Selenium and Tellurium

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Selenium and tellurium, rare elements widely distributed within the Earth's crust, do not occur in concentrations high enough to justify mining solely for their content. They are recovered as byproducts, mostly from the anode slimes associated with electrolytic refining of copper. An estimated 41,000 wet metric tons per year (t/yr) of copper anode slimes is generated, with about 17% of these being produced at refineries without equipment for processing them.

Electrolytic refining utilizes a sulfate-based electrolyte for its role in absorbing copper ions on the cathode. In addition, this type of electrolyte does not dissolve precious and base metals, leaving them to accumulate along with refractory components at the bottom of the electrolytic cell. The presence and amount of these metals (such as bismuth, tellurium, selenium, and others) are dependent on their initial content in the anode material and therefore on the ores from which the copper concentrate originated.

Slimes resulting from primary metal refining can have average selenium concentrations of 10%, increasing to as high as 40% in a few cases. Tellurium concentrations are generally lower, 5% being the maximum (Weerts, 2002).

Domestic production of primary selenium decreased in 2002. Selenium and tellurium can be recovered economically from industrial scrap and chemical process residues. Manufacturers recycle obsolete and damaged photoreceptor drums from copy machines; selenium and tellurium alloys removed from the drums are shipped to refineries for recovery of selenium and tellurium. About 15% of refined selenium production comes from these secondary sources (Selenium-Tellurium Development Association, 2002c§[1]).

Selenium, a nonmetal, is chemically similar to sulfur but with some metal properties. It is used as a photoreceptor in copiers in the form of arsenic triselenide. Selenium, as cadmium sulfoselenide, has wide use as a pigment. Selenium is also used as a decolorizing agent in the glass industry and in the metallurgical industry to improve the properties of steel, copper, and lead with which it is alloyed.

Tellurium's major use is as an alloying additive in iron, steel, and copper to improve machining characteristics. It is also used as a catalyst in the chemical industry and in electronic applications, such as photoreceptors and photovoltaic devices.

Domestic Data Coverage

Domestic data are collected through a voluntary survey of U.S. selenium and tellurium producers. The production survey was sent to the two known domestic producers of selenium and the sole domestic producer of tellurium. All but one company responded to the survey. In order to protect proprietary interests of the companies, survey data are withheld from publication.

Production

About 250 t/yr of secondary selenium is produced worldwide. World refinery production of primary selenium (excluding U.S. production) increased by less than 1% to 1,480 metric tons (t) (table 5). Japanese output, which accounted for approximately 50% of the world total, is reported to have increased by 1% to 740 t. Belgium, Canada, Japan, and the United States represent more than 80% of the total world refinery production of selenium and tellurium. Most of the selenium and tellurium mined in the United States comes from Arizona, New Mexico, and Utah.

The major world producers of refined tellurium were Canada, Japan, Peru, and the United States. In the United States, one firm recovered tellurium from anode slimes produced in copper refining and from soda slag skimmings generated in lead refining. Secondary tellurium was not produced domestically, but some scrap was exported for recycling. Production data reported to the U.S. Geological Survey are treated as company proprietary information.

Selenium.—Selenium output cannot be easily determined because it is a byproduct of copper production. Only about 20 of the approximately 80 copper refineries in operation around the world report recovery of selenium and less than one-half of that number report tellurium refining (Selenium-Tellurium Development Association, Inc., 2002). Domestic production of selenium was estimated to have been lower in 2002 than in 2001. In the United States, only one domestic copper refinery recovered selenium—ASARCO Incorporated, Amarillo, TX. One domestic producer exported semirefined selenium (90% selenium content) for toll-refining in Asia. Three other companies generated selenium-containing slimes, but did not produce selenium. Selenium-containing slimes from these refineries were exported for processing.

Most domestic selenium is produced as commercial-grade metal, averaging a minimum of 99.5% selenium and available in various forms. This commercial-grade selenium is also further refined to make minimum 99.999% selenium for use in thermoelectric applications.

Tellurium.—Data on the production of tellurium are not readily available. The world's leading producers—Asarco in the United States and Umicore, SA in Belgium—do not publish production figures. Asarco produced commercial-grade tellurium at its refinery complex in Amarillo mainly from copper anode slimes but also from lead refinery skimmings. Asarco also produced tellurium, selenium, and compounds of these metals in high-purity form for specialty applications at

[1]References that include a section mark (§) are found in the Internet References Cited section.

its Globe plant in Denver, CO. Domestic tellurium production was estimated to have increased in 2002, compared with that of 2001.

Consumption

The average annual global consumption of selenium during the past 4 years is estimated to have been about 2,000 t. Estimates of end-use demand in 2002 are as follows: glass, 35%; chemicals and pigments, 20%; electronics, 12%; and other uses, including agriculture and metallurgy, 33%. Domestic consumption is believed to have decreased in 2002 (Hilliard, 2003a).

Metallurgical uses dominate tellurium demand, estimated to be about 220 t/yr. In 2002, about 60% of the tellurium was used as an alloying element to improve the properties of copper, iron, lead, and steel. Other domestic uses included catalysts and chemicals at 25% of total use, photoreceptors and thermoelectric devices at 8% of total use, and DVDs and other minor uses at 7% of total use (Hilliard, 2003b).

Selenium.—In glass manufacturing, selenium is used to decolorize the green tint caused by iron impurities in glass containers and other soda-lime silica glass. It is also used in art glass and other glasses, such as that used in traffic lights, to produce a ruby red color and in architectural plate glass to reduce solar heat transmission through the glass. Glass manufacturing accounted for about 35% of the selenium market in 2002.

An estimated 24% of the selenium market involves metallurgical uses, and more than one-half of the metallurgical selenium is used as an additive to cast iron, copper, lead, and steel alloys. In these applications, it improves machinability and casting and forming properties.

The use of selenium as an alloy with bismuth to substitute for lead in plumbing continued to increase during 2002 in response to requirements of Public Law 104-182, the Safe Drinking Water Act Amendments of 1996. The Act requires that no lead be contained in any pipes, fixtures, solders, and fluxes used for the installation or repair of facilities that provide water for human consumption after August 1998.

The addition of a small amount, about 0.02% by weight, of selenium to low-antimony lead alloys, used to support the grids of lead-acid batteries, improves the casting and mechanical properties of the alloy. Other uses, mainly agricultural, comprise about 9% of the selenium market.

Although it is a diminishing end-use market, electronics accounted for 12% of selenium use. Photoreceptors on the drums of plain-paper copiers had been the largest single application for selenium during the 1970s and 1980s. Organic photoreceptor compounds (OPCs) have replaced these high-purity selenium compounds. OPCs are free of the environmental concerns involved with the disposal of selenium compounds and reportedly offer better performance and cost at lower printing speeds. Other electronic uses of selenium included rectifier and photoelectric applications.

Chemical uses of selenium, which account for approximately 20% of use, include industrial and pharmaceutical applications. Dietary supplements for livestock and humans are a small portion of this category. Selenium added to fertilizer is the larger portion of this category where it is used in growing animal feed. This practice is more common outside the United States, especially in countries with selenium-poor soils. Selenium's principal pharmaceutical use is in shampoo to control dermatitis and dandruff.

Cadmium sulfoselenide compounds are used as pigments in plastics, ceramics, paints, and glazes. Selenium in pigments has good heat stability, reacts well to moisture, and is resistant to ultraviolet or chemical exposure. It can be used to produce a wide range of red, orange, and maroon colors, but because of the relatively high cost and the toxicity of cadmium-based pigments their use is generally restricted.

Additionally, selenium is used in catalysts to enhance selective oxidation; in plating solutions, where it improves appearance and durability; in blasting caps and gun bluing; and to increase yields in the electrolytic production of manganese (Selenium-Tellurium Development Association, 2002a§).

Tellurium.—World demand for tellurium is believed to have decreased in 2002. The largest use for tellurium was as a metallurgical alloying element. Approximately 60% of the market demand for tellurium was 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.

Chemicals and catalyst usage made up about 25% of the world market with tellurium being used as a vulcanizing agent and accelerator in the processing of rubber and as a component of catalysts for synthetic fiber production. Electrical uses, such as photoreceptor and thermoelectric applications, accounted for about 8% of tellurium demand. Other uses, as an ingredient in blasting caps and as a pigment to produce various colors in glass and ceramics, were about 7% of consumption (Selenium-Tellurium Development Association, 2002b§).

Tellurium catalysts are used chiefly for the oxidation of organic compounds but are also used in hydrogenation, halogenation, and chlorination reactions. Tellurium dioxide is used as a curing and accelerating agent in rubber compounds.

High-purity tellurium is used in electronics applications, such as thermoelectric and photoelectric devices. Thermal imaging devices use mercury-cadmium telluride as a sensing material. Semiconducting materials using bismuth telluride are being employed in electronics and consumer products as thermoelectric cooling devices. These devices consist of a series of couples of semiconducting materials, which, when connected to a direct current, cause one side of the thermoelement to cool while the other side generates heat.

These thermoelectric coolers are most commonly used in military and electronics applications, such as the cooling of infrared detectors, integrated circuits, medical instrumentation, and laser diodes. Their application in consumer products, such as portable food-and-beverage coolers, continues to increase.

Prices

Platts Metals Week's average New York dealer price for selenium in 2002 was $4.27 per pound. From November 2001 through September 2002, the price of selenium held steady at $4.00 to $4.50 per pound. In September 2002, it dropped to $3.75 to $4.25 per pound and remained at that level for the rest of the year. The Mining Journal published net tellurium price for United Kingdom lump and powder at 99.95% grade ranging from $6.00 to $8.00 per pound during 2002, with higher grade material selling at a premium.

Trade

International trade is important to U.S. selenium and tellurium markets. In 2002, exports of selenium metal and waste and scrap almost doubled 2001 levels on a weight basis. The Philippines was by far the largest market for selenium metal, waste, and scrap from the United States—accounting for almost 90% of these exports (table 2).

In 2002, imports of selenium dioxide and unwrought waste and scrap decreased by one-third to 322,000 kg, which was valued at $2.95 million (table 3). The United States was a net importer of selenium in 2002 by 241 t (including the selenium content of selenium dioxide) compared with 442 t in 2001. Canada, Belgium, the Philippines, and Germany (in order of decreasing quantity) were the leading foreign suppliers of U.S. selenium markets. They accounted for 90% of the imports of selenium metal and dioxide into the United States in 2002.

Imports of unwrought tellurium and tellurium waste and scrap, on a gross weight basis, decreased by almost 10% during the year (table 4). The leading suppliers were Germany, the Philippines, and Belgium (in order of decreasing quantity), accounting for 78% of the total imports of tellurium metal into the United States. Data for tellurium exports were not available.

World Review

The Selenium-Tellurium Development Association (STDA) ceased operating in early 2003 after serving the industry for more than a decade. During 2002, the STDA presented a CD-ROM update of the Selenium World Atlas, which also included a table of contents for all bulletins published since 1991, recommendations for the safe handling of selenium, and the proceedings of 1998 and 1999 STDA Symposia (Oldfield, 2002).

World production and consumption data for selenium and tellurium are limited. World refinery production of selenium was estimated to have remained stable in 2002 (table 5). A slight increase was seen in Japanese production of selenium. A previous tendency toward excess supply has been replaced by steady production matched by increased demand from China and Japan (Roskill's Letter from Japan, 2002).

It is estimated that production of selenium increased marginally in 2002 and tellurium decreased slightly during this same period. In spite of various interruptions, cutbacks, and closures in the copper industry, world production of both byproducts has been fairly steady during the past few years. Increasing demand, especially for selenium, has resulted in a slight upward pressure on prices.

Japan.—Four of the major producers of selenium in Japan are Mitsubishi Materials Corporation; Nippon Mining & Metals Co., Ltd.; Shinko Kagaku Kogyo Co., Ltd.; and Sumitomo Metal Mining Co., Ltd. Selenium production increased by slightly more than 3% in 2002 compared with that of 2001 (Roskill's Letter from Japan, 2003). Approximately 80% of Japanese production of selenium is exported and the largest portion (nearly 70%) is sent directly to China or through Taiwan to China, where it is used in paints for mosaic tiles. India, where the most important market for selenium is in pharmaceuticals, is another one of Japan's growing markets for selenium exports. Other growth markets for Japanese selenium exports are as paints and as soil additive and animal feedstock in the European market and as a replacement for lead in lead-free stainless steel (Platts Metals Week, 2002; Roskill's Letter from Japan, 2002).

Tellurium output was reduced by 27% in 2002 compared with that of 2001. A 5% reduction of tellurium stocks accompanied this reduction in output.

Russia.—The Russian copper refiner Uralelektromed JSC increased production of selenium by almost 24% to 53 t, and tellurium production rose by more than 8% to 13 t in 2002 (Metal-Pages, 2002a§). Much of the increased selenium production is related to new technology that makes the processing more completely enclosed. Plans are now being developed to increase direct recovery of selenium from dust by adding new gas cleaning systems (Metal-Pages, 2003c§).

Current Research and Technology

The Bureau of Reclamation's Advanced Water Treatment Group in Denver has developed a cost-effective water-treatment method for removing toxic selenium from water. The process, which has been patented by the Bureau, involves the generation of ferrous hydroxide (using lime and ferrous sulfate) and subsequent use of the ferrous hydroxide in the process for removal of selenium from the wastewater stream (Messaros, 2003).

Until recently, selenium has been one of the least distinguished human nutrients because selenium deficiencies are rare (in the United States) and its toxicity is a risk at high levels of ingestion. The toxicity risk has eclipsed the beneficial use of selenium as a human food supplement for many years, although the necessity of providing selenium in the diet of farm animals has been well established for some time.

Selenium's curative and antioxidant properties have been demonstrated through research to assist with a number of human health problems. The use of selenium as a dietary supplement has been shown to have a positive effect on the following health problems—cardiovascular diseases, arthritis, cancer, AIDS, asthma, pancreatitis, Alzheimer's disease, viral infections, thyroid function, and reproduction. The amount of selenium for individual doses is relatively small. However, some countries, including Finland and New Zealand, have added selenium to fertilizers to increase low selenium content of soils. This use requires much larger amounts of selenium than using selenium as a dietary supplement (Oldfield, 2003).

Phelps Dodge Corporation in Arizona announced that its copper concentrate leaching demonstration plant at Bagdad, AZ, was operating at design capacity (Phelps Dodge Corporation, 2003). This plant's concentrate pressure leach with solvent extraction and electrowinning (SX/EW) technology is an alternative to conventional smelting and refining for chalcopyrite flotation concentrates. Copper recovery for this new process has averaged 98%, but since it is an electrowinning process, selenium- and tellurium-rich anode slimes may not be produced. The recovery of byproducts from the new process technology is currently under evaluation by the technical staff at the Bagdad demonstration plant.

Researchers at Edinburgh University have been studying the effect of high pressure on tellurium and selenium. Their research reveals that by squeezing samples of these elements an atomic structure is formed that is so complex it never repeats itself. These findings may reveal why tellurium and selenium superconduct more easily at high pressures (Metal-Pages, 2003b§).

Outlook

The supply of selenium is directly affected by the supply of the main product from which it is derived, copper, and also to a lesser extent by the supply of nickel where the nickel production is from a sulfide ore. The selenium price is often inversely related to the supply of the major product from which it is derived—copper. For example, as a byproduct of copper refining, selenium prices typically fall during periods of high copper production.

Some key events in the copper market during 2002 were the reduction of domestic smelting and refining with the closure of Phelps Dodge's Chino smelter and Miami electrolytic refinery (both in Arizona) and significant reductions in ASARCO Incorporated's Amarillo, TX, refinery resulting from cut backs at its Mission Mine in Arizona. Additional reductions of mine production at Phelps Dodge's Bagdad, AZ, and Sierrita, AZ, operations also affected production of selenium- and tellurium-bearing copper concentrates. When a copper plant closes or converts to processes that do not generate anode slimes, the ultimate amount of selenium and tellurium that is produced decreases.

Production of selenium and tellurium is expected to fall in the short term as a result of the expected drop in copper output. In 2002, copper prices dropped only by about 1% compared with 2001 prices. A worldwide apparent surplus of refined copper production fell to 240,000 t in 2002 from an estimated 780,000 t in 2001. Any increase in copper production will most likely translate into an increased supply in both selenium and tellurium (Edelstein, 2003, p. 1).

China has been purchasing large quantities of crude selenium. As this material becomes scarcer, the price for standard grade selenium may rise (Mining Journal, 2003). The combination of these two factors—the decline of selenium-containing concentrates from North America and the growth of Chinese demand—should firm up the price for selenium in the short term (Metal-Pages, 2003a§).

Demand for selenium in photoreceptors is likely to continue declining as the cost of substituting organic compounds decreases. Once a major consumer of selenium and tellurium, use in photoreceptors has reached the replacement-only stage, as selenium has been supplanted by alternative materials in newer model copiers (Hilliard, 2003a).

Further use of selenium in cancer prevention and for other health benefits may eventually lead to increased consumption of the metal. Dosages taken directly for human consumption will not induce large increases in demand for the metal because only minute quantities are necessary for effective therapy. Nevertheless, a relatively large consumption increase could occur if selenium is applied directly to the soil for crops to be consumed by humans or livestock.

Tellurium supply and demand has remained in fairly close balance for a decade. In the short term, significant increases are not anticipated in either consumption or production, although reductions in copper production may have a bearing on tellurium supply (Metal-Pages, 2002b§). An increase in demand for high-purity tellurium for cadmium telluride solar cells might have a major impact on tellurium consumption. The use of tellurium alloys used in DVDs consumes only small amounts of tellurium and will, therefore, have minimal impact on tellurium demand (Metal-Pages, 2002c§).

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TABLE 1
SALIENT SELENIUM AND TELLURIUM STATISTICS[1]

(Kilograms of contained metal unless otherwise specified)

		1998	1999	2000	2001	2002
Selenium:						
United States:						
Production, primary refined		W	W	W	W	W
Shipments to consumers		W	W	W	W	W
Exports, metal and waste and scrap		151,000	233,000	82,100	41,200	80,900
Imports for consumption[2]		339,000	326,000	476,000	483,000	322,000
Apparent consumption, metal[3]		W	W	W	W	W
Dealers' price, average, commercial grade[4]	dollars per pound	$2.49	$2.50	$3.84	$3.80	$4.27
World, refinery production		1,470,000	1,410,000	1,460,000 r	1,470,000 r	1,480,000 e
Tellurium, United States:						
Imports for consumption[5]		88,900	38,000	52,300	28,000	25,300
Producer price quote, yearend, commercial grade	dollars per pound	$18.00	$15.00	$14.00	$13.00	NA

[e]Estimated. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Data are rounded to no more than three significant digits, except prices.
[2]Include unwrought waste and scrap and selenium dioxide.
[3]Calculated by using reported shipments, imports of selenium metal, and estimated exports of selenium metal, excluding scrap.
[4]Source: Platts Metals Week. Calculated from published price ranges.
[5]Includes only wrought and waste and scrap.

TABLE 2
U.S. EXPORTS OF SELENIUM METAL AND WASTE AND SCRAP[1]

(Kilograms of contained selenium)

	2001		2002	
Country	Quantity	Value	Quantity	Value
Belgium	233	$3,600	1,370	$21,200
Canada	2,640	74,500	1,810	50,300
China	--	--	339	5,840
Costa Rica	334	2,760	541	5,100
Egypt	38	3,080	--	--
France	--	--	578	8,950
Germany	50	3,250	--	--
Guatemala	625	9,930	--	--
India	998	8,800	--	--
Israel	--	--	178	2,760
Italy	543	6,740	--	--
Japan	3,540	54,800	1,070	16,600
Korea, Republic of	820	11,600	--	--
Mexico	23,200	169,000	337	5,220
Netherlands	--	--	379	5,860
Philippines	--	--	72,700	510,000
Singapore	1,120	11,800	1,130	18,300
Sweden	244	3,000	--	--
Taiwan	351	5,440	--	--
United Kingdom	6,440	43,100	500	3,500
Total	41,200	411,000	80,900	653,000

-- 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]

(Kilograms of contained selenium)

Class and country	2001 Quantity	2001 Value	2002 Quantity	2002 Value
Unwrought waste and scrap:				
Australia	22,000	$131,000	--	--
Belgium	30,100	498,000	56,900	$712,000
Canada	261,000	1,560,000	188,000	1,300,000
China	--	--	34	9,320
Finland	3,310	24,800	--	--
Germany	8,050	124,000	9,690	113,000
Hong Kong	--	--	6,000	46,500
India	24,000	62,800	1,410	42,300
Japan	1,070	51,400	2,750	77,600
Korea, Republic of	366	3,750	13,000	88,800
Mexico	68	2,030	--	--
Peru	7,000	46,800	--	--
Philippines	92,100	861,000	23,400	355,000
Russia	8,500	50,200	8,060	71,400
Switzerland	--	--	10	2,400
United Kingdom	10,900	79,900	1,000	8,080
Total	468,000	3,490,000	311,000	2,820,000
Selenium dioxide:[2]				
France	114	2,610 r	--	--
Germany	12,600	129,000 r	10,700	112,000
India	1,420	12,100 r	--	--
Japan	354	3,010 r	354	1,960
Philippines	--	--	354	4,150
Spain	142	2,690 r	142	2,220
Ukraine	1	3,840 r	--	--
Total	14,600	153,000 r	11,500	121,000
Grand total	483,000	3,650,000 r	322,000	2,950,000

r Revised. -- Zero.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Totals revised to 71% of original quantities and values.

Source: U.S. Census Bureau.

TABLE 4
U.S. IMPORTS FOR CONSUMPTION OF TELLURIUM[1]

(Kilograms of gross weight)

Class and country	2001 Quantity	2001 Value	2002 Quantity	2002 Value
Unwrought waste and scrap:				
Belgium	3,790	$55,600	5,240	$181,000
Canada	2,210	722,000	2,560	612,000
China	616	41,200	98	36,400
Czech Republic	469	13,900	--	--
Germany	1,320	52,900	8,900	215,000
Japan	36	36,600	14	23,100
Kazakhstan	--	--	1,980	30,400
Philippines	19,100	637,000	5,730	369,000
Russia	7	10,900	--	--
Ukraine	87	41,800	471	86,500
United Kingdom	346	16,000	337	15,500
Total	28,000	1,630,000	25,300	1,570,000

-- 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

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

(Kilograms of contained selenium)

Country[3]	1998	1999	2000	2001	2002[e]
Belgium[e]	200,000	200,000	200,000	200,000	200,000
Canada[4]	398,000	359,000	350,000	232,000 r	226,000
Chile[e]	49,000	49,000	40,000	40,000 r	40,000
Finland	28,000 e	26,000	36,300 r	38,900 r	39,000
Germany[e]	100,000	100,000	100,000	100,000	100,000
India[e, 5]	11,500	11,500	11,500	11,500	11,500
Japan	549,615	546,292	612,316	730,895 r	740,000
Peru	18,006	23,008	21,000 r	16,000 r	16,000
Philippines[e]	40,000	40,000	40,000	40,000	40,000
Serbia and Montenegro	40,866	20,080	20,000 e	20,000 e	20,000
Sweden[e]	20,000	20,000	20,000	20,000	20,000
United States	W	W	W	W	W
Zambia[6]	14,670	11,620 r	9,820	12,520 r	11,000
Zimbabwe[e]	-- r	-- r	-- r	-- r	--
Total	1,470,000	1,410,000	1,460,000 r	1,470,000 r	1,480,000

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data. -- Zero.

[1]World totals, U.S. data, and estimated data have been rounded to 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 May 27, 2003.

[3]In addition to the countries listed, Australia, and some countries of the former Soviet Union, including Kazakhstan, Russia, and Uzbekistan, produced refined selenium, but output is not reported, available information is inadequate for formulation of reliable estimates of output levels. Australia is known to produce selenium in intermediate metallurgical products and has facilities to produce elemental selenium. In addition to having facilites for processing imported anode slimes for the recovery of selenium and precoius metals, the United Kingdom has facilities for processing selenium scrap.

[4]Excludes selenium intermediates exported for refining.

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

[6]Data are for year beginning April 1 of year stated. Gross weight, purity unknown.

TABLE 6

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

(Kilograms of contained tellurium)

Country[3]	1998	1999	2000	2001	2002[e]
Canada[4]	62,000	64,000	53,000 r	51,000 r	45,000
Japan	38,977	35,272	35,687	39,008	39,000
Peru	21,682	17,110	22,000	19,000 r	20,000
United States	W	W	W	W	W

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

[1]World totals and 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, notably the Commonwealth of Independent States and the United States. Table includes data available through May 27, 2003.

[3]In addition to the countries listed, Australia, Belgium, Chile, Germany, the Philippines, and some countries, including Kazakhstan, Russia, and other 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.