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SURFACE AND GROUND WATERS IN TERRESTRIAL PERMAFROST REGION

HYDROGEOLOGICAL CONDITIONS IN THE LENA RIVER FLOODPLAIN NEAR YAKUTSK

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This paper reports on the hydrogeological conditions and groundwater regime in the Lena River floodplain near Yakutsk. The published and archive materials, including field data collected by the authors in 2013–2021, were analyzed. Data from more than 70 boreholes were examined to characterize permafrost and hydrogeological conditions in the area. Data on groundwater level monitoring in the reclaimed area of the floodplain were also used. Over 250 sample analyses were interpreted to characterize the chemical composition of surface and ground waters. The results suggest that suprapermafrost waters in the high floodplain are recharged both by infiltration of river water and by a transit water flow under the river channel hydraulically connected to floodplain taliks. The seasonal and spatial variability of the chemical composition of waters was revealed in the Lena River and in the studied taliks. The surface and ground waters of the Quaternary aquifer on the east bank of the Lena River are characterized by the lowest total dissolved solids (TDS) concentration (0.1–0.3 mg/L) and by the magnesium–calcium chloride–bicarbonate composition. These waters are recharged by fresh water of the supra- and interpermafrost taliks of the Bestyakh terrace and by the riverbed taliks under small rivers. In the vicinity of Yakutsk, TDS concentrations in the Lena River and in the Quaternary aquifer increase to 0.5–1.3 g/L due to high mobility of chloride and sulfate ions migrating with the surface and suprapermafrost runoff from the low terrace, where the city is located.

Keywords: *Lena River, floodplain taliks, suprapermafrost water, hydrodynamic regime, chemical composition.*

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INTRODUCTION

Floodplain and under-channel taliks in river valleys are important, in terms of hydrogeology, in the area of continuous permafrost. Groundwater generally passes through suprapermafrost taliks in the zone of free water exchange [*Romanovsky, 1983; Mikhailov, 2013*]. Open under-channel taliks are a kind of a buffer providing water exchange between the surface and subpermafrost waters [*Fotiev, 2009; Chang, Qianlai, 2017; Shepelev, 2021*].

In recent years, the study of the floodplain taliks in the middle reaches of the Lena River has become more relevant. First of all, this is caused by the increasing demand of the population of Central Yakutia for water. It is difficult to cover this demand by exploiting subpermafrost aquifer complexes due to their limited natural resources and the significant thickness (165–470 m) of permafrost. Secondly, the technogenic load on the river ecosystem increases due to the engineering development of the territory. For example, in 1980–2013, in the vicinity of Yakutsk, the part of the Lena River floodplain was reclaimed and two residential city quarters were built up. In the early 2000s, an underwater gas pipeline was laid along the river bed. In addition, a bridge over the river is planned to be built. To provide the safe operation of these facilities, as well as the further development of floodplain areas, it is important to assess the distribution of groundwater in the Lena River valley. The purpose of this work was to study the permafrost-hydrogeological conditions of the floodplain-channel complex in the section Tabaga–Yakutsk, where the above-mentioned engineering structures are concentrated.

MATERIALS AND METHODS

Data from the permafrost-hydrogeological and hydrogeochemical studies of the aquifers developed under the channel, watercourses, and floodplain of the Lena River were used in this work. The data have been collected over many years. To characterize the geological-hydrogeological and geocryological conditions of the territory, more than 70 boreholes were studied. Hydrodynamics of groundwater of the taliks was considered on the basis of the archive materials and the data of monitoring made by the author's team in the floodplain in 2013–2021. The chemical composition of the surface and groundwaters was analyzed for more than 250 water samples. Of these, 78 samples were collected from the Lena River and its tributaries, 60 samples from the boreholes that uncovered suprapermafrost groundwater of the under-channel and floodplain taliks, 94 samples from 9 boreholes equipped for monitoring in the reclaimed floodplain area of Yakutsk, 20 samples from the boreholes drilled through the open under-channel talik in the area of Tabaga village and Pokrovsk settlement, 6 samples from under-channel taliks of the Tamma and Shestakovka rivers. In addition, the results of chemical analyses of inter- and subpermafrost waters developed in the adjacent area were involved.

HYDROLOGICAL CONDITIONS

The studied territory is located in the middle reaches of the Lena River, where the river passes from the Prilensky Plateau to the Central-Yakutia Lowland. The narrow (4–5 km) valley of the river with a bluff right bank at Tabaga Cape is replaced downstream by the wide (8–15 km) terraced accumulative plain downstream. The mean annual runoff of the Lena River near Yakutsk is 7070 m^3/s; the maximum runoff is 36 200 m^3/s [*Chalov et al., 2016*]. The river belongs to the East Siberian type. The water level is 81.7–83.5 m a.s.l. during the winter low-water season (March–April). During the spring flood, the water level rises up to 7–11 m and causes flooding of the wide floodplain; the 5% probability maximum water level in the river reaches 94.7 m a.s.l. (in Yakutsk). Ice on the Lena River forms in October. Temperature of river water varies according to the changes in hydrological conditions: it is 0–1°C in winter and during the spring flood, about 10–12°C in June, and 15–17°C in July [*Gautier et al., 2018*].

Downstream Tabaga Cape, the branching of the Lena River channel is observed; there are numerous islands of 0.5 to 10 km in length (Fig. 1). The erosion of river banks and islands in some areas and the accumulation of sediment in others lead to shifts in the mainstream and to the redistribution of river runoff along several branches contributing to their migration, dissection, and periodic shallowing and deepening [*Tananaev, 2016*]. For example, at the beginning of the 20th century, a ship track was laid along the Gorodskaya watercourse [*Chistyakov, 1952; Chalov et al., 2016*]. In the 1940s and early 1950s, the dynamic axis of the river flow shifted to the right bank. Later on, under the influence of natural channel processes and the construction of an enclosing dam, the Gorodskaya watercourse shallowed and gradually turned into a secondary stream crossing the floodplain.

The floodplain of the Lena River is two-sided. The exception is the section near the settlement of Nizhnii Bestyakh, where the water flow adjoins the Bestyakh terrace. The floodplain topography is slightly hilly, with numerous narrow elongated oxbow lakes and watercourses and low ridges.

The uneven thickness of the Quaternary alluvial sediments under the river bottom is due to deformations of the channel. The thickness of the alluvium varies from 1 to 18 m directly under the channel and watercourses of the Lena River [*Stognii, 2003; Khristoforov, Omelyanenko, 2013*]. It is represented by fine- and medium-grained quartz-feldspar sands, with fine and coarse gravels of quartz, flint, and limestone at the base of the section. The floodplain ridges are composed of sands of channel facies in the lower part of the section and loamy sandy and loamy sediments of 0.5–5.0 m in thickness in the upper part [*Roman et al., 2008*]. The total thickness of the alluvial formations in the floodplain near Yakutsk is about 7–15 m. The Quaternary sediments are underlain by the Middle Jurassic siltstone and quartz-feldspar micaceous sandstone with frequent interlayers of clay.

Small tributaries of the Lena River (the left-bank rivers – Shestakovka, Markhinka, and Khorogor and the right-bank rivers – Tamma and Myla) periodically dry up in summer and freeze completely in winter, except for the deepest parts of river channels [*Anisimova, Pavlova, 2014*].

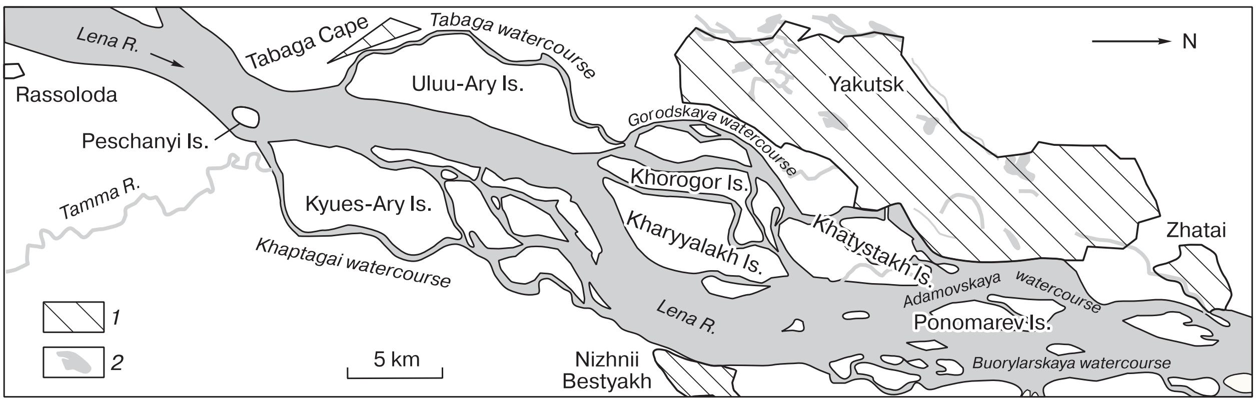

Fig. 1. Schematic map of study area.

1 – settlements; *2* – watercourses and water bodies.

Floodplain taliks

Studies of taliks in the Lena River valley near Yakutsk began in the 1930s–1960s in connection with the search for groundwater to provide technical and drinking water supply for the city population [*Melnikov, 1963; Efimov, 1964*]. As a result of these works, a suprapermafrost talik of 24–30 m in thickness was found under the Gorodskaya and Adamovskaya watercourses of the Lena River; its contours are limited by the low-water level of the river [*Hydrogeology of the USSR, 1970*]. Groundwater with a temperature of 0.5–2°C occur in the Quaternary alluvial sediments and the upper part of the weathered Middle Jurassic deposits.

The thickness of the suprapermafrost water-bearing taliks does not exceed 10–12 m under the drying and freezing watercourses of the Lena River, as well as under the oxbow lakes flooded during floods (Fig. 2) [*Balobaev et al., 2003; Roman et al., 2008; Pavlova et al., 2020*]. The cryogenic aquiclude occurs deeper. According to the classification by N.N. Romanovskii [*Romanovskii, 1983*], most floodplain taliks belong to the soil-filtration class, but there are also taliks with stagnant water [*Anisimova et al., 2005*].

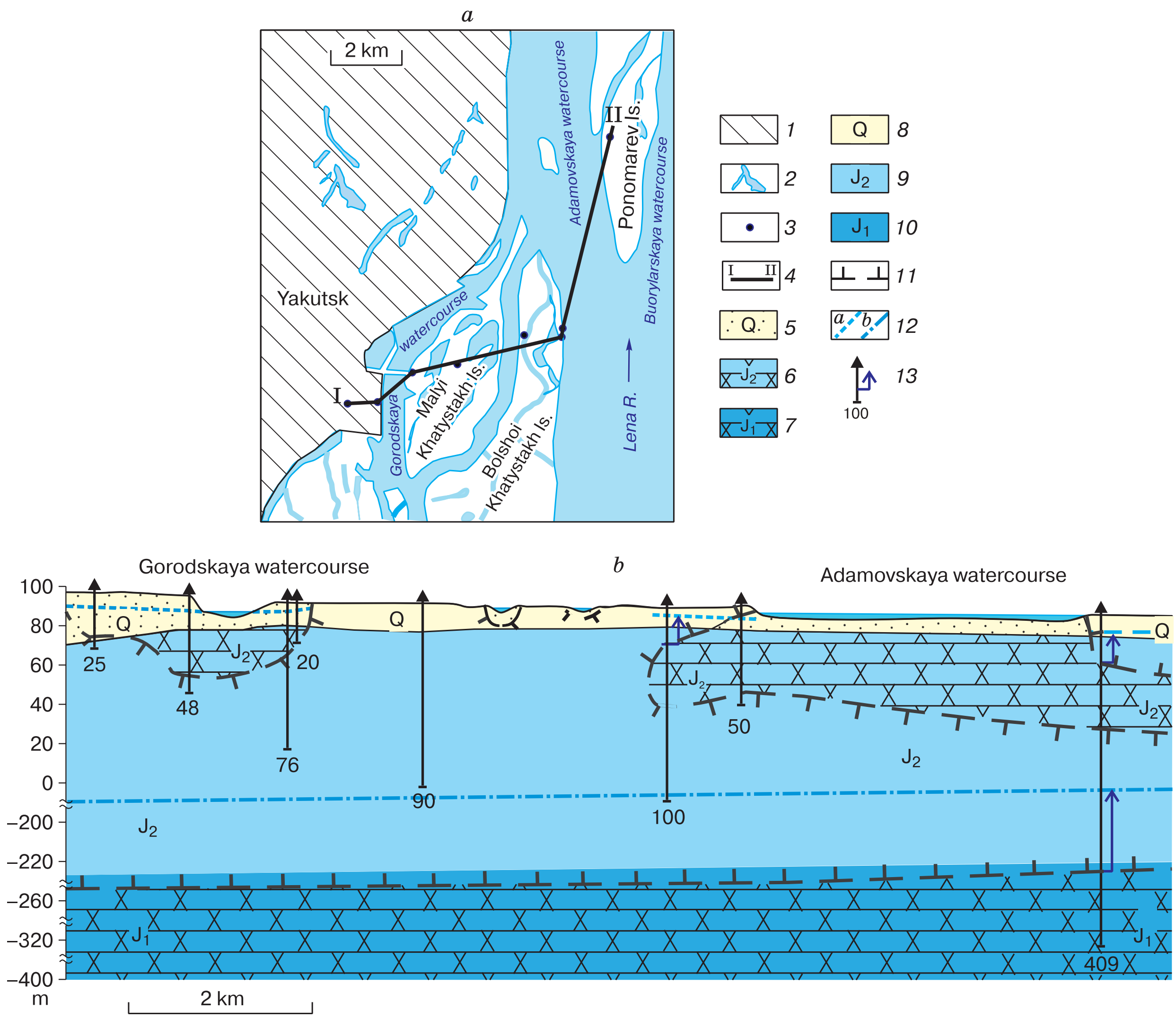

Fig. 2. Schemes of the (*a*) borehole and (*b*) the hydrogeological section of the Lena River floodplain near Yakutsk.

a: (*1*) Yakutsk territory, (*2*) watercourses and water bodies, (*3*) exploration hydrogeological borehole; (*4*) line of the hydrogeological section; *b*: (*5*) local aquifers in Quaternary sediments (sands, gravels), (*6*) local aquifers in the Middle Jurassic deposits (sandstone, siltstone, clay), (*7*) subcryogenic (subpermafrost) aquifer in the Lower Jurassic deposits (sandstone, siltstone, aleurite); (*8–10*) permafrost aquicludes in the Quaternary, Middle Jurassic, and Lower Jurassic deposits, respectively; (*11*) permafrost boundary; (*12*) groundwater level position (*a* – suprapermafrost groundwater, *b* – subpermafrost groundwater); (*13*) exploration hydrogeological boreholes (lower figure, depth (m); side arrow, groundwater head).

Often, the spatial position of the suprapermafrost taliks does not correspond to the modern channels of watercourses. This discrepancy is caused by displacement of surface water flows during repeated deformations of the channel, by thermoabrasion of the banks, and by the formation of frozen rocks on the drying near-channel banks [*Romanovskii, 1983; Tananaev, 2005; Shepelev, 2011*]. River waters are known to be the main source of heat on floodplains; the heat and mass transfer between watercourses and rocks is carried out mainly by convection [*Fotiev, 1968, 2009; Romanovskii, 1983; Mikhailov, 2013*]. In the periodically flooded floodplain of the Lena River valley, the convective heat transfer is limited by the alluvium sequence, which has good filtration properties. The underlying Jurassic deposits have poor water abundance because of the predomination of impermeable layers in the section. Therefore, when the heat source (surface flow) is displaced, the conditions for freezing both above and below are created in the closed floodplain taliks, and only well-permeable sediments remain thawed and provide the supra- and interpermafrost runoff. The direction of this runoff (toward a bank or to a low-water river channel) may vary throughout the year in dependence on the ratio of the water level in the aquifer and in the watercourse, but generally corresponds to a slope of the river.

In addition to natural taliks, there are natural-technogenic taliks in the Lena River floodplain. They are widespread under the reclaimed soils of Yakutsk. During creation of the reclamation base for civil construction in 1970–1990, the oxbow lakes and taliks under them were buried under 10–15-m-thick layer of alluvial sands. On the floodplain ridges composed of frozen sands and loamy sands, the top of the cryogenic aquiclude deepened due to a high temperature of the pulp; and artificial water-saturated taliks of up to 3–5 m in thickness were formed under the technogenic soil of 6–8 m in thickness. Suprapermafrost water-bearing taliks under the reclamation massif are preserved to the present day. For example, during the engineering and geological surveys in the residential block 203 in 2013–2019, suprapermafrost groundwater was uncovered by boreholes everywhere at the depths from 6.4 to 13 m [*Roman et al., 2008; Shesternev et al., 2014; Pavlova et al., 2020*]. The thickness of the water-bearing strata varies from 0.5–6.0 m of the floodplain ridges to 12 m or more in the areas of the former oxbow lakes [*Pavlova et al., 2020*]. The aquifer is underlain by permafrost soils of the natural basement. The temperature of the water-bearing sediments, as in natural taliks, varies from 0.1 to 1.5°C.

The absence of the cryogenic aquiclude within the floodplain and under the Lena River channel opposite Yakutsk has not been proved or disproved by drilling and geophysical works so far. The open talik connecting subpermafrost and surface waters, was established under the Lena River by the geophysical works and drilling to the south of the studied area near Pokrovsk and in the area of Tabaga Cape on Peschanyi Island [*Balobaev et al., 2003; Shepelev, Makogonova, 2010*]. Near Pokrovsk, sandy gravelly deposits of up to 27 m in thickness underlain by the Cambrian fractured limestone were uncovered by deep (70–200 m) boreholes on the islands and in the river channel. In this area, the water-discharge talik partially drains the Cambrian subpermafrost water-bearing complexes [*Beletsky, 1975*]. Downstream the Lena River, fractured calcareous rocks dip beneath the Jurassic terrigenous sandstones and siltstones. At Peschanyi Island, according to the data from the 360-m borehole, the Lower Jurassic 238-m-thick aquifer was uncovered under the 21-m sequence of alluvium; the Middle and Lower Cambrian aquifer complexes lie deeper [*Balobaev et al., 2003*]. Within the Pokrovsk–Tabaga section, some loss of the river runoff indirectly indicates the presence of a water-recharge talik [*Shepelev et al., 2002*].

The open talik in Tabaga Cape area is limited in plan by the Lena River channel. Drilling on the left-bank floodplain of the river near Tabaga settlement revealed permafrost from the surface to a depth of 165 m [*Shepelev et al., 2002*]. On the right bank, it is possible that the open talik may have spread to the floodplain, as well. Before the 19th century, the axis of the main branch of the Lena River was located here; it shallowed over time and formed the Khaptagai watercourse [*Chalov et al., 2016*]. Taking into account the conditions of the formation of the under-channel taliks and their evolution during the displacement of surface water flows, we can expect the decrease in thickness of permafrost to first tens of meters on the right bank near the modern shoreline of the river. It should be noted that the aforementioned open taliks are located in the areas, where the river channel is crossed by tectonic faults or by rock crushing zones.

Within the studied area, the interpermafrost taliks have been uncovered by exploration boreholes on the islands to the north of Tabaga Cape. For example, between Adamovskaya and Buorylarskaya watercourses on Ponomarev Island, thawed water-bearing sediments lie under permafrost rocks from a depth of 25 m. The thickness of the talik is 35 m, and the base of the underlying cryogenic aquiclude was recorded at a depth of 320 m [*Stogny, 2003*]. The water uncovered in the Middle Jurassic sandstone is sodium bicarbonate with the high content of chlorides; the water mineralization is about 1 g/L. This composition may be due to the impeded water exchange in the talik. Permafrost was found on Khatystakh Island, between the Gorodskaya watercourse and the main channel of the Lena River. In the central part of the island, the 90-m deep borehole uncovered permafrost in the entire section (Fig. 2).

Under the small tributaries of the Lena River, the thickness of the under channel taliks varies from

1.5 to 60 m. For example, in the near-mouth part of the Tamma River, water-saturated rocks occur from the depths of 0.3–3.0 m at the end of winter [*Anisimova, Pavlova, 2014*]. The thickness of the talik does not exceed 20 m. It is preserved under the freezing river with a relatively small channel width (10–20 m) due to good filtration properties of sandstone and gravels and because of the relatively high subzero temperature (from –0.2 to –0.7°C) of the surrounding permafrost. The thickness of the under-channel taliks increases in the areas, where sandy gravelly deposits are underlain by the Cambrian fractured calcareous rocks. For example, to the south of the studied area, in the lower reaches of the Mendy River, the thickness of the water-bearing talik is up to 60 m. The under-channel waters of small right-bank tributaries are discharged into the talik of the Lena River.

Under the left-bank small tributaries of the Lena River, taliks are preserved in winter only in some deeper sections of channels; their thickness rarely exceeds 1.5 m [*Anisimova, 1996*].

Hydrodynamic regime of taliks

The hydrodynamic regime of groundwater under the Lena River channel remains poorly studied, because it is difficult to equip the monitoring boreholes in the water area of the river and to keep them safe during ice drift. However, prospecting and exploration works in the Gorodskaya and Adamovskaya watercourses demonstrated that groundwater level in suprapermafrost taliks in winter lowers in parallel to a decrease in the surface water level [*Hydrogeology of the USSR, 1970*]. After experimental pumping from the boreholes, the time of groundwater level recovery is only 15–60 minutes.

The influence of the Lena River on hydrodynamics of groundwater is not limited to the under-channel flow. This is confirmed by the data of long-term observations in the reclaimed area of Yakutsk [*Roman et al., 2008; Pavlova et al., 2020*]. The free surface of suprapermafrost groundwater in the taliks under the reclamation massif is affected by seasonal fluctuations (Fig. 3). Its lowest levels are observed in March–early May corresponding to the winter low-water period in the Lena River. The level of river water at this time is 3–4 m lower than that of the suprapermafrost water in the reclaimed area. In May, with the beginning of flood on the Lena River, water saturation of soils takes place s due to filtration of river waters along the contour of the reclamation massif. The calculated zone with a backwater effect extends to 150–170 m from the watercourse [*Roman et al., 2008*]. In fact, the groundwater surface rises during the period of the maximum river flow also in the boreholes distant from the river shoreline, at a distance of 400–600 m [*Pavlova et al., 2020*]. The highest levels of suprapermafrost groundwater are observed in the areas, where lakes previously existed.

The rise of water level in the boreholes at such a distance can only be explained by transfer of pressure from the river along the under-channel taliks connected with the taliks of the buried ancient lakes. Annual extremes of the level regime of groundwater lag behind river water by 35–63 days. The rate of hydrodynamic impulse spreading from the river along the aquifer was calculated on the basis of the regime ob-

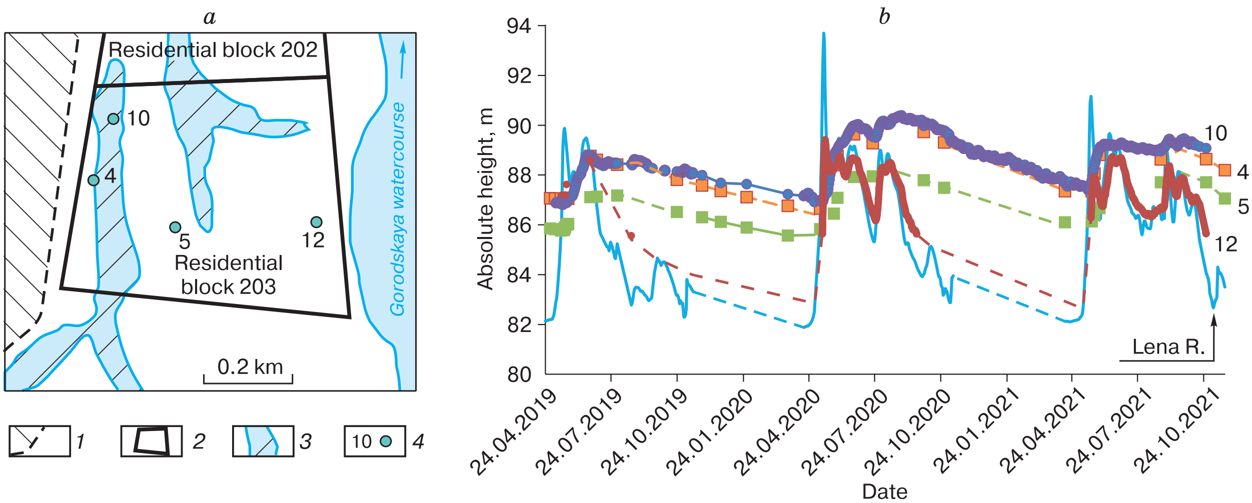

Fig. 3. Location of hydrogeological monitoring boreholes (*a*) and the plot of changes in the level of suprapermafrost groundwater in the floodplain-reclaimed area of Yakutsk and the Lena River (Yakutsk gauging station) in 2019–2021 (*b*).

(*1*) first terrace of the Lena River, (*2*) contour of the reclaimed area, (*3*) oxbow lakes buried during reclamation, (*4*) hydrogeological monitoring boreholes. Symbol and number on the plot correspond to the hydrogeological borehole and its number on the scheme.

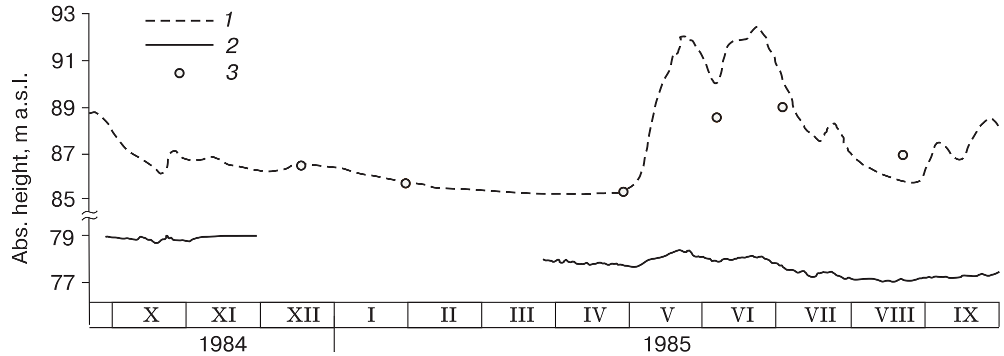

Fig. 4. Graph of changes in the water level in the (*1*) Lena River and (*2*) boreholes equipped for the Lower and Middle Cambrian aquifer on the high floodplain of the Lena River and on (*3*) Peschanyi Island.

Based on the archive materials of the Sakhageoinform unitary enterprise and the Melnikov Permafrost Institute, Siberian Branch of the Russian Academy of Sciences.

servations; it is about 4.6×10^3 m^2/day. The similar hydrodynamic regime of groundwater can be expected in the suprapermafrost taliks on islands and reclaimed areas in the river floodplain.

The groundwater regime of the Lower–Middle Cambrian aquifer complex was studied in the area of the open under-channel talik of Tabaga Cape in the 1980s by the employees of "Yakutskgeologiya" PGO. As a result of these studies, it was found that the change in the piezometric level of groundwater is synchronous with the fluctuations in the Lena River level. The influence of the river on the hydrodynamic regime of subpermafrost water can be traced in the borehole drilled on the high floodplain (Fig. 4). On the low terraces, the level of subpermafrost waters is not affected by seasonal changes and is closely related to water intake from the production boreholes [*Shepelev et al., 2002*].

Suprapermafrost groundwater is generally characterized by pressure-free regime under the freezing small rivers and waterbodies [*Anisimova, Pavlova, 2014*]. From July to March, as long as the conditions exist for their water filtration through the strata and the boundary of the freezing layer does not reach water-bearing rocks, the groundwater has the free surface. When the aquifer freezes, the cryogenic pressure appears in the talik and reaches its maximum value in May–June.

Quality of surface water and groundwater of the suprapermafrost taliks

The chemical composition of water in the Lena River depends on its feeding conditions. In spring and summer, when the river runoff is formed generally due to snow melting and liquid precipitation, the surface water mineralization is 70–100 mg/L with chloride–bicarbonate sodium–calcium or magnesium–calcium composition. By the end of summer, the concentration of dissolved substances increases to 170–180 mg/L. The ratio of anions in water does not change. Its cationic composition becomes mostly sodium–calcium near Yakutsk and magnesium–calcium near the right bank (Table 1). The probable reason for such variability is the inflow of small rivers with bicarbonate calcium–magnesium water from the right bank into the Lena River. In winter, during transition to the underground feeding, the water mineralization in the Lena River fairway is about 300–500 mg/L; in

Table 1. **Chemical composition of water in the Lena River watercourses**

Watercourse	pH	Sum of mineral dissolved solids, mg/L	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO	SO	Cl
Tabaga	7.5	164	24/45	7/22	20/33	1/0	107/59	18/13	29/28
Gorodskaya	7.0	138	20/45	5/19	18/36	1/0	94/62	8/7	28/31
Rassoloda	7.4	147	30/55	12/35	6/9	1/1	159/96	<1/0	5/4
Khaptagai	7.7	161	28/50	10/31	12/19	1/0	159/83	9/6	12/11

Note: Numerator, mg/L; denominator, % (meq).

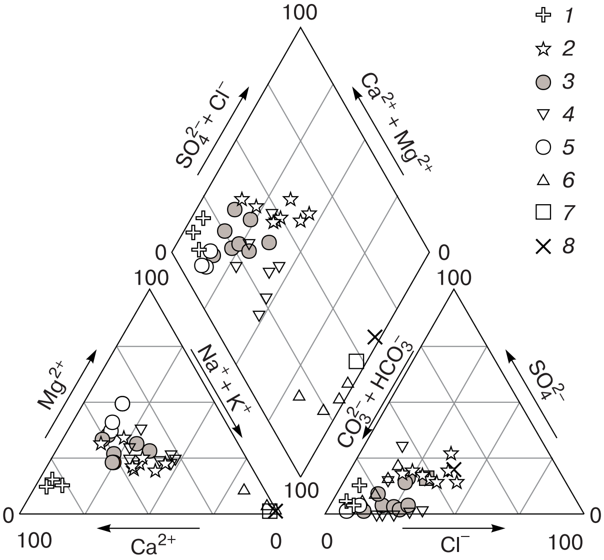

Fig. 5. Piper diagram of the macrocomponent composition of natural waters.

(*1*) atmospheric precipitation (rain); (*2*) Lena River, (*3–5*) suprapermafrost groundwater of the Quaternary aquifer under the Lena River watercourses, in the reclaimed floodplain area of Yakutsk (left bank of the Lena River), and under the Tamma River channel and floodplain (right bank of the Lena River), respectively; (*6*) suprapermafrost groundwater of the Middle Jurassic aquifer; and (*7, 8*) interpermafrost water of the open under-channel talik of the Lena River within the Lower Jurassic (sampling interval 106–261 m) and Cambrian (sampling interval 261–320 m) aquifers, respectively.

the channels near Yakutsk, it is up to 800 mg/L. The chemical composition of water is transformed to chloride–bicarbonate calcium–sodium.

In the suprapermafrost underwater talik of the Lena River, in the upper part of the Quaternary aquifer, the concentration of dissolved substances in water is 0.4–0.8 g/L [*Anisimova et al., 2005*]. In the annual cycle, the fractional ratio of main anions and cations changes according to the composition of the feeding river water.

The groundwater quality of the Middle Jurassic aquifer is formed under the conditions of relatively slow water exchange. Consequently, their mineralization increases to 0.8–1.1 g/L; alkalinity becomes higher (pH 7.7–8.4), and sodium steadily prevails over other cations (up to 87–98%) (Fig. 5).

In the subpermafrost open talik of the Lena River near Tabaga Cape, the water mineralization also increases along the section from 0.6 g/L in the top of the Lower Jurassic aquifer complex to 1.3 g/L in the Lower Cambrian aquifer complex [*Balobaev et al., 2003*]. The anionic composition of water changes in depth from bicarbonate to chloride–bicarbonate in the Jurassic sediments, while in the Cambrian aquifer complex, it becomes bicarbonate–chloride (Table 2). Regardless of the lithology and rock age, sodium ions prevail in the groundwater of the open talik among cations; their share increases with depth from 81 to 98%. Relatively low water mineralization in the under-channel sediments, as compared to the subglacial

Table 2. **Chemical composition of groundwater in the area of Tabaga Cape**

Location	Symbol of aquifer; sampling depth, m	HCO	Cl^-	SO	Ca^{2+}	Mg^{2+}	$(Na+K)^+$	F^-	pH	M, mg/L
				Open subchannel talik						
Peschanyi Is.	J_1 24–105	358/84	31/12	13/4	11/7	8.7/10	143/83	1.4/–	8.4	599
	J_1 106–261	344/53	134/31	93/16	6/2	2/1	270/97	í /ä/–	8.5	725
	$Є_1 + Є_2$ 261–320	465/43	249/37	184/22	8/1	6/1	417/98	1.8/–	8.6	1346
				Subpermafrost water, left bank of the Lena River						
Tabaga settlement	J_1 172–267	613/50	392/48	24/2	8/2	2/1	519/97	5.0/–	7.3	1573
	$Є_1 + Є_2$ 273–450	507/21	478/35	810/44	175/22	63/13	661/65	2.2/–	7.9	2701
				Subpermafrost water, left bank of the Lena River						
Khaptagai settlement	$Є_2$ 320–500	604/27	269/21	909/52	34/5	35/8	428/87	2.5/–	7.3	2280

Note: Numerator, mg/dm^3; denominator, % (equiv,); nd – no data; M – mineralization.

aquifer complexes, is the result of surface water infiltration along the open talik.

In the taliks under shallow watercourses, oxbow lakes, and small tributaries of the Lena River, the chemical composition of suprapermafrost water depends on the degree of flowability of watercourses and water bodies. With good water exchange, the composition is close to the composition of the Lena River under-channel waters. Therefore, on the right-bank floodplain of the river, the water mineralization in the suprapermafrost taliks at the end of winter is 0.2–0.4 g/L, the chemical composition is mostly magnesium–calcium bicarbonate. Water in under-channel taliks of small rivers (Tamma and Menda), has a similar composition in winter.

In the taliks on the left-bank floodplain of the Lena River, the water mineralization is 0.5–0.8 g/L. Increased chloride-ion content (up to 25–37% of the sum of anions) and predomination of sodium ions (41–45% of the sum of cations) are caused by worsening water exchange conditions and by the influence of cryogenic metamorphization processes on the composition of water. Near Yakutsk, an increase in the concentration of sulfate anions and nitrogen compounds is often noted in floodplain taliks, indicating the technogenic contamination of suprapermafrost groundwater.

CONCLUSIONS

In the area of Yakutsk, the long-term migration of the Lena River channel and its tributaries and processes of cryogenesis resulted in the local distribution of groundwater streams in the floodplain sediments that often do not coincide with the water surface in the river branches. Despite the presence of permafrost and limited distribution of suprapermafrost taliks on the river floodplain, the groundwater contained in them is hydraulically connected with the surface and under-channel waters of the Lena River. This connection is distinctly manifested during floods, when, under the backwater effect, suprapermafrost water of the floodplain taliks is recharged not so much by downward infiltration of river waters into the aquifer as by the underground flow filtered through the network of connecting taliks.

The chemical composition of water in the Lena River and its under-channel talik is variable in the lateral and vertical directions and depends on the presence of tributaries and conditions of interconnection of the surface and ground waters. The minimal mineralization is typical for the under-channel waters of the Quaternary aquifer closer to the right bank of the Lena River. Here, there are the conditions for the aquifer recharge by the suprapermafrost water from the Bestyakh terrace and under-channel taliks developed under small tributaries of the Lena River. An increase in water mineralization along the section of the under-channel talik is caused by the change in the lithological composition of water-bearing rocks and deterioration of their filtration properties with depth.

The increased concentration of sulfate and chloride ions, sodium ions, and, sometimes, nitrogen compounds in water is observed near Yakutsk, in the Lena River channels, suprapermafrost taliks under them, and in small rivers. The probable causes are the cryogenic metamorphization of water and water-bearing rocks under the conditions of poor water exchange and the input of polluted runoff from the floodplain terrace, where the city is located.

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