

## IMPACT OF THE FLUORIDE ION AND SULFURIC ACID CONTENT IN LEACHING SOLUTION ON THE GRANITE WEIGHT DECREASE

<sup>1</sup>Korovin V.Yu., <sup>2</sup>Pohorielov Yu.M., <sup>1</sup>Shestak Yu.G., <sup>1</sup>Valiaiev O.M.

<sup>1</sup>*Institute of Geotechnical Mechanics named by N. Poljakov of National Academy of Sciences of Ukraine,* <sup>2</sup>*Dniprovsky State Technical University*

**Abstract:** The paper presents the results of the study regarding the impact of the initial concentrations of fluoride ion and sulfuric acid in a leaching solution on the weight decrease of granite mined at Pridniprovsk Specialized Quarry. Decrease of the weight of granite samples were measured using an analytical balance after the sample treatment with the above reagents with subsequent filtration, rinsing and drying of the treated samples at a temperature of 105 °C until constant weight. Fluoride ion concentration was measured with a fluorine-selective electrode relatively the saturated silver chloride half-cell, solution acidity was measured by titrimetry. Weight decrease was studied for a granite sample, grain fraction 2.0 + 1.0mm, in batch mode depending upon the sulfuric acid concentration in the range 18.8 g/dm<sup>3</sup> to 76.6 g/dm<sup>3</sup> and exposure time 7, 14, and 21 days. It was found that sulfuric acid solution resulted in the decrease of granite weight by 1.65 % to 3.18 % depending upon acid concentration and exposure time. The study was carried out regarding the impact of fluoride ion concentration on the granite sample weight decrease depending on the fluoride ion concentration 3.25×10<sup>-2</sup> g/dm<sup>3</sup> to 5.00×10<sup>-1</sup> g/dm<sup>3</sup> as well as sulfuric acid concentration within the range 18.8 g/dm<sup>3</sup> to 76.6 g/dm<sup>3</sup> and exposure time 7, 14, and 21 days. It was found that the impact of fluoride ion on the sample weight decrease was extremal at the sulfuric acid concentration in the range 18.8 g/dm<sup>3</sup> to 37.7 g/dm<sup>3</sup> with maximum values within the concentration range 0.3 g/dm<sup>3</sup> to 0.5 g/dm<sup>3</sup>. Weight decrease became higher pro rata the fluoride ion concentration at the sulfuric acid concentration 76.6 g/dm<sup>3</sup>. The data were presented regarding the change of fluoride ion content depending upon exposure time, concentration of fluoride ion and sulfuric acid. The change in fluoride ion concentration ambiguously depended on the exposure time, initial concentration of fluoride ion and sulfuric acid and even resulted in its increase, which was probably due to the dissolution of fluoride-containing minerals (mica, fluorite, etc.) in the samples.

**Keywords:** granite, ammonium bifluoride, sulfuric acid, weight decrease, fluoride ion.

**Introduction.** Ammonium fluorides are the most convenient and processable fluorinating agents used to decompose silicon component of ores. Advanced processing with fluorides was considered for silicon, zirconium, titanium, beryllium minerals [1], rare-earth elements from monazite concentrates [2].

Ammonium fluoride-bifluoride is used to activate ores and chemically inert concentrates to promote their leaching, in particular, to intensify uranium leaching from refractory ores due to the destruction of the solid uranium-containing minerals with high content of silicon dioxide [3]. Silicon dioxide presents as feldspar, quartz and silicates that form solid structures with uranium mineral inclusions: brannerite, pitch blende, etc. In this connection, standard leaching methods do not result in the complete uranium recovery even using oxidizing agents.

The impact of geological processes (metasomatoses and tectonics) was studied [4] on conversions in uranium-containing rocks; uranium behavior was checked under conditions approximate to natural ones. The experiment was carried out, which conditionally simulated metasomatic processes in granites and crystalline schist. The study was performed in 6 samples of contrast composition – 3 samples each from granites of Middle-Pridneprovsk Megablock, Ukrainian Shield, and albitized aposhales of ore horizons at Zhovtorichenskoye deposit. Results were presented regarding rock conversions for biotite granites (subway construction), amphibole-magnetite of biotite-quartz aposhale (Nova mine, depth 380 m), and granite mined at Pridniprovsk Specialized Quarry. Ammonium fluoride-bifluoride and urea nitrate

(urea adduct with nitric acid) were used as additives to intensify structure decomposition in uranium-containing solid rocks.

This paper presents the results of the study on the impact of the initial concentration of fluoride ion and sulfuric acid in a leaching solution on the weight decrease for the samples of granite mined at Pridniprovsk Specialized Quarry. The study is a constituent of the study on the impact of the intensifying additives based on ammonium fluoride-bifluoride and urea nitrate on the destruction of the crystalline lattice of refractory uranium-containing ores.

**Methods.** The study was carried out using ground and sieved granite sample taken from Pridniprovsk Specialized Quarry, fraction  $-2.0 + 1.0$  mm sieved in MLW Thy 2 laboratory vibrating sieve.

Weight decrease of granite samples after exposure with ammonium fluoride-bifluoride and sulfuric acid was measured by Nagma analytical scales, type AV IV S/3 (with weighing limit up to 200 g and accuracy 0.001 g). The treated samples underwent filtration, rinsing and drying in the MLW WS 100 drying box at a temperature of 105 °C until constant weight.

Ammonium fluoride-bifluoride (with 61.2 % fluoride content) and 40 % sulfuric acid, reagent grade, were used during experiments.

Reagent concentrations in the solutions were selected based on the data about technological processes used in the uranium industry [5, 6].

Fluoride ion concentration was measured using an ELIS-131F fluorine-selective electrode relatively EV1-1M3 saturated silver chloride half-cell by an MV-88 pH-meter [7]. Reagents used during the measurement were at least reagent grade. Acidity of solutions was measured by titrimetry.

## **Results and discussion.**

### **Impact of sulfuric acid concentration on the granite weight decrease.**

Decrease of the granite sample weight was studied in batch mode at the solid (S) to liquid (L) phase ratio S:L=1:100 (sample weight portion was ~10 g) depending upon the initial concentration of sulfuric acid [H<sub>2</sub>SO<sub>4</sub>] at intermittent agitation and temperature 20 °C during 7, 14, and 21 days. Sulfuric acid concentration was 18.8 g/dm<sup>3</sup>, 37.7 g/dm<sup>3</sup>, and 76.6 g/dm<sup>3</sup>.

The sulfuric acid concentration was selected concerning the fact that excessive acidity of [H<sub>2</sub>SO<sub>4</sub>] is maintained within the range 10 g/dm<sup>3</sup> to 20 g/dm<sup>3</sup> equivalent to sulfuric acid during uranium leaching, and the residual acidity was pH = 1.5 to 2.5 at the leaching process end. These conditions ensure the maximum sorption capacity of anionites used for uranium subsequent recovery. Thus, in cooperation with the Central Research Laboratory of Eastern Mining and Processing Plant State Enterprise, we used anionite AM-p-2 manufactured by Smoly State Enterprise when recovering uranium from the heap leaching solution at pH = 1.64. We also applied AMP anionite to recover uranium from the pH = 2.5 acidic pulp formed after leaching of radioactive waste stored at Zakhidne tailings facility, and AM-p-2

anionite when treating radioactive waste with pH = 1.45 accumulated at Tsentralny Yar tailings facility of the former Production Union Pridneprovsk Chemical Plant [9].

Table 1 and Figure 1 illustrate the sample weight decrease depending on the sulfuric acid initial concentration and exposure time.

Table 1 – Decrease of the granite sample weight

Exposure time, days	Sample weight before treatment, $m_1$ , g	Sample weight after treatment, $m_2$ , g	Weight decrease, $\Delta m$ , %
$[\text{H}_2\text{SO}_4] = 18.8 \text{ g/dm}^3$			
7	10.021	9.855	1.66
14	10.021	9.781	2.39
21	10.021	9.744	2.76
$[\text{H}_2\text{SO}_4] = 37.7 \text{ g/dm}^3$			
7	10.001	9.811	1.90
14	10.001	9.745	2.56
21	10.001	9.710	2.91
$[\text{H}_2\text{SO}_4] = 76.6 \text{ g/dm}^3$			
7	10.004	9.775	2.28
14	10.004	9.707	2.97
21	10.004	9.685	3.19

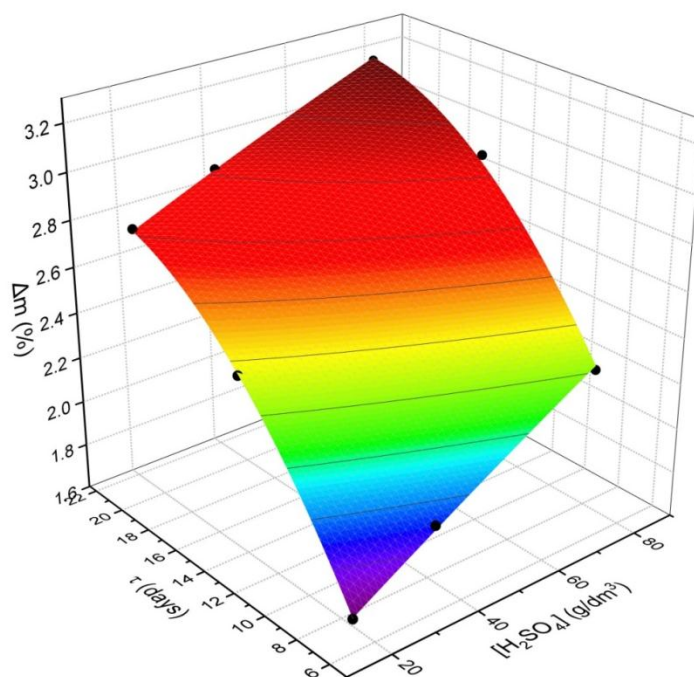


Figure 1 – Decrease of the granite sample weight vs. sulfuric acid concentration and exposure time

The experimental data were processed with the second-order polynomial, the results are shown in Figure 1; polynomial equation is:

$$\Delta m = 0.2946 + 0.0138 \cdot x + 0.1906 \cdot y - 1.22 \cdot 10^{-5} \cdot x^2 - 0.0039 \cdot y^2 - 2.27 \cdot 10^{-4} \cdot x \cdot y \quad (1)$$

where:  $x$  is sulfate acid concentration,  $\text{g/dm}^3$ ,  $y$  is exposure time, days.  $R^2 = 0.9988$ .

It was defined that sulfate acid solution caused the weight decrease in the granite sample 1.66 % to 3.19 % at the S:L=1:100 ratio depending on the acid initial concentration and the exposure time.

Additionally, weight decrease was studied for a granite sample with grain size - 1.0 + 0.5 mm under similar conditions for 7 days at sulfuric acid concentration 18.8 g/dm<sup>3</sup>. It was found that the mass decrease was 2.32 % at an initial sample weight 9.985 g that was higher as compared with the granite sample -2.0 + 1.0 mm ( $\Delta m$  was 1.66 %).

**Impact of fluoride ion concentration on the granite weight decrease.** The study was performed regarding the impact of the fluoride ion initial concentration on the weight decrease of the granite sample depending upon the content of fluoride ion  $[F^-]$   $3.25 \times 10^{-2}$  g/dm<sup>3</sup> to  $5.00 \times 10^{-1}$  g/dm<sup>3</sup>, sulfuric acid concentration 18.8 g/dm<sup>3</sup> to 76,6 g/dm<sup>3</sup> and exposure time 7, 14, and 21 days. The experiment was carried out in batch mode at the solid-to-liquid phase ratio S:L=1:100 (sample weighed portion was ~10 g) at intermittent agitation and temperature of 20 °C during 7, 14, and 21 days.

Concentration ranges for fluoride ion was selected considering the ability of anion exchangers to recover fluoride ion that may decrease the uranium recovery degree from sulfuric solutions formed during the refractory ore leaching.

Experimental data and their processing results are given in Tables 2 and 3 and in Figures 2-4.

Table 2 – Decrease of the granite sample weight and fluoride ion concentration

Exposure time, days	Sample weight before treatment $m_1$ , g	Sample weight after treatment $m_2$ , g	Weight decrease $\Delta m$ , %	Residual content of fluoride ion $[F^-]_{res.}$ g/dm <sup>3</sup>	Decrease of the fluoride ion content $\Delta[F^-]$ , g/dm <sup>3</sup>
$[H_2SO_4] = 18.8 \text{ g/dm}^3$					
$[F^-] = 3.25 \cdot 10^{-2} \text{ g/dm}^3$					
7	10.005	9.825	1.80	$2.26 \cdot 10^{-2}$	$9.88 \cdot 10^{-3}$
14	10.005	9.721	2.84	$3.44 \cdot 10^{-2}$	$-1.90 \cdot 10^{-3}$
21	10.005	9.710	2.95	$2.01 \cdot 10^{-2}$	$1.24 \cdot 10^{-2}$
$[F^-] = 0.152 \text{ g/dm}^3$					
7	10.021	9.765	2.55	$1.35 \cdot 10^{-1}$	$1.77 \cdot 10^{-2}$
14	10.021	9.668	3.52	$1.86 \cdot 10^{-1}$	$-3.27 \cdot 10^{-2}$
21	10.021	9.616	4.04	$1.40 \cdot 10^{-1}$	$1.31 \cdot 10^{-2}$
$[F^-] = 0.500 \text{ g/dm}^3$					
7	10.006	9.700	3.06	$3.02 \cdot 10^{-1}$	$1.98 \cdot 10^{-1}$
14	10.006	9.581	4.25	$4.14 \cdot 10^{-1}$	$8.55 \cdot 10^{-2}$
21	10.006	9.500	5.06	$2.76 \cdot 10^{-1}$	$2.24 \cdot 10^{-1}$
$[H_2SO_4] = 37.7 \text{ g/dm}^3$					
$[F^-] = 3.27 \cdot 10^{-2} \text{ g/dm}^3$					
7	10.010	9.80.072200	2.10	$2.36 \cdot 10^{-1}$	$8.93 \cdot 10^{-3}$
14	10.010	9.730	2.80	$3.02 \cdot 10^{-1}$	$2.28 \cdot 10^{-2}$
21	10.010	9.690	3.20	$2.19 \cdot 10^{-2}$	$-5.43 \cdot 10^{-2}$

continuation of table 2

Exposure time, days	Sample weight before treatment $m_1$ , g	Sample weight after treatment $m_2$ , g	Weight decrease $\Delta_m$ , %	Residual content of fluoride ion $[F^-]_{res.}$	Decrease of the fluoride ion content $\Delta[F^-]$ , g/dm <sup>3</sup>
$[F^-] = 0.173 \text{ g/dm}^3$					
7	10.012	9.753	2.59	$1.47 \cdot 10^{-1}$	$2.60 \cdot 10^{-2}$
14	10.012	9.660	3.52	$1.86 \cdot 10^{-1}$	$-1.27 \cdot 10^{-2}$
21	10.012	9.603	4.09	$1.34 \cdot 10^{-1}$	$3.88 \cdot 10^{-2}$
$[F^-] = 0.424 \text{ g/dm}^3$					
7	9.997	9.670	3.27	$3.52 \cdot 10^{-1}$	$7.22 \cdot 10^{-2}$
14	9.997	9.544	4.53	$4.18 \cdot 10^{-1}$	$5.70 \cdot 10^{-3}$
21	9.997	9.465	5.32	$2.58 \cdot 10^{-1}$	$1.65 \cdot 10^{-1}$
$[H_2SO_4] = 76.6 \text{ g/dm}^3$					
$[F^-] = 3.38 \cdot 10^{-2} \text{ g/dm}^3$					
7	10.007	9.797	2.10	$2.55 \cdot 10^{-2}$	$8.42 \cdot 10^{-3}$
14	10.007	9.738	2.69	$3.15 \cdot 10^{-2}$	$2.34 \cdot 10^{-3}$
21	10.007	9.701	3.06	$2.34 \cdot 10^{-2}$	$1.05 \cdot 10^{-2}$
$[F^-] = 0.170 \text{ g/dm}^3$					
7	10.001	9.745	2.56	$1.47 \cdot 10^{-1}$	$2.26 \cdot 10^{-2}$
14	10.001	9.657	3.44	$1.86 \cdot 10^{-1}$	$-1.62 \cdot 10^{-2}$
21	10.001	9.593	4.08	$1.29 \cdot 10^{-1}$	$4.09 \cdot 10^{-2}$
$[F^-] = 0.407 \text{ g/dm}^3$					
7	9.993	9.634	3.59	$3.52 \cdot 10^{-1}$	$5.43 \cdot 10^{-2}$
14	9.993	9.501	4.92	$3.90 \cdot 10^{-1}$	$1.63 \cdot 10^{-2}$
21	9.993	9.400	5.93	$2.49 \cdot 10^{-1}$	$1.57 \cdot 10^{-1}$

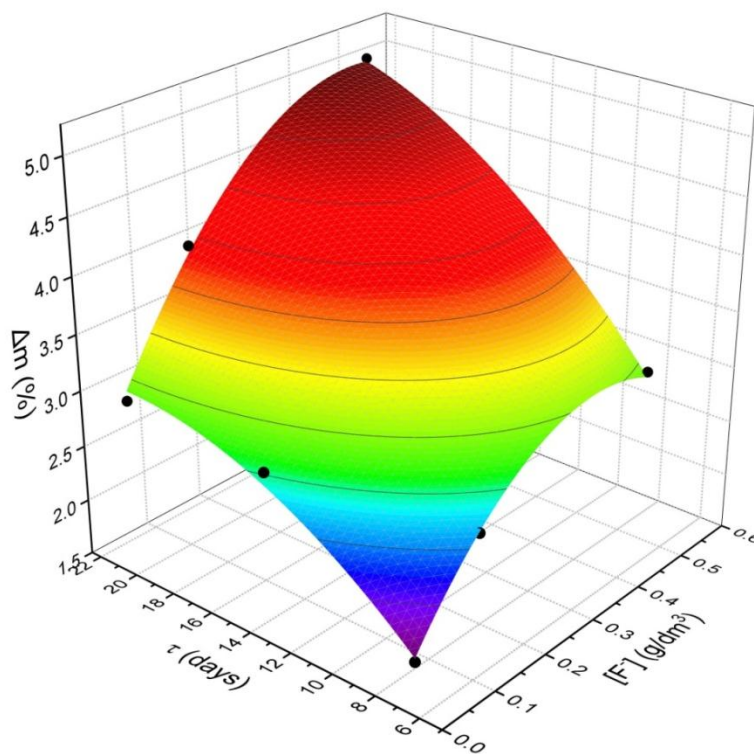


Figure 2 – Decrease of the granite sample weight vs. exposure time and fluoride ion concentration at sulfuric acid content 18.8 g/dm<sup>3</sup>

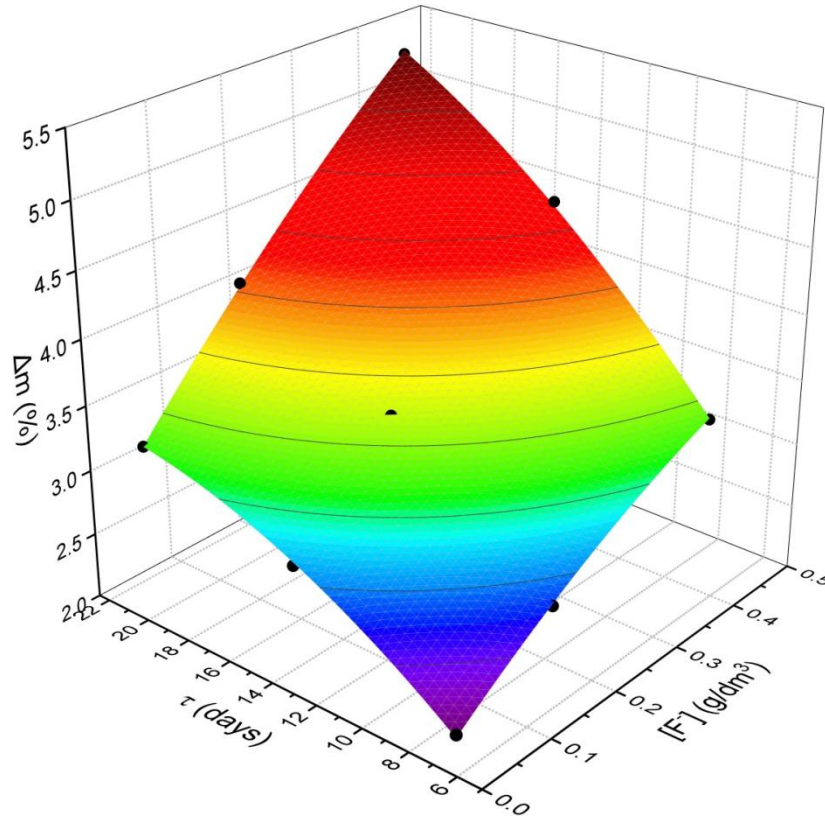


Figure 3 – Decrease of the granite sample weight vs. exposure time and fluoride ion concentration at sulfuric acid content  $37.7 g/dm^3$

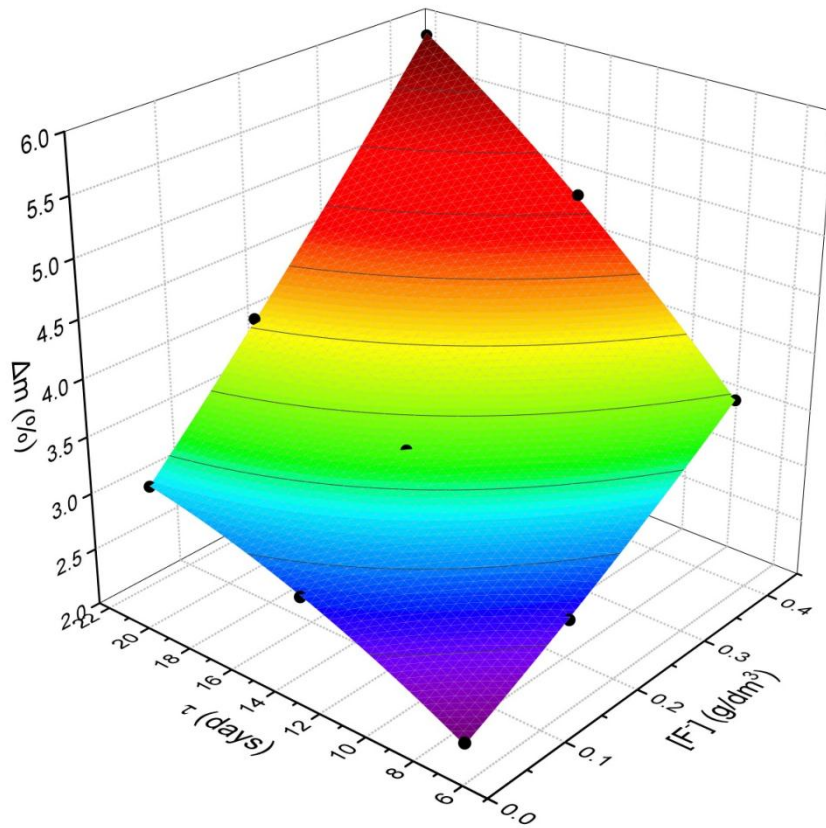


Figure 4 – Decrease of the granite sample weight vs. exposure time and fluoride ion concentration at sulfuric acid content  $76.6 g/dm^3$

The experimental data showed that the sample weight decreased with the increase of exposure time, initial concentration of fluoride ion and sulfuric acid. Sample weight decreased by 1.80 % to 5.06 % for sulfuric acid concentration 18.8 g/dm<sup>3</sup>, 2.10 % to 5.32 % for sulfuric acid concentration 37.7 g/dm<sup>3</sup> and 2.10 % to 5.93 % for sulfuric acid concentration 76.6 g/dm<sup>3</sup>.

Table 3 – Second order polynomial equation

Figure	Equation	R <sup>2</sup>
2	$\Delta m = 0.8468 + 3.1737 \cdot x + 0.1824 \cdot y - 2.8405 \cdot x^2 - 0.0038 \cdot y^2 + 0.1714 \cdot x \cdot y$ (2)	0.9953
3	$\Delta m = 1,15 + 1.4181 \cdot x + 0.1357 \cdot y + 1.8075 \cdot x^2 - 0.0027 \cdot y^2 + 0.2622 \cdot x \cdot y$ (3)	0.9996
4	$\Delta m = 1,15 + 1.4181 \cdot x + 0.1357 \cdot y + 1.8075 \cdot x^2 - 0.0027 \cdot y^2 + 0.2622 \cdot x \cdot y$ (4)	0.9996

where:  $x$  is fluoride ion concentration, g/dm<sup>3</sup>,  $y$  is exposure time, days

The study has revealed that the dependence of the fluoride ion concentration on the sample weight decrease was extreme at the sulfuric acid content within the range 18.8 g/dm<sup>3</sup> to 37.7 g/dm<sup>3</sup>. Maximum  $\Delta m$  was observed at  $[F^-]$  within the range 0.3 g/dm<sup>3</sup> to 0.5 g/dm<sup>3</sup> while it increased pro rata with the increase of fluoride ion concentration at  $[H_2SO_4] = 76.6$  g/dm<sup>3</sup>.

Tables 2, 4 and Figures 5 to 7 contain data regarding the decrease of fluoride ion concentration  $\Delta[F^-]$  vs. exposure time and initial concentration of fluoride ion and sulfuric acid.

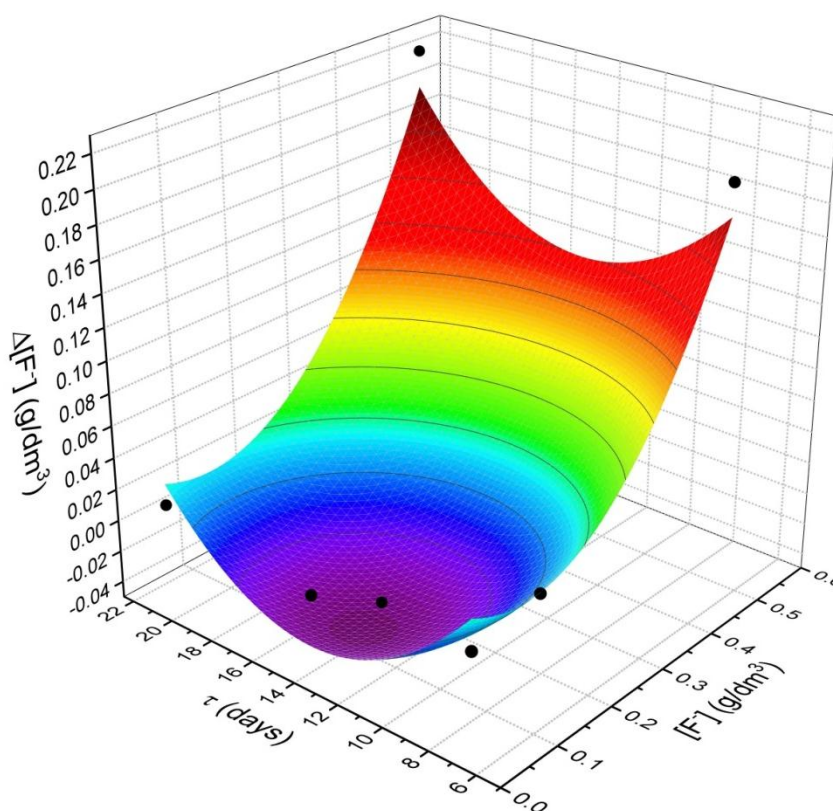


Figure 5 – Decrease of the fluoride ion content  $\Delta[F^-]$  vs. exposure time and the initial fluoride ion concentration at sulfuric acid content 18.8 g/dm<sup>3</sup>

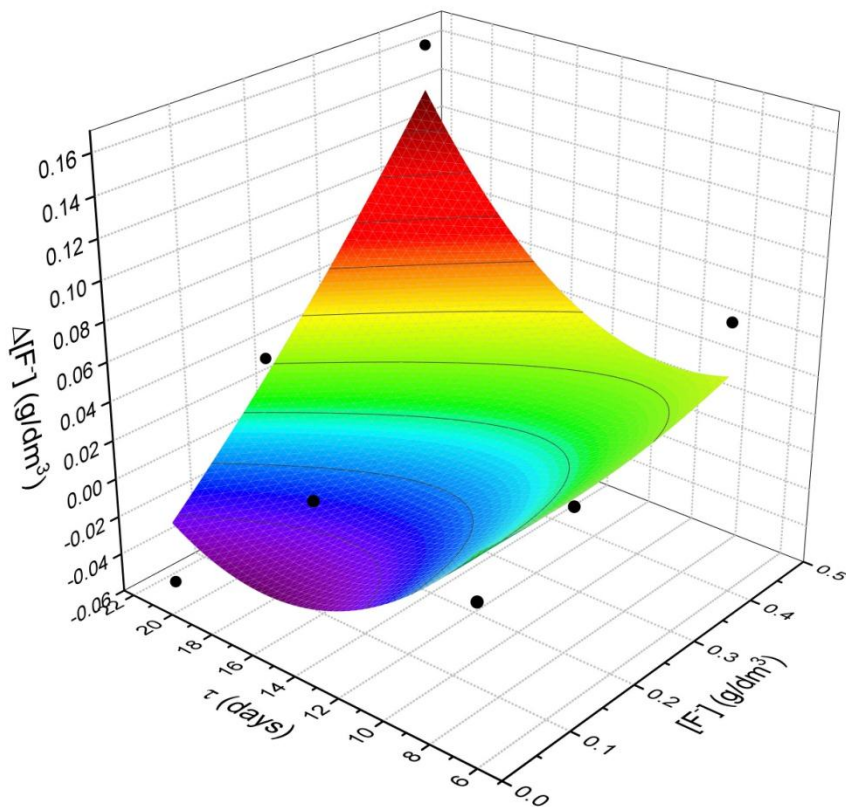


Figure 6 – Decrease of the fluoride ion content  $\Delta[F^-]$  vs. exposure time and the initial fluoride ion concentration at sulfuric acid content  $37.7 \text{ g/dm}^3$

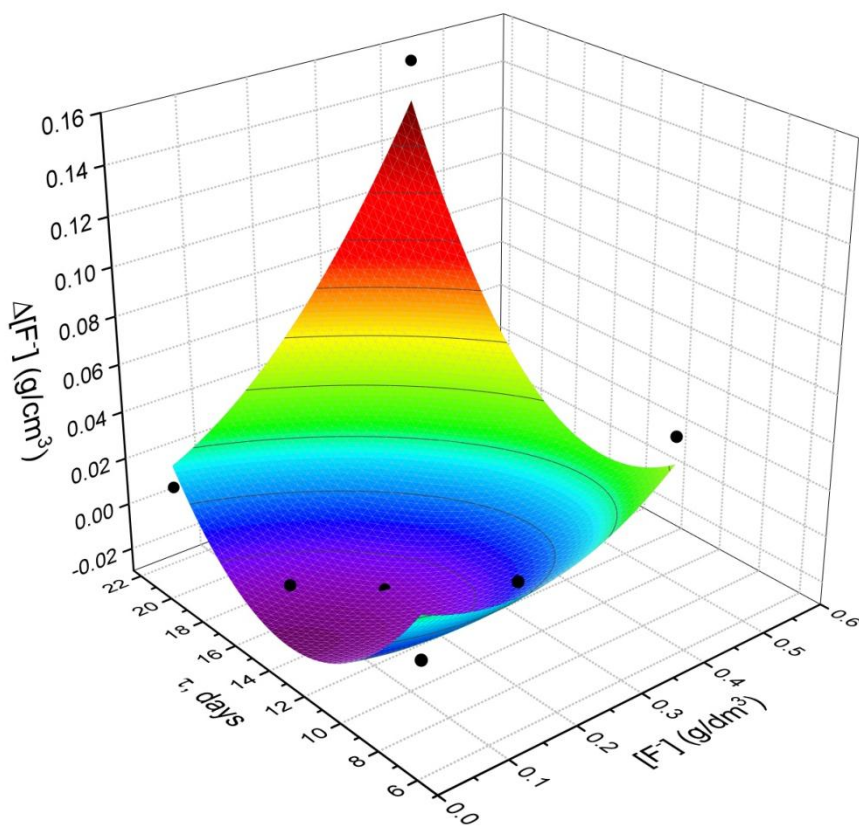


Figure 7 – Decrease of the fluoride ion content  $\Delta[F^-]$  vs. exposure time and the initial fluoride ion concentration at sulfuric acid content  $76.6 \text{ g/dm}^3$



It may be seen from the above data that the decrease in the fluoride ion concentration depended ambiguously upon the exposure time and the initial concentration of fluoride ion and sulfuric acid. The decrease in the content of fluoride ion was extreme within the studied range of the sulfuric acid and fluoride ion concentration with minimal values at an exposure time of 14 days. Generally, the increase in the fluoride ion content resulted in the increase in the difference between the fluoride ion initial and final concentrations while the increase in the sulfuric acid concentration caused, on the contrary, its decrease. Thus, the decrease of fluoride ion content after 7 days of exposure was  $-7.22 \times 10^{-2} \text{ g/dm}^3$  to  $8.42 \times 10^{-3} \text{ g/dm}^3$ . At the same time, both the decrease in concentration was observed up to  $8.55 \times 10^{-2} \text{ g/dm}^3$  after 14 days of exposure and its increase was up to  $(-3.27) \times 10^{-2} \text{ g/dm}^3$  while these values were  $2.24 \times 10^{-1} \text{ g/dm}^3$  and  $(-5.43) \times 10^{-2} \text{ g/dm}^3$ , correspondingly, after 21 days. In our opinion, this increase in fluoride ion concentration was caused by the dissolution of fluorine-containing minerals (mica, fluorite, etc.) in the samples.

Table 4 – Second order polynomial equation

Figure	Equation	R <sup>2</sup>
5	$\Delta[\text{F}^-] = 0.2275 - 0.3380 \cdot x - 0.0359 \cdot y + 1.1768 \cdot x^2 + 0,0042 \cdot y^2 + 0.0013 \cdot x \cdot y$ (5)	0.9341
6	$\Delta[\text{F}^-] = 0.1804 - 0.2519 \cdot x - 0.0263 \cdot y + 0.1942 \cdot x^2 + 0,00077 \cdot y^2 + 0.0278 \cdot x \cdot y$ (6)	0.7161
7	$\Delta[\text{F}^-] = 0.1842 - 0.3192 \cdot x - 0.0286 \cdot y + 0.5086 \cdot x^2 + 0,001 \cdot y^2 + 0.020 \cdot x \cdot y$ (7)	0.8848

where:  $x$  is fluoride ion concentration,  $\text{g/dm}^3$ ,  $y$  is exposure time, days

Thus, granite processing with ammonium fluoride-bifluoride resulted in the loosening and destruction of strong silicate structures due to partial silicon transfer in to solution making minerals leached by sulfuric acid more accessible.

**Conclusions.** It was defined that the sulfuric acid solution with initial concentration  $18.8 \text{ g/dm}^3$  to  $76.6 \text{ g/dm}^3$  resulted in a decrease in the granite sample weight by 1.65 % to 3.18 % depending upon its concentration and exposure time.

It was found that the impact of the initial concentration of fluoride ion on the granite sample weight decrease at the sulfuric acid concentration within the range  $18.8 \text{ g/dm}^3$  to  $37.7 \text{ g/dm}^3$  was extremal with the maximum concentration of fluoride ion within the range  $0.3 \text{ g/dm}^3$  to  $0.5 \text{ g/dm}^3$ . Weight decrease increased pro rata with the increase of fluoride ion concentration at sulfuric acid concentration  $76.6 \text{ g/dm}^3$ .

The residual content of fluoride ion ambiguously depended upon exposure time, initial concentration of fluoride ion and sulfuric acid and even exceeded the initial concentration in certain cases, which was associated, probably, with the dissolution of fluoride-contained minerals (mica, fluorite, etc.) in the studied samples.

Based on the assessment of the impact of fluoride ion concentration on the granite weight decrease, the recommended content of fluoride ion in leaching process solutions should be  $0.03 \text{ g/dm}^3$  to  $0.15 \text{ g/dm}^3$  depending upon the ore type.

The work was done within research project DR 0117U004231.

#### REFERENCES

1. Dyachenko, A. (2022), *Ammonium Fluorides in Mineral Processing*, [Online], available at: <https://www.intechopen.com/online-first/80042> (Accessed 3 July 2022). <https://doi.org/10.5772/intechopen.101822>
2. Muslimova, A.E. (2019), "Rare-Earth Element Recovery from Monazite Concentrate", Ph.D. thesis, Seversk Technological Institute, Seversk, the Russian Federation.
3. Gulyuta, M.A., Andreev, V.A., Buinovskiy, A.S., Makaseev, Yu.N., Molokov, P.B., Sofronov, V.L., and Ivanov, Z.S. (2014), "Research of Activation of Persistent Uranium Ores by Ammonium Fluoride Solutions", *Bulletin of the Tomsk Polytechnical University*, vol. 324, no. 3, pp. 53-59.
4. Baranov, V.A., Mametova, L.F., and Korovin, V.Yu. (2020), "Modelling of Metasomatism in Radiogenic Rocks as a Factor of Transformation of Their Properties", *Geophysical Journal*, vol. 42, no. 1, pp. 86-95. <https://doi.org/10.24028/gzh.0203-3100.v42i1.2020.195478>
5. Verkhovtsev, V.G., Lisichenko, G.V., Zabulonov, Yu.L., and Vozniak, D.K. (2014), "Perspektivy rozvytku uranovoyi syrovynnoyi bazy yadernoyi enerhytyky Ukrayiny" [Prospects of the Development of the Uranium Raw Material Industry], *Naukova Dumka*, Kyiv, Ukraine.
6. Babak, M.I., Koshik, Yu.I., Avdeev, O.K., Bezrodnyi, S.A., Saveliev, Yu.Ya. (2001), "Dobycha i Pererabotka Uranovykh Rud v Ukraine" [Uranium Ore Mining and Processing in Ukraine], in Chernov, A.P.(ed.), ADEF-Ukraine, Kyiv, Ukraine.
7. Midgley, D., and Torrans, K. (1980), *Potentsiometricheskyy Analiz Wody* [Potentiometric Water Analysis], Translated by Kahan B.B., Mairanovskiy S.G. (ed.), Mir Publ., Moscow, USSR.
8. Korovin, V., Valiaiev, O., Zontov, O., Zontona, L., Pilchuk, V. and Pysmennyi, B. (2019), "Uranium (VI) Sorption from Sulphuric Solutions by AM-p-2 Anionite", *Essays of Mining Science and Practice 2019. E3S Web of Conferences*, Dnipro, Ukraine, 09 July 2019, pp.1-8. <https://doi.org/10.1051/e3sconf/201910900039>
9. Korovin V.Yu., Valiaiev O.M., Pohorielov Yu.M., Shestak Yu.G., Lavrova T.V. and Haneklaus N. (2021), "Uranium Sorption from Radioactive Waste of Uranium Ore Processing at Pridneprovsk Chemical Plant", *Geo-Technical Mechanics*, no. 157, pp. 212-223. <https://doi.org/10.15407/geotm2021.157.212>

#### About authors

**Korovin Vadym Yuriiovych**, Ph.D. (Chem.), Head of Laboratory of New Technologies for Raw and Industrial Waste Processing, Department of Elastomeric Component Mechanics in Mining Machines, Institute of Geotechnical Mechanics named by N. Poljakov of National Academy of Sciences of Ukraine (IGTM NAS of Ukraine), Dnipro, Ukraine, [sorbent2005@ukr.net](mailto:sorbent2005@ukr.net)

**Pohorielov Yurii Mykolaiovych**, Senior Researcher at Sorbent Scientific and Pedagogic Center, Dniprovsk State Technical University (DGTU), Kamianske, Ukraine, [yura50\\_11\\_08@ukr.net](mailto:yura50_11_08@ukr.net)

**Shestak Yurii Hryhorovych**, Senior Engineer in Laboratory of New Technologies for Raw and Industrial Waste Processing, Department of Elastomeric Component Mechanics in Mining Machines, Institute of Geotechnical Mechanics named by N. Poljakov of National Academy of Sciences of Ukraine (IGTM NAS of Ukraine), Dnipro, Ukraine, [or-numiz@ukr.net](mailto:or-numiz@ukr.net)

**Valiaiev Oleksandr Mykhailovych**, Engineer in Laboratory of New Technologies for Raw and Industrial Waste Processing, Department of Elastomeric Component Mechanics in Mining Machines, Institute of Geotechnical Mechanics named by N. Poljakov of National Academy of Sciences of Ukraine (IGTM NAS of Ukraine), Dnipro, Ukraine, [alexandr.valyaev@gmail.com](mailto:alexandr.valyaev@gmail.com)

### ДОСЛІДЖЕННЯ ВПЛИВУ ВМІСТУ ФТОРИД-ІОНУ ТА СУЛЬФАТНОЇ КИСЛОТИ У РОЗЧИНІ ДЛЯ ВИЛУГОВУВАННЯ НА ЗМЕНШЕННЯ МАСИ ГРАНІТУ

*Коровін В.Ю., Погорєлов Ю.М., Шестак Ю.Г., Валяєв О.М.*

**Анотація:** В роботі представлені результати щодо впливу початкової концентрації фторид-іону та сульфатної кислоти у розчині для вилугування на зменшення маси граніту Орільського спеціалізованого кар'єру. Зниження маси зразків граніту вимірювали на аналітичних вагах після фільтрації, промивання та висушування при температурі 105 0С до постійної маси. Концентрацію фторид-іону визначали за допомогою фтор-селективного електроду відносно насиченого хлор-срібного електроду, кислотність розчинів вимірювали титриметрично. Досліджено зменшення маси зразку граніту фракції -2,0 + 1,0 мм у статичних умовах в залежності від концентрації сульфатної кислоти в діапазоні від 18,8 до 76,6 г/дм<sup>3</sup> та часу витримки 7, 14 та 21 діб. Визначено, що розчин сульфатної кислоти призводить до зменшення маси зразку граніту від 1,65 до 3,18 % в залежності від концентрації кислоти та часу витримки зразків. Проведене дослідження щодо впливу концентрації фторид-іону на зменшення маси зразку граніту в залежності від концентрації фторид-іону в діапазоні від 3,25×10<sup>-2</sup> г/дм<sup>3</sup> до 5,00×10<sup>-1</sup> г/дм<sup>3</sup>, а також концентрації сульфатної кислоти в межах 18,8–76,6 г/дм<sup>3</sup> та часу витримки 7, 14, 21 діб. Визначено, що при концентрації сульфатної кислоти в межах 18,8–37,7 г/дм<sup>3</sup> вплив концентрації фторид-іону на зменшення маси зразку має екстремальний характер з максимальними значеннями в діапазоні 0,3–0,5 г/дм<sup>3</sup>, а при концентрації сульфатної кислоти 76,6 г/дм<sup>3</sup>

зменшення маси зростає пропорційно концентрації фторид-іону. Наведені дані щодо зменшення вмісту фторид-іону від часу витримки, концентрації фторид-іону та концентрації сульфатної кислоти. Зміна концентрації фторид-іону неоднозначно залежить від часу витримки, початкової концентрації фторид-іону та сульфатної кислоти, та призводить навіть до її збільшення, що, вірогідно, пов'язано з розчиненням фторид-вмісних мінералів (слюда, флюорит та ін.) у зразках.

**Ключові слова:** граніт, біфторид амонію, сульфатна кислота, зменшення маси, фторид-іон.

*The manuscript was submitted 15.02.2022*