The need for increasing the recovery of noble metals from refractory ores that are difficult to concentrate is stimulating the development of new concentration processes. One of the promising approaches in research in this field is the use of high-energy actions to change the technological indexes of recovery of the valuable components.

Here we are presenting results from an investigation of how exposure in a microwave radiation field affects the engineering parameters of a gravity concentrate obtained in dressing primary gold ores from one of the Ural deposits. The study included the development of a model of the interaction process. This particular concentrate was selected for investigation because of problems encountered in developing process technology for its enrichment, and also because of the prospects for commercial application if favorable results were obtained. The main difficulty that had to be overcome was in the severance or unlocking of the primary ore mineral (pyrite) and the associated fine gold particles.

It had been found in earlier studies [1-3] that pretreatment of various types of mineral raw materials in a microwave radiation field offered promise from the standpoint of unlocking the useful components, as well as shortening the process time and reducing the energy consumption and the milling time. It was demonstrated in [2] that the use of microwave heating in the oxidative roasting (neutral atmosphere) of a refractory pyrite-arsenopyrite flotation concentrate (85% yield of class \(-0.074\) mm) gave good results, with a 99% gold recovery.

1. MATERIAL COMPOSITION AND PARTICLE SIZE DISTRIBUTION OF GOLD-CONTAINING PYRITE CONCENTRATE

The material composition and particle size distribution of the gravity concentrate were investigated by mineralogical analysis, screen analysis, and complete chemical analysis and fire assay. These results are presented in Tables 1-3. The primary ore mineral in this concentrate is pyrite (Table 1), accounting for 34% of the concentrate. Of the other ore minerals, we must note mainly arsenopyrite, pyrrhotite, and antimonite [stibnite], as well as sphalerite, galena, and chalcopyrite. The total content of sulfides in this concentrate was about 41%. The rock-forming minerals in the concentrate consisted mainly of carbonates and quartz, with small amounts of feldspars.

According to the results of particle size analysis of the gravity concentrate (Table 2), more than 68% consists of coarse-grain material \((+0.1\) mm), which contains 54% of the total gold and 59% of the total silver in the form of intergrowths with sulfides and gangue minerals; the remainder of the noble metals is concentrated in the productive class \((-0.1\) mm) in a finely divided state, dispersed in the sulfides, mainly pyrite. The slime \((-0.02\) mm), the yield of which is very low \((1.33%)\), accounts for no more than 0.34% of the total gold and 0.41% of the total silver.

In terms of the content of the valuable component, gold (53.20 g/ton; see Table 3), the concentrate is commercial-quality; it contains silver as a second valuable component (63.80 g/ton); and the quantities of limiting impurities (arsenic and antimony) do not exceed the allowable limits (0.5%).

Phase analysis data indicate that most of the gold, up to 85%, is in the form of free grains, subject to cyaniding. Recovery of the remainder of the gold requires operations that will weaken and break up those mineral components (sulfides, quartzites, carbonates) in which the gold is present in a finely divided state, such that contact of the gold with the leaching solution is impossible.

2. INFLUENCE OF DIFFERENT MODES OF TREATMENT IN A MICROWAVE FIELD ON THE EFFICIENCY OF RECOVERY OF NOBLE METALS

It was postulated that as a result of processing the gravity concentrate in a microwave radiation field, the finely dispersed gold inclusions would be unlocked — inclusions that were originally inaccessible for the cyanide solution. The analytical data indicated that about 15% of the total weight of gold was locked up in these inclusions in the original concentrate.

In selecting the processing conditions [4] for treatment of this concentrate, the following specific features were taken into account: The concentrate contains stibnite, galena, sphalerite, tellurides, and carbonates. Stibnite and tellurides bring about fusion of gold at temperatures above 600°C. Heat-treatment of materials containing galena and sphalerite leads to losses of gold to the gas phase. Dissociation of carbonates at temperatures above 350°C leads to excess alkalinity in cyaniding.

With the aim of determining the optimal method for increasing the efficiency of gold recovery, we tested the following process schemes for microwave treatment of the gold concentrate: 1) calcination at 360°C; 2) oxidative roasting at about 600°C; 3) sintering with KOH at about 380°C, with subsequent leaching. In all cases, the final operation was recovery of the gold from the calcine by cyaniding in the sorption mode (Table 4).

In Table 5 we have listed values of the process indexes as calculated from gold and silver assays of the concentrate before and after treatment in a microwave field, and also assays of the tailings from cyaniding. It will be seen that calcining at 360°C in a microwave field gave higher values of the indexes in comparison with those for the original concentrate. The lower recovery of gold when the concentrate was sintered with caustic is probably due to the formation of films on the