USGS
science for a changing world

2009 Minerals Yearbook

SELENIUM AND TELLURIUM

U.S. Department of the Interior
U.S. Geological Survey

August 2011

Selenium and Tellurium

By Micheal W. George

Domestic survey data and tables were prepared by Maria Arguelles, statistical assistant, and the world production tables were prepared by Glenn J. Wallace, international data coordinator.

In 2009, the average U.S. dealers' prices for commercial-grade selenium and tellurium lump and powder declined from those of yearend 2008. Estimated global consumption for both metals also declined. One copper refinery in Texas reported domestic production of primary refined selenium and tellurium. Domestic production of selenium and tellurium decreased in 2009 as did estimates of global production.

Selenium and tellurium were recovered as byproducts of nonferrous metal mining, mostly from the anode slimes associated with electrolytic refining of copper. Selenium and tellurium were also recovered as byproducts from gold, lead, nickel, platinum, and zinc mining.

In a 2006 survey of 56 worldwide electrolytic copper refiners, 52 and 45 plants, respectively, reported selenium and tellurium in their anode slimes. The selenium-containing slimes averaged 7% selenium by weight, with a few containing as much as 25% selenium. Tellurium concentrations were generally lower and averaged 2% (Moats and others, 2007, p. 202–241).

Selenium and tellurium can also be recovered economically from industrial scrap and chemical process residues. Obsolete and damaged photoreceptor drums from plain paper copy machines have been shipped by manufacturers to refineries for recovery of selenium and tellurium metal. The supply of old drums, however, has declined in recent years and now appears to be nearly exhausted.

Production

Asarco LLC's (Tucson, AZ) copper refinery in Amarillo, TX, was the only U.S. producer of refined selenium and tellurium. One copper refinery produced and exported semirefined material containing 90% selenium plus tellurium for toll-refining in Asia. Two other refineries generated selenium- and tellurium-containing slimes that were exported for processing. Most of the selenium and tellurium contained in domestic anode slimes came from copper ores in Arizona and Utah. One refinery processed anodes imported from Canada. Domestic production of selenium and tellurium decreased in 2009 compared with that of 2008.

Asarco had operated under bankruptcy protection since August 2005. In 2009, Grupo Mexico S.A.B. de C.V. (Mexico City, Mexico) (the parent company of Asarco) regained control of the Asarco refinery and on December 9, Asarco was fully released from its legal contingencies and exited bankruptcy protection (Grupo Mexico S.A.B. de C.V., 2010, p. 2).

With the higher price of tellurium that persisted during 2007–09 and projected increases in demand, tellurium was increasingly viewed as a valuable byproduct. This helped stimulate exploration for gold-telluride ores, including some early stage projects in the Western United States.

Consumption

Selenium.—In 2009, world consumption of selenium was estimated to be lower than revised 2008 consumption data owing to the global economic downturn. Compared with revised 2008 consumption levels, consumption of selenium was estimated to be down by 10% to 20% in the glass industry, by 15% in the electrolytic manganese industry, and by 40% in the animal feed and agriculture industry. Selenium used in chemical and pigments applications in 2009 was down slightly compared with that in 2008. Other metallurgical, electronic, and other applications in 2009 were estimated to be higher compared with 2008 consumption levels (Metal-Pages, 2009g). The estimated global distribution of consumption of selenium by application was metallurgy, 35%; glass manufacturing, 25%; agriculture, 10%; chemicals and pigments, 10%; electronics, 10%; and other, 10%. This represents a significant shift in the demand pattern; glass manufacturing was the leading end use for selenium for more than a decade.

The main use for selenium in metallurgical end uses was for the production of electrolytic manganese in China where selenium dioxide (SeO_2) was substituted for sulfur dioxide to reduce the power required to operate electrolytic cells. In 2009, demand for selenium by electrolytic manganese metal producers in China decreased compared with that in 2008 owing to decreased consumption of electrolytic manganese metal by steel producers. About 2 kilograms of SeO_2 were used per metric ton of electrolytic manganese metal produced (Selenium-Tellurium Development Association, 2002; Metal-Pages, 2009c).

Metallurgical-grade selenium was used as an additive to cast iron, copper, lead, and steel alloys to improve machinability and casting and forming properties. In the United States, selenium was used as an alloy with bismuth to substitute for lead in plumbing fixtures in response to requirements of the Safe Drinking Water Act Amendments of 1996 (Public Law 104–182) to reduce lead in potable water supplies. In lead-acid storage batteries, the addition of a small amount, about 0.02% by weight, of selenium to low-antimony lead alloys used in the support grids improves the casting and mechanical properties of the alloy.

Selenium was used to decolorize the green tint caused by iron impurities in container glass and other soda-lime silica glass. It was also used as a colorant in art and other glass, such as that used in traffic lights, and in architectural plate and automobile glass to reduce solar heat transmission through the glass.

Selenium, an essential micronutrient for animal and human health, was added to fertilizer used to grow crops for animal and human consumption. This practice was more common outside the United States, in countries with selenium-poor soils, such as Australia and China.

Chemical and pigment uses of selenium include industrial and pharmaceutical applications. Selenium's principal pharmaceutical use was in shampoo to control dandruff and dermatitis and as an antifungal agent. Cadmium sulfoselenide compounds were used as pigments in ceramics, glazes, paints, and plastics, but because of the relatively high cost and the toxicity of cadmium-based pigments, their use was generally restricted to applications where they were uniquely suited. Additionally, selenium was used in catalysts to enhance selective oxidation in plating solutions to improve appearance and durability, in blasting caps and gun bluing, in digital x-ray detectors, and in zinc selenide for infrared windows in carbon dioxide lasers.

Although conventional silicon-based cells remained the dominant photovoltaic (PV) technology, thin-film PV cells production continued to increase in 2009. Three major types of thin-film PV cells were in commercial production—amorphous silicon and thin-silicon, cadmium telluride (CdTe), and copper indium gallium diselenide (CIGS). Several companies announced plans to expand production of nonsilicon-based solar cells within the next several years. It was projected that CIGS production would reach almost 1 gigawatt (GW) by 2010 and 2.5 GW by 2012. Recent advancements in CIGS thin films have reduced production costs, improved performance, and reduced the environmental impact of production. In 2009, more than 40 companies were involved in the development of CIGS products. Commercial CIGS solar cells have achieved conversion efficiencies of 12% using 0.01% of the material contained in crystalline silicon-based solar cells. It was estimated that to generate 1 GW of power by CIGS solar cell would require about 55 metric tons (t) of selenium, 20 t of indium, 15 t of copper, and 4 t of gallium (Kanellos, 2008; Kho, 2008; Ullal, 2008; Metal-Pages, 2009d, h).

Tellurium.—World demand for tellurium was estimated to have decreased in 2009. The leading use for tellurium was as a metallurgical alloying element. Tellurium was used in steel as a free-machining additive, in copper to improve machinability while not reducing conductivity, in lead to improve resistance to vibration and fatigue, in cast iron to help control the depth of chill, and in malleable iron as a carbide stabilizer. Owing to recent higher prices, many steel and nonferrous metals producers have reduced consumption and found substitutes for tellurium.

Consumption in chemical, catalysts, and other uses, the next largest end-use category, declined owing to the recent increases in price. Tellurium was used as a vulcanizing agent and as an accelerator in the processing of rubber and in catalysts for synthetic fiber production. Other applications included the use of tellurium in blasting caps and as a pigment to produce blue and brown colors in ceramics and glass.

High-purity tellurium was used in alloys for electronics applications, such as thermal imaging, thermoelectric, phase-change memory, and photoelectric devices. Consumption of tellurium in these applications was estimated to have decreased in 2009 because of the global economic downturn.

Mercury-cadmium-telluride was used in thermal-imaging devices to convert the raw image into a crisp picture on the screen, for infrared sensors, and for heat-seeking missiles. Semiconducting bismuth telluride was used in thermoelectric cooling devices employed in electronics and consumer products. These devices consist of a series of couples of semiconducting materials which, when connected to a direct current, cause one side of the thermo element to cool while the other side heats. Thermoelectric coolers were most commonly used in electronics and military applications, such as the cooling of infrared detectors, integrated circuits, laser diodes, and medical instrumentation. The devices were also used in high-end automobile car seats to cool seats on hot days. However, with the global economic downturn in late 2008, tellurium consumption in thermoelectric consumer goods decreased in 2009.

During 2009, the CdTe thin-film PV cell industry increased investments in research and capacity. First Solar Inc. (Phoenix, AZ), the global leader in CdTe production, had plants in Germany, Ohio, and, Malaysia. In 2009, estimated global production for First Solar rose to 1,230 megawatts (MW), from 716 MW in 2008 owing to expansion at its new plant in Malaysia. In the fourth quarter 2009, First Solar reported that efficiency of its CdTe cells reached 11.1%. In April, Abound Solar Inc. (Fort Collins, CO) opened its first full-scale CdTe solar cell production facility in Longmont, CO, that had a capacity of 200 MW. Other manufacturers that were planning to produce CdTe solar cells were Calyxo GmbH (Bitterfeld-Wolfen, Germany) and PrimeStar Solar Inc. (Arvada, CO). 5N Plus Inc. (Saint-Laurent, Quebec, Canada) was the principal supplier of high-purity cadmium and tellurium to the thin-film industry. The thin-film industry accounted for three-quarters of 5N Plus' business (Kho, 2008; Ullal, 2008; Abound Solar Inc., 2009; 5N Plus Inc., 2010, p. 6; First Solar Inc., 2010, p. 1–10).

Prices

The Platts Metals Week annual average New York dealer price for selenium was $23.07 per pound in 2009 and was 26% lower than the annual average price in 2008. The price remained about $20 per pound for the first 7 months of 2009, down from the yearend 2008 price of $23 per pound. Some analysts thought that after peaking at more than $40 per pound in March 2008, the downward-trending price was caused by an oversupply that developed in 2008 because of decreased demand and continued into the first half of 2009. The price rose in August because of increased demand from glass and ceramics production in India and electrolytic manganese metal production in China and finished the year at $29 per pound (Metals Bulletin, 2009; Poole, 2009; Roskill's Letters from Japan, 2009).

The United Kingdom price for lump and powder, 99.95%-pure tellurium, as published in Mining Journal, started 2009 at $160 to $190 per kilogram. The price range decreased to $125 to $170 per kilogram on February 23 and again decreased to $110 to $150 per kilogram in September when Mining Journal discontinued publishing tellurium prices. On November 3, Metal-Pages started publishing a Rotterdam 99.99%-pure tellurium price range, from $135 to $160 per kilogram. The price range increased to $145 to $170 per kilogram on December 17 and remained at this level for the rest of the year.

Foreign Trade

Exports of selenium materials in 2009 increased by 13% compared with those of 2008. In descending order, Hong Kong, China, Australia, Germany, the Republic of Korea, and Sweden accounted for 88% of selenium exports in 2009 (table 2).

In 2009, imports of selenium (SeO_2 and selenium unwrought and waste and scrap) decreased by 49% to 263 t, compared with 2008 imports (table 3). Germany, Canada, Mexico, Belgium, the Philippines, Japan, China, and the United Kingdom, in descending order, accounted for 99% of the imports of selenium metal and SeO_2 into the United States in 2009.

Imports of unwrought tellurium and tellurium waste and scrap decreased by 18% in 2009 compared with the alltime high imports in 2008. The leading suppliers, in descending order, China, Canada, the Philippines, Russia, Belgium, Japan, and Mexico, accounted for 99% of the total imports of tellurium metal into the United States (table 5). The annual average value of imports in 2009 was $134.95 per kilogram of tellurium was high by historic standards but was lower than the alltime high of $174.21 per kilogram in 2008.

In 2009, tellurium exports fell to 8 t, an 84% decrease from 50 t in 2008. The main destinations, in descending order, were Germany, China, Hong Kong, the United Kingdom, and Taiwan, and accounted for 93% of total tellurium exports (table 4). Despite lower prices for tellurium metal, the annual average value of exports of tellurium in 2009 was $148.34 per kilogram, which was higher than the 2008 value of $60.57 per kilogram but lower than the alltime high of $200.07 per kilogram in 2006. In 2009, much of the stockpiles of low-value tellurium scrap were depleted owing to increased exports of scrap in 2008 because of the higher price that year.

World Review

Global selenium and tellurium output cannot be easily determined because not all companies or countries report production and because trade in scrap and semirefined products may be included in selenium trade data.

In 2009, refinery production of selenium based on data from a select few countries increased slightly to 2,280 t (table 6). Total world production was estimated to be about 3,000 to 3,500 metric tons per year (t/yr) of selenium and 450 to 500 t/yr of tellurium. Based on global copper refinery data (Moats and others, 2007, p. 202–241), the U.S. Geological Survey estimated that just copper anode slimes in 2006 contained 4,600 t and 1,200 t of selenium and tellurium, respectively.

Canada.—In 2009, the Canadian Government estimated selenium production to be 173 t, up by 11% compared with that of 2008. Tellurium production in Canada was 16 t, down by 19% from that of 2008 (Natural Resources Canada, 2010).

China.—In 2009, China was the leading consumer and a significant producer of selenium. China still depended, however, on imports for most of its selenium needs and imported 1,400 t of selenium products in 2008, a 3% increase compared with 2008 imports. China's consumption was estimated to be 1,500 to 2,000 t/yr, with electrolytic manganese production consuming about 1,000 t/yr and ceramics and glassmaking consuming 350 t/yr. In 2009, the country had about 400 t/yr of refined selenium capacity, but this was expected to increase to 600 t/yr of selenium when new production techniques are implemented (Metal-Pages, 2009b).

Apollo Solar Energy, Inc. (Chengdu, Sichuan Province) was investigating the possibility of starting up two mines where the primary product is tellurium. The company announced that the indicated and inferred resources for the Dashuigou project were 30,200 t of ore grading 1.09% tellurium and containing 328 t of tellurium, and the Majiagou project resources were 13,400 t of ore grading 3.26% tellurium and containing 437 t of tellurium (Metal-Pages, 2009e).

China planned to impose a new 2% import tax on tellurium imports in 2010. Sources suggested that the tax would have little influence on the price of tellurium because of the relatively small amount of tellurium imported. The import tariffs for selenium were to be lowered to 2% in 2010 from 3% in 2009 (Metal-Pages, 2009a).

Japan.—The major producers of selenium and tellurium were Mitsubishi Materials Corp.; Mitsui Metal Mining and Smelting Co., Ltd.; Nikko Metals Co., Ltd.; Nippon Rare Metals, Inc.; Shinko Chemicals Co., Ltd.; and Sumitomo Metal Mining Co., Ltd. In 2009, selenium production was estimated to be 780 t, an increase of 3% compared with that of 2008. Japanese principle production of tellurium was as a byproduct of copper refining, and the majority was consumed in the Japanese steel industry. In 2009, stocks of selenium decreased to 116 t, a 27% decline compared with stocks at the end of 2008 (Roskill's Letters from Japan, 2010).

Mexico.—In 2009, Southern Copper Corp. (Phoenix, AZ) operated the La Caridad precious metals plant in the State of Sonora, which had a capacity to produce 342 kilograms per day of selenium. Production in 2009 likely declined owing to lower production of refined copper (Southern Copper Corp., 2010, p. 72).

Peru.—Southern Copper produced selenium at its Ilo refinery in the southern part of Peru. In 2009, selenium production was 56,000 kilograms, up by 27% compared with that of 2008 (Southern Copper Corp., 2010, p. 47).

Poland.—Copper producer KGHM Polska Miedź S.A. (Lubin) produced selenium at its precious metal plant at the Glogów smelter from anode slimes generated at its Glogów and Legnica copper refineries (KGHM Polska Miedź S.A., 2010).

Russia.—The major producers of selenium were OSJC MMC Norilsk Nickel (Moscow), Kyshtymsky Electrolyte Copper JSC (Ekateinburg), and Uralelectromed JCS (Verkhnaya Pyshma), with Norilsk and Uralelectromed also producing tellurium. Annual production was estimated to be 140 t and 34 t of selenium and tellurium, respectively, with annual consumption estimated to be 55 t and 10 t of selenium and tellurium, respectively (Metal-Pages, 2009f).

Outlook

The supply of selenium and tellurium is directly affected by the production of the principal product from which it is derived—copper—and to a lesser extent, by the production of gold, lead, nickel, or zinc produced from sulfide ores. Since global refined production of copper was projected to remain relatively unchanged, production of selenium and tellurium also was expected to remain about the same in 2010. Increased recovery rates at copper refiners could increase selenium and tellurium supply, and longer term investments in gold-tellurium deposits and other sources of tellurium could supply growth exceeding that of copper production growth. Although increased environmental regulation and prices have encouraged the recycling of electronic scrap, recovery of selenium and tellurium has been declining during the past several years owing to the reduction in available scrap selenium- and tellurium-based copier drums. However, many high-grade tellurium producers and users were recovering much of the manufacturing scrap from the production of consumable goods. Also, solar-cell recycling plants have been built in the United States and around the world that would capture selenium and tellurium from CIGS and CdTe cells.

Demand from China for selenium was expected to increase owing to increased demand for agriculture and from the electrolytic manganese metal industry. Global demand for selenium from glass and solar cell manufacturers will probably increase as there are few substitutes in glass manufacturing, and the expansion of solar-cell production was expected to continue.

In 2010, tellurium consumption was expected to increase, chiefly from increased electronics and solar-cell production. As the technologies for these uses, especially solar-cells and thermoelectronics, continue to advance, manufacturers likely will find ways to reduce unit consumption through efficiency, recycling, and thrifting. Consumption for metallurgical alloying and chemicals was expected to decrease as the cost of tellurium continues to rise; producers of low-value products were expected to find substitutes.

References Cited

5N Plus Inc., 2010, Annual report—2009: Saint-Laurent, Quebec, Canada, 5N Plus Inc., 58 p.

Abound Solar Inc., 2009, Abound Solar opens first production facility: Fort Collins, CO, Abound Solar Inc. news release, April 14, 1 p.

First Solar Inc., 2010, Annual report—2009: Phoenix, AZ, First Solar Inc., 156 p.

Grupo Mexico S.A.B. de C.V., 2010, Fourth quarter results 2009: Mexico City, Mexico, Grupo Mexico S.A.B. de C.V., February 5, 16 p.

Kanellos, Michael, 2008, How the CIGS explosion will play out: Greentech Media, September 3. (Accessed September 10, 2008, at http://www.greentechmedia.com/articles/how-the-cigs-explosion-will-play-out-1351.html.)

Kho, Jennifer, 2008, Thin-film solar has bright future: Greentech Media, May 29. (Accessed June 2, 2008, at http://www.greentechmedia.com/articles/thin-film-solar-has-bright-future-946.html.)

KGHM Polska Miedź S.A., 2010, Smelter zone: Lubin, Poland, KGHM Polska Miedź S.A. (Accessed May 12, 2010, via http://www.kghm.pl/index.dhtml?module=articles&id=991.)

Metal Bulletin, 2009, Selenium climbs 24% in six weeks in hot trading: Metal Bulletin, no. 9111, August 17, p. 8.

Metal-Pages, 2009a, China to change import tariffs on selenium and tellurium in 2010: Metal-Pages, December 17. (Accessed February 24, 2010, via http://www.metal-pages.com/.)

Metal-Pages, 2009b, China's selenium output expected to increase—Yunnan Copper: Metal-Pages, December 14. (Accessed February 24, 2010, via http://www.metal-pages.com/.)

Metal-Pages, 2009c, Chinese minor metals weekly roundup—Magnesium flat, tungsten smelter under pressure from costly raw materials, antimony rebounds: Metal-Pages, April 18. (Accessed February 24, 2010, via http://www.metal-pages.com/.)

Metal-Pages, 2009d, CIGS makers to produce nearly 3 gigawatts of solar panels by 2012: Metal-Pages, February 2. (Accessed February 26, 2010, via http://www.metal-pages.com/.)

Metal-Pages, 2009e, Encouraging resource estimates for Apollo's Chinese Te project: Metal-Pages, May 15. (Accessed February 24, 2010, via http://www.metal-pages.com/.)

Metal-Pages, 2009f, Russian minor metals industry overview—KVAR: Metal-Pages, December 1. (Accessed February 24, 2010, via http://www.metal-pages.com/.)

Metal-Pages, 2009g, Selenium little change expected in coming year—Retorte: Metal-Pages, March 25. (Accessed February 24, 2010, via http://www.metal-pages.com/.)

Metal-Pages, 2009h, Solar cells to increase indium, gallium and selenium demand: Metal-Pages, April 29. (Accessed February 26, 2010, via http://www.metal-pages.com/.)

Moats, Michael, Davenport, William, Demetrio, Sergio, Robinson, Tim, and Karcas, George, 2007, Electrolytic copper refining—2007 world tankhouse operating data: Toronto, Ontario, Canada, Electrorefining and Electrowinning, v. V, p. 195–241.

Natural Resources Canada, 2010, Mineral production annual statistics: Natural Resources Canada, Mineral and Metals Sector. (Accessed April, 14, 2010, via http://mmsd.mms.nrcan.gc.ca/stat-stat/prod-prod/ann-ann-eng.aspx.)

Poole, Anthony, 2009, Selenium off the boil, despite buoyant manganese metal: Platts Metals Week, v. 80, no. 35, August 31, p. 17.

Roskill's Letters from Japan, 2009, Selenium—Prices rise by 50%: Roskill's Letters from Japan, no. 399, November, p. 6–7.

Roskill's Letters from Japan, 2010, Non-ferrous metals—Japanese production in 2009: Roskill's Letters from Japan, no. 403, April, p. 1–6.

Selenium-Tellurium Development Association, Inc., 2002, Applications for selenium: Cavite, Philippines, Selenium-Tellurium Development Association, Inc. (Accessed September 24, 2002, via http://www.stda.com/.)

Southern Copper Corp., 2010, Annual report—2009: Phoenix, AZ, Southern Copper Corp., 124 p.

Ullal, Harin, 2008, Overview and challenges of thin film solar electric technologies: National Renewable Energy Laboratory Conference Paper NREL/CP–520–43355, Glasgow, Scotland, July 19–25, 2008, World Renewable Energy Congress X and Exhibition 2008, 4 p.

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

Mineral Commodity Profiles—Selenium. Open-File Report 03–018, 2004.

Selenium. Ch. in Metal Prices in the United States Through 1998, 1999.

Selenium. Ch. in Mineral Commodity Summaries, annual.

Selenium. Ch. in United States Mineral Resources, Professional Paper 820, 1973.

Tellurium. Ch. in Metal Prices in the United States Through 1998, 1999.

Tellurium. Ch. in Mineral Commodity Summaries, annual.

Tellurium. Ch. in United States Mineral Resources, Professional Paper 820, 1973.

Other

American Metal Market.

Metal Bulletin.

Selenium. Ch. in Mineral Facts and Problems, U.S. Bureau of Mines Bulletin 675, 1985.

Tellurium. Ch. in Mineral Facts and Problems, U.S. Bureau of Mines Bulletin 675, 1985.

TABLE 1

SALIENT SELENIUM AND TELLURIUM STATISTICS[1]

(Kilograms, contained metal, unless otherwise specified)

	2005	2006	2007	2008	2009
Selenium:					
United States:					
Production, primary refined	W	W	W	W	W
Exports	254,000	191,000	562,000	545,000	613,000
Imports for consumption	589,000	409,000	544,000	519,000	263,000
Dealers' price, average, commercial grade,[2] dollars per pound	51.43	24.57	33.08	32.29	23.07
World, refinery production	2,020,000 r	2,160,000 r	2,250,000 r	2,220,000 r	2,280,000
Tellurium, United States:					
Production, primary refined	W	W	W	W	W
Exports	51,000	3,550	15,100	50,000	8,130
Imports for consumption	42,200	31,100	43,700	102,000	84,000
Price at yearend, commercial grade,[3] dollars per kilogram	110.00	60.00	110.00	175.00	130.00

[r]Revised. W Withheld to avoid disclosing company proprietary data.

[1]Data are rounded to no more than three significant digits, except prices.

[2]Source: Platts Metals Week.

[3]Average yearend price published by Mining Journal for United Kingdom lump and powder, 99.95% tellurium. On September 14, 2010, the price was discontinued. For 2009, the price was the average September 14 price published by Mining Journal for United Kingdom lump and powder, 99.95% tellurium.

TABLE 2

U.S. EXPORTS OF SELENIUM[1]

	2008		2009	
Country	Quantity (kilograms, contained Se)	Value	Quantity (kilograms, contained Se)	Value
Argentina	--	--	5,540	$85,800
Australia	115,000	$1,790,000	93,200	1,440,000
Belgium	--	--	12,000	138,000
Canada	5,590	171,000	11,100	313,000
Chile	23,000	356,000	2,170	33,700
China	90,200	1,400,000	141,000	2,410,000
Colombia	3,480	61,000	3,970	67,500
Costa Rica	--	--	550	2,940
Dominican Republic	6,580	83,200	--	--
Germany	75,300	1,320,000	64,200	1,090,000
Hong Kong	49,500	1,050,000	151,000	2,650,000
India	12,300	191,000	--	--
Indonesia	--	--	3,470	51,900
Italy	479	7,430	245	3,800
Japan	2,500	38,800	2,530	39,300
Jordan	1,440	22,400	--	--
Korea, Republic of	58,600	886,000	51,100	832,000
Malaysia	3,120	48,300	170	2,630
Mexico	8,250	124,000	10,400	172,000
Netherlands	26,100	404,000	--	--
Panama	2,350	36,400	1,680	26,000
Peru	--	--	841	13,000
Philippines	4,600	90,500	--	--
Singapore	3,360	29,700	6,120	44,800
South Africa	4,500	69,700	141	9,280
Sweden	39,700	615,000	38,700	626,000
Taiwan	612	3,760	--	--
Thailand	31	2,830	--	--
United Kingdom	5,810	90,000	1,610	25,000
Venezuela	--	--	11,100	169,000
Vietnam	2,030	32,200	--	--
Total	545,000	8,920,000	613,000	10,200,000

-- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 3

U.S. IMPORTS FOR CONSUMPTION OF SELENIUM[1]

Class and country	2008 Quantity (kilograms, contained Se)	2008 Value	2009 Quantity (kilograms, contained Se)	2009 Value
Selenium:				
Australia	2,000	$10,700	--	--
Belgium	234,000	9,960,000	39,100	$1,760,000
Canada	68,600	3,960,000	43,000	1,950,000
China	15,100	1,300,000	18,000	1,090,000
Germany	82,000	5,540,000	43,900	2,320,000
Hong Kong	--	--	1	3,400
India	5	9,500	--	--
Japan	22,600	1,270,000	19,600	846,000
Korea, Republic of	1,000	81,600	--	--
Mexico	23,800	1,450,000	42,000	1,680,000
Netherlands	4,670	140,000	1,280	54,000
Peru	-- r	-- r	1,800	64,000
Philippines	24,100 r	1,050,000 r	35,600	2,080,000
Russia	60 r	5,100 r	--	--
United Kingdom	30,100	1,620,000	15,700	897,000
Total	508,000	26,400,000	260,000	12,700,000
Selenium dioxide:[2]				
China	4,970	432,000	--	--
Germany	5,360	463,000	3,230	197,000
Japan	708	63,200	193	12,700
Total	11,000	958,000	3,420	210,000
Grand total	519,000	27,400,000	263,000	13,000,000

[r]Revised. -- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Selenium content calculated as 71% of gross weight of material.

Source: U.S. Census Bureau.

TABLE 4

U.S. EXPORTS OF TELLURIUM[1]

Country	2008 Quantity (kilograms, contained Te)	2008 Value	2009 Quantity (kilograms, contained Te)	2009 Value
Belgium	722	$72,200	213	$32,000
Brazil	--	--	92	16,400
Canada	9,610	447,000	157	7,540
China	19,800	491,000	2,010	301,000
France	138	105,000	13	7,760
Germany	109	187,000	2,250	476,000
Hong Kong	4,610	374,000	1,880	161,000
India	7,000	175,000	95	13,100
Korea, Republic of	126	46,400	--	--
Malaysia	5,080	533,000	--	--
Mexico	38	5,110	--	--
Spain	900	410,000	--	--
Taiwan	28	4,260	556	81,000
United Kingdom	1,810	175,000	878	110,000
Total	50,000	3,030,000	8,130	1,210,000

-- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 5

U.S. IMPORTS FOR CONSUMPTION OF TELLURIUM[1]

Country	2008 Quantity (kilograms, contained Te)	2008 Value	2009 Quantity (kilograms, contained Te)	2009 Value
Belgium	6,570	$1,020,000	3,220	$227,000
Canada	10,100	2,430,000	18,300	4,030,000
China	70,100	11,500,000	39,400	3,310,000
Germany	1,230	139,000	12	7,880
Japan	73	54,700	3,020	485,000
Kazakhstan	--	--	200	36,000
Korea, Republic of	600	162,000	500	198,000
Mexico	--	--	2,790	377,000
Netherlands	1,040	252,000	52	3,500
Peru	4,200	660,000	--	--
Phillippines	2,000	132,000	10,200	1,890,000
Russia	5,550	1,380,000	5,780	691,000
Ukraine	247	11,400	--	--
United Kingdom	51	10,800	390	69,000
Total	102,000	17,700,000	84,000	11,300,000

-- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 6

SELENIUM: WORLD REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Kilograms, contained selenium)

Country[3]	2005	2006	2007	2008[e]	2009[e]
Belgium[e]	200,000	200,000	200,000	200,000	200,000
Canada[4]	107,000	106,000	144,000	156,000 [5]	173,000 [5]
Chile[e]	84,000	74,000	70,000	78,000	70,000
Finland[e]	62,000 [5]	62,000	60,000	64,730 [r, 4]	65,000
Germany[e]	680,000 [r]	720,000 [r]	700,000 [r]	690,000 [r]	700,000
India[e, 6]	13,000	13,000	14,000	14,000	15,000
Japan	624,630	730,100	805,600	754,000	780,000 [5]
Peru	48,800	49,800	45,000	45,000	45,000
Philippines[e]	68,000	65,000	65,000	65,000	65,000
Russia[e]	100,000	110,000	120,000 [r]	130,000 [r]	140,000
Serbia[e]	8,315 [5, 7]	7,500	7,500	7,500	7,500
Sweden[e]	20,000	20,000	20,000	20,000	20,000
United States	W	W	W	W	W
Total	2,020,000 [r]	2,160,000 [r]	2,250,000 [r]	2,220,000 [r]	2,280,000

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data; not included in total.

[1]World totals and estimated data have been rounded to no more than three significant digits; may not add to totals shown.

[2]Insofar as possible, data relate to refinery output only; thus, countries that produced selenium contained in copper ores, copper concentrates, blister copper, and (or) refinery residues but did not recover refined selenium from these materials indigenously were excluded to avoid double counting. Table includes data available through June 7, 2010.

[3]In addition to the countries listed, Australia, China, Iran, Kazakhstan, Mexico, Poland, and Uzbekistan produced refined selenium, but output is not reported, and available information is inadequate for formulation of reliable estimates output levels. Australia is known to produce selenium in intermediate metallurgical products and has facilities to produce elemental selenium. In addition to having facilities for processing imported anode slimes for the recovery of selenium and precious metals, the United States has facilities for processing selenium scrap.

[4]Excludes selenium intermediates exported for refining.

[5]Reported figure.

[6]Data are for Indian fiscal year beginning April 1 of year stated.

[7]Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.

TABLE 7

TELLURIUM: WORLD REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Kilograms, contained tellurium)

Country[3]	2005	2006	2007	2008[e]	2009[e]
Canada[4]	11,000	10,000	14,000	19,000	16,000
Japan	34,000	35,000	41,000	40,000	38,000
Peru	32,880	37,000 [r]	35,000 [r]	28,000 [r]	30,000 [p]
Russia[e]	34,000	34,000	34,000	34,000	34,000
United States	W	W	W	W	W

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.

[1]Estimated data are rounded to no more than three significant digits.

[2]Insofar as possible, data relate to refinery output only; thus, countries that produced tellurium contained in copper ores, copper concentrates, blister copper, and (or) refinery residues but did not recover refined tellurium are excluded to avoid double counting. Table is not totaled because of exclusion of data from major world producers.

[3]Australia, Belgium, Chile, China, Colombia, Germany, Mexico, the Philippines, Poland, and some countries of the Commonwealth of Independent States are known to produce refined tellurium, but output is not reported; available information is inadequate for formulation of reliable estimates of output levels.

[4]Excludes tellurium intermediates exported for refining.