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CHARACTERIZATION OF COMPLEX BAUXITE ORE - Part II

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Abstract

This paper presents the results of a detailed physicochemical, mineralogical and textural characterization of a complex bauxite ore with a content of about 55% Al_2O_3, with the aim of defining the exact characteristics of the phases and their mutual relationships. Mineralogical analysis showed that the monohydrate phase of boehmite dominates the aluminum matrix, with a smaller share of diaspore. The key technological limiting factor of the raw material is the extremely high content of iron, primarily present in the form of hematite (about 23%), as well as a significant share of titanium dioxide (about 3% TiO_2). Given the complexity and fine interweaving of useful minerals and tailings, detailed characterization is the zero step for predicting the behavior of the raw material and choosing the optimal process for its future enrichment. An integrated approach was used for the characterization of the samples, which includes advanced instrumental methods: classical chemical analysis, X-ray diffraction (XRD) analysis, but also other analyses that will be presented later. The obtained results provide a fundamental scientific and practical basis for defining the required degree of grinding, the success of mineral release and the design of future technological processes for the purification of this complex raw material.

Keywords: *complex bauxite, boehmite, hematite, phase characterization, chemical analysis, XRD*

1 INTRODUCTION

In the modern world economy, bauxite represents an irreplaceable mineral raw material as a primary source for the production of alumina and aluminum metal. However, the constant trend of depleting high-quality and easily processed deposits forces the mining and metallurgical industry to exploit complex, poorer and high-iron (ferruginous) bauxite ores. Such raw materials are characterized by pronounced heterogeneity, fine-grained structure and close, micron intergrowth of useful minerals with tailings minerals, which significantly complicates their further technological processing, which is in accordance with the general geological and mineralogical characteristics of these deposits [1]. The technological potential and economic justification of bauxite exploitation directly depend on the form and modifications in which minerals of aluminum, iron and accompanying elements appear. The tested

bauxite ore is characterized by a relatively high raw content of the useful component of about 50-57% Al_2O_3, where the monohydrate phase of boehmite dominates in the mineral matrix, with a smaller share of structurally tougher diaspore. However, the main limiting factor and technological challenge of this raw material is the extremely high concentration of iron, primarily bound in the form of hematite (about 23%), as well as the significant presence of titanium dioxide (about 3% TiO_2). The presence of hematite in this percentage not only reduces the relative share of aluminum in the total mass, but the finely developed morphology of its grains directly dictates the behavior of the material. From an engineering point of view, the degree of entanglement of hematite with boehmite determines critical parameters such as the optimal grinding coarseness and the degree of freedom of mineral grains, without knowledge of which it is impossible to design an efficient process of selective iron separation. Therefore, a detailed physico-chemical, mineralogical and textural characterization of the ore is a fundamental and unavoidable step that precedes any attempt at laboratory or industrial pretreatment and concentration. The modern approach to the characterization of mineral raw materials goes beyond the classical methods of chemical analysis and requires an integrated instrumental chain.

2. EXPERIMENTAL

For research purposes, a technological sample of complex high-iron bauxite ore from a specific locality was provided. Considering the marked natural heterogeneity of the raw material, a standard procedure of primary preparation was applied in order to obtain a representative sample for physico-chemical and mineralogical tests

2.1. Preparation of Bauxite ore for physico-chemical and mineralogical analyses

A sieved sample of the size class -4+0 mm was used for preparation and selection of the representative sample. In order to select a representative sample for chemical and mineralogical characterization cone, cake and chess field forming was used. The sample was also shortened according to a known procedure

2.2. Chemical analysis

For the chemical analysis of the composite representative sample of the bauxite ore, X-ray fluorescence (XRF) and Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES) methods were used. The chemical composition based on these analyses is shown in Table 1.

From the chemical analysis shown in Table 1, it can be seen that iron content in bauxite ore is high, about 22.49% Fe. The ore contains a significant amount of TiO_2 (3.73%), and rare earth elements are also present.

Table 1. *Chemical composition of Bauxite ore based on XRF and ICP-AES.*

Elements	Bauxite ore	Analytical method
% Al_2O_3	57.46	XRF
% SiO_2	2.50	
% CaO	0.73	
% TiO_2	3.73	
% Cr_2O_3	0.17	
% Fe_2O_3	22.49	
% ZrO_2	0.15	
ppm As	52.6	ICP-AES
ppm Ba	6.7	
ppm Be	3.4	
ppm Co	27.9	
ppm Cr	552.0	
ppm Cu	27.7	
ppm Li	8.2	
ppm Mn	16.1	
ppm Nb	38.0	
ppm Ni	77.8	
ppm P	120	
ppm Sn	11.1	
ppm Sr	64.8	
ppm V	253	
ppm Zn	21.6	
ppm Sc	6.3	
ppm Ga	12.1	
ppm Th	10.6	
ppm Y	4.4	
ppm La	12.2	
ppm Ce	50.4	
ppm Nd	14.9	
ppm Pb	16.6	

2.3. Mineralogical analysis of bauxite ore

2.3.1. XRD analysis

The examination of the bauxite ore powdered sample was performed using the X-ray diffraction (XRD) method on a Rigaku SmartLab powder diffractometer under the following experimental conditions such as operating voltage: U = 40 kV, current strength: I = 30 mA, X-ray radiation from the anticathode of copper (Cu), wavelength: CuKα = 1,54178 Å, scope of testing: 2 – 75° 2θ, step: 0,01° 2θ, time constant: 5 °/m.

The obtained data on the position of the maximum diffraction 2θ (°), the values of interplane distances dhkl(Å) for all hkl reflections, as well as the corresponding relative intensities I/Imax are given graphically. Based on the obtained values of intensity I/Imax, interplane distances d and by comparison with literature data and the ICDD database, the present crystalline phases were identified. The X-ray powder diagram of the tested bauxite ore sample is given in Figure 1, together with the reflection positions of the corresponding phases from the database. A database search in the bauxite ore sample revealed the presence of several crystalline phases (Figure 1): boehmite - aluminum oxyhydroxide, AlO(OH), rhombic symmetry (PDF# 01-073-6509), hematite - iron(III) oxide, Fe_2O_3, rhombohedral symmetry (PDF# 01-087-1166), diaspore - aluminum oxyhydroxide, AlO(OH), rhombic symmetry (PDF# 01-088-2351) and anatase - titanium oxide, TiO_2, tetragonal symmetry (PDF# 01-071-1166).

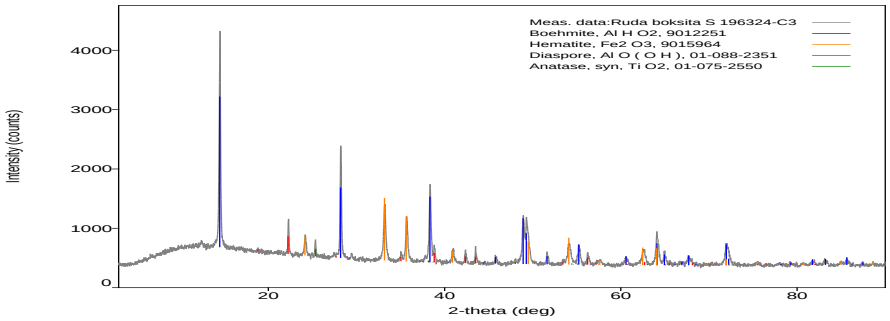


Figure 1. *XRD Diffractogram of the tested bauxite ore sample*

The results of the quantitative analysis (WPPF method) of the confirmed crystal phases in the bauxite ore sample are shown in Table 2. Quantitative phase and structural parameters of minerals were determined using Rietveld refinement [2].within the accompanying software package.

Table 2. *Results of quantitative analysis of bauxite ore sample based on XRD*

Sample of the bauxite ore	
Phase	***(%)***
boehmite	52
hematite	25
diaspore	12
anatase	3

In the bauxite ore sample, in addition to the phases shown in Figure 1, the presence of very small amounts of kaolinite is possible. Also the presence of minerals from the group of potassium feldspar and calcite, whose presence cannot be unequivocally confirmed due to the small number/weak intensity of the peaks (mainly due to very low abundance) on the diagram, which would confirm the present phases with certainty, is also possible. Since the confirmed minerals in the bauxite ore sample do not contain silicon in the general chemical formula, the SiO_2 content in the chemical analysis can be attributed to the possibly present minerals - kaolinite and potassium feldspar.

3. RESULTS AND DISCUSSION

Based on the conducted chemical and mineralogical tests of the complex boehmite-hematite bauxite ore, using complementary instrumental methods (XRF, ICP-AES and XRD), the following key conclusions can be drawn: High potential of the useful component: Chemical analysis confirmed that the ore has a significant basic aluminum content of about 55% Al_2O_3, which makes it a high-quality raw material from the point of view of the total share of useful metal. Monohydrate character of the matrix: X-ray diffraction analysis (XRD) determined that the aluminum matrix is of mixed monohydrate type. It is convincingly dominated by the mineral boehmite, while the structurally more compact diaspore is present in a much smaller proportion. High ferruginous content: The main technological limiting factor of this raw material is the extremely high iron concentration of about 23% Fe_2O_3. XRD analysis confirmed that the iron is primarily bound in the form of the crystalline phase of hematite, whose sharp and intense peaks indicate a stable and well-defined crystal structure of the tailings. Identification of titanium phases: By analyzing accompanying impurities, titanium dioxide was detected in the amount of about 3%. Diffraction analysis successfully located this oxide in the form of anatase mineral, which provides an important guideline that titanium builds its own tetragonal mineral phase which is confirmed by similar studies in the literature [3], instead of being randomly incorporated into the lattices of boehmite or hematite.

4. CONCLUSION

Technological significance: Exact identification and quantification of the phases (boehmite-hematite-anatase) indicate a high degree of mineralogical complexity. The results of this work prove that the further successful processing of this ore does not depend only on the overall chemistry, but on the need to develop a specific technological purification procedure (beneficiation) that would remove hematite before introducing bauxite into the metallurgical cycle. This detailed basic characterization represents an indispensable scientific basis and a successful zero step, which opens up space for further research that will be directed towards the experimental definition of the optimal degree of grinding and the application of pyrometallurgical treatment in order to of selective iron removal.

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REFERENCES

[1] Bárdossy, G. (1982). Karst Bauxites: Bauxite Deposits on Carbonate Rocks. Elsevier Scientific Publishing Company, Amsterdam.

[2] Vlahović, M., Martinović, S., Volkov-Husović, T. (2015). Kvantitativna XRD analiza faza u mineralnim kompleksima primenom Rietveldovog rafinmana. Industrijski materijali, 49(2), 115-122.

[3] Gao, J., Li, C., Sun, H. (2021). The occurrence of titanium in bauxite ores and its mineralogical phase transformation during beneficiation. International Journal of Mineral Processing, 160, 102-110.