International Journal of Mining Science and Technology xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

International Journal of Mining Science and Technology

journal homepage: www.elsevier.com/locate/ijmst

Characterization of the Oum El Khacheb phosphorites (South Tunisia) and enrichment of big rejections by grinding

Mâamri Alimi Jihen [a,*], Abbassi Leila [b], Batis Harrouch Narjes [a]

[a] National Institute of Applied Sciences & Technology, Carthage University, Tunis 1080, Tunisia
[b] Researches' Centre of Gafsa's Phosphates' Company, Metlaoui 2130, Tunisia

ARTICLE INFO

Article history:
Received 12 December 2015
Received in revised form 26 January 2016
Accepted 29 March 2016
Available online xxxx

Keywords:
Characterization
Phosphate
Big rejections
Methodology of experimental research
Grinding

ABSTRACT

In the last decade, the phosphate reserves have started to decrease. In this study, both phosphate of Oum El Khacheb's (O.E.K) region (South of Tunisia) and its big rejections were characterized mineralogically and chemically by several analysis methods such as the binocular magnifying glass, X-rays diffraction technique, Technicon auto-analyzer, atomic absorption spectroscopy, and carbon sulfur analyzer. Then, this work focuses on the coarse rejections of O.E.K's phosphorites which can be valorized by the wet grinding method. Therefore, we have used the methodology of experimental research to determine the optimal grinding conditions. Results found by Doelhert matrix are: a duration at about 4 min, a pulp on solid concentration of 45.00%, a number of cycles equals to 60 rpm and 3.87 as the jar's loading. The enhancement of the weight yields of phosphate recuperation increased significantly by 46.39% from big rejections with 24.60% of P_2O_5 concentration.

1. Introduction

Since the beginning of the 20th century, the phosphate of Tunisia has aroused a considerable interest on behalf of the whole world researchers. Its agronomic qualities and advantages are universally recognized and it is highly recommended for various types of culture like phosphates' fertilizer in direct application and other industries such as medical applications [1,2].

For Tunisia, the phosphates have a paramount importance for both the local transformation and its export. In fact, it ranks 5th when it comes to phosphate producing-countries in the world [3]. Tunisia may find the benefits by developing and exploiting the smallest amount reserve on the ground. This concerns particularly big discharges of phosphates waste of Oum El Khacheb's (O.E.K) deposits (basin Gafsa Metlaoui, South west of Tunisia), as noted in Fig. 1. Tragically, these big rejections of phosphate are causing pollution problems in the area of Metlaoui and embrace a considerable content of P_2O_5 [4–8]. Actually, there are many enrichment methods of phosphates in the world.

In Morocco, the phosphate calcination is due to the presence of the organic matter which requires often a supplementary addition of the sulphuric acid during the phosphoric acid's manufacture [9–11].

The Abbotabad phosphates ores, in Pakistan, contain high concentrations of carbonates and silicates. The shape of the particle tested is between 74 and 208 μm. This phosphorite's type is enriched by acid leaching like HCl in order to increase the P_2O_5 concentration giving the best quality of phosphates in the world [12].

In South Africa, the Phalaborwa's igneous phosphate is a layer with mixed ores of Cu–Fe–P associated with carbonates whose copper constitutes the principal ore of this layer.

The process of enrichment consists in floating the copper ore, the remaining magnetic product will be attracted by the electromagnet and the non-magnetic ore (of igneous phosphates) that remains is valorized by direct flotation to recover phosphate's concentrate [13].

The AbouTartour sedimentary phosphate ore, in Egypt, consists of a matrix of pyrites dolomites minerals. Valorization is done through a highly intensive magnetic separation [14,15].

However, the calcination requires two engines with high temperature treatment; the cost of such treatment remains too expensive to valorize O.E.K's phosphate rejections.

The acid leaching treatment is like the lixiviation but it is applied only in case of fine phosphate particles. Over a diameter of 210 μm, the fraction will be out of the recovery zone. This study aims the phosphates' big rejection that is why such a treatment is inconvenient.

* Corresponding author. Tel.: +216 97028862.
E-mail address: maamri-jihen@hotmail.com (A.J. Mâamri).

http://dx.doi.org/10.1016/j.ijmst.2016.05.053
2095-2686/© 2016 Published by Elsevier B.V. on behalf of China University of Mining & Technology.

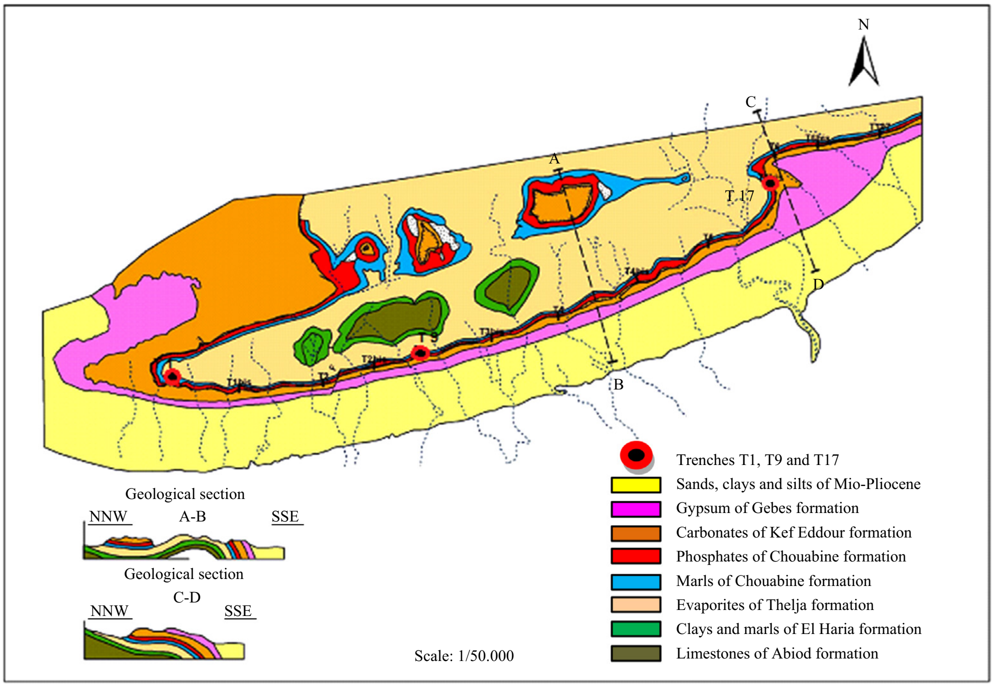

Fig. 1. Oum El Khacheb's geological site (South of Tunisia).

The valorization by magnetic separation is based on two separation process which is characteristic of particular igneous or slightly magnetic phosphate types. This is not our case. Then these four techniques aren't suitable either for the economic or for the characteristic of O.E.K's phosphates' wastes. Therefore, this work focuses on the grinding technique which is convenient to both mineralogical and economical characteristics of Tunisian phosphate.

2. Materials and methods

2.1. Reagents

Our reagents for grinding are O.E.K phosphate and its big discharges. In the following paragraphs, we intend to show the procedures and precautions to be taken since the sampling of the ore till the completion of the mineralurgic tests of the phosphorite elements.

Only very few ores' layers prove to be homogeneous. Those taken in various places of the layer do not show a certain variation in their response to processing techniques of phosphate ores [16]. Then, it is ensured of the right choice of representative samples for analysis. It is essential that the geologist has a clear vision of the mineralurgic implications entrained by various characteristics of the ore. These features include the mineral species and their associations, the dissemination degree and the deterioration one of the oxidation due to the bad weather [17,18]. No doubt that the gathered information will guide the mineralogist in his program of testing. In fact, sufficient number of samples in various places of the layer must be taken. The sampling must sweep all the deposit of O.E.K. Therefore, the results of the tests should mirror what the processing plants would really receive. For the same reason, the samples are sufficiently significant and hence complete analysis can be carried out on only one sample without having to remake sampling.

Location in O.E.K distinct exits: from the east trench 17 (T17), the center (T9) and the west (T1).

Quantity: one ton of each trench.

These samples were collected during November 2011.

2.2. Materials

The grinding is a step of dividing a solid, to increase its specific surface and consequently its reactivity. In mineral processing, grinding is done until the mesh's liberation.

The release of an inorganic mesh is the size below which an inorganic particle is completely released, that is to say, consisting solely of mineral species to develop [19].

In the enrichment process, grinding constitutes an important stage to increase the levels of P_2O_5 for the phosphate's treatment especially for the big evacuations. In phosphate industry, there are two types of grinding methods, the dry and the wet ones. We have chosen wet one using a grinder with rod mills and balls for this spot.

In fact, the particularity of this grinding process is that particles spread and the limit layer's phenomena are widely dependent on viscosity of prepared pulp [20]. In addition, grinding isn't the last treatment before expedition. There are other treatments like desliming and flotation which demand humid pulp as reagent. Finally, the recovery rate of wet grinding is far away important than the dry one and the process has a benefit of 30% of energy at list.

Conditions to apply wet grinding using rod mills and balls are as follows: discontinuous grinding time is between 30 min and 20 h; rate of filling must be between 20% and 40% of the grinder's total volume; and rotation's speed that must be calculated hence remains in 50–85% of the critical engine failure speed [20,21].

For a grinder within internal diameter D (m), its critical engine failure speed V_{Cr} (r/min) is calculated from Eq. (1)

$$V_{Cr} = \frac{42.3}{\sqrt{D}} \tag{1}$$

There are two stages of grinding. In the first stage, the matter will be crushed according to two operations: percussion and trituration. The second stage of grinding is the completion.

Please cite this article in press as: Mâamri AJ et al. Characterization of the Oum El Khacheb phosphorites (South Tunisia) and enrichment of big rejections by grinding. Int J Min Sci Technol (2016), http://dx.doi.org/10.1016/j.ijmst.2016.05.053