part of the regional cross-section becomes the boundary of pre-Carboniferous erosional cut which is the most significant angular unconformity in the section of the North Kara basin. In the East Barents megabasin, the identified complex is of various structure, with thickness changing from about 1 to 2.5 km. In the western, most sunken part of the megabasin, resolution ability of seismic survey was insufficient to reliably interpret the lower sedimentary section. Based on the results of stratigraphic referencing to the sequence recovered by the Admiralteiskaya-1 borehole [20] and by the holes drilled in the Pechora Sea, the age of deposits in this complex was referred to Carboniferous [31].

The following complex up the section has the clearly clinoform structure in places (deposits P_1a-s in Fig. 4). Downlaps of the seismic horizons are directed away from the North Kara basin, and particular clinoforms are up to 300 m in height. West of here, towards the axial part of the megabasin, clinoforms change to the condensed section. The considered seismic complex pertaining to the sequence recovered by the Admiralteiskaya-1 borehole is dated to the Early Permian (Asselian–Sakmarian) and is composed of supposedly carbonate rocks [20].

Deposits of the overlying complex are distinguished in the lower part from the angular unconformity known as the Ia seismic reflector (SR). This unconformity has signs of local erosional washing and is traced over the entire area of the East Barents megabasin. It was revealed from sequences of holes drilled in the Pechora Sea and the Admiralteiskaya-1 borehole that this boundary corresponded to an abrupt change in sedimentation conditions that occurred after the Asselian–Sakmarian and thus marked the transition from carbonate to terrigenous sedimentation. Deposits of this complex are of clinoform structure, with the clinoform of up to 300 m high (deposits P_1ar-k–P_2 in Fig. 4). The age of these deposits is Artinskian–Late Permian.

The following complex is distinguished from the boundary where they overlap Permian terrigenous deposits. Accumulation of sediments of this complex is related to rapid filling of the deep sedimentation paleobasin. In the central and southern parts of the East Barents megabasin, as well as in the area of the Al'banovskaya saddle, the strata of the clinoform structure prograding westwards are traced within the limits of this complex. Upsection, the character of the seismic record within this complex becomes more chaotic, but nevertheless particular SRs (M1, M2, and M3) are traced in the seismic profiles over the entire area of the megabasin (see Figs. 2, 3, 10, 11); hence,

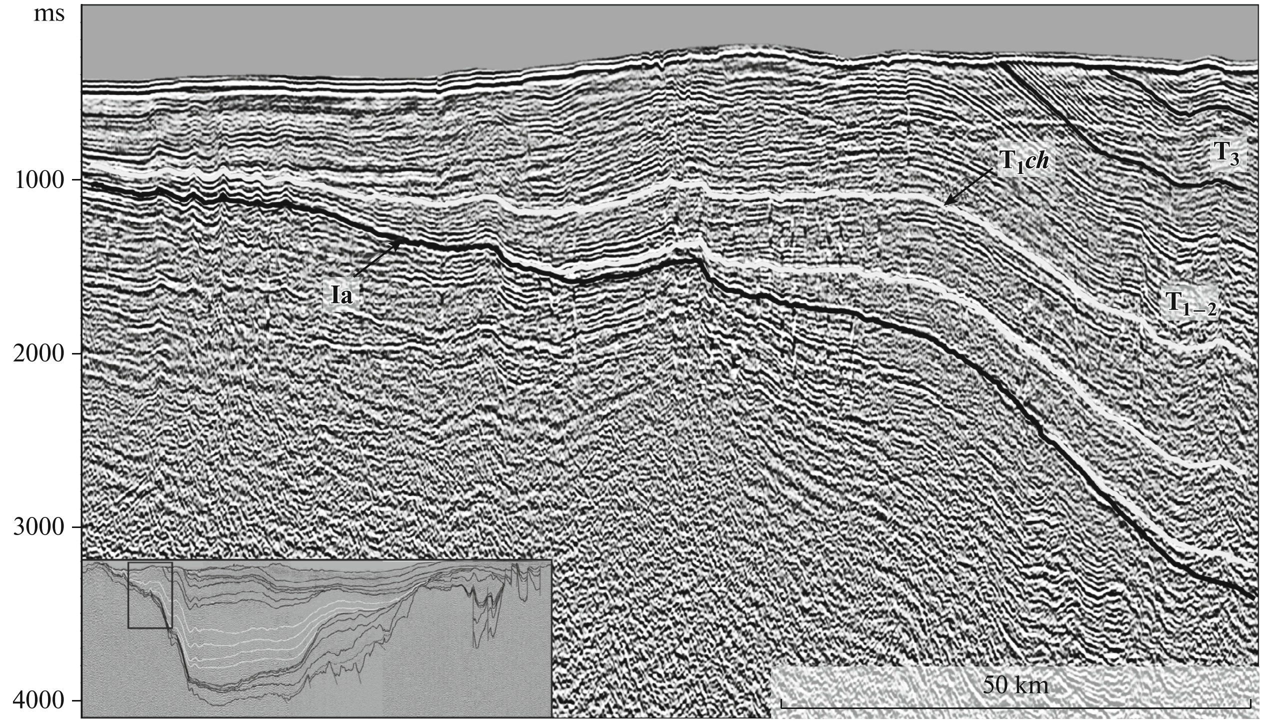


Fig. 5. Clinoform structure of Triassic complex in western part of East Barents megabasin in 4-AR profile. In inset, rectangle shows location in 4-AR profile.

we can interpret them as maximum flood surfaces. In the area of the Al'banovskaya saddle, incut valleys up to 10 km wide are identified in lateral view at the tops of particular horizons; this indicates the presence of sedimentation hiatuses in the eastern East Barents megabasin and, likely, a shift in sedimentation processes to the western part of the megabasin. Upper boundary of this complex is conditionally drawn along the clear SR (T_1*ch*) identified in the stratum possessing chaotic shape of seismic record and being conditionally referred to Lower Triassic units analogous to those recovered by boreholes at the North Gulyaevskaya, South Dolginskaya, and other oil areas in the Pechora Sea. Thickness of deposits in this complex is up to 7–8 km in the most sunken parts, indicating extremely high sedimentation rates in the Early Triassic.

Age of deposits of the next seismic complex is determined as the Middle Triassic–Early Jurassic based on the data of stratigraphic subdivision of sequences from the Ludlovskaya, Shtokmanovskaya, and Arkticheskaya boreholes. The Middle Triassic part of the complex in the western East Barents megabasin is of clinoform structure (Fig. 5), whereas characterized by chaotic pattern on east. Up the section, the chaotic appearance changes to horizontally bedding shape of seismic horizons supposedly related to Upper Triassic–Lower Jurassic deposits. In the area of the Al'banovsko-Gorbovskii threshold (saddle), deposits of the complex demonstrate a local change in thickness (Fig. 6), which is interpreted as the result of sedimentation in the background of increasing tectonic uplift. Thus, we distinguished the syn-inversion complex of deposits of approximately Middle-to-Late Triassic–Early Jurassic age. This seismic complex in the central parts of the basin is up to 5 km thick.

In some places, the seismic pattern within Triassic complexes is distorted by high-amplitude wave anomalies. At present, it is known that similar anomalies are caused by Early Cretaceous basaltic sills recovered by boreholes at the Arkticheskaya, Shtokmanovskaya, and other oil areas.

The next complex (deposits $J_{2\text{-}3}$–K_1nc in Fig. 7) is separated from the previous (underlying) one by an unconformity carrying traces of erosional washing. This unconformity marks the end of inversion deformations that affected the deposits of earlier complexes. Based on drilling data from the Ludlovskaya, Shtokmanovskaya, and Arkticheskaya oil areas, the age of the unconformity has been determined at the pre-Middle Jurassic, whereas the age of deposits in the complex proper is Middle-to-Late Jurassic–Neocomian. The Jurassic part of the section is represented by plane-parallel reflectors and the Neocomian part clearly has a clinoform structure observed in the central and southern East Barents megabasin. Particular clinoforms are up to 100 m thick.

The last (uppermost) complex identified in the profile (K_1a-al–K_2 in Fig. 8) is separated from the one occurring below by an unconformity separating

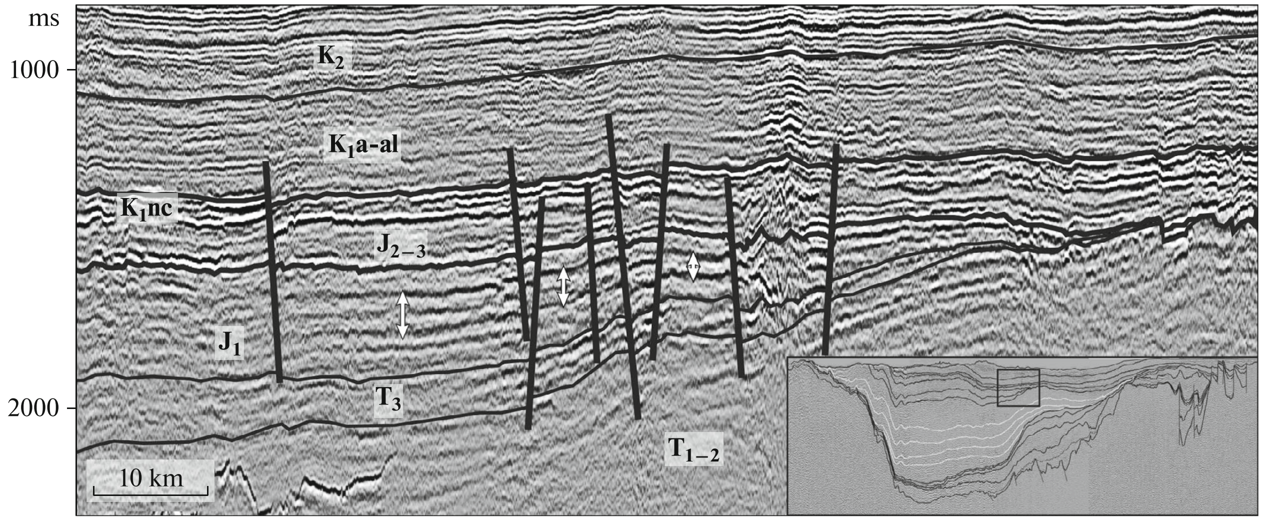


Fig. 6. Upper Triassic–Lower Jurassic complex in 4-AR profile. In inset, rectangle shows location in 4-AR profile. Arrows denote local change in thickness of Lower Jurassic deposits in background of increasing tectonic uplift.

deposits with different degrees of deformation. Based on drilling data from the Ludlovskaya, Luninskaya, Shtokmanovskaya, and Arkticheskaya oil areas, the age of this unconformity has been determined as pre-Aptian, while the deposits proper are Aptian–Albian and Late Cretaceous in age. The complex has a horizontally layered structure disturbed by recent folding and fracturing deformations. Deposits of this complex are heavily eroded and, based on geometric estimates, the thickness of already eroded rocks along the 4-AR profile is up to 800 m (Fig. 9).

GEODYNAMIC EVOLUTION OF THE EAST BARENTS MEGABASIN

Based on our geological interpretation of seismic profiles running across the East Barents megabasin, we compiled paleotectonic reconstructions illustrating the structure of the megabasin at the key moments of its geological evolution, which are marked by unconformities (Fig. 10). We did these reconstructions on the basis of the 4-AR profile on the time scale, using alignment to the main unconformities and corrections to supposed paleogeographic conditions. Paleoreconstructions were carried out without compaction of rocks taken into account; hence, they have a schematic character.

Based on the geological modeling results, the evolution of the East Barents megabasin is seen as follows.

In the Early Frasnian (Fig. 10a), the territory of the East Barents megabasin underwent synrift sinking. Detrital and volcanic deposits of various facies accumulated in narrow grabenlike depressions. The thickness of synrift deposits was up to 3–4 km.

In the Late Frasnian (or, probably, slightly later), postrift sinking of the region began to form a deep (up to 1500 m) paleomegabasin with noncompensated sedimentation.

During the Carboniferous–Early Permian, a thick fan consisting of supposedly terrigenous and carbonate deposits formed west of Severny (Northern) Island of Novaya Zemlya. Postrift sinking in the megabasin took place on the background of general uplift of the region corresponding to the present-day North Kara basin (Fig. 10b).

In the Late Permian (Fig. 10c), the deep basin began to be filled with terrigenous material supplied from areas of the present-day North Kara basin and Taimyr. The Early Triassic evolution stage can be distinguished by its particularly rapid sedimentation rates. On the background of marine basin regression, detrital material was transported by multiple river systems into the East Barents megabasin.

In the Middle-to-Late Triassic–Early Jurassic, the studied region was covered by a thick stratum of shallow marine and continental deposits (Fig. 10d). This is the time when vertical inversion deformations had begun to manifest.

In the Middle-to-Late Jurassic, shallow marine deposits accumulated in the East Barents megabasin, whereas in the Neocomian, the clinoform character of filling of the megabasin dominated (Fig. 10e).

In the pre-Aptian, the study region underwent another deformation episode. In the Aptian–Late Cretaceous, terrigenous deposits accumulated under quiet platform conditions.

Later, the considered region underwent post-Middle Cretaceous (probably, Cenozoic) gently folding deformations and glacial erosion in the Quaternary [24] (Fig. 10f).

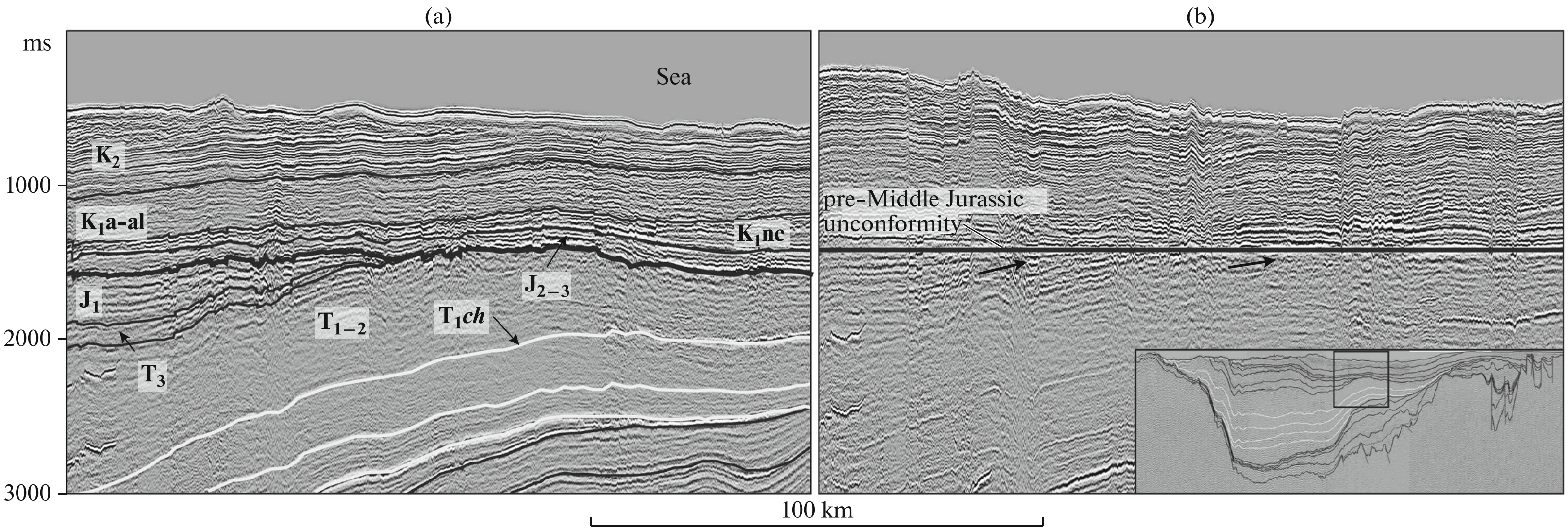


Fig. 7. Pre-Middle Jurassic unconformity in 4-AR profile. In inset, rectangle shows location in 4-AR profile. Boundary of pre-Middle Jurassic unconformity: (a) without smoothing, (b) with smoothing.

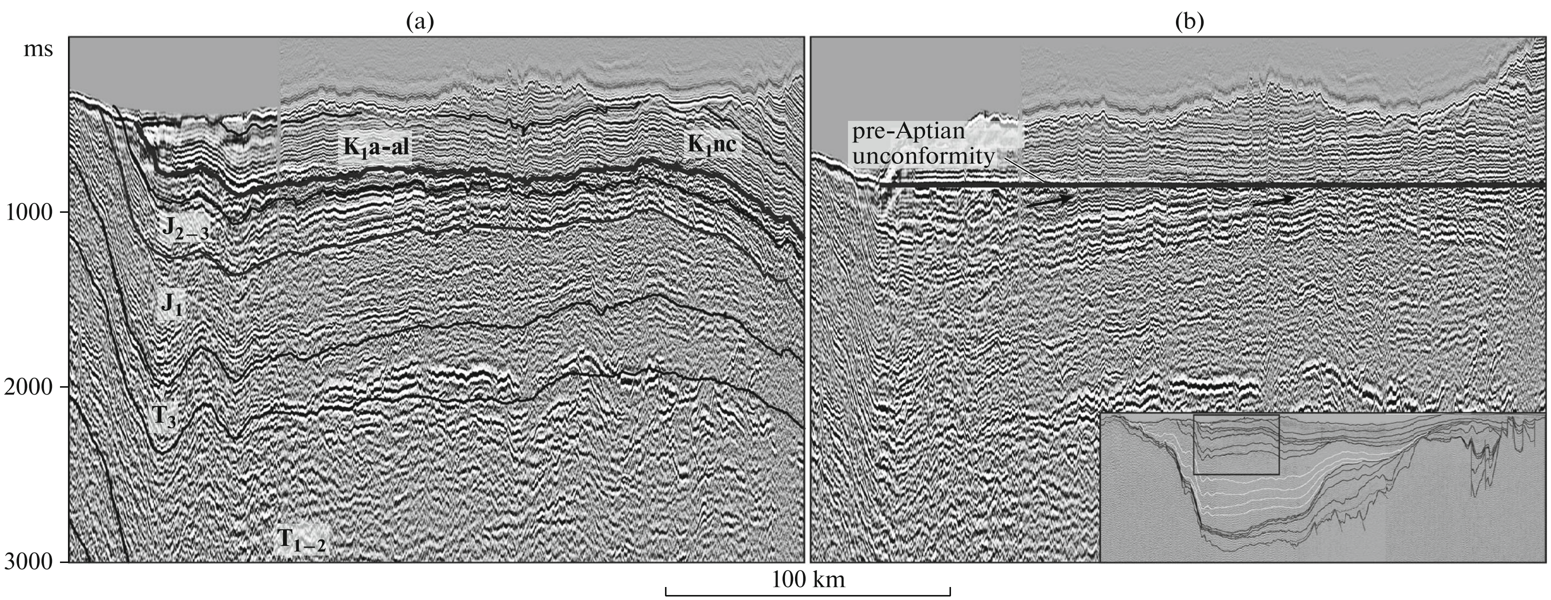


Fig. 8. Pre-Aptian unconformity in 4-AR profile. In inset, rectangle shows location in 4-AR profile. Boundary of pre-Aptian unconformity: (a) without smoothing, (b) with smoothing.

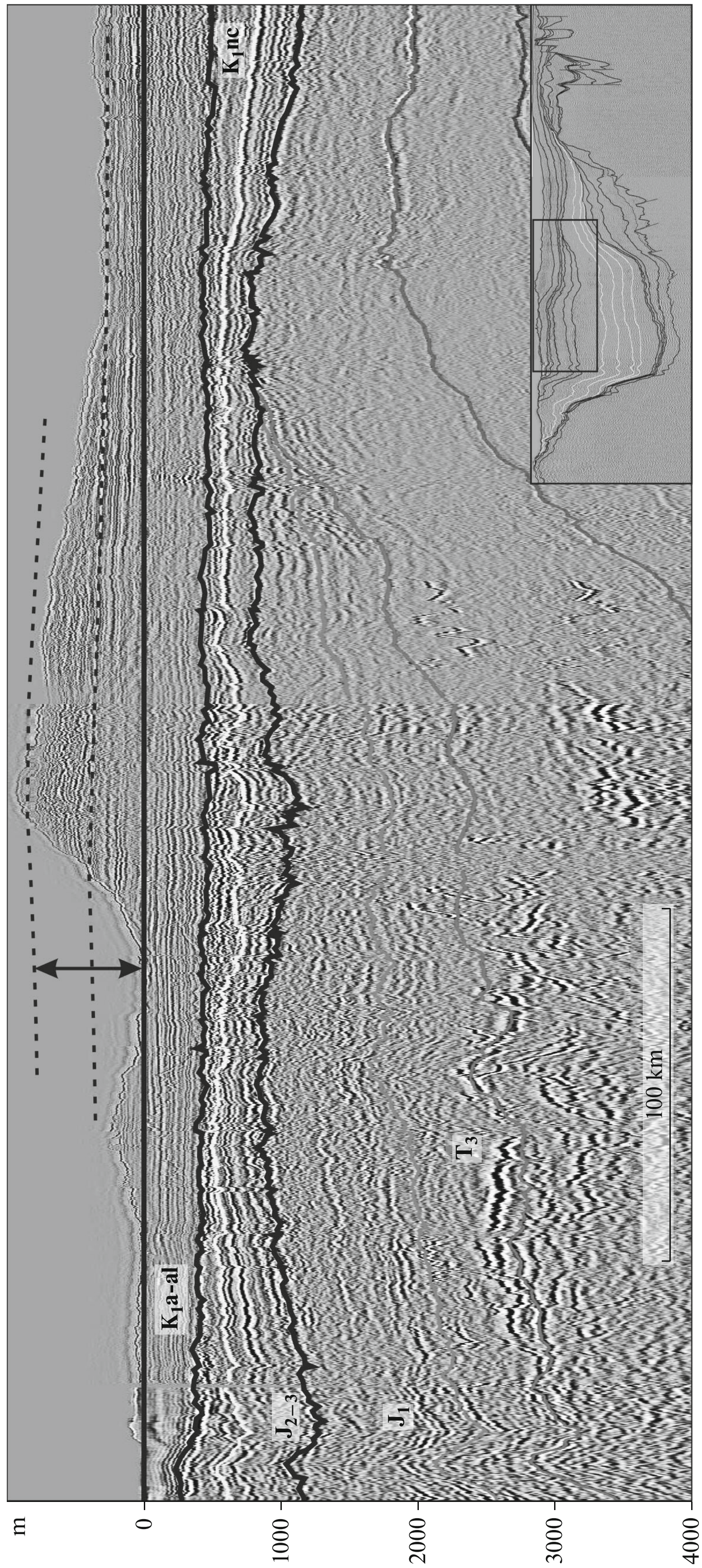
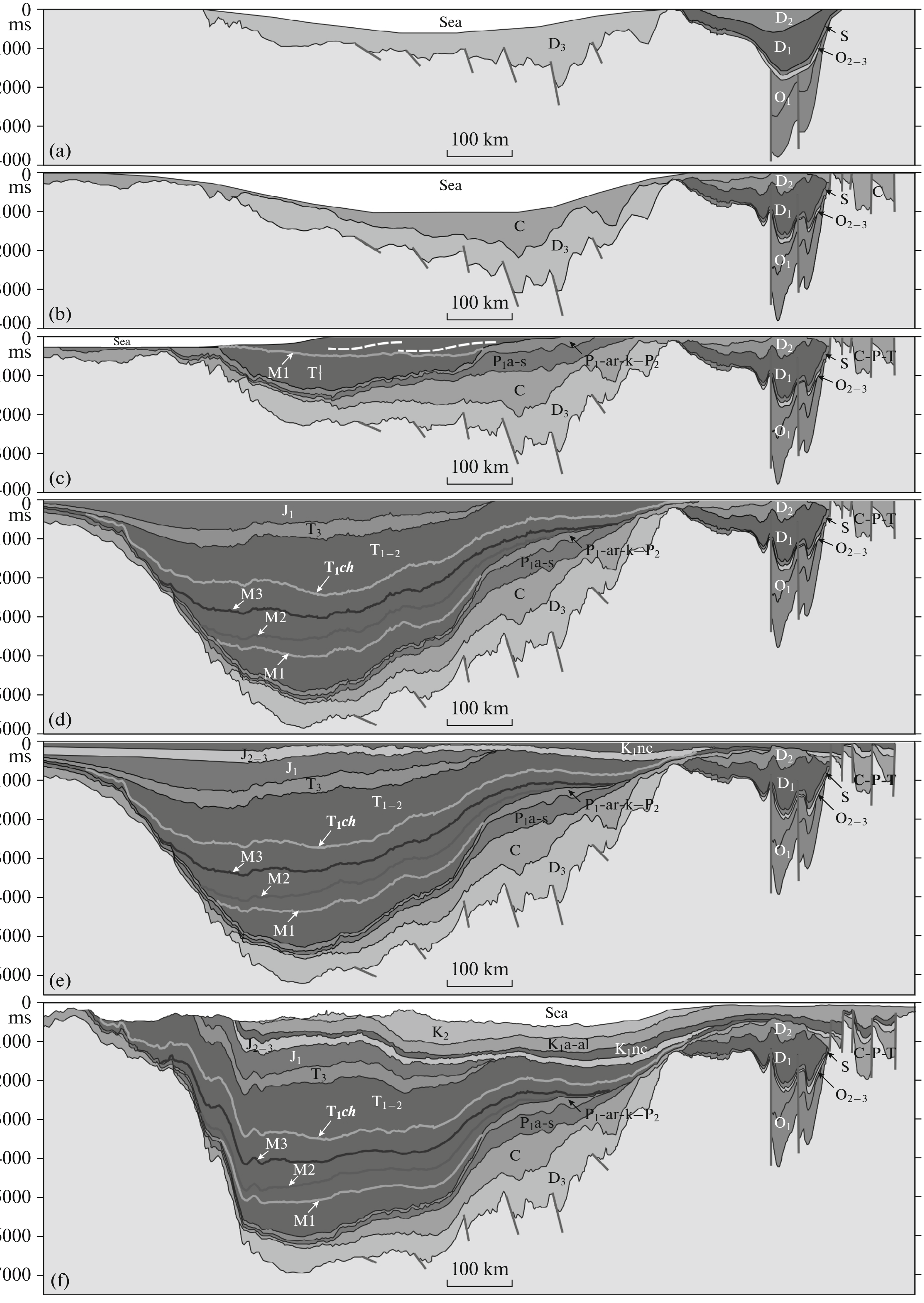


Fig. 9. Adjustment of 4-AR profile to base of Upper Cretaceous deposits on depth scale. Arrow indicates approximate value of Quaternary erosion.



(a)
ms
0
1000
2000
3000
4000
Sea
D3
D2
S
D1
O2–3
O1
100 km
(b)
C
(c)
M1
T1
P1a-s
P1-ar-k–P2
C-P-T
(d)
6000
5000
J1
T3
T1–2
T1ch
M3
M2
(e)
J2–3
K1nc
(f)
7000
K2
K1a-al

Fig. 10. Paleoreconstruction of East Barents megabasin on time scale: (a) end of Devonian–beginning of Carboniferous, (b) end of Carboniferous–beginning of Permian, (c) middle Early Triassic, (d) end of Early Jurassic–beginning of Middle Jurassic, (e) end of Neocomian–beginning of Aptian, (f) contemporary cross section. White dashed lines show progradation of deposits as traced in seismic profiles.

RECONSTRUCTION OF CRUSTAL EXTENSION

The geological model we constructed for the East Barents megabasin was coupled with a lithosphere structure model of the Barents Sea region (Fig. 11) developed at Sevmorgeo using the AR-series network of deep reference geological and geophysical profiles [26].

It seems possible to estimate the value of crustal extension in the region resulting from the pre-Frasnian rifting event and the subsequent downwarping of the crust under pressure of the sedimentary cover based on the geometric behavior of deep horizons in the earlier obtained crustal model (Fig. 12). Pre-Upper Devonian units of the North Kara basin were included into the upper crust. The predeformation state of the crust in the East Barents megabasin was reconstructed by the equal areas method, which uses the classical model of rift sedimentary basin formation proposed by D.P. McKenzie [28]. The essence of the method is the assumption that thinning of the crust in the central part of the basin resulted from tension along the profile, whereas before extension, the crust had a more homogeneous geometry (i.e., an approximately rectangular cross section). For extension directed along the profile, the cross-sectional areas of the upper and lower crusts should remain unchanged, whereas thinning, being maximum in the axial part of the basin, should have almost not effect on the marginal parts of the basin. With the known value of the cross-sectional area of the crust along its profile and that of the maximum crustal thickness, we can calculate the length of crustal cross section in its predeformation state. We chose the vertical line at the eastern margin of the 4-AR profile to be the fixed line, because the crust is thickest here.

Based on the geometric reconstruction results, the extension in the megabasin region is 350 km, with a crustal elongation coefficient of 1.35. Note that these values should be considered as preliminary, because many initial data used in modeling can be interpreted ambiguously.

DISCUSSION

To quantitatively analyze the evolution of the East Barents megabasin, we constructed the curves of regional sinking along the virtual hole sequence conditionally “drilled” in the 4-AR profile (along the vertical cross section at the point indicated in Fig. 3) (Fig. 13). The figure shows the variation curves for sedimentation surfaces (paleogeographic curve), pre-Late Devonian basement sinking (epeirogeneic curve), tectonic sinking (curve of calculated sinking of the regional basement surface under the condition that the weight of sediments was zero and the sediment load did not affect sinking), and sedimentation rate. Calculations were performed in software developed by A.V. Ershov [13]. Analysis shows that the megabasin underwent two major sinking epochs during its evolution: Late Devonian and Early Triassic. Similar results were obtained from similar reconstructions based on analysis of sequences from holes drilled on the shelves of the Barents and Pechora seas [10, 27]. As we have shown in this work, Late Devonian sinking was definitely determined by considerable extension of the lithosphere as a result of rifting. The estimated extension value is approximately 350 km. The fact of extension itself is verified by the presence of the large number of Late Devonian normal faults that controlled development of grabens and semigrabens. In the Carboniferous–Permian, the basement surface sank more gradually and the entire region also underwent tectonic sinking related to postrift thermal cooling of the regional lithosphere, which was substantiated theoretically by D.P. McKenzie [28, 33]. Thermal sinking of the region was accompanied by deepening of the megabasin to about 1–2 km. Considerable and unique in terms of spatial extent, sinking within the limits of the study area took place in the Early Triassic, when sediments about 5 km thick accumulated over a period of about 5 Ma. By the end of the Early Triassic, the deep paleobasin had been completely filled with sediments (the sedimentation process terminated with continental sedimentation). Progradation of marine sedimentation settings and clinoform filling of the paleobasin with sediments took place gradually, predominantly from east to west (in present-day coordinates). Tectonic sinking of the region is almost not observed in this period, as indicated by structural analysis of the study region based on the series of seismic profiles, which do not contain any structural forms, including faults, of Triassic age. Hence, in the Early Triassic, tectonic processes were not activated and the main cause of rapid (avalanche) sedimentation and sinking of the paleobasin was related to the appearance of large-scale provenance areas and the development of multiple river systems that transported considerable volumes of detrital material into the earlier existing deep basin. It is these processes that caused filling of the paleobasin with sediments. In the post-Early Triassic, thermal sinking of the megabasin continued, as well as its slower filling with sediments.

We have provided results of analysis of the geological and geodynamic evolution of the East Barents megabasin based only on the seismic profile. However, the key episodes of geodynamics of the entire

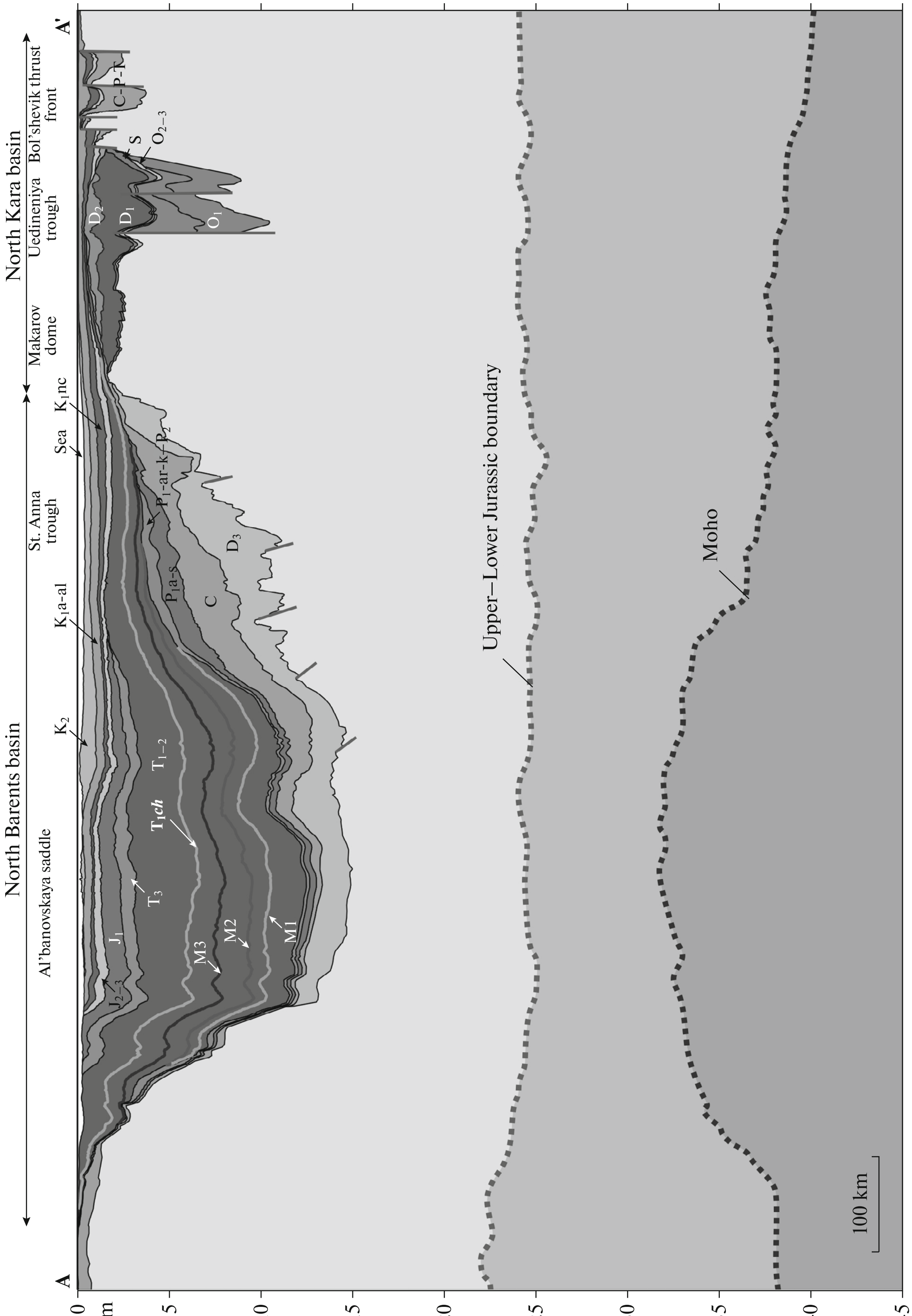


Fig. 11. Crustal model of East Barents megabasin along 4-AR profile, after data from [26], with sedimentary cover interpretation made by authors. A–A' is 4-AR profile (see Fig. 1).

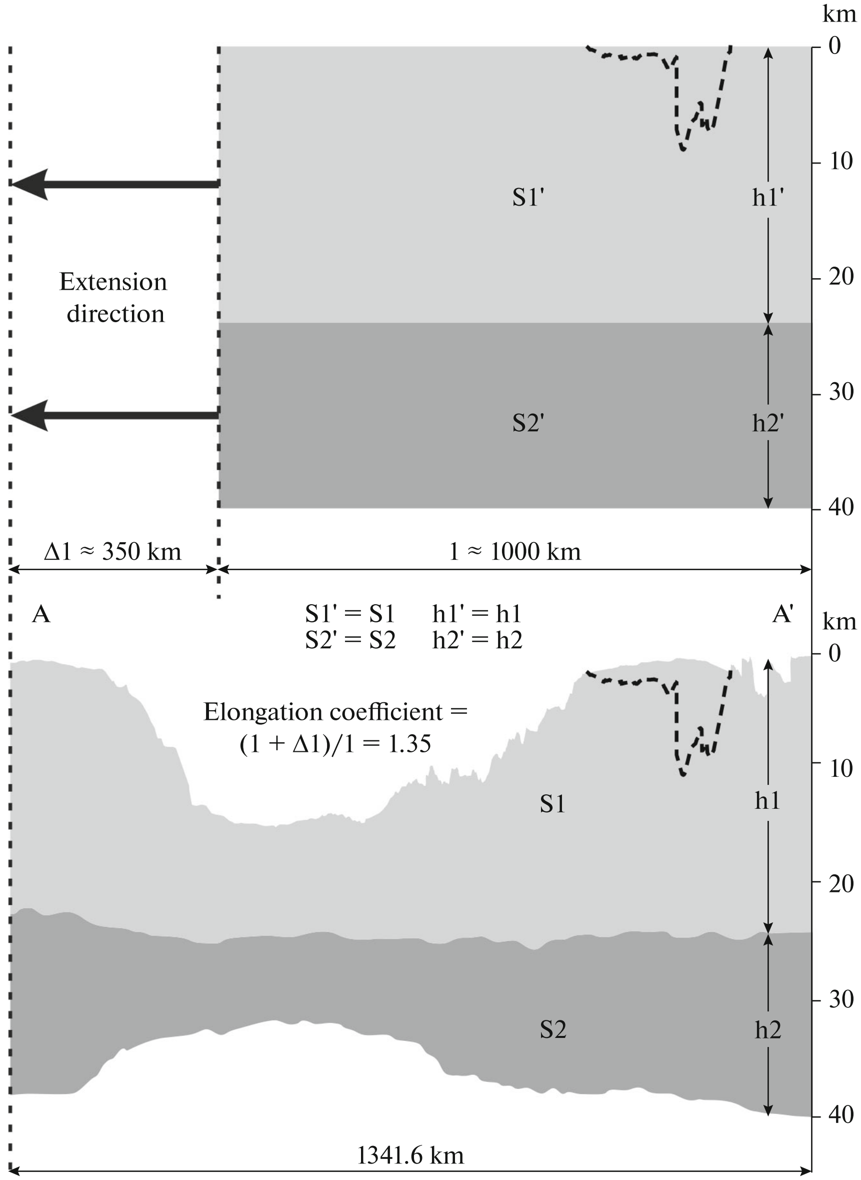


Fig. 12. Reconstruction of predeformation state of upper and lower crust for East Barents megabasin along 4-AR profile. Dashed line indicates location of North Kara basin.

region can be seen here, and they generally coincide with our earlier conclusions on this region [22, 30].

CONCLUSIONS

Based on analysis of a series of regional seismic profiles and more detailed reconstructions along the 4-AR profile (for the northern part of the megabasin), the following conclusions can be made regarding the geodynamic evolution of the East Barents megabasin.

(1) In the Late Devonian, the study area was characterized by large-scale rifting, crustal extension, and the onset of the formation of deep basins.

(2) In the Carboniferous–Permian, postrift thermal sinking took place in the region, as well as deepening of the paleobasin to 1–2 km. In the central (axial) part of the paleobasin, thin depression sediments accumulated, whereas on the sides, shelf carbonate platforms formed, which would be replaced on the slopes by clinoform rock strata and, probably, turbidite fans of terrigenous rocks.

(3) In the Early Triassic, extremely rapid sedimentation was reported. Clays, siltstones, and sandstones dominant in it progradationally filled the earlier existing deep paleobasin. Avalanche sedimentation was caused by the inflow of an enormous amount of detrital material into the paleobasin from the land framing it in the east.

(4) In the Middle Triassic–Cretaceous, thermal sinking continued, as well as relatively slower filling of

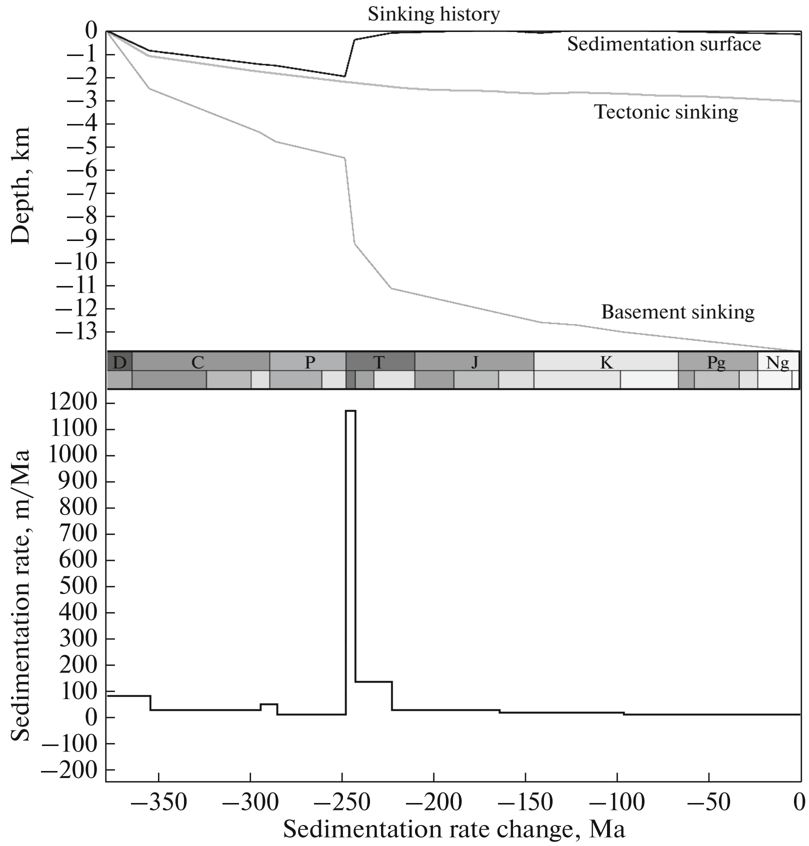


Fig. 13. History of sinking and sedimentation rate in East Barents megabasin based on virtual borehole (see virtual borehole location in Fig. 3).

the paleobasin with detrital deposits and clays; particular episodes of inversion movements also occurred.

(5) In the Late Cretaceous–Cenozoic, gently folded pressure deformations occurred to form gentle anticline rises.

(6) In the Quaternary, the study area (more precisely, the upper part of its sedimentary cover) underwent considerable glacial erosion.

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