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ORIGINAL ARTICLE

Application of acid mine drainage for the biooxidation of a high-grade refractory sulfide gold ore

Elaheh Nouhi[1] · Ali Ahmadi[1]

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Abstract

Acid mine drainage (AMD) is one of the challenging environmental issues in sulfidic mines. These hazardous solutions generally contain a mixture of indigenous iron- and sulfur-oxidizing microorganisms that could be used as a source for biotechnological purposes. In this study, the ability of an AMD from a sulfide-bearing gold mine to biooxidize its high-grade pyritic gold ore was investigated and its efficiency was compared with iron- and sulfur-oxidizing microorganisms from a microbial culture bank. Experiments were conducted at 35 and 45°C, initial pH values of 1.5 and 2 in a Norris culture medium prepared from deionized and saline local waters. The effects of some critical parameters including the initial pH and the concentrations of ferrous or ferric sulfate were investigated on the efficiency of the biooxidation process and gold extraction. The results showed that the AMD microorganisms had a greater ability to oxidize the sulfide ore than the microorganisms from the microbial bank. The addition of ferrous and ferric sulfates increased the efficiency of biooxidation, while high concentrations of these ions caused the formation of inhibitory precipitates (jarosite) and decreased gold extraction. The results showed that biooxidation using the AMD medium in the saline local water increased the extraction of gold from 73 to 99%. It can be concluded that the application of AMD for the treatment of refractory gold sulfide ores could be an efficient solution for increasing gold extraction and reducing environmental problems.

Keywords Acid mine drainage · Biooxidation · Refractory sulfidic ore · Gold · Inhibiting precipitates

Introduction

Acid mine drainage (AMD) causes environmental problems because it may contain some heavy and toxic metals including copper, arsenic, aluminum, zinc, iron, nickel, and cadmium. In some metal mines, including gold mines, these environmental problems are very challenging and costly. AMD is caused by the oxidation of sulfide minerals, such as pyrite, by the catalytic activity of the iron- and sulfur-oxidizing microorganisms in the presence of water and oxygen at low pH levels as presented in Eqs. (1–3) (Natarajan 2008):

$$2FeS_2 + 7O_2 + 2H_2O \rightarrow 2Fe^{2+} + 4SO_4^{2-} + 4H^+ \quad (1)$$

$$4Fe^{2+} + O_2 + 4H^+ \rightarrow 4Fe^{3+} + 2H_2O \quad (2)$$

$$FeS_2 + 14Fe^{3+} + 8H_2O \rightarrow 15Fe^{2+} + 2SO_4^{2-} + 16H^+ \quad (3)$$

Most gold-bearing sulfide ores are refractory as gold particles are encapsulated inside the sulfide phase, and it is necessary to decompose this sulfide phase before the gold extraction. One of the main decomposition methods is biooxidation, in which acidophilic iron and sulfur oxidizing microorganisms are used (Aylmore and Jaffer 2012). These microorganisms originate from the sulfide ore or acid mine drainages (Chen et al. 2022). Therefore, it is expected that the use of AMD in the biooxidation process will help to decompose these refractory minerals, and this phenomenon can be a suitable application for AMD, both from an environmental and economic point of view (Bailey 2018). There are some challenges in the leaching of gold from high-grade refractory sulfide ores, and so far, some research has been carried out on investigating the role of chemical factors such as ferrous and ferric ions on the rate of oxidation, as well as the formation of inhibitory precipitate in the biooxidation process, especially on the high-grade gold ores. In this

✉ Ali Ahmadi
a.ahmadi@iut.ac.ir

[1] Department of Mining Engineering, Isfahan University of Technology, Isfahan 84156-83111, Iran

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