PHYSICO-CHEMICAL BASICS OF PROCESSING OF URANIUM-CONTAINING ORES OF THE "WESTERN TAJIKISTAN" DEPOSIT

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The article presents the results of chemical and mineralogical analysis of uranium-containing ores from the "Western Tajikistan" deposit and the study of the kinetics of the maceration process of these ores with sulfuric acid. The analysis showed that the ore is uranosilicate with a silicon oxide content of more than 37%. Therefore, the decompounding of the ore was carried out by the acid method using sulfuric acid. The kinetic parameters of the maceration process of ore with changing of temperature, length of time and concentration of sulfuric acid were studied. The magnitude of the apparent activation energy equal to 14.11 kJ / mole is calculated. The optimal parameters of the ore maceration process were found: the concentration of sulfuric acid is 30%, the temperature is 80°C and the length of time is 60 minutes. Based on the optimal parameters of the maceration process, a flow sheet for processing uranium-containing ore from the "Western Tajikistan" deposit has been developed.
Keywords: *extraction, processing, chemical analysis, maceration, sulfuric acid, kinetics.*

In recent years, with reference to the expansion of the search for new deposits of uranium-containing ores in Tajikistan, work on the possibility of extracting uranium from ore has become topical. The possibilities of sulfuric acid maceration of uranium-containing ores and uranium industry wastes from local raw materials of Tajikistan were previously studied [1 - 4]. The study of the physicochemical properties of ores from other deposits, such as the "Western Tajikistan" deposit, is of great interest. The chemical composition of the ore of the "Western Tajikistan" deposit was determined by various chemical methods (Table 1).

The mineralogical composition of the ore was determined by X-ray phase analysis on a DRON-3 instrument (upgraded) with digital processing on a copper anode (35kV and 20mA) and a nickel filter. The main ore minerals are quartz, albite, muscovite, pyrite, uraninite, uranium mica (Fig. 1).

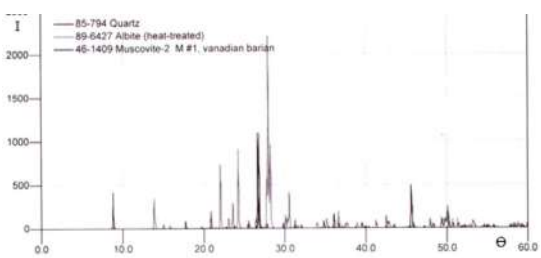

Figure 1. Roentgenogram of ore from Western Tajikistan deposit

To determine the radionuclide composition of the ore, a gamma-spectrometer analysis with a semiconductor detector and a digital processing of the Genie 2000 spectrum was carried out at the Canberra gamma-spectrometer (Table 2).

Table 1. Chemical composition of ore from Western Tajikistan deposit

Components	AI2O3	SiO2	Fe2O3	MnO2	TiO2	Pb	U	As	Cr	V	Zn
%	13,7	69,4	8,13	0,08	0,53	0,10	0,11	0,07	0,01	0,05	0,027

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Table 2. Radionuclide composition of ore from Western Tajikistan deposit

Radionuclides	Average weighted activity, kBq /kg
K-40	$4.687399 \cdot 10^{-1}$
Pb-212	$4.273295 \cdot 10^{-2}$
Bi-214	$1.591636 \cdot 10$
Pb-214	$1.369677 \cdot 10$
Ra-226	$3.269666 \cdot 10$
Ac-228	$5.077794 \cdot 10^{-2}$
U-235	$6.201537 \cdot 10^{-1}$
U-238	2.109164

Taking into account that the ore is silicate, a sulfuric acid method with the addition of nitric acid as an oxidizing agent was used to lighten the ore. The results of the studies are presented in Tables 3, 4 and 5.

Studies have shown that with an increase in the concentration of sulfuric acid, the degree of extraction of uranium from ore first increases to 88.17% and then decreases markedly due to lack of water. With increasing temperature, the degree of extraction of uranium from ore also increases and reaches its maximum at 80°C. The duration of the maceration also affects the degree of extraction of uranium from the ore and reaches its maximum at a time of 60 minutes.

The kinetics of the maceration process of uranium ore was studied in the temperature range 293-363 K, with a process duration from 15 to 90 minutes.

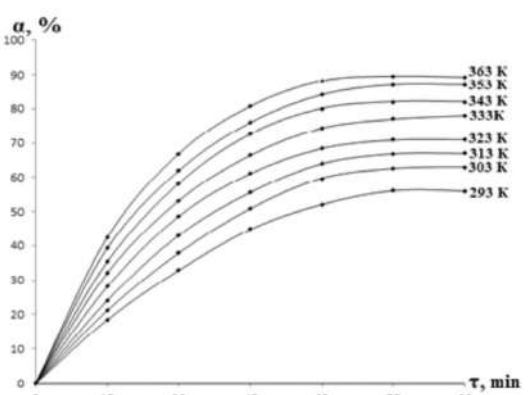

Figure 2. The dependence of extraction degree of uranium on time duration of leaching at different temperatures.

Based on the results obtained, kinetic curves were constructed (Fig. 2). With increasing temperature and duration of the maceration process, the degree of extraction of uranium from ore increases significantly. Kinetic curves are parabolic. Maximum recovery is observed with a maceration time of 60 minutes. Kinetic curves are well described by a first order equation:

$$\frac{d\alpha}{d\tau} = K \cdot (1-\alpha)$$

where: α – degree of recovery; τ – time, min.; K – decompounding rate constant, min^{-1}.

After simple mathematical transformations, we obtain an expression in the form:

$$\lg(1-\alpha) = -\frac{K \cdot \tau}{2{,}303}$$

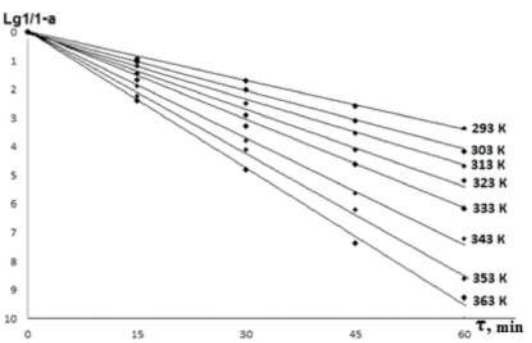

Figure 3. The dependence of extraction degree of uranium on lg and time duration.

On the dependency graph $\lg\frac{1}{1-\alpha}$ on time (Fig.3) the received straight lines have a negative slope equal to $\frac{K}{2{,}303}$. The magnitude of the apparent activation energy (E) and the pre-exponential factor (K0) were determined graphically using the Arrhenius equation:

$$K = K_o \cdot e^{-E/RT},$$

$$\text{or: } \lg = -\lg K_o - \frac{E}{2{,}303\,RT},$$

where: R – universal gas constant, kJ/mol·hail; T – absolute temperature, K.

To find the activation energy and more accurately determine the extent of the maceration process, the dependency graph of logarithm of the average values of the reaction rate constants against the reciprocal absolute temperature was built, it

Table 3. Dependence of extraction degree of uranium on the concentration of sulfuric acid

Concen-tration of H_2SO_4 (%)	Ratio of solid and liquid S:L	Value of HNO_3 (ml)	Time duration, t (hour)	Temperature (°C)	Uranium extraction degree (%)
10	1:2	1	1	80	70.86
20	1:2	1	1	80	77.24
30	1:2	1	1	80	88.17
40	1:2	1	1	80	81.14
50	1:2	1	1	80	74.10
60	1:2	1	1	80	72.21
70	1:2	1	1	80	70.85
80	1:2	1	1	80	69.25

gives a straight line. Based on the tangent of the angle of inclination, the value of the activation energy process was calculated (Fig. 4).

As can be seen from Fig. 4, the points fit satisfactorily on a straight line, along the slope of which the apparent activation energy is calculated to be 14.11 kJ/mol. The numerical value of the activation energy and the dependence of the reaction rate on the temperature and duration of the maceration process indicate its occurrence in the diffusion area. The studies performed and the calculated values of the kinetic characteristics make it possible to choose a rational mode of the maceration process.

Based on the results, a process flow sheet was developed for obtaining uranium oxide (U3O8) from the ore from "Western Tajikistan", which consists of the following main stages: ore preparation, maceration, filtration, sorption, desorption, precipitation, drying and calcining (Fig. 5).

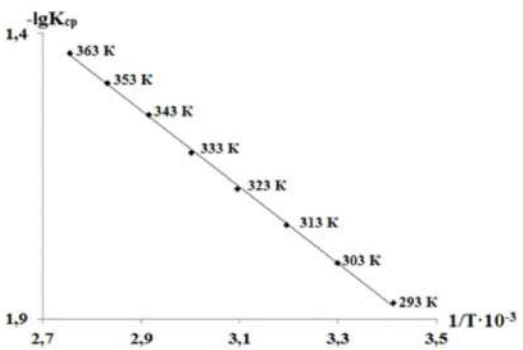

Figure 4. The dependence of lgK on the inverse of the absolute temperature

Table 4. Dependence of extraction degree of uranium on temperature

Concen-tration of H_2SO_4 (%)	Ratio of solid and liquid S:L	Value of HNO_3 (ml)	Time duration, t (hour)	Temperature (°C)	Uranium extraction degree (%)
30	1:2	1	1	20	54.09
30	1:2	1	1	30	63.82
30	1:2	1	1	40	63.87
30	1:2	1	1	50	68.69
30	1:2	1	1	60	77.89
30	1:2	1	1	70	83.03
30	1:2	1	1	80	88.17
30	1:2	1	1	90	88.14

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Table 5. Dependence of extraction degree of uranium on the time duration

Concen-tration of H_2SO_4 (%)	Ratio of solid and liquid S:L	Value of HNO_3 (ml)	Time duration, t (hour)	Temperature (°C)	Uranium extraction degree (%)
30	1:2	1	0,5	80	55.45
30	1:2	1	1	80	88.17
30	1:2	1	1,5	80	88.74
30	1:2	1	2	80	89.33
30	1:2	1	2,5	80	89.90
30	1:2	1	3	80	89.34
30	1:2	1	3,5	80	89.01
30	1:2	1	4	80	89.11

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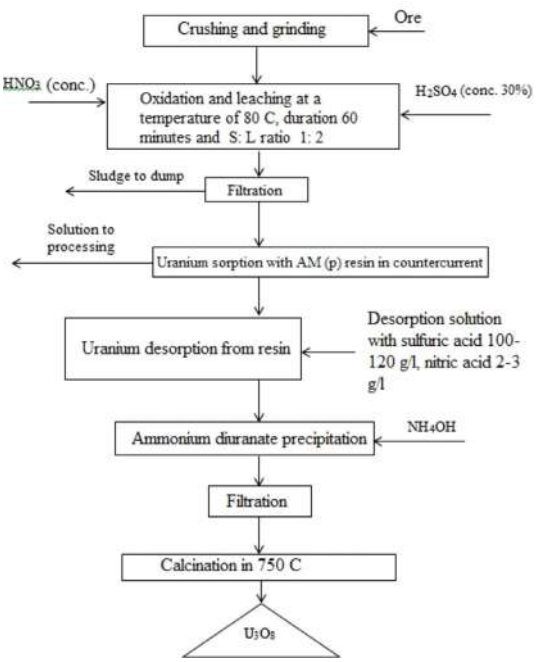

Figure 5. Technological process scheme of uranium Extraction by sulfuric acid from Western Tajikistan deposit.