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# TOKTARULY BAKYTZHAN

"Intensification of underground uranium leaching using various reagents."

8D07203 – Mining

# Annotation

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Academic advisor
**Aben E.H.**
"Associate Professor at the Department of Mining, Candidate of Technical Sciences."
**Onika S.G.**
Doctor of Technical Sciences, Professor

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## Introduction

The Republic of Kazakhstan holds the second-largest uranium reserves globally, with nearly three-quarters of these reserves being developed through the method of underground in-situ leaching. The distinctive feature of uranium deposits in Kazakhstan lies in their proximity to regional zones of in-situ oxidation. This type of deposit is not common worldwide, making it subject to development through the most advanced, budget-friendly, and environmentally friendly method of underground in-situ leaching [1,2]. According to this technology, the ore remains in place, allowing liquids to pass through it for leaching minerals from the ore. Thus, the integrity of the soil cover is almost entirely preserved, and there is no formation of tailings and waste rock. Compared to conventional methods of resource extraction, underground leaching reduces both short-term and long-term negative impacts on the population while significantly lowering radiation levels and producing minimal radioactive waste.

The cost of extraction through underground leaching via wells is 2.5-3 times lower than that of underground mining, and the extraction efficiency coefficient in underground leaching ranges from 49% to 88%, averaging 65%. Therefore, this method remains the most promising.

Currently, areas with unfavorable geological and mining conditions, such as low filtration coefficients, low uranium content in the ore, clayey characteristics, and a lack of trivalent iron in the structure of formation waters and ore mass, are being attracted to development. As a result, uranium extraction from these areas is about 50%, with sulfuric acid content in leaching solutions ranging from 10-15 g/l.

As demonstrated by the practice of uranium ore leaching, during the stages of ore mass oxidation, there is an increase in the content of the useful component along with an increase in residual acidity. When the process transitions to the stage of active leaching, a peak in uranium content in the solution is observed, followed by a sharp decrease. This is evidenced by the fact that by this point, the chemically active hexavalent uranium has almost completely entered the solution, leaving in the ore the more resistant tetravalent uranium, which is less susceptible to the action of sulfuric acid.

To accelerate the leaching process, two additional requirements exist: uniform injection while maintaining an overall balance and minimal deviation of wellbores from the design positions (within 1-2 meters). Failure to meet these requirements complicates the interpretation of control drilling data and reduces the accuracy of the calculations performed."

"To reduce the operating time of the leaching field to achieve the required extraction efficiency (85-90%), one can decrease the distance between injection and extraction wells or increase their productivity. However, both approaches pose technical challenges. Currently, drilling wells without a filter deviation of 3-5 meters from the design position at depths of 400-700 meters is practically impossible. Therefore, the minimum acceptable distance between extraction and injection wells is considered to be 20-35 meters, depending on the drilling depth. Significantly increasing well productivity is also impractical due to technical complexity, increased construction costs, and the filtration properties of the productive horizon.

The estimated operating time for leaching fields without a central cell to achieve the required extraction, according to calculations, is approximately 3 years, and with a decrease in well flow rates due to colmatation phenomena, it extends to 4-5 years.

Hence, one method to intensify the uranium in-situ leaching process is the application of various oxidizers.

The aim of the study is to enhance the efficiency of underground in-situ leaching of uranium using different reagents. The concept involves increasing the uranium content in the productive solution by saturating the leaching solution with oxygen from the air using a special Venturi injector tube.

The research tasks include:

- Studying the geological features and analyzing the applied in-situ leaching technology for uranium at the "Central Mynkuduk" deposit.
- Developing a technology for saturating the leaching solution with oxygen from the air.
- Conducting research to determine the influence of flow rate and volume of the leaching solution on the concentration of oxygen in the solution.
- Laboratory studies on the impact of leaching solution saturation on underground in-situ leaching indicators.
- Processing research results and providing recommendations.

**Scientific novelty:**

- A technology for air intake and saturating the leaching solution with oxygen using a Venturi injector tube is proposed, characterized by creating sections with different solution pressures inside the injector, enhancing the transfer of oxygen from gaseous to liquid phase.
- Dependencies of oxygen concentration in the solution on the flow rate and volume of the leaching solution were obtained, allowing the determination of the maximum possible oxygen concentration in the solution under various solution volume conditions in production."
- Dependencies of the concentration of bivalent and trivalent iron and uranium content in the productive solution on leaching time and the distance of leaching solution transport after saturation with oxygen have been obtained.

**Scientific positions proposed for defense:**

- The use of a special Venturi injector tube allows increasing the oxygen concentration in the leaching solution and uranium content in the productive solution by altering the pressure of the leaching solution as it passes through the narrowed and expanded sections of the injector.
- The concentration of oxygen in the leaching solution depends on the flow rate and volume of the supplied leaching solution, allowing the determination of oxygen concentration in the solution considering the regulation of leaching solution delivery to the technological block.

- The concentrations of oxygen and trivalent iron in the leaching solution depend on leaching time and the distance of transport from the oxygen-saturation point to the formation.

**Connection of the research with other scientific works:**

The dissertation work was carried out within the framework of the theme: "Intensification of the extraction process using oxidizers in the leaching process at the 'Central' section of the 'Mynkuduk' deposit" (contract No. 438060/2020/1 dated May 29, 2020).

**The research object** is the "Central" section of the uranium deposit "Mynkuduk" in the Turkestan region.

**The research subject is underground in-situ leaching of uranium.**

Author's personal contribution includes the analysis of geological conditions, literature review on the research topic, conducting laboratory studies, processing the results of laboratory work, and preparing conclusions.

**Implementation of the conclusions and recommendations of the work:**

Pilot-industrial tests and research were conducted in Block 48-5 of the "Central" section of the "Mynkuduk" deposit.

**Publications related to the dissertation include 2 articles, including publications in journals.**

(2021) Mining of Mineral Deposits, 15 (3), pp. 39-44. DOI: 10.33271 / MINING 15.03.039

(2022) Eurasian Mining, 2 (38) pp. 50-53 EFFECT OF PROCESS SOLUTION SATURATION WITH OXYGEN ON URANIUM IN-SITU LEACHING PERFORMANCE

## CONCLUSION

Based on the results of the conducted laboratory work, the following conclusions can be drawn:

1. The proposed technology of saturating the solution with oxygen using a Venturi tube allows, as the solution passes through the tube constriction, to ensure air intake and active mixing of air with the solution. It contributes to the effective transition of oxygen from the air to the solution by changing the pressure in the solution.

2. The dependencies established by the laboratory experiments include:

- The dependence of oxygen concentration in the solution on the speed and volume of the leaching solution, which will allow determining the maximum possible oxygen concentration in the solution for various volumes of the supplied solution in production conditions.

- Dependencies of oxygen and trivalent iron concentration in the leaching solution on the distance of transportation, which will determine the time required to achieve maximum oxygen saturation in the solution.

- Dependencies of bivalent and trivalent iron concentration and uranium content in the productive solution on leaching time during oxygen saturation of the solution.

3. The advantages of this technology include low capital and operational costs, ease of installation and maintenance, and the absence of the need for consumables such as chemical additives.

4. Oxygen saturation of the working solution ensures the oxidation of bivalent iron to trivalent, leading to an increase in uranium content in the productive solution and a reduction in the time required to deplete uranium reserves in the technological block.

5. The expected economic effect for one block is estimated at 37,792,218 tenge.