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Beneficiation of a gold bearing enargite ore by flotation and As leaching with Na-hypochlorite

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Abstract

The deep mineralized bodies of the Italian Serrenti-Furtei gold-bearing deposit, located in southern Sardinia, contain substantial amounts of enargite-luzonite and pyrite with subordinate tennantite, covellite, chalcopyrite and arsenopirite. The gold, which occurs as grains of between a few tens of micrometres and submicron size, is not amenable to direct cyanidation. These ores are beneficiated by bulk flotation using sulphydryl collectors and the resulting concentrates are then pyrometallurgically processed to produce gold and copper. However, the concentrates contain significant amounts of arsenic, severely reducing their market value; the abatement of this highly toxic metal in the flue gas to comply with stringent emission limits, increases processing costs significantly.

In order to reduce the arsenic content in the concentrates and hence the penalties incurred, we carried out an investigation on enargite leaching using sodium hypochlorite to selectively dissolve the arsenic.

By suitably adjusting the main influencing variables, leaching was found to be effective, achieving 96% arsenic removal without significant Au and Cu losses, increasing the commercial value per tonne of concentrate.

Keywords: Gold ores; Sulphide ores; Froth flotation; Leaching; Environmental

1. Introduction

The mineralogic and petrographic characteristics of the epithermal gold mineralisations in the Serrenti-Furtei mining district in southern Sardinia vary considerably with depth (Garbarino et al., 1991; Fadda et al., 2004). The upper part of the deposit, where the rock is moderately porous due to intense oxidation and contains lower gold grades, has been open-pit mined and the gold recovered by direct cyanidation using either heap or vat leaching. The deeper parts host mainly sulphide mineralisations which have a more compact structure and are composed for the most part of enargite-luzonite, to which chiefly gold is associated, and pyrite. These minerals are not amenable to direct cyanidation but contain economically interesting concentrations of enargite. A conventional flotation process was devised to recover the gold and copper in a bulk concentrate to be subjected to further processing via pyrometallurgical techniques (Ghiani et al., 2000).

The process was designed using ethylxanthate as collector and lime as pyrite depressant. Commercial application to the ores in question proved to be fairly efficient, achieving high Cu and Au recoveries in the bulk concentrate (Di Giovanni et al., 2003).

Unfortunately, the prevalence of enargite among the copper-bearing minerals and as a result the relatively high As content in the concentrates severely reduces their economic value, owing to the hazardous emissions

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generated from pyrometallurgical processing. Thus, in unfavourable metal market conditions, direct roasting may well prove to be an uneconomical option.

In an attempt to solve this problem, we explored the possibility of dissolving the arsenic from the concentrates prior to pyrometallurgical processing.

Two techniques for arsenic removal from enargite are proposed in the literature, namely:

(a) alkaline leaching of enargite concentrates using sodium sulphide solutions after mechanical activation via fine grinding (Baláž et al., 2000);
(b) leaching of natural enargite crystals with sodium hypochlorite under alkaline oxidizing conditions whereby the enargite is converted into crystalline CuO and the arsenic solubilises forming AsO_4^{3-} (Viñals et al., 2003).

The second method was judged to be especially attractive in terms of its potential application at the commercial scale. Thus we decided to focus our attention on this particular leaching technique.

The investigation described here aimed at exploring the possibility of applying this method to the marketable Au–Cu concentrates obtained by flotation of the sulphide ores from the Serrenti-Furtei deposit described above. We experimentally determined the influence of the most important process variables, such as grain size of the solid material, solids concentration in the solution, temperature, pH and hypochlorite concentration in the leachant as well as contact time.

2. Experimental procedure

The bulk Au–Cu concentrate used in the experiments was obtained in a laboratory flotation cell from drill cores made in the deep zones of the deposit during prospecting.

The as received material was first dry crushed to 100% passing 2 mm and then wet ground to below 0.150 mm operating in closed circuit in a porcelain ball mill.

The ground product was subjected to flotation with ethylxanthate after pyrite depression with lime. The cleaned concentrate obtained, assaying 90.25 g/10^3 kg Au, 33.15% Cu, 12.55% As and 9.16% Fe, was suitable for the pyrometallurgical production of gold and copper.

Diffractometric analysis (XRD) (Fig. 1) shows the concentrate to contain significant concentrations of enargite.

This concentrate −0.150 mm and samples of the same wet ground to less than 0.050 mm, were experimentally investigated to evaluate the potential of sodium hypochlorite leaching to remove the arsenic.

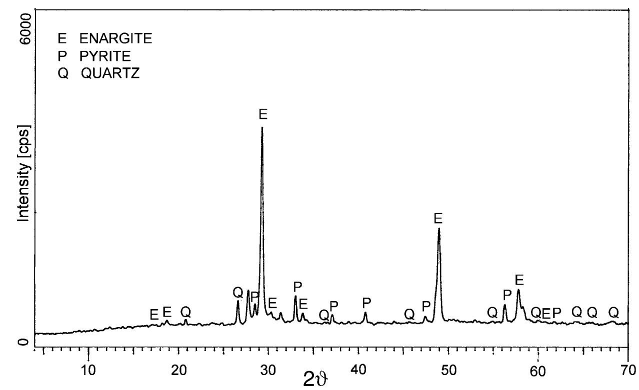

Fig. 1. XRD patterns of a representative sample of the flotation concentrate.

Leach tests were conducted in a 1-litre thermostated Pyrex glass reactor containing NaClO solutions mechanically stirred at 500 rpm, as shown in the schematic of Fig. 2.

As mentioned in the introduction, the effect of the main influencing parameters, namely solids concentration (0.004, 0.01, 0.04 w/w), initial hypochlorite concentration (0.05, 0.13, 0.20, 0.28 M), pH (10.5, 11.5, 12.5), temperature (20, 30, 40, 45 °C), leach time (up to 120 min) was experimentally evaluated on both grain size fractions. All experiments were carried out using 0.5 kg of leachant.

The influence of the single variables was then determined following the classic procedure of varying the value of one variable while keeping the other variables constant.

Leach results were evaluated through As, Cu and Au determinations on the leachate and solid residue obtained after filtration. Sodium hypochlorite consump-

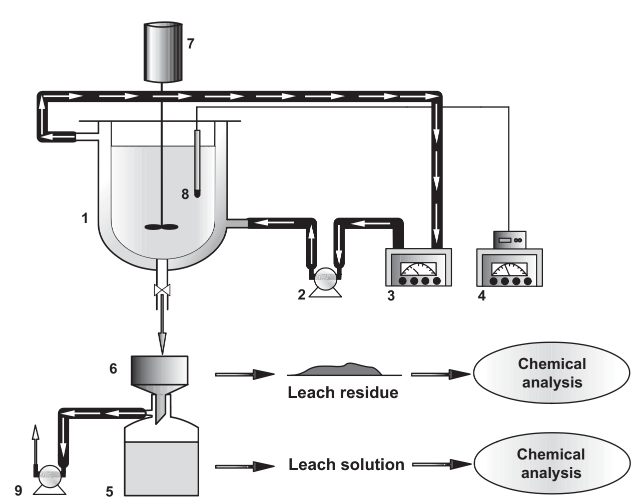

Fig. 2. Schematic of the experimental set-up and procedure: (1) thermostated reactor, (2–3) heated circulating bath, (4) pH-meter, (5) filtering flask, (6) Bückner funnel, (7) mechanical stirrer, (8) electrode, (9) vacuum pump.