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ARCTIC AND FAR EAST
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Abstracts

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The present digest is compiled of the materials of the VI International Conference «Russian Offshore Oil and Gas Development: Arctic and Far East» (ROOGD-2016), held at Gazprom VNIIGAZ on 25–26 October 2016.

The structure of the digest corresponds to the Program of the conference and includes the following sections: Plenary Session and Sessions (A, B, C, D, E, F, G, S).

The order of abstracts corresponds to the order of presentations at the conference.
PLENARY SESSION
Gazprom PJSC is known to be currently involved in extensive work for development of new and expansion of existing gas production, transporting and processing facilities. The purpose is to maintain a high level of energy security nation-wide, improving gas supply to the customers, providing appropriate market entry conditions and gas exports.

One of the critical activities is development of the offshore hydrocarbons reserves of the Russian Federation. The company’s Board of Directors has approved “Unified Policy of Gazprom Group in development of hydrocarbon reserves in the continental shelf of the Russian Federation”. A new offshore gas production center is established within the Eastern gas program. New production wells were drilled in Kirinskoye field. Exploration is continued in Yuzhno-Kirinskoye field along with structures and facilities development. A new gas field was discovered in Yuzhno-Lunskaya structure of Kirinskiy prospect (“Sakhalin-3”) in September this year.

The government of the Russian Federation has granted a license to the Russian-Kazakhstan JV Tsentralnaya Oil and Gas Company, LLC with Gazprom PJSC’s share of 25 %. The license was granted for exploration and production of hydrocarbons in Tsentralnaya field in the southern part of Russian sector of Caspian Sea. The recoverable gas reserves ($C_1+C_2$) are totalling 135 MMt.

Gazprom, PJSC pays great attention to the training programs for qualified engineering staff involved in servicing and management of the offshore production facilities, as well as environment safety issues. Complying with the Company’s rules the appropriate contingency&rescue plans and environment safety measures are developed for each field.

Gazprom continues development of regulatory documents to be applied in the Arctic and Far-East offshore projects and cooperates with the Federal executive and legislative authorities to provide State support for Gazprom continental shelf projects.
Concerning the role of Gazprom VNIIGAZ LLC in development of offshore fields

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Gazprom VNIIGAZ is the head research center of Gazprom PJSC in the areas of development of hydrocarbon resources of the continental shelf. The Institute is tasked for scientific support of Gazprom PJSC activity in the following areas:

– geology and development of offshore fields;
– offshore field infrastructure development;
– operation of offshore field facilities;
– economic assessments and justification of various options of technical and process development of offshore hydrocarbon fields;
– regulatory support of design, construction, and operation of offshore hydrocarbon field facilities;
– industrial and ecological safety during development of offshore hydrocarbon fields.

According to adopted Unified Policy of Gazprom Group on development of the shelf of the Russian Federation within Gazprom PJSC, Gazprom VNIIGAZ LLC also provides scientific support of projects related to development of offshore hydrocarbon fields based on the following strategic priorities:

– Safety – life and health care of employees, provision of industrial and ecological safety during work conduction at all stages of development of shelf fields of oil and gas.
– Effectiveness – improvement of economic efficacy of development of shelf fields by means of applying of actual approaches to work organization.
– Social responsibility – development and support of Gazprom Group’s contribution into social and economic evolution of presence regions during implementation of projects in the shelf of the Russian Federation.
– Leadership – strengthening of leader positions of Gazprom Group in the area of development of shelf fields. Creation and improvement of own approach based on the best practices of implementation of shelf projects.
– Russian participation – provision of high potion of domestic participation in implementation of shelf projects by means of stimulation of evolution of equipment and material production, as well as creation of new technologies for development of offshore fields of oil and gas on the territory of the Russian Federation.
Industrial and environmental safety during the development of the Far East shelf fields

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The development of oil and gas fields on the continental shelf of the Russian Federation referred to the number of the most important state tasks. Particular attention is paid to the development of raw stock base of the Sakhalin shelf. Development of field Kirinskoje unit is in progress.

General part:
1. Environment characteristics: Kirinskoje GCF is located in the waters of the south-western part of the Okhotsk Sea in the exclusive economic zone of the Russian Federation.
   The environment is characterized by the ice period during 160-210 days, extreme wave statistics to 20.7 meters and 426 meters long, 9-point earthquake intensity as per the MSK scale.
2. Labor safety. industrial safety.
   Gazprom Dobycha Shelf Yuzhno-Sakhalinsk LLC pays special attention to industrial safety at all stages of offshore fields development. Work in these areas is organized in accordance with the Policy on occupational health and industrial safety of Gazprom PJSC.
   For the first time in Russian practice, the subsea production system is installed by domestic companies. For security purposes, real time round the clock monitoring of wells and gas collection manifold performances is carried out.
4. Environmental safety.
   In accordance with the international standard ISO 14001, the Company implemented the environmental management system and developed the basic principles of the Environmental Policy of Gazprom Dobycha Shelf Yuzhno-Sakhalinsk LLC.
   Difficult conditions of field development have had the significant impact on the technical solutions adopted in the arrangement project. However, the successful implementation of the project, as well as in terms of industrial and environmental safety will allow using the experience gained in other fields of the continental shelf of the Russian Federation.
Ice-resistant fixed platform of Kamennomysskoye-more field

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Plans for development of Gazprom Dobycha Yamburg LLC propose the further development of the north-east with consistent exploration of 7 offshore fields: Kamennomysskoye-more, Severo-Kamennomysskoye, Obskoye, Chugoriakhinskoye, Semakovskoye, Antipayutinskoye and Tota-Yakhinskoye, as well as the group of Parusovye fields.

Currently, the concept of the ice-resistant platform design and block conductors for Kamennomysskoye-more field has been elaborated. The platform will be an elongated pontoon with sides formed by flat surfaces with vertical and inclined portions to reduce the ice impact, and block conductors will be made in a sand-glass shape with the minimum distance between the parallel sides in the area of narrowing.

A huge amount of works of pre-project cycle was preceded the commencement of the investment stage of Kamennomysskoye-more field development. We were examined dozens of versions for the field development and construction, infrastructure development and placement of production facilities. To determine the share stability of pile foundations of offshore ice-resistant platforms in plastic soils, the model of substructure of Kamennomysskoye-more field was tested in ice and seekeeping basins, as well as the experiment on soil erosion under the structure was performed in shallow basin on the experimental basis of FSUE “Krylov State Research Center”.

During the test the superstructure model was subjected to a global and wave loads, and data available from experiments allowed to adjust the platform hull design.

The concentration and consolidation of efforts of leading industry institutions when designing the platform for development of the Kamennomysskoye-more field will allow to put the decisions providing the required reliability, strength and spatial invariance of hydrotechnical structure.
Ice-resistant stationary platform construction in OSK group companies by means of distributed shipyard

I.V. Shakalo
(OSK JSC)

For the purpose of the Kamennomysskoye-More oilfield construction located in the water area of the Gulf of Ob between the Kamenny and Parusny capes, the LSP "A" ice-resistant stationary platform is planned to be arranged, which construction is possible within the OSK Group activities.

Structurally, LSP "A" shall consist of two construction areas:
– supporting base with pile mounted units (SB);
– topside structure (TS).

In order to organize TS construction, LSP "A" is divided into a number of construction units by construction areas on the basis of the installed equipment functions.

The top structure comprises the minimum number of units, with the maximum permitted weight and design dimensions, which can be developed on horizontal staples; floating cranes provide unloading and shipment.

LSP "A" TS parts are mainly developed from fully factory-assembled modular units, which helps to minimize the scope of construction and installation works performed in marine conditions in the field.

The ice-resistant stationary platform construction concept provides production of TS and SB units by means of "the distributed shipyard".

The modular units of the topside structure and supporting base are planned to be manufactured within the activities of Zvezdokha Shiprepairing Center JSC, Vyborg Shipyard PJSC, Caspian Energy and "Krasnaya Kuznitsa" Shiprepairing Plant JSC Groups, with TS and SB integration in the territory of Zvezdokha Shiprepairing Center JSC or Vyborg Shipyard PJSC.

The concept is based on the design implementation within the existing production infrastructure of OSK JSC which is in the European part of Russia.
Gazprom flot LLC achievements in production drilling at the Kirinskoye GCF (Sea of Okhotsk shelf)

V.V. Paliy
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Since 2009 Gazprom Flot LLC has been drilling wells at the shelf of Sakhalin as part of the Eastern Gas Program. An essential component of the Program’s resource base is Kirinskoye GCF, located 30 km to the south of the Sakhalin Island and featuring sea depths from 70 to 90 m.

Operations of Gazprom Flot LLC at this field include construction of one wildcat well (Kirinskaya No. 2), one appraisal well (Kirinskaya No. 3) and five production wells (P5, P6, P4-bis, P1, P2). Two more production wells (P7, P3) are currently in progress and will be finished in the drilling season of 2017.

In the course of production drilling at the Kirinskoye GCF the company for the first time in the history of Russian shelf development completed wells with running and installing underwater horizontal X-tree.

Starting from 2012 drilling operations have been performed using 6th-generation semisubmersible drilling rigs Polyarnaya Zvezda (Polar Star) and Severnoye Siyaniye (Northern Lights).

Construction of production wells is carried out using state-of-the-art drilling technology, including the following:

– Riserless Mud Recovery system for top hole (surface pipe) drilling;
– Rotary steerable systems (RSS) and logging while drilling (LWD) for horizontal sidetrack directional wellbores;
– Geomechanical simulation;
– Geo-steering, which allows to perform drilling at the most potentially productive zone;
– Biopolymer drilling fluid helps to preserve reservoir properties.
The Sonsub HyDrone: a resident intervention ROV

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Engineering, Technologies and Interventions are the pillars for an effective “Life Of Field Subsea”, i.e. a new comprehensive approach to field integrity management that represents a transition of paradigm between the old, reactive, IMR approach to a new, preventive, autonomous solution to daily integrity issues.

Nowadays,
– the complexity of present and future offshore fields (e.g. under the ice),
– the need to efficiently manage operational risks,
– and the need to substantially reduce costs of IMR campaigns call for new methods to support Life Of Field Subsea in complex subsea scenarios, overcoming the limits of current technologies and the constant need of support vessels.

The Saipem solution is a Modular, Subsea Resident Intervention Platform, directly integrated within the subsea field and capable to work subsea for long time without MSV support.

This modular platform, called HyDrone, is an evolution of work class ROVs, designed to allow reliable remote interventions on complex or inaccessible subsea infrastructures, also integrating AUV functionalities and features.
Forsys Subsea. An innovative approach
to offshore field development

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Forsys Subsea is a joint venture, between FMC Technologies and Technip, that unites the skills and capabilities of two subsea industry leaders, redefining the way subsea fields are designed, delivered and operated, for life. Bringing the industry’s most talented subsea professionals together early in the project concept phase allows significantly reduce the cost of subsea field development, project risks and duration.

Forsys Subsea reduces the interfaces of the subsea umbilical, riser and flowline systems (SURF) and subsea production and processing systems (SPS). It also simplifies the seabed layout, reducing complexity and installation risks and accelerating time to first oil.
Strategy of prospecting and exploration in the Russian Arctic

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The water area of the Russian Arctic is one of the few underexplored regions in which there is an opportunity to discover new oil and gas fields. The location of large and unique deposits of hydrocarbons is determined at the regional stage of exploration works and depends on the interpretation of geological factors that determine the history of the basin development and the sequence of formation of hydrocarbon systems at various stages of its creation. The basin analysis gives an idea of the time of formation of the modern structural plan of the region and its fluid dynamic processes. When carrying out the basin analysis, it is important not only to understand its structure in the current borders, but also in Paleozoic borders in view of the ancient structural plan, which is often excluded from the study of the sedimentary mantle of the region due to poor state of exploration and is not considered in relation to its oil and gas potential.

The basin analysis of the Russian Arctic water area shows that large new oil and gas fields will be opened in the region. Currently, major gas discoveries (Shtokmanovskoe, Rusanovskoye, Leningradskoe, Pobeda) have been made in the Russian sector of the Barents and Kara Seas. Large gas and oil fields were discovered in the American sector (Prudhoe Bay, Burger, Lisburn) and associated with upper Ellesmere (Upper Permian and Upper Jurassic), rift (Upper Jurassic and Early Cretaceous), Early Brook (Cretaceous) and Late Brook (Cenozoic) oil and gas complexes. The spread of these complexes and their potential in the adjacent sector of the Russian Arctic remains poorly studied due to the lack of drilling and an insufficient grid of regional seismic profiles. Since the shelf section is not penetrated by wells in the eastern part of the Russian Arctic, the only source of the sedimentary basin section research is archipelago islands. A comprehensive analysis of available geological and geophysical data such as the map of gravitational and magnetic anomalies, seismic data, description of key sections of adjacent islands and offshore drilling data allow predicting the age of the sedimentary mantle and spreading of sediments within the basins.
Xodus Group experience with arctic development in Barents sea

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Developments carried out in the Arctic provide an array of unique challenges. As with any environment with a climate which is unprecedented in previous developments, tried and tested techniques may no longer be sufficient. Xodus Group will take this opportunity to discuss some of the novel and innovative solutions to meet these challenges whilst keeping cost and risk low. From our experience working in the Barents Sea, Xodus Group will look to address some of the following key issues:

- flow assurance challenges, especially the risk of ice, hydrate and wax formation with low ambient temperatures. Xodus Group undertook an early stage assessment and proposed a thermal management strategy for a shallow arctic field with a reservoir temperature of only 20 °C and seawater temperature of −2 °C;
- challenges associated with the design and operation of topside system and equipment at low temperature, cold and windy environment, and ice accretion, atmospheric icing and sea spray icing;
- challenges such as sea ice, icebergs and the weather conditions in the area for the design of the hull, winterization;
- challenges associated with logistics like distance from shore and the weather conditions;
- the availability of power supply from shore and long distance transmission;
- challenging seabed topography like iceberg scarred seabed causing difficulties in routing, upheaval buckling and terrain induced slugging.
Experience of planning and conducting of marine fieldworks on hydrometeorological conditions study at Okhotsk sea shelf for preparation of initial data on hydrocarbon resources development

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Development of hydrocarbon resources of Okhotsk sea shelf adjacent to Sakhalin island should be based on accurate information on corresponding water areas natural conditions. This issue is especially topical currently for licence blocks regions with sea depth more than 100 m. At these water areas removed from a cost by 50–90 km natural conditions (geological, hydrometeorological, ice) can significantly vary from those we observe at already developed fields – they are removed from coast only by 15–25 km and located at significantly lesser depths. For reliable planning of development wells drilling operations, marine construction works performing, conducting of maintaining and repair of underwater systems precise information on ice conditions and performance hydrometeorological characteristics is required. To evaluate technical realization of stationary and, may be, floating platforms usage – with support of ice conditions control system - it is necessary to have reliable forecasting of extreme ice conditions and correct evaluation of extreme ice loads. Defining of required performance and extreme characteristics is based on data of field measurements performed under field researches. The report includes information on field researches performed at Sakhalin island shelf during ice-free and ice seasons in 2015–2016, as well as information in future expeditions in 2017–2018.
Innovative technologies of seismic studies during geotechnical surveys on the arctic shelf of Russia

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(MAGE JSC)

Currently, when it comes to competitive Russian marine geophysics, we can confidently specify MAGE JSC as the bright illustration of production and scientific potential during geophysical surveys in the most severe climatic conditions of the arctic shelf.

Geotechnical surveys are important and relatively new activity for the company. Currently, MAGE performs the entire range of engineering surveys, but it places primary emphasis upon geophysical surveys using innovative technologies. Along with the standard survey methods we would like to specify innovative technologies used by MAGE JSC based on Russian equipment that is very important “during the time of import substitution”. Talking about innovative methods of work, first of all, we would like to talk about high-resolution seismic survey and ultra-high resolution acoustic survey. A distinctive feature of this technology is a reduced pitch between channels of streamer (6.25 and 3.125 m), which allow to significantly increase the seismic section detail. Our company has two types of streamers produced by Hydroscience Technologies and Russian “Sea Technology Tools”. We use these technologies for the detailed differentiation of the upper section to detect gas “lenses” and the gas hydrate deposits, as well as to predict shallow gas accumulations in the upper part of the section.

Timely detection of the accumulations of shallow gas in the top of the section is the relevant task in the course of surveying and development of the fields of hydrocarbons on the shelf. Excessive formation pressure occurring in such gas pockets presents significant risks in the course of construction.

The report will show the results of the use of various innovative technologies in the water areas of the Kara Sea (Leningrad and Nyarmeisky LP) and the Sea of Okhotsk (Ayash area, Yuzhno-Lunskaya area of South Kirinskoye GCF) received over the last few years.
Assessment of geological and resource support of implementing LNG projects on the shelf of the countries of far abroad

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The development of the market of liquefied natural gas (LNG) is characterized by expansion of its areal and continuous formation of new complexes for its production. Since 1964 (when the largest Arzev complex was commissioned) LNG production has grown more than 20-fold, reaching 340 Mil ton in 2015. By now, 37 LNG projects have been implemented; in 2016 12 LNG projects are in their implementation stage. Mainly these lie in offshore regions of Africa, South-East Asia and Latin America.

The largest projects of LNG complexes are based on the resources of shelf deposits in the countries of Persian Gulf and NW aquatoria of Australia. Several LNG projects are based on dry land deposits that are remote from the existing gas transportation systems (GTS). Recent discoveries of major gas deposits on the shelf of Eastern and Western Africa and the north Atlantics has expanded significantly the geography of LNG production.

A revolutionary step forward in developing gas resources of the shelf is floating LNG plants (FLNG). They expand considerably the potential resource base for LNG production via involvement of deep water sites. The countries featuring the largest resource potential in deep water natural gas are those of the Latin America (11.0 Tril m$^3$), Africa (9.6 Tril m$^3$) and South-East Asia (3.3 Tril m$^3$). Developing these resources, including underwater production complexes and FLNG will strengthen significantly the potential of LNG production.

The resource potential of shelf areas of the far abroad may be expanded via developing prospective site in the East Greenland Sea, the Beaufort Sea, the Baffin Bay, South Atlantics, the Bay of Bengal, Zandeland, etc. Note that LNG projects are more cost-effective for long distance transportation of gas than the traditional GTS. In the long-term perspective LNG supplies will catch up with network export of gas.
TECHNICAL SESSIONS
Analysis of shelf sea activity in the context of crisis and weak oil prices

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Up until recently a shelf sea has been considered as an important reserve of hydrocarbon materials for the foreseeable future, not just in Russia. Foreign companies also conducted active surveillance and mining in various water areas of the world. However oil prices collapse and lack of objective prerequisites of its significant rise in the nearest future forced many companies to correct their plans on shelf sea, because offshore projects capital capacity is extremely high. In Russia imposing sanctions by USA and EU, which significantly affected circumstances in this region, overlapped this process. Declared import substitution program has not showed any significant results yet.

Crisis primarily affected Russian and foreign service companies, because “getters” drastically curtailed orders for new explorations and significantly shortened mining at offshore fields with highest mining costs. Thus, just seismic operations at foreign water areas alone have been reduced in 2–4 times in different regions, resulting to divisible reducing of the largest geophysical companies CGG, Polarcus, PGS stock values and actual bankruptcy of the smaller ones.

In Russia marine seismic survey volume in 2015 reduced almost twice, and regarding the results of 2016 it will fall further. In 2014–2015 prospect drilling at Arctic and Far East water areas was actually stopped, but in 2016 it recovered on a limited scale.

In the current situation of shelf sea activity significant financing gap we should reconsider priorities in offshore facilities survey and exploration, preferring ones that are located near traditional development areas and do not require enormous investments, providing potential exploration profitability in conditions of rather moderate prices on hydrocarbons.

The report includes analysis of different aspects of this problem by regions and technical and economical parameters.
Sub-bottom gas potential of Barents and Kara seas, western Arctics

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The Russian Federation controls sea shelf areas of epicontinental seas of the Arctic Ocean. West to East these are the Barents (BS), Kara (KS), Laptev (LS), Novosibirsk (NS) and Chukchee (ChS) seas totaling 5 Mil km². The geological structure of sub-bottom areas of Western Arctic seas (WAS) differs from that of both the adjacent land areas and one another. The BS features powerful Devonian, Permian and Triassic layers in combination with weak Jurassic and thin Cretaceous layers (totaling up to 12–14 km of depth). The KS has a powerful layer of lower Cretaceous (up to 2.5 km thick), mudded off at its lower levels, which is overlaid by sandy Alb-Cenomanian. Sandy clay depths of lower/mid- Jurassic (upper Jurassic is mudded off) in the Southern Kara are submerged quite deep. The level of geological and geophysical exploration, especially of survey drilling is deteriorating sharply West to East, from dozens of marine wells in the BS, especially in its Norwegian sector, to just 6 in the Kara Sea (discounting the Gulf of Ob and the Taz Bay) and to zero in shelf to the east of Taimyr.

Nine deposits of hydrocarbons have been discovered and partially explored in the Arctics so far, including 7 gas containing ones in the BS, one of them being unique (the Shtokman field of 3.9 Trln m³, mid-Jurassic-Callovian), and two just discovered but not explored at all in the KS. There are 16 field of land/sea type (Kharasavei and others). There is no industrial level oil in WAS.

The total explored deposits of free gas in WAS are available in amount of 7.5 Trln m³, C₂ category among them is 3.1 Trln m³. There is no oil, and no reliable data on the “Pobeda” are available. The author has analyzed the ontogenesis of hydrocarbon accumulations. The range of C-org content varies from 1.0 to 5.0 %, higher figures being rare even in the analogs of the Bazhenov suite (3–4 %), the average being 1.8–5.0 %, its organic matter types are free gas, gas mixture, gas (CГ, ГС, Г).

According to the official assessment of 2009 the BS resources of free gas are 30.0 Trln m³, and those in the KS are 54.5 Trln m³. These are definitely overestimated assessments of traditional resources. Following the latest estimates by the experts of Gazsprom VNIIGAZ LLC, the total resources of gas in the two seas reach 33–35 Trln m³, the potential of the Kara Sea slightly exceeding those of the Barents Sea, oil resources not exceeding 3.5 Bln t (geological).
Prospects of Russian Arctic seas shelf gas resources development

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Subsoil of the continental shelf of Russian Arctic seas is a real and significant reserve for exploration and development of gas fields. Unexplored potential of Arctic zone HC at Russian shelf is 91%. Initial extractable explored in the region gas reserves at the shelf are around 10.1 bln. m³.

There are 20 marine and 13 transit oil and gas fields explored in Russian zone of Arctic shelf. Exploration operations are carried out by Gazprom PJSC, Gazprom Neft PJSC, Rosneft oil company PJSC and NOVATEK PJSC. Marketable gas and gas condensate production at Yurkharovskoe field in Taz Bay has begun in 2003.

Important project on Arctic gas resources development is Yamal-SPG project, resource base of which is South Tambey field located on shore of the Gulf of Ob. Proven and possible field reserves according to PRMS international classification are measured in 926 bln. m³ of gas and 30 mln. t of liquid hydrocarbons.

According to various estimates, gas potential of Arctic sector bays subsoils is 92–100 tln. m³. Barents sea subsoil gas resources are confined to deposits (Lower-Middle Jurassic + Triassic), Kara (Lower Cretaceous + Cenomanian + upper levels of Middle Jurassic peripherally).

In water areas of the Gulf of Ob and Taz Bay of Kara sea, mainly at Cenomanian deposits, large gas fields are explored with reserves of about 2 tln. m³.

Pobeda oil and gas condensate field was explored at Kara sea during drilling of Universitetskaya-1 well in 2014. According to official estimate filed reserves are 130.0 mln. t of oil and 395.6 bln. m³ of gas by C₁+C₂ category. Gas reserves are observed in Cenomanian and Aptian-Albian chalk deposits, and oil reserves in Jurassic deposits.

There were no wells drilling at the shelves of East Arctic seas – Laptev sea, East Siberia sea and Chukchee sea, exploration operations are under way.
Geological aspects, oil and gas bearing prospects and programme of exploration at Gazprom PJSC license blocks at Barents sea shelf

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Currently Arctic seas shelf exploration is the most important strategic task, providing timely updating of resource and raw material base. According to modern views, Arctic shelf resource potential is estimated near 100 bln. t. of fuel equivalent.

Geologic-geophysical study of Barents sea continental shelf has been started from early 60-ies of XX century. During this time various variants (aero- and on-board) of gravi- and magnetic surveys were carried out, network of regional seismic profiles was developed, as well as detailed 2D seismic operations to develope and detail gas and oil prospective structures. Barents sea shelf is underexplored by drilling.

In water areas of Barents sea in 2013 Gazprom PJSC obtained licenses with the objective of geological surveying of subsoil, surveying and production of hydrocarbons raw materials with the duration of 30 years. Considered areas are located in central part of Barents sea continental shelf in territorial waters of the Russian Federation, north of Stockman field, and include two large fields – Ludlow gas field and Ledovoe gas and condensate field, as well as three prospective structures – Medvezhya, Demidovskaya and Fersmanovskaya.

Currently under Russian Federation national register there are gas reserves and resources in a volume of around 2.5 tln. m³, meanwhile resources share is about 75 %.

The report includes geological and tectonic aspects of the territory under study, allocation of HC reserves and resources in terms of fields and prospective structures, design solutions offered on HC search and exploration within license blocks to provide increment of reserves of Gazprom PJSC mineral resources base.
Carbonates as possible prospecting indicator of HC within arctic shelf

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Carbonate rocks are one of the most common sedimentary formations. They are critical in global carbon cycle, can be HC reservoirs, and in some cases can be formed due methane oxidation or its generation. Such carbonates can be theoretically used as search criterion for hydrocarbons (e.g. Golyshev et al., 1981), therefore the necessity of this direction study is obvious.

Currently carbonates formation mechanisms are highly examined. One of the defining criteria used during genesis reconstruction are data on δ¹³C and δ¹⁸O stable isotopes content. δ¹³C values are successfully used for defining of carbon source included in carbonates crystal lattice, and δ¹⁸O measurement results allow to reconstruct crystallization paleotemperature and/or oxygen isotope composition (paleosalinity) in “water” surrounding growth zone.

Carbonates are divided by main crystallization mechanisms: 1) organigenic-biochemogenic; 2) diagenetic due microbial destruction of organic material; 3) diagenetic due aerobic/anaerobic oxidation of biochemical/catagenetic methane; 4) diagenetic due microbial generation of methane; 5) “hydrothermal” (abiogenic methane oxidation); 6) “catagenetic” (kerogen destruction). Despite the fact that some of the abovementioned categories are defined by isotopic labels convergence, in most cases carbonates carbon source can be successfully defined.

Russian West Arctic shelf seas have high oil and gas potential. Within their limits significant amount of seeps was observed (Portnov et al., 2015). Seeps in turn can contain authigene carbonates formed by methane oxidation. Another possible option of carbonates crystallization in Arctic is diagenetic oxidation of organic material if there is rather high content of it. Both mechanism simultaneous participation is possible too. Carbonates should be checked on its possible marking of discharge zones of HC-fluids or paleoseeps by isotopes research. Arctic diagenesis specifics consist in the fact that there is almost no formation of calcite, aragonite and dolomite observed. Instead icaite crystals (CaCO₂·6H₂O), not stable under normal conditions, are rather common here. During its destruction calcite pseudomorphs - glendonites are formed. We have studied icaite forming mechanisms in the context of HC-fluids discharge and in background deposits of Arctic shelf seas. Special attention is given to Kara sea icaites. The report includes methods of detecting of carbonates genesis connection with HC.

The study is performed with support of RFFI-16-05-00979 grant.
A aerogravimetric survey at the Russian Federation shelf: experience, problems and prospects

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(Sevmorgeo JSC)

The report presents the results of aerogravimetric survey carried out at the shelf of Okhotsk, Bering and East Siberian Seas, the comparison with combined marine shooting and seismic data.

Methodological issues related to the development of this type of surveys are discussed.
The analysis of geological and geophysical data on the structure of Korotaikhinskaya Trench points to significantly wider propagation of blanket deformations than it was believed earlier. It enables one to identify new types of oil and gas accumulation areas.

In general, the structure of that trench was largely determined by the stripping of sedimentary mantle off the salts of the Upper Ordovician. In the area of Upper Ordovician salt pinch-outs along the western border of the trench subtabular layering of sedimentary mantle transforms into a system of infold and overthrust deformations.

In the southern portion of the deep such deformation systems are of relatively simple structure with predominating overthrusts of western vergence (Talotinsky overthrust). Significant oil accumulations are observed in the frontal bars of overthrust area in the Devonian and Lower Carboniferous dry-land deposits of the Timan-Pechora Basin (Northern Saremboyskoe, Western Lekeyyaginskoe). Going NW into the Barents Sea, the structure of that fault complicates significantly. Major frontal bars are also distinguished here, controlled by overthrusts from the western border of the trench (the area of Dolgy Island). These are of significant exploration interest. Moreover, seismic data point to the appearance of overthrusts of opposite falling in that area, their fault planes falling to the west. Such structural conditions make possible the formation of large dead-end traps tectonically shielded on the western border of Korotaikhinskaya trench. These traps may accumulate oil and gas migrating from the immersed axial part of the deep.

Seismic data indicate that exploration potential of the northern part of Korotaikhinskaya trench is associated with overthrust areas of the eastern part of the trench, locally formed by the Upper Devonian-Tournaisia banks and their fragmental tails, and pinch-out areas of Carboniferous and Perm deposits on the western border of the trench.
New geological and geophysical data are summarized from the regional exploratory and survey studies in oil and gas, models are updated of geological formations, tectonic and oil and gas zoning, patterns in location of the largest zones of oil and gas accumulation, as well as prospects of building up resource base for oil and gas production in the oil and gas basin of the Barents Sea. Actual issues are highlighted in a timely manner in reading the resource base of the newly formed Shtokman megacenter of gas production, which may be resolved including the largest forecasted zones of oil and gas accumulation into long-term plans for licensing and exploring and surveying activities. It is demonstrated that while initial assessment of potential resources of hydrocarbons is quite promising, highly reliable localized prospective resources of $C_3$ and $D_{1l}$ categories and the respective new industrial facilities with their expected unique resources of industrial categories actually feature high risk of failed confirmation of forecasted deposits of hydrocarbons. An assessment is offered of the resource potential of hydrocarbons in zones of oil and gas accumulation along the western border ledge of the East-Barents flexure, in its northern extension, plus the Saint Anna trough and the Northern Kara potentially petroliferous basin. It is proven that the principal factor of high geological and economic efficiency of exploratory and prospecting activities consists in outpacing of unique and extra-large deposits of hydrocarbons. Accounting for the need to build up the resource base of gas production around the Shtokman gas condensate deposit, the following satellite structures in neighboring regions of that future center of gas production, poorly studied so far, feature oil and gas accumulation zones with their largest forecasted deposits: Ledovo-Ludlovskaya zone, lying in the axial area of the East-Barents flexure, subject to further prospecting; 150 km to the north of it is the Luninskaya zone; still farther north by 250 km, within the limits of Albanovskaya anticline is the Orlovskaya zone; 100 km to the NW of Shtokman gas condensate deposit, along the western border ledge of the East-Barents flexure there lies the Demidovsko-Medvezhya zone and to the SW of it is the Fedynskaya zone.
The Barents Sea basin is one of the largest Russian oil and gas basins with a proven productivity. The unique gas field of Shtokmanovskoe and large one of Ledovoe and Ludlovskoe were discovered in Jurassic deposits of the Russian part of the Barents Sea. Jurassic sand reservoirs are also productive in the Norwegian sector, where there is the gas field of Snovit and oil and gas ones of Havis and Skrugart. In 2013, the Norwegian geologists made a new oil discovery in the Lower and Middle Jurassic reservoirs of the Hoop-Maud downfold, in the northern part of the Norwegian continental shelf. The Jurassic complex is promising for new discoveries, but its structure is not studied until the end.

On the shelf of the Kara Sea, Rusanovskoe and Leningradskoe fields in Cretaceous deposits were opened. The productivity of Aptian-Albian and Cenomanian complexes was confirmed in 2014 by drilling the Universitetskaya well, from which the gas inflow was obtained. The oil flow was obtained from Jurassic sediments, after which the State Reserves Committee approved a new oil and gas field of Pobeda.

The model describing the formation conditions, structure and composition of Jurassic natural reservoirs is needed for planning exploration works at new structures of the Barents Sea shelf (BSS) and selection of facilities for licensing. New seismic data collected in Norwegian and Russian sectors of the Barents Sea allowed the identification of the distribution area of the Jurassic oil and gas complex, evaluation of its thickness, tracking the direction of the sediment migration and determination of the consequent change of sedimentation. A comprehensive analysis of the regional structure of the Jurassic oil and gas complex and detailed studies of specific areas enable to predict the spread areas of Jurassic high-capacity reservoirs at BSS structures and to assess their oil and gas potential.

The development and discovery of new fields in the Barents Sea region are one of the priorities of the long-term state program of studying bowels and reproduction of mineral raw materials in Russia.
Assessment of block shearing deformations impact on distribution and forecast of hydrocarbon deposits at subsoil areas of Ob-Taz shallow water by Gazprom PJSC

(Gazprom Geologorazvedka LLC)

Issues on HC deposits distribution and evaluation of oil- and gas-bearing prospects of Lower Cretaceous and Jurassic deep horizons at Senakovskiy, Tota-Yahinksy and Antipayutinsky subsoil areas within water areas of Taz bay and south coast of Gydan, as well as Parusovaya group of areas located in northwest end of Taz peninsula are considered. In terms of tectonic they are confined to Mesoyakhsky sill (ridge). In 2010–2014 within area boundaries 3D CDP seismic operation were performed, separate cubes of which are combined to supercubes with the following unified processing and interpretation of the materials. The latter ones allowed singling out and tracing by areas size block shearing deformations that have flower (palm) form on seismic section. In the plan up to the section from Jurassic to Upper Cretaceous deposits they represent sequence of upstanding blocks and depressions between them of different width and spread at time slices on seismo-stratigraphic units from the axis of shear, affecting the rocks of consolidated foundation.

By configuration axial lines of shearing on the plan are in good agreement with Taz bay coastline. Therefore the assumption has been made that the last forming cycle took place during neotectonic period. By Cenomanian deposits roof block shearing deformations impact gas massive deposits height and GWC high-altitude position. ATZ has been singled out at Semakovskiy area in Cenonian deposits section of Berezovskaya suite by seismic attributes. During its development in wells 104 and 54 gas showings were observed.

Within Parusovaya upheaving group and Semakovskiy doming in tectonic terms confined to Aderpayutinsky megaswell, where considerable amount of well drilled with opening of Aptian, Neocomian and Middle-Jurassic (10 units) deposits, sporadical distribution of gas and oil accumulation in Aptian and Hauterivian depositions is observed. Thus, at North Parusovaya license block of Aptian and Neocomian oil and gas bearing complex amount of HC deposits is varied from two to seven with sporadical distribution by section and non-equilibrium position of gas- and oil-water interfaces, their deviation from gravity factor by areas size. Vertical flows of gas and local water on slip planes with low thickness values of clay caps, that are recorded by similar values of water mineralization and comparability of bed resistivity – reservoirs in wide range (up to 300 m) of their bedding, are not excluded.

By prospective Jurassic objects within North Parusovaya license block the fluctuation of anomalous pressure from 1.5 to 1.9, as well as lack of HC commercial inflow during open hole and deep well column formation test in the presence of reservoir beds and their gas saturation by GMS complex are observed. In well 25 of Tota-Yahinksy license block located in one of the upstanding blocks near shear line the “column” of prospective Jurassic objects in the range exceeding 1000 m, that can be limited by a shear, was observed.

We offer to consider revealed peculiarities of HC deposits distribution within zones of block-shearing deformations development on shore of Taz and Gydan peninsulas areas during forecast of new accumulations of gas and oil in water area of Taz bay.
Geodynamical aspects of structuring of Priyamal shelf – as a part of northwest part of Yamal geoblock of Western Siberian plate

(Gazprom Geologorazvedka LLC)

Assessment of geodynamical development of structure elements and their boundaries joint has been performed based on analysis of sedimentary complexes thickness and sedimentation velocity gradients both in depressions and megaswells of South Kara synecline and Yamal peninsula.

Prospects of oil and gas bearing of geoblocks related with megaswells within West Coast of Yamal and near-Yamal shelf are possibly caused by geodynamics of sedimentary complexes development in Pukhuchanskaya depression and Beloostrovsky megaswell during Mesozoic and Cainozoic.

Migration impact of basin downwarping centers, with which areas with maximum thicknesses of Mesozoic and Cainozoic sedimentary rocks in paleodepressions and megaswells are connected, on position and configuration in plan of positive structures of the first (megaswells) and second (domings and swells) is defined.

Research of downwarping of a foundation and sedimentary cover rocks shows their fading during Lower and Upper Cretaceous. During Neotectonic period structure plan inversion was followed, resulting in modern structure of the main depression zone – Pukhuchanskaya depression, as well as positive structures of the first and second orders surrounding it.

History of development of Skuratovsky and Rusanovsko-Leningradsky megaswells has showed that they have no unified ancient foundation base. Therefore the options of their combinement into unified Rusanovsko-Skuratovsky swell are not really competent.

Visualization of sedimentation velocity gradients shows their sinusoidal oscillating nature, that is mainly predetermined by interchange of sea transgression and regression in Kara sea and partly at Yamal. Besides, such nature of their geodynamics considering mechanism of stress-deformation rocks state contributed to accumulation of huge mechanical energy in geosystems of closed or semi-closed type. Existence of AKZ (ILM) and elements of block tectonics, fracture zones at Rusanovsky, Leningradsky and Harasaveisky fields, as well as Neva swell, shows it during their modern stage of development.

Existence of unique fields concerning HC reserves around Pukhuchanskaya depression can be interpreted as existence of megacircular superorder geological structure, naftidogenesis processes in which were controlled by increased energy potential in the past and are partly controlled currently due to tectonic movements, passing, in our view, by impulse-wave mechanism.
Hydrocarbon prospects of the Kara sea southern part

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The Priyamal shelf and Kara sea southern part hydrocarbon prospects within the South-Kara shelf region are highly evaluated by many researchers. The wide stratigraphic interval of the sedimentary rocks industrial productivity is forecasted from the Turonian-Cenomanian to lower Jurassic sediments. Within the Yamal peninsula the sedimentary section is well studied with drilling up to basement in the bounds of the region positive structural elements. It gives the possibility to assess the character of industrial hydrocarbon potential in terms of structural-tectonic position of objects drilled.

The main hydrocarbon pools are associated with the large high-amplitude anticlines in axis parts of megaswells, swells and arched uplifts. In these zones there is a maximum stratigraphic interval of the hydrocarbon pools presence, as a rule from Cenomanian to Jurassic. On the slopes of swells there are separated structural complications with low amplitude prospect objects. From 1 to 3 wildcats wells were drilled there. Some hydrocarbon fields (Syadorskoe, East-Bovanenkovskoe, Verkhne-Tiuteyskoe, West-Seyakhinskoe) were discovered. Generally, the only productive rocks of these fields are Cenomanian deposits, except the West-Seyakhinskoe field. Evidently, a hydrocarbon potential of every single prospective object depends on traps’ amplitude and hypsometric position. Within the Yamal peninsula there is a trend: low amplitude prospective objects of swell slopes even at hydrocarbon productivity are characterized with: 1) the only gas content, 2) stratigraphic range reduction of industrial hydrocarbon potential, 3) reduction of net gas pay, 4) reservoir rock water cut of the bottom parts of the section (lower part of Neocomian and Jurassic).

It is necessary to take into account the discovered particular qualities of the section hydrocarbon productivity within the Yamal peninsula while evaluating the resource potential of the same prospective objects of the southern part of the Kara Sea. According to main seismic level reflectors (LR «G», «M'», «B») its structure features are less defined within the bounds of the Kara Sea than adjoining onshore lands of the Yamal peninsula. This factor can significantly limit the prospects of hydrocarbon charge for the most rises within the Kara sea southern part.
Seismic operations in water area of the Gulf of Ob and Taz bay – NOVATEK researches experience

V.I. Kuznetsov
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Seismic researches in the zones of transition from ground to sea (transit zones), including elements of both sea and ground works, are one of the most advanced types of geophysical service, requiring using of the most advanced equipment, technology and logistics.

In the north of Western Siberia shallow water areas adjacent to sea costs are not sufficiently studied to handle the problems of research and estimation stage of geological survey. Please note that we are talking about hundreds of thousands square kilometers of potentially oil and gas prospective territories.

Under Western Siberia conditions regions with large lakes can be referred to transit zones – Ob, Gydan, Baydaratskaya and Taz bays. In terms of seismic survey transit zone is a water area, where marine streamer usage is impossible due to shallow depth, geophones coordination with the environment is difficult, explosive treatment is forbidden, seismic source point usage is ineffective. Besides, there are increased environmental safety requirements to operations in transit zone.

The main problems of seismic researches in transit zones are:
– in the zone of “ground – sea” transition in the upper part of geological section there are rather significant changes of velocities and absorption properties of the rocks, therefore proper seismic modelling is a serious methodological problem;
– necessity of usage of polyvariant systems of excitation, reception and registration, i.e. combined use of explosions, surface sources, seismic source points – combined with bottom, surface and submerged geophones and hydrophones;
– necessity of overriding and use of special technology data communication between data received by different systems, including different (summer, winter) field seasons.

Group of companies NOVATEK PJSC has positive experience of abovementioned problems solving. Results uniqueness consists in the fact, that despite usage of heterogeneous complex of technical means and procedures, under hardest surface conditions of the Subarctic it is possible to obtain complete 3D data set.
Forecasting of oil and gas potential of Jurassic and Low Cretaceous sediments of the area of the junction of Ob and Taz estuaries of the Kara sea

D.A. Astafiev, A.V. Tolstikov, M.A. Kalita, L.A. Naumova
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Analysis of oil and gas bearing potential of Jurassic and Low Cretaceous sediments in the discovered Kamennomysskoe, Semakovskoe and Obskoe fields and gas condensate fields Severo-Kamennomysskoe and Chugoryakhinskoe taking into account tectonic structure and oil and gas bearing potential of Kara-Yamalo-Gydanskaya and Nadym-Pur-Tazovskaya synclises allows for making conclusion about high potential of discovery of new hydrocarbon (HC) deposits here. Assumption of the forecast: favorable structural and tectonic conditions (junction of large Nurminskoe and Nizhne-Messoyakhskoe megalithic banks surrounded by graben and rift troughs – Soyakhinsky in the north and Parusovy in the south; presence of regional, zonal and local reservoirs in the sedimentary cross section combined with strong HC generation sources and hydrogen degassing facilitating hydrogenation of organic substance and synthesis of hydrocarbons. In Yamal Peninsula HC deposits were discovered in Jurassic and Low Cretaceous sediments in Novoportovskya, Bovanenkovskaya, Kharasaveyskaya, Malyshevskaya, Severo-Tambeyskaya structures; in the Kara Sea they were discovered in Universitetskaya structure; in Gydansky Peninsula they were discovered in Geofizicheskaya, Utrennyaya, Minkhovskaya, Gydanskaya structures; to the south of Taz estuary they were discovered in Urengoiskaya, Severo-Urengoiskaya, Medvezhya and other structures). Strong oil and gas potential of Jurassic and Low Cretaceous sediments is determined also taking into account identified features of the discovered fields and structures – increase of the size and amplitudes with the depth and displacement of domes relative to the explored hydrocarbon deposits in cenomanian and apto-albian sediments. Accounting for these characteristics of the structure allows for optimum localization of seismic acquisition, exploration and appraisal drilling in the Jurassic and Low Cretaceous traps both in the discovered fields and in new areas such as offshore extension of Khambateiskaya structure. New hydrocarbon deposits in Jurassic and Low Cretaceous sediments are expected in Kamennomysskoe, Severo-Kamennomysskoe and Semakovskoe fields. Larger hydrocarbon deposits unlike the cenomanian sediments are predicted in the Jurassic age sediments at Obskoe field.
Structure and oil and gas potential of the Yenisei-Khatanga bay eastern part

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Currently, there is a renewed interest in the study of the Yenisei-Khatanga Basin – one of the few regions in Russia which is poorly studied in geological respect regarding oil and gas. This Arctic region is characterized by a complex geological structure, remoteness from major industrial centers, but it has prospects for the search for large accumulations of hydrocarbons. Since 2007, the active research in the region has begun. Several column-mounted wells were drilled and more than 5 thousand RKM of 2D seismic profiles worked out, with the basin territory categorization according to its oil and gas potential. In 2015, Lukoil PJSC (Zhuravliny arch) and Rosneft PJSC (Khatanga Bay) received license blocks for the use and now they are actively drilling and carrying out geological and geophysical studies.

According to the regional seismic survey, the crystalline basement surface varies from 4–5 to 12–14 km and more, which is confirmed by the data of gravity and magnetic fields and electrical surveys – the Yenisei-Khatanga downfold has a sedimentary mantle of up to 14 km and a width of up to 300 km. The main question that determines the stratigraphic completeness of the section in the survey area is related to the time of laying the deep downfold. The first stage of active immersion was related to the Riphean stage of development of the Taimyr region and the adjacent part of the East-Siberian platform. It is confirmed by the seismic picture of deep horizons corresponding to the pre-Paleozoic section interval, and some sections of wells that penetrated Riphean-Vendian deposits on the northern slope of the Anabar anteclise. It is difficult to clearly trace separate Riphean grabens on the regional 2D profile, but they take shape in a sharp change of the seismic picture of lower seismostratigraphic complexes.

Upper Proterozoic deposits are typically of platformal differences – at the bottom there are red sandstones and gravelites, aleurolites, argillites overlain by a layer of dolomites and clay dolomites. Having a sharp angular displacement, they lie everywhere on Early Proterozoic or Archaean residuum rocks or on Archaean metamorphic formations.
Comparative evaluation of oil and gas bearing prospects on the Laptev sea shelf by various methods

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According to data of various investigators, evaluations of HC potential of the East Arctic Seas are significantly differ from 1.9 billion TOE as per evaluations of US Geological Survey (USGS) to 12.2 billion TOE as per evaluations of the RF Ministry of Natural Resources (as of January 01, 2002). It relates both to various methods of HC resources evaluation, and to different understanding of development history and basins structures.

Features of the East Arctic shelf are its extremely low degree of seismic knowledge (lower than 0.01 km/km² in the East Siberian Sea to 0.08 km/km² in the Laptev Sea) and absence of deep wells. Sedimentary mantle within the shelf basins is presented by all-ages deposits, the foundation is composed from all-ages blocks of ancient cratons and fold structures [Khain V.E., 2007]. Thus, it should be noted that the extension of the latter in the waters is arguable.

Currently, for the age of the foundation and stratigraphic completeness of sedimentary mantle on the Laptev Sea shelf there are two main points of view [Malyshev N.A., 2010]:

1. The Western part of the Laptev Sea basin is located on the extended Siberian platform, its foundation has the early Proterozoic. All units of Riphean and Cainozoic rocks are included in sedimentary mantle. The Eastern part foundation is Late Cimmerian, the mantle is presented by the Cretaceous-Cainozoic deposits.

2. The basin foundation of the whole shelf has the Late Cimmerian (Early Cretaceous, early Aptian) age, the mantle is presented by more recent (the Cretaceous-Cainozoic) deposits.

Up to the present, according to the absent of deep drilling on the Laptev Sea shelf, industrial hydrocarbon accumulations are not specified. However, the immediate vicinity of Yenisei-Khatanga oil and gas bearing region, presence of natural bitumen fields within the Lena-Anabar downfold (Olenyokskoye, etc.), and multiple bitumen occurrences on the Laptev Sea and the New Siberian islands to the shelf, oil and gas occurrences in deep-drilling wells within the Anabar-Khatanga saddle and the Lena-Anabar downfold allow to highly evaluate the prospects of the Laptev Sea shelf in terms of indication of industrial oil and/or gas deposits.
Oil and gas bearing potential of Sakhalin shelf sedimentary cover and basement rock

D.A. Astafiev, A.V. Tolstikov, M.A. Kalita, L.A. Naumova (Gazprom VNIIGAZ LLC), V.A. Ignatova (FSUE VNIGNI)

The oil and gas bearing potential forecast was developed for lower horizons of sedimentary cover and basement rock of all Sakhalin shelf structures accessible for development based on accumulation of new geological and geophysical information about geological structure and oil and gas bearing potential of the Sakhalin shelf (both eastern and western), updating of hypsometric data of reflectors of sedimentary cover, discovery of fields with large hydrocarbon reserves in high amplitude protrusions of basement rock in other oil and gas basins. It was found that all dry wells in Sakhalin shelf were drilled outside the contours of structures due to low reliability of mapping by seismic surveys at initial exploration stages which prevented from finding reservoirs and seals in the vaulted sections of existing structures. Based on the re-interpretation of seismic data the feasibility of resuming hydrocarbon exploration was justified for lower horizons of sedimentary cover and basement rock in developed license areas of the Sakhalin eastern shelf – Kirinsky, Vostochno-Odoptinsky and resuming exploration in other license areas not only in the eastern shelf but also in the western shelf of Sakhalin. This will allow for development of additional resources of hydrocarbons required for LNG plants and regional power supply. Yuzhno-Kirinskaya and Mynginskaya structures within Kirinsky license area, Vostochno-Odoptinskaya structure in the north part of Vostochno-Odoptinsky license area and Kerosinnaya structure within Pogranichny license area are recommended as priority areas for resuming exploration. Presence of favorable combination of reservoirs and seals in the western shelf of Sakhalin is justified almost for all identified formations of sedimentary covers and basement rock. Full field models were developed both for the only Izylmetyevskoe gas field and predicted fields of Lamanonskaya, Boshnyakovskaya and Kholmskaya oil and gas accumulation zones.
The Cretaceous and Pleistocene deposit layers with the significant thickness (7–9 km) take part in the structure of peri-continental (shelf and slope) sedimentary basins of Atlantic passive margins of South America and Western Africa. Terrigenous rocks [Konyukhov A.I., Khain V.E., 2008] are prevail in the composition of the main oil and gas bearing complexes in both regions; they were accumulated at the rift stage ended in the Aptian stage with settlement of evaporites and at the oceanic stage of development. As from the Coniacian and Campanian time, the accumulation of terrigenous clastic formations in pericontinental basins of Eastern Brazil was determined by the major phases of orogeny in the Peruvian Andes; in the West African basins it was specified by shifts caused by the development of the East African Rift System [Anjos S., Silva S., 2005].

Pericontinental sedimentary basins (confined to the areas of deflection at the junction of the underwater continental margins and oceanic structure, when the continent smoothly begins submersion [Brod I.O., 1965]) of the South Atlantic have a common origin and similar structure of both foundation, and sedimentary mantle. Throughout the development cycle they were in a similar paleogeographic and paleotectonic conditions. The process and scheme for formation of the shelf and slope basins on these passive continental margins were basically identical. Their evolution is divided into three stages corresponding to the rift, early spreading and late spreading ones of development of the southern Atlantic Ocean segment, during which sedimentary complexes typical for that phase were accumulated in basins [Polyakova I.D., 2004].

Thus, the sedimentary basins of the continental margins in the central part of West Africa and South-East Brazil formed by the common scenario against the opening of the Atlantic Ocean the southern segment. The basins similarity appeared in similar structural styles, qualitative and quantitative composition of lithologic and stratigraphic filling, biomarker oil composition identical with the stratigraphic range of the oil and gas bearing floor. Individual differences are related to local features of halokinesis, time difference in progradation of turbidites and substrates of gravity currents, especially intensified at the final stage of basins development.
According to existing ideas, the hydrology of the White Sea is determined by its feeding from two main sources: water of rivers falling into it and the influx of open ocean waters (from the Barents Sea). In order to study the hydrological conditions of the White Sea, the isotopic composition of oxygen, hydrogen and tritium of surface and deep waters of the sea, its water supply sources, as well as pore water of the top part of bed deposits have been studied. The sampling was carried out from bedrocks chosen based on the results of hydrooptical and hydrophysical exploration. The measurements were made using V-SMOW and SLAP standards.

The studies have shown that the isotopic composition of oxygen and hydrogen of researched waters is characterized by a range of values: \((-13.2)\div(-2.42) \, ^\circ\text{SMOW}\) – for \(\delta^{18}\text{O}\) and \((-102.6)\div(-19.10) \, ^\circ\text{SMOW}\) – for \(\delta^{D}\). The lightest by isotopes is water of the Kem river, the heaviest is water of the open sea and pore water of bedrocks. It was found that the investigated water area does not lie on the global meteoric water line, but constitute a line of local precipitation close to the dependence of \(\delta^{D} = 8 \cdot \delta^{18}\text{O}\).

Consideration of the nature of changes in the isotopic composition of oxygen and hydrogen of researched water samples according to the sea depth showed that the general rule for all sections is the enrichment of water by heavy isotopes from surface sea water to its deep lines, that shows a fairly expressed stratification of sea waters. According to the study of tritium content in the water it was found that a significant impact on the stratification of sea water is carried out by the bottom discharge of land water.
Offshore drilling units of Drillmec company

Yu.L. Parnivoda
(Drillmec)

Drillmec produces full range of offshore equipment sets for well drilling with the usage of innovation technologies, high quality standards, as well as with involving of experienced professionals for satisfying all needs of their Clients. Drillmec offshore drilling equipment sets are designed for all types of work conditions, loads, and requirements for certification (ABS, PMPC, CE, NORSOK, ATEX, GOST, API).

Drillmec proposes wide range of offshore equipment for platforms, barges, semi-submersible platforms, and drilling vessels providing the widest spectrum of requirements for exploration, recovery, and development of oil and gas fields. Drillmec supplies everything starting from drilling platforms and ending with top-driving systems (TDS), drilling mud circulation systems, control systems, derricks, work systems for pipelines, pipe tongs, and turntables of any capacity.

Among ambitious offshore projects of Drillmec implemented within recent years the following ones may be deemed outstanding:

– Full sets of drilling equipment Drillmec 2000 hp from IRP-1 (ЛСП-1) and IRP (ЛСП-2) platforms of Filanovsky oil field, the Russian Federation, Lukoil-Nizhnevolzhskneft LLC.
– Modular drilling facility Drillmec НН-300 FA with hydraulic lift for the platform No.20 of West Absheron field, Azerbaijan, SOCAR-AQS company.
– Drilling facility Drillmec 3000 hp for the platform No.11 of месторождения Gunashli, Azerbaijan, SOCAR-AQS company.
– Drilling facility 3000 hp and topside of the Pemex platform, Mexico, Perforadora Mexico company.
Experience and challenges of hydrodynamic wells testing with subsea completion

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The only Russian project at the production stage, where applicable subsea production systems are used, is Kirinskoye gas condensate field. When developing and exploitation of the field, the industry faced a number of challenges and problems in the sphere of technologies, equipment, methodology of work, and economic factors. One of the challenges facing the subsoil user is a qualitative assessment of field characteristics, including its hydrodynamic, gas-dynamic and condensate properties under the development monitoring.

Oilteam Company is one of the key contractors for the study of Gazprom Group wells. Since 2015 the Company was entrusted a very important work for the development and research of P4-bis wells, P1, P2, P3, P4 of Kirinskoye GCF after drilling. At the moment, works for 3 wells have been completed. Works for another 2 wells are planned for 2017.

Methodology and technology of works at the field is quite different from the procedures adopted not only on land, but even on stationary platforms. The specificity is that drilling and completion of production wells with parameters and properties which are critically important to monitor the development over the entire field cycle. In contrast to the stationary platforms and onshore projects, the reality is that at SPS there will not be possible to perform repeated comprehensive hydrodynamic studies with measurement of flow rate due to the technological and economic reasons.

The report considers the following challenges in the area of hydrodynamic studies with monitoring the fields development with subsea completion:

– observance of regulatory requirements applicable in the oil and gas industry, in the area of dynamic well testing during field development monitoring;

– technology and methodology for calibration of measuring instruments installed in the well and on SPS to recognize their metrological significance;

– international experience and problems, their solutions in the area of DWT at the fields with SPS;

– proposals for the development of technology and methodology for well testing with SPS wells while monitoring the field development.
Brooks: resistant to aggressive contaminates system of drilling fluid for use during offshore drilling

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The Arctic Region is a worldwide storage of energy reserves. Because of the expensive logistics all technologies must be environmentally friendly and efficient. One of the main components of the technological well construction is drilling fluid suitable for many drilling operations. Retention of wellbore stability before the interval is closed by a casing string, and prevention of drilling problems depends on properties of the drilling fluid. In order to reduce influence of external aggressive media by spillover, it is necessary to use drilling fluids containing chemical reagents resistant to influence of different types of contaminants while drilling. It is especially relevant for water-based fluids.

PSK “Burtechnologii” has developed and conducted industrial and laboratory tests of the water-based fluid “Brooks”. Main advantages of the drilling fluid “Brooks” are as follows: environmentally friendly reagents, resistance to aggressive contamination, and the possibility to use the fluid under different geological-and-technical conditions. The drilling fluid “Brooks” is a hydrophobic micro-emulsion system where globules of organic substances are enclosed in a thin membrane of aqueous dispersing medium. Use of reagents based on derived polysaccharides allowed improving the resistance to the different contaminants. The analysis of the laboratory research has proved that the drilling fluid “Brooks” is able to retain effectively its technological properties when different aggressive contaminants are being added. The chemical reagents used in the drilling fluid’s system are resistant to the added contaminants. The composition of the drilling fluid is minimized by the quantity of reagents used.
General principles of the cluster approach to the development of offshore oil and gas fields

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A.S. Tertyshnikova (CDB CORALL JSC)

The south-eastern part of the Barents Sea (Pechora Sea) is characterized by significant reserves of hydrocarbons, which locate in a relatively shallow part of the water area (the average depth is 20–30 m). The water area of the Pechora Sea is divided into several sections, the licenses for the development of which belong to the leading national oil and gas companies.

Within each license section there are usually several fields separated from each other by a distance of 20–100 km. Thus, for the full development of the entire licensed section in each field, an ice-resistant platform or a wellhead platform is required.

The described district has almost no necessary infrastructure for the supply of offshore production facilities (coastal bases, support fleet), as well as systems of prevention and elimination of consequences of emergency spills.

The cluster approach allows optimization of the development process in such a difficult area (severe natural conditions, lack of infrastructure), i.e. development of several fields in a single system.

The cluster approach enables reducing the cost of development of licensed sections through the unification of facilities, creation of a unified system of transportation and shipment of products, as well as the overall supply infrastructure.
Application of Welltec robotic technologies for geotechnical jobs using logging cable

V.E. Kuchukov
(Welltec Oilfield Services LLC (RUS))

The Welltec Company its revolutionary development of WellTractor® in 1994 – it was Downhole Tractor opening the era of robotic cable tools in the oil and gas industry and having become a recognized world leader in its class for more than 20 years of successful activity. Having started with the usual delivery of geophysical equipment in horizontal wells on the cable, the company is steadily increasing its service package and currently successfully implementing such projects as:

- down hole valves and stops control;
- cutting well tubes and casing columns;
- riserless light intervention to deep water wells;
- installation and breakdown of packers and plugs;
- removal of solid deposits, paraffin and hydrate plugs without well killing;
- multi-stage fracking ports and packer elements cutting;
- innovative integrated solution of horizontal completion Flex Well®;
- WAB external liner packers;
- inflow control clutches;
- wireless reservoir monitoring systems, etc.

One of the main areas of the company activity is shelf projects in various parts of the world, including in the Russian Federation. In these circumstances, GTJ using logging cable are the optimal, most effective and economically viable solution for maintaining production of hydrocarbons at an acceptable level. The Welltec Company carries out its industrial activity in Russia since 2008, having successfully implemented more than 1000 well operations during this time.
Forecasting of wells capacity at shelf fields

G.M. Geresh, T.Yu. Lukina, D.S. Efimchenko
(Gazprom VNIIGAZ LLC)

During marine field development design stage one of the most important tasks is development wells production rate grounding. Previously rate defining by gas-dynamics research (GDR) results was the main method of wells capacity grounding. Currently the methods of research prosecution at offshore wells are improving, including MDT wireline testing usage in productive part. In case of complex usage of results, these methods synergy allows to improve quality and reliability of permeability dependance (GMS and MDT) in productive interval for the following wells production rate grounding based on GDR results.
Challenges of small offshore field development in Barents sea water area (as seen at Murmanskoye gas field)

L.G. Kulpin, V.M. Maksimov
(Institute of Problems of Oil and Gas, RAS)

Shelf of Barents Sea holds significant hydrocarbon stock evaluated in billions of tons of fuel oil equivalent. Natural gas comprises a major part of these resources. Still, efficient development of these resources is hindered, or, in some cases, rendered impossible by challenging natural and climate conditions, large distance to the shore and outlet markets, and insufficient shore infrastructure. The report considers possible development of such resources as seen at Murmanskoye Gas Field.

It was discovered in 1983 at the South of Barents Sea, with participation of the authors. Drilling and exploration was performed by “Viktor Muravlenko” drilling vessel, with participation of the authors. The field stock is classified as large and is closest to Murmansk and Severomorsk cities (300–350 km). Sea depth exceeding 120 m and ice transit do not allow for design of a production platform resting on the sea bottom. Upon introduction of subsea gas production technologies similar to Ormen Lange field in Norway etc., a task is set to develop Murmanskoye field for gas supply to the said districts, as their current power industry is based completely on fuel transported from other regions of Russia (coal, heating oil, liquefied gas).

The report provides design recommendations to the field development using underwater well completion with gas supply to a manifold and multiphase transport by subsea pipelines with possible flow compression at an underwater compression unit. Main process principles of gas production, treatment and transport to consumers are described.
Preparing the model of low permeability formation for tests in forming oriented fissure

L.N. Nazarova
(Oil & Gas Research Institute of RAS)

Applied studies have yielded a model of low permeability formation to run tests in forming oriented fissure. The maximum discrepancy between the computational and the actual indicators (70%) over the whole covered range of oil viscosity in the formation was found for formations with low porosity and permeability properties: reservoir permeability below 10 mD and thickness below 5 m. With permeability exceeding 50 mD and formations thicker than 5 m the discrepancy increases.

With the formation parameters changing (its absolute permeability, effective oil saturated depth and formation oil viscosity) the nature of changes in conductivity and hydraulic conductivity of the formation may change in principle. Developing oil reservoirs with oil viscosity below 1 mPa results in changes of oil filtration through the formation which should result in reviewing the computational value of oil recovery factor, ORF. With oil viscosity reaching 2.5 mPa the nature of changes in formation conductivity and hydraulic conductivity becomes identical.

The analysis of actual values of ORF obtained for various combinations of filtering properties demonstrated that formations with hydraulic conductivity below 10 dm/Pa and permeability below 5 mD should be considered for implementing the system of flooding. Other working agents shall be considered for such reservoirs, including gaseous ones.

Study results were obtained within the scope of applied scientific studies with financial support by the RF Ministry of Education and Science (Unique Identifier RFMEFI60714X0080).
Justification and selection of optimum process flow pattern of Achimovsky wells for their reliable operation

M.G. Zharikov, M.Yu. Safronov
(Gazprom Dobycha Urengoy LLC)

Effective development of Achimovsky deposits of Urengoiskoe oil-gas condensate field and full use of their high resource potential associated with ensuring stable operation of deep gas condensate wells in low-permeable reservoir with abnormally high pore pressure and significant effect of phase transformations of the formation fluid on production processes.

Key elements in the process of study and management decisions for hydrocarbons production and preparation of efficient wells process flow pattern are the following:

– representative information on component-fractional composition of the formation fluid, its physicochemical and thermodynamic properties in the mining-and-geological conditions of the Achimovsky deposits;
– accurate representations of flow structure in the service rig of wells of various profiles and its hydrodynamic parameters for correct calculation of bottom hole pressure and prediction of optimal values of drawdown;
– account of bottom zone rocks reaction on the created drawdowns and account of processes that affect the productivity of the wells as the deposits depletion and increase of effective pressure – reduction of reservoir properties, change of saturation and permeability, reduction of the effect of hydrofracturing operations.

Justification of the rational production conations of wells to minimize losses of condensate in the bed is reduced to solving problems for nodal analysis of “well-formation” system. Calculation of pressure loss and bottom hole pressure in the wells is based on the mechanical modeling of multiphase flow at preset head parameters; in this case, the phase state of the produced fluid shall be calculated in each well calculated elements, and the change of phases and flow structure quality in the hole shall be explicitly taken into account. In addition, determination of optimal production conditions of well relates to the need to determine a bed productivity for the calculated value of bottom hole pressure and drawdown.
Changes in the pore space structure of Daghinsky reservoir in modeling of reservoir conditions

V.S. Zhukov, Yu.M. Churikov, V.V. Motorygin (Gazprom VNIIGAZ LLC)

In the work there is a study of the pore space structure and its changes at the transition from atmospheric to reservoir conditions on the example of Daghinsky reservoir of Miocene age at the Sakhalin shelf. Programs of hydrodynamic modeling of development processes include the presence of fracture porosity data, representing the total porosity as the sum of two components: intergranular and fracture chambers.

The reservoir samples presented by medium- and fine-grained, silty sandstones, sandy and clay aleurolites were studied, which had an open porosity in the atmospheric conditions of 2.9–28.5 abs. %. It was assumed that these relatively younger rocks are plastic and do not contain cavities. Results of lithological and mineralogical research have revealed a widespread availability of micro-cavities along the cleavage planes and grain boundaries. The collection of 236 samples was investigated for the open porosity, velocity of elastic longitudinal waves in atmospheric conditions and at simulating reservoir conditions.

The size of fracture and intergranular porosity of rock samples were determined according to the data of the total porosity and the velocity of elastic longitudinal waves. The ratio of the velocity value measured on rock samples to the calculated rate expressed as a percentage is called the Q-factor which characterizes the integral action of pores and fractures to the rock.

The predicting of changes in the pore space structure (of intergranular and fracture porosity) at increasing the effective pressure is one of the ways to assess changes of filtration and capacitive properties of reservoirs which accompany processes of development at reducing the reservoir pressure.

It was revealed that the average value of open porosity decreased by 1.28 abs. % at the transition from reservoir to atmospheric conditions, accompanied by the actual stress increase. The intergranular porosity has decreased by an average of 0.779 abs. %, the fissure porosity – by 0.493 abs. %.

The mean value of fracture porosity in the open porosity in atmospheric conditions was 3.53 %, and in reservoir conditions – 1.33 %. It is shown that the transition from atmospheric to reservoir conditions reduced volumes of both microfractures and intergranular pores. The impact of the actual stress on intergranular and fracture porosity is estimated and the distribution assessment is obtained, both in atmospheric and reservoir conditions. These data can be used both for the calculation of reserves and in the preparation of development projects.
FMC Technologies shallow water subsea equipment

A.A. Khaustov
(FMC Eurasia LLC)

Mudline Suspension Equipment is considered an Integral Part of the Casing String. The SD1 and used in exploration drilling or as part of a production platform solution.

Utilizing the current system allows to suspend casing-weight at sea bottom, not on platform or rig and provides a safe means to abandon exploration wells, permitting return for well recovery at a later date.

FMC Technologies continually develops shallow-water drilling and completion technology to meet the needs of operators drilling wells in less than 400 feet (121 m) of water. FMC Technologies is among the most experienced companies in shallow water completions, with more than 250 installed worldwide.

FMC’s tree complies with certifications for a two-string tieback. The standard tree configuration and trim FF (stainless steel) provide for flexibility and protection against H₂S, CO₂, and chlorides, with chemical injection and gas lift capability.
Mordraga LLC – construction of marine infrastructure, technologies and achievements

I.V. Pogorelov
(Mordraga LLC)

Mordraga LLC is a Russian company performing the complete cycle of dredging, gravelling and hydraulic engineering works in ports, as well as on the open sea when laying underwater pipelines and assembling offshore structures, including platforms.

Mordraga LLC was founded in 2005 as a holding structure of a world leader in dredging, gravelling and hydraulic engineering works – the Belgian group of companies DEME.

We rely on 150 years of experience of the DEME Group in the area of:
– marine and hydrotechnical construction;
– dredging and gravelling of artificial territories;
– mining and quarrying of non-ore materials from underwater pits;
– coast protection.

The mission of Mordraga LLC is integration with Russian companies and design institutes in the field of dredging and hydraulic engineering works.

Education and training of experts for working at projects both in the Russian Federation and worldwide.
Replacement of imported cabling products for the needs of technological deck equipment of platforms and marine fleet for the development of continental shelf

A.N. Gerasimenko  
(Redaelli SSM JSC)

While under economic sanction Russia has encountered the issue of absence of its own production of equipment and spares in practically every industry, including shelf production of hydrocarbons. It has already served as a driver for the emergence of numerous enterprises busy in designing domestic analogs of imported products.

Working to provide hoist mechanisms with high quality steel cables, "Redaelli SSM" (Volgograd) has mastered and proceeds mastering a number of popular designs by well-known global brands and keeps improving the quality of its products launching new equipment and introducing new production technologies. The launch of two new machines during 2015–2016 and upgrade of a number of drawing machines at the company Volgograd plant has made it possible to expand and improve considerably its lines of products enjoying demand from shipbuilding, offshore industries and shelf production of oil and gas. Such are cables for winches of positioning systems, travel cables for drilling rigs, plus dedicated cables for high lifting capacity cranes and reloaders. The company provides every kind of production service to procure products fully ready for operation. Among them are operational low temperature grease serving to adapt the cable to harsh Arctic conditions, advance drawing of cables and other products, plus high strength cable endings of every kind.

Products by "Redaelli SSM" is a cost-effective option in replacing globally known cable brands. Test programs run jointly with consumers confirm that the quality, hence mean time to failure by company products are on a par with imported analogs. The company spearheads several projects implemented together with well-known Russian design institutes. These include procuring cabling products for the Russian Navy in 2015/2016. All that testifies to the fact that "Redaelli SSM" is capable of providing science-intensive high-tech quality products.
Critical ice impacts on offshore oil and gas field structures

M.N. Mansurov (Gazprom VNIIGAZ LLC),
V.K. Vostrov (Melnikov CNIIPSK JSC)

The report provides the dynamic analysis of the ice fields interaction with the offshore oil and gas structures using one-dimensional mathematical models of structures oscillations, the basis of which is the conditions for self-oscillations occurrence and development.

Dynamic ice loads on structures shall be determined and the conditions for the establishment of self-oscillations shall be analyzed along with the parameters prediction parameters.

The methods for determination of emergency ice loads and accidental design situations missing in the national and international standards SP 38.13330.2012 and ISO 19906:2010(E); these data are the basis of industrial and mechanical safety of hazardous production facilities during the design and operation of ice-resistant oil and gas field structures.
FLNG platform for deepwater Arctic shelf

K. Berezhnoy
(Krylov State Research Centre)

The paper describes the conceptual design of the floating platform for the liquefaction of natural gas in the Arctic deep-water fields. This platform can be used for example in the Shtokman field, the Fedynskogo field, gas fields in the Sea of Okhotsk. Special attention in the paper is dedicated to the anchor system, the optimization of the hull shape for reducing ice loads, the concept of LNG production, the location of processing facility and the logistics component of the project.
Fiber-optical technologies for continuous distributed control, monitoring and protection of offshore oil and gas production fields

A.L. Ermilov
(Laser Solutions CJSC)

Long-term power strategy of Russia envisages wide scope development of oil and gas fields in remote regions with harsh climate, including the Arctic shelf.

Global practices offer multiple approaches and technologies developed specifically to overcome physical difficulties encountered in operating offshore pipelines used to transport hydrocarbons from marine shelf to dry land. However, beside selecting and substantiating specific design and technological features for the newly constructed pipeline infrastructure, it is important to acquire detailed exact data on its current state in the course of operation.

The seasonal changes of the state of ground underlying pipelines present a particular risk for their integrity. The migrating sea bottom profile may alter the spatial position of offshore pipeline resulting from longitudinal and transverse displacements which entail changes in stress-strain deformations of the pipe wall. In some cases that may result in faults in pipeline carrying capacity and its collapse.

Harsh natural climate conditions affect other facilities constructed and operated in the course of developing offshore oil and gas production fields (power transmission and communication cable lines, wells, production platforms, buildings and structures of dry land infrastructure). Monitoring their integrity is vitally important for mitigating impact on the vulnerable natural environment of the Far North, as well as minimizing risks of leaks and downtime.

The current presentation describes fiber-optical technologies developed by «Laser Solutions» CJSC and systems based on them for advancing the safety and economic efficiency of operating infrastructure facilities located in remote regions of harsh climate. Also the global and national experience in implementing fiber-optical systems for continuous distributed monitoring of elements of infrastructure and their protection is reviewed.
Ensuring safe operation of underwater pipelines in the presence of subaquatic permafrost in landfall sections of shallow Arctic shelf

(Gazprom VNIIGAZ LLC)

Developing Artic shelf oil and gas fields relies heavily on constructing underwater pipelines that ensure transportation of hydrocarbons from the shelf to dry land. The state of surface soils in shallow waters is determined by joint impact of thermal and radiation fluxes from the atmosphere, the ocean and underlying beds of subaquatic permafrost (SAPF). The analysis of behavior of landfall sections of underwater pipelines in the presence of SAPF is important for ensuring their operation reliability. Complex processes of energy and thermal exchange between the elements of "pipeline-soil" geotechnical system may result in alternating frosting-defrosting of the system. They may change the spatial position of such pipelines by way of longitudinal and transversal displacements. Displacing the pipeline from its design position results in alternating stress-strain state of its wall. Some sections of the pipeline may thus exhaust their bearing capacity and fail eventually.

The paper presented is dedicated to issues of ensuring safe operation of underwater pipelines along the landfall sections of Arctic shelf in the presence of SAPF.
Bench tests of power unit for conditioning and pumping oil from standalone process facilities

Yu.A. Sazonov
(Gubkin Russian State University of Oil and Gas (NRU))

The newly developed test bench is designed to simulate operating conditions of power units designed for oil production on offshore platforms. When conditioning and pumping oil from standalone process facilities, the power unit uses reservoir energy to drive dynamic separator. Hydrocarbons coming from the well are directed to a dedicated turbine which converts reservoir energy into mechanical rotation energy of the rotor of dynamic separator.

In the course of study tests of such experimental power unit and bench plant, joint operation is simulated of the turbine and dynamic separator, the turbine driving agent being either fluid, or gas, or gas-fluid mixture. A separately developed and patented reticulated turbine is adapted for operation in alternating modes when the density and mass flow of operating medium keeps changing.

The adjustment system of power unit was tested for the conditions of gas and fluid fed to the set of nozzles. The effect of nozzles and rotor design on operation of the unit was studied. During the study, the overload protection system of the power unit was tested.

The basic range of application for R&D results from the study shall be offshore oil and gas production where the task of power saving and rational use of reservoir energy is especially important. In the meanwhile, study results may be applied to building energy efficient equipment for other production industries, such as processing of hydrocarbons.

The study was financially supported by the Ministry of Education and Science of the Russian Federation (unique project ID RFMEFI57714X0132).
Organization of control of engineering and manufacturing complex of marine fields arrangement is a complex and heterogeneous task. It is defined by a set of specific requirements related to engineering and manufacturing objects peculiarities.

Two main components can be singled out in Stockman field arrangement.

1. Marine production complex, including underwater production unit and technological complex of gas and gas condensate preparation, as well as equipment required for prepared gas transportation to onshore facility (from offshore wells head equipment to onshore facility mouth structures):
   - marine floating oil and gas producing complex of shipboard type,
   - underwater production unit (including production gas wells, headers, riser pipes, turret),
   - underwater pipelines system,
   - dispatch risers system, including risers connection device and pipeline termination head,
   - marine intrafield pipeline,
   - system of water reinjection into formation.

2. Onshore facility, including:
   - ground area of marine intrafield pipeline,
   - gas treatment plant,
   - liquefied natural gas (LNG) production plant,
   - seaport, including tank farm, refuelling base, waterfront structure, infrastructure objects,
   - gas measuring station with gas commercial metering,
   - off-site utilities of engineering service,
   - production and maintenance and packaging base,
   - power supply objects,
   - solid and domestic construction waste landfill,
   - marine objects support base,
   - administrative area,
   - operating personnel rotational village,
   - other auxiliary objects.

TP IACS SGCF should provide coordinated control of production facilities included in SGCF technological complexes, providing gas and gas condensate production, its preparation, processing (gas liquefaction, gas condensate stabilization), storage and transportation of the products.

TP IACS SGCF primary purpose is providing of automated control and technological and production process monitoring, as well as providing of subject- and object-oriented information to dispatch (shift) office personnel and production personnel to make effective, timely and grounded decisions on these processes control. Management decision making support systems play an important role in that.
Development of oil and gas fields of Russian continental shelf deals with a large scope of administrative and engineering works of construction of offshore engineering facilities, including subsea pipelines and cables (SPC).

Complicated natural and climate conditions of Russian Arctic shelf require to ensure safe and reliable operation of SPC. Timely organization of technical state monitoring, maintenance and repair of SPC is crucial to implement this task.

SPC technical state monitoring, maintenance and repair are performed to prevent breakdowns and failures, technical state forecast, repair planning and management according to the actual technical state, substantiation of decisions regarding possibility and conditions of further SPC operation.

To achieve those purposes, technical state monitoring, maintenance and repair of all SPC elements should be arranged, together with collection, processing and storage of data obtained during construction, commissioning, monitoring, maintenance and repair of SPC.

Repair works for SPC operability restoration are planned by the results of technical state monitoring, maintenance and servicing performed. SPC technical state monitoring and maintenance should account for the results of monitoring at all life cycle stages: construction, operation and repair.
Technical and technological solutions for the creation of national equipment for underwater preparation and compressing of hydrocarbon products at developing Arctic offshore fields

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(Gazprom VNIIGAZ LLC)

Taking into account the role of oil and gas in the national industry and in the modern economy of Russia, the extent of the hydrocarbon potential of the Russian Arctic shelf, and finally, the current trend of deterioration of stocks structure and dynamics of the oil and gas production in traditional areas of development, the Arctic continental shelf should be considered as a strategic hydrocarbon reserve, the area of Russia's strategic interests. Namely this status is given to the region based on the constant attention thereto at the highest state level – only in the last decade there was a large number of "offshore" and "Arctic" programs with specific targets for oil and gas production, with different plans, basical technical solutions and the scale of specific projects. However, the actual state of the process of industrial development of the Russian Arctic hydrocarbon potential has not yet moved from the initial level.

The development of fields at the freezing continental shelf of the Russian Federation is hindered by difficult climatic conditions and the lack of the necessary technical means, especially underwater production equipment. Realizing the importance of this problem, the authors propose technical and technological solutions for the creation of the national equipment for underwater preparation and compressing of hydrocarbon products.
Innovative solutions for the development of the fields on the shelf of the Russian Federation – reliability management

(Gazprom proyektirovaniye LLC)

Development of the field on the Arctic shelf of the Russian Federation is connected with the solution of certain technical issues. Conditions on the Arctic shelf of the Russian Federation are so unique that world practice does not have any ready technical solutions.

When designing items for the development of shelf fields, special attention should be paid to modern, innovative technologies significantly increasing the reliability of the system of natural gas recovery.

One of the prospective directions for the evolution of subsea equipment for the development of shelf fields is the creation of all-subsea arrangement systems including subsea production units, subsea facilities for the treatment of gas for transport, and subsea compressor plants.

Trend analysis of the evolution of technologies and equipment for development of shelf fields shows that nowadays, creation of a set of equipment allowing for the performance of all-subsea recovery, treatment, and transportation of gas is almost complete.

During the design of shelf facility arrangements, the most essential task is management of reliability and risks.

Based on the analysis of the main trends in the evolution of subsea gas technologies, Gazprom proyektirovaniye LLC has designed the concept of subsea development of gas fields of the Arctic shelf.

Gazprom proyektirovaniye LLC has created methods for the management of a reliability system of designed facilities allowing justification of the reservation level of elements and systems, determination of the needs of a process facility for spare parts, determination of labor intensity for scheduled and unscheduled maintenance and repair, and the development of design solutions on facilities of repair production infrastructure.

Based on the methods of reliability management, a research series of reliability analysis has been conducted and recommendations for the reservation of subsea equipment designed.
Underwater development systems operation under conditions of long-term inaccessibility

A.V. Melnik, A.A. Petrulevich
(Gazprom VNIIGAZ LLC)

The world has accumulated considerable experience in the use of underwater systems for development of offshore fields in ice-free conditions. The ideology for design and operation of these systems is focused on the rapid removal of underwater equipment failures when they occur as a result of underwater engineering operations.

For seas with long ice cover, during which underwater operations are impossible, there is no experience of underwater development systems operation. The inability to quickly eliminate failures, accidents and leaks of hydrocarbons arising during the period of inaccessibility may result in significant economic and reputational damage.

Successful operation requires additional technical solutions for remote monitoring and control of underwater development system, as well as more stringent requirements for the arrangement of maintenance. However, omissions in the comprehensive consideration of the above issues at the design stage, cannot be compensated by the activities in the course of operation.
Destruction of hydrate plug in offshore pipeline with pressure relief

N.A. Buznikov, V.A. Suleimanov
(Gazprom VNIIGAZ LLC)

Hydrate development is the most severe operating problems arising in offshore pipelines during transportation of multiphase fluid containing formation and waste water. At the stage of design, along with the measures on hydrate development prevention, the methods on removal of offshore pipeline blockage shall be provided in case of emergency hydrate blocks development.

We investigated one of the main methods of hydrate plugs destruction in offshore pipelines: gas discharge to purge plug included in the shore block valve station. Applicability conditions of hydrate plug destruction method were evaluated.

Pressure release was simulated using software system OLGA for several dummy pipelines of different length and sea bed depth. It is proposed that hydrate plug develops at the beginning of the pipeline in case of its long-term shutdown. Pressure release dynamics was investigated for various values of gas consumption at which the pipeline was operated before the stop.

The performed evaluation showed that restriction in the applicability of the pressure release method to remove hydrate plug relates to a hydrostatic pressure level by means of fluid column above the developed hydrate plug. It was determined that the pressure release method may not be applicable for destruction of hydrate plug in long pipelines with large volume of accumulated liquid phase as pressure value after the release may be over the balanced pressure of hydrate development.

It was demonstrated that there are some critical values of gas rate related with the possibility to perform operations on pressure release to destruct hydrate plug; this pressure depends on the sea bed depth, pipeline length, its route profile and transported fluid content. Critical gas rate rises with increasing pipeline length, and for long pipelines, it approximates the gas flow rate at which the transition to liquid accumulation mode takes place.
Investigation of problem for ice gouging impact on the buried pipeline by 3D modelling within the frames of computer system ANSYS

D.A. Onischenko (Gazprom VNIIGAZ LLC),
A.V. Slyusarenko (State Oceanographic Institute)

The paper presents some results on the study of the problem of stress-strain state (SSS) of the “soil – buried pipeline” system in the process of ice gouging of the sea bottom by ice keels. This problem is actual for the design, construction and operation of underwater pipelines in the seas in the ice conditions.

The simulation was performed using finite element method (FEM) with the computer system ANSYS. 3D (three dimensional) modeling was studied. The following was considered: the scenario of the ice keel horizontal displacement in the soil body comprising a pipeline located below the specified gouging depth, as well as model problems for vertical introduction of a rigid object in the soil body directly above the pipe. The model is implemented as parametric form that allows to change a keel shape and gouging depth, pipeline diameter and laying depth, as well as pipeline characteristics.

The main attention was paid to the case of a relatively natural soil with a high coefficient of adhesion such as stiff loam. For sufficiently wide keel with a sloping front edge, the effect of significant pipeline displacement as part of the soil body was determined, which led to a significant deformation of pipe walls due to its bending. It is noted that the maximum intensity of the soil impact on the buried pipe is observed when the keel is at a distance from the pipeline axis.

The developed model can be used to make the justified selection of pipeline laying depth under ice gouging for the given soil.
Methods for conversion of soft soil base properties at design and construction of oil and gas field offshore structure of the Russian Federation

S.V. Grekov, S.I. Golubin, K.N. Saveliev
(Gazprom VNIIGAZ LLC)

One of the most important problems related with offshore fields is to provide soil bearing capacity as reliable base for foundations of oil and gas constructions.

At the development of offshore fields of oil and gas of the Russian Federation, a problem of reliable bases consist in marine soils, as usual, represented by silty sands and clays with a lot of organic inclusions and silt. Almost all the soils are characterized by high porosity, low structural strength, low bearing capacity and high compressibility under loadings. Selection of the soil base on the Far East offshore is complicated by the fact that the soft soil is spread over large areas, their depth reaches 20–30 meters and according to Table 3, SP 14.13330.2011 “Construction in seismic regions”, this soil are sensitive to destruction in the form of liquefying at earthquakes of more than 6 scores.

In such a situation, the usage of offshore bottom sediments as a base is not allowed in unimprovement condition. Currently used methods to increase the bearing capacity of the base provide the complete replacement of bottom sediments to soil with specified properties (gravel base) at offshore fields, which use subsea extraction technology of oil and gas. This approach to the problem is not always justified from an engineering and economic point of view.

This article describes the modern methods and technologies of improvement of soft marine soil in-situ. These technologies make it possible to improve the soft soils, increase the soil shear strength and bearing at the site, without the need for excavation and replacement of the base soils.
Research of characteristics of submersible multiphase pump in gas-liquid and viscous media

V.S. Verbitsky, A.V. Dengaev
(Gubkin Russian State Oil and Gas University (NRU))

Currently there are different methods of bed stimulation in the world, the production of which is viscous oil and bitumen. In this paper, the method of steam assisted gravity drainage (SAGD) (Steam Assisted Gravity Drainage) is considered. For wells exploitation in the heated bed part, an electric submersible pump is dropped into the horizontal well bore. The well construction consists of the mouth, the axis of which has a deviation angle from the ground surface equal to 45 degrees, which allows easy dropping down the equipment. The exploitation issues of electric submersible pumps are steam breakthrough modes and viscous well products. In order to determine the possible consequences at the work of the electrical submersible pump in off-optimum conditions, the authors performed computational and experimental studies.

As a test object, a submersible multiphase pump assembly was used, which had been specially designed and manufactured for complicated conditions of wells operation being close to off-optimum SAGD modes. Flowing elements of the pump assembly were made of special polymer material. The pump is structurally different from mass-produced analogues in that the multiphase pump wheels have open impellers, which enhances the work opportunities of such pump when operating viscous fluids.

The results of bench testing of prototypes of new designs of multiphase pumps showed a stable work by increasing the gas content at the input of up to 40 % by volume. The results of computational and experimental studies indicate the possibility of equipping mass produced submersible electrical centrifugal pumps in SAGD wells with a multiphase section (with the amount steps of no less than 36).

The work is carried out within the Federal Target Program “Research and development in priority areas of the Russian scientific and technological complex in 2014–2020”, with the financial support of the Ministry of Education and Science of the Russian Federation, unique research identifier RFMEFI57714X0126.
Development and creation of test bench for thermal energy generator

M.A. Mokhov, V.V. Voronova
(Gubkin Russian State Oil and Gas University (NRU))

Development and creation of test bench addresses the relevant tasks of improvement of the efficiency of oil and gas production. One of the promising aspects of improvement of oil and gas production efficiency is related to recovery of the energy of compressed gas. Using special gas turbines the potential energy of gas can be converted into thermal energy or electric energy.

A new thermal generator was developed with gas turbine and heat transport fluid circulation circuit. Loop blades were used for development of the turbine. One of the specific features of the developed and patented turbine is the direction of the gas flow along the plane which is perpendicular to the rotation axis of the turbine. In the known turbines with loop blades the gas stream is directed along the turbine rotation axis. The obtained results offer the options for development of simpler and cheaper power units using the compressed gas energy for broader power range from several kW to hundreds of kW.

The main area of application of this solution is related to the oil and gas production facilities. At the same time some results can be used in other industries, for example, for development of machines for marine and air transport where reduction of the weight and improvement of reliability is especially critical.

The work is performed as part of applied scientific research with financial support of the Ministry of Education and Science of the Russian Federation (unique identifier RFMEFI57414X0129).
Development and arrangement of oil and gas fields of Arctic shelf is impossible without reliable rescue support.

Creation and development of rescue support system at sea of objects of survey, extraction and sea transport of Gazprom PJSC hydrocarbons is carried out in strict correspondence with international documents and Russian legislation.

For this purpose Gazprom PJSC conducts operations including:

– development of normative documents of Gazprom PJSC standardization system on rescue support;

– readiness inspection of marine oil and gas fields development projects for emergency management (comprehensive training exercises for marine and onshore field objects accidents management are carried out annually, including the ones on oil and oil products spill containment and response);

– organization of cooperation with departmental sea rescue services and formations during organization of rescue support and conducting of accident rescue operations.

Gazprom PJSC is actively involved in international cooperation on rescue support and emergency oil spill response issues, which is organized by directions:

– work in Arctic Council;

– participation on “Barents-2020” project.

Providing of ecological safety during development of oil and gas fields of Arctic continental shelf of the Russian Federation is one of the major priorities of Gazprom PJSC activity and requires special attention.
Condition and prospects of national rescue support in the Arctic

A.V. Marichev  
(Gazprom VNIIGAZ LLC)

The report examines the current condition of the national systems to ensure rescue support in the Arctic sub-sectors of Russia, Norway, Iceland and Denmark (Greenland). A review of major rescue forces and means and their locations is presented, capabilities for rescue operations on open water and in ice conditions are studied.

The analysis of works on the development of international, Russian and foreign regulatory documents in the area under consideration, are considered relevant research projects, involving various technical and organizational aspects of planning and carrying out rescue operations.

The progress of rescue works carried out in recent years in Russia and abroad is considered, and technical and technological problems that limit the effectiveness of rescue support systems are determined.

The conclusion about the need to develop functional requirements for rescue support system in the Arctic has been made, the works on the development of regulatory documents, design of rescue means, creation of new technologies and equipment will be planned on the basis of these requirements.
Technogenic safety control for offshore oil and gas production using neural systems

S.N. Mislavsky
(Consulting and Innovation Company Service VMF JSC)

Offshore oil and gas production especially in the freezing seas using both onshore and offshore oil and gas production facilities poses high technogenic and environmental risks.

Based on the analysis the prevailing factor of such risks are skills of the personnel including timely decision making within the competence. Due to the expansion of the activity and growth of offshore production the human factor problem becomes global.

In the modern conditions for prevention of the technogenic and environmental risks during all-year-round operations outsourcing of various resources and means is required. This resulted in the formation of contractual system with multi-tier competence system for evaluation of the readiness and mobilization of these resources within the framework of the existing emergency response plans.

Because of that the algorithmic solutions in situational management of technogenic safety are becoming more complicated and inefficient or completely impossible.

As a preventive measure it is proposed to implement integrated safety control systems using self-configurable and learning neural networks which will ensure high promptness and objectivity of decisions owing to the automatic classification of real situation including actions of the personnel, availability of fire and explosion protection systems, timely mobilization, readiness of resources and equipment, competence of persons in charge.

Integrated systems will function in combination with continuous monitoring, recording and analysis of all parameters of all resources and means not only on the facility but in the real time mode at a specially designed site.
On development of rescue equipment at marine objects in Arctic

V.N. Ilyukhin
(Association for Search and Rescue Technology Development)

Peculiarities, trends and main directions of development of individual and collective rescue equipment at maritime activities vessels in Arctic as priority direction of development of search and rescue forces and means of Russian maritime activities are examined. Active commercial development of Arctic region and significant increase in used workforce situated in complicated nature conditions of polar environment pose special requirements to conditions of individual and collective rescue equipment usage. Rough hydrometeorological conditions and imperfection of search and rescue system in Arctic zone make application of current and commonly used at the present time at oil and gas production platforms and sea vessels rescue equipment insufficiently effective. Multifactorial considering of environment conditions (water, air, wind) and various variants of accidents development defines structure and complement of individual and collective rescue equipment. Technical solutions for individual rescue equipment for marine objects in Arctic are offered. Multifunctional rescue apparatus of amphibian-type is offered as collective rescue equipment. Its advantages over current equipment are justified.
Pipeline repair systems (PRS): a robust solution to manage subsea emergency situations

M. Fontolan, F. Cavallini
(Saipem S.p.A.)

In an historical phase characterized by reduced oil price and distressed market, deploying means to maximise uptime is deemed paramount, both for brownfield/ageing subsea assets, as well as new developments. This is particularly true offshore and especially subsea, where technological implications are much evident with a greater impact as far as water depth increases.

Experience has shown that quite often threats represented by external interfaces (vessels, anchors, fishing gears) or unexpected environmental influence (extreme conditions, earthquake, seabed motions, etc.) may be extremely dangerous for production systems, with associated huge impacts to the environment.

This particularly applies to remote locations, where needed technologies and intervention assets may not be readily available to timely react to an emergency situation by deploying the most effective repair solution.

Establishing upfront an Emergency Pipeline Repair capability is therefore deemed to be the most effective way to develop a comprehensive production interruption policy. This shall leverage on reliable/field-proven equipment and technologies in order to address in a robust manner the peculiarities of remote subsea fields.
Development prospects of personal rescue equipment for low temperatures conditions

A.I. Kinnunen
(“Morskie Spasatelnye Sredstva” R&D enterprise LLC)

Preamble of the report presents brief description of “Morskie Spasatelnye Sredstva” R&D enterprise, that specializes on researches, development and production of rescue equipment, including rescue drysuits, for over 20 years.

The main part of the report begins from analysis of current Russian and foreign rescue drysuits as primary personal rescue equipment for marine objects personnel, general specifications of produced rescue drysuits are specified. Conclusion on non-correspondence of current rescue equipment to Polar code requirements and necessity of a new product development is made.

Main stages of development of Arctic drysuit additionally equipped with small-size personal device for distressed person localization and personal survivor set are examined further.

Currently used materials and their thermal properties, including volume nonwoven materials, in personal rescue equipment are analyzed. Studies of heat-retaining isolation for double circuit drysuit and comparison plot of heat-retaining properties of thermal isolation circuit packages of drysuit from various materials are given.

Issue of necessity of drysuit equipping with small-size satellite communication, providing effective localization of a person in emergency, is examined.

In the end of the report the issue of necessity of personal survival package creation used combined with drysuit for Arctic conditions is examined.
On development of collective rescue equipment at ice-resistant offshore platforms

S.D. Popov
(Scientific and Production Center “Special machinery” of Moscow State Technical University named after N.E. Bauman)

Shelf of freezing Arctic and Far East seas of Russia is characterized by harsh hydrometeorological and ice conditions in the regions of oil and gas offshore fields. Overall the problem of creation of effective collective rescue equipment for abandonment and rescue from emergency marine objects under ice conditions is not resolved until the present. Prospective equipment should not only timely provide emergency object abandonment by personnel and crew during emergency situation appearing, but also distancing from emergency object at a safe distance over ice and water for saved persons transfer to search and rescue support forces. According to experience of search and rescue operations conducting, this condition non-compliance significantly reduces possibility of people rescue. Analysis shows that the majority of developing or current rescue equipment cannot provide assured rescue of ship crew and marine engineering structures during emergency or accident. Usually loss of lives happens before search and rescue support forces arrive to emergency object.

Realization of required possibilities of collective rescue equipment of amphibian type is possible upon condition of its allocation directly on marine objects, however existing organic (on-board) CAC of ships and drilling platforms are not capable of providing these requirements fulfilling under ice conditions. Usage of air means of rescue (helicopters) is possible and efficient not in all cases, and concerning the whole set of marine objects the helicopters usage during emergency is impossible.

Development of collective rescue equipment of a new type for personal leaving the marine objects, including under ice conditions, should contribute to solving one of the most important social problems related to development of Arctic and Far East regional sectors of Russia.
Challenging issues of oil spill response in Arctic and main directions of their solutions

A.B. Fedorov, N.N. Shalagin
(The State Research Navigation-Hydrographic Institute)

Oil spill response requires heavy spendings and efforts under any circumstances, and Arctic conditions create additional difficulties related to environmental protection and logistics. At the same time unique peculiarities of Arctic environment in some cases contribute to spill response. Effective usage of existing technologies and equipment during reacting in certain cases depends on several factors, such as:

– attempt to cope with dynamic nature and unpredictability of ice;
– remoteness and large distances to overcome during response operations in such regions as Arctic;
– low temperatures, ice and complicated operating environment impacting on liquidators and equipment used during response;
– lack of shore infrastructure and communication systems that could contribute to effective response.

There is a reasonable necessity in improving of domestic oil and oil products spill response system. Current condition of forces and means of basin emergency authorities does not correspond to rapidly growing level of oil spill danger in Arctic. Creation of the Program of technologies and equipment creation for oil, oil products and gas condensate spill response will allow significantly increase emergency system efficiency and level of ecological and industrial safety during operation at Gazprom PJSC shelf.
The Arctic marine environment is one of the most diverse in the world and is recognized on a global level for its sensitivities and vulnerability. Operations in this region need to be able to overcome many environmental challenges (ice, temperature, light) whilst preserving this environment for the myriad of organisms that are dependent upon it for long-term survival. The frontier basin of the Arctic is in a unique situation to consider environmental safety upfront, during the design phase. Xodus Group believes that there is a real opportunity to improve environmental safety over the life of the asset by integrating environmental considerations within a project, rather than allowing it to exist as a silo process or report. This process can be invaluable to the success of a project and in turn safe operation of the asset. The value of this approach is that it ensures environmental safety whilst minimising costs over the life of a facility by allowing design measures to be implemented to remove or reduce impacts early in the project cycle. In addition, embedding a robust environmental philosophy in to the corporate and project management cycle can lead to both major reputation and performance benefits at later stages of the project.

Xodus will describe a range of quantitative environmental tools that exist for assessing environmental hazards and risks which when properly applied by specialists, alongside a thorough understanding of both the environmental and regulatory landscape, can inform project decisions. It can assist with balancing CAPEX and OPEX, reducing project risk and engineering risk, contribute to the identification of critical preventative, control and mitigation measures, safety environmental critical equipment, and ultimately the management of environmental risk from concept selection to decommissioning which is key in such a diverse and exciting natural environment as the Arctic.
Environmental safety during hydrocarbon field development

O.A Nikolayev, V.V. Mironov, A.K. Arabsky, L.A. Solovischuk
(Gazprom Dobycha Yamburg LLC)

The Far North tundra is extremely sensitive to the man-made impact and requires significant efforts for the conservation and restoration of disturbed natural landscapes in the area of business activity.

The Company is planning to develop and explore hydrocarbon fields within the water area of Gulf of Ob and Taz bay: Severo-Kamennomysskoye, Kamennomysskoye-more, Chugoriakhinskoye, Obskoye, Semakovskoye, Antipayutinskoye, Tota-Yakhinskoye, Severo-Parusovoye and Yuzhno-Parusovoye fields. With the unique experience of developing the northern fields in the absence of infrastructure, the Company will ensure compliance with the most stringent requirements of environmental safety standards and spawning grounds of valuable fish and vulnerable Arctic nature. It is based on the unique technologies developed together with a number of institutes and protected by 93 patents of the Russian Federation.

The guaranteed level of environmental safety will be provided by modern equipment and technologies, the best practices of drilling wastes handling which minimize negative impact on the environment including enforcement of environmental law and execution of deep-sea disposal of wastes principle.

Environmental monitoring of compliance with all the necessary process standards and rules of construction and operation of the pipeline system will minimize the risk of accidents.

Therefore, Gazprom Dobycha Yamburg LLC sets the goal of environmental safety during implementation of project for development of the Gulf of Ob and Taz Bay fields at all stages of their life cycle: design, development and operation of facilities.

Achieving this goal provides for the solution of complex organizational and technical issues related to the environmental safety and management during the construction and operation, as well as the set of issues on environmental rehabilitation.
Hazardous sea disturbance at potential subsea pipeline landfall sites and points of oil production platform installation at the shelf

P.D. Kovalev, D.P. Kovalev
(Institute of Marine Geology and Geophysics, Far-Eastern Department of the Russian Academy of Sciences)

Possibility of exploration drilling and hydrocarbon production at the shelf, and construction of subsea pipelines with landfall depends substantially on the disturbance mode of a specific area. Several types of sea disturbance exist that can pose a threat to engineering facilities at the shelf and littoral area, and thus a preliminary study of disturbance mode at the operation site is required.

Main types of disturbance posing threat to safe operation are considered on the basis of studies performed by the authors. Major threat is also expected from storm surges, non-periodic variations of sea level due to meteorological phenomena, such as ground atmospheric pressure and wind speed variations. In that case, sea level rise can reach one meter, and surges exceeding a half of meter are considered dangerous. Wind wave and ripple impact increases greatly at its background.

Seiches play also a large part in dynamics of bays and coves and affect operation conditions of the shore ports and other industrial facilities greatly. For most coves, resonance periods are close to characteristic periods of tsunami waves, so that tsunamis become mainly a spurt of seiches.

Infragravity waves are formed in littoral area and at the shelf as a result of non-linear interaction of wind waves and ripple and play a part in shore destruction. Also, they facilitate generation of rip currents, a forceful reciprocal water movement in open bays, causing impacts of ships against each other or berths, tear of mooring lines and disturbance of cargo handling operations.
Issues of LNG plants industrial safety in Arctic zone

A.A. Leskonog, G.Yu. Churkin
(Agency for the Research of Industrial Risks ANCO)

LNG industry, being one of the fastest growing oil and gas industries, is defined by continuous LNG plants capacity growth due to increase of performance and number of LNG liquefaction production lines, volumes increase of LNG insulated storage tanks. Meanwhile foreign and native LNG plants fire and explosion hazard management normative base is almost not corrected to reflect plants dynamic development. It may result in major industrial accidents at LNG plants. Within this framework the issues of rapid development of R&D and LNG plants industrial and fire safety management normative base are of significant value.

As a result of LNG normative base analysis it was revealed that marine LNG and GC dispatch terminals are the least covered by industrial safety requirements structures as a part of LNG plants. This is due to the fact, that normative coverage of LNG and GC dispatch terminals industrial safety is interfaced by normative bases of isothermal storage and sea transport of LNG, which are developed almost independently of one another.

The most important aspects of LNG and GC dispatch terminal industrial safety standardization are:
- LNG and GC dispatch piping staging;
- loading arms of LNG dispatch to tankers with systems of safety and emergency disconnection of loading arms from tankers in case of per-emergency or emergency;
- terminal emergency shutdown device (ESD) based on concept of cooperation of terminal and tanker ESD during LNG dispatch operation;
- prevention of gas pollution and leaks at terminal;
- LNG emergency drainage and protection from cryogenic spillage;
- personnel safety providing at the terminal during cargo operations, customs and border services safety providing during their allocation on the territory of LNG and GC dispatch terminals.
Model of thermoelastic state dynamics of sea ice

A.N. Chetyrbotsky
(Far-Eastern Geological Institute of the Far-Eastern Department of the Russian Academy of Sciences)

Efficiency boost of hydrocarbon exploration and production at the shelf of freezing seas is mainly determined by reasonable combination of properties and parameters of natural objects, high strength of sea ice, in particular. True, this quality is widely used for placement of various equipment, offshore berths, air fields, etc. At the same time, more information on spatial and time dynamics and forecast of the current state are required for actual utilization of vast expanses of sea ice.

Adequate presentations of this state are defined by correlations accounting for effects of external environment of the sea ice (atmosphere and sea interfaces) and physical state of the ice itself. A wide range of relevant solutions is developed in the practice of spatial and time dynamics simulation. Here, results of studies are used for simulation of ambient effects. Thermoelastic state of sea ice is determined by Navier equations:

\[
\rho \frac{\partial^2 u}{\partial t^2} = (\lambda + 2\mu) \nabla (\nabla \cdot u) - \nabla \times \nabla \times u + \rho g - \alpha \nabla T;
\]

\[
c\rho \frac{dT}{dt} = \nabla \cdot (D_T \nabla T) - K\alpha T \frac{\partial}{\partial t} (\nabla \cdot u);
\]

\[
\nabla u|_\Gamma = f_u(X|_\Gamma, t), u(X, 0) = u_0(X), T(X, 0) = T_0(X),
\]

where \(\rho, c\) is density and specific isobaric heat capacity of ice; \(t\) is time; \(u \equiv u(X, t)\) are current shifts in the ice layers, caused by stress; \(X\) are coordinates used in the sea ice layers; \(\lambda, \mu\) are Lame constants; \(g = (0, 0, 9.8)\) is a free fall acceleration vector; \(\alpha, K, D_T\) are thermal expansion, bulk elasticity modulus and diffusion factors; \(d/dt\) is a substantial derivative of time; \(T \equiv T(X, t)\) is ice temperature; \(\Gamma\) is the area border; \(f_u(X|_\Gamma, t)\) are conditions at the medium interfaces; \(u_0(X), T_0(X)\) is initial condition.
Assessment of ice drift speed at north-east shelf of Sakhalin island
by radar measurement data

G.V. Shevchenko (Institute of Marine Geology and Geophysics
of the Far East Department of the Russian Academy of Sciences),
V.S. Tambovsky (Ecological Company of Sakhalin)

Results of many years of ice drift monitoring by three radars erected at
the North-East shore of Sakhalin – Levenstern cape (1992–1996), Odoptu
measurements were supported by materials of instrumented current speed
measurement, spatial variation of ebbtide drift with extremely complex nature
due to the presence of diurnal shelf waves (topographic Rossby waves) in that
region was studied.

Seasonal variation of non-periodic drift component reaching its
maximum in south direction in January-December (strong stable N and NW
winds, active Eastern Sakhalin Current) and decreasing slowly by the end of
ice season was studied. Within two-dimensional regression model, wind
factors were calculated, their stability for each radar station shown in
calculations for different years.

Extreme ice drift speed of rare occurrence (over 2 m/s) was calculated
by composition of ebbtide and non-periodic component distributions. Values
obtained can be used in assessment of potential loads on ice-resistant
foundations of drilling platforms and other facilities of oil and gas production
center.

Obtained harmonic constants of ebbtide drift and wind factors were used
in online calculations of drift for single extreme ice formations. Special
attention is paid to the effect of late (late May – early June) offset of heavy ice
to the water area of North-East shelf already cleared of ice cover. That ice can
move against the wind adjusted to summer monsoon with South winds
prevailing, and cannot be forecast within the model proposed.
Use of the regional weather forecast system of COSMO-Ru for studying hydrometeorological conditions at the Okhotsk sea shelf: detailed fields of meteorological elements for years 1985–2015

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M.I. Varentsov, A.V. Kislov, V.S. Platonov
(Lomonosov Moscow State University),
M.M. Chumakov (Gazprom VNIIGAZ LLC)

The reliable meteorological data are needed when designing and ensuring the safe operation of oil and gas field facilities at the Okhotsk Sea shelf. Currently, the data of ground meteorological observation network may incorrectly reflect the atmospheric processes at a considerable distance from the coast, and the data of global reanalysis (e.g., NCEP/NCAR and ERA-Interim) are characterized by a fairly low spatial resolution, and therefore the values of extreme wind characteristics are substantially underestimated in the reanalysis data.

The report shows that the regional weather forecast system of COSMO-Ru can be used to obtain reliable meteorological data. Using the mesoscale downscaling method and ERA-Interim reanalysis data as the initial and boundary conditions, highly detailed fields of meteorological elements from 1985 to 2015 throughout the Okhotsk Sea with a spatial resolution of 13.2 and 6.6 km were calculated. The obtained data analysis allowed the identification of fifteen extreme weather patterns characterized by the highest values of wind speed in the water area of the central part of the Sakhalin east coast. A modeling with a grid step of 2.2 km was carried out in order to specify the maximum wind speeds at the development of the identified situations. It is shown that the wind speeds increase in most cases when reducing the grid steps.
Sheet ice on the Okhotsk sea shelf – the problems of identification and potential threat to marine structures

S.V. Pisarev, A.S. Tsvetsinsky (State Oceanographic Institute),
D.A. Onischenko (Gazprom VNIIGAZ LLC)

In March – April 2016, FGBI GOIN carried out complex research expedition work at the Okhotsk Sea shelf. The aim of this research was to obtain information for modelling and correct determination of regular and extreme characteristics of ice and hydrometeorological processes required for the subsequent determination of design loads on projected and prospective resettlement facilities of South Kirinskoye field (SKF). The research covered a vast water area of the eastern shelf of the Sakhalin island, included the measurement of various parameters of ice formations (IFs) being vast ice floes (potentially, with the greatest thickness), fields of deformed ice and ridges. The research was conducted by landing of experts with complete sets of equipment to IFs, as well as from the board of an icebreaker ship (IBS) and from a helicopter, with the help of an unmanned aerial vehicle (UAV), 17 freestanding ice-marking buoys and a submersible. The analysis of satellite images of various types was performed. Apart from a few terabytes of digital and visual information, it was confirmed that it is necessary to have at least the simplest visual observation from “the close distance” – from the floe, the ship, the low-flying helicopter or UAV, in order to perform the correct interpretation of remote sensing of ice from a satellite or an airplane. For instance, many IFs at satellite images and from the helicopter flight altitude of 200 m had been previously identified as flat one-year ice with a thickness of 70–80 cm. However, at closer examination (from a distance of 10–30 m or less), it turned out that IFs are structurally composed of 4–5 layers of one-year sheet ice and their total thickness is more than 3 m. The research of these IFs clearly showed that their weight is at least 3–4 times greater than the one of ice-fields of flat non-deformed one-year ice of a similar horizontal size. Such IFs can be potentially definitive in terms of design situations taken into account at the facilities design.
Approaches to the environmental monitoring and monitoring of biodiversity conservation at the Arctic shelf

O.I. Zemlyanova  
(FRECOM LLC)

The purpose of the operational environmental monitoring is providing organizations (subsoil users) with information on the environment state and pollution, which is needed by them to carry out activities to preserve and restore the natural environment, rational use and reproduction of natural resources, prevention of the negative impact of economic and other activity on the environment and elimination of its consequences.

In accordance with request of the President No. ПР-1530 for the Arctic, programs for the conservation of biological diversity are implemented in addition to the operational environmental monitoring.

The basis of the works are “Programs of conservation of biological diversity on the basis of the list of species of flora and fauna being the indicators of a steady state of marine ecosystems of the Russian Federation Arctic zone” developed by license holders.

The environmental monitoring and monitoring of biodiversity use both field (contact) and remote methods (e.g. satellite imagery interpretation). Both methods have positive and negative features. The field methods allow a direct assessment of the situation in the working area and sampling. However, they do not ensure the constancy of observations. Thanks to remote methods it is possible to perform the continuous monitoring, with no dependence on seasonal agricultural works and the coverage of a vast area. However, a direct measurement of the natural environment is not possible.

The unity of the methods of environmental monitoring and biodiversity conservation programs enables to use them together. A part of environmental monitoring works is also included into the biodiversity monitoring program (the study of phyto-, zoo- and ichthyoplankton, benthos and ichthyological sweeping). Activities within the common travels will provide more representative and comparable data than the fulfillment of works in the licensed areas at different times. In addition, receiving of a part of the biodiversity data within operational environmental monitoring and control and the use of a single logistic scheme has a positive economic effect.
Problems of site selection for LNG plants (projects: Pacific Northwest, Vladivostok-LNG, LNG plant near Klykov peninsula)

V.V. Afanasiev  
(Institute of Marine Geology and Geophysics of FEB RAS)

It was supposed to build liquified natural gas production plant in Primorye in Lomonosov peninsula near Perevoznaya bay of Khasansky District. Despite the project is postponed indefinitely, it should be noted that we have discovered siltstones, easily damageable in sea water, here at shoreface. This sort of thing we have observed at dredging in Aniva bay during LNG plant construction. Due to the fact that composition peculiarities of hard rocks (easy swelling siltstones) extracted during dredging were not considered, area of bad influence on ground species as a result of bottom surface covering by loose deposits was many times higher than design value.

Authors of Pacific northwest project in Skina river mouth (British Columbia) claim that impact and risks for environment and biota of Skina river estuarine zone were minimum, however they did not provide any information on forecast of inshore water circulation changes as a result of ground relief change. Projects authors are optimist, however 16 m² of intertidal soft bottom habitat at Lelu Slough is an obvious dissimulation. In conditions of 7 m floods and corresponding flow velocities the trestle supports should be strengthened and these structures will occupy hundreds of m². They also do not take into account lythodynamical situation changes resulted by deformation of ground relief, coastal circulation and additional volumes of solid flow from areas affected by ground pipeline. This is highly dim sighted in conditions of highly-energetic seashore. Besides, near Kitson Island in a sea cliff we have defined siltstones easily damageable in sea water.

Currently the situation with LNG plant near Klykov peninsula (De-Kastri) has been cleared up for the better. We have not discovered water seepages, testifying for suffusion, in a sea cliff of assumed site area in contrast to adjacent area.
Catastrophic tsunami waves are an immense threat to shore settlements of Russian Far East. The hazard is highest at the Pacific shore of Kurily islands and Kamchatka Peninsula, the waves reaching Sakhalin are weakened significantly by passage through Kurily straits. For that reason, hazards to oil and gas industry facilities located at the North-East shelf and various shore sites of the island is largely underestimated.

In this study, specific features of tsunami at Sakhalin shores, including combination of tsunami with ebbs and tides, are viewed on the basis of materials of instrumented observations by sea bottom recorders and archive of digitalized tidal curves. At the shore of Sea of Okhotsk, main attention is paid to the most dangerous event related to remote catastrophic earthquake at the Chili shores on May 22, 1960. E.g., in Aniwa Bay, large height of tsunami (1.8 m) was caused by amplification of low-frequency resonance mode of the basin with a period of ca. 5 hours. In general, resonance properties of bays, coves and shelf and related local amplifications are crucial for the nature of tsunami manifestation at the island shore. Thus, in Kholmsk port, all tsunamis, including the most dangerous Nevelsk tsunami of 02.08.2007 at the south-west shore of Sakhalin, were manifested mainly in amplification of resonance mode of the bay with a period of ca. 8 minutes.

One of the key factors of tsunami impact on drilling platforms, pipelines and other structures includes ice fracturing and violent movement of ice formations (ice fields, heavy hummock ice, etc.). For example, shore ice belt fracture in Mordvinov Bay during Toohoku tsunami of March 11, 2011, required prompt evacuation of several thousands of fishermen, and the event was characterized by ice fracture and casting onshore in river estuaries.
Web service-based meteorological support

Yu.I. Yusupov
(Research and Production Center “MAP MAKER” LLC)

Weather affects shelf exploration surveys, gas and oil production and offshore field operations immensely.

As a science of atmosphere, meteorology is actively developing IT for hazardous event forecasting.

For more than 25 years Russian company Research and Production Center “Map Maker” has been leading the market of hydrometeorological and related services and is a founder of IT meteorology, a meteorological area absolutely new to Russia.

Contemporary data technologies and solutions of Research and Production Center “Map Maker” provide required meteorological data to a customer by using weather web services. Weather web services is an up-to-date method of meteorological support.

Various weather data are displayed on a basemap (GIS system) of the customer in the form of SHP and GEOJSON shape files. Forecasts are made by Map Maker. Data exchange is implemented via an FTP server. Ground resolution up to 1 km is available.

Our company, Research and Production Center “Map Maker”, uses its own forecast center, powerful computation resources and staff of highly qualified meteorologists and programmers.
Real-time forecast of tsunami in the Far East

Yu.P. Korolev
(Institute of Marine Geology and Geophysics FEB RAS)

The coast of the Far East is subject to such dangerous natural phenomenon as the tsunami. Not only local tsunamis occurring in the Kuril-Kamchatka zone in the Sea of Japan, but also distant ones occurring, for example, off the coast of South America are dangerous. Tsunami is danger not only to the population, onshore facilities, vessels at berth, but also to facilities near the shoreline, on the shelf.

Real-time forecast of tsunami is unresolved problem to this moment. The task urgency will only increase in the future due to the development of the middle Kuril Islands, the shelf of the Far East seas not occupied at the moment. The problem is warning services announce not only justified general alerts, but also those which are differentiated by the degree of risk for specific sections of the coast. According to modern concepts, tsunami alarm should be announced only in those places where the tsunami is a real danger, and supported by information on first wave arrival time, wave height, waves quantity and time intervals between them, maximum wave arrival time and height and on the expected time of the tsunami completion (tsunami alarm over).

The proposed method of real-time tsunami forecast allows to give the detailed advance forecast of the expected tsunami at any point based on information about the tsunami in the open ocean (e.g., obtained by deep bottom stations). The method functions in the real-time mode. To make the forecast of the Seismological Service, data on the earthquake start time and location at the epicenter are required only.

The efficiency of the proposed method was checked based on the examples of near and distant tsunamis (e.g., Tohoku 2011, Chile 2010, 2014). The method can be used not only by the centralized tsunami warning service, but also by any point, facility if it is able to receive real-time information on tsunamis from distant monitoring stations in the open ocean.
Peculiarities of morpholythodynamics on shores of subarctic seas during cold period

V.V. Afanasiev
(Institute of Marine Geology and Geophysics of FEB RAS)

We have noted that in conditions of homogeneous sea cliff with comparable parameters of a beach (main wave suppression structure) and hydrodynamic drag the most intensive wash out happens in November – January. During that period at the upper levels of beach profile, that are wave suppressing for storm conditions with maximum tide water, beach deposits freezing up to depth of 40–50 cm and associated wave suppressing (mainly drain and roughness) properties decreasing are happened. As observed, warming effect of a sea during intensive hydrodynamic event period does not recover wave suppressing beach properties on time and overwash elevations height increases by 30–45 %. However the calculations have showed that for sand and gravel beach swash height is 2.21, and for smooth (ice) slope with the same morphometrical parameters swash height is 5.67 m.

Formation of stable coastal icing and fast ice is happened about 1.5–2 months after beach deposits freezing and whole period of “open sea” morpholythodynamical processes in beach-sea cliff system are significantly active.

At the stage of icing formation, according to math modelling and field studies, increasing of slopes of a neighboring part of shoreface is happened. Oversteepening of a beach profile and depths in swash zones correspondingly results in increasing of overwash height.

With fast ice forming during tidal sea conditions offshore deformations increase is happened under fast ice. Probably as a result of strengthening of flows tidal components.

Considering abovementioned, we consider that an opinion on stoppage of active morpholythodynamical phase of shore development at temperatures transition to average daily minus elevations is a mistaken one. Detected peculiarities of subarctic seas shores development should be considered at the stages of survey, design and exploitation of the objects at shore.
Oil spill vulnerability assessment of shores of the Pechora and Kara seas

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An analysis of own and published data on the shores morpholithodynamics, as well as cartographic materials, shows that the most important general conditions of formation of the Pechora and Kara Seas shores are: geological and geomorphological heterogeneity of the coast and a ice coverage of the seas which significantly limits the intensity of the impact of sea waves on the shore. The formation of the Kara Sea shore relief is also noticeably influenced by cryomorphogenesis processes.

According to the recommendations of the International Petroleum Industry Environmental Conservation Association (IPIECA), the environmental sensitivity index (ESI) should be used in the preparation of the shores oil spills vulnerability maps, which is based on indicators developed by Gundlach and Hayes (1978). The essence of the basic principles is that the sensitivity to oil increases depending on the shore shelteredness from waves impact, the penetration of oil into the underlying sediment layer, the time of the natural oil retention on the shore and the biological productivity of shore organisms.

Depending on the complex of nature factors there are the categorization of shoreline sections of the Pechora and Kara Seas according to the degree of oil pollution vulnerability and maps of the shores vulnerability.

The most vulnerable are accumulative shores with gravel and pebble beaches, open lagoon accumulative shores and wind foreshores protected from heaving. Gravel and pebble beaches are characterized by highly permeable substrate with the penetration of oil to a depth of up to 100 cm. The oil may remain there for years. Shallows and foreshores protected from heaving are zones of high “biological activity”, which is manifested in a combination of high productivity and bioturbation. The threat for the biological community can be substantial, especially for infauna, which in turn can lead to food resources degradation for other animals.
Priorities of development of environmentally sound methods
of hydrocarbon spill response in arctic conditions

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This article describes the problem of the creation and use of efficient and environmentally friendly technologies for oil spill response. As the practice shows, marine oil spills have serious consequences for the environment and economic complex. Risks of accidents accompanied with the pollution of environmental components, even at high levels of organization of facilities of production, transmission, processing and storage of hydrocarbons, are always actual. In the conditions of the Arctic shelf, these risks can become catastrophic. When developing strategies and plans for oil spill response, including in terms of used technologies and technical means, specific climatic, oceanographic, environmental, logistic and other conditions and limitations of the Arctic regions must be taken into account.

The article provides the analysis of the current level of development of means and methods for the hydrocarbon spill response in the conditions of Arctic seas. Many of currently used methods are insufficiently effective and carry a potential risk of secondary pollution.

The author examines problems and future directions for research projects in the field of the highest practicable environmental friendliness of oil spill response technologies. There is the description of the experience of Gazprom VNIIGAZ LLC in the development of technologies for hydrocarbon spill response on land and in water areas of Arctic seas, water treatment and disposal of oil sludge.
Gas condensate spill behavior under ice conditions

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Considering increase of oil, gas and condensate production at Arctic fields and corresponding increase of traffic of oil and gas condensate tanker transportation along Northern Sea Route, risk of hydrocarbons spill in Arctic seas is also increased. It is necessary to study various factors to create effective methods of hydrocarbons spill control: physical and chemical properties of product and processes arising during spill, environmental conditions (ice condition, steam and wind speed, air and water temperature, etc.), potential spill volumes, detection and response equipment efficiency under these conditions.

The purpose of the following report based on results of detailed study of Russian and foreign literature on hydrocarbons spill (studies of behavior, mechanisms of propagation and transformation of hydrocarbons under Arctic conditions) is detecting of main gaps in knowledge and technologies of their prevention and liquidation.

Russian regulations on composition and content of oil spill response plans (OSRP) include all types of liquid hydrocarbons (raw oil, various oil products, gas condensate) in “oil” term, however we think that for gas condensate (stable and non-stable) spill response it is necessary to develop special technologies different from standard OSRP, increasing efficiency of spill response considering the following behavior peculiarities of gas condensates from other oil products:

1. Gas condensate spill mechanisms under Arctic conditions.
2. Gas condensate transformation processes in spills (evaporation, biodegradation, emulsification, dispersion, etc.) under low temperatures of Arctic shelf.
4. Hydrometeorological and ice conditions impact on spill behavior.
The Arctic in the global oil and gas industry development in the conditions of low energy prices

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The matrix of the evolving global balance of liquid fuel is extremely complex and multifactorial. It involves various types of hydrocarbon resources and deposits of different genesis: the traditional (Middle East, North Africa, Russia and other regions), the deep-water oil fields, tight (light tight) oil of the United States, oil sands in Canada, extra heavy oil of Venezuela, etc.

Each of them differs not only in the amount of resources and their quality, but also in the cost of production. Accordingly, the profitability of their development is largely determined by the level of existing and prospective oil prices, which depend, in turn, on the vast number of different factors, both fundamental and attendant, including the monetary ones.

In the conditions of the energy surplus the main task consists not in the energy as such, but in the minimization of the total costs borne by the society for these purposes. This leads to fierce competition among the various sources of conventional and unconventional hydrocarbons, and between hydrocarbon and non-hydrocarbon energy in general, especially strong in light of low oil prices.

The main purpose of the refusal of OPEC to reduce oil production in 2014–2015 was the pushing out from the market of the producers with significant costs, primarily the United States with their shale oil. However, the low prices primarily affected the projects related to the development of deep-water fields and Arctic shelf.

In the coming period, in the scenario of low oil prices, the matrix forming the balance of the world liquid fuel will primarily be determined by the competition between the newest technical and technological solutions in terms of hydrocarbon production on the Arctic shelf and increasing oil and gas producing fields and development of unconventional sources of oil and gas. These results will permit to find the optimal ratio of each of these areas of oil and gas.
On new economic conditions of hydrocarbon offshore fields development

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Currently domestic prices or export prices are used for economic evaluation of offshore gas fields depending on planned directions of products realization. Domestic prices are traditionally formed by methods of planned economy. They are established directive and envisage recovery of expenses on gas extraction and transportation, as well as appropriate profit taking. World gas prices are formed in relation to competitive energy source price – usually oil products. They significantly exceed domestic prices.

In our country the idea of gas equally efficient prices forming is discussed for about 10 years. Work on gas open trade development on domestic market can be considered as the first attempts of transition to market relations in this area.

This problem solution can have significant impact on providing of economic efficiency of investments in development of offshore gas fields characterized by increased level of costs for arrangement.

Economic sanctions directly influence offshore fields development costs, significantly limiting access of domestic companies to technical means for offshore fields’ development. As the result the necessity of domestic manufacturers’ orientation arises. However it should be considered that time for creation of brand new for Russian manufacturers’ equipment, as well as the fact that production of practically experimental specimens is always significantly more expensive than production models.

The law has introduced classification of new offshore fields for the purpose of taxation of extracted hydrocarbon raw materials. Ad valorem tax rates, dependent on calendar dates, commercial production start date and HC type, are introduced to calculate MET. Besides, the discounts are provided for other types of taxation. New tax system testing showed that for some regions it does not stimulate fields’ development.
Development of hydrocarbons deposits at Russian shelf sea is a new promising direction for oil and gas industry. Currently at the largest native shelf sea defined by highly diversified natural and climatic and geological conditions only 8 oil and gas deposits are developed. As a result there is no representative data base for basic standard costs grounding in the country.

At the same time many foreign countries already have significant experience in marine deposits development in different conditions.

Under the circumstances we have to use foreign normative base adapted for Russian water areas for costs calculation. This base is formalized in QUE$TOR software made by HIS company, that provides development objects modelling at Russian Federation coastal shelf. However long-term experience of this package applying shows that obtained cost parameters are far from actual investments.

To improve this situation we have developed method of QUE$TOR data correction.

It is based on applying of coefficients, defining correlation of investments for various directions of deposits development by software data and Russian deposits costing. Meanwhile costs for identical technical parameters of marine deposits development systems are always compared. Then, using QUE$TOR, costs changing related to technical parameters change with regard to basic ones are considered.

Besides, if it is necessary to consider possible dollar rate change related to foreseeable world market oil price level, share of Russian manufacturers in marine deposits development system production is additionally considered.
Main features and challenges of taxation in development of offshore hydrocarbon fields in the Russian Federation

V.A. Krivolapov (Gazprom VNIIGAZ LLC)

One of the most important criteria for investing in the development of oil and gas resources is the stable and transparent tax system of the country. Constant change in volumes of seizure of oil and gas companies profits through the tax, as well as a high proportion of the mineral extraction tax (MET) in the total structure of costs are one of the factors limiting investments in the development of new offshore fields.

The disadvantages of the current tax system can also include the proposed grouping of new offshore fields by geographic location, as well as the dislocation of ad valorem tax rates in different regions.

The tax system of new offshore fields can be improved by means of transfer of grace period commencement of action at the time of field commissioning. This will be a significant step to facilitate the company’s activities (currently, a grace period is valid from the date of license issue).

In terms of corporate multi-level management structures, oil and gas companies cannot reduce the financial risks for new offshore fields at the expense of other financial income, as losses on each new deposit shall be considered separately.

The non-transparent system of natural gas excise tax creates additional problems in assessing the cost-effectiveness of projects, as its estimation shall be provided by international contracts of the Russian Federation.

One of the expansionary actions to increase the production of natural gas could be the implementation of flexible customs tariff regulation in calculating the gas export duty similar to the rates for oil.

The creation of the balanced and fair fiscal system as a whole and the tax system particularly is one of key factors for attraction of investors to participate in the development of prospective projects.
One of the response measures of Gazprom PJSC on emergency in the Gulf of Mexico was creation of the system of emergency response support of subsea fields within Gazprom PJSC.

Nowadays, the ERS system functions; work continues on increasing of its efficiency, reducing of costs on its functioning. Amount of costs is very significant. Reducing of costs is possible for several directions. It is reasonable to attract economical potential to solving issues on reduction of costs on the ERS system functioning.

The report contains several directions of work on reduction of costs on maintenance of the ERS system.
Regulatory control of engineering and geological surveys at shelf during development of oil and gas resources at Russian shelf

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Condition of shelf survey normative base is unsatisfactory. It is caused by nearly destruction of standards system that existed during Soviet times. Traditionally the necessary requirements had state status in the form of SNiP, Sets of Rules, methodological recommendations and other documents of construction industry (where surveys are in the chain: construction-design-survey). FZ-184 “On technical regulation” practically cancelled existed system and offered implementation of technical guidelines and technical regulation system. Mainly they did not replace Construction norms, being substituted by various orders and regulations of the government and industry ministries on necessity of application of certain existing regulations and standards.

Along with this, for shelf operation SP 47.13330.2012 – “Engineering survey for construction. Basic principles” – updated version of early existed SNiP 11-02-96, was issued in 2012. Set of Rules was initially issued as an optional usage document, but from 1.07.2015 by order of the government No.1521 it became mandatory to use. SP 47.13330.2012 provoked a lot of disputes along practising geologic engineers as it contradicted to established standardization system, terminology and by its content it tried to include all possible operations, type of operations and regulatory documents. It is no wonder that after three months it was included in Ministry of Construction plan for normative documents remaking and updating (order No.470). Currently it is updating, as well as SP 11-114-2004 “Engineering surveys at continental shelf for construction of offshore oil and gas field structures".
Creation of normative base of Gazprom PJSC for offshore oil and gas fields development operations providing

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The author studies current state of domestic and international normative bases, providing offshore oil and gas fields’ development. Conclusion was made that currently there is almost lacking of normative base in Russian Federation, covering all aspects and stages of operation at shelf for offshore oil and gas fields’ development. The most actual normative documents are developed for ice-free sea conditions, they are outdated and do not consider modern level of technics and technologies development.

It was noted that international and foreign normative base in studied area is developed significantly better, however some lack of requirements for operations in freezing seas fields was noted.

The problems related to the normative provision for the safe development of oil and gas fields on the Russian continental shelf in the Arctic conditions were examined.

As part of the report the results of works on creation of Gazprom PJSC normative base for providing of offshore oil and gas fields development operations, including implementation of the Program of national standards GOST R development for offshore fields development in Arctic conditions, were presented.

Gazprom PJSC solution on development of integrated program of creation of normative base, covering all issues of hydrocarbon offshore fields development, is presented in the report.
Ensuring safe healthy labor and habitation environment for teams on board offshore production rigs of Russian Arctic shelf. Regulatory and practice requirements

A.V. Terebnev, O.N. Emelyanov, I.N. Pimenova
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Climate conditions and factors of labor environment are analyzed that shape specific features of work process in the course of developing mineral resources in the Arctic. Accident and incident statistics are presented based on Gazprom PJSC corporate data, as well as the data from the World Offshore Accident Database (WOAD) International Company. Causes of incidents and incident prevention practices on board offshore production rigs (OPR) are determined.

Regulatory and practice requirements are developed to ensure safe labor and habitation conditions for OPR workers. These need to be adhered to during OPR design and operation phases.

Analysis is carried out of international, intergovernmental (by member states of the Eurasian Interstate Council for Standardization, Metrology and Certification, EASC), national methodologies and practices in ensuring safe labor and habitation conditions for OPR workers.
Management of occupational risks at offshore structures

A.L. Terekhov
(Gazprom VNIIGAZ LLC)

Currently, more than 85% of oil and gas resources is concentrated in the Arctic seas. As a result, the extraction of oil and gas in the extreme conditions of the Arctic shelf is now actual and timely. In these conditions, assessment and management of occupational risks through a systematic analysis of possible causes of occupational diseases and accidents at work, predicting their consequences and to taking necessary appropriate technical and organizational decisions are necessary to ensure safety at the workplace. With the growth of the energy consumption in modern production processes, increase of their intensity, extension of the list of used chemicals and biological factors, the risk science is among the leading ones. The risk appears in various forms in all areas of human activity, production processes and their interaction with the environment.

At the present time, in Russia there is a contradiction between the market character of production and the state health and safety management system. Until now, there are regulations that provide an unconditional and absolute production safety through obligatory compliance with the requirements of public supervision authorities in the area of occupational health and safety. The transition to a professional risk management system should be based on the regulatory framework which has no contradictions and discrepancies. The conducted analysis of occupational risk assessment methodologies brought us to the conclusion that the currently acceptable method for the use at the facilities of Gazprom PJSC is the expert method of subjective evaluation. Taking into account the fact that there are currently not enough offshore structures at the Arctic shelf, this method is the only possible one.

The report shows the results of the occupational risks assessment using materials of working group RN-5 of project Barents 2020, identifies the main groups of occupational risks when operating offshore facilities of the Arctic shelf.
Degree of geological and geophysical knowledge and exploration of Russian shelf, including Arctic, is rather small. Despite insufficient knowledge, inferior by order of 1 or 2 to famous offshore oil and gas bearing regions such as North Sea, Gulf of Mexico, West Africa shelf, etc., at RF shelf more than 20 oil and gas natural basins are observed.

Over the last decade a lot of “shelf” or “Arctic" programs with defining of certain goals on hydrocarbon production were formed in RF, distinctive by plans and inherent technical solutions, scale of specific projects. However, the actual state of the process of industrial development of the Russian Arctic hydrocarbon potential has not yet moved from the initial level. The development of fields at the freezing shelf of the Russian Federation is hindered by difficult climatic conditions and the lack of the necessary technical means, especially underwater field development. That is why the creation of new equipment for underwater field development at Russian Federation Arctic shelf is extremely crucial task.

Realizing importance of this task, the author examined and formed science and technology-based approach to development of domestic equipment for underwater production field using scientific and design potential of Russian institutes and design bureaus and technological equipment manufacturing plants.
Platforms concept for Arctic and Far East deposits development

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Close attention is paid to Arctic surfaces, as well as Far East deposits recently. Conditions that specialists faced during development of platform projects for Sakhalin and Arctic shelf seas significantly vary. That’s why it is necessary to use already accumulated experience during new deposits development, but considering all Arctic peculiarities.

In this study I have examined already discovered deposits, from which I have selected the workable ones considering already existing technologies. After deposits selection natural and climatic conditions in the areas of deposits under examination were analyzed. Major differences, that influence on selection of platform type, its supporting block composition and topside, were revealed. Taking this into consideration deposits development concepts were offered. Methods of raw material transportation from a platform to onshore facilities were also indicated.

However technological process does not stand still. And nowadays we can see that current methods, assemblies and various equipment are of higher levels than we had 10 or 15 years ago. That’s why possible development of technologies, that will allow to operate in the areas currently inaccessible, is also provided in the study.
Unification of ice-resistant platforms for deep water areas of Arctic seas

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This report deals with issues of unification of ice-resistant deep sea platforms for development of hydrocarbon resources of Arctic seas.

Unification is an independent are of standardization and deals with determination of optimum number of varieties of engineering facilities, their parameter values and dimensions, in order to ensure consistency of engineering facilities. Unification results in cost reduction and streamlining of design, construction and operation.

Unification has application points in the context of offshore oil and gas production facility design for development of Russian shelf as well. A concept is already developed for unification of ice-resistant stationary platforms for 20, 40 and 60 m depths that are most promising for oil and gas field development in Pechora and Kara Seas.

Nevertheless, a number of fields at the Russian shelf are located in deep water areas of freezing Barents Sea and Sea of Okhotsk. Thus, the development of a concept for unification of deep-water ice-resistant platforms is a pressing matter for development of Arctic shelf.

Main platform types meeting requirements of deep-water freezing Arctic seas are floating marine oil-and-gas structures - platforms of SPART, TLP, BUOY type, and combined-type platforms. In these cases, the following platform components can be unified: Vertical seismic profiling, bearing part, mooring and bottom fixation system, as well as riser system. Unified vertical seismic profiling would differ by product type (oil/gas), riser system would differ by product type and depth, bearing part and mooring system would be classified by depth, and bottom fixation system would differ by the soil type.

Thus, the main purpose of unification of ice-resistant platforms for both shallow and deep waters is to allow for design and construction technology development enabling its application in a wide range of factors, namely soils with different parameters, large range of sea depth and different duration of ice-free period, with minimum modifications.
System for ultrasonic protection of offshore drilling rigs against the power impact of drifting ice and ice cover in the Arctic

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The article is devoted to solving the urgent technical problem on reliable operation of drilling rigs used in conditions of freezing seas. The principles and means for protection of rigs against drifting ice are described herein. A method for rig protection and corresponding system for its implementation are proposed. The system operation principle is based on ice crushing by means of ultrasonic transducers.

Breaking effect is based on the so-called ultrasonic cavitation. In case of high-intensity ultrasonic waves propagation in the liquid medium, alternation of high and low-pressure phases takes place at its certain point. During the low pressure phase as a result of liquid boiling and dissolved gas releasing, steam bubbles (cavities) generation appears. When passing through the vicinity of the high-pressure phase wave point, cavities “collapse”, causing local water hammer of considerable force. Ice crystals are broken under the hydraulic impact. Note that ultrasonic waves shall be propagated in the liquid medium to generate cavitation. This means that the presence of the water layer between the ultrasonic transducer and breakable ice is required to apply the described effect.

To implement the described principle, we propose the relative device called “ultrasonic dynamic ring” (USDR).
Turret systems for platform fixation at combined engineering of oil and gas fields of Arctic and Far Eastern shelves

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The use of ice-resistant shipboard-type platforms at combined engineering of oil and gas fields in the Barents and Okhotsk Seas will allow the production of hydrocarbons over the majority of course of the year with the use of modern methods of enhanced oil recovery and of the complete preparation of well products for the transportation. The exploitation of fields in these areas can be year-round if monitoring and management of ice conditions are arranged.

At this type of engineering, one of the main problems is a reliable stabilization of the technology platform at the point of its installation. Currently, there are various technologies of stabilization depending on the platform type and the area of its application.

The report describes some of stabilization systems for shipboard-type platforms, their features and the ability to use them at engineering of offshore oil and gas fields. There is a detailed description of the structure of turret stabilization systems (TSS), including functions of each of TSS key elements.

There is also a conclusion about the practicability of shipboard-type technological platforms with TSS at the combined engineering of offshore oil and gas fields of the Arctic and Far Eastern shelves at depths of over 50 meters, since shipboard-type technological platforms are characterized by large spaces for the equipment installation, capacities for storage of liquid hydrocarbons, which allows the use of on-land approved technologies of mining and exploitation of oil and gas fields with the application of modern methods of enhanced oil production rate and ensuring a high oil recovery factor.
Information value of continuous monitoring of horizontal wells for the optimization of the development of the Prirazlomnoye field

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For the purpose of optimizing the development of the Prirazlomnoye oil field located in the shelf area of the Arctic region in the Pechora Sea, a series of investigations including continuous hydrodynamic well monitoring is being held. Performance of such investigations is especially important during the early stage of field development, when uncertainty regarding formation characteristics and geological risks is very high, and the influence of decisions taken on development system effectiveness is relatively strong.

The applied technology of continuous hydrodynamic monitoring allowed the following results to be obtained:
- the porosity and permeability of the formation have been estimated;
- the absence of significant clogging of the well shaft was noted;
- the presence of hydrodynamic binding between the top and bottom formation members has been confirmed. Thus, they may be considered as a single integrated hydrodynamic object;
- the interrelation of injection and producing wells was revealed and the expected geology of the formation confirmed, based on which the formation pressure maintenance system in the development area of interest has been optimized;
- the influence of the edge water zone (aquifer) has been estimated as weak, which formed the basis for a decision on the growth rate for the implementation of a formation pressure maintenance system.

Revised information on the geology and certain porosity and permeability of the formation were considered in the planned development system. Taking into account the information obtained about the formation system, the decision to apply an influx control device was taken to balance the influx and injection profiles, which would allow more effective water flooding to be achieved and, as a result, the maximum oil recovery rate.
State and prospective directions of development of diagnostic devices for offshore pipelines of Gazprom PJSC

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Currently the range specter of methods and technical diagnostic means is used for Gazprom PJSC offshore pipelines technical diagnostic during operation and repair, including the following technologies with usage of divers, remotely operated vehicles, manned underwater vehicles and unmanned underwater vehicles, means of inline inspection.

The use of various types of diagnostic equipment is regulated by normative requirements of Gazprom PJSC.

The following technologies can be generally used during technical diagnostics:
  – visual inspection;
  – instrumental inspection;
  – hydroacoustic methods inspection;
  – inline diagnostics, etc.

Each technology individually does not provide for the possibility of reception of the whole information on the technical condition of the controlled facility. The most effective method of this problem solving is a development of methodological approaches to integrated use of diagnostics means.

The report includes main means of technical diagnostics of offshore gas pipelines. Their advantages and disadvantages are designated, development directions of technical diagnostics means and diagnostic maintenance system in general are offered.
Acoustic insulation for pipelines of offshore structures

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In order to ensure healthy and safe working conditions at offshore facilities, it is necessary to create acceptable conditions for the noise level in industrial and residential premises in accordance with the requirements of regulatory documents. A comfortable environment providing a proper and safe mode of human life and activities – is one of the main tasks of offshore production platforms the space of which is limited.

It is known from the medical practice that the impact of noise to the human body leads to overtiredness, extreme irritability, fatigue accumulation and malfunctions of vital human organs. All this causes the reduced efficiency and increased risk of errors associated with the human factor.

In order to prevent the spread of noise from acoustically active piping, high efficiency technical solutions based on easy assembling structures have been developed, which combine sound proofing, sound absorption, as well as damping properties of elastomeric materials.

The report presents the results of tests of constructions made of K-Flex materials, which showed their distinct advantages compared to usually applied materials. There is work on creation of a structure for the use in explosion and fire risk areas. There is durability monitoring in operating conditions at existing compressor stations to determine the durability of these structures. The use of these structures improves the quality of work and rest conditions for the personnel of production platforms and, consequently, ensures the human security in a severe environment.
Computational method of noisy pipelines sound-proof coating for offshore structures

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A.L. Terekhov (Gazprom VNIIGAZ LLC)

The noise control for pipelines used for gas fuel mixtures pumping is one of the most world scientific and technical challenges of our time. On offshore structures (OS), the problem of pipelines noise control is actual, as staff constantly attends on (OS) and the requirements for residential and industrial premises noise are specified with limitation of permissible level.

Gas and oil pumping pipelines noise has aerodynamic and structural origin and is one of the main components of OS noise. In addition to noise pollution, intense acoustic loading of pipelines can cause fatigue damage of structural elements and the failure of various systems.

The purpose of the study was to develop computational methods, create high efficiency sound-proof pipeline design and to determine the effect of installation of the appropriate sound-proof and vibration-absorbing materials to achieve the desired noise reduction.

The practical value is to develop an engineering method for computation of the effectiveness of means using for reduction of pipelines vibration and noise, as well as to develop the algorithms for computation of pipelines noise emissions. The optimization of soundproofing materials costs by the use of techniques attracted was also important.

To achieve this goal, the following methods were used: analytical and experimental. The processing of data obtained as a results of experiments was based on the software methods. Sound-proof structures optimized by the computational method were tested in the Research Institute of Structural Physics. Results reliability was confirmed by convergence of theoretical and experimental investigation data and is defined by the precision of measuring equipment and enough experiment size.
Regional modeling of hydrocarbon systems of the Yenisei-Khatanga basin

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An object of particular interest in the Russian Arctic region is the Yenisei-Khatanga downfold, where there are prospects of opening of hydrocarbon accumulations which are associated with both the Mesozoic and Paleozoic complexes. In order to study oil and gas potential of the basin, a regional 2D modeling was carried out based on 5 profiles which were interpreted and simulated by employees of the Subdepartment of Geology and Geochemistry of Combustible Minerals of Lomonosov Moscow State University.

The sedimentary mantle lithological section is represented by a lower carbonate structural level (R-C1) and an upper terrigenous one (P-MZ). Totally there are 9 oil source sequence (OSS), with the best generational potential at Permian and Devonian deposits. The hydrocarbon systems analysis showed that the greatest degree of OSS organic matter maturity is typical for the Kharutamussky downfold, where there are Triassic and Permian OSS in the “oil window”. At elevations and monoclines, the “working” ones are Riphean and Early Proterozoic OSS.

On the basis of 2D modeling as well as features of the OSS spread, types and maturity degree, the oil-and-gas saturation in mostly Mesozoic and Middle Carboniferous-Permian complexes is predicted. According to the modeling results, the sites being most promising and accessible for drilling are at the Zhuravliny arch (the prospects are connected with Jurassic and Permian sand deposits), the Nordviksky arch (Triassic and Permian sediments), the North-Anabar monocline (in upper carboniferous deposits), as well as in the whole middle carboniferous Permian complex of the Yenisei-Khatanga downfold and the Tigyano-Anabar arch. The structural plan analysis results show that the majority of traps were formed before the active hydrocarbon migration from OSS, less often – simultaneously, that is generally a favorable factor for the formation and preservation of hydrocarbon deposits.
Depletion of majority of oil and gas bearing basins of continental part of the Russian Federation has caused development of large-scale exploration works at Arctic shelf of the country. The most intensively studied region of the Russian Arctic is Barents sea shelf, where over 30 years history of oil geological works unique and large hydrocarbon (HC) fields confined to Mesozoic deposits were observed.

There are four seismic sequences separated out in Mesozoic part of section structure: Triassic, Jurassic, Neocomian and Lower-Upper Cretaceous. All sequences are divided by unconformity surfaces and defined by different formation conditions.

Distribution and concentration of HC at Barents sea shelf are resulted by long-term geological processes: generation, migration and accumulation. Paleogeographic conditions and tectonic regimen are the most important factors, impacting on deposits propagation in Mesozoic part of section. They resulted in formation of large positive structures, traps of different types and sizes.

Separate phase forecast dependent on tectonic features of a region allows to separate zones with primarily oil, oil and gas, gas-oil and gas composition. Zones with mainly gas composition are enclosed in deep downfolds due to liquid HC driving to cavity borders. Oil accumulations are attracted to platform parts, where sedimentary cover is thinner and source rocks are defined by lower degree of maturation.

Prospects of Mesozoic section oil and gas occurrence are connected with Triassic sandstones of alluvian-deltaic genesis, Jurassic shelfal sands, Neocomian sandstones and Apto-Albian coastal-marine deposits.
Here we present the first paleomagnetic data for the early Jurassic (190 Ma) and the early Cretaceous (137–125 Ma) magmatic complexes of the Franz Josef Land (FJL) Archipelago in the Russian High Arctic region. The paleomagnetic data were obtained through detailed thermal and alternating field demagnetization experiments, using the principal component analysis of demagnetization data. A positive fold test indicates that the isolated paleomagnetic directions correspond to the primary magnetization components. A new mean paleomagnetic pole for the Jurassic rocks was calculated as Plat = 63.3°; Plon = 136.5°; A95 = 5.3° (Note: Plat/Plon = Pole latitude/longitude; A95 = 95 % confidence interval). Mean paleomagnetic pole for the Cretaceous rocks was calculated as Plat = 75.4°; Plon = 204.1°; A95 = 4.1°. Early Cretaceous FJL pole coincides within the error with corresponding part of the Apparent Polar Wander Parts (APWP) for the Europe, which is expectable, and implies a "rigid coupling" of FJL as part of Svalbard plate, with other elements of the Arctic margin of Europe since at least the Cretaceous. However, the Early Jurassic paleomagnetic pole for the FJL is ~ 40 degrees away from a coeval part of the European APWP. Paleotectonic reconstruction for 190 Ma and 130 Ma were created based on paleomagnetic data (Fig. 4). In this reconstruction FJL, Spitsbergen and Novaya Zemlya are assumed as a unified tectonic element – the Svalbard plate. In the Early Jurassic the plate was shifted relative to Europe at a distance of ~ 500 km, so its Novaya Zemlya margin “continued” the Ural structures. As a result of strike-slip displacements and the opening of the South Kara depression, the Svalbard plate was shifted to the northwest, which is reflected in the almost 40° rotation of the Early Jurassic poles relative to the poles of Eastern Europe. In the Early Cretaceous these movements either ended or their scale was much smaller than the resolution of the paleomagnetic method.

The data obtained are of fundamental importance for the reconstruction of the tectonic evolution of the Barents-Kara continental margin in the Mesozoic and contribute significantly to create a database of paleomagnetic data for the Arctic.
Intelligent information rescue system in the shelf

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For effective advancement of the Northern Sea Route and the development of oil and gas resources of the Russian shelf, new technical and process solutions are required both in the field of hydrocarbon production and transportation, and emergency and rescue system.

The main trend in the field of security is the study and simulation of the so-called pre-emergency situations, improvement of risk management techniques at the stages of prevention and control. These measures make it possible to add significant changes to the project at the design stage. However, the reality is that more detailed and deeper consideration of possible emergencies are required to be ready to resolve the most complex ones.

This paper proposes to consider the risk management technique developed at the protective barriers for reduction of exposure and evacuation in emergency cases on oil and gas offshore facilities and vehicle, and the model of intelligent information rescue system built on the basis of the technique.

The system is a software system of remote multiple access, by means of which, due to database established beforehand and quick enter of current data on the emergency situation at the facility, it is possible to evaluate case scenarios with the corresponding probability, time, consequences, to promptly take the most effective measures in the rescue operation, automatically calculate the forces and means, give rational recommendations in distress, etc.

Based on its use, it is possible to improve overall emergency and rescue system efficiency in the shelf by means of flexibility, simultaneous multiple access, use of past experience, automation of computing processes and system capability.
Modern technologies of response to oil and oil products spills, minimization of the negative impact to the coastline and SPNR

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To date, the risk of oil and oil products spills and their potential environmental consequences are in the focus of attention of public and state organizations. In order to timely plan and develop preventive activities to protect the marine area and adjacent territories, there is the evident need for early detection and development of a clear concept of minimization of environmental risks. Therefore, it is the optimal choice of technologies and means of localization of oil and oil products spills that determines the general success of works for the spills consequences liquidation. At the availability of such a broad set of methods of elimination of emergency spills, the practical preference is given to the mechanical one. Its advantages are in the possibility of rapid and repeated use, disposal of the collected oil, as well as in minimal side disorders of natural conditions, however, the application of the conventional method in difficult meteorological conditions reduces its efficiency.

There is a need to modernize the ways of localization of emergency spills. It is important to note that we are not talking about creating the entire infrastructure of manpower and resources for responding oil spills from the ground up. The optimization and taking into account the international experience are required, that will allow the promptest localization of the accident not only in the water area, but also enable the protection of the coastal zone from the negative anthropogenic influence.
Integrated safety assessment of hazardous production facility
Prirazlomnaya OIFP

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Actuality of the selected topic is determined due to the fact, that Gazprom neft shelf LLC is currently developing oil field Prirazlomny at Pechora sea shelf. Prirazlomnaya offshore ice-resistant fixed platform is created to execute the project, having no analogues in Russia on its scales and design features and providing all technological operation conducting: wells drilling, extraction, storage, loading of oil to tankers, electrical generation. The key feature of the platform is ice loads resistance, longtime self-sufficiency and year-round work capacity.

Considering abovementioned features and difficulties, that leave its mark on many work directions on the project, providing industrial, ecological, occupational and civil safety during Arctic field development in particular, the Institute has decided to develop Integrated safety assessment of Prirazlomnaya OIFP.

Starting point in creation of report on integrated safety assessment and its key core is hazards identification and control, including the following stages:
- Defining of main/base hazards by developing the register.
- Developing of major accident hazards list based on possible scenarios at the platform.
- Defining of protective measures by quality and quantity analysis of major accident hazards by risks visualization and security barriers utilization efficiency.
- Developing of Matrix of simultaneous operations on OIFP.
- Providing of escape and evacuation pathways in case of major accident hazards.
- HSE & CD system functional test.
- Defining of EEI (equipment of especial importance) and equipment correspondence by critical assignments.

Thus, all the risks and hazards related to the object or performed operations are known. All proper measures are applied to achieve risks level defined as low as reasonably practicable.
Factor analysis of conditions for Russian arctic shelf development.
Differences between strategies of OC Rosneft OJSC and Gazprom OJSC

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(Thomson Reuters)

The current Russian economic situation and features of the licensed distribution of areas at the Arctic shelf being one of the main sources of production capacity in the future, state a number of difficulties for license holders. They consist in insufficient knowledge of areas, the lack of technologies for the development of the majority of licensed territories and the lack of adequate financial resources including the sanctions.

The rate of licenses acquisition by Rosneft and Gazprom and the associated intensification of exploration companies in the continental shelf area for the last three years detect the difference in the strategies of these companies, which leads to differing effects of sanctions on the one and the other. Performance of license commitments for exploration could provide a leap in the shelf development, however, the sanctions effect and further oil price downturn have challenged the work program performance. Companies commitment may remain unfulfilled at the existing licensed allocation of Russian Arctic shelf subsoil areas due to a number of factors.

The main factors forcing the companies can be defined as follows: the areas knowledge, processing factor, financial factor and distribution of licenses as a whole. Two of four factors are resulted from the sanctions impact on the Russian Federation, which began in 2014. Technological and financial sanctions differently affect individual sections and the entire shelf as a whole. As well as sanctions differently force the companies activity because of the difference in assets, financial condition, experience of technologies application during operations in the shelf.

Having compared all the factors affecting the Arctic development, comparative disadvantages/advantages of the Arctic shelf development strategies are revealed for each of these companies. Licenced allocation is evaluated in Russian shelf, particularly in the Arctic shelf. Rosneft and Gazprom are not equally vulnerable during the period of sanctions and low oil prices.
Legal regulation of subsoil use in Arctic zone of the Russian Federation

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On the one side, Arctic region is defined by biological diversity and mineral resources high endowment, but on the other side - extremely fragile and hardly recoverable flora and fauna. For which reason it is necessary while making decisions related to mineral deposits engagement in commercial development, to consider region peculiarities and to impose increased ecological and legal requirements to subsoil users.

However, analysis of Russian legislation has showed that effective legal regime of fragile Arctic ecosystems protection is not formed currently.

Subsoils legislation analysis has showed that all ecological and legal requirements directed to minimize impact of operations related to subsoils usage on ecosystem should be included in terms and conditions of the use of subsoil resources. Due to variety and unique character of Arctic nature it is impossible to offer unified measures of its protection. It seems that in conditions of subsoils usage separate protection measures program should be developed for each individual area.

Thus, considering vulnerability of the Russian Federation Arctic zone environment, while defining condition of subsoils usage for survey and extraction of minerals, for geological study, survey and extraction of minerals in the Russian Federation Arctic zone in regard to all types of subsoil areas, excluding reserve ones, it is necessary to legislate special requirements for Arctic subsoil areas protection, which should be included in a license.

Considering issues on creation of reserve areas federal fund serving the interests of the future generations of the Russian Federation citizens in minerals, it is offered to formalise the possibility of subsoil areas, located within the Russian Federation Arctic zone, referring to reserve fund.

Considering peculiarities of Arctic geographic location, necessity of implementation of complex and rational subsoil usage with interstate cooperation of Arctic nations, in regard to study and development of subsoil transboundary areas, obligement of transboundary field development by unified technical design should be determined in Russian subsoil legislation; as well as compliance with special requirements offered for Arctic subsoil area protection.

Analyzing the issue on early termination of subsoils user license, it is offered to enact in the Russian Federation Law “On subsoils” the possibility of early termination of subsoil user license in case of failure to comply with special requirements offered for Arctic subsoil area protection.
The significance of the Far East’s hydrocarbon potential is difficult to overestimate, however, in addition to the economic importance, this region has unique environment, which has no analogues in Russia in terms of biological diversity. The region natural potential preservation is possible when environmental requirements are reflected in the territories development plans. For this purpose the planning shall be based on the ecosystem approach principles. The mechanism for the ecosystem approach implementation is marine spatial planning. The water area planning shall be carried out not only to preserve biodiversity undisturbed, but also to maintain ecosystem services which are provided for the society by oceans, coasts and estuaries. Currently, in the Far East there is the conflict between the sectors of environmental and economic activities, between the use of fishery waters and oil and gas natural resources. To resolve this conflict will require a comprehensive assessment of water area with methodical ecosystem examination, and consideration of all types of use and their anthropogenic load. Only using this approach will be useful to resolve this problem.
Assessment of probabilistic characteristics of air temperature conditions in shelf area of Kara sea considering climatic changes

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Development of northern part of the shelf and oil and gas platforms operations depend mainly on temperature conditions and ice conditions defined primarily by air temperature conditions, cold sums during frost period in particular and temperature conditions over year overall.

Currently a supposition is made on climate change in recent decades, which is increasingly confirmed for certain regions. This study includes analysis of annual, seasonal and intraseasonal temperature characteristics in regard to Kara sea coast based on long-term temperature data of meteorological station near Dickson.

The following tasks were completed:
- Trends obtaining of annual and seasonal temperature values for the whole set of observations;
- Assessment of observations set values uniformity;
- Defining of statistical temperature parameters of annual and seasonal values;
- Assessment of possibility of temperature conditions worst-case scenarios.
POSTER PRESENTATIONS

Justification of need for development of logical-and-probabilistic model to forecast frequency of high power gas pumping units failure

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Development of gas transmission system, implementation of high power gas pumping units (GPU) provide the need to assess technical risks for prevention of emergencies and failures. For this purpose, risks assessment, analysis and control methods shall be developed. Taking into account the GPU specification and the requirements of fundamental documents for industrial safety: Federal Law No. 116-FZ dated September 21, 1997, “On Industrial Safety of Hazardous Production Facilities”, federal rules and regulations in the field of industrial safety “Rules for Industrial Safety Examination”, etc., Gazprom PJSC has developed:

– STO Gazprom 2-2.3-351-2009, STO Gazprom 2-2.3-400-2009, STO Gazprom 2-2.3-569-2011.

In all developed methods of risks analysis, if there are no Gazprom PJSC statistical information of emergencies and failures, conventional values of failures frequency \( \lambda \) are used for all types of GPU.

During the study we analyzed over 100 literary sources regarding challenges of GPU risks assessment and control. The result of the performed work is the conclusion that a method for collection, analysis and classification of data on emergencies, accidents and failures to analyze the risk on GPU sites, as in the society there is no unified statistical data base of compressor stations;

Thus, there is the need to improve the approach to the risk analysis, specifically for the expected frequency of failures, accidents and emergencies on aviation-driven GPU sites. As big-diameter pipelines implementation has resulted in study of high power units, then the special attention in this issue shall be paid to the areal facilities with prospective GPU of 16 and 25 MW. The report justifies the need for development of logical-and-probabilistic model for technical risks assessment. This model will allow to develop the measures on control of these risks.
Morpholythodynamics of shore zones with complex
of the pleistocene-holocene terraces and shores of accumulative
barrier forms

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Sakhalin oil and gas complex objects at Sakhalin shore are located at Holocene accumulative elements of barrier forms of large lagoons, at high geomorphological levels (12–28 m) of Neogene-Pleistocene fragments of barrier forms of large lagoons and at sea Holocene levels attached to ancient sea cliff.

For three of five large kyles (lagoons essentially) and almost for all smaller lagoons the composite shore barrier forms, cutting them off from the Sea of Okhotsk, are typical. Regions with high sea cliffs made by Neogene-Pleistocene settlements (mainly nonconsolidated, sand and pellite fractions) interchange here with actual Holocene barrier spits. However it should be noted that there are no regions with high levels in the zones of Late Holocene sea gates migrations. They were destroyed here during the first phases of offshore-maritime accumulation.

Analysis of morpholythodynamics peculiarities of composite and “classical” sand barrier spits, cutting lagoons off of open sea, has showed that higher deformations variability of Holocene regions maritime edge is typical for composite barrier forms, rather than for fully Holocene barrier spits. Bigger morphometric parameters variability of shore profile upper part is typical for these barrier forms. The lowest morpholythodynamical parameters variability is typical for marine terraces attached to ancient sea cliffs.

Thus, each type is described by its own morpholythodinamical position in high order morpholythosystem with long (Middle and Late Holocene) history of development and peculiarities of modern morpholythodinamics related to conditions and possibilities of material mobilization from different elements of shore profile, transfer and accumulation. It requires different approaches for evaluation of impact values and defining of development scenarios.
Standard development for exploration of Russian shelf

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Currently, oil and gas industry development is defined majorly by exploration of Russian Arctic and Far East shelf. It includes a scope of works related to hydrocarbon production and transportation in challenging natural, climate and geophysical conditions.

Multiple technical means of oil and gas exploration and production, construction and operation of subsea pipeline systems require special attention to the staff safety and equipment reliability and operability issues. Key part of the solution of the issue consists in high-quality design solutions, selection of reliable equipment, process optimization, application of materials with account of operation condition. These parameters should be defined precisely in regulatory documents serving as a basis for design and operation of oil and gas facilities in the specific conditions.

It is reasonable to commission development of regulations to competent organizations that can use combined production, engineering and research resources at all stages from detailed documentation development to facility construction and operation. It is only logical that Gazprom Group companies are most suitable for that purpose for gas industry facilities. In this relation, it would be reasonable to develop STO Gazprom standards initially with full account of all specific features of design, construction and operation of the corporate facilities, and then to promote the standards to a national and interstate status.

Use of Gazprom PJSC regulations as a basis for national standards has economic (no extra investment in document development required), engineering (involves tests at different document performance levels), administrative advantages (the document is introduced promptly and does not require additional approvals and amendments).
Analysis of promising directions of liquefied hydrocarbon gases (LHG) usage

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Growth of gas component in fuel and energy balance of the country is observed most clearly lately. Alternative fuels usage, LHG in particular, becomes more actual.

World’s leading LHG suppliers are USA, Saudi Arabia and China. Russia currently takes fourth place, which amounts 10–15 % share of the market. Main LHG manufacturer in our country is SIBUR Holding PJSC, covering about 38 % of the market. Its principal competitors are Gazpromgazenergoset JSC – 19 % and Rosneft PJSC – 10 %.

As part of the study comparison characteristics of LHG with competitive fuel types by main criteria has been observed. As a result, concerning correlation of general expenses on hydrocarbon raw materials, LHG takes second place, however its large-scale realization is limited due to some difficulties related to gas physical and chemical properties, high explosion risk in particular. Evaluation of main directions of its usage has been conducted in the study, corresponding analytical models have been built.

Major consumer-regions in domestic market are the Republic of Dagestan (15 %), Astrakhan Region (9 %) and Stavropol Territory (6 %). Oil processing, occupying 30 % of the market, is one of the priority directions. The perspective is in realization of petrochemical industry programs projects. LHG consumption in public utility segment (22 %) will remain the same in the foreseeable future. LHG usage at AGRS (12 %) is one of the most promising directions in spite of its low market share. Energy service contracts usage is becoming actual.

There is a possibility of LHG realization export direction development. Main importers are Western countries (35 %). Removal of export duties and implementation of new pricing system should expand and establish production of liquefied hydrocarbon gases in Russia.
Oil and gas extraction platforms and subwater pipelines operation at Arctic shelf: asphaltene sediments prevention

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Natural resources extracting in Arctic is extremely difficult and dangerous not only from technological, but from ecological point of view. Under hard climate conditions emergency situations possibilities increase massively. That's why scientific studies conducting to provide technological and ecological safety during oil and gas extraction at Arctic shelf is priority. It is critical to summarize experience of “Sakhalin-1” and “Sakhalin-2” projects marine platforms operation in conditions similar to Arctic, including arising from oil-field chemistry reagents industrial use.

Under hard Arctic conditions the problem of asphaltene sediments (AS) prevention at oil extracting equipment and in pipelines is critical. According to the authors, modern AS inhibitors will not become widely used at offshore oil extracting in Arctic zone due to high operational doses, low flash temperature and high freezing temperature.

Cleaning of inner surfaces of subwater pipelines from marine platforms using scrubbers is a main way of arisen AS removing and pipelines rated capacity maintaining. In 2010 anti-turbulent additive (ATA) was supplied to Sakhalin-2 project marine pipeline to increase its capacity. It was noted that during ATA supplying AS mass scrubbed out of pipeline and remained only in receiving trap is significantly decreasing. In other words, ATA existence in oil results either in AS portion better dispersing to oil, or shearing stress significantly decreases at AS layers slipping and AS portion comes to receiving trap without delay. Therefor ATA usage during subwater pipelines inner surface cleaning by scrubbers is the great promising technique of protection from AS.