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Inaccuracies in Estimation of Bauxite Extractable and Mineralogical Constituents

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Abstract

It is necessary to know the complete mineralogy of bauxite to understand, interpret and predict correctly the outcome of mining, the plant digestion process as well as to know bauxite's commercial value. Over the years several methods have played a major role in the quantitative phase analysis of bauxite. The loss of mass on ignition (LOM) and elemental analysis of bauxite using modern instrumentation (XRF, ICP) yield excellent reproducibility and high productivity. However, the mineralogy required to evaluate the amount of recoverable alumina and other Bayer plant parameters has been much less readily accessible. Wet chemistry (WCh) is known to be slow, complex, expensive, occasionally erratic and delivers results of extraction but not of mineralogy. The X-ray diffraction analysis (XRD) requires a separate sample preparation stream. Interpretation of X-ray diffractograms is mainly influenced by amorphous phases and a poor limit of detection. The objective of this paper is to compare the performance of WCh, XRD and mathematical modeling (BauxQ software), using experimental data from several laboratories. The present state of analytical methodology for bauxite characterization is worrisome. The aluminium industry, which depends heavily on the conventional (WCh) and instrumental (XRD) data, often does not know the exact value of its principal raw material. Also, the industry should use mineralogical and not elemental composition to estimate bauxite's commercial value. Bauxite building blocks must be known and mass balance must be observed. The results demonstrate that mathematical modeling has distinct advantages for bauxite mineralogical quantification of various deposits, because it is the most consistent approach and provides an opportunity to significantly reduce operational costs. If the bauxite mineralogy is known, it is an easy step to calculate Bayer process parameters to obtain a better understanding of bauxite's economic value, leading to more efficient production control of a Bayer plant.

Keywords: bauxite mineralogy, methods of analysis, WCh, XRD, BauxQ.

1. Introduction

Composition of bauxite deposits and aluminium bearing minerals, like any other mineral ores, can be described from many points of view. The geologist seeks to identify and quantify mineral phases or understand the qualities of the material which he knows from experience to be useful to alumina extraction. He wants to be able to measure the extent of a mineral deposit and perhaps attach to it an approximate monetary value. The process engineer wants to blend mined bauxite and to predict its behavior in a given alumina extraction process. He will also want to measure the efficiency of his plant against defined benchmarks. The analytical chemist seeks to characterize a series of samples using standard analytical techniques and to convert the results into data that the geologist and the process engineer can use. These various needs give rise to three different sets of descriptors:

- Elemental composition (oxides and LOM).
- Phase composition (gibbsite or tri-hydrate, boehmite or mono-hydrate, kaolinite, etc.).
- Extractive mineralogy (available alumina, reactive silica, etc.).

The commercial objective is to obtain fundamental information on mineralogical phase distribution in bauxite and to know the building blocks of the material. Bauxite mineralogical composition is important and must be known to estimate its commercial value and to guide the process of its conversion to alumina. Several analytical methods are employed for this purpose. The cost, reliability, accuracy of determination and ease of use play an important role in the consideration of the best methods to use.

The main objective of this paper is to reflect on the present state of analytical methodology in bauxite quantitative phase (mineralogical) analysis. Another objective is to compare performance of WCh, XRD and mathematical modeling (BauxQ software), using recent experimental data from several laboratories.

2. Wet Chemistry (WCh)

Wet chemical procedures (WCh) involving laboratory bomb digestion were the first used for quantitative phase analysis of bauxite [1]. The bomb digestion analyses are performed under standardized conditions. Various terms may be employed to describe Al_2O_3 determined during low-temperature (LT) digestion (~140 – 150 ºC) with caustic, for example available alumina Av. Al_2O_3, ATH, or simply Al_{LT}. Silica extracted at low temperature is called Si(LT) or reactive silica ($RxSiO_2$) [2,3]. It is determined in a standard low temperature digestion as the amount of silica reacting with the liquor by passing first into the solution and then precipitating as an acid soluble alumino-silicate, called Bayer sodalite. As far as is known, it is mainly the kaolinite-type minerals that will dissolve under low temperature digestion conditions. Quartz will not dissolve, unless finely divided or poorly crystallized. Therefore, it is assumed that any silica not dissolving under these conditions represents quartz, plus other clay-type silicates rarely detected by XRD [4].

In the laboratory high temperature (HT) digestion (~225 – 270 °C), not only gibbsite and boehmite are dissolved but also kaolinite, phosphates, some quartz, in addition to other minerals. It is assumed that additional parameters can be determined, for example Net Extractable Alumina = Al(HT) and Total Available Alumina (TEA = Al(HT) - 0.85 $RxSiO_2$), which is used to describe alumina in gibbsite and boehmite. TEA is also known by the name "total extractable alumina". Sometimes corrections are made for silica dissolved from partial attack of quartz and other minerals. Hence, the TEA determination is less accurate than the determination of Al(LT), because it is based on several determinations, each with its own analytical error. As a result, the so-called MONO (Al_2O_3 in boehmite) that is calculated by the difference between TEA and Al(LT) is considered less accurate than boehmitic Al_2O_3 (b.Al_2O_3) determined by a direct method.

In general, there are five major problems associated with the WCh approach:

- the laboratory bomb digestion is carried out under different conditions from plant digestion
- the parameters of the bomb and plant digestion vary from one location to another; therefore, comparison of results is difficult or impossible
- concentration ranges of constituents determined by WCh are limited
- Bayer process control accuracy is limited by using the WCh data generally available
- the chemical analysis (bomb digestion) cannot accurately predict the mineral composition of bauxite most of the time.

Some bauxite is known to contain a very fine boehmite that partially dissolves at low temperature digestion conditions and contributes to Al(LT) [5]. Such boehmite may act as seed for Al_2O_3 already dissolved taking it out of the Bayer solution into the red mud, which reduces alumina recovery in the Bayer process. This phenomenon is known in the literature as boehmite reversion [6]. To avoid boehmite reversion or boehmite dissolution the digestion must be carried out within a limited and controlled A/C ratio (Al_2O_3/Caustic expressed as Na_2CO_3). The required sample quality correlation among different methods for these constituents is much more difficult than for gibbsite or kaolinite.

8. References

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