Chapter 29

The potential for hydrocarbon resource development on the Russian Arctic Ocean Shelf

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Abstract: The dramatic rise in the world oil and gas demand has led to concerns about the energy future for mankind. In the twenty-first century the sedimentary basins of the Arctic Ocean will play a leading role as petroleum provinces, including its Russian shelf areas. This article deals with the characteristics and assessment of resources in the Russian sector of the Arctic Ocean offshore areas. One can predict with 0.90 probability that the Arctic Ocean initial in-place hydrocarbon resources exceed 90 billion tons oil equivalent (toe). The assessments lead to the conclusion that during these years a petroleum production industry will develop on the Arctic Ocean Shelf.

The dramatic rise in world gas and, especially, oil demand has led to justified worries and concerns about the energy future of mankind. These concerns are well founded, but currently hydrocarbon resources are far from depleted, as is confirmed by the results of assessments performed by American experts (Ahlbrandt *et al.* 2005). Estimations performed at the Institute of Petroleum Geology and Geophysics SB RAS (Kontorovich 2009) have given these forecasts:

- maximum world oil production will be attained in 2020–2030;
- maximum world oil production level will be about 4.6–4.8 billion tons per year;
- the main offshore oil-producing regions during this period will be the Persian Gulf and western and eastern Siberia;
- during these years the oil- and gas-producing industry will be actively developed on the Arctic Ocean Shelf;
- an oil production level of 4.2–4.5 billion tons per year can be maintained until the 2040s;
- by the end of the twenty-first century the cumulative world oil production will amount to 470–500 billion tons of oil and the annual production will be equal to 2.1–2.4 billion tons per year, that is, will drop to the level of 1970–1975;
- one should bear in mind that these assessments are relevant only for traditional oil resources and reserves. If oil prices rise to allow 'heavy oil' production growth and processing of hydrocarbons from black shale resources then an oil production level of 4.0–4.5 billion tons can be maintained at least until the end of the twenty-first century. However, this oil will be expensive.

As one can see from this assessment, during the middle and second half of the twenty-first century the sedimentary basins of the Arctic Ocean, including a substantial part of the Russian Arctic Seas Shelf, will play an important role in the oil and gas supplies. This article gives a brief characterization and assessment of the resources in the Russian sector of the Arctic Ocean Shelf.

The initial theoretical position: I. S. Gramberg's conception of the oceans' staged development

Russian geology has a tremendous store of expertise in geological studies and hydrocarbon resource assessments in the Arctic sedimentary basins. The development of today's conceptions of the geology and petroleum potential of the Russian Eurasian continental margin is connected with the names of, among others, N. A. Gedroyts, I. S. Gramberg, V. N. Saks, N. A. Bogdanov, Yu. N. Kulakov, M. L. Verba, R. M. Demenitskaya, V. L. Ivanova, D. V. Lazurkin, Yu. E. Pogrebitsky, L. I. Rovnin, D. S. Sorokov, O. I. Suprunenko and V. E. Khain (Bogdanov & Khain 1998; Burlin & Shipelkevich 2006; Filatova & Khain 2007; Khain & Filatova 2007; Khain & Polyakova 2007; Khain *et al.* 2009). The most significant input into the development and solution of the fundamental scientific problems was made by the scientific school of Academician I. S. Gramberg – the prominent surveyor of the Arctic Continent and Ocean Geology (Gramberg *et al.* 1984, 1993, 2000, 2004; Salmanov *et al.* 1993; Gramberg & Suprunenko 2002).

Delineation of the Arctic oil- and gas-bearing super-basin (Gramberg *et al.* 1984) was very important in order to understand the geology of the Arctic Ocean sedimentary basins and adjoining continental areas. Also important was the concept of the oceans staged development, proposed by I. S. Gramberg (Gramberg 1993, 2001; Gramberg & Pogrebitsky 1993). Using a comparative analysis of the geology and oil- and gas-bearing potential of the Earth's oceans, I. S. Gramberg came to the conclusion that a clear correlation exists between the oil- and gas-bearing resource magnitude of the oceans' continental margins and their evolution stage or geological maturity level.

According to I. S. Gramberg, the history of the ocean's evolution can be divided into three stages: early, mature and late ('ancient' ocean). At the early stage of the ocean's evolution the shelf margins of young oceans are vast in area and are represented by sedimentary basins inherited from the previous stages of tectonic evolution. The shelf margins in the Arctic Ocean cover about 55% of the whole ocean's area. They are older than the ocean. In addition to that, as recent geophysical studies indicate, a quite

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thick structural stage (up to 10–12 km) was formed synchronously with the ocean in some areas of the Arctic Ocean. This stage is represented by Cenozoic sediments, in distinct sedimentary basins, but their base is formed by geological bodies of sedimentary basins inherited from the previous stages of tectonic evolution.

During the ocean's mature stage the sedimentary basins are synchronous with the ocean itself. The sedimentary basins of previous stages are usually either destroyed or submerged under newly formed sedimentary basins. Sedimentary basins are youngest under conditions of active continental margin development during the ocean's 'ancient' stage. Their age corresponds to the latest stage of the ocean evolution. The lifetime of such basins is comparatively short. The products of volcanism play a significant role in their sediments' composition.

I. S. Gramberg came to conclusion that the continental margins of the young oceans are richest in oil and gas. This conclusion is fully justified by our analysis of the newest geological and geophysical data and by probabilistic estimations of the initial hydrocarbon resources in the World's ocean basins. The Arctic Ocean is the youngest one – Neogene. However, because the basins of the previous stages have not yet been destroyed in the Arctic Ocean and the cover, synchronous with the ocean, is quite thick in some sub-basins, its stratigraphic oil- and gas-bearing interval will be the largest and will include Upper Proterozoic and all the Phanerozoic systems.

According to performed estimations, one can assert with 0.90 probability that the Arctic Ocean's initial in-place hydrocarbon resources exceed 90 billion tons oil equivalent (oe). In the mature Atlantic and Indian Oceans the estimations are 40 and 35 billion tons o.e., respectively. With the same probability one can assert that the ancient Pacific Ocean's initial in-place hydrocarbon resources exceed only 10 billion tons o.e. One can assert with the same 0.90 probability that initial in-place hydrocarbon resources in the Arctic Ocean are below 252 billion tons o.e.; in the Atlantic Ocean, below 70 billion tons o.e.; in the Indian Ocean, below 65 billion tons o.e.; and in the Pacific Ocean, below 25 billion tons o.e.

Resource assessment methodology

This work's goal is to give a short presentation of the results for probabilistic assessment of hydrocarbon resources in the Russian Eurasian sedimentary basins on the Arctic Seas shelf.

Several large petroleum provinces were mapped in the Russian Eurasian continental margin according to their tectonic nature, sedimentary cover age and oil- and gas-bearing potential (Fig. 29.1). In the Western part of the continental margin these are the Western Barents Sea, Eastern Barents Sea, Timan–Pechora (Pechora Sea) and Western Siberian (South Kara region) petroleum provinces; in the Eastern part these are the Eastern Arctic and Novosibirsk–Chukchi petroleum provinces. In addition to these provinces, in the central part of the Arctic Seas Shelf, the South Kara and Laptev petroleum regions were mapped.

The geological–geophysical maturity of the sedimentary basins on the Arctic Seas Shelf is very low; this complicates the assessment of oil and gas resources in these areas. The sedimentary basins of the Russian Arctic Western part, within the limits of Barents and Kara seas, are comparatively better explored. Substantial geophysical studies have been performed in these offshore areas; several wells were drilled and 13 oil and gas fields were discovered. The geological exploration in the Central and Eastern parts of the Russian Arctic (Laptev Sea, Eastern Siberian Sea and Chukchi Sea shelf areas) has just been started using modern geological–geophysical methods.

In order to estimate the oil and gas resources in underexplored sedimentary basins, the best thing is to rely on stochastic regression correlation between initial in-place petroleum resources and the volume of the basin's sedimentary fill for the basins of various ages. Elements of a similar approach to the initial in-place hydrocarbon resources assessment can be found in the early publications of L. G. Weeks (Weeks 1948, 1950). Sedimentary basins were first marked as assessment objects by Dvali & Dmitrieva (1976).

M. S. Modelevsky, A. A. Trofimuk and authors (Kontorovich *et al.* 1979, 1983, 1986, 1988) used significant sampling analysis and came to the conclusion that the best description of empirical stochastic correlation between the volume V of a basin's unmetamorphosed sedimentary fill and the initial in-place hydrocarbon resources Q is given by the equation:

$$\ln Q = a + b \cdot \ln V \qquad (1)$$

Such an approach was approved in the second part of 1970s and in 1980s for sedimentary basins on the Siberian Platform. Its effectiveness was confirmed by subsequent exploration works.

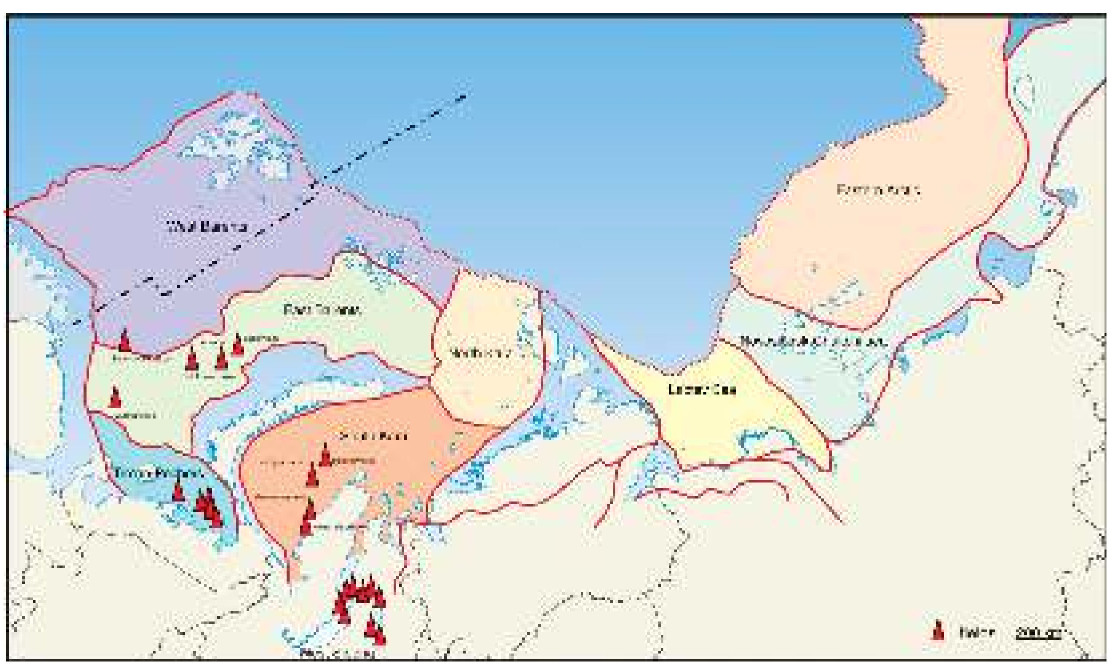

Fig. 29.1. Petroleum provinces of the Russian Arctic shelf.

Previously it was shown (Kontorovich *et al.* 1988) that for basins with significantly different ages of sedimentary fill it is better to use individual correlations. According to the latest statistical data (sampling from 38 relatively well-studied basins), for basins with a predominantly Cenozoic age of sedimentary fill this correlation is described by the equation:

$$\ln Q = 1.86 + 0.70 \cdot \ln V, \quad R = 0.71, \ \sigma = 1.05$$

where Q is the initial in-place hydrocarbon resources (billion tons o.e.), V is the volume of unmetamorphosed sedimentary fill, R is the correlation factor and σ is the standard deviation for $\ln Q$. The method gives both pointed and probabilistic assessments of initial in-place hydrocarbon resources.

For basins with a Palaeozoic–Mesozoic age of sedimentary fill (sampling from 61 relatively well-studied basins), this correlation is described by the equation:

$$\ln Q = 0.94 + 1.11 \cdot \ln V, \quad R = 0.85, \ \sigma = 0.96.$$

Since the mid-1990s this method has been used for assessment of the hydrocarbon resources in sedimentary basins on the Russian Arctic Ocean Shelf (Kontorovich *et al.* 2010). The results of these assessments are given below.

Hydrocarbon resources on the Eurasian shelf of Russian seas

The petroleum provinces of the Western Arctic shelf of Northern Eurasia are located on the Barents–Kara marginal–continental platform and on the northern margin of the West Siberian platform (Fig. 29.1).

Petroleum provinces of Barents–Kara Platform

The sedimentary cover thickness of the Barents–Kara Platform achieves 20 km. The offshore area with good prospects for petroleum potential is equal to 980 000 square km. The sedimentary cover is composed of terrigenous–carbonate formations of Palaeozoic age (Timan–Pechora Province), Upper Jurassic–Triassic rifted terrigenous formations and overlying Jurassic and Cretaceous syneclise formations. Petroleum potential of these basins is associated with all three stratigraphic complexes, with Middle–Upper Palaeozoic platform complex, with Upper Permian–Triassic rifting complex and with Middle–Upper Jurassic syneclise above-rifting complex. The petroleum potential of all these complexes has been proved. Oil and condensate gas accumulations in the Middle–Upper Paleozoic complex have been found at the northern end of Timan–Pechora Province (Pechora Sea–Prirazlomnoye, Dolginskoye, Varandey-more, Medunskoye and other fields). The Triassic complex is gas-bearing in the Southern Barents Sea Depression and is oil-bearing on the Kolguev Island. Unique gas and gas-condensate deposits of Shtokmanovskoe, Ledovoe and Ludlovskoe fields in Jurassic horizons are located in Shtokmanovsko–Luninskaya mega-anticline, which separates the Southern and Northern Barents Sea Depressions. The areas with the largest potential in the various complexes are spatially separated.

Middle–Upper Paleozoic sediments are considered to be the main sources of oil and gas in the sedimentary cover of the Barents–Kara marginal–continental platform. The Jurassic sedimentary complex occurs at shallow depths and has not been buried into the main oil window. Geological data indicate that both lateral and vertical hydrocarbon migration processes are widespread in the sedimentary cover of the Barents–Kara platform during oil-field formation.

The Western Barents, Eastern Barents, the northern end of the Timan–Pechora (Pechora Sea) and the North Kara provinces are marked on the Barents–Kara platform. All four provinces have petroleum potential. It is fair to say with 0.95 degree of probability that they contain not less than 21 billion tons of recoverable oil reserves and not less than 34 trillion cubic metres (tcm) of free gas reserves. Table 29.1 contains full data on the results of hydrocarbon initial resources assessment in the sedimentary cover of Barents–Kara platform. The most probable estimate of recoverable resources on this platform is 35.3 billion tons of oil and 55.1 tcm of free gas (Table 29.2).

Western Siberian petroleum province, South Kara petroleum region

The southern part of the Kara Sea represents the offshore northern end of the West Siberian sedimentary basin (Fig. 29.2). The thickness of Jurassic–Cretaceous and Cenozoic rocks within the limits of this depression, one of the deepest in the basin, exceeds 12 km. The sedimentary cover here is the same as in the basin's onshore northern part (Fig. 29.3). The difference is that the main oil generator in the West Siberian basin, the Bazhenovskaya formation, is deeply buried in the Kara Sea offshore area and the maturity level of the organic matter (catagenetic transformation) in it is

Table 29.1. *Estimations of initial in-place oil, gas and condensate resources in sedimentary basins of the Russian Eurasian continental margin (probabilistic assessment)*

Province, petroleum region	Age of potential complexes	Initial hydrocarbon resources (oil, condensate, associated gas – recoverable, free gas – in-place)							
		Oil (10^9 tons)		Associated gas (10^9 Sm^3)		Free gas (10^{12} Sm^3)		Condensate (10^6 tons)	
		95+	95−	95+	95−	95+	95−	95+	95−
Western Barents Sea	Upper Palaeozoic–Mesozoic	5.0	18.0	160	580	5.0	14.0	25	70
Eastern Barents Sea	Palaeozoic–Cenozoic	12.0	35.0	1120	3350	25.0	75.0	125	380
Timan–Pechora	Upper Palaeozoic–Mesozoic	2.5	7.5	20	65	1.5	2.5	7	15
North Kara	Palaeozoic–Cenozoic	1.5	4.0	40	110	2.5	5.0	10	20
South Kara	Mesozoic	5.0	12.0	160	370	15.0	40.0	120	300
Laptev	Upper Palaeozoic–Cenozoic	1.5	4.0	40	110	2.5	7.0	10	25
Eastern Arctic	Palaeozoic–Cenozoic	4.0	10.0	12	30	3.0	8.0	13	27
Novosibirsk–Chukchi	Cretaceous–Cenozoic	0.3	1.5	8	40	0.7	3.0	4	16
Total		31.8	92.0	1560	4655	55.2	154.5	314	783

95+, with 0.95 probability that real resources are higher than this value. 95−, with 0.95 probability that real resources are lower than this value.

Table 29.2. *Estimations of initial in-place oil, gas and condensate resources in sedimentary basins of the Russian Eurasian continental margin (the most probable assessment)*

Province, petroleum region	Age of potential complexes	Initial hydrocarbon resources (oil, condensate, associated gas – recoverable, free gas – in-place)			
		Oil (10^9 tons)	Associated gas (10^9 Sm^3)	Free gas (10^{12} Sm^3)	Condensate (10^6 tons)
Western Barents Sea	Upper Palaeozoic–Mesozoic	9.0	300	8.0	40
Eastern Barents Sea	Palaeozoic–Cenozoic	20.0	1863	41.0	205
Timan–Pechora	Upper Palaeozoic–Mesozoic	4.0	35	1.8	10
North Kara	Palaeozoic–Cenozoic	2.3	63	3.3	13
South Kara	Mesozoic	7.0	230	23.0	180
Laptev	Upper Palaeozoic–Cenozoic	2.3	63	4.2	15
Eastern Arctic	Palaeozoic–Cenozoic	6.0	18	4.7	17
Novosibirsk–Chukchi	Cretaceous–Cenozoic	0.7	19	1.1	8
Total		51.3	2449	87.1	488
10^9 tons, oil equivalent		141.3			

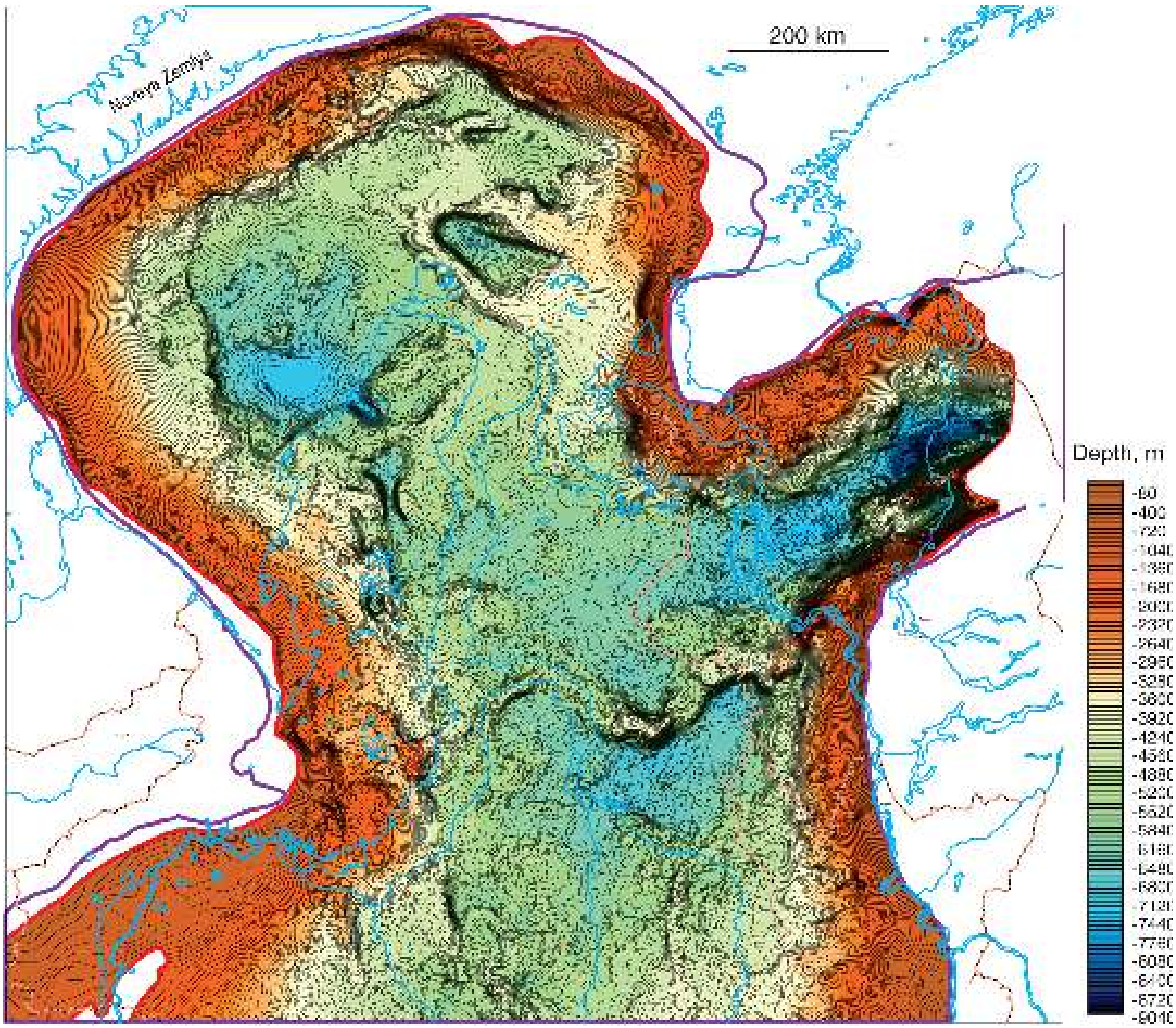

Fig. 29.2. Depth map of base Jurassic in the Arctic regions of the Western Siberian basin (ed. by A. E. Kontorovich).

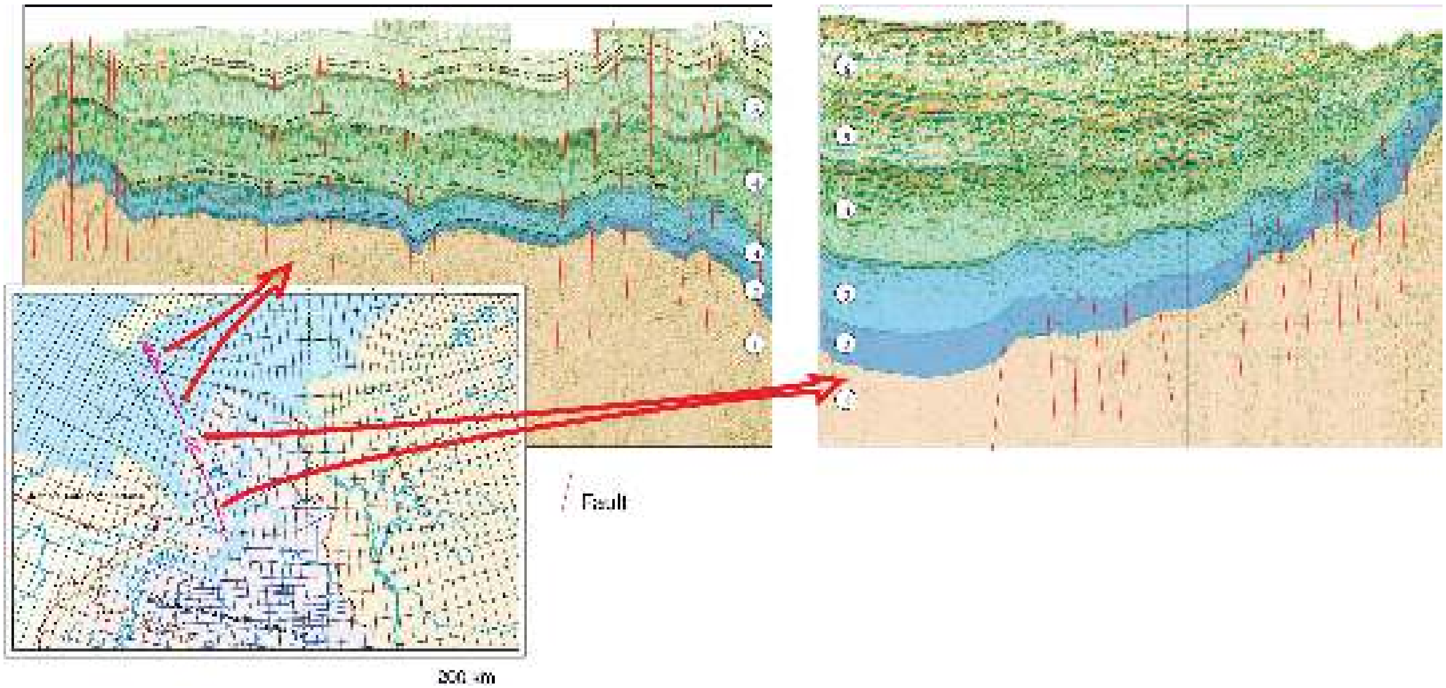

Fig. 29.3. Regional seismic profiles of the Western Siberian basin (data of the Institute of Petroleum Geology and Geophysics, SB RAS). Seismic sequences: 1, pre-Jurassic; 2, Lower Jurassic; 3, Middle to Upper Jurassic; 4, Neocomian; 5, Aptian–Albian–Cenomanian; 6, Turonian–Danian.

very high. The catagenesis of the organic matter in the Bazhenovskaya formation, over the largest part of the offshore area, recalculated to vitrinite reflectivity, is equal to 0.85–1.5% and in the deepest part of depression exceeds 2%. An even bigger catagenetic transformation of the organic matter has occurred in the Lower and Middle Jurassic rocks. Over the largest part of the South Kara syneclise the vitrinite reflectivity in the organic matter of the base Jurassic exceeds 3.5%. This means that the substantial part of the Jurassic oil and gas source rocks during the Late Cretaceous and Cenozoic were producing mainly dry methane gas, and oils formed during earlier stages of geological history have been subject to catagenetic transformations. In the Lower Cretaceous of the South Kara petroleum region one can expect discoveries of gas condensate, light oil and natural gas liquids. Oil accumulations could be preserved also in the peripheral parts of the syneclise. Two giant gas fields have been discovered in the province – Leningradskoye and Rusanovskoye.

The resource estimation performed allows, with 0.95 degree of probability, a prediction that in the southern Kara region of the West Siberian platform the recoverable oil resources exceed 5 billion tons and gas resources exceed 15 tcm (Table 29.1). The most probable estimate of recoverable resources in the South Kara region is 7 billion tons of oil and 23 tcm of free gas (Table 29.2).

Laptev petroleum region

This region represents the Siberian platform's subsea margin. Like the Siberian platform, one can assume that the geological profile of this offshore area is formed by carbonate and terrigenous–carbonate rocks of Upper Proterozoic, Palaeozoic and Mesozoic. The structure of the sedimentary sequence is poorly studied.

Hydrocarbon source rocks in the Laptev petroleum region could be sediments from Upper Proterozoic to Cenozoic inclusively. However, hydrocarbon kitchens in Cenozoic and more ancient sediments are spatially separated. Vendian (Khatyspytskaya formation) and Upper Cambrian (Yunkyulyat–Yuryakhskaya formation) mudstones are most enriched in aquagenic organic matter. Most probably they were the main oil generators in the region. Mesozoic sediments could generate only gas. There are reasons to expect significant thicknesses of Cenozoic sediments in the northern areas of the province, as well as in the Lena River delta. Substantial hydrocarbon resources can be associated with them. The problem needs to be studied further.

The resource estimation performed allows, with 0.95 degree of probability, a prediction that in the Laptev petroleum region recoverable oil resources are not less than 1.5 billion tons and free condensate gas resources are not less than 2.5 tcm (Table 29.1). The most probable estimate of recoverable resources in the Laptev region is 2.3 billion tons of oil and 4.2 tcm of free gas (Table 29.2).

Eastern-Arctic and Novosibirsk–Chukchi petroleum provinces

These are the least explored areas. According to the geological data available, the lower structural stage of sedimentary cover in these provinces is formed by Palaeozoic and Mesozoic carbonate terrigenous–carbonate and terrigenous rocks. These are overlain by Upper Cretaceous and Cenozoic volcanogenic–sedimentary rocks.

The main sources of liquid hydrocarbons in the Novosibirsk–Chukchi petroleum province are Lower–Middle Devonian and Lower–Middle Triassic strata, enriched by aquagenic organic matter. Permian and Carbon terrigenous rocks could be powerful gas generators. Similar information is not available for the Eastern-Arctic Province.

According to geological criteria, the Eastern-Arctic Province has high potential. The resource estimation performed allows, with 0.95 degree of probability, a prediction that in the Eastern-Arctic Province recoverable oil resources are not less than 4 billion tons and free condensate gas resources are not less than 3 tcm (Table 29.1). The most probable estimate of recoverable resources in the Eastern-Arctic Province is 6 billion tons of oil and 4.7 tcm of free gas (Table 29.2).

The assessment of initial recoverable resources of oil and gas in the Novosibirsk–Chukchi petroleum province is more modest. The resource estimation performed allows, with 0.95 degree of probability, a prediction that in the Eastern-Arctic Province recoverable oil resources are not less than 500 million tons and free condensate gas resources are not less than 700 bcm (Table 29.1). The most probable estimate of recoverable resources in the Novosibirsk–Chukchi Province is 700 million tons of oil and 1.1 tcm of free gas (Table 29.2).

Summing up the resource estimations, we can indicate that the Russian shelf and deep zones of the Arctic Ocean contain about 52 billion tons of oil and about 90 tcm of gas.

For objectiveness it should be noted that, in the second part of 2008, the US Geological Survey published hydrocarbon resource assessments much lower than even the probabilistic 'low' assessment given above (Bird *et al.* 2008; Gautier *et al.* 2009). According to those assessments, the petroleum (especially oil) potential of the Arctic Ocean with adjacent territories of the Arctic petroleum basins is much lower than the estimations of the Russian experts. Objectively, such an assessment can dramatically reduce the interest in exploration in the Arctic Ocean. It is clear that the information available is not sufficient for a reliable assessment. However, undervalued assessments can disorient the specialists and reduce the interest in investment in oil and gas exploration activities on the Arctic Ocean Shelf.

Petroleum resources development on the Arctic Seas Shelf of Russia

The preparation of resource bases for the Russian Arctic Seas Shelf, for the development of new oil and gas production centres, is of strategic character and will play an important role in oil and gas supplies not only to Russia, but also in potential imports of hydrocarbons. Geological studies and exploration for oil and gas fields in the shelf areas of all the Russian seas in the Arctic Ocean are priority tasks for the coming decades.

However, one should be aware of the complexity and high costs of these tasks. Innovative scientific solutions, new technologies, new equipment and new transportation facilities will be needed for efficient prospecting, exploration and development of the offshore hydrocarbon fields in shelf areas of the Arctic Ocean. There is an opinion that, with respect to their complexity, these tasks can be compared with outer space programsme. That is why the development of the rich resources in the Russian Arctic will require intensive development of academic and applied sciences.

Petroleum resource development in the shelf areas and deep zones of the Arctic Ocean is a long-term task, involving high geological and economical risks, and huge investments, which will give substantial payoff only in 20–30 years. Thereupon it appears that mainly governments will undertake mineral resource (primarily oil and gas) development in the shelf areas of the Arctic Ocean and the associated geological and economical risks. A state programme will be designed for solving a whole set of tasks, including exploration, academic and applied research activities, funding and establishing a state agency for system management of this program. In addition, a large state corporation will be established, which will be responsible for regional prospecting and exploration works and for field development, taking into account environmental issues. The Russian Academy of Sciences and industrial R&D institutes will be made responsible for solving scientific problems. A state programme of R&D activities will be prepared for this prioritized direction of Russia's development, having in mind not only fundamental, technical, mining, geological and environmental problems, but also the social and economical aspects of the regions' development. Special attention will be paid to specialists' education in technical universities and workers' training for work in the Arctic areas.

Role of Arctic Ocean hydrocarbon resources

Summing up the above characteristics of the Arctic Ocean Eurasian shelf areas and of the Arctic Ocean in total (Gramberg 1993, 2001; Gramberg & Pogrebitsky 1993), several important remarks should be made.

(1) In terms of oil and gas resources, the Arctic petroleum super-basin, in particular the Arctic Ocean Eurasian shelf areas, can be compared with the largest world petroleum basins such as the Persian Gulf and Western Siberia. The development of resources in the Arctic Ocean Eurasian shelf areas will give Russia the opportunity partially to satisfy its needs in these energy resources and to fulfill the export obligations of international agreements in the nearest decades, especially in the second half of the twenty-first century. At the same time, oil and gas production in these shelf areas will give Russia opportunities to remain the largest exporter of energy resources to the global market.
(2) Owing to the fact that the geological and geophysical maturity of the Arctic Ocean Eurasian shelf areas is still low, especially in the Eastern Siberian and Chukchi Seas, the performed assessments will be considered as preliminary. Past experience from the work of Russian geologists in the Volga–Urals, Western Siberia, Lena–Tungus and other provinces shows that these assessments usually improve during regional geological and exploration work.
(3) During the second half of the twenty-first century, hydrocarbon production in the Arctic petroleum super-basin will play an equal role in securing energy resources for mankind to that of the Persian Gulf and Western Siberia. The geological structure and natural conditions of the Arctic Ocean require modern methods of oil and gas prospecting, exploration, production, treatment and transport. The Arctic Ocean and its resources are not the property of any single country. This is a serious reserve for energy resources supplies to the whole of mankind, within the frame of existing international agreements. This means that scientists and engineers of all developed countries will upgrade the technologies of hydrocarbon resource development in the Arctic petroleum super-basin and design the needed equipment and tools. The development of hydrocarbon resources in the Arctic Ocean is a two-fold challenge – to extract these resources from the Earth and to not to disturb the beautiful and unique nature of the Arctic.

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