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АКЦИОНЕРНОЕ ОБЩЕСТВО «НАЦИОНАЛЬНАЯ АТОМНАЯ КОМПАНИЯ «КАЗАТОМПРОМ»
АО «ВОЛКОВГЕОЛОГИЯ»

# СБОРНИК ТРУДОВ

## IX МЕЖДУНАРОДНОЙ НАУЧНО-ПРАКТИЧЕСКОЙ КОНФЕРЕНЦИИ

# АКТУАЛЬНЫЕ ПРОБЛЕМЫ УРАНОВОЙ ПРОМЫШЛЕННОСТИ

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АО «НАЦИОНАЛЬНАЯ АТОМНАЯ КОМПАНИЯ «КАЗАТОМПРОМ»
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**Часть 1**

Алматы
2019

# STUDY OF DIFFERENT CASES OF URANIUM DISSOLUTION BY SULFURIC ACID SOLUTION

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The ISL process of uranium in Kazakhstan's fields is based on the injection of sulfuric acid into the permeable layers of the subsoil, the leaching of solid uranium minerals, and the transfer and pumping through the production wells. This process differs from oil production processes by simpler hydrodynamics, but more complex chemical kinetics.

Chemical kinetics is based on reactions occurring in the reservoir as a result of the injection of the leaching solution (sulfuric acid). Reaction rate constants are vital to accurately model any given system of chemical equations. Empirical experiment available in the literate had been taken to determine appropriate constants that can be used for the purposes of numerical simulation. Chemical kinetics of In-Situ Leaching of uranium in subterranean environment with sulfuric acid solution were assumed according to Gromov's research [1], where the dissolution of uranium can be described by the following chemical equations:

$$H_2SO_{4(liquid)} \leftrightarrow 2H^+_{(liquid)} + SO_{4(liquid)}, \quad (1)$$

$$UO_{3(solid)} + 2H^+_{(liquid)} \rightarrow UO^{2+}_{2\,(liquid)} + H_2O_{(liquid)} \quad (2)$$

at the same time, a reaction takes place between uranium dioxide and sulphate:

$$UO^{2+}_{2\,(liquid)} + SO^{2-}_{4(liquid)} \rightarrow [UO_2SO_4]_{(liquid)}, \quad (3)$$

Studies show that the dissolution of uranium dioxide ($UO_{2(solid)}$) is a more complex and slower process than the dissolution of uranium trioxide even at high concentrations of leaching solution [2]. However, various catalysts are used to speed up the dissolution of uranium dioxide, which speeds up the leaching process. One of the widely used catalysts is iron, which reacts as follows [1, 3]:

$$UO_{2(solid)} + 2Fe^{3+}_{(liquid)} \rightarrow UO^{2+}_{2\,(liquid)} + 2Fe^{2+}_{(liquid)}, \quad (4)$$

In the presence of iron (III) hydroxide in the stratum, the following reaction should also be taken into account:

$$Fe(OH)_{3(solid)} + 3H^+_{(liquid)} \rightarrow Fe^{3+}_{(liquid)} + 3H_2O_{(liquid)}, \quad (5)$$

The mathematical model was constructed in the form of a system of differential equations based on mass conservation law for each component, dissolution of solid minerals and transport of dissolved components and the law of mass action [4, 5]. For verification and to determine reaction rate constants, the model was tested based on experimental data from the Uranium Geotechnology Tutorial by NAC Kazatomprom JSC [6]. In particular case, at the site of uranium deposit, iron (3+) was not directly used on an industrial scale, but a significant number of laboratory experiments were carried out, confirming the possibility and validity of the addition of iron salts (3+) to leaching solution. Research was conducted on uranium leaching from experimental pipe. In particular, the following series of experiments were carried out:

1. concentration of leaching solution 20 g/l (experiment 1);
2. concentration of leaching solution 20 g/l with addition of $Fe_2(SO_4)_3$ in the amount of (if recalculated with $Fe^{3+}$) 0,5 g/l (experiment 2);
3. concentration of leaching solution 30 g/l (experiment 3).

In accordance with the parameters of the experiments, the reaction rate constants were determined. The experiments were repeated numerically, and similar curves were plotted for the concentrations of uranium relative to L:S. Results of numerical solution as compared to aforementioned laboratory experiments are shown on Figure 1.

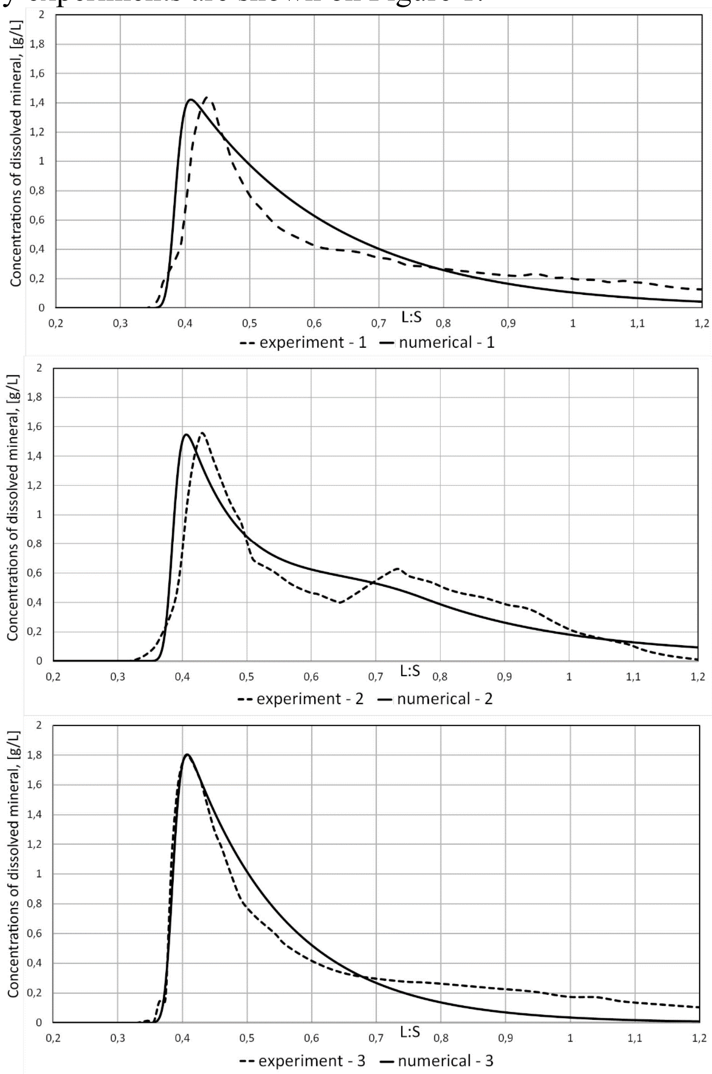


Figure 1 – The results of calculations of the kinetics of the chemical leaching process of uranium in comparison with three laboratory experiments

As can be seen in the chart, the effect of oxidizing agents is reflected in the appearance of the distinctive “hump”. This is mostly due to uranium dioxide being less soluble, and hence the increase of it in dissolved form occurs later in the experiment. The work was supported by the Ministry of Education of Kazakhstan through the program of targeted financing BR05236447.

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