SPE-166815-MS

Hydrocarbon potential of the Enisei-Khatangsk Region with in the Taimyr Autonomous district (TAD) and the extent of its development.

A.N. Dmitrievsky, OGRI RAS, N.A. Eremin, OGRI RAS, N.A. Shabalin, OGRI RAS

Summary

The geological studies carried out on the territory of the Taimyr autonomous district of the Krasnoyarsk Krai during the period of 1930-1950 by the Glavsevmorputi subdivisions, the USSR Mingeo organizations and the institutes of the USSR Academy of Sciences (AS) show a considerable thickness of sedimentary deposits perspective for oil and gas, the availability of the Paleozoic salt-bearing sections, the prolongation of the continental tectonic structures into the water area of the marginal seas followed by the increase of the sedimentary deposits The TAD borders on three oil and gas bearing provinces of Siberia such as the West-Siberian, the Khatango- Vilyuisk and the Leno-Tungussk the limits of which allocate the Enisei-Khatangsk OGR and partially the Pur – Tazovsk OGR. (20). The total area of the oil and gas potential lands is over 550 th square km (13).

The history of the development of the Arctic segment of the Earth form the view of the plate tectonics .

In the process of the disintegration of the Pungea supercontinent the deposition of the Arctic segment of the Earth began. The course of crushing and dragging of separate sections of the Lavrasia continent and the simultaneous joining it up with small microcontinents resulted in the formation of the Arctic ocean basin with its numerous depressions and uplifts – ranges (15,18). In the Devonian the riftogenesis caused the formation of the oceanic basin of the recent Arctic Ocean (21) . The Arctic basin continued to exist as gigantic gulf of the Pacific Ocean without any changes from the Devonian to the Late Jurassic (4).

The early period of the formation of the Early Mesozoic rift systems of the West-Siberian platform, North-West Europe, the North Sea, North America the Paleozoic median-ocean ridges of the Arctic Ocean and the Atlantic Ocean witnessed the downwarping of large territories and the formation of the Permian sedimentary basins of the sedimentation (19,21)

The splitting of the lithosphere followed by the formation of the abovementioned rift systems ,the formation of separate microcontinents separated from the continental platforms by the foredeeps was observed in the Triassic (19).

From the Late Jurassic to the Late Cretaceous there was observed the formation of the ocean crust in the Makarov and Kanadian cavities.

The extension of the territory of the East-Siberian depression in the Upper Jurassic and the Early Cretaceous resulted in the formation of the East-Siberian lithospheric plate, and the spreading of the continental Taimyr block-microcontinent was followed by the formation of the Enisei-Khatangsk trough. The formation of the typical Hertzianocean results from the downwarping compensated by a powerful sedimentation (10).

The course of spreading of the lithospheric plates in the Late Mesozoic and the Early Cenozoic exhibits a regular downwarping of large territories and the formation of the depressions of the Arctic and the Atlantic oceans (4,10).The median-ocean ridges with the crust of the ocean type are formed in the axial zones of the ocean. The axial ramparts and depressions are formed in the foredeeps (8,9,15,22).

The Cenozoic witnesses the extension of the rift along the Gakkel-Nansen ridge followed by the spreading of the ocean bottom and the formation of the Cenozoic basin of the Arctic ocean as the stratified structure in the Late Mesozoic shelf basin(4). The Euroasian basin results from the formation of the Euroasian lithospheric plate (the plate of the Kara Sea and the plate of the Laptev Sea and the broken off continental Lomonosov block-ridge (10).

The Siberian platform from the Early Paleozoic trough the Triassic is characterized by a general tendency of the subsequent dislocation of the areas of the intensive downwarping and the sea basins northwards. At the interface of the Silurian and the Devonian the phase of considerable uplifts was replaced by the phase of relative foredeeps in the western part of the Siberian platform in the Middle-Upper Paleozoic and the Early Triassic. All this resulted in the release of the trap magma in the Permian-Early Triassic (14,17).

The current outline of the Siberian platform in the north is fringed by the Ust-Enisei-Khatansk (UEKh) regional trough open in the east in the direction of the West-Siberian platform (17).

In the north the boundary between the UEKh trough (conventionally) passes along the Lower Anabara – the northern end of the Udzhinsko-Zhigalovsk faulted zone of the crystalline platform foundation. To the west of the Udzhinsko-Zhigalovsk faulted zone the zone of the Mesazoicforedeep greatly expands followed by the total low sinking of the bottom of the Jurassic-Cretaceous deposits westwards and the UEKh / Predtaimyr / trough open in the west in the direction of the West-Siberian platform is clearly outlined on the structural maps.

In the west the boundary of the Siberian platform and the West-Siberian plate passes along the Enisei river on the eastern outline of the overall propagation of the Jurassic-Cretaceous deposits of the West-Siberian plate . On the left bank of the Enisei these deposits overlap the lowered western edge of the Siberian platform and occur in the Lower Paleozoic and the Pre-Cambrian rocks. The magnetometry data show that the boundary of the ancient platform is marked west of the Enisei. Probably, the western boundary of the Epiarchean Northern platform passes along the valley of the Taz river, 250-300 km away from the Enisei (11). Having undergone a deep sinking into the Jurassic-Cretaceous periods, the western and the northern sections of this ancient platform were incorporated into the heterogeneous foundation of the Epihercian West-Siberian plate and the Enisei-Khatangsk trough adjacent to it. The remaining section of the Epiarchean platform located to the east of the Enisei preserved its stable position in the Jurassic-Cretaceous period. This basic part of the ancient platform is named the Siberian platform in the true sense (5).

The junction of the West-Siberian plate and the Siberian platform is in the seam zone of the Main Enisei fault located on the left bank of the Enisei parallel to its current and the river-bed. The eastern part of the Pur-Tazovsk OGR covers the eastern part of the West-Siberian plate adjacent to the Siberian platform. It is characterized by the vast isometric depressions separated by the narrow shifted highs of the north-east and the submeridional direction. The thickness of the sedimentary mantle is 7-8 km (12). The western part of the EKhRT (Enisei-Khatansk regional trough) – the Ust-Eniseisk trough (thePredtaimyr) is clearly delineated by the foundation, the surface of the crystalline foundation being sunk to 12-14 km below the ocean level..The trough has steep (4-6 degrees) northern and southern flanges. The relative sinking of the foundation on the northern flange is 4-6 km and more. The marks of the foundation surface in the central part of the trough , being wide in its eastern section (the Khatansk) and narrower and deeper in its western section , are (-) 10 and (-) 12 km, respectively. On the northern fringe of the trough there is outlined the Jangodo-Gorbatsk projection, while on the southern fringe there is a rise corresponding to the Gulinsk projection in the sedimentary mantle. The Balakhninsk rampart of the Mesozoic deposits is characterized by a large rise of the foundation surface. In the west the UEKh trough is open in the direction of the West-Siberian plate. The trough is joined up with the Siberian platform along the zone of the Malokhetsk – Khetsk faulted zone (17).

THE PUR – TAZOVSK NGR.

The eastern sectin of the Pur-Tazovsk NGR covers the eastern section of the West-Siberian plate adjacent to the Siberian platform. It is characterized by the vast isometric depressions separated by the narrow shifted highs of the north-eastern and submeridionaldirections.The thickness of the sedimentary mantle is 7-8 km (12).

The deposits were accumulated in conditions of the littoral in the course of the regression of the Jurassic basin. They are mainly fine-grained sandstones, coarse siltstones, arcoarse varieties.

The texture of the deposits is from wavy and lenslike to horizontal and cross-stratified (6).

In this area of the Taimyr district there were discovered and prospected 11 oil and gas fields with the ultimate geological reserves of 1773722 thousand tons of standard fuel by the Russian categories C1+C2 as of 01.2011.

THE ENISEI- KHATANGSK NGR

In this area of the Taimyr district there were discovered and prospected 5 oil and gas fields with the ultimate geological reserves of 409652 th t of standard fuel by the Russian categories C1+C2 as of 01.2011 .

The oil shows in the Enisei – Khatangsk NGR were determined in the stratigraphical interval from the Reefey(?) to the Lower Cretaceous. In the southern part of the NGR in Norilsk district there was exhibited the presence of oil and gas in the Ordovician and Silurian deposits. In the northern section of the NGR in the Enisei-Khatangsk trough eastwards the stage of oil content is increasing downwards to the Carboniferous and Devonian deposits inclusive. Because of the lower occurence depth and sand content of the Cretaceous deposits the conditions of accumulation and conservation of hydrocarbon deposits in the Upper Jurassic and Cretaceous deposits are worse than in the west of the trough (17).

From the tectonic point of view, the Enisei-Khatangsk NGR consists of two sections: the southern-northern borderland of the Siberian platform to the boundaries of the Tungussksyneclise (12). The northern section of the Enisei-Khatangsk NGR is the deep narrow Enisei-Khatangsk regional trough (EKhRT) separating the Siberian platform from the folded Taimyr . In the west the Enisei-Khatangsk regional trough opens into the Antiayutinsk depression of the West-Siberian plate. In the east the trough joins up with the Leno-Anabarsk trough and the Laptev Sea depression through the rapids of the Anabaro-Khatangsksaddle.The area of the Enisei-Khatangsk regional trough is about 400 thsq km, the thickness of the sedimentary mantle in its range is up to 12-14 km. The basic structure of the trough is east, north- east (7,17)..

For the well-investigated regions of the world the average density of hydrocarbon resources by the volume of the sedimentary performance amounts to 15.5 th t of standard hydrocarbon material per cubic km (15.5 th t /cu km). As estimated in the year 1979 the volume of the sedimentary performance in the Enisei-Khatangsk NGR to the depth of 7 km amounts to 1148 th cu kм . The volume of possible reservoirs is equal to 179.2 th cub km containing 9374 mln. t. of standard fuel including 1765 mln. t. of oil and 7609 bln cub m of gas (1). The distribution of the hydrocarbon resources along the oil and gas -bearing regions of the Enisei-Khatangsk regional trough is shown in the table 1.

OIL-Gas Region	Oil, mln.t.	Gas, bln. cub. m.	Standard fuel, mln. tons
Malokhetsky	48	386	434
Tanamsky	39	302	341
Enisey Gulf	71	692	763
Agapsky	119	1003	1122
Pyasinsky	27	244	271
Rassokhinsky	78	653	731
Dudyptinsky	91	800	891
Pyasino-Khetsky	39	200	230
Gorbitsko-Taymyrsky	157	921	1078
Paiturinsky	139	1017	1156
Zhdanikhinsky	15	10	25

Table 1. Oil-Gas resources of Enisei-Khatangsk Region (2)

In the western part of the EKhRT the surface of the crystalline foundation is submerged to 14-16 km from the level of the world ocean. The trough has steep (4-6 degrees) north-south flanges. In the west and south-west the Ust-Enisei trough joins up with the structures of the north-east part of the West-Siberian plate, in the east and south-east it borders on the Tungussksyneclise, and on the Taimyr folded area in the north. The latter is considered by some specialists as the Taimyr microcontinent(16).The depression is filled with Jurassic and Cretaceous deposits of 6-7 km in thickness which quietly occur in the Paleozoic-Triassic folded complex of 6 km in thickness lying on the Pre-Cambrian foundation. In the central section of the depression theoccurence depth of the foundation exceeds 12 km (14).

At the beginning of the Late Jurassic period the West-Siberian plate acquired the modern outlines with the isolation of the internal area and the external zone corresponding to the external and transition zones of the Enisei-Khatangsk regional trough. The integrated ocean sedimentary basin expanded and stabilized. The sedimentary complex on the West-Siberian platform and in the Enisei-Khatangsk regional trough is made up of the deposits of marine and offshore-marine facies and includes the sedimentary deposits of the Upper Jurassic, the Lower and Upper Cretaceous. The Valanginian - Senomanian period is characterized by the powerful mainly sandy mass. (20).

In the Ust-Enisei depression / the Ust-Enisei trough the structures are of sublatitudinal strike. The central ramparts gravitate towards the edge of platform, while the deeper depressions are to the north of these ramparts. The Pre-Jurassic foundation consists of three stages.

The lower structural stage is similar to the structural framing and is made up of strongly metamorphic rocks of the Archeisk - Proterozoic period.The total thickness is 15-25 km,the occurrence depth of the roof of the Lower structural stage reaches 16 km (23).The DSI data (Deep Seismic Investigation) show that the thickness of the lower structural stage under the deep EKhRT depressions is reduced and the Mokho surface occurs at the depth of 33 km..For comparison the depth of the Mokho surface on the Putoran plateau is 45 km.

The middle structural stage occurs on the lower one with a sharp angular unconformity.It is made up of the Upper Proterozoic-Middle Paleozoic carbonate and carbonate- clasticunmetamorphic intensively dislocated rocks similar in composition and facies to the analogous/synchronous/ coeval deposits of the Siberian platform. The total thickness of the middle structural stage is 4-6 km, the roof occurrence depth in deep depression s is about 11 km.

The upper structural stage is made up of the sediments from the Upper Mesazoic to the modern ones. This stage is subdivided into two structural stages different in the sedimentation conditions and relating to various tecto-magmatic cycles. The foundation of the territory of the Mesozoic mantle are the Late Paleozoic-Early Mesazoic deposits of the lower stage similar by the composition to the Triassic and the Upper-Permian deposits in the south of the mountain Taimyr and in the north of the Siberian platform. The thicknesses of the coeval/synchronous depositions are approximately equal.

The Mesozoic-Cenozoic mantle . The trough is made up of terrigenous deposits of the upper floor of the upper structural stage. A distinction is made between 3 substageslithologically similar but different by tectonic conditions of deposition.

The Middle Triassic- the Lower Jurassic substagewith the angular unconformity in some places with washouts occurs in the volcanic and volcanic-sedimentary rocks of the Lower Triassic.The foundation of the substage consists of irregular grained, sandy, poorly sorted terrigenous deposits of the Middle and Upper Triassic. The sources of the washout are volcanic deposits of the trapped formation of the Siberian platform.The sediments of the terrigenous Triassic fill in the roughnesses of the buried relief of the volcanic complex and the narrow troughs and grabens formed in the course of the tectonic reconstruction connected with the trap magmatizm.

The Lower Jurassic deposits occur transagressively above without an unconformity and consequently without a seismic boundary.

The Jurassic substage. The transition took place in the Jurassic from filling in the grabens and
the depressions to the deposition of the unbroken sedimentary mantle.The sea basin of the Ust-Enisei trough occupies all the southern and the south-eastern part of the present area and joins up with sea basin of the West-Siberian plate 60 km west of the recent valley of the Enisei on the latitude of the Vankorskarea.Theagrillaceous-aleurolite mass of the Upper Jurassic deposits occurs in these sediments.They spread ewerywhere excluding separate sections of the megaramparts where these deposits are partially washed out.The Upper Jurassic deposits are present in the north –east framing of the Siberian platform and in the south of the mountain Taimyr.In deep depressions (the Zhdaninskaya depression) the total thickness of the Middle Triassic-Jurassic deposits reaches 5 km.

The Cretaceous substageoccurs with the angular unconformity on the underlying sediments .

The foundation of the substage comprises the lensing-sigmatoic bodies overlying each other like tiles and successively rejuvenating the further they get from the Siberian platform into the external framing. The overlying sediments up to the Upper Cretaceous are similar in facies with the Lower –Middle Jurassic but with less evident and more frequent rhythmical pattern .

As a result of the accumulation of the sedimentary masses the relief of the previous tectonic stage is completely levelled.The maximum pitch angles of the stratigraphical boundaries of the Lower Cretaceous do not exceed 5 degrees, with the thickness of this mass of about 2.5 km.Along all the area of the propagation the endured thickness of the Upper Cretaceous deposits is 1 km. They cover a smaller territory as compared with the Middle Cretaceous deposits and are not available on the middle ramparts of the EKhRT.The eastern section of the EKhRT is the Khatangsktrough.In the eastern part of the trough,theKhatangsk depression/the Khatangsk trough, the long axes of the structures are oriented north-east.The central ramparts are shifted to the Taimyr folded zone/the Taimyr microcontinent. The deeper depressions are located south of the central ramparts.The fringes of the trough are steep (to10 degrees) the foundation dislocation is of a block character.

On the surface of the Reefal(?) – Middle Paleozoic complexes the width of this negative assymetrical structure is about 280 km.The deposits of these complexes are split by fractures into blocks of 15-20 km wide. The structural plan of the Mesozoic complex inherits the structural plan of the Upper Paleozoic-Lower Mesozoic complex but acquires a more plicative character.

In the south the Khatangsk trough joins up with the northern borderland of the Anabarsyneclise and in the north it is limited by the folded Taimyr zone/ the Taimyr microcontinent. In the east the trough joins up with the Leno-Anabar trough in the form of wings the northern part of which stretches into the shelf of the Laptev Sea. The Khatangsk trough was finally formed in the Cretaceous period.The cumulative thickness of the Jurassic and the Cretaceous deposits is about 2.5-3.5 km. The Jurassic and the Cretaceous deposits occur horizontally, but in some sections they are dislocated. The Triassic exhibits an intensive downwarping in the northern and the north-eastern part of the Khatangsk trough. The thickness of the Triassic deposits is 1.5-2.5 km .The Triassic deposits are an independent structural stage of the foundation made up of the dislocated rocks of the Middle and Upper Paleozoic, and on some uplifts they outcrop to the surface.The central section of the Khatangsk trough reveals the structures of the first order, such as the Balakhninsk rampart,the Kyriako –Tassk projection and the structures of the second order , such as the Noviy,the Kharatum and the Tigyano-Anabarsk ramparts,the uplifts of the Belaya hill. At the southern flange of the trough there are selected the Kamensky and the Tulinsk projections as the structures of the first order.At the junction of the Khatangsk and the Leno-Anabarsk troughs there was discovered a salt-bearing section complicated by the salt tectonics (17). The Upper Palezoic deposits in the Khatangsk depression are represented by the coastal-marine, lagoon deposits of the Lower and Upper Permian periods (7).The age of the basalt layers of the Upper Paleozoic deposits from the west to the east is becoming younger, and to the east the facies are getting more marine (7). In the eastern part of the OGR in the Anabaro-Khatangskinterriver there was reliably established an oil bearing capacity of the Permian terrigenous section spread on the territory of 4500 square km (17) . The porosity of the Permian deposits on separate areas reaches 20 %, the permeability is up to 500 millidarsy.The oils of the region are of a different composition and properties.The specific gravity in the interval from 0.76 g/sq cm to 0.985 g/sq cm.With the increased occurrence depth the specific weight and viscosity of oils reduce and the content of paraffin and low-boiling fractions increases. The explored structures occur at the depths of up to 2000 m. The regional character of the presence of oil is indicated by the considerable inflows of formation waters (up to 130 cu m/day), a widening of the reservoirs in the oil-bearing strata, considerable water inflows (17).

The oil shows were exhibited in the course of the oil-prospecting operations from the year 1934 to the year 1953 .In 7 prospecting areas in the Anabaro-Khatangskinterriver(?) the discovery was made of 6 oil fields,such as , the Nordviksk,theYuzhno-Tigyansk,theZapadnoye,the Vostochnoye, the Ilyinskoye and the Kozhevnitcheskoye. The discovered deposits were of small sizes and the production rates were from 0.5 t/day to 10 t/day. There was no qualitative evaluation of the reserves and the resources.

The basic restraining factor of the oil-prospecting operations and putting on production of the explored hydrocarbon fields is the lack of the infrastructure to transport the produced hydrocarbons to the market.The developed infrastructure is concentrated in the Ust-Eniseisk region and is aimed at servicing the Norilsk mining and metallurgical plant in the towns of Norilsk and Dudinka. It is the Dudinka port connected with Norilsk via the railway and Alikel airport joining the Taimyr region and the regions of the KrasnoyarskyKrai in Russia on the whole,and the Dixon port that realize all the marine freights via the North sea route.

In operation are 3 fields located in the eastern section of the Pur-Tazov NGR.From 3 to 4 milliard cu m of gas are produced in the Messoyakhsk,Pelyatkinsk andSoleninsk (YANAO) fields to provide for the Norilsk mining and metallurgical plant,the towns of Norilsk and Dudinka and Alikel airport.Since the year 2010 in the Vankorsk field there have been produced over 10 ml t of oil annually which is delivered via the pipeline to the trunk pipeline at the Purpe terminal in YANAO. The estimated throughput flow capacity of the Vankor-Purpe pipeline is 15 mln. tons annually thus enabling to increase the volumes of oil recovery in the Vankor field.

At the end of the 90s of the past age the Anglo-Siberian company (Shell is the main shareholder of the company), the former owner of the license in the Severo-Vankor field , elaborated the feasibility study of the trunk pipeline from the Vankor field to the Dixon sea port (the length is 730 km, the diameter is 711 mm, the throughput flow capacity is 40000 cub.m/daily) and the export terminal near the Dixon sea port (the EfremovKamen cape).The sea depth in this shelf area enables to tow the tankers with the tonnage over 100 thousand tons.

Lately the rates of the field development of the Taimyr autonomous district, such as, the Vankor, the Lodotchnoye, the Suzunskoye and the neighbouring fields of the Krasnoyarsk Krai and YANAO, the geologo-prospecting operations in the shelf of the Karsk Sea and the Laptev Sea make think over the optimal development of the transportation infrastructure of the region.The matter of hydrocarbon transportation via the North sea route is becoming more evident.

Literature

1 A.F.Babintsev, Geological and economic analysis for the oil and gas exploration works in the Krasnoyarsk region, 1980, Krasnoyarsk, Eniseyneftegazgeologiya

2 A.F. Babitsev, The compilation of the summary map of the Krasnoyarsk region geological and economic zoning (1:500 000) and the explanatory notes thereto.1983,Krasnoyarsk, Eniseyneftegazgeologiya

3 N. I. Bayborodskikh, The anakysis and synthesis of the oil exploration works on the Norilsk area and the operational substantiation for the further trend of work. 1965, Krasnoyarsk, Geological Division of Ministry of Geology

4 K. Burke, The plate-tectonic history of the Arctic. Moscow,27 IGC, v.4, 1984

5 M.L.Verba, Tectonic framework of the Igarka-Norilsk region and the comparative assessment of the oil-gas local structure. 1969,Leningrad, NIIGA

6 T.N. Vetrova, The lithological and petrographic features of the reservoir horizons and the seals of fields in the western part of the Siberian platform and Bolshekhetskoemagaswell. 1989,Krasnoyarsk, Eniseyneftegazgeologia

7 I.S.Gramberg, The upper Paleozoic and Triassic sediments of the Yenisei-Khatanga trough. 1971,Leningrad, NIIGA

8 A.N.Dmitrievsky, The serpentinite source of the oceanic crust formation hydrocarbons. Oil and Gas Geology, № 3,2002

9E.N.Isaev,V.V.Samoylyuk, N.A, Shabalin,The structural-geophysical model of the volcano-sedimentary cover and basement of Aden-Red Sea region. Moscow,27 IGC,v.3,1984

10 A.M.Karasik, V.I.Ustritsky,A.N.Khramov, The history of the Arctic Ocean. Moscow,27 IGC,v.4,1984

11 Yr.A.Kosygin, A.R.Basharin and etc.,The basic structural blocks of Siberia in the Late Cambrian.Novosibirsk, Geology and Geophysics, v.10,1962

12D.P.Kulikov, The patterns of the distribution of oil and gas reservoirs in the Mesozoic sediments of the Ynisei-Khatanga oil and gas area and the eastern part of the Pur-Naz oil and gas area., 1989, Krasnoyarsk, Eniseyneftegazgeologiya

13 A.I.Larichev, The creation of modern models of the geological structure of productive and perspective complexes of the Taymir autonomous area to determinate the priority of exploration works oil and gas.2007, St.Petersburg, VSEGEI

14N.V.Lopatin, The forecast of new oil and gas bearing zones and the foundation of the objects for the priority research and the licensing in the Pur-Taz (Krasnoyarky Region) and the Enisei-Khatanga (Taymyr Autonomous Okrug) oil and gas areas on the basis of the concept of hydrocarbon generation-accumulation systems and the integration of geological and geophysical and geochemical information. Moscow,2011, VNIIgeosystem

15 J.K.Pogrebitsky, The transition zones of the “mainland-ocean” in the geodynamic system of the Arctic Ocean. Moscow,27 IGC,v.7,1984

16 V.I. Poroskun, The current evaluation of oil and gas reserves of the Paiayka and North Paiaikha fields,Moscow,2011,VNIGNI-2

17 Yr. A.Pritula, The geologic evolution of the Siberian platform as a basis for assessing the prospects for its oil nd gas bearing and methods of the prospecting and exploration works for oil and gas, Leningrad,1973, VNIGRI

18 L.A.Savostin, P.M. Nathan, A.P.Stawski, The Mezozoicpaleogeodynamics and paleogeography of the Arctic region. Moscow,27 IGC, v.e, 1984

19 V.S.Surkov, O.G.Geraud, L.V. Smirnov, Arctic-Atlantic rift system. Moscow,27 IGC, v.3, 1984

20 V.S. Staroselthev, The clarification quantify of the hydrocarbon potential of the Taymyr Autonomous Okrug and economic analysis of the development of oil and gas fields, 1999,Novosibirsk-Norilsk, SNIIGiMS

21 V.I.Ustritsky, G.E. Chernik, The structure of the Paleozoic continental margin on the New Earth. Moscow,27IGC,v.3,1984

22 S.A.Ushakov,V.V.Fedynskiy, N.A.Shabalin, The dynamic of lithospheric plates and geosynclinals regions.Moscow,Internal Geodynamics. Common questions of geodynamics, Issue 1, 1972

23 N.M.Chernyshev, The synthesis of geological and geophysical data for the West and East Siberia on the basis of works of

exchange method of earthquake waves and the deep seismic sounding made by Special Regional Geophysical Expedition. 1983, Moscow, Soyuzgeophizika