

# **2006 Minerals Yearbook**

# CADMIUM

# CADMIUM

### By Amy C. Tolcin

# Domestic survey data and tables were prepared by Barbara J. McNair, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

In 2006, estimated cadmium metal production in the United States was 700 metric tons (t), a 52% decrease from that of 2005 (table 1). Metal production decreased in 2006 as a result of the temporary shutdown of the Big River Zinc complex in Sauget, IL. Apparent consumption of cadmium was 561 t, a 20% decrease from that of 2005. Cadmium metal, including alloys and waste and scrap, was primarily exported to the Republic of Korea (49%), China (18%), and the United Kingdom (17%) (table 3). Australia (49%) and Canada (19%) supplied the bulk of the corresponding imports (table 4). In 2006, the monthly average New York dealer price of cadmium metal was \$2.98 per kilogram (\$1.35 per pound), a decrease of 10% from the average price in 2005.

In 2006, world refined production of cadmium was 19,300 t. Most of the world's primary cadmium (approximately 50%) was being produced in Asia and the Pacific—specifically China, Japan, and the Republic of Korea—followed by North America (20%), Central Eurasia (16%), and Europe (12.5%). Global secondary cadmium production accounted for approximately 19% of all refined cadmium production, and this percentage was expected to increase in the future (Hugh Morrow, International Cadmium Association, unpub. data, 2007). Most secondary metal was produced from nickel-cadmium (NiCd) battery recycling. There were three major NiCd collection and recycling programs in the world—the Rechargeable Battery Recycling Corp. (RBRC) program in the United States and Canada, the Battery Association of Japan program, and the CollectNiCad program in Europe.

World refined cadmium consumption in 2006 increased slightly from that of 2005 (World Bureau of Metal Statistics, 2007). Leading consumers of refined cadmium included Belgium, China, and Japan. NiCd battery production was the leading end use of cadmium, accounting for approximately 83% of global cadmium consumption. Rechargeable NiCd batteries are used in portable consumer products (for example, appliances, power tools, and toys) and in industrial applications as a source of emergency power. Other end uses of cadmium include alloys, anticorrosive coatings, pigments, polyvinylchloride stabilizers, and semiconducting compounds for solar cells. The percentage of cadmium consumed globally for NiCd battery production has been increasing, while the percentages for the other traditional end uses of cadmiumspecifically, coatings, pigments, and stabilizers-have gradually decreased because of environmental and health concerns. Most of the NiCd battery market is concentrated in Asia. In 2005 (latest data available), Asia accounted for approximately 85% of NiCd battery sales. Japan, alone, constituted 35% of global NiCd battery sales (Global Industry Analysts, Inc., 2006, p. II-19).

#### Production

*Primary.*—In 2006, all primary cadmium in the United States was recovered from lead and/or zinc concentrates, with zinc-

to-cadmium ratios in typical zinc ores ranging from 200:1 to 400:1. Lead and/or zinc concentrate-producing States included Alaska, Idaho, Missouri, Montana, New York, and Washington. At least 11 mines produced lead and/or zinc concentrates, the largest being the Red Dog Mine in Alaska. Red Dog, the leading zinc mine in the world, is operated by Teck Cominco Alaska, Inc. (a subsidiary of Teck Cominco Limited, Canada) under an agreement with the NANA Regional Corporation, Inc. Analyses of trace elements in sphalerite samples at Red Dog have shown that the mean percentage by weight of cadmium in yellowbrown sphalerite was 0.5%. Yellow-brown sphalerite is the most abundant of the four types of sphalerite found in the Red Dog deposits and is volumetrically the most significant sulfide in the ores. Tan sphalerite found in late-stage breccias averaged 0.6% cadmium and was enriched in germanium relative to the earlier three types (Kelley and others, 2004). In 2006, the Red Dog operation produced 557,500 t of zinc in concentrate, a decrease of 2% from 568,000 t produced in 2005. Reduced production was attributed to lower zinc grades, compensated partially by increased mill throughput. Approximately 25% of Red Dog's zinc concentrates was refined in Canada at Teck Cominco's Trail smelter in British Columbia. The remaining concentrates were shipped to Asia and Europe (Teck Cominco Limited, 2007, p. 18). The Greens Creek Mine on Admiralty Island, near Juneau, AK, was the second leading producer of zinc concentrate in the United States. The mine is a joint venture of Kennecott Minerals Co. (70.3%) and Hecla Mining Co. (29.7%). Teck Cominco's Pend Oreille zinc-lead mine in northeast Washington was in third place.

The zinc operations of Asarco LLC (Tucson, Arizona) in northeastern Tennessee were idle in 2006 and did not produce any byproduct cadmium. Asarco suspended operations at its Coy, Immel, and Young underground mines (formerly known as the Tennessee Mines Division) in November 2001 following a period of sustained low zinc prices. The Young Mill at Strawberry Plains (Jefferson County) was placed on care-andmaintenance status at the same time. Historically, the combined output of the three mines reportedly has been about 56,800 metric tons per year (t/yr) of zinc in concentrate (Asarco, Inc., 2001). On May 19, Asarco sold the Coy, Immel, and Young Mines to Glencore International AG (Baar, Switzerland). Glencore planned to reopen the mines in 2007 and created the East Tennessee Zinc Co. to manage operations (Mining Engineering, 2007).

On November 9, 2005, HudBay Minerals, Inc. (Winnipeg, Manitoba, Canada) announced that it would reopen its Balmat No. 4 Zinc Mine in New York State. The underground mine, located on the western edge of Lawrence County, had been on care and maintenance since 2001. Some sphalerite at Balmat reportedly contains 1,200 to 1,400 micrograms of cadmium per gram of zinc sulfide (Doe, 1960, p. 94). In May, St. Lawrence Zinc (a wholly owned subsidiary of HudBay) began preproduction of zinc concentrate at Balmat No. 4. According to company officials, the Balmat Mine has 2.08 million metric tons (Mt) of ore reserves averaging 10.8% zinc and 1.45 Mt of additional, less defined resources averaging 12.8% zinc. By yearend 2006, the mine had produced 9,037 t of zinc in concentrate. All of the 2006 output reportedly was sold to Xstrata plc (Zug, Switzerland). In 2008, Balmat is expected to reach full production capacity—60,000 t/yr of zinc in concentrate, which equates to approximately 200 t/yr of cadmium. Concentrates will be primarily sent to Xstrata's Canadian Electrolytic Zinc refinery (Salaberry-de-Valleyfield, Quebec, Canada), located 158 kilometers (km) from the mine (HudBay Minerals, Inc., 2007, p. 23, 30).

Primary cadmium has been traditionally refined in two States—Illinois (Big River Zinc) and Tennessee (Clarksville). Operating since 1929, the Big River Zinc complex (BRZ) in Sauget, IL, has historically been an electrolytic zinc refinery. Zinc concentrates had previously been sourced from Illinois, Missouri, and Tennessee. In 1997, Korea Zinc Co. Ltd. purchased BRZ for \$50 million and then spent more than \$80 million upgrading the operation. As BRZ's source mines began to close, Korea Zinc idled the Sauget plant and put it up for sale in December 2005 (Lerner, 2005). In June 2006, ZincOx Resources plc (Surrey, United Kingdom) acquired BRZ with the intent of building a new leach and purification circuit designed to produce secondary zinc from electric arc furnace dust (EAFD) (ZincOx Resources plc, 2006). EAFD, a waste product generated by the steel industry, averages 0.05% cadmium by weight.

Clarksville, owned and operated by Zinifex Ltd. (Melbourne, Australia), is located in Montgomery County, TN, 80 km northwest of Nashville. Clarksville is the smallest of Zinifex's smelting and refining complexes and had a production capacity of 115,000 t/yr of zinc metal in 2006. The complex also produces approximately 145,000 t/yr of byproduct sulfuric acid. Much of the cadmium produced at Clarksville in 2006 was recovered from zinc concentrates imported from Australia, Central America, Ireland, and South America. Zinifex's Century Mine in northwest Queensland produced 19% of the Australian zinc concentrate. Prior to 2004, Clarksville obtained the bulk of its cadmium-bearing zinc concentrates from the Gordonsville and Clinch Valley Mines in Tennessee, which were formerly operated by Pasminco Limited. Gordonsville (Smith County) was closed in 2003; Clinch Valley (Grainger County), in 2004.

*Secondary.*—Secondary cadmium in the United States was produced by the International Metals Reclamation Company, Inc. (INMETCO) (a subsidiary of CVRD Inco Limited, Brazil) at its metals recovery facility in Ellwood, PA. The cadmium recovery plant, which began operating in December 1995, thermally recovers cadmium from recycled NiCd batteries, including those collected by the Rechargeable Battery Recycling Corporation (RBRC). Both large industrial NiCd batteries (such as those used in various utilities as a source of backup power) and small consumer NiCd batteries are recycled. The bulk of the cadmium is sold back to battery manufacturers. Chromium and nickel are also reclaimed in the recovery process as a ferrous remelt alloy for stainless steel production.

#### Recycling

Various States and cities prohibit the disposal of NiCd batteries as municipal solid waste, including California, Florida, Iowa, Maine, Maryland, Minnesota, New Jersey, New York City, Rhode Island, and Vermont. INMETCO has developed several different collection programs to help battery manufacturers and consumers comply with the various State laws and regulations. The most successful recycling program in the United States is operated by RBRC. Established when INMETCO began cadmium recycling in 1995, RBRC has organized a multifaceted collection program. The program is financed with proceeds from licensing its seal of approval to individual companies involved in the importation, manufacturing, and distribution of rechargeable batteries or battery-operated products. The RBRC recycling program, Call2Recycle, facilitates uniform battery labeling, removeability from appliances, a national network of collection systems, regulatory relief to facilitate battery collection, and widespread publicity to encourage public participation. To increase participation, RBRC has undertaken an extensive public education campaign and has established numerous collection sites throughout the United States and Canada (Money and others, undated). In 2006, RBRC collected 2,540 t [5.6 million pounds (Mlbs)] of rechargeable batteries-the majority of which was from the United States, an increase from the approximate 2,300 t (5 Mlbs) that was collected in 2005. In terms of weight, NiCd batteries were the leading type of rechargeable battery collected (Linda Gabor, Manager of Marketing and Media Relations, Rechargeable Battery Recycling Corporation, written commun., April 20, 2007). Since 2005, business participation in RBRC's recycling program had increased 48%; community and public agency participation, 23%; and retailer participation, 18% (Rechargeable Battery Recycling Corporation, 2007).

Although NiCd battery recycling rates have increased and the consumption of NiCd batteries has decreased in the United States, only a small fraction of cadmium continues to be recycled when compared with the total amount of cadmium contained in all retired NiCd batteries for a given year. In 2005 (latest data available), the total cadmium recovery rate was 12%. It was estimated that in the 10-year period between 1996 and 2005, some 40,000 t of cadmium was not recycled. About 20,000 t was discarded as municipal solid waste, while the other 20,000 t remained in temporary storage—for example, household storage or industry stockpiles (D.R. Wilburn, Physical Scientist, U.S. Geological Survey, unpub. data, September 2006).

#### Prices

Platts Metals Week publishes a weekly and monthly New York Dealer price for cadmium (minimum 99.95% purity) in dollars per pound. The monthly average New York Dealer price of cadmium in 2006 was \$2.98 per kilogram (\$1.35 per pound). During early 2006, cadmium prices fell sharply. Chinese buyers reportedly stayed off the market and drew down material from excess stocks built up during the second half of 2005. In April, prices began to rise after Chinese and Indian battery manufacturers returned to the market. Prices then turned downward during the summer—a decline largely attributed to temporary oversupply rather than a lack of demand. The cadmium price for December was \$3.86 per kilogram (\$1.75 per pound).

#### Legislation

In California, temporary disposal exemptions that allowed residents to continue discarding batteries with other household trash ended on February 8. Beginning on February 9, all batteries in California were considered universal (hazardous) waste and had to be either recycled or taken to a hazardous waste disposal facility (California Department of Toxic Substances Control, 2006). Furthermore, the Rechargeable Battery Recycling Act of 2006 required California retailers who sold rechargeable batteries to accept and collect used rechargeable batteries for recycling without charge as of July 1. Rechargeable batteries include lithium ion, nickel cadmium, nickel metal hydride, and small sealed lead. RBRC provided battery collection plans to retailers free-of-cost (Rechargeable Battery Recycling Corporation, 2006).

New York City's Rechargeable Battery Law (Local Law 97 of 2005) took effect on December 1, 2006. Similar to California's Rechargeable Battery Recycling Act, New York City's battery law prohibits consumers from discarding rechargeable batteries. Any New York City store that sells rechargeable batteries, with the exception of food stores with less than 14,000 square feet of display space, must accept rechargeable batteries for recycling free-of-charge. Retailers were encouraged to join RBRC's Call2Recycle Program at no cost to facilitate compliance. The manufacturers are required to pay for the collection and disposal of batteries (New York City, 2005).

In Europe, the European Commission issued a revised battery directive (2006/66/EC) in September repealing the 1991 battery directive (91/157/EEC). Both directives regulated battery waste in the environment by restricting certain types of batteries and requiring Member States to organize national battery collection and recycling programs. The 1991 directive applied to only 7% of all portable batteries placed on the market, making collection and recycling programs difficult to implement and confusing to consumers. Directive 2006/66/EC, which will take effect on September 26, 2008, applies to all portable batteries. The directive specifies that all NiCd batteries containing more than 0.002% cadmium by weight are to be banned from the market. However, NiCd batteries used in certain cordless power tools, emergency systems, and medical equipment are exempt. Each year, approximately 800,000 t of automotive batteries, 190,000 t of industrial batteries, and 160,000 t of portable consumer batteries enter the European Union (EU) marketplace. The mandated collection rate for portable batteries is 25% after 6 years and 45% after 10 years. A recycling rate of 75% for cadmium-containing batteries, 65% for lead-containing batteries, and 50% for all other batteries is to be met after 3 years. If the target collections and recycling requirements outlined under the revised directive are achieved, an estimated 1,500 t of cadmium will be recovered each year (European Commission, 2006b, p. 3, 7, 8).

The EU's "Restriction of the Use of Hazardous Substances" (RoHS) directive (2002/95/EC) went into effect on July 1, 2006. Adopted in February 2003, the RoHS directive prohibits manufacturers from incorporating heavy metals (cadmium, hexavalent chromium, lead, and mercury) into most electrical and electronic devices sold in the EU after the 2006 deadline. The directive covers computers, DVD players, electronic tools and toys, household appliances, radios, telephones, televisions, and many other products. However, RoHS does not directly apply to NiCd batteries. Cadmium plating of electronic circuitry is specifically exempted from the RoHS directive (European Commission, 2006a, p. 11).

The EU's Council of Environmental Ministers formally adopted the "Registration, Evaluation, and Authorization of Chemicals" (REACH) regulation in December. The purpose of REACH is to better identify the properties of chemical substances manufactured and traded in the EU and to place greater responsibility on industry for managing risks associated with hazardous chemicals. REACH will require producers and importers to register all chemicals brought to the EU market in quantities greater than 1 ton. An independent agency, the European Chemicals Agency, will be established to oversee the administrative, scientific, and technical aspects of the policy. Registration information of all chemicals will be evaluated for environmental and health risks. If a chemical is determined to pose an unacceptable risk, its use in consumer products may be restricted, or it may be completely banned. Enforcement of REACH policy was to begin in June 2007, with the European Chemicals Agency beginning operations in June 2008 (European Commission, 2007, p. 2, 3, 6). United States chemical firms have begun working through industry associations, consortia, and customer-supplier negotiations to facilitate compliance by the June 2007 deadline. The Synthetic Organic Chemical Manufacturers Association has already created ChemSortia, a consortium of international testing programs and laboratory partnerships designed to help manufacturers and downstream users comply with REACH. Some think that any future amendments to the Environmental Protection Agency's Toxic Substances Control Act may be loosely based on REACH legislation (Sissell, 2007). Common cadmium compounds include-cadmium hydroxide and cadmium oxide for NiCd batteries, cadmium sulphides for pigments, cadmium carboxylates for polyvinylchloride stabilizers, and cadmium telluride for photoelectric and photovoltaic devices.

In February 2006, China issued the "Measures for Administration of the Pollution Control of Electronic Information Products." The regulations were to take force on March 1, 2007, and were designed to reduce pollution from the toxic components of electronic waste and encourage the production of more environmentally friendly electronic products. Toxic substances mentioned in the measures include cadmium, hexavalent chromium, lead, mercury, polybrominated biphenyls, and polybrominated diphenyl ethers. The Ministry of Information Industry of the People's Republic of China will regulate the program and create mandatory standards for both the manufacturers and importers (Ministry of Commerce of the People's Republic of China, 2006).

#### World Review

*Canada.*—In 2006, Canada produced approximately 549 t of recoverable cadmium in zinc-lead concentrates, a 24% decrease from 723 t produced in 2005. Production of refined cadmium increased by 21% to 2,094 t (Natural Resources Canada, 2007). Leading Canadian producers of refined cadmium included Falconbridge Limited<sup>1</sup> (Toronto, Ontario), HudBay Minerals, Inc. (Winnipeg, Manitoba), and Teck Cominco Limited (Vancouver, British Columbia).

Noranda Income Fund (partially owned by Falconbridge, now a subsidiary of Xstrata) produced cadmium at the Canadian Electrolytic Zinc refinery (CEZinc) near Montreal. CEZinc produces zinc and various byproducts, including copper cake and sulfuric acid. In 2005 (latest data available), CEZinc produced 429 t of refined cadmium, a 24% increase from that of yearend 2004 (Noranda Income Fund, 2006).

Teck Cominco has been producing approximately 1,000 t/yr of refined cadmium at its Trail Metallurgical Complex (owned and operated under the subsidiary Teck Cominco Metals) in British Columbia. Refined zinc and lead metal are the major products produced at Trail along with a number of byproducts that include copper compounds, germanium dioxide, gold, indium, silver, and sulphur. The Trail cadmium plant was constructed in 1991 to handle the increased cadmium input from the Red Dog Mine in Alaska and can produce up to 1,400 t/yr of refined cadmium (Teck Cominco Limited, undated, p. 13). Cadmium metal products, which are mostly consumed by NiCd battery manufacturers, include balls, billets, and sticks. Teck Cominco also produces cadmium chemicals and continuously cast cadmium sheet. Cadmium sheet is commonly used to shield radiation measurement and control devices from slow neutrons.

*China.*—Battery producers in Japan and the Republic of Korea, such as Matsushita Electric Industrial Co., Ltd. and Sanyo Electric Co., Ltd., have relocated production operations to China in recent years in order to take advantage of the country's growing economy and lower labor costs. As a result, China's NiCd production of and demand for cadmium have increased substantially. According to China's General Administration of Customs, in 2006, China imported 9,347 t of cadmium metal, an increase of 37.4% from that of 2005. The top five suppliers of cadmium to China were the Republic of Korea (2,332 t), Kazakhstan (2,270 t), Mexico (1,059 t), Canada (827 t), and Japan (604 t). Total value of 2006 imports was \$22.5 million, an 86% increase from the total value in 2005 (Metal-Pages, 2007).

On September 14, the cadmium export tax rebate in China was cut from 13% to zero. Contracts signed before September 14 were allowed to keep the rebate until December 14 (Metal Bulletin, 2006b).

Leading producers of refined cadmium in China were Huludao Zinc Smelter (Liaoning Province), Shaoguan Smelter (Guangdong Province), and the Zhuzhou Lead-Zinc Smelter (Hunan Province). Several smelters closed between late 2005 and early 2006 after two toxic spills involving cadmium took place. In December 2005, Shaoguan was temporarily shut down after a cadmium spill in the nearby Beijiang River was discovered. The smelter did not resume operations until late February 2006. Authorities closed more than 30 arsenic and cadmium smelters in Hunan Province after a cadmium spill took place in the Xiangjiang River in early January.

*Korea, Republic of.*—Korea Zinc Co., Ltd. (Seoul) is one of the largest suppliers of cadmium metal to China. Production capacity of refined cadmium at Korea Zinc's leading smelter, the Onsan zinc-lead refinery in Kyoung Nam Province, is approximately 3,000 t/yr. Korea Zinc (under the subsidiary Sorin Corporation, Seoul) exported a total of 2,400 t of cadmium in its 2005 financial year, mostly to NiCd battery manufacturers (Korea Zinc Co., Ltd., 2006, p. 23, 30). In 2007, Korea Zinc reportedly was expecting to reduce its exposure to cadmium's market volatility by cutting spot sales of cadmium 30% and increasing sales volumes in its contract negotiations with Chinese, European, and Indian buyers. Approximately 40% of Korea Zinc's monthly cadmium sales are on the spot market (Metal Bulletin, 2006a).

*Mexico.*—Refined cadmium in Mexico is mainly produced by Met-Mex Peñoles S.A. de C.V. (a subsidiary of Industrias Peñoles S.A. de C.V.) and Minera Mexico S.A. de C.V. (a subsidiary of Grupo México S.A. de C.V.). In 2006, Met-Mex Peñoles produced 993 t of refined cadmium at its electrolytic zinc refinery at the Peñoles Metallurgical Complex located in Torreon, Coahuila (Industrias Peñoles S.A. de C.V., 2007). Minera Mexico, owned by Southern Copper Corporation, traditionally produces an estimated 1,000 t of 99.95% cadmium at its electrolytic zinc refinery in San Luis Potosi. In early 2006, a fire in the zinc refinery hampered production. The refinery did not become fully operational until third quarter 2006. As a result, San Luis Potosi produced only 408 t of refined cadmium in 2006, down from 706 t in 2005 (Southern Copper Corporation, 2007, p. 34).

#### Outlook

Concern over cadmium's toxicity has spurred various recent legislative efforts, especially in the EU, to restrict the use of cadmium in most of its end-use applications. The final effect of these legislations on global cadmium consumption has yet to be seen. The percentage share of NiCd batteries in the rechargeable battery market has already been on the decline since the mid-1990s. NiCd batteries accounted for 56% of the rechargeable battery market 10 years ago. By 2006, that percentage had decreased to 18%. World sales of NiCd batteries have also decreased substantially. During the past year alone, global sales of NiCd batteries decreased by approximately 16% from that of 2005 (Battery Association of Japan, 2006). However, demand for cadmium may increase owing to several new market opportunities for NiCd batteries, particularly in industrial applications. NiCd batteries currently power approximately 80% of battery electric vehicles in circulation and are also used as a source of power in a limited number of hybrid electric vehicles. A small community on Utsira Island in Norway relies completely on renewable energy that is backed up by NiCd batteries. The community consumes energy generated by a wind power and hydrogen storage installation that is buffered by a 37kilowatthour NiCd battery system. The battery system provides up to 30 minutes of emergency power (Saft Groupe S.A., 2006).

<sup>&</sup>lt;sup>1</sup>Xstrata plc acquired Falconbridge Limited in November 2006.

Primary cadmium production may increase in 2007 as zinc concentrate production was forecast by the International Lead and Zinc Study Group to increase by 9.4%. However, primary producers may opt to voluntarily cutback primary cadmium production. High zinc prices have recently allowed smelters to discard byproduct cadmium as hazardous waste rather than process it. If recent legislation involving cadmium dramatically reduces long-term demand, a situation could arise, such as has been recently seen with mercury, where an accumulating oversupply of byproduct cadmium will need to be permanently stockpiled.

#### **References Cited**

Asarco, Inc., 2001, Asarco announces plans to suspend zinc operations in Tennessee: Phoenix, AZ, Asarco, Inc. news release, October 29, 2 p.

Battery Association of Japan, 2006, Secondary battery sales statistics by volume: Tokyo, Japan, Battery Association of Japan, 1 p. (Accessed June 22, 2007, at http://www.baj.or.jp/e/statistics/index06.html.)

California Department of Toxic Substances Control, 2006, Sunset of the temporary disposal exemptions for universal waste—frequently asked questions (FAQs): Sacramento, CA, California Department of Toxic Substances Control, February 23, 6 p. (Accessed June 22, 2007, at http://www.dtsc.ca.gov/HazardousWaste/UniversalWaste/upload/ Temporary\_Disposal\_Exemption\_FAQ\_02-23-061.pdf.)

Doe, B.R., 1960, The distribution and composition of sulfide minerals at Balmat, New York: Pasadena, CA, California Institute of Technology, Ph.D. dissertation, 236 p.

European Commission, 2006a, Frequently asked questions on Directive 2002/95EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS) and Directive 2002/96/EC on waste electrical and electronic equipment (WEEE): Brussels, Belgium, European Commission, 19 p. (Accessed June 22, 2007, at http://ec.europa.eu/environment/waste/pdf/faq\_weee.pdf.)

European Commission, 2006b, Questions and answers on the new battery directive: Brussels, Belgium, European Commission, 13 p. (Accessed June 22, 2007, at http://ec.europa.eu/environment/waste/batteries/pdf/qa.pdf.)

European Commission, 2007, Questions and answers on REACH: Brussels, Belgium, European Commission, February, 37 p. (Accessed March 21, 2007, at http://ec.europa.eu/environment/chemicals/pdf/qa.pdf.)

Global Industry Analysts, Inc., 2006, Cadmium—A global strategic business report: San Jose, CA, Global Industry Analysts, Inc., 107 p.

HudBay Minerals, Inc., 2007, Annual report—2006: Winnipeg, Manitoba, Canada, HudBay Minerals, Inc., 96 p.

Industrias Peñoles S.A. de C.V., 2007, Production volumes: Col. Polanco, Mexico, Industrias Peñoles S.A. de C.V., 1 p. (Accessed May 9, 2007, at http://www.penoles.com.mx/penoles/ingles/invest/info\_operativa/ volumen\_produccion/anual.php.)

Kelley, K.D., Leach, D.L., Johnson, C.A., Clark, J.L., Fayek, M., Slack, J.F., Anderson, V.M., Ayuso, R.A., and Ridley, W.I., 2004, Textural, compositional, and sulfur isotope variations of sulfide minerals in the Red Dog Zn-Pb-Ag deposits, Brooks Range, Alaska—Implications for ore formation: Economic Geology, v. 99, no. 7, November, p. 1509-1532. Korea Zinc Co. Ltd., 2006, Annual Report—2005: Seoul, Republic of Korea, Korea Zinc Co. Ltd., 45 p.

Lerner, Matthew, 2005, Big River Zinc set to halt output as costs take toll: New York, NY, American Metal Market LLC, 2 p. (Accessed August 10, 2006, at http://www.findarticles.com/p/articles/mi\_m3MKT/is\_47-4\_113/ ai\_n15933906.)

Metal Bulletin, 2006a, Korea Zinc looks to cut spot cadmium sales in 2007: Metal Bulletin, no. 8971, November 20, p. 16.

Metal Bulletin, 2006b, Minor metals in 'Mexican standoff' after rebate tax changes: Metal Bulletin, no. 8963, September 25, p. 17.

Metal-Pages, 2007, Chinese Cd imports surge; value soars: Metal-Pages, February 14, 1 p. (Accessed March 9, 2007, via http://www.metal-pages.com.)

Mining Engineering, 2007, Zinc mining to return to three sites in Tennessee: Mining Engineering, v. 59, no. 1, January, p. 26.

Ministry of Commerce of the People's Republic of China, 2006, Measures for administration of the pollution control of electronic information products: Beijing, China, Ministry of Commerce of the People's Republic of China, May 9, 7 p. (Accessed May 14, 2007, at http://english.mofcom.gov.cn/ aarticle/policyrelease/domesticpolicy/200605/20060502132549.html.)

Money, Kenneth, Tomaszewski, Mark, and Bleakney, Russell, [undated], Pyrometallurgical battery reclamation at the International Metals Reclamation Company: Ellwood City, PA, The International Metals Reclamation Company, Inc., 16 p.

Natural Resources Canada, 2007, Canada selected metal statistics: Ottawa, Ontario, Canada, Natural Resources Canada, 2 p.

New York City, 2005, NYC rechargeable battery law—Local law 97 2005: New York, NY, 5 p.

Noranda Income Fund, 2006, Annual information form: Toronto, Ontario, Canada, Noranda Income Fund, March 24, p. 9. (Accessed May 30, 2007, at http://www.norandaincomefund.com/pdfs/AIF NIF 2006 FINAL.pdf.)

Rechargeable Battery Recycling Corporation, 2006, Rechargeable Battery Recycling Corporation (RBRC) provides solution for retailers seeking to comply with California's new Rechargeable Battery Recycling Act: Atlanta, GA, Rechargeable Battery Recycling Corporation news release, June 28, 2 p.

Rechargeable Battery Recycling Corporation, 2007, The Rechargeable Battery Recycling Corporation reports year-end collection numbers: Atlanta, GA, Rechargeable Battery Recycling Corporation news release, January 9, 2 p.

Saft Groupe S.A., 2006, Saft rechargeable Ni-Cd batteries help Norway's Utsira Island community to become renewable energy self-sufficient: Paris, France, Saft Groupe S.A. news release, August 29, 2 p.

Sissell, Kara, 2007, U.S. firms brace for Reach backlash: Chemical Week, March 28, p. 23.

Southern Copper Corporation, 2007, Form 10-K—2006: Phoenix, AZ, Southern Copper Corporation, 168 p.

Teck Cominco Limited, [undated], Cominco Trail Operations: Vancouver, British Columbia, Canada, Teck Cominco Limited, 31 p.

Teck Cominco Limited, 2007, Annual Report—2006: Vancouver, British Columbia, Canada, Teck Cominco Limited, 117 p.

World Bureau of Metal Statistics, 2007, Cadmium, *in* World Bureau of Metal Statistics Yearbook 2007: Ware, Herts, United Kingdom, World Bureau of Metal Statistics, p. 20-21.

ZincOx Resources plc, 2006, Big River Zinc Smelter acquisition agreement signed: Bagshot, Surrey, United Kingdom, ZincOx Resources plc news release, June 5, 3 p.

TABLE 1
SALIENT CADMIUM STATISTICS <sup>1, 2</sup>

		2002	2003	2004	2005	2006 <sup>e</sup>
United States:						
Production of metal <sup>3</sup>	metric tons	1,280 <sup>r</sup>	1,450 <sup>r</sup>	1,480 <sup>r</sup>	1,470 <sup>r</sup>	700
Shipments of metal by producers <sup>4</sup>	do.	1,470 <sup>r</sup>	1,200 <sup>r</sup>	1,410 <sup>r</sup>	1,680 <sup>r</sup>	1,010
Exports of metal, alloys, scrap	do.	264	615	154	686	483
Imports for consumption, metal, alloys, and	d scrap do.	81	112	263	288	180
Stocks of metal, U.S. Government, yearend	ď do.	146				
Apparent consumption of metal	do.	1,700 <sup>r</sup>	1,020 <sup>r</sup>	1,840 <sup>r</sup>	699 <sup>r</sup>	561
Price, average, New York dealer <sup>6</sup>	dollars per pound	0.29	0.59	0.55	1.50	1.35
Do. <sup>6</sup>	dollars per kilogram	0.64	1.31	1.20	3.30	2.98
World, refinery production	metric tons	17,800 <sup>r</sup>	18,700 <sup>r</sup>	19,400 <sup>r</sup>	19,700 <sup>r</sup>	19,300

<sup>e</sup>Estimated. <sup>r</sup>Revised. -- Zero.

<sup>1</sup>Data are rounded to no more than three significant digits, except prices.

<sup>2</sup>Cadmium content

<sup>3</sup>Primary and secondary cadmium metal. Includes equivalent metal content of cadmium sponge used directly in production of compounds.

<sup>4</sup>Includes metal consumed at producer plants to make oxide and other cadmium compounds.

<sup>5</sup>Defense National Stockpile Center, December 31. Includes material for sale pending shipment.

<sup>6</sup>Price for 1 - to 5-short ton lots of metal having a minimum purity of 99.95% (Platts Metal Week).

TABLE 2
SUPPLY AND APPARENT CONSUMPTION OF CADMIUM METAL <sup>1, 2</sup>
(Metric tons)

	2002	2003	2004	2005	2006 <sup>e</sup>
Producer stocks, January 1 <sup>3</sup>	1,340 <sup>r</sup>	1,360 <sup>r</sup>	1,430 <sup>r</sup>	1,170 <sup>r</sup>	1,540
Production <sup>3</sup>	1,280 <sup>r</sup>	1,450 <sup>r</sup>	1,480 <sup>r</sup>	1,470 <sup>r</sup>	700
Imports for consumption, metal, alloys, and scrap	81	112	263	288	180
Shipments from Government stockpile excesses	627	146			
Total supply	3,320 <sup>r</sup>	3,070 <sup>r</sup>	3,170 <sup>r</sup>	2,930 <sup>r</sup>	2,420
Exports of metal, alloys, scrap	264	615	154	686	483
Producer stocks, December 31 <sup>3</sup>	1,360 <sup>r</sup>	1,430 <sup>r</sup>	1,170 <sup>r</sup>	1,540 <sup>r</sup>	1,380
Consumption, apparent <sup>4</sup>	1,700 <sup>r</sup>	1,020 <sup>r</sup>	1,840 <sup>r</sup>	699 <sup>r</sup>	561

<sup>e</sup>Estimated. <sup>r</sup>Revised. -- Zero.

<sup>1</sup>Data are rounded to no more than three significant digits, except prices.

 $^{2}$ Excludes supply and apparent consumption of cadmium sulfide, cadmium telluride, and related cadmium chemicals.

<sup>3</sup>Partially estimated.

<sup>4</sup>Total supply minus exports and yearend stocks.

TABLE 3

#### U.S. EXPORTS OF CADMIUM PRODUCTS, BY COUNTRY AND TYPES<sup>1</sup>

	200	5	2006		
	Quantity		Quantity		
	(kilograms)	Value	(kilograms)	Value	
Cadmium metal: <sup>2</sup>					
Canada	- 8,590	\$211,000	25,200	\$192,000	
China	337,000	421,000	87,900	183,000	
France	34,800	129,000	31,400	109,000	
Germany	275	118,000	5,220	1,650,000	
Israel	112	16,000	12,000	52,500	
Korea, Republic of	295,000	343,000	236,000	260,000	
Mexico	110	56,400	2,000	34,200	
Singapore	6,690	37,000	2,080	8,200	
Switzerland	629	4,510			
Taiwan	2,810	27,800			
United Kingdom			80,000	1,370,000	
Other			1,160	12,700	
Total	686,000	1,360,000	483,000	3,870,000	
Of which:					
Unwrought and powder	141	7,270	17,800	118,000	
Waste and scrap	17,900	25,900	5,140	1,530,000	
Other	668,000	1,330,000	460,000	2,210,000	
Total	686,000	1,360,000	483,000	3,870,000	
Cadmium sulfide, gross weight:					
Australia	12,900	6,710			
Canada	89,400	38,900			
Chile	5,830	3,030			
Germany	4,820	2,510			
Israel			9,110	4,740	
Malaysia			9,550	4,970	
Mexico			38,500	20,000	
Philippines			4,860	2,530	
Switzerland	7,440	3,870			
Total	120,000	55,000	62,000	32,200	
Total, calculated Cd content	93,700	XX	48,200	XX	

XX Not applicable. -- Zero.

<sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Includes exports of cadmium in alloys (Schedule B 8107.90) and scrap (Schedule B 8107.30).

TABLE 4

#### U.S. IMPORTS OF CADMIUM PRODUCTS, BY COUNTRY AND TYPES<sup>1</sup>

	200	)5	2006		
	Quantity	Quantity			
	(kilograms)	Value	(kilograms)	Value	
Cadmium metal: <sup>2</sup>	-				
Australia	53,000	\$126,000	88,300	\$239,000	
Belgium	12,100	192,000	6,400	102,000	
Canada	41,400	1,000,000	34,200	494,000	
China	39,000	116,000			
Germany	243	37,300	17,400	117,000	
Hong Kong	5,650	22,500			
India			23,000	81,100	
Japan			15	16,300	
Mexico	97,000	239,000	454	3,440	
Peru	40,000	89,000	10,000	30,800	
Russia	3	24,300			
Taiwan			322	26,000	
Total	288,000	1,850,000	180,000	1,110,000	
Of which:					
Unwrought and powder	207,000	811,000	179,000	902,000	
Waste and scrap					
Other	81,300	1,040,000	1,220	207,000	
Total	288,000	1,850,000	180,000	1,110,000	
Cadmium sulfide, gross weight:					
Canada			51	13,100	
China	50	5,000			
Russia	6,890	47,000	113,000	311,000	
United Kingdom	1,810	22,600	2,270	26,600	
Total	8,760	74,600	115,000	350,000	
Total, calculated Cd content	6,810	XX	89,700	XX	

XX Not applicable. -- Zero.

<sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Includes imports of cadmium in alloys [Harmonized Tariff Schedule of the United States (HTS) 8107.90] and waste and scrap (HTS 8107.30).

## TABLE 5 CADMIUM: WORLD REFINERY PRODUCTION, BY COUNTRY<sup>1,2</sup>

#### (Metric tons)

Country <sup>3</sup>	2002	2003	2004	2005	2006 <sup>e</sup>
Algeria <sup>e</sup>	8	5			
Argentina		25	39 <sup>r</sup>	3 <sup>r</sup>	10
Australia	370 <sup>r</sup>	350 <sup>e</sup>	469 <sup>r</sup>	429 <sup>r</sup>	400
Belgium	117				
Brazil <sup>4</sup>	151	189	187	200	200 <sup>p</sup>
Bulgaria	345	307	356	319	319
Canada <sup>5</sup>	1,706	1,759	1,880	1,703	1,710 <sup>p</sup>
China <sup>e</sup>	2,440	2,710	2,800	3,000	3,000
Finland <sup>6</sup>	4	<sup>e</sup>			
France <sup>6</sup>	63	120 <sup>r</sup>	120 <sup>r</sup>	100 <sup>r</sup>	100
Germany	422	640	640 <sup>e</sup>	640 <sup>e</sup>	640 <sup>e</sup>
India	466	477	489	409 <sup>r</sup>	453 <sup>7</sup>
Italy	391	22			
Japan	2,444	2,497	2,233	2,297	2,287 7
Kazakhstan	1,300	1,351	1,900	2,000	2,000
Korea, North <sup>e</sup>	200	200	200	200	200
Korea, Republic of	1,825	2,175	2,362	2,582 <sup>r</sup>	3,249 7
Macedonia <sup>e</sup>	111	75			
Mexico <sup>8</sup>	1,382	1,590	1,594	1,627 <sup>r</sup>	1,400
Netherlands	485	495	572	575	570
Norway	209	331	260	260	153
Peru	422	529	532	481	416 7
Poland, metal, primary refined	440	375	356	350	356 <sup>7</sup>
Russia <sup>e</sup>	950	950	950	1,000	1,100
Ukraine <sup>e</sup>	25	25	25	25	25
United Kingdom	292	22			
United States	1,280 <sup>r</sup>	1,450 <sup>r</sup>	1,480 <sup>r</sup>	1,470 <sup>r</sup>	700
Total	17,800 <sup>r</sup>	18,700 <sup>r</sup>	19,400 <sup>r</sup>	19,700 <sup>r</sup>	19,300

<sup>e</sup>Estimated. <sup>p</sup>Preliminary. <sup>r</sup>Revised. -- Zero.

<sup>1</sup>This table gives unwrought production from ores, concentrates, flue dusts, and other materials of both domestic and imported origin. Sources generally do not indicate if secondary metal (recovered from scrap) is included or not; where known, this has been indicated by a footnote. Data derived in part from World Metal Statistics (published by World Bureau of Metal Statistics, Ware, United Kingdom) and from Metal Statistics (published jointly by Metallgesellschaft AG of Frankfurt am Main, Germany, and World Bureau of Metal Statistics). Cadmium is found in ores, concentrates, and/or flue dusts in several other countries, but these materials are exported for treatment elsewhere to recover cadmium metal; therefore, such output is not reported in this table to avoid double counting. This table includes data available through May 8, 2007.

<sup>2</sup>World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown. <sup>3</sup>Romania, Thailand, and Uzbekistan may produce primary cadmium metal or oxide, but information is inadequate to make reliable estimates of output.

<sup>4</sup>Exports from Anuário Mineral Brasileiro (Departamento Nacional de Produção Mineral).

<sup>5</sup>Includes secondary.

<sup>6</sup>Excludes secondary production from recycled nickel-cadmium batteries.

<sup>7</sup>Reported figure.

<sup>8</sup>Excludes significant production of both cadmium oxide and cadmium contained in exported concentrates.