ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ
Satbayev University

ХАБАРЛАРЫ

ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН
Satbayev University

NEWS

OF THE ACADEMY OF SCIENCES
OF THE REPUBLIC OF KAZAKHSTAN
Satbayev University

SERIES
OF GEOLOGY AND TECHNICAL SCIENCES

4 (448)

JULY – AUGUST 2021

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, NAS RK

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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.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

«ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Меншіктеуші: «Қазақстан Республикасының Ұлттық ғылым академиясы» РҚБ (Алматы қ.).

Қазақстан Республикасының Ақпарат және қоғамдық даму министрлігінің Ақпарат комитетінде 29.07.2020 ж. берілген **№ KZ39VPY00025420** мерзімдік басылым тіркеуіне қойылу туралы куәлік.

Тақырыптық бағыты: *геология, мұнай және газды өңдеудің химиялық технологиялары, мұнай химиясы, металдарды алу және олардың қосындыларының технологиясы.*

Мерзімділігі: жылына 6 рет.

Тиражы: 300 дана.

Редакцияның мекен-жайы: 050010, Алматы қ., Шевченко көш., 28, 219 бөл., тел.: 272-13-19

http://www.geolog-technical.kz/index.php/en/

Типографияның мекен-жайы: «Аруна» ЖК, Алматы қ., Мұратбаев көш., 75.

«Известия НАН РК. Серия геологии и технических наук».

ISSN 2518-170X (Online),

ISSN 2224-5278 (Print)

Собственник: Республиканское общественное объединение «Национальная академия наук Республики Казахстан» (г. Алматы).

Свидетельство о постановке на учет периодического печатного издания в Комитете информации Министерства информации и общественного развития Республики Казахстан **№ KZ39VPY00025420,** выданное 29.07.2020 г.

Тематическая направленность: *геология, химические технологии переработки нефти и газа, нефтехимия, технологии извлечения металлов и их соеденений.*

Периодичность: 6 раз в год.

Тираж: 300 экземпляров.

Адрес редакции: 050010, г. Алматы, ул. Шевченко, 28, оф. 219, тел.: 272-13-19

http://www.geolog-technical.kz/index.php/en/

Адрес типографии: ИП «Аруна», г. Алматы, ул. Муратбаева, 75.

News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technology sciences.

ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Owner: RPA «National Academy of Sciences of the Republic of Kazakhstan» (Almaty).

The certificate of registration of a periodical printed publication in the Committee of information of the Ministry of Information and Social Development of the Republic of Kazakhstan **No. KZ39VPY00025420,** issued 29.07.2020.

Thematic scope: *geology, chemical technologies for oil and gas processing, petrochemistry, technologies for extracting metals and their connections.*

Periodicity: 6 times a year.

Circulation: 300 copies.

Editorial address: 28, Shevchenko str., of. 219, Almaty, 050010, tel. 272-13-19

http://www.geolog-technical.kz/index.php/en/

Address of printing house: ST «Aruna», 75, Muratbayev str, Almaty.

NEWS
OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN
SERIES OF GEOLOGY AND TECHNICAL SCIENCES
ISSN 2224-5278
Volume 4, Number 448 (2021), 36-41 **https://doi.org/10.32014/2021.2518-170X.79**

UDC 669.1.017

Khairullayev N.B.[1*], Aliev S.B.[2], Aben Y.Kh.[1], Uisimbek A.A.[1]

[1]Satbayev University, Almaty, Kazakhstan;
[2]Institute of Comprehensive Exploitation of Mineral Resources, Moscow, Russia.
E-mail: khayrullaev.n@gmail.com

STUDY OF THE EFFECT OF SOLUTION ACTIVATION ON THE DENSITY OF THE PREGNANT SOLUTION AND ON THE CONTENT OF THE USEFUL COMPONENT

Abstract: this paper presents the results of a laboratory study of the influence of the activation of the leaching solution on the density of the solution and the content of the useful component in the productive solution during the development of uranium deposits by the method of in-situ leaching (ISL). Comparative dependences of the density of the solution and the content of the useful component in the productive solution were obtained during leaching of uranium without activation and with activation of the solution. When conducting studies with non-activated and activated solutions for 5 minutes, and a reaction time of 5 minutes, the density of the leaching solution is 1.32 m^3 / t and 1.34 m^3 / t, respectively, and the content of the useful component in the productive solution is 4.06 mg / l and 4.48 mg / l, respectively, i.e. with the same density of the productive solution and the reaction time, the content of the useful component in the activated solution is 10% higher. With a reaction time of 10 minutes, the content of the useful component in the activated solution is 19% higher. Activation of the solution from 5 minutes to 10 minutes leads to a decrease in the density of the solution, while the content of the useful component in the productive solution increases. A further increase in activation leads to an increase in the density and content of the useful component in the solution.

Key words: in-situ leaching (ISL), leaching solution, productive solution, solution activation, density, content of useful component.

Introduction. In recent years, significant amounts of funds have been invested in the development of the uranium industry: over the past 15 years, the volume of investments has exceeded US $ 3 billion. This led to a steady increase in production volume: from 2004, the volume of uranium mining increased more than 6 times.

To the mining group of JSC NAK Kazatomprom includes 16 enterprises with full andpartial ownership thatare developing 20 underground minesin-situ leaching. Uranium deposits are located on the territories of South Kazakhstan, Kyzylorda and Akmola regions [1-12].

Currently, all uranium deposits in Kazakhstan are mined by in-situ leaching.

In-situ leaching is a physicochemical process of mining minerals (metals and their salts) by washing them out of the rock with various solvents pumped into the reservoir through wells.

The process starts with drilling wells, explosives or hydraulic fracturing can also be used to facilitate the penetration of the solution into the reservoir. After that, a solvent (leaching agent) is pumped into the well through a group of injection wells, where it combines with the ore. The mixture containing the dissolved ore is then pumped through pumping holes to the surface where it is extracted.

Underground leaching is an alternative to open pit and underground mining. Compared to them, underground leaching does not require a large amount of excavation or direct contact of workers with rocks at their location. Effective even in poor deposits, as well as for deep-seated ores.

Despite its advantage, there are a number of disadvantages, the main of which are an increase in the cost of production and a decrease in the content of the useful component in the rock mass.

There are various ways to improve the technology of underground borehole leaching and increase the recovery of uranium content in the productive solution [1,2,3,4]. But they are expensive and technologically difficult to use. Therefore, the purpose of this work is to study the influence of the activation (cavitation) process of the leaching solution on the density and content of the useful component in the productive solution.

One of the methods is the cavitation of the leaching solution to increase the recovery of the useful component from the massif.

Cavitation is the process of formation and subsequent collapse of bubbles in a liquid flow, accompanied by noise and hydraulic shocks, the formation of cavities (cavitation bubbles, or voids) in the liquid, which may contain rarefied vapor [5,6]. Cavitation occurs as a result of a local decrease in pressure in a liquid, which can occur either with an increase in its velocity (hydrodynamic cavitation), or with the passage of a high-intensity acoustic wave during a half-period of rarefaction (acoustic cavitation); there are other reasons for the effect. Moving with the flow to a region with a higher pressure or during a half-period of compression, the cavitation bubble collapses, while emitting a shock wave. Basically, cavitation has the same mechanism of action as a shock wave in air, which occurs when a solid body overcomes a sound barrier.

In [7], we found that the use of the cavitation effect leads to an increase in the content of the useful component in the productive solution. However, in the course of the conducted studies, it was found that with an increase in the degree of cavitation, the density of the leaching solution changes, which can lead to a change in the gravity and, accordingly, the process of precipitation of the productive solution. This, in turn, can lead to a change in uranium recovery.

Technological solutions have increased density and viscosity in comparison with groundwater [8]. In a medium uniform in permeability, technological solutions will tend to move mainly along the lower part of the aquifer. The practice of underground leaching confirms the sinking of heavier solutions into the lower part of the aquifer. The higher the concentration of the solution, and, consequently, its density, the higher the speed of gravitational descent. The rate of gravitational lowering of solutions in the absence of fluid movement under the action of the difference in pressure can be approximately determined from the following expression [8]:

$$v_{\Gamma} = \frac{K_{\phi}}{n_{э}} \frac{\Delta\gamma}{\gamma\eta} \qquad (1)$$

Where, K_{ϕ} – filtration coefficient;
$\Delta\gamma$ – the difference between the densities of the displacing and displaced fluid;
$n_{э}$ – effective porosity;
η – coefficient of anisotropy.

In permeable ore-bearing sands, Vг is usually about 1 cm/h. Studies show that when using a filter limited by an ore interval, the lower part of the aquifer (below the filter) is exposed to the reagent and, in addition, losses of solutions, the richest in the useful component, can occur in it.

Therefore, to study the effect of the cavitation process on the change in the density of the solution and the extraction of uranium, laboratory studies were carried out.

Laboratory work technique. The main task solved during laboratory work: obtaining comparative data on the activity and density of a sulfuric acid solution during leaching of a model substance, depending on the degree of treatment of the solution with a cavitator.

The working unit for leaching research consists of a LAUDAECOE - 4 thermostat, a thermostated glass beaker and a BP 8000 EKROS mechanical stirrer. The appearance of the leaching plant is shown in Figure 1. Leaching experiments are carried out as follows. The thermostat turns on and sets the required temperature for work. The required amount of sulfuric acid solution is poured into a thermostated glass, dipped into a solution mixer and the timer is set for the time required for the solution in the thermostated glass to reach the temperature of the thermostat.

Before the start of a series of leaching experiments, preliminary experiments were carried out, according to the results of which the volume of the leaching solution was selected - 200 ml, L:S = 2/1, the leaching time was 60 minutes, the concentration of sulfuric acid in the solution was 10 g / l.One of the main promising proposals for increasing the turnaround time of wells is the use of increasing the activity of the leaching solution by treating it with a cavitator. A laboratory setup with a cavitator (Figure 2) consists of a closed loop, which includes a centrifugal pump with an electric drive, a cavitator, a pipeline, a drain valve tank [9].

Figure 1: Working installation for the study of leaching on a mixer

The process of processing the leaching electrolyte with a cavitator is carried out as follows. A working sulfuric acid solution is poured into the container and the electric pump motor is turned on. The solution passes under pressure through the cavitator and returns to the container. To determine the pumping speed, control measurements were carried out, as a result of which it was determined that the flow rate of the liquid was 1 liter in 3 seconds.

To obtain comparative data, laboratory studies were carried out with both the initial solution and the activated solution.

Results and its discussion. The results of the study of changes in the density of the non-activated solution and the content of the useful component in the solution are presented in table 1 and in Figure 3.

Table 1. Change in density (A) and the content of reference metal in the original non-activated leaching solution (C, g/l)

Parameters	Reaction time, min					
	5	10	20	30		
A	1,323	1,398	1,468	1,542		Initial solution

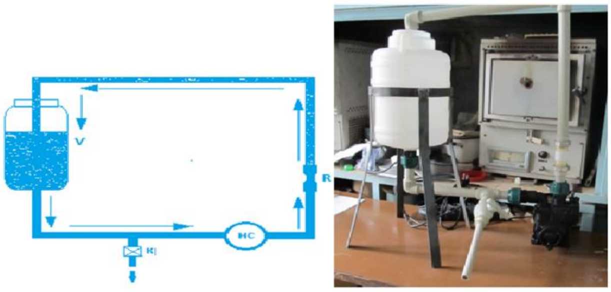

Figure 2. Laboratory installation with a cavitator

As can be seen from the table, with an increase in the reaction time with a solution without activation (initial solution) from 5 minutes to 30 minutes, the density of the solution increases from 1.32 m3 / t to 1.54 m^3 / t, i.e. increases by 17%, while the content of the useful component in the productive solution increases by 15%.

By processing the data in Table 1, graphs of the change in density and the content of the reference metal in the original leaching solution were obtained (Figure 3).

The results of the study of changes in the density of the solution and the content of the useful component in the solution during its processing with a cavitator for 3 to 20 minutes are presented in Table 2 and Figure 4.

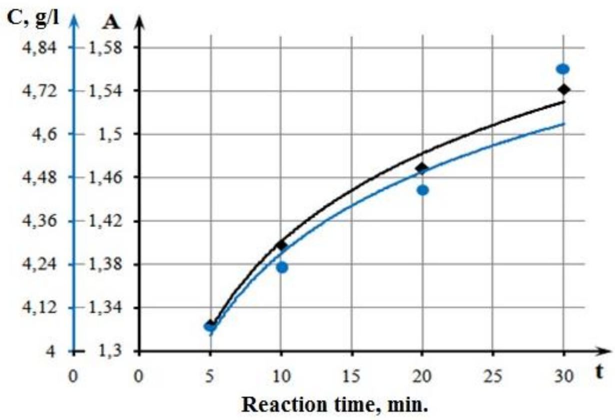

Figure 3. Graph of the change in density (A) and the content of equivalent metal in the original leaching solution (C, g/l) versus leaching time (reaction time)

Table 2. Time variation of the density (A) and the content of the useful component in the leaching solution (C, g/l) after treatment of the solution with a cavitator.

Parameters		Reaction time, min	
		5	10
Treatment of the solution with a cavitator for 3 minutes.	Density (A)	1,42	1,492
	Metal content in the productive solution (C, g/l)	4,48	4,51
Treatment of the solution with a cavitator for 5 minutes.	Density (A)	1,34	1,432
	Metal content in the productive solution (C, g/l)	4,80	5,06
Treatment of the solution with a cavitator for 10 minutes.	Density (A)	1,4	1,463
	Metal content in the productive solution (C, g/l)	4,80	5,09
Treatment of the solution with a cavitator for 20 minutes.	Density (A)	1,419	1,54
	Metal content in the productive solution (C, g/l)	4,30	4,67

By processing the data in Table 2, graphs of the change in density (A) and the content of the reference metal in the leaching solution (C, g/l) were obtained with a reaction time of 5 minutes.

From the analysis of the table it follows that when the solution is processed with a cavitator for 3 minutes, the density of the solution is 1.42 m^3/t, with an increase in the cavitation time to 5 minutes, it led to a decrease in density to 1.34 m^3/t, and a further increase in the cavitation time to 10 - 20 minutes has already led to an increase in the density of the solution to 1.42 m^3/t. The content of the useful component in the productive solution during cavitation for 3 minutes was 4.48 g/l, and at 5, 10 - 20 minutes, 4.8 g/l and 4.3 g/l, respectively.

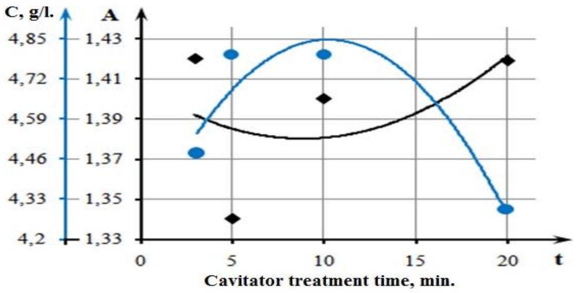

Figure 4. Graph of the change in density (A) and the content of equivalent metal in the leaching solution (C, g/l) versus the time of treatment with a cavitator with a reaction time of 5 minutes.

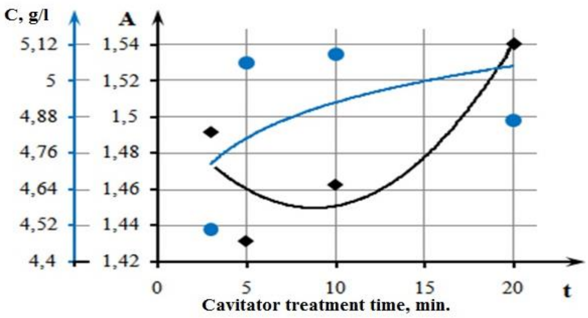

Figure 5: Graph of the change in density (A) and the content of equivalent metal in the leaching solution (C, g/l) versus the time of treatment with a cavitator with a reaction time of 10 minutes.

Changes in the density of the productive solution and the content of the useful component in the productive solution at 10 minutes of reaction are shown in Figure 5.

From the analysis of the table, it follows that when the solution is processed with a cavitator for 3 minutes, the density of the solution is 1.49 m^3/t, with an increase in the cavitation time to 5 minutes, it led to a decrease in density to 1.43 m^3/t, and a further increase in the cavitation time to 10 - 20 minutes has already led to an increase in the density of the solution to 1.54 m^3/t. The content of the useful component in the productive solution during cavitation for 3 minutes was 4.51 g/l, and at 5, 10 - 20 minutes, respectively, 5.06 g/l and 4.67 g/l.

Conclusions. When conducting studies with an inactivated solution and an activated solution for 5 minutes, and a reaction time of 5 minutes, the density of the leaching solution is 1.32 m^3/t and 1.34 m^3/t, respectively, and the content of the useful component in the productive solution is 4.06 mg/l and 4.48 mg/l, respectively. Thus, with the same density of the productive solution and the reaction time, the content of the useful component in the activated solution is 10% higher. With a reaction time of 10 minutes, the content of the useful component in the activated solution is 19% higher. Activation of the solution from 5 minutes to 10 minutes leads to a decrease in the density of the solution, while the content of the useful component in the productive solution increases. A further increase in activation leads to an increase in the density and content of the useful component in the solution.

Хайруллаев Н.Б.[1*], Алиев С.Б.[2], Абен Е.Х.[1], Уйсимбек А.[1]

[1]Сәтбаев университеті, Алматы, Қазақстан;
[2]Жер қойнауын кешенді игеру мәселелері институты, Мәскеу, Ресей.
E-mail: khayrullaev.n@gmail.com

ЕРІТІНДІНІ БЕЛСЕНДІРУДІҢ ӨНІМДІ ЕРІТІНДІНІҢ ТЫҒЫЗДЫҒЫНА ЖӘНЕ ПАЙДАЛЫ КОМПОНЕНТТІҢ МӨЛШЕРІНЕ ӘСЕРІН ЗЕРТТЕУ

Аннотация: бұл жұмыста шаймалау ерітіндісінің активтенуінің ерітіндінің тығыздығына және жерасты ұңғымалық шаймалау (ЖҰШ) әдісімен уран кен орындарын өңдеу кезінде өнімді ерітіндідегі пайдалы компоненттің құрамына әсерін зертханалық зерттеу нәтижелері келтірілген. Уранды активтендірмей және ерітіндіні белсендіре отырып сілтілеу кезінде ерітінді тығыздығының және өнімді ерітіндідегі пайдалы компоненттің құрамының салыстырмалы тәуелділігі алынды. Белсенді емес және белсендірілген ерітінділермен 5 минут және реакция уақыты 5 минут ішінде зерттеулер жүргізген кезде шаймалау ерітіндісінің тығыздығы тисінше 1,32 м^3/т және 1,34 м^3/т құрайды, ал өнімді ерітіндідегі пайдалы компоненттің құрамы тиісінше 4,06 мг/л және 4,48 мг/л құрайды, яғни өнімді ерітіндінің тығыздығы мен реакция уақытының бірдей шамасы кезінде активтендірілген ерітіндідегі пайдалы компоненттің құрамы 10%-ға артық болады. Реакция уақыты – 10 минут, белсенді ерітіндідегі пайдалы компоненттің мөлшері 19%-ға көп. 5 минуттан 10 минутқа дейін ерітіндінің активтенуі ерітіндінің тығыздығының төмендеуіне әкеледі, ал өнімді ерітіндідегі пайдалы компоненттің мөлшері артады. Активтендірудің одан әрі артуы ерітіндідегі пайдалы компоненттің тығыздығы мен құрамының жоғарылауына әкеледі.

Түйін сөздер: жерасты ұңғымалық шаймалау (ЖҰШ), шаймалау ерітіндісі, өнімді ерітінді, ерітіндінің активтенуі, тығыздығы, пайдалы компоненттің құрамы.

Хайруллаев Н.Б.[1*], Алиев С.Б.[2], Абен Е.Х.[1], Уйсимбек А.[1]

[1]Satbayev University, Алматы, Казахстан;
[2]Институт проблем комплексного освоения недр, Москва, Россия.
E-mail: khayrullaev.n@gmail.com

ИССЛЕДОВАНИЕ ВЛИЯНИЯ АКТИВАЦИИ РАСТВОРА НА ПЛОТНОСТЬ ПРОДУКТИВНОГО РАСТВОРА И НА СОДЕРЖАНИЕ ПОЛЕЗНОГО КОМПОНЕНТА

Аннотация: в данной работе приведены результаты лабораторных исследований влияния активации выщелачивающего раствора на плотность раствора и содержание полезного компонента в продуктивном растворе при отработке месторождений урана методом подземного скважинного выщелачивания (ПСВ). Получены сравнительные зависимости плотности раствора и содержание полезного компонента в продуктивном растворе при выщелачивании урана без активации и с активацией раствора. При проведении исследований с неактивированным и активированным растворами в течение 5 минут и времени реакции 5 минут плотность выщелачивающего раствора составляет соответственно 1,32м^3/т и 1,34 м^3/т, а содержание полезного компонента в продуктивном растворе – соответственно 4,06 мг/л и 4,48 мг/л, т.е. при одинаковой величине плотности продуктивного раствора и времени реакции содержание полезного компонента в активированном растворе больше на 10%. При времени реакции – 10 минут, содержание полезного компонента в активированном растворе больше на 19%. Активация раствора от 5 минут до 10 минут приводит к снижению плотности раствора, при этом содержание полезного компонента в продуктивном растворе возрастает. Дальнейшее повышение активации приводит к повышению плотности и содержанию полезного компонента в растворе.

Ключевые слова: подземное скважинное выщелачивание (ПСВ), выщелачивающий раствор, продуктивный раствор, активация раствора, плотность, содержание полезного компонента.

Information about the authors:

Khairullayev Nursultan - Ph.D. student. Non-commercial joint-stock company "Satbayev University", the department "Mining", Almaty, the Republic of Kazakhstan, E-mail*:* khayrullaev.n@gmail.com, ORCID ID:https://orcid.org/0000-0001-9702-2430;

Aliev Samat Bikitaevich - Doctor Ph.D., Professor. Non-commercial joint-stock company "Institute of Comprehensive Exploitation of Mineral Resources Russian Academy of Sciences", Moscow, the Russian Federation, E-mail: alsamat@gmail.com,ORCID ID: https://orcid.org/0000-0002-3699-832;

Aben Erbolat - PhD in Engineering Science., Assoc. Professor. Non-commercial joint-stock company "Satbayev University", the department "Metallurgy and Mineral Processing", Almaty, the Republic of Kazakhstan, E-mail: y.aben@satbayev.university, ORCID ID:https://orcid.org/0000-0001-8537-229X;

Uisimbek Akbope - Master's degree student in Technical Science. Non-commercial joint-stock company "Satbayev University", the department "Metallurgy and Minerals processing", Almaty, the Republic of Kazakhstan, E-mail: a.uisimbek@satbayev.university, ORCID ID:https://orcid.org/0000-0002-5399-4331.

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ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Редакторы: *М.С. Ахметова, А. Ботанқызы, Д.С. Аленов, Р.Ж. Мрзабаева*
Верстка на компьютере *В.С. Зикирбаева*

Подписано в печать 15.08.2021.
Формат 60x881/8. Бумага офсетная. Печать – ризограф.
4,6 п.л. Тираж 300. Заказ 4.

Национальная академия наук РК
050010, Алматы, ул. Шевченко, 28, т. 272-13-19