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ENRICHMENT IN A HYDROCONCENTRATOR

Annotation. The technological study of gold-bearing ores consists mainly of analysis and experiments necessary to determine the material composition of ores and the technology for extracting precious metals and other valuable components from them.

The ultimate goal of the study is to develop a technology for the maximum recovery of all commercially valuable components from economically viable ores while meeting safety requirements. Technological study of gold ores mainly consists of analysis and experiments necessary to determine the composition of the material. ores and technology for extracting precious ores, metals and other valuable components from them [1].

The ultimate goal of the study is to develop a technology to maximize the recovery of all commercially valuable components from economically viable ores while meeting safety requirements. The object of research is the Vasilkovskoye field.

The enrichment process is a single system in which the individual elements are interconnected. High results can be achieved only taking into account a systematic approach that takes into account the interaction of system elements, i.e. in this case, the whole complex of processes.

Keywords: ore, beneficiation, scheme, crushing, crushing, screening, classification.

The schemes and modes of concentration of gold-bearing ores depend significantly on their mineral composition, destruction, presence or absence of impurities that complicate the extraction of gold, as well as on the size of gold particles.

Research of gold-bearing ores at the stage of preliminary exploration is carried out, as a rule, on a laboratory scale. The developed technological schemes are checked by carrying out enlarged laboratory experiments in a closed loop.

Technological research is also carried out in the course of operational exploration. The obtained information about the material composition and technological properties of ores is used for operational quality control of raw materials sent to the factory and planning of processing results. At enterprises and institutes, research is carried out in order to improve the performance of ore processing at operating factories (reducing the loss of gold and other recoverable elements, improving the quality of concentrates, increasing the complexity of the use of raw materials, etc.). For this, new concentration and hydrometallurgical methods, more advanced schemes and treatment modes, new reagents and apparatuses are tested. Research is carried out both in laboratory and on a semi-industrial and industrial scale.

Despite the wide variety of technological studies, almost all of them are carried out in the following sequence:

1) familiarity with the relevant literature and reporting data;
2) sampling at a field or at a factory;
3) preparation of samples for research;
4) study of the material composition of ores;
5) technological experiments in the laboratory;
6) verification and refinement of the results obtained in the laboratory at semi-industrial continuously operating installations, experimental and industrial factories;
7) technical and economic assessment of work results and drawing up a report [3,7].

However, knowledge of traditional research methods does not yet guarantee success in technological research of gold and silver-bearing ores. The exceptional variety of ore material composition, different geographic and economic conditions of the deposit area, constantly increasing environmental requirements make each technological study unique and difficult. The object of research is often ores that have no analogues either among those processed by industry, or among those studied in laboratory conditions. There are frequent cases when a positive technological assessment of ores is possible only with the use of new processing methods. Certain difficulties arise in the study of foreign ores. Therefore, one of the indispensable conditions for creating an effective technology for processing gold and silver-containing ores is the creative attitude of performers to technological research.

The tasks of the integrated use of raw materials, the development of the processing of rare-metal ores necessitate the search for new effective methods to increase the extraction. Similar work is being carried out abroad. [6] Gravity beneficiation usually precedes flotation or cyanidation and is intended for those gold and silver particles that are not recoverable or are difficult to recover by these methods. These particles primarily include large particles of native metals. In recent years, the feasibility of gravitational extraction of small particles of gold and silver, especially those with surface coatings, has been proven.

The most common gravitational apparatus in gold recovery factories is a jigging machine; less often they use locks, drum (tube) concentrators, screw separators, concentration tables, short-cone hydrocyclones and a number of other devices. In some cases, for gold- or silver-bearing ores, concentration in heavy suspensions is effective. Technological processes for the production of gold have been improved over many centuries. Methods such as washing sand, disintegration by hand in stone mortars, millstones have been known since ancient times. Enrichment was carried out on primitive gutters, and gold was captured on the skins of wild animals.

Modern technology for processing gold-bearing ores includes two main stages: beneficiation and metallurgy. When enrichment, a combination of sequential technological operations is used: crushing, screening, crushing, disintegration and washing (for placers). gravity, flotation. Metallurgical processing of ores and concentrates includes cyanidation processes (or other leaching methods), amalgamation, roasting, smelting, sorption methods for extracting gold from pulp and solutions, extraction methods for concentrating gold from leaching solutions, precipitation of gold from solutions with reducing agents (cementation), electrolysis gold and leaching of difficult forms of gold and refining production [9,10].

In recent years, a typification of the ores of the deposits has been carried out, taking into account the technological factors of gold extraction. The classification is based on the separation of ores according to the size of the extracted gold: very coarse more than 0.3 mm finely dispersed less than 10 microns. The characteristics of the geometric forms of gold have been determined: isometric, lamellar, scaly, stick, indefinite, dendroid, crystalline. The concepts of surface cleanliness are highlighted: clean, partially covered with a film and with a continuous film. The boundaries of the persistence of mineral raw materials are indicated, when gold is considered difficult to recover: finely dispersed gold; in sulfides; antimony gold; arsenic gold; gold associated with clay and carbonaceous matter.

The processing of gold-bearing raw materials at all historical stages of the development of gold production was determined by: the presence in the ores of accompanying useful components of industrial importance; the content of oxidized and sulphide minerals in ores; the presence of components that complicate the processing technology; phase composition and size of gold particles [11, 13].

The main raw materials for gold production are:

- gold ores and placers;
- non-ferrous metal ores and polymetallic mineral raw materials;
- secondary raw materials (industrial and household scrap, waste);
- technogenic raw materials.

For the extraction of free gold, gravitational methods of concentration are used both from ore and from the products of its processing (tailings, cyanidation, cinders), using various gravitational devices for this. Until the 80s of the _XX century. For the extraction of free gold, gravity was very often combined with amalgamation, but since the 80s in Russia, the use of amalgamation has been prohibited by law. Flotation methods are commonly used to recover gold from refractory and complex ores, complex ores and sulfide ores.

When processing gold-bearing refractory ores of the Vasilkovskoye deposits, the gravitational enrichment method is used. The ores are resistant to arsenic (arsenopyrite) and finely dispersed gold, a significant part of which is associated with both sulfides (mainly arsenopyrite) and rock-forming minerals. The most effective apparatus for the extraction of gold and heavy minerals is currently the jigging and enrichment of concentration tables and a centrifugal concentrator, which is used abroad - in Canada, the USA, Russia and other countries with a developed mining industry.

Evaluation of the gravitational concentration of coarse-crushed ore (up to 40-60mm) performed using fractional analysis revealed the possibility of separating the ore into heavy and light fractions. In the heavy fraction with a density of +2900 kg / m3 at a yield of 10.2%, up to 25% of all gold is extracted and up to 45% of sulfur and arsenic in the heavy fraction, in comparison with ore, is enriched in gold 2.4 times in sulfur and arsenic in 4.8 times. The results of gravitational enrichment methods (on a screw separator, a jigging machine, a concentration table) are shown in Tables 1-3.

Table 1. **Results of enrichment experiments on a screw separator**

Products	Output		Gold content, g / t	Gold weight, g	Distribution%
	g	%			
1 concentrate	43.0	2.15	21.5	0.4622	13.39
2 concentrate	65.0	3.15	7,6	0.2470	7.15
Tails	1892.0	94.6	2.9	2.7434	79.46
Ore	2000	100	3.5	3.4526	100

Table 2. **Results of dressing experiments on a jigging machine**

Products	Output		Gold content, g / t	Gold weight, g	Distribution%
	g	%			
1 concentrate	32	1.6	77	0.1232	5.76
2 concentrate	51	2.55	5.7	0.1454	6.8
Tails	1917	95.85	1.95	1.8690	87.44
Ore	2000	100	2.3	2.1376	100

Table 3. **Results of enrichment experiments on a concentration table**

Products	Output		Gold content, g / t	Gold weight, g	Distribution%
	g	%			
1 concentrate	29.0	1.45	11	0.1595	4.57
2 concentrate	48.0	2.4	4.5	0.1080	3.1
Tails	1923	96.15	3.35	3.2210	92.33
Ore	2000	100	3.5	3.4885	100

Studies have established the following: the gold extracted from the concentration products of the free particle has a size ranging from 10 to 50 microns, and the main part has a size less than 20 microns, this indicates that the bulk of the studied ore is very finely dispersed. In a series of initial jigging experiments, there was a desire to obtain richer gravity concentrates at a lower yield, which was achieved by increasing the pulsation frequency and reducing the stroke of the diaphragm. The resulting primary concentrates were cleaned twice on a concentration table. In these experiments, the table concentrate yield was maintained at the level of 0.9-1.1%. The following results were obtained, shown in table 4.

Table 4. **Results of experiments on jigging and cleaning on a concentration table.**

No. of experiments	Yield of primary concentrate by jigging,%	The output of the cleaned concentrate,%	Gold content, g / t		Recovery of gold into concentrate,%
			In ore	In concentrate	
1	6.3	0.97	9.6	108	11.10
2	4.17	1.5	2.4	21.4	13.43
3	5.25	1.32	3.8	24.5	11.43

The results of the experiments, given in Table 4, were obtained at a diaphragm oscillation frequency of 295 per minute, a water flow rate of 5.22 dm3 / min and a diaphragm stroke of 10 mm. To improve the yield of the primary concentrate, the jigging mode was changed:
-the frequency of oscillations of the diaphragm is 224 per minute;
- aperture travel 6 and 4mm;

The water consumption is left unchanged. The refining operation was performed on a concentration table.

We also studied the concentration in centrifugal concentrators used for processing coarse-grained sands in the exploration of gold-bearing placer deposits [14, 19]. In recent years, centrifugal concentrators such as centrifuges have been recommended for use in concentrator schemes for the extraction of fine free gold from various products [16, 19, 22]. In Russia, work on centrifugal concentrators began in the 1950s at the All-Union Research Institute of Gold and Rare Metals (VNII-1) (29). However, the centrifugal separators developed at that time did not find application due to the complexity of the design and low technological parameters.

The following tasks are solved with the help of centrifugal apparatus:
- fine and fine gold lost by other devices is recovered;
- the uniformity of raw materials in terms of size and material composition is achieved;
- the content of the useful component in the raw material increases.

The pioneer of centrifugal separators is the centrifugal separator V.M. Man'kov, A.I. Chernysheva (USSR AS No. 878339, class B03B5 / 32, 1973), in which for the first time in the world the principle of a rotating double-walled conical bowl and with inter-reef water supply through slotted openings is implemented.

Work on the creation of centrifugal apparatuses for capturing fine gold during the enrichment of gold-bearing ores was also carried out in Canada and the USA. Designed by:
Earl J. Young horizontal centrifuges, patented in Canada in 1981 and 1983 (No. 1.110.206 and 1.153.336) and the USA in 1981 and 1982 (4.265.743 and 4.347.130).

Double-wall centrifugal concentrators Falcone by Steve McAlister, tested in the field in British Columbia and patented in 1995 in the US Bureau of Certification No. 5.462.513. The development is based on the McNicol centrifuge, invented in 1935 in Australia.

The currently recommended industrial concentrator is a hemispherical bowl lined with a corrugated rubber insert [26, 25]. The bowl is mounted on a special platform (platform), which receives rotation from an electric motor through a V-belt transmission. The concentrator works periodically. To unload the concentrate captured by the corrugated rubber surface, the bowl is stopped and rinsed.

When working on coarse gold-bearing sands, the concentrator provides a reduction rate of up to 1000 times when recovering gold with a grain size of plus 0.25 mm to 96-98%. The concentrator-centrifuge of continuous operation provides for the unloading of heavy grains settled on the wall of the rotor along spiral grooves upward due to the rotation of the pulp and the imposition of vibrations. The tailings are discharged using a siphon. The performance of such a concentrator is much lower.

A design of a centrifugal separator with periodic unloading of concentrate without stopping the rotation of the bowl has been proposed [25]. The fundamental difference of this design is that the concentrate is discharged through a system of slot-like holes evenly spaced on the side surface of the bowl. In the working position, the holes are closed with an elastic diagram, and when rinsing, they open and the concentrate is automatically discharged from the bowl by centrifugal force and water.

An effective design of centrifugal separators is the RS-400 rotary separator designed for mining drilling exploration samples and finishing sluice concentrates. A distinctive feature of the rotary separator is the provision of complex movement of the bowl with simultaneous rotation around its geometric center.

Attempts to use the RS-400 rotary separator for the processing of lock concentrates at concentrate concentrates have not yielded positive results due to low operational reliability, insufficiently high technological parameters and the inability to control the concentration modes.

Further development of centrifugal separators is the development of P.A. Bragin with employees of centrifugal-vivid concentrators, which provide an increase in the efficiency of material separation by creating a fluidized bed of material in a rotating conical bowl. Industrial designs of concentrators TsVK-460, TsVK-500, TsVK-900 and TsVK-1000 have been developed. Centrifugal concentrators of the company Nelson Concentrate (Knelson) are considered to be among the most advanced ones. They are available in a wide range of models with working body diameters from 3 "to 48". The productivity of the apparatuses is from several kg / h to 90 t / h [25, 26].

The fundamental difference between Knelson concentrators from other centrifugal concentrators is that in a weakly conical rotor, the settled mineral bed is additionally loosened with water supplied through perforations in the side wall of the rotor. These concentrators form the backbone of the intensive gravity technology offered by Intertech Corporation in mineral processing. The prospects for their use are associated with the processing of technogenic raw materials. This is evidenced by the results of the operation of concentrators at OJSC Norilsk Mining Company when extracting platinoids from various man-made materials and encouraging results of tests of concentrators at one of the dredges in Russia.

There are many more alternative installations, centrifuges "Itomak", Knudsen and Neff, jigging machines Gekko, "Goldfield", as well as concentrators Orokon, rotary separators, centrifugal-vibration concentrators of the "Grant" company (Naro-Fominsk, Russia), centrifugal devices with floating bed (Titan-TsKPP), concentrators A.B. Leitis, OKTB "Rotor", centrifugal-bubbling concentrator IRGIREDMET and centrifugal-jigging machines of SKB "GOM" and others.

Known centrifugal separator of the Tula plant "Rotor". Separator of JSC "Rotor" with a bowl diameter of 630 mm, made of ordinary ferrous metal, tested at the Gaiskaya concentrating plant on the sands of a short-cone hydrocyclone after removing the metal scrap. High efficiency of the separator and the possibility of obtaining a coarse concentrate containing up to 85 g / t of gold have been shown. The further development of this separator was the manufacture of a bowl from polyurethane and the improvement of the system for automatic regulation of feed and concentrate discharge.

The Krasnoyarsk State Academy of Nonferrous Metals and Gold has developed the KITsM centrifugal apparatus. This apparatus is distinguished by the centrifugal method of loosening the material layer. The cylindrical part of the rotor is made of an elastic material-tire, which is deformed by rollers for periodic even loosening of the material. There is a high extraction of fine (less than 0.04 mm) particles of noble metals.

The first Kazakhstan samples of laboratory (with a capacity of 500-1000 kg / hour for solid) centrifugal apparatus were manufactured in 1992 (CRITS "NTK", Stepnogorsk).

In 1993-1994. tests of laboratory samples of devices for enrichment of gold ores were carried out in the operating mode of the factories of NJSC "Altynalmas" - mines Aksu, Bestube, Zholymbet, AKbakai.

Centrifugal apparatus (the Kazakh version of the AGK aero hydroconcentrators) is a type of centrifuge, when in centrifugal fields in liquid or air-liquid media there is a separation of minerals by specific gravity. By the way, air at high pressures behaves like a liquid. Since the chemical composition and internal structure of minerals remain unchanged, this type of gravitational enrichment is usually called mechanical processing of minerals.

The first, like all subsequent ones, prototypes of Kazakhstani centrifugal apparatuses were developed, manufactured and tested in Stepnogorsk, Akmola region in the Kazakh-Russian engineering center "New Technologies to Kazakhstan", then in the Stepnogorsk engineering center and now in KRITS NTK LLP.

The disadvantages of existing centrifugal concentrators include the complexity of the design and operation, the need to stabilize the characteristics of the initial feed. The low efficiency of collecting plate-shaped particles in the Knelson centrifugal concentrator is noted. At the same time, the maximum losses of gold are observed in the smallest and largest grain sizes.

Adequate compaction of particles, loosening of the suspension by a counterflow of water (for example, in a Knelson separator) does not provide an increase in the efficiency of separating particles by their density, since this countercurrent carries out small classes of heavy fractions into the tailings.

The inconsistency of data on the use of centrifugal concentrators indicates the need for a more detailed study of this undoubtedly effective separation process. The tasks of improving centrifugal concentrators can be to simplify the design, reduce the metal and energy consumption, and increase the operational reliability of the apparatus.

Determination of geometric dimensions and structural elements of the developed apparatus.

As you know, the main working body of a centrifugal hydroconcentrator is a bowl, in which the process of stratification of the initial material by density is carried out.

The bowl of known hydroconcentrators has the following drawback: the design provides only the movement of the initial material in a mixture with loosening water along the generatrix of the cone and, due to the decomposition of the acting forces on the inclined plane, has an increased speed, and since the inter-reef space is filled with a “bed” (such a surface can be considered practically smooth), then the movement of the mixture approaches laminar, and therefore the stratification of the flow is insufficient. For example, in the case of gravitational concentration of gold-bearing ores, this leads to the fact that fine, dusty, and especially plate-like gold is carried away with the flow into the tailings.

In the apparatus we are developing, this drawback is eliminated by the fact that in the more often a hydroconcentrator containing a working surface in the form of a truncated conical surface with a downward-oriented cone top, on the inner side of which there are corrugated walls with holes evenly spaced along the circumference of each riffle, the working surface is made prefabricated and consisting of successively alternating from bottom to top cylindrical, conical and cylindrical surfaces, while the ratio of the diameters of the upper and lower cylinders of the working surface is 1.2 ... ... 1.5, the ratio of the height of the upper and lower cylinders of the working surface is 1.2 ... ... 1.5, and the ratio between the diameter of the upper cylinder of the working surface and the height of the bowl is 1.4 ... 1.5**.**

Experimental studies have established the optimal ratios between the structural elements of the bowl, which may vary slightly depending on the type of ore to be concentrated.

Optimum design parameters of the bowl:

1) The ratio of the diameters of the upper D3 and lower D1 cylinders D3 / D1 = 1.2 ... ... 1.5;

2) The ratio of the heights of the upper H3 and lower H1 cylinders H3 / H1 = 1.1 ... ... 1.15;

3) The ratio between the diameter of the upper cylinder D3 of the working surface and the height of the bowl Nchash: D3 / Nchashi = 1.4 ... .1.5;

4) Angle of opening of the cone: α = 130… ..200;
5) Number of holes Ø1.5 mm per 1 m of area: 2000 …… .2500 pcs;
6) Specific water consumption (m3) per 1 ton of dry material: 1.0… .1.5 m3
7) Centrifugal acceleration on the upper cylinder: 70… .95.
Figure 1 shows the developed centrifugal hydroconcentrator.

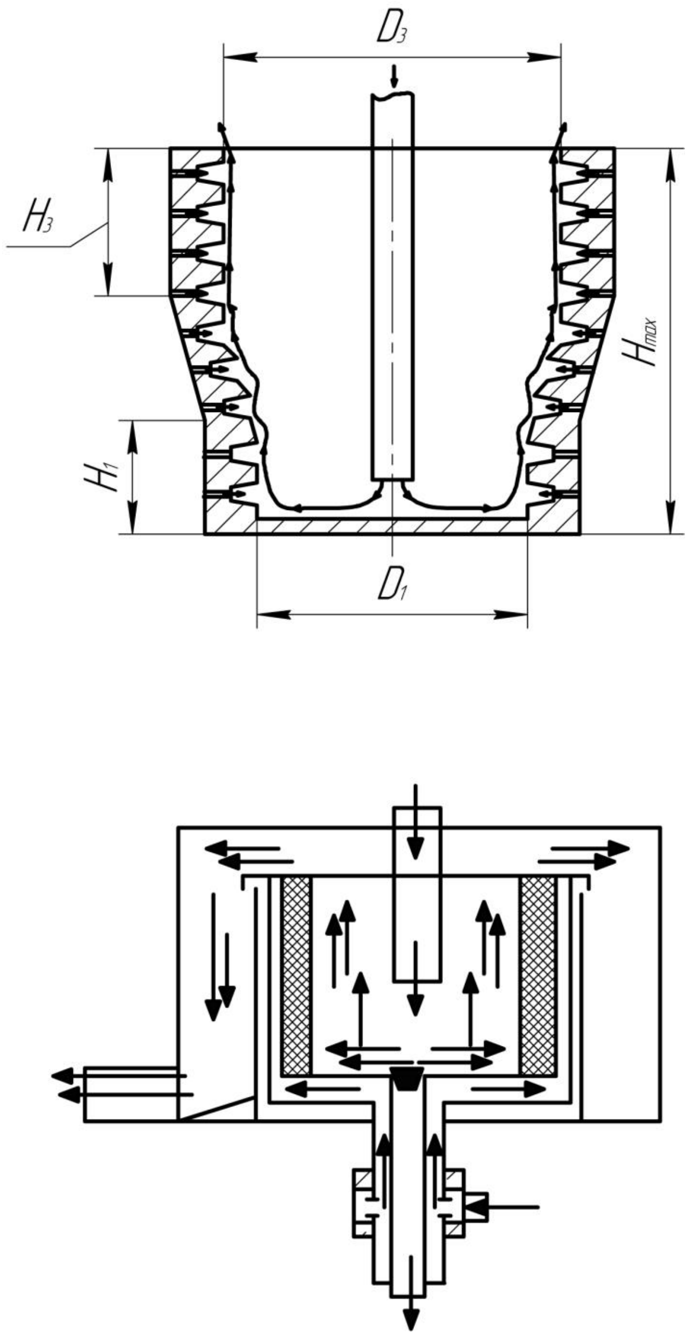

Figure 1. Centrifugal hydro concentrator

The centrifugal concentration of the separated minerals according to their density is accompanied by an internal supply of turbulizing water in the bowl of the hydroconcentrator.

The results of the study on gravity concentration in this apparatus in comparison with the used in production the "Knelson" concentrator are shown in Table 5.

Table 5. **Results of gravitational concentration of gold-bearing ores on centrifugal hydroconcentrators (Kazakhstan and Knelson.**

Fortification products	Kazakhstan hydroconcentrator				Hub and Knelson			
	Weight, kg	Output. %	Content Au,%	Extraction of Au,%	Weight, kg	Output %	Content Au,%	Extraction of Au,%
Akbakay Gold Plant. Table concentrate (13.2 g / t Au)								
Concentrate	0.7	0.40	2391.0	72.2	0.95	0.92	1001.3	69.69
Tails	174.3	99.6	3.7	27.8	102.01	99.08	4.04	30.31
Food	175.0	100	13.2	100	102.96	100	13.2	100
Akbakay Gold Refinery, stagnant tailings (2.1 g / t Au)								
Concentrate	0.84	2.1	20.6	20.6	0.73	0.9	42.2	18.3
Tails	39.16	97.9	1.7	79.4	81.36	99.1	1.73	81.7
Food	40.0	100	2.1	100	82.09	100	2.1	100
Aksu gold mine, current flotation tailings (0.85 g / t Au)								
Concentrate	0.97	0.27	16.3	5.2	0.13	0.05	14.2	1.54
Tails	364.03	99.730.894.8	0.8	94.8	249.87	99.95	0.65	98.46
Food								
Weathered crust gold ore								
Concentrate	0.96	0.8	283.5	56.7	-	-	-	-
Tails	119.04	99.2	1.75	43.3	-	-	-	-
Food	120.0	100	4.0	100	-	-	-	-

Due to the high intensity of the centrifugal field and the counteraction of the flow of fluidizing water, productivity is significantly increased and the capture of gold particles up to several microns in size is ensured, increasing the efficiency of the process. Compared to other devices, this separator consumes 5 times less energy, is environmentally friendly and ensures the production of concentrates with a higher content of the component. Separators are used to recover gold and silver of all forms - free and in intergrowths with sulfides. An important factor - hydroconcentrators can be used in modular installations for enrichment of gold ores of low-volume deposits. These installations are mobile and do not require large capital expenditures; they can be quickly assembled and dismantled.

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ГИДРОКОНЦЕНТРАТОРДАҒЫ БАЙЫТУ

Аннотация. Құрамында алтын бар кендерді технологиялық зерттеу негізінен кендердің материалдық құрамын және олардан бағалы металдар мен басқа да бағалы компоненттерді бөліп алу технологиясын анықтауға қажетті талдаулар мен эксперименттер жүргізуден тұрады.

Зерттеудің түпкі мақсаты - қауіпсіздік талаптарын сақтай отырып, экономикалық тиімділігі жоғары кендерден барлық өндірістік құнды компоненттерді максималды алу технологиясын жасау. Алтын құрамы бар кендерді технологиялық зерттеу негізінен материалдың құрамын анықтау үшін қажетті анализдер мен тәжірибелер жүргізуден тұрады. кендер және олардан бағалы кендерді алу технологиясы, металдар мен басқа да бағалы компоненттер.

Зерттеудің түпкі мақсаты - қауіпсіздік талаптарын сақтай отырып, экономикалық тиімділігі жоғары кендерден барлық коммерциялық құнды компоненттерді максималды бөліп алу технологиясын жасау. Васильковское кен орнының зерттеу объектілері болып табылады.

Байыту процесі - бұл жеке элементтер өзара байланысты болатын біртұтас жүйе. Жүйе элементтерінің өзара әрекеттесуін ескеретін жүйелік тәсілді ескере отырып қана жоғары нәтижеге қол жеткізуге болады, яғни бұл жағдайда процестердің толық ауқымы.

Негізгі сөздер: кен, байыту, схема, ұсату, ұсату, елеу, жіктеу.

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ОБОГАЩЕНИЕ В ГИДРОКОНЦЕНТРАТОРЕ

Аннотация. Технологическое изучение золотосодержащих руд состоит в основном из анализа и экспериментов, необходимых для определения вещественного состава руд и технологии извлечения из них драгоценных металлов и других ценных компонентов.

Конечная цель исследования - разработать технологию максимального извлечения всех промышленно ценных компонентов из экономически жизнеспособных руд при соблюдении требований безопасности. Технологическое изучение золотых руд в основном состоит из анализа и экспериментов, необходимых для определения состава материала. руды и технология извлечения из них драгоценных руд, металлов и других ценных компонентов [1].

Конечная цель исследования - разработать технологию максимального извлечения всех коммерчески ценных компонентов из экономически жизнеспособных руд при соблюдении требований безопасности. Объект исследования - Васильковское месторождение.

Процесс обогащения представляет собой единую систему, в которой отдельные элементы взаимосвязаны. Высоких результатов можно достичь только с учетом системного подхода, учитывающего взаимодействие элементов системы, т.е. в данном случае весь комплекс процессов.

Ключевые слова: руда, обогащение, схема, дробление, дробление, грохочение, классификация.