Mineralogical and Compositional Description of Al Taweelah Alumina Refinery's Bauxite Residue

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Abstract

Bauxite residue is a complex mineralogical array of mineral species that reflect the origin of the bauxite and the transformations that have occurred as a result of the Bayer process including all of its inputs (caustic, lime, impurities, among other). Of the total elemental composition space often identified suitably through X-ray Fluorescence (XRF) spectrometry, some elements are conjoined in large, systematic, 3-dimensional arrays (crystalline minerals) that can be traced and identified using X-ray diffraction, while other associations are too small in size and often too random in composition to produce traceable diffraction signatures (amorphous phases). EGA's Al Taweelah alumina refinery, operational since April 2019, produces approximately 2.4 million tonnes of alumina per annum (MTPA) with a concomitant rate of 0.9 dry tonnes of bauxite residue for every tonne of alumina. Al Taweelah alumina refinery's bauxite residue is a complex of 25 identifiable crystalline mineral species with an average of 10-13 % X-ray amorphous and 87-90 % crystalline minerals present. Proto-hematite/hematite and aluminous goethite dominate more than 75 % of the crystalline mineral composition with the remaining 25 % crystalline minerals divided over aluminosilicates (desilication products (DSP): sodalite, cancrinite), titanium (anatase, rutile, pseudobrookite, ilmenite), calcium (carbonatic-apatite, calcite, tri-calcium aluminate, katoite, hibschite, grossular) and aluminium species. The X-ray amorphous content is dominated by Al, Na, and Si, with significant correlation between Na and Si pointing to the possible presence of X-ray amorphous DSP phases. In the current study, we present findings from cluster and principal component analyses to describe the mineralogical variance of 16 bauxite residue samples collected over a period of 4 months (Oct 2022-Jan 2023), the changes that have occurred to the residue since start-up in 2019, and the implications for processing bauxite residue into optimized bauxite residue (OBxR), the primary feedstock material for EGA's Turba (*Arab*. soil).

Keywords: Al Taweelah alumina refinery, Cluster analysis, Principal component analysis, X-ray diffraction, X-ray amorphous.

1. Introduction

Emirates Global Aluminium's (EGA) Al Taweelah alumina refinery is a nameplate 2.0 MTPA alumina refinery that commenced production in April 2019. Within only a short period of approximately 12 months, Al Taweelah alumina refinery reached its nameplate production and thereafter proceeded with a production creep that currently culminates at 2.4 MTPA. The concomitant bauxite residue load is approximately three million tonnes at an average moisture content of 28 wt. % (~ 2.16 million dry tonnes per annum).

Initially, the refinery processed solely CBG bauxite, however, starting in February 2020, bauxite from EGA's GAC (Guinea Alumina Corporation) mine became regularly co-processed with CBG bauxite.

Al Taweelah Alumina refinery continues to operate at high temperature (~ 270 °C) with a pre-desilication stage. In 2020, lime injection to the holding tubes of the digestion units was increased from its original settings to lower Fe concentrations in pregnant green liquor. Other pertinent changes since start-up in 2019, which would impact on bauxite residue quality, include the gradual build-up of impurities specifically organics, carbonates and other Na-binding/coordinating anions, and regular operations of the causticizer in the counter-current decantation train that doses milk of lime to the residue slurry to recovery caustic (NaOH) from the liquor.

Emirates Global Aluminium continues to be fully committed to utilize 100 % of the bauxite residue produced by its Al Taweelah alumina refinery. Currently EGA is operating one pilot facility (Small Soil Manufacturing & Research Facility, SSMRF), has one pilot facility under construction (Ra'ed I: 5.6 TPD OBxR Pilot Plant; Ra'ed, *Arab.* Pioneer), one facility in execution stage (basic/detailed engineering), and two additional pilot facilities under planning and/ or pre-feasibility study. For all of these efforts, a detailed understanding of the elemental and mineralogical composition of the bauxite residue builds the baseline from which treatment effects on the residue can be gauged; this is especially true for the manufacture of optimized bauxite residue (OBxR), which is the near neutral, non-saline counterpart to the original bauxite residue. OBxR's main use is currently envisaged for direct utilization in manufactured soils (Turba, *Arab.* Soil), which can be mixed with suitable quantities of sand, compost and other soil-forming materials according to the needs of the grower. Research conducted on behalf of EGA at The University of Queensland has evidenced the superiority of Turba to natural dune sand with respect to water holding capacity, cation exchange capacity, nutrient availability, and biomass production.

In the following study we describe the variance among 16 bauxite residue samples collected over a period of four months to obtain an updated baseline of the residue that EGA intends to treat across some of its pilot facilities. A consistent quality of the feedstock is paramount for any industrialized process. Deviations from the norm must be recognizable and evaluated for their potential impact on processability and final product quality.

2. Experimental

2.1 Sampling Period and Treatment

Sixteen bauxite residue samples were collected from the filtration facility of the refinery between October 2022 and January 2023. Four samples with and 12 samples without oxalate filter cake were obtained. The samples were dried in an oven at 105 °C overnight, lightly ground in an agate mortar with an agate pestle; micronizing the samples was not required.

2.2 Measurements

Three measurements were performed on each sample: powder X-ray diffraction (XRD), X-ray fluorescence (XRF) analysis and thermogravimetric analysis (TGA) for determination of the mass percent for Loss on Ignition (LOI). The TGA-derived LOI value was entered into the XRF analysis program as a fixed variable. The details of the XRD and XRF data acquisition are described here [1]. For relevance, approximately 1.60 to 1.65 grams of the lightly ground powder was backfilled and lightly pressed into the sample holder affording even and consistent packing across all samples. The diffraction data was collected using monochromatic Co K-alpha radiation using a 20-micron Ni filter and a fixed divergence slit of 1.00 °. Eight sequential scans were collected and co-added after inspection for beam damage.

change in the nature of the residue: Perovskite and cancrinite formed, the amorphous content dropped by approximately 33 % to 10–13 % and calcite became a regular observation in the residue. The data set collected and presented here serves as an excellent baseline which we may now expand with other datasets from laboratory and pilot plant results.

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6. References

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