Chapter 5
Zinc Industry

INTRODUCTION

Zinc has been used in brass and bronze since ancient times. The metal was produced in its elemental form much later. In the 20th century, the invention of froth flotation spurred zinc production and the development of galvanizing increased its use.

Uses

Zinc is the third most used nonferrous metal, after aluminum and copper. Most primary zinc is recovered as slab. The largest use of slab zinc is for galvanizing (and electrogalvanizing), an application which accounted for 51 percent of U.S. consumption in 1988. Other uses include zinc-based die-cast alloys (23 percent), brass alloys (13 percent), chemicals, and dusts. The galvanized products are used in the steel, automobile, and construction industries. No substitute for galvanizing exists for protecting large tonnage iron and steel products from corrosion. Secondary zinc, most of which comes from new scrap, is used to produce brass and bronze (46 percent of 1988 domestic use), slab zinc (26 percent), chemicals (18 percent), and dusts (7 percent).

Production Methods and Technologies

Zinc is produced mostly from the sulfide ores: sphalerite (ZnS) and marmatite ([Zn,Fe]S). These ores, also known as zinc blende, are commonly associated with galena, the principal lead ore. Over 80 percent of nonsocialist world (NSW) zinc mines are underground operations. After mining, the ore is crushed, ground and subjected to several froth flotation steps to remove the lead, iron, and gangue (waste rock). The resulting zinc concentrates typically contain 50 to 64 percent zinc. These beneficiation steps are performed at the minesite.

At the smelter/refinery, zinc is produced by one of several processes that smelt and refine the metal simultaneously. Regardless of the process, the concentrates are first roasted into zinc-oxide materials. In roasting, the concentrates are burned in the presence of oxygen (usually from air) thus forming crude zinc oxides and gaseous sulfur dioxide. Most modern roasters are fluid-bed reactors.

The crude oxide is then smelted/refined by electrolytic or pyrometallurgical methods. The electrolytic process is the most common method, accounting for about 80 percent of NSW smelting/refining capacity. In the first step of this process, the crude oxide feed is leached with sulfuric acid to produce a zinc sulfate solution. This is then purified and pumped into electrolytic cells. The cells use lead-silver anodes and aluminum cathodes. Upon application of the current, the zinc in the solution is reduced and pumped into electrolytic cells. The cells use lead-silver anodes and aluminum cathodes. Upon application of the current, the zinc in the solution is reduced and deposited on the cathode. The cathode is stripped periodically and the zinc metal is cast into ingots. Virtually all impurities remaining from the preparation processes are eliminated. Electrolytic zinc needs no further refining. Purity normally exceeds 99.95 percent and can possibly be 99.995 percent or better.

In the pyrometallurgical production methods, the crude zinc oxides from the roaster are first sintered in a Dwight-Lloyd moving grate machine or a rotary kiln to yield a homogeneous feed. The sinter is then heated to above 1,832 °F (a temperature at which zinc is vapor) in the presence of a reducing agent (chiefly carbon monoxide) in one of four types of furnaces. This reduces and vaporizes the zinc, which is then collected in a condensation vessel.

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3Zinc oxide ores, which have declined in importance since the development of the froth flotation process, and other zinc bearing secondary materials are generally not concentrated at the minesite. They are pyrometallurgical concentrates at the smelter in a Waelz rotary kiln or slag fuming.
4The four pyrometallurgical production technologies are: the horizontal (Belgian) retort, the vertical (New Jersey) retort, the electrothermic (St. Joseph) retort, and the blast (Imperial Smelting) furnace. The Imperial Smelting Process (ISP), which is used primarily in Europe, Japan and Australia, is the most common. It is basically a lead blast furnace with a zinc recovery system added. It can treat mixed zinc and lead concentrates, low-grade concentrates, and oxide concentrates. The Belgian process, the oldest, is a batch method. The New Jersey and St. Joseph methods are continuous processes. A fifth pyrometallurgical technology, the Soviet-developed Kivcet process, has found limited use. It can process lead-zinc concentrates directly, thus eliminating the need for sintering.
Most of the impurities are eliminated to the furnace residues. Zinc recovered by any of the pyrometallurgical methods is less than 99 percent pure. The quality is adequate for hot-dip and continuous line galvanizing, and for some brass uses. However, for die casting, the zinc must be further refined. Fractional distillation is the most common method of upgrading the lower purity zinc.

THE 1980s

The U.S. zinc market started the 1980s on a mixed note (see figures 5-1 and 5-2). Prices (averaging $0.37/lb) in 1980 were slightly higher than those of the late 1970s. In 1980, domestic mine production (349,000 tonnes) was higher than it had been in the two previous years, but below what it had been for most of the 1970s. Slab zinc production (370,000 tonnes) was much lower in 1980 than it had been in previous years.

The price of zinc, unlike those of the other metals in this study, remained above its 1980 level for the entire decade. The greatest increase came in the late 1980s, when zinc prices rose from $0.42/lb in 1987 to $0.83/lb in 1989. U.S. mine production fell during 1980-86. It rose in the later years, but ended the decade down 20 percent. Primary refined production, which declined sharply in 1982, finished the decade down 26 percent.

Secondary zinc increased its importance in the market during the 1980s. In 1989, it accounted for 23 percent of slab zinc production in the United States. Most secondary material is recovered as products other than slab zinc. The extensive use of zinc in galvanizing and other dissipative uses limits the potential for increased recycling. New scrap is principally zinc alloy and brass from manufacturing operations.

U.S. slab zinc consumption rose throughout most of the 1980s. Its only large decline came during the recession in 1982. Consumption in 1989 was 21 percent greater than that in 1980 (but only 8 percent greater than the 1975-79 average). Most zinc used in the United States is imported. In 1989, total U.S. slab production (primary and scrap-based) amounted to only 34 percent of domestic consumption.

In the nonsocialist world, zinc output and use rose fairly steadily during the decade (see figure 5-3). NSW production and consumption in 1988 were both around 5.2 million tonnes, which represented a 17 percent increase over the 1980 levels.

The openings, closings, and ownership changes that occurred in the U.S. primary zinc industry during the 1980s are profiled in table 5-1. Two new zinc mine (Pierrepont and Ward Mountain) and two zinc-producing precious metals mines (Greens Creek and Montana Tunnels) opened during the decade. In addition, zinc is recovered from the West Fork lead mine which opened in 1985. The Butte Hill zinc-lead-silver mine, which had been closed since the early 1970s, reopened in 1990. The Red Dog zinc-lead mine is slated to begin full production in 1990. Five zinc mines were permanently closed in the 1980s. In the processing sector, three smelter/refineries were closed permanently and no new ones opened. During 1980-88, U.S. primary slab zinc capacity declined 44 percent to 320,000 tonnes.

Aeco-Union Miniere (based in Belgium) increased its position in the U.S. zinc industry in the 1980s. It acquired full control of Jersey Miniere in 1984 and purchased the USX zinc facilities in 1989. Horsehead Industries entered the industry by purchasing zinc facilities from New Jersey Zinc and

5These figures represent the slab zinc recovered from both new and old scrap. Old scrap comes from discarded products, new scrap is waste from fabricating and other manufacturing processes. In 1988, 342,000 tonnes of secondary zinc were recovered from old scrap (97,000 tonnes) and new scrap (245,000 tonnes), and recovered as slab zinc (89,000 tonnes) and other products (254,000 tonnes). James H Jolly, “Zinc,” Minerals Yearbook, vol. I, 1988 ed. (Washington, DC: U.S. Department of the Interior, Bureau of Mines, 1990).
Fluor (St. Joe). It merged them into a venture called the Zinc Corporation of America (ZCA). Other new zinc mining companies include Doe Run, Montana Tunnels, Greens Creek, Washington Mining, Bunker Hill Mining, Star-Phoenix Mining, New Butte Mining, Alta Gold, and Cominco-NANA. Big River is the only new zinc processor. It purchased the Sauget, Illinois facility from Amax in 1988. Five companies (New Jersey Zinc, USX, Bunker Hill, Amax, and Standard Metals) left the U.S. industry during the 1980s.

**PRODUCER PROFILES, 1990**

Most zinc is produced in industrialized countries (see figure 5-4). Compared with copper, very little zinc capacity is government-owned. Developed countries account for about 70 percent of mine capacity and even greater percentages of primary smelter/refinery capacity. Canada is the largest producer in both the mining and processing sectors. Australia is a large mine producer and a medium-sized processor. Peru and Mexico have large mine production, but little processing capacity. Japan and European countries are large refined zinc producers. The United States has a medium-sized zinc industry.

In most parts of the world, zinc and lead are mined and processed together. The situation is somewhat different in the United States. The U.S. zinc and lead industries are relatively separate, though there are some domestic mines that produce both metals.

**United States**

The United States is a medium-sized zinc producer. It ranks sixth in the NSW in mine output and eighth in primary metal production. The country was a net importer of zinc concentrates during 1983-88, but a net exporter in 1989. For refined (slab) zinc, the United States is dependent on imports for about two-thirds of its needs. The major suppliers during 1985-88 were Canada (accounting for 56 percent of imports), Mexico, and Spain. Slab exports are small.


**Asarco**

Asarco is the largest U.S. zinc mining company (see figure 5-5). Most of its production is from its four mines in eastern Tennessee, but some also comes from its Missouri lead mines and its partially owned Leadville, Colorado operation. These facilities accounted for 37 percent of U.S. zinc mine

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In this report, little distinction is made between the smelting and refining sectors of the zinc industry. One or the other, but not both, of the processing steps is usually sufficient to produce marketable zinc.
Table 5-1—Profile of U.S. Primary Zinc Production Industry, 1980 and 1990

<table>
<thead>
<tr>
<th>1980</th>
<th>1990</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Major mines:</strong></td>
<td></td>
</tr>
<tr>
<td>Ward Mountain, NV</td>
<td>Alta Gold</td>
</tr>
<tr>
<td>Young, TN</td>
<td>Asarco</td>
</tr>
<tr>
<td>Immel, TN</td>
<td>Asarco</td>
</tr>
<tr>
<td>New Market, TN</td>
<td>Asarco</td>
</tr>
<tr>
<td>Coy, TN</td>
<td>Asarco</td>
</tr>
<tr>
<td>Beaver Creek, TN</td>
<td>New Jersey Zinc*</td>
</tr>
<tr>
<td>Jefferson City, TN</td>
<td>New Jersey Zinc*</td>
</tr>
<tr>
<td>Elwood-Gordonville, TN</td>
<td>Jersey Miniere*</td>
</tr>
<tr>
<td>Freidensville, PA</td>
<td>New Jersey Zinc*</td>
</tr>
<tr>
<td>Austinville/Ivanhoe, VA</td>
<td>New Jersey Zinc*</td>
</tr>
<tr>
<td>Idaho, TN</td>
<td>New Jersey Zinc*</td>
</tr>
<tr>
<td>Zinc Mine Works, TN</td>
<td>US Steel (USX)</td>
</tr>
<tr>
<td>Balmat, NY</td>
<td>St. Joe</td>
</tr>
<tr>
<td>Sterling, NJ</td>
<td>New Jersey Zinc*</td>
</tr>
<tr>
<td><strong>Mixed lead-zinc mines:</strong></td>
<td></td>
</tr>
<tr>
<td>Leadville, CO</td>
<td>Asarco-Newmont*</td>
</tr>
<tr>
<td>Bunker Hill, ID</td>
<td>Bunker Hill Mining</td>
</tr>
<tr>
<td>Red Dog, AK</td>
<td>Cominco-NANA*</td>
</tr>
<tr>
<td>Butte Hill, MT</td>
<td>New Butte Mining</td>
</tr>
<tr>
<td>Star-Morning Unit, ID</td>
<td>Bunker Hill-Hecla*</td>
</tr>
<tr>
<td><strong>Lead mines:</strong></td>
<td></td>
</tr>
<tr>
<td>West Fork, MO</td>
<td>Asarco</td>
</tr>
<tr>
<td>Magmont, MO</td>
<td>Cominco-Dresser*</td>
</tr>
<tr>
<td>Buick, MO</td>
<td>Amax-Homestake*</td>
</tr>
<tr>
<td>Montana Tunnels, MT</td>
<td>Montana Tunnels*</td>
</tr>
<tr>
<td>Sunny side, CO</td>
<td>Standard Metals</td>
</tr>
<tr>
<td><strong>Smelter/refineries:</strong></td>
<td></td>
</tr>
<tr>
<td>Corpus Christi, TX</td>
<td>Asarco</td>
</tr>
<tr>
<td>Sauget, IL</td>
<td>Big River</td>
</tr>
<tr>
<td>Kellogg, ID</td>
<td>Bunker Hill*</td>
</tr>
<tr>
<td>Clarksville, TN</td>
<td>Jersey Miniere*</td>
</tr>
<tr>
<td>Monaca, PA</td>
<td>St. Joe</td>
</tr>
<tr>
<td>Bartlesville, OK</td>
<td>National Zinc</td>
</tr>
<tr>
<td>Palmetton, PA</td>
<td>New Jersey Zinc*</td>
</tr>
<tr>
<td><strong>Precious metals mines:</strong></td>
<td></td>
</tr>
<tr>
<td>Greens Creek, AK</td>
<td>Greens Creek*</td>
</tr>
<tr>
<td>Lucky Friday, ID</td>
<td>Hecla</td>
</tr>
<tr>
<td>Montana Tunnels, MT</td>
<td>Montana Tunnels*</td>
</tr>
<tr>
<td><strong>Note:</strong></td>
<td></td>
</tr>
</tbody>
</table>

1New Jersey Zinc was a subsidiary of Gulf and Western Industries Inc.
2Jersey Miniere was a subsidiary of New Jersey Zinc and Union Miniere.
3Union Miniere is a subsidiary of Union Zinc. Union Zinc is a subsidiary of
4Ace-Union and Cimiero.
5Zinc Corp. of America (ZCA) is a subsidiary of Horsehead Industries.
6Asarco-Newmont each own 50 percent of the Leadville mine. Asarco is the
7operator.
8Bunker Hill was a subsidiary of Gulf Resources and Chemical Corp.
9Cominco-Alaska developed and operates the Red Dog mine. NANA owns
10the mineral rights.
11The Star Morning Unit was owned 70% by Bunker Hill and 30% by Hecla.
12It was operated by Hecla.
13Cominco and Dresser Industries each own 50 percent of the Magmont
14mine. Cominco is the operator.
15Amag and Homestake each own 50 percent of the Buick mine.
16Bunker Hill and Franklin are joint ventures.
17Asarco share of Jersey Miniere sold to Union Miniere.
18New Jersey Zinc share of Jersey Miniere sold to Union Miniere.
19*Zinc assets of Fluor (St. Joe) sold to Horsehead Industries and merged
20with New Jersey Zinc Co. Inc. (NJZI) to form Zinc Corp. of America (ZCA)
21in 1987.
22Sold to Horsehead Industries investment group and operated as New
23Zinc Corp. of America (NJZI) in 1991.
24Bunker Hill Mine was sold to Bunker Hill Ltd. partnership in 1982. Bunker
26Leads of Fluor (St. Joe) and Homestake merged to form Doe Run
27in 1986. Doe Run was owned 57.5% by Fluor and 42.5% by Homestake
28in 1988. Fluor became sole owner by purchasing Homestake's share
29in 1990.
30Exploration and development by Noranda 1981-86, British Petroleum
311986-1988; Hecia became a minority partner 1987; RTZ became majority
33Owned by U.S. Minerals Exploration (USMX); explored by Placer
34Development 1981-82, Centennial Minerals 1983-85; Centennial Minerals
35acquired by Pegasus Gold in 1985; USMX share sold to Pegasus Gokt
36in 1987.
37Echo Bay and Altai Gold (owned by Silver King and Pacific Silver) formed
38the Altai Bay Venture in June 1988. Altai Bay is 60% owned by Altai Gold
39and 40% owned by Echo Bay. Echo Bay contributed the Sunnyside, CO
40mine and other properties to the venture. Washington Mining (which owns
41the property) became a 35% partner in November 1988 and the mine
42operator in January 1989. Altai Bay owns the remaining 650.

Chapter 5--Zinc Industry

Figure 5-4--NSW Zinc Production, Country Profile, 1988

NOTE: Secondary production is refined metal recovered from old and new scrap.
SOURCE: Metal Statistics, Metallgesellschaft Aktiengesellschaft.

output in 1988. The company sells and/or tolls most of its zinc concentrate production. Asarco no longer has slab zinc processing capacity. It converted its Corpus Christi, Texas refinery to a hazardous waste processing facility in 1988. It does, however, operate a zinc-oxide plant at Hillsboro, Illinois.

Jersey Miniere

Jersey Miniere is the second largest domestic zinc producer. The company accounted for an estimated 20 percent of U.S. mine production and 29 percent of refinery capacity in 1988. Jersey Miniere’s operation is fully integrated. It has a mine and a smelter/refinery in central Tennessee. In addition, its parent Union Zinc, purchased The Zinc Mine Works in Jefferson City, Tennessee from USX in 1989. With this additional capacity, the company’s U.S. mines can provide two-thirds of the concentrate feed needed by its Clarksville refinery.

Jersey Miniere is owned by Union Zinc, a subsidiary of Belgium-based Acec-Union Miniere (the nonferrous and nonmetallic minerals unit of Societe Generale de Belgique). Acec-Union Miniere

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7 This figure includes entire production of the Leadville mine.
Figure 5-5—U.S. Zinc Industry, Company Profile, 1988

![Graph showing mine production and slab capacity for various companies.]

Mine Production
256,000 tonnes

- Asarco 31%
- Leadville 5%
- Jersey Miniere (est) 20%
- Doe Run 9%
- Montana Tunnels 7%
- ZCA (est) 13%
- Magmont 3%
- Other 11%

Slab Capacity
323,000 tonnes

- Big River 24%
- ZCA 47%
- Jersey Miniere 29%

NOTE: Mine production figures for Jersey Miniere and ZCA are OTA estimates. Jersey Miniere's mine production includes that of the USX mine purchased in 1989. About one-third of ZCA’s slab capacity is used to process secondary zinc.


is one of the world’s largest zinc and lead producers. Its other lead and zinc interests include Metallurgie Hoboken-Overpelt (MHO), Vieille-Montagne, and Asturienne. Acec-Union Miniere began reorganizing its operating units in early 1990.

Zinc Corporation of America

Zinc Corporation of America (ZCA) is also a fully integrated producer. It accounted for an estimated 13 percent of the country’s mine production and almost one-half of the refinery capacity in 1988. ZCA has two mines in New York, a smelter/refinery in Pennsylvania, and a refinery in Oklahoma. It also processes steelmaking dusts into zinc at a plant in Pennsylvania.

ZCA, a subsidiary of Horsehead Industries Inc., was formed in 1987. It represents the merger of Horsehead’s St. Joe operation (acquired from Fluor in 1987) and its New Jersey Zinc facilities (acquired in 1981).

Doe Run

Doe Run, the largest U.S. lead company, produces some byproduct zinc at its Buick mine. It accounted for 9 percent of U.S. zinc mine output in 1988.

Montana Tunnels


Cominco

Cominco is a major Canadian minerals company that is among the world’s largest lead and zinc producers. It is developing the Red Dog mine in Alaska, which is scheduled to begin production in 1990. This mine has estimated ore reserves of 77 million tonnes grading 17.1 percent zinc, 5 percent lead, and 80 grams/tonne silver. At its planned annual production of 325,000 tonnes of zinc in concentrates, Red Dog will be the world’s largest zinc mine. It will nearly double U.S. zinc mine

9Cominco-Alaska is developing the mine and will operate it when it is commissioned. NANA (an Alaskan Native corporation) owns the mineral rights to the property.
production over 1989 levels. The mine will ship half of its concentrates to Cominco’s Trail zinc-lead smelter in British Columbia and the rest to coastal smelters in the Far East and Europe.\footnote{Losti, of the Division of Geological and Geophysical Surveys, Alaska’s Mineral Industry, Special Report 43, 1988.}

Cominco also owns half of the Magmont lead-zinc mine in Missouri. Magmont, which is currently the second largest lead mine in the country, accounted for 3 percent of U.S. zinc mine production in 1988. Dresser, a machinery manufacturer, is the other owner of Magmont.

**Big River**

Big River bought the Sauget, Illinois smelter/refinery from Amax Zinc in 1988. The plant accounts for about a quarter of domestic zinc processing capacity. The company has no mines.

**Other Companies**

The other major firms in the U.S. zinc industry are mining companies. Alta Gold recently opened a zinc mine in Nevada. Bunker Hill Mining, Star-Phoenix Mining, and New Butte Mining operate lead-zinc mines. Hecla, Greens Creek (a joint venture of RTZ, Hecla, Exalas Resources, and CSX Oil & Gas), and Washington Mining (in partnership with Alta Gold and Echo Bay) produce zinc from precious metals mines.

**U.S. Interests in Other Countries**

The U.S.-based companies that currently have foreign lead-zinc holdings are: Asarco, Phelps Dodge, and Cerro Copper. Asarco has ties to MIM, a large Australia-based producer of nonferrous metals and coal.\footnote{Asarco owns 19 percent of MIM, and MIM owns 25 percent of Asarco. The relationship is one of passive ownership and entails little operational control.} MIM has lead facilities in Australia (Mt. Isa mine) and the United Kingdom (the Britannia refinery) as well as equity interests in Cominco. Asarco also owns part of Medimsa which runs silver-lead-copper-zinc mines, mills, and smelters in Mexico. Phelps Dodge is primarily a copper company, but owns part of Black Mountain, a major lead-silver-zinc-copper mine in South Africa. Cerro Copper has interests in the Buenaventura zinc-lead mines in Peru. Two other U.S. firms have recently sold their foreign lead and zinc holdings. Amax sold its share of Fresnillo in Mexico. USX sold its share of the exhausted Prieska mine in South Africa.

**Other Countries**

Zinc and lead are often produced by the same set of countries and companies. To avoid repetition, the profiles of zinc and lead producers outside of the United States are given in chapter 4 only.