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Extraction of precious metals from technogenic placers of primorye

Molchanov V.P.[1], Medkov M.A.[2], Belobeletskaya M.B.[2], Medvedev E.I.[1]

(1. FEGI FEB RAS, Vladivostok, 690022, Russia;2. ICh FEB RAS, Vladivostok, 690022, Russia)

Abstract: Intensive development of gold placer deposits in the South Far East of Russia has produced numerous technogenic placers (concentration dump tailings) that contain fine free and bound gold and the platinum group metals. The secondary processing of these technogenic placers makes it possible to extract the whole set of precious metals from the concentration tailings.

The authors have elaborated the low－waste technology of extraction of useful components using the methods of gravitation, magnetic and electromagnetic separation, hydrometallurgy, and extraction. Usually, precious metals are leached with cyanide solutions that significantly deteriorate the ecological situation. Instead of them we propose to use thiocarbamide, thiocyanate, and mixed thiocarbamide and thiocyanate solutions in the process of utilization of the technogenic placers. Introduction of thiocyanate ions into the thiocarbamide leaching solutions increases the indices of gold extraction into a leaching solution. Efficiency of the precious metal extraction into leaching solutions is 91%－96%.

Our investigations showed that liquid extraction of gold and silver from the leaching solutions permits the precious metals to be extracted with additional separation from admixtures and essential decrease of specific thiocarbamide consumption. Comparatively inexpensive tributyl phosphate and diphenyl thiourea that are manufactured in production quantities, are used as extragents.

Utilization of the technogenic placers of Primorye will produce the raw material for repeated extraction of precious metals and will be favorable for the ecological situation in the populous districts of the region where the placers exist.

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The centuries-old mining of gold from placers of Primorye resulted in significant exhaustion of its reserves. This has not failed to adversely affect the production of precious metals. At the same time, there are grounds to assume that potential resource of placers of the region is far from full exhaustion. It can be inferred if only by the fact that in the process of service, only large particles of metals were evacuated from placers, and small and fine particles, the share of which is about 20% of the initial reserves of deposits, were brought to final tailings of concentration. It is well known that many placers of Primorye are complex because in addition to gold they contain platinoids and other minerals (magnetite, ilmenite, chromite, sulfides of iron and arsenic, etc.), in which precious metals are free or combined (inside grains of minerals). All these components were not extracted from placers and went away to waste because the technique of concentration of metal-bearing sands was imperfect. Modern methods of extraction of useful components allow

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re—evaluation of all worked out (technogenic) placers of the South Far East with the aim to develop them in complex so that to extract free (fine and thin) and bound gold and the platinum group elements that remained in tailings.

The placers of the Fadeevsky Node, localized within populous southwest Primorye, were studied as a base object. Native gold was mined here since the end of the XIX century. When developing placers, French Mining Company used trenching steam-power shovels, and the concentrating mill operated. In succeeding years, gold was mined rather intensively up to now. For a long time, the precious metal was extracted with technologies based on use of mercury. In recent decades (since the late 80s of the last century), all operations for final concentration of gold-bearing sands were performed on heavy concentrate-processing plants (CPP) evacuating only native gold. This results in formation of significant accumulations of concentration tailings in the areas of CPP location. Only rough data are available on the matter composition of tailings. The following problem has arisen: may these wastes be a quite accessible raw material for industrial activity or only an essential source for the environment contamination.

Mineralogical study by one of the authors [4] revealed significant amounts of ilmenite, magnetite, chromite, zircon, and sphene in the gravitational concentrate of final tailings. Ore minerals are dominated by sulfides (pyrite, arsenopyrite, galena, sphalerite, molybdenite). Cassiterite, wolframite, minerals of bismuth and tellurium, cinnabar, and rutile, and platinoids were found also. Many particles of free gold, extracted from concentrate, bear the signs of amalgamation due to long-term use of technogenic mercury in the concentration process. Mercury occurs as fine silvery globules of liquid metal that is poorly soluble in water but easily reacts with oxygen of the air with temperature increase in summer. Mobility of mercury and penetrability of its fumes, rather toxic for human organism, is a matter of common knowledge.

The fineness of unaltered grains of gold from placers varies within 890-940. The platinum group minerals (PGM) are characterized by predominant solid Pt-Fe solutions and small admixture of osmirides. Microprobe analysis of Pt-Fe alloys[4] showed them to be similar in chemistry to isoferroplatinum. Composition of solid Os-Ir-Ru solutions varies from native osmium to native iridium. Heavy fraction, after gold extraction, contains the following components (mass %): Fe_2O_3—41.2; TiO_2—15.4; Al_2O_3—1.0; CaO—0.5; MgO—0.5; MnO—1.7; SiO_2—20.1; PbO—4.0; As_2O_3—3.8; Cr_2O_3—3.6; WO_3—0.8; Mo—0.2; V—0.1; Cu—0.3; Co—0.02; In—0.04; Ag—0.006; Hg—0.2; S—3.0.

This paper describes the investigations of extraction of gold and PGM from thiocarbamide solutions using liquid extraction as a possible way of effective processing of precious-metal concentrates from tailings of gold mining of past years.

The possibility of use of thiocarbamide solutions as a replacement for cyanide solutions for dissolution of gold, inherent in different kinds of raw materials, was discussed in literature repeatedly [3]. In particular[1], it was reported that use of thiocarbamide solutions for dissolution of gold offers the following advantages in comparison with cyanide ones: reduction of ecological charge, 10 times increase of gold dissolution rate, and decrease of corrosive action to equipment. Besides, the process is less prone to the action of ions-admixtures. At the same time, there are two key problems preventing from wide industrial use of thiocarbamide dissolution of gold: price of thiocarbamide (25% higher than that of NaCN) and losses of thiocarbamide at different stages of the process.

These losses can be connected with the following operations: (1) At the stage of filtration after leaching, a part of mother liquor, containing thiocarbamide, can be lost with wet cake. Repeated washing of cake is necessary to avoid losses. (2) At the stage of extraction of gold from leaching solutions, when methods of extraction and sorption are used, gold passes to the phase of sorbent and extract in the form of thiocarbamide complexes [2] that al-

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so influences the loss of thiocarbamide. With electrochemical method of precious metal extraction from leaching solutions, anode oxidation of thiocarbamide is possible. Through cementation at high temperatures thiocarbamide may disintegrate. Different reagent methods of gold precipitation, as does cementation, result in pollution of leaching solutions. This makes it difficult to use them in circulation without additional operations of regeneration of solutions that also leads to losses of thiocarbamide.

We studied the process of extraction of gold from thiocarbamide solutions with use of liquid extraction as a possible way to decrease the losses of thiocarbamide through processing of gold-bearing concentrates. We used tributyl phosphate (TBPh), diphenyl thiourea (DPhTU), and mixture of them. It was established that thiocarbamide complexes of gold formed in the process of leaching of raw material are practically not extracted by individual extragents and poorly extracted by mixture of DPhTU and TBPh. At the same time, gold is extracted by mixture of DPhTU and TBPh with high coefficients of distribution with injection of thiocyanate-ions into thiocarbamide solutions. Injection of sodium thiocyanate into thiocarbamide solutions does not worsen the indices of gold extraction at the stage of leaching, and of prime importance is the fact that extraction is not accompanied by passing to organic phase of thiocarbamide because gold is extracted in the form of thiocyanate complexes. Thus, using of liquid extraction at the stage of gold extraction from leaching solutions makes it possible to avoid the loss of thiocarbamide.

The technological scheme of gold extraction includes the following operations: (1)demercurization; (2) leaching of raw material with circulating thiocarbamide-thiocyanate solution; (3)filtration and washing of cake; (4)extraction of gold with mixture of TBPh and DPhTU from leaching solutions combined with solutions of washings; (5)re-extraction of gold; (5)oxidizing fusion.

The through extraction of gold from raw material according to the given scheme is 89%-90%. The composition of the obtained precious metal (fineness 980), in addition to PGM (Pt—62 g/t and Pd—18 g/t), includes the following useful components (g/t): Cu—4700; Bi—36; As—18; Mn—6.4; Ni—2.7.

In summary it should be noted that by present the initial mineral resources of gold-bearing placers of Primorye have been exhausted, and the wastes of their service bring the threat to the environment. We have directed the way to resolution of this ecological problem. The essence of the new approach is the introduction of the technique of the secondary processing of old tailings. Utilization of technogenic placers, if it is profitable, will make it possible to obtain the raw material for repeated extraction of precious metals. Involving of wastes of concentration into the sphere of production will have a beneficial effect on ecological environment in populous districts and will provide the requirements of the region for gold and PGM.

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