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THE BAUXITES OF QUADRILÁTERO FERRÍFERO, MINAS GERAIS, BRAZIL

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The mountainous region of Quadrilátero Ferrífero is known as a mining province already for a long time, although at the beginning mainly as an iron-bearing area. In this paper its significance as a bauxite domain is investigated. Four distinct groups of bauxites were established, and are described geologically, genetically, and mineralogically. The relation between the age of the bauxites and the landscape evolution was stressed, too.

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BOKSITI PODRUČJA QUADRILÁTERO FERRÍFERO U BRAZILSKOJ DRŽAVI MINAS GERAIS

Brdovita oblast Quadrilátero Ferrífero poznata je kao rudarsko područje već odavno, ali isprva uglavnom kao željezonosna zona. U ovom je radu proučavano njeno značenje kao boksitnog područja. Utvrđene su četiri odvojene grupe boksita koje su i opisane geološki, genetski i mineraloški. Istaknut je i odnos između boksita i evolucije krajolika.

(R. M.)

INTRODUCTION

The Quadrilátero Ferrífero, located in central part of Minas Gerais state, southeast Brazil, covers an area of nearly 7 000 km². It is a montainous Precambrian region included in the folded belt of São Francisco schield.

The stratigrafic column of this region was firstly proposed by **Harder** and **Chamberlin** [8, 9], modified priorly by **Door** [2] and later by **Ladeira** [11]. Geologicaly it is caracterized by four great litostratigraphic units (Fig. 1):

— the oldest rocks of this region are gneisses and migmatites, Archean in age, which constitute the crystaline basement for the supracrustal units;

— the Rio das Velhas Supergroup is an Archean greenstone belt type sequence, and hosts the major gold deposits of this region;

— Minas and Itacolomy Supergroups are formed by thick units of Proterozoic metasedimentary rocks. The Minas Supergroup has the most important deposits of iron, manganese and aluminium.

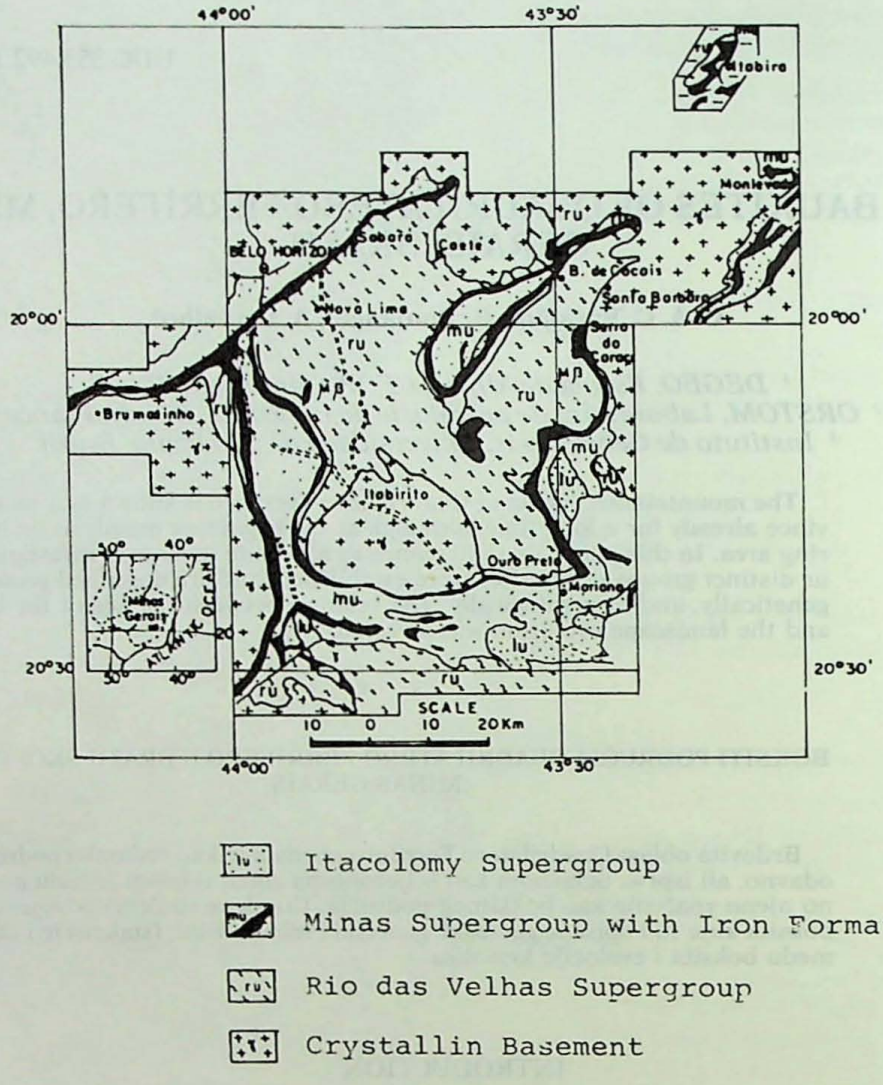

Fig. 1. Geological map of the Quadrilátero Ferrífero. Mod. after **Dorr** and **Barbosa** [3]

The general metamorphic grade is lower greenschist facies, increasing from west to east. In this iron rich region, the pattern of its structuraly controled delimiting ranges results from a complex deformational history, with three main trends: north, east and south.

The Quadrilátero Ferrífero presents bauxites reserves estimated to about 10 millions tons, distributed in 14 small deposits, which ranges from 150 to 1 500 thousand tons (Fig. 2).

The genesis of these deposits is a matter of controversy:

— According to **Fleischer** and **Oliveira** [5] Quadrilátero Ferrífero bauxite deposits are determined by two kinds of control. Firstly, the most part of them are related to Itabira Group, Minas Supergroup (geologic control), and secondly these

Fig. 2. Index map of the Quadrilátero Ferrífero showing the localization of bauxite deposits

deposits would be related to karstic traps, exiting in the planation surfaces (paleogeographic control). Other authors [1, 15] also mention lacustrine sediments as the protore for bauxite deposits;

— Many authors [2, 4, 6, 7, 10, 13, 14, 17] considered an in situ evolution from philites, dolomitic philites and schists.

THE BAUXITE DEPOSITS

CLASSIFICATION ACCORDING TO THE CHEMICAL CHARACTERISTICS

The triangular diagram (Fig. 3) based on thousands of chemical analysis obtained from regional mining companies and from the distribuition pattern allow to identify four distinct groups of deposits.

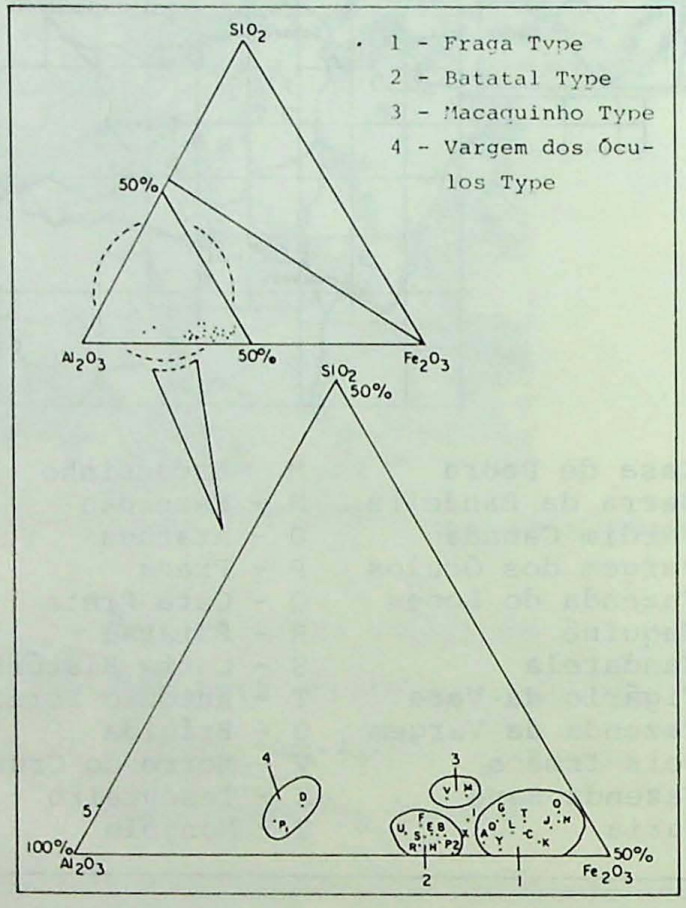

Fig. 3. Triangular diagram showing the behavior of Quadrilátero Ferrífero bauxite deposits on function of its main chemical components.

Later it was observed that these groups show a close correlation with the morphological units: the Fraga type (I) — slope, Batatal (II) and Macaquinho (III) — plateaux, and Vargem dos Óculos (IV) — depression.

DESCRIPTION OF DEPOSITS TYPE

I. The Fraga Type

The bauxite deposit of Morro do Fraga is located in the eastern border of the »Quadrilátero Ferrífero« (Fig. 2), 7 km far from Santa Rita Durão District. It is situa-

ted on the inverted limb of Santa Rita Syncline, constituted by formation of the Itabira Group. The area is characterized by a bended ridge (altitude of 1 000 m) of itabirites covered by iron-crust, and a steep slope where the bauxite deposit is preserved by an alumino-ferruginous hardpan.

In a schematic vertical profile we observed from the bottom to the top (Fig. 4) the following bauxite facies:

— a massive bauxite: it is an homogeneous, dark-red, hard, porous and vesicular facies; it consists of a skeleton of few quartz grains (1 %) and opaque minerals (1 %) envolved by a hematitic and gibbsitic dark red matrix that changes locally into light red gibbsitic matrix; in both matrix the voids (smaller than 4 mm), with irregular shapes and distribution, are coated with gibbsite and hematite:

— a friable bauxite: the transition is gradual by a simple increase of the porosity of the massive facies that forms relict volumes envolved in an alumino-ferruginous matrix; this matrix is formed by various generations of alluvial ferruginous cutans and gibbsitans;

— a massive alumino-ferruginous hardpan: the transition with the former facies is irregular and clear; this brownish red to yellow facies is characterized by a redistribution of the constituents of the underlain facies with an alumina remobilization and a tendency to an alumina remobilization and a tendency to an iron accumulation;

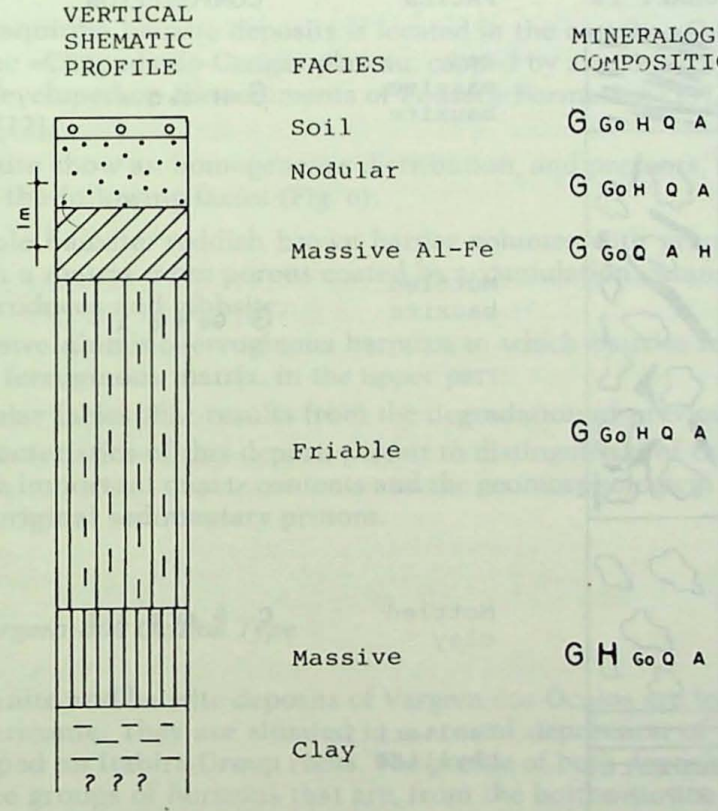

Fig. 4. Mineralogical composition of bauxite facies in a vertical schematic profile of Morro do Fraga deposit

— a nodular facies: the nodules are of irregular shapes and sizes, and with the same as the alumino-ferruginous hardpan; they result from its degradation.

The characteristics of this profile suggest an in situ evolution. The present tendency of this evolution shows that the massive bauxite is undergoing now a deferruginization. On the other hand, the transition to the friable facies is marked by the redistribution of the iron and also by a transformation of hematite into goethite. In the upper part the formation of the hardpan results from the relative accumulation of the iron in the goethite from.

II. The Batatal Type

The bauxite deposit of Batatal, also located in the eastern part of the »Quadrilátero Ferrífero« (Fig. 2), occurs on a plateau showing a smooth declivity. The thickness of the deposit increases to downslope. The substratum would be also constituted by formations of the Itabira Group [13].

The vertical profile shows, from the bottom to the top, the following facies (Fig. 5):

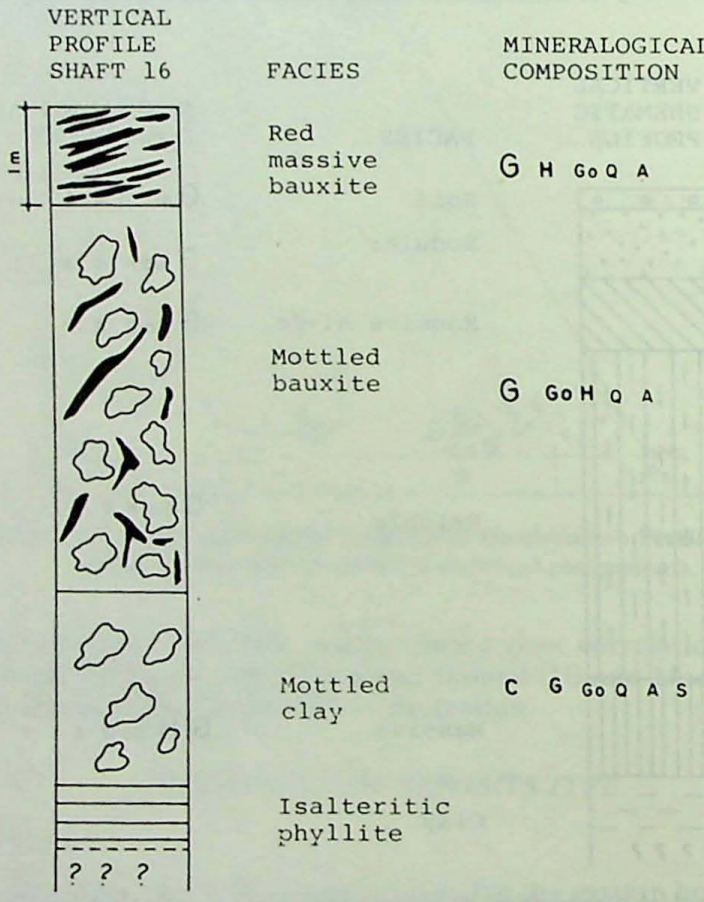

Fig. 5. Mineralogical composition of bauxite facies of shaft 16 of Batatal Deposit

— an isalterite: it is a weathered phyllite, with the preserved schist structure, that shows a juxtaposition of volumes, some green with original minerals (muscovite), others red dark, reach in iron, with white kaolinite spots and voids coated with gibbsite;

— a mottled clay with dark red hematitic to white kaolinitic spots indicating a process of deferruginizations;

— a mottled bauxite: showing an association of dark red hematite and gibbsite volumes more important in the upper part, changing in brown yellow goethite and gibbsite volumes more important in the lower part;

— a massive red bauxite with various generations of ferruginous and aluminous cutans forming locally a true hardpan.

The analysis of this profile show the presence of two discontinuities: the first between the isalterite and the mottled clay, the second between mottled bauxite and the massive bauxite. Thus it is difficult, in the present step of the study, to precise if the parent rock is the basal phyllite. A filiation between the mottled bauxite and the mottled clay indicate the present evolution in the low part of the profile by deferruginization and suggest a possible resilication.

III. The Macaquinho Type

The Macaquinho bauxite deposits is located in the eastern »Quadrilátero Ferrífero« on the »Chapada do Canga« plateau, capped by argilo-ferruginous hardpans probably developed on the sediments of Fonseca Formation [13], which are Eocenic in age [12].

The bauxite show an homogeneous distribution, and presents, from the bottom to the top, the following facies (Fig. 6);

— a friable bauxite: reddish brown harder volumes with granular texture are embeded in a matrix more porous coated by accumulation cutans of alumino-ferruginous produces and gibbsite;

— a massive alumino-ferruginous harpdan in which bauxite fragments are cemented by ferruginous matrix, in the upper part;

— a nodular facies that results from the degradation of previous hardpan.

The characteristics of this deposit permit to distinguish it of the others, mainly by the more important quartz contents and the geomorphological disposition related to the original sedimentary protore.

IV. The Vargem dos Óculos Type

The kaolinite and bauxite deposits of Vargem dos Óculos are located at 15.5 km of Belo Horizonte. They are situated in a central depression of Moeda Syncline and developed on Itabira Group rocks. The profile of both deposits are characterized by three groups of horizons that are, from the bottom to the top:

— lower clay with a facies of a compact kaolinite going up to kaolinite with ferruginous zonation and showing relict micronodules with and/or gibbsite;

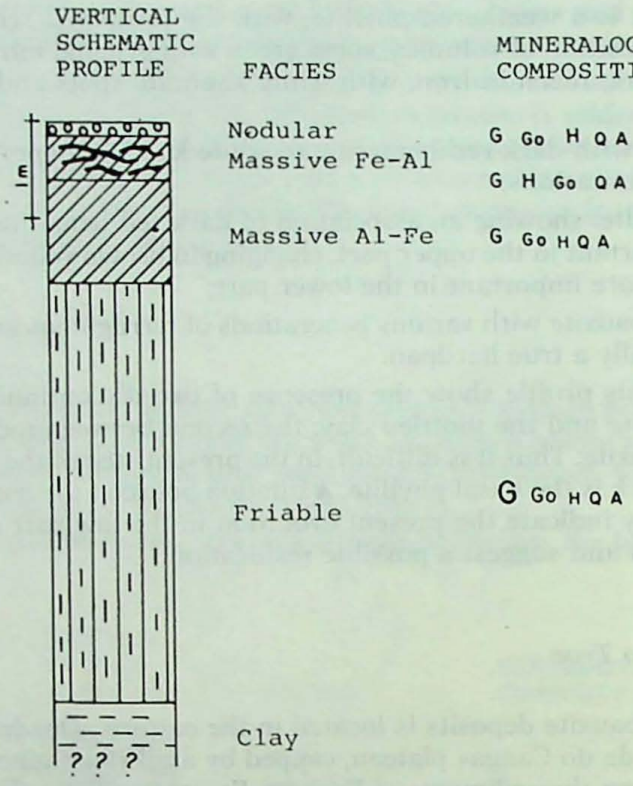

Fig. 6. Mineralogical composition of bauxite facies in a vertical schematic profile of Macaquinho Deposit

— middle bauxite with hematite gibbsite red relict facies and white gibbsitic facies in vertical pockets of deferruginization; in the upper part the relict nodules of bauxite can be cemented by an argilo-ferruginous material and form a true hardpan;

— the barren covering layer present clear sedimentary characteristics.

These deposits are mainly characterized by deferruginization and resilication processes in the lower part of the bauxite.

AGE OF BAUXITES AND LANDSCAPE EVOLUTION

The distribution of the deposits in function of altitude (Fig. 7) shows that the different described types are not related with only one altimetric level. Thus, considering that deposits of the same type are formed at the same age we could state that, at that time, these different altimetric leves were already present.

Considering the Eocenic age of the Fonseca Formation and the reasoning presented in the previous topic, we can suppose that Quadrilátero Ferrífero bauxite deposits were formed at the Miocenic time. Nevertheless, the fact that most of »ty-

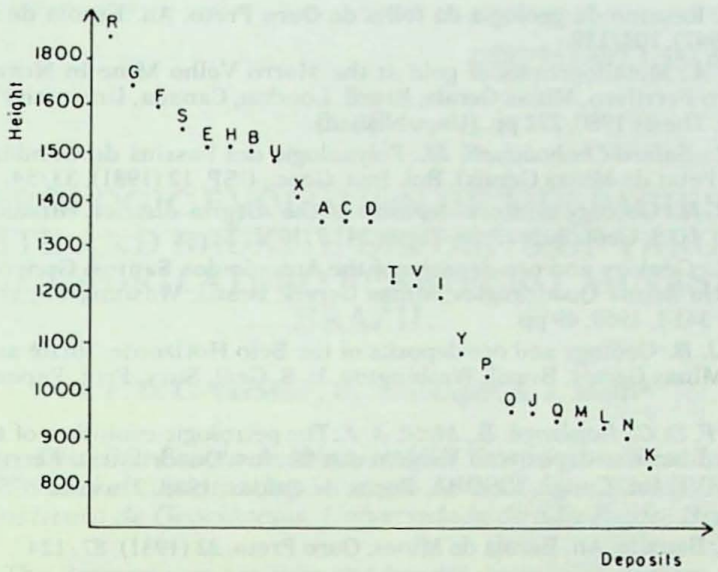

Fig. 7. Height distribution of the Quadrilátero Ferrífero bauxite deposits

pe II« deposits here presented are located in the highest levels is an aspect of Quadrilátero Ferrífero bauxites that deserves a close attention.

Therefore, the study of bauxite deposits and other surface formations can conduct to new considerations on the Quadrilátero Ferrífero morphogenetic evolution. That is to say, if these different altimetric levels had the same age, we could state that lithostructural control was the factor of strongest influence on regional landscape evolution.

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