The Barro Alto Bauxite Mine: A New and Wholly-Exploitable Deposit in Goiás State, Central Brazil

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Abstract

The Barro Alto bauxite mine is situated in Central Brazil, about 200 km Northwest of Brasília, in a region served by good infrastructure (paved roads, rail, energy, human resources, etc.). Exploration and research works were developed from 2004 to 2012 and revealed a large and peculiar outcropping deposit, composed of high-grade bauxite, low-grade bauxite and associated kaolinite. It was formed by alteration of anorthosites, included in a large Proterozoic mafic-ultramafic complex. The total resources reached 300 million tons of ore, without barren cover. Mining activities started in 2013, with good results. The excellent quality of the bauxites and clays permits the entire exploitation of the resources and allows several industrial uses for the ores, apart from the classic metallurgical application.

Keywords: bauxite, new mine, Central Brazil, anorthosites.

1. Introduction

The Barro Alto bauxite mine is situated in Central Brazil, about 200 km Northwest of Brasília and 200 km North of Goiânia (Figure 1). The lands belong to two municipalities in the State of Goiás: Barro Alto and Santa Rita do Novo Destino.

The region is served by good infrastructure and has a favorable geo-economic environment. Paved highways, electric power, human resources, etc. are available. The mine is close to an important future railway junction between North-South railway FE-151 (under construction 40 km away of Santa Rita) and the East-West railway FE-354 (planned).

2. Geo-environmental Context

The bauxite deposit occurs within the Neoproterozoic Brasília Fold Belt and is located in the Northern part of the great Mafic-Ultramafic Barro Alto Massif, more specifically in the Upper Series, which consists of anorthosites, gabbros and pyroxenites [1], [2]. It is located nearby an important nickel laterite deposit mined by Anglo American (Figure 2).

The region is located within the Tocantins Basin. The landscape is dominated by a high ridge with levels exceeding 1 200 m. These elevated terrains have no significant economic use, the soil is poor with thin vegetation. On the other hand, the lowlands have fertile soils derived from mafic rocks that is utilized for industrial agriculture (sugar cane, rubber plantations, tomatoes, fenced-in cattle).

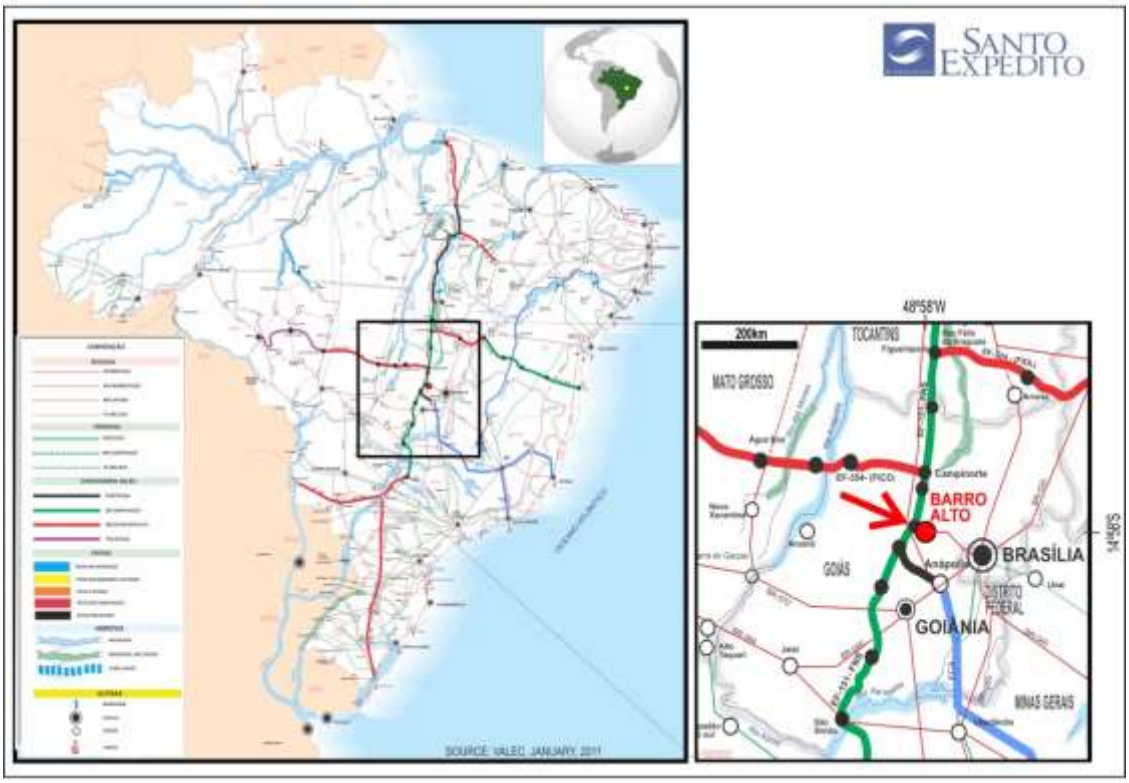

Figure 1. Location and infrastructure.

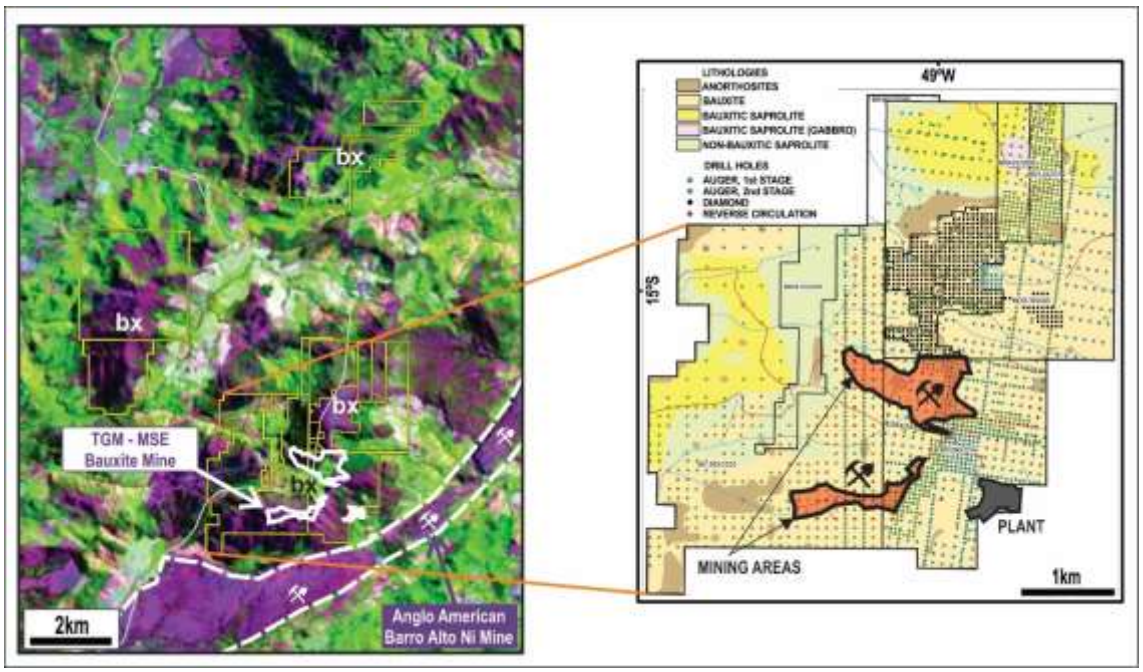

Figure 2. Environmental context and mine geology.

3. Project History and Mineral Rights

The Barro Alto bauxite deposit is the first to be discovered in Central Brazil. The history of the Project may be summarized as follows [1], [3], [4]:

- In 1999, geologists of EDEM – Empresa de Desenvolvimento em Mineração Ltda. conceived an exploration program for bauxite in Goiás, with a view to discover small deposits suitable for producing aluminum sulphate (utilized for water treatment). This regional investigation led to the discovery of the main bauxite deposit.
- In 2004 EDEM formed an association with Terra Goyana Mineradora Ltda. (TGM) to study the area. Later, they formed Mineradora Santo Expedito Ltda. (MSE). TGM and MSE are the actual title holders.
- The research was initiated with technical and operational support from Mineração Curimbaba Ltda. (MCL), an established producer of bauxite derivatives in Poços de Caldas – Minas Gerais. Technical procedures dedicated to bauxite research in Minas Gerais were then adopted. However, it was gradually realized that this was a unique deposit, with great dimensions and noteworthy quality, suitable for diverse uses. Confirmation of metallurgical suitability allowed discussions with CBA – Companhia Brasileira de Alumínio.

Note that EDEM, TGM, MSE, MCL and CBA are all Brazilian companies.

4. Project Evolution

Exploration has involved the following stages:

- 2004-2005: 1st exploration stage – relatively shallow auger drilling with chemical analyses for industrial use.
- 2006-2007: 2nd exploration stage – the principal areas were revisited using a new approach, with deeper drilling and chemical analysis also geared toward metallurgical use.
- 2007-2008: The project was evaluated by GEOS – Geologia para Mineração Ltda, with a view to verifying exploration procedures and improving parameters and controls.
- 2008-2010: New auger drilling undertaken to detail selected portions of the deposit.
- 2010-2011: Drilling by reverse circulation undertaken as well, with a view toward industrial uses of the deposit.
- 2012: Mining trial conducted by MSE.
- November 2013: Commencement of regular mining.

5. Ore Geology

The substrate of the deposit is dominated by banded anorthosites displaying high-grade metamorphism. These rocks allow impressive elevations (1 200 to 1 500 m) corresponding to a gently undulated ridge, highlighting the regional landscape (Figure 3).

The alteration of the anorthosites results in bauxite and minor kaolinite. Initially, it was supposed that bauxite and kaolinite would be produced by lateritic weathering of the anorthosites, according to the classical genetic model of bauxites [5], [6], [7].

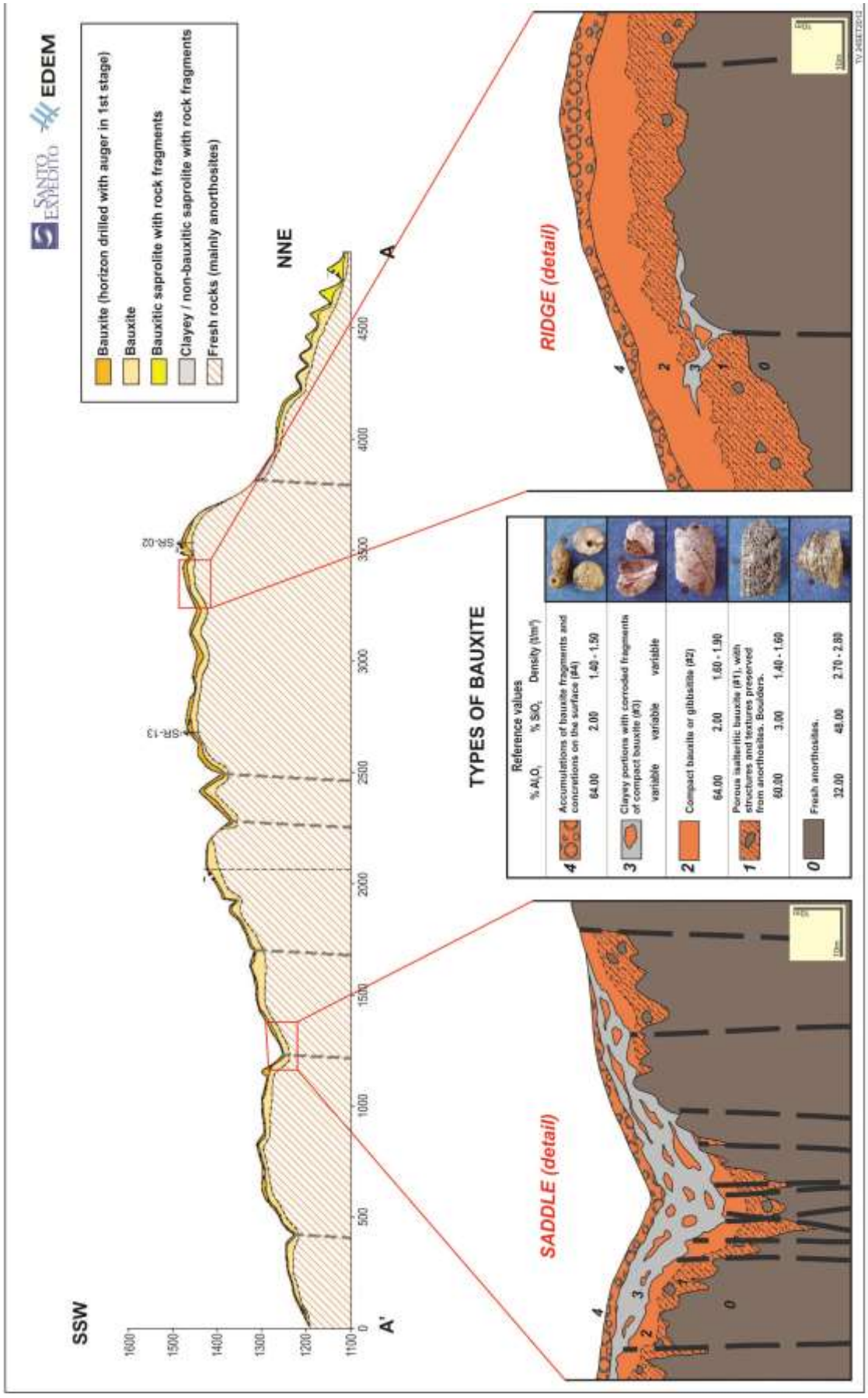

Figure 3. Geological Sections and types of ore.

Nevertheless, the mining operation has exposed some geological features compatible with hydrothermal origin. Advanced studies coordinated by Professor Marcondes Lima da Costa are being developed at the University of Pará, aiming to elucidate the evolution of this peculiar deposit.

The bauxite outcrops in the form of leached rock fragments, at times with a clayey matrix or clayey portions. It forms a great deposit, differing from type reference models in other parts of Brazil and the world [8], [9].

The deposit extends more than 6 000 m and has a width of 3 000 m. Thickness of the altered rock exceeds 20 m in the upper portions of the deposit, but at times it exceeds 60 m. Porous bauxites predominate, marked by light and dark bands relict after the original layering. Preservation of structures and textures of the primary rocks is evidence of an *in-situ* origin. The altered rocks are partially eroded, with accumulations of bauxite fragments on the surface.

The transition from fresh rock to bauxite is always abrupt, even on a microscopic scale, which attests to the intensity of the leaching process. It resulted in intense removal of SiO_2, K_2O, CaO and MnO. At the same time, it promoted the relative enrichment of Al and Fe, represented by gibbsite and goethite respectively.

The grades are impressive, in the order of 52 % total Al_2O_3 (crude basis, *in natura*) comparable with the best deposits available in Brazil. The bauxitic cover is very regular, but includes clayey portions with corroded fragments of bauxite, resulting in significant reserves of aluminous clays.

6. Resources

The database in 2012 comprised results of auger drilling, diamond and reverse circulation drilling, totaling 2 698 holes and 32 473 m drilled. The deposit evaluation considered parameters adjusted to the reality of the area and market requirements.

The ore was classified according to metallurgical uses: AA is *Available Alumina* and RS is *Reactive Silica*. The following classifications are made (grades *in natura*):

- Higher grade ore: AA $\geq$ 30 % and RS $\leq$ 7 %.
- Lower grade ore: AA $\geq$ 30 % and RS > 7 %.
- Clay with Bauxite: AA between 10 % and 30 %.
- Clay: AA < 10 %

The calculated resources indicate 220 million tonnes of ore. When including the areas of MCL and CBA, they increase to 300 million tonnes.

7. Mining and Ore Processing

Mining of bauxites and clays is done in large and shallow open pits, using hydraulic excavators. The ore processing involves crushing and dry sieving, which results in several types of bauxites: metallurgical grade, chemical grade, abrasive grade and cement grade (Figure 4). Clays have other industrial uses.

Figure 5 shows the location of the present consumers of all the Barro Alto products, largely distributed in Central and Southern Brazil and neighbor countries.

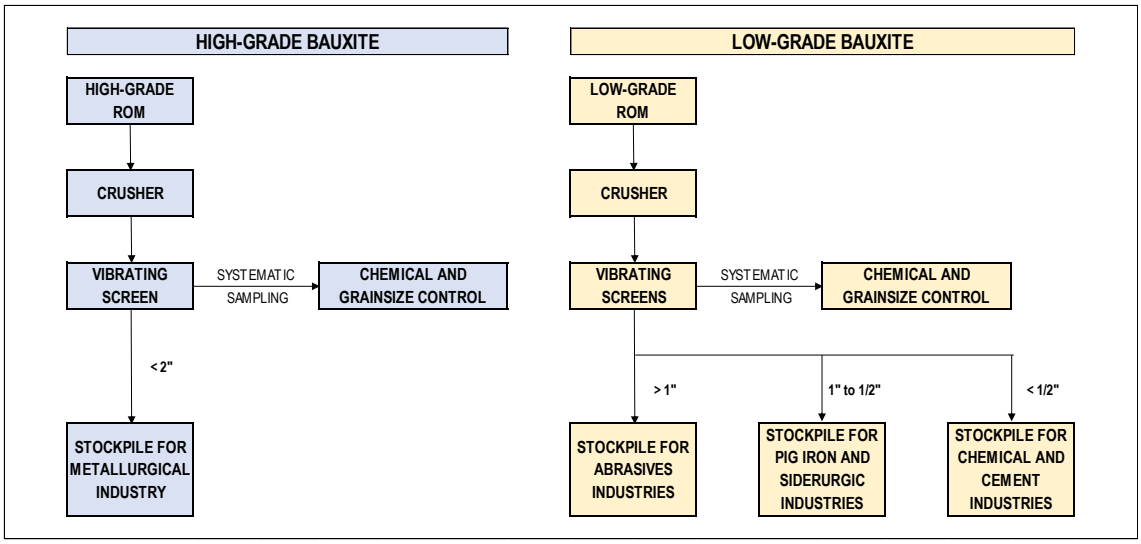

Figure 4. Ore processing flowsheet.

Figure 5. Consumers and uses.

The proposed mining has a minor environmental impact, as the ore processing does not use water. Recovery of excavated areas accompanies the progression of mining. It involves the smoothing of the slopes, restoration of organic soil and planting of grasses and native trees.

8. Final Considerations

The Barro Alto Bauxite Mine should be considered as a *mine of the future*, in the words of Professor Marcondes Lima da Costa. Bauxite outcrops in large extensions, without barren cover.

The high quality of the ores allows simple circuits of treatment and permits the attendance of diversified and growing demands, largely distributed in Brazil and neighbor countries. As seen, the ore processing does not need water or generate tailings.

Everything has the potential to be economically useful in this peculiar ore deposit. Many of its geological features are suggestive of hydrothermal origin, presently under scientific investigation at University of Pará.

Mining operations started in November of 2013 and already occupies a remarkable place within the Brazilian mineral industry. This resource contributes to numerous industries, thus contributing decisively to the development of the region in a sustainable fashion.

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