Bauxite and Aluminum Handbook

Commodities and Export Projections Division
Economic Analysis and Projections Department

February 1981

TABLE OF CONTENTS

February 1981

List of Tables and Figures

List of Tables and Figures (Cont'd)

February 1981

Conversion Factors

Product	Inputs to Produce 1 ton of Product
Alumina	2 - 2.5 tons of Bauxite
Aluminum	1.9 - 1.95 tons of Alumina
Aluminum	3.8 - 4.9 tons of Bauxite
Calcined Abrasive Bauxite	1.75 tons of Bauxite
Calcined Refractory Bauxite	1.8 tons of Bauxite

I. CHARACTERISTICS OF BAUXITE/ALUMINA/ALUMINUM

A. Introduction

1. Bauxite, which consists of oxide type ores containing hydrated alumina is mainly used for the production of aluminum. In addition, minor amounts of bauxite and alumina are consumed in the refractory, abrasive and chemical industries. 1/ Aluminum is obtained from two basic sources: (i) bauxite ores which are refined into alumina and then processed into aluminum and (ii) aluminum from scrap. 2/

B. Definition of Products

2. The principal types of bauxite are the trihydrate, gibbsite ($Al_2O_3.3H_2O$) and the monohydrates, boehmite and diaspore ($Al_2O_3.H_2O$). Monohydrates are commonly found in Europe and Northern Asia. In other parts of the world, bauxite is found as gibbsite, but in some cases containing as much as 20 percent boehmite. Trihydrate bauxite is preferred due to its higher solubility in caustic solutions and the lower pressures and temperatures required for the refining of alumina. 3/ The most objectionable impurities associated with bauxite are silicates and iron oxide. Bauxite with a low iron content may be used in the chemical industry. Calcined bauxite, prepared by heating bauxite at high temperature is used by the refractories industry and to make intermediate abrasive products.

3. Alumina, is aluminum oxide (Al_2O_3) used for the production of aluminum and in lesser amounts to produce calcined alumina for the manufacture of fused alumina abrasives and high temperature refractories and activated alumina for chemical processes.

1/ In the U.S., about 12 percent of the aluminum consumed in 1975 was used as bauxite or alumina in nonmetal applications. See Stamper and Kurtz.

2/ In the U.S.S.R., alumina is also extracted from nepheline and alunite.

3/ Stamper and Kurtz.

4. Aluminum scrap is classified into new and old scrap. New Scrap is generated in the manufacture of primary aluminum and of aluminum products. It may be recycled by the same company that generates it or purchased by other companies. Old scrap comes from discarded, used and worn out products such as aluminum engines or body parts, used aluminum cans and utensils and old wire and cable. 1/

5. Aluminum metal has relatively low density, high electrical and thermal conductivity, good resistance to corrosion and may be alloyed and treated to yield a high strength-to-weight ratio. 2/ Aluminum is available commercially as ingots with a minimum content of 99.5 percent aluminum. Higher prices are paid for purer grades.

6. Ingots, molten aluminum and aluminum scrap with alloying materials are transformed into mill products, such as bars, rods and wire; plates, sheets and strip; tubes and pipes; and other products.

C. Uses

7. Most of the bauxite is used for the production of alumina. The remainder is used as bauxite by the abrasive, refractory and chemical industries; to produce aluminum sulfate and other chemicals for water treatment and for the paper industry; and for cements, catalysts and fluxes.

8. Alumina is mainly used to produce aluminum. Other uses are as calcined alumina in the abrasive, refractory and glass industries; as alumina hydrates to produce aluminum chemicals and fire retardants; in tubular form for ceramics and refractories, and as activated alumina used to dehydrate liquids and gases in the chemical and petroleum industries.

9. Consumption of aluminum metal by end uses is shown in Table I.2. The transportation industry accounts for about one fourth of metal consumption,

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1/ Ibid.

2/ Stamper and Kurtz.

Table I.1: CLASSIFICATION OF BAUXITE/ALUMINA/ALUMINUM PRODUCTS

Product	SITC /a
Dried Bauxite	287.31
Alumina	287.32
Aluminum Ingots	684.1
Aluminum Products:	684.2
Bars, rods, angles, shapes, sections and wire	684.21
Plates, sheets and Strip	684.22
Foil	684.23
Powders and flakes	684.24
Tubes, pipes and blanks thereof, hollow bars	684.25
Tube and pipe fittings	684.26

/a SITC Revision 2.

Source: United Nations, "Standard International Trade Classification, Revision 2, New York, 1975.

Table I.2: CONSUMPTION OF ALUMINUM BY END USES, 1978

	W. Europe /1	Japan	U.S.	World Average
	(%)			
Transport	29.5	23.1	23.6	24.9
Mechanical Engineering	6.8	4.5	6.1	5.9
Electrical Engineering	9.7	10.5	10.2	10.1
Building and Construction	16.7	34.4	23.8	24.2
Packaging	10.4	6.8	22.0	16.2
Domestic and Office Appliances	9.3	6.2	7.2	7.5
Metal Industries and Miscellaneous	17.6	14.5	7.1	11.2
	100.0	100.0	100.0	100.0

/1 Germany, France, United Kingdom, Italy

Source: Computed from Metal Statistics, Metallgesellschaft, 66th Edition, 1979.

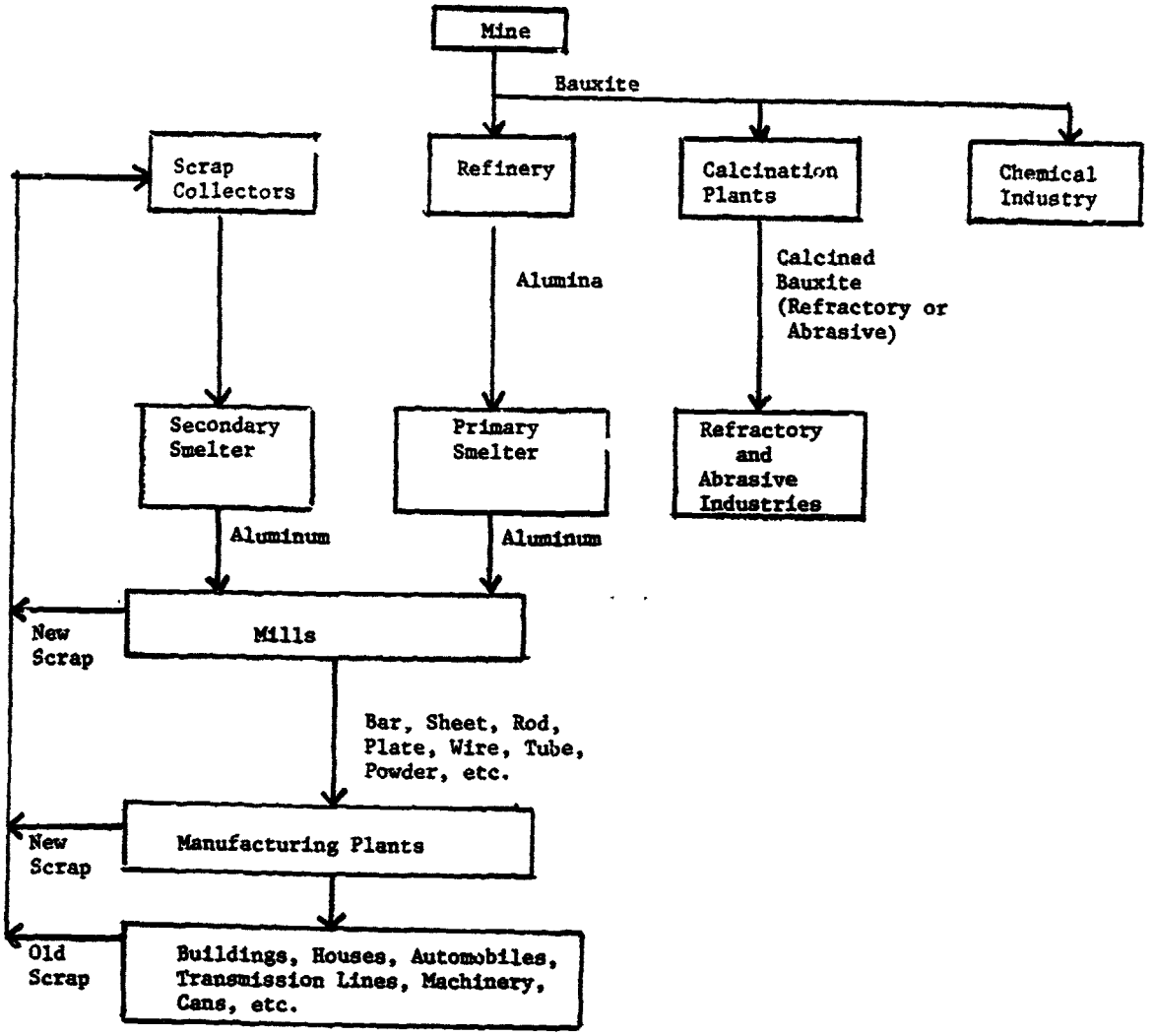
where aluminum is used in motors, vehicle parts, electrical uses and paints. The main attraction of aluminum in this sector is its high strength to weight ratio. Near to 6 percent of aluminum metal is for machinery and equipment (mechanical engineering). The electrical engineering and communications sector uses one tenth of the aluminum metal produced. Aluminum's high electrical conductivity and lower density than copper are responsible for the displacement of the latter metal in many applications in this sector. About one fourth of aluminum consumed is used in building and construction, for doors and windows, heating and air conditioning, structures and other uses. Resistance to corrosion has permitted the replacement of steel and other materials by aluminum in packaging, such as flexible packaging, food containers, metal cans and foil. Consumption of aluminum by the packaging sector as a percentage of total consumption varies widely, from a low 6.8 percent in Japan to 22 percent in the United States. About 7.5 percent of aluminum is for the production of consumer durables, such as refrigerators, air conditioners, washing machines and other appliances.

D. Technology

10. Compared with other non-ferrous metals, bauxite mining costs represent a small percentage of total costs of metal production. Many deposits require little or no stripping of the overburden. For example, in Jamaica and Weipa in Western Australia, no blasting is required, the few feet of overburden being removed by bulldozers and scraper loaders. In Europe, the overburden is much thicker, requiring underground mining. Ore benefication is limited to crushing, washing or wet screening and drying. Differences in thickness and hardness of the overburden, moisture content, inland transportation requirements as well as infrastructure are reflected in the wide variations in bauxite mining costs estimated in 1980 between US$12/mt and US$30/mt. Labor accounts for 20-30 percent of the cost, energy for about 25 percent, and depreciation and interest for another 30 percent. Besides, some of the main producing countries have imposed levies on bauxite mining which go from US$10 to US$27 per metric ton. 1/ Transportation costs of bauxite also account for

1/ In 1980, based on an aluminum price of $1,550 per ton.

Figure I.1: PLANTS AND PRODUCTS OF THE ALUMINUM INDUSTRY



Source: World Bank, Economic Analysis and Projections Department, Commodities and Export Projections Division, February 1981.

a significant part of the delivered cost of bauxite ranging from US$6.25/mt from Jamaica to the U.S. East Coast to US$29.50/mt from Australia to Europe.

Table I.3: MAIN INPUTS TO PRODUCE ONE METRIC TON OF BAUXITE

	Type of Bauxite	
	Caribbean	South America
Energy, million Btu /1		
Mining and drying (oil, gas, electricity)	0.25 - 0.45	0.5 - 0.8
Shipping to U.S. ports (oil)	0.45 - 0.70	1.0 - 1.3
Total Labor and supervision, man-hours	0.9 - 2.0	0.8 - 2.3

/1 Assumed energy equivalent of oil is 150,000 Btu per gallon, natural gas 1,000 Btu per cubic foot, coal and pitch, 24 million Btu per short ton; petroleum coke, 26 million Btu per short ton, electricity, 3.413 Btu per Kilowatt-hour.

Source: Stamper, John W., and Horace F. Kurtz, Mineral Facts and Problems, 1975 Edition, Bureau of Mines, U.S. Department of the Interior.

11. Most of the commercially produced alumina is obtained by the Bayer process. The main exceptions occur in the U.S.S.R., where alumina is obtained from diaspore (monohydrate) by the Pedersen process which involves sintering and from nepheline and alunite, by a different process which consists of sintering and leaching. The Bayer process consists basically of four stages:

(i) Digestion. Bauxite, caustic soda (which may be made from - CaO - and soda ash - Na_2CO_3) and hot water are digested at elevated temperature and pressure. Bauxite is dissolved, while silica, iron oxide and other impurities remain insoluble. Leaching temperatures range from about 220°F for trihydrate bauxite up to 550°F when most of the bauxite is present in monohydrate form. Approximately 1.1 weight units of alumina and 1.2 units of soda are lost for each unit of reactive silica. Bauxite with more than 8 percent silica needs a previous leaching treatment.

(ii) Filtration and Settling. The resulting solution is cooled to atmospheric boiling temperature. The red mud of insolubles is partially separated by decantation in settling tanks, which is then pumped to a disposal pond.

(iii) Precipitation. The liquid sodium aluminate is cooled until it becomes supersaturated and then seeded with aluminum hydroxide crystals, which gradually settle out of the solution.

(iv) Calcination. The aluminum hydroxide crystals are roasted at more than 1000°C to remove the water.

The different ore qualities such as bauxite type, alumina content and impurities influence considerably the processing conditions and production costs. For technical and economic considerations the alumina refineries are limited to specific bauxite quality ranges. Table I.4 shows the inputs required to produce one metric ton of alumina. Representative current costs of production at a bauxite producing country are about US$130/metric ton, including bauxite costs but excluding levies. 1/

1/ In 1980 US dollars.

Table I.4: INPUTS TO PRODUCE ONE METRIC TON mt OF ALUMINA

		Type of Bauxite	
		Caribbean	South America
Bauxite - dry metric tons		2.4 - 2.5	2.05 - 2.4
Caustic or equivalent soda ash and lime			
Na OH	pounds	115 - 155	126 - 160
Lime (CaO)	pounds	34 - 115	57 - 115
Starch	pounds	17 - 23	2 - 3.5
Energy, million Btu: /1			
Steam (coal, oil, gas)		14 - 17	11 - 14
Calcining alumina (oil, gas)		4 - 6	4 - 6
Miscellaneous uses (coal, oil, gas, electricity)		1 - 2	1 - 3
Total labor and supervision man-hours		1.7 - 3	1.7 - 3

/1 a. Assumed energy equivalent of oil is 150,000 Btu per gallon; natural gas, 1,000 Btu per cubic foot; coal and pitch, 24 million Btu per short ton; petroleum coke, 26 million Btu per short ton, electricity, 3,413 Btu per kilowatt hour.

b. Excludes energy required to produce lime and caustic soda, estimated at .3 - .6 million Btu and 2.4 - 4 million Btu, respectively, per metric ton of alumina.

Source: Stamper, John W. and Horace F. Kurtz, Mineral Facts and Problems, 1975 Edition, Bureau of Mines, U.S. Department of the Interior.

12. Aluminum is produced from alumina by electrolysis, using the Hall-Heroult process, developed in 1886. An aluminum smelter consists of one or more pot lines, each containing about 125 - 150 electrolytic cells. The cells consist of a carbon-lined box containing a pad of molten aluminum (cathode), a carbon anode and a molten bath of natural or synthetic cryolite ($NA_3Al\ F_6$). Electrolysis of alumina takes place in the cryolite bath. Cryolite and aluminum fluoride are added to the electrolyte to maintain the adequate ratio of sodium and aluminum fluoride. The anode, which is consumed during the operation, is replaced by the Soderberg continuous method or the prebaked method.

13. Aluminum smelting is energy intensive. Electrolysis of aluminum requires about 14,000 kwh to 16,000 kwh of electricity to produce one metric ton of primary aluminum (Table I.5). Production costs of aluminum range between US$1,100/mt and US$1,700/mt depending on the age of the plants, on the source of power and on plant location.

14. Molten aluminum can be cast into ingots or used directly at adjacent mills. Ingots, molten aluminum and aluminum scrap with alloying materials are transformed into mill products.

15. Current research in aluminum technology centers around developing processes to produce alumina from other sources (clay, anorthosite, alunite and dawsonite) and in improving the energy efficiency of both the Bayer process to produce alumina and cf the Hall Heroult process to produce aluminum. A new process to produce primary aluminum has been reported by Alcoa. This involves the chlorination of alumina to produce aluminum chloride and the electrolytic reduction of the alumina chloride bath. According to Alcoa, this process operates at reduced temperatures, avoids fluoride pollution and uses 30 percent less electric energy than the Hall-Heroult process.

Table I.5: ESTIMATED INPUTS TO PRODUCE ONE METRIC TON OF PRIMARY ALUMINUM METAL

	Type of Anode	
	Prebaked	Soderberg
Alumina metric tons	1.9 - 1.95	1.9 - 1.95
Makeup cryolite (Na_3AlF_6) pounds	10 - 80	10 - 80
Makeup aluminum fluoride (AlF_3) pounds	28 - 65	28 - 65
Calcium fluoride (CaF_2) pounds	4.5 - 9	4.5 - 9
Energy, million Btu: /1		
Alumina reduction (electricity)	50 - 60	60 - 70
Electrode carbon		
Petroleum coke, calcined (800-1,050 pounds)	10 - 13	10 - 11
Pitch (300 - 360 pounds)	3.5 - 4.5	3.5 - 4.5
Anthracite coal (55 - 90 pounds)	.6 - .8	.8 - 1.1
Anode and cathode baking (oil, gas, electricity)	2.5 - 6	.11 - .22
Holding furnace, ingot casting and melting operations (gas, oil, electricity)	6 - 8.5	6 - 8.5
Total labor and supervision man-hours	9 - 17	11 - 22

/1 a. Assumed energy equivalent of oil is 150,000 Btu per gallon; natural gas, 1,000 Btu per cubic foot; coal and pitch, 24 million Btu per short ton; petroleum coke, 26 million Btu per short ton; electricity, 3,413 Btu per kilowatt-hour.

b. Excludes energy required to produce fluorine compounds, estimated at 2.2 - 8 million Btu per metric ton of primary aluminum, and to calcine petroleum coke, equivalent to about 1 - 2 million Btu per ton of primary aluminum.

Source: Stamper, John W. and Horace F. Kurtz, Mineral Facts and Problems, 1975. Edition, Bureau of Mines, U.S. Department of the Interior.

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3. Hashimoto, Hideo, "Bauxite Processing in Developing Countries" Draft, World Bank, December 1980.

4. Metallgesellschaft, "Metal Statistics" (Frankfurt am Main) (Annual).

5. Stamper John W., and Horace F. Kurtz, "Aluminum" in "Mineral Facts and Problems, 1975 Edition" (Bureau of Mines, Washington, D.C., 1975).

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II. THE LOCATION OF THE INDUSTRY

A. Production

1. Bauxite reserves (reserve base) 1/ are estimated at 22.7 billion tons. As can be seen from Table II.1, seven countries account for over 75 percent of world reserves which in order of importance are: Guinea, Australia, Brazil, Jamaica, Guyana, Greece and Suriname.

2. World production of bauxite reached 76.3 million metric tons in 1979, equivalent to about 0.3 percent of bauxite reserves. In the last two decades Australia has risen to be the main bauxite producing country, participating in 1979 with over 31 percent of the share of world output, higher than its share in world reserves (20.2%). Guinea has also increased significantly its bauxite output, but to a lesser extent than Australia. Jamaica and Suriname maintain their position of important producers and exporters of bauxite, their share of world output being higher than that of their share of reserves. Brazil has started in the last decade an intensive program of bauxite exploration and exploitation, backed by its considerable reserves.

3. World production of alumina has grown at 7.4 percent per annum from 1966 to 1977, decreasing to 3.1 percent per annum from 1977 to 1979 due mainly to the slowdown of the world economy. Since 1977, Australia has become the most important alumina producer displacing the United States. In 1979, Australia accounted for 23 percent of the world alumina output, United States 20 percent, Jamaica 6.4 percent and Japan 5.6 percent.

4. Primary aluminum world production, grew at 6.9 percent per annum from 1960 to 1977, and at 2.8 percent per annum from 1977 to 1979, totalling 15.2 million metric tons in 1979. As can be seen in Table II.4, the share of aluminum output in developing countries has increased substantially, from 3.2% in 1960 to 13.7% in 1979, reflecting the availability of hydroelectrical

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1/ It includes demonstrated reserves which are currently economic as well as those which are marginally economic and some which are currently subeconomic.

Table II.1: WORLD BAUXITE RESERVES

(Thousand Metric Tons)

	Volume	Share of World Total
United States	40,000	.2
Australia	4,600,000	20.2
Brazil	2,500,000	11.0
Greece	700,000	3.1
Guinea	6,500,000	28.5
Guyana	700,000	3.1
Jamaica	2,000,000	8.8
Suriname	490,000	2.2
Other Market Economy Countries	4,000,000	17.6
Hungary	300,000	1.3
U.S.S.R.	300,000	1.3
Yugoslavia	400,000	1.8
Other Central Economy Countries	200,000	.9
WORLD TOTAL	22,700,000	100.0

Source: Bureau of Mines, Mineral Commodity Summaries, 1980.

Table II.2: BAUXITE /a - WORLD PRODUCTION BY MAIN COUNTRIES AND ECONOMIC REGIONS

	Volume							Growth Rate		Share of World Total		
	1960	1965	1970	1975	1977	1978	1979	1960-77	1977-79	1960	1970	1979
	('000 tons)							(% per annum)				
Industrialized Countries	4,513	5,779	14,650	25,353	30,176	27,965	31,332	14.9	1.9	16.3	24.1	35.7
of which: Australia	70	1,186	9,256	21,034	26,086	24,293	27,584	41.6	2.8	0.2	15.2	31.4
Developing Countries	17,979	24,828	36,178	40,623	43,355	44,344	44,960	5.8	1.8	65.1	59.0	51.1
Africa, South of Sahara	1,579	2.134	3,285	9,455	12,322	12,694	13,130	12.6	3.2	5.7	5.4	14.9
of which: Guinea	1,378	1,600	2,490	8,406	11,300	11,648	12,199	12.9	3.9	5.0	4.1	13.9
South Africa	0	0	0	0	0	0	0	/c	/c	0	0	0
North Africa & Middle East	0	0	0	0	0	0	0	/c	/c	0	0	0
Asia & Pacific	1,532	2,389	3,743	2,791	3,430	3,285	3,415	5.5	0.0	5.5	6.2	3.9
of which: India	387	707	1,374	1,094	1,512	1,663	1,934	7.9	13.1	1.4	2.3	2.2
Latin America & Caribbean	12,959	17,442	24,702	22,426	22,082	22,676	22,323	4.0	0.5	46.9	40.7	25.4
of which: Jamaica	5,837	8,651	12,010	11,570	11,433	11,736	11,505	4.4	0.3	21.1	19.8	13.1
Suriname	3,455	4,360	6.022	4,751	4,856	5,113	4,741	3.4	-0.1	12.5	9.9	5.4
Guyana	2,511	2,919	4,417	3,828	3,344	3,479	3,354	2.7	0.1	9.1	7.3	3.8
Brazil	121	188	510	969	1,035	1,131	1,642	15.8	26.0	0.4	0.8	1.9
Southern Europe	1,911	2,863	4,448	5,951	5,521	5,689	6,092	6.7	5.0	6.9	7.3	6.9
Centrally Planned Economies	5,128	6,686	9,898	11,269	11,557	11,650	11,626	4.9	0.3	18.6	16.3	13.2
WORLD TOTAL	27,620	37,293	60,726	77,245	85,088	83,959	87,918	7.7	1.6	100.0	100.0	100.0
MARKET ECONOMIES	22,492	30,607	50,828	65,976	73,531	72,309	76,292	8.2	1.9	81.4	83.7	86.8

/a Gross Weight.
/b Preliminary
/c Incomputable

Source: Metallgesellschaft, Metal Statistics and World Bureau of Mines, World Metal Statistics (actual):
World Bank, Economic Analysis and Projections Department (projected).

Table II.3: ALUMINA - WORLD PRODUCTION BY MAIN COUNTRIES AND ECONOMIC REGIONS

	Volume						Growth Rates		Share of World Total		
	1966	1970	1975	1977	1978	1979	1966-77	1977-79	1966	1970	1979
	('000 tons)						(% per annum)		(%)		
Industrialized Countries	9,054	12,774	16,077	19,219	19,246	20,231	7.1	2.6	61.2	60.3	62.6
of which:											
United States	5,338	6,051	5,135	6,033	5,960	6,450	1.1	3.4	36.0	28.5	20.0
European Economic Community	1,717	2,074	3,114	3,421	3,689	3,720	6.5	4.3	11.6	9.8	11.5
Japan	662	1,285	1,565	2,045	1,767	1,822	10.8	-5.7	4.5	6.1	5.6
Australia	307	2,152	5,129	6,659	6,776	7,415	32.3	5.5	2.1	10.2	23.0
Developing Countries	2,479	4,608	5,831	6,031	6,219	6,624	8.4	4.8	16.7	21.7	20.5
Africa, South of Sahara	525	610	639	562	622	662	0.6	8.5	3.5	2.9	2.0
of which: Guinea	525	610	639	562	622	662	0.6	8.5	3.5	2.9	2.0
North Africa & Middle East	0	0	0	0	0	0	/a	/a	0	0	0
Asia and Pacific	205	369	383	438	531	551	7.1	12.2	1.3	1.7	1.7
Latin American & Caribbean	1,581	3,191	3,969	3,888	4,017	4,002	8.5	1.5	10.7	15.1	12.4
of which:											
Jamaica	804	1,719	2,259	2,047	2,141	2,074	8.9	0.6	5.4	8.1	6.4
Suriname	407	1,036	1,148	1,215	1,261	1,199	10.4	0.0	2.7	4.9	3.7
Guyana	302	317	294	277	250	280	-1.0	0.0	2.0	1.5	0.9
Brazil	68	119	268	349	365	449	16.0	13.4	0.5	0.6	1.4
Southern Europe	168	438	840	1,143	1,049	1,409	19.0	11.0	1.1	2.1	4.4
Centrally Planned Economies	3,275	3,816	4,772	5,262	5,362	5,444	4.4	1.7	22.1	18.0	16.9
WORLD TOTAL	14,808	21,198	26,680	30,512	30,827	32,299	6.8	2.9	100.0	100.0	100.0
MARKET ECONOMIES	11,533	17,382	21,908	25,250	25,465	26,855	7.4	3.1	77.9	82.0	83.1

/a Incomputable.

Source: Metallgesellschaft, Metal Statistics and World Bureau of Mines, World Metal Statistics (actual); World Bank, Economic Analysis and Projections Department.

Table II.4: PRIMARY ALUMINUM - WORLD PRODUCTION BY MAIN COUNTRIES AND ECONOMIC REGIONS

	Volume							Growth Rates		Share of World Output		
	1960	1965	1970	1975	1977	1978	1979	1960-77	1977-79	1960	1970	1979
	(million tons)							(% per annum)		(%)		
Industrialized Countries	3,475	4,818	7,263	8,441	9.626	9,869	9,873	6.2	1.3	76.7	70.5	64.9
of which:												
United States	1,828	2,499	3,607	3,519	4,118	4,358	4,557	4.9	5.2	40.4	35.0	29.9
European Economic Community	517	735	952	1,816	1,987	2,007	2,021	8.2	0.9	11.4	9.2	13.3
Japan	133	292	728	1,013	1,188	1,058	1.010	13.7	-8.8	2.9	7.1	6.6
Canada	691	753	962	878	973	1,048	864	2.0	-6.7	15.2	9.3	5.7
Norway	171	276	522	595	637	657	674	8.0	2.9	3.8	5.1	4.4
Developing Countries	143	273	792	1,453	1,687	1,729	2,092	15.6	11.4	3.2	7.7	13.7
Africa, South of Sahara	44	51	165	271	278	236	300	11.4	3.9	1.0	1.6	2.0
of which:												
Ghana	0	0	113	143	154	114	169	/a	4.8	0	1.1	1.1
South Africa	0	0	0	76	78	81	86	/a	5.0	0	0	0.5
North Africa & Middle East	0	0	0	164	233	249	238	/a	1.1	0	0	1.6
Asia & Pacific	27	83	205	213	231	273	286	13.4	11.3	0.6	2.0	1.9
of which India	18	64	161	167	184	205	212	14.6	7.3	0.4	1.6	1.4
Latin America & Caribbean	18	53	167	275	360	407	667	19.3	36.1	0.4	1.6	4.4
of which:												
Brazil	18	30	56	121	168	186	238	14.0	19.0	0.4	0.5	1.6
Venezuela	0	0	22	50	43	71	207	/a	119.4	0	0.2	1.4
Southern Europe	54	91	255	530	586	564	601	15.0	1.3	1.2	2.5	3.9
Centrally Planned Economies	911	1,491	2,246	2,941	3,046	3,156	3,247	7.4	3.2	20.1	21.8	21.3
WORLD TOTAL	4,529	6,587	10,301	12,835	14,360	14,754	15,217	7.0	2.9	100.0	100.0	100.0
MARKET ECONOMIES	3,618	5.096	8.055	9,894	11,314	11,598	11,970	6.9	2.8	79.9	78.2	78.7

/a Incomputable.

Source: Metallgesellschaft, Metal Statistics and World Bureau of Mines, World Metal Statistics (actual); World Bank, Economic Analysis and Projections Department

potential and other types of cheap energy in these countries (electrical energy represents about 25% of the production cost of aluminum at a price of electricity of 1.5 US¢/kwh).

5. Aluminum recovered from scrap is an important source of metal for the aluminum industry. Scrap recoveries were estimated for Western countries at 856 thousand metric tons in 1960, 2,183 thousand metric tons in 1970 and 3,752 thousand metric tons in 1979, which represents a growth rate of 8% per annum from 1960 to 1979. 1/ This rate of production, higher than that of primary aluminum, reflects the increased interest by the industry in purchasing scrap which requires significantly less energy than alumina to be processed into aluminum. 2/

B. Consumption

6. Consumption of aluminum during the sixties and seventies has grown at a higher rate than other major metals. The annual growth rate for aluminum consumption has been 8 percent from 1960 to 1977, and 5.8 percent from 1977 to 1979, which nearly doubles that of copper, and more than doubles that of tin. The growth of aluminum consumption has been due to the substitution of aluminum for other materials in a wide range of end uses due to its favorable price levels as well as physical properties. Aluminum has partially substituted copper in overhead transmission cable, and is continuously penetrating into the beverage container market, mainly at the expense of steel. For weight saving purposes, the use of aluminum has expanded considerably in the transporation sector. Aluminum is used in construction both for its physical properties as well as for its appearance.

1/ Metallgesellschaft, "Metal Statistics".

2/ Banks (op. cit.) mentions that the energy used to produce a unit of aluminum from scrap is between 5% to 20% of that needed to produce an equivalent amount of primary aluminum.

Table II.5: PRIMARY ALUMINUM - WORLD CONSUMPTION BY MAIN COUNTRIES AND ECONOMIC REGIONS

	Volume							Growth Rates		Share of World Total		
	1960	1965	1970	1975	1977	1978	1979	1960-77/1977-79		1960	1970	1979
	('000 tons)							(% per annum)		(%)		
Industrialized Countries	3,047	4,845	7,104	7,310	9,728	10,221	10,725	7.3	5.0	74.3	71.4	67.0
of which: United States	1,541	2,852	3,488	3,265	4,756	4,978	5,009	6.1	2.6	37.6	35.1	31.3
European Economic Community	1,065	1,264	2,008	2,039	2,598	2,654	2,888	6.2	5.4	26.0	20.2	18.0
Japan	151	298	911	1,171	1,422	1 656	1,802	16.3	12.6	3.7	9.2	11.2
Developing Countries	141	394	796	1,292	1,565	1,853	1,921	14.9	10.8	3.4	8.0	12.0
Africa, South of Sahara	11	20	60	95	78	81	80	15.4	1.3	0.3	0.6	0.5
of which: South Africa	11	20	49	68	53	51	55	12.3	1.9	0.3	0.5	0.3
North Africa & Middle East	0	11	18	70	99	136	121	/a	10.6	0	0.2	0.8
Asia & Pacific	25	103	246	283	394	553	561	15.0	19.3	0.6	2.5	3.5
Latin America & Caribbean	44	117	186	382	407	480	563	14.0	17.6	1.1	1.9	3.5
Southern Europe	61	143	286	462	587	552	541	15.0	-4.0	1.4	2.9	3.4
Centrally Planned Economies	912	1,392	2,046	2,686	2,984	3,312	3,371	7.4	6.3	22.2	20.6	21.0
WORLD TOTAL	4,100	6,631	9,946	11,288	14,277	15,386	16,017	7.9	5.9	100.0	100.0	100.0
MARKET ECONOMIES	3,188	5,239	7,900	8,602	11,293	12,074	12,646	8.0	5.8	77.8	79.4	79.0

/a Incomputable.

Source: Metallgesellschaft, Metal Statistics and World Bureau of Mines, World Metal Statistics (actual).

C. Trade

7. World exports of bauxite (Table II.6) have grown at 5.3 percent per year between 1960 and 1977, lower than that of bauxite production (7.7 percent per year), reflecting increased processing in bauxite producing countries. The main exporting countries are Guinea, Australia, Jamaica, Suriname and Guyana, accounting in 1978 for over 75 percent of world trade.

8. The industrialized countries account for most of the world's bauxite imports, 83 percent in 1978; but the Centrally Planned Economies, where bauxite production has stagnated, have been increasing substantially their imports of bauxite (Table II.7), at an annual rate of 10.2 percent between 1960 and 1977.

9. The industrialized countries are net importers of primary aluminum (Tables II.8 and II.9). In 1979, the United States' net imports amounted to 7 percent of its consumption, Japan's net imports amounted to 41 percent and those of the EEC to 24 percent. These ratios should increase over time due to the lack of cheap electrical energy for new aluminum projects. Net imports of aluminum in the Centrally Planned Economies represented in 1979 less than 4 percent of their consumption. During the last decade, major increases in aluminum exports have taken place in North Africa and the Middle East (Bahrain and Egypt), Latin America and the Caribbean (Venezuela) and New Zealand, reflecting the startup of new operations in those areas.

Table II.6: BAUXITE /a - WORLD EXPORTS BY MAIN COUNTRIES AND ECONOMIC REGIONS

	Actual						Growth Rates
	1960	1965	1970	1975	1977	1978 /b	1960-77
	(million tons)						--(% per annum)--
Industrialized Countries	383	993	4,020	8,145	7,486	8,000	22.4
of which: Australia	30	620	3,834	7,966	7,306	6,422	38.3
Developing Countries	14,994	19,282	23,138	24,191	26,463	26,970	3.6
Africa, South of Sahara	937	713	1,601	8,250	11,077	11,300	20.4
of which: Guinea	705	244	811	7,269	10,100	10,300	29.4
South Africa	0	0	0	0	0	0	/c
North Africa & Middle East	0	0	0	0	0	0	/c
Asia and Pacific	1,161	1,606	2,126	1,736	1,714	1,570	2.3
of which: India	93	63	55	14	26	30	-12.7
Latin America & Caribbean	11,168	14,639	16,144	11,327	11,214	11,500	0.6
of which: Jamaica	4,214	6,893	7,125	5,482	6,090	6,000	1.6
Suriname	3,634	4,369	3,420	2,249	2,114	2,300	-2.5
Guyana	2,129	1,786	3,052	2,154	1,659	1,700	1.9
Brazil	2	2	3	18	4	0	9.8
Southern Europe	1,728	2,324	3,267	2,878	2,458	2,600	2.4
Centrally Planned Economies	499	499	660	603	639	700	0.3
WORLD TOTAL	15,876	20,774	27,818	32,939	34,588	35,670	5.3
MARKET ECONOMIES	15,377	20,275	27,158	32,366	33,949	34,970	5.4

/a Gross weight.
/b Preliminary.
/c Incomputable.

Source: UNCTAD and World Bank, Economic Analysis and Projections Department.

Table II.7: BAUXITE /a - WORLD IMPORTS BY MAIN COUNTRIES AND ECONOMIC REGIONS

	Actual						Growth Rates
	1960	1965	1970	1975	1977	1978 /b	1960-77
	('000 tons)						(% per annum)
Industrialized Countries	14,487	18,144	24,526	27,377	30,212	29,200	4.9
Developing Countries	95	259	561	462	423	454	9.5
Africa, South of Sahara	0	8	14	32	13	15	/c
of which: South Africa	0	8	14	32	13	15	/c
North Africa & Middle East	5	3	1	2	3	3	-0.8
Asia & Pacific	25	105	126	114	163	170	5.0
Latin America & Caribbean	41	54	69	83	82	86	4.9
Southern Europe	24	89	351	231	162	180	13.9
Centrally Planned Economies	1,053	1,380	2,480	4,926	4,932	5,500	10.2
WORLD TOTAL	15,635	19,783	27,567	32,765	35,567	35,154	5.5
MARKET ECONOMIES	14,582	18,403	25,087	27,839	30,635	29,654	5.0

/a Gross weight.
/b Preliminary.
/c Incomputable.

Source: UNCTAD and World Bank, Economic Analysis and Projection Department.

Table II.8: PRIMARY ALUMINUM /a - WORLD EXPORTS BY MAIN COUNTRIES AND ECONOMIC REGIONS

	Actual							Growth Rates	
	1960 /b	1965 /b	1970	1975	1977	1978 /c	1979 /c	1967-1977	1977-1979
	('000 tons)							(% per annum)	
Industrialized Countries	-	-	2,033	2,189	2,617	2,994	2,677	4.7	1.1
of which: United States	-	-	370	169	89	102	163	-4.0	35.3
European Economic Community	-	-	303	724	870	982	1,003	14.5	7.4
Japan	-	-	6	84	100	55	8	55.0	-71.7
Developing Countries	-	-	284	467	549	583	668	7.2	10.3
Africa, South of Sahara	-	-	148	174	200	212	220	-6.4	4.9
of which: South Africa	-	-	0	14	28	37	29	51.6	1.8
North Africa & Middle East	-	-	0	104	128	150	180	80.0	18.6
Asia & Pacific	-	-	3	0	5	5	0	-53.7	/d
Latin America & Caribbean	-	-	55	26	66	67	80	1.0	10.1
Southern Europe	-	-	78	163	150	149	159	7.3	3.0
Centrally Planned Economies	-	-	477	602	696	720	613	10.1	-6.2
WORLD TOTAL	-	-	2,794	3,258	3,862	4,297	3,958	4.9	1.2
MARKET ECONOMIES	-	-	2,317	2,656	3,166	3,577	3,345	5.1	2.8

/a Unwrought alumina and aluminum alloys.
/b Not available.
/c Preliminary.
/d Incomputable.

Source: World Bureau of Metal Statistics, World Metal Statistics
Metallgesellschaft, Metal Statistics

Table II.9: PRIMARY ALUMINUM /a - WORLD IMPORTS BY MAIN COUNTRIES AND ECONOMIC REGIONS

	Actual							Growth Rates	
	1960 /b	1965 /b	1970	1975	1977	1978 /c	1979 /c	1967-1977	1977-1979
	('000 tons)							(% per annum)	
Industrialized Countries	-	-	2,121	2,022	2,832	3,089	3,125	4.5	5.0
of which: United States	-	-	318	415	611	686	517	0.6	-8.0
European Economic Community	-	-	1,417	1,095	1,528	1,536	1,689	-0.3	5.1
Japan	-	-	258	378	534	740	748	11.9	18.3
Developing Countries	-	-	138	172	375	413	297	-5.9	-11.0
Africa, South of Sahara	-	-	49	2	0	0	0	-37.9	/d
of which: South Africa	-	-	49	2	0	0	0	-37.9	/d
North Africa & Middle East	-	-	0	0	0	0	0	/d	/d
Asia & Pacific	-	-	3	7	120	155	160	-10.0	15.5
Latin America & Caribbean	-	-	0	96	170	170	88	12.0	-28.0
Southern Europe	-	-	86	67	85	88	49	0.1	-24.1
Centrally Planned Economies	-	-	55	388	500	550	738	19.0	21.5
WORLD TOTAL	-	-	2,314	2,582	3,707	4,052	4,160	4.2	5.9
MARKET ECONOMIES	-	-	2,259	2,194	3,207	3,502	3,422	4.2	3.3

/a Unwrought aluminum and aluminum alloys.
/b Not available.
/c Preliminary.
/d Incomputable.

Source: World Bureau of Metal Statistics, World Metal Statistics
Metallgesellschaft, Metal Statistics.

REFERENCES

1. Banks, Ferdinand E., "Bauxite and Aluminum: An Introduction to the Economics of Nonfuel Minerals," Lexington Books (Lexington, Massachusetts, 1979).

2. Metallgesellschaft, "Metal Statistics," (Frankfurt am Main, Annual).

3. U.S. Bureau of Mines, "Mineral Commodity Summaries" (Washington, D.C., 1980).

4. World Bank, "Price Prospects for Major Primary Commodities," (Washington, D.C., 1980).

5. World Bureau of Metal Statistics, "World Metal Statistics" (London, October 1980).

Note: Exports and Imports on bauxite and alumina were obtained from unpublished information from UNCTAD.

III. THE STRUCTURE OF THE INDUSTRY

A. Organization

1. The aluminum industry may be characterized as an industry where vertical and horizontal integration are predominant. From its beginnings in 1886 through the first half of this century, the industry was dominated by two integrated firms: the Aluminum Company of America (ALCOA) and Pechiney (France).

2. Presently, over 60 percent of the world productive capacity for bauxite and alumina and over half of the world aluminum capacity 1/ is operated by six corporations: Aluminum Company of America (ALCOA), Alcan Aluminum Ltd., Reynolds Metals Company, Kaiser Aluminum and Chemical Corporation, Pechiney Ugine Kuhlmann Group (PUK) and Swiss Aluminum Ltd. (Alusuisse) (see Tables III.1 - III.3). These corporations are mainly concerned with the production of aluminum, its semimanufactures and manufactures, and connected activities, such as the generation of electrical energy for aluminum production and the operation of shipping firms for the transportation of bauxite/alumina/aluminum. Besides, PUK, Alusuisse and Kaiser have also significant interests in other metals and chemical industries.

3. Apart from the six major aluminum companies, there are about 40 other firms which account for about 25 percent of world production capacity. Most of these producers are nonintegrated, and some of them are state-owned companies or companies where the state has a decision-making role. Tables III.1 to III.3 show the most significant of these companies, listed after the "big six."

4. The most important barriers to entry are access to commercial bauxite deposits, economies of scale, high capital costs and proprietary technology. 2/ The minimum efficient scale seems to be 300,000 metric tons per year for an alumina refinery and about 100,000 metric tons per year for an aluminum smelter.

1/ Excluding Centrally Planned Economies.

2/ From "Policy Implications of Producer Country Supply Restrictions; The World Aluminum Bauxite Market," prepared by Charles River Associates, Inc., for the National Bureau of Standards.

Table III.1: COMPANY CONCENTRATION IN BAUXITE MINING, 1977

Company	Capacity[a, b] (Mt/a)	Share (%)	Cumulative share (%)
Alcoa	20.8	22.0	22.0
Kaiser	12.5	13.2	35.2
Alcan	6.4	6.8	42.0
Rio Tinto Zinc	6.2	6.6	48.6
Reynolds	5.7	6.0	54.6
Alusuisse	4.6	4.9	59.5
Pechiney	4.6	4.9	64.4
Guyana government interests	4.0	4.2	68.6
Ergoinvest (Yugoslavia)	3.5	3.7	72.3
PT Timah (Government of Indonesia)	1.3	1.4	73.7
Noranda	1.2	1.3	75.0
Martin Marietta	1.2	1.3	76.3

/a Including proportionate share of capacity in joint-venture projects.

/b Capacity figures reflect equity ownership or control; actual disposal of bauxite may differ.

Source: UNIDO, Mineral Processing in Developing Countries.

Table III.2: COMPANY CONCENTRATION IN ALUMINA REFINING, 1977

Company	Capacity[a] (Mt/a)	Share (%)	Cumulative share (%)
Alcoa	6.8	22.4	22.4
Alcan	3.0	9.9	32.3
Reynolds	2.9	9.6	41.9
Kaiser	2.9	9.6	51.5
Pechiney	2.6	8.6	60.1
Alusuisse	1.6	5.3	65.4
VAW (Germany, Federal Republic of)	1.0	3.3	68.7
EFIM (Italy)	0.9	3.0	71.7
Nippon Light Metal	0.9	3.0	74.7
Sumitomo	0.8	2.6	77.3
Rio Tinto Zinc	0.6	2.0	79.3
Ergoinvest (Yugoslavia)	0.6	2.0	81.3

/a Including proportionate share of joint-venture projects.

Source: UNIDO, Mineral Processing in Developing Countries.

Table III.3: COMPANY CONCENTRATION IN PRIMARY ALUMINUM SMELTING, 1977

Company	*Capacity (Mt/a)*	*Share (%)*	*Cumulative share (%)*
Alcan	1 766	13.1	13.1
Alcoa	1 752	13.0	26.1
Reynolds	1 262	9.4	35.5
Kaiser	1 056	7.8	43.3
Pechiney	914	6.8	50.1
Alusuisse	704	5.2	55.3
VAW (Germany, Federal Republic of)	450	3.3	58.6
Sumitomo	439	3.3	61.9
Nippon Light Metal	400	3.0	64.9
Mitsubishi	358	2.7	67.6
Anaconda (Arco)	328	2.4	70.0
Rio Tinto Zinc	282	2.1	72.1

Source: UNIDO, Mineral Processing in Developing Countries.

Considering about US$5,000/metric tons for an integrated complex (from mine to smelter) the total capital investment required for a plant capacity of 150,000 metric tons per year of aluminum would be around US$750 million (in 1980 dollars).

5. Although industrial concentration in the aluminum industry remains high, it seems to be decreasing slowly over time. Langton 1/ anticipates that over the next four years the amount of western world production accounted for by independent aluminum smelters will nearly double to about 8.5%. The growing use of scrap also provides a source of metal which is not tied to vertically integrated systems. According to Langton, the deconcentration of the industry may be the most significant structural change in the sector during the 1980s, a trend which is already being reflected in the two tier pricing system (see para. 10).

1/ Langton, Thomas G., "Economic Aspects of the Bauxite/Aluminum Industry," Chase Econometrics, June 25, 1980.

6. Bauxite and aluminum producers are actively involved in several international organizations at both government and non-government levels. Eleven bauxite producing countries conform the International Bauxite Association (IBA): Australia, Dominican Republic, Ghana, Guinea, Guyana, Haiti, Indonesia, Jamaica, Sierra Leone, Suriname and Yugoslavia. 1/ The IBA holds meetings regularly to discuss issues on bauxite pricing and control of production facilities. Besides, bauxite is included in the UNCTAD Integrated Programme for Commodities. Most of the aluminum producing companies are members of the International Primary Aluminum Institute (IPAI), which aims at the promotion of understanding the aluminum industry. The OECD has an ad hoc committee on aluminum, which studies the industry prospects. 2/

B. Marketing

7. Due to vertical integration, most bauxite is traded internally, within the six major aluminum companies including its subsidiaries and affiliated companies. In 1976, about 90 percent of total trade of bauxite and about 83 percent of total trade of alumina occurred through intrasystem transfer. No similar data is available for aluminum, but it is estimated that a higher percentage is traded through open markets.

8. Due to the preponderance of internal trade of bauxite and alumina within the companies, there are no indicative market prices for these products. Transfer prices of bauxite are set by the companies as a function of their costs of production and taxes, and therefore, vary widely within deposits. Prices for bauxite and alumina are kept highly confidential, but may be estimated from statistics on international trade.

9. Although the major aluminum companies process their aluminum into semimanufactures, they sell significant quantitites to non-integrated producers.

1/ In 1978, these countries accounted for 74% of the world bauxite production and practically all exports.

2/ From Hashimoto, Hideo, "Bauxite Processing in Development Countries," December 1980.

The prices are set by the companies, presumably taking into account long-term market conditions as well as production costs. The most significant producer quotations are ALCAN's export prices, due to its preponderance in world markets and ALCOA's producer prices, due to the importance of the U.S. market.

10. Since October 1978, aluminum was introduced in the London Metal Exchange, therefore causing the appearance of a new quotation of aluminum, much more volatile in nature than the producer prices, reflecting short-term fluctuations in the industry.

11. In the seventies, taxation had increased substantially in many bauxite producing countries. The leading country was Jamaica, which in May 1974 imposed a new tax system consisting of a standard royalty of 50 Jamaican cents per long dry ton of all the bauxite mined and a production levy on bauxite equivalent to 7.5% of the average realized price of primary aluminum (in aluminum content). This action raised taxes in that year from under US$2 to around US$14 per dried ton of bauxite. 1/ Jamaica's lead in increasing taxation was followed by other producers. The Dominican Republic, Haiti, Suriname, Guyana, Sierra Leone, Guinea and Indonesia, also raised their taxes, the first four of these introducing production levies similar to Jamaica's. Guinea introduced a variant, whereby the levy is also linked to the realized ingot price, but varies with the quality of the ore resulting in a significantly lower rate. During 1980, Jamaica and other bauxite producers are considering some reductions in their levies on bauxite production in order to attract new investments.

12. Most of the major consuming countries protect their domestic production. Table III.4, shows tariffs on bauxite/alumina/aluminum for major industrialized countries. It may be seen from that table that these countries tend to impose significantly higher tariffs on aluminum/ingot and aluminum fabricated products, permitting the existence of plants which operate at relatively high costs.

1/ Mining costs in Jamaica were estimated at US$6/metric ton, thus, the levy had a major impact on the price of bauxite which rose from US$12.50/metric ton in 1973 to US$23.20/metric ton in 1974. (Cif., U.S., import price).

Table III.4: POST-KENNEDY ROUND TARIFFS ON BAUXITE, ALUMINA, ALUMINUM

Commodity and SITC Member	United States	EEC	Japan
	In Advalorem Equivalent, %		
Bauxite, 283.3	0	0	0
Alumina, 513.6	0	5.6	0
Aluminum unwrought 684.1	4	5.8	10.4
Aluminum wrought 684.2	9.1	16.0	13.6

Source: UNIDO, Mineral Processing in Developing Countries, 1980.

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1. Charles River Associates, "Policy Implications of Producer Country Supply Restrictions: The World Aluminum Bauxite Market," (prepared for the National Bureau of Standards), (Cambridge, Massachusetts, 1977).

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8. Vedavalli, R., "Market Structure of Bauxite/Alumina/Aluminum and Prospects for Developing Countries," World Bank 1977.

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IV. ECONOMIC PARAMETERS FOR MARKET ANALYSIS OF THE BAUXITE-ALUMINUM INDUSTRY

A. Demand and Supply Elasticities

1. Few studies provide estimates of elasticities for bauxite/aluminum. Table IV.1 summarizes the information currently available. Demand elasticities have been estimated through econometric models by Banks, 1/ Pindyck 2/ and Woods and Burrows 3/. Because supply elasticities for bauxite and aluminum are not available in the literature, some estimates are provided by analyzing cost of production data for new projects which would come on stream within the decade of the eighties.

2. The price elasticity of world demand for bauxite/aluminum is reported by Banks as -0.13 in the short-run and -0.80 in the long-run. Also, Woods and Burrows, of Charles River Associates, report for the U.S. price elasticities of demand of -0.12 in the short-run and -0.726 in the long-run. For the EEC and the rest of the world, they report long-run elasticities of -0.108 and -0.168 respectively. These estimates support the hypothesis that aluminum prices have little impact on demand in the short run, but seem to affect it more in the long-run. However, caution should be exercised in the use of the price elasticity values provided here, due to the relatively high standard deviations of the estimates. At a 95% confidence level price elasticities of demand for aluminum range from -0.03 to -0.21 in the short-run for the U.S. and -.1963 to 1.256 in the long-run for the U.S. The rest of the price elasticity estimates by Woods and Burrows are not significantly different from 0 at a 95% confidence level. The other authors do not report the necessary information to evaluate the goodness of their estimates.

1/ Banks, Ferdinand, "Bauxite and Aluminum: An Introduction to the Economics of Nonfuel Minerals," Lexington Books, Massachusetts, 1979.

2/ Cited in Banks (op. cit.)

3/ Woods, Douglas and James Burrows, "The World Aluminum Bauxite Market", A Charles River Associates Research Paper, Praeger, New York, 1980.

3. Table IV.1 shows the demand elasticity of aluminum with respect to industrial production for different countries as estimated by Woods and Burrows. These run from a low 0.98 for the EEC to a high 2.1 for the rest of the world, indicating that aluminum consumption, other things being equal, grows on the average at about 50 percent more rapidly than industrial production.

4. The price elasticity of supply is roughly estimated as 1.6 for bauxite, while that for aluminum ranges from 1.5 to 2.7. As mentioned in para. 1 above, these estimates are based on the prices which would be necessary to bring on stream new projects (at a reasonable profit) in order to satisfy world demand during the decade of the eighties. These values reflect the higher costs of operating new mines as well as adjustments for a decrease in ore quality in the case of bauxite, and the increase in the price of hydro-electric power required for smelting in the case of aluminum.

B. Price Determination Mechanisms

5. Most aluminum ingots are traded at the producers' prices. The major aluminum producers post a list price for their product, which is changed infrequently, and which reflects presumably long-run average costs and other long-run factors. 1/ However, actual transaction prices set by the producers are generated from the list price and a premium of discount determined by the extent of shortage or surplus prevailing in the market.

6. Woods and Burrows 2/ suggest the following simple model which determines consumption, prices and scrap recoveries:

1/ Woods and Burrows, op. cit.

2/ Op. cit.

Table IV.1: ELASTICITIES FOR BAUXITE/ALUMINUM

	Short Run	Long Run
Price Elasticity of Demand (Bauxite-Aluminum)		
World		
- Banks	-0.13	-0.80
- Pindyck /1	-0.20	-1.00
United States		
- CRA /2	-0.12	-0.726
European Economic Community		
- CRA /2		-0.108
Rest of World		
- CRA /2		-0.168
Cross Price Elasticity of Aluminum With Respect to Copper		
United States		
- CRA /2	0.023	0.209
European Economic Community		
- CRA /2		0.246
Rest of World		
- CRA /2		0.166
Demand Elasticity with Respect to Industrial Production		
United States		
- CRA /2		1.49
European Economic Community		
- CRA /2		0.979
Japan		
- CRA /2		1.45
Rest of World		
- CRA /2		2.133
Supply Elasticity with Respect to Price		
Bauxite /3		1.6
Aluminum /3		1.5 - 2.7

/1 Cited in Banks.
/2 Refers to the Charles River Associates Report by Woods and Burrows.
/3 Own calculations based on cost of production estimates for marginal projects.

Sources: Banks, Ferdinand, "Bauxite and Aluminum: An Introduction to the Economics of Nonfuel Minerals," Lexington Books, Massachusetts, 1979.
Woods, Douglas and James Burrows, "The World Aluminum Bauxite Market," A Charles River Associates Research Report, Praeger, New York, 1980.

$$D = f1\ (PT, \overline{Y}) \qquad (1)$$

$$SO = f2\ (PS, \overline{Vo}) \qquad (2)$$

$$SN = f3\ (PS, \overline{Vn}, D) \qquad (3)$$

$$DN = D - SO - SN \qquad (4)$$

$$PL = f4\ (C, K, DN, \overline{X}) \qquad (5)$$

$$\frac{PT}{PL} = f5\ (DN, K, \overline{Z}) \qquad (6)$$

$$PS = f6\ (PT, \overline{Q}) \qquad (7)$$

where:

- D = consumption
- PT = transaction price
- $\overline{Y}$ = exogenous variables affecting the demand for aluminum
- SO = old scrap recovery
- PS = price of scrap
- $\overline{VO}$ = exogenous variables affecting the supply of old scrap
- SN = new scrap recovery
- $\overline{Vn}$ = exogenous variables affecting the supply of new scrap
- DN = net consumption of primary aluminum
- PL = list price of aluminum
- C = long-run average cost of production
- K = total capacity
- $\overline{X}$ = exogenous variables affecting the list price
- PT = transaction price of aluminum
- $\overline{Z}$ = exogenous variables affecting the transaction price
- Q = exogenous variables affecting the price of scrap.

According to this formulation, during periods of surplus aluminum capacity, the transactions price is determined by the extent of the price discounting offered by primary producers. Scrap being a substitute for primary aluminum ingot, its price will adjust to be consistent with the transaction price of primary aluminum. During periods of shortage, the transactions price will rise above the list price, the scrap price will also rise and secondary supply will be increased. The transactions price must rise by enough to equate the excess demand to the increase in output from scrap. Primary supply does not appear directly in the model, being set equal to consumption of primary aluminum.

REFERENCES

1. Banks, Ferdinand, "Bauxite and Aluminum: An Introduction to the Economics of Nonfuel Minerals" (Lexington Books, Massachusetts, 1979).

2. Woods, Douglas and James Burrows, "The World Aluminum Bauxite Market," A Charles River Associates Research Report (Praeger, New York 1980).

V. MARKET PRICES FOR BAUXITE, ALUMINA AND ALUMINUM

A. Bauxite

1. Bauxite is not an homogeneous commodity. Differences include physical qualities, chemical composition, impurities, humidity and the percentage of recoverable alumina. Besides, alumina refineries are not equipped to treat all types of bauxite. Therefore, bauxite prices refer to a specific type. Samuel Moment 1/ studied bauxite pricing for the 10 major Western bauxite producing countries, finding five types of market relationsips between producing countries and consumers in determining price levels:

"(a) Prices may be determined between investor-owned producer companies and unrelated consumers, as in Australia. Such prices are used by others as standards to be met by the competition.

(b) Prices may be determined by government-owned producing enterprises in contracts with independent consumers, as in Guyana and Indonesia. These prices also are used by others as standards to be met by the competition.

(c) Prices may be determined or approved by governments under laws and through contracts with consumers as in the Dominican Republic, Suriname, Guinea and Brazil. A principal purpose in such prices is to produce revenues for governments through taxes and levies.

(d) Prices may be determined between investor-owned producing companies and their affiliated companies under common ownership as in Jamaica, Sierra Leone

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1/ Moment, Samuel, "The Pricing of Bauxite from Principal Exporting Countries, 1974-1978, United Nations Industrial Development Organization, Vienna, Austria.

and Haiti. Governments do not in these cases fix the bauxite prices but affect them through the level of taxes and levies. Since the buyers and sellers are under common ownership, bauxite prices are at times determined so as to keep to a minimum the combined taxes paid in the producing country and the consuming country, as affected by the laws of each country.

(e) Prices are also affected as between all buyers and sellers by different conditions governing long-term and short-term or spot agreements. Long-term agreements relate prices to total costs and profits for the seller. Short-term agreements or spot transactions relate prices to temporary conditions affecting either buyer or seller..." 1/

Therefore, the differences in the costs of extracting the alumina as affected by the qualities of the bauxite, the market relationships between buyers and sellers, and the incidence of transport costs to the points of consumption of the bauxite, may lead to considerable differences among the various price levels.

2. There are no posted or list prices for bauxite due to the variety of conditions affecting its value (see para. 1), the lack of a market for small volumes, and the fact that the bulk of world bauxite trade is either within integrated companies or through long-term agreement between buyers and sellers. Bauxite prices may be obtained from trade sources (customs data and/or international trade statistics) or may be estimated as a function of costs of production. Both types of price figures do not seem to be totally appropriate. Prices obtained from trade sources reflect, to a great extent,

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1/ Moment, op. cit., page 3.

intracompany trading, where these companies establish the price of bauxite for their internal accounting to minimize taxes as well as for other purposes of company strategy. Prices estimated as a function of costs or production, on the other hand, do not take into account market conditions although they may be considered as reflecting long-term trends.

3. The World Bank estimates bauxite prices based on production costs, through the following formula: 1/

$$P_{Bx} = (P_{ALM} \times a \div b) + R + C$$

where

P_{ALM} = Realized aluminum ingot price ($/ton)

P_{Bx} = delivered bauxite price of Jamaican bauxite to the U.S. coast ($/ton)

R = royalty ($/ton)

a = levy rate (%)

b = conversion factor

C = general costs (mine operation and capital costs, and transportation cost to the U.S. coast).

World Bank's bauxite prices for 1960-1980 are shown in Table V.1.

4. The study by S. Moment 2/ cited in para. 1, gives a comprehensive view on bauxite pricing and prices. Moment has compared prices for Jamaican bauxite from four different sources: the U.S. Bureau of Mines, the International Monetary Fund, the Jamaica Bauxite Institute and the World Bank. These are shown in Table V.2. The same author has compiled approximate bauxite prices for 1977 for shipments from selected countries to the U.S. and Japan, which are reproduced in Table V.3.

1/ See World Bank, "Price Prospects for Major Primary Commodities," January 1980.

2/ Op. cit.

Table V.1: BAUXITE PRICES, WORLD BANK ESTIMATES, 1960-1980

(CIF, $/ton) /a

	Current $	1977 Constant $
Actual		
1960	7.5	19.1
1961	7.5	19.0
1962	7.5	19.2
1963	7.5	19.1
1964	7.5	18.8
1965	7.5	18.2
1966	12.0	29.0
1967	12.0	28.6
1968	12.0	30.5
1969	12.0	30.2
1970	12.0	27.3
1971	12.0	25.2
1972	12.0	22.8
1973	12.5	19.7
1974	23.2	29.4
1975	25.3	27.8
1976	27.2	29.3
1977	30.8	30.8
1978	34.3	29.6
1979	36.6	27.9
1980	41.6	27.3

/a US import reference price based on imports from Jamaica.

Source: World Bank, Economic Analysis and Projections Department (actual).

Table V.2: PRICES OF JAMAICA BAUXITE IMPORTED INTO THE UNITED STATES 1972-1977, U.S. DOLLARS PER METRIC TON

Year	U.S. Bureau of Mines 1/	International Monetary Fund 2/	Jamaica Bauxite Institute 3/	World Bank 4/
1972.....	13.27	11.93	11.94	12.00
1973.....	13.07	10.00	11.84	12.50
1974.....	...	18.32	16.27	23.50
1975.....	22.15	21.46	19.81	25.30
1976.....	25.44	21.73	19.72	27.20
1977.....	...	18.65	34.19	30.80

1/ Minerals Yearbook, U.S. Bureau of Mines. Adjusted by U.S. Bureau of Mines to dry basis per long ton, 1972-1975, and converted to metric ton values. 1976 value is on a wet basis.

2/ Calculated from International Financial Statistics, International Monetary Fund, December, 1978, p. 206, value of Jamaica bauxite exports in Jamaica dollars, converted at official exchange rates. U.S. dollars per Jamaica dollar: 1.25 in 1972 and 1.10, 1973-1978. Export tonnages from Jamacia Bauxite Institute.

3/ Calculated from export tonnage and values in Jamaica dollars as reported by the Jamaica Bauxite Institute to the U.S. Embassy, Kingston, converted into U.S. dollars per ton at official exchange rates, U.S. dollars per Jamaica dollar: 1.25 in 1972 and 1.10, 1973-1978.

4/ Commodity Trade and Price Trends (1978 edition), Economic Analysis and Projections Department, World Bank, p. 98, "U.S. Import Reference Price Based on Imports From Jamaica."

Source: Moment, Samuel, "The Pricing of Bauxite From Principal Exporting Countries, 1974-1978," UNIDO, Vienna, Austria, 1979.

Table V.3: APPROXIMATE BAUXITE PRICES, TAXES, AND IMPACT ON ALUMINA COSTS, WESTERN COUNTRIES, 1977
(U.S. dollars per metric ton)

Exporter	Importer	Base grade /1 Al_2O_3- % SiO_2- % Monohydrate-% Trihydrate-%	Free moisture as shipped %	Price, dry basis, f.o.b.	Transportation cost: Wet basis	Transportation cost: Dry basis (4) $\frac{8}{9}$ (1-(2))	C.I.F. price, dry basis. (3) + (5)	Tons dry bauxite per ton alumina	Special taxes, /2 levies, royalty Per ton bauxite	Extra proce costs for w hydrate or conditions?
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
COMMERCIAL SALES										
AUSTRALIA										
Comalco-Weipa bauxite...	Japan	Al_2O_3-56% SiO_2-5% Mono-9-10% Tri-60-63%	11%	$9.50	$8.00	$9.00	$18.50	2.1	NA	Yes
Gove	Japan	Al_2O_3-50% SiO_2 - 3.4% Mono - 1% Tri - 49%	8%	9.50	8.00	8.70	18.20	2.4	NA	No
SURINAME										
Billiton	U.S.A.	Al_2O_3-59% SiO_2- 4.8% Tri - 59%	3.4%	25.13 /3	9.85	10.26	35.39	2	$15.56	No
GUYANA										
Guyhum (Government)	U.S.A.	Al_2O_3-58% SiO_2- 5% Tri - 58%	4%	17.42 /4	7.88	8.20	25.62	2	NA	No
INDONESIA										
Aneka Tambang (Government)	Japan	Al_2O_3-53% SiO_2- 5% Tri - 53%	10%	8.39	7.00 /e	7.78	16.17	2.2 /e	NA	Yes
NON-COMMERCIAL SALES TO AFFILIATES, INCLUDING PROFITS AFTER TAXES										
JAMAICA										
Kaiser	U.S.A.	Al_2O_3- 51.4% SiO_2- 0.7% Mono - N.A. Tri - N.A.	14-1 :	33.35 /5	2.73	3.21	36.56	2.3 /e	18.04	No
SURINAME										
Alcoa	U.S.A.	Al_2O_3-56% SiO_2- 3% Tri - 56%	4% /e	19.13 /6 29.22 /7	7.71 8.26	8.03 8.60	27.16 37.82	2 /e 2 /e	15.56 /e 15.56 /e	No No
DOMINICAN REPUBLIC										
Alcoa	U.S.A.	Al_2O_3- 47-49% SiO_2- 2.6% Mono - N.A. Tri - N.A.	15-19%	28.05 /8	NA	3.63	31.68	2.7 /e	16.29	Yes
HAITI										
Reynolds	U.S.A.	Al_2O_3- 50% SiO_2- 3% Mono - N.A. Tri - N.A.	12%	31.32 /9	4.10	4.65	35.97	2.5	16.75	Yes
GUINEA										
Alcoa	U.S.A.	Al_2O_3- 58-60% SiO_2- 1.5% Mono - 3% Tri - 55-57%	4%	22.36- 24.22 /10	8.25	8.59	30.95- 32.81	1.9	8.43	No
SIERRA LEONE										
Alusuisse	U.S.A.	Al_2O_3- 59% SiO_2- 4-5% Tri - 59%	NA	12.30- 14.00	8.14	NA	22.50 /e	2 /e	NA	No
BRAZIL										
Reynolds	U.S.A.	Al_2O_3-55.9% SiO_2- 4.8% Tri - 55.9%	(one 3%(grade (one 13%(grade	22.34 /11	9.00 /e	9.28- 10.34	31.62- 32.68	2 /e	1.00	No

/1 Al_2O_3 : alumina, SiO_2 : silica, mono : monohydrate bauxite, Tri: trihydrate bauxite.

/2 Equivalent to total government revenue including any deductions for income tax or other levies paid separately. Excludes general taxes applying to all industries such as property or social insurance taxes.

/3 Price adjusted from 4% free moisture to dry basis.

/4 Price adjusted from 4% free moisture to dry basis.

/5 Price adjusted from 15% free moisture to dry basis.

/6 Price at Mobile, adjusted from 4% free moisture to dry basis.

/7 Price at Galveston, adjusted from 4% free moisture to dry basis.

/8 Reported on dry basis.

/9 Price at Galveston, adjusted from 12% free moisture to dry basis.

/10 Prices under two contracts.

/11 Proposed by president of Trombetas consortium, October, 197[illegible].

/NA Information not available

/e Estimate.

Source: Homent, Samuel, "The Pricing of Bauxite from Principal Exporting Countries, 1974-197[illegible] Vienna, Austria 197[illegible].

B. Alumina

5. Although a limited amount of alumina is traded in spot markets, alumina prices are considered highly confidential. S. Moment, 1/ using data on imports from the U.S. Bureau of the Census, computed average prices at the U.S. for alumina shipments from Guyana (GUYBAU), Suriname (ALCOA), and Jamaica (ALCOA). These are shown in Table V.4. The lower prices obtained by GUYBAU from Guyana reflect its dependence upon short-term sales during a period of inactive markets, as well as the fact that long-term arrangements for alumina to serve existing smelters offer limited opportunities to other types of sales contracts. 2/

C. Aluminum

6. Producer prices are the prevailing pricing system for alumina due to the high degree of integration in the aluminum industry (about 80% of primary aluminum production goes from the primary producer to a subsidiary producing semifabricates.) The basic world producer price is Alcan's which is the world's largest exporter. The list price of major US producers is widely used because presumably it reflects long-term trends. Producer prices differ in different countries, due to limited competition and because of trade barriers. Besides producer prices, there are dealer or free market prices, which are regularly quoted in trade journals. The Metals Week U.S. market price for aluminum and the Mining Journal's Free Market price for aluminum are commonly used price quotations. The London Metal Exchange (LME) introduced an aluminum contract for cash and 3-month contracts during 1977-1978. Daily metal LME quotations are cited in most trade journals. The main pricing systems for aluminum are summarized in Table V.5.

7. The World Bank (Commodities and Export Projections Division, Economic Analysis and Projections Department) uses generally the U.S. Major Producer

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1/ Moment, Samuel, op. cit.

2/ Ibid.

Table V.4: AVERAGE PRICES OF ALUMINA AT THE U.S. FOR SHIPMENTS FROM DIFFERENT COUNTRIES

----------(US dollars per metric ton)----------

	From Guyana (GUY BAU) at Mobile, Alabama		From Suriname (ALCOA) at Norfolk, Virginia		From Jamaica (ALCOA) at Norfolk, Virginia	
	FOB price	CIF price	FOB price	CIF price	FOB price	CIF price
1974	62.43-81.02	72.33-88.52	72.10-76.00	77.50-80.54	72.75-90.00	73.96-91.30
1975	73.50-88.18	82.60-103.65	108.34-123.34	109.73-124.82	90.00-144.92	91.30-146.53
1976	69.78-81.00	...-92.48	133.61	134.86	88.13-156.69	89.24-157.90
1977	82.54-92.48	90.37-108.31	141.03-152.61	142.29-153.88	140.00-183.73	141.22-185.05

Source: Moment, Samuel, "The Pricing of Bauxite from Principal Exporting Countries, 1974-1978," Vienna, Austria, 1979. Data originally in US dollars per long-term ton converted to US dollars per metric ton.

Table V.5: MAIN PRICING SYSTEMS FOR ALUMINUM

Producer Prices	Description	Sources
ALCAN - World Price, US$/metric ton	Aluminum, virgin ingots, from Canada to Hong Kong and Rotterdam CIF	Metal Bulletin
US major producer	List price of major US producers 99.5% pure	Metals Week
Kaiser	CIF main ports	Metal Bulletin
Producer prices from various countries	CIF main ports	Metal Bulletin
Free Market Prices		
London Aluminum (99.5%)	Free market	Mining Journal
MW U.S. market	Metals Week canvas of dealers/producers/Consumers	Metals Week
Exchange Market Prices		
LME aluminum, cash and 3-months	Primary aluminum of minimum 99.5% purity (quoted daily)	Major trade journals

Aluminum price from Metals Week and the London Aluminum Free Market Price from Mining Journal. The former is chosen as a representative price for long-term market trends, while the latter reflects short-term conditions.

8. Table V.6 provides annual data on primary aluminum prices for both the U.S. Major Producer (Metals Week) and the London Free Market (Mining Journal). It may be observed from that table, the absence of market price fluctuations during the fifties and sixties due to the high degree of integration prevailing in the industry, which permitted a balance of the world supply and demand of aluminum. In the seventies, this situation changed. During 1971 and most of 1972, aluminum producers had excess capacity which forced them to decrease their prices by 6 to 7 percent. At the end of 1972 and up to the first part of 1974, the world economy had a prosperous period which resulted in a rapidly rising demand for aluminum. Both producer prices and market prices increased considerably in current terms during that period. Producer prices in the U.S. rose from an average of US$582 per metric ton in 1972 to US$752 per metric ton in 1974. However, aluminum prices did not recover in constant terms to the levels prevailing in the sixties. Although the 1974 world recession had a negative impact in the demand for aluminum, the industry resorted to cutbacks in production instead of lowering prices. The free market prices dropped substantially but the main producers maintained their posted prices. After 1976, consumption of primary aluminum has been recovering, and except for a recession induced decline during the end of 1980 and part of 1981, it is expected to continue along a rising path into the mid-eighties. This is being accompanied by a substantial increase in current producer prices from about US$877/mt in 1975 (40 US¢ per pound) to US$1,531/mt in 1980 (69 US¢ per pound). However, in constant terms, aluminum prices remain substantially lower than those of the sixties (see Table V.6).

Table V.6: PRIMARY ALUMINUM PRICES 1950-1980

(US$/metric ton)

Year	U.S. Producer Price /1		London Market /2	
	Current $	1977 Constant $	Current $	1977 Constant $
1950	390	1,277	314	965
1951	419	1,155	342	886
1952	428	1,152	429	1,084
1953	461	1,294	432	1,139
1954	480	1,372	430	1,154
1955	522	1,471	460	1,217
1956	530	1,442	524	1,338
1957	560	1,472	543	1,340
1958	547	1,428	508	1,246
1959	545	1,423	497	1,218
1960	573	1,462	513	1,230
1961	561	1,420	513	1,221
1962	527	1,348	498	1,201
1963	499	1,273	499	1,196
1964	523	1,311	526	1,244
1965	540	1,314	540	1,238
1966	540	1,304	540	1,226
1967	551	1,312	544	1,216
1968	564	1,435	553	1,321
1969	599	1,509	587	1,388
1970	633	1,439	614	1,317
1971	639	1,342	626	1,242
1972	582	1,104	590	1,062
1973	551	869	669	1,010
1974	752	952	948	1,149
1975	877	963	686	722
1976	978	1,055	859	888
1977	1,132	1,132	995	957
1978	1,170	1,009	1,045	873
1979	1,310	998	1,538	1,135
1980	1,531	1,005	1,746	1,146

/1 For 1950-59, primary pig; 1960 onwards unalloyed ingot, 99.5%, producer list price.

/2 99-99.5% ingot, spot price.

Sources: Metal Week (New York market)
Mining Journal (London market)

REFERENCES

1. American Metal Market (daily), American Metal Market (New York).

2. Banks, Ferdinand E., "Bauxite and Aluminum: An Introduction to the Economics of Nonfuel Minerals," Lexington Books (Lexington, Massachusetts, 1979).

3. Engineering and Mining Journal (monthly), McGraw-Hill, Inc., (New York).

4. Metal Bulletin (twice a week), Metal Bulletin Ltd., (London).

5. Metals Week (weekly), McGraw-Hill, Inc., (New York).

6. Mining Journal (weekly), The Mining Journal Ltd. (London).

7. Moment, Samuel, "The Pricing of Bauxite From Principal Exporting Countries, 1974-1978," United Nations Industrial Development Organization (Vienna, 1979).

8. Woods, Douglas and James Burrows, "The World Aluminum Bauxite Market," A Charles River Associates Research Report, Praeger (New York, 1980).

9. World Bank, "Price Prospects for Major Primary Commodities," (Washington, D.C., 1980).

10. World Bank, "Commodity Trade and Price Trends," August 1980 (Washington, D.C.).

VI. SPECIAL ISSUES

A. Shipping

1. The shipping of aluminum raw materials is an important issue which affects considerably bauxite and alumina prices. Ocean freight, as well as shipping and cargo handling charges account for as much as 50% of the delivered cost of bauxite. Apart from market factors, the level of freight charges depends on shipment distance, the size of the shipment (vessel) and the type of transport arrangements. Some aluminum companies own their own vessels, but they also supplement their transport capacity by chartering ships.

2. The size of the vessel exerts considerable influence on shipping costs. The operating costs per ton of a 25 thousand tonnes, a 60 thousand tonnes and a 110 thousand tonnes dry bulk carrier as compared to a 15 thousand tonnes ship are 75, 53 and 39 percent respectively. 1/ Therefore, aluminum companies would choose the largest vessel size possible, if it were not for port capacity. Long-haul trades such as from Australia to Western Europe and Guinea to the U.S.A., use carriers of 50 to 70 thousand tonnes. Approximately two-thirds of the international seaborne trade of bauxite and alumina is shipped in carriers of more than 20 thousand tonnes capacity. Nevertheless, short routes combined with shallow drafts available at some ports, such as in Guyana and Suriname, make it convenient to employ vessels of no more than 20 thousand tonnes. Table VI.1 shows the characteristics of principal ports loading bauxite and alumina.

3. Bulk materials, such as bauxite and alumina can be handled more cheaply per ton than aluminum and its fabricated products. According to Brubaker 2/ these higher costs reflect also the greater diversity in destination of the metal as compared with the raw materials. Steamship rates for ingot, which are liner terms, tend to be 2-3 times the rate for bauxite/alumina.

1/ H.P. Drewry (Shipping Consultants Ltd.), "The Operation of Dry Bulk Shipping: Present and Prospective Trading Costs in the Context of Current and Future Market Trends". London, January 1979.

2/ Brubaker, Sterling, "Trends in the World Aluminum Industry," for Resources for the Future Inc., Johns Hopkins Press, Baltimore, 1967.

Table VI.1: PRINCIPAL PORTS LOADING BAUXITE AND ALUMINA

EXPORTER	TERMINAL (OPERATOR)	MAX. SHIP SIZE (DWT)	REMARKS
	1. BAUXITE PORTS		
Jamaica	Ocho Rios (Reynolds)	60,000	Max. freeboard 54'
	Port Rhoades (Kaiser)	40,000	Max. length 660'
Haiti	Miragoane (Reynolds)	45,000	One fixed shiploader
Dominican Republic	Cabo Rojo (Alcoa)	50,000	Max. length 600'
Trinidad	Chaguaramas (Alcan)	25,000	Transhipment terminal
	Tembladora (Alcoa)	35,000+	Transhipment terminal
Suriname (1)	Moengo (Alcoa)	20,000	Max. length 525'
	Paramaribo (Panama) (Alcoa)	20,000	
	Smalkalden (Billiton)	20,000+	
Guyana (1)	Everton (Guybau)	15,000	
	Mackenzie (Guybau)	15,000	Max. length 570'
Brazil	Porto Trombetas (MRN)	50,000	
Australia	Gove (Nabalco)	80,000	
	Weipa (Comalco)	60,000	
Indonesia	Bintan (PN Aneka Tambang)	30,000	Terminal is at Kijang
Malaysia	Telok Ramunia (Seaba)	25,000	Vessels must be grabfitted
Ghana	Takoradi (Baco)	25,000	Max. length 505
Sierra Leone	Sherbro (Alusuisse)	35,000	Vessels must be grabfitted
Guinea	Conakry (Kindia)	25,000	
	Port Kamsar (Halso)	70,000	Max. length 740'
Greece	Itea	15,000	
	2. ALUMINA PORTS		
Canada	Port Alfred (Alcan)	60,000	
US	Corpus Christi (Reynolds)	45,000	Max. length 750'
	Point Comfort (Alcoa)	45,000	
	Baton Rouge (Kaiser)	40,000	
	Gramercy (Kaiser)	40,000	
Jamaica	Port Kaiser (Alpart)	30,000	
	Port Esquivel (Alcan)	30,000	
Trinidad	Tembladora (Alcoa)	35,000	Transhipment terminal
Suriname	Panama (Alcoa)	20,000	
Guyana	Mackenzie (Guybau)	15,000	Max. size controlled by bar draft
Australia	Gladstone (QAL)	60,000	
	Kwinana (Alcoa)	45,000	
	Banbury (Alcoa)	40,000	
	Gove (Alusuisse)	80,000	
Guinea	Conakry (Frialso)	25,000	
Virgin Islands	St. Croix (Martin Marietta)	30,000	One fixed shiploader
Italy	Porto Vesme (Eurallumina)	60,000	
W. Germany	Stade (AOS)	80,000	

(1) Max. size governed by bar draft; vessels of 25/30,000 DWT may part load and top-up at the Trinidad transfer stations.

Source: H.P. Drewry (shipping consultants Ltd.), "The Structure of Bauxite/Alumina - Trade and Trends in Ocean Transportation," London, August 1980.

B. The International Bauxite Association (IBA)

4. The International Bauxite Association (IBA) was established in 1974. Initially the Association comprised seven members, which accounted for 67% of the world bauxite production: Australia, Guinea, Guyana, Jamaica, Suriname, Yugoslavia and Sierra Leone. By the end of 1975, Ghana, Haiti, the Dominican Republic and Indonesia had also joined the IBA. The Association now accounts for about 74 percent of world production of bauxite and 90 percent of world trade.

5. The objective of the IBA as set out in its statutes are:

i. To promote the orderly and rational development of the bauxite industry.

ii. To secure for member countries fair and reasonable returns from the exploitation, processing and marketing of bauxite and its products for the economic and social development of their people, bearing in mind the recognized interests of consumers.

iii. Generally to safeguard the interests of member countries in relation to the bauxite industry.

6. For the achievement of its objective, the Association's Charter encourages the following activities among its member countries:

"i. exchange of information concerning all aspects of the exploitation, processing, marketing and use of bauxite and its derivatives;

ii. endeavor to harmonize their decisions and policies relating to the exploitation, mining, processing and marketing of bauxite, alumina and aluminum, bearing in mind the need to ensure that:

a) member countries enjoy reasonable returns from their production;

b) the consumers of these commodities are adequately supplied at reasonable prices;

iii. take action aimed at securing maximum national ownership and effective national control over the exploitation of this natural resource within their territories and to support as far as possible any such action on the part of member countries;

iv. endeavor to ensure that operations or projected operations by multinational corporations in the bauxite industry of one member country shall not be used to damage the interests of other member countries;

v. conduct jointly such research as may be deemed appropriate in their mutual interests;

vi. explore the possibilities of joint or group purchasing of materials and equipment and of providing common services to member countries in their mutual interests." 1/

C. The Integrated Program for Commodities

7. Bauxite (but not alumina nor aluminum) is one of the products covered in the proposal for the Integrated Programme for Commodities sponsored by UNCTAD. The integrated programme seeks to deal with the problems of commodities as they affect developing countries, such as price fluctuations, export earnings instability, lack of integration in the economy, etc. The integrated programme comprises five basic elements:

1/ International Bauxite Association, "Bauxite and the New International Economic Order," in IBA Quarterly Review, Vol. 3, No. 1, September 1977, Kingston, Jamaica, 1977.

"i. The establishment of internationally owned stocks covering a wide range of commodities.

ii. The establishment of a common financing fund that will make resources available for the acquisition of stocks.

iii. The institution, when justified, of a system of medium to long-term commitments to purchase and sell commodities at agreed prices.

iv. The institution of more adequate measures that are at present available to provide compensatory financing to producers to cover shortfalls in export earnings.

v. The initiation of an extensive programme of measures to further the processing of commodities by the producing countries." 1/

By the end of 1980, the integrated programme had not yet been established and preliminary consultations for bauxite were incipient.

D. United States Government Stockpile

8. The Stockpiling Act of the United States Government provides that a stock of strategic and critical materials be held to decrease dependence upon foreign sources in times of emergency. The purpose of the stockpile is to serve the interest of national defense only and is not to be used for economic or budgetary purposes. The quantities of the materials stockpiled should be sufficient to sustain the United States for a period of not less than three years in the event of a national emergency. The stockpile goal as of April 1980 for the aluminum metal group was 7.15 million short tons of

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1/ Quoted from UNCTAD, "An Integrated Programme for Commodities and Indexation of Prices," in Sauvant and Hasenpflug, editors, "The New International Economic Order: Confrontation and Cooperation between North and South," Westview Press, Boulder, Colorado, 1977.

aluminum equivalent (bauxite metals grade, alumina and aluminum) and for the aluminum oxide abrasive grades group it was 638 thousand short tons of aluminum oxide equivalent (bauxite abrasive grade and aluminum oxide). Table VI.2 shows the government's desired inventory mix for these two stockpile groups for 1980.

Table VI.2: U.S. GOVERNMENT DESIRED INVENTORY MIX FOR STOCKPILE GROUPS

Commodity	Unit /1	Desired Inventory Mix
Aluminum Metal Group	ST Aluminum	7,150,000
Alumina	ST	0
Aluminum	ST	700,000
Bauxite Metal Grade, Jamaica Type	LDT	21,000,000
Bauxite Metal Grade, Suriname Type	LDT	6,100,000
Aluminum Oxide, Abrasive Grade Group	ST of Abrasive Grain	638,000
Aluminum Oxide, Abrasive Grain	ST	0
Aluminum Oxide, Fused, Crude	ST	0
Bauxite, Abrasive Grade	LCT	750,000

ST - Short Ton, LDT - Long Dry Ton, LCT - Long Calcined Ton

/1 Conversion factors to aluminum metal: Bauxite Jamaica Type 0.231, Bauxite Suriname Type 0.204, alumina 0.518. Conversion factors to Aluminum Oxide Abrasive Grade: Aluminum Oxide Fused 0.85.

Source: Federal Emergency Management Agency, "Stockpile Report to the Congress October 1979 - March 1980," Washington, D.C., July 31, 1980.

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