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Research Of Geotechnologıcal Factors Influencıng The Muddıng Of The Wells

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Abstract

In the article, the author focuses on the significance of the negative impact of drilling fluids on the permeability of the formation, which forms an increase in hydraulic resistance during the supply and pumping of technological solutions, on the throughput of pumping and injection wells.

The article also provides information on ways to reduce drilling fluid while maintaining the throughput of the wells. In the main part of the work, the author establishes a relationship between the content of aleuropelites in the rocks - loose unbound lithological impurities and filtration coefficients, which allows a comprehensive assessment of the reservoir properties of the ore-forming formation and introduces the concept of the coefficient of lithological and hydraulic conductivity.

The work shows that the greatest degree of hydrodynamic study in the rock area of the productive horizon is observed during the operation of the hexagonal (seven well) cell. The area of study (coverage) of rocks by leaching solutions is 80 percent or more. The smallest exploration area was found for a trihedral (four well) well location cell - 57 percent or less.

Keywords: *Underground leaching, mudding, geotechnological well, hydraulic head, filter zone, aeration of solutions, flow turbulization, hydraulic gradient, siltstone.*

In the world, the method of underground leaching (PV) has several advantages over traditional and expensive methods of mining. Uranium mining by the PV method is constantly increasing and in the last decade it has increased from 5 to 34%. The PV method allows to reduce by 2-4 times capital investments in the construction of enterprises and to reduce the time of construction of mines, to increase labor productivity by 2-4 times and, accordingly, reduce the cost of the finished product by optimizing jobs. With such a rapid increase in uranium demand, mining practice sets the task for scientists to develop unconventional technologies. One of these tasks is the involvement of uranium ores in mining. Therefore, the development of uranium ore reserves using a new technology is an important scientific and technical problem.

In contrast to the traditional mining method, which deals with solid PI, uranium mining using PV is associated with its extraction from the bowels in the form of a productive solution. Uranium is extracted from solutions using ion-exchange technology, followed by regeneration of the sorbent and obtaining products suitable for further processing.

As reagents for leaching of uranium, weak solutions of sulfuric acid, carbonate (bicarbonate) containing ammonium, sodium, potassium, calcium and magnesium salts are used. Carbonate leaching must be carried out using an oxidizing agent (hydrogen peroxide, oxygen, etc.)

Uranium oxides react with acid

ore leaching method

$UO_{3\,тв} + 2H^{+}_{водн} \rightarrow UO_2^{2+}{}_{водн} + H_2O;$

$UO_{2тв} + 0{,}5O_2 + 2H^{+}_{водн} \rightarrow UO_2^{2+}{}_{водн} + H_2O;$

$UO_{2тв} + 2Fe^{3+}_{водн} \rightarrow UO_2^{2+}{}_{водн} + 2Fe^{2+}_{водн};$

$3UO_{2тв} + ClO_{3\,водн} + 6H^{+}_{водн} \rightarrow 3UO_2^{2+}{}_{водн} + Cl^{-}_{водн} + 3H_2O;$

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$UO_{2\ тв}+2H_2SO_4 \rightarrow U(SO_4)_2 + 2H_2O$.

Dilute sulfuric acid is used as a solvent in the acidic PV process. Sulfuric acid is convenient for transportation (black steel tanks are used), has a high content of the basic substance in the initial aqueous solution, can serve as a solvent without the use of an oxidizing agent, and very poorly transfers radium and other nuclides to the solution.

The initial concentration of sulfuric acid for leaching of uranium is usually 12-15 g / l with a further decrease to 7-8 g / l (after completion of the acidification stage). The residual acidity of the solutions should be lower than the precipitation pH of uranyl hydroxide (pH 2-2.5). In practice, it is 1-2 g / l.

Minerals in which uranium is in the hexavalent state are well soluble in sulfuric acid solutions. Minerals of tetravalent uranium slowly interact with sulfuric acid solutions according to reaction equation (1.5), but practically under conditions of PV this reaction does not take place and leaching takes place according to equation (1.3), since ferric iron is always present in the solution, passing into them from the host rocks .

To increase the dissolution rate of uranium, an increased concentration of ferric ions in the solution is desirable; therefore, if there is an insufficient concentration of these ions in the leach solution, it is necessary to add iron (III) sulfate or introduce another oxidizing agent, for example, NaClO3.

During the operation of pumping and injection wells in the process of developing a field using the PV method, as a rule, their flow rates decrease. The main reason for this negative technological factor is the process of colmatization of the pore volume of rocks in the filter zone of the wells, as well as the "overgrowing" of the perforation of the filters themselves.

The main, if not the main condition for reducing the flow rates of geotechnological wells is the clogging of filters and filter zones of rocks of the productive horizon, which forms an increase in hydraulic resistance during the supply and pumping of technological solutions.

In the process of mechanical mudding, the water intake openings of the filters and pore sections of the solution-conducting channels are blocked by thin sand-clay particles contained both in the drilling fluid during the construction of wells and during their operation as a result of the development of suffusion. So, when using high-clay muds with a density of 1.15-1.18 g / cm3 in the drilling process to strengthen the walls of geotechnological wells constructed at hydrogen deposits represented by interbedded loose, mostly loosely coupled sand-clay differences, their production rates decrease ten times. In the process of claying the rocks of the productive formation of the prefilter zone, a clay crust up to 5-7 mm thick is created on the wall of the wells, whose permeability is 4-5 orders of magnitude lower than the permeability of the rocks.

The swelling of clay particles of the drilling fluid filling the pore volume of the filter zone of the reservoir reduces the flow area of the effective pore channels, which also increases the hydraulic resistance of the driving fluid phase. With an increase in the contact time of the clay drilling mud with the solid phase, the resulting clay cake is compacted under the action of adsorption processes and molecular interaction forces, which leads to certain costs (construction pumping) to remove it. Based on the kinetics of the formation of such poorly permeable clay screens, the contact time of the drilling fluid with the rocks of the reservoir should be minimal.

Along with mechanical colmatation of filter perforations and pore volume of rocks of the filter zone of the reservoir, chemical colmatation processes also occur, which is associated with a change in the chemical composition of the supplied and pumped solutions during their interaction with groundwater and with a change in the hydrodynamic parameters of fluid filtration.

Investigations of geotechnological factors affecting the processes of filter maturation and the filter zone of technological wells were carried out at the experimental block of the Tohumbet field.

Geographically, the Tohumbet deposit is located in the Gidzhuvansky district, 40 km north of the city of Kanimekh.

Ore-bearing is the Tohumbet horizon. The main lithological type of ore-bearing rocks is sands, sands with the inclusion of clay and carbonate cement, less often gravel. The sand filtration coefficient is from 2 to 10 m / day, mainly 5 - 7 m / day prevails. For gravel lithologies increases to 12 or more m / day; for sandstones it is reduced to 1 or less m / day. Thus, the water permeability of the rocks of the productive horizon, in General, is favorable for the technology of underground leaching.

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Ore-bearing rocks are composed of minerals inert to sulfuric acid solutions. The main minerals are quartz - up to 70 - 80%; feldspars - 8-20%; chlorite, muscovite, biotite - 1-3%; clay minerals - hydromica, kaolinite and montmorillonite admixtures - 1-4%.

The thickness of permeable rocks of ore-bearing horizons is up to 20 m. The thickness of uranium ore deposits varies from 0.5 to 20 m, an average of 3-5 meters; the ratio of ore body capacities to host permeable rocks from 1: 2 to 1: 10, mainly from 1: 3 to 1: 7 prevail.
The productivity of ore deposits in uranium, on average, is at the level of 2 - 6 kg / m2.
The morphology of the ore bodies in the plan is represented by tape-shaped bodies varying in width (from 300 to 700 m), in the section - classical rolls with wide bag parts up to hundreds of meters and wings adjoining them, also of considerable width up to 200 - 400 m. In areas of close rhythm packs of the horizon twin, sometimes even structured rolls with common intermediate wings are formed, which gravitate towards dividing apertures.
According to the complexity of the morphological structure, ore bodies in the deposit are divided into stratum, simple roll and complex roll deposits.
The lithological, mineralogical, geochemical, and filtration properties of ore-bearing horizons in exogenous-epigenetic deposits of uranium are formed under the influence of a number of natural factors, which may include bedrock composition in the area of drift, the nature and depth of their development by weathering processes, distance and speed transportation of clastic material, conditions of sedimentogenesis, diagenesis and catagenesis of sediments. An important role is also played by the transformation of rocks that occur as a result of the imposition of processes of an oxidizing and reducing nature.
Industrial uranium deposits occurring in sedimentary rocks include reservoir and soil oxidation deposits. Deposits of formation oxidation are confined to permeable horizons of sedimentary strata and are found in various geological, structural and hydrogeological situations. The raised wings of artesian basins located in the activated parts of ancient and young platforms are favorable for their formation; They also include separate artesian basins of suborogenic regions separated by masses of basement rocks and instrumental sections of intraorogenic depressions.
The study of ore content, lithological, mineralogical, geochemical, and filtration properties of ore-bearing deposits in deposits intended for PV is aimed at identifying and mapping various types of rocks and ores, taking into account a number of qualitative and quantitative parameters and their ratios that affect technological parameters leaching. Mapping and sections are based on documentation and core testing with widespread use of geophysical methods with the detail required for different stages of work. A special role belongs to the materials obtained in the course of laboratory and field geotechnological studies at pilot sites, according to the results of which indicators of field development are predicted.
The clay content of rocks and ores and the composition of clay cement largely determine the permeability of rocks and the consumption of reagent. It is generally believed that when the content in the rock is more than 20% clay material, it becomes almost impenetrable. It should be borne in mind that the content of the clay fraction, determined from the data of particle size analysis, in some cases cannot be linked to the permeability of rocks and ores without studying the texture features of the distribution of clay material. As a result of the development of secondary argillization processes, clay minerals can isomorphically replace feldspar grains, and in other cases a significant part of the clay material is associated with clay pellets, as a result of which the total content of the clay fraction exceeds the content of that part that is part of the cement and determines the permeability of the rocks. The composition of clay minerals, depending on many reasons, varies from essentially kaolinite, hydromica or montmorillonite to mixed in different ratios. An increase in acid consumption is observed in the series kaolinite - hydromica - montmorillonite. An unfavorable property of clays is their ability to swell, especially in the case when the injected solutions in terms of salt composition substantially differ from the composition of formation waters.

Table 1

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Subdivision of rocks by degree of permeability and fracture

Characterization of ores and rocks	Favorable conditions for PV	Adverse conditions for PV
Active porosity	15% and more	less than 15%
Permeability (Kf)	1,0m / day and more	less than 1.0m / day
Water capacity, l / s	0.1 and more	less than 0.1
Admixture of clay particles	less than 20%	more than 20%
Coefficient of filtration heterogeneity	more than 0.25	less than 0.25

The texture features of rocks and ores largely determine their permeability. Water permeability over bedding, as a rule, exceeds permeability across bedding by 2-5 times, therefore, the study of texture features of rocks is one of the most important tasks of lithological studies.

The structure of ores and host rocks (pore space shape, bond strength between grains and type of cement) should be taken into account when studying their filtration properties.

The water permeability of rocks and ores and the nature of the filtering heterogeneity of ore-bearing deposits are among the most important indicators that determine the effectiveness of underground leaching. Water permeability is determined using field hydrogeological, geophysical and laboratory methods. Experimental pumping (injection) from hydrological wells gives a very approximate characteristic of the change in filtration properties, since this method determines the average water permeability of the studied horizon.

For a comparative assessment of water permeability and, therefore, porosity under conditions of their natural occurrence, the method of experimental pumping, filling and injection of water into wells is widely used. Empirically, the filtration coefficient can be calculated according to the particle size distribution. The results obtained are very approximate and should only be used in forecast calculations of a non-economic nature.

Almost all lithological differences of the productive horizon are ore-bearing. The most common: sand-clay and sand-gravel rocks. The main ore components in the deposit are regenerated uranium oxides.

The Tokhumbet aquifer is ubiquitous; it is absent only in the northwestern and eastern parts of the basin, where water-bearing sands and sandstones are replaced by clay. The thickness of aquifers is 15-40m, increasing westward. The depth of the aquifer roof is from 100 m in the marginal parts of the basin to 500 m in its center. Groundwater flows in a northwest direction. Water mobility and water permeability of horizon deposits are low. Groundwater is mainly sulphate-chloride sodium-calcium with a salinity of 2-4 g / l, which also indicates favorable conditions for the technology of uranium mining by underground leaching.

At the experimental site, the level of groundwater is 20–35 m, the excess pressure on the roof of the aquifer is 40 m. The horizon waters are slightly brackish (Ph = 7.1–7.3). Water temperature + 20 - 220C.

In the field of nutrition and in the zone of oxidized rocks, groundwater is oxygen (O2 up to 1.5 mg / l), the electrochemical potential is from + 25 to + 118 mV.

The uranium content in them varies from 10-6 to 10-5 g / l. Directly in the wells that reveal uranium mineralization, the uranium content in groundwater rises to (7 - 9) · 10-5 g / l.

In the non-oxidized part of the ore formation, the oxidation potential Eh is negative: - 65 to - 93 mV, the uranium content in the waters decreases to n · 10-7 g / l.

The presence of a stream of oxygen-containing groundwater provides a relatively deep penetration of the formation oxidation zone (ZPO) and the displacement of the wedging zone boundaries in a westerly direction.

The development of a deep-depth ZPO, which is powerful in depth, indicates the predominant presence of uranium in hexavalent form, which is very favorable for underground leaching.

So, in [1, 2], the parameters of the filtration grids were studied for various cellular well layout schemes -

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from four to hexagonal. The latter are widely used in uranium deposits of Kazakhstan.

It was shown [3, 4] that the cellular layout of technological wells provides a radial movement of solutions from injection to injection wells. Such a hydrodynamic regime is undoubtedly a positive factor in the conditions of constantly changing geological and hydrogeological parameters of the ore deposit. Reducing or increasing the latter allows you to change the geometric parameters (the distance between technological wells) based on the results of production exploration.

It was shown in the works that the greatest degree of hydrodynamic study in the rock area of the productive horizon is observed during the operation of the hexagonal (seven borehole) cell. The area of study (coverage) of rocks by leaching solutions is 80 percent or more. The smallest exploration area was found for a trihedral (four well) well location cell - 57 percent or less.

However, the advantages of the hydrodynamic regime during the operation of the hexagonal arrangement of technological wells are significantly reduced due to increased costs in the process of equipment (strapping) them and connecting to communications. Difficulties also arise in the application of intensification methods — the reversal of leaching solutions at the final stage of PV.

The choice of the location of the experimental block was also due to the fact that it was necessary to evaluate the effect of mudding on rocks with different values of filtration indices Kph and Km.

In the block, wells were selected in which the average values of the filtration coefficients were: Kf ≤ 2.5 m / day (wells 10 - 5 - 3-1); 2.5> Kf <5 m / day (borehole 10 - 5 - 9-2) and Kf ≥ 5 m / day (borehole 10 - 5 - 11-3). The uranium content (C) and the thickness of the productive horizon (m) for the wells were:

No. / No. of wells C,% m, m
10 - 5 - 3 0.052 10.4
10 - 5 - 9 0.046 10.6
10 - 5 - 11 0.045 10.4

The depth of the reservoir is 147 m.

The duration of the experiment was determined by the time to reach the value of W: T - 0.6 m3 / t.

To exclude the influence of injection and pumping wells of neighboring cells on the operation of experimental wells, this experiment was carried out only on a cell with a pumping well of 10 - 5 - 2. Before the supply of working solutions, formation water was injected into the wells - 10 - 5 - 3; 10 - 5 - 9 and 10 - 5 - 11, to determine the initial specific values (q) of productivity (flow rates) of wells, which amounted to:

скв. 10 – 5 – 3$q = \frac{0{,}76\ м^3}{сут} * м$;

скв. 10 – 5 – 9 $q = \frac{0{,}84\ м^3}{сут} * м$;

скв. 10 – 5 - 11- $q = \frac{1\ м^3}{сут} * м$.

Based on the average thickness of the ore formation - 10.5 m and the average specific flow rate –0.85 m3 / day · m, the initial production rate of each injection well was: 0.85 m3 / day · m · 10.5 m = 8.7 m3 / day Thus, at the initial stage of the experiment, 34.8 m3 / day of leaching solutions were fed into the cell of the experimental unit.

Experimental cell parameters: area - 375 m2, ore bed thickness - 10.5 m, ore mass volume - 3937.5 m3, rock density - 2.3 m3 / t, ore mass weight - 9056.3 t.

At the final stage of the pilot work, the specific productivity of the wells was:

скв. 10 – 5 – 3 $q = \frac{0{,}20\ м^3}{сут} * м$;

скв. 10 – 5 – 9 $q = \frac{0{,}20\ м^3}{сут} * м$;

скв. 10 – 5 - 11- $q = \frac{0{,}08\ м^3}{сут} * м$,

those. decreased, respectively, in 3.8; 7.0 and 12.5 times. Thus, at the final stage of the experiment, the average q value was 0.13 m3 / day · m, and the average flow rate of each of the wells was 1.355 m3 / day, i.e., it decreased on average 6.37 times. The duration of the experimental work was about 7 months, while

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the value of W: T equal to 0.6 m3 / t was achieved.

During the experiment, the flow rates of injection wells were controlled, and the flow rate of the pumping well changed (decreased) depending on the decrease in the total productivity of the supply wells. Such a hydrodynamic regime ensured the maximum development of the ore bed with leaching solutions. The volume of filtration of solutions beyond the geometrical boundaries of the cell was reduced to a minimum, and the degree of dilution of productive solutions with the produced reservoir waters was minimized.

The equality of the values of the pumped out and feed solutions is one of the main conditions for maintaining the hydrodynamic parameters at an effective level: filtration rate, hydraulic gradient, uniform distribution of the solution flow along the streamlines of the hydrodynamic grid; the simultaneous achievement by the solutions of pumping wells and the formation of equivalent W: T values in the plan and section of the reservoir [4,5].

The values of q and Ж: T values for each pilot injection well are given in the graphs q = f (Ж: T), Fig. 1. - 3.

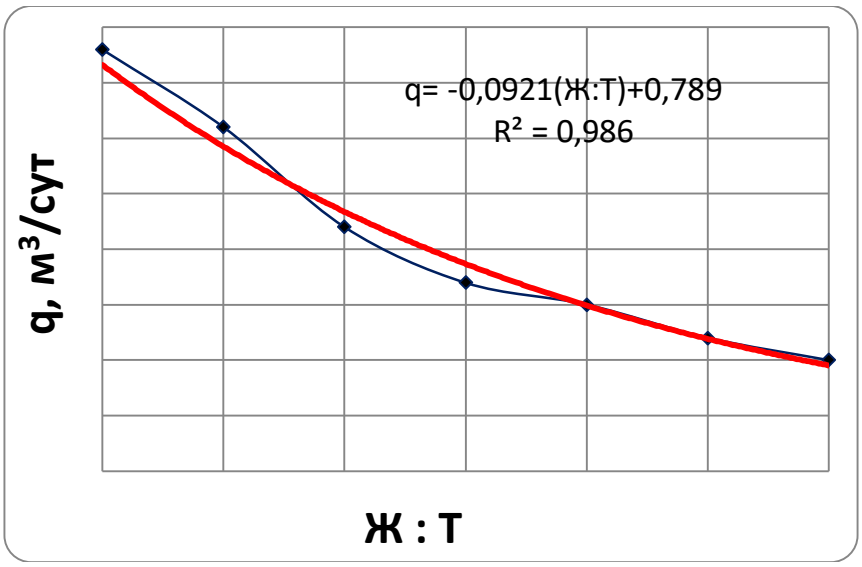

Fig. 1. Dependence on the value of W: T specific consumption (q).

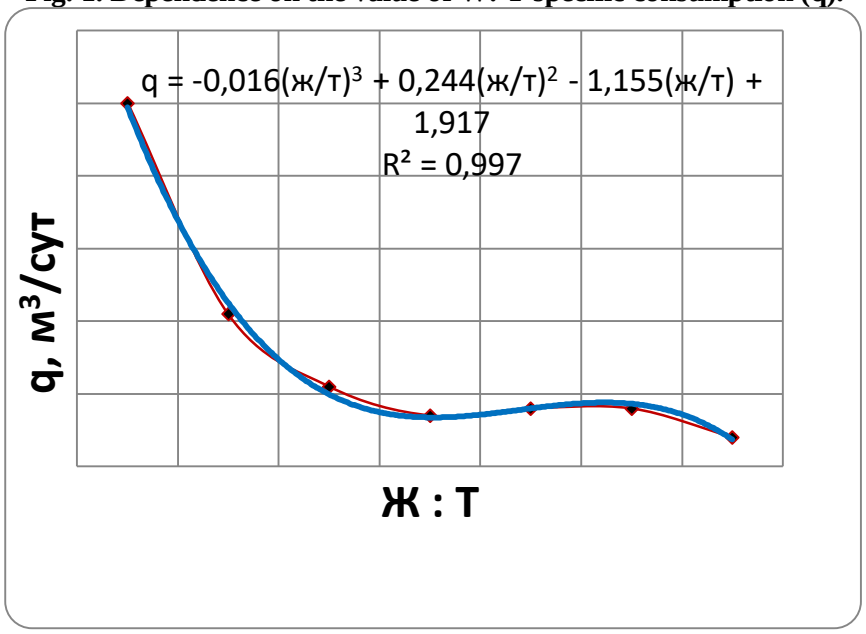

Fig. 2. Dependence on the value of W: T specific consumption (q).

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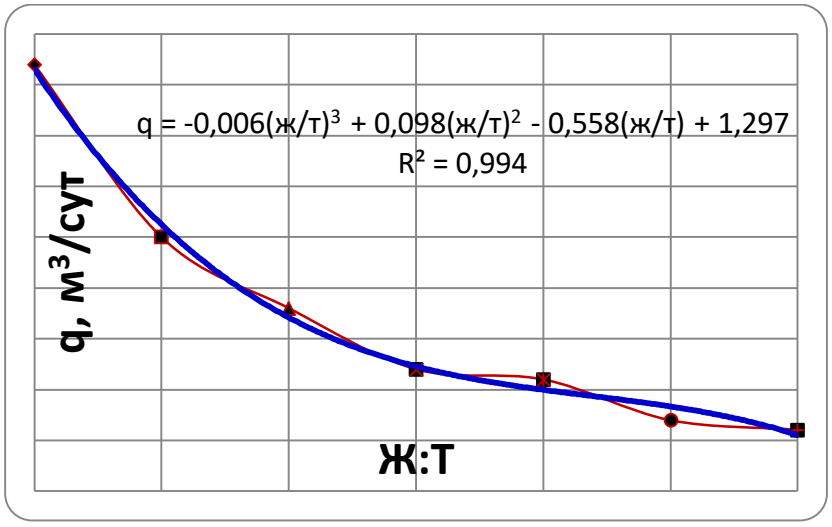

Fig. 3. Dependence on the value of W: T specific consumption (q).

Simultaneously with the allocation of ore intervals by the values of Kph, the effect on the hydraulic conductivity of the content of aleuropelite impurities in lithological differences of the rocks was estimated.

From the geology of the genesis of uranium deposits, it is known that, mainly, uranium mineralization of epigenetic deposits of formation oxidation zones is associated with geochemical barriers - reducers of clay cement, the presence of which is one of the main search features. Based on such conditions, the presence in the rock mass of aleuropelite particles, including sulfide, carbonate or organic compounds, directly control the formation of elevated uranium contents.

Thus, it is necessary, along with the presence of reducing agents in the deposition zone of low-valent uranium compounds with a low oxygen coefficient of 2.4 - 2.2, to evaluate the presence of aleuropelite cement, characterized by an increased specific surface of the constituent particles, increasing their sorption properties and, at the same time, determining the filtration properties of the ore mass.

During the construction of technological wells in the experimental cell of the experimental unit, the ore interval was drilled with full (maximum) coring. This core material was used in laboratory conditions to determine the Kf values and the content of admixtures of siltstone. The determination of these parameters was carried out according to standard methods used in hydrogeology and engineering geology [1-7].

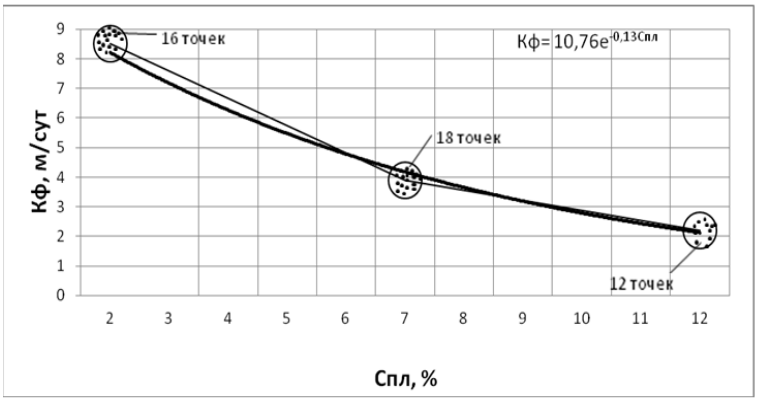

Fig. 4. The dependence of the filtration coefficient on the content of aleuropelite cleanlings, K = f (Cpl)

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The main investigated object of geological documentation at the Ketmonchi field is exploration well No. 3. Documentation of boreholes was carried out by core, the output of which was ensured by complete coring. The structure of the core documentation includes its description, fixing the location of the core samples, monoliths and samples, as well as gamma-measurement of the core.

Geological documentation was divided by design into 2 parts primary and summary. The primary documentation included a geologist's field book from the Center for Geological Survey and Geological Survey, NMMC, a log for testing core cores and a well passport.

A 90 m deep exploration well was drilled at the Tohumbet field, from which 16 core pieces of monoliths were taken. various lengths (20-40 cm) with a diameter of 90 mm. This core material was used in laboratory conditions to determine the Kf values and the content of siltstone impurities. The determination of these parameters was carried out according to standard methods used in hydrogeology and engineering geology.

Before the selection of monoliths, the core was cleaned of drilling mud.

The field log of geological documentation of wells was the main primary document, which recorded:

- description of the core and its sketch with the indication of the number of the sampling deposit and the numbers of core samples, monoliths, samples and the results of gamma - measurement of the core. Using the SRP-88 radiometer, the results were recorded in a sampling log;
- gamma measurement results with separation of the interval of core sampling.

The well passport (graphical application) was the main primary document, which was compiled using all the data recorded in the documentation log, in the sampling log, as well as data on all types of well logging. The passport of the well served as the basis for the construction of geological sections. For all wells, a design and estimate study was compiled to study the lithological part of the section, the interval of the ore-bearing horizon (with a partial grasp of the underlying and overlapping horizons) at a scale of 1:50.

Thus, 46 core samples were taken from 4 wells, 10 - 12 samples from each well. On average, one sample from the ore interval with a thickness of ≈ 1 m. The selection was based on the visual method, after cleaning the surface of the core column from the drilling fluid. In the laboratory, the prototype was divided into 2 parts: one part was used to determine the value of the filtration coefficient, the other to determine the content of aleuropelites, a thin, clay binder. The determination of Kf values was carried out in laboratory instruments KFZ (Znamensky), the cage of which was filled with the material to be studied by pressing it into the core column by bedding of lithological differences.

The obtained 46 Kph values were grouped in three intervals. When choosing the boundary values of the Kf intervals, we proceeded from the equal representativeness of each of the obtained values of the filtration coefficients. So, the number of samples in the range of 1 - Kph ≤ 2.5 m / day was 16; in the range of 2 - 2.5> Kph <5 m / day - 18 pcs.; in the interval 3 - Kf ≥ 5 m / day - 12 pcs. The average value of Kph for: interval 1 - 2.2 m / day; interval 2 - 3.9 m / day; interval 3 - 8.5 m / day, the maximum value is 11.3 m / day [3,4,5].

The content of aleuropelites was determined by the second part of the core material in the volumes of selected values of Kph of 3 intervals.

Interval 1 - the content of aleuropelites is more than 9.5%, the maximum value is 18.5%, the average value is 12.5%.

Interval 2 - the content of aleuropelites in the interval of less than 9.5% and more than 5 5.3%, the average value is 7.0%.

Interval 3 - the content of aleuropelites is less than 5.3%, the average value is 2.1%.

Such a methodological approach to assessing the water conductivity of the rocks of a productive formation made it possible to identify a hydrodynamic parameter characterizing both lithological and filtration properties: lithological and hydraulic conductivity.

We introduce the coefficient Kl-g, which characterizes the hydraulic conductivity of the rocks of the ore bed, depending on the content of aleuropelites, expressed in%. Dividing the value of Kf by the content of aleuropelites (Spl), we obtain the specific conductivity by 1% of aleuropelites. Then, for the selected

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intervals, we obtain the following values of lithological-hydraulic conductivity:
interval 1 – $K_{л-г} = \frac{K_ф}{C_{пл}} = \frac{2,2}{12,5} = 0,18 \frac{м}{сут} * \%$;

interval 2 –$K_{л-г} = 0,56 \frac{м}{сут} * \%$;

interval 3 –$K_{л-г} = 0,4 \frac{м}{сут} * \%$.

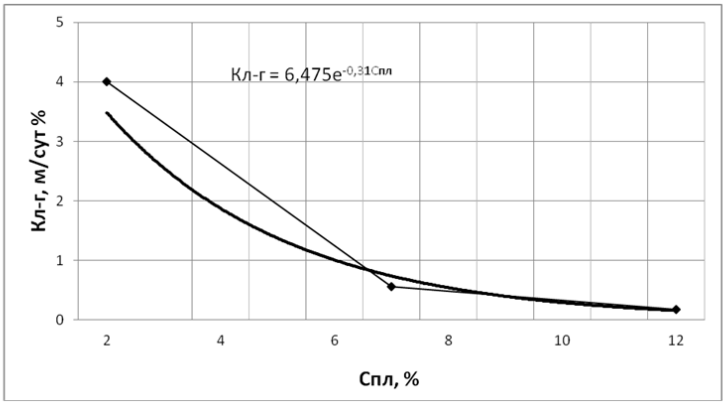

Fig. 5. The dependence of the coefficient of lithological and hydraulic conductivity on the content of siltstone cleanlings, Kl-g = f (Spl).

The relationships between the specific injectivity (q) of the wells and the values of the Zh: T index (time parameter) for each of the established and calculated average values of Kf revealed during the studies indicate that the process of colmatization manifests itself more intensively in lithological differences with high hydraulic conductivity (Kf> 5 m / day), fig. 2-4.

The selection of intervals with different hydraulic conductivities was based on the determination of silt pelite impurities in the composition of sand lithologies.

It should be noted that the values of the content of admixtures of aleuropelites and Kf are given by the average for statistical processing.

We introduce the coefficient Kl-g, which characterizes the hydraulic conductivity of the rocks of the ore bed, depending on the content of aleuropelites, expressed in%. Dividing the value of Kf by the content of aleuropelites, we obtain the specific value of conductivity by 1% aleuropelites (e.g. 2.5 m / day: 9.5% = 0.26 m / day%). By comparing the Kl-g values of various intervals of Kf values, it is possible to predict the change in the productivity of wells over time, using the identified dependencies, Fig. 2-4.

The integral coefficient Kl-g characterizes the processes of colmatization of the pore volume of rocks, depending on the presence of solid suspensions — pelitic clay particles and salts precipitating from solutions — in the form of gel-like substances when the physicochemical conditions of the filter fluid change [6].

Findings

1. The revealed dependences of the specific injectivity of injection wells (q) on the value of W: T make it possible to predict a decrease in well productivity depending on the water permeability of the ores.
2. A relationship has been established between the content in the rocks of a productive formation of aleuropelites and filtration coefficients, which made it possible to comprehensively evaluate the reservoir properties of the ore formation and introduce the concept of a coefficient of lithological-hydraulic conductivity$К_{l-g.}$

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