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DETERMINATION OF TECHNOLOGICAL SCHEMES FOR EXTRACTION OF GOLD FROM ORES OF THE GYZYLBULAG DEPOSIT AND THEIR PRACTICAL IMPORTANCE

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ABSTRACT
This article is devoted to the study and determination of optimal process flow charts for gold extraction from the Gyzylbulag deposit ores, as well as to the analysis of their practical significance in the context of modern mining production. In the context of growing demand for gold and resource limitations, it is important to develop effective methods that not only increase the extraction rate, but also minimize the environmental impact and economic costs.The article considers the features of the ore composition of the Gyzylbulag deposit, their mineral and chemical composition, which play a key role in choosing the appropriate extraction technology. The authors analyze in detail the efficiency of traditional methods, such as gravity concentration, for processing these ores, considering each of them in terms of extraction rate. Particular attention is paid to the integration of various methods into a single process flow chart, which allows to increase the overall gold extraction rate and reduce losses of the precious metal at all stages of processing. The practical significance of the results lies in the proposal of processing schemes that can be applied not only at the Gyzylbulag deposit, but also in other regions with similar geological conditions. These schemes are aimed at optimizing gold extraction while reducing production costs and environmental impact, which meets the objectives of sustainable development in the mining industry. The article is addressed to specialists in the field of mineral processing, researchers and practitioners involved in the development of effective methods for processing gold-bearing ores.

KEYWORDS:
native gold;
gravity;
gold dimensions;
flotation.

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Introduction.

One of the pressing issues of modern geological science is the typomorphism of native gold, which has not received sufficient attention for a long time.

Recently, in connection with the development of scientific research by N. A. Petrovskaya, A. A. Nikolaeva, R. P. Badalova, A. I. Ginzburg, M. I. Novgorodova, M. M. Konstantinov and other researchers, great progress has been made in this area [1-3].

The importance of studying the problem of typomorphism of native gold [4-6], continues to be relevant today for the creation of a system of knowledge and varying features of gold depending on the genesis, nature of the environment and metallogeny of regions in order to develop new criteria for prospecting and evaluating gold deposits.

Taking into account the above, we have studied some typomorphic features of native gold (granulometric composition, gold-bearing mineral associations and forms of allocation), which allow us to evaluate and determine the most rational technological schemes for their processing, and this will be of great practical importance in the industrial development of this deposit.

The deposit is located in the conjugation zone of the Agdam and Garabagh anticlinoriums of the Lok-Garabach structural-formational zone of the Lesser Caucasus [7, 8].

The geological structure of this deposit includes lava-pyroclastic deposits of andesite-basalt, and to a lesser extent, dacite-rhyolite composition. Rocks of acidic composition fill the caldera of sedimentation in the central part of the volcano-dome structure. Quartz diorites are noted among the intrusive formations at the deposit. The main ore-controlling structure of the deposit is the Gyzylbulag fault of submeridional strike, dipping to the east at an angle of 55-600 [9].

The main hypogene minerals are pyrite, chalcopyrite, and secondary ones are galena, sphalerite, marcasite, melnikovite, pyrrhotite, etc. The following non-metallic minerals are also present: quartz, barite, aragonite. Of the hypergene minerals, iron hydroxides,

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limonite, chalcocite, covellite, malachite, azurite, bornite are common.

The following main types are distinguished at the Gyzylbulag deposit according to textural features: massive, disseminated, veined, veined-disseminated, brecciated, nested and spotted. The most common are hypidiomorphic-granular and allotriomo-phic-granular structures, characteristic of aggregates of pyrite, chalcopyrite and sphalerite. The following mineral associations are distinguished: quartz-pyrite, quartz-pyrite-chalpyrite, quartz-chalcopyrite and quartz-carbonate [6, 10].

The process of gold extraction from ores is a multi-stage operation, during which several technologies are used to separate gold from ore materials. The choice of the process flow chart depends on a number of factors, such as the type of ore, mineralogical composition and gold content in the ore. Let's consider the main methods in more detail.

Gravity extraction is one of the simplest and most cost-effective methods used to extract gold from placer deposits or ores in which gold is present in the form of large particles with high density. This method is based on the principle of the difference in the density of gold particles and waste rock. It is especially effective in processing ores with large gold particles (over 0.5 mm). The advantages of this method include a high degree of gold extraction, low equipment costs and energy consumption.

Flotation is based on differences in the surface properties of minerals, when gold in combination with other minerals is processed using chemical reagents, causing gold-bearing particles to float to the surface with the help of air. Used to extract gold from ores where it is bound to sulfides and other minerals.

Cyanidation is one of the most common methods of extracting gold from ores containing fine particles of gold or chemically bound gold.

Hydrometallurgy includes a number of processes such as amalgamation, where gold is extracted using mercury solutions, and the use of various acids and alkalis to separate gold from ores. Hydrometallurgy also includes technologies that use sulfuric acid solutions or other solvents to extract gold from ores [11, 12].

Pyrometallurgy is used to extract gold from ores containing a lot of sulfur, copper and other impurities. The smelting process allows separating gold from other metals by oxidizing them and forming slags.

The choice of the optimal process flowsheet depends on many factors, including the mineralogical composition of the ore, the gold content, the presence of foreign metals and economic feasibility. Depending on the ore type, a combination of methods may be used, such as flotation before cyanidation or the use of gravity for preliminary enrichment before the main process. Each of these technologies requires preliminary research and testing to select the most effective gold extraction scheme for the specific conditions of the deposit.

The Gyzylbulag gold deposit is one of the largest gold-bearing objects in Azerbaijan. Extraction of gold from the ores of this deposit requires the use of modern and effective technologies, taking into account the specific characteristics of the mineralogical composition of the ores.

Gold-bearing veins have been identified in the mines of the Gyzylbulag deposit, where gold is often found in the form of large particles, which makes gravity methods effective. The use of such technologies allows separating gold from gangue with minimal costs. The advantages of the method include low energy costs and its cost-effectiveness when processing ores with a high gold content [13, 14].

Gold extraction using cyanide solutions is the main method for processing ores with a low gold content and sulphide mineralogy, which is typical for the Gyzylbulag deposit. For ores in which gold is associated with sulphides or other difficult-to-extract minerals, flotation is an effective method. This technology is based on the difference in the surface properties of minerals. When flotation reagents are added, gold and its sulphide compounds float and can be separated from the gangue.

In some cases, such as for gold ores with fine gold particles, hydrometallurgy or amalgamation can be used. These methods are effective for extracting gold from low-grade ores and improve gold recovery from gold-bearing concentrates that can be processed using such schemes.

The correct choice of a process flow chart for gold extraction from the ores of the Gyzylbulag deposit is of great practical importance both in terms of increasing gold recovery and taking into account economic feasibility. The composition of the ores of this deposit requires an integrated approach, which makes it necessary to use several methods of enrichment and processing of gold-bearing materials [15-17].

In addition, the effective use of modern technologies helps to minimize waste, improve environmental safety and reduce processing costs. This is important for the sustainable development of the field in the long term.

The long-term development of deposits, including Gyzylbulag, requires an integrated approach that takes into account both economic and environmental factors. This includes the selection of efficient and sustainable gold recovery technologies, resource management and minimization of environmental impacts. It is important to ensure sustainable resource management. This involves not only gold recovery, but also waste minimization and environmental restoration. For long-term

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development, it is important to use processing methods that reduce the impact on the ecosystem, such as the cycling of water in the process and the recycling of chemical reagents such as cyanides to prevent pollution of water resources.

In the long term, technologies should be used that allow for the most efficient gold recovery with minimal pollution. Continuous updating of the technological base and the introduction of new processing methods, such as hydrometallurgical technologies or the use of new sorbents for gold recovery, can significantly improve the efficiency of recovery, especially when processing low-grade ores.

The development of the deposit must be economically viable in the long term. This includes optimizing the gold recovery process to ensure maximum profitability. For example, the use of gravity concentration and flotation in combination with cyanidation for complex ores can reduce overall processing costs.

Thus, the long-term development of the Gyzylbulag gold deposit will be successful if a balance is achieved between efficient resource recovery, minimizing environmental impacts and maintaining economic sustainability.

Granulometric composition of gold

As a rule, gold enclosed in sulphides is usually fine to finely dispersed; the more sulphides in the ores, the more fine and fine gold they contain. The early stages of the ore process almost always contain fine gold, and the subsequent stages contain coarser gold. Increased gold size is characteristic of areas of ore bodies subjected to post-ore metamorphism with intra-ore rearrangement of matter. The sizes of native gold segregations in nature are very diverse. Most of the gold in rocks is the smallest particles visible only under an electron microscope. Such finely dispersed gold is called invisible, since the particles are smaller than 10 μm (0.01 mm). The sizes of visible gold range from dust-like particles to large segregations several millimetres in size. According to a number of researchers, the average grain size, characteristic of each formation type of ore, has been proposed as a typomorphic feature of gold, which links information about the grain sizes of gold of all size fractions in the form of a single characteristic.

The grain sizes of gold from the ores of the Gyzylbulag deposit were studied based on observations in polished sections and the largest weight of crushed ore samples. It was found that the gold size in polished sections ranges from 0.015 mm to 0.02 mm. Given the low probability of detecting large particles in polished sections, it can be assumed that the given sizes deviate from the average to the smaller side and the average statistical sizes of gold are actually 0.04-0.05 mm (taking into account the data obtained from crushed samples). The size of gold particles extracted from crushed ore samples ranges from 0.1 to 2.0 mm and more. These sizes, of course, are not fully representative, since the smallest particles are not extracted during crushing and washing. The obtained results on the granulometric composition of native gold can be used when choosing a technological scheme for extracting gold from gold-containing ores of the Gyzylbulag deposit.

Gold-bearing mineral associations

In the composition of ores of gold-bearing deposits, multi-temporal mineral associations (parageneses) are established, representing equilibrium groups of minerals that arise in certain narrow physicochemical conditions of the intermittent stage process of ore deposition [18].

Native gold crystallizes at certain moments of ore formation, corresponding to the productive stages of the ore process. In most cases, two or three such stages are established, one of which is the most productive.

At the Gyzylbulag deposit, there are the following stages of mineralization: quartz-pyrite-chalcopyrite, quartz-chalcopyrite and chalcopyrite-sphalerite. All of the named mineral associations are gold-bearing [19-23]. However, the degree of gold content varies. The quartz-chalcopyrite is more productive for gold in this deposit. As a result of mineralogical studies, it was established that at this stage of mineralization, gold is located inside chalcopyrite, as well as in intergrowths with the main sulfide minerals (fig.).

The predominant amount of native gold is found in intergrowths with the main sulphide minerals.

The obtained data are confirmed by the results of phase analysis of the ores of the Gyzylbulag deposit (table 1).

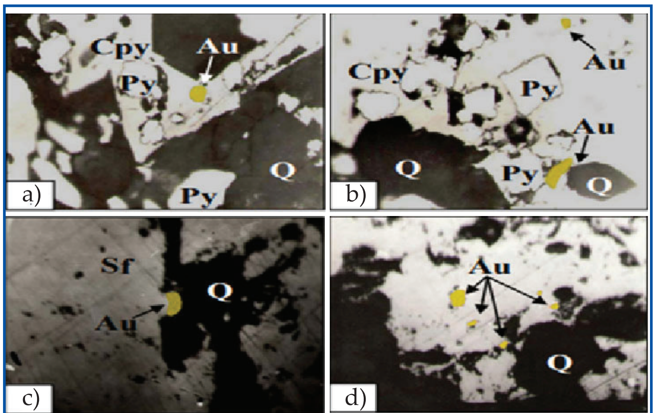

Fig. Gold-bearing mineral associations of the Gyzylbulag deposit (in polished sections)
a, b) gold is located inside chalcopyrite, ×380; c) gold is intergrown with pyrite and quartz in chalcopyrite, ×400; d) gold is associated with chalcopyrite and quartz, ×210

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Table 1

The results of phase analysis of the ores of the Gyzylbulag deposit

№	Form of gold and silver occurrence	Distribution, %		True content, g/t	
		Au	Ag	Au	Ag
1	Gold free with clean surface	17.2	1.8	0.78	0.12
2	Gold in aggregates, silver sulfides	67.2	28.6	3.05	1.87
3	Gold and silver in iron hydroxides	7.0	4.3	0.32	0.28
4	Gold and silver trapped in sulfide minerals	5.1	62.1	0.23	4.07
5	Gold and silver embedded in silicates and quartz	3.5	3.2	0.16	0.21
6	Total	100.0	100.0	4.54	6.55

Table 2

Technological types and methods of processing gold-bearing ores of the Gyzylbulag deposit

Name of the deposit	Types of Ore	Mineral composition of ores	Characteristics of gold	Technological features of ores	
				Technological type	Enrichment schemes
Gizylbulag	Gold-quartz-copper-pyrite	Chalcopyrite Pyrite Quartz Sphalerite	Fine and finely dispersed.	Gold Silver Copper	Flotation Gravity

As can be seen from the table, according to the phase analysis data, about 67% of gold is with sulfides, 17.2% is free gold extracted by amalgamation, 7.0% in iron hydroxides, 5.1% is contained in sulfide minerals, only 3.5% of gold is contained in silicates and quartz, and is not revealed when crushing the ore to 0.074 mm. According to the results of phase analysis, the gold fineness of 867‰ was established at this deposit.

As is known, the effective extraction of gold from gold-bearing mineral raw materials largely depends on a number of its typomorphic features, including: the size of gold grains, various associations (intergrowths with late sulfide minerals) and forms of occurrence (free-visible, small, dispersed, contained in sulfides). According to a number of researchers, the size of native gold and the forms of its intergrowth with surrounding sulphide minerals are very significant factors for determining the technological properties of gold-containing mineral raw materials [24, 25].

Large visible gold, freed from intergrowths during ore crushing, is easily captured during gravity enrichment, but is difficult to float (due to high specific gravity) and slowly dissolves during leaching with cyanide solutions.

Discussion

Fine gold in crushed ore is in a free state, and partially in intergrowth with other sulfide minerals. Free fine gold is well floated, quickly dissolves during cyanidation, but is difficult to extract by gravity methods. Fine gold in intergrowths with an open surface is also successfully dissolved during cyanidation, and the flotation efficiency of such gold particles is determined by the flotation capacity of the mineral associated with them. Some of these minerals can be characterized as practically non-floatable, which causes, accordingly, certain losses of gold with tailings (waste) of enrichment.

The results obtained allow us to determine the technological types and methods of processing gold-bearing ores of this deposit (table 2).

The technology for processing primary copper-bearing gold ores of the Gyzylbulag deposit has been tested in semi-industrial conditions. Based on the results of these tests, a combined gravity-flotation technology has been recommended to produce high-quality gold flotation concentrate and gold-bearing copper concentrate, recommended for processing at a copper smelter with selective extraction of gold and copper from it.

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Conclusions:

1. The size of visible gold varies from dust particles to large segregations several millimeters in size.
2. In the ores of this deposit, gold is associated with late sulfide minerals (chalcopyrite, sphalerite)
3. The granulometric composition and mineral associations of native gold have been established, which can be used when choosing a process flow chart for extracting gold from gold-bearing ores of the Gyzylbulag deposit.

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