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HYDROGEOLOGY OF THE WESTERN PART OF THE YENISEI-KHATANGA REGIONAL TROUGH

For the first time in 35 years all the available hydrogeological data on the western part of the Yenisei-Khatanga regional trough are summarized. Methodologically, the study is based on the application of necessary techniques ranging from the geological and stratigraphic methods to the construction of hydrogeological models of hydrocarbon fields. For the first time schematic illustration of the hydrogeological superposition of the studied area has been composed. Hydrogeological conditions of aquifer systems of the lower hydrogeological stage have been clarified (below the Turonian-Oligocene regional seal). It is shown that different types of the vertical thermobaric and hydrogeochemical zonation are developed within the studied area. The main parameters, which determine the composition of groundwaters and controlling the type of hydrogeochemical zonation, are as follows: 1) the history of geological development of the region 2) genetic type of groundwaters 3) the interaction degree within the system "water-rock-gas-organic matter".

***Key words**: groundwaters; hydrogeological complex; hydrogeological superposition; thermobaric and hydrogeochemical zonation.*

INTRODUCTION

Since the beginning of exploration for oil and gas in Western Siberia a lot of the factual material has been accumulated, which reflects the chemical and gas composition of groundwaters of the hydrocarbon deposits. General information on the West Siberian megabasin hydrogeology is given in the publications of N.M. Kruglikov et al., V.M. Matusevich, and A.A. Rozin [Kartsev et al., 1986; Kontorovich, Zimin, 1968; Kontorovich et al., 1975; Kurchikov, 1992; Nazarov, 2004; Shvartsev, Novikov, 2004; Stavisky et al., 2004]. From the 1950s several cumulated monographs on the basin have been published. E.A. Bars, A.E. Kontorovich et al., V.M. Matusevich, B.F. Mavritsky, A.A. Rozin, and V.B. Torgovanova et al. [Kruglikov, 1964; Rostovtsev, Ravdonikas, 1958]. Multivolume monograph "The USSR hydrogeology vol. XVI" should also be noted [Nudner, 1970] that devoted to West Siberia.

Hydrogeological studies of sedimentary basins are carried out in many regions of the world. Various issues are solved on the genesis and formation conditions of groundwaters, the structural features of hydrodynamic field and the geothermal regime of subsurface, the development of petroleum exploration criteria, etc. [Bachu, Underschultz, 1993; Cao et al., 2011; Domrocheva, Novikov, 2009; Ferguson et al., 2007; Fowler, Grasby, 2006; Hao et al., 2009; Kreitler, 1989; Novikov, Shvartsev, 2009; Patz, Jordan, 1980; Powley, 1990; Shvartsev, Novikov, 2004; Stavitsky et al., 2004; Toth, 1987a, 1987b; Vugrinovich, 1988].

Hydrogeologically, the studied area is related to the transition zone from the West Siberian geosyneclise to the western part of the Yenisei-Khatanga regional trough and the Khatanga artesian basin of the East Siberian artesian region. Tectonically, the studied area comprises the Outer belt structures: Pre-Taimyr megamonoclise, Pre-Yenisei megamonoclise; Yamal-Kara depression: South Taimyr megamonocline, North Messoyakha megamonocline, Dolgon mezomonocline, East Taz mezomonocline; Ob step: Krasnoselkupsk monoclise, South Kara megasaddle, and North Chaselka saddle (Fig. 1).

Hydrogeology of Mesozoic deposits in the studied area is described in the most of publications by G.A. Ivanova and others [Bro et al., 1973; Ginsburg, Ivanova, 1971; Ravdonikas, 1962; Rostovtsev, Ravdonikas, 1958].

Here for more than 35 years (from 1977) no large-scale hydrogeological studies have been performed. To date, 216 deep wells in the studied area have been drilled. The level of knowledge of the hydrogeological conditions, hydrogeothermics, hydrodynamics, hydrogeochemistry and cryolitic conditions is different in areal extent and through the geological section.

HYDROGEOLOGICAL CONDITIONS

According to the accepted hydrogeological superposition of the West Siberian megabasin [Kruglikov, 1964; Matusevich et al., 2005; Nazarov, 2004; Nudner, 1970] and the available data on the study region within the lower hydrogeological stage five aquifer systems can be distinguished (top – down): *Aptian-Albian-Cenomanian, Neocomian, Upper Jurassic, Lower-Middle Jurassic and Triassic-Paleozoic (undivided).* The established Mesozoic complexes are composed mainly of permeable sand-siltstone rocks that are separated by the claystone seals. The above-mentioned complexes are isolated from the zone of active water exchange (hypergenesis) by the reliable persistent Turonian-Oligocene seal. Its screening features are got broken only when it is lithologically replaced by the permeable varieties in the cut off parts of the basin.

As shown by the detailed analysis of all the available material, the hydrogeological structure of the basin is rather complicated within the studied area due to the transition type of the section, lithofacies replacement, seal erosion and complicated fault structure. Thus, for example, the washout of the Dorozhkovkii seal of the Aptian-Albian-Cenomanian complex is revealed in the Nizhne-Khetskaya, Malo-Khetskaya, Dolganskaya, Tochinskaya and Sukho-Dudinskaya aeas. The washout of Neocomian seals (Yakovlevskii, Nizhne-Yakovlevskii, etc.) within the Malo-Khetskaya and Tochinskaya areas, of the Jurassic seals in the Yuzhno-Soleninskaya, Messoyakhskaya, Tampeiskaya, Zimnaya, Simeonovskaya and Malo-Khetskaya areas is detected.

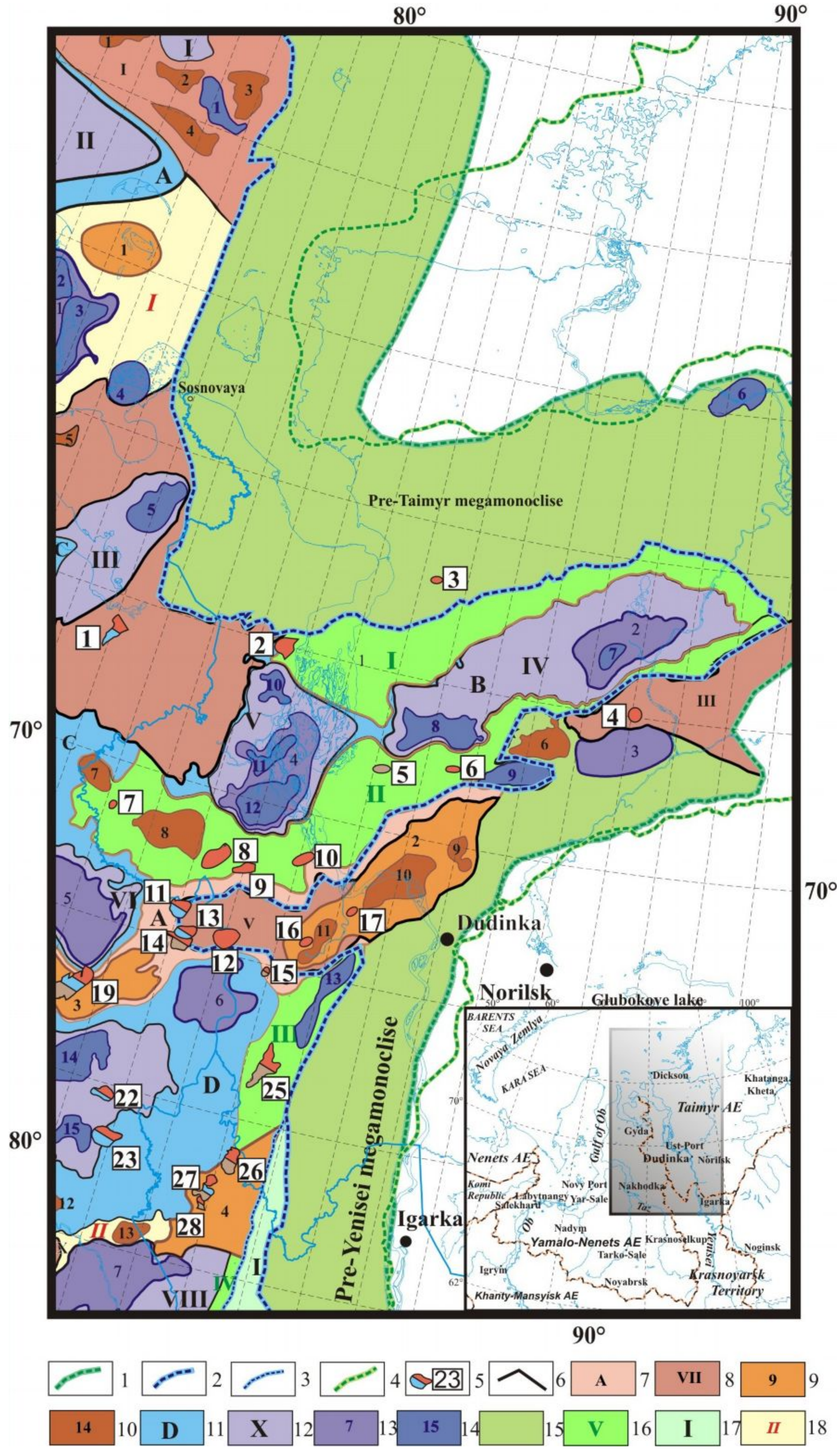

Fig. 1. Location of the studied area

1- Boundary of the Jurassic sedimentary basin 2 – boundary of the Inner region and the Outer belt 3 - boundary of the Yamal-Kara depression, 4 - boundary of supra-rank structures 5 - field and its number 6 – line of the hydrogeological section. Tectonic elements. Positive: - 7 supra-rank, rank 0: A – Messoyakha tilted mountain range, 8 – rank I: I – North Taimyr tilted megaswell, II – North Gydan megasalient, III - Tundra megasalient, IV - Gydan megasalient, V - Ust-Port megasalient, 9 –rank II: 1 - Neupokoev dome-shaped mezouplift, 2 – Rassohino mezosalient, 3 – Mid--Messoyakha mezoswell, 4 – Togul mezonose, 10 – rank III: 1 - Vystupnoye dome uplift, 2 – Soglasnoye dome uplift 3 - Pritaimyr dome uplift, 4 - Nozhov swell, 5 – East-Zelenomysovsk swell, 6 – Upper Yangoda dome uplift, 7 – South Gydan dome uplift, 8 - Pagodsk dome uplift, 9 – Sukhodudinka dome uplift arch, 10 – Ust-Malaya Kheta dome uplift, 11 – Ust-Solenyi swell, 12 - Ust-Yurideiyakha dome uplift, 13 – Russko-Rechenskoye dome uplift. Negative: 11 - supra-rank structures, rank 0: A - Kara megasyneclise, B - Agapka-Yenisei trench, C - Antipayutinsk-Tadebeyakha megasyneclise, D – Bolshaya Kheta megasyneclise, 12 –rank I: I – North Kara megadepression, II – Central Kara megadepression, III – Mid-Gydan megaentrenchment, IV - Agapka megatrough, V - Yenisei megadepression, VI – East Antipayutinsk megadepression, VII – North Taz megadepression, VIII - Taz structural megabay, 13 – rank II: 1 – North Gydan mezodepression, 2 – Agapka mezodepression, 3 – Dudylta mezodepression, 4 - Belovo mezodepression, 5 – Vnutrennyaya mezodepression, 6 – South Messoyakha mezodepression, 7 – Lower Taz mezodepression, 14 – rank III: 1 – Severo-Vostochnii trough, 2 - Shokalka depression 3 – Peschanaya depression, 4 – Oleniya depression, 5 – Mid-Sayakha depression, 6 - Tareyas depression, 7 - Yakimsk depression, 8 – Mungui trough, 9 – Krestovskii trough, 10 - Polikarpovka depression, 11 – Nosoksk trough, 12 - Karaulsk depression, 13 – Dolgon trough, 14 – Mid-Indikyakha depression, 15 – Upper Indikyakha depression. Intermediate: 15 - Megamonoclises of the Outer belt: Pre-Taimyr megamonoclise, Pre-Yenisei megamonoclise, 16 - Mega- and meso-, monoclines of the Yamal-Kara depression: I – South Taimyr megamonocline, II – North Messoyakha megamonocline, III - Dolgon mezomonocline, IV – East Taz mezomonocline, 17 – Mega- and meso- monoclines of the Ob step: I - Krasnoselkupsk monoclise, 18 Mega- and meso-saddles: I – South Kara megasaddle, II – North Chaselka saddle.

Fields: 1 – Ladertoyskoye, 2 – Deryabinskoye, 3 – Habeyskoye, 4 – Dzhangodskoye, 5 – Payakhskoye, 6 – Ozernoye, 7 – Nanadyanskoye, 8 – Pelyatkinskoye, 9 - Ushakovskoye, 10 –Kazantsevskoye, 11 – Severo-Soleninskoye, 12 - Messoyakhskoye 13 – Yuzhno-Soleninskoye, 14 - Novosoleninskoye, 15 - Gorchinskoye, 16 – Zimneye, 17 – Nizhne-Hetskoye, 18 – Zapadno-Messoyakhskoye, 19 – Vostochno-Messoyakhskoye, 20 - Yuzhno-Messoyakhskoye, 21 - Pyakyahinskoye, 22 – Severo-Halmerpayutinskoye, 23 - Halmerpayutinskoye, 24 - Tazovskoye 25 - Suzunskoye, 26 – Vankorskoye, 27 - Lodochnoye, 28 - Tagulskoye.

The seals within the Lower-Middle Jurassic complex were influenced by denudation in the Messoyakhskaya, Semyonovskaya and Malo-Khetskaya areas. Intense manifestation of faulting is well traceable from seismic data and drilling results in the Nizhne-Khetskaya, Malo-Khetskaya, Tochinskaya, Sukho-Dudinskaya, Dzhangodskaya and other areas (Fig. 2).

Eight types of structures by the type of hydrogeological section have been distinguished (Fig. 3). The first type is characterized by the presence in the section of all the aquifers and seals from the Lower Jurassic to the Upper Cretaceous. In terms of location, it is developed within the Anomalnaya, Gorchinskaya, Severo-Soleninskaya, Suzunskaya and other areas. The peculiarity of the second type is argillization of the Oxfordian regional reservoir in the Upper Jurassic aquifer system, and its distribution in the northern and western areas of the Verkhne-Kubinskaya, Kazantsevskaya, Ozernaya, Payutskaya and other areas. The third type of the section is characterized by argillization of the Nizhne-Khetskii and Nizhne-Khetskii-Sukhodudinskii reservoirs in the Neocomian complex and the development in the Nanadyanskaya, Payakhskaya, Yarovskaya areas of the western regions. The peculiarities of the fourth type are the almost complete absence of deposits of the Aptian-Albian-Cenomanian and Upper Jurassic complexes and the local washout of the Malyshevskii and Zimnii reservoirs. The structures with this type of the section are confined to the eastern regions (Dolganskaya, Malo-Khetskaya, Nizhne-Khetskaya and other areas). The fifth type of the section with local or complete washout of deposits of the Upper Jurassic complex is distributed in the Zimnaya, Messoyakhskaya, Simyonovskaya, Tampeiyskaya and other areas. The peculiarity of the sixth type is missing from the section of the base of the Neocomian complex along with the Upper Jurassic deposits (Nizhne-Khetskii and Nizhne-Khetskii-Sukhodudinskii reservoirs). The Vostochno-Messoyakhskaya area could be taken as an example. Within the structures (Deryabinskaya, Sukho-Dudinskaya and other areas), where the seventh type of the section is developed, the boundaries of the Lower Middle-Jurassic complex lack its lower part (Zimnii Sharapovskii, Nadoyakhskii and Vymskii reservoirs). Also, as in the second and third types, the Oxfordian regional reservoir and the reservoirs of the lower Neocomian are completely argillized (Nizhne-Khetskii, Nizhne-Khetskii-Sukhodudinskii and Nizhne-Sukhodudinskii). The eighth type is distributed in the cut off parts of the basin (Bolshelaydinskaya area, etc.) and is characterized by almost complete missing of Jurassic deposits from the section.

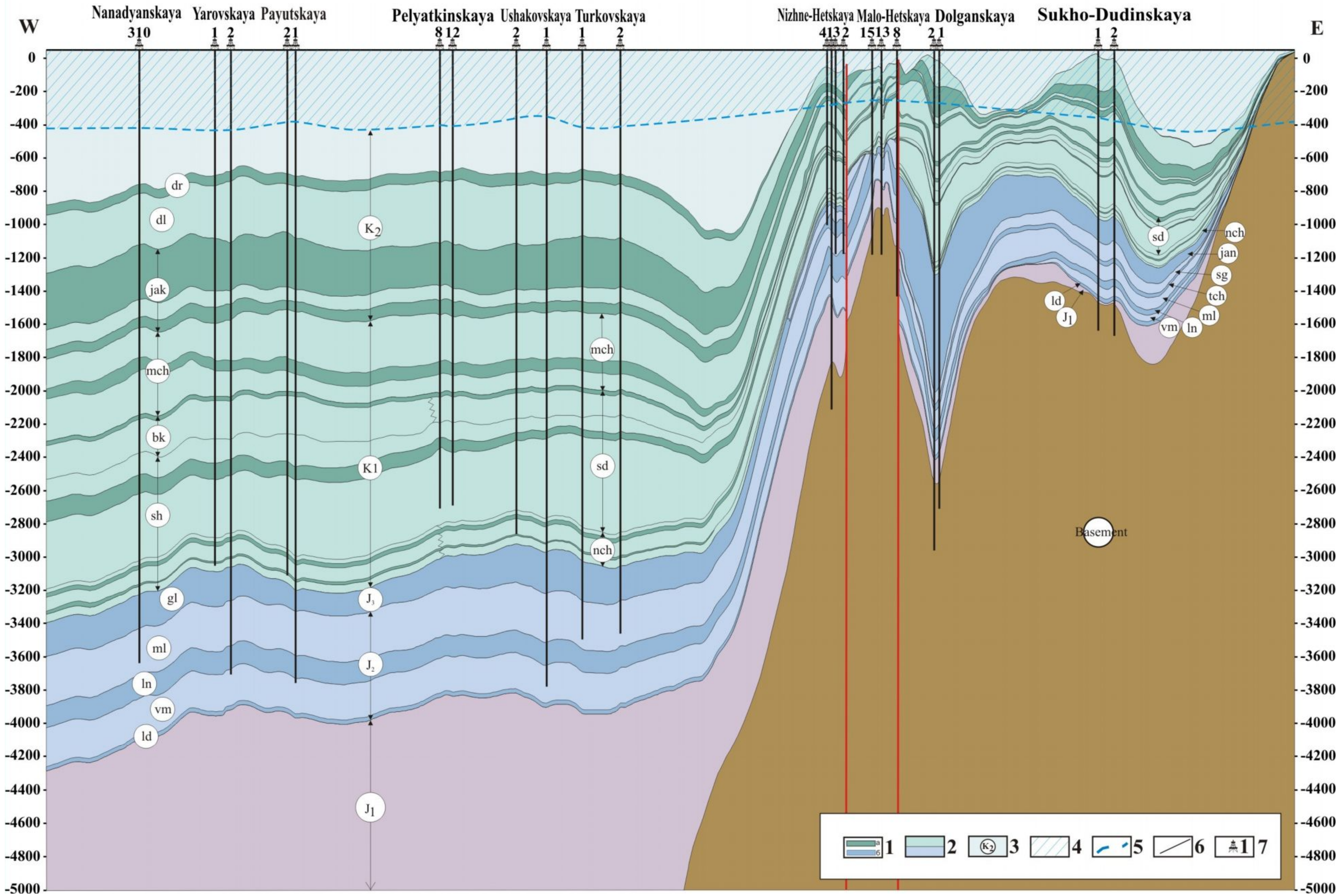

Fig. 2. The hydrogeological cross section along the line Nanadyanskaya-310 and Sukho-Dudinskaya-2 wells

1 – Regional seals, 2 – permeable complexes, 3 – age of the deposits, 4 – permafrost rocks (PFR), 5 – lower boundary of the PFR distribution, 6 – boundaries of regional seals and permeable complexes, 7 – well and its number. Indexes of formations: J2 – ld – Laydinskaya, vm – Vymskaya , ln – Leontievskaya, ml – Malyshevskaya, tch – Tochinskaya; J3 – sg – Sigovskaya, jan – Yanovstanskaya; J2 – 3 – gl – Golchihynskaya; K1 – nch – Nizhne-Hetskaya, sd – Sukho-Dudinskaya, sh – Shuratovskaya, bk – Baikalovskaya, mch – Malo-Hetskaya, jak – Yakovlevskaya; K1– 2 – dl – Dolganskaya; K2 – dr – Dorozhkovskaya.

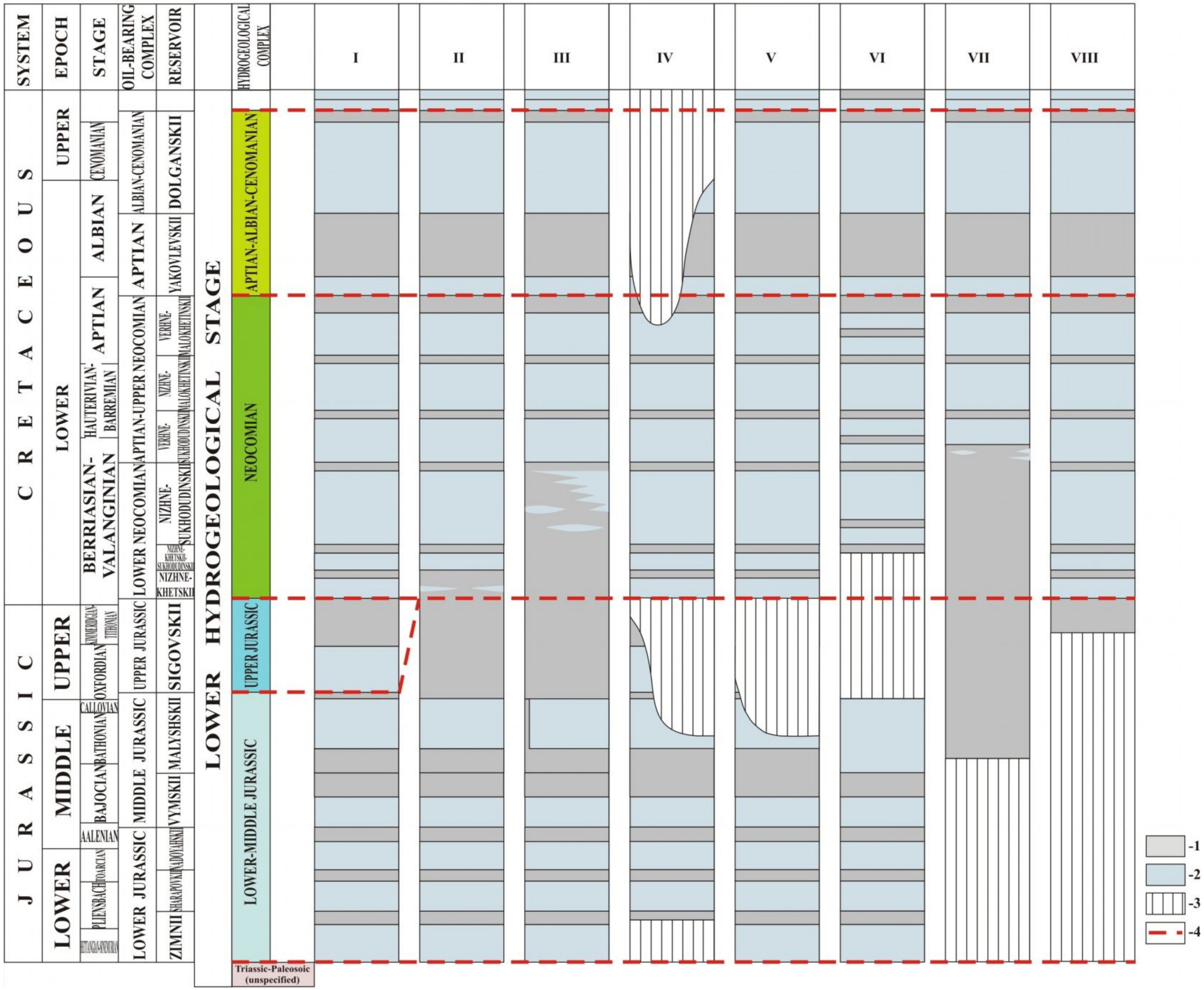

Fig. 3. Scheme of hydrogeological superposition of the western part of the Yenisei-Khatanga regional trough

1 – seal;; 2 – aquifer; 3 – absence of deposits; 4 –boundary of hydrogeological complexes.

It should be noted that in a first approximation this separation of structures of the western part of the Yenisei-Khatanga regional trough and the adjoining areas was given only on the basis of the hydrogeological features of the structure (presence or absence of certain hydrogeological stratigraphic units). Further details of the hydrogeological superposition should be based on the hydrodynamics and hydrogeochemistry features of the study basin.

When investigating the hydrogeological conditions and justification of hydrogeological superposition of the studied area, a special geological object, permafrost rocks, which compose the current cryolithic zone, should be taken into account. The territory of the Yenisei-Khatanga regional trough is confined to the zone of continuous monolithic permafrost distribution [Baulin et al., 1967; Grechishchev, 1983; Ravdonikas, 1962; Rosenbaum, Shpolyanskaya, 2000; Trofimov, Vasilchuk, 1987], which allows a regional seal to be distinguished in the upper part of the geological section (Fig. 2).

It is especially important to obtain reliable information on the hydrodynamics of hydrocarbon deposits in the severe environmental conditions of West Siberia and the Yenisei-Khatanga regional trough. Despite the fact that in the studied area more than 200 deep exploration wells were drilled, the percent of reliable hydrodynamic information is extremely low. Exploration maturity of the different hydrogeological objects is also different; the Neocomian aquifer system is most studied, which is associated to its high prospectivity for hydrocarbon (Fig. 4). The Jurassic aquifer systems are least studied with regard to hydrodynamic conditions. Analysis of the hydrodynamic conditions of the studied area is given in publications that noted below [Ravdonikas, 1962; Ginsburg et al., 1969; Ginsburg, Ivanova, 1971].

In this paper, comprehensive analysis of the hydrodynamic structure of the sedimentary basin with the elements of paleohydrogeological reconstructions was carried out. Thus, the reduced pressures of the Aptian-Albian-Cenomanian aquifer system (plane of reference - 2250 m) are from 20.2 to 23.0 MPa. Values higher than 22.0 MPa are traceable in the zones which correspond to internal catchment areas. This is also evident in the analysis of the of the anomaly coefficients of formation pressures. Its higher values are established in the Zapadno-Messoyakhskaya, Yuzhno-Messoyakhskaya and Pyakyahinskaya areas.

Below the results of research of the most studied Neocomian complex will be considered in detail. After a detailed sorting of the initial hydrodynamic materials, the reliable information on the test results of 271 objects of 100 wells in 26 areas. The distribution of formation pressures, reduced to the plane of reference of -3500 m, is of rather complex character.

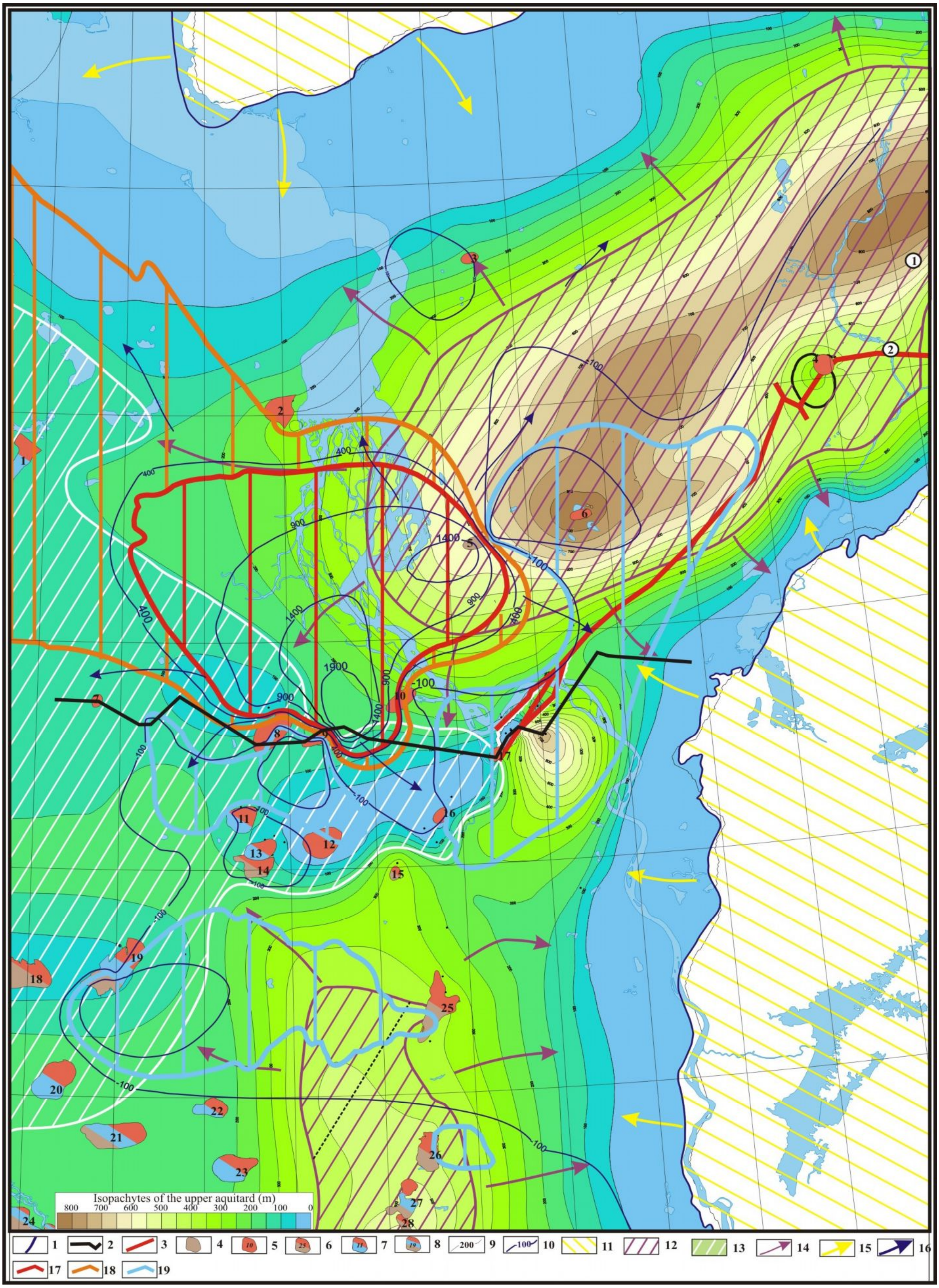

Fig. 4. Hydrodynamic map of the bottom of the Neocomian aquifer system (Nizhnekheskii, Nizhnekhetskii-Sukhodudinskii, Nizhnesukhodudinskii formations) with the elements of the paleohydrodynamical reconstructions

1 – distribution boundary of the Mesozoic-Cenozoic sedimentary cover, 2 – line of the hydrogeological section 3 – tectonic faults and fields (listed in Fig. 1): 4 – oil, 5 – gas, 6 – oil and gas, 7 – gas condensate, 8 – oil and gas condensate, 9 – thicknesses of the Upper Jurassic seal, 10 – hydroisopiestic lines of the Lower Neocomian complex, 11 – outer catchment area, 12 – piezomaximums (internal catchment area), 13 – piezominimums (internal discharge area), stream course of: 14 – fossil elision waters, 15 – meteoric infiltration waters, 16 – current elision waters; zones of reservoir pressures (by Ca value): 17 – anomalously high, 18 – high, 19 – lowered.

Here we have a zone of abnormally high formation pressures confined to the Payakhskaya, Sredne-Yarovskaya, Turkovskaya and Tanamskaya areas (Fig. 3). The highest values of the anomaly ratio (Ka) are observed in the wells: Turkovskaya-1 - 2.45; Turkovskaya-2 - 1.46; Payahskaya-1 - 1.45 and Payahskaya-2 - 1.49.

The abnormally high formation pressures zone borders on the higher pressure area, which begins to expand on the southwest and northeast, penetrating to the northwestern regions. The zones of lowered pressures in the Ozernaya, Nizhne-Khetskaya, Malo-Khetskaya, Sukho-Dudinskaya, Tochinskaya and Dolganskaya areas are associated with the values of reduced pressures less than 35-36 MPa.

Paleohydrodynamical reconstructions suggest that at all the stages of the basin development the outer catchment areas were located in the cut off parts of the study region. Internal catchment areas of the Neocomian complex formations formed in the most buried areas of the basin with the maximum thickness of compacting clayey rocks of Pelyatka member in the Lower Cretaceous (Vostochno-Antipayutin megadepression, Sredneindikyakha mezodepression, complicating the North Taz megadepression), and the Upper Jurassic (Vankor-Tagul tilting mezoswell, marginal part of the Bolshaya Kheta megasyneclise, northeastern part of the Belovo megadepression, Agapka megatrough, etc.)

We can judge on the dynamics and direction of the groundwater filtration within the studied area from the maps of isopiestic lines. Thus, if at the previous elision stages of the sedimentary basin development the internal head producing areas were in the northern, northeastern and southern areas of the region (Fig. 4), at the present stage of the petroleum system development they are located in the central part. There is a regular decrease in the intensity of the hydrodynamic field with the distance from the central part to the cut off parts. The outer catchment areas have not changed significantly. Penetration of fossil infiltration waters was also observed in the Malo-Khetskaya and Tochinskaya areas during the washout of the Malaya Kheta Formation clays during the Aptian. The highest values of pressure gradients are revealed in the Payakhskaya, Kazantsevskaya, Turkovskaya, Ushakovskaya, Pelyatkinskaya, Sredne-Yarovskaya and Anomalnaya areas. Further, there is a marked decrease in them in the northern, eastern, northwestern and southeastern regions.

The situation is not as unambiguous in the underlying Jurassic aquifer systems. The Upper Jurassic complex is sealed off over almost the entire area and there are no conditioning hydrodynamic materials for it. It could be noted only that in the distribution areas of its permeable deposits in the cutoff parts, formation pressures are insignificantly higher than the hydrostatic ones as they fully reflect the infiltration type of the geohydrodynamic system.

Within the Lower-Middle Jurassic complex, almost the entire center of the studied area falls into the abnormally high formation pressures development zone. Here, the pressure scatter reduced to the plane of reference of –3.500 m changes from 40 to 54 (and higher) MPa. This zone includes the same areas as in the abnormally high formation pressures zone of the Neocomian complex, as well as the Nanadyanskaya, Yarovskaya, Payutskaya, Pelyatkinskaya, Ushakovskaya, Kazantsevskaya, Messoyakhskaya, Severo- and Yuzhno-Soleninskaya areas. The abnormally high formation pressures zone is marked by a range of values of reduced pressures of 37-40 MPa. The remaining area of the Yenisei-Khatanga regional trough is characterized by the distribution of the normal pressure zone.

Thus, at the present, there are two types of the natural water drive system in the studied area: elision in the internal areas and infiltration in the outer cut off parts.

In this paper, all the available geothermal data have also been summarized (published and archive) for the studied area. When compiling the database of geothermal parameters, the thermometries of 46 wells were digitized; their interpretation was carried out by the stratigraphic levels, 345 spot measurements of temperature were analyzed, and the geothermal reservoir parameters were calculated. The geothermal parameters necessary for the analysis were obtained using the well-known computational methods; G.A. Cheremensky, N.M. Frolov, and N.N. Neprimerov et al. [Diakonov, 1958; Kurchikov, 1992].

On this basis, the main geothermal patterns were established and the geothermal zonation of the western part of the Yenisei-Khatanga regional trough and the adjoining areas was carried out. Several types of the hydrogeothermal section have been revealed that characterize the distribution of formation temperatures within the sedimentary cover thickness penetrated by drilling (Fig. 5). The observed change in geothermal gradients based on the well columns and the areal extent of the studied areas is not random, but is subject to certain patterns of the distribution of the Earth's natural thermal field, which is associated mainly with the lithological characteristics of rocks, geological structure and hydrogeological features of the studied areas, as well as assigning these areas to some large structural and tectonic elements.

It is established that in the areas of the regional faults the higher geothermal gradients of - 3-3.4 m ^{0}C/100 are marked; therefore, disjunctive tectonics confirms its insulating effect here. In general, the geothermal structure of the studied part of the trough is characterized by gradients not exceeding 2.5-2.8 m ^{0}C /100. The geothermal gradient is 2.37 m ^{0}C /100 in the eastern area, 2.5 in the southwest, and 2.8 m ^{0}C /100 in the central and northern areas.

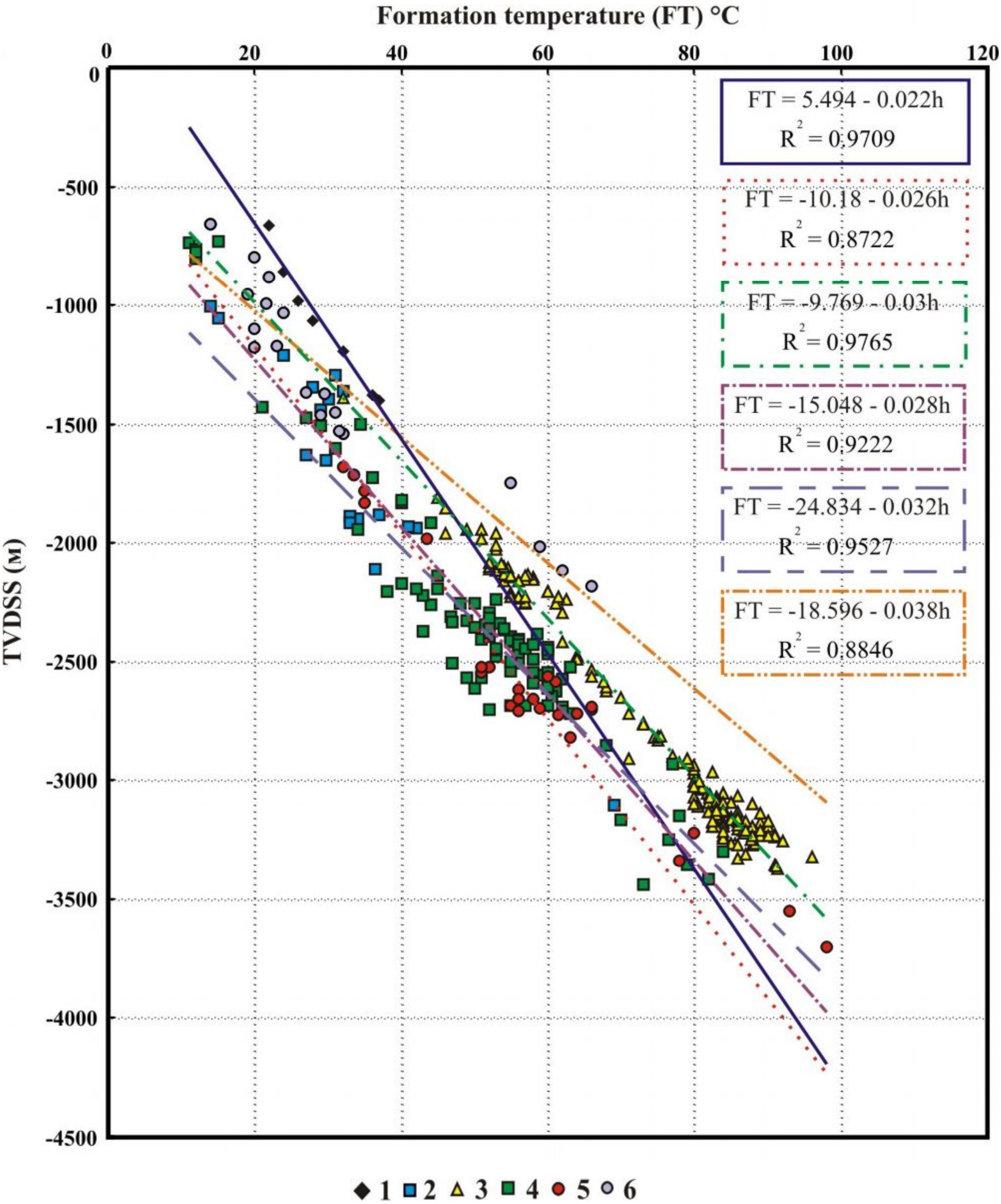

Fig. 5. Types of the vertical hydrogeochemical zonation in the western part of the Yenisei-Khatanga regional trough and adjoining areas

Trough areas: 1 – margin, 2 – east, 3 – southwest, 4 – center, 5 – north, 6 – fault zone.

The presence of structural maps and regression dependencies of geothermal features of the sedimentary cover in different parts of the studied area allowed the construction and correction of geothermal maps for top of the main hydrogeological complexes (Aptian-Albian-Cenomanian, Neocomian, Upper Jurassic, Lower-Middle Jurassic and Paleozoic), with regard for the available data on the spot measurements of formation temperatures and the temperature logs of wells.

GROUNDWATER GEOCHEMISTRY AND HYDROGEOCHEMICAL ZONING

The first evidence on the hydrogeological conditions and hydrogeochemistry of oil-and-gas bearing deposits in the studied area appeared with the beginning of exploration for oil in the Ust-Yenisei region in 1936 (V.N. Saks) [Obidin, 1959; Ponomarev, 1960].

Hydrogeochemical investigations of the Yenisei-Khatanga regional trough in last years were of general nature and no specific features and details for this area in the construction of hydrogeochemical zonation maps of the West Siberian megabasin were not marked (the northeast of the basin was assigned to a single hydrogeochemical zone of brackish, predominantly NaCl waters) [Kruglikov, 1985]. Hydrogeological conditions of the Malaya Kheta uplift were most fully studied, but very poor data have been given on the geochemical features of groundwaters [Ravdonikas, 1962].

Within the studied structures, groundwaters of the different chemical composition are revealed. NaCl, Cl-HCO_3Na and HCO_3-ClNa types are predominant [after Shchukarev, 1934]. Each of them has its own peculiarities in the distribution of basic salt-forming macro- and microcomponents, whose concentrations are directly dependent on the extent of their salinity (Table 1). There is a natural increase in the content of Cl, Na, Mg, Ca, K and microcomponents: Br, I, B, and NH_4^+ with its growth. With water salinity of 15-20 g/dm^3 and higher, the content of HCO_3^- in them decreases. The concentrations of SO_4^{2-} on average do not exceed 20-60 mg/dm^3 due to the well-known process of its reduction to H_2S, O.V. Shishkina [Strakhov, 1963]: $SO_4^{2-}+2C_{org}+2H_2O=2HCO_3^-+H_2S$.

Within the Aptian-Albian-Cenomanian aquifer system, NaCl waters with salinity from 2 to 15 g/dm^3 are predominant, and HCO_3Na and HCO_3-ClNa waters to a lesser extent (20 and 10 % of occurrence, respectively). The average of salinity of the complex is 7.9 g/dm^3. It is established that the eastern margin and the northeastern part of the studied area have lower values of salinity, up to fresh waters. The most saline waters are established in the Lodochnaya, Zapadno-Lodochnaya, Sredne-Yarovskaya, Anomalnaya and Pelyatkinskaya areas. This complex is characterized by mostly uneven distribution of the Cl-Br ratio; three areas with its value of more than 300 are distinguished.

Table 1

Groundwater typical tests of the western part of the Yenisei-Khatanga regional trough

Area	Well num.	Test interval		pH	Salinity, g/dm^3	Concentrations, mg/dm^3											Water type after Shchukarev
		from	to			Na+K	Ca	Mg	NH_4	Cl	SO_4	NO_2	HCO_3	I	Br	B	
Aptian-Albian-Cenomanian hydrogeological complex																	
Pelyatkinskaya	12	808	812	8.0	12.8	4727	168	46	-	7571	8	-	183	10	32	2.0	Cl Na
Bolshelaydinskaya	1	742	758.5	7.0	7.7	3027	38	-	2.0	4323	53	-	281	6	16	-	Cl Na
Ozernaya	9	1106	1115	8.1	1.9	617	9	2	-	549	9	-	683	1	2	0.5	HCO_3-Cl Na
Neocomian hydrogeological complex																	
Halmerpayutinskaya	2006	2243	2247	7.6	15.8	5479	511	55	18,0	9574	0	0	159	13	12	3.1	Cl Na
Ozernaya	9	1878	1888	8.1	11.1	4012	309	9	-	6643	16	-	65	13	43	5.0	Cl Na
Habeiskaya	2	1732	1745	7.6	8.9	2615	316	252	6	4971	58	-	610	3	30	-	Cl Na
Pelyatkinskaya	8	2651	2660	8.0	2.8	836	11	5	-	427	10	0.01	1507	2	2	2.5	Cl-HCO_3 Na
Deryabinskaya	2	2729	2734	7.9	5.0	1540	16	5	-	1008	26	-	2368	8	7	12.1	Cl-HCO_3 Na
Ushakovskaya	2	2355	2360	7.7	8.6	2898	301	54	9	5016	8	-	166	6	9	100	HCO_3-Cl Na
Yuzhno-Messoyakhskaya	20	3150	3157	7.8	3.6	1087	150	2	15	1539	10	-	732	6	10	8.0	HCO_3-Cl Na
Upper Jurassic hydrogeological complex																	
Rassohinskaya	1	1317	1326	8.6	14.6	5586	42	40	0.1	8393	30	-	360	25	55	20	Cl Na
Vankorskaya	1	3100	3100	8.0	13.1	4864	100	56	-	7931	7	-	116	6	10	30	Cl Na
Yuzhno-Noskovskaya	318	3799	3799	8.3	8.1	2564	64	0	-	1653	46	-	3753	3	39	-	Cl-HCO_3 Na
Nizhne-Khetskaya	1	892	905	7.8	6.1	2185	29	12	-	2489	12	-	1318	5	10	4.5	HCO_3-Cl Na
Lower-Middle Jurassic hydrogeological complex																	
Rassokhinskaya	1	1892	1910	8.4	8.9	3289	48	25	0.1	4477	151	-	854	7	31	10	Cl Na
Sukho-Dudinskaya	1	1408	1433	8.0	11.2	4260	301	-	-	6004	623	-	-	-	-	-	Cl Na
Tampeiskaya	1	1932	1950	7.9	7.6	2382	28	17	-	1805	42	-	3283	2	6	4.5	Cl-HCO_3 Na
Simeonovskaya	2	2648	2654	8.2	9.7	3069	17	11	4	2277	58	0.01	4198	3	9	1.5	Cl-HCO_3 Na
Sredne-Yarovskaya	4	3345	3360	8.0	10.8	3993	20	-	15	4047	260	0.1	2397	35	44	-	HCO_3-Cl Na
Ozernaya	8	3810	3825	8.0	10.0	3483	51	10	-	3962	17	-	2477	7	22	14.4	HCO_3-Cl Na

Note: «-» - no data avaliable.

Waters of the complex are non-SO_4; its content does not exceed 43.6 mg/dm^3 with the average – 15.2 mg/dm^3. The content of microelements I and B is not high, but still allows us to distinguish five small zones with higher concentrations of I (>9 mg/dm^3) in the Zapadno-Messoyakhskaya, Yuzhno-Messoyakhskaya, Halmerpayutinskaya, Vankorskaya, Severo-Vankorskaya, Sredne-Yarovskaya, Anomalnaya, Pelyatkinskaya, Ushakovskaya and Severo-Soleninskaya areas. Higher concentrations of B are detected in the Vostochno-Messoyakhskaya and Yuzhno-Messoyakhskaya areas. Rather high contents of Br (>35 mg/dm^3) allow the hydrogeochemical anomalies in the Yuzhno-Messoyakhskaya, Vankorskaya and Severo-Vankorskaya areas. Generally, it could be noted for groundwaters of the Aptian-Albian-Cenomanian complex that all of the hydrogeochemical anomalies are within the field of water distribution with the Cl-Br ratio value of more than 300.

In the underlying Neocomian complex the change of salinity from almost fresh to saline waters with salinity to 14 g/dm^3 is traceable. NaCl waters are distributed most widely, and HCO_3-ClNa and Cl-HCO_3Na waters to a lesser extent. Its highest values are observed in waters of the Lodochnaya, Vankorskaya, Severo-Vankorskaya, Bolshelaydinskaya, Gorchinskaya, Pelyatkinskaya, Anomalnaya, Sredne-Yarovskaya, Beregovaya, Yakovlevskaya, Khabeyskaya and Dzhangodskaya areas. The average values of the complex groundwater salinity are about 6.5 g/dm^3, which are lower than those of the overlying Aptian-Albian-Cenomanian complex. At the same time, the marginal northern and eastern parts of the studied area, as well as the large region in the southwest are notable for the presence of waters with lower salinity. The studied area is characterized by the background values of the Cl-Br ratio less than 300. Abnormally high values have not been identified, which is indicative of mainly elision (connate) genesis of groundwaters of the complex. Hydrogeochemical anomalies for J content (>20 mg/dm^3) are established in the vicinity of the Yuzhno-Noskovskaya, Sredne-Yarovskaya, Anomalnaya and Suzunskaya areas; B content (>30 mg/dm^3) – in the Severo-Vankorskaya, Vankorskaya, Zapadno-Lodochnaya and Lodochnaya areas, and the content of NH_4 (>25 mg/dm^3) in the vicinity of the Verkhne-Kubinskaya, Gorchinskaya, Tokachinskaya, Suzunskaya and Vostochno-Charskaya areas.

As noted above, the water-bearing deposits of the Upper Jurassic complex are not distributed ubiquitously (as a rather narrow strip in the east of the studied area), the rest is a zone of argillization. The average value of salinity is of 9.3 g/dm^3 (variation ranges from 5.8 to 14.5 g/dm^3) that allows their assignment to brackish NaCl and HCO_3-ClNa waters. The highest values of salinity are characteristic of groundwaters in the Rassohinskaya, Severo-Vankorskaya, Vankorskaya, and Lodochnaya areas. Groundwaters contain SO_4 in the amount from 2 to 74 mg/dm^3. Hydrogeochemical anomalies are identified for J (>14 mg/dm^3) and B (>13 mg/dm^3) contents and are limited by the Rassohinskaya and Dzhangodskaya areas; the Severo-Vankorskaya, Vankorskaya, and Lodochnaya areas are also marked for iodine content.

Waters of the Lower-Middle Jurassic deposits are distributed ubiquitously in the studied area. In the most of the regions, the waters are fresh (north and northwestern parts, eastern margin). The average value of salinity is 8.4 g/dm^3 (variation ranges from 0.9 to 23.3 g/dm^3). Waters have the highest variety in the chemical composition. HCO_3-ClNa, NaCl and Cl-HCO_3Na waters are distinguished. Hydrogeochemical anomalies for J content (>12 mg/dm^3) are established in the Sredne-Yarovskaya and Anomalnaya areas.

To date, geochemical features of the undivided Triassic-Paleozoic aquifer system are not yet studied.

The analysis of correlational relationships between the concentrations of chemical elements and compounds such as Na, K, Ca, Mg, Cl, HCO_3, I, Br, B, and TDS allowed clarification of their geochemical features in formation waters in the western part of the Yenisei-Khatanga regional trough and the adjoining areas. Each hydrogeological complex in this case has its own features (Table 2).

The waters of the Aptian-Albian-Cenomanian complex show strong positive correlation between salinity and Na, Mg, Cl, I, and Br ($r_{Na\ M}$=0.973, $r_{Mg\ M}$=0.660, $r_{Cl\ M}$=0.964, $r_{I\ M}$=0.886, $r_{Br\ M}$=0.857). Chlorine is strongly correlated with Na, Ca, Mg, I and Br ($r_{Na\ Cl}$=0.973, $r_{Ca\ Cl}$=0.560, $r_{Mg\ Cl}$=0.642, $r_{I\ Cl}$=0.876, $r_{Br\ Cl}$=0.881), the correlations between Na, I and Br are also identified ($r_{Na\ I}$=0.883, $r_{Na\ Br}$=0.867, $r_{I\ Br}$=0.715).

In the Neocomian complex, the nature of the correlation relationships is somewhat different. Strong positive relationships are traceable only between Na and Cl $r_{Na\ Cl}$=0.890, as well as between these elements and salinity ($r_{Na\ M}$=0.922, $r_{Cl\ M}$=0.926).

In contrast to the Neocomian complex, in the Upper Jurassic complex a strong relationship is marked between salinity and almost all the elements, except K and Br. Sodium has strong positive relations with Mg, Cl, I, and B; K with I, Br and B; Ca and Mg with Cl and I; Cl with I; Br with I and B. It should be noted the high negative relationships between Mg and HCO_3 ($r_{HCO3\ Mg}$=-0.381), Cl and HCO_3 ($r_{HCO3\ Cl}$=-0.425).

The waters of the Lower-Middle Jurassic complex have strong relationships between salinity and Na, Mg, Cl and Br; Na with Cl and Br, Mg with Cl, Br with Cl and B. The negative relationships are marked between HCO_3 and Ca, HCO_3 and B ($r_{HCO3\ Ca}$=-0.441, $r_{HCO3\ Mg}$=-0.558).

Table 2

The correlations between the concentrations of chemical elements and compounds and salinity in groundwaters of the western part of the Yenisei-Khatanga regional trough

A

Na *	1.000									
*K**	0.391	1.000								
*Ca**	0.406	0.287	1.000							
*Mg**	0.612	0.481	0.292	1.000						
*Cl**	0.973	0.425	0.560	0.642	1.000					
HCO_3*	-0.173	0.042	-0.384	-0.102	-0.344	1.000				
*J**	0.883	0.323	0.375	0.756	0.876	-0.187	1.000			
*Br**	0.867	0.307	0.391	0.759	0.881	-0.230	0.715	1.000		
*B**	0.447	0.298	0.178	0.181	0.400	0.144	0.261	0.524	1.000	
*M***	0.973	0.451	0.498	0.660	0.964	-0.137	0.886	0.857	0.435	1.000
	*Na**	*K**	*Ca**	*Mg**	*Cl**	HCO_3*	*J**	*Br**	*B**	*M***

B

Na *	1.000									
*K**	0.280	1.000								
*Ca**	0.218	0.116	1.000							
*Mg**	0.177	-0.043	0.245	1.000						
*Cl**	0.890	0.244	0.537	0.287	1.000					
HCO_3*	-0.043	0.057	-0.285	-0.118	-0.339	1.000				
*J**	0.264	0.144	0.042	-0.086	0.227	-0.001	1.000			
*Br**	0.208	-0.023	0.049	-0.061	0.173	0.021	0.318	1.000		
*B**	0.134	-0.167	0.120	-0.102	0.172	-0.091	0.262	0.242	1.000	
*M***	0.922	0.262	0.473	0.264	0.926	-0.029	0.233	0.207	0.155	1.000
	*Na**	*K**	*Ca**	*Mg**	*Cl**	HCO_3*	*J**	*Br**	*B**	*M***

C

Na *	1.000									
*K**	0.452	1.000								
*Ca**	0.315	0.203	1.000							
*Mg**	0.641	-0.070	0.888	1.000						
*Cl**	0.859	0.348	0.724	0.922	1.000					
HCO_3*	-0.287	0.079	-0.152	-0.381	-0.425	1.000				
*J**	0.603	0.887	0.751	0.807	0.797	-0.269	1.000			
*Br**	0.486	0.843	-0.217	-0.140	0.200	-0.003	0.294	1.000		
*B**	0.584	0.791	0.053	0.149	0.517	-0.035	0.820	0.816	1.000	
*M***	0.876	0.394	0.714	0.879	0.962	-0.178	0.765	0.225	0.517	1.000
	*Na**	*K**	*Ca**	*Mg**	*Cl**	HCO_3*	*J**	*Br**	*B**	*M***

D

Na *	1.000									
*K**	0.347	1.000								
*Ca**	0.193	-0.143	1.000							
*Mg**	0.593	0.428	0.533	1.000						
*Cl**	0.868	0.288	0.535	0.798	1.000					
HCO_3*	0.122	0.173	-0.441	-0.300	-0.292	1.000				
*J**	0.393	0.011	0.126	0.203	0.407	-0.179	1.000			
*Br**	0.818	0.236	0.429	0.835	0.923	-0.354	0.535	1.000		
*B**	0.521	0.183	0.505	0.636	0.696	-0.558	0.516	0.728	1.000	
*M***	0.936	0.324	0.343	0.660	0.870	0.127	0.302	0.751	0.481	1.000
	*Na**	*K**	*Ca**	*Mg**	*Cl**	HCO_3*	*J**	*Br**	*B**	*M***

Note: Waters of the A - Aptian-Albian-Cenomanian, B - Neocomian, C - Upper Jurassic, D - Lower-Middle Jurassic complexes - mg/dm^3; ** - g/dm^3*

According to the hydrodynamic and hydrogeothermal conditions of aquifer systems in the Jurassic and Cretaceous deposits, the following main hydrogeochemical trends are established: along the northeastern boundary of the Yenisei-Khatanga regional trough, HCO_3Na and Cl-HCO_3Na waters with salinity up to 5 g/dm^3 are distributed. They are replaced by NaCl waters with salinity up to 15-20 g/dm^3 as they advance to the central and southwestern areas. Hydrogeochemical situation of groundwaters indicates the differentiation of aquifer systems in the Jurassic and Cretaceous deposits. Various types of the vertical hydrogeochemical zonation could be distinguished in the section (Fig. 6).

Thus, the inverse type of the vertical hydrogeochemical zonation is characteristic of the Balakhninskaya, Vostochno-Messoyakhskaya, Deryabinskaya, Zapadno-Messoyakhskaya, Zimnaya, Kazantsevskaya, Lodochnaya, Pelyatkinskaya, Pakyahinskaya, Rassohinskaya, Russkorechenskaya, Severo-Soleninskaya, Sredne-Yarovskaya, Suzunskaya, Halmerpayutinskaya, Yuzhno-Messoyakhskaya and Yarovskaya areas. The normal (direct) type is established in the Bolshelaydinskaya, Nizhne-Khetskaya, Ozernaya, Simyonovskaya, Sredne-Pyasinskaya, Sukho-Dudinskaya, Turkovskaya and Yuzhno-Soleninskaya areas A more complex type is marked in the section of the Malo-Khetskaya and Ushakovskaya areas, where together with the inversion in the Neocomian complex, the increase in salinity with depth is traceable in the Lower-Middle Jurassic deposits.

Thus, the direct hydrogeochemical zonation is characteristic of the eastern and northeastern areas of the described territory, a usual inversion in the southern, western and northern areas, a variable or even more complex zonation in the central areas, which could be accounted for by the specific conditions of formation of the groundwater composition.

It follows from the above that groundwaters of the Jurassic and Cretaceous deposits of the Yenisei-Khatanga regional trough are characterized by a rather complicated type of hydrogeochemical zonation. Within the Messoyakhskaya inclined ridge, it is of direct type, which in some areas is complicated by the inversion in the Neocomian complex. On the whole, the composition diversity of groundwater which is observed at the bottom of the sedimentary cover decreases up the section and a significant equalization of the hydrogeochemical conditions and leveling of the groundwater salinity occur in the Aptian-Albian-Cenomanian complex. The indicated hydrogeochemical features, on the one hand, are associated with the paleohydrogeological conditions of the region and various post-sedimentation processes in the "water - rock - gas - organic matter" system, and with the influence of hydrocarbon accumulations, their formation and fracturing, on the other.

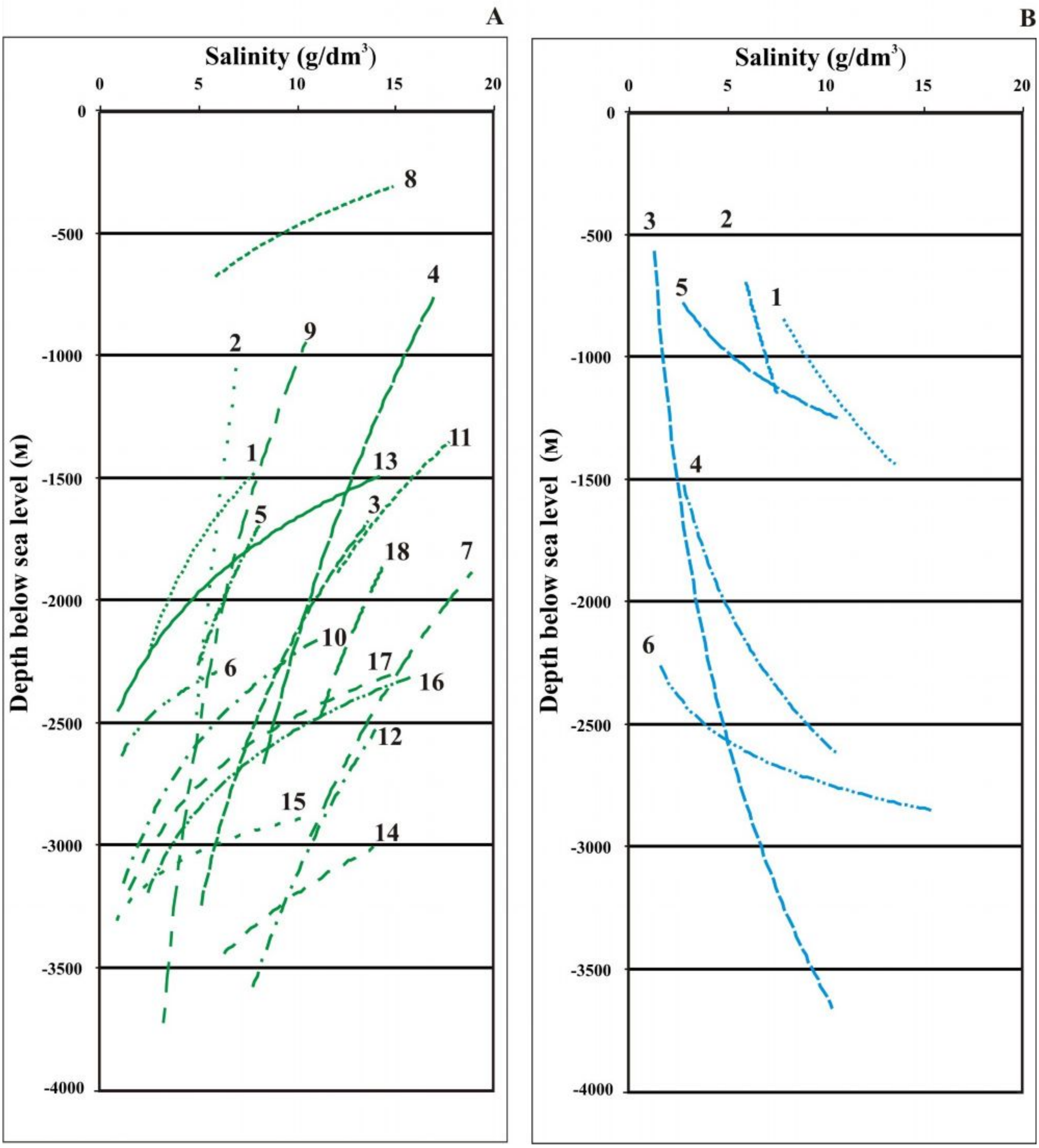

Fig. 6. Types of the vertical hydrogeochemical zonation in the southwestern part of the Yenisei-Khatanga regional trough

A – inverse; 1 - Balakhninskaya 2 - Vostochno-Messoyakhskaya 3 – Deryabinskaya 4 - Zapadno-Messoyakhskaya 5 – Zimnaya 6 – Kazantsevskaya 7 – Lodochnaya 8 - Malo-Khetskaya 9 – Pelyatkinskaya 10 - Pyakyahinskaya11- Rassohinskaya 12 – Russkorechenskaya 13 - Severo-Soleninskaya 14 - Sredne-Yarovskaya 15 – Suzunskaya 16 – Halmerpayutinskaya 17 - Yuzhno-Messoyakhskaya 18 – Yarovskaya B – direct; 1 – Bolshelaydinskaya 2 - Nizhne-Khetskaya 3 – Ozernaya 4 – Simyonovskaya 5 - Sukho-Dudinskaya 6 - Yuzhno-Soleninskaya.

GROUNDWATER GENESIS

The studied area is located in the transition zone on the border of the West Siberian and Khatanga artesian basins with all the ensuing consequences: the occurrence parameters of waters, hydrodynamics and hydrogeothermy, permeability of deposits, chemical and gas composition, groundwater gas saturation, etc.

According to the classical publications (E.A. Bars, G.A. Ivanova, A.E. Kontorovich et al., N.M. Kruglikov et al., V.M. Matusevich, N.N. Neprimerov et al., A.A. Rozin, N.M. Kruglikov et al.), the genetic type of water could be identified using "genetic" coefficients, reflecting the relations of various macro-, and microcomponents in its composition: rNa/rCl, Cl/Br, rNa/(rCa+rMg), rNa+rMg/rCa, rCa/rMg, $rSO_4 \cdot 100/rCl$, $rHCO_3 \cdot 100/rCl$, $Br \cdot 10^3/M$, $I \cdot 10^3/M$, $NH_4 \cdot 10^3/M$, Br/I, HCO_3/SO_4, (M/H)·100, (rCa/rNa)·100, and other elements., [Shchukarev, 1934; Ravdonikas, 1962; Nudner, 1970; Kartsev et al., 1986; Trofimov, Vasilchuk, 1987; Subbota et al., 1990; Kurchikov, 1992].

A detailed analysis of groundwater geochemistry of hydrocarbon deposits (Table 3) made it possible to distinguish three groups of samples with the predominance of a particular genetic type of groundwaters: type "A" - condensation waters, type "B" - fossil infiltration and lithogene waters, type "C" - connate waters (Fig. 7).

It has been established that condensation waters have the greatest diversity of the chemical composition and the variety of genetic coefficients. In our case, we have a mixture consisting of various phases of background formation and condensation waters. Their TDS value varies from 2 to 5 g/dm^3. The salinity gradient ((M/H)·100) is minimal and averages 0.2, and rNa/rCl and Cl/Br ratios range from 0.52 to 6.33 and from 132 to 2431, respectively. These waters are identified in local areas near the gas-water contacts in all the complexes in most of the studied fields.

Lithogene and fossil infiltration waters differ from the previous type in higher values of salinity (5-20 g/dm^3) and the coefficient values (M/H)·100, rNa/(rCa+rMg), rNa+rMg/rCa, $Br \cdot 10^3/M$, $I \cdot 10^3/M$, $NH_4 \cdot 10^3/M$, Br/I, and HCO_3/SO_4. Territorially, fossil infiltration waters are predominant in the eastern cut off parts of the sedimentary basin, as well as within the ancient catchment areas, which formed in some intervals of the Jurassic and Cretaceous periods during the washout of seals overlying the aquifers; for example, in the Sukho-Dudinskaya, Tochinskaya, Malo-Khetskaya, Simyonovskaya, Tampeyskaya, and other structures.

Table 3

Average chemical composition of groundwaters with various salinity and their genetic characteristics

Ratio	Reference stand	TDS, g/dm^3				
		<5	5-10	10-15	15-20	>20
pH	-	8.2	8.3	8.3	7.3	7.3
HCO_3^-	mg/dm^3	721	1285	763	674	242
SO_4^{2-}	- " -	83	51	58	27	30
Cl^-	- " -	1225	3190	6220	9386	13509
Br^-	- " -	9.9	47.2	47.8	46.1	116.8
I^-	- " -	7.4	9.4	14.8	18.8	30.5
Na^+	- " -	1050	2450	3974	5585	6702
Ca^{2+}	- " -	97	130	269	536	1189
Mg^{2+}	- " -	12	19	45	59	202
K^+	- " -	27	31	40	43	57
NH_4^+	- " -	4.5	4.8	6.3	11.4	24.0
SiO_2	- " -	24.6	20.6	22.4	16.7	*
B^+	- " -	16.2	11.9	33.2	31.2	92.3
F^-	- " -	3.3	2.7	1.9	1.7	*
Naphthenic acids	- " -	3.7	6.4	2.2	0.5	*
Total	g/dm^3	3.0	7.2	11.8	16.7	22.5
(M/H)*100	-	0.2	0.5	0.9	1.2	1.3
rNa/rCl	-	2.28	1.37	1.03	0.94	0.76
Cl/Br	-	269	259	244	224	141
rNa/(rCa+rMg)	-	42.0	44.6	37.6	20.1	5.1
(rNa+rMg)/rCa	-	62.2	74.4	52.7	32.6	8.7
rCa/rMg	-	12.3	7.1	8.4	7.1	4.7
(rSO_4*100)/rCl	-	3.80	0.83	0.35	0.14	0.07
($rHCO_3$*100)/rCl	-	114.2	38.6	10.7	5.5	1.0
(Br*10^3)/M	-	1.9	4.6	4.7	2.7	5.3
(I*10^3)/M	-	1.5	1.4	1.3	1.1	1.4
(NH_4*10^3)/M	-	1.2	0.9	0.6	0.9	1.2
Br/I	-	3.2	3.7	3.3	3.2	2.9
HCO_3/SO_4	-	33.7	99.5	41.5	45.6	9.2
Saline composition of waters (after Schukarev)	-	Cl-Na, Cl-Ca-Na, Cl-Na-Ca, Cl-HCO_3-Na, Cl-HCO_3-Ca-Na, Cl-HCO_3-Na-Ca, HCO_3-Cl-Na, HCO_3-Na	Cl-Na, Cl-Ca-Na, Cl-Na-Ca, Cl-HCO_3-Na, Cl-HCO_3-Ca-Na, Cl-HCO_3-Na-Ca, HCO_3-Cl-Na	Cl-Na, Cl-Na-Ca, Cl-HCO_3-Na, Cl-HCO_3-Na-Ca, HCO_3-Cl-Na	Cl-Na, Cl-Na-Ca, Cl-HCO_3-Na, Cl-HCO_3-Na-Ca	Cl-Na, Cl-Na-Ca
Number of analyses	items	148	159	56	20	7

*Note: * - no data avaliable.*

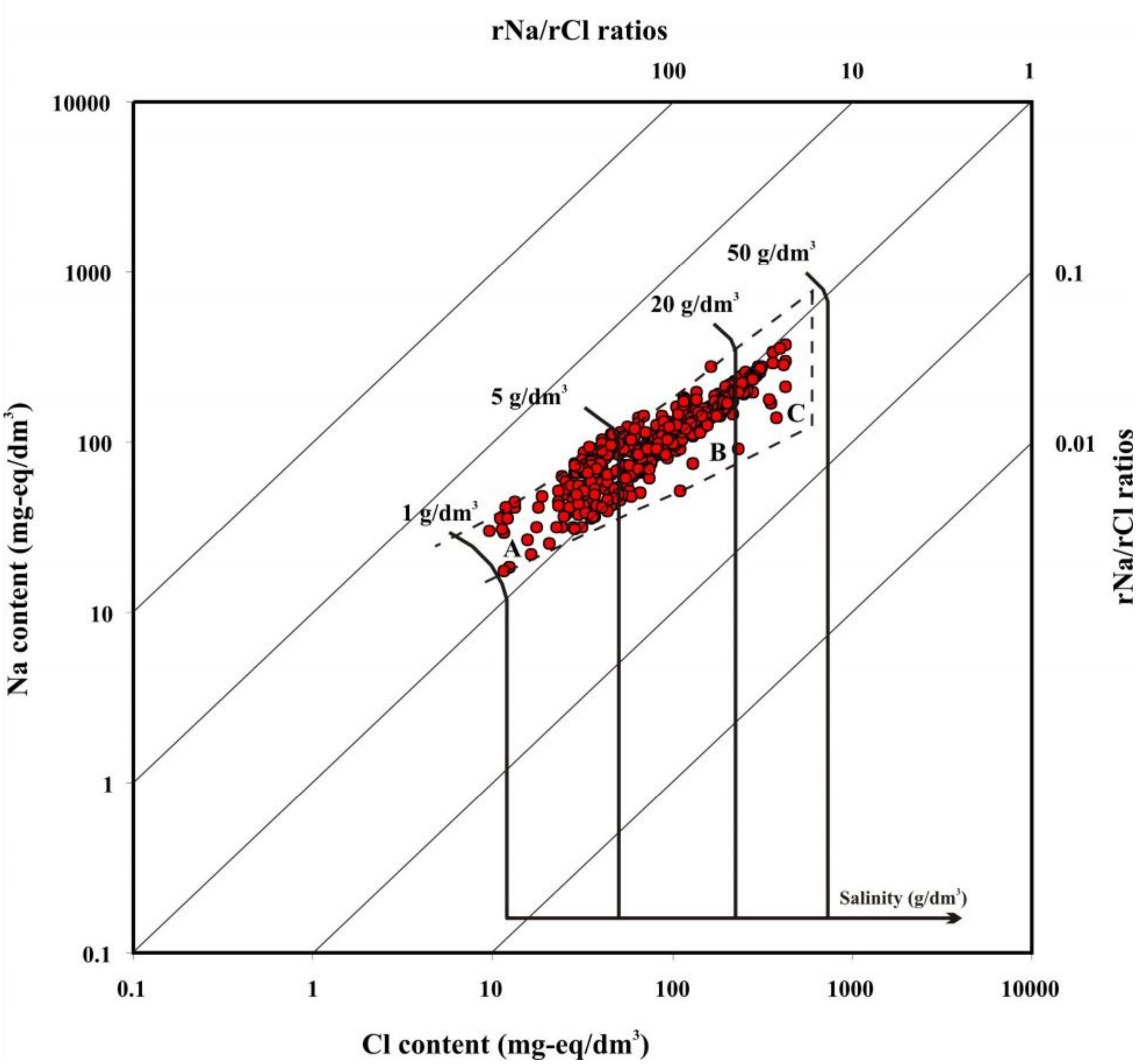

Fig. 7. Hydrogeochemical correlation diagram of oil and gas deposits of underground waters in the western part of the Yenisei-Khatanga regional trough

Types of waters: A – with a marked predominance of condensation, B – mixed (condensation, fossil infiltration, lithogene), C – predominantly connate.

Lithogene waters are distributed mainly in the central, western and eastern areas. In the hydrogeology of many oil-and-gas bearing basins connate waters and brines play a particular role that indicative of the high degree of the hydrogeological subsurface closure and the zones of limited and highly limited water exchange, in which the most favorable conditions are created for hydrocarbon migration and accumulation. Connate waters in the western part of the Yenisei-Khatanga regional trough are characterized by salinity above 20 g/dm^3 and the values of the water metamorphization coefficient rNa/rCl (averaging 0.76) and Cl/Br ratio (averaging 141) which are lower than in the previous types (Table 3). Connate waters are established within deposits of the

Paleozoic and Lower-Middle Jurassic complexes (Sukho-Dudinskaya area), in the Upper Jurassic complex (Vankorskaya area), in the Neocomian complex (Vankorskaya and Suzunskaya areas), and in the Aptian-Albian-Cenomanian complex (Vankorskaya, Pelyatkinskaya and Tagulskaya areas). Brines within the studied area have not yet been revealed.

Thus, in the section of oil-and-gas bearing deposits of the western part of the Yenisei-Khatanga regional trough In the conditions of elision regime in the central areas and infiltration regime in the cut off parts of the basin, three genetic types of waters have been established: 1) abruptly predominant infiltration waters, 2) mixed (condensation, fossil infiltration, and lithogene) waters, and 3) mainly connate waters. Lithogene, fossil infiltration and connate waters are predominant. Condensation waters localized in the small-scale sites near the gas-water contacts and oil-water contacts are notable for the high degree of gas saturation along with low salinity.

CONCLUSION

Summarizing all the above, it should be noted that in the present work a synthesis of all hydrogeological data on the southwestern part of the Yenisei-Khatanga regional trough and the adjacent territory was conducted for the first time since 1977. A detailed analysis of used data allows the following conclusions: 1) in the compiled hydrogeological superposition schematic illustration of the studied area, the eight types of structures have been distinguished based on geological section features. Further details and selection of the types of hydrogeological structures will be based on the hydrodynamics and hydrogeochemistry features.

2) The extensive development of a thick permafrost sequence, in general, and its appearance before the formation of the modern forms of the relief predetermines the long-existing conditions of the limited water exchange in the most part of the territory. Partial thawing of the frozen zone in the floodland of the Yenisei River and under its bed and large lakes, as well as in the localities confined to fault zones is responsible for a more active water exchange in these areas.

3) The evolution of the hydrodynamic structure proceeded in close relation with the cyclic hydrogeological development of the basin, which is confirmed by the paleohydrogeological reconstructions. Detailed analysis of the latter revealed the potential internal and outer main producing areas. At the present time, there are two types of natural water drive systems in the studied area: elision in the internal areas and infiltration in the outer cutoff parts.

4) Hydrocarbon deposits are characterized by an inhomogeneous structure of temperature field that is characterized by the presence of six different types of the vertical hydrogeothermal section, which are the consequence of the geological history of the region. The minimal geothermal gradients are confined to the cut off parts with small thicknesses of the sedimentary cover and the

development of the infiltration water drive system, and the maximal geothermal gradients are identified in the zones of regional disjunctive tectonics, which caused a significant warming effect on the geological section. All other established areas have a transitional type of the hydrogeothermal section between these edge zones.

5) According to the hydrodynamic conditions of aquifer systems in the Jurassic and Cretaceous deposits, the main hydrogeochemical trends are established: along the northeastern boundary of the Yenisei-Khatanga regional trough, HCO_3Na and $Cl\text{-}HCO_3Na$ waters are distributed with salinity up to 5 g/dm^3, which are replaced by the NaCl waters with salinity of 15-20 g/dm^3 with moving to the central and southwestern areas. Various types of the vertical hydrogeochemical zonation could be identified in the section. The eastern and northeastern areas are characterized by the direct hydrogeochemical zonation; the southern, western and northern areas by the normal inversion, and the central areas by the reversed or even more complex inversion which is explained only in the specific conditions of the groundwater formation.

6) In the conditions of elision regime in the central areas and infiltration regime in the cut off parts of the basin, three genetic types of waters have been established: 1) abruptly predominant infiltration waters, 2) mixed (condensation, fossil infiltration, and lithogene) waters, and 3) mainly connate waters. Lithogene, fossil infiltration and connate waters are predominant. Condensation waters are localized in the small areas near the gas-water contacts and along with low salinity, have the high degree of gas saturation.

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