BR-80

MINISTERIO DAS MINAS E ENERGIA
COMPANHIA DE PESQUISA DE RECURSOS
MINERAIS

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PROJECT REPORT
Brazil Investigations BR.
(IR)BR-80

ALUMINUM RESOURCES OF BRAZIL

U. S. Geological Survey
OPEN FILE REPORT 75-30
This report is preliminary and has
not been edited or reviewed for
conformity with Geological Survey
standards or nomenclature

1975

ALUMINUM RESOURCES OF BRAZIL

By

Max G. White
U.S. Geological Survey

PROJECT REPORT: BRAZIL
INVESTIGATIONS BR.

CONTENTS

ILLUSTRATION

TABLES

ALUMINUM RESOURCES OF BRAZIL

By Max G. White
U.S. Geological Survey

ABSTRACT

Large deposits of bauxite, the principal ore of aluminum, occur at several places in Brazil. The largest deposits now undergoing extensive exploration and development are in the eastern Amazon Basin. Most of these deposits are in the State of Pará, but some are in Amazonas and Maranhão.

Discovery of large-scale resources of bauxite in the Amazon Region is so recent that mining has not begun, but government geologists estimate the total resources in aluminum deposits in the lower Amazon to be in the multibillion ton range.

The annual production rate of bauxite ore in Brazil, much of it from Poços de Caldas in Minas Gerais, is about 760,000 metric tons of ore from which about 100,000 tons of aluminum metal is produced, most of which is consumed by Brazilian industry.

The Amazon bauxite deposits are on terraces formed on sedimentary rocks of Tertiary age; in Minas Gerais the deposits are formed on Precambrian metasedimentary rock, and at Poços de Caldas on a circular alkalic pluton of Cretaceous age.

INTRODUCTION

In Brazil, as in most countries, bauxite is the only ore of aluminum. Bauxite is a complex mixture of aluminous minerals and impurities, and the most common minerals are aluminum hydroxides (Patterson and Dyni, 1973). Gibbsite ($Al_2O_3 \cdot 3H_2O$) is the principal bauxite mineral in Brazil, but boehmite ($Al_2O_3 \cdot H_2O$) occurs in a few deposits. In the processes now used in making aluminum, alumina is extracted from bauxite, and this oxide is reduced to metal. Both bauxite and alumina are used to make products other than metal in Brazil. However, the quantity consumed in such uses is small compared with that used in making the metal, and little attention will be given herein to the special types of bauxite required for the other uses.

In Brazil the aluminum industry has expanded considerably in recent years. Three companies or consortia are now operating integrated complexes (mining bauxite and producing alumina and aluminum); a few others are mining bauxite; and several are active in exploration or development. One company, Alumínio de Minas Gerais S. A. (Aluminium Company of Canada and Brazilian interests), has bauxite reserves in several districts in Minas Gerais (figure 1) and produces alumina and aluminum in a recently expanded plant at Saramenha, Minas Gerais, and a new plant at Aratú, Bahía. Companhia Brasileira de Alumínio, which is Brazilian owned, mines and washes bauxite in the Poços de Caldas district and operates an aluminum plant at Sorocaba, São Paulo. ALCOMINA (Cia Miniera de Alumínio) owned by ALCOA and the State of

Minas Gerais, operates an integrated complex in the Poços de Caldas district. In addition to the forementioned complexes, a beneficiation plant is under construction at Oriximiná-Obidos on the Trômbetas tributary to the Amazon River (Mining Journal, 1974) by Mineração Rio do Norte, S.A., a consortium of ALCAN and Brazilian and foreign interests. Shipment of washed bauxite from this plant was scheduled to begin in 1974. Plans are also being considered for large-scale development of other bauxite districts in the lower Amazon region.

Recently it was announced that (Mineração e Metalurgia, 1974) an agreement has been signed by the Governments of Brazil and Japan to finance the construction of major hydroelectric power development on the Tocantins River with the specific purpose of producing power for reducing the bauxite ores of the lower Amazon to metal. The project is to be undertaken by a new corporation called Alumínio Brasileiro, S. A. (ALBRAS), which is a consortium of the Companhia Vale do Rio Doce and five of the largest aluminum producing companies in Japan. The first stage of the power development project will be construction of a dam in the vicinity of Tucuruí (lat $3^{\circ}42'$S., long $49^{\circ}40'$W.) on the Tocantins River in Pará.

Several Brazilian and foreign companies and Brazilian Government agencies actively explored for bauxite in Minas Gerais and nearby states in the 1950's and early 1960's; and bauxite material was known to be present along the Amazon (Abreu, 1962). The enormous bauxite resources of the region were not discovered until large-scale exploration, employing many geologists, shifted to the Amazon, beginning about 1968.

The deposits in this region are now thought to be so large that when adequately explored, Brazil may rank with Australia and the Republic of Guinea as the leading countries in bauxite resources.

Exploration and plans for development of bauxite deposits in the Amazon region are being carried out in two general areas; one is along the lower Amazon River and the other is the Paragominas region (figure 1). The four large areas under investigation along the Amazon River and some of its tributaries are as follows: 1) along the middle Jatapú River in the State of Amazonas, 2) on the lower Trombêtas River and along the Amazon River in the Oriximiná-Óbidos area, 3) on the lower Jarú and the Parí Rivers and along the Amazon River in the Almeirim area; and 4) in an area east of the Xingú River near the divide with the Rio Pará drainage. The last three districts are in the State of Pará. The Paragominas deposits are in a large area in eastern Pará along the border region with Maranhão. The district takes its name from the hamlet of Paragominas (lat 2°57'S.; long 47°22'W.) 160 km south of Belem on the Brasília-Belem highway. The bauxite district extends north, south, and southwest of Paragominas into the headwaters region of the Rio Capim and the Rio Gurupí, which are east of the Amazon Basin. Smaller bauxite districts are located on Piriá River in the northeast corner of Pará and on the Island of Trauíra on the northwest coast of Maranhão (figure 1).

The widespread activity in the mining and exploration for bauxite extends over very large areas. A Brazilian Government report (Brazil, Dept. Nac. Produção Mineral, 1972) indicates the existence of registered mining concessions distributed as follows: 16 in Minas Gerais, 16 in Pará, 6 in São Paulo, and 1 in Espirito Santo. In 1971, 441 applications for bauxite exploration licenses were made to the Departmento Nacional da Produção Mineral. The interest in the lower Amazon region is indicated by the fact that about 85 percent of these licenses were in Pará, Maranhão, and Amazonas. Some indication of the quantities of land involved in concessions and licenses can be calculated from the Brazilian mining code (Brazil, Dept. Nac. Produção Mineral, 1960). The Brazilian Government allows as much as 10,000 hectares (24,700 acres) for each license for bauxite and certain other minerals in remote areas such as the Amazon region. Mining licenses in more accessible regions, such as districts in Minas Gerais, are restricted to 1,000 hectares (2,470 acres). According to government geologists, the area of bauxite exploration rights applied for in 1972 in the Paragominas region of Pará alone (figure 1) amounted to more than 1.5 million hectares (approximately 58,000 sq. mi. or about the area of the state of Florida).

BAUXITE PRODUCTION

Bauxite has been produced in Brazil for many years, and most mining has been in the Poços de Caldas district, Minas Gerais. During the period 1961-1972 (table 1) the annual production increased progressively, with a few yearly setbacks, from 118,000 metric tons to 765,000 tons. Virtually all the increased production was needed to fulfill the demands of the expanding national aluminum industry, as the relatively small demand for bauxite and alumina for uses other than in making metal in Brazil have increased only moderately.

Aluminum production in Brazil in 1972 was 97,711 metric tons (table 1), but output has apparently increased moderately since that date and is likely to expand considerably in the future. The moderate increases in 1973 and 1974 were brought about by expanding existing plant capacity. When new plant facilities are completed in 1976, Brazil will be able to produce about 190,000 tons of aluminum (Mining Journal, 1974, p. 63), which will be more than double the 1972 output. Major expansions beyond that date may also take place, as the Brazilian Government has released plans for a very large complex in the Oriximiná area by 1980 (Metals Sourcebook, 1974). According to these plans, 5.2 million tons of bauxite, 2 million tons of alumina, and 700,000 tons of aluminum will be produced annually.

Table 1. Production of bauxite and aluminum in Brazil, 1961-1972[1/]

Year	Bauxite tons		Aluminum metal tons	
	Metric	Short	Metric	Short
1961	118,316	130,147	18,500	20,350
1962	137,066	150,762	23,500	25,850
1963	196,898	216,587	21,700	23,870
1964	187,965	206,761	25,990	28,589
1965	168,798	185,677	29,687	32,655
1966	267,806	294,586	32,468	35,714
1967	260,858	286,943	37,516	41,267
1968	284,696	313,165	41,291	45,410
1969	350,912	386,000	42,545	46,799
1970	509,803	560,783	57,199	62,918
1971	584,999	643,498	80,647	88,701
1972	764,525	840,977	97,711	107,677

1/ Figures published by Brazil Departamento Nacional da Produção Mineral (1972; 1973).

EXPORTS, IMPORTS, AND CONSUMPTION

In the decade ending in 1970, Brazil's exports of bauxite ore were at a rate of only 2,000 to 3,000 tons per year; in 1971, about 4,000 tons of bauxite and 1,100 tons of aluminum were exported. Essentially no bauxite was imported, but 30,200 tons of manufactured aluminum products was imported at a cost of US $19,621,000.

Significant changes in bauxite exports seem destined to take place, possibly beginning even before this report is released. Shipments of washed and dried bauxite from the Mineração Rio do Norte, S. A. plant in the Oriximiná-Óbidos area, Pará, to Canada are planned for 1974. According to Lefond (1973, p. 39), bauxite exports from this district may be increased to 4 million tons annually by 1977.

GEOLOGY

Lower Amazon region

The bauxite deposits in the lower Amazon region are on terraces; those near the river and along its principal tributaries are at elevations of 100 to 200 m above sea level, and the deposits in the Paragominas district are at 90 to 130 m. Most of the terraces along the Amazon are isolated geomorphic features, whereas the terraces in the Paragominas region form extensive tablelands that have been only moderately dissected by streams.

Klammer (1971), on the basis of a thorough study of the geomorphology along the Amazon River and some of its tributaries, found that Pliocene and Pleistocene terraces differ in their sedimentary composition, physiography, and structure. He believes the Pliocene terraces, which are essentially level and poorly drained, are of lacustrine origin. After the lakes were drained, a laterite-clay sequence developed on the surfaces, and the terraces were dissected by headward erosion of streams. The Pleistocene terraces are remnants of a sequence of cyclically reworked and aggraded, poorly sorted, coarse-grained to pebbly fluvial sands. Klammer found these Pleistocene terraces to be more widespread than is shown on most geologic maps of this region.

The lower Amazon bauxites are of the laterite type, and they formed by the weathering of horizontal beds of clay and sandy clay of continental origin. The bauxite is predominantly gibbsite; some of it contains as much as 50 percent clay and quartz impurities. The gibbsite forms mainly as pisolites and concretions, but it also is massive, compact, and, rarely, friable. Minable deposits contain 50 percent Al_2O_3 and only about 5 percent SiO_2 after the ore is washed.

The following generalized sections of the bauxite deposits in the two principal regions have been reported (Wolf, 1972):

Amazon River section (top to bottom):

	Range of Thickness
Concretionary zone;	
1. Yellow plastic clay	0 to 8 m (26 ft.)
2. Pisolitic gibbsite and iron oxide	0 to 1.50 m (5 ft.)
3. Concretionary iron oxide clay matrix	0 to 1.50 m (5 ft.)
4. Hard, blocky, red, ferruginous and siliceous concretions in clay matrix or ferruginous laterite which may grade into underlying zone	0 to 1.50 m (5 ft.)
Leached zone;	
5. Hard, pink or red gibbsite, slightly or highly ferruginous; at times blocky and hollow concretions in a clay matrix	0 to 4 m (13 ft.)
6. Transition zone of nodular blocky gibbsite alternating with kaolinite in a variegated clay matrix	0 to 1 m (3.3 ft.)
7. Pink, red, white speckled clay	

The Paragominas section (top to bottom):

Concretionary zone:

1. Yellow plastic clay — 0 to 22 m (72 ft.)
2. Ferruginous, aluminous, spherical concretions less than 2 cm in width — 0 to 2 m (6.5 ft.)
3. Ferruginous blocky laterite in clay matrix — 0 to 4 m (13 ft.)

Leached zone:

4. Pink, red, white, hard gibbsitic bauxite in columnar form (10 cm length) — 0 to 4 m (13 ft.)
5. Pink, red, white variegated clay, partly gibbsitic, with blocky and columnar gibbsitic bauxite at top — 0 to 4 m (13 ft.)
6. Highly weathered silty or sandy clay — 0 to 1 m (3.3 ft.)

In the newly discovered Jabotí-Futuro area, located north of Paragominas, the bauxite is derived from ferruginous sandstone and argillite of the Alter do Chão Formation of late Tertiary age. A typical profile of the deposits in this locality is:

Clayey capping
Bauxitic and/or ferruginous pisolites
Concretionary, nodular, bauxite, laterite
Ferruginous laterite
Bauxitic laterite
Kaolinitic clay
Sandstone

The bauxitic material is generally found in disseminated blocks in a clay matrix associated with (1) a pisolitic layer that ranges from 0.5 to 2.0 m in thickness, and (2) a layer of bauxitic laterite 0.5 to 3.0 m in thickness. The clay capping is from 0 to 18 m in thickness. In this area the grade of the bauxite is 48 to 53 percent Al_2O_3, and the average thickness of the capping or overburden is about 9 m. Reactive silica contained in the ore is below 6 percent.

Other deposits in northern Brazil

Amapá deposits

The discovery of a large gibbsitic bauxite deposit in the territory of Amapá by Emprêsa Santa Rita de Mineração (Ethyl Corp. subsidiary) was announced recently (Mining Journal, 1974, p. 63). The location of these deposits was unknown to me at the time this report was prepared; however, the discovery is probably the result of exploration in the vicinities of some of the numerous occurrences of bauxite in Amapá noted by Moraes (1959). Most of the occurrences Moraes mentioned are laterite-type bauxite overlying Precambrian rocks.

Maranhão

Trauíra and Chapada Pirocaus.--Phosphatic bauxite and aluminous laterite deposits are located on Trauíra Island and on the Chapada (mesa) Pirocaus on the northwest coast of the State of Maranhão (figure 1). The deposits are formed on Precambrian phyllite. The phosphate is in guano containing 20 to 30 percent P_2O_5, and overlies the bauxite. Drilling in the Trauíra deposits shows decreasing phosphate content with depth. The bauxitic rock is reported to contain 30 percent Al_2O_3 (Abreu, 1962). Although they are low in aluminum content, these deposits may be of value because of the possibility of recovering phosphate as a coproduct (Feigl etal, 1946). Based on preliminary development work, the phosphatic bauxite deposits on Trauíra Island are estimated to contain 10 million metric tons (Jobim, 1941). These deposits are currently being evaluated under an exploration license issued by the Departamento Nacional da Produção Mineral to Mineração Osaki, Ltda.

Deposits in southern Brazil

Minas Gerais

Poços de Caldas.--The Poços de Caldas plateau is a circular feature approximately 30 km in diameter (lat 21°48'S.,long 46°34'W.) in western Minas Gerais near the border with the State of São Paulo. It is underlain by gneiss and granite of Precambrian age intruded by Late Cretaceous alkaline rocks. The alkaline rocks include gneissic textured syenite, eudialyte-syenite, nepheline syenite, nepheline-cancrinite-syenite, and phonolite and phonolite porphyry.

The bauxite deposits are at elevations ranging from 1,220 m at the foot of the highlands to 1,678 m on the tops of ridges and on slopes having a maximum inclination of 27°. Deposits are particularly abundant on alkaline intrusives in the northern part of the plateau.

The principal bauxite mineral is gibbsite, and the clay, where present, is mainly kaolinite. The bauxite occurs in four principal forms: 1) surficial nodule layers less than 1 meter thick, formed from the weathering of homogeneous bauxite deposits and removal of interstitial clay; 2) light-yellow, porous, homogeneous bauxite composed almost entirely of gibbsite; 3) nodular gibbsite or kaolinite in a clay matrix; and 4) irregular masses of homogeneous bauxite in a clay matrix, which is apparently the result of incomplete bauxitization of the kaolinite clay. Impurities in the bauxite reflect the type of rock on which it formed. For example, eudialyte rock produces iron-rich bauxite, and sphene-bearing rock produces bauxite rich in titanium. According to Webber (1959), high-quality bauxite commonly has formed on nepheline-syenite containing cancrinite, and on the high-level alluvial deposits which were transported from nepheline syenite and phonolite porphyry. The bauxite formed on gneiss generally contains silica as free quartz.

Webber (1959) considers the bauxite in the Poços de Caldas region to have formed mainly in the Holocene, and in places it is still forming today. The reasons for this are that three of the required environmental conditions for bauxite formation are present. First, aluminous parent rocks are abundant. Second, rainfall is ample, mounting to 2,300 mm annually in the highland areas where most of the bauxite is located. The third condition is the rather high porosity and permeability of the parent rocks caused by abundant joints and fracture systems. This condition results in effective subsurface drainage which enhances leaching and causes weathering to progress to considerable depths.

Some of the bauxite apparently has formed directly from the alkaline rocks and some indirectly through an intermediate stage in which laterization or kaolinization takes place preceding bauxitization. Drilling and pitting in the Companhia Geral da Minas deposits, which comprise more than half the known reserves, has shown that 65 percent of the bauxite is separated from the bedrock by a layer of clay, and 35 percent lies directly on rock, thus indicating that only about one-third of the bauxite was formed directly. The process relates to the drainage or passage of water on and through the rock and to pH conditions. According to Webber (1959), in an active subsurface drainage area such as in the Poços de Caldas, water having a neutral pH will result in the formation of bauxite directly, but where there is an acid pH the process produces kaolin. In poorly drained areas, the rock alters to kaolin until the drainage is rejuvenated or becomes active, when with a neutral pH of the water, the kaolin clay will be altered to bauxite. Webber believes that more than half of the bauxite in the district is formed with this intermediate kaolin stage.

Ouro Preto.--Although it is difficult to identify the rock on which it is formed, because of the intense weathering in the area, the bauxite at Ouro Preto appears to have weathered from a hematitic-sericitic phyllite located at the top of the Minas Group of Precambrian age (Abreu, 1962, p. 552-553). The bauxite is pink to red; the color results from the amount and state of oxidation of the iron inherited from the parent rock. The lighter-colored bauxite tends to have the higher content of silica. The ore occurs in compact masses and in disseminated concretions in laterized rock.

Other deposits in southern Brazil

In addition to the principal bauxite deposits of Brazil in the lower Amazon Valley and in Minas Gerais, deposits have been noted in the Municipios de Nepomuceno, Descoberto, and Diamantina in Minas Gerais; Municipio de Mimoso do Sul in Espirito Santo; Municipios de São Paulo, São Bernardo do Campo, Aguas da Prata, Mogi das Cruzes in São Paulo State; the Itatiaia massif of alkaline rocks in Rio de Janeiro State; and the Municipios de Correntina and Barra do Mendes in the State of Bahia (Abreu, 1962). Some of these may currently be under study or evaluation.

RESOURCES

According to estimates published in 1973 (table 2), the total measured, inferred, and indicated resources of bauxite in Brazil are a little more than 440 million metric tons. This estimate by the Departamento Nacional da Produção Mineral (1973) was presumably compiled from documents relating to mining concessions and exploration rights. As with virtually all bauxite reserve and resource estimates that have been made for deposits throughout the world, the information on which the estimates were made was incomplete; almost certainly the total bauxite reserves are somewhat greater. This is indicated by the greater estimates of 17,168,000 tons indicated and 24,261,000 tons inferred bauxite for deposits in Minas Gerais by the Departamento Nacional da Produção Mineral (1972). Also, the bauxite reserves in the Oriximiná area alone are now thought to be as much as 500 million metric tons, according to one recently published statement (Metals Sourcebook, 1974).

The total resources of bauxite in Brazil, which include, in addition to reserves, the subeconomic, hypothetical, and undiscovered deposits, are very large. No doubt many millions of tons of subeconomic bauxite is present at several places in Brazil, but by far the largest deposits are in the lower Amazon region.

Table 2. Bauxite reserves in Brazil, in metric tons [1/]

State	Measured	Indicated	Inferred	Average Grade (percent Al_2O_3)
Espirito Santo	1,096,000	----	----	45
Maranhão	18,000,000	----	----	--
Minas Gerais	56,171,288	8,103,442	4,203,284	47
Pará	287,557,258	64,062,000	2,995,900	50
São Paulo	210,589	141,184	10,000	45
Total	363,035,135	72,306,826	7,209,184	

1/ Figures published by the Departamento Nacional da Produção Mineral (1973).

In an effort to give some indication of the total bauxite in the lower Amazon Basin, Wolf (1972) of the Departamento Nacional da Produção Mineral, listed a rounded figure of 4 billion tons for the total bauxite resources. As this figure presumably includes large areas where the presence of bauxite is inferred by comparisons of geologic characteristics and topography with known districts, probably most of this total should be classified in the subeconomic or undiscovered resource categories until more information is available.

SELECTED REFERENCES

Abreu, Sylvio, Fróes, 1962, Alumino, in Recursos minerais do Brasil; Vol II, Combustiveis fosseis e minerios metalicos: Brazil, Inst. Nac. Tec., Rio de Janeiro, p. 545-562.

Brazil Departamento Nacional da Produção Mineral, 1970, Codigo de mineração e legislação correlativa: Brazil Ministerio das Minas e Energia, Dept. Nac. Produção Mineral, Pub. Espec. 11, 122 p.

Brazil Departamento Nacional da Produção Mineral, 1972, I Anuário Mineral Brasileiro 1972: Rio de Janeiro, Brazil Ministerio das Minas e Energia, Dept. Nac. Produção Mineral, 255 p.

Brazil Departamento Nacional da Produção Mineral, 1973, Anuário Mineral Brasileiro 1973: Rio de Janeiro, Brazil Ministerio das Minas e Energia, Dept. Nac. Produção Mineral, 329 p.

Feigl, F., Braile, N., and Miranda, L. I., 1946, A solubilização da bauxita fosforosa do Maranhão, Brasil: Cong. Panamericano de

Engenharia de Minas e Geologia, 2d, Petropolis, Anáis, v. 2, p. 141-162

Ferreira, E. O., 1972, Carta tectônica do Brasil--Nóta explicativa: Brazil Ministerio das Minas e Energia, Dept. Nac. Produção Mineral, Bol. 1, 19 p. (in Portuguese and English).

Guimaraes, D., and Coelho, I. S., 1945, Bauxita do Morro do Cruzeiro, em Ouro Préto-Minas Gerais: Brazil Dept. Nac. Produção Mineral, Div. Fomento Produção Mineral, Bol. 67, 40 p.

Jobim, José, 1941, The mineral wealth of Brazil: Rio de Janeiro, Livraria José Olympio Editôra, 169 p.

Klammer, Gerhard, 1971, Uber Plio-pleistozäne Terrassen und ihre Sedimente im unteren Amasonasgebiet: Zeitsch. Geomorphologie, v. 15, no. 1, p. 62-106 (with English and Portuguese abs.).

Lefond, S. J., 1973, Brazilian mining--Relaxed govt. attitudes pave the way for exploiting critical reserves: Mining Engineering, v. 25, no. 11, p. 31-

Machado, J. E., Wolf, F. d A. M., and Sudgen, D., 1972, Excursão E. Rodovía Belem Brasilia, <u>in</u> Roteiro das Excursoes: Cong. Brasileiro Geologia, 26th, Belem, Bol. 3, p. 35-43.

Metals Sourcebook, 1974, Aluminum: Metals Sourcebook, v. 2, no. 2, p. 1-2.

Mineração e Metalurgia (1974), Brasil e Japão criam a ALBEAS para produzir aluminio na Amazonia: Miner. e Metalurgia no. 355, Sept. 1974, p. 6-7.

Mining Journal, 1974, Aluminium: Mining Journal, Mining Ann. Rev., p. 60-67,

Moraes, L. J. de, 1959, Bauxite et autres richesses minières du Territoire Fédéral d'Amapa (Brésil): Conf. Geol. Guyannes, 4th, Cayenne 1957, Commun., p. 92-101.

Patterson, S. H., and Dyni, J. R., 1973, Aluminum and bauxite, in United States Mineral Resources: U.S. Geol. Surv. Prof. Paper 820, p. 35-43.

Pinto, M. da S., 1938, Bauxita em Poços de Caldas: Brazil Dept. Nac. Produção Mineral, Servico Fomento Produção Mineral, Bol. 22, 71 p.

Towse, D., and Vinson, P. E., 1959, Lateritas aluminosas do Baixo Amazonas: Engenharia, Mineração, e Metalurgia, v. 30, no. 177, p. 133-135.

U.S. Bureau of Mines, 1970, Mineral facts and problems: U.S. Bur. Mines Bull. 659, 1291 p.

Webber, B. N., 1959, Bauxitização no distrito de Poços de Caldas, Minas Gerais, Brasil: Soc. Brasileira Geologia Bol. 8, no. 1, p. 17-30 (Portuguese with English abs.).

Wolf, F. de A. M., 1972, Bauxita na Amazonia, in Resumo das Comunicações: Cong. Brasileiro Geologia, 26th, Belem, Bol. 1, p. 36-38.

World Minerals and Metals, 1973, Alcan-CVRD reactivate bauxite study in Brazil: World Minerals and Metals, no. 11, p. 26.

GPO 884-707

56-57.

[illegible] de, 1970, Bauxite et autres [illegible] du

[illegible] Caldas (Brésil): [illegible] Geol. Congress

[illegible] Congress 1970 [illegible], p. [illegible]

[illegible] F. R., and [illegible], 1973, Aluminum and bauxite, in

[illegible] States Mineral Resources: U. S. Geol. Survey Prof. Paper

[illegible], p. 35-45.

[illegible] B., 1939, Bauxite of Pocos de Caldas, Brazil: Dept.

[illegible] Producao Mineral, [illegible] Fomento Producao Mineral, Bol. 32,

p.

[illegible], 19[illegible], [illegible] bauxita [illegible]

[illegible]: [illegible], no. 17[illegible],

[illegible]

[illegible], [illegible] of bauxite [illegible] U.S. Bur.

[illegible] Bull. [illegible], 1961.

[illegible], 1956, Bauxitas do [illegible] de Pocos de Caldas, Minas

[illegible] Brasil: Soc. Brasileira Geologia Bol. 5, no. 1, p. 11-

[illegible] (Portuguese with English abstract).

[illegible] M., 1971, Bauxita de Maranhão, in Anais dos Congresso

[illegible] Cong. Brasileiro Geologia, [illegible], Anais, vol. 1, p. 56-58.

[illegible] and [illegible], 1973, [illegible] bauxite [illegible]

[illegible] Brazil: World Minerals and Metals, no. 11, p. 28.

1 plate