



2008 Minerals Yearbook

VANADIUM

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In 2008, reported vanadium consumption in the United States was 5,090 metric tons (t) of contained vanadium, a slight increase from that of 2007 (table 1). The United States exported 281 t of ferrovanadium (FeV), 249 t of vanadium pentoxide (V_2O_5), and 1,040 t of other oxides and hydroxides of vanadium collectively valued at \$29.6 million. Total exports of these vanadium-bearing materials increased by 42% from those of 2007. This increase is attributed to an 82% increase in FeV exports and a 66% increase in exports of other oxides and hydroxides. The United States imported (measured in vanadium content) 2,800 t of FeV; 3,700 t of V_2O_5 ; and 144 t of other oxides and hydroxides of vanadium collectively valued at \$278 million. Total imports for consumption of these vanadium materials increased by 43% from those of 2007. This increase is attributed to a 55% increase in V_2O_5 imports and a 240% increase in imports of other oxides and hydroxides.

Vanadium was produced in the United States solely by recovery from various industrial waste materials, such as vanadium-bearing fly ash, petroleum residues, pig iron slag, and spent catalysts. Fewer than 10 firms, primarily in Arkansas, Ohio, Pennsylvania, and Texas, processed these materials to produce V_2O_5 , FeV, and vanadium metal. Metallurgical applications in which vanadium was used as an alloying element with iron, steel, and titanium remained the dominant end use. Catalysts represented the leading nonmetallurgical use for vanadium.

Legislation and Government Programs

In November, the U.S. International Trade Commission (ITC) determined that revoking the existing antidumping duty orders on FeV from China and South Africa “would be likely to lead to continuation of material injury to an industry in the United States within a reasonably foreseeable time.” As a result, the existing antidumping orders on imports of FeV from China and South Africa remain in place. The duty orders cover all FeV regardless of chemistry, form, grade, shape, or size. The review excluded vanadium additives other than FeV (such as nitrated vanadium), vanadium-aluminum master alloys, vanadium chemicals, vanadium oxides, vanadium waste and scrap, and vanadium-bearing raw materials (such as boiler residues, fly ash, and slag) (U.S. Department of Commerce, International Trade Administration, 2008).

Production

The major vanadium commodities are aluminum-vanadium master alloys, FeV, vanadium-bearing ash, residues and slag, vanadium chemicals, and V_2O_5 and other oxides and hydroxides of vanadium. In 2008, companies in the United States produced all of these materials with the exception of

vanadium-bearing slag from the manufacture of iron and steel. Vanadium-containing steels can be subdivided into microalloy or low-alloy steels that generally contain less than 0.15% vanadium and high-alloy steels that contain as much as 5% vanadium.

Strategic Minerals Corp. Inc. (Stratcor) announced that its Vametco Alloys (South Africa) subsidiary succeeded in reducing peak power requirements by 10% at its production facility in Brits, South Africa. The effort was expected to help avoid the power interruptions that hindered Vametco and many other metal producers in South Africa in 2008. Vametco’s Brits plant is a fully integrated facility that processes ore to produce nitrated vanadium, an alloy containing 76% to 81% vanadium. Stratcor markets the product under the trade name Nitrovan as a replacement for FeV (Metal-Pages Ltd., 2008c).

Stratcor temporarily shut down vanadium operations at its Hot Springs, AR, and Brits plants in December because of the reduced demand for vanadium products. Production was expected to resume in March 2009 and the company expected to operate the two facilities at levels that would maintain the inventories needed to supply customer needs. Stratcor announced that during the shutdown it had sufficient inventories to meet all customer requirements (Strategic Minerals Corporation, 2009).

Rocky Mountain Resources Corp. completed a scoping study on its Gibellini vanadium project in Nevada. The base case study considered a 2-million-metric-ton-per-year (Mt/yr) heap-leach operation with a 9.5-year mine life producing approximately 8.4 million pounds of V_2O_5 per year. A feasibility study to further demonstrate the potential viability of the project to become the sole domestic producer of primary vanadium in North America was expected to be launched (Rocky Mountain Resources Corp., undated).

Consumption

The U.S. Geological Survey (USGS) derived vanadium consumption data from a voluntary survey of domestic consuming companies. For this survey, more than 80 companies were canvassed on a monthly or annual basis. Some industry estimates indicated that actual domestic consumption was much greater than reported consumption.

Metallurgical applications continued to dominate U.S. vanadium use in 2008, accounting for 94% of reported consumption. Nonmetallurgical applications included catalysts, ceramics, electronics, and vanadium chemicals. The dominant nonmetallurgical use was in catalysts. Based on USGS data, reported domestic vanadium consumption in 2008 was 5,090 t, a slight increase from that of 2007. This increase in reported vanadium consumption reflected stable demand by steel producers.

Most vanadium is consumed in the form of FeV, which is used as a means of introducing vanadium into steel, in which it provides additional strength and toughness. FeV is available as alloys containing either 45% to 50% or 80% vanadium. The 45%- to 50%-grade FeV is produced by silicothermic reduction of V_2O_5 in slag or other vanadium-containing materials. Most of the 80%-grade FeV is produced by aluminothermic reduction of V_2O_5 in the presence of steel scrap or by direct reduction in an electric arc furnace.

Prices

In 2008, the price for domestic FeV, as published in Metal Bulletin, ranged from \$18.00 to \$46.00 per pound of contained vanadium, compared with \$15.25 to \$21.00 per pound reported in 2007. The price averaged \$18.38 per pound in January, increased to \$20.25 per pound in February, and more than doubled in March to an average of \$42.00 per pound. The price decreased to \$37.00 per pound in May through July, but averaged \$33.50 per pound through December. The European FeV price ranged from \$26.00 to \$93.00 per kilogram compared with \$28.50 to \$42.00 per kilogram in 2007. The European price averaged \$40.87 per kilogram in January, rose to a high of \$93.00 per kilogram in February, and decreased to an average of about \$78.88 per kilogram in March. The price continued to decrease in April to an average of \$62.58 per kilogram, rebounded in May and June to an average of \$77.89 per kilogram, and finally drifted down for the rest of the year to end the year at an average of \$28.83 per kilogram in December.

The Metal Bulletin published price for domestic V_2O_5 ranged between \$7.20 and \$18.40 per pound in 2008, compared with \$5.71 and \$8.30 per pound in 2007. The price averaged about \$8.12 per pound in January, increased to about \$14.09 per pound in February and continued to gradually increase to \$17.66 per pound in June, before significantly decreasing to \$7.35 in December.

World Review

Nearly all the world's supply of vanadium came from primary sources. Five countries recovered vanadium from ores, concentrates, slag, or petroleum residues (table 7). In four of the five countries, the mining and processing of magnetite-bearing ores was an important source of vanadium production. The leading vanadium-producing nations remained China, Russia, and South Africa. Japan and the United States were thought to be the only countries to recover significant quantities of vanadium from petroleum residues.

Recycling of vanadium-containing alloys for recovery of vanadium was negligible and involved mainly a small quantity of tool steel. Vanadium's major end use was as an alloying-element in iron, steel, and titanium-bearing alloys, from which it is lost to slag and not recovered when those metals are recycled. Only small quantities of vanadium were recovered from recycling vanadium-bearing catalysts and that material was reused to make new catalysts.

World vanadium reserves at more than 13 million tons (Mt) are sufficient to meet vanadium demand into the next century at the present rate of consumption. Increased recovery of

vanadium from fly ash, petroleum residues, slag, and spent catalyst is not taken into account and is expected to extend the life of the reserves significantly.

Australia.—Windimurra Vanadium Ltd. began construction of its Windimurra vanadium project and was expected to commence operations in the second quarter of 2009. Operations were postponed owing to the late delivery of equipment and supply of materials and delays in obtaining statutory approvals. The project, owned 90% by Windimurra Vanadium Ltd. and 10% by Noble Resources Ltd. (Hong Kong), includes an open pit mine, processing plant, and ancillary facilities. When in full operation, the mine was expected to produce approximately 5,600 metric tons per year (t/yr) contained vanadium (Windimurra Vanadium Ltd., 2008b). The overall ore reserve estimate for the project increased to 98 Mt from 79 Mt. The revised reserve estimate is at a similar grade of 0.47% V_2O_5 , including 41 Mt proved and 57 Mt probable ore reserves. This increase was attributed to a redesign of the drilling area of the mine based on results from an optimization study (Windimurra Vanadium Ltd., 2008a).

Reed Resources Ltd. estimated an ore reserve of 39.7 Mt grading 0.82% V_2O_5 for its Barrambie vanadium deposit, located north of Sandstone, Western Australia. The mine life was expected to be 12 or more years at a 3.2-Mt/yr production rate (Reed Resources Ltd., 2008).

Canada.—Apella Resources Inc. commenced a field exploration program on its 100%-owned Lac Dore North vanadium-titanium-iron zone in central Quebec. The company announced that assays from a recent channel sampling program were very encouraging. Apella's claims cover a significant portion of the Bell River complex, where previous exploration work carried out by Noranda Inc. during the 1990s delineated and confirmed the presence of vanadium and titanium (Apella Resources Inc., 2008).

China.—China exported 4,290 t of FeV compared with 1,445 t in 2007. China cancelled the export duty on FeV 80%, which was the probable cause for an increase in the export volume of FeV. Owing to a severe storm in southern China in early 2008, the supply of domestic vanadium remained very limited. In the first quarter of 2008, China exported only 284 t of FeV compared with 2,828 t in the second quarter. However, the global economic downturn caused a significant decrease in exports of FeV in the third quarter of 2008 (Asian Metal Ltd., 2009).

China's Panzhihua New Steel and Vanadium Co., Ltd. (a subsidiary of Panzhihua Iron and Steel Group) completed the expansion of its Panhong vanadium products plant in southwestern China's Sichuan Province. The expansion increased the plant's FeV production capacity to 9,000 t/yr and V_2O_5 production capacity to 18,000 t/yr, making the plant the world's largest-capacity vanadium plant (Metal-Pages Ltd., 2008b, p. 6–7).

In August, four unlicensed vanadium plants were closed in Hubei Province after reports of a skin disease spreading among local villagers. The plants were in the townships of Chiba, Rongchen, and Sanzhou in Jianli County. The Jianli Government had closed a vanadium oxide smelter in April 2006, but recently a small number of people had illegally

reestablished smelting plants in remote towns and villages. In June, the Government launched an investigation and discovered 10 plants either already complete or under construction. None of these plants had applied for an environmental assessment as required by law and most were using outdated technology that emits chlorine gas, chlorine hydride gas, slag, and waste water, all of which cause pollution. In September, the county government cancelled the business licenses of the 10 plants, cut off electricity supplies, and sealed their premises. Four of the plants tore off the government's seals and restarted production. The Government then proceeded to demolish the four illegal factories, and the managers of the four plants were arrested, and their bank accounts were frozen (Zhang, 2008).

India.—The Indian Government imposed a customs duty of 5% on FeV, previously exempt from basic customs duty, to provide protection to the domestic FeV industry. This customs duty was in effect starting October 31 (Metal Bulletin, 2008).

Russia.—Vanadium produced by Evraz Group S.A. (Moscow) was increasingly funneled into North American and other markets in 2008, where it was primarily being converted to FeV. Evraz's third quarter operational results showed that its U.S. subsidiary, Stratcor, produced 487 t of vanadium contained in alloys and chemicals, a 36.3% increase from that of 2007 (Metal-Pages Ltd., 2008a).

South Africa.—Xstrata Alloys Ltd. (Rustenburg) reported that the reduced power supply from Eskom, South Africa's national power utility, affected FeV volumes, which decreased by 8% compared with those of the same quarter in 2007. Since February, the utility had been supplying 90% of the normal power requirement to industrial users (Metal-Pages Ltd., 2008d).

South African steel producer Highveld Steel and Vanadium Corp. Ltd. (Witbank), in which Evraz had a controlling stake, announced in April that it would sell its vanadium assets to Vanchem Vanadium Products Pty Ltd. (Witbank). Vanchem, controlled by Swiss firm Duferco Investment Partners, would pay \$160 million for the integrated assets, which included the Mapochs Mine, the Vanchem operation, and a 50% shareholding in South Africa Japan Vanadium Pty Ltd. A payment of \$100 million would be paid immediately, and the balance, upon completion of specific environmental projects at Vanchem. The sale of the assets formed part of the European Commission's conditions to the approval of the 2007 merger of Highveld and Evraz.

The Mapochs Mine produced lumpy titaniferous magnetite ore, which was supplied exclusively to Vanchem operations to produce a variety of vanadium products. Highveld entered into a supply agreement with Duferco for the supply of fine ores from the mine and for the supply of vanadium-bearing slag, which is produced as a byproduct of steel production. Vanchem's operations comprise the Vanchem facility and a FeV smelter within Highveld's steelworks. Vanchem produced FeV, V_2O_5 , and a range of vanadium chemicals, which are sold to third party customers in South Africa as well as internationally (Webb, 2008).

In June, the South African Competition Commission raided Highveld's offices amidst concerns raised by various stakeholders regarding pricing practices. The raid was part of a

wider investigation into price fixing. In 2007, the commission found ArcelorMittal South Africa Ltd. guilty of excessive pricing and fined the company \$86 million (American Metal Market, 2008).

Highveld reported record earnings of more than 2 billion R (\$250 million) for the 9 months ended September 2008, mainly because of the price increases in steel and vanadium products. This was an increase in earnings of about 215% compared with the same 9-month period in 2007. However, Highveld informed shareholders that such earnings could not be sustained for the last quarter of 2008, owing to significant reduction in demand, and it would reduce production to reflect the level of demand (van der Merwen, 2008).

Outlook

Vanadium's primary use is as a hardening agent in steel, and it is critical in imparting toughness and wear resistance. These properties are especially important in high-strength low-alloy steels, which are growing in use as the construction, energy, and transportation industries seek to maximize the strength and minimize the weight of their products.

There is growth potential in vanadium's other end-use industries as well. Aerospace applications are rapidly expanding, and vanadium consumption has been increasing with the introduction of the next generation commercial aircraft. The quest for fuel efficiency is key in the aerospace industry but also extends to automobiles, high-speed drilling, powerplants, and rail cars.

There are several different battery technologies in the process development and early commercialization. One technology showing promise in stabilizing energy distribution in renewable systems is the vanadium redox battery (VRB), which consists of an assembly of power cells in which two vanadium-base electrolytes are separated by a proton exchange membrane. The main advantages of the VRB are that it can offer almost unlimited capacity simply by using sequentially larger storage tanks; it can be left completely discharged for long periods of time with no ill effects; it can be recharged by replacing the electrolyte if no power source is available to charge it; and the battery suffers no permanent damage if the electrolytes are accidentally mixed (Johnstone, 2008).

The extremely large capacities possible from VRBs make them well suited for use in large power storage applications. For example, VRBs can help even out the peaks and troughs in the production of electricity by highly variable generation sources, such as wind power. In October, VRB Power Systems Inc. (Canada) announced that Scotian Windfields Inc. (Canada), a Nova Scotia community-owned wind company, was interested in purchasing two, 60-kilowatt, 4-hour VRB energy storage systems for a pilot wind project (PRNewswire-First Call, 2008).

Fuel-cell producer Cellennium Co. Ltd. (Thailand), aimed to promote its vanadium fuel cell technology globally after gaining investment capital from MFC Energy Fund, established by MFC Asset Management plc. Cellennium planned to use the fund's investment to develop two 20-megawatt powerplants in Pattaya, located on the east coast of the Gulf of Thailand. The company also planned further projects using vanadium fuel

cells in electric buses, mobile telephone repeaters, and small powerplants (Prachyakorn, 2008).

Researchers at the University of Massachusetts, Boston have developed a vanadium boride air fuel cell with a much larger capacity than that of current vehicle batteries. The cell has ten times the energy capacity of lithium ion batteries and three times the energy density of zinc air batteries. The vanadium boride air fuel cell needs only air and fresh fuel to complete the recharge process. Engineering details and system optimization all need to be developed before the fuel cell can be commercialized (Crombie, 2008).

The vanadium market came into oversupply in October owing to the decline in demand from its dominant consumer, the steel industry. Vanadium producers responded by cutting production, but cuts in production have not been deep enough to stop the growth in worldwide vanadium stocks. The timing of a recovery in worldwide steel production remains the key to the future health of the vanadium industry (Bunting, 2009, p. 19).

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TABLE 1
SALIENT VANADIUM STATISTICS¹

(Metric tons of contained vanadium, unless otherwise specified)

	2004	2005	2006	2007	2008
United States:					
Production, ore and concentrate:					
Recoverable vanadium ² : value thousand dollars	--	--	--	--	--
Consumption	4,050	3,910	4,030	4,970	5,090
Exports:					
Ferrovandium	285	505	389	154	281
Vanadium pentoxide (anhydride)	240	254	341	327	249
Other oxides and hydroxides of vanadium	584	899	832	626	1,040
Imports for consumption:					
Ferrovandium	3,020	11,900	2,140	2,220	2,800
Ore, slag, ash, residues	2,350	1,690	997	921	921
Vanadium pentoxide (anhydride)	1,040	1,370	1,920	2,390	3,700
Other oxides and hydroxides of vanadium	120	186	129	42	144
Stocks:					
Ferrovandium	320	343	275	253	234
Oxide	6	2	6	22	24
Other ³	10	26	49	48	76
World, production from ore, concentrate, slag ^c	51,900	56,400	57,900 ^f	58,500 ^f	56,100

^cEstimated. ^fRevised. -- Zero.

¹Data are rounded to no more than three significant digits.

²Recoverable vanadium contained in uranium and vanadium ores and concentrates received at mill, plus vanadium recovered from ferrophosphorous slag derived from domestic phosphate rock.

³Consists principally of vanadium-aluminum alloy, small quantities of other vanadium alloys, vanadium metal, and ammonium metavanadate.

TABLE 2
U.S. CONSUMPTION OF VANADIUM, BY END USE AND FORM¹

(Kilograms of contained vanadium)

	2007	2008
End use:		
Steel:		
Carbon	1,190,000	763,000
Full alloy	1,380,000	2,070,000
High-strength low-alloy	1,560,000	1,580,000
Stainless and heat resisting	61,400	116,000
Tool	379,000	267,000
Total	4,570,000	4,800,000
Cast irons	W	W
Superalloys	43,700	4,910
Alloys (excluding steels and superalloys):		
Welding and alloy hard-facing rods and materials	W	W
Other alloys ²	W	W
Chemical and ceramic uses:		
Catalysts	W	W
Pigments	W	W
Miscellaneous and unspecified	356,000	285,000
Grand total	4,970,000	5,090,000
Form:		
Ferrovanadium	3,780,000	4,260,000
Oxide	326,000	91,700
Other ³	860,000	741,000
Total	4,970,000	5,090,000

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified."

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

²Includes magnetic alloys.

³Consists principally of vanadium-aluminum alloy, small quantities of other vanadium alloys, vanadium metal, and ammonium metavanadate.

TABLE 3
U.S. IMPORTS AND EXPORTS OF ALUMINUM-VANADIUM MASTER ALLOY
AND VANADIUM METAL, INCLUDING WASTE AND SCRAP¹

	Aluminum-vanadium master alloy		Vanadium metal, including waste and scrap	
	Quantity, gross weight (kilograms)	Value	Quantity, gross weight (kilograms)	Value
Imports for consumption:				
2007	1,110,000	\$2,110,000	3,620	\$198,000
2008:				
Canada	18,600	42,900	--	--
China	49,700	173,000	71	34,300
France	--	--	2,540	141,000
Germany	--	--	1,900	196,000
Greece	537,000	2,480,000	--	--
Netherlands	12,900	64,200	--	--
United Kingdom	--	--	83	36,900
Total	618,000	2,760,000	4,600	409,000
Exports:				
2007	21,100,000	72,700,000	49,400	2,690,000
2008:				
Australia	44,500	431,000	--	--
Barbados	790	23,200	--	--
Belgium	116,000	3,050,000	--	--
Brazil	5,130	125,000	--	--
Canada	7,640,000	23,300,000	2,480	79,700
Chile	5,370	69,800	993	17,400
China	16,200	102,000	--	--
Costa Rica	287	8,450	--	--
France	1,140	19,700	--	--
Germany	28,900	849,000	--	--
Hong Kong	882	7,380	--	--
India	11,400	334,000	9,070	1,000,000
Israel	1,170	16,700	--	--
Japan	135,000	3,450,000	37,400	2,380,000
Korea, Republic of	1,950	19,400	--	--
Mexico	13,800,000	41,700,000	--	--
Netherlands	27,700	161,000	--	--
Pakistan	--	--	408	6,020
Peru	582	17,100	--	--
Portugal	454	4,040	--	--
Saudi Arabia	--	--	6,740	260,000
Singapore	4,790	141,000	--	--
Switzerland	96	2,820	--	--
Taiwan	1,620	6,910	--	--
United Kingdom	83,600	2,330,000	--	--
Total	21,900,000	76,200,000	57,100	3,740,000

-- Zero

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

Source: U.S. Census Bureau.

TABLE 4
U.S. IMPORTS AND EXPORTS OF FERROVANADIUM, VANADIUM PENTOXIDE (ANHYDRIDE), AND
OTHER OXIDES AND HYDROXIDES OF VANADIUM¹

	Ferrovanadium		Vanadium pentoxide (anhydride) ²		Other oxides and hydroxides of vanadium	
	Quantity, V content (kilograms)	Value	Quantity, V content (kilograms)	Value	Quantity, V content (kilograms)	Value
Imports for consumption:						
2007	2,220,000	\$81,300,000	2,390,000	\$46,800,000	41,900	\$1,400,000
2008:						
Austria	322,000	18,500,000	4,250	258,000	37,700	2,190,000
Brazil	8,690	665,000	--	--	--	--
Canada	647,000	34,500,000	--	--	1	3,160
China	--	--	1,210,000	40,900,000	--	--
Czech Republic	49,500	2,500,000	--	--	--	--
Germany	3,620	454,000	1,460	79,700	--	--
India	1,200	104,000	--	--	--	--
Israel	--	--	--	--	4,790	81,100
Japan	5,850	265,000	8,530	241,000	--	--
Korea, Republic of	1,710,000	98,200,000	--	--	--	--
Mexico	4,940	264,000	--	--	--	--
Netherlands	3,990	319,000	--	--	--	--
Netherlands Antilles	--	--	--	--	5,480	262,000
Russia	--	--	1,550,000	39,700,000	--	--
South Africa	--	--	916,000	33,100,000	80,000	1,550,000
Switzerland	21,400	1,300,000	--	--	--	--
Taiwan	23,700	1,410,000	13,900	848,000	--	--
United Kingdom	--	--	--	--	15,800	243,000
Total	2,800,000	158,000,000	3,700,000	115,000,000	144,000	4,320,000
Exports:						
2007	154,000	5,810,000	327,000	5,460,000	626,000	7,530,000
2008:						
Argentina	--	--	700	30,600	--	--
Australia	326	10,900	--	--	--	--
Belgium	--	--	--	--	9,230	155,000
Brazil	1,320	43,800	699	31,600	16,400	234,000
Canada	210,000	9,730,000	--	--	64,700	560,000
China	--	--	--	--	2,820	13,200
France	--	--	17,900	716,000	--	--
French West Indies	--	--	--	--	305	3,490
Germany	--	--	13,600	286,000	93,100	1,170,000
Italy	--	--	101,000	1,810,000	--	--
Japan	--	--	--	--	3,440	30,600
Korea, Republic of	2,330	77,600	--	--	1,000	8,940
Mexico	59,200	2,080,000	2,410	71,900	95,700	604,000
Netherlands	--	--	--	--	28,000	468,000
Russia	--	--	61,300	1,760,000	721,000	8,060,000
Saudi Arabia	--	--	41,800	538,000	464	4,130
Switzerland	--	--	--	--	899	8,000
Taiwan	--	--	--	--	892	8,440
Trinidad and Tobago	7,950	616,000	10,300	408,000	845	4,000
Total	281,000	12,600,000	249,000	5,650,000	1,040,000	11,300,000

-- Zero.

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

²May include catalysts that contain vanadium pentoxide.

Source: U.S. Census Bureau.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF VANADIUM-BEARING ASH, RESIDUES, AND SLAG¹

Material and country	2007		2008	
	Quantity, V ₂ O ₅ ² content (kilograms)	Value	Quantity, V ₂ O ₅ ² content (kilograms)	Value
Ash and residues:				
Canada	73,700 ^r	\$215,000 ^r	13,200	\$4,700
Mexico	931,000	9,750,000	1,030,000	18,000,000
Total	1,000,000 ^r	9,960,000 ^r	1,040,000	18,000,000
Slag, from the manufacture of iron and steel ³	641,000 ^r	913,000 ^r	601,000	795,000

^rRevised.

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

²V₂O₅ Vanadium pentoxide.

³Slag imports from South Africa, as adjusted by the U.S. Geological Survey.

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF MISCELLANEOUS VANADIUM CHEMICALS^{1,2}

Material and country	2007		2008	
	Quantity, V ³ content (kilograms)	Value	Quantity, V ³ content (kilograms)	Value
Sulfates:				
China	80,200	\$775,000	2,010	\$88,800
India	11	7,370	150	30,500
Total	80,200	783,000	2,160	119,000
Vanadates:				
China	34,400	1,140,000	3,280	97,700
Germany	7,540	316,000	659	37,700
India	--	--	99	13,800
Japan	44,500	237,000	395	43,400
Russia	7	5,600	--	--
South Africa	116,000	1,810,000	160,000	3,800,000
United Kingdom	8,070	47,400	23,000	240,000
Total	211,000	3,550,000	187,000	4,230,000

-- Zero.

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

²Comprises vanadium ore and miscellaneous vanadium chemicals.

³Vanadium.

Source: U.S. Census Bureau.

TABLE 7
VANADIUM: ESTIMATED WORLD PRODUCTION, BY COUNTRY^{1,2}

(Metric tons of contained vanadium)

Country	2004	2005	2006	2007	2008
Production from ores, concentrates, slag:³					
Australia	150 ⁴	100 ⁴	--	--	--
China ⁵	16,000	17,000	17,500	19,000	20,000
Kazakhstan	1,000	1,000	1,000	1,000	1,000
Russia	10,900	15,100	15,100	14,500	14,500
South Africa	23,302 ⁴	22,604 ^{r,4}	23,780 ⁴	23,486 ^{r,4}	20,000
Total	51,400	55,800	57,400	58,000 ^r	55,500
Japan, petroleum residues, ash spent catalysts ⁶	560	560	560	560	560
Grand total	51,900	56,400	57,900	58,500 ^r	56,100

^rRevised. -- Zero.

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

²In addition to the countries listed, vanadium is also recovered from petroleum residues in Germany and several other European countries, but available information is insufficient to make reliable estimates. Table includes data available through May 30, 2009.

³Production in this section is credited to the country that was the origin of the vanadiferous raw material.

⁴Reported figure.

⁵Estimated 40% of vanadium recovered from vanadiferous slag.

⁶Production in this section is credited to the country where the vanadiferous product is extracted; available information is inadequate to permit crediting this output back to the country of origin of the vanadiferous raw material.