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Research Article

GEOCHEMICAL FACTORS OF GOLD-BEARING BRINES FORMATION

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ABSTRACT
Despite the relatively small range of pH fluctuations in natural waters, changes in the concentration of hydrogen ions have a significant effect on chemical equilibria and the rate of reactions. Among the factors effects high concentration of microelements in underground waters of Bukhara-Karshi artesian basin (in particular iodine, bromine, lithium, rubidium and including gold) apart geological and hydrogeological/ techtonical and paleogeological conditions (influencing forming industrial waters in this region) there are also geochemical conditions (including pH and Eh).

INTRODUCTION
Results of Application of Estimation Method
By gold-bearing brines, we mean industrial waters, in which the concentration of gold is equal or higher than 1 µg / l (that is, the amount at which its extraction from groundwater is profitable). It is well known from literary sources that the geochemical situation of groundwater, in addition to temperature, pressure, the presence of certain components, the chemical composition of water-containing rocks and the waters themselves, depends on pH and Eh. (Kraynov *et al.*, 1992).
The pH values can vary widely (0 ÷ 14-16), but for natural waters they range from 6 to 8, which indicates that the reactions of aqueous media are close to neutral. This is quite understandable and explicable, since aquatic environments, like thermal solutions, are flexible mobile fluids that continuously interact with each other and host rocks. Naturally, the neutralization reaction should be very widespread, which affects the ratio of the concentrations of H and OH ions in aqueous solutions. Obviously, this can explain the fact that the pH value in natural waters is usually not very different from the neutral reaction (Baikonurov, No Date). In addition, it is known from general chemistry that every reaction always tends to equilibrium.
Despite the relatively insignificant range of pH fluctuations in natural waters, the change in the concentration of hydrogen ions has a huge impact on chemical equilibria and the rate of reactions. It has been defined that, depending on the chemical nature of the elements, salts of some metals at given pH values can be held in water, while salts of others (at the same pH values) are decomposed with precipitation of insoluble hydroxides.
For example, it is characteristically that $Fe(OH)_3$, $Sn(OH)_4$, $Mg(OH)_2$, $Al(OH)_3$hydroxides released from solutions at relatively low temperatures, with an increase in the latter are precipitated as Fe_2O_3, SnO_2, MgO, $Al_2O_3Fe_2O_3$oxides, $Fe_2(SO_4)_3$ferric sulfate can be in solution only under the condition that the pH of the aqueous medium is less than three (i.e., under very acidic conditions). But, if the solution becomes less acidic (or even more alkaline), then this compound undergoes hydrolysis with the formation of hard-soluble iron hydroxide: $Fe_2(SO_4)_3 + 6\ H_2O = 2\ Fe(OH)_3 + 3\ H_2SO_4$
Soluble salts of divalent copper ($CuSO_4$) with a pH of solutions less than seven do not precipitate out of them at all; precipitation can occur only in a neutral or alkaline medium in the form of hydroxyl-containing salts (malachite, azurite, etc.).
Thus, the role played by the aquatic environment (including the indicator as pH) is important in studying the issues of migration of individual components in the aquatic environment, since “the overwhelming mass of chemical reactions in deposits of hydrothermal origin proceeded, apparently, in weakly alkaline or neutral " (Baikonurov. No Date).

The dependence of the pH value on the ambient temperature can be illustrated by the following example: if at T = 18 ° C, the pH is 7.07, then at T = 200 ° C, this value decreases to 5.7, i.e. media from neutral becomes acidic. This is an important point, since the conditions of migration and deposition of one or another element depend on it (Baikonurov, No Date).
The redox potential of Eh plays an equally important role in the study of the geochemical conditions of migration and / or deposition of elements. It reflects not only chemical reactions in the medium itself, but also determines the conditions of interaction between water-bearing rocks and water (which migrates through them), the interaction of elements with each other, as well as changes in geochemical conditions in which exchange, dissolution, migration and / or precipitation reactions items. Zvjagintsev (1941) noted that following reagents act on metallic gold: chlorine, bromine, iodine, aqua regia, acids in the presence of oxidizing agents, etc.

MATERIALS AND METHODS

Research Method

Thus, it can be stated with confidence that groundwater containing bromine and iodine, in one way or another, is involved in the process of transition of gold into an aqueous solution and in the series of elements affecting gold, they are in the first place.
Each element has a certain redox potential, which to some extent characterizes the chemical activity of the element. From this it follows that both of these elements are chemically active, which promotes the leaching of gold.
When conducting experimental geotechnological studies on the leaching of gold from refractory ores, to determine the possibility of iodide leaching technology, it was defined that for the technological iodine solution this index varies from 538 to 556 mV, and bromine from 986 to 1028 mV. The raw materials for research were gold-bearing oxidized ores from poor-sulphide deposits.
The ores of the Perovoye deposit, according to the data of material analysis, are classified as poor sulphide and contain quartz - 47%; carbonates - 26%; sericite, muscovite ~ 10%; plagioclase - 8%; pyrite ~ 2%; biotite - 1%. The main part of gold is in a fine-dispersed, pulverized, native form, its greatest content is noted in quartz and rocks enriched in quartz. The average gold grade in the ore is 3.86 g / t. According to rational analysis, 94% of gold is in the form of free metal grains of 3.63 g / t; 3.10% associated with sulfides (pyrite, arsenopyrite, 0.12 g / t); 1.81% with carbonates and hydroxides Fe^{+2} and Mg^{+2} 0.07 g / t; 1.04% finely disseminated in acid-insoluble minerals (0.04 g / t) (Akhmedov, 1988).

RESULTS AND DISCUSSION

Results of Application of Estimation Method

For laboratory testing, the ores from this deposit were not ground, i.e. one of the main technological cycles for the preparation of ore for leaching. The experiments were carried out in a statistical mode without constant stirring at room temperature (about 24 ° C). Nevertheless, the experiments recorded the leaching of gold, the results of which are given in Tables 1.

Table 1: Influence of pH solution on gold extraction in iodine-iodide solution from ore of the first deposit

<table>
<tr><th rowspan="4">Experiment number</th><th rowspan="4">Period, hours</th><th rowspan="4">pH solution</th><th colspan="8">Leacheate</th></tr>
<tr><th colspan="4">Fixed residue</th><th colspan="4">Solution</th></tr>
<tr><th rowspan="2">Weight, g</th><th colspan="3">Au</th><th rowspan="2">Volume. dm^3</th><th colspan="3">Au</th></tr>
<tr><th>г/т</th><th>мг</th><th>%</th><th>мг/л</th><th>мг</th><th>%</th></tr>
<tr><td>1</td><td>2</td><td rowspan="2">8.0</td><td>49.1</td><td>3.9</td><td>0.191</td><td>96.0</td><td>0.5</td><td>0.015</td><td>0.0075</td><td>3.77</td></tr>
<tr><td>2</td><td>4</td><td>49.5</td><td>3.7</td><td>0.183</td><td>92.0</td><td>0.5</td><td>0.020</td><td>0.010</td><td>5.03</td></tr>
</table>

3	12		49.7	2.3	0.114	57.44	0.5	0.085	0.0425	21.36
4	24		49.1	2.9	0.142	71.55	0.5	0.075	0.0375	18.84
5	2	2.5	48.3	1.8	0.0869	43.68	0.5	0.03	0.015	7.54
6	4		48.5	1.6	0.0776	38.99	0.5	0.08	0.040	20.1
7	12		47.7	2.6	0.124	62.31	0.5	0.02	0.010	5.03
8	24		47.1	3.8	0.179	89.94	0.5	0.055	0.0275	13.82

Note: ore loading 50 g; fraction +1.5 mm; Au content is 3.98 g / t - 0.199 mg; volume of solution is 500 ml; the content in the solution of iodide ion 12.3 g / l; the specific consumption of iodine ion is 6.15 g / 0.199 mg = 30.9 g / g Au.

Thus, according to the results of experiments, obtained in pH ranges of 2.5 and 8.0, with a leaching duration of 2 to 24 hours (coarse grinding of raw materials and without mixing and heating of the pulp), despite repeated overestimation of iodine consumption (in 30.9: 2.58 ≈ 12 times) it can be seen that gold recovery does not exceed 21%. Analyzes of alkaline leaching solutions reflect a slight increase in the extraction of gold in the solution over time up to 12 hours (21.36%) and a decrease in this indicator with a 24-hour holding process (18.84%). In an acidic environment, the trend is reversed: at the beginning of the process, an increase in extraction to 20.1% is observed in 4 hours, and over time to 12 hours, this indicator decreases to 5.03%. The low recovery of gold into the solution is primarily due to the large grain size of the raw material used in the experiments (grain size exceeded 1.5 mm), which is unacceptable due to the fact that, as shown above, the bulk of gold (about 94%) is in ore in fine, pulverized, native form as a part of rock-forming minerals.

The results of the leaching of gold from the oxidized low-sulphide ores of the second deposit (with a gold grade of 1.08 g / t), carried out by the same method with an iodine solution, are given in Table 2.

Table 2: The influence of correlation process time, solid to liquid ratioand primary pH solution on gold extractionin solution from ore of Kumtosh deposit fracture +1.5mm

Experiment number	Period, hours	Solid to liquid ratio	pH solution	After leaching							
				Fixed residue				Solution			
				Вес, г	Au, г/т	Au, мг	Au, %	Объем, $дм^3$	Au. мг/л	Au, мг	Au, %
1	2	1:10	8.0	49.2	1.2	0.059	84.2	500	0.10	0.050	71.4
2	4			49.4	1.3	0.064	91.7	500	0.09	0.045	64.3
3	24			49.5	0.62	0.031	43.8	500	0.14	0.070	100
4	2	1:3		49.1	1.4	0.0687	98.2	150	0.52	0.078	>100
5	4			47.6	1.7	0.081	>100	150	0.21	0.315	45.0
6	24			49.1	0.92	0.045	64.3	150	0.39	0.059	83.6
7	2	1:10	2.5	48.2	2.2	0.106	>100	500	0.08	0.040	57.1
8	4			48.4	1.0	0.048	69.1	500	0.09	0.045	64.3
9	24			47.8	0.57	0.027	38.9	500	0.14	0.070	100
10	2	1:3		47.1	2.2	0.104	>100	150	0.37	0.056	79.3
11	4			48.0	1.4	0.067	96.0	150	0.36	0.054	77.1
12	24			48.3	1.3	0.063	89.7	150	0.50	0.075	100

Note. Loading of ore 50 g; fracture +1.5mm; content Au 1,40 g/t –0.070 mg; solution volume 500 ml; content in solution of iodide-ion 12.3 g/l; specific charge of iodine-ion 6.15 г/0.070mg=87.9 g/g Au.

Thus, the results of experiments and assay analysis of solid residues show that in almost all cases gold remains in solid residues. The exception is experiment 3, where for 24 hours at solid to liquid ratio = 1:10, pH = 8.0, in the solid product 43.8% gold; under the same conditions, but at solid to liquid ratio = 1: 3 (experiment 6) 64.3%. The best result was obtained in experiment 9, where in 24 hours, solid to liquid ratio = 1: 10, pH = 2.5, the residual metal content is 38.9%.

As can be seen from the results of the experiments, the iodine-iodide method of leaching gold from oxidized raw materials in the indicated technological mode in the degree of gold leaching does not exceed 61.1% (experiment 9, according to the analysis of the solid residue). Similar results with the use of iodine as a non-toxic gold leachant were obtained in (Baikonurov, No Date; Krylova and Ibragimova 2003, Krylova and Sedelnikov 2003).

Despite the low percentage of leaching, these data indirectly confirm the fact that the presence of iodine and bromine in the underground brines of the Bukhara-Karshi artesian basin plays a certain role in the leaching of gold from aquifers, oil (of different composition) and its transition to solutions.

The presence of iodine and bromine in the groundwater of the Bukhara-Karshi artesian basin is evidenced by numerous works devoted to the study of this problem, as well as the monograph by Bakiev (2012), one of the last summarizing the results of many years of research. The factors contributing to the high concentration of microelements in the groundwater of the Bukhara-Karshi artesian basin, and in particular iodine and bromine, are well described in the works of Ibragimov *et al.*, (1990**)** and Bakiev (1955).Where they are considered in detail geological, hydrogeological and tectonic and paleogeological conditions of the above-mentioned basin, contributing to the formation of industrial waters in this region

Thus, the gold content in the associated groundwater, discharged after the separation of hydrocarbon raw materials, is several times higher than its concentration, at which its extraction is profitable.

CONCLUSION

Thus, from here it is again possible to conclude that the pH and Eh indicators play an important role in the dissolution and / or precipitation of individual elements that migrate in underground brines.

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