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EXPLORATION OF THE TECHNOLOGY OF URANIUM EXTRACTION FROM PRODUCTIVE SOLUTIONS WITH A HIGH CONTENT OF CHLORIDE IONS

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Abstract: Currently, geotechnological methods of mining have become widespread in Uzbekistan and abroad, which have several serious advantages over the traditional labor-intensive mining method. Among them, geotechnologies of underground (in-situ) leaching of uranium, rhenium, copper, nickel, iron, zinc, aluminum, gold, etc. occupy a special place.

Depending on the hydrogeological conditions of the ore body and the chemical composition of minerals, for each deposit prepared for uranium extraction by the in-situ leaching method, not only a thorough study of the reagent leaching scheme is required, but also a reasonable choice of technology for further processing of productive solutions. It is known that the presence of a significant amount of chloride ions, as a result of their competitive influence, suppresses the sorption of uranium from productive solutions and leads to a significant decrease in the capacity of resins. Therefore, the study of the technology of uranium extraction from sulfuric acid productive solutions with a high content of chloride ions is undoubtedly an urgent task.

Key words: Uranium, productive solution, sorption, desorption, chloride ion.

TARKIBIDA XLORID-IONLARI KO'P BO'LGAN MAHSULDOR ERITMALARDAN URANNI AJRATIB OLISH TEXNOLOGIYASINI TADQIQ QILISH

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Annotatsiya: Hozirgi vaqtda foydali qazilmalarni qazib olishning geotexnologik usullari O'zbekistonda va xorijda keng tarqalgan bo'lib, an'anaviy qazib olish usuliga nisbatan bir qator jiddiy afzalliklarga ega. Ular orasida uran, mis, nikel, temir, rux, alyuminiy, oltin va boshqalarni yer osti tanlab eritish geotexnologiyasi alohida o'rin tutadi.

Ruda tanasining gidrogeologik sharoiti va minerallarning kimyoviy tarkibiga qarab, yer osti tanlab eritish usulida uranni qazib olish uchun tayyorlangan har bir kon uchun nafaqat reagentli yuvish sxemasini sinchkovlik bilan o'rganish, balki uni qayta ishlash uchun oqilona texnologiyani tanlash ham talab qilinadi. Ma'lumki, xlorid ionlarining sezilarli miqdori, ularning raqobatbardosh ta'siri natijasida, uranning mahsuldor eritmalardan sorbsiyasini sezilarli darajada kamaytiradi va ion almashinuvchilari uranga nisbatan sig'imini sezilarli darajada pasayishiga olib keladi. Shu bois, tarkibida xlorid ionlari ko'p bo'lgan sulfat kislota mahsuldor eritmalaridan uran olish texnologiyasini tadqiq etish, shubhasiz, dolzarb vazifadir.

Kalit so'zlar: Uran, mahsuldor eritma, sorbsiya, desorbsiya, xlorid ioni.

ИССЛЕДОВАНИЕ ИЗВЛЕЧЕНИЯ УРАНА ИЗ ПРОДУКТИВНЫХ РАСТВОРОВ С ПОВЫШЕННЫМ СОДЕРЖАНИЕМ ХЛОРИД ИОНОВ

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Аннотация. В настоящее время в Узбекистане и за рубежом получили широкое распространение геотехнологические способы добычи полезных ископаемых, имеющие ряд серьёзных преимуществ перед традиционным трудоемким горным способом. Среди них особое место занимает геотехнология подземного выщелачивания металлов урана, меди, никеля, железа, цинка, алюминия, золота и др.
В зависимости от гидрогеологических условий залегания рудного тела и химического состава минералов, для каждого месторождения, подготавливаемому к добыче урана методом ПВ, требуется не только тщательная проработка реагентной схемы выщелачивания, но и обоснованный выбор технологии дальнейшей переработки продуктивных растворов. Известно, что присутствие значительного количества хлорид-ионов, в следствие их конкурентного влияния, подавляет сорбцию урана из продуктивных растворов и приводит к значительному снижению емкости ионитов. Поэтому, исследование технологии извлечения урана из сернокислых продуктивных растворов с повышенным содержанием хлорид-ионов, несомненно, является актуальной задачей.
Ключевые слова: Уран, продуктивный раствор, сорбция, десорбция, хлорид-ион

Until recently, most uranium deposits were developed using traditional methods: in 2001, the underground method accounted for 45% of the world uranium production, while the open pit method extracted 27% of the metal from the subsurface. The share of in-situ leaching in the world practice as a method of uranium ore deposits development was relatively small and amounted to only 19% [1]. Despite the projected insignificant growth of uranium mining by the IS method, by 2010 this method became the main method, and its share in the world practice increased to 50% by 2015 [2].

The in-situ leaching method has a number of obvious advantages over traditional methods of field development. Firstly, due to the absence of the need for surface development and construction of tailings ponds, reduction of the volume of mine workings, minimizes the negative impact on the environment [3]. Secondly, the implementation of this method excludes such stages as ore transportation, crushing and enrichment, which significantly simplifies the technological chain of uranium concentrate production. Thirdly, the turnover of production solutions saves money on the purchase of reagents and reduces the cost of production. Fourthly, the possibility of almost complete automation of the process increases the productivity of the enterprise. Labor conditions are also significantly improved at the enterprises extracting uranium using the in-situ method [4].

The presence of chloride ions in the productive solution expectedly led to a drop in the uranium capacitance characteristics of all ionites without exception due to the competing process of Cl^- sorption. The matter is that in sulfuric chloride containing productive solutions uranium is represented not only by sulfate, but also by uranyl chloride complexes. Figure 1 shows the distribution diagram of uranium ionic forms depending on the concentration of chloride ions in the productive solutions.

It follows from the diagram of ionic forms distribution that with increasing concentration of chloride ions in the productive solutions the share of cationic complex UO_2Cl^+ increases, which leads to a decrease in the uranium capacity of the ionites

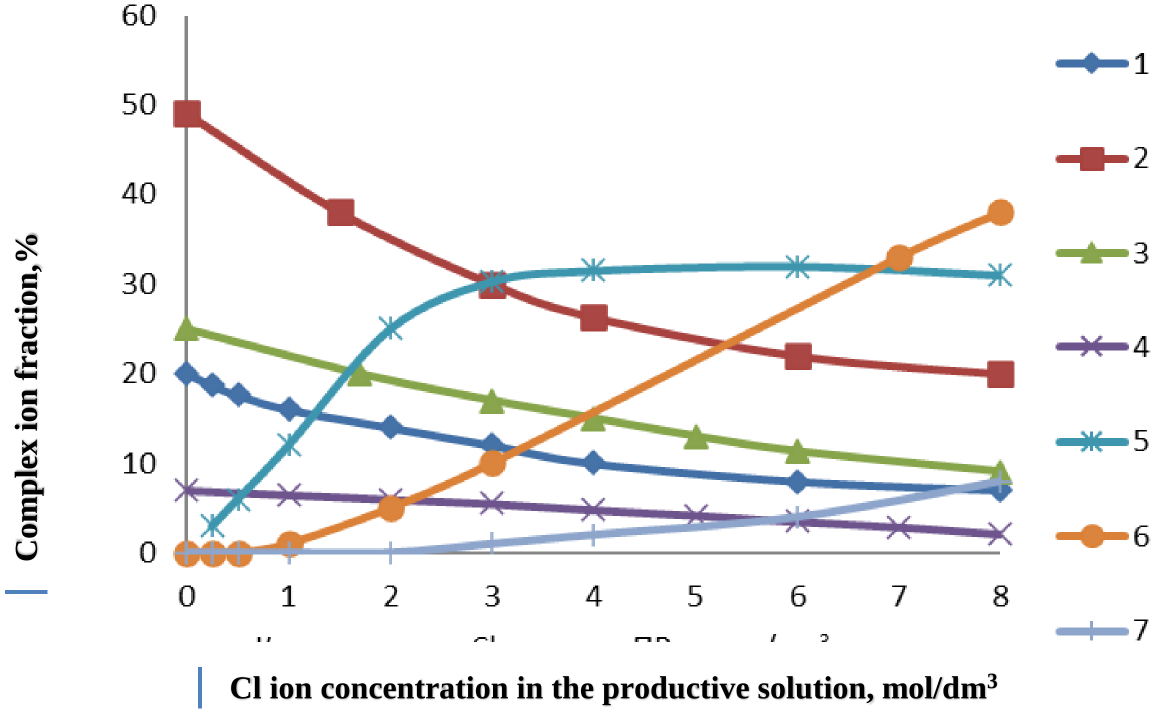

Figure 1: Distribution diagram of ionic forms of uranium in sulfate-chloride productive solutions: 1- UO_2^{2+}; 2 - UO_2SO_4; 3 -$[UO_2(SO_4)_2]^{2-}$; 4 - $[UO_2(SO_4)_3]^{4-}$; 5 - UO_2Cl^+; 6 - UO_2Cl_2; 7 - $[UO_2Cl_3]$

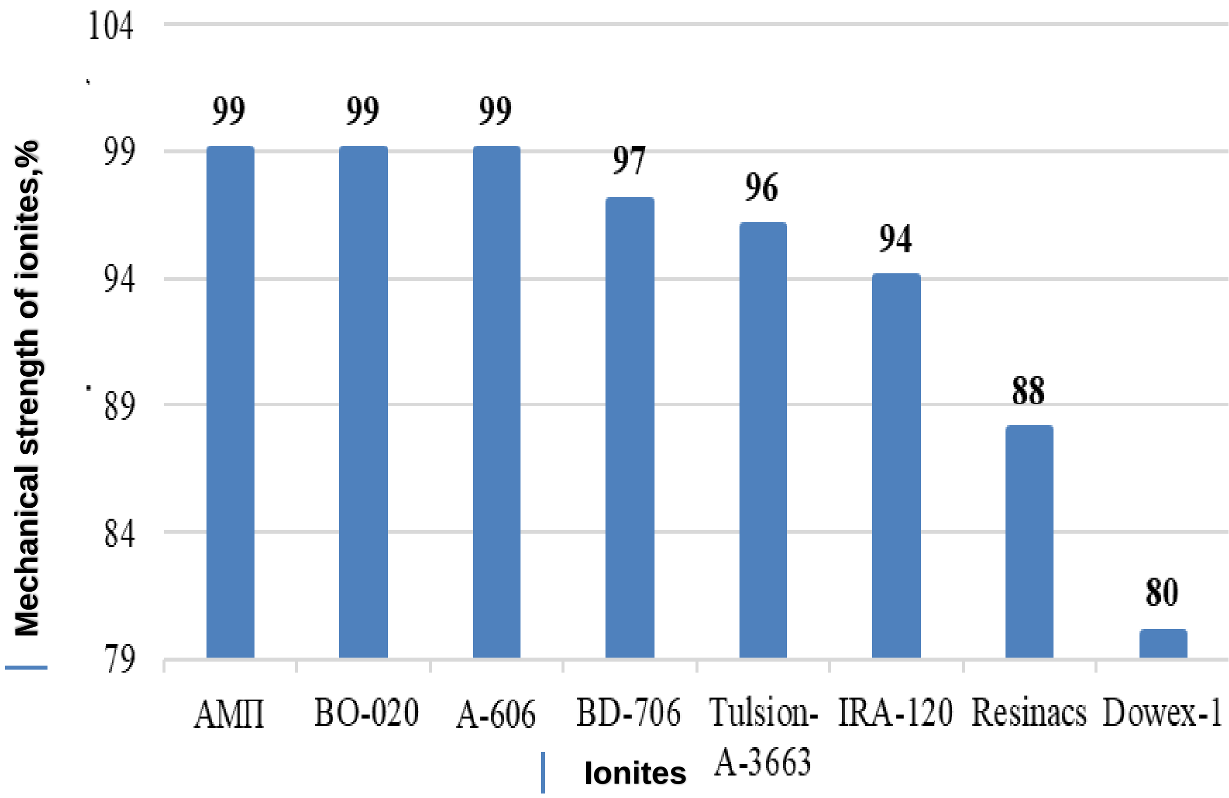

Figure 2: Graph comparing mechanical strength of ionites

An important feature of wide-porous ionites is their high mechanical strength and many times different from helium ionites transition of ionites from one form to another, osmotic resistance of granules. Test performance: Dense anionite weighing up to 100 sm^3 is loaded into a mill with distilled water. The total volume of anionite and water should be about 200 sm^3, the mill is filled with balls and sealed. Anionite is milled for 58 minutes, then the mass of anionite is sieved, swollen grains are divided into 3 parts according to GOST 10900-84. The fraction remaining on the sieve is placed in a measuring cylinder and the volume of anionite is measured.

Ranking of ionites by quality according to mechanical strength is presented in the following order: BO-020 > AMP > BD-706 > Resinacs > Purolite A-606 > Dowex-1 > Amberlite IRA-120 > Tulsion 3663. has the lowest mechanical strength.

The following parameters are selected to determine the quality of the resin:

I Particle size distribution;

II Mechanical strength;

III Porosity volume;

IV Density;

V Selectivity;

VI Regeneration level.

	Resin grade	Position under Rules I-VI						Total number of points	Place in the queue
		I	II	III	IV	V	VI		
1	BO-020	1	2	1	5	1	4	14	1
2	АМП	2	1	2	2	4	6	17	2
3	BD-706	3	4	8	6	3	1	25	3
4	Resinacs	4	7	4	1	2	7	25	4
5	Amberlite IRA-120	6	6	6	3	6	2	29	5
6	Tulsion	7	5	5	4	5	5	31	6
7	Purolite A-606	5	3	7	7	7	3	32	7
8	Dowex 1	6	8	3	8	8	8	41	8

According to the selected criteria (particle size distribution, mechanical strength, resin pore size, ionite density, selectivity, regeneration level) the ionite quality is determined by the following sequence of values: BO-020 > AMP > BD-706 > Resinacs > Amberlite IRA-120 > Tulsion 3663 > Purolite A-606 > Dowex-1.

Results.

Technological schemes provide for the sorption of uranium from sulfuric acid solutions on anionites with their separation at the desorption stage.

The development of effective methods for extracting metals from technological solutions depends on the degree of knowledge of their chemical state in these solutions. It is important to consider the influence of factors such as the composition of the medium, temperature, and the introduction of additional reagents into the technological solution on the chemical state of the elements.

The use of ion exchangers in the chloride working form increases the sorption capacity by more than 15% compared to the sulfate form. An increase in the content of chloride ions in sulfuric acid productive solutions up to a certain point leads to a decrease in the capacity of ion exchangers almost to zero. With a further increase in the concentration of Cl^- ions, the capacity of the anion exchangers increases, which is associated with a change in the state of uranium and an increase in the proportion of negatively charged uranyl chloride complexes. The vinyl pyridine anion exchanger BO-020 with a macroporous structure has the best sorption characteristics - the value of the constant dynamic capacity of the ion exchanger when extracting uranium from sulfuric acid productive solutions containing chloride ions of 0.25 mol/dm^3 was 40.0 kg/m^3 (99.33 kg/t), which will allow the sorption installation to be operated without loss of productivity. The kinetics of uranium sorption by the BO-020 ion exchanger from solutions with a high content of chloride ions is limited by internal diffusion. In the process of sorption from productive solutions with a high content of chloride ions (0.25 mol/dm^3), the values of the static exchange capacity for uranium decrease for all ion exchangers without exception: for АМП, Purolite A660 and Dowex-1, the value of the static exchange capacity for uranium decreased by 2,5-4 times; for the macroporous vinyl pyridine ion exchanger BO-020, the reduction in static exchange capacity for uranium is minimal - only 1.2-1.4 times.

Conclusion

Chloride-containing solutions are highly corrosive, so the use of cast iron, carbon, and stainless steel is excluded. Cl^- ions disrupt the passivity of the solution or prevent its onset. The effect of chlorides on the corrosion of stainless steels in the presence of oxygen leads to intergranular corrosion cracking since chlorine ions can be adsorbed by oxide films and displace oxygen from them, thereby forming soluble iron chloride. Thus, it is recommended to use nickel-based alloys, polyethylene, as well as various lining coatings (ceramics, rubber, and varnishes) as the main materials for the technological scheme of apparatuses and devices when organizing the processing of productive solutions with a high content of chloride ions.

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