THE COMPETITIVE ENVIRONMENT FOR A NEW BAUXITE MINE IN GUINEA

by

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A thesis submitted to the Faculty and the Board of Trustees of the Colorado School of Mines in partial fulfillment of the requirement for the degree of Master of Science (Mineral Economics).

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ABSTRACT

The Republic of Guinea, since acquiring independence in 1958, has committed itself to evaluating and developing its rich mineral resources. Among several other minerals, bauxite is the most important both in quality and quantity of reserves. Like any mineral-rich developing country, Guinea encourages foreign investment in its mineral industry to obtain foreign exchange, to create infrastructure, and to generate economic growth and development. Presently three mines are in operation with a total capacity of 14 million tonnes per year. Since 1978, the government has tried, without success, to develop at least one of the deposits of Dabola, Tougue, and Aye-Koye. Meanwhile the international Bauxite Producers Association (IBA), created in 1974, has failed in its attempt to form a cartel and to establish coordinated and uniform bauxite pricing and taxation policies. The primary aluminum/alumina/bauxite market which used to be dominated by the "six big sisters"--Alcoa, Alcan, Alusuiss, Kaiser, Pechiney, and Reynolds--is becoming more competitive. Today, this competition is more noticeable on the bauxite supply side than on the demand side because multinational mining companies are continuing to shift from high cost and "risky" sources to low cost and "safe" ones. Presently,

there are four large competing suppliers of bauxite in the world: Australia, Guinea, Jamaica, and Brazil. Opening a new mine in any of those countries depends on both market conditions (supply/demand relationship) and the competitiveness of the project.

The question then is whether Guinean bauxite presents competitive advantages--ore quality, price, production costs, government tax policy, etc.,--to justify the opening of an additional mine given the current and expected bauxite market conditions. This thesis is intended to answer this question. Market conditions are analyzed by comparing world expected bauxite capacities to demand. Guinea's mining prospects, bauxite prices and production costs, and governmental policy are compared to those of Australia, Jamaica and Brazil. In addition, a breakeven price analysis of the output of Guinea's new mine (Aye-Koye) is performed to determine whether and when Guinea can open its new mine.

The analysis of market conditions shows that an excess supply of bauxite has existed since the 1982 recession and will continue to exist until after 1990, delaying the start-up date of most planned mines. Guinea's bauxite presents qualitatively competitive advantages over its competitors, but its tax policy and investment incentives are less attractive to multinational mining companies than those of Australia and Brazil. Guinean Bauxite is cost competitive, but adjusted c.i.f. prices per tonne of bauxite from Australia and Brazil are a little lower than those of Guinea and Jamaica. In addition, the breakeven price of the Aye-Koye new mine is relatively high for current market conditions.

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ACKNOWLEDGEMENTS

The author wishes to express his deepest gratitude to his sponsors, Halco Mining Inc. and the government of Guinea, for giving him the opportunity to come to the United States to pursue his study in the mining field, and to expand his expertise in mineral economics. It has been a great experience of learning and thought.

In the course of writing this thesis, the author has acquired a debt of gratitude to Dr. Thomas D. Kaufmann, thesis advisor, for his generous guidance and assistance. The author is sincerely thankful to his two other committee members, Dr. Charles W. Berry and Dr. John Cordes, for their helpful assistance. Many thanks to Mrs. Lita Dunham, editorial reviewer, for her indispensable contribution in putting this thesis in a convenient form. Thanks go to all who directly or indirectly helped the author in putting this paper together.

INTRODUCTION

Approximately 30% of the world's economic reserves of bauxite occur in Guinea. Three mines are currently in operation with a total annual capacity of 14 million tonnes. Three other deposits have been proven economically extractable, and the government has ambitious development plans for these deposits. The most likely project to come on stream is Aye-Koye because of its proximity to the mine of Sangaredi and to the port of Kamsar, and because of its low infrastructure requirements. A multinational joint venture is being organized for this project. Since 1978, the Guinean government has asked foreign bauxite mining companies to manifest their interest.

On the other hand, the poor aluminum market conditions observed during the past few years and the excess bauxite capacity foreseen in the next five years have created some doubt about whether and when the planned Aye-Koye mine can open. Given the nature and the structure of the bauxite market, and the political risk perception of multinational mining companies, the opening of the Aye-Koye mine depends not only on market conditions, but also on the competitiveness of Guinea's bauxite on the world market. The competitiveness of Guinean bauxite depends on the quality of the ore (available alumina, reactive silicate, free moisture, and monohydrate contents), inland and ocean transportation costs, and, as important, the political attractiveness of the government mineral policy. To determine the relative competitiveness of Guinean bauxite and to find out whether and when the new mine of Aye-Koye can open, comparison will be made between Guinean bauxite and the bauxites of Australia, Jamaica, and Brazil.

This thesis is divided into 4 chapters. Chapter 1 summarizes world bauxite, alumina, and primary aluminum capacities after the 1981-82 recession. Chapter 2 presents a survey of forecasts of aluminum demand from which demand for bauxite is derived. The objective of these two chapters is to determine world's bauxite supply/demand relationships by comparing capacities to consumption to find out whether demand is strong enough to motivate the opening of new mines. Chapter 3 presents bauxite reserves, mining activities, capacities, and future development plans by each of the competing suppliers; performs a comparative analysis of the bauxite taxation policy of each country under study to determine the most politically attractive policy; presents a marginal cost analysis to determine low cost producers; and makes a shipping point price comparison to find the cheapest bauxite on a dry tonne and common ore grade basis. Chapter 4 performs a breakeven price analysis of the planned Aye-Koye mine output to determine whether that breakeven price is competitive enough to justify its opening. The study ends with the conclusions and recommendations.

CHAPTER 1

WORLD BAUXITE, ALUMINA, AND PRIMARY ALUMINUM CAPACITIES: AN OVERVIEW

This chapter examines world bauxite, alumina, and primary aluminum capacities, to determine present and expected supplies of bauxite which, later on, will be compared to demand to see whether a new mine can be opened without idling existing capacity. Since bauxite remains the only economic raw material for processing alumina, the market for it depends on demand for alumina and primary aluminum.

Because the demand for aluminum is income elastic, interest rate sensitive, and thus cyclical, the depressed economic conditions that the world has experienced since 1980 have brought about the following conditions in the primary aluminum industry: (1) low demand and tumbling prices for aluminum and aluminum products; (b) cutbacks in production, temporary and permanent closures of existing marginal capacities (mines, smelters, and refineries); (c) delays of start-up dates of most planned capacities; and (d) financial losses by most principal primary producers. The result is an imbalanced supply/demand relationship. A world summary of current and expected bauxite, alumina, and primary aluminum capacities follows.

THE UNITED STATES

Bauxite

After the 1981-82 recession, only seven of nine bauxite mines remained in operation (U.S. Bureau of Mines, 1983). At the beginning of 1983, those mines were operating at 50% of nominal capacity. Present bauxite capacity is estimated at 0.85 million tonnes and is expected to remain at this level until 1985. However, the present economic recovery will improve capacity utilization of remaining mines.

Alumina and Primary Aluminum

In early 1983 the major alumina and primary aluminum capacity adjustments were as follows:

Alcoa--temporary closure in March 1982 of its 800,000 short ton per year (st/y) Mobile, Alabama, alumina plant. Permanently closed its 170,000 st/y capacity smelter at Point Comfort, Texas.

Martin Marietta Aluminum--increased by 130,000 short tons (st) the capacity of its St. Croix aluminum plant, bringing capacity to 700,000 st/y. Reportedly postponed start-up of an additional 33,000 st/y expansion at its 105,000 st/y capacity plant at Goldendale.

Reynolds Metals--closed temporarily its smelter in Alabama, and its 114,000 st/y at the San Patricio smelter in Texas.

Kaiser Aluminum and Chemical Corporation--reportedly closed temporarily its 163,000 st/y capacity smelter at Ravenswood.

Comolco--closed permanently its 33,000 st/y aluminum plant at Lake Charles.

Revere Copper and Brass--reportedly shut down its 177,000 st/y capacity smelter at Scottsboro.

Estalco--(Howmet and Alumex co-joint venture)--idled its 22,000 st/y capacity at Frederick.

As a result of these and other closures, expected 1983 year-end capacity has been estimated at 6.4 million short tons (tons) for alumina, and 3.9 million tons for primary aluminum.

It is possible that some of these plants will reopen as economic conditions improve.

CANADA

Bauxite

There are no bauxite mining activities in Canada.

Alumina and Primary Aluminum

One plant produces alumina-- Alcan Smelters and Chemical Ltd. at Arvida, Jonquiere, Quebec. Capacity is 1.22 million tonnes per year. Work on the installation of three fluid flash calciners to replace old rotary kilns is under way.

Primary aluminum is also produced by Alcan which operates five smelters, and by Canadian Reynolds Metals Co. which operates a 158,757 st/y smelter at Baie Comeau, Quebec, using imported alumina.

These plants, protected by Canada's supply of relatively cheap electricity, continue to operate at over

80% capacity. Changes in capacities, however, include the following:

Alcan--increased the rated capacity of its smelter at Arvida by 10,000 st/y to 432,000 st/y. A new 40,000 st/y fluoride plant is under construction with start-up planned in mid-1984. Feasibility study for a 200,000 st/y aluminum smelter and related hydroelectric generating facilities at Manitoba are in progress.

Canadian Reynolds Metals Co.--postponed start-up of a second 57,000 st/y potline at Grande Baie until market conditions improve. A third 57,000 st/y potline is under construction and is expected to bring capacity to 171,000 st/y.

Pechiney Ugine Kuhlman of France is conducting a feasibility study for a 200,000-300,000 st/y primary aluminum smelter in the Three River region of Quebec on the basis of an offer of initially inexpensive power by Quebec Hydropower.

Canada's alumina capacity is expected to stay at the level of 1.22 million tonnes per year up to 1985, while its primary capacity will go from 1.2 million tonnes in 1983 to 1.2 million tonnes per year in 1985.

JAPAN

Bauxite

There are no bauxite mining activities in Japan.

Alumina and Primary Aluminum

Because Japanese industry relies heavily on imported oil for their source of power, its primary aluminum industry was severely hit by the 1980-82 recession and oil price increase. In 1982, the country's primary operating rate was 44%. Capacity adjustments are as follows:

Nippon Light Metal--(50% Alcan)--downrated its aluminum plant at Tomakomai from 134,000 st/y to 72,000 st/y.

Sumitomo Aluminum--closed its 79,000 st/y capacity at Isoura smelter in March 1982. Its two other smelters at Toyama (82,000 st/y) and Toyo (99,000 st/y) are running at about 30,000 st/y, but the company hopes to raise the combined output of these two smelters to 140,000 st/y by 1985.

Sumikei Aluminum--closed its 99,000 st/y capacity at its Sakata smelter and went out of business.

Mitsubishi Light Metal--reportedly closed its 160,000 st/y capacity at Naeksu smelter. A 68,000 st/y capacity has been permanently idled at the Sakaid smelter.

Showa Denko Metal--closed its remaining 18,000 st/y capacity at Omachi in July 1982 and its 17,000 st/y aluminum at Kitakata in September 1982. Its largest aluminum plant at Chiba was downrated from 127,000 st/y to 59,000 st/y.

It is estimated that 1983 alumina year-end capacity will drop 200,000 st/y with no increase until 1985. Primary capacity is expected to be 400,000 st/y from 1983 to 1985.

Japan's reaction to rising energy costs and to the 1982 recession has been to expand its plants overseas, particularly in South America, Australia, and New Zealand, and to shift to aluminum scrap. If current upward movements of primary price and demand last, however, Japan may reopen some of its plants.

THE UNITED KINGDOM

Bauxite

No bauxite is produced locally.

Alumina and Primary Aluminum

Only one alumina plant is in operation. Its capacity is expected to remain at current levels of 120,000 st/y up to 1985.

Changes in primary capacities are as follows:

British Aluminium--Permanent closure of its 120,000 st/y primary smelter at Invergordon. Completion of work at Lochaber smelter at Fort William.

Anglesey Aluminium--output was cut by one-third to an annual rate of 75,000 tpa.

FRANCE

Bauxite

Bauxite capacities through 1985 are estimated at approximately 1.91 million tonnes/year.

Alumina and Primary Aluminum

Pechiney operates three alumina plants whose combined capacities are expected to remain at 1.335 million tonnes per year through 1985. With energy efficient technology and increased government participation, the smelters have operated close to capacity. Capacity increased by 35,000 st/y at St. Jean de Maurienne and Lannemezan reduction plants.

GERMAN FEERAL REPUBLIC

Despite worldwide depressed economic conditions, the primary aluminum industry has performed relatively well in Germany. Two expansion schemes are in progress:

Addition of 15,000 st/y of Norf will bring capacity to 205,000 st/y.

A 12,000 ton expansion of the smelter at Voerde will bring capacity to 186,000 tpa.

The output of the Lipperwerk alumina plant was cut by some 30% from 430,000 tons. In spite of expansion, alumina capacity is expected to remain at 1.63 million tonnes per year, while primary capacity is expected to drop to 635,000 st/y during 1983-85 because of high energy and environmental protection costs.

YUGOSLAVIA

Bauxite

Yugoslavia's bauxite capacity is expected to be 4.65 million tonnes per year.

Alumina and Primary Aluminum

Five alumina plants are in operation. With the closure of the 300,000 st/y alumina plant at Obravac, total alumina capacity is estimated at 1.335 million st/y through 1985.

Despite depressed economic conditions, primary production has continued to expand. Capacity changes include the following:

<u>Master Smelter</u>--the second potline at the 52,000 st/y plant started up in 1982 and was expected to reach full capacity by the end of 1983.

<u>Titograd</u>--Sibik (Razine)--10,000 st/y expansion has been completed. A 40,000 st/y expansion began in 1983.

The country's primary aluminum capacity is expected to be 425,000 st/y in 1982-85.

NORWAY

Primary aluminum production dropped slightly during the last two years. At Hoyanger, the 20,000 st/y smelter is expanding to 67,000 st/y; at Karmory, the smelter is expanding to 160,000 st/y.

SPAIN

Only one alumina plant is operating with an annual capacity of 800,000 st/y and is expected to continue at that rate. Primary aluminum production in 1982 dropped 8.5%.

<u>Endasa</u>--experiencing energy cost problems at its smelter at Valladolid, a plant reportedly in need of modernization. Increased governmental involvement is foreseen.

<u>Aluminio Espanio</u>--increased design capacity of its new reduction plant at San Ciprian by about 7,000 st/y.

SWITZERLAND

Primary production declined sharply during the last two years. No additions or reductions of plant capacity were reported. Primary capacity is expected to remain at 86,000 st/y.

THE SOVIET UNION

Bauxite

Domestic bauxite reserves are becoming depleted and the country is increasingly dependent on imported bauxite. There is a need for use of other raw materials for aluminum production to alleviate this condition. According to Mining Journal (Mining Annual Review, June 1983), Nepheline currently accounts for approximately 16% of aluminum production, while less than 2% of aluminum production is from alunite. Principal suppliers of U.S.S.R. in bauxite and alumina are Greece, Guinea, Hungary, and Yugoslavia, with importation periodically from Brazil, France, Jamaica, Japan, and Turkey. In 1983 a plan to import 500,000 tonnes of bauxite from Brazil, and a year earlier (1982), a contract for Jamaica to supply the U.S.S.R. with one million tonnes of bauxite a year for seven years beginning in 1984, was concluded.

To increase alumina production, the U.S.S.R. intends to develop new bauxite deposits. This includes the development of the Severoonezhskoye deposit as a supplier of bauxite to the Tikhvin alumina plant to replace the depleted deposits in the Tikhvin area; the exploitation of the Kazakhstan high carbonate deposit; the extraction of Sredne-Timan bauxite to serve as base raw material for the Ukhta alumina plant in the Komi and the development of the Belinskiy deposit in Kazakhstan which was to begin in 1983. Soviet bauxite capacity is expected to be about 6.65 million tonnes by the end of 1985.

Alumina and Primary Aluminum

During 1982-85, the U.S.S.R. hopes to increase its aluminum production by 15% to 20%. Growth will be achieved by construction of new plants being completed, increased capacity of existing potlines, development of new bauxite deposits, and eventual importation of greater quantities of bauxite. The following development projects were reported:

Nikolayevsk alumina plant--the fourth and final stage was put into operation in 1982. Total capacity is one million tonnes per year. Part of the output is to be shipped to France as payment for equipment and technical assistance.

Kirovabad alumina plant--low production rates due to an inadequate supply of bauxite have been observed. The plant also produces alumina from alunite. Renovation is being conducted.

Pavlodar alumina-aluminum plant--alumina capacity was to expand in 1983 in conjunction with the development of the Belinskiy bauxite deposit.

Bratsk aluminum plant--reportedly renovation was completed, and a refinery for producing 99.997% aluminum was put into operation in 1982.

Kanaker aluminum plant--expansion and renovation of aluminum foil production facilities are underway. When completed, 70% of the output will be foil.

Sayansk aluminum plant--start-up is scheduled in 1984. Equipment will be supplied by the German Federal Republic.

Kandalaksha aluminum plant--renovation of potlines is being conducted.

Novokuznetsk aluminum plant--renovation of potlines in progress.

Krasnoyarsk aluminum plant--construction in progress.

Regar (Tadzhik) aluminum plant--construction in progress.

As a result of these expansion projects and others, the U.S.S.R. alumina capacity in 1985 is expected to be 5 million tonnes, while primary aluminum capacity will be 4 million tonnes per year.

CHINA

Bauxite

China has large bauxite deposits located in Guangxi (Pingguo), Guizhou (Huaxi, Wengan, and Xiuyi), Fujian (Longyan), Hebei (Cixian and Tangshan), Henan (Boshan and Huixian), Liaoning (Fuxian, Liaoyang, and Yanji), Sichuan (Leshan), and Yunnan (Kunning) which are in the course of development.

Alumina and Primary Aluminum

China possesses several alumina and aluminum plants which are in operation. With foreign cooperation, growth in the industry is expected. Recent expansion projects include the following:

Guiyang Guizhou plant--built by Japan, Nippon Light Metal Corporation of Japan, began trial operations in 1982. The installation includes an 80,000 st/y refinery and a 200,000 st/y alumina plant. Full operation was expected in mid-1983. This plant is expected to raise China's aluminum metal production by 20%.

Napping refinery--expansion plans are being considered, but foreign participation is needed.

Hebei refinery--plan for construction is under consideration.

The Guangdong provincial government reportedly has awarded a contract to Mass-Global Corp. (U.S.) to design and to build an aluminum anodizing plant. In addition, an extrusion plant has been subcontracted to Texas Hydraulic Corp. (U.S.). Scheduled completion of this project is for late 1983.

ERIE

Construction work is in progress at the 800,000 st/y alumina plant at Aughinish owned by Alcan (40%), Shell-Billiton (35%), and Anaconda (25%). Production was expected to start in 1983 using bauxite from Guinea and Brazil.

MIDDLE EAST

Primary production continues to expand.

Aluminum Co. of Egypt--a capacity increase of 36,000 st/y at the Nag Hammadi plant brings total capacity to almost 150,000 st/y.

Dubal (Dubai)--a capacity increase of 88,000 st/y brings total capacity to almost 150,000 st/y.

AUSTRALIA

Bauxite

Australia is the world's largest producer of bauxite. Its current capacity is 29.5 million tonnes per year and is expected to reach 36.5 million tonnes per year by 1986. Of the six deposits initially planned for production, only three are being considered: (a) a new mine at Mount Saddleback will have an initial capacity of 2.1 million tonnes per year, (b) feasibility studies continue for the development of the Mitchell plateau in West Australia, and (c) Aurukun Associates is considering development of the Aurukun deposit south of Weipa in the Cape York Peninsula.

Alumina and Primary Aluminum

Although some growth in plant capacities has taken place, other plants have experienced cutbacks and construction delays.

Alcoa of Australia--the new Wagerup refinery has been mothballed until needed (Metal Bulletin, 1983). The first 500,000 st/y stage of a third refinery in West Australia has been considered, but start-up has been delayed until market conditions improve. Work suspended for two years on a second smelter at Portland, Victoria, because of a 25% increase in the cost of power to be supplied by the

State Commission. A plan to build a 236,000 st/y smelter in 1985 at Lochinvar, N.S.W., has been postponed indefinitely. The 2.44 million tonnes per day refinery at Gladstone is expanding to 2.74 million tonnes per year.

Alcan of Australia--completed expansion of its Kurikuru smelter in New South Wales from 67,500 st/y to 90,000 st/y. Further expansion to 135,000 st/y has been deferred.

With the current improvement in market conditions, some plants may reopen.

BRAZIL

Bauxite

Blessed with one of the world's largest reserves of bauxite in the Amazon region, and with abundant undeveloped hydropower, Brazil is experiencing fast growth of its bauxite/aluminum industry.

In addition to four mines presently in operation, development plans include expansion of the Trombetas mine from 3.4 to 4.4 million tonnes per year, and development of a second mine in that area. The Paragominas deposits in Para and Maranho where reserves are estimated to be 174.6 million tonnes is still being considered. A production capacity of 2 million tonnes per year is planned.

Brazil's bauxite production capacity is expected to reach 10.43 million tonnes per year by the end of 1985.

Alumina and Primary Aluminum

Recent developments in production and capacities include the following:

Cia. Brasileria do aluminio--increased capacity of its Marinque alumina plant.

Aluminas--(Alcan affiliate)--increased capacity of its Saramenha aluminum plant by 75,000 st/y in 1980.

Valdosul Aluminio--completed its 95,000 st/y smelter at Santa Cruz, Rio de Janerio in 1982.

Alcan--increased capacity at its Aluminio do Brazil smelter at Aratu to 64,000 st/y.

Alcoa (60%), Shell-Billiton (40%)--a 1984 start-up is planned by the consortium for a major alumina/aluminum complex at Sao Luis in the Amazon region. Initial capacity will be 500,000 st/y for alumina and 100,000 st/y for aluminum. Bauxite will come from the CVRD Trombetas mines.

West Germany's state-owned VAW--Postponement of construction of a 110,000 st/y smelter in the State of Pernambuco, in Northeast Brazil, in conjunction with Alune, a state subsidiary.

Albras-Alunorte--a 800,000 st/y alumina plant at Vila do Conde, near Balem is under consideration. Work continues on the Albras smelter, scheduled for completion in 1985.

GUYANA

Since the nationalization of the bauxite industry in 1971, output has declined. High costs of removing the overburden covering the ore have contributed to the decline.

JAMAICA

Jamaica's bauxite, alumina, and aluminum industry has declined progressively since the imposition of heavy bauxite levies by the government in 1973. Since 1979, bauxite prodution capacity has leveled, while mines' operating rates have been dropping with the level of production. All refineries have been operating with idle capacities during the last two years. No major increases in capacity and production are foreseen.

SURINAM

Alcoa has decreased production of alumina at its Paranam plant. Bauxite production dropped 21% in 1981, and 22% in 1982. No new plants or mines have been reported.

VENEZUELA

Two smelters are in operation. The newer unit with 280,000 st/y at Mantanzas, owned by Venalum (state, 80%; Japanese companies, 20%), was suffering from startup energy and labor problems. Alumina is presently imported; however, the first stage of a 1 million tonne alumina plant is complete and started operations in March 1983. Full capacity is expected by 1986.

Venezuela hopes to open its own bauxite mine at Los Pijiguaos in 1986 with an initial capacity of 3 million tonnes per year. Reserves are estimated at about 500 million tonnes.

INDONESIA

The Asahan smelter at Kuala Tanjung, Sumatra, started production in 1982 from its first 75,000 st/y potline. Two more potlines are to be built by 1984 to raise capacity to 225,000 st/y. The plant is owned by Indonesia government (25%) and by a Japanese consortium (75%) composed of Japan's five primary aluminum producers. Alumina is currently supplied by Japan, but a plan exists to build a 600,000 st/y alumina plant on Bitan Island which will use local bauxite.

INDIA

In general, bauxite and primary aluminum production is increasing, but not as much as planned.

The modernization and capacity expansion of Renukoot smelter is under way. The Indian Aluminum Co. (Alcan, 55%) is also working on an expansion of capacity. The 2,000 million tonnes of bauxite recently discovered in Orissa is to be developed by the National Aluminum Co. Ltd. in conjunction with Pechiney of France. Plans are to start bauxite production in 1985 at an annual rate of 2.4

million tonnes per year, alumina production by 1986 at 800,000 st/y and primary aluminum, also by 1986, at 218,000 st/y. The construction of a 800,000 st/y alumina plant at Vishakapatnam, with the technical and financial assistance of the U.S.S.R., is planned.

GUINEA

Guinea presently mines bauxite at three mine locations and produces alumina. The output of these two products has declined slightly since 1981. The government plans to develop the deposits of Aye-Koye (Boke), Dabola, and Tougue. No start-up date has been set.

OTHER

About 22 other countries produce bauxite, alumina, primary aluminum or a combination of these products.

Principal changes in capacities include the following:

In Argentina, a 35,000 st/y expansion at the Aluminio Argentina SA smelter is scheduled for 1986; in the Netherlands, Pechiney Nederland reportedly cut back production by 20% due to increased power costs; in Italy, doubling the capacity of the sole 720 st/y alumina plant is in abeyance and the high cost of freighting bauxite from Australia to Porto Vesme is of concern; in Bolzano, Italy, the 45,000 st/y aluminum smelter of Aluminio Italia was to be scrapped during 1983, leaving the company with a capacity of 163,000 st/y. In Greece, Parnasse Mining Co., the largest independent bauxite producer in Europe, has concluded a contract with U.S.S.R. for the construction of a 600,000 st/y alumina plant at Itea. The contract calls for the U.S.S.R. to take two-thirds of the output and provide most of the financing, which will permit Parnasse Co. to expand its mining capacity to about 2.5 million tonnes per year. In Turkey, a project to double the capacity at its 60,000 st/y smelter has been postponed; in Sweden, the expansion project at the Swedish 83,000 st/y smelter was deferred in 1982 and probably will be completed in 1987; in New Zealand, a third potline under construction in 1983 at the Bluff Smelter is expected to raise capacity from 160,000 st/y to 224,000 st/y, and a predicted increase in power costs has deferred the building of a second smelter at Aramoana until market conditions improve; in Ghana, at the Volta Aluminum Company's Tema smelter, three of the five potlines have been closed down, reducing capacity from 200,000 st/y to 132,000 st/y of aluminum due to the insufficient supply of water, poor market conditions, and high energy costs; in South Africa, primary aluminum capacity reportedly doubled last year as a result of the transfer of an 87,000 st/y smelter from Japan;

in Hungary, work on opening up two new mines at Tata and Fenyofo is in progress; and in Taiwan, an 80,000 st/y smelter has been closed following heavy losses due to increased power costs.

SUMMARY

The summary of world capacities of bauxite, alumina, and primary aluminum (1980-1985) is presented in Tables A-1, A-2, and A-3 (Appendix A). The capacities reported for 1980-82 are actual year-end capacities, while the 1983-85 capacities are projections adjusted for the impact of the recession.

Table A-4 (Appendix A), compares the 1980-83 world capacity with actual production. The resulting operating rates indicate that in 1982 bauxite capacity utilization was only 66%.

Table A-5 (Appendix A), shows bauxite capacity utilization rates for the four leading bauxite producing countries (Australia, Brazil, Guinea, and Jamaica). This table indicates that Australia began 1983 with a 29% idle capacity; Brazil, 20%; Guinea, 25%; and Jamaica, 49%.

The Mining Engineering (1983) reports that world bauxite production declined 12% in 1982 to an estimated 76 million tonnes (84 Mil. st) due to the continuing decrease in demand for alumina and aluminum. U.S. bauxite production declined nearly 54%. Australia continued as the world's leading bauxite producer even though its production decreased 10% in 1982. Brazil's output increased 2%. Production in Guinea fell 16%; Jamaica, 31%; Surinam, 22%; and Guyana, 11%. Production in other countries remained near or slightly below the 1981 level.

CONCLUSION

The survey of world's current bauxite capacity and demand for the past three years (1980-82) shows that world bauxite capacity is presently much larger than the demand. About 40% of world capacity remains idle. All principal bauxite-producing countries entered 1983 with idle capacity. In addition, all exhibit a high potential for increased capacity. The question is, how long will it take to absorb these idle capacities to induce the opening of new mines. To answer this question, it is necessary to forecast the demand for bauxite. The following chapter is concerned with this matter.

CHAPTER 2

FORECASTS OF WORLD BAUXITE DEMAND AND CAPACITY

It has been noted that the demand for bauxite is derived from alumina and primary aluminum demands, which in turn are derived from the demand for their end-use products. This chapter presents a survey of forecasts of aluminum demand by industrial specialists. The author believes that these forecasts reflect the cyclical aluminum demand more accurately than linear forecasting methods.

Almost all predictions of aluminum demand made before 1979 estimated an annual growth rate equal to or greater than 6% through the year 2000. In this paper, we will confine ourselves to the most recent forecasts starting from 1979. These studies generally foresee a moderate growth rate in demand for aluminum. Two recent studies, "World Mineral Market" (an econometric and simulation analysis) and an elasticity approach study, predict average growths of 5.1% and 4.8% in the world consumption of primary aluminum in the period 1980-85 (Metal Bulletin, 1980). A summary of primary aluminum demand forecast by industry specialists is presented in Table 2.1.

TABLE 2.1

PRIMARY ALUMINUM DEMAND FORECAST
BY INDUSTRY SPECIALISTS

Source	Date of Forecast	Period	Average Annual Rate (%)
G. J. Haymarket, Alcoa Aust in the Financial Times-World Commodity Report	30 June 1979	1980-1990	4.9
1979 Alcan Annual Report, page 7	Jan 1980	1980-1985	4.5
James King CRU-IVGSJ Symposium 1980, Kington, Jamaica	23-27 June 1980	1979-1985	4.6
1979 Baco Annual Report, page 5	Jan.1980	1980-1985	4.0-5.0
Chase Econometrics, Metal Bulletion	22 Apr. 1980	1980-1990	4.9
Spector	3 Dec. 1979	1979-1984	4.9
Pechiney Ugine Kuhlmann Group, World Commodity Report	4 Jun. 1980	1980-1985	4.1
Rayner-Hariwill "Economic Review of the Metal Markets" Metal Bulletin	25 Apr. 1980	1980-1985	5.0

Source: Metal Bulletin, World Aluminum Survey, 1980.

The Chemical Bank of New York anticipates a growth rate of 4% to 5% in the demand for the light metal over the next 20 years (Mining Journal, September 3, 1982) The bank's optimism is based on the following assumptions: the rate of growth in aluminum demand will continue to exceed that of economic activities in both developing and developed countries; aluminum will continue to be substituted for nickel, tin, and zinc in many end-products; aluminum will probably maintain a favorable position over its competitors due to future increases in price of oil and other energy costs between now and year 2000; it will maintain a dominant position in the aerospace industry because of its substantial light-weight advantages.

In 1982 Alcoa made a detailed analysis of the timing, size, and probability of capacities of new smelters around the world in planning or construction stages. It also made estimates of current capacities which are likely to be permanently closed down. This study concluded that for the 1983-86 period the permanent closing of about 12 smelters would offset capacity expansions, leaving the industry in 1986 with about 14 million tonnes of capacity for the free world. Alcoa also predicted an average growth rate of 3% in primary aluminum from 1979 to 1986 (Alcoa Annual Report, 1982). Alcoa assumes that during the modest economic recovery in 1983 and 1984 producers will reduce inventories before spending money to restart idle capacities, and that in 1985-86, they will return to 90% utilization of remaining capacities. No new plants are foreseen until after 1986, at least in the free world.

Andreas Anderson, executive director of the Metal Group at Norway's Ardal Og Sundal Verk pessimistically estimates that high growth rates in aluminum demand in the past were due to the development of new applications and penetration of new markets through substitution of aluminum for other materials, a condition not expected to continue in the future. Hence, Anderson estimates a growth rate of 2 to 3% for the 1980s, and a probable zero growth rate in the long run. (Metal Bulletin, September 28, 1982).

For Desmond Fitzgerald and Gerald Pollio, (Journal of Metals, 1982), the question is whether unfavorable development in energy costs will lead to a deterioration in aluminum's competitive position sufficient to offset its inherent advantages. They find there is no real evidence that aluminum will lose its competitive position vis-a-vis other materials. They assume that if the increase in energy costs continues, the competitive advantages of plastics will decrease, while substitution of lower cost energy supplies in the generation of electricity will favor aluminum. They also assume that the expected expansion of aluminum use in canning, transportation, construction, and aerospace applications will offset a weaker use in electrical applications. They thus estimate that aluminum demand will grow at an annual rate of 4.5%.

Cornell Maier of Kaiser Aluminum (Mining Journal, May 1983), believes that the annual growth in aluminum will average 3% in the United States and 5% to 6% in the major industrialized countries for an overall growth of 4% to 5% in 1984 and beyond.

T. D. Kaufmann, professor of Mineral Economics at the Colorado School of Mines, in a recent study, analyzed aluminum demand and made a prediction for the next ten years. In this study, Kaufmann shows that the demand for aluminum has become increasingly cyclical (business cycles following each other at more or less regular intervals of five years), and that the structural demand will grow at a slower rate in the future than in the past. He then estimates future demand for aluminum for the United States, for Western and Eastern Europe, and for the rest of the world. He derives the demand for primary aluminum by subtracting the expected total supply by secondary sources (old and new scrap) from world totals of expected demand. The resulting figures are summarized in Table A-6 (Appendix A). The logic behind the numbers in this table is as follows:

1. Aluminum is input good with applications mostly in the industrial sectors of building and construction, transportation, consumer durables, and machinery and equipment, producing final goods for which demand is interest rate and income sensitive, thus cyclical. Aluminum is also largely used by can and packaging industries where demand is less cyclical.
2. Although some new applications are being developed, their impact on the level of demand is not expected to be significant.
3. Aluminum intensity of use per capita is expected to grow faster in the rest of the world than in the United States where it is relatively high.
4. The quantity of demand supplied by secondary sources from old scrap is expected to grow at an annual rate of some 9%.

Based on these and other assumptions, Kaufmann expects world demand for aluminum to grow at an average annual rate of 3% to 5%. Taking into account the growing supply of secondary aluminum, he estimates that primary aluminum demand will grow at an average annual rate of 2% to 4% from 1979 level. In addition, Kaufmann estimates that with the economic recovery, the economy will go back to "full use" of resources, wages will go up, and inflation will increase. On the other hand, with large U.S. government deficits and with the elections in 1984, there is little chance for immediate governmental action against inflation. After the elections, the newly-elected administration will probably take action. This will lead to lower demand and higher interest rates at a time when some of the special demands which have been feeding the recovery will have run their course. On that basis, Kaufmann believes another recession can be expected in 1986-1987. (Table A-6, [Appendix A]).

According to a worldwide study by Predicasts Inc., a Cleveland-based market research firm, (American Metal Market, March 26, 1982), demand for aluminum will rise to 4.5% through 1995. The report, which covers primary aluminum, primary and secondary copper, lead, and zinc, notes that the growth in the consumption of lead and aluminum outpaced world economic growth from the mid-1960s through 1979. While the world gross domestic product rose an average of 4.4% per year, consumption of aluminum increased 6.3% and lead consumption expanded 4.9% annually (American Metal Market, March 26, 1982). The study notes that the growth in demand for aluminum was sustained by a large and steady supply of metal of superior physical properties and a relatively low price. It concludes that growth in aluminum demand through 1995 will be moderated by rising energy costs which will lead to higher costs of the metal. Since aluminum has already made almost total penetration into copper and zinc markets, its rate of substitution for other materials is expected to level off.

The World Bank projects an annual growth rate of 4% through 1995. The U.S. Bureau of Mines expects demand to grow at an annual rate of 4% to 5%.

This brief survey of forecasts indicates that future demand for aluminum will grow at an average annual rate of 3% to 5%. Considering that about 25% of world aluminum demand is supplied by secondary sources and that this is expected to grow at 9% per year, this study will assume a primary aluminum demand growth rate of 2% to 4% per year from the 1979 level. Based on these assumptions, the primary aluminum demand projections presented in Table A-7 (Appendix A), were calculated for the period 1979-2000. The metallurgical grade bauxite demand projections were derived from predicted primary aluminum demand by using the bauxite/aluminum ratio of 4.9. In Table A-8 (Appendix A), the future total demand for bauxite was determined by assuming that 85% of total bauxite demand will be for metallurgical grade and that the remaining 15% will be for other uses (non metallic grade alumina, refractory bauxite, etc.)

Primary demand projections presented in Table A-7, indicate that 1982 year-end capacities are sufficient to cover primary aluminum average demand up to 1985. It is thus reasonable to expect a tight supply of bauxite in 1985 if no new plants are brought into production before then.

For bauxite, the linear projections of Table A-8, show that there will be a sufficient supply of bauxite to meet demand up to 1989. It should also be noted that it will be difficult to open new mines before that date. Observations based on these linear projections lead the author to conclude that opening new mines will not be advisable before 1988.

The linear projections of demand for bauxite and aluminum presented in Table A-7 and A-8, could be misleading for the simple reason that demand for aluminum has become more cyclical than in the past. To account for this cyclicality, some historical data on primary aluminum demand have been considered in Table A-9, (Appendix A). On the other hand, macroeconomics shows that recessions took place in 1967-69 and 1981-82. Following this pattern of approximately five years between the consecutive cycles, and considering the present and future trends in world economy, it seems logical to assume that another recession will take place in 1986-87. It will be difficult to predict the magnitude of the impact of that recession on the aluminum industry; however, in Table A-9, it can be assumed that primary demand will increase 0.5% in 1983 from the 1979 level, and that growth rates of 1.5% and 2.5% will be observed, respectively, in 1984 and 85. Comparing projected capacities and the corresponding demand indicates that primary supply will be tight by the end of 1984, and that the possibility exists that new plants will be opened in 1985.

On the other hand, if a recession takes place at the end of 1985 or at the beginning of 1986, primary demand growth will drop to a probable rate of 1.5% in 1986 and 1.0% in 1987. If this happens, plants expected to be put into operation may have to be delayed. In that case, the supply of bauxite will remain higher than its demand up to after 1990.

Based on the analysis presented above, bauxite supplies are expected to be tight during 1988-89 if demand grows according to the linear projections of Table A-8. For that reason, new mines may not be advisable before that time.

On the other hand, if a recession occurs in 1986-87, it is likely that demand for bauxite will remain weak for a long time. This will further delay the opening of new mines. In addition, a growing supply of aluminum from secondary sources will make matters even worse. Therefore, at this point, it is difficult to predict when new mines can be opened without idling present capacity. Nevertheless, it is possible that a new mine might be economic if present costs and prices are low enough to force present capacity to close down. Hence, a more detailed economic analysis is required to discover whether developing a new deposit could present a competitive advantage over a marginal existing mine.

CHAPTER 3

COMPETITIVENESS OF GUINEAN BAUXITE

It was shown in previous chapters that present world bauxite capacity is much larger than demand. It was also shown that the 1982 year-end capacity will probably be sufficient to meet world demand up to 1990. Yet the Guinean government would like to increase its bauxite capacity by opening at least one new mine. With today's oversupply of bauxite, a new mine should be competitive in a number of areas including quality, location, transport, and governmental tax policies. The question, then, is whether Guinean bauxite presents some competitive advantages which could justify its extraction. In order to answer this question, a comparison must be made between Guinean bauxite and that of its major competitors. The big competing bauxite suppliers are Australia, Guinea, Jamaica, and Brazil.

These four countries control over 60% of world's proven reserves of high quality bauxite, and are the world's largest producers (JBI Journal, July 1981). In 1982, their production totaled 46.6 million tonnes, about 63% of the world total. Australia is presently the world's largest producer of bauxite and alumina and is pursuing a policy of total integration of its industry. Guinea is the second largest producer with tremendous possibilities for growth. Jamaica is third with some 14 million tonnes capacity and is ready for rapid growth. Brazil, despite its current relatively low rate of production, is in an excellent position for a major take-off. With the exception of Jamaica, the three countries possess indigeneous energy resources: coal in Australia, and hydropower in Guinea (potential) and Brazil. In addition to these natural advantages, all except Jamaica pursue favorable taxation policies.

This chapter will review current bauxite mining operations, reserves, production capacities, and perspectives for future development in the four countries; compare the characteristics of the main deposits and government tax policies in order to find out whether Guinean bauxite presents some advantages over its competitors; perform a marginal cost analysis to see where future increases in supply will be coming from; and finally, compare bauxite shipping point prices to find out which ore is cheaper from buyers' perspectives.

RESERVES AND PRODUCTION CAPACITY

Guinea

The geological survey undertaken by Guinea's General Direction of Mines and Geology during 1967-80 led to an evaluation and estimation of total potential bauxite resources. Table B-1 (Appendix B), summarizes the results. Reserves were estimated at 18,202.5 million metric tonnes based on a cutoff grade of 40% alumina content. Guinea's demonstrated reserves are estimated to be about 5,000 million tonnes, approximately 30% of world total reserves (U.S. Bureau of Mines, 1983). Since 1976, Guinea has become the world's second largest producer of bauxite, and the world's largest exporter of bauxite raw material. Presently, six deposits have been evaluated. Of those deposits, three are currently in production: Fria, Sangaredy, and Kindia.

The Company Friguia (Frialco, 51%; Guinea government, 49%) mines the Fria deposits and operates the associated alumina plant. The Frialco participants are Pechiney, Alusuiss, British Aluminium, VAW and Noranda. Bauxite production capacity is 2.1 million tonnes a year. Output is processed at the Fria alumina plant. Reserves are estimated to be 364 million tonnes.

La Compagnie des Bauxites de Guinee (C.B.G.) [Halco, 51%; Guinea government, 49%] operates the Sangaredy mine. Halco Mining is composed of Alcan, 27%; Aloca, 27%; Martin Marietta, 20%; Pechiney, 10%; VAW, 10%; and Alumetal Spa, 6%. Production capacity is 9 million tonnes per year.

Total output is exported to North America and Europe. Reserves are estimated at 300 million tonnes.

Office des Bauxites de Kindia (O.B.K.), a wholly state-owned corporation, exploits the Kindia bauxite. Total output is shipped to the Soviet Union. The annual capacity is 2.5 million tonnes. Reserves are 250 million tonnes. These three mines together have an annual capacity of about 14 million tonnes.

Three other deposits, Tougue, Aye-Koye, and Dabola are candidates for future development.

In 1973, Societe Miniere de Participations Guinee-Alusuisse (Somiga) completed feasibility studies on a deposit at Tougue. These studies indicate proven reserves of 2,500 million tonnes (World Bauxite Survey 1979:10). A mine with 8 million tonnes a year bauxite capacity is planned, but no start-up date has been announced.

La Societe Guineo-Arabe d'alumine et d'Aluminum (Alugui) is being organized to develop a bauxite/alumina complex to exploit the large deposits of Aye-Koye near Boke. Feasibility studies in 1978 by Alusuiss indicate reserves of 250 million tonnes. A project with an annual capacity of 5 million tonnes of bauxite and 2 million tonnes of alumina is envisaged, Ultimately, a fully integrated plant will be developed producing primary aluminum metal. No start-up date has been set.

Finally, a deposit of 425 million tonnes has been studied in the Dabola Region by a Yugoslavian exploration group. A mine with a capacity of 2 million tonnes is planned by a joint venture of the governments of Yugoslavia and Guinea. The reserves, capacities, and ownership of these deposits are presented in Table B-2 (Appendix B).

To summarize, Guinea has large reserves of good quality bauxites. The present state of exploration works estimates about 5,000 million tonnes, and further exploration works are likely to double this number.

Australia

Since 1972, Australia has been the world's largest producer of bauxite and alumina. Production capacity is about 30 million tonnes per year. Approximately 23% of world reserves of bauxite occur in Australia. Ten deposits have been evaluated, with estimated total reserves of 4,600 million tonnes.

Bauxite is mined in the Darling Range, west of Perth in Western Australia, at Weipa in the Cape York Peninsula, and at Gove in the Northern Territory. These mines and associated refineries and smelters are held by the following companies.

Alcoa of Australia Ltd. mines bauxite at three locations in the Darling ranges: Jarrahdale, Del Park, and Huntley. The bauxite is mainly gibbsitic, reserves are estimated at over 500 million tonnes, and the annual production rate is 13.5 million tonnes. Alcoa, established in 1961, is owned by Alcoa (U.S.A.), 51%; and Australian interests, 49%.

Comalco Ltd. (CRA, 75%; Amp Society, 15%), the second largest producer of bauxite, operates two mines at Weipa. The ore is a mixture of gibbsite and boehmite. Reserves are estimated at 3,000 million tonnes, and the annual production rate is 11 million tonnes.

Nabalco Pty. Ltd. (Swiss Aluminum, 70%; Gove Alumina, 30%) operates a bauxite mine and an alumina plant at Gove. The ore is mainly gibbsitic. Reserves are 250 million tonnes, and annual production capacity is 5 million tonnes. Bauxite for export is produced by the mines of Gove and Weipa where ore grade is higher than that of other mines.

Before the 1982 recession, six deposits were to come into production, but presently only three remain under consideration with no start-up dates defined. They are as follows:

Michell Plateau (Western Australia): Feasibility studies for a mine and a refinery have been made (*Mining Journal*, June 1983). The deposit has estimated reserves of 410 million tonnes with a capacity of 6 million tonnes per year predicted. Further feasibility studies are required. The leaseholder is the Michell Plateau Bauxite Co. (CRA, 52%; Alcoa, 17%; Billiton, 10%; Sumitomo, 15%; and Marubeni, 5%).

Aurukun (south of Weipa in the Cape York Peninsula): Reserves are estimated at 200 million tonnes. Leaseholder is Aurukun Associates (Tipperay Corporation, 40%; Billiton, 40%; and Pechiney, 20%).

Worsley (Mount Saddleback): Leaseholder is the Worsley consortium consisting of Reynolds, 40%; Billiton, 30%; Dampier Mining, 20%; and Japanese interests, 10%. Planned capacity is 2.5 million tonnes, and reserves are estimated at 250 million tonnes.

Table B-3 (Appendix B) summarizes Australian bauxite reserves, capacity, and ownership.

Brazil

Presently, seven deposits have been evaluated for an estimated total of 2,300 million tonnes (Peterson and Arbelbide, 1983), about 11% of the world's reserves. Currently, four deposits are being mined by the following companies:

The Alcan subsidiary, Alcan Aluminio do Brazil (Alcan, 100%), mines bauxite at Ouro Preto with a production capacity of 420,000 tonnes per year.

Alcominas (Alcoa, 50%; Hana [U.S.], 32%; Minas Gerais Development Bank [Brazil], 15%; Brazil private, 3%) produces bauxite from the Pocos de Caldas deposit. The annual production rate is 600,000 tonnes.

The Cia Brasileria do Aluminio (CBA) (Brazil, private, 80%; Brazil Government, 20%) extracts bauxite from a deposit at Pocos de Caldas (Sorocaba). Bauxite from this mine is supplied to the company's integrated alumina-aluminum plants in Brazil. The mine's production capacity is 406,000 tonnes a year.

Mineracao do Rio Norte (Brazil Government [CVRD], 51%; CBA [Brazil], 10%; Alcan, 19%; Reynolds, 5%; Billiton, 5%; Spanish Group, 5%) is extracting part of Trombetas bauxite. The MRN reserves are estimated to be 600 million tonnes. The current production rate is 3.3 million tonnes per year to be expanded to 4.4 million tonnes. Alcoa (U.S.A.), holding over 600 million tonnes of bauxite in the Trombetas reserves, is planning to open a new mine with an annual capacity of 3 million tonnes per year.

Development plans are being considered for the Paragominas deposits in Maranhao, about 400 kilometer (Km) northeast of Serra dos Carajas. Reserves are estimated at 7,780 million tonnes. An annual capacity of 2 million tonnes is planned. The capacity, reserves, and ownership of Brazilian bauxites are presented in Table B-4 (Appendix B).

Jamaica

Jamaica, formerly the world's second largest producer is now in third place. Jamaica's bauxite mines are owned predominantly by Alcan, Alcoa, Revere, and Reynolds, all North American companies. State participation is generally small.

Alcan operates mines at Kirkvine and Ewarton with capacities of 1.15 and 0.7 million tonnes per year, respectively. Alcoa Minerals of Jamaica Inc. operates the May Pen mine, Clarendon Parish, which has a capacity of 1.88 million tonnes. Aluminum Partners of Jamaica (Alpart), owned jointly by Kaiser, 36.5%; Reynolds, 36.5%; and Anaconda, 27%, produces bauxite from its mine at Spur Tree, St. Elizabeth with a capacity of 3 million tonnes per year. Kaiser of Jamaica operates the largest Jamaican mine at Port Rhodes, St. Annes. The capacity is 5.5 million tonnes per year. Reynolds of Jamaica Mines Ltd. produces bauxite at Lyford, St. Annes, approximately 9.61 Km inland from

Ocho Rios Bay on the north coast. The capacity is 2.3 million tonnes per year. Revere Jamaica Ltd. owned a relatively small mine at Maggotty, with an annual capacity of 0.7 million tonnes.

According to the U.S. Bureau of Mines, 15 deposits have been evaluated in Jamaica, the total reserves of which are estimated to be 2,000 million tonnes (Peterson and Arbebide, 1983). The ownership, reserves, and production capacities of these deposits are presented in Table B-5 (Appendix B).

ELEMENTS OF COMPARISON

The economic value of any deposit of bauxite depends essentially on (1) the quality of ore including total and available alumina content, reactive silicates, monohydrate and trihydrate alumina content, free moisture, iron and titanium content, and volume of overburden; (2) the geographical location which includes accessibility to the deposit, availability of infrastructure, long-term safe supplies of water and power sources, distance of transport from the mine to processing facilities or port for export, and environmental restrictions; and (3) host countries' risk and taxation policies.

This section will analyze these factors in the four competing countries to determine the competitive position of Guinea.

Comparing bauxites from different sources is not an easy task because physical properties and chemical compositions of bauxite vary from country to country, from deposit to deposit, and within the same deposit. Therefore, this study will be based on the general characteristics of each deposit under consideration.

Bauxite Ore Characteristics

Alumina Content: Total alumina content is defined as the percentage of alumina present in the ore when dried, before deduction of loss caused by chemical combination with reactive silicate. Available alumina, on the other hand, is the percentage of theoretically extractible alumina. The quantity of alumina that can actually be extracted depends upon the percentage of available alumina, the percentage of reactive silicate, and the efficiency of the refinery. Since the purpose of treating bauxite is to obtain alumina from which aluminum metal can be extracted, the greater the available alumina content, the more valuable the bauxite.

Monohydrate and Trihydrate Content: The nature of chemical liaisons between the molecules of Al_2O_3 and those of H_2O of crystalization makes the distinction between monohydrate ($Al_2O_3.H_2O$) and trihydrate ($Al_2O_3.3H_2O$). These two types of bauxite require different processing techniques and sometimes are processed in separate installations. Processing costs also differ. Monohydrate (boehmite or diaspore) ores are processed at higher pressures and temperatures and require higher concentrations of caustic soda and longer decomposition times than do trihydrate (gibbsite) ores. For these reasons, gibbsitic ores are preferred.

Total and Reactive Silicate: The terms total silica and reactive silicate are used to distinguish between silica, such as quartz or sand (free silica), that does not react chemically with soda and alumina, and silicate that is chemically active and reacts with soda and alumina. The presence of reactive silicate increases the costs of processing alumina and reduces the recovery level.

Free Moisture Content: Free moisture increases transportation costs. Generally, most free moisture is removed by drying before shipping long distance. It is customary in bauxite trade contracts to establish a base price for a specific bauxite and to vary the base price according to variations in alumina, silicate, and free moisture content.

Iron and Titanium Content: These elements increase costs and create environmental problems. The red mud disposal problem is a critical one for many alumina plants.

Mechanical Properties: Hardness and friability of rock, among other properties, affect mining method and cost. Hard bauxites require drilling and blasting and more difficult and expensive crushing, milling, and grinding operations.

Overburden: The overburden is the volume of waste that covers the mineral ore. Generally the volume of overburden serves as a guide to decide whether a deposit should be extracted by underground or surface mining methods. Most bauxite deposits are exploited by surface mining methods, but a high stripping ratio increases costs and complicates mining operations.

Deposit Location

Accessibility: Access to a deposit of bauxite refers to the means of reaching it and transporting the ore after extraction. Generally, the difficulty of access to a deposit depends on the topography and the relief in which it is located, the remoteness of its location, and the disposition of the orebody in the ground. The more difficult it is to reach a deposit, the more costly it will be to exploit it.

Water and Power Supply Sources: Water and energy play important roles in bauxite mining and processing operations. Close Sources of supply increase ore economic value and competitive position. Their absence could make a relatively good deposit a marginal one.

Proximity to Port Site, Processsing and Consumption Centers: Transportation costs, in most cases, are much higher than mining costs. mines located near export ports or consumption centers present a big advantage over those which are not.

Ore characteristics and mine locations of selected deposits in Guinea, Australia, Brazil, and Jamaica are summarized in Tables B-6 through B-9 (Appendix B). Only deposits that are presently mined and those for which future development is planned are considered. Table B-10 (Appendix B), is a recapitulation of Tables B-6 through B-9 for comparison purposes.

Of the four countries, Guinea has the advantage of deposits with the highest concentrations of available alumina, the lowest reactive silicate contents, and lowest stripping ratios. Its "homogeneous" (no inclusion of waste) ore bodies with a simple geology are easy to mine. Disadvantages are that Guinea's bauxites have the highest iron content, the longest inland transportation distances, and a high percentage of monohydrate in the Boke deposits.

BAUXITE TAX AND LEVY CONSIDERATION

Today, taxes and levies influence greatly the viability of bauxite mining projects because they have become an important cost factor and source of instability in some countries. In the case of the four largest bauxite producing countries, policies have followed different patterns even though they pursue the same objectives. The purpose of this section is to compare Guinea's taxation policy with those of its competitors, Australia, Brazil, and Jamaica, to determine the competitiveness of Guinea's present tax policy. Alternative policies of these countries are also considered with the objective of determining the relative position of Guinea on the market.

Despite significant differences between their bauxite levy rates and structures, countries under study pursue similar objectives. They all wish to attract foreign capital in the mineral sector to create infrastructure and to promote economic growth and development. All seek to capture greater value added through the vertical integration of domestic processing of their primary minerals. All wish to sustain a reasonable level of employment and foreign exchange earnings over the long term, and they seek increased governmental or national corporate participation in mining ventures to gain greater sovereignty over their national economic resources.

To achieve these objectives, each country has established some policies that are described below.

CURRENT POLICIES

Australia

To understand Australia's present bauxite tax and levy system, it is necessary to comprehend that the constitution limits the powers of the Commonwealth. Powers not assigned to the Commonwealth automatically reside with the states (provincial governments).

Australian companies or individuals who negotiate contracts with foreign buyers for domestic minerals must submit the contracts to the federal government for scrutiny. Prices must reflect prevailing international prices. As a general rule, the Commonwealth and state governments do not own equity or participate in commercial mineral development. The guidelines, however, provide that Australians have 50% equity and 50% of the voting strength on the board.

State governments enjoy wide powers to regulate matters within their boundaries and are involved in day- to-day regulation of mining operations. Consequently, each state has the power to grant exploration rights and mining leases, approve mining operations, assess environmental impacts, and rehabilitation aspects of development proposals, and most important, to levy royalties and like charges (The JBI Journal, November 1980:79).

With fierce competition among state governments to attract investment and stimulate regional development, and with the federal government's total refusal to join any cartel, bauxite mining companies benefit from low tax and royalty charges.

Nabalco (Gove, Northern Territory) pays a royalty of A$0.4/tonne on locally processed bauxite and A$0.5/tonne on exported bauxite; Comalco, in Weipa (Queensland), pays A$1.0/tonne on locally processed bauxite, and A$0.5/tonne on exported bauxite; Alcoa, in Western Australia, which does not export bauxite, pays a royalty of A$1.2/tonne.

In addition to these royalty rates, companies are liable for a corporate income tax of 45% of net profits. The net profit is obtained by reducing the gross income by a number of deductible items (See Appendix D). To attract foreign capital and technology, Australian governments have provided the following incentives:

1. Low rates for services and use of facilities controlled by the regional governments such as ports,

harbors, water, electricity, and communication, wherever possible. In remote areas, mining companies are expected to provide much of this infrastructure.

2. Relaxation of some federal restrictions on foreign investments. According to Golder Associates (Country Profile, Australia, 1981), a framework has been established that allows for the voluntary "Australianization" of foreign-owned companies over a gradual period of time. Under this policy, a company is considered as "Australianized" if the following conditions exist:
   a. At least 25% of the company's equity is under Australian ownership.
   b. The company has entered into a formal agreement with the government to progressively raise this to 51%.
   c. A majority of the board of directors are Australians, with effective local management and control.
3. The government has relaxed procedural requirements so that proposals for foreign investment in new mining projects will not require approval if they involve an investment of less than A$5 million

(except in the uranium sector).

4. Establishment of a Foreign Investment Review Board to give advice on foreign investment to the government, the public, and potential Australians or overseas investors.
5. Three agencies have been established to assist in financing the development of mining and other industrial projects:
   a. Australian Industry Development Corporation (AIDC) helps in providing funds obtained largely through overseas borrowing. The AIDC also endeavors to secure Australian resident participation in the ownership and control of companies.
   b. Commonwealth Development Bank of Australia (CDBA) provides financing for the establishment or development of industrial undertakings in cases where capital might not otherwise be available on suitable terms or conditions.
   c. Australian Resources Development Bank (ARDB) provides financing for Australian enterprises seeking to establish or participate in large-scale industrial projects.

6. There is no provision for a long-term capital gains tax.

Guinea

Unlike Australia, Guinean economic activities are directed and regulated by the government. All mineral resources are state properties; there are no state-owned corporations or private companies participating in mining ventures.

Guinea's policy is outlined in the 1980 investment code of its five-year plan. Large enterprises, including mining ventures, may conclude special agreements with the state for up to twenty-five years, during which time all levies remain at their original levels. Transfer of profits from approved investments is permitted, and foreign capital is guaranteed protection. Future mining ventures are expected to follow the established pattern of having the state as a minority shareholder.

The rules as they apply to present mining companies are:

The government's participation is 49% and includes a vice presidential seat on the board of directors. In addition, the government receives 65% of net profits as follows: 30% in the form of corporate income tax and

35% = 50% (100-30), as a return on its equity. Future, and existing companies are required to have a long term plan for training local workers, including engineers and managers for the "Africanization" of the labor force. This Africanization represents little danger for foreign capital. At least 10% of the profits and all interest payments arising from an investment may be repatriated. At the end of any fiscal period granted, 10% to 15% of capital invested may be transferred each year. While such capital remains in the country, it is protected against expropriation. The code makes provision for arbitration procedures to be agreed on before investment is made. All transfers are carried out by the Central Bank. Salaries paid to expatriates may be partially transferred abroad. According to the 1969 decree, any investment over $20,000 involving the government requires presidential approval. To obtain approval, foreign interests must submit planning documents containing investment details, production plans, foreign exchange requirements, labor needs, import and export projections, and environmental control plans. Foreign trade is conducted by the state trading company, Importex, which requires a license for all imports. All companies pay a corporate income tax of 30% on the net profits. Deductions from the gross profit for tax purposes are presented in Appendix D.

In 1974, following the example of Jamaica, the government added a levy on each tonne of bauxite exported. This levy is linked to the price of primary aluminum ingot as shown in Table 3.1 below:

TABLE 3.1

Guinea's Bauxite Levy Structure

Available alumina content of bauxite	Levy per ton of available aluminum content as % of primary aluminum price
45% or less	0.50
45% to 50%	0.55
50% to 55%	0.55
Greater than 55%	0.75

Source: The JBI Journal V.1, 1981:84

To determine the amount of levy charged per tonne of bauxite, one must use the formula:

$L = \frac{P}{F}$ (PARC) (Peterson and Arbelbide, 1983), where L= the production levy per LDT (Long Dry Ton) of bauxite, P = the bauxite tax per pound of aluminum as a percent of PARC, F = the LDT of bauxite required to produce one short tonne of aluminum, and PARC = the average realized price of primary aluminum per short ton in U.S. dollars. For Guinea, Alcan published price is considered.

Royalties and long-term capital gains taxes are not applicable. Although investment incentives are not defined, it is possible that the government will make special deals e.g., exemption from some duties, depending on the importance of the project to the national interest).

Brazil

With its potential as a leader in the aluminum industry, coupled with its dependence on foreign investment, Brazil has developed a policy oriented toward attracting foreign capital and technology. The official policy is that Brazilian state and private equity combined exceed 50% in all new mineral development projects. The principal state enterprise in Brazil's non-fuel mineral industry is the Companhia Vale do Rio Doce (CVRD), which owns a 41% share in the Rio de Norte bauxite venture. This policy, however, is not expected to be enforced in the development of the Alcoa Trombetas deposits.

The Brazilian mining code enforced by the National Department of Mineral Production (DNPM) requires that permission to prospect and authorization to operate as a mining company be obtained from the Minister of Mines and Energy. Mining concession grants are obtained through presidential decree. These may be granted only to

Brazilian nationals or to "mining concerns," defined as Brazilian firms, associations, or corporations. These mining concerns may have as members, Brazilians, foreigners, or judicial persons.

Presently, the Brazilian bauxite levy system is one of the simplest: 2% of production costs, currently US$1.0/ tonne of bauxite. In addition, a corporate income tax of 35% of net profit, plus another 5% on distributed profits, is charged. Deductions from gross profits for income tax calculation are listed in Appendix D.

Incentives to attract foreign capital include the following:

1. Import duty exemption of 80% on foreign mining equipment and material when suitable products are not available in Brazil. On application to import, a deposit of 100% of the f.o.b. value of the imported goods is required to be made with the Central Bank of Brazil. This deposit is held by the bank without interest for 360 days.
2. Government financing can be available, up to 200% of original capital for companies producing metals or minerals which Brazil currently imports. To qualify, a company must be at least 50% owned by Brazilians.

3. Government subsidies may be given for geological and engineering research projects.
4. Use of accelerated depreciation methods of fixed assets is possible.
5. Exemption from income tax on the proportion of taxable income represented by export sales of processed minerals. For example, the MRN (Trombetas mining partnership) has received a 100% exemption of the corporate income tax for 15 years.
6. Exemption from value-added taxes on all bauxite exported.

Jamaica

The present Jamaican bauxite taxation policy is a reflection of dramatic changes that took place in 1974. After the victory of the People's National Party (PNP) under the leadership of Michael Manley (1972), the new government announced its intention of exercising more control over the extraction of its mineral resources and transforming Jamaica from producer of raw materials into a manufacturer of finished goods. In the bauxite and alumina industry, this decision called for renegotiations of contracts for new structures of partnership with the existing North American mining companies.

In 1974, a five-fold increase in the government levy on bauxite mining operations was announced by Manley. The new levy was set at 7.5% of the realized price of primary aluminum per ton of available aluminum content. This rate was to increase to 8% in the following year and 8.5% by 1976-77. In addition, a royalty of J$0.50 was added to each tonne of bauxite processed. This decision was met with disappointment and outrage by multinational companies working in Jamaica (Alcoa, Reynolds, Kaiser, and Alcan). During the 1976-78 period, the government established partnerships with each company, and the levy was kept at 7.5% of the average price of primary aluminum. In late 1979, the government reached a new agreement with the mining corporations to modify the levy. The revised levy is linked to the world market price of aluminum and to the rate of utilization of capacity in each company. As the average price of aluminum rises, the marginal levy rate declines as shown in Table 3.2 below.

TABLE 3.2

Jamaican Bauxite Levy Structure

Aluminum average price: US$/lb	Levy as % of Primary Aluminum average price per ton of available aluminum content
.53	7.5
.53 to .58	6.8
For higher prices, a dual formula involving a base or cape price is used	
58-63: base price - 58	6.8
63-69: base price - 59	6.8
Base price greater than 59	6.5

(See previous section on Guinea for the calculation of the amount of the levy). The rates that are defined above change according to production levels. As output rises above a floor of 85% of each firm's capacity, the marginal levy likewise decreases. For an increase of 200,000 tonnes above the floor, the levy is reduced to 75% of the applicable rate; for the next increment of 400,000 tonnes, the levy is reduced to 50% of the applicable rate.

Mining companies are also liable for a corporate income tax of 35% of net profit defined as gross profit minus deductions, (See Appendix D). Company profit tax is 15% and gain on depreciable properties is taxed as ordinary income to the extent of the depreciation allows. The incentive provided by the government is the full exemption from income tax, customs, and consumption duties on equipment and machinery.

ADVANTAGES AND DISADVANTAGES OF CURRENT POLICIES

The notion of advantage and disadvantage is relative in this context, because it depends on whether one is a foreign investor or a member of a host government. The advantages and disadvantages below are from the perspective of the foreign investor.

Australia

The bauxite taxation policy of Australia is very favorable to bauxite mining companies. Australian state governments do not charge a levy other than a royalty of A$.40/tonne to A$1.30/tonne depending on the state in which companies operate and whether bauxite is processed locally or exported as raw material. Another advantage is the Commonwealth's refusal in 1974 to follow Jamaica in tax increases and to join other IBA members in the formation of a cartel. Australia has no restriction on foreign exchange, and capital from outside the country is guaranteed protection.

Australia has two restrictions, not all that serious, which foreign investors may fear. First, the requirement that the Australian equity participation be at least 51% was designed to give control to the state. On the other hand, it reduces the risk exposure of foreign investors (which may continue to rule anyway). Second, the requirement that 50% of managerial positions go to Australians might be viewed as a weakening of multinational firms in the country. Considering the level of intellectual development in Australia, however, one should expect high participation by Australians in decision making. If mining firms see these regulations as a long-term solution, they will not view them as a handicap. The government has established financial institutions which assist state corporations and Australian individual investors in project financing. Furthermore, Australian state governments provide excellent incentives for foreign capital investment. Australia's present policies offer more advantages than disadvantages to foreign investors.

Brazil

Like Australia, Brazil offers many advantages to overseas investors. The growing power of Brazil in the bauxite-aluminum industry comes mainly from the tremendous reserves of high quality bauxite at Trombetas. The development of these reserves began after the formation of IBA. Brazil is not a member of IBA and did not follow high taxation policies as IBA members. Conscious of its dependence on foreign capital and technology to promote the national development, Brazil has adopted a very low tax policy, about US$1.0/tonne of bauxite at Trombetas. There are no royalty fees, and incentives including tax holidays, exemption from import duties, use of accelerated depreciation method, etc., are provided. Brazil is one of the rare developing countries which provides for depletion allowances. All in all, it can be said that Brazil's policy presents only advantages.

Guinea

Unlike Brazil and Australia, Guinea's tax rate is relatively high, about US$13/tonne of bauxite exported (case of Boke). Guinea is a member of IBA and is in favor of the formation of a cartel. A multinational, however, could find the following advantages:

First, national mining policy is stable, and the government is considered to be a serious and a reliable partner in mining ventures. There are no royalty fees.

Second, the programs of education and training for local workers who are to be hired by mining projects could increase costs to companies in the short run. In the long run, it will increase the availability of local skilled labor for all companies.

Third, labor strikes are forbidden.

Fourth, as in Brazil and Australia, the government offers some incentives to foreign investment.

Despite Guinea's high bauxite tax rate, the country offers some advantages to mining companies.

Jamaica

Unlike Brazil and Australia, Jamaica's levy and royalty rates are very high, presently about US$21/tonne of bauxite exported. This high tax policy and the instability of Jamaican policy have made its bauxite less attractive than that of Guinea, Brazil, and Australia. Jamaica is the only country which imposes a long-term capital gains tax. Hence, although the government offers some incentives to attract capital from outside the country, Jamaican bauxite remains politically less attractive than that of its competitors.

COMPARATIVE COMMENT

Appendix C reviews comparative policies of the countries under consideration.

In summary, all four countries offer high equity participation of either the state government (Guinea and Jamaica), or state corporation (Brazil) or national private companies (Brazil and Australia). This policy is generally advantageous to multinationals because of the shared risk.

Australia and Brazil impose low tax and royalty rates. Australia imposes royalties only when income tax reaches 45% of net profits. Brazil imposes no royalty and its levies are low (US$1.0/tonne). Guinea imposes no royalty, but its present levy of US$13 to US$14/tonne of bauxite is much higher than that of Australia and Brazil, but much lower than that of Jamaica. Jamaica is an extreme case where both royalties and levies are comparatively high. Jamaica is also the only country among the four which imposes a capital gains tax.

All provide some incentives to attract foreign investments. Incentives provided by Australia and Brazil are the most appealing. Other advantages that Australia and Brazil possess reside in the variety and richness of their mineral resources and mining activities. They do not depend exclusively upon the revenues collected from bauxite mining companies. Australia, Brazil, and Guinea have stable policies and a reputation for being reliable partners. Investment in these countries is protected against expropriation.

From the foreign investors' perspective, Australia and Brazil are more attractive than Guinea and Jamaica, and Guinea is much more appealing than Jamaica.

ALTERNATIVE POLICIES OF COMPETITORS

Brazil and Australia

The present policies of Australia and Brazil are more attractive to foreign investors than those of Guinea and Jamaica. The author does not anticipate any policy changes that will improve the attractiveness of the latter two countries. Depending on their need for foreign exchange, the quality of their bauxites and some other economic conditions, Brazil and Australia may find it expedient to increase their levy rates. If this happens, depending on the magnitude, they may lose their competitive position with respect to Guinea.

Jamaica

As already noted, Jamaica's tax policy represents the worst case from a foreign investor's point of view. The

Jamaican government undoubtedly will not make this policy more restrictive than it is today. The government has already realized that since the imposition of heavy bauxite levy rates in 1974, bauxite production has declined, Jamaica's position in the world market has fallen, and foreign investment in its bauxite and alumina industry has almost stopped. Faced with pressing needs for foreign exchange, and depending heavily on revenues collected from bauxite mining companies, Jamaica has learned the hard way that its 1974 decision is not a long-term solution. The author predicts a decrease in Jamaican levy rates. The original law has been modified more than once to encourage companies to increase their production rates. It is the author's perception that a decrease in the Jamaican levy rate will not change the present picture of the market. The reason for this is that multinational companies, having learned their lesson, will no longer depend solely upon any one source of supply. They have already discovered a variety of good sources in Australia, Brazil, Guinea, and other countries. Therefore, a cut in the Jamaican levy will probably lead to an increase in production by companies presently operating in the country, but it is unlikely that it will motivate new investments for the short term, especially when present market conditions are considered. It will take time before Jamaica can convince mining companies that its policies are stable. The author does not see any changes in Jamaican policy which will affect Guinea's competitive position in the near future.

CONCLUSION

This study has shown that in the world market, development of Guinean bauxite faces tough competition from bauxite developement in Australia, Brazil, and Jamaica. Although Guinea's present bauxite taxation policy is attractive to multinational mining companies, the taxation policies of Brazil and Australia appear to have more appeal. Policy changes are likely to occur in Jamaica soon, but the author does not anticipate a negative effect of this change on the competitiveness of Guinean bauxite. It is not likely that Brazil and Australia will make their policies more appealing to foreign investors than they are now, but it is possible that they may increase either their royalty or levy rates. If this happens, they may lose their competitive position over Guinea, assuming that Guinea's policy stays the same.

MARGINAL COST ANALYSIS

From an economic point of view, the marginal cost is the incremental cost of producing one additional unit of output. Economists distinguish between short- and long-run marginal costs. In the short run, plants' capacities and capital costs are fixed. Therefore, the marginal cost is the variable costs which, for most bauxite mines, are approximately the same as operating costs. In the long run, capital costs and mines' capacities are variable, and can be adjusted to changes in output, due to variations in demand. The long-run, marginal cost is the change in total costs due to a one-unit increase in production over a period of time.

Estimates of marginal costs presented in this section are based on the following:

1. Capital investments and operating costs are the estimates of the U.S. Bureau of Mines in 1980 dollars, unless otherwise noted.
2. To convert costs into current dollars, an escalation factor of 7% per year for capital investments, and 5% for operating costs will be assumed.
3. Capital expenditures for mining plants and equipment are depreciated over 10 years, using straight line depreciation. Capital investments for

infrastructure are depreciated over 15 years by straight line depreciation.

4. In cases where a mine and associated refinery and/or smelter are to be built together, it is assumed that 30% of total investment in infrastructure are chargeable to the mine.
5. Total capital investments are assumed to be raised in the financial market at an annual interest rate of 13%, with equal annual payments (principal, plus interest) over 20 years.
6. Overland transportation costs, levies and/or royalties are included in operating costs. (Ocean transportation costs, and bauxite ore quality are considered for comparison purposes).
7. Only mines whose output is totally or partially exported are considered in the short run marginal cost analysis.

Guinea

There are three mines in operation with a capacity of 14 million tonnes of bauxite per year. The output of the Kindia mine is not very cyclical because of the special long-term contract that exists between the governments of Guinea and the Soviet Union. The production at the mine of Fria is processed locally and is generally constrained by the capability of the alumina plant. The mine of Boke (Sangaredi) is the most important because of its capacity (9 million tonnes per year), the quality of its ore, and its international dimension. It is presently operating at 80% of capacity, and therefore, production can be increased at the prevailing operating cost of 1983 US$18.44/tonne without any incremental capital investment. Boke's capacity utilization may reach 90% to 95% by 1985. If demand grows beyond this level, additional capital expenditure will be needed to expand the mine's capacity.

In the midterm, there are plans to raise capacity at both Fria and Kindia, but there is no information on the incremental capital costs of those expansion projects.

In the long-run, the government plans to develop the deposits of Aye-Koye, Tougue, and Dabola, but only Aye-Koye is likely to come on stream in the near future. The evaluation of that project is presented in Chapter 4.

Australia

Australian mines are presently operating with some 25% of their capacity idle. A short-term increase in demand for Australian bauxite can be met by using this idle capacity at the current operating cost of about US$7.86/tonne (U.S. Bureau of Mines, 1983). The author estimates that by 1985, Australia's mines will be operating at full capacity.

In the long-run there are plans to develop the deposits of Mount Saddleback and Aurukun with associated refineries. Feasibility studies are underway for the development of the Michell Plateau deposit.

The long-run marginal cost of producing one tonne of bauxite from projected mines at Mount Saddleback and Aurukun are estimated below:

Mount Saddleback Project

Reserves (million tonnes)		250
Planned production (million tonnes)		2.1
Capital investments (million US$)		
Mine	$(.70)(320)(1.07)^3$	274.41
Infrastructure	$(.30)(320)(1.07)^3$	177.60
Total capital expendiutes (million US$)		392.01
Amortization (US$/tonne)		18.71
Interest (US$/tonne)		17.24
Operating costs (US$/tonne)		8.25
Total cost (US$/tonne)		43.81

Aurukun Project

Reserves (million tonnes)		200
Annual production (million tonnes)		2.3
Capital investments (million US$)		
Mine	$300\ (1.07)^3$	367.51
Infrastructure	$(.30)\ (440)\ (1.07)^3$	161.71
Total investments (million US$)		529.22
Amortization (US$/tonne)		20.66
Interest (US$/tonne)		21.22
Operating costs (US$/tonne)		7.86
Total cost (US$/tonne)		49.74

Brazil

Trombetas mine is presently operating at full capacity. There is a plan to increase capacity to 4.4 million tonnes/year from the current level of 3.3 million tonnes/year. The incremental capital investment of this expansion is estimated to be US$55 million (Metal Bulletin, August 1983). Based on this, the incremental cost of producing one more tonne of bauxite at Trombetas is estimated below:

Trombetas' expansion project

Incremental capacity (million tonnes)	1.1
Capital investment (million of US$)	55
Amortization (US$/tonne)	5.00
Interest (US$/tonne)	4.61
Operating costs (US$/tonne)	9.71
Total cost (US$/tonne)	19.32

To expand capacity to 8 million tonnes per year, the marginal cost will be higher.

Jamaica

In the short-run, Jamaica has great possibilities for increasing production at prevailing costs because its mines are operating at about half capacity. Therefore, higher demand for Jamaica's bauxite can be met at the prevailing operating cost of US$27.46/tonne in 1983 escalated dollars. Under the modified tax law, companies can reduce their tax burden by operating at over 80% capacity utilization level. It can be assumed that Jamaica's idle capacity will be reduced to about 20% to 10% by 1985, when demand for bauxite reaches its peak. If the plan of reducing its levy rate becomes a reality, Jamaica's short-term marginal cost will be much lower than the figure noted above.

For the long-term, there is no information on whether Jamaica will expand the capacity of some of its existing mines or open new mines. There are, however, several deposits under consideration for development, although no feasibility studies have been done. It can be assumed that no new mines will open until the idle capacity of existing mines is absorbed.

COMPARATIVE SUMMARY

The short-run marginal costs, which are the same as prevailing operating costs, are summarized in Table 3.3.

Transportation costs from each mine to the U.S. gulf coast are added; furthermore, the U.S. gulf costs are adjusted for the free moisture and the available alumina content of each type of bauxite. The available alumina content of bauxite of Boke (Guinea) is considered as a basis.

TABLE 3.3

SHORT RUN MARGINAL COST COMPARISON

	Operating Costs at Local Port	Transport to US Gulf	Total Cost at US Gulf Coast	Adjusted Total Cost
Boke (Guinea)	18.44	12.44	30.88	32.00
Grove (Australia)	7.86	20.00	27.86	36.67
Weipa (Australia)	7.86	20.00	27.86	35.23
Water Valley (Jamaica)	27.46	4.46	32.23	46.34
Lydford (Jamaica)	27.46	6.53	33.99	50.55
Trombetas (Brazil)	19.32	10.99	30.31	31.91

This table shows that Guinea and Brazil have about the same adjusted costs, these costs are lower than those of Australia and Jamaica. Jamaica is the highest cost producer.

In the long-term, total cost estimated for the mines of Aurukun and Mount Saddleback seem very high. The question is where the cost of the new mine of Guinea will be as compared to those mentioned above.

SHIPPING POINT PRICE COMPARISON

The purpose of this section is to compare prices of bauxite from countries under study at destination ports, to find out which bauxite is the cheapest for consumers. Presently bauxite is shipped from Guinea to the U.S.A., U.S.S.R., France, West Germany, Canada, Italy, Switzerland, and Yugoslavia; from Australia to Japan, Italy and W. Germany; from Brazil to the U.S.A. and Canada; finally, from Jamaica to the U.S.A., Canada and the U.S.S.R. For comparison purposes, bauxite prices are estimated at the ports of U.S.A. (Gulf Coast), Canada (Port Alfred, Quebec), U.S.S.R. (Black Sea), West Germany (Stade), and Japan. Presently there is no trade in bauxite between Australia and the U.S.A., U.S.S.R., and Canada; between Brazil and U.S.S.R, W. Germany, and Japan; between Guinea and Japan; and between Jamaica and Germany, and Japan. It could be assumed, however, that in the future, a bauxite market will be established between these countries if the economic conditions are favorable. Nevertheless, because of the long distances between Guinea and Japan, and between Australia and U.S.S.R., it is unlikely that bauxite will be shipped from Guinea to Japan and from Australia to U.S.S.R.

It is worthwhile to note that comparing prices of bauxites from various sources and to different customers is not an easy task for several reasons. First, bauxites are materials which are physically and chemically different, mainly by their composition in monohydrate, trihydrate, available alumina content, reactive silicate and free moisture content. The percentage content of each of these elements affects the price and the economic value of ore in different ways. Second, no international or standard pricing system of bauxite exists, nor does there exist a spot market. The price in each individual contract is determined by bargaining between buyers and sellers. Third, transportation costs vary from country to country. Fourth, bauxite producing countries often impose different levies and royalties on mining companies. Fifth, the existence of captive mines with their transfer pricing fails to give the real market value of the ore. Sixth, bauxite sold on long term contracts and escalation clauses differ from contract to contract.

All these factors contribute to varying prices of the same type of ore to different customers. In this paper the following are considered:

F.O.B. Prices

The f.o.b. (freight on board) price is the contract price of bauxite delivered to the ship and ready for export. Because prices determined in individual contracts are not generally published, the weighted average prices calculated from f.o.b. prices obtained from the U.S. Customs Bureau for the first six months of 1983 are considered unless otherwise noted. These weighted average prices are assumed to be the same for all producers in the same country. For Australia, whose prices are not in the U.S. Customs' data, the 1978 f.o.b. price of U.S.$12.50/ tonne published by Samuel Moment (1979) was escalated at 10% per year.

Ocean Transportation Freight and Insurance

Bauxite ocean transportation cost depends on transport distance, fuel cost, and the size of the ship which is, in turn, a function of the ability of the loading port to accommodate big cargoes, energy cost, the amount of shipping capacity idle at time of charter and the chance of getting a cargo for the back haul. The transportation cost is generally composed of fixed and variable costs. Fixed costs consist of capital outlay, interest charges, depreciation, amortization of the vessel, and sometimes, administrative costs. Variable costs include fuel costs, voyage cost, maintenance and repair, crew wages, port charges, etc. (IBA, Towards Increased Cooperation in Bauxite Development, 1980: 136). Shipping costs given by the U.S. Bureau of Mines (Peterson and Arbelbide, 1983) are considered. But in cases where those costs are not available, the weighted average transportation costs between the relevant exporting countries and the U.S. gulf were extrapolated by assuming that 40% of these costs are fixed and that the remaining 60% are linearly proportionate to the distance of transport. The distances between countries were estimated on a world map; therefore, they may not be the exact distances. Shipping costs per metric tonne of bauxite are presented in the second column of Table 3.4.

CIF Prices

Costs, insurance and freight (c.i.f.) of bauxite under study are determined by summing up f.o.b. prices and ocean transportation costs and insurance. The c.i.f. price is the value of bauxite ore at the port of consuming countries. The c.i.f. prices of bauxite from countries under consideration at the port of selected consuming countries are

TABLE 3.4

SHIPPING POINT PRICES OF BAUXITES FROM GUINEA, AUSTRALIA, BRAZIL, AND JAMAICA

(All Values in U.S. 1983 Dollars Per Metric Tonne)

	F.O.B.	Freight & Insurance	C.I.F. As Shipped	Adjusted CIF
From AUSTRALIA				
a) Weipa to	16.00			
US gulf coast		20.00	36.00	42.02
Canada		21.00	37.00	43.28
W. Germany		22.50	38.50	45.18
Japan		22.50	38.50	45.18
U.S.S.R.		--	--	--
b) Gove to	16.00			
US gulf coast		20.00	36.00	45.80
Canada		21.01	37.01	47.13
W. Germany		22.50	38.50	49.05
Japan		22.50	38.50	49.05
U.S.S.R.		--	--	--
From GUINEA				
Boke to	33.96			
US gulf coast		12.44	46.40	48.08
Canada		12.60	46.56	48.25
W. Germany		10.50	44.46	46.07
Japan		--	--	--
U.S.S.R.		--	--	--
From BRAZIL				
Trombetas to	31.51			
US gulf coast		10.99	42.50	45.29
Canada		12.79	44.30	47.32
W. Germany		15.10	46.61	49.91
Japan		19.91	51.42	55.32
U.S.S.R.		15.09	46.60	49.90

TABLE 3.4 (Continued)

SHIPPING POINT PRICES OF BAUXITES FROM GUINEA, AUSTRALIA, BRAZIL, AND JAMAICA

(All Values in U.S. 1983 Dollars Per Metric Tonne)

	F.O.B.	Freight & Insurance	C.I.F. As Shipped	Adjusted CIF
From JAMAICA				
a) Water Valley to	29.73			
US gulf coast		5.65	35.38	49.61
Canada		9.02	38.75	55.72
W. Germany		16.37	46.10	66.29
Japan		26.42	56.15	80.74
U.S.S.R.		26.40	56.13	80.71
b) Lyndford to	32.05			
US gulf coast		5.05	37.10	55.83
Canada		9.02	41.07	61.80
W. Germany		16.37	48.37	72.78
Japan		26.42	58.47	87.98
U.S.S.R.		26.40	58.45	87.95

Prepared by the Author

presented in the third column of Table 3.4. Those are the c.i.f. prices of bauxite as shipped. To make them comparable to each other at the same destination port, they must be calculated on dry bauxite and common ore grade basis. Bauxite from Boke (Guinea) with 55% available alumina and 1% reactive silicate is considered as basis. Prices of bauxite from other countries are adjusted for available alumina content by multiplying the relevant c.i.f. price by the factor $\frac{55}{AAl}$, where 55 represents the available alumina content of Boke bauxite (Guinea), and AAl represents the available alumina content of the relevant type of bauxite. To adjust for reactive silicate content, an average US$1.00 penalty/ premium is considered for each 1% silicate above/ below the base 1% silicate. Because all bauxite are shipped with a certain percentage of free moisture, the c.i.f. prices resulted from the above adjustments are reported to a dry ton of bauxite by dividing the adjusted c.i.f. prices by $\frac{100-W}{100}$, where W is the percentage of free moisture in the relevant bauxite as shipped. These adjusted prices are presented in the last column of Table 3.4. The characteristics of bauxite considered in this study are presented in Table 3.5. Adjustments described above are based on those characteristics.

TABLE 3.5

CHARACTERISTICS OF BAUXITES AS SHIPPED FOR MINES CONSIDERED

	Available Alumina (%)	Reactive Silicate (%)	Free Moisture (%)	Monohydrate (%)
GUINEA				
Boke (Base Case)	55.0	1.0	3.5	5.0
AUSTRALIA				
Gove	46.0	2.5	9.0	3.0
Weipa	50.0	4.5	13.0	9.0
BRAZIL				
Trombetas	51.5	3.36	5.0	nil
JAMAICA				
Water Valley	45.0	1.0	15.0	High
Lydford	43.0	1.0	15.0	High

Source: (1) U.S. Bureau of Mines, Aluminum Availability-Market Economy Countries, Information Circular No. 8917 (Washington, DC: GPO, 1982)

(2) Metal Bulletin, World Aluminum Survey, 1980

To summarize, Table 3.4 shows that Australia's and Brazil's bauxites are cheaper than Guinea's bauxite at U.S. gulf and the port of Quebec (Canada). At Germany's port, only Australia's bauxite (Weipa) is cheaper than Guinea's. In all cases, Jamaica's prices are the highest. No comparison has been made at the port of U.S.S.R. because of the special deal between Guinea and that country.

CHAPTER 4

DETERMINATION OF BREAKEVEN PRICE FOR THE OUTPUT OF AYE-KOYE NEW MINE

The breakeven price can be defined as the per unit output price that equates the net present value (NPV) of the project to zero at a specified rate of return on investment (Stermole, 1982). The purpose of this chapter is to determine the breakeven price for the planned Aye-Koye mine and to find out whether that price is competitive.

BRIEF GEOLOGIC DESCRIPTION OF THE DEPOSIT AND RESERVES

The bauxite deposit of Aye-Koye consists of two plateaus: Diandian and Sinthourou located at about 15 Km northwest of Sangaredi in the Boke area. According to the 1978 feasibility studies of Alusuiss, Aye-Koye bauxite is composed of gibbsite ($Al_2O_3.3H_2O$), 60%; boehmite ($Al_2O_3.H_2O$), 8%; kaolin associated with other minerals, 2%; hematite and gohetite, 21.7%; titanium and other, 10.3%.

A vertical section through a typical plateau shows three distinct zones with completely different mineralogical composition. Some 2m of brown-red bauxitic cuirass rich in iron oxide overlies a 3m bed of yellow-red massive bauxite. The highest alumina content is found in this massive bauxite. Below the massive bauxite lies a 5m bed of gravelly bauxite with decreasing concentrations of alumina from its upper part to the lower limit. At the bottom of this zone rests a 10-15m bed rich in kaolin and iron oxide, but poor in alumina.

The quality and reserves of Aye-Koye bauxite are presented in Tables 4.1 and 4.2 Table 4.1 presents reserves according to the cutoff grade, Table 4.2 shows reserves of high quality bauxite in each plateau.

MINE DEVELOPMENT PLAN

In its 1978 feasibility studies, Alusuisse considered 9 variants of production. In this paper only variant number 4 is considered. This variant projects an annual production of 4 million tonnes of bauxite: 2.5 million tonnes for conversion into alumina at an associated refinery to be built at Aye-Koye, and 1.5 million tonnes to be exported. This study will focus on the following mining activities. A road will be constructed from the crusher to each plateau. Mining operations will start on both plateaus at the same time. Bauxite from Sinthourou, because of its low grade, will go to the local alumina plant, and bauxite from Diandian will be exported. Stripping of the small volume of overburden will be carried out by Caterpillar D8k

TABLE 4.1

AYE-KOYE: RESERVES OF BAUXITE ACCORDING TO THE CUT-OFF GRADES

		40%	42%	44%	46%	48%	50%
RESERVES IN MILLIONS OF METRIC TONS							
DIAN-DIAN	AO	27.78	27.30	25.78	23.92	21.24	17.60
	A1	10.08	10.08	9.70	9.18	8.36	6.38
	A2	6.80	6.80	6.74	6.48	5.78	4.14
	A3	3.62	3.62	3.62	3.50	3.12	2.64
	B	14.82	14.50	13.94	12.04	9.82	8.52
	C	6.04	5.60	5.20	4.92	4.24	3.30
	D	12.06	11.90	10.58	8.56	6.44	3.80
	E	6.88	6.88	6.64	5.94	4.44	1.80
	F	13.38	13.38	13.04	11.98	9.84	7.24
TOTAL DIANDIAN		101.46	100.06	95.24	86.52	73.28	55.36
SINTHOU-ROU	SE.A	8.68	8.58	8.08	6.78	5.58	4.04
	SE.B	42.42	41.92	39.58	34.16	27.64	18.76
	SE.C	7.44	7.04	6.58	6.16	5.76	3.40
	SW	6.50	5.98	5.46	4.56	1.90	1.38
	NE.A	2.20	2.14	2.12	1.20	0.56	0.32
	NE.B	3.30	2.92	2.44	2.06	1.38	0.92
	N. A	7.46	7.04	6.80	5.12	3.14	2.04
	N. B	18.40	17.84	16.88	14.68	11.56	8.72
	C. A	7.50	7.44	6.86	6.14	5.32	3.46
	C. B	35.12	34.50	32.30	27.82	21.50	14.84
TOTAL SINTHOUROU		139.02	135.40	127.10	108.68	84.34	57.78
TOTAL AYE-KOYE		140.48	235.46	222.34	195.20	157.62	113.14

Source: Aluminum Suisse, S.A., Etude de Faisabilite Aye-Koye, 1978

TABLE 4.2

HIGH QUALITY BAUXITE RESERVES OF AYE-KOYE
(Millions of Tonnes)

LOCATION	BLOCK	NUMBER OF HOLES	RESERVES 10^6t	QUALITY ALUMINA	QUALITY SILICA	BAUXITE THICKNESS (m)	DISTANCE FROM THE CRUSHER
	A0	150	22.60	50.40	1.3	8.0	9.5
	A1	50	8.70	49.80	1.6	9.2	10.0
	A2	40	6.10	49.20	1.7	8.1	8.5
DIAN-	A3	23	3.30	51.40	1.8	7.6	9.5
DIAN	B	77	11.30	50.20	1.5	7.8	11.0
	C	30	4.60	48.50	2.0	8.2	12.0
	D	51	8.10	47.90	2.4	8.4	13.0
	E	31	5.60	50.20	1.9	9.6	15.5
	F	69	11.40	48.50	2.2	8.7	16.5
TOTAL DIANDIAN		521	81.70	49.63	1.7	8.4	
	SE.A	46	6.40	49.10	1.6	7.4	5.0
	SE.B	176	32.30	48.90	2.3	9.7	5.5
	SE.C	29	5.90	48.90	2.1	10.6	7.5
	SW	27	4.30	47.10	1.7	8.4	2.5
SINTHOU-	NE.A	07	1.10	47.80	2.0	8.6	5.0
ROU	NE.B	16	2.00	47.6	1.6	6.4	6.5
	N. A	28	4.80	48.30	2.2	9.1	4.5
	N. B	98	13.90	48.80	1.6	7.5	2.5
	C. A	38	5.80	48.90	1.3	8.1	2.5
	C. B	181	26.20	48.80	1.5	7.7	2.2
TOTAL SINTHOUROU		646	102.70	48.73	1.84	8.35	4.37
TOTAL AYE-KOYE		1167	184.40	49.13	1.78	8.37	

Source: Aluminum Suisse S.A., Etude de feasibilite Aye-Koye, 1978 bulldozers. The exposed bed of bauxite will be drilled with Atlas Copco Roc 810H drills, and blasted with the explosive ANFO; hydraulic front-end loaders will load the blasted material into Caterpillar 772 45-ton trucks for hauling to the crushing plant or to an intermediate stockpile to be located in the proximity of the crushing station. From the crusher, a conveyor will carry bauxite to the car loading station at the mine rail terminal or to the alumina plant. At the car loading station, bauxite will be loaded into 75 gondola cars which will be assembled into trains for a 155-Km trip to the port of Kamsar where it will be loaded into ships for exporting.

CAPITAL AND OPERATING COSTS

A summary of capital and operating costs is presented in Appendix E. Mining equipment capital and operating costs are from the feasibility studies of Alusuiss. Those costs have been escalated at an annual rate of 7% for capital costs and 5% for operating costs. Infrastructure and other indirect costs which were not available have been estimated by the author by using O'Hara's quick capital and operating cost estimation method (Canadian Mining and Metallurgical Bulletin, 1980).

Working capital was estimated to be 3 months operating cost. It is assumed that replacement costs will be 10% of mining equipment cost every other year starting in year six (1989).

CASH FLOW AND BREAKEVEN PRICE CALCULATION

The cash flow (CF) calculation is presented in Appendix F. It is assumed that the breakeven price "p" is unknown and is to be determined; therefore, the CF is expressed as a function of P. The calculations are based on the following assumptions:

1. Project construction to begin in 1984 will take 3 years. Production the fourth year will be 1.5 million tonnes; in the fifth year, 3 million tonnes; in the sixth year and beyond, 4 million tonnes. An evaluation life of 25 years is considered.
2. Fifty percent of total initial capital investment (US$211.54 million) will be borrowed at a 13% per year interest rate with uniform mortgage payment of US$211.54 (A/P 13%,20 = US$30.11 million per year over 20 years starting in year 6.
3. Gross revenues are assumed to escalate at 6% per year, and operating costs at 8% per year.

4. Capital assets are straight line depreciable assets over 15 years for infrastructure and crushing plant, and over 7 years for mining equipment and replacement costs. Depreciation for all initial capital investment will start in year 4 when production begins.
5. Two cases of income tax are assumed: In the first case, the government charges an income tax of 35% of net profit with no free equity. This case yields CF(1). The second case corresponds to the government applying an income tax of 35% of net profit and taking 30% of profits as return on its equity participation under the form of infrastructure. This yields CF(2) in the cash flow calculation.

For both cash flows, f.o.b. breakeven price is determined for the after tax rate of returns (DCFROR) of 15%, 18%, and 20% as shown in Table 4.3.

In Table 4.4, U.S. gulf c.i.f. price of Aye-Koye bauxite as shipped is calculated by adding freight and insurance costs of US$12.44/tonne to f.o.b. price determined above, and is adjusted for the quality of bauxite.

TABLE 4.3

BREAKEVEN PRICE CALCULATION CF 1

CF1			NPV at 15%		NPV at 18%		NPV at 20%	
Year	P	C	P	C	P	C	P	C
0								
1		105.77		91.97		89.64		88.14
2		113.17		85.67		81.28		78.59
3								
4	.98	25.68	.55	14.68	.50	13.25	.47	12.38
5	2.07	28.62	1.03	14.23	.90	12.51	.83	11.58
6	2.92	57.91	1.26	25.04	1.08	21.45	.98	19.39
7	3.09	55.53	1.16	20.88	.97	17.43	.86	15.50
8	3.29	65.83	1.08	21.52	.88	17.51	.77	15.31
9	3.48	63.51	.99	18.05	.78	14.32	.67	12.31
10	3.69	75.16	.91	18.58	.71	14.36	.60	12.14
11	3.91	75.08	.84	16.14	.63	12.16	.53	10.10
12	4.15	88.75	.78	16.59	.53	12.18	.47	9.95
13	4.39	85.59	.71	13.91	.51	9.95	.41	8.00
14	4.65	101.72	.66	14.38	.46	10.02	.36	7.92
15	4.93	98.19	.61	12.07	.41	8.20	.32	6.37
16	5.24	116.81	.56	12.48	.37	8.27	.28	6.32
17	5.54	112.96	.51	10.50	.33	6.78	.25	5.09
18	5.88	128.48	.48	10.38	.30	6.53	.22	4.83
19	6.23	138.37	.44	9.72	.27	5.96	.20	4.33
20	6.60	163.23	.40	9.97	.24	5.96	.17	4.26
21	7.00	158.68	.37	8.43	.22	4.91	.15	3.45
22	7.42	187.42	.34	8.66	.19	4.91	.13	3.39
23	7.87	182.51	.32	7.33	.17	4.06	.12	2.75
24	8.34	215.74	.29	7.54	.16	4.06	.10	2.71
25	8.84	210.47	.27	6.39	.14	3.36	.09	2.21
TOTAL			14.57	475.01	10.80	389.05	8.99	346.96

P(15%) = 475.01/14.57 = 32.60 (1987 US escalated dollars)

P(18%) = 389.05/10.80 = 36.02 (1987 US escalated dollars)

P(20%) = 346.96/8.99 = 38.60 (1987 US escalated dollars)

TABLE 4.3 (Continued)

BREAKEVEN PRICE CALCULATION CF 2

CF2			NPV at 15%		NPV at 18%		NPV at 20%	
Year	P	C	P	C	P	C	P	C
0								
1		105.77		91.97		89.64		88.14
2		113.17		85.57		81.28		78.59
3								
4	.53	.79	.30	.45	.27	.41	.26	.38
5	1.11	.87	.55	.43	.49	.38	.45	.35
6	1.57	20.45	.68	8.84	.58	7.58	.53	6.85
7	1.67	16.35	.63	6.15	.52	5.13	.47	4.56
8	1.77	25.06	.58	8.19	.47	6.67	.41	5.83
9	1.87	21.03	.53	5.98	.42	4.74	.36	4.08
10	1.98	30.66	.49	7.58	.38	5.86	.32	4.95
11	2.10	30.68	.45	6.59	.34	4.97	.28	4.13
12	2.23	42.24	.42	7.89	.31	5.80	.25	4.74
13	2.37	36.41	.39	5.92	.28	4.23	.22	3.40
14	2.51	50.30	.35	7.11	.25	4.96	.20	3.92
15	2.66	45.71	.33	5.62	.22	3.82	.17	2.97
16	2.82	59.75	.31	6.39	.20	4.23	.16	3.23
17	2.99	53.36	.28	4.96	.18	3.20	.13	2.41
18	3.16	70.90	.26	5.73	.16	3.60	.12	2.66
19	3.36	77.66	.24	5.46	.14	3.35	.11	2.43
20	3.56	99.08	.22	6.05	.13	3.62	.09	2.58
21	3.77	89.82	.20	4.77	.12	2.78	.08	1.95
22	4.00	114.61	.18	5.30	.10	3.00	.07	2.08
23	4.24	104.28	.17	4.19	.09	2.32	.06	1.57
24	4.49	132.96	.16	4.64	.08	2.50	.06	1.67
25	4.76	121.45	.14	3.69	.08	1.94	.05	1.27
TOTAL			7.85	298.58	5.82	255.17	4.84	233.99

P(15%) = 298.58/7.85 = 38.04 (1987 US escalated dollars)

P(18%) = 255.17/5.82 = 43.84 (1987 US escalated dollars)

P(20%) = 233.99/4.84 = 48.34 (1987 US escalated dollars)

TABLE 4.4

AYE-KOYE BAUXITE BREAKEVEN PRICE

DESCRIPTION	DCFROR 15%	DCFROR 18%	DCFROR 20%
f.o.b. price in US 1987 escalated dollars			
case 1	32.60	36.02	38.60
case 2	38.04	43.84	48.34
f.o.b. price in US 1983 constant dollars			
case 1	24.87	27.48	29.45
case 2	29.02	33.45	36.88
c.i.f. US gulf price as shipped in US 1983 constant dollars			
case 1	37.27	39.48	41.85
case 2	41.42	45.85	49.28
Adjusted c.i.f. US gulf price 1983 constant dollars			
case 1	45.00	48.15	50.53
case 2	50.61	55.35	59.49

Compiled by the author

Comparing the above adjusted c.i.f. prices to those of Australia, Brazil, and Jamaica (see Table 3.4, page 83) indicates that based on the assumptions presented, the new mine of Aye-Koye will be competitive for DCFROR of 15% and 18% if the government applies an income tax of 35% of net taxable. With an income tax rate of 65%, the break-even price of US$50/tonne at DCFROR of 15% is relatively high. This price will be competitive only with current Jamaican prices.

CONCLUSIONS AND RECOMMENDATIONS

From the preceding study, the following conclusions and recommendations are formulated.

Large bauxite reserves and mining capacities exist throughout the world, especially in Australia, Guinea, Jamaica, and Brazil. Demand for bauxite, alumina, and primary aluminum will continue to grow at lower rates than in the past. An excess supply of bauxite has existed since the 1981-82 recession and will continue to exist until after 1990, delaying start-up date of planned mines and plants. Guinea's bauxite presents qualitatively competitive advantages over its competitors, but tax policies and investment incentives are less attractive than those of Australia and Brazil. Based on the assumptions made, Guinea's bauxite is cost competitive but adjusted prices per tonne of bauxite from Australia and Brazil are lower than those of Guinea and Jamaica, a condition stemming from the high levies imposed by the last two countries.

The new mine of Aye-Koye (Guinea), would be competitive if an income tax of 35% of net profit were applied alone, and if a DCFROR of 15% were considered on investor's 50% equity. At the current tax rate of 65%, the Aye-Koye break-even price is not competitive with prices of bauxite from Brazil and Australia at the U.S. gulf coast.

Therefore, considering the excess supply of bauxite, and given the relatively high breakeven price of the planned mine, it is unlikely that foreign mining companies will invest in Aye-Koye unless some changes are made in government policies. Changes are likely to occur since most current mining venture arrangements require host government participation in capital outlay. This, coupled with the government decision to effectively participate in managerial decision-making processes, will eliminate the problem of free equity. In this case, the Aye-Koye adjusted breakeven price of US$45/tonne (in 1983 constant dollars) is competitive with prices of Brazilian and Jamaican bauxite, but still higher than the price of Australian bauxite. The author estimates that the Aye-Koye mine is not feasible until market conditions improve. In addition, the author recommends the following:

Considering that mining activities play an important role in Guinea's economic development, and that the government, because of a lack of capital funds, managerial and marketing skills, coupled with the oligopolistic structure of the industry, cannot develop a bauxite mine on its own, it is indispensable that the government establish a coherent and reasonable mineral policy. This policy should cause minimum distortion in resource allocation, permit the government to reach its long term development objectives and maximize long term earnings. The policy should be easily understandable, sufficiently flexible for adjustment to changes in economic conditions, stable over a long period of time, and allow for efficient administration.

The competitiveness of the Aye-Koye project depends more on government policy than on the quality of ore; therefore, an income tax of 35% of net profit with a lower levy rate, will make the project cost competitive and probably motivate opening the mine before 1990. Some other investment incentives may be applicable.

The author acknowledges that additional information on Aye-Koye cost data and more sophisticated cost estimation procedures are needed to determine accurately the breakeven price of Aye-Koye output. The author recognizes also that more information on mining cost structure, pricing policies, ore qualities and transportation costs of bauxite from the countries under consideration is required for a more valuable comparative analysis.

Finally, the project Aye-Koye is an ambitious one which includes the building of an integrated alumina/aluminum plant on the basis of supply of power by Konkoure hydropower, yet to be developed. Therefore, the author believes that additional research is necessary for analysis of the requirements of the Konkoure hydropower development, and to assist in determining the optimum size and economic viability of the planned alumina/aluminum complex.

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APPENDIX A

WORLD CAPACITIES AND DEMAND PROJECTIONS OF BAUXITE/ALUMINA AND PRIMARY ALUMINUM

TABLE A-1

WORLD SUMMARY OF CAPACITIES (1980-1985)
ADJUSTED FOR 1981-82 CAPACITY CLOSURES AND
DELAY OF SOME PLANNED CAPACITIES

(Millions of Metric Tons)

BAUXITE COUNTRIES	1980	1981	1982	1983	1984	1985
AUSTRALIA	29.50	29.50	29.50	29.50	31.50	36.50
BRAZIL	4.77	4.90	5.40	6.43	10.43	10.43
CHINA	1.00	1.00	1.00	1.50	1.50	3.20
DOMINICAN R.	1.20	1.20	1.20	1.20	1.20	1.20
FRANCE	2.04	1.96	1.94	1.91	1.91	1.91
GHANA	.40	.40	.40	.40	.40	.40
GREECE	3.66	3.66	4.66	4.66	4.66	4.66
GUINEA	13.50	13.50	13.50	13.50	13.50	13.50
GUYANA	4.00	4.00	4.00	3.00	3.00	3.00
HAITI	.60	.60	CLOSED			
HUNGARY	3.46	3.56	3.56	3.66	3.66	3.66
INDIA	1.51	1.51	1.51	1.51	1.51	1.51
INDONESIA	1.30	1.30	1.30	1.30	1.30	1.30
JAMAICA	14.32	14.32	14.32	14.32	14.32	14.32
MALAYSIA	.75	.75	.75	.75	.75	.75
RUMANIA	1.00	1.10	1.20	1.30	1.40	1.50
SIERRA LEONE	.70	.70	.70	.70	.70	.70
SURINAM	7.00	7.00	.60	5.00	5.00	5.00
TURKEY	.53	.64	.64	.64	.64	.64
U.S.A.	1.85	1.85	1.85	.85	.85	.85
U.S.S.R.	6.20	6.40	6.60	5.80	6.30	6.65
YUGOSLAVIA	4.38	4.50	4.60	4.65	4.65	4.65
TOTAL WORLD	103.67	104.34	104.62	102.57	109.17	116.32
MID-YEAR CAPACITY		104.00	104.50	103.60	105.80	112.70

Prepared by Dr. T. D. Kaufmann, Hector Ramos and Sidiki Conde

TABLE A-2

WORLD SUMMARY OF CAPACITIES (1980-1985)
ADJUSTED FOR 1981-82 CAPACITY CLOSURES
AND DELAY OF SOME PLANNED CAPACITIES

(Millions of Metric Tons)

ALUMINA COUNTRIES	1980	1981	1982	1983	1984	1985
AUSTRALIA	7.20	7.20	7.70	8.20	8.20	8.20
BRAZIL	.62	.54	.54	.51.04		1.27
BULGARIA	The plant will not open					
CANADA	1.22	1.22	1.22	1.22	1.22	1.22
CHINA	.60	.60	.60	.60	.60	.60
CZECHOSLOVAKIA	.10	.10	.10	.10	.10	.10
FRANCE	1.33	1.33	1.33	1.33	1.33	1.33
EAST GERMANY	.06	.06	.06	.06	.06	.06
WEST GERMANY	1.63	1.63	1.63	1.63	1.63	1.63
GUINEA	.70	.70	.70	.70	.70	.70
GREECE	.50	.60	.60	.60	.70	.70
GUYANA	.35	.35	.35	.35	.35	.35
HUNGARY	.86	.88	.88	.88	.88	.88
INDIA	.84	.84	.84	.84	.84	.84
IRELAND	--	--	--	.20	.20	.20
ITALY	.92	.92	.92	.72	.72	.72
JAMAICA	2.85	2.85	2.85	2.85	2.85	2.85
JAPAN	2.21	.90	.40	.20	.20	.20
POLAND	--	.08	.10	.10	.10	.10
RUMANIA	.65	.65	.65	.65	.65	.65
SPAIN	.80	.80	.80	.80	.80	.80
SURINAM	1.32	1.32	1.32	1.32	1.32	1.32
TAIWAN	.10	.10	.10	.10	.10	.10
TURKEY	.20	.245	.24	.24	.24	.24
U. KINGDOM	.12	.12	.12	.12	.12	.12
U.S.A.	6.97	7.10	7.10	6.35	6.35	6.35
U.S.S.R.	4.35	4.35	4.58	4.00	5.00	5.00
VENEZUELA	--	--	--	.30	1.00	1.00
YUGOSLAVIA	1.64	1.64	1.34	1.34	1.34	1.34
TOTAL WORLD	38.14	37.31	37.40	35.85	38.65	39.38
MID-YEAR CAPACITY		37.72	37.35	36.62	37.25	39.01

Prepared by Dr. T. D. Kaufmann, Hector Ramos and Sidiki Conde, Colorado School of Mines.

TABLE A-3

WORLD SUMMARY OF CAPACITIES (1980-1985)
ADJUSTED FOR 1981-82 CAPACITY CLOSURES
AND DELAY OF SOME PLANNED CAPACITIES

('000' of Metric Tons)

PRIMARY ALUMINUM COUNTRIES	1980	1981	1982	1983	1984	1985
ALGERIA	--	--	125	125	125	125
ARGENTINA	140	140	140	140	140	140
AUSTRALIA	367	367	425	470	470	1,118
AUSTRIA	93	93	93	93	93	93
BAHRAN	125	170	170	170	170	170
BRAZIL	268	268	414	414	586	586
CAMEROUN	52	80	80	80	80	80
CANADA	1,117	1,174	1,231	1,231	1,231	1,231
CHINA	486	526	526	526	526	526
CZECHOSLOVAKIA	65	65	65	65	65	65
DUBAI	37	40	80	80	80	135
EGYPT	133	166	166	166	166	166
FRANCE	445	445	445	445	445	445
EAST GERMANY	85	85	85	85	85	85
WEST GERMANY	727	733	733	635	635	635
GHANA	200	200	200	200	200	200
GREECE	145	145	145	145	145	145
HUNGARY	73	73	73	73	73	73
ICELAND	85	85	85	85	85	85
INDIA	321	321	321	321	321	325
IRAN	50	50	50	50	50	50
ITALY	286	286	280	280	280	280
JAPAN	1,297	1,297	400	400	400	400
NORTH KOREA	20	20	20	20	20	20
MEXICO	44	44	44	44	44	44
NETHERLANDS	264	264	264	264	264	246
NEW ZEALAND		152	152	152	152	152
NORWAY	718	718	718	718	718	718
POLAND	115	115	135	135	161	161
RUMANIA	263	263	263	263	263	263
SOUTH AFRICA	84	84	84	84	168	168
SOUTH KOREA	18	18	18	18	18	18
SPAIN	92	92	92	92	92	92
SURINAM	66	66	66	66	66	66
SWEDEN	85	85	85	85	85	85
SWITZERLAND	86	86	86	86	86	86

TABLE A-3 (Continued)

WORLD SUMMARY OF CAPACITIES (1980-1985)
ADJUSTED FOR 1981-1982 CAPACITY CLOSURES
AND DELAY OF SOME PLANNED CAPACITIES

('000' of Metric Tons)

PRIMARY ALUMINUM COUNTRIES	1980	1981	1982	1983	1984	1985
TAIWAN	74	74	74	74	74	74
TURKEY	60	60	60	60	60	60
U. KINGDOM	379	387	185	185	185	185
U.S.A.	5,016	5,016	3,905	3,905	3,905	3,905
U.S.S.R.	3,175	3,185	3,385	3,395	3,645	3,695
VENEZUELA	300	300	300	300	320	400
YUGOSLAVIA	295	295	380	425	425	425
TOTAL WORLD	17,863	18,093	16,648	16,650	17,201	18,139
MID-YEAR CAPACITY	17.98	17.37	16.65	16.92	17.67	

Prepared by Dr. T. D. Kaufmann, Hector Ramos and Sidiki Conde, Colorado School of Mines.

TABLE A-4

WORLD'S BAUXITE-ALUMINA-P. ALUMINUM CAPACITY PRODUCTION AND OPERATING RATES (1980-1983)

		1980	1981	1982	1983
I.	P. ALUMINUM				
	CAPACITY	19,694	19,948	18,354	18,357
	PRODUCTION	16,940	16,613	14,200	--
	OP. RATE (%)	86	80	77	--
II.	ALUMINA				
	CAPACITY	42,049	41,129	41,233	39,519
	PRODUCTION	34,772	34,100	29,147	--
	OP. RATE (%)	83	81	71	--
III.	BAUXITE				
	CAPACITY	114,413	114,953	115,344	114,182
	PRODUCTION	89,933	85,729	75,800	--
	OP. RATE (%)	79	75	66	--

Compiled by the author.

TABLE A-5

BAUXITE CAPACITY, PRODUCTION AND OPERATING RATES FOR THE FOUR LEADING PRODUCING COUNTRIES ('000' of Short Tons)

		1980	1981	1982	1983
I.	AUSTRALIA				
	CAPACITY	32,524	32,524	32,524	32,524
	PRODUCTION	27,584	25,541	23,000	--
	PCT CHANGE	--	-7.4	-10.0	--
	OP. RATE (%)	85	79	71	--
II.	BRAZIL				
	CAPACITY	5,266	5,954	5,954	7,085
	PRODUCTION	3,970	5,300	5,400	--
	PCT. CHANGE	--	+33.5	+1.9	--
	OP. RATE (%)	75	89	91	--
III.	GUINEA				
	CAPACITY	14,884	14,884	14,884	14,884
	PRODUCTION	13,780	12,100	11,200	--
	PCT. CHANGE	--	-12.2	-15.7	--
	OP. RATE (%)	93	81	75	--
IV.	JAMAICA				
	CAPACITY	15,788	15,788	15,788	15,788
	PRODUCTION	12,271	11,664	8,000	--
	PCT CHANGE	--	-5.0	-32	--
	OP. RATE (%)	77.6	74.0	51.0	--

Compiled by the author.

TABLE A-1

FORECAST OF ALUMINUM DEMAND
(Million of Metric Tons)

	1982	1983	1984	1985	1986	1987	1988	1989	1990
U.S.A.									
Buildings & Construction	1.0	1.3	1.8	1.8	1.5	1.0	1.3	1.8	1.8
Transportation	.8	1.2	1.5	1.8	1.2	.9	1.2	1.5	1.8
Electrical	.5	.6	.7	.8	.6	.5	.6	.7	.8
Containers & Packaging	1.6	1.7	1.8	1.8	1.9	2.0	2.0	2.1	2.2
Durables & Equipment	.6	.8	.8	.9	.8	.6	.8	.8	.9
Other	.3	.3	.3	.3	.3	.3	.3	.3	.3
TOTAL U.S.A.	4.8	5.9	6.9	7.4	6.3	5.3	6.2	7.2	7.8
TOTAL W. Europe	3.7	4.0	4.5	4.7	4.3	3.7	4.0	4.5	4.7
TOTAL Japan	2.1	2.1	2.4	2.6	2.0	1.6	2.0	2.4	2.6
TOTAL E. Europe	3.6	3.7	3.8	3.9	4.0	4.2	4.4	4.6	4.8
TOTAL Rest of the World	3.2	3.5	3.7	4.0	4.4	4.5	4.6	5.0	5.2
TOTAL WORLD DEMAND (1)	17.4	19.2	21.3	22.6	21.0	19.3	21.2	23.7	25.1
RECYCLING FROM									
New scrap (15%)	2.7	2.9	3.2	3.4	3.1	2.8	3.2	3.6	3.8
Old scrap:									
a. U.S.A.	.9	1.0	1.0	1.1	1.2	1.3	1.4	1.5	1.6
b. Elsewhere	.6	.7	.8	.8	.9	1.0	1.1	1.2	1.3
TOTAL SCRAP (2)	4.2	4.6	5.0	5.3	5.2	5.1	5.7	6.3	6.7
TOTAL PRIMARY DEMAND (1-2)	13.2	14.6	16.3	17.3	15.8	14.2	15.5	17.4	18.4
PRIMARY CAPACITY	17.3	16.6	16.9	17.7	18.6	19.6	20.0	20.0	21.0
PRIMARY CAPACITY UTILIZATION (%)	76.3	88.0	96.4	97.7	84.9	72.4	77.5	87.0	87.6

Prepared by Dr. T. D. Kaufmann, Colorado School of Mines.

TABLE A-7

PRIMARY ALUMINUM AND METALLURGICAL GRADE BAUXITE DEMAND PROJECTIONS (1980-2000) (Million of Metric Tons)

	PRIMARY ALUMINUM				METALLURGICAL GRADE BAUXITE		
Year	Mid-yr Capacity	Demand Low	Demand Avge	Demand High	Demand Low	Demand Avge	Demand High
1979							
1980	--	14.9	15.0	15.2	73.0	73.5	74.5
1981	17.9	15.2	15.5	15.8	74.5	75.6	77.5
1982	17.4	15.5	16.0	16.4	75.9	78.0	80.6
1983	16.6	15.8	16.4	17.1	77.5	80.3	83.8
1984	16.9	16.1	16.9	17.8	79.0	82.7	87.2
1985	17.7	16.4	17.4	18.5	80.6	85.2	90.6
1986	--	16.8	18.0	19.2	82.2	87.8	94.3
1987	--	17.1	18.5	20.0	83.9	90.4	98.0
1988	--	17.4	19.0	20.8	85.5	93.1	102.0
1989	--	17.8	19.6	21.6	87.2	95.9	106.0
1990	--	18.2	20.2	22.5	89.0	98.8	110.3
1991	--	18.5	20.8	23.4	90.8	101.7	114.7
1992	--	18.9	21.4	24.3	92.6	104.8	119.3
1993	--	19.3	22.1	25.3	94.4	107.9	124.0
1994	--	19.6	22.7	26.3	96.3	111.2	129.0
1995	--	20.0	23.4	27.3	98.2	114.5	134.2
1996	--	20.4	24.1	28.4	100.2	117.9	139.5
1997	--	20.9	24.9	29.6	102.2	121.5	145.1
1998	--	21.3	25.6	30.8	104.3	124.1	150.9
1999	--	21.7	26.4	32.0	106.3	128.9	157.0
2000	--	22.1	27.2	33.3	108.5	132.7	163.2

Prepared by the author.

TABLE A-8

TOTAL BAUXITE DEMAND PROJECTIONS (1980-2000)
(Million of Metric Tons)

Year	Mid-Year Capacity	Bauxite Demand Low	Bauxite Demand Average	Bauxite Demand High
1979				
1980	--	85.9	86.5	87.6
1981	104.0	87.6	89.1	91.1
1982	104.5	89.3	91.8	94.7
1983	103.6	91.2	94.5	98.5
1984	105.8	92.9	97.4	102.5
1985	112.7	94.8	100.3	106.6
1986	--	96.7	103.3	110.8
1987	--	98.7	106.4	115.3
1988	--	100.6	109.6	119.9
1989	--	102.6	112.9	124.7
1990	--	104.7	116.2	129.7
1991	--	106.8	119.7	134.9
1992	--	108.9	123.3	140.3
1993	--	111.1	127.0	145.9
1994	--	113.3	130.8	151.7
1995	--	115.6	134.8	157.8
1996	--	117.9	138.8	164.1
1997	--	120.3	143.0	170.6
1998	--	122.7	147.3	177.5
1999	--	125.1	151.7	184.6
2000	--	127.6	156.2	191.9

Prepared by the author.

TABLE A-9

BAUXITE AND PRIMARY ALUMINUM DEMANDS; HISTORICAL DATA (1971-1982) AND PROJECTIONS ADJUSTED FOR A POSSIBLE RECESSION (Million of Metric Tons)

PRIMARY ALUMINUM						BAUXITE
Year	Cap.	Demand	Growth rate from 1979's level	Growth rate from Previous year level	Capacity	Production
1971	--	9.9	--	--	--	66.8
1972	--	10.6	--	6.6	--	70.8
1973	--	11.5	--	6.5	--	79.9
1974	--	12.5	--	9.1	--	84.0
1975	--	11.5	--	8.8		76.3
1976	--	11.9	--	3.5	--	79.6
1977	--	13.8	--	15.9	--	84.8
1978	--	14.1	--	2.2	--	84.5
1979	--	15.6	--	10.6	--	87.9
1980	17.8	15.4	-1.3	-1.3	103.7	89.9
1981	18.1	15.1	-1.7	-1.9	104.3	85.7
1982	16.6	13.9	-3.6	-7.9	104.6	75.8
1983	16.6	15.9	0.5	14.4	102.6	91.6
1984	17.2	16.8	1.5	5.7	109.2	96.8
1985	18.1	18.1	2.5	7.7	116.3	104.3
1986	--	17.3	1.5	-4.4	--	99.7
1987	--	16.2	1.0	--	--	92.4
1988	--	14.2	0.0	-6.4	--	81.9
1989	--	16.3	0.5	14.8	--	93.9
1990	--	17.2	1.0	5.5	--	99.2

Prepared by the author.

APPENDIX B

BAUXITE RESERVES, CAPACITY, OWNERSHIP AND ORE CHARACTERISTICS (AUSTRALIA, GUINEA, JAMAICA AND BRAZIL)

TABLE B-1

GUINEA: ESTIMATES OF RESERVES OF BAUXITE
(Million of metric tons)

DEPOSIT LOCATION NAME	Overburden Thickness (m)	Bauxite Thickness (m)	Quality of Bauxite: Alumina	Silica	Iron Oxide	RESERVES
NORTH-WEST:						
Group of Boke	0.5	7.1	50.60	1.5	7.2	4,700
Sangaredi	0.5	30.0	59-65	1.0	7.2	300
Group of Koumbia		8.5	45	3.5		1,300
Group of Paraou-Yamia			45	3-6		3,612
Group of Termesse-Hore Herinko		7.1	40-50	3-6		1,609
TOTAL NORTH-WEST						11,521
SOUTH-WEST						
Group Fria	1.5-2.0	2-10	47.50	1.8		364
Group Somore		10	50.0	1.4	30	563.9
Guemessoron		12	43.9	2.4	25.9	145
Wonkoma		6	48-60	1.5	7.7	44
Bogoro		8	41-49	4.8	19.8	29
Group Sampiri		10-4	46	4.0	25.0	88
Group Manga		8.8	46	4.6		507
TOTAL SOUTH-WEST						1,522.9
CENTRAL PART						
Zone Donguel Sigon		8.3	47.1	2.1		703
Bantignel		4.8	45.50	1.4		471.6
Bougoume		7.2	47.50	2.5		200

TABLE B-1 (Continued)

GUINEA: ESTIMATES OF RESERVES OT BAUXITE
(Million of metric tons)

DEPOSIT LOCATION NAME	Overburden Thickness(m)	Bauxite Thickness (m)	Quality of Bauxite Alumina	Silica	Iron Oxite	RESERVES
Bokira		6.8	46.0	3.0		98
Dabola		6.8	45.2	1.5		1,100
Tougue		7.0	43.5	3.0		2,86
Zone Kindia						200
TOTAL CENTRAL PART						5,158.6
TOTAL GUINEA						18,202.5

Prepared by the author from data collected from the geological survey of Guinea by the General Direction of MINES and GEOLOGY of GUINEA.

TABLE B-2

GUINEA: BAUXITE OWNERSHIP, CAPACITY, AND RESERVES (Million of metric tons)

DEPOSIT	OWNERSHIP	CAPACITY	RESERVES
FRIA (Kimbo)	Frialco and Guinea Government	2.20	364.00
Sangaredy (Boke)	Halco Partners and Guinea Government	9.00	300.00
Debele (Kindia)	Guinea Government	2.50	250.00
Aye-Koye (Boke) (P)	Guinea Government	4.0-9.0	250.00
Tougue (P)	Guinea Government	na	2,500.00
Dabola (P)	Guinea Government	na	800.00
GUINEA TOTAL			4,464.00

(P) = project

Source: (1) U.S. Bureau of Mines, Aluminum Availability-Market Economy Countries, Information Circular No. 8917 (Washington, DC: GPO, 1982)

(2) Metal Bulletin, World Aluminum Survey, 1980

TABLE B-3

AUSTRALIA: BAUXITE RESERVES, CAPACITY, AND OWNERSHIP (Million of metric tons)

DEPOSIT	OWNERSHIP	CAPACITY	RESERVES
Gove	Swiss Al. Australia Ltd. Gove Alumina Ltd	5.00	250.00
Darling Range			
Huntley-Del Park	Alcoa of Australia	13.50	500.00
Jarrahdale	Alcoa of Australia		
Weipa and Andoom	Kaiser, Rio Tinto & Public (COMALCO)	11.00	3,000.00
Aurukun (P)	Billiton, Pechiney	5.00	200.00
Michell Plateau	Mitchell, Billiton Sumitomo	6.00	410.00
Mount Sad-leback (P) (Worsley)	Worsley Consortium	2.1	na
Cape (P) Bougainville	Alumex, Mitsui Nippon Steel	na	na
Cittering Mucheal (P)	Pacminex, Hanwright Metal Miniere	0.40	na

TABLE B-3 (Continued)

AUSTRALIA: BAUXITE RESERVES, CAPACITY, AND OWNERSHIP (Million of metric tons)

DEPOSIT	OWNERSHIP	CAPACITY	RESERVES
Mount William (P)	Alcoa of Australia	na	na
TOTAL AUSTRALIA		29.90	4,360.00

(P) = Project (not in production presently)

Source: (1) U.S. Bureau of Mines, Aluminum Availability - Market Economy Countries, Information Circular No. 8917 (Washington, DC: GPO, 1982)

(3) Metal Bulletin, World Aluminum Survey, 1980

TABLE B-4

BRAZIL, BAUXITE RESERVES, CAPACITY, AND OWNERSHIP (Million of metric tons)

DEPOSIT	OWNERSHIP	CAPACITY	RESERVES
Ouro Preto	Alcan	0.42	na
Almeirim-Jutai	Companhia Vale do Rio Doce	-	na
Paragomina (P)	Mineracao Vera Cruz Sa	2.00	788
Pocos do Caldas	Alcominas	0.65	na
Pocos do Caldas	Companhia Brasileria do Aluminio	0.60	-
Trombetas	Mineracao Rio do Norte (MRN)	3.30	600.00
Trombetas (P)	Alcoa	3.00	600.00
TOTAL BRAZIL		6.70	3,500.00

(P) = project

Source: (1) U.S. Bureau of Mines, Aluminum Availability-Market Economy Countries: Information Circular N.8917 (Washington, DC: GPO, 1982)

(2) Metal Bulletin, World Aluminum Survey, 1980

TABLE B-5

JAMAICA: BAUXITE RESERVES, CAPACITY, AND OWNERSHIP (Million of metric tons)

DEPOSITS	OWNERSHIP	CAPACITY	RESERVES
Alpart	Kaiser, Reynolds, Anaconda	2.500	na
Breadnut Valley	Alcoa and Jamaican Government	1.600	na
Ewarton	Alcan and Jamaica Government	0.700	na
Kirkvine	Alcan and Jamaica Government	1.410	na
Lydford	Reynolds and Jamaica Government	-	-
Water Valley	Kaiser and Jamaica Government	na	na
Cambridge (P)	Jamaica Government	na	na
New Market East (P)	Jamaica Government	na	na
Samalco (P)	Jamaica Government	na	na
Schwallen-dursh West (P)	Jamaica Government	na	na
Spanish Town (P)	Jamaica Government	na	na
Trelawny (P)	Jamaica Government	na	na

TABLE B-5 (Continued)

JAMAICA: BAUXITE RESERVES, CAPACITY, AND OWNERSHIP (Million of metric tons)

DEPOSITS	OWNERSHIP	CAPACITY	RESERVES
Williamsfield East (P)	Jamaica Government	na	na
TOTAL JAMAICA		14.00	2,000.00

(P) = project

Source: (1) U.S. Bureau of Mines, Aluminum Availability-Market Economy Countries: Information Circular No. 8917 (Washington, DC: GPO, 1982)

(2) Metal Bulletin, World Aluminum Survey, 1980

TABLE B-6

CHARACTERISTICS OF AUSTRALIAN BAUXITES

DESCRIPTION	GOVE	DARLING RANGE	WEIPA & ANDOOM	MICHELL PLATEAU	MOUNT SADDLEBACK	AURUKUN (CAPE YORK)
Status	Production	Production	Production	Project	Project	Project
Type of ore	Gibbsite + Boehmite-3%	Gibbsite + Boehmite	Gibbsite + Boehmite-10%	Gibbsite Boehmite	Gibbsite Boehmite	Gibbsite Boehmite
Total alumina (%)	45 - 58	39 - 59	48 - 56	47	32.2	52 - 60
Available alumina (%)	45	33 - 43	50	--	-	45
Total silica (%)	2 - 6	6 - 18	4 - 9	2 - 3	1 - 2	2 - 20
Reactive silicate		1 - 3				
Total iron (%)	8 - 23	7 - 27	7 - 12	21	--	5 - 13
Total Titanium (%)	17	.9 - 3.10	2	4	--	2.1 - 3.1
Loss of ignition (LOI %)	28	25	22	25	--	21 - 29
Stripping ratio	.23:1	.13:1	.31:1	.13:1	.33:1	1:1
Hardness	Blasting required					
Other properties			Washing required			
Distance from processing plant (Km)						
Distance from port site (Km)	120	120	72.4	80	241.4	121

Source: (1) G. R. Peterson and S. J. Arbelside, Aluminum Availability--Market Economy Countries, U.S. GPO, 1983.
(2) Metal Bulletin, World Aluminum Survey, 1980

TABLE B-7

CHARACTERISTICS OF GUINEAN BAUXITES

DESCRIPTION	SANGAREDY (BOKE)	KIMBO (FRIA)	DEBELE (KINDIA)	AYE-KOYE (BOKE)	DABOLA	TOUGUE
Status	Production	Production	Production		Project	Project
Type of ore	Gibbsite + Boehmite-5%	Gibbsite	Gibbsite	Gibbsite + Boehmite-8%	Gibbsite	Gibbsite
Total alumina (%)	50 - 65	40 - 55	48	50 - 58	45 - 50	46
Available alumina (%)	45 - 60	45	45	45 - 50	44	43
Total silica (%)	2	2.5	1 - 3	1.9		
Reactive Silicate (%)	1	1.5	1.5	1.5	1.4	1.5
Total iron (%)	7.2	24	24	21.7	28.6	-
Total Titanium (%)	2.5	2.2	-	-	-	-
Loss of ignition (LOI %)	28	25	26	27	26	25
Stripping ratio	0:1	.05:1	.015:1	.05:1	.07:1	.02:1
Hardness	require drilling and blasting					
Other properties	Homogeneous	Heterogeneous	Homogeneous and easy to mine			
Distance from processing plant (Km)		5 - 8				
Distance from port site (Km)	126	145	140	160	440	550

Source: (1) G. R. Peterson and S. J. Arbelside, Aluminum Availability--Market Economy Countries, U.S. GPO, 1983.
(2) Metal Bulletin, World Aluminum Survey, 1980.

TABLE B-8

CHARACTERISTICS OF BRAZILIAN BAUXITES

DESCRIPTION	TROMBETAS	OURO PRETO	POCOS DE CALDAS	PARAGOMINAS
Status	Production	Production	Production	Project
Type of ore	Gibbsite	Gibbsite	Gibbsite	Gibbsite
Total of alumina (%)	55.8	37 - 47	46 - 54	50 - 58
Available alumina (%)	51.5	44	49	50.6
Total Silica	4.0		5 - 6	3 - 7
Reactive Silicate (%)	3.36	2.3	3.5	4.0
Total iron	10.5	24.94	9	8.2
Total Titanium (%)	1.1	1.5	1.4	1.5
Loss of ignition (LOI %)	28.3	28	28	29
Stripping ratio	1:1	.2:1	.1:1	5:1 - 7:1
Hardness	soft but require occasional drilling and blasting			
Other properties	require washing and drying			
Distance from processing plant (Km)				
Distance from port site (Km)	45.0	121.86	120	575

Source: (1) G. R. Peterson and S. J. Arbelside, Aluminum Availability--Market Economy Countries, U.S. GPO, 1983.
(2) Metal Bulletin, World Aluminum Survey, 1980.

TABLE B-9

CHARACTERISTICS OF JAMAICAN BAUXITES

DESCRIPTION	LYDFORD	SAMALCO	MAGGOTTY	WATER VALLEY
Status	Production	Project	Project	Production
Type of ore	Gibbsite + Boehmite	Gibbsite + Boehmite	Gibbsite + Boehmite	Gibbsite + Boehmite
Total alumina (%)	48	44	43	40 - 45
Available alumina	42.5	41	40	40
Total silicate	5.0	3.0	3.0	3.0
Reactive silicate (%)	1.0	1.5	1.5	1.5
Total iron	18	18	19	17
Total Titanium	2.7	2.2	2.1	2.1
Loss of ignition (LOI %)	20	22	21	21
Stripping ratio	0:1	.1:1	.1:1	.1:1
Hardness				
Other properties				
Distance from processing plant (Km)				
Distance from port site (Km)	11.3	-	-	24

Source: (1) G. R. Peterson and S. J. Arbelside, Aluminum Availability--Market Economy Countries, U.S. GPO, 1983.
(2) Metal Bulletin, World Aluminum Survey, 1980.

TABLE B-9 (Continued)

CHARACTERISTICS OF JAMAICAN BAUXITES

DESCRIPTION	ALPART	BREADNUT VALLEY	EWARTON	KIRKVINE
Status	Production	Production	Production	Production
Type of ore	Gibbsite + Boehmite	Gibbsite + Boehmite	Gibbsite + Boehmite	Gibbsite + Boehmite
Available alumina	42 - 50	43 - 44	43	45
Available alumina (%)	43	40	42	43
Total silica	1 - 20	4	1.8	-
Ractive silicate	1.5	1.5	1.2	1.0
Total iron	6 - 26	21.0	18.0	18.0
Total Titanium	1.7 - 3.5	2.7	2.7	2.7
Loss of ignition (LOI %)	25 - 27	19.5	20.0	20.0
Stripping ratio	.125:1	0:1	1:1	0:1
Hardness	Soft	no drilling and blasting required		
Other properties				
Distance from processing plant (Km)	8	17.7	8.0	
Distance from port site (Km)	13.0	29.0	51.5	43.5

Source: (1) G. R. Peterson and S. J. Arbelside, Aluminum Availability--Market Economy Countries, U.S. GPO, 1983.
(2) Metal Bulletin, World Aluminum Survey, 1980.

TABLE B-10

RECAPITULATIVE SUMMARY OF CHARACTERISTICS OF GUINEAN, AUSTRALIAN, BRAZILIAN AND JAMAICAN BAUXITES

DESCRIPTION	AUSTRALIA	GUINEA	BRAZIL	JAMAICA
Type of ore	Mixture of mono & trihydrates, but predominantly gibbsitic.	Essentially gibbsitic; only two deposits contain small proportion of boehmite.	Gibbsite only	Mixture of gibbsite and boehmite, but predominantly gibbsitic.
Available alumina (%)	45 - 50	45 - 60	44 - 51.5	43 - 45
Reactive silicate (%)	2.5 - 4.5	1 - 2.5	2 - 4	1 - 2
Total iron	5 - 23	7 - 29	8 - 25	6 - 26
Total Titanium	1 - 17	1 - 2.5	1 - 2	1 - 4
Free moisture	6 - 16	5 - 12	8 - 18	15 - 28
Loss of ignition (LOI)	21 - 30	25 - 30	25 - 30	25 - 28
Stripping ratio	.13:1 - 1:1	0:1 - .07:1	.1:1 - 7:1	0:1 - .2:1
Hardness	Requires blasting	Requires blasting	Occasional blasting	Soft, no blasting
Distance from port (Km)	72 - 245	136 - 550	32 - 575	13 - 52

Compiled by the author

APPENDIX C

SUMMARY OF THE POLICIES OF GUINEA, BRAZIL, AUSTRALIA AND JAMAICA

	AUSTRALIA	BRAZIL	GUINEA	JAMAICA
Government Participation	Not necessary, but Australians require 50% equity and 50% of seat on the board of directors	State corporations and Brazilians have at least 51% equity	Government Serves as a minority shareholder (49%)	Companies enter into partnership with the government
Corporate Income Tax	45% of taxable net profits	33% of taxable net profits	35% of taxable net profits + 30% of profit on "free" equity	35% of taxable net profits
Royalty	A$0.4 to A$1.2 per tonne of bauxite produced	Nil	Nil	J$0.50 per tonne of bauxite
Levy	Nil	2% of production cost per tonne. Presently, about US$1.0/t	Is a function of primary aluminum price and the quality of bauxite. Presently, about US$13.0/t	Is a function of primary aluminum price and bauxite production rates. Presently about US$21.0/t
Incentives	Low rate for use of state owned facilities; state financial institutions facilitate that project financing	80% exemption from import duties on mining equipment; availability of government financing; accelerated depreciation; tax holiday, etc.	Exemption from import duties on equipment and machinery, exemption from corporate income tax	Full exemption from income tax, customs, and consumption duties on equipment and machinery

Compiled by the author

APPENDIX D

DEDUCTIONS FROM GROSS INCOME FOR INCOME TAX CALCULATIONS IN AUSTRALIA, BRAZIL, GUINEA, AND JAMAICA

AUSTRALIA	BRAZIL	GUINEA	JAMAICA
-Business expenses in generating the income, -Capital expenditure allowances, -Depreciation, -Investment allowances, -Inventory valuation, -Interest, -Losses incurred in the year or forward for 7 years, -Other, including the following: -Technical assistance and deductible fees paid to non-residents, -Superannuation or pension contributions providing retirement benefits for employees, -Insurance premiums if paid to non-resident insurers, -Bad debts, -Repairs, except those representing improvements of the property, -Borrowing expenses.	-Operating costs, -Interest and financial charges on loans, -Working capital currency depreciation calculated annually to compensate for inflation, -Provision for bad debts -Depreciation of fixed assets, -Depletion allowance, 20% of income to cover depletion during the first 10 years of production, -Past losses deductible from profits in the three following years to the extent they are not covered by reserves.	-Interest paid -Taxes paid (except those on profits, -Losses forward (up to 5 years), -Property income tax and income from transferable securities which are taxable separately -Expenses incurred, -Amortization of fixed assets.	-All operating expenses, -Research and development expenditures, -Bad debts, -Losses forward (losses can be carried forward for 5 years), -Royalties, -Management service and interest payments and -Depreciation of capital assets, usually calculated by using declining balance method.

APPENDIX E

SUMMARY OF CAPITAL AND OPERATING COST OF AYE-KOYE MINE

TABLE E-1

AYE-KOYE CAPITAL COST SUMMARY

ITEM	NUMBER	UNIT PRICE (US$ 000)	TOTAL (US$ 000)
Bulldozer Caterpillar D8K	3	188.00	564.00
Drill Atlas Copco	4	232.65	930.60
Loader Caterpillar 245	3	344.00	1,032.00
Shovel 998B	2	300.00	600.00
Truck Caterpillar 773	20	254.00	5,080.00
Grader Caterpillar 140G	3	99.00	297.00
Pick up	8	44.00	352.00
Light vehicles	15	8.80	132.00
SUBTOTAL			8,987.60
Escalated Subtotal			12,605.57
Crushing plant and conveyor system			116,000.00
Railroad and car load station			13,125.00
Extension of port of Kamsar			10,000.00
Offices and warehouses			2,636.00
Water supply system			870.00
Power supply system			11,500.00
Site preparation			2,500.00
Maintenance shop			2,700.00
Townsite			35,750.00
SUBTOTAL			195,081.00
Escalated subtotal			273,611.19
Working capital (escalated)			12,160.00
Engineering fees (6% of direct cost)			12,244.12
Construction and Management (8% of direct cost)			16,325.49
Escalated subtotal			52,230.36
General total (escalated)			338,447.12
Contingencies (25%)			84,611.78
TOTAL			423,058.90

TABLE E-2

OPERATING COST SUMMARY

(All Values in 1983 Escalated Dollars)

DESCRIPTION	COST/TONNE US$/tonne
Stripping and mining	1.21
Crushing, stocking, and conveying	.92
Transportation	2.94
Ship loading	.57
Labor	2.46
Fringe Benefit (35% of labor)	.86
Power and Water supply	.25
Subtotal	9.21
Contingency (15%)	1.38
Total direct cost	10.59
Indirect cost	2.35
Contingency (15%)	.35
Total indirect cost	2.70
Levy	3.30
TOTAL OPERATING COST	16.59

APPENDIX F

AYE-KOYE MINE
CASH FLOW CALCULATION

CASH FLOW CALCULATIONS

(All Values in Millions of US$ Escalated)

	1984 1	1985 2	1986 3	1987 4	1988 5
Gross Revenues	--	--	--	1.50P	3.18P
Operating cost	--	--	--	56.46	60.98
Interest	--	--	--	--	--
Depreciation	--	--	--	31.49	31.49
Taxable income	--	--	--	1.50P- 87.95	3.18P-92.47
Tax (35%)(1)				(.53P- 30.70)	(1.11P-32.36)
Tax (65%)(2)				(.98P- 57.17)	(2.07P-60.11)
Net after tax(1)	--	--	--	.98P- 57.17	2.07P-60.11
Net after tax(2)	--	--	--	.53P- 30.70	1.11P-32.36
+Depreciation	--	--	--	31.49	31.49
-Capital payment				--	--
-Cash investment	105.77	113.17	--	--	--
Cash flow(1)	-105.77	-113.17		.98P-25.68	2.07P-28.62
Cash flow(2)	-105.77	-113.17		.53P 0.79	1.11P- 0.87

CASH FLOW CALCULATIONS

(All Values in Millions of Escalated US$)

	1989 6	1990 7	1991 8	1992 9	1993 10
Gross Revenues	4.49P	4.76P	5.06P	5.35P	5.67P
Operating costs	65.85	71.12	76.81	82.96	89.59
Interest	27.50	27.16	26.78	26.34	25.85
Depreciation	31.49	32.30	32.30	32.30	32.92
Taxable income	4.49P-124.84	4.76P-130.58	5.06P-135.89	5.35P-141.60	5.67P-148.36
Tax (35%)(1)	(1.57P- 43.69)	(1.67P- 45.70)	(1.77P- 47.56)	(1.87P- 49.56)	(1.98P- 51.93)
Tax (65%)(2)	(2.92P- 81.15)	(3.09P- 84.88)	(3.29P- 88.33)	(3.48P- 92.04)	(3.69P- 96.43)
Net after tax(1)	2.92P- 81.15	3.09P- 84.88	3.29P- 88.33	3.48P- 92.04	3.69P- 96.43
Net after tax(2)	1.57P- 43.69	1.67P- 45.70	1.77P- 47.56	1.87P- 49.56	1.98P- 51.93
+Depreciation	31.49	32.30	32.30	32.30	32.92
-Capital payment	2.61	2.95	3.34	3.77	4.26
-Cash investment	5.64	--	6.46	--	7.39
Cash flow(1)	2.92P- 57.91	3.09P- 55.52	3.29P- 65.83	3.48P- 63.51	3.69P- 75.16
Cash flow(2)	1.57P- 20.45	1.67P- 16.35	1.77P- 25.06	1.87P- 21.03	1.98P- 30.66

CASH FLOW CALCULATIONS

(All Values in Millions of Escalated US$)

	1994 11	1995 12	1996 13	1997 14	1998 15
Gross revenues	6.01P	6.38P	6.76P	7.16P	7.59P
Operating cost	96.76	104.50	112.86	121.89	131.64
Interest	25.30	24.61	23.97	23.17	22.26
Depreciation	25.92	25.92	27.13	26.32	27.70
Taxable income	6.01P-147.98	6.38P-155.03	6.76P-163.95	7.16P-171.38	7.59P-181.60
Tax (35%)(1)	(2.10P- 51.79)	(2.23P- 54.26)	(2.37P- 57.39	(2.51P- 59.98)	(2.66P- 63.56)
Tax (65%)(2)	(3.91P- 96.19)	(4.15P-100.77)	(4.39P-106.57	(4.65P-111.40)	(4.93P-118.00)
Net after tax(1)	3.91P- 96.19	4.15P-100.77	4.39P-106.57	4.65P-111.40	4.93P-118.04
Net after tax(2)	2.10P- 51.79	2.23P- 54.26	2.37P- 57.39	2.51P- 59.98	2.66P- 65.56
+Depreciation	25.92	25.92	27.13	26.32	27.70
-Principal payment	4.81	5.44	6.15	6.95	7.85
-Cash investment	--	8.46	--	9.69	--
Cash flow(1)	3.91P- 75.08	4.15P- 88.75	4.39P- 85.59	4.65P-101.72	4.93P- 98.19
Cash flow(2)	2.10P- 30.68	2.23P- 42.24	2.37P- 36.41	2.51P- 50.30	2.66P- 45.71

CASH FLOW CALCULATIONS

	1999 16	2000 17	2001 18	2002 19	2003 20
Gross revenues	8.06P	8.53P	9.04P	9.59P	10.16P
Operating cost	142.18	153.55	165.83	179.10	193.43
Interest	21.24	20.09	18.79	17.31	15.65
Depreciation	26.78	28.36	27.30	59.98	4.77
Taxable income	8.06P-190.20	8.53P-202.00	9.04P-211.92	9.59P-202.39	10.16P-213.85
Tax (35%)(1)	(2.82P- 66.57)	(2.99P- 70.70)	(3.16P- 74.11)	(3.36P- 70.84)	(3.56P- 74.85)
Tax (65%)(2)	(5.24P-123.63)	(5.54P-131.30)	(5.88P-137.75)	(6.23P-131.55)	(6.60P-139.00)
Net after tax(1)	5.24P-123.63	5.54P-131.30	5.88P-131.75	6.23P-131.55	6.60P-139.00
Net after tax(2)	2.82P- 66.57	2.99P- 70.70	3.16P- 74.17	3.36P- 70.84	3.56P- 74.85
+Depreciation	26.78	28.36	27.30	5.98	4.77
-Principal payment	8.87	10.02	11.33	12.80	14.46
-Cash investment	11.09	--	12.70	--	14.54
Cash flow(1)	5.24P-116.81	5.54P-112.96	5.88P-128.48	6.23P-138.37	6.60P-163.23
Cash flow(2)	2.82P- 59.75	2.99P- 53.36	3.16P- 70.90	3.36P- 77.66	3.56P- 99.08

CASH FLOW CALCULATIONS

	2004 21	2005 22	2006 23	2007 24	2008 25
Gross Revenues	10.77P	11.42P	12.10P	12.83P	13.60P
Operating cost	208.90	225.62	243.66	263.16	284.21
Interest	13.77	11.64	9.24	6.53	3.46
Depreciation	6.85	5.47	7.85	6.27	9.05
Taxable income	10.77P-229.52	11.43P-243.73	12.10P-260.75	12.83P-275.96	13.60P-296.72
Tax (35%)(1)	(2.77P- 80.33)	(4.00P- 84.96)	(4.24P- 91.26)	(4.49P- 96.59)	(4.76P-103.85)
Tax (65%)(2)	(7.00P-149.19)	(7.42P-157.77)	(7.87P-169.49)	(8.34P-179.37)	(8.84P-192.87)
Net after tax(1)	7.00P-149.19	7.42P-157.77	7.87P-169.49	8.34P-179.37	8.84P-192.87
Net after tax(2)	3.77P- 80.33	4.00P- 84.96	4.24P- 91.26	4.49P- 96.59	4.76P-103.85
+Depreciation	6.85	5.47	7.85	6.27	9.05
-Principal payment	16.34	18.47	20.87	23.58	26.65
-Cash Investment	--	16.65	--	19.06	--
Cash flow(1)	7.00P-158.68	7.42P-187.42	7.87P-182.51	8.34P-215.74	8.84P-210.47
Cash flow(2)	3.77P- 89.82	4.00P-114.61	4.24P-104.28	4.49P-132.96	4.76P-121.45