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2015 Minerals Yearbook

VANADIUM [ADVANCE RELEASE]

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VANADIUM

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In 2015, the United States continued to be a major producer of vanadium products from secondary sources and imported (measured in vanadium content) 2,010 metric tons (t) of ferrovanadium (FeV), 2,870 t of vanadium pentoxide (V_2O_5), and 94 t of other oxides and hydroxides of vanadium, collectively valued at $99 million (table 4). Total imports for consumption of these vanadium-bearing materials decreased by 26% from those of 2014. The United States exported (measured in vanadium content) 122 t of FeV, 356 t of V_2O_5, and 100 t of other oxides and hydroxides of vanadium, collectively valued at $7.5 million (table 4). Total exports of these vanadium-bearing materials decreased by 28% from those of 2014. Reported vanadium consumption in the United States was 3,930 t of contained vanadium, a slight decrease from reported consumption in 2014 (table 1). In 2015, estimated worldwide production of vanadium decreased by 6% to 77,800 t compared with the revised 82,600 t in 2014 (table 7).

Vanadium's primary use was as a hardening agent in steel, in which it is critical for imparting toughness and wear resistance. These properties are especially important in high-strength low-alloy (HSLA) steels. 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. Catalysts are the leading nonmetallurgical use for vanadium.

Secondary vanadium production from various industrial waste materials, such as vanadium-bearing fly ash, petroleum residues, pig iron slag, and spent catalysts, was the only source of U.S. vanadium production, primarily in Arkansas, Ohio, Pennsylvania, and Texas, where processed waste materials were used to produce FeV, V_2O_5, and vanadium metal.

Legislation and Government Programs

In January 2015, the ITC determined that revoking the existing antidumping duty orders on FeV from China and South Africa would likely lead to continuation or recurrence of material injury. As a result, the existing orders on imports were ordered to remain in place (U.S. Department of Commerce, U.S. International Trade Commission, 2015).

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 2015, companies in the United States produced all these materials with the exception of vanadium-bearing slag from the manufacture of iron and steel.

Energy Fuels Inc.'s (Toronto, Ontario, Canada) White Mesa Mill, near Blanding, UT, has the only vanadium joint product recovery circuit in the United States. In 2014, Energy Fuels reported no vanadium production and the company announced that it expected no vanadium production in 2015 (Energy Fuels Inc., 2015, p. 37).

EVRAZ plc consisted of Nikom in the Czech Republic, Strategic Minerals Corp. (Stratcor Inc.) in the United States and South Africa, Vametco Alloys Proprietary Ltd. in South Africa, and Vanady Tula in Russia. Stratcor operated a facility in Hot Springs, AR, where vanadium ash, residues, and other raw materials were converted into vanadium alloys and vanadium chemicals used by the chemical, steel, and titanium industries (EVRAZ plc, 2016, p. 63). Stratcor has the capacity to produce up to 5,400 metric tons per year (t/yr) of vanadium oxide. Some of this oxide is then converted into vanadium-aluminum that meets the requirements of titanium alloys used in jet aircraft and other aerospace applications. The Hot Springs facility also converts the vanadium oxide into many other specialty products that play an important role in the production of chemicals, gases, and storage batteries (EVRAZ plc, undated b).

American Vanadium Corp. (Vancouver, British Columbia, Canada) announced that its Gibellini vanadium property in Eureka County, NV, was in the permitting stage. The company was expected to produce vanadium electrolyte from Gibellini for vanadium redox flow battery (VRB) storage systems. The company announced that, owing to the early stage of the energy storage market and internal financing constraints, permitting work in 2015 at Gibellini had been slowed significantly (American Vanadium Corp., 2015, p. 2–3).

Consumption

The U.S. Geological Survey (USGS) derived vanadium consumption data from a voluntary survey of domestic consuming companies. For this survey, 67 companies were canvassed on a monthly or annual basis.

Metallurgical applications continued to dominate U.S. vanadium use in 2014, accounting for 95% of reported consumption (table 2). Nonmetallurgical applications included batteries, catalysts, ceramics, electronics, and vanadium chemicals. The dominant nonmetallurgical use was in catalysts. A number of vanadium chemicals were used in catalysts to manufacture a variety of industrial chemicals and to clean industrial process waste streams.

Most vanadium is consumed in the form of FeV, which is used to introduce vanadium into steel to provide 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.

Vanadium is becoming more widely used in green technology applications, especially in battery technology. The VRB is being installed for commercial energy storage across Africa, Asia, Europe, and North America. The main advantages of the VRB are that it can offer almost unlimited capacity simply by using sequentially larger storage tanks, can be left completely discharged for long periods of time with no ill effects, can be recharged by replacing the electrolyte if no power source is available to charge it, and suffers no permanent damage if the electrolytes are accidentally mixed (Johnstone, 2008). However, cost, equipment, and raw material availability continued to be barriers for entry into the battery market. The U.S.-based manufacturers, all at different levels of establishing VRB production lines, included Ashlawn Energy LLC, Imergy Power Systems, UniEnergy Technologies, LLC, United Technologies Corp., Sumitomo Corp., and Vionx Energy Corp. and Willey Battery Utility, LLC.

Sumitomo (New York City, NY) announced in January 2016 that they would commence operation of their innovative battery storage system that was constructed with Willey Battery Utility, LLC in Hamilton County, Ohio. This was the company's first investment in a large-scale stand-alone battery storage facility in the United States (Sumitomo Corp., 2016).

Prices

In 2015, the average monthly price for domestic FeV, as published by CRU Group, ranged from \$6.185 to \$12.250 per pound of vanadium content, compared with \$12.506 to \$13.581 per pound reported in 2014. In 2015, the European average monthly price for FeV ranged from \$13.288 to \$23.500 per kilogram, compared with \$24.188 to \$27.250 per kilogram in 2014. The average monthly price for domestic V_2O_5 published by CRU Group ranged from \$2.615 to \$5.350 per pound in 2015, compared with \$5.350 to \$5.750 per pound in 2014 (fig. 1).

World Review

Most of the world's supply of vanadium was derived from mined ore, either directly as mineral concentrates derived from vanadiferous titanomagnetite (VTM) or from steelmaking slags, where the steel was produced from VTM. Vanadium was recovered from ores, concentrates, slag, or petroleum residues in five countries (table 7). The leading vanadium-producing nations remained China, Russia, and South Africa, providing 93% of world production. Canada, Germany, Japan, and the United States, as well as several other European countries, continued to recover vanadium from petroleum residues.

World vanadium reserves, estimated at more than 15 million metric tons (Mt), are likely sufficient to meet vanadium needs into the next century at the present rate of consumption. Increased recovery of vanadium from fly ash, petroleum residues, slag, and spent catalysts is not taken into account and is expected to significantly extend the life of the reserves.

Austria.—Treibacher Industrie AG (Althofen) announced in July 2015 that it continued to meet customer orders for vanadium products despite its supplier, EVRAZ Highveld, being in business rescue. Treibacher, which normally produced 6,000 to 7,000 t/yr of vanadium products, was running at reduced levels but announced that it would have sufficient stocks to continue producing (Argus Media group—Metal-Pages, 2015d).

Brazil.—Largo Resources Ltd.'s (Toronto, Ontario, Canada) Maracas Menchen Mine, located 813 kilometers (km) northeast of Brasilia, produced 5,800 t of V_2O_5 in 2015. During the fourth quarter of 2015 and the first quarter of 2016, Largo completed the last of the engineering changes necessary to achieve full rampup of capacity. Production capacity was expected to be 9,634 t/yr of V_2O_5 (Largo Resources Ltd., 2016, p. 1–4). According to the company, the vanadium is contained within a massive titaniferous magnetite deposit that has much higher grades of both V_2O_5 and iron than any other vanadium project in the world. The very low level of contaminants in the deposit, particularly silica, was expected to make the extraction and processing of vanadium much easier. This in turn was expected to lower operating costs and produce superior concentrate (SA Mining, 2015). Largo has an offtake agreement with Glencore International plc for 100% of its material for the first 6 years (Largo Resources Ltd., undated).

Canada.—VanadiumCorp Resource Inc. announced that it received a technical report with an updated resource estimate for its Lac Doré project in northern Quebec. The inferred resource estimate was 99.1 Mt grading 1.08% V_2O_5 (IOS Services Géoscientifiques Inc., 2015, p. 4).

China.—In April, China's Ministry of Finance announced that it would remove the export duty on V_2O_5 effective May 1, 2015. The change was expected to promote exports and ease domestic oversupply (Argus Media group—Metal-Pages, 2015a).

Pangang Group Vanadium Titanium and Resources Co. Ltd., located in Panzhihua, Sichuan Province, has a gross production capacity of 260,000 t/yr of vanadium slag, 22,000 t/yr of V_2O_5, 16,000 t/yr of FeV, and 4,000 t/yr of vanadium-nitrogen alloy (Argus Media group—Metal-Pages, 2014).

In July 2015, a number of FeV smelters halted operations in response to high production costs as well as a lack of purchasing from steelmakers. The closed smelters included Jinzhou Guangda Ferroalloys Co. Ltd. and Sichuan Guangyuan Wangcang Ltd. (Argus Media group—Metal-Pages, 2015b).

China-based VRB companies included Golden Energy Century, Golden Energy Fuel Corp., Prudent Energy Corp., Rongke Power Co. Ltd., and Shanghai Shen-Li High Tech Co. Ltd. According to the company, Shanghai Shen-Li High Tech was heavily funded by the Ministry of Science and Technology of China and financially supported by Shanghai Municipal Government (Shanghai Shen-Li High Tech Co., Ltd., undated).

Czech Republic.—Nikom (part of EVRAZ plc) had an FeV production capacity of 4,940 t/yr. Nikom has one processing facility, which is used to process V_2O_5 from Russia and China and also vanadium trioxide from Vametco into FeV (EVRAZ plc, 2016, p. 62).

Russia.—EVRAZ Nizhny Tagil Metallurgical plant (NTMK), an integrated metallurgical complex located in Nizhny Tagil in the Sverdlovsk region, continued to be one of the leading world processors of VTM (EVRAZ plc, undated a). The Vanady Tula facility, 200 km south of Moscow, uses low-cost, highly efficient technology to process the vanadium slag produced by NTMK.

Vanady Tula has a capacity of 5,000 t/yr of FeV and 7,500 t/yr of V_2O_5 in its electrometallurgical and hydrometallurgical plants. Vanady Tula produced 8,500 t of vanadium-containing products in 2015. EVRAZ announced that it expected to maintain 2015 production levels for 2016 (EVRAZ plc, 2016, p. 62).

South Africa.—On April 13, 2015, EVRAZ Highveld Steel and Vanadium Ltd. were placed under business rescue procedures to avoid liquidation. The rescue procedures were expected to either result in Highveld being refinanced or restructured or, if that was not possible, to undergo liquidation under the supervision of a business rescue practitioner to maximize the return to creditors (EVRAZ plc, 2016, p. 90).

Vanchem Vanadium Products Pty Ltd. (eMalahleni) stopped production in May after its raw material supplier, the Mapochs Mine, went into business rescue along with its owner, EVRAZ Highveld. At the end of June, Vanchem had begun to receive vanadium from the Mapochs Mine and was expected to be operating at normal levels by the end of July if vanadium shipments from the Mapochs Mine continued. Vanchem, part of Switzerland-based Duferco S.A., produced approximately 5,000 t/yr of vanadium products prior to being in business rescue (Argus Media group—Metal-Pages, 2015e).

In December 2015, creditors of Mapochs Mine voted to accept the proposal put forward by Hong Kong-based International Resources Project Ltd. to save the company from liquidation. In September 2015, International Resources offered to acquire both EVRAZ Highveld and the Mapochs Mine. EVRAZ Highveld launched court action against the acceptance of this business rescue plan (Argus Media group—Metal-Pages, 2015c).

EVRAZ Vametco Alloys Ltd. in Brits, North West Province, sourced VTM from its own adjacent mine, Krokodilkraal Mine. It produced products such as modified vanadium oxide and Nitrovan®, a vanadium-nitrogen alloy (EVRAZ plc, undated c).

Glencore Xstrata plc (Baar, Switzerland) announced that its Rhovan vanadium facility, 30 km northwest of Brits, produced 9,480 t of V_2O_5 in 2015, a slight increase compared with 9,430 t of V_2O_5 produced in 2014 (Glencore Xstrata plc, 2016, p. 52).

Outlook

Production cuts, as well as the idling of vanadium and ferrovanadium operations in China and South Africa, resulted in lower exports in 2015. However, there was little indication of new supply from other countries, other than Brazil, to compensate for this loss. The World Steel Association forecast global steel demand to decrease by 0.8% in 2016, following a contraction of 3.0% in 2015 (World Steel Association, 2016). Owing to the fact that almost all vanadium is consumed in the production of steel, consumption trends are greatly influenced by trends in steel production; however, the use of vanadium in a wider range of steels has continued to increase. The outlook for demand in nonferrous alloys is largely dependent on trends in demand for titanium alloys in business, commercial, and military aircrafts.

The one area of potential growth is in the energy storage market, specifically with VRBs. According to the REN21 Renewables 2015 Global Status Report, by early 2015, 164 countries had defined renewable energy targets (REN21, 2015, p. 18). Many countries are seeking to meet renewable energy targets by 2030 or earlier and VRB storage is proving to be a potential sensible answer, with many countries having numerous implementations already underway. However, the high cost of the electrolyte used in the VRBs and the system complexity of the batteries may be difficult to overcome. Major technological developments to reduce the purity required for the use of vanadium in VRBs, as well as the amount of vanadium required will be important before VRB technology can be widely adopted (Mining News, 2016).

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TABLE 1
SALIENT VANADIUM STATISTICS[1]

(Metric tons of contained vanadium, unless otherwise specified)

	2011	2012	2013	2014	2015
United States:					
Production, ore and concentrate, recoverable vanadium[2]	590	106	591	--	--
Consumption, reported	4,140	3,960	3,980	4,070	3,930
Imports for consumption:					
Ferrovanadium	2,220	4,190	3,710	3,230	2,010
Vanadium pentoxide (anhydride)	2,800	1,640	2,040	3,410	2,870
Other oxides and hydroxides of vanadium	886	905	205	104	94
Ash and residues[3]	1,510	2,210	4,190	6,160	9,440
Exports:					
Ferrovanadium	316	337	299	253	122
Vanadium pentoxide (anhydride)	89	62	90	201	356
Other oxides and hydroxides of vanadium	264	305	427	350	100
Stocks, year end:					
Ferrovanadium	126	155	140	147	W
Oxide	W	W	W	W	W
Other[4]	67	64	80	78	78
World, production from ore, concentrate, slag[e]	71,500	74,900	80,400	82,600 [r]	77,800

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data. -- Zero.
[1]Data are rounded to no more than three significant digits.
[2]In 2009–11, Denison Mines Corp. produced vanadium as a joint product from mining uraniferous sandstones.
Source: Denison Mines Corp. Web site. In 2012–13, Energy Fuels Inc. produced vanadium. Source: Energy Fuels Inc. Web site.
[3]Not from the manufacture of iron and steel.
[4]Includes vanadium-aluminum alloy, other vanadium alloys, vanadium metal, vanadates, chlorides, and other specialty chemicals.

TABLE 2
U.S. CONSUMPTION OF VANADIUM, BY END USE AND FORM[1]

(Kilograms of contained vanadium)

	2014	2015
End use:		
Steel:		
Carbon	710,000	743,000
Full alloy	1,540,000	1,460,000
High-strength low-alloy	W	W
Stainless and heat resisting	61,400	61,400
Tool	W	W
Total	2,320,000	2,270,000
Cast irons	W	W
Superalloys	8,180	9,450
Alloys (excluding steels and superalloys):		
Welding and alloy hard-facing rods and materials	1,570 r	W
Other[2]	W	W
Chemical and ceramic:		
Catalysts	W	W
Pigments	W	W
Miscellaneous and unspecified[3]	1,740,000 r	1,650,000
Grand total	4,070,000	3,930,000
Form:		
Ferrovanadium	3,230,000	3,090,000
Other[4]	838,000	836,000
Total	4,070,000	3,930,000

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

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

[2]Includes magnetic alloys.

[3]Includes electrical steel and unspecified steel.

[4]Includes vanadium-aluminum alloy, other vanadium alloys, vanadium metal, vanadium pentoxide, vanadates, chlorides, and other specialty chemicals.

TABLE 3
U.S. IMPORTS AND EXPORTS OF ALUMINUM-VANADIUM MASTER ALLOYS
AND VANADIUM METAL, INCLUDING WASTE AND SCRAP[1]

	Aluminum-vanadium master alloy[2]		Vanadium metal, including waste and scrap	
	Quantity, gross weight (kilograms)	Value	Quantity, gross weight (kilograms)	Value
Imports for consumption:				
2014	431,000	$9,820,000	161,000	$3,860,000
2015:				
Belgium	900	26,900	--	--
China	91,900	2,110,000	155,000	2,400,000
Czech Republic	--	--	7	3,710
Germany	95	106,000	26,000	814,000
Japan	85	16,800	--	--
Latvia	--	--	960	127,000
Netherlands	1,000	28,600	--	--
Russia	107,000	2,120,000	--	--
Taiwan	2,720	11,800	--	--
Turkey	202	71,800	--	--
United Kingdom	8	26,200	524	105,000
Total	204,000	4,520,000	182,000	3,450,000
Exports:				
2014	443,000	12,400,000	31,900	1,150,000
2015:				
Australia	3,180	250,000	3,230	239,000
Belgium	9,140	141,000	--	--
Canada	--	--	119	3,170
China	146	5,620	3	4,690
France	372	14,300	--	--
India	261	12,800	1,620	62,600
Italy	24	3,120	--	--
Japan	16,900	406,000	--	--
Kazakhstan	25,700	1,410,000	--	--
Korea, Republic of	207	7,970	--	--
Malaysia	--	--	218	45,300
Netherlands	178	6,120	--	--
Russia	106,000	2,250,000	--	--
Singapore	102	3,670	--	--
Switzerland	172	6,640	--	--
United Kingdom	67,400	1,930,000	--	--
Total	229,000	6,440,000	5,200	354,000

-- Zero.

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

[2]Aluminum-vanadium master alloy consisting of 35% aluminum and 64.5% vanadium. Includes Harmonized Tariff Schedule code 8112.99.200.

Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.

TABLE 4
U.S. IMPORTS AND EXPORTS OF FERROVANADIUM, VANADIUM PENTOXIDE (ANHYDRIDE), AND OTHER OXIDES AND HYDROXIDES OF VANADIUM[1]

	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:						
2014	3,230,000	$94,700,000 r	3,410,000	$46,300,000	104,000	$1,950,000
2015:						
Austria	624,000	12,500,000	14	2,260	17,400	354,000
Brazil	--	--	1,980	14,500	--	--
Canada	482,000	11,000,000	--	--	--	--
China	--	--	190,000	3,060,000	9,800	231,000
Columbia	1,760	79,700	--	--	--	--
Czech Republic	--	22,000,000	--	--	--	--
Germany	2,060	125,000	43,600	564,000	--	--
India	265	12,000	--	--	--	--
Japan	18,300	413,000	--	--	--	--
Kazakhstan	--	--	--	--	--	--
Korea, Republic of	757,000	16,000,000	--	--	--	--
Russia	125,000	2,650,000	585,000	4,510,000	--	--
Singapore	--	--	--	--	--	--
South Africa	--	--	1,970,000	23,100,000	66,500	1,260,000
Switzerland	--	--	--	--	--	--
Taiwan	--	--	80,400	1,450,000	--	--
United Kingdom	--	--	--	--	--	--
Total	2,010,000	64,700,000	2,870,000	32,800,000	93,700	1,840,000
Exports:						
2014	253,000	7,500,000	201,000	2,890,000 r	350,000	4,800,000
2015:						
Argentina	--	--	--	--	605	10,500
Canada	108,000	2,630,000	--	--	4,480	67,300
China	--	--	--	--	592	5,270
Columbia	582	6,020	--	--	--	--
Estonia	--	--	19,000	197,000	--	--
Germany	--	--	2,260	32,500	20,300	214,000
India	--	--	294	2,790	--	--
Italy	--	--	14,400	227,000	--	--
Japan	--	--	22,400	227,000	--	--
Korea, Republic of	8,770	380,000	--	--	--	--
Kuwait	--	--	--	--	--	--
Mexico	--	--	3,300	60,000	1,480	13,200
Netherlands	--	--	284,000	2,330,000	4,530	40,300
New Zealand	113	3,330	--	--	--	--
Peru	2,540	116,000	--	--	--	--
Saudi Arabia	--	--	--	--	--	--
Singapore	2,050	49,200	--	--	--	--
South Africa	--	--	--	--	--	--
Thailand	--	--	700	17,500	--	--
Trinidad and Tobago	--	--	9,800	338,000	67,800	490,000
Vietnam	191	6,350	--	--	--	--
Total	122,000	3,190,000	356,000	3,430,000	99,800	841,000

rRevised. -- Zero.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]May include catalysts that contain vanadium pentoxide.

Source: U.S. Census Bureau.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF VANADIUM-BEARING ASH AND RESIDUES[1, 2]

Country	2014 Quantity, V_2O_5[3] content (kilograms)	2014 Value	2015 Quantity, V_2O_5[3] content (kilograms)	2015 Value
Canada	4,600,000	$23,000,000	4,660,000	$13,700,000
Germany	54,600	29,600	--	--
Mexico	72,500	1,230,000	3,160,000	10,100,000
Russia	1,410,000	13,500,000	1,630,000	12,900,000
Trinidad and Tobago	15,800	127,000	--	--
Total	6,160,000	37,900,000	9,440,000	36,700,000

-- Zero.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Includes Harmonized Tariff Schedule codes 2620.40.0030 and 2620.99.1000.
[3]Vanadium pentoxide.

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF MISCELLANEOUS
VANADIUM CHEMICALS[1, 2]

Material and country	2014 Quantity, V content (kilograms)	2014 Value	2015 Quantity, V content (kilograms)	2015 Value
Sulfates:				
China	9,900	$121,000	12,500	$134,000
Finland	7,890	65,300	--	--
India	6	4,400	--	--
Japan	819	37,300	93	4,340
Netherlands	--	--	44	3,620
Total	18,600	228,000	12,600	142,000
Vanadates:				
Austria	16,400	431,000	4,600	83,600
China	38,500	967,000	--	--
Germany	7,440	201,000	11,000	275,000
India	42	7,500	--	--
Japan	532	59,100	395	27,300
Netherlands	--	--	13,000	148,000
South Africa	119,000	1,950,000	62,700	909,000
Spain	575	84,200	640	28,900
Sweden	--	--	2,610	19,700
Taiwan	--	--	74,000	756,000
United Kingdom	14,400	391,000	4,030	77,700
Total	197,000	4,090,000	173,000	2,330,000

-- Zero.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Comprises vanadium ore and miscellaneous vanadium chemicals.

Source: U.S. Census Bureau.

TABLE 7
VANADIUM: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons of contained vanadium)

Country	2011	2012	2013	2014	2015[e]
Production from ore, concentrate, slag:[3]					
Brazil[e]	--	--	--	936 [r, 4, 5]	5,800 [5]
China[6]	36,400	40,000	44,000	45,000	42,000
Russia	12,860	14,856	14,403	15,125	16,000
South Africa	21,652	19,957	21,397	21,582 [r]	14,000
United States[7]	590	106	591	--	-- [5]
Total[e]	71,500	74,900	80,400	82,600 [r]	77,800

[r]Revised. -- Zero.

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

[2]In addition to the countries listed, in 2012 and 2013 a small amount of vanadium was produced in Australia from titanomagnetite ore; Canada, Germany, Japan, and the United States, as well as several European countries, continued to recover vanadium from petroleum residues, but available information is insufficient to make reliable estimates. Includes data available through September 15, 2016.

[3]Credited to the country of origin of the vanadiferous raw material.

[4]During the period of September 2013 through December 2014.

[5]Reported figure.

[6]To convert vanadium content to gross weight (V_2O_5 in vanadiferous slag), divide by 0.56. V_2O_5 content in vanadium slag is estimated to be 17%. Data rounded to two significant digits.

[7]In 2009–11, Denison Mines Corp. produced vanadium as a joint product from mining uraniferous sandstones. Source: Denison Mines Corp. Web site. In 2012–13, Energy Fuels Inc. produced vanadium. Source: Energy Fuels Inc. Web site.

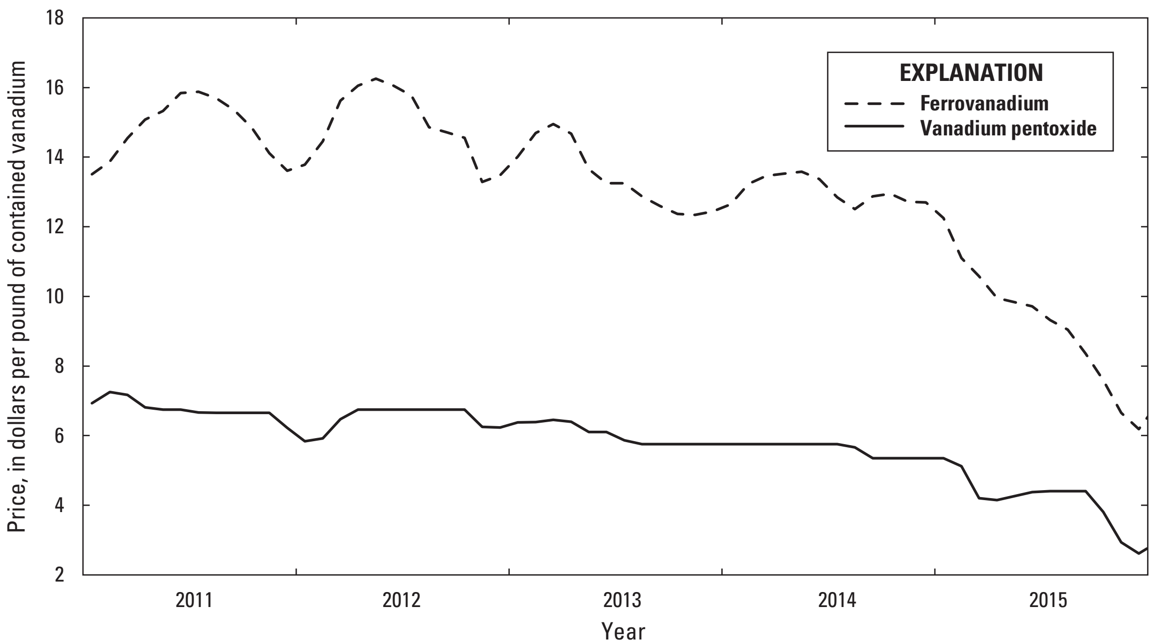

Figure 1. Average monthly prices for U.S. vanadium pentoxide and U.S. ferrovanadium from 2011 through 2015. Source: CRU Group.