The Study of Tailings at Mina Alumina Limited, Mozambique.

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Abstract

The beneficiation of gibbsite at their washing plants is one of the most important processes at Mina Alumina Limited in Mozambique. During this operation, large volumes of tailings are produced. Since the company started operating in this region in the early decades of the 20th century, only a few geologists, mining engineers and environmental scientists have studied the material in these tailings deposits. This paper summarises observations and measurements made in one of the inactive Mina Alumina tailings deposits. The deposit was divided into three sections and samples were collected for laboratory studies. Pycnometry was used to determine the density variation of the solids around of the deposit. X-Ray Diffraction was used to determine the mineralogical composition and for phase quantification. Chemical analysis was by Graphite Furnace Atomic Absorption Spectrometry (GFAAS) and Flame Atomic Absorption Spectrometry (FAAS). Through the graphs constructed after grain size analysis, it was possible to demonstrate the variation of the Fineness Modulus, Curvature Coefficient, Uniformity Coefficient and the variation of permeability around the deposit. Studies of these tailings are important in informing future options for reuse of the material and facilitating studies of their environmental impacts.

Keywords: Penhalonga, Mina Alumina Limited, Gibbsite, Tailings, Tailings' deposit.

1. Introduction

Mina Alumina Limited is a bauxite mining and processing company operating on the Penhalonga Mountain in the Province of Manica, Mozambique. It was the first mine to be owned by an individual or organisation from outside Mozambique, having operated since 1935 and is presently the only bauxite mine operating in Southern Africa. Production was carried out continuously until 1974 and during that period roughly 4 000 tonnes of ore per annum were mined for the manufacture of aluminum sulphate and refractory bricks. After an interruption of 10 years, production was resumed in 1985 and until the beginning of the 1990s about 6 000 tonnes per annum were extracted from seven quarries [1].

1.2. Geological Setting of the Bauxite Deposits of Penhalonga

The bauxite deposits occur in the northern margin of the Precambrian greenstone belt in Manica Province, and extends along the Mozambique - Zimbabwe border at altitudes ranging from 800 to 1 800 metres.

This Precambrian unit is built up of Archean and Proterozoic, as well as Phanerozoic magmatic and metamorphic rocks. The laterite-bauxite blanket overlies mainly basement Precambrian gabbros, anorthosites, diorites, granites and metamorphosed basic volcanic rocks. The ore bodies, of residual character, overlie gabbro-anorthositic rocks, metabasalts, talcschist and also granite.

The deposit is part of the South-East African Province of lateritic bauxites [2]. The total area of the deposit has approximately 1 600 hectares [3].

1.3. Reserves

The deposit's bauxite reserves were initially evaluated in 1963, at 600 000 tons, but in 1994, the reserves were revaluated with the support of the United Nations Development Program (UNDP) at 1 374 000 tonnes. Up to the end of 2017 about 112 000 tons were extracted leaving approximately 1 262 000 tonnes, which can be mined for at least 105 years assuming 2017 levels of production [3]. The different ore grades extracted and processed at Mina Alumina Limited are used mainly for the manufacture of aluminum sulphate used in water purification.

1.4. The Grades and Distribution of Ore Bodies

According to the principal petrographic and chemical characteristics, four main ore types/grades can be defined, and their chemical analyses are presented in Table 1.

Table 1. Chemical composition of representative ore types from the Penhalonga deposit [1].

Oxide (wt %)	Ore type A	Ore type B	Ore type C	Ore type D
Al_2O_3	58.43	49.65	44.02	57.16
Fe_2O_3	1.55	13.81	17.78	0.64
TiO_2	0.27	0.84	3.07	0.00
SiO_2	9.0	9.19	9.92	16.92
L.O.I.	28.62	23.9	24.12	24.03
Na_2O	0.04	0.04	0.07	0.11
K_2O	1.65	1.20	0.10	0.58
CaO	0.02	0.08	0.00	0.03
MgO	0.27	0.09	0.00	0.00
P_2O_3	0.01	0.04	0.21	0.02
MnO	0.06	0.03	0.07	0.06
Total	99.92	98.93	99.36	99.57

The main characteristics of the ore types are as follows:

Type A: White saprolitic bauxite, friable, texturally porous and light. Primary parent rock structures, notably joints and fractures, are often preserved. It is related to anorthosites.

Type B: Yellowish brown saprolitic bauxite presenting similar characteristics as grade A. It is related to the intermediate members of the gabbro/anorthosite series.

Type C: Reddish brown to dark brown, ferruginous, saprolitic bauxite. Fine grained, friable, but also indurated in some places, with lateritic appearance showing ferruginous cement. It is related to the metabasalts.

Type D: White kaolinitic clays, with concretionary, collomorphic gibbsite. The contents of gibbsite nodules are very variable and so are their sizes and shapes. The clay is sticky when wet and extremely fine and friable when dry. It is also related to anorthosites.

1.5. Gibbsite Beneficiation

The gibbsite nodules contained in the type D ore are beneficiated at the washing plants to separate them from the kaolinitic clays, residual bauxite, and other impurities. After separation, the gibbsite nodules are carried straight to the processing plant where they are crushed and later

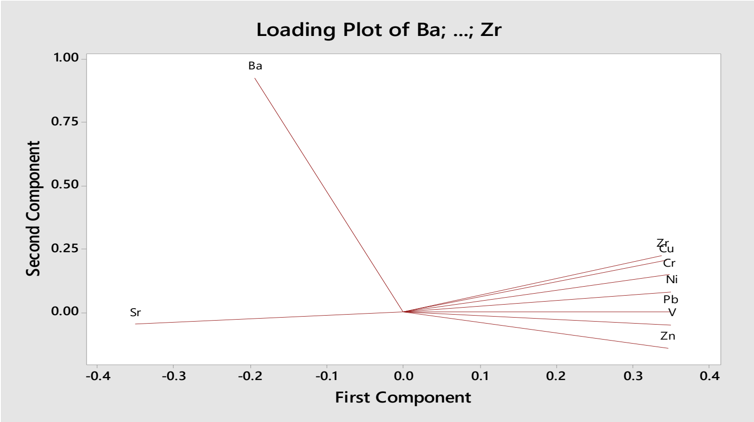

Figure 9. Loading plot showing the association of the trace elements analyzed.

5. Conclusions

During gibbsite beneficiation at Mina Alumina Limited a large volume of residue is produced and transported to the tailings deposit. The tailings deposit studied was divided into three sections and through laboratory analysis it was observed that the grain size distribution is not uniform in particle size, density and mineralogy. Section A, which is closest to the discharge point, contains coarse particles whose deposition occurs almost horizontally or obliquely, while very fine clay particles whose deposition occurs almost vertically, predominate in section C.

The particles from section A are the densest, with density decreasing with distance from the discharge point. The well graded tailings in section A may have application in civil engineering due to their wide size range. Kaolinite is the most abundant mineral in the tailings, detected in all 8 samples analyzed. Gibbsite was also detected in considerable quantities in samples from section A and B, obviously passing the washing plant's vibrating screen. Through the levels of similarity observed by dendrogram analysis, three groups of trace elements were distinguished, revealing their geochemical correlation. The trace element concentrations analyzed do not represent levels of toxicity to the neighboring soils and ground water, but should continue to be monitored. Further investigations are foreseen concerning the actual contents/concentrations of rare trace elements accompanying bauxite formation.

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