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ГЕОЛОГИЯ ЖӘНЕ ТЕХНИКАЛЫҚ ҒЫЛЫМДАР СЕРИЯСЫ

♦

СЕРИЯ ГЕОЛОГИИ И ТЕХНИЧЕСКИХ НАУК

♦

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Қазақстан Республикасы Ұлттық ғылым академиясы "ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы" ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

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DEVELOPMENT OF SORPTION TECHNOLOGY OF RARE-EARTH METALS RECOVERY FROM URANIUM IN-SITU LEACHING SOLUTIONS

Abstract. Present article is dedicated to development of rare-earth metals recovery sorption technology from in-situ leaching uranium solutions. Sampling of productive solutions were performed from different technological blocks of one uranium deposit. Intermediate products of in-situ leaching technology were also sampled.

Bench-scale test works on rhenium, scandium and dysprosium dynamic sorption were realized.

Lab studies on sorption and elution of valuable components on Purolite A170, Ambersep 920, Am-p-2, AMR, Lewatit TP260, TVEX D2EHPA, KU-2-8, Lewatit 108H ion-exchange resins were performed.

Obtained results of valuable components contents are only indirect proof of its occurrence and distribution on uranium-bearings blocks. Leaching solutions already include certain amount of valuable components.

Uranium ISL process solution samplings resulted in confirming presence of accompanying valuable components, from which feasible grade were shown by scandium and REM and in a less degree by rhenium.

It was proved that rhenium content in solutions strongly depends on RedOx potential and therefore on conditions of uranium blocks processing (acidity, RedOx, impurities, etc.).

Executed chemical analysis of samples allows us to determine potential recovery sources of byproducts.

Key words: rhenium, scandium, dysprosium, rare-earth metals, in-situ leaching, byproduct, sorption, uranium.

Introduction. Natural ore sources of rare-earth metals (REM) at current and immediate outlook are far from development and therefore, are needed arises of REM byproduction on current operating plants and facilities of mineral processing and chemical enterprises. Widespread involvement of such sources would allow increasing of resource-saving in large scale, wherethrough capital and operational expenditures savings spent on exploration and mining and would also positively impact on environment. One more advantage is very short term of startup in comparing with traditional mineral processing approaches [1-8].

Among prospective sources of raw materials of REM the most interesting is process solutions of uranium ores treatment - uranium in-situ leaching (ISL) solutions [9].

As normal, special features of uranium ISL solutions processing are REM low content and complicated chemical composition. Therefore, many developed technologies of REM processing and recovery appear to be non-feasible. As the first step of such solution treatment, sorption process seems to be the most advantageous [10-17].

It is important to say that currently well-known technologies of REM recovery from highly mineralized process solution do not meet overall requirements that claimed to modern resource-saving technologies [18-20]. Mentioned here facts actualize performing of research on searching and testing of different sorbents with advanced characteristics for using at provided applications [21].

Goal of work is developing sorption technology of REM byproduction from uranium ISL solutions.

Experimental. Commercial trademarks of ion exchange resins from different global leading manufacturers were used in current test work. Potential of mentioned resins were reflected in reliable publications [22, 23].

In case of rhenium recovery the following trademarks were tested: Ambersep 920U (The Dow Chemical Company), A170 (Purolite), Am-p-2 и AMR (GP "Smoly").

In case of scandium recovery the following trademarks were tested: TVEX D2EHPA (GP "Smoly"), Lewatit TP260 (LANXESS).

In case of REM recovery the following trademarks were tested: Lewatit 108H (LANXESS), KU-2-8 (OOO "Smoly").

Methods. Before testing in dynamic conditions there were performed tests in static conditions. Whereby ration liquid-solid (L:S) was 1000:1 (5 dm^3 of productive solution and 5 g of wet resin). Vessel was stirring to prevent precipitation of resin particles during 48 hours, after which solution was sampled and analyzed.

This allowed to concentrate in current article on testing in dynamic conditions. Sorption recovery in dynamic conditions were performed in plexiglass columns 30 cm^3 capacity with height to diameter ratio 4.8:1.

Solution was passed through compacted layer from bottom to the top, whereby specific feed load composed 10 sp.vol./sp.vol./hour. Using controlled load sorption filtrate were fractionally sampled and analyzed.

Experiments. Purolite A170, Ambersep A920 (from uranium process circuit, after uranium elution step), AM-p-2 and AMR resins were chosen for research.

During testing of rhenium byproduction it was necessary to determine basic applicability and feasibility of rhenium sorption to the resin rom the following sources: 1) barren solution (filtrate) of uranium sorption; 2) eluted resin from uranium circuit.

Tests of rhenium sorption in dynamic conditions were performed on resins A170, Am-p-2, AMR. Experiments duration were limited by resource at the testing moment, for which reason full dynamic exchange capacity was not obtained in some cases. The following capacities were obtained:

a) A170 0.25 kg/m^3 after passing 4800 sp.vol.;

b) Aм-p-2 approx. 0.001 kg/m^3 after passing 1342 sp.vol.;

c) AMR 0.001 kg/m^3 after passing 1438 sp.vol.

Perspective ion exchange resin A170 was determined;

As alternative option of production arrangement, rhenium recovery method from eluted resin of uranium process circuit was considered. This approach is applicable at rhenium low concentrations in productive solution and allows to simplify process equipment arrangement [24]. Rhenium content in sample from uranium ISL plant was 0.0055 kg/m^3 or approx. 0.016 kg/t;

Rhenium elution tests from A170 and A920 (from uranium circuit) resins were performed. Parameters were closed to optimal conditions and achieved recoveries were:

a) A170 94% after passing 10 sp.vol.;

b) A920 95.31% after passing 16 sp.vol.

Results of rhenium sorption recovery in dynamic conditions are presented on figure 1.

Figure 2 shows results of scandium sorption recovery in dynamic conditions.

Obtained resins loading capacity are limited by available resources for performing experiments and analysis. Nevertheless it was determined that under passed amount of solution the following loading capacities were achieved:

a) TP260 0.024 kg/m^3after passing 700 sp.vol.;

b) D2EHPA 0.211 kg/m^3 after passing 2382 sp.vol.

Results and discussion. Uranium ISL process solution samplings resulted in confirming presence of accompanying valuable components, from which feasible grade were shown by scandium and REM and in a less degree by rhenium. However deep understanding of byproduction potential requires analysis of archival core material and performing of leaching column tests, thus modelling uranium ISL conditions.

Analysis results of sampled products of productive solutions are brought together in table and shown on figures 3–5.

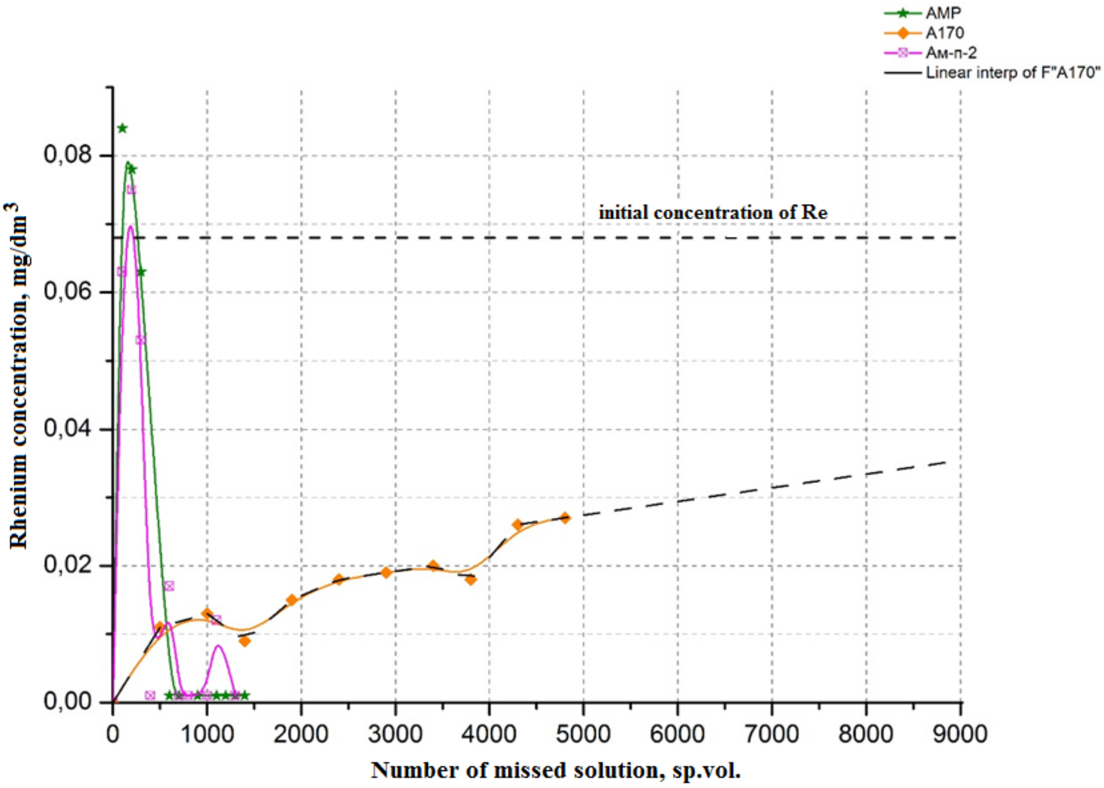

Figure 1 – Sorption curve of rhenium on Purolite A170, Am-p-2 and AMR resins

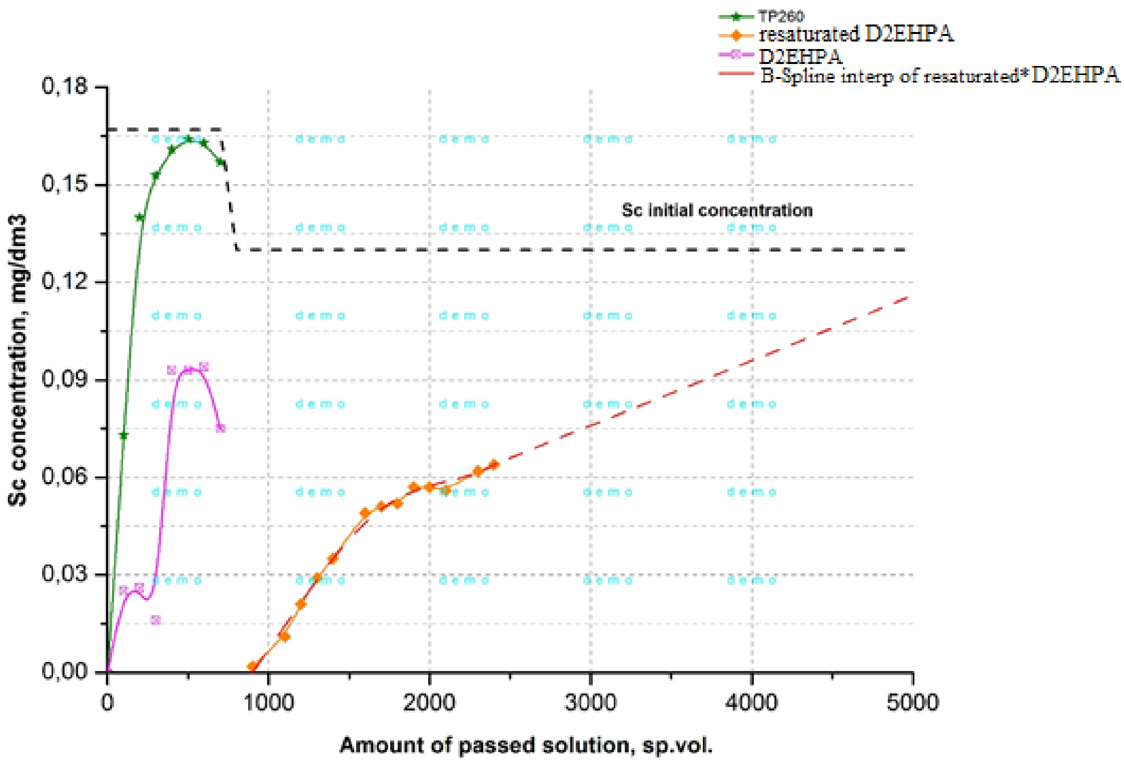

Figure 2 – Sorption curve of scandium on Lewatit TP260 and TVEX D2EHPA resins

Analysis of productive solutions from current operating wells of one of uranium ISL mine

№	Technological block	Rhenium, mg/dm^3	Scandium, mg/dm^3	Dysprosium, mg/dm^3
1	Block A mean	–	0.120	0.436
2	Block B mean	–	0.096	0.441
3	Block C mean	0.009	0.110	0.585
4	Block D mean	–	0.084	0.309
5	Block E mean	0.007	0.119	0.972
6	Block F mean	-	0.090	0.665
7	Block G mean	0.004	0.121	0.515
8	Block H mean	-	0.083	0.494
9	Block I mean	0.013	0.214	0.534
10	Block J mean	0.021	0.284	0.649
11	Block K mean	0.023	0.217	0.734
	Average mean	0.018	0.209	0.673

Table data analysis demonstrated the following:

– rhenium contents are fluctuated within 0.005-0.089 mg/dm^3;

– scandium contents in productive solutions of uranium technological blocks are fluctuated within the range from 0.051 mg/dm^3 up to 0.459 mg/dm^3;

– dysprosium content range as indicator of REM group of elements in productive solutions are presented within values from 0.231 mg/dm^3 to 1.564 mg/dm^3.

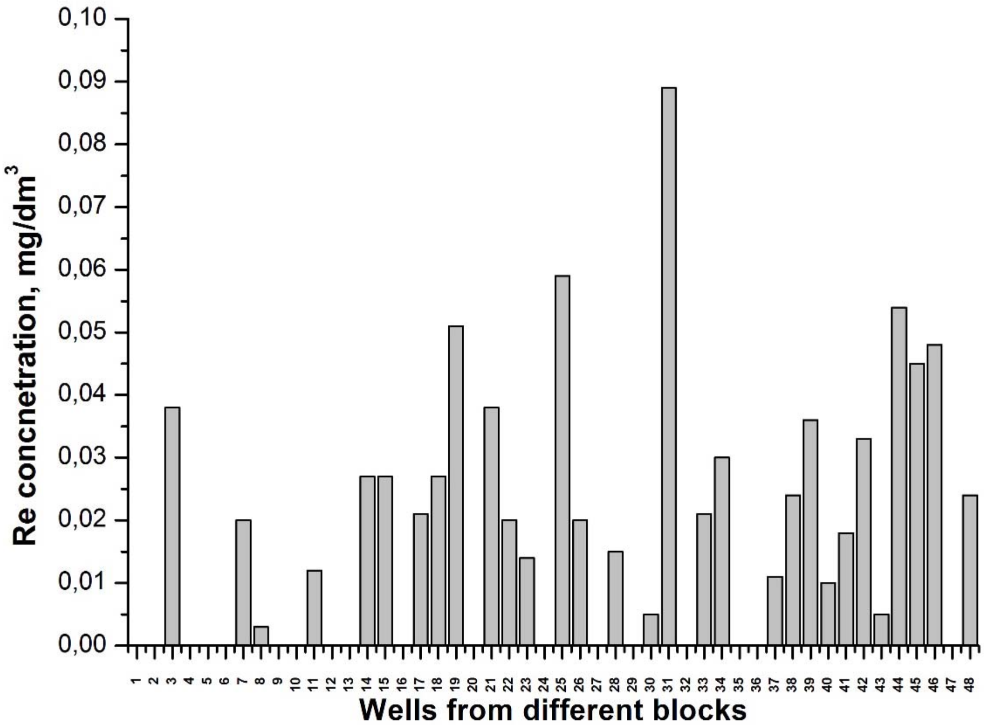

Figure 3 – Rhenium contents in productive solutions
from different operating wells of one of uranium ISL mine

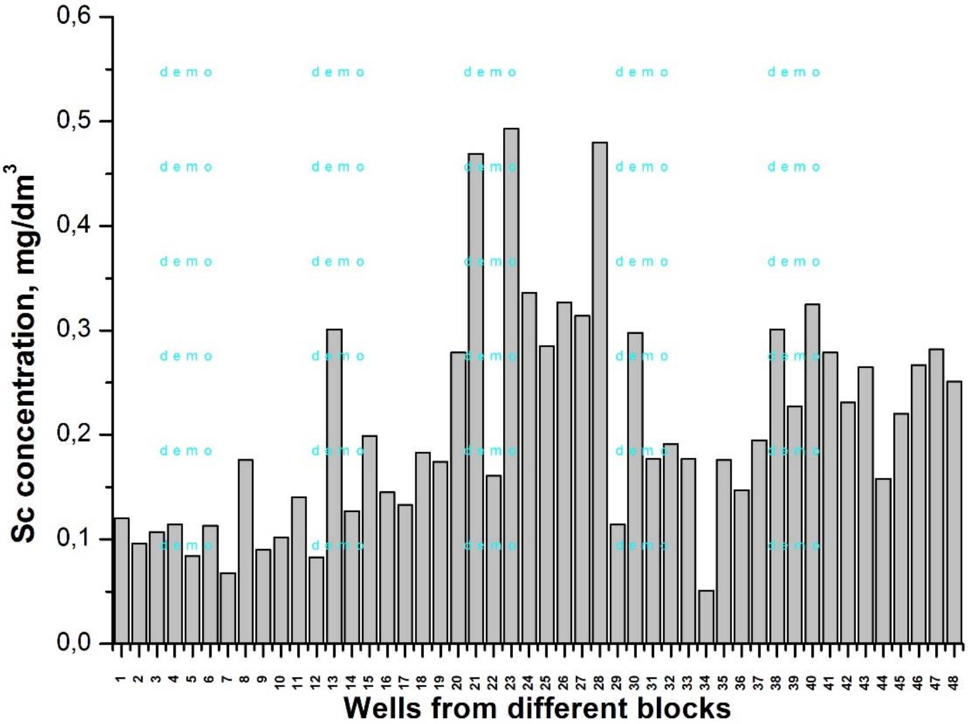

Figure 4 – Scandium contents in productive solutions
from different operating wells of one of uranium ISL mine

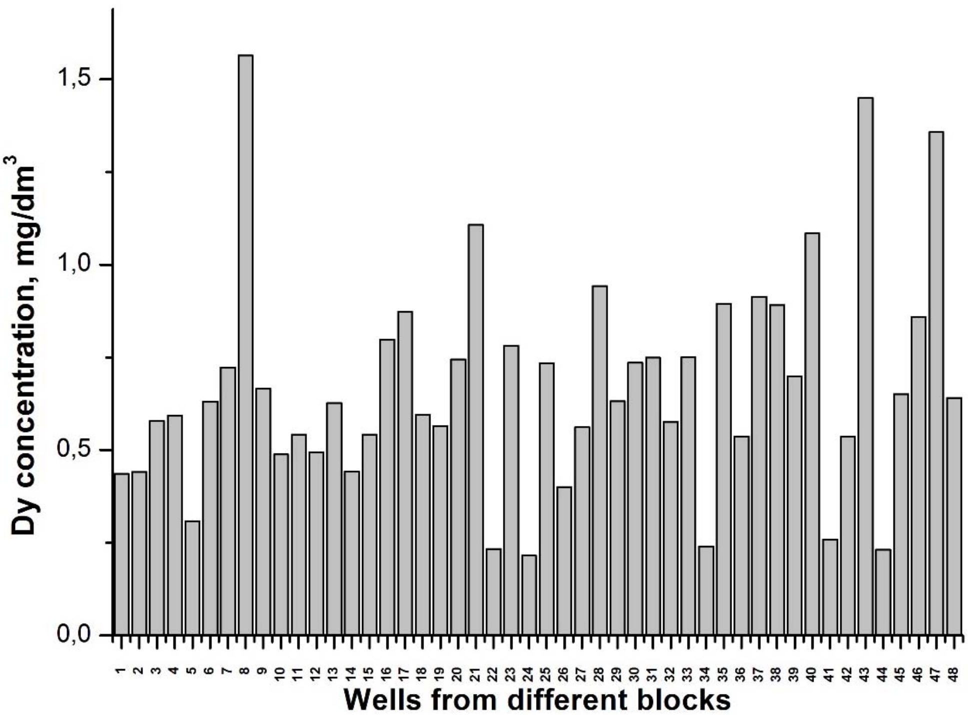

Figure 5 – Dysprosium contents in productive solutions
from different operating wells of one of uranium ISL mine

Conclusion. It should be noted that obtained results of valuable components contents are only indirect proof of its occurrence and distribution on uranium-bearings blocks. Leaching solutions already include some amount of valuable components and these elements are not extracted (partly or completely) on uranium sorption stages and again recycled to leaching operation.

Also the following needs to be pointed out - rhenium content in solutions strongly depends on RedOx potential and therefore on uranium blocks processing conditions (acidity, RedOx, impurities, etc.).

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ЖЕР АСТЫ УРАН ҰҢҒЫМАЛАРЫН ШАЙМАЛАУ ЕРІТІНДІЛЕРІНЕН СИРЕК ЖЕР МЕТАЛДАРЫН АЛУ ҮШІН СОРБЦИЯЛЫҚ ТЕХНОЛОГИЯНЫ ДАМЫТУ

Аннотация. Мақала жер асты ұңғымалық шаймалау әдісімен әзірленген уран кендерінен сирек жер металдарды алу үшін сорбциялық технологияны дамытуға арналған. Бір уран кен орнының түрлі технологиялық блоктарынан өндірістік ерітінділерді іріктеу жүргізілді. Сондай-ақ, жерасты шаймалау технологиясының аралық өнімдері де таңдалды.

Рений, скандий және диспрозияның динамикалық сорбциясы бойынша зертханалық жұмыс жүргізілді.

Purolite A170, Ambersep 920, АМ-п-2, АМР, Lewatit TP260, ТВЭКС Д2ЭГФК, КУ-2-8, Lewatit 108H ион алмастырғыш шайырларында сорбция және зертханалық зерттеулер жүргізілді.

Бағаланатын компоненттердің мазмұны алынған құндылықтар олардың пайда болуының және уран кенішінің блоктарын таратудың жанама дәлелі болып табылады. Сілтісіздендіру ерітінділерде бағалы компоненттердің белгілі бір саны бар.

Уранды жер асты шаймалау технологиялық өнімдерін сынақтан өткізу нәтижесінде скандий, сирек кездесетін металдар және аз дәрежелі рений мазмұны өнеркәсіптік қызығушылық тудыратын құнды бағалы компоненттердің болуы белгіленді.

Ерітінділердегі рений мазмұны негізінен қоршаған ортаның қайта қалпына келтіру әлеуетіне, және тиісінше, уран блоктарының тау-кен режимдеріне (қышқылдық, редокс потенциалы, қоспалар, тағы басқа) байланысты екендігі дәлелденді.

Жиналған үлгілердің химиялық талдауы бізге байланысты материалдарды ұйымдастыру үшін шикізаттың ықтимал көздерін анықтауға мүмкіндік берді.

Түйін сөздер: рений, скандий, диспрозий, сирек жер металдар, жерастылық шаймалау, ілеспе компонент, сорбция, уран.

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РАЗРАБОТКА СОРБЦИОННОЙ ТЕХНОЛОГИИ ИЗВЛЕЧЕНИЯ РЕДКОЗЕМЕЛЬНЫХ МЕТАЛЛОВ ИЗ РАСТВОРОВ ПОДЗЕМНОГО СКВАЖИННОГО ВЫЩЕЛАЧИВАНИЯ УРАНА

Аннотация. Настоящая статья посвящена разработке сорбционной технологии извлечения редкоземельных металлов из урановых руд, разрабатываемых способом подземного скважинного выщелачивания. Отбор проб продуктивных растворов проводился из разных технологических блоков одного уранового месторождения. Были также отобраны промежуточные продукты технологии подземного скважинного выщелачивания (ПСВ).

Реализованы лабораторные работы по динамической сорбции рения, скандия и диспрозия.

Проведены лабораторные исследования сорбции и элюирования ценных компонентов на ионообменных смолах Purolite A170, Ambersep 920, АМ-п-2, АМР, Lewatit TP260, ТВЭКС Д2ЭГФК, КУ-2-8, Lewatit 108H.

Полученные значения содержаний ценных компонентов являются лишь косвенным свидетельством об их появлении и распределении урановорудных блоках. Выщелачивающие растворы уже содержат определенное количество ценных компонентов.

В результате опробования технологических продуктов ПСВ урана было установлено присутствие попутных ценных компонентов, из них промышленный интерес представляют содержания скандия, РЗМ и в меньшей степени рения.

Было доказано, что содержания рения в растворах во многом зависят от окислительно-восстановительного потенциала среды и, соответственно, режимов отработки урановых блоков (кислотность, ОВП, примеси).

Выполненный химический анализ отобранных проб позволил определить потенциальные источники сырья для организации попутной.

Ключевые слова: рений, скандий, диспрозий, редкоземельные металлы, подземное выщелачивание, попутный компонент, сорбция, уран.

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