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Short Communication

Tailings reprocessing from Cabeço do Pião dam in Central Portugal: A kinetic approach of experimental data



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ABSTRACT

The mining waste and tailing dam are object of discussion due to the accidents that occur due to a lack of control or due to interest in the remaining minerals present in these materials. Most of the old tailings dams have high contents of heavy metals which could represent potential risks to the environment or be an alternative source of some critical raw materials. The case study of the Cabeço do Pião dam in Central Portugal involved tailings from a processing plant that belonged to the Panasqueira Mine Complex, which has been in operation for over 120 years. Waste rock and mining tailings were deposited in the area until 1995, and they represent an environmental liability for the local population due to their high content of toxic metals. Tailings reprocessing can be considered as a solution that minimizes social and environmental impacts, recovers some essential minerals, such as Zn, W, and Cu which can help to offset investments made. The project design involves several stages of metal concentration, determined by experiments, as well as a model of the process. The overall model will take into account technological constraints, social-economic conditions and environmental impacts. A preliminary result of an optimization study of the kinetic approach is presented in this piece of work.

1. Introduction

The low ore grades in recently found deposits and a shortage of essential metals have contributed to a higher volume of waste rock and tailings being produced during mining activity. Also, the global demand for metals and minerals has led to an increase in prices. However, the availability of mineral resources and their excessive consumption come together with an important fact, which is the inevitable depletion of non-renewable resources of raw materials (Dubiński, 2013). In this way, the traditional exploration model is becoming unsustainable, as the critical raw materials list has expanded over the years (EU, 2017). Further, sustainable management of mining activity involves safe waste disposal and reclamation of the total area affected.

Many mining sites, which are often abandoned, in Europe and worldwide have an old dam which has generated high impacts and presents several potential risks to the local community, contributing to a reduction in confidence in this industry. Deposited tailings originating from metallic mining, in particular, due to their sulfide content could result in the spread of this contaminant material through air or water to other regions. Sulfides when exposed to atmospheric conditions may be oxidized in a process known as Acid Mine Drainage (AMD), and this

results in the successive formation of low pH effluents with several toxic metals (Kagambega, Sawadogo, Bamba, Zombre, & Galvez, 2014).

The leachates generated in AMD have a variable chemical composition because the geological background varies from site to site as well as over time for the same place. These heterogeneities of the tailing characteristics associated with geotechnical instabilities can generate a rupture followed by the failure of a dam.

New mining industry based on the use of alternative sources of energy and raw minerals, can consider the reprocessing of these tailings (EIT, 2017). Literature reports some pieces of work, such as (Liu & Huang, 2017; Lèbre, Corder, & Golev, 2017; Yin et al., 2018), obtained satisfactory results in metal recovery from mining tailings.

The objective of this paper is to present the progress of the tailing reprocessing model developed in the scope of the European project ERA-MIN “REMinE: Improve Resource Efficiency and Minimize Environmental Footprint”. This project involves mines sites and institutions from three countries: Cabeço do Pião in Portugal, Sasca in Romania and Yxsjöberg in Sweden.

Although there is an extensive list of work concerning Cabeço do Pião (Ávila, da Silva, Salgueiro, & Farinha, 2008; Candeias, da Silva, Ávila, Coelho, & Teixeira, 2014; Candeias et al., 2013; Salgueiro, Ávila,

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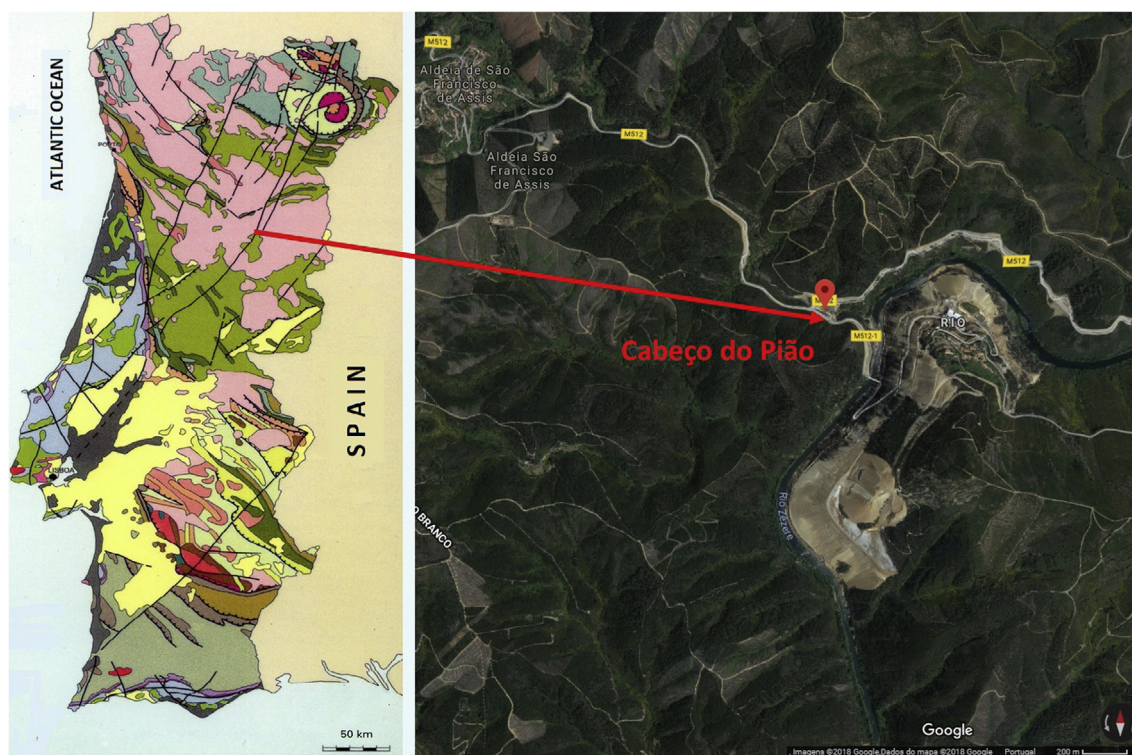


Fig. 1. a) Cabeço do Pião location in Portugal (IGM, 2010); b) View area (Google Earth, 2018).

Melo, & da Silva, 2013) which have primarily studied the geochemistry and mineralogy of these materials and the impacts in this area, however, none of these pieces of work ever considered tailing reprocessing as a permanent solution.

Reprocessing represents an option of recovering valuable metals present in the old dam. This work presents an approach regarding the elaboration of a model of optimization, to study the feasibility of this project. The research motivation is to seek a sustainable mining, with the generation of values to the society, the conservation and preservation of environmental compartments, as well as, sites remediation.

2. Case study

The area studies is Cabeço do Pião located in the Panasqueira Complex Mine area in Central Portugal (Fig. 1). The old dam was an open site for the deposit of waste rock and mining tailings. It was built on the riverbanks of the Zêzere and poses potential risks to the surrounding area and watercourses.

Over 70 years Cabeço do Pião received residues from the Panasqueira Mine, among them were coarse material and sludge. Mostly, the materials consist of schists and quartz, with a lower percentage of pyrite and arsenopyrite (Wheeler, 2016). The tailing dam shows a degraded landscape accelerated by the frequent adverse climatic conditions in this region. The predominantly fine grain size of these materials creates highly specific surfaces which are available for chemical reactions and AMD generation.

It is estimated that a total of more than 8 million tons of material was deposited in the tailing facilities of Panasqueira's mine, occupying an extensive area (Wheeler, 2016). These residues have high concentrations of metals, namely Cu, Zn W and especially As.

3. Materials and methods

A field sample campaign was performed according to a regular grid of the topsoil of the Cabeço do Pião dam in an area of about 2.6 ha. In total, 66 samples were collected at two topographic levels: on the

surface (up to 50 cm depth) and at depth (approximately 2–2.5 m). GPS (Global Position System) was used to determine the coordinates of the samples and the georeferenced was done using the UTM (Universal Transverse Mercator) system.

3.1. Chemical analysis

Firstly, tailings samples were submitted to the preparation stage, in conformity with the requirements of the experiment bellow.

The material was analyzed using the Energy Dispersive X-ray Fluorescence (XRF) method to determine the metal contents using the X-MET8000 Oxford instrument. The mean results of the chemical analysis were within 95% confidence limits of the recommended values given for the certified materials. The Relative Standard Deviation was between 0% and 5%. Interesting elements were detected, such as As, W, Zn, Cu, and Fe which are shown in Table 1.

4. Preliminary model formulation

The definition of the reprocessing technologies, applicable to this material, is based on the physical, chemical and mineralogical characteristics that constitute a guide to distinguishing between primary and secondary minerals. As these materials resulted from the ore processing plant, mainly through the tungsten recovery process, where the addition of several reagents takes place, including sulfuric acid, lime, cresylic acid, pine oil and fuel oil (Wheeler, 2016), a predominance of secondary minerals is expected. These tailings are exposed to open air and experience the impacts of weather and this contributes to the transformation of the material characteristics.

Laboratory characterization plays an essential role in defining the

Table 1
Chemical analysis of tailings from Cabeço do Pião dam (ppm).

Mean	As	W	Zn	Cu	Fe
	143041	2496	99944	4738	238389

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