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Geometallurgy and processing of North Ras Mohamed poly-mineralized ore materials, South Sinai, Egypt

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ABSTRACT

The present work aims to study the link between mineralogy and process characteristics of North Ras Mohamed ore materials. The chemical nature of the latter was also studied to determine the type of treatment employed from one hand and the preferred lixiviate option from the other hand.

For this purpose, three technological samples representing three different deposit types were examined for their potential processing options. These include basal sandstone, aplite dyke and pegmatitic bodies which were found to assay 0.05, 0.04 and 0.06% U, 0.13, 0.10 and 0.07% Th and 0.14, 0.13 and 0.09% REEs respectively, while Nb assays 1.3% and Ta 0.5%, in the pegmatitic ore sample. The corresponding minerals of these elements of interest include thorite and uranothorite in the basal sandstone ore material. On the other hand, the multiple-oxide minerals samarskite, fergusonite and allanite are found in both the aplite and the pegmatite bodies. However, the zircon, fluorite, apatite, titanite and brookite are considered as the main accessory minerals in the three study ore materials

Based on the available chemical and mineralogical data on the three different ore material types of Ras Mohamed area, a physical upgrading process would be required as a major recommendation for future prolific metallurgical work.

1. Introduction

The present work deals with the mineralogical and chemical characteristics of different mineralization in North Ras Mohamed area, South Sinai, Egypt. In addition, the leaching potentialities of the concerned three ore materials, namely, basal sandstone, aplite dyke and pegmatitic bodies of ore breakdown have been determined. The study area is located in the Southernmost part of Sinai Peninsula at North (N) Ras Mohamed area between latitudes 27° 47′–28° 9′ N and longitudes 33° 55′–34° 24′ E (Fig. 1).

The Paleozoic sedimentary rocks in the Southern part of Sinai, including the study area, are of great importance especially from the mineralogical and radioactive points of view. It hosts several types of mineral deposits such as manganese-iron deposits (Mart and Sass, 1972; Abu El Hassan and Baioumy, 2003), copper deposits (Hilmy and Mohsen, 1965; El Sharkawi et al., 1990; Amer, 1997), silver deposits (Amer, 1993; El Agami, 1996), uranium deposits (El Aassy et al., 1986; Dabbour and Mahdy, 1988; El Reedy et al., 1988; Hussein et al., 1992; Abdel Monem et al., 1997; Amer, 1993, 1997) and some transitional metals like Zn, Sn, Ni, Mo and Pt (Ahmed, 2003). These discovered sites were subjected to extensive studies from the geological, mineralogical, geochemical and now the hydrometallurgical points of view.

According to Saleh (2006) and Abu khoziem (2012), prospective resources of rare metals (e.g., U, Th, REE, Nb and Ta) are eventually related to mineralization of the younger granitic units as well as associated pegmatites and aplites besides the basal sandstone along the unconformity surface in the Ras Millan area. Therefore, the present work is concerned with studying leaching potentialities of these three ore materials collected from pegmatites of G. Samma and aplites of Wadi Lathi besides the basal sandstone in the Ras Millan area. As far as the authors are aware, the present leaching or breakdown study is the first hydrometallurgical contribution for the potential recovery of the metal values of these three ore materials in South Sinai.

For this purpose, diverse hydrometallurgical techniques have been applied, starting with the conventional process (sulfuric acid agitation leaching), passing through pug leaching and ending with non-conventional process, namely, the bisulfate fusion procedure. Accordingly, a comparative study has been undertaken about the leaching potentialities of these three ore materials. To realize these objectives, three technological samples representing the above mentioned three study ore materials have been collected. Before leaching experiments, these samples have first been subjected to both chemical and mineralogical characterization. The obtained data are used to extrapolate the optimal process that outfits the characteristics of a particular ore.

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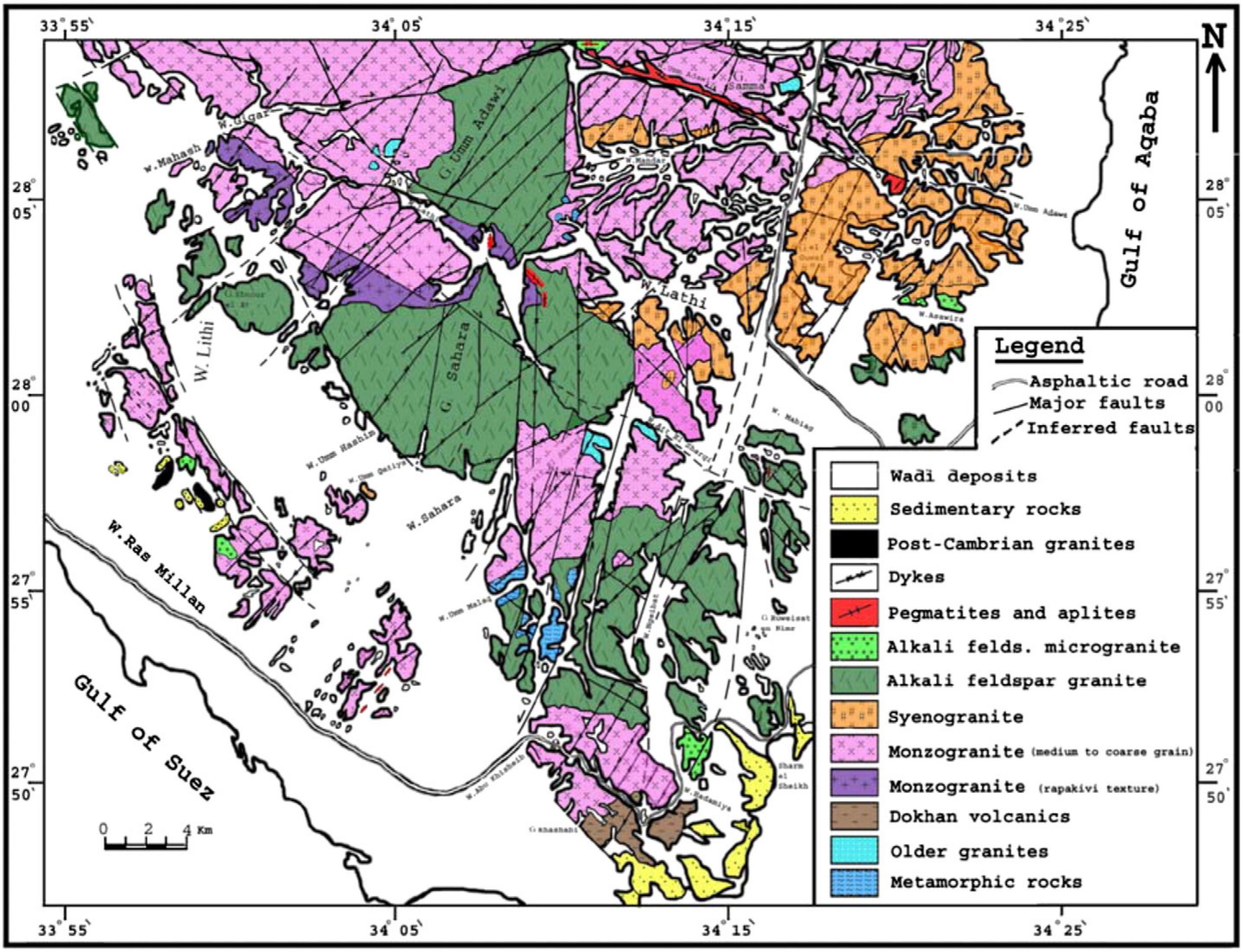

Fig. 1. Geological map of the studied area North Ras Mohamed, South Sinai, Egypt (After Saleh, 2006).

2. Experimental

2.1. Characterization of the study ore materials

Determining chemical composition of the three different ore material types, as well as the minerals that host the economic and valuable metals is the most important stage in this ores processing study.

2.1.1. Chemical characteristics of the study ore materials

The collected representative three samples were chemically analyzed for major oxides and trace elements including the REEs, using the inductively coupled plasma-mass spectrometry (ICP-MS) technique in the ACME Lab of Vancouver in Canada. On the other hand, during leaching experiments the determination of thorium and total REEs were carried out by using Arsenazo III according to Marchzenko (1986) while determination of uranium (VI) was conducted via titration method using ammonium meta-vanadate as titrant and di-amino 4-sulfonic acid as indicator (Daveis and Gray, 1964). It is worthy to mention herein that the preparation and analyses were carried out at the laboratories of the Nuclear Materials Authority of Egypt.

2.1.2. Mineralogical characteristics of the study ore materials

The grinding of rock samples to mesh size was adequate to liberate the accessory minerals. The ground samples were then washed by water and the slimes were removed by repeated decantation. The dry fractions were then sieved into the size intervals: 0.4, 0.315, 0.2 and 0.1 mm. The light and heavy fractions were separated from the different sizes by bromoform (sp. gr. 2.8). The heavy mineral grains were picked from each of the obtained heavy fractions under binuclear microscope. Some of these selectively picked grains were analyzed by X-ray diffraction technique (XRD). Some others of the separated grains were examined by environmental scanning electron microscope (ESEM).

2.2. Ores processing procedures

The three technological samples representing the different ore materials, namely, basal sandstone, aplite dyke and pegmatite were further ground to -200 mesh size and mixed well by quartering to attain homogeneity. Several sample portions were subjected to leaching experiments. In the present work, three leaching methods have been adopted, the first is acid agitation leaching using sulfuric acid, the second is pug leaching and/or sulfatization roasting process and the third one is potassium bisulfate fusion process.

2.2.1. H_2SO_4 acid agitation leaching method

In this leaching method, each agitation leaching experiment was performed by mixing a weighed portion of the ground sample (10 g) with a certain amount of specific concentration of sulfuric acid at certain solid/liquid (S/L) ratio and stirring for a certain period of time at fixed