

THE FORMATION OF THE HYDROGEOLOGY OF THE ABSHERON PENINSULA

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Abstract

The process of formation of hydrogeological conditions on the Absheron Peninsula is extremely complex. Geomorphological, tectonic, geological-lithological conditions, the activity of the Caspian Sea, climatic indicators, individually participate to a certain extent in the process of formation of groundwater. The distribution of geological stratigraphic units on the Absheron Peninsula, the heterogeneity of their lithological compositions in the area, and the geomorphological-tectonic structures of the territories confirm what is said. The general regularities for the studied areas include the uneven distribution of surface water, the almost absence of rivers, the scarcity of atmospheric precipitation and the fact that evaporation exceeds atmospheric precipitation by several times. Clayey facies predominate in stratigraphic units of different ages on the Absheron Peninsula. The fact that the collector layers participating in the intersection are in the form of layers, the presence of clay in the composition of the water-retaining rocks, the fact that the layers separating them consist of completely solid, thick-layered clays, the presence of salts of various compositions in the clay rocks, etc. have created conditions for the formation of fresh and weakly saline water horizons in these areas. The complexity of the tectonic conditions in the areas where the research was conducted also confirms what has been said. Thus, the replacement of anticlines and synclines consisting of rocks of different ages in the area, the presence of numerous tectonic faults and disturbances have led to the formation of completely unrelated water complexes. For many years, in some areas of the Absheron Peninsula, groundwater levels have approached the surface of the earth, their distribution areas have increased, and the process of decreasing the degree of mineralization in groundwater has been observed. In some areas, the opposite has been observed. All this has had a certain impact on the formation and change of hydrodynamic and hydrochemical conditions of the areas.

Keywords: groundwater, pressurized water, hydrodynamic indicators, degree of mineralization, hydrogeological exploration

I. Introduction

The geological structure of the Absheron Peninsula includes modern sediments from the Quaternary period to the Cretaceous sediments. The tectonic and geomorphological conditions of the area are very complex.

The Absheron Peninsula is divided into two parts according to its geological and lithological, tectonic and geomorphological, hydrogeological characteristics: Western Absheron and Eastern Absheron. The stratigraphic boundaries between Western Absheron and Eastern Absheron pass through the Productive layer, Agjagil and Lower Absheron layers. This boundary extends in the southeast direction through the villages of Goradil, Fatmai, Mammadli. Zabrak, Surakhani, and then in the south to Govsan [1-3,19,20].

The hydrodynamic conditions of the groundwater of the Absheron Peninsula are formed in very complex geological and geomorphological, tectonic and anthropogenic conditions.

Both soil and pressurized aquifers are widespread on the Absheron Peninsula. The water-retaining rocks in the aquifers consist of limestones, sandstones, sands, and gravels. Aquifers cover all stratigraphic ages from the Quaternary to the Productive layer [1,10-12].

According to tectonic zoning, the Western Absheron hydrogeological region covers the Western Absheron highland, the Haji Zeynalabdin Tagiyev Binagadi subsidence area, the Chuvaldagh and Guzdak plateaus. Here, a limited closed Baku depression and the eponymous groundwater basin are separated. Sediments of the Santon layer of the Cretaceous system to the Yunusdagh stratum are distributed in Western Absheron. The hydrogeological conditions of Western Absheron correspond to the hydrogeological conditions of Gobustan. Unlike Gobustan, artificial factors also participate in the formation of groundwater in Western Absheron. This process became even more active after the construction of the Jeyranbatan reservoir in 1956 [4,5,16-18].

When studying the hydrogeological conditions of the study object, the landscape indication method was used, whereby the recipient components of the landscape were studied through their physiognomic components. At points with easily traceable technogenic influences, appropriate study sites were selected, and the chemical composition and level of groundwater were studied using dug wells (Fig.1) [6-9].

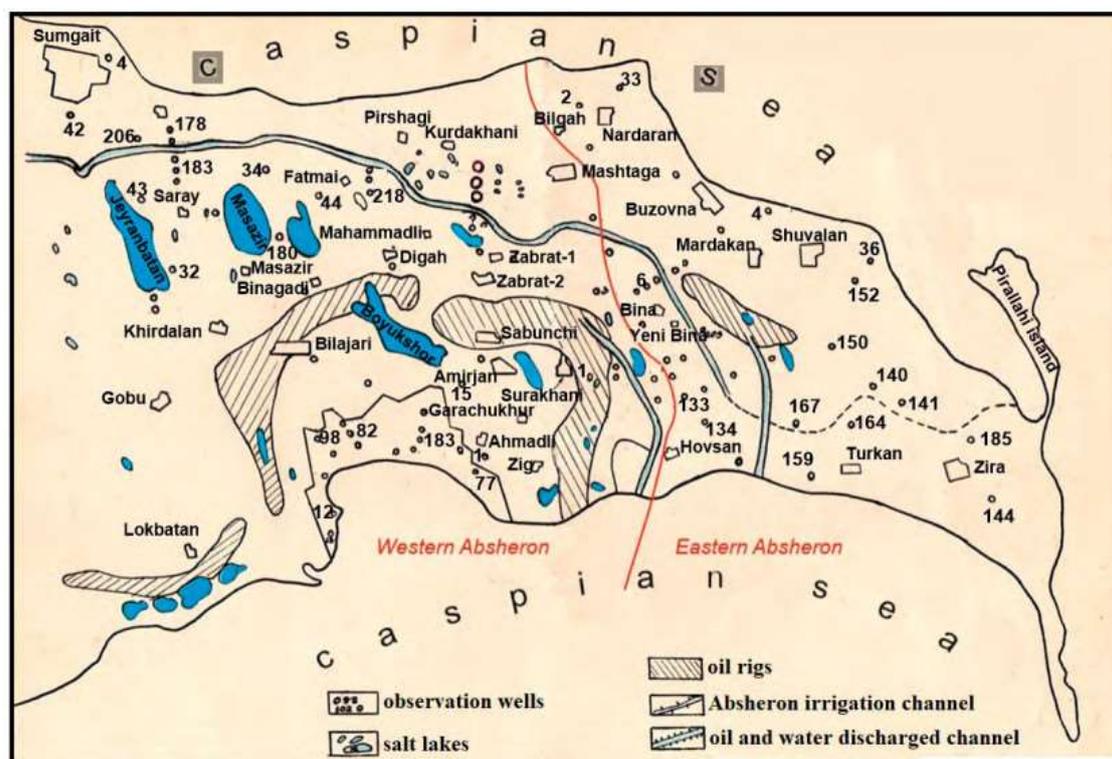


Figure 1: Exploration wells drilled in the Absheron Peninsula

In general, hydrogeological and exploration wells have been drilled for various purposes in the Absheron Peninsula over the past 30-40 years. The characteristics of the hydrodynamic conditions of the peninsula were compiled based on data from wells drilled over many years [13-15,21].

According to the tectonic zoning scheme, East Absheron covers the territories of the Kurdakhani-Mashtaga uplift, Bina-Govsan, Dubandi-Zira depressions. The geological and geomorphological conditions of East Absheron create favorable conditions for the formation of groundwater here. Sediments of the Modern Period - Absheron stratum are widespread in this area. Since the productive layer sediments lie under layers of great thickness, they are not

important from a hydrogeological point of view. In addition to natural factors, artificial factors also play a major role in the formation of groundwater in the East Absheron territory.

Groundwater in the East Absheron territory covers all the places we have mentioned. In order to analyze the hydrodynamic conditions of groundwater, a map of hydroisohypses, depth, mineralization and chemical composition was compiled for the territory of the Absheron Peninsula based on multi-year data.

The western borders of the area of undifferentiated stratigraphic classification of groundwater in the Absheron Peninsula extend from the Haji Zeynalabdin Tagiyev settlement to the Gumyamag Lake in the southeast direction. 3 km south of this, the border connects with the western shore of Jeyranbatan Lake. The border extends in this direction and reaches the city of Khirdalan. From here, the borders are slightly drawn to the east and extend to the sea in the direction of Lokbatan. To the west of these borders, groundwater is distributed sporadically.

The flow of groundwater is from west to southeast and east. In the north-west of Absheron, the direction of underground flow is north, towards the sea. Hydroisohypses are located here in a radial form, breaking between absolute heights of +30 m (-30 m). The absolute height of the groundwater surface detected by wells varies between 38.9 m and -27.5 m. The slope of the groundwater flow is 0.01 between the Jeyranbatan reservoir and Sumgayit city, 0.02 in the Novkhani gardens area, and 0.04 in the Goradil gardens district. In the Khirdalan district, the underground flow is towards the Jeyranbatan reservoir. Here, the absolute height of the level varies between 74.3 m and 31.4 m. In the Masazir and Mirzaledi lakes districts, the underground flow is towards the lake along the perimeter of the lakes. In the peripheral areas, groundwater has a sporadic distribution. In the Boyuk Shor lake district, the absolute height varies between -62.7 m and 43.2 m. From here, the hydroisohypses are located at +30 m in both directions. Between the city of Khirdalan and the settlement of Bilajari, the hydroisohypses are divided into two directions. The highest level of hydroisohypses to the north is +40m. The direction is towards Boyukshor Lake. In the south, the slope is towards Khojahasan Lake. Here, the direction of groundwater flow is from the Yasamal valley towards Gırmızı Lake, and from there towards the coastal settlement. The absolute height of groundwater in these areas varies from -25.1 m to 9.9 m.

In the Baku depression, groundwater is distributed in the sediments of all stratigraphic layers. Here, groundwater flow has a uniform radial flow form in the seaward direction.

The presence of Balakhani-Sabunchu-Ramani, Surakhani and Garachukhur-Zikh anticlines in the eastern part of the city creates conditions for changing the shape of groundwater flow. The flow of groundwater spreads radially from these structures in all directions. The slope of the hydrorelief in the city is variable. In the west and east, the slope varies between 0.01-0.1, in the north 0.06-0.01, and in the coastal strip in the south 0.014-0.1. On the Keshla plateau, the slope of groundwater flow varies between 0.003-0.08 [22,23].

Groundwater formed in the territory of Baku is used in the central parts of the city and along the sea coast.

Groundwater emerges to the surface in various areas of the city. The flow of groundwater formed in the territory of Baku city falls into a single general flow in accordance with geological and structural conditions.

The general flow of the groundwater basin on the Absheron peninsula is in the direction from Western Absheron to Eastern Absheron. The flow of groundwater along the entire perimeter of Eastern Absheron flows into the sea. In the central parts of the peninsula, the slope of the groundwater flow is 0.01, and along the sea coast - 0.0025. In the direction of the Bina settlement, the slope of the groundwater flow is 0.0001. The hydroisohyps of groundwater in Eastern Absheron is radially with a slight slope towards the sea.

II. Methods

In order to study the hydrodynamic properties of groundwater in the Western Absheron area, wells 60-73, 34-49 were drilled in accordance with the Middle and Upper Absheron and Productive layer sediments. Groundwater was detected in some of these wells, while in others it was not detected (Table 1).

Table 1: Data from wells drilled into groundwater of the Middle and Upper Absheron sediments on the Absheron Peninsula

No	Well №	Static level, m	Dynamic level, m	Level drop, m	Consumption, l/s	Special consumption, l/s.m	The permeability of water-retaining rocks, K_{ϕ} m/day	Sukeçiricilik əmsali, K_m , m ² /day	Level and pressure transmission coefficient (a), m ² /day	Irrigation coefficient, μ
1	60	1,2	36,7	35,5	0,4	0,011	0,07	1,33	0,6·10 ²	0,02
2	65	5,5	32,4	26,9	0,07	0,003	0,04	0,32	0,16·10 ²	0,019
3	68	6,8	32,4	25,6	0,3	0,01	0,11	1,32	0,2·10 ³	0,02
4	69	7,3	38,2	30,9	0,19	0,006	0,3	8,4	0,4·10 ³	0,025
5	70	18,2	40,3	22,1	0,015	0,0006	0,04	0,08	0,05·10 ²	0,02
6	71	17,2	37,2	20,0	0,02	0,001	0,03	0,12	0,21·10 ²	0,017
7	72	6,5	31,48	24,98	0,8	0,032	2,3	34,5	0,8·10 ³	0,05
8	73	7,5	31,65	24,15	1,2	0,05	0,7	9,8	0,5·10 ³	0,02

As can be seen from the table, although the data of the wells located in different areas of Absheron Peninsula are different, their hydrodynamic properties are characterized by very small dimensions.

The depth of the groundwater level is 1.2-17.2 m. The well flow rate during pumping is 0.015-1.2 l/s, the specific flow rate is 0.0006-0.05 l/s.m. The filtration coefficient of the water-bearing rocks is 0.03-2.3 m/day, the water permeability coefficient is 0.08-34.5 m²/day, the level permeability coefficient is 0.05·10²-0.8·10³ m²/day, the water permeability coefficient of the water-bearing rocks varies between 0.017-0.05. No groundwater was detected in other wells drilled into the sediments of this layer in Western Absheron.

Wells 34, 35, 36, 37, 38, and 39 were drilled to study the hydrodynamic properties of groundwater in the sediments of the productive layer in Western Absheron. Of these, groundwater was discovered in wells 34, 36, and 39 (Table 2).

Table 2: Data from wells drilled into Balakhani (Productive layer) sediments

No	Well №	Static level, m	Dynamic level, m	Level drop, m	Consumption, l/s	Special consumption, l/s.m	The permeability of water-retaining rocks, K_{ϕ} m/day	Sukeçiricilik əmsali, K_m , m ² /day	Level and pressure transmission coefficient (a), m ² /day	Irrigation coefficient, μ
1	34	7,5	32,0	24,5	0,7	0,03	0,5	3,0	2·10 ²	0,02
2	36	10,0	38,5	28,5	0,09	0,003	0,07	0,35	0,2·10 ²	0,017
3	39	8	38,0	30,0	1,2	0,04	0,62	4,34	0,2·10 ³	0,05

The hydrodynamic parameters of the pressurized waters of Western Absheron were studied using well No. 11. The well is located 1.5 km west of the Hokmali settlement. The piezometric level is 12.5 m. The consumption of the well during the drawing time is 0.8 l/s, the specific consumption is 0.028 l/s.m. percolation coefficient of water retaining rocks is 0.09 m/day, permeability coefficient is 3.15 m²/day, level transfer coefficient is 0.8.102 m²/day.

The depth of groundwater on the Absheron peninsula varies. In Western Absheron, the depth of groundwater varies from 1 m to 15.2 m (well No. 7). The lowest depth of groundwater is observed in the area between Sumgayit city and Jeyranbatan Lake. The groundwater depth interval in these areas is between 1-2 m. Around Lake Boyukshor, in the Yasamal Valley, in the southern parts of Lokbatan settlement, in the Red Lake district, in the Sahil settlement district, the groundwater depth is in the interval of 1-2 m.

According to the information received, the hydrodynamic parameters of groundwater in the areas where the wells are located are very weak. The well's flow rate during pumping is 0.03-1.2 l/s, the specific flow rate is 0.03-0.003 l/s.m. The filtration coefficient of the water-bearing rocks is 0.07-0.62 m/day, the water permeability coefficient is 0.39-4.34 m²/day, the level permeability coefficient is 0.2.102-0.3.103 m²/day, the water permeability coefficient of the water-bearing rocks varies between 0.017-0.05.

In the Masazir settlement district and in the surrounding lakes, the groundwater depth increases as it is separated from the lakes, reaching a depth of 16.5 m and more. In the territory of Baku city, the groundwater depth repeats the shape of the relief. On the edges of the Baku amphitheater, the depth - 10-12 m, and in some places 20-25 m and more. In the direction of the sea, the groundwater depth decreases to an interval of 1-2 m.

In the territory of Eastern Absheron, the groundwater depth varies from 0 to 30 m. In the territory of Central Absheron, the groundwater depth is close to the surface of the earth. The depth of groundwater in Kurdakhani, Pirshaghi, Mammadli, Nardaran, Mashtaga, Fatmai, Surakhani and other areas varies between 1-2 m. In the areas from Nardaran to Zira, the depth of groundwater varies between 10-20 m (Fig.2.).

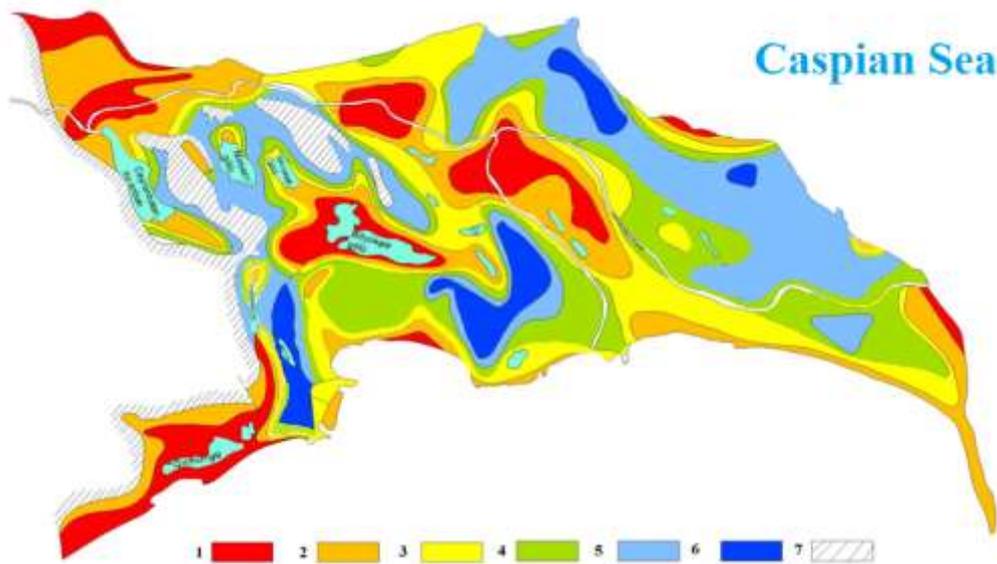


Figure 2: Map of groundwater depth of the Absheron Peninsula
The depth of the water: 1. 0-1 m; 2. 1-3m; 3. 3-5 m; 4. 5-10 m; 5. 10-20 m; 6. >20 m;
7. Areas of sporadic groundwater flow

The water content of the water-retaining rocks in Western Absheron varies in very low intervals. The water consumption during the pumping period of wells drilled between Sumgayit city and Novkhani gardens varies between 0.03-3.0 l/s. In the Jeyranbatan Lake region, the water consumption of wells is 0.4-0.9 l/s, and the specific water consumption is 0.05-0.3 l/s.m. The most common specific water consumption is 0.03-0.09 l/s.m. The filtration coefficient of the water-retaining rocks varies between 0.3-3.6 m/day. In the area between Mirzaledi, Masazir and Boyuk Shor lakes, the specific water consumption of wells is 0.06-0.12 l/s.m, and the filtration coefficient of the water-retaining rocks varies between 0.9-2.1 m/day. In the Khirdalan area, the flow rate of wells is 0.6 l/s, the specific flow rate is 0.05 l/s.m. The rock filtration coefficient is 0.7 m/day. The flow rate of wells drilled in the Khoja-Hasan Lake region is 0.2 l/s, the specific flow rate is 0.02-0.05 l/s.m, and the rock filtration coefficient varies between 0.1-0.7 m/day. The flow rate of wells drilled south of the lake is 0.5 l/s, the specific flow rate is 0.06 l/s.m, and the filtration coefficient is 3.1 m/day.

In the southwest of the Absheron Peninsula, the flow rate of wells increases to 3.5 l/s. The specific flow rate of wells in this direction varies between 0.01-0.09, 0.15-0.23 l/s.m. The permeability of water-retaining rocks varies between 0.03-1.0 m/day.

In the Baku depression, the rocks of the groundwater horizon are more watery. The thickness of the water horizons is variable. The flow rate of wells during the water withdrawal was between 0.2-5.9 l/s. The greatest water content is distributed in the Yasamal settlement. The reason for this is explained by the influence of Ganly Lake. The specific flow rate of wells is 0.02-0.3 l/s.m. The permeability of water-retaining rocks varies between 0.1-25.9 m/day. The permeability of water-retaining rocks in the central parts of the Baku depression varies between 0.2-9.2 m/day. The flow rate of wells is 0.2-5.0 l/s, and the specific flow rate is 0.02-0.3 l/s.m.

The flow rate of wells drilled into groundwater in East Absheron is up to 9.8 l/s. The flow rate of wells in the Nardaran and Zagulba zones varies between 2.0-10.0 l/s. The specific flow rate of wells in these areas is 0.2-1.1 l/s.m. The filtration coefficient of water-retaining rocks is 1.1-5.2 m/day. The thickness of the aquifer is 60-70 m. This thickness is observed everywhere in East Absheron. The flow rate of wells in the Mashtaga area is 0.8-1.5 l/s, and in the Mardakan-Shuvalan area it is 0.4-2.1 l/s. The specific flow rate of wells varies between 0.14-0.38 and 0.03-0.25 l/s.m. The filtration coefficient of water-retaining rocks varies between 0.2-2.3 m/day. The infiltration rate of the water-retaining rocks in the Bina-Govsan basin is 1.0-4.8 m/day. The flow rate of the wells is 0.9-3.0 l/s, and the specific flow rate is 0.06-1.2 l/s.m.

The pressurized groundwater distributed on the peninsula has a high degree of mineralization. Therefore, these waters have not been well studied due to their lack of practical significance.

Pressurized aquifers on the peninsula have been studied during hydrogeological, hydrogeological-ameliorative mapping, and exploration and exploration works for balneological purposes. Pressurized waters lying in deeper layers have been studied during oil exploration.

Unlike groundwater, pressurized waters on the Absheron Peninsula have created a single aquifer horizon and characterize separate stratigraphic units of the section. In these areas, pressurized aquifers have no hydraulic connection with other horizons.

In the western parts of the Absheron Peninsula, pressurized aquifers have developed in the sediments of the Productive layer. In the northwestern part of the peninsula, the ceiling of pressurized aquifers has been discovered at a depth of 49-70 m. In the southwest, this depth varies between 30-54 m. In the northwest, pressurized waters have been studied to a depth of 200-250 m, and in the southwest - up to 100 m. In the northwest of the peninsula, in the Sumgayit city district, in the west, in the Goradil village, in the Masazir Lake area, the piezometric levels of pressurized waters are at a depth of 3.4-18.7 m. The flow rate of wells during water withdrawal varies between 1-7 l/s. The specific flow rate of wells is 0.07-0.8 l/s.m. The filtration coefficients of water-retaining rocks are 0.2-1.9 m/day. In the Garadagh-Puta area, the piezometric level is at 1-2 m. The flow rate of wells during water withdrawal is 0.3-0.9 l/s, and the specific flow rate is 0.03-0.11 l/s.m.

The infiltration rate of water-retaining rocks is 0.03-0.11 m/day. Pressurized waters are sporadically distributed in Western Absheron.

Pressurized waters are found everywhere in the Baku Basin. Pressurized aquifers consist of several pressurized aquifer layers and were formed in the sediments of the Absheron-Quaternary period. The water-bearing rocks consist of sand, silt, sandstones and limestones. The feeding area of pressurized aquifers in the Baku Basin is the area where their collector rocks emerge to the surface. Such conditions are found everywhere in the Absheron Peninsula. The flow direction of pressurized waters everywhere repeats the flow direction of groundwater. In the central parts of the city, pressurized waters both feed groundwater and flow into the Caspian Sea. In the western and eastern parts of the city, groundwater feeds pressurized waters. The role of artificial factors in the feeding of pressurized waters is very low. As a result of the feeding of pressurized water horizons with different waters on the edges of the basin, the levels of both groundwater and pressurized waters increase in the central parts. This process is observed everywhere in the city. The depth of the top of the pressurized aquifer varies between 20-105 m. The lowest depth of pressurized water is observed in the coastal area. In these areas, the top of pressurized water is found at a depth of up to 36 m. In the central parts of the city, the top of pressurized water lies at a depth of 92-105 m. The general direction of groundwater flow is towards the sea. The direction of the flow is formed in accordance with the geological-tectonic and geomorphological conditions of the area. The piezometric level in these areas varies between 99.7 m (-22.7 m). The highest value of the piezometric level is observed in the Yasamal settlement, and the lowest values are observed along the coast. In areas after the "O" horizon, the piezometric level is above the ground surface in wells drilled for pressurized water. The flow rate of wells during pumping in these areas is 0.1-3.8 l/s. The seepage coefficient of water-bearing rocks is 0.1-1.2 m/day.

Pressurized aquifers are found everywhere in Eastern Absheron. Pressurized aquifers are widespread in the Khazar, Gurgan, Baku, and Upper Absheron sediments. The aquifers are sand, gravel, sandstone, and limestone. In Eastern Absheron, the Agjagil and Lower Absheron sediments are anhydrous.

There is no data to characterize the vertical section of the aquifers located in the Agjagil and Prodeuctive layer sediments in Eastern Absheron. There is no data to characterize the vertical section of the aquifers located in the Aghjagil and Mushkildar sedimentary beds in Eastern Absheron. The Quaternary-Upper Absheron sedimentary layers were formed at a depth of 700-800 m in these areas. The studied thickness covers 200-250 m. The depth of the ceiling parts of the Absheron floor was found to be 66-88 m through wells. The sediments of this layer are distributed in the regions of the villages of Pirshaghi-Bilgah and Mashtaga-Buzovna. The base of the layers was discovered at a depth of 144-235 m. The piezometric level is located at a depth of 7.4-12.9 m. The flow rate of the wells during the water withdrawal is 0.6-2.6 l/s, and the specific flow rate is 0.21-0.5 l/s.m. The filtration coefficient of the water-retaining rocks varies between 0.3-1.9 m/day. In the Mashtaga-Shuvalan area, a complex of pressurized waters was discovered at 60-72 m. The base of the pressurized layers is located at a depth of 190-241 m. The flow rate of the wells during the water withdrawal is 1.90-2.40 l/s, and the specific flow rate is 0.15-0.30 l/s.m. The permeability of water-retaining rocks is 0.6-1.4 m/day.

Two pressurized water horizons were discovered through wells in the Bina-Govsan depression. Here, the ceiling of the Baku horizon lies at a depth of 30-46 m, and the bottom at a depth of 35-75 m. The piezometric level is located at a depth of 4-16 m. In the Govsan village district, the piezometric level is located at +0.5 m. During the water withdrawal period, the flow rate of the wells varies between 1.0-5.0 l/s, and the specific flow rate is 0.9-4.5 l/s.m. The permeability of water-retaining rocks reaches 10 m/day.

The second pressurized horizon in the Bina-Govsan depression belongs to Absheron sediments.

At the Gala height, this horizon lies at a depth of 19-69 m. During the water withdrawal period, the wells have a flow rate of 1.0 l/s, and a specific flow rate of 0.15 l/s.m. The percolation coefficient of the water-retaining rocks is 0.32 m/day.

The pressurized aquifer horizon at the Zira and Shahov capes belongs to the Baku and Absheron layers. The ceiling of the pressurized aquifer complex lies at a depth of 27-62 m, and the base at a depth of 40-68 m. The effective thickness of the aquifers is 4-6 m. The piezometric level is at a depth of 17-23 m. During the water withdrawal period, the wells have a flow rate of 0.7-1.0 l/s, and a specific flow rate of 0.02-0.04 l/s.m. The percolation coefficient of the water-retaining rocks is 1.0 m/day.

III. Results

The Absheron Peninsula, especially in the past 30-40 years, has been thoroughly studied through various hydrogeological exploration activities, and it exhibits a variety of hydrogeological characteristics. During this period, the data from drilled wells have been used to analyze the hydrodynamic conditions of the region in detail.

The tectonic structure of Eastern Absheron is characterized by the presence of structural formations such as the Kurdakhani-Mashtaga uplift, the Bina-Govsan and Dubəndi-Zira ridges. The geological and geomorphological features of these areas have created favorable conditions for the formation of groundwater reservoirs. The Absheron formation of sedimentary layers in Eastern Absheron is primarily represented by modern-day deposits. Due to the considerable thickness of these deposits, the productive groundwater layers are mainly found at deeper strata.

In the hydrogeological context of Absheron Peninsula, artificial factors, along with natural ones, also play a significant role. The dynamics of groundwater flow, especially in the central and eastern parts of the region, exhibit distinct patterns. The flow of groundwater in this area is primarily directed west, southeast, and east, which corresponds to the dynamic flow patterns defined by the region's geological structures.

Hydroisohypses maps and other hydrodynamic charts illustrate the absolute elevation of groundwater and its mineralization characteristics. Analyzing the density and hydrodynamic properties of the groundwater provides insights into how these waters spread across different areas, such as Khirdalan, Masazir, and others, and how these waters approach the surface. Notably, in the Baku formation area, the flow of pressurized waters and their relation to groundwater, as well as the discharge and filtration coefficients of pressurized horizons in the northwest and southwest parts, are essential for understanding the dynamics of groundwater.

The interaction between pressurized waters and groundwater in Baku city and other regions of the Absheron Peninsula represents significant indicators of the hydrogeological conditions formed by the groundwater flow. These relationships provide essential data for managing water reservoirs and properly assessing the region's hydrogeological situation. The high mineralization of pressurized waters in the central parts of the city and their location in unusual hydrogeological conditions is also crucial.

Therefore, in-depth study of the hydrogeological characteristics of Absheron Peninsula, considering both natural and artificial factors, allows for efficient management of groundwater resources. This provides necessary information for evaluating the dynamics of underground water reservoirs.

CONFLICT OF INTEREST.

Authors declare that they do not have any conflict of interest.

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