

INTRODUCTION

Aluminum is the newcomer among the metals covered in this study. It was initially isolated as an element in the 1820s and first produced commercially in the 1880s.

Uses

Aluminum is the most widely used nonferrous metal. Its light weight, corrosion resistance, ease of recycling, and high electrical/thermal conductivity make it useful in a variety of applications. The largest market is the containers and packaging sector (beverage and food cans, foil, etc.). In the United States, this sector accounted for 27 percent of aluminum use in 1988. The other major markets are the transportation sector (21 percent), buildings and construction (18 percent), and electrical uses (9 percent).¹

Production Methods and Technologies

Aluminum is the second most abundant metal element (after silicon) in the Earth's crust. It can be recovered from many minerals (e.g., clays, andorosit, nepheline syenite, and alunite), but is produced most economically from bauxite, an impure form of alumina (Al_2O_3).³ Approximately 90 percent of all bauxite is produced from surface mines. To extract the aluminum, the ore is crushed, washed, and dried (at the minesite) and then refined and smelted.⁴

The refining step produces pure alumina from bauxite. The Bayer process, discovered in 1888, is the principal refining method. The bauxite is crushed and ground, then digested in hot (280 to 450° F) caustic soda (NaOH) solution. The alumina minerals

in the ore react with the caustic soda and dissolve as sodium-aluminate. Most of the impurities in the ore precipitate out as "red mud" which is removed by countercurrent recantation and filtration. The solution is then seeded with starter crystals and agitated to crystallize out alumina hydrate. This material is then calcined in kilns (to remove the water) and the result is pure alumina.

The smelting process reduces the alumina to aluminum. Modern processes are based on those discovered independently by Hall and Héroult in 1886. Alumina is dissolved in a molten cryolite (Na_3AlF_6) bath contained in carbon-lined steel cells (pots). In each pot, a direct current is passed through the bath (between a carbon anode and the carbon bottom of the cell) to reduce the dissolved alumina into aluminum. Molten aluminum collects at the bottom of the pots and is siphoned off into large crucibles. The aluminum (averaging about 99.8 percent purity) is poured directly into molds to produce foundry ingot or further refined/alloyed to make fabricating ingot. Scrap aluminum may be added to the melt either at this last stage or when the ingot is remelted at the foundry or fabricating facility.

The smelting process is continuous. Alumina is added, anodes are replaced, and molten aluminum is siphoned off without interrupting current in the cells. A potline may consist of 50 to 200 cells with a total line voltage of up to 1,000 volts at current loads of 50,000 to 225,000 amps. Electricity use in today's smelters is 6 to 8 kWh/lb of aluminum.⁵ Electric power is one of the most costly raw materials in aluminum production.

¹Patricia A. Plunkert, "Aluminum," *Minerals Yearbook*, vol. I, 1988 ed. (Washington, DC: U.S. Department of the Interior, Bureau of Mines, 1990).

²Allen S. Russell, "Aluminum," *McGraw-Hill Encyclopedia on Science and Technology* (New York, NY: McGraw-Hill, 1987). Frank X. McCawley and Luke H. Baumgardner, "Aluminum," *Mineral Facts and Problems*, 1985 ed. (Washington DC: U.S. Department of the Interior, Bureau of Mines, 1985).

³The bauxite ores used to produce aluminum metal typically contain 40 to 60 percent alumina (Al_2O_3) along with 1 to 15 percent silica (SiO_2), 7 to 30 percent hematite (Fe_2O_3), 1 to 5 percent titania (TiO_2), and 12 to 30 percent combined water. Nonmetallurgical grades of bauxite are used to produce abrasives, refractories, and chemicals.

⁴Unlike the other metals in this study, aluminum is refined before it is smelted.

⁵Though the basic process of aluminum smelting is 100 years old, the technology has improved steadily. Just after World War II, about 12 kWh of electricity was required to produce a pound of aluminum.

THE 1980s

The U.S. aluminum market started the 1980s on a good note (see figures 3-1 and 3-2). In 1980, domestic primary aluminum production (4.7 million tonnes) was high and prices (averaging \$0.76/lb) were high compared with the late- 1970s. The market went through several cycles during the decade. Prices fluctuated between \$0.47 and \$0.76/lb in the 1980-87 period, before ending the decade somewhat higher (\$1.10/lb in 1988 and \$0.89/lb in 1989). U.S. production of primary aluminum also fluctuated, but never rose above its 1980 level. It fell to around 3.3 million tonnes per year (tpy) in 1982-83 and 3.0 million tpy in 1986, and then rose to about 4.0 million tpy in 1988-89. The 1989 output was 13 percent lower than that of 1980, but comparable to the levels of the late- 1970s.

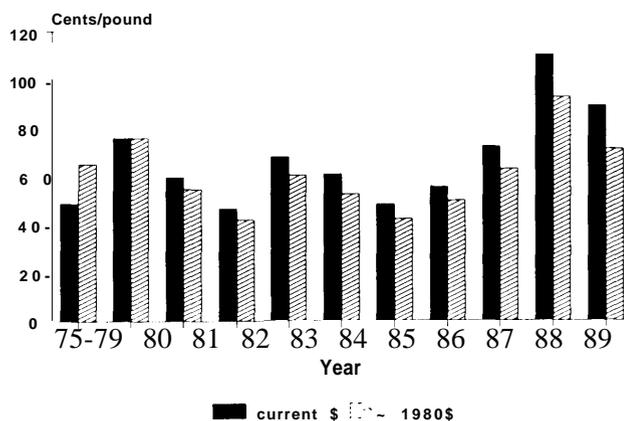
Secondary production (from old and new scrap) rose about 40 percent during the decade. Most of the growth occurred in 1987-89. This category represented about one-third of total U.S. aluminum production during the decade.⁶

U.S. aluminum consumption also went through several cycles during the decade. Consumption fell from 6.1 million tonnes in 1980 to 5.3 million tonnes in 1982. It then fluctuated between 6.0 to 6.2 million tpy during 1983-86 and 6.4 to 6.7 million tpy during 1987-89.

The nonsocialist world (NSW) aluminum market experienced more muted cycles than those that occurred in the United States (see figure 3-3). After the 1982 recession, NSW aluminum production and consumption grew fairly steadily. In 1988, primary production was 13.8 million tonnes (up 8 percent from 1980), secondary production was 5.4 million tonnes (up 40 percent), and consumption was 19.8 million tonnes (up 27 percent).

The openings, closings, and ownership changes that occurred in the U.S. primary aluminum industry during the 1980s are profiled in table 3-1. The Mount Holly smelter in South Carolina (which opened in 1980) is the most recent aluminum facility to be built in the United States. During the decade, 4 alumina refineries and 10 aluminum smelters closed. More

Figure 3-1—Aluminum Prices, 1975-89



NOTE: U.S. spot market price-primary aluminum ingot. Prices in constant 1980 dollars were calculated using producer price index. Bars labeled 75-79 represent averages for the period 1975-79.

SOURCE: U.S. Bureau of Mines.

were closed temporarily at some time during the 1980s, because of low prices. All of the permanently closed refineries and smelters were in the southern United States (Texas, Louisiana, Alabama, Arkansas, and Tennessee). During 1980-88, U.S. refinery capacity declined 29 percent to 5.1 million tonnes of alumina and smelter capacity declined 20 percent to 4.0 million tonnes.

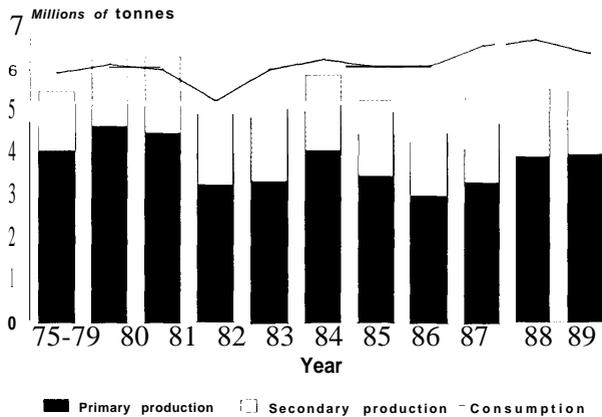
Amax (through its Alumax subsidiary) became a major aluminum producer during the 1980s. The company grew by building the Mt. Holly smelter and by purchasing Pechiney's shares of Intalco and Eastalco in 1983. After consolidating its position, Alumax sold about a quarter of each of its plants to raise money to expand in Canada.

Kaiser experienced several ownership changes in the 1980s. The company was acquired first by Alan Clore, a British investor, and then by Maxxam.

Three companies (Conalco, Anaconda Aluminum, and Revere Copper and Brass) left the U.S. industry during the 1980s. Another company (Martin Marietta) decreased its presence in the industry by selling one of its smelters and leasing the other to an independent producer. Six companies (Columbia Aluminum, Columbia Falls, Alcan, Vanalco, Ravens-

⁶These figures represent the total aluminum recovered from both new and old scrap. As such they overstate the amount of refined aluminum that is actually entering the manufacturing stream. Old scrap comes from discarded products, new scrap is waste from fabricating and other manufacturing processes. In 1988, 2.1 million tonnes of secondary aluminum were recovered from old scrap (1.0 million tonnes) and new scrap (1.1 million tonnes), and recovered as refined metal (2.1 million tonnes) and other "non-refined" products (37,000 tonnes). Patricia A. Plunkert, "Aluminum," *Minerals Yearbook*, vol. I, 1988 ed. (Washington, DC: U.S. Department of the Interior, Bureau of Mines, 1990).

Figure 3-2—U.S. Aluminum Production and Consumption, 1975-89



NOTE: Secondary production is refined metal and other products recovered from old and new scrap. Bars labeled 75-79 represent averages for the period 1975-79.

SOURCE: *Metal Statistics*, Metallgesellschaft Aktiengesellschaft.

wood, and Northwest Aluminum) entered U.S. industry during the decade. A seventh (Ormet) was essentially new to the industry also. It was sold to its current owners, Ohio River Associates, in 1986.

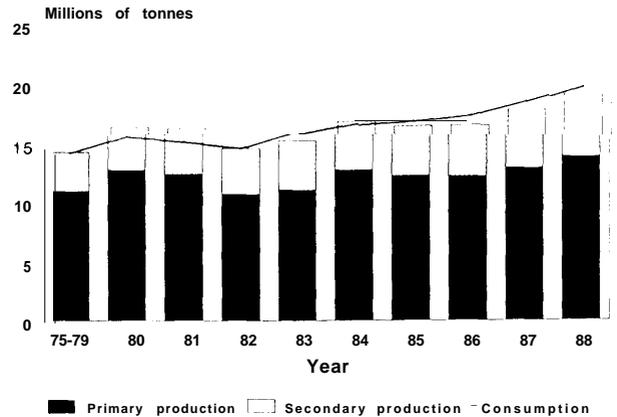
PRODUCER PROFILES, 1990

Since the second World War, two major groups of countries have been involved in the production of aluminum, the “miners” and “smelters.” Bauxite was mined in tropical developing countries such as Guyana, Guinea, Jamaica, and Suriname. Aluminum was smelted in the electricity-rich developed regions of North America and Europe. Alumina refining, the middle processing step, originally took place in the smelting countries, but is now done in the mining countries also.

A new group of “integrated” producing countries, active in all three sectors of the primary aluminum business, has emerged in the last 20 years. Australia and Brazil are two such producers (see figure 3-4). Australia is the largest NSW bauxite miner and alumina refiner, and ranks third in smelting. Brazil’s industry is smaller, ranking third in mining, fifth in refining, and fourth in smelting.

The other major bauxite producers are involved in the processing sector to varying degrees. Guinea, Guyana, and Sierra Leone have little or no refining capacity and export most of their output. Jamaica, Suriname, India, Yugoslavia, and Greece have

Figure 3-3—NSW Aluminum Production and Consumption, 1975-88



NOTE: Secondary production is refined metal and other products recovered from old and new scrap. Bars labeled 75-79 represent averages for the period 1975-79.

SOURCE: *Metal Statistics*, Metallgesellschaft Aktiengesellschaft.

significant refinery capacity, and export both alumina and bauxite.

Until the ascendancy of Australia and Brazil, the smelting industry was located almost exclusively in North America, Japan, and Europe. The United States has been the largest smelting country since the birth of the industry. Japan was the second largest smelter in the mid- 1970s, but has since closed most of its capacity because of high electricity prices. Canada is now the second largest producer. In Europe, where most nations have some smelting capacity, Norway and West Germany are the industry leaders. Among the older smelting countries, the United States, West Germany, and Canada have the largest refining sectors.

Despite the industry’s geographical diversity, a high degree of concentration and vertical integration was attained by the major companies. The Big Six (Alcoa, Kaiser, Reynolds, Pechiney, and Alusuisse) operated as an oligopoly for most of the post World War II period (see box 3-A). Although these companies were principally smelters and fabricators, they owned or controlled most of the world’s bauxite production. Over the years, the Big Six have lost some of their influence over the industry, especially in the mining sector, but the individual companies remain important.

The International Bauxite Association (IBA) was established in 1974. Its members are Australia, Ghana, Guinea, Guyana, India, Indonesia, Jamaica,

Table 3-I—Profile of U.S. Primary Aluminum Production industry, 1980 and 1990

| 1980 | | 1990 | |
|------------------------------|---------------------------------|---------------------------------|---|
| Alumina refiners: | | | |
| Point Comfort, TX..... | Alcoa | Alma | |
| Bauxite, AR..... | Alma | Alcoa | Has produced only specialty alumina (no metal-grade alumina) since 1988 |
| Mobile, AL..... | Alcoa | — | Closed 1982; permanent closure 1984 |
| St Croix, Virgin Islands.... | Martin Marietta | Clarendon ^a | Closed 1985; sold to Clarendon 1989; reopened 1990 |
| Gramercy, LA..... | Kaiser | Kaiser ^b | Note 1 |
| Baton Rouge, LA..... | Kaiser | — | Closed 1983; permanent closure 1985; specialty alumina plant sold to LaRoche Chemicals 1988 |
| Burnside, LA..... | Ormet ^c | Ormet ^d | Closed 1985; reopened 1988; Notes 2,3,4 ote 3/ |
| Corpus Christi, TX..... | Reynolds | Reynolds | |
| Hurricane Creek, AR..... | Reynolds | — | Closed 1983; permanent closure 1984 |
| Aluminum smelters: | | | |
| Sebree, KY..... | Anaconda Aluminum | Alcan | Note 5; sold to Alcan 1985 |
| Rockdale, TX..... | Alcoa | Alcoa | Capacity reduced 1986, restored 1987 |
| Evansville, IN..... | Alcoa | Alcoa | |
| Wenatchee, WA..... | Alcoa | Alma | |
| Alcoa, TN..... | Alcoa | Alcoa | Capacity reduced 1986, restored 1987 |
| Massena, NY..... | Alma | Alcoa | Capacity reduced 1986 |
| Badin, NC..... | Alcoa | Alcoa | |
| Palestine, TX..... | Alma | — | Closed 1983; permanent closure 1985; experimental plant |
| Point Comfort, TX..... | Alcoa | — | Closed since 1978; permanent closure 1982 |
| Mount Holly, SC..... | Alumax ^e | Alumax-Clarendon ^g | Opened 1980; Notes 6&7 |
| Frederick, MD..... | Eastalco ^{eh} | Alumax-Mitsui ^{fi} | Notes 8,6,9 |
| Ferndale, WA..... | Intalco ^{eh} | Alumax-Mitsui ^{fi} | Notes 8,6,9 |
| Goldendale, WA..... | Martin Marietta ^l | Columbia Aluminum ^l | Sold to Comalco 1985, to Columbia Aluminum 1987 |
| Columbia Falls, MT..... | Anaconda Aluminum | Columbia Falls ^l | Note 5; sold to Columbia Falls 1985 |
| New Johnsonville, TN.... | Conalco ^m | — | Closed 1986; Note 2 |
| Lake Charles, LA..... | Conalco ^m | — | Closed 1981; Note 2; carbon plant sold to Reynolds 1983 |
| Mead, WA..... | Kaiser | Kaiser ^b | Note 1 |
| Tacoma, WA..... | Kaiser | Kaiser ^b | Note 1 |
| Chalmette, LA..... | Kaiser | — | Closed 1983; capacity written off 1986-87; Note 1 |
| New Madrid, MO..... | Noranda | Noranda | |
| The Dalles, OR..... | Martin Marietta ^l | Northwest Aluminum ⁿ | Northwest Al signed lease-purchase agreement 1986 |
| Hannibal, OH..... | Ormet ^d | Ormet ^d | Notes 2,3,4 |
| Ravenswood, WV..... | Kaiser | Ravenswood ^o | Note 1; sold to Ravenswood 1988 |
| Scottsboro, AL..... | Revere Copper & Brass | — | Closed 1982; Note 3 |
| Longview, WA..... | Reynolds | Reynolds | |
| Massena, NY..... | Reynolds | Reynolds | |
| Troutdale, OR..... | Reynolds | Reynolds | |
| Listerhill, AL..... | Reynolds | — | Closed 1986 |
| Jones Mills, AR..... | Reynolds | — | Closed 1985 |
| Arkadelphia, AR..... | Reynolds | — | Closed 1985 |
| San Patricio, TX..... | Reynolds | — | Closed 1981; permanent closure 1984 |
| Hawesville, KY..... | National-Southwire ^p | Southwire | Note 10 |
| Vancouver, WA..... | Alcoa | Vanalco | Sold to Vanalco 1987 |

NOTES:

^aClarendon is a subsidiary of Marc Rich.^bKaiser is a subsidiary of Maxxam.^cOrmet was a subsidiary of Conalco (owned by Alusuisse and Phelps Dodge) and Revere Copper and Brass.^dOrmet is a subsidiary of Ohio River Associates.^eAlumax was a subsidiary of Amax 50%, Mitsui 45% and Nippon Steel 5%.^fAlumax is a subsidiary of Amax.^gThe Mount Holly, SC, smelter is owned by Amax 73% and Clarendon (a subsidiary of Marc Rich) 27%.^hEastalco and Intalco were subsidiaries of Alumax and Howmet, a subsidiary of Pechiney.ⁱThe Ferndale, WA, and Frederick, MD, smelters are owned by Alumax 75%, Mitsui 11%, Toyo Sash 7%, and Yoshida Kogyo 7%.^jThe Dalles, OR, and Goldendale, WA smelters were 87% owned by Martin Marietta.^kColumbia Aluminum is 30% employee owned.^lColumbia Falls is a subsidiary of Montana

Aluminum Investors.

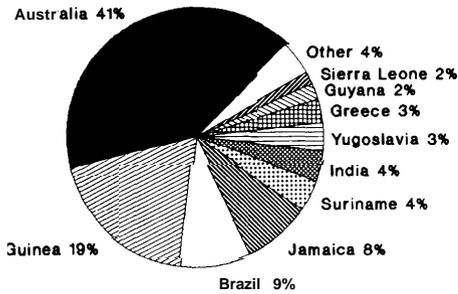
^mConalco was a subsidiary of Alusuisse 60% and Phelps Dodge 40%.ⁿThe Dalles, OR, smelter is 87% owned by Martin Marietta and operated by Northwest Aluminum under a lease-purchase agreement.^oRavenswood is a subsidiary of Stanwich Partners.^pNational-Southwire was a subsidiary of National Steel (later National Intergroup) and Southwire.¹Alan Clore acquired control of Kaiser 1986. Maxxam acquired Kaiser 1988.²Alusuisse became the sole owner of Conalco by purchasing the share of Phelps Dodge 1980.³Revere Copper and Brass began operating under Chapter 11 of the bankruptcy code in October 1982.⁴Ohio River Associates, an investor group, acquired Ormet through a leveraged buyout 1986. Conalco and Revere Copper and Brass received prorated shares of the Hannibal, OH plant output

for the first four years of production.

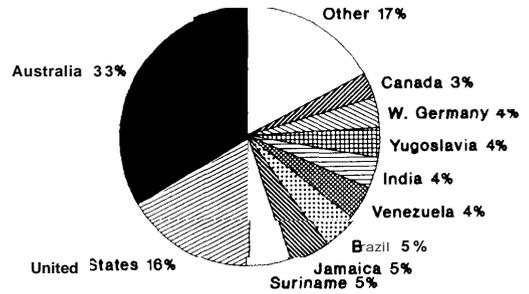
⁵Atlantic Richfield (Arco) acquired Anaconda Aluminum 1982.⁶Amx became the sole owner of Alumax by purchasing the shares of Mitsui and Nippon Steel 1986.⁷Clarendon, a subsidiary of the Marc Rich trading company, acquired a 27 percent interest in the Mount Holly, SC smelter 1987.⁸Alumax became the sole owner of Eastalco and Intalco by purchasing the assets of Howmet, a subsidiary of Pechiney 1983.⁹A consortium of Mitsui, Toyo Sash, and Yoshida Kogyo acquired a 25 percent interest in the Ferndale, WA and Frederick, MD smelters 1988.¹⁰Southwire became the sole owner of the Hawesville, KY smelter by purchasing the share of National Intergroup 1990.

Figure 3-4—NSW Aluminum Production, Country Profile, 1988

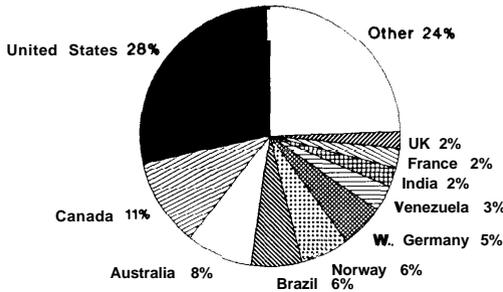
Mine Production
87.5 million tonnes bauxite



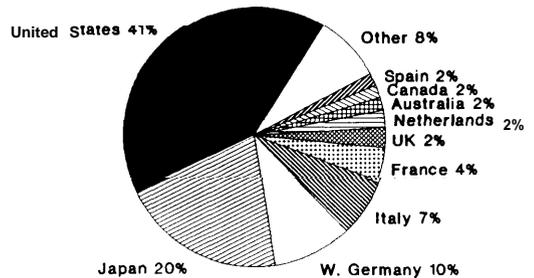
Refinery Production
31.4 million tonnes alumina



Primary Production
13.9 million tonnes



Secondary Production
5.4 million tonnes



NOTE: Secondary production is refined metal and other products recovered from old and new scrap.

SOURCE: *Metal Statistics*, Metallgesellschaft Aktiengesellschaft.

Sierra Leone, Suriname, and Yugoslavia. These countries produced about 85 percent of the NSW's bauxite and about half of the alumina in 1988. The goals of the IBA are to promote the orderly and rational development of the bauxite industry, to secure fair and reasonable returns for the exploitation of the bauxite, and to generally safeguard members' interests in relation to the bauxite industry.⁷ The interest in establishing the organization

came in the early 1970s. Bauxite-producing nations were dissatisfied with the revenues their resources were generating. It was also during this period that bauxite levies and government equity positions in bauxite companies became popular. The final inducement for forming a producer organization came when the Organization of Petroleum Exporting Countries (OPEC) was successful in quadrupling oil prices in 1973.

⁷G.R. Peterson and S.J. Arbelbide, *Aluminum Availability—Market Economy Countries*, IC 8917 (Washington, DC: U.S. Department of the Interior, Bureau of Mines, 1983).

Box 3-A—The Big Six Aluminum Companies

Aluminum was not produced commercially until late in the 19th century, long after most other structural metals had found widespread use. Alcoa (then the Pittsburgh Reduction Co.) controlled the North American aluminum industry from its inception until World War II.

In the mid-1940s, the country's capacity was tripled to meet growing military needs. The U.S. Government, through the Defense Plant Corp., built new aluminum smelters which were then operated by Alcoa and several other companies. Following the war, the smelters were leased and then sold to two of the operators, Kaiser and Reynolds as part of an antitrust action against Alcoa. In 1950, Alcoa was ordered to divest itself of its Canadian affiliate Alcan (then Aluminum Ltd.). Consequently, the North American monopoly held by Alcoa was replaced by the oligopoly resulting from the emergence of Alcan, Kaiser, and Reynolds as major producers.

In Europe, a more oligopolistic aluminum industry developed in the early years. After World War II, government actions consolidated the position of Pechiney and Alusuisse in this market.

Though their market control declined, these "Big Six" companies accounted for about 65 to 85 percent of NSW aluminum production from World War II to the early 1970s. The leaders were able to set prices at cost plus a margin of profits, known as 'producer prices.' Prices remained stable, because changes in demand were met with immediate adjustments to inventories and operating rates. In the long run, the major producers kept prices stable by building capacity in anticipation of demand. This "planned excess capacity" enabled the major producers to supply their customers as their demand increased and also provided an added barrier to entry into the industry.¹ The high rate of growth in aluminum consumption and the coordination of capacity expansion among the major producers made this strategy very successful.

During this time, the major producers strove for a high degree of vertical integration. Control of bauxite and alumina resources enabled them to supply their own operations at cost, with profits realized at the latter stages of production. Excess raw materials were selectively sold by the leaders so that they could decide, in effect, who their competition would be. The same factors that strengthened Alcoa's earlier in the century—control of natural resources, high barriers to entry and access to the lowest cost energy—provided the oligopolistic leaders with the competitive edge to control the industry from the 1940s until the 1970s.

In the early 1970s, the aluminum industry changed radically and the competitiveness of the top producers was shaken. Electricity, labor, and capital costs rose sharply and demand slowed. As the profit margins declined, the major producers began to pursue different strategies. LME pricing took effect in the late 1970s. The leaders no longer operated as a cohesive group. Some sought to maintain prices by reducing production, while others built capacity in low cost foreign locations. Both strategies were unsuccessful at maintaining the producers' market power.

Concentration of Primary Aluminum Production (percent of NSW production)

| | 1955 | 1965 | 1970 | 1972 | 1981 |
|-----------------|------|------|------|------|------|
| Alcoa | 23.2 | 17.1 | 16.3 | 15.4 | 13.8 |
| Alcan | 24.5 | 15.6 | 16.3 | 15.3 | 11.9 |
| Reynolds | 13.5 | 13.2 | 12.8 | 11.0 | 9.8 |
| Kaiser | 13.3 | 11.5 | 9.4 | 8.8 | 8.4 |
| Pechiney | 6.1 | 8.4 | 9.3 | 8.1 | 8.0 |
| Alusuisse | 4.0 | 6.8 | 6.6 | 5.6 | 5.7 |
| Big Six | 84.5 | 72.3 | 70.7 | 64.2 | 57.7 |

SOURCE: J.L. Mardones et al., "The Copper and Aluminum Industries: A Review of Structural Changes," *Resources Policy*, March 1985.

¹Paulo de Sá, "Structural Changes and Price Formation in the Minerals and Metals Industry," *Resources Policy*, vol. 14, December 1988.

United States

The United States mines little metallurgical-grade bauxite, but is the NSW's second largest alumina refiner and largest aluminum smelter. All of the domestic alumina refineries are located near the Gulf Coast (see table 3-1). Smelter capacity is located roughly one-third in the Pacific Northwest, one-third in the Ohio Valley, and the rest in the Carolinas, New York, and Texas.

Nearly all U.S. aluminum production is based on imported raw material. In terms of recoverable aluminum, the imports are about one-half bauxite and one-half alumina. The principal sources are Guinea and Jamaica for bauxite and Australia for alumina.⁸ The major U.S. aluminum companies own shares of many of their foreign suppliers.⁹

The United States produces about a quarter of the NSW's aluminum metal, but does not make enough to meet its fabricating needs. During 1984-88, the country's net imports averaged 12 percent of its consumption of primary and secondary aluminum. Most of the imported metal comes from Canada. Exports during this period were 17 percent of domestic production.

Three companies (Alcoa, Reynolds, and Kaiser) own about 90 percent of the country's refinery capacity (see figure 3-5). They, along with a fourth firm (Alumax), own about 60 percent of domestic smelter capacity. These companies are also heavily involved in the downstream fabrication sectors of the business. Having both smelting and fabricating capabilities helps the companies manage business risk. Though the various downstream products vary in their exposure to aluminum ingot prices, rising prices generally favor smelters and declining prices favor the fabricated products.¹⁰ The remainder of the primary aluminum industry is comprised of seven

domestic firms (Ormet, Southwire, Columbia Aluminum, Columbia Falls, Vanalco, Ravenswood, and Northwest Aluminum) and two Canadian firms (Alcan and Noranda).

Alcoa

Early in the century, Alcoa held a monopoly over the aluminum industry. Though its influence has since diminished greatly, it remains the world's largest aluminum company and the Nation's leading nonferrous metals producer.¹¹ Its domestic facilities include refineries in Texas and Arkansas, and smelters in Texas, Indiana, Washington, Tennessee, New York, and North Carolina. The six smelters account for about 31 percent of total U.S. capacity, and an estimated 60 percent of the company's worldwide smelting capacity. Alcoa's major foreign interests include bauxite and alumina facilities in Jamaica, Suriname, and Guinea; and smelters in Australia, Brazil, Norway, Suriname, and Mexico.

Alcoa has diversified over the years, but is still principally an aluminum company.¹² Aluminum ingots, chemicals, and fabricated products account for about 90 percent of the company's sales. Some of the aluminum is sold as primary metal, but more is sold as packaging materials (e.g., can stock and bottle caps) and sheet, plate, and extrusions for aerospace and industrial applications.

The company's emphasis on the fabricating business has left it with insufficient primary metal capacity to meet all of its needs. Alcoa buys about one-half of the aluminum used in its fabricated products. To further its goals as both a buyer and a seller of aluminum ingot, the company is an active hedger in the commodities futures markets.

Alcoa has a reputation for being among the most innovative of the companies in the nonferrous metals industry. It spends heavily on research and

⁸During 1985-88, bauxite imports came from Guinea (50 percent), Jamaica (23 percent), Australia (11 percent), and Brazil (5 percent). Alumina imports came from Australia (80 percent), Suriname (8 percent), and Jamaica (5 percent). U.S. Bureau of Mines, *Mineral Commodity Summaries*, 1990 ed. (Washington DC: U.S. Department of the Interior, Bureau of Mines, 1990).

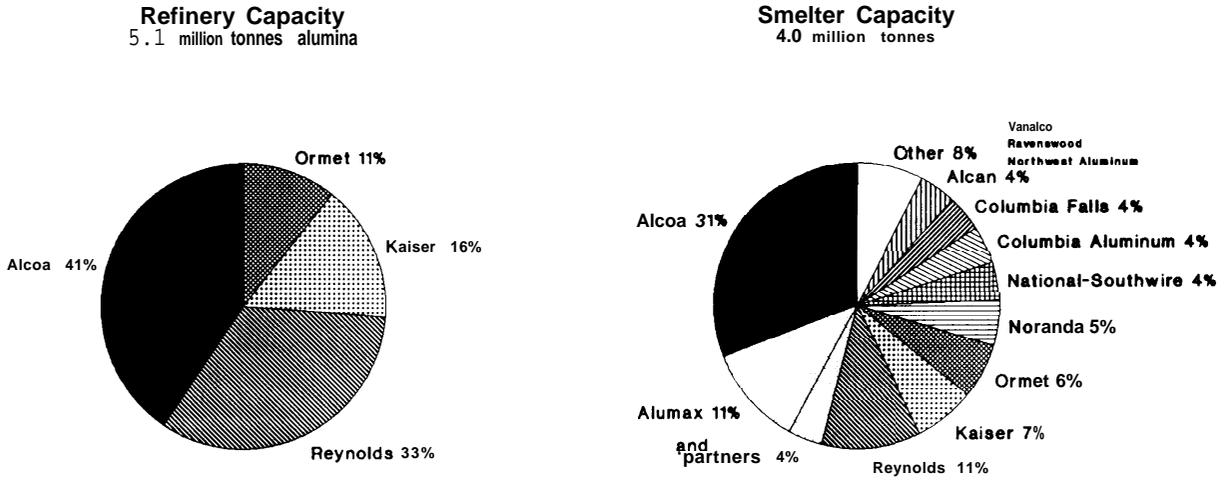
⁹U.S. aluminum companies do not typically own their foreign suppliers outright, but in partnership with other multinational aluminum producers and local governments.

¹⁰Companies are becoming increasingly aware of the Opportunity Cost of aluminum ingot and transferring metal at this cost (the going aluminum price) to their fabricating facilities. Price increases cannot be passed on in the case of low-end fabricated products (e.g., common alloy sheet used in the building, construction and transportation sectors) that have low margins. These products are typically undifferentiated and as such must compete in terms of price. Higher end products (e.g., aerospace plate) do not necessarily compete in terms of price and have large enough margins to allow producers to either pass on price fluctuations or absorb them. These are generally niche markets. Based on reviewer comments by RSI Inc.

¹¹Alcoa is the only nonferrous metals company included in the Dow Jones 30 Industrials stock index.

¹²The company's nonaluminum activities are mainly in the area of materials sciences, including electrical, ceramic, plastic, and composite materials, manufacturing equipment, and separations and defense systems.

Figure 3-5--U.S. Aluminum Industry, Company Profile, 1988



NOTE: Alcoa's refinery capacity includes 340,000 mt of capacity that was closed in 1988.

SOURCES: *Minerals Yearbook* (various issues), U.S. Bureau of Mines; *Non-Ferrous Metal Data 1988*, American Bureau of Metal Statistics Inc.; company annual reports.

| Alcoa and its share of affiliates (000s mt) | 1986 | 1987 | 1988 |
|---|-------|-------|-------|
| Sales: | 452 | 493 | 796 |
| Primary metal | | | |
| Fabricated and finished products | 1,563 | 1,720 | 1,708 |
| Total | 2,015 | 2,213 | 2,504 |
| Production: | | | |
| Primary metal | 1,401 | 1,498 | 1,814 |
| Recycled cans | 200 | 225 | 270 |
| Total | 1,601 | 1,723 | 2,084 |

Reynolds

Reynolds, the second largest U.S. aluminum company, has been in production since the 1940s. It operates a refinery in Texas and smelters in Washington, New York, and Oregon. The three domestic smelters account for 11 percent of U.S. capacity. Reynolds' major foreign operations include bauxite mines in Brazil, Jamaica, Guinea, and Australia; refineries in Australia, Jamaica, and West Germany; and smelters in Canada, Ghana, Venezuela, and West Germany. At yearend 1988, over 90 percent of the company's primary capacity was in North America.

Aluminum products accounted for about 85 percent of the company's sales in 1988. Reynolds sells some aluminum ingot, but stresses its fabricating business. The company's emphasis on finished goods, however, is greater than that of its competitors. It is the only aluminum producer that makes cans from its can stock. Reynolds' largest business is its packaging and containers line, which includes aluminum, plastic, and paper consumer products (e.g., aluminum foil, plastic wrap, waxed paper, food containers, and garbage bags). The company also manufactures aircraft and automotive products. The

development (\$120 million to \$167 million annually during 1985-88) for both manufacturing technologies and product development.¹³

During the mid-1980s, Alcoa pursued a three-pronged strategy. It sought to withdraw from the primary aluminum business, to develop a higher degree of downstream integration, and to diversify into the production of engineering materials. The goal was to have one-half of its sales come from new nonaluminum businesses by 1995. The company has since slowed its diversification into engineering materials and concentrated its efforts on the aluminum metal and fabrication businesses.¹⁴

¹³Alcoa Annual Report, 1988.

¹⁴Olivier Bomseil and Paulo de Sá, *Diversification: What Direction for Growth To Cope With Price Uncertainty*, Seminar on Mineral Economics and Strategy, Centre d'Économie des Ressources Naturelles (CERNA), Ecole Nationale Supérieure des Mines des Paris, June 1989.

| Reynolds and its share of affiliates (000s mt) | 1986 | 1987 | 1988 |
|--|-------|-------|-------|
| Aluminum sales: | | | |
| Primary metal | 111 | 128 | 156 |
| Fabricated products | 654 | 733 | 787 |
| Finished products | 331 | 348 | 379 |
| Total | 1,096 | 1,208 | 1,322 |
| Aluminum production: | | | |
| Primary metal | 654 | 769 | 845 |
| Recycled | 281 | 311 | 369 |
| Total | 935 | 1,080 | 1,214 |

5-year plan announced in 1987 calls for expansion of the foreign operations, including a new can plant in Brazil and new wheel plants in Venezuela and Canada.

Since 1986, the company has been investing heavily in precious metals. It has acquired interests in two Australian gold mines (Boddington and Mt. Gibson). In 1988, Reynolds share of the gold from these two mines was 4.4 million grams.

Though Reynolds stresses that its emphasis remains with fabricated and finished products, it is investing in additional aluminum ingot capacity. It is expanding its Baie Comeau smelter in Canada from the present capacity of 280,000 tpy to 400,000 tpy by 1992. Also, Reynolds acquired a 25 percent equity position in the Becancour smelter in Canada in 1987. The smelter is currently being expanded by 50 percent to 360,000 tpy.¹⁵ The company claims that its present sources of bauxite and alumina (including joint ventures and long-term supply contracts) are more than adequate to meet its requirements for the foreseeable future. Reynolds is a net buyer of scrap and ingot.

Capital spending for modernization in the mid-1980s was primarily to lower basic metals costs (reduced by about 25 percent during 1983-87). The company's emphasis is now on improving fabricating costs and expects to spend about \$300 million per year during 1988-93 in this effort. Its research

and development budget has been \$32 million annually during the mid-1980s. The emphasis is on the development of products, such as the resealable aluminum cans.

Alumax

Amax, through its Alumax subsidiary, is the third largest U.S. aluminum producer. It operates three smelters, located in Washington, South Carolina, and Maryland. The company owns 11 percent of U.S. smelter capacity.¹⁶ It also has a one-quarter share in the Becancour smelter in Canada.

Amax is a century-old minerals company that has been involved in the aluminum industry (mostly as a partial owner of Alumax) for 35 years.¹⁷ Alumax only became a major producer in the 1980s. It expanded by building the Mt. Holly, South Carolina smelter in 1980 and purchasing the U.S. assets of Pechiney (Howmet) in 1983. In 1986, Amax acquired full control of Alumax.

During 1987-88, Amax sold 27 percent of the Mt. Holly smelter to Clarendon Ltd. and one-quarter of its Washington (Intalco) and Maryland (Eastalco) smelters to the Mitsui trading company and two Japanese fabricating companies.¹⁸ Alumax has a 10-year tolling contract with Clarendon Ltd. The agreement covers 50 percent of Mt. Holly's production, but reports are that Clarendon Ltd. has been taking about three-quarters of the smelter's output.¹⁹ Amax has stated that it intends to rebuild its primary metal business and be more involved in the sale of aluminum metal.²⁰ To this end, the funds from the two equity sales were used to obtain the company's interest in the Becancour facility in 1988. Alumax also has plans to build a 200,000 tpy smelter at Deschamault in Quebec.

Amax produces aluminum, coal, molybdenum, and gold.²¹ Aluminum accounted for about two-thirds of the company's sales during 1987-88. Most

¹⁵Reynolds Annual Report, 1988.

¹⁶When the shares of the partner companies are included, the Alumax smelters account for 15 percent of domestic capacity.

¹⁷For most of its history, Amax was principally a base metals producer. It was the world's fifth largest copper producer until it sold its Zambian properties to that government in 1970. It has since left the copper business completely. Amax also once held 60 percent of the world molybdenum market. It is still a major producer, but has lost much of its control over the market.

¹⁸Clarendon Ltd., owned by trader Marc Rich, is based in Switzerland and markets alumina produced for the Jamaican Government by the Clarendon JV refinery. Clarendon is thought to control 30 percent of world aluminum trade. Paulo de Sá, *From Oligopoly to Competition: The Changing Aluminum Industry*, Centre d'Économie des Ressources Naturelles (CERNA), Ecole Nationale Supérieure des Mines des Paris, February 1989.

¹⁹David Humphreys, "Aluminum," *Mining Journal, Mining Annual Review*, 1988.

²⁰Amax First Quarter Report, 1989.

²¹Coal, molybdenum, gold, and other metals accounted for 18 percent, 6 percent, 2 percent, and 7 percent of 1987-88 sales, respectively.

| Alumax and its share of affiliates (000s mt) | 1986 | 1987 | 1988 |
|--|------|------|------|
| Aluminum sales: | | | |
| Primary metal | 271 | 349 | 254 |
| Fabricated and finished products | 533 | 532 | 501 |
| Total | 805 | 881 | 755 |
| Aluminum production: | | | |
| Primary metal; | 582 | 668 | 642 |

of the aluminum is sold as fabricated products. The company is especially strong in the architectural and building products line.

Kaiser

Kaiser, the fourth largest domestic producer, is the smallest of the U.S. majors. The company has been producing aluminum since the 1940s. Its domestic operations include a refinery in Louisiana and two smelters in Washington. The smelters account for 7 percent of U.S. capacity. Kaiser's foreign interests include bauxite mines in Jamaica; alumina refineries in Jamaica and Australia; and smelters in Ghana, the United Kingdom, Australia, and Bahrain.

Kaiser was the target of several corporate takeover attempts during 1985-87. British investor Alan Clore was successful in acquiring the company in 1987. However, he overextended himself in the process and was forced to sell out to Maxxam in 1988. Maxxam has refocused the company's businesses and reduced its debt by restructuring and asset selling. Kaiser is being regrouped around the aluminum metal products business. Since 1984, the company has sold its agricultural, industrial, and specialty chemicals, refractories, international trading, and real estate operations. The company's Ravenswood smelter was sold to the Stanwich Partners in 1988. Further sales, particularly of foreign operations, are expected.²²

Kaiser fabricates most of the aluminum it produces. In 1987, the company sold 83 percent of its aluminum in the fabricated form. The biggest product groups are can stock and other sheet and plate products. Other lines include rod, bar, wire, forgings, and extrusions.

| Kaiser and its share of affiliates (000s mt) | 1986 | 1987 | 1988 |
|--|------|------|------|
| Sales: | | | |
| primary metal | 75 | 125 | 278 |
| fabricated & finished products . | 688 | 649 | 487 |
| total | 763 | 774 | 765 |
| Production: | | | |
| primary metal | 578 | 633 | 641 |

Alcan

Alcan is Canada's principal aluminum company, and most of its operations are in that country (see next section). In the United States, it owns the Sebree, Kentucky smelter, which it bought from Atlantic Richfield (Arco) in 1984.

Noranda

Noranda is a diversified minerals producer that is based in Canada. Its principal primary aluminum facility is its New Madrid, Missouri smelter.²³ Noranda's aluminum fabricating plants are all located in the United States. Overall Noranda's aluminum operations contributed 9 percent of the corporation's operating profit (revenues minus costs and depreciation) in 1988.²⁴

Other U.S. Producers

Independent firms held 27 percent of U.S. smelter capacity in 1988. National-Southwire ran the smelter at Hawesville, Kentucky. The company, a joint venture of National Intergroup and Southwire, had operated the plant since the late 1950s. In early 1990, Southwire bought out National Intergroup and became sole owner of the smelter. The other six independent companies are all new to the aluminum industry in the 1980s. Ormet, the largest, has a refinery in Louisiana and a smelter in Ohio. Ohio River Associates, an investor group, bought the company from Conalco (Consolidated Aluminum, a subsidiary of Alusuisse) and Revere Copper&Brass in a leveraged buyout in 1986. The purchase agreement calls for the two previous owners to receive part of Ormet product for 4 years. Montana Aluminum Investors purchased the Columbia Falls, Montana smelter from Arco in 1985. Arco had obtained the plant when it purchased Anaconda Aluminum in 1982. Columbia Falls operates the plant, which toll-converts alumina for Hydro Alumi-

²²David Humphreys, "Aluminum," *Mining Journal, Mining Annual Review*, 1989.

²³Noranda is also a partial owner of the Friguia mine and refinery in Guinea.

²⁴Noranda Annual Report, 1988.

num (Norway) and BHP (Australia). Columbia Aluminum bought the Goldendale, Washington smelter from Commonwealth Aluminum (a subsidiary of Comalco) in 1987. It tolls for Hydro Aluminum and Reynolds, and also produces metal for its own account. Vandalco (owned by Bay Resources) purchased the Vancouver, Washington smelter from Alcoa in 1987. The company produces metal for its own account. Its alumina comes from Alcoa of Australia. Northwest Aluminum (an investor group headed by a former Bonneville Power Authority executive) negotiated a lease-buy arrangement for The Dalles, Oregon smelter with Martin Marietta in 1986. Northwest Aluminum is operating the smelter under a 3- to 5-year lease, and has the option to purchase the plant when the lease expires. The plant is tolling alumina for Clarendon Ltd. Ravenswood (owned by Stanwich Partners) purchased its West Virginia smelter from Kaiser in 1988.

Canada

Canada ranks second in the smelting sector of the NSW aluminum industry. It is a much smaller refining country and has no mine capacity. The industry is based in Quebec, and to a lesser extent, British Columbia. The major foreign sources of alumina are Jamaica and Australia. Canada exports about three-quarters of its primary aluminum. During 1984-88, the United States received 75 percent of Canada's aluminum exports.

Alcan dominates the Canadian aluminum industry. It runs the country's sole alumina refinery, the Vandereuil plant in Jonquiere, Quebec. The facility supplies an estimated 30 percent of Canada's alumina needs. Its bauxite feed is imported from Brazil (mostly MRN's Trombetas mine), Guyana, and Guinea. Alcan has six Canadian smelters, five in Quebec and one in British Columbia, which account for 68 percent of the country's capacity. The largest smelter is the Arvida operation attached to the Vandereuil refinery. Alcan's foreign interests include bauxite mines in Brazil, Guinea, Ghana, Jamaica, India, and Malaysia; refineries in Australia, Brazil, Guinea, Jamaica, India, Ireland, the United Kingdom, and Japan; and smelters in Australia, the United States, Brazil, India, the United Kingdom, Japan, and Spain.

| Alcan and its share of affiliates (000s mt) | 1986 | 1987 | 1988 |
|---|--------------|--------------|--------------|
| Shipments: | | | |
| Ingot and ingot products | 731 | 787 | 832 |
| Fabricated products | 1,388 | 1,410 | 1,446 |
| Total | 2,119 | 2,197 | 2,278 |
| Production: | | | |
| Primary metal | 1,641 | 1,587 | 1,619 |

Alcan, the world's second largest aluminum company, accounted for about 12 percent of NSW primary metal production in 1988.²⁵ It is a low-cost ingot producer and is known as a fast moving company which buys and sells metal to match the rapidly shifting supply and demand levels worldwide.²⁴

The company remains committed to its traditional aluminum business. A new smelter is being built at Laterriere, Quebec to replace several potlines of similar capacity at the Arvida plant that are to be closed for environmental reasons. Facilities are being upgraded to produce higher value ingots. The company's Kemano hydroelectric plant in British Columbia is being expanded to power new smelters that will be built when market conditions are right.

Alcan is also investing in new businesses such as metal matrix composites, aluminum lithium alloys, fiber optics, ceramics, and micro separation technologies. The company has adopted a conservative approach to get into these new businesses. It is building each business step-by-step through joint research projects, small acquisitions, and strategic alliances.

There are two Canadian smelters that are not affiliated with Alcan. Both are in Quebec. The larger, and older, is the Baie Comeau operation owned by Reynolds. It currently accounts for 19 percent of the country's capacity, and is being expanded by 120,000 tpy. The other is the Becancour smelter, equally owned by Reynolds, Pechiney, Alumax, and Albecour (an arm of the Quebec Government). It started production in 1986 and accounts for about 13 percent of Canadian capacity. It is also being expanded by 120,000 tpy.

Several new smelter projects are underway in Canada. Alouette (owned by VAW, Austria Metall, Hoogovens, Albecour, Marubeni, and Kobe Steel)

²⁵Alcan owns about 13 percent of the NSW's refinery capacity.

²⁶Paulo de Sá, From *Oligopoly to Competition*, *The Changing Aluminum Industry*, Centre d'Economie des Ressources Naturelles (CERNA), Ecole Nationale Supérieure des Mines des Paris, February 1989.

has announced that it will build a new 278,000 tpy smelter at Sept-Iles, Quebec. Alumax has plans to build a 200,000 tpy smelter at Deschamault in Quebec. When the expansion projects and the new smelters have all been completed (probably in 1992), Canada will overtake the United States as the world's largest aluminum producer.

Australia

Australia is the NSW's largest bauxite miner and alumina refiner, and ranks third in aluminum smelting. It exports an estimated 95 percent of the aluminum content of its bauxite output. Of these exports, roughly one-quarter is in the form of bauxite, 60 percent is in the form of alumina, and the remainder is aluminum metal. Over half of the primary metal exports are bound for Japan, and most of the remainder go to other Asian countries.

Australia's aluminum industry is comprised of five groups of companies, Alcoa of Australia, Comalco, Gove, Worsley, and Alcan Australia. Each is affiliated with the major multinationals.

Alcoa of Australia (partially owned by Alcoa and Western Mining) is Australia's largest bauxite producing concern. It has three large mines (Jarrahdale, Huntley-Del Park, and Willowdale) and three alumina refineries in the Darling Range of Western Australia. It is the world's largest alumina seller. The company also operates two smelters, both near Melbourne in Victoria. It owns the Point Henry facility, and has a 45 percent interest in the Portland plant.²⁷

Comalco (partially owned by CRA, an RTZ affiliate) is the country's second largest producer. The company operates two mines (Weipa-Andoom and Mitchell Plateau) in northern Australia. Bauxite from the Weipa-Andoom mine is refined by Queensland Alumina or exported to Japan or Europe. Queensland Alumina (owned by Comalco, Kaiser, Alcan, and Pechiney) runs the Gladstone refinery on the east coast of Queensland. Two smelters, Boyne and Bell Bay, receive their alumina feed from Gladstone. Boyne (owned by Comalco, Kaiser, and a Japanese consortium) is located next to Queensland Alumina. Bell Bay (owned by Comalco) is located in Tasmania.

Gove (partially owned by CSR) is the common thread in the Gove Project mine and refinery and the Tomago smelter. The Gove Project (owned by Gove and Alusuisse) in the Northern Territories is managed by Nabalco. Bauxite from the mine is either refined on site or exported. Tomago (partially owned by Gove, Pechiney, and VAW) runs a smelter in New South Wales.

Australia's other producers are Worsley and Alcan Australia. Worsley (owned by Reynolds, Billiton/Shell Australia, and Kobe Alumina) runs the Mt. Saddleback mine and the Worsley refinery in the Darling Range of Western Australia. Alcan Australia runs the Kurri Kurri smelter in New South Wales.

Brazil

Brazil ranks third in the NSW in bauxite mining and fourth in aluminum smelting. The refining sector is disproportionately small, thus Brazil has net exports of bauxite and aluminum, but net imports of alumina. The bauxite is exported mostly to Canada and Venezuela. During 1984-87, Brazil exported 41 percent of its primary aluminum output, primarily to Japan, Europe, and the United States.

Mineracao Rio do Norte (MRN) is Brazil's largest bauxite mining company. The company's largest holder is the partially government-owned Companhia Vale do Rio Doce (CVRD). Lesser stakes in MRN are held by Alcan, Cia Brasileira de Alumínio (CBA), Billiton, Reynolds, and Norsk Hydro. MRN's mine at Trombetas in the State of Para accounts for about three-quarters of Brazil's bauxite production. Most of the operation's output is exported. Brazil's other mines are run by Alcan Alumínio, CBA, and Alcoa Alumínio (partially owned by Alcoa). Their bauxite is, for the most part, refined and smelted domestically.

Four companies operate both refineries and smelters in Brazil. The largest is Alumar (owned by Alcoa Alumínio and Billiton). Its facilities are located at Sao Luis, Maranhao and currently account for about 28 percent of the country's smelting capacity. The Sao Luis smelter is being expanded from 245,000 tpy to 328,000 tpy. The other refinery/smelter complexes are run by CBA (Sorocaba, Sao Paulo), Alcan Alumínio (Minas Gerais operations), and Alcoa Alumínio (Pocos de Caldas, Minas Gerais).

²⁷Alcoa (through Alcoa of Australia) owns 51 percent of the Point Henry smelter, but has access to all of the metal produced.

Two companies, Albras and Valesul, are involved only in the smelting sector. Albras (owned by CVRD and a Japanese consortium) runs a smelter at Belem, Para. A project to double the capacity of the Belem smelter is underway. Albras has been dependent on imported alumina, because finding problems stalled the construction of the nearby Alunorte refinery. The refinery should be in production by the end of 1990. Valesul (owned by CVRD, Billiton, and Reynolds) runs a smelter in Rio de Janeiro.

Jamaica

Jamaica is the fourth largest NSW miner and refiner, but has no smelting capacity. Most of the country's operations are partnerships between the government and foreign firms. The largest bauxite producer is Kaiser Jamaica (owned by the government and Kaiser). Its Water Valley mine has no associated refinery in Jamaica; most of its bauxite is sent to Kaiser's Gramercy, Louisiana plant. Three other companies operate both mines and refineries in Jamaica. Alpart (owned by Kaiser and Hydro Aluminum) has facilities at Nain. Clarendon Alumina (owned by Alcoa and the government) runs the Breadnut Valley mine and the Clarendon refinery. Jamaican (owned by Alcan and the government) has operations at Ewarton and Kirkvine.

Jamaica's alumina production was uneven in the mid- 1980s. The government and the companies disagreed on whether or not to close various facilities. Alumina export levies and sagging alumina markets (especially the closures of U.S. Gulf Coast smelters) were at the center of the disputes. These problems have generally been resolved. Significant expansion projects are being considered by Alcan, Alpart, and Comalco.

Guinea

Guinea, which ranks second in NSW bauxite output, is the world's largest bauxite exporting country. It has little refinery capacity and no smelting capacity.

The Sangaredi-Boke mine is Guinea's largest mine, accounting for about two-thirds of the country's capacity. It is run by Compagnie des Bauxites de Guinea (CBG) which is owned by the government and Halco (a consortium of Alcoa, Alcan, Pechiney, VAW, Comalco, Alumina SpA, Reynolds, and

Billiton). Most of the bauxite is shipped under long-term contracts to refineries in Europe and the United States. The Endasa plant in Spain and Aughinish plant in Ireland are major recipients.²⁸

The next largest mine, Debele, is run by the state-owned Offices de Bauxites de Kindia (OBK). The Soviet Union helped finance the mine and takes a large portion of its output under a barter arrangement. The remaining mine, and the sole refinery, are run by Friguia. The company is owned by the government and Frialco (a consortium of Noranda, Pechiney, British Alcan, Alusuisse, and VAW).

India

India is currently a medium-sized bauxite miner and alumina refiner. It will become a comparable aluminum smelter when ongoing expansion projects are completed in the early 1990s. There are four integrated companies producing aluminum in India. Nalco and Bharat are both owned by the government. Indalco is partially owned by Alcan. Hindalco, until recently, was partially owned by Kaiser. A fifth, smaller company, Malco operates a refinery and smelter, but has no mines.

Suriname

Suriname, once the third largest bauxite miner, is a medium-sized bauxite producer with a small amount of refining and smelting capacity. Suralco (owned by Alcoa) and Billiton operate facilities in the country. Suralco runs a mine and a smelter. Suralco and Billiton jointly own another mine and a refinery.

Yugoslavia

Energoinvest (owned by the government) is Yugoslavia's largest aluminum producer. It runs four mines, two refineries, and a smelter. About half of its alumina production is smelted domestically, and half is exported, primarily to the Soviet Union. The government also owns the country's three other smelters.

Greece

Greece exports most of its bauxite. Parnasse, the country's largest bauxite producer, accounts for over half of the country's output. The company exports about 60 percent of its bauxite primarily to the

²⁸Annual Review of the World Aluminum Industries 1985, Shearson Lehman Brothers.

Eastern bloc and Europe. Greek Helikon, another bauxite producer, also exports much of its product. Elbaumin (owned by the government) sends its bauxite to the country's only refinery and smelter, run by Aluminium de Grece (partially owned by Pechiney). Hellenic Alumina (ELVA) is constructing an alumina plant at Thisbi. The plant, which is being partially funded by the Soviet Union, is scheduled for completion in 1992. All of the refinery's output will be exported to the Soviet Union.

Guyana

Guyana has three mines and is estimated to produce 60 percent of the world's nonmetallurgical grade bauxite. It exports most of its product. Guyana nationalized its industry in 1971.

Sierra Leone

Sierre Leone Ore and Metals (SIEROMCO), owned by Alusuisse, is the country's the sole producer. It exports all of its bauxite, primarily to Europe.

Venezuela

Venezuela has carved out a niche as an alumina refiner. It imports bauxite and exports alumina. The country currently has ambitious plans to expand its capacity in the smelting sector. The industry is dominated by the state-owned Corporation Venezolana de Guayana (CVG). The company has some stake in all of the country aluminum operations.

Venezuela began bauxite production with the opening of the Bauxiven (owned by CVG and Alusuisse) Los Pijiguaos mine in 1987. The mine is expected to produce 4 million tpy of bauxite at full capacity. At this rate, Venezuela would be the fifth largest bauxite producer.

Inter-alumina (owned by CVG and Alusuisse) runs the country's sole refinery. It is located at Ciudad Guayana next to two smelters. The larger smelter is run by Venalum (owned by CVG and a consortium of six Japanese companies). The other is operated by Alcasa (owned by CVG and Reynolds).

Venezuela is undergoing an aggressive expansion program to take advantage of its vast bauxite resources and its position as the world's lowest cost aluminum producing country. The Interalumina refinery is being enlarged. The Venalum and Alcasa smelters, with a current capacity of 600,000 tpy, are to be expanded to about 860,000 tpy in the early 1990s. Furthermore, **seven other CVG-associated** companies Alisa, Alamsa, Aluguay, Alusur, Aluyana, Vexxal, and Angostura have construction plans.²⁹ If all of the plans were realized, Venezuela's capacity would rise to 1.4 million tpy by 1994 (2.0 million tpy by 2000) and the country would be among the top three or four NSW aluminum smelters.³⁰ However, the construction schedules are far from certain. The government has proposed delaying five of the seven planned smelters, because of financial problems. Only Alisa has arranged the financing necessary to begin construction on its 120,000 tpy facility.

Norway

Norway produces no bauxite or alumina, but is the world's fifth largest aluminum smelter. It exports about 90 percent of its production, primarily to West Germany, the Netherlands, Italy, and the United Kingdom.

Norway's industry is comprised of three firms. Hydro Aluminum (owned by Norsk Hydro) is the largest. It has four smelters and accounts for almost three-quarters of Norway's capacity. Hydro Aluminum has tolling agreements with Columbia Falls and Columbia Aluminum in the United States, and owns a share of Alpart in Jamaica, to enhance its geographical diversification.³¹ Norway's other producers are Mosal (owned by Alcoa and Elkem) with two smelters and Soral (owned by Norsk Hydro and Alusuisse) with one smelter.

West Germany

After Norway, the largest of the European producers is West Germany. Its refinery production is handled by three firms, Aluminium Oxide Stade, Alusuisse, and VAW. Aluminium Oxide Stade (owned by Reynolds and VAW accounts for almost

²⁹Among CVG's partners in these ventures are Austria Metall and Pechiney for Alamsa, and Alcoa and Sural for Alusur, possibly Alusuisse and Alumax for Aluguay. Alamsa will build its smelter in neighboring Guyana.

³⁰"Venezuela Boosts Aluminum Output," *Engineering and Mining Journal*, May 1988. David Humphreys, "Aluminum," *Mining Journal*, *Mining Annual Review*, 1988.

³¹David Humphreys, "Aluminum," *Mining Journal*, *Mining Annual Review*, 1988.

60 percent of the country's refinery capacity. The major suppliers of concentrates are Australia, Guinea, and Sierra Leone.

Four firms are involved in the smelting sector. VAW owns about half of the capacity and Alusuisse, through two subsidiaries, accounts for a quarter. The others are Hamburg Aluminum (owned by Reynolds, VAW, and the City of Hamburg) and Hoogovens. Imports of alumina come primarily from Australia, Italy, and Guinea.

France

France's sole aluminum producer is Pechiney (owned by the government). The company is the largest aluminum producer in Europe and the fourth largest in the world. It has interests in bauxite mines in France, Guinea, and Greece; refineries in France, Guinea, Greece, and Australia; and smelters in France, Greece, the Netherlands, Australia, and Canada. Pechiney has a 30 percent interest in the 180,000 tpy Alamsa smelter being proposed in Venezuela. It announced in 1988 that it would build a new 210,000 tpy state-of-the-art smelter in Dunkerque, France. It recently purchased American National Can to enhance its fabricating capabilities in the United States.

Switzerland

Switzerland produces little aluminum, but is home to Alusuisse. The company (also called Swiss Aluminum) is the smallest of the majors. It owns major shares of bauxite mines in Australia, Sierra Leone, and Guinea; refineries in Australia and West Germany; and smelters in Norway and West Germany. Minor interests are held in mines and refineries in Venezuela.

In 1987, 69 percent of Alusuisse's sales came from aluminum products and the remainder came from chemicals. The aluminum was sold mostly as fabricated products (64 percent), but also as primary metal (20 percent), and bauxite and alumina (10 percent). The major markets were Europe and, to a

lesser extent, North America. Because of the weak European markets of the mid-1980s, the company retreated from raw material production and expanded into fabricated products.

Alusuisse's corporate strategy calls for a partial withdrawal from primary metal to concentrate on specialized, high-value aluminum products and ceramics, composites, and chemicals. The company's primary metal capacity has been pared to less than half of the 800,000 tpy it once was. About 30 to 40 percent of the metal required by the fabricating operations must be brought from outside the corporation. The smelter capacity that remains is relatively high cost. The alumina and fabricated products segments are somewhat healthier.³²

The Middle East

There are several producers in the Middle East taking advantage of the low-cost energy (based on natural gas) in that region. The current producers are Alba (partially owned by Reynolds) in Bahrain and Dubai Aluminum in the United Arab Emirates. Capacity in the region is currently being expanded considerably. Alba is expanding its smelter from 180,000 tpy to 225,000 tpy in a program to be completed in 1990. The Bahrain Government is considering further expanding the plant to 400,000 tpy. A consortium of Chinese, U. S., and British investors have plans to build a 240,000 tpy smelter in Qatar, UAE to be completed in 1992. Alujain (controlled by Saudi shareholders) has talked of building a 220,000 tpy smelter in Saudi Arabia.³³

Other Countries

Other producers include: Aluminio Espanol and Endasa in Spain; British Alcan and Anglesey Aluminum in the United Kingdom; Hoogovens in the Netherlands; Alumina SpA in Italy; Austria Metall and Salzburger (Alusuisse) in Austria; Grange Aluminum in Sweden; and Aughinish (owned by Alcan and Billiton) in Ireland.

³²Paulo de Sá, *From Oligopoly to Competition: The Changing Aluminum Industry*, Centre d'Economie des Ressources Naturelles (CERNA), Ecole Nationale Supérieure des Mines des Paris, February 1989.

³³David Humphreys, "Aluminum," *Mining Journal, Mining Annual Review*, 1989.