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Heat flow and presence of oil and gas (the Yamal peninsula, Tomsk region)

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Abstract. The possibilities of Geothermy as a geophysical method are studied to solve forecast and prospecting problems of Petroleum Geology of the Arctic regions and the Paleozoic of Western Siberia. Deep heat flow of Yamal fields, whose oil and gas potential is associated with the Jurassic-Cretaceous formations, and the fields of Tomsk Region, whose geological section contents deposits in the Paleozoic, is studied. The method of paleotemperature modeling was used to calculate the heat flow density from the base of a sedimentary section (by solving the inverse problem of Geothermy). The schematization and mapping of the heat flow were performed, taking into account experimental determinations of the parameter. Besides, the correlation of heat flow features with the localization of deposits was revealed. The conceptual and factual basis of research includes the tectonosedimentary history of sedimentary cover, the Mesozoic-Cenozoic climatic temperature course and the history of cryogenic processes, as well as lithologic and stratigraphic description of the section, results of well testing, thermometry and vitrinite reflectivity data of 20 deep wells of Yamal and 37 wells of Ostanino group of fields of Tomsk region. It was stated that 80 % of known Yamal deposits correlate with anomalous features of the heat flow. Bovanenkovskoe and Arkticheskoe fields are located in positive anomaly zones. 75 % of fields of Ostanino group relate to anomalous features of the heat flow. It is shown that the fields, which are characterized by existence of commercial deposits in the Paleozoic, are associated with the bright gradient zone of the heat flow. The forecast of commercial inflows in the Paleozoic for Pindzhinskoe, Mirnoe and Rybalnoe fields is given. The correlation between the intensity of naftidogenesis and the lateral inhomogeneity of the deep heat flow is characterized as a probable fundamental pattern for Western Siberia.

Key words: the deep heat flow, oil and gas fields, Yamal, Paleozoic, Tomsk Region, the correlation, Western Siberia

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Introduction

Within the development paradigm of hydrocarbon resources base of Russia, the Arctic regions and the Paleozoic of Western Siberia become subsequent objects of geological exploration and demand perfecting of criteria and updating prospecting methods (Kontorovich, 2016; Kontorovich, 2017). Present work is related to the enhancement of possibilities of Geothermy as a geophysical method for solving forecast and prospecting problems of Petroleum Geology (Isaev et al., 2018).

Key role belongs to fundamental geodynamic parameter – the deep heat flow density (Khutorskoy, 1996). This is the main parameter, determining the thermal history of potentially oil source sediments, the realization degree of generation potential of organic matter, the syngenesis of foci of hydrocarbon generation and accumulating reservoirs (Isaev, 2004). To the point, the following is a quotation from monograph (Kurchikov, 1992): "Thus, according to the new obtained data about deep heat flow, a widespread viewpoint concerning the omnipresent confinedness of oil and gas deposits to *geotemperature anomalies* zones is not confirmed. Nevertheless, it is found out that the majority of hydrocarbon accumulations are located in zones of substantial lateral inhomogeneity of *the deep heat flow*" (*italics* by article authors). A relevant contribution to the formation of Geothermy as an oil prospecting method, especially for the Arctic regions, of A.R. Kurchikov (Kurchikov, 2001) and M.D. Khutorskoy (Khutorskoy et al., 2013; Nikitin et al., 2015) must be mentioned.

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Objects for present research are territories of hydrocarbon fields localization in the northern part of Yamalo-Nenets Autonomous Okrug, where oil and gas potential is associated, predominantly, with the Lower Cretaceous deposits of the Akhskaya suite, and in Tomsk Region, which geological section contents deposits in the Upper Jurassic as well as in the contact zone of the Paleozoic and the Mesozoic and in the Inner Paleozoic.

Research purpose is to investigate a consistent pattern of the deep heat flow changes, to evaluate the correlation between the heat flow peculiarities and localization of hydrocarbon fields and to define possible prospecting geothermal criteria of oil and gas potential through the example of the territories, which were mentioned earlier.

Investigation and evaluation have been carried out, foremost, based on *calculated* values of the deep heat flow density from the base of a sedimentary section, besides the *experimental* determinations of the deep heat flow have been also analysed.

The methodology of deep heat flow calculation

The deep heat flow is determined by solving inverse problem of Geothermy with the aid of software package tools for 1D basin modelling (Isaev et al., 2018a; Isaev et al., 2018b). Solution is performed within the parametric description of the sedimentation history and the history of thermophysical properties of the sedimentary layer only, beginning from the Jurassic, without invoking information about the nature of heat flow and geodynamics below the base of the sedimentary section. For the conditions of Western Siberia, characterized, starting from the Jurassic time, by the quasistationarity of the deep heat flow (Duchkov et al., 1990; Kurchikov et al., 2001), the solution of the inverse Geothermy problem – determining the density of heat flow – is carried out uniquely.

To solve the inverse problem of Geothermy, we use as "observed" both measurements of reservoir temperatures obtained during well tests and temperature logs of steady-state boreholes (Method of definite geotemperature gradient, DGG) and also geotemperatures recalculated (Isaev, Fomin, 2006) from the values of vitrinite reflectance (VR). The geotemperatures from VR are included immediately in a rigorous mathematical form. No separate "calibrations" for VR temperatures are required.

The first boundary condition of the model is determined by the temperature of the surface of sedimentation in the Mesozoic-Cenozoic, i.e. paleoclimate factor, and is given as a piecewise linear function of the "local" secular temperature pattern on the Earth's surface. The "local" secular temperature patterns of the Arctic zone and the south-eastern part of Western Siberia were built on the basis of synthesis of experimental definitions and paleoclimatic reconstructions (Iskorkina et al., 2015; Isaev et al., 2016; Isaev et al., 2017).

Parametrization of sedimentary section, exposed by a well, which defines parameters of sedimentation and thermophysical model, accepts in compliance with the lithologic and stratigraphic dedicated breakdown.

Petrophysical dependences of thermal conductivity of sediments on their lithology and density are used for setting the thermal conductivity of rocks (Isaev et al., 2002). Thus, the thermal conductivities of rocks (1,27-1,65) W/m·K were determined by their density in the range (2,02-2,46) g/cm^3. The coefficients of thermal diffusivity (6,5-8,0)*10^{-7} m^2/s and thermal extraction density of radioactive sources (1,1-1,3)*10^{-6} W/m^3 were determined according to the lithology of stratigraphic sequence as well. The formation, existence and degradation of the permafrost and ice mass in the Neopleistocene and Holocene are taken into account as a kind of dynamic lithologic and stratigraphic complexes with anomalous thermal conductivity (2,09-2,25) W/m·K, thermal diffusivity (1,05-1,20) *10^{-6} m^2/s and density (0,92-2,10) g/cm^3.

The upper boarder of sedimentation mass – depositional surface, daylight surface. Therefore, paleotemperature reconstructions immediately are conjugated with paleostructural reconstructions. The sedimentation rate in the model may be set to zero and negative values, that allows to take into account non-depositional hiatus and denudation.

The main criterion for the accuracy of the results of modeling is the *optimal* consistency ("discrepancy") of the maximum calculated geotemperatures with the "observed" temperatures of the "maximum paleothermometer" – temperatures determined by VR. *The optimality* of the "discrepancy" of calculated geotemperatures with "observed" reservoir temperatures is equally important. The optimal "discrepancy" is the mean square difference between the calculated and "observed" values, which is equal to the error of observations (Strakhov et al., 2000). In our case, the error of observations is of the order of ± 2ºC (Isaev et al., 2018b). To be noted that not infrequently "discrepancy" of calculated geotemperatures with "observed" reservoir temperatures at depths less than 1,000 m noticeably goes beyond the optimal.

The important criterion for the accuracy of the results of modelling is the consistency of the calculated values of the heat flow density with the data of its experimental determination in the study area.

The heat flow of Yamal

The Mesozoic-Cenozoic sedimentary cover in the study area began to form in the Lower Jurassic. In this time *Kiterbyutskaya argillaceous suite J_1t, which had an oil-source potential*, was accumulating. Till the end of the Volgian Age the marine transgression has expanded, *Bazhenov formation (J_3tt+K_1b), which is the most enriched in organic matter*, was accumulating. According to the average VR value – R^0_{vt} = 0,96 % – the Bazhenov formation is in the end of the main oil generation zone within the limits of the Arctic area.

Marine regime has prevailed since the Aptian-Cenomanian until the beginning of the Eocene. Thickness analysis of Paleogene-Neogene testified that sedimentation had gone to the middle of the Miocene for 32 million years (Nyurolskaya, Tavdinskaya, Atlymskaya, Novomikhaylovskaya, Turtasskaya, Abrosimovskaya formations) and amounted to 335-535 m, then these sediments have been degraded in the Early Bicheul time.

In the Middle Miocene-Early Pliocene, since the end of the Bicheul time and till the end of the Novoportov accumulation had gone of the order of 100 m thick sediments, which in the subsequent stage of positive tectonic movements over 1.3 million years were denudated. With the onset of the Late Miocene, Pliocene-Quaternary lacustrine-alluvial sediments accumulated.

The Middle Jurassic oil and gas complex (OGC) includes reservoirs in Vimskaya suite ($J_2b_1^1$) with $YuYa_{7-9}$ formations and Malyshevskaya suite ($J_2b_2^2$-bt_{1-2}) with $YuYa_{2-4}$ formations in lower subsuite. *The Upper Jurassic OGC* combines Nurminskaya suite (J_2bt^3-$k+J_3ok$-tt_1), while *the Cretaceous* – Akhskaya, Tanopchinskaya and Yarongskaya the Lower Cretaceous suites. Achimovskaya sequence is identified in the bottom of the Cretaceous with a group of Ach formations.

Stratigraphic breakdowns, well testing results and VR data of deep wells (Database of the Trofimuk Institute of Petroleum Geology and Geophysics of Siberian Branch of Russian Academy of Sciences, 2018) are invoked for purpose of building sedimentation and thermophysical 1D-models. The breakdowns are accepted considering the dynamic of tectonic events during the formation of sedimentary section in the territory of Yamal. Account the permafrost is performed beginning from 0.52 Ma, while ice mass – beginning from 0.182 Ma (Isaev et al., 2017). The glacier has completely degraded by the time of 15 thousand years ago (the end of the Sartan time).

The scheme of heat flow density of Yamal (Fig. 1A) was built using *calculated* values of heat flow density from the base of the sedimentary section in 8 wells and data of *experimental* determinations of deep heat flow density in 12 wells (Table 1).

To be noted, that the pattern concerning increasing the deep heat flow density towards the north-west direction (Khutorskoy et al., 2013), which was earlier established, is observed on the obtained calculated scheme as well (Fig. 1).

It is interesting to match *calculated* values of the heat flow, obtained with the authors' methodology (Isaev et al., 2018a; Isaev et al., 2018b), *with calculated* values of heat flow, obtained earlier via use of the physical-mathematical model of A.R. Kurchikov (Kurchikov, 1992). Thus, cataloged values of the heat flow density (Kurchikov, 1992) in wells of Kharasaveyskoe, Kruzenshternskoe and Bovanenkovskoe fields are in the range of 56-62 mW/m^2, whereas the scheme (Fig. 1) gives the range of 57-62 mW/m^2. And then cataloged values of the heat flow density (Kurchikov, 1992) in wells of Arkticheskoe and Sredne-Yamal'skoe fields are in the range of 54-56 mW/m^2, whereas the scheme (Fig. 1) gives the range of 51-57 mW/m^2.

Presumed, Table 1 and also Table 3 (calculated heat flow, "discrepancies" of modelling) are of self-consistent interest. Along with that, this information is an argument for reliability of modelling results, values of the heat flow in tables may become a basis for following 2D and 3D basin modelling. One of the most problem-plagued and quite difficult stage of the basin modelling is receiving the heat flow appraisals. The complicacy and ambiguousness of heat flow determination from the base of sedimentary section, which is based in systems GALA, Temis, PetroMod on the models of the lithosphere rifting ("defined rift phases") (Hantschel et al., 2009; Kontorovich et al., 2013; Galushkin, 2016), is known, but far from always mentioned.

It is possible to see the following peculiarities in the scheme (Fig. 1B): "positive anomaly" (for example, Bovanenkovskoe area); "negative anomaly" (Yuzhno-Tambeyskoe area); "bay-shaped configuration of isolines" (Rostovtsevskoe area); "non anomalous field" (Sredne-Yamal'skoe area).

Analysis of correlation between the heat flow and localization of 13 well-known fields shows the following. 6 fields are in the zones of *positive anomalies* of heat flow (46 % of the total number), the biggest among them – Bovanenkovskoe and Arkticheskoe. 1 field is in the zone of *negative anomaly* of the heat flow (8 %) – Yuzhno-Tambeyskoe. 4 fields are in the zones of *bay-shaped configuration of isolines* (31 %): Kruzenshternskoe, Neytinskoe, Rostovtsevskoe and Novoportovskoe.

Consequently, *in the order of 80-85 % of known hydrocarbon fields of Yamal are associated with anomalous peculiarities of the deep heat flow.*

The heat flow of Ostanino group of fields (Tomsk Region)

The study area is located in Parabel District of Tomsk Region between rivers the Chuzik and the Chizhapka (Fig. 2). As to sediments of the platform cover the research territory is in the articulation zone of two tectonic structures of the first order: Nyurol'skaya megadepression and the south part of Srednevasyuganskiy megaswell (Kontorovich et al., 2006).

Identification number (Fig. 1A)	Well	Temperature, °C						Heat flow, mW/m^2 / depth, m
		Depth, m	Reservoir	By VR	By DGG	Modelling (calculated)	Difference between calculated and experimental	
Calculated by authors								
1	Rostovtsevskoe 64	2470	75	-	-	75	0	**50** /3485
		2650	81	-	-	81	0	
		2660	81	-	-	81	0	
		2096	-	84	-	85	+1	
		2600	-	98	-	101	+3	
		2827	-	111	-	108	-3	
2	Sredne-Yamal'skoe 14	846	17	-	-	23	+6	**51**/ 3383
		1700	-	83	-	81	-2	
		2200	-	100	-	97	-3	
		3000	-	120	-	122	+2	
3	Malo-Yamal'skoe 3002	2312	68	-	-	68	0	**51**/ 2751
		2355	69	-	-	69	0	
		2391	75	-	-	70	-5	
		2552	76	-	-	75	-1	
		1917	-	80	-	79	-1	
		1922	-	81	-	79	-2	
		1937	-	81	-	79	-2	
		2300	-	90	-	91	+1	
		2315	-	90	-	91	+1	
4	Arkticheskoe 11	3533	125	-	-	124	-1	**58**/ 2792
		3560	126	-	-	125	-1	
		2000	-	100	-	102	+2	
		2500	-	120	-	121	+1	
5	Bovanenkovskoe 116	2610	94	-	-	96	+2	**62**/ 3388
		2657	97	-	-	97	0	
		2795	103	-	-	103	0	
		3050	113	-	-	112	-1	
		2615	-	120	-	119	-1	
Imported calculated values (Popov, Isaev, 2011)								
6	Ust'-Yuribeyskoe 31	1165-1178	67		-	-	-	**48**/2900
7	Severo-Mantoyskoe 51	469-472	10		-	-	-	**47**/2400
		873-878	22		-	-	-	
		891-900	23		-	-	-	
		1368-1376	27		-	-	-	
		2322	-	56	-	-	-	
		2430	-	61	-	-	-	
		2434	-	65	-	-	-	
8	Novoportovskoe 54	2520-2540	83	-	-	-	-	**52**/2500
Imported experimental values (Khutorskoy et al., 2013)								
9	Rusanovskoe 2	-	-	-	-	-	-	**76**/-
10	Leningradskoe 1	-	-	-	-	-	-	**73**/-
11	Beloostrovskoe 1	-	-	-	-	-	-	**54**/-
12	Beloostrovskoe 3	-	-	-	-	-	-	**53**/-
13	Beloostrovskoe 4	-	-	-	-	-	-	**55/-**
14	-	-	-	-	-	-	-	**53/-**
15	-	-	-	-	-	-	-	**49/-**
16	-	-	-	-	-	-	-	**56/-**
17	-	-	-	-	-	-	-	**58/-**
18	-	-	-	-	-	-	-	**56/-**
19	-	-	-	-	-	-	-	**53/-**
20	-	-	-	-	-	-	-	**54/-**

Table 1. The heat flow in wells of the Yamal Peninsula

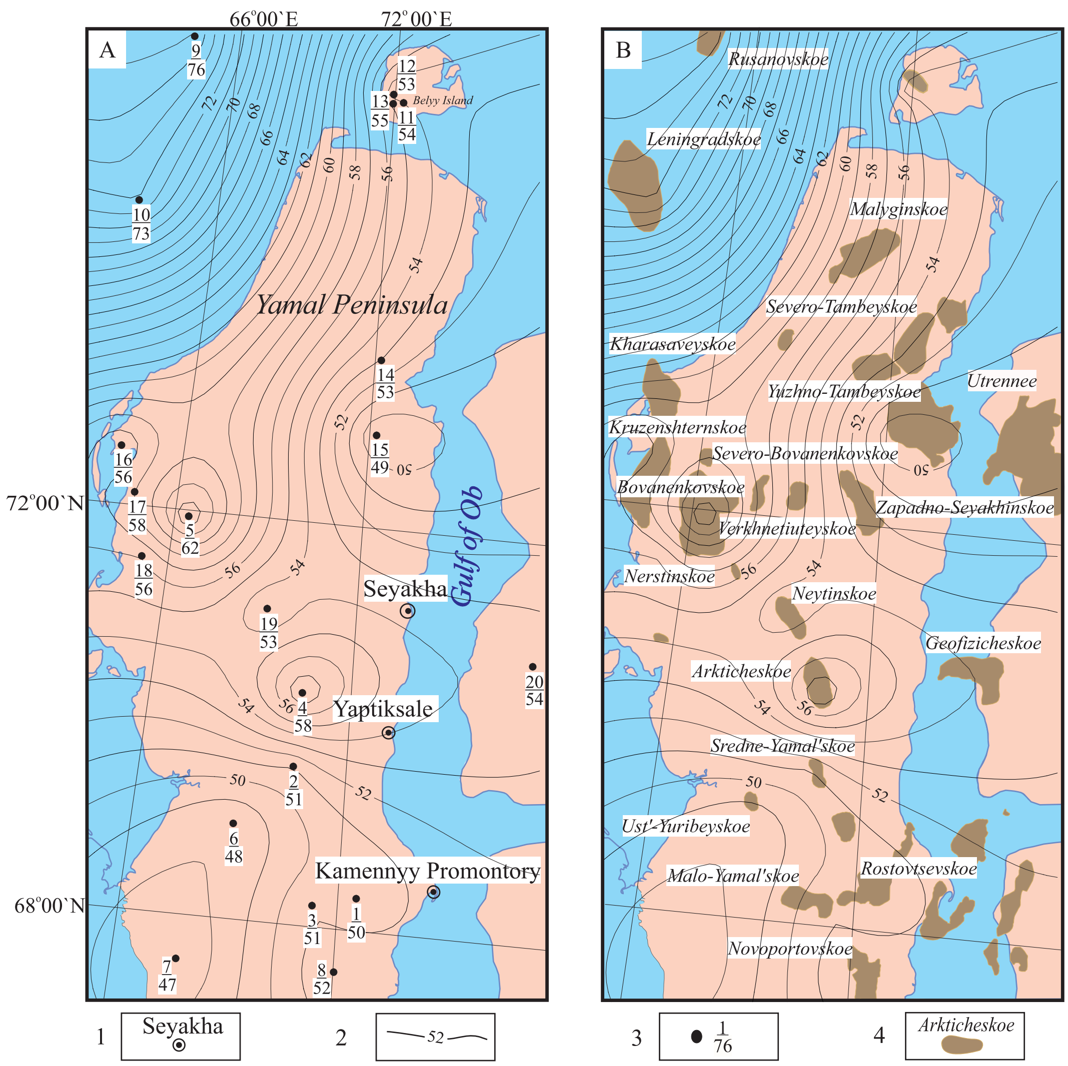

Fig. 1. The Yamal Peninsula. The heat flow (A) and its correlation with hydrocarbon deposits (B): 1 – residential place and its name; 2 – isolines of deep heat flow values; 3 – well, the numerator is an identification number, the denominator – heat flow density value, mW/m^2; 4 – field outline and the name

The Jurassic sedimentary rocks rest with non-depositional hiatus and angular unconformity on erosional suppression of the Paleozoic carbonate rocks of the Devonian-Lower Carboniferous.

Oil and gas fields, mainly, are associated with the Upper Jurassic sandy reservoirs of horizon Yu1. Hydrocarbon deposits are concentrated in anticline, fault-bounded traps of the Upper and Middle Jurassic and *in the oil-and-gas horizon of weathering crust* (*M formation*) and *in the Inner Paleozoic (M1 formation*) (Table 2). The deposits of the uppermost part of basement rocks are relating to metasomatically altered bioaccumulated limestones, which represent as reservoir rocks of porous-fissured type.

Commonly spread in the study territory the Upper Jurassic *Bazhenov Formation* is an oil source rock *for the Middle and Upper Jurassic OGC* (Fomin, 2011). Potentially oil-source the Lower Jurassic *Togurskaya suite* is accepted as a traditional hydrocarbon source *for the pre-Jurassic OGC* (Kostyreva, 2005). However, this formation has quite limited spread – the south-western edge of the study area (Fig. 2A). In this connection it is impossible to except the version, which suggests accounting *the Devonian strata* as a hydrocarbon generating source for the pre-Jurassic reservoirs (Lobova et al., 2018). The hypothesis of *"Bazhenov source of origin"* of the pre-Jurassic hydrocarbon deposits is more disputable and it has only indirect arguments (Galieva, Krutenko, 2019).

The calculations of the heat flow density performed for geological sections of 35 exploratory and 2 parametric wells on the study area (Fig. 2). Data of deep wells testing (reservoir temperatures) and temperature logs DGG were investigated and summed up from primary "well historical data", reserve calculation reports, operational analysis reports and generalization of geological and geophysical database of Tomsk Region (Database of Tomsk branch of the "Territorial fund of geological information, Siberian federal district", 2018). VR values determined in the Laboratory of Oil and Gas Geochemistry of the Institute of Petroleum Geology and Geophysics of Siberian Branch of Russian Academy of Sciences (Novosibirsk).

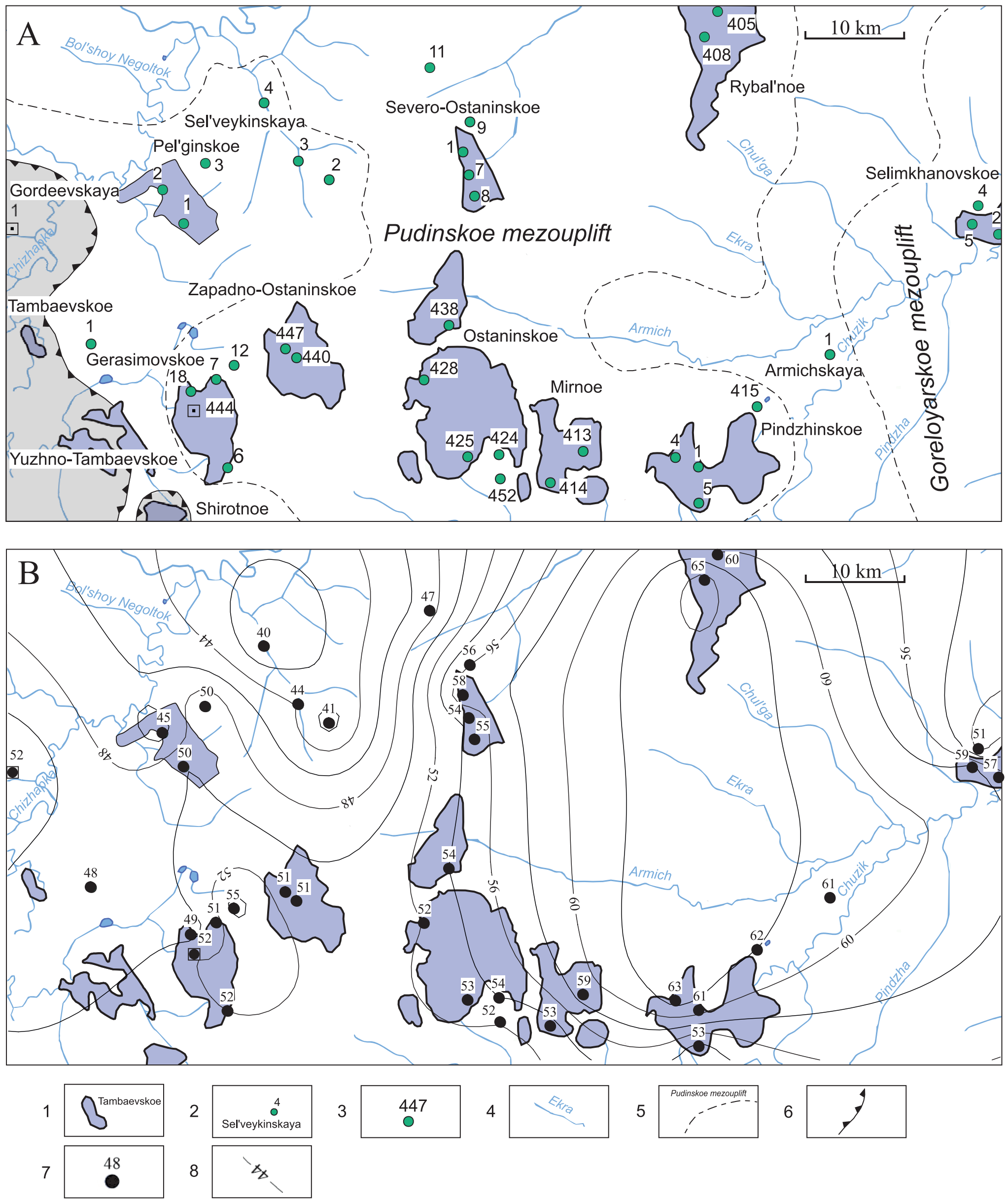

Fig. 2. Tomsk Region. Review scheme (A) and map of the heat flow density (B) of Ostanino group of oil and gas fields. 1 – hydrocarbon field outline; 2 – drilling area; 3 – well of paleotemperature modelling, a number of it; 4 – river system; 5 – tectonic structures of the second order; 6 – boarder of Togurskaya suite spread; 7 – well, calculated value of the heat flow (mW/m²); 8 – isolines of the heat flow density values.

The comparison of modelling temperatures with reservoir temperatures and with temperatures determined by DGG and by VR is provided in the Table 3. As is evident, the calculated model of heat distribution in the sedimentary section coincides with "observed" values in the optimal way at a level of ±2°C.

The reliability of the results of paleotemperature modelling is confirmed consistency of the obtained *calculated* values of the heat flow density with *experimental* determinations of A.D. Duchkov (Western Siberia. Geology and mineral resources of Russia, 2000). Experimental data is surrounded with isoline of 60 mW/m^2, calculated values are in the range of 41-65 mW/m^2.

The following anomalous peculiarities are observed in the map of the deep heat flow distribution (Fig. 2B): "positive anomaly", "gradient zone", "negative anomaly", "bay-shaped configuration of isolines".

Hydrocarbon fields in the eastern part of the territory are associated with the striking *gradient zone*, which surrounds a large *positive anomaly*. There 6 fields are located: Rybal'noe, Selimkhanovskoe, Pindzhinskoe, Mirnoe, Ostaninskoe, Severo-Ostaninskoe, that accounts 50 % of the total number of the fields in the study area. 3 fields (25 %) are *in the zone of bay-shaped configuration of isolines* – Pel'ginskoe, Gerasimovskoe, Zapadno-Ostaninskoe. Remarkably, hydrocarbon fields are absent in the zone of *negative anomaly* of the heat flow in the north-western part of the territory.

Therefore, *9 fields (75 %), which are located in the study area, are associated with the anomalous peculiarities of the deep heat flow distribution*. 3 fields – Shirotnoe, Yuzhno-Tambaevskoe, Tambaevskoe, do not correlate with the anomalous peculiarities of the heat flow.

Field	Oil and gas complex	Inflows (formation)		Fluid type
		Commercial	Noncommercial	
Mirnoe	The Upper Jurassic	Yu_1^{1-2}	-	OGC
Rybal'noe	The Upper Jurassic	-	Yu_0	O
		Yu_1^1, Yu_1^3, Yu_1^4	-	O
	The Paleozoic	-	M	O
Pindzhinskoe	The Upper Jurassic	Yu_1^1,Yu_1^2	-	O
	The Middle Jurassic	-	Yu_8	G
	The pre-Jurassic	-	M	OGC
Ostaninskoe	The Upper Jurassic	Yu_1^1, Yu_1^2, Yu_1^3, Yu_1^4	-	GC
	The Middle Jurassic	Yu_3, Yu_4	-	GC
	The pre-Jurassic	M, M_1	-	OGC
Severo-Ostaninskoe	The pre-Jurassic	M	-	OGC
Gerasimovskoe	The Upper Jurassic	Yu_1^{1-2}, Yu_1^3, Yu_1^4	-	GC
	The Middle Jurassic	Yu_2	-	GC
		-	Yu_7	O
		-	Yu_8	O
		-	Yu_9	O
		Yu_{10}	-	OGC
		Yu_{11}	-	GO
		Yu_{12}	-	GO
	The Lower Jurassic	Yu_{14}	-	GO
		Yu_{15}	-	GO
	The pre-Jurassic	M, M_1	-	GO
Selimkhanovskoe	The Upper Jurassic	Yu_1^{1-2}	-	OGC
		Yu_1^{3-4}	-	GO
	The Middle Jurassic	-	Yu_2	O
	The pre-Jurassic	M	-	OGC
Pel'ginskoe	The Upper Jurassic	Yu_1^1	-	GO
Tambaevskoe	The Middle Jurassic	-	Yu_6, Yu_7	GO
	The pre-Jurassic	M	-	GO
Yuzhno-Tambaevskoe	The Lower Jurassic	-	Yu_{14}	O
	The pre-Jurassic	M, M_1	-	GO
Shirotnoe	The Middle Jurassic	Yu_{13}	-	OGC
		-	Yu_{10}	O
	The Lower Jurassic	-	Yu_{15}	GO
		-	Yu_{16}	O
	The pre-Jurassic	-	M	OGC

Table 2. Oil and gas potential of Ostanino group of fields (according to the Database of Tomsk branch of the "Territorial fund of geological information, Siberian federal district", 2018). Fluid type: G – gas, O – oil, GC – gas condensate, OGC – oil and gas condensate, GO – gas and oil.

Independently important to note, that Selimkhanovskoe, Ostaninskoe, Severo-Ostaninskoe and also Gerasimovskoe fields, within which deposits are exposed with commercial hydrocarbon inflows, are associated with the substantial lateral inhomogeneity of the heat flow density (*gradient zones*) (Table 2). Pindzhinskoe, Mirnoe and Rybal'noe fields are also included in the striking *gradient zone*, within them it is possible *to forecast* deposits with commercial hydrocarbon inflows.

Yuzhno-Tambaevskoe and Tambaevskoe fields, within which deposits are exposed with commercial hydrocarbon inflows, are separated from anomalous peculiarities of the heat flow. Interesting to point, that particular these fields are located within the boarders of spread of potentially oil-source the Lower Jurassic Togurskaya suite.

Conclusion

The scheme and the map of the deep heat flow were built for the territory of localization of the Arctic hydrocarbon fields of Yamal and Tomsk Region, where the Paleozoic oil deposits were exposed in geological section.

No.	Well	Temperature, °C						Calculated heat flow, mW/m^2 / depth, m
		Depth, m	Reservoir	By VR	By DGG	Modelling (calculated)	Difference between calculated and experimental	
1	Zapadno-Ostaninskoe 440	2530	87	-	-	88	+1	**51** /2750
		2495	87	-	-	86	-1	
		2512	87	-	-	87	0	
2	Zapadno-Ostaninskoe 447	2510	87	-	-	87	0	**51** /2790
		2512	87	-	-	87	0	
3	Ostaninskoe 424	2839	106	-	-	102	-4	**54** /2880
		2494	89	-	-	91	+2	
		2541	90	-	-	92	+2	
4	Ostaninskoe 425	2515	88	-	-	90	+2	**53** /2825
		2700	100	-	-	96	-4	
		2776	-	112	-	114	+2	
5	Ostaninskoe 428	2000	-	-	70	72	+2	**52** /2750
		2400	-	-	84	85	+1	
		2500	-	-	90	88	-2	
		2510	86	-	-	89	+3	
		2680	-	-	97	94	-3	
6	Ostaninskoe 438	2704	-	115	-	115	0	**54** /2750
		2570	94	-	-	94	0	
		2512	94	-	-	92	-2	
		2119	77	-	-	79	+2	
7	Ostaninskoe 452	2538	-	103		106	+3	**52** /2895
		2556	-	107		107	0	
		2895	-	120		118	-2	
8	Severo-Ostaninskoe 1	2541	-	117	-	115	-2	**58** /2645
		2576	-	115	-	116	+1	
		2629	-	115	-	118	+3	
		2425	95	-	-	95	0	
		2555	101	-	-	99	-2	
		2388	93	-	-	93	0	
9	Severo-Ostaninskoe 8	2829	106	-	-	106	0	**55** /2840
		2831	105	-	-	106	1	
10	Severo-Ostaninskoe 9	2783	-	120	-	120	0	**56** /2800
		2784	-	120	-	120	0	
11	Severo-Ostaninskoe 7	2773	-	115	-	117	+2	**54** /2790
		2782	-	119	-	117	-2	
12	Severo-Ostaninskoe 11	2776	-	105	-	105	0	**47** /2790
13	Armichskaya 1	2480	-	115	-	116	+1	**61** /2900
		2540	-	120	-	119	-1	
14	Gordeevskaya 1P	2874	-	120	-	120	0	**52** /3280
15	Tambaevskoe 1	2590	-	96	-	102	+6	**48** /3040
		2593	84	-	-	84	0	
		2682	86	-	-	87	+1	
		2754	87	-	-	89	+2	
		2936	98	-	-	94	-4	
		2984	100	-	-	96	-4	
16	Pel'ginskoe 1	2630	89	-	-	89	0	**50** /3020
17	Pel'ginskoe 2	2588	-	98	-	98	0	**45** /3040
		2595	-	98	-	98	0	
		2597	-	98	-	98	0	
		2605	-	98	-	98	0	
		2610	-	98	-	98	0	
		2615	-	99	-	99	0	

Table 3. The heat flow in wells of Ostanino group of fields (Tomsk Region)

18	Pel'ginskoe 3	2615	-	106	-	107	+1	**50** /2970
		2630	-	106	-	107	+1	
		2640	-	109	-	108	-1	
		2729	-	111	-	110	-1	
		2766	-	112	-	112	0	
		2822	-	113	-	113	0	
19	Selimkhanovskoe 2	2255	84	-	-	87	+3	**57** /2430
		2265	89	-	-	87	-2	
		2360	91	-	-	90	0	
20	Selimkhanovskoe 4	2455	-	98	-	98	0	51 /2480
21	Selimkhanovskoe 5	2247	92	-	-	89	-3	**59** /2480
		2299	89	-	-	91	+2	
		2330	92	-	-	92	0	
22	Sel'veykinskaya 2	2579	90	-	-	89	-1	**41** /2900
		2623	90	-	-	90	0	
		2808	96	-	-	94	-2	
		2904	96	-	-	97	+2	
		2909	96	-	-	97	+2	
		2947	96	-	-	98	+2	
23	Sel'veykinskaya 3	2549	-	91	-	93	+2	**44** /2800
		2648	-	92	-	95	+3	
		2798	-	104	-	99	-5	
24	Sel'veykinskaya 4	2812	-	92	-	92	0	**40** /2810
25	Gerasimovskoe 6	2570	-	104	-	104	0	**52** /2870
		2596	-	103	-	105	+2	
		2859	-	115	-	113	-2	
26	Gerasimovskoe 7	2565	87	-	-	89	+2	**51** /2740
		2710	96	-	-	94	-2	
27	Gerasimovskoe 12	2586	-	110	-	109	-1	**55** /2840
		2775	100	-	-	102	+2	
		2797	-	118	-	116	-2	
		2821	-	118	-	117	-1	
		2838	-	117	-	118	+1	
28	Gerasimovskoe 18	2214	-	-	72	75	+3	**49** /2890
		2387	-	-	77	80	+3	
		2528	-	-	82	84	+2	
		2541	-	-	83	84	+1	
		2878	102	-	-	95	-7	
29	Gerasimovskoe (Zapadno-Ostaninskoe 444)	2754	94	-	-	97	+3	**52** /2860
		2770	94	-	-	97	+3	
		2810	95	-	-	99	+4	
		2795	-	118	-	113	-5	
		2840	-	120	-	115	-5	
30	Mirnoe 413	2507	100	-	-	100	0	**59** /2810
31	Mirnoe 414	2328	81	-	-	83	+2	**53** /2650
		2510	89	-	-	89	0	
		2593	94	-	-	92	-2	
32	Mirnoe 415	2356	98	-	-	100	+2	**62** /2690
		2560	109	-	-	107	-2	
33	Pindzhinskoe 1	2540	105	-	-	105	0	**61** /2890
34	Pindzhinskoe 4	2530	107	-	-	107	0	**63** /2595
35	Pindzhinskoe 5	2528	-	111	-	109	-2	**53** /2885
		2546	-	109	-	109	0	
		2808	-	116	-	118	+2	

Continue Table 3. The heat flow in wells of Ostanino group of fields (Tomsk Region)

It was stated that 75-80 % of hydrocarbon fields, which were located in the study areas, correlated with the anomalous peculiarities of the deep heat flow distribution.

The reliability of calculated values of Yamal heat flow was reasoned with performing of the classical geophysical criterion – criterion of "discrepancy", consistency with earlier revealed tendency of the heat flow density increase towards the north-western direction, comparability with the catalogue of calculated values of the heat flow, which was presented in earlier published monographic work (Kurchikov, 1992). The reliability of calculated values of the heat flow of Ostanino group of fields of Tomsk Region was substantiated with performing the criterion of "discrepancy", consistency with the map of the heat flow determinations of Western Siberian Plate.

The confinedness of fields with commercial hydrocarbon inflows from the deposits of pre-Jurassic OGC to the strongly marked *gradient zone* of the heat flow density values was placed emphasis through the example of Ostanino group of fields. This allows to forecast getting commercial inflows from the pre-Jurassic OGC in Pindzhinskoe, Mirnoe and Rybal'noe fields.

Afore-named characterize lateral inhomogeneity of the heat flow (*gradient zones*), probably, not as forecast criterion of oil and gas potential, but rather as an existence of the fundamental correlation between the intensity of naftidogenesis and lateral inhomogeneity of the deep heat flow of Western Siberia.

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