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Depositional Environments and the Hydrocarbon Generative Potential of Triassic Rocks of the Barents Sea Basin

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Abstract—With the recent large hydrocarbon discoveries in the Barents Sea, interest is turning to Triassic shales as the most likely source rocks. The results reveal the relationship between the quality of Triassic source rocks, the amount and type of organic matter, and the environments of deposition. The best source rocks are confined to the Lower and Middle Triassic successions deposited in a deep-water shelf environment in the western part of the basin. Shallow-marine and deltaic argillaceous rocks exhibit fair to poor gas-generative potential. Triassic fluvial-lacustrine deposits have little to no hydrocarbon generative potential.

Keywords: Triassic source rocks, geochemical studies, hydrocarbon generative potential, depositional environments, lithofacies zones, Barents Sea basin

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INTRODUCTION

With the recent large hydrocarbon discoveries in the Mesozoic reservoirs of the Barents Sea, the interest of many geologists is turning to Triassic shales as the most likely source rocks. Successful exploration in the region will require assessing the distribution and lateral and vertical variation in the quality of the Triassic source rocks. Because depositional environments have a strong influence on the type, quantity, and preservation of organic matter in a sediment, i.e., on original source rock potential, we estimated the geochemical parameters and lithofacies characteristics of the Triassic deposits for the entire Barents Sea basin.

In the late 1980s, studies were launched by Arktikmorneftegazrazvedka and VNIIOkeangeologiya to evaluate the quality of the Triassic source rocks using core and cuttings analysis from stratigraphic wells drilled in the Barents Sea and on the surrounding islands (Danyushevskaya, 1995). Numerous occurrences and seepages of oil and bitumen in Triassic rocks reported from wells and outcrops have been studied at the All-Russia Petroleum Research Exploration Institute (VNIGRI) (Klubov et al., 1998). Relationship between the quality of Triassic source rocks from different parts of the Barents Sea and their depositional environments were discussed in previous publications (Grigor'eva et al., 1998; Bjoroy et al., 2010; Leith et al., 1992).

MATERIALS AND METHODS

All geochemical analyses were performed in laboratories at the Faculty of Geology and Geochemistry of Fossil Fuels at the Department of Geology of the Moscow State University. Twenty source rock samples were collected from Triassic outcrops during fieldworks on the Franz Josef Land (FJL) and Spitsbergen archipelagos. Moreover, the study was supplemented by literature geochemical data and results of pyrolysis of Triassic samples collected from outcrops on Spitsbergen and from the Nagurskaya, Heiss, and Severnaya wells on FJL (Danyushevskaya, 1995), and from offshore wells drilled in the Barents and Pechora seas (Official website of Norwegian..., 2010).

Study of Triassic depositional environments in the Triassic successions in the Barents Sea was based on outcrops, core and cuttings descriptions, as well as well log analysis. For the evaluation of the southeastern part of the Barents Sea basin we also used the results of our interpretation of seismic data (Kazanin et al., 2011) acquired by MAGE in 2008–2010. Lithofacies maps for the Early, Middle, and Late Triassic were compiled using literature data (Atlas: Geological History..., 2009; Glorstad-Clark et al., 2010).

The geochemical methods that were used in this study included a combination of both qualitative and quantitative characterization of organic matter, such as macro- and microscopic examination of rock samples, Rock-Eval pyrolysis, luminescence microscopy and source rock extraction in chloroform, separation of asphaltene and malthene fractions of the extract. Normal and isoprenoid alkanes were analyzed using gas-liquid chromatography (GC) on a Perkin-Elmer gas chromatography system. Saturated and aromatic fractions of extracts were analyzed by gas chromatography/mass spectrometry (GCMS) using a Finnigan

MAT-900 XP mass spectrometer. The results of geochemical analyses were discussed in detail in our previous study (Kiryukhina et al., 2012).

The Triassic sequences were divided into lithofacies, each with a characteristic set of rock lithologies, structures, textures, thickness, flora and fauna fossils. The distinguished lithofacies zones were supported by lithostratigraphic columns generated for the Triassic sections based on well data and field outcrops on the basin's margins. The sea-level curves show cyclical changes from continental to shelf marine environments (Fig. 1). Lithofacies zones in the undrilled areas were interpolated from seismic data on the basis of continuity, boundaries, thickness variation, and the characteristics of the seismic facies of the Triassic seismostratigraphic complex (Kazanin et al., 2011) with a general account of the regional tectonic and geological framework.

Triassic lithofacies zones. During the Triassic, the Barents Sea represented a large epicontinental basin with water depths of up to 200 m, connected in the north with the open sea. Permian strata are overlain with a minor hiatus by Triassic strata. The boundary between Permian and Triassic deposits is clearly visible on seismic sections at the flanks of the basin (Kazanin et al., 2011), while the unconformity is not recognizable in the central part of the basin. Several intra-Triassic hiatuses were produced due to local uplift and general shallowing of the basin during the Triassic. Subsequent widespread pre-Jurassic erosion took place during Rhaetian times near the incipient Novaya Zemlya orogen (Kazanin et al., 2011), which experienced multiple phases of uplift since the Middle Triassic. The Upper and Middle Triassic deposits were partially removed as a result of differential uplift and intense erosion within the Barents Sea basin during the Late Cretaceous and Cenozoic.

During Triassic times, a continental, marginal marine to marine depositional environment became established in the Barents Sea shelf. One or several lithofacies zones were distinguished for each depositional environment based on rock lithologies, sedimentary structures and textures, thickness, and fossil contents (Fig. 1) (Gradziński et al., 1980; Obstanovki osadkonakopleniya..., 1990).

Lithofacies zones of erosion and fluvial–lacustrine plain are distinguished in the continental environments. Zones of erosion tend to be dominated by erosional processes, so they act as a provenance of clastic sediments and plant detritus.

Fluvial–lacustrine plains have considerable lateral and vertical lithologic variation. *Fluvial deposits* consist of well-sorted sandstones, siltstones, and shales, commonly lenticularly interbedded, with conglomerate intercalations. The rocks are usually variegated to red colored due to the presence of hematite and iron oxides, the prevailing oxidizing environments and rapid burial. The sandstones and siltstones are polymictic with clay and clay–carbonate cement and common tangential or multi-directional cross-bedding. Lenticular bedding is the predominant sedimentary structure in sands and shales. Recognizable fossils are scarce but include freshwater mollusk shells, fish, and reptile bones. Fragments of higher land plants, spores, and pollen occur.

The *transitional marginal marine environments* are characterized by a variety of lithofacies zones, including delta plains, delta fronts, prodeltas, tidal floodplains, and lagoons, sand-banks, occasionally inundated by the sea. The *deltaic environment* is commonly divided into three zones: delta plain, delta front, and prodelta, differing in the composition and characteristics of sediments. The *delta plain* includes distributary channels with their subaerial levees, interdistributary marshes and swamps, small lakes, and lagoons. The *delta front* is a narrow, steeply sloped submarine part of the delta where distributary channels meet the open sea. As a result of continuous sediment supply delta front propagates basinward. The *prodelta zone* includes the distal submarine part of the delta.

The *delta plain* deposits are mostly polymictic sands deposited in distributary channels and channel-mouth bars, typically dominated by tangential cross beds, traces of erosion, and intercalations of pelitic layers; levee fine-grained sandstones and thin bedded silts are also present. Delta plain marshes, lakes, and lagoons are dominated mainly by argillaceous thin bedded sediments, as well as coal lenses and beds deposited under humid climatic conditions. The *delta front* deposits are well-sorted, tangentially cross-bedded sands and thinly bedded silts. The *prodelta* facies are represented by thin-laminated silt and clay varieties with abundant plant debris and mica, but rare spores and pollen transported by rivers. Faunal remains are usually scarce, but include occasional bivalves. Bioturbation is common in the lower part of the prodelta and lagoons.

Extensive areas of the sea coasts were occupied by *tidal floodplains and lagoons*. Tidal plains are dissected by a network of tidal channels through which seawater rose and flooded the adjacent coastal flats. The tidal floodplain boundaries are defined by tidal inundation range. The deposits are thinly interbedded sands and shales with characteristic parallel and lenticular lamination. Shales are interpreted as highstand deposits, while sands are deposited in a lowstand or during the early phases of sea-level rise. The sand deposited in the lower part of this zone exhibit well-sorting and bimodal tangential cross-bedding. A scarce, low-diversity marine fauna is present; heavy bioturbation, siderite, and glauconite are also common.

The prevailing *lagoonal* facies are shales and siltstones. The coarse clastic material could occur if had been transported by fluvial systems from the continent or by tidal currents from the sea. Bioturbation is common, a low-diverse marine fauna and plant remains are present.

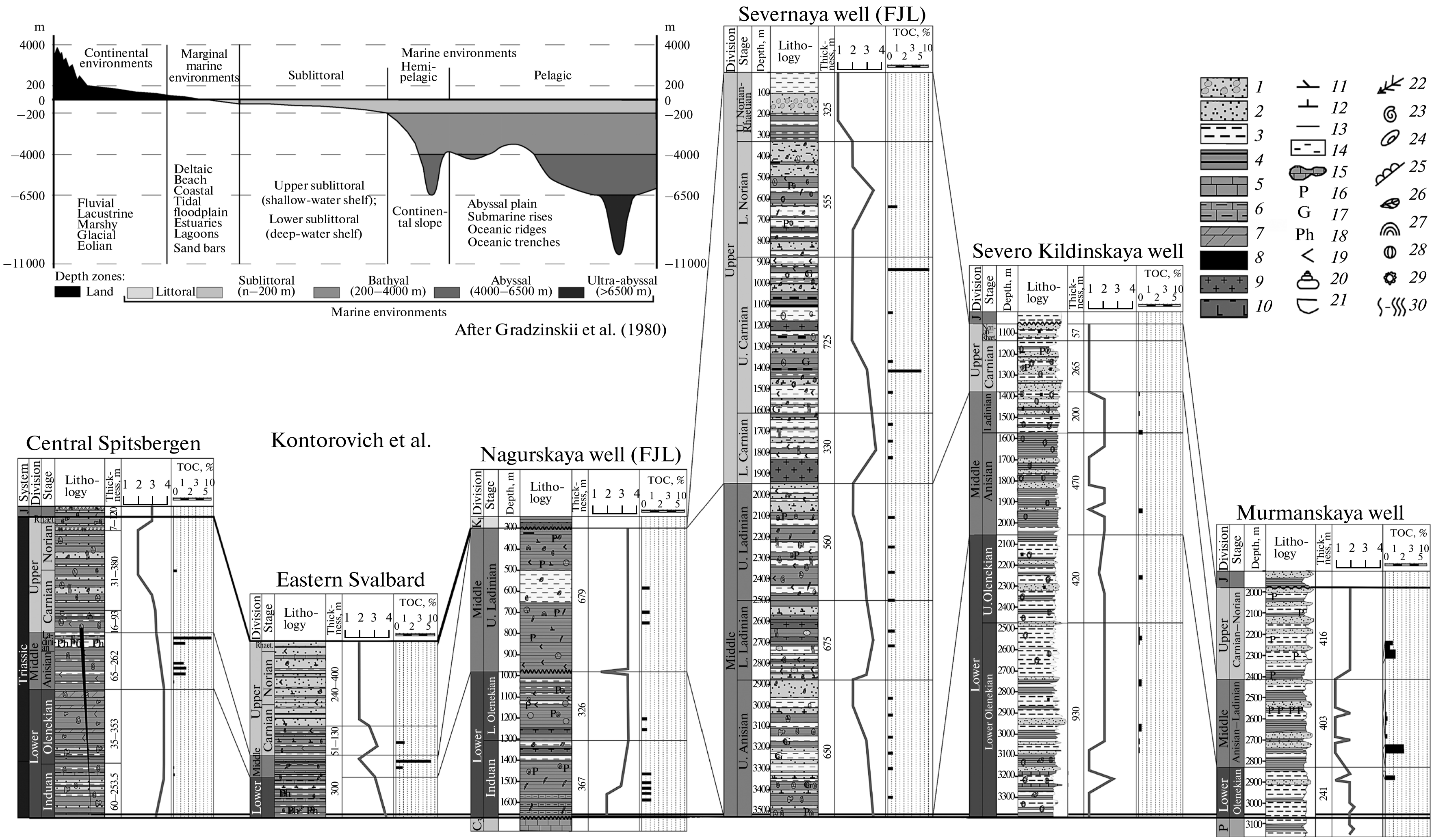

Fig. 1. Correlation of Triassic rocks from wells and outcrops within the Barents Sea basin: *1*, conglomerate; *2*, sandstone; *3*, siltstone; *4*, shale/mudstone; *5*, limestone; *6*, argillaceous limestone; *7*, dolomite; *8*, coal; *9*, diabase; *10*, basalt; *11*, sideritic cement; *12*, calcite cement; *13*, shale content; *14*, carbonized plant debris; *15*, carbonate concretions; *16*, pyrite; *17*, glauconite; *18*, phosphorite; *19*, bivalves; *20*, gastropods; *21*, brachiopods; *22*, fish remains; *23*, ammonites; *24*, ostracods; *25*, foraminifers; *26*, plant fragments; *27*, algae; *28*, spores; *29*, pollen; *30*, bioturbation. Depositional environments: 1, continental; 2, marginal marine; 3, shallow-water shelf; 4, deep-water shelf.

Sand banks, periodically inundated by the sea, are located above the mean rising tide level and may be covered by saltmarshes mainly in temperate regions. These sediments represent the alternation of shales and siltstones, in which primary sedimentary structures were destroyed by bioturbation and plant-root traces.

The *marine environments* are represented by inner shallow shelf (up to 50 m) and outer deep-water shelf (50–200 m) facies. The *inner shelf* facies (upper sublittoral zone) developed above the storm wave-base and was subject to tidal wave action. This zone is dominated by the deposition of sand and silt varieties, with parallel or low-angle tangential cross stratification and contain occasional shale beds.

The *outer-shelf* facies (lower sublittoral zone) developed below the storm wave-base under low-energy hydrodynamic conditions. This area is dominated by the deposition of dark grey to black shales, showing burrows and horizontal lamination and containing thin intercalations of fine sandstones as well as pyrite, phosphate, and calcareous concretions. Marine deposits contain abundant faunal remains of corals, sponges, brachiopods, gastropods, belemnites, and ammonoids.

Lower Triassic source rocks. During the Early Triassic, deposition in the southern (Pechora Sea) and northeastern (Novaya Zemlya and North Kara paleo-land) areas of the basin occurred in fluvial–lacustrine environments (Fig. 2) under high-energy hydrodynamic and oxic conditions, dominated by red beds, mostly shales and siltstones, with coal lenses and high sand content. Such environments were detrimental to the preservation of organic matter. The large rivers began high in the Ural Mountains and Timan Ridge and, possibly, on the North Kara paleo-land, rising into multiple branches in the coastal area and making up the main delta systems (Peschanoozerskaya and Kolguevskaya wells). The transported material filled up the actively subsiding South Barents Sea basin and resulted in the deposition of a 2–4 km thick Lower Triassic sequence, which is clearly visible on seismic sections. Sediments with high concentrations of plant remains (identified in thin sections as coal detritus) transported from the continent were deposited in delta plain and delta front environments. Therefore, Lower Triassic source rocks from these lithofacies zones contain humic-type organic matter. The low organic matter contents (0.002–0.2%) and low hydrocarbon generative potential of shales in this zone reflect the prevailing oxidizing environments and, probably, large dilution effects due to high sedimentation rates.

The central parts of the South and North Barents Sea basins were inferred to represent the prodelta lithofacies zones with more favorable conditions for the preservation of organic matter, which can be explained by the accumulation of fine-grained materials, mostly silt- and clay-sized particles, which are capable of absorbing organic matter, as well as by a possible lower-energy environment as compared to the delta and fluvio–lacustrine plains.

The deposition of variegated thinly intercalated sand and shale beds occurred in the tidal floodplain environment along the margins of Novaya Zemlya, on the northern slope of the Baltic shield, along the Finmark monocline and western flank of the Barents Sea basin (Fig. 2). The Lower Triassic shales of this lithofacies zone contain organic matter of the humic type because of the proximity to the provenance area. The low contents of organic matter (0.04–0.1% in the Murmanskaya well, 0.5% in the Severo Kildinskaya well, and 0.1–0.5% in Induan sediments of central and southern Spitsbergen) and extract (0.0006–0.16%) are caused by poor preservation of primary organic matter in the oxygenated water column due to high-energy hydrodynamic conditions and tidal action. The shaly deposits of this lithofacies zone have very low hydrocarbon generative potential ($S_1 + S_2 = 0.12–0.56$ mg HC/g rock), it is still doubtful that they can be regarded as hydrocarbon source rocks.

During the Lower Triassic, much of the Barents Sea basin consisted of shallow shelf environments (Fig. 2), which were more favorable for the preservation of organic matter in sediments. The organic matter content in Lower Triassic rocks of the FJL (in the vicinity of the Nagurskaya well) is as high as 1.2%. The humic character of organic matter (HI = 10–33 mg HC/g TOC) is caused by the proximity of a large delta in the east. These rocks, although they have poor generative potential (up to 0.3 mg HC/g TOC), can be regarded as gas prone. Shallow marine shales of the Finmark monocline and Hammerfest basin (Havert Formation) contain up to 0.4–1% of humic organic matter. Weakly oxic conditions in the sediments are indicated by a number of geochemical indices, such as Pr/Ph, Pr/n-C_{17}, and Ph/n-C_{18} (well 7124/3-1) (Fig. 3).

The Olenekian transgression in central Spitsbergen led to the deposition of shallow marine silty and argillaceous sediments (the Sticky Keep Formation). Dark grey mudstones here have typical TOC values of up to 3%, extract contents of 0.4–0.8%, and organic matter of the mixed humic–sapropelic type (HI = 194–318 mg HC/g TOC). The presence of a significant sapropelic component is caused by the absence of large rivers. The higher organic matter content of these source rocks reflect the prevalence of low-energy, weakly reducing conditions and the increased propportion of pelitic-sized fractions in the basin sediment supply. These sediments have Pr/Ph of 1.4–2, Pr/n-C_{17} and Pr/n-C_{18} of 1.5–1.6 and 1.2–1.6, respectively (Fig. 3), suggesting the presence of mixed-type organic matter accumulated under weakly reducing conditions (Abdullah, 1999). Therefore, the Olenekian rocks deposited in this part of the archipelago can be interpreted as having good source rock potential (3.6–8.9 mg HC/g rock) (Fig. 2).

The outer deep-water shelf lithofacies zone occupied the eastern tip of Svalbard and extended south-

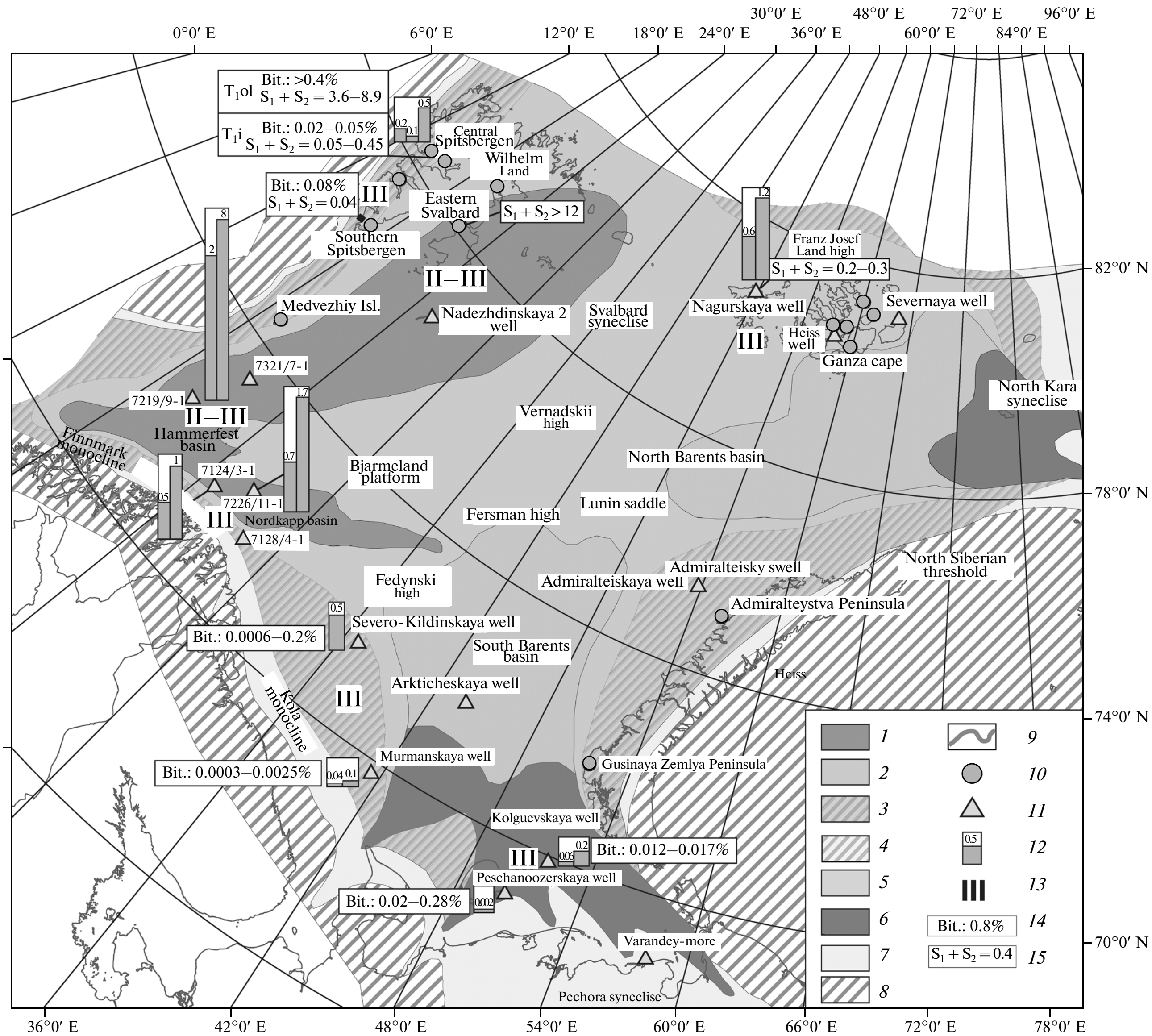

Fig. 2. Comparison of geochemical data for Lower Triassic source rocks and lithofacies zones of Early Triassic age: *1*, deep-water shelf (50–200 m); *2*, shallow-water shelf (to 50 m); *3*, tidal floodplain and lagoons; *4*, sand banks periodically inundated by the sea; *5*, prodelta, *6*, delta plain and delta front; *7*, fluvial–lacustrine plain; *8*, areas of erosion; *9*, present-day shoreline; *10*, outcrops; *11*, wells; *12*, TOC values, % (recalculated to the initial values are denoted by subscript 0); *13*, organic matter type (II, humic-sapropelic, III, humic); *14*, extract content, %; *15*, hydrocarbon generative potential, mg HC/g rock (recalculated to the initial values are denoted by subscript 0).

ward and southwestward into the Norwegian shelf and Nordkapp basin (Fig. 2). The eastern and southern limits of this zone are defined by the westernmost edges of Lower Triassic clinoforms (Glorstad-Clark et al., 2010). Predominantly argillaceous facies of Olenekian age deposited on eastern Spitsbergen, Edge, and Barents islands have high organic matter contents (up to 6%, mixed humic–sapropelic type) and good hydrocarbon generative potential (average $S_2 = 12$ mg HC/g rock) (Bjoroy et al., 2010). On the Norwegian shelf, the organic matter content is up to 1.7–2% in the Induan mudstones and up to 2–8% in the Olenekian mudstones, with HI of up to 500 mg HC/g TOC. The C_{27}, C_{28}, and C_{29} sterane ratios suggest an open-sea environment (Official website of Norwegian..., 2010). As suggested by Bjoroy et al. (2010), the hopane distribution of these rocks indicates marine deposition under highly reducing conditions and is similar to that reported from eastern Svalbard. This correlation suggests that good source rocks were deposited during the Early Triassic throughout the entire outer deep-water shelf zone.

Middle Triassic source rocks. During the Middle Triassic, deposition in the southern and southeastern Barents Sea shelf occurred on fluvial-lacustrine, deltaic and coastal plains (Fig. 4). The Middle Triassic

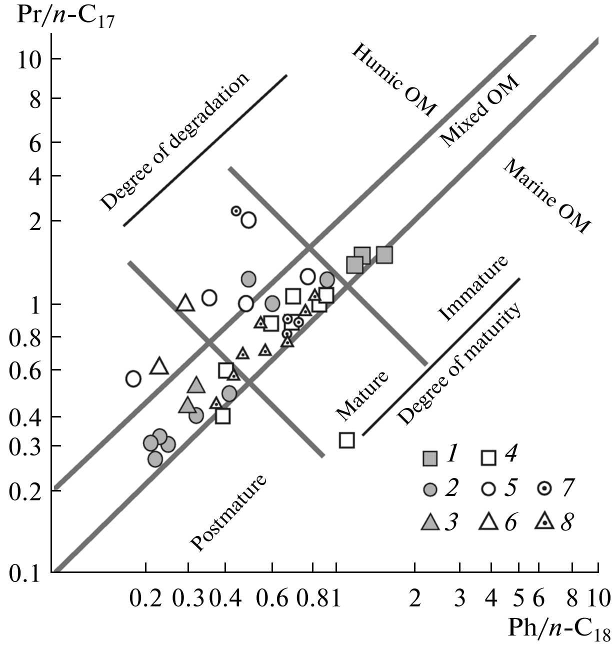

Fig. 3. $Pr/n\text{-}C_{17}$ vs. $Ph/n\text{-}C_{18}$ plot for extracts from Triassic source rocks: *1–3*, Lower Triassic: *1*, Spitsbergen; *2*, Nordkapp basin, well 7226/11; *3*, Hammerfest basin, well 7124/3-1; *4–6*, Middle Triassic: *4*, Spitsbergen, *5*, well 7226/11-1, *6*, well 7124/3-1; *7–8*, Upper Triassic: *7*, well 7226/11-1, *8*, well 7124/3-1.

succession is composed of greenish grey, fine- to medium-grained sandstones interbedded with variegated shales and occasional beds of black pyritized shales (Grigor'eva et al., 1998), which are characterized by poor hydrocarbon generative potential (<0.4% TOC) and extract content of 0.006–0.03% (Murmanskaya and Severo–Kildinskaya wells).

Strong variability of organic matter types and contents in the Middle Triassic shallow shelf facies tends to reflect variations in their source rock potential. For example, argillaceous facies in the eastern part of the Hammerfest basin contain up to 1.5% organic matter of the humic type. However, moving farther northward from the provenance area (Baltic shield), in the more stable shallow marine settings, the organic matter content of these rocks increases to 3% (Nordkapp basin). The values of the $Pr/n\text{-}C_{17}$ and $Ph/n\text{-}C_{18}$ ratios (wells 7124/3-1 and 7226-11) indicate the dominantly humic type of organic matter (Fig. 3) (Official website of Norwegian..., 2010).

During the Middle Triassic, thick sequences (up to 2 km) of alternating sandy, silty and argillaceous rocks with abundant mica flakes and shell fragments, were deposited in the east of the FJL under shallow marine environments in the proximity to their provenance area (Figs. 1, 4). Shale beds contain up to 0.1–1% organic matter. The peak of *n*-alkane distribution in the C_{21}–C_{22} range, a predominance of both high- and low-molecular-weight odd-numbered alkanes, as well as the presence of a pronounced naphthene hump in the region of polycyclic aromatic compounds altogether indicate a predominance of humic-type organic matter formed in a marginal marine environment (Fig. 5). The low generative potential of these rocks (up to 0.53 mg HC/g rock) is due to the high-energy depositional regime (wavy and cross-lamination, frequent intercalations), the oxidizing conditions in the sediment (the presence of siderite), as well as dilution effects. The data from earlier works (Danyushevskaya, 1995) show that the TOC values of the Anisian rocks encountered in the Heiss and Severnaya wells do not exceed 0.7%, while those of the Ladinian rocks are not greater than 0.9%. These rocks generally show little remaining hydrocarbon generative potential (up to 0.28 mg HC/g rock). The remaining generative potential for highly mature rocks was recalculated to the early oil window. Middle Triassic rocks from FJL have initial TOC values of 0.8–2.1% (a calculation factor of 1.5–2, according to the data of T.K. Bazhenova) and HI of up to 130 mg HC/g TOC. These values correspond to poor–fair initial generative potential, based on the classification of Peters and Cassa (up to 2.7 mg HC/g rock).

Dark grey to black thin-laminated mudstones deposited in central Spitsbergen in a shallow-marine prodelta to lagoonal environment (carbonate interbeds, bioturbation) have a present-day organic matter content of up to 1.4–1.7% and fair to good hydrocarbon generative potential ($S_1 + S_2 = 2.3$–6.2 mg HC/g rock) (Fig. 4). Since these rocks are thermally mature (approaching the late oil window), initial values were higher. TOC values calculated for the early oil window may have been as high as 3.5% and the hydrocarbon generative potential could be very high. These calculations are consistent with the literature data on less mature rocks: up to 7% TOC, excellent generative potential (>29 mg HC/g rock), extract content of >1.2% (Abdullah, 1999).

The humic–sapropelic type of organic matter (HI = 130–337, initial HI up to 450 mg HC/g TOC), bimodal *n*-alkane distribution (peaks at $n\text{-}C_{20}$ and $n\text{-}C_{31}$) (Fig. 5), a pronounced naphthene hump, and a predominance of high- molecular-weight odd-numbered alkanes ($CPI\ 2 = 2C_{29}/(C_{28} + C_{30}) > 1$) are indicative of the increased input of continental components from the westerly deltas, whereas Pr/Ph (1.4–2) and $Pr/n\text{-}C_{17}$ and $Ph/n\text{-}C_{18}$ suggest a moderately reducing depositional setting (Fig. 3) (Abdullah, 1999).

The outer deep-water shelf lithofacies zone, which extends along the western basin margin (Fig. 4), represents the best source rocks of Middle Triassic age. On Edge Island and Norwegian shelf, they comprise mostly black shales, which have organic matter contents (for the early oil window maturity) of 4–10% and 8–16%, respectively. Present-day TOC values are slightly lower for the rocks of the Norwegian shelf (2–6%) due to high thermal maturity of mixed-type organic matter, which shows a significant input of the sapropelic com-

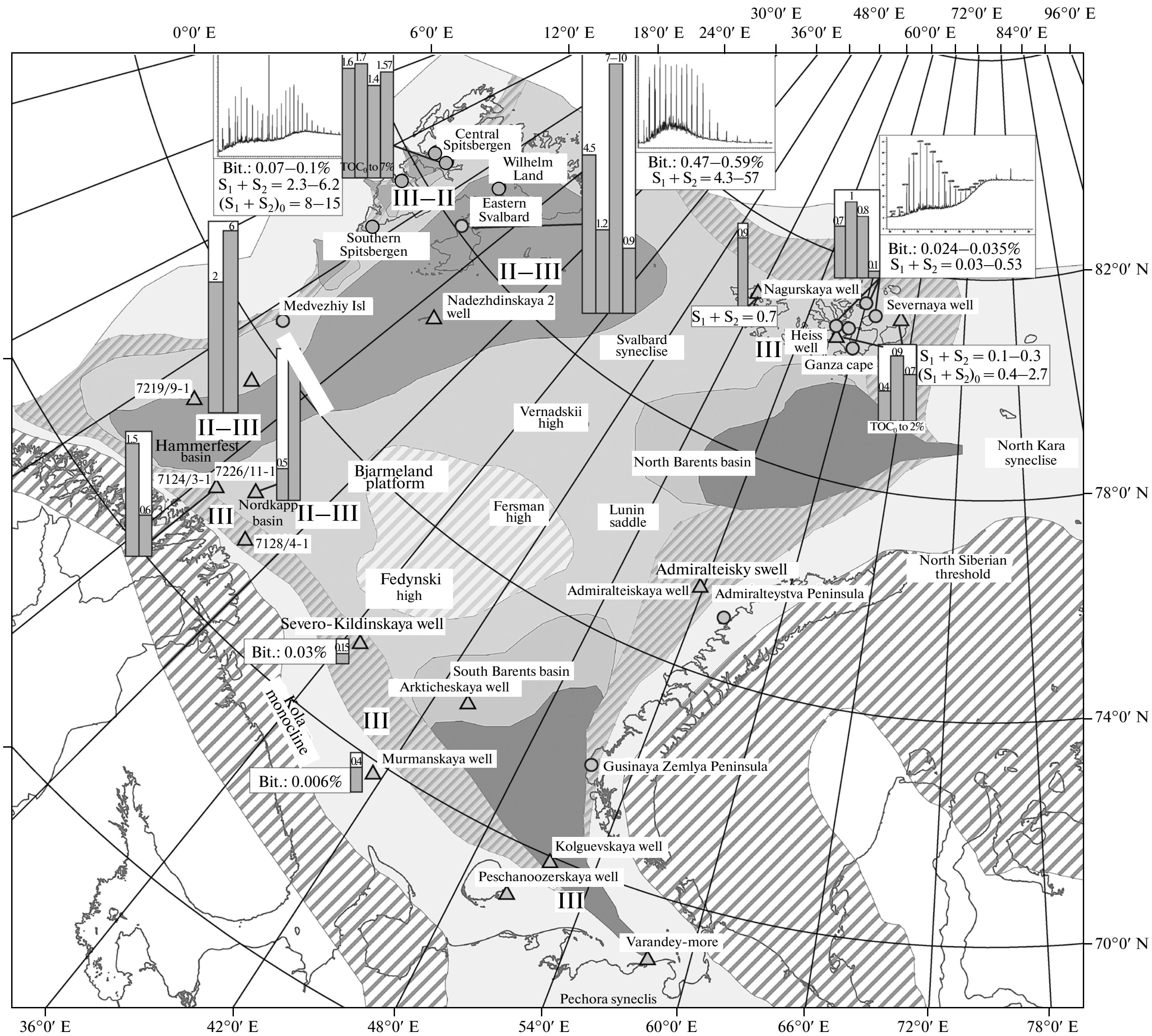

Fig. 4. Comparison of the geochemical data of Middle Triassic source rocks and lithofacies zones of Middle Triassic age. The legend is the same as in Fig. 2.

ponent (HI of up to 525 mg HC/g TOC). The distribution of *n*-alkane with a maximum in the low-molecular-weight region and a minor naphthene hump are indicative of a predominance of sapropelic organic matter (Fig. 5). The deposition of excellent source rocks ($S_2 = 2.5–57$ mg HC/g rock, 19 mg HC/g rock) in this lithofacies zone is caused by the increased content of pelitic material that is capable of absorbing organic matter and low-energy, predominantly reducing conditions.

Upper Triassic source rocks. Towards the end of Triassic time, a general shallowing of the basin resulted in the widespread deposition of terrigenous rocks enriched in humic organic matter (Fig. 6). The amount and rate of clastic deposition decreased in the Late Triassic. The fluvial–lacustrine shale interbeds deposited in the southeast of the basin cannot be regarded as good source rocks due to their very low organic matter content (<0.8%). An extensive tidal floodplain occupied the central and western parts of the study area. Upper Triassic shales in the South Barents Sea basin and on the FJL generally have low gas generative potential, but in some isolated lagoons and swamps conditions promoted better preservation of organic matter (for example, Carnian black shales and coal layers in the vicinity of the Severnaya well on the FJL) (Fig. 6). Black shales have high content of organic matter (up to 11%) of predominantly humic type (HI = 214 mg HC/g TOC) and excellent hydrocarbon generative potential (up to 24 mg HC/g rock). Similar depositional settings may have existed within the Nordkapp and Hammerfest basins, as suggested by

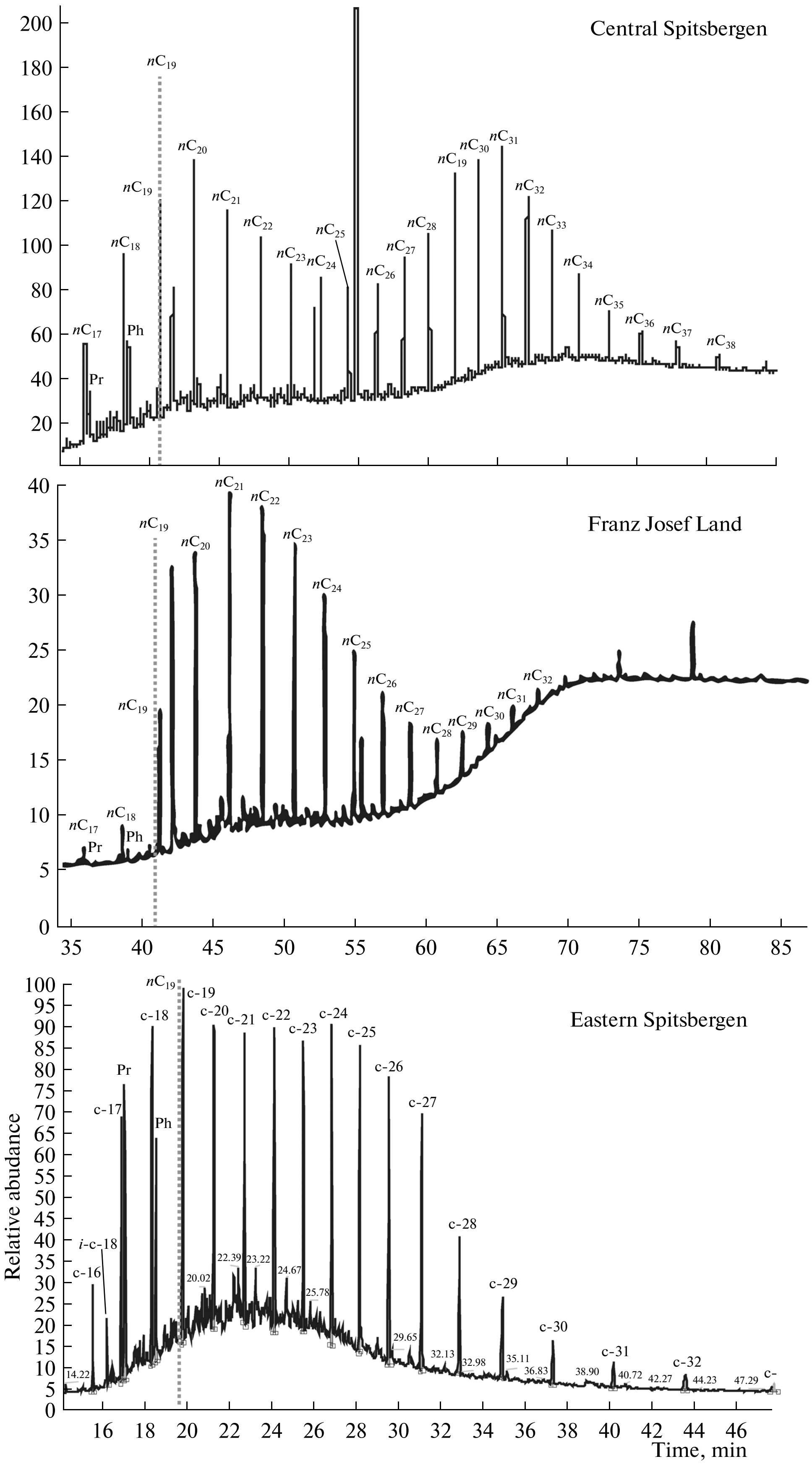

Fig. 5. Gas chromatograms of source rock extracts of Anisian mudstones from Spitsbergen and FJL outcrops.

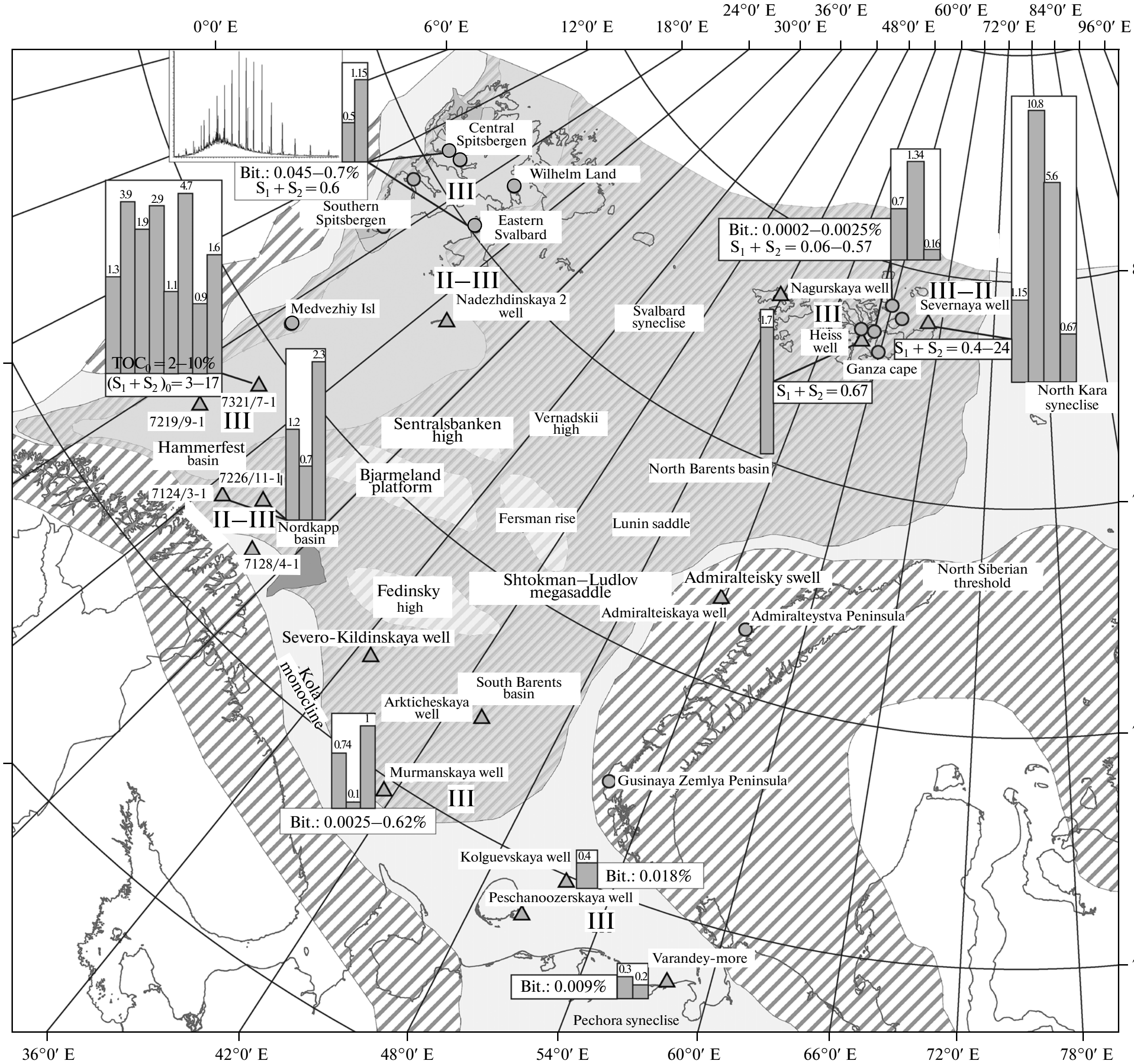

Fig. 6. Comparison of the geochemical data from Upper Triassic source rocks and lithofacies zones of Late Triassic age. The legend is the same as in Fig. 2.

Pr/n-C_{17} and Ph/n-C_{18}, indicating mixed-type organic matter (Fig. 3).

Shallow-marine shales of the Upper Triassic successions in the western part of the basin are characterized by high contents of humic-type organic matter; on the Norwegian shelf they have present-day TOC values of 0.9–5% and initial TOC values of 2–10% (Fig. 6). The limited connection to the open sea and restricted water circulation promoted preservation of organic matter and the excellent hydrocarbon generative potential of these rocks on the Norwegian shelf. On Spitsbergen, Upper Triassic rocks have lower organic matter contents (0.5–1.2%) and poor generative potential (0.6 mg HC/g rock) caused by high-energy water circulation and proximity to the open sea located to the north of the study area.

CONCLUSIONS

1. Lateral and vertical variations in the amount and type of organic matter in Triassic source rocks of the Barents Sea shelf are a function of the depositional settings. The best source rocks (up to 7–16% organic matter of the mixed humic–sapropelic type) with excellent initial generative potential are confined to the outer deep-water shelf lithofacies zone, which during the Early and Middle Triassic formed an N–S-trending strip in the western part of the basin. These facies comprise Olenekian and Anisian rocks in eastern Spitsber-

gen and the Norwegian shelf. This zone, which is characterized by deposition of predominantly pelitic material, low-energy or sometimes stagnant reducing water conditions, promoted better preservation of organic matter.

2. Shaly rocks of shallow-marine lithofacies zones, which occupied much of the basin during the Triassic, have moderate contents of humic organic matter (1–2%) and fair to poor gas-generative potential. These facies comprise the Induan sediments on Spitsbergen and the Norwegian shelf, as well as the Lower and Middle Triassic rocks on the FJL. Similarly to the Upper Triassic rocks of the Norwegian shelf, stagnant-water shallow-marine conditions in this area may have been favorable for better preservation of organic matter and higher generative potential of these rocks.

3. Delta plains developed due to the enhanced input of clastic material eroded from the Ural and Pay Khoy mountain ranges. Shale beds in these successions contain predominantly humic-type organic matter. Oxic conditions and sediment dilution were responsible for the poor hydrocarbon generative potential of Lower and Middle Triassic rocks from the South and North Barents Sea basins. Good source rocks can be confined to the maximum flooding surfaces, which are readily visible on seismic data as high-amplitude continuous reflectors (Kazanin et al., 2011).

4. Shaly deposits of tidal floodplain lithofacies zones have low organic-matter content, which is caused by high-energy waters and prevailing oxic conditions. A general shallowing of the basin and the widespread establishment of these depositional settings by the Late Triassic could be responsible for the poor generative potential of the Upper Triassic rocks of the Barents Sea basin. At the same time, the restricted lagoon environments may have promoted the preservation of large amounts of organic matter of both the humic and humic–sapropelic types. For example, the Carnian black shales on the FJL generally exhibit good to excellent gas-generative potential.

5. Since the higher-energy oxidizing conditions in sediments of fluvial–lacustrine plains were unfavorable for the preservation of organic matter; Triassic rocks in the south and southeast of the study area have little or no hydrocarbon generative potential.

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