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2016 Minerals Yearbook

VANADIUM [ADVANCE RELEASE]

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Vanadium

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In 2016, the United States continued to be a major producer of vanadium products from secondary sources such as spent catalysts, ashes, and petroleum residues. The United States was 100% import reliant for vanadium and imported (measured in vanadium content) 1,590 metric tons (t) of ferrovanadium (FeV), 2,460 t of vanadium pentoxide (V_2O_5), and 660 t of other oxides and hydroxides of vanadium, collectively valued at $83 million (table 4). Ash and residues were also imported containing (measured in vanadium content) 5,030 t valued at $10 million (table 5). Total imports for consumption of these vanadium-bearing materials decreased by 26% from those of 2015. The United States exported (measured in vanadium content) 400 t of FeV, 5 t of V_2O_5, and 81 t of other oxides and hydroxides of vanadium, collectively valued at $8.1 million (table 4). Total exports of these vanadium-bearing materials decreased by 16% from those of 2015. Reported vanadium consumption in the United States was 3,830 t of contained vanadium, a slight decrease from reported consumption in 2015 (table 1). In 2016, estimated worldwide production of vanadium decreased 7% to 79,000 t compared with the revised 84,600 t in 2015 (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.

Legislation and Government Programs

In October 2016, the U.S. International Trade Commission (USITC) preliminarily approved a request by a group of U.S. companies to levy antidumping duties on imports of FeV from the Republic of Korea. The USITC reported that an investigation determined that imports of FeV from the Republic of Korea were sold in the United States at dumping margins of 4.48% and 54.69%. A preliminary dumping margin of 4.48% was assigned to all other producers and exporters of FeV from the Republic of Korea. The final determination was scheduled to be announced in 2017 (U.S. Department of Commerce, U.S. International Trade Commission, 2016a, b).

Production

Industry convention for describing the production of V_2O_5 usually applies the terms primary production, coproduction, and secondary production according to the raw material source for production. Primary production is from mined ore as mineral concentrates derived from vanadiferous titanomagnetite (VTM). Coproduction refers to vanadium slags that are produced during steelmaking. When a VTM iron ore is used to produce iron, vanadium is contained in the crude steel that must be extracted whether or not the finished steel will contain vanadium. Secondary vanadium production occurs from various industrial waste materials, such as vanadium-bearing fly ash, petroleum residues, and spent catalysts. Secondary vanadium production was the only source of U.S. vanadium production in 2016, primarily in Arkansas, Ohio, Pennsylvania, and Texas, where processed waste materials were used to produce FeV, specialty alloys, vanadium chemicals, vanadium metal, and vanadium oxides.

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. Vanadium oxides are the most commonly produced vanadium compound, although most pentoxide and trioxide is further processed into FeV. V_2O_5 is the most widely produced oxide. In 2016, companies in the United States produced all these materials except vanadiferous 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 coproduct recovery circuit in the United States. It has not produced vanadium since 2013 owing to a combination of low demand and low prices (Energy Fuels Inc., 2017).

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 low demand during 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).

Strategic Minerals Corp (Stratcor Inc.), owned by EVRAZ plc, 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 consisted of Nikom in Czechia, Stratcor Inc. in the United States and South Africa, Bushveld Vametco Alloys Proprietary Ltd. in South Africa, and Vanady Tula in Russia (EVRAZ plc, undated a).

AMG Vanadium, a wholly owned subsidiary of Advanced Metallurgical Group in Cambridge, OH, was a major producer of FeV and other ferroalloys from spent oil refinery catalysts and powerplant residues (AMG Vanadium, undated). Kennametal International Specialty Alloys Inc. produced FeV and vanadium master alloys in New Castle, PA. Gulf Chemical and Metallurgical Corp., a subsidiary of the Eramet Group, had a processing facility for spent catalysts at its Freeport plant in Texas. In June 2016, Gulf filed for bankruptcy protection but were unable to find a purchaser and decided to cease operations (Sanchez, 2016).

Consumption

The U.S. Geological Survey (USGS) derived vanadium consumption data from a voluntary survey of domestic consuming companies. For this survey, 65 companies were canvassed on a monthly or annual basis.

Metallurgical applications continued to dominate U.S. vanadium use in 2016, 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. VRBs are 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; UniEnergy Technologies, LLC; United Technologies Corp.; Vionx Energy Corp.; and Willey Battery Utility, LLC.

In March 2017, Sumitomo Electric Industries Ltd. (Osaka, Japan) along with utility, San Diego Gas and Electric, launched a pilot VRB storage project in California to research how VRB technology can reliably integrate renewable energy and improve grid management. During a 4-year period, Sumitomo was expected to test the VRB, which the company claimed to be the largest of its kind in the United States (Kenning, 2017).

Prices

In 2016, the average monthly price for domestic FeV, as published by CRU Group, ranged from $5.950 to $11.519 per pound of contained vanadium, compared with $6.185 to $12.250 per pound reported in 2015. In 2016, the European average monthly price for FeV ranged from $14.225 to $23.156 per kilogram, compared with $13.288 to $23.500 per kilogram in 2015. The average monthly price for domestic V_2O_5 published by CRU Group ranged from $2.784 to $4.650 per pound in 2016, compared with $2.615 to $5.350 per pound in 2015 (fig. 1).

World Review

Most of the world's supply of vanadium was derived from either primary production or coproduction. Production from these two sources is shown in table 7. The leading vanadium-producing nations remained China, Russia, and South Africa, providing 90% of world production. Secondary production in Canada, Germany, Japan, and the United States, as well as several other European countries, continued.

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 considered and is expected to significantly extend the life of the reserves.

Brazil.—Largo Resources Ltd.'s (Toronto, Ontario, Canada) Maracas Menchen Mine, located 813 kilometers (km) northeast of Brasilia, produced 8,000 t of V_2O_5 in 2016. 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. In the second quarter of 2016, the company produced 2,311 t of V_2O_5 compared with 1,169 t of V_2O_5 in the first quarter of 2016. Production capacity was expected to be 9,600 t/yr of V_2O_5 (Largo Resources Ltd., 2017b, 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 of operation (Largo Resources Ltd., 2017a).

Canada.—VanadiumCorp Resource Inc. signed a memorandum of understanding (MOU) with C-Tech Innovation Ltd. to collaborate on the development of a vanadium electrolyte plant in Canada. Under the MOU, a test plant capable of producing battery-ready electrolyte would be established in Quebec. C-Tech was also expected to collaborate with VanadiumCorp on a commercial-scale vanadium electrolyte plant. VanadiumCorp's Lac Doré project in northern Quebec was in the development stage, with an estimated resource of 280,000 t of V_2O_5 contained in magnetite ore (VanadiumCorp Resource Inc., 2017).

China.—In December, many vanadium producers in the Panzhihua vanadium and titanium high-tech industrial development zone were forced to suspend vanadium production owing to the local government conducting environmental inspections caused by polluted water in the Jinsha River. State-owned producer, Panzhihua Iron and Steel Group (Pangang), was expected to reduce its V_2O_5 output by 200 tons per month. It was unclear how long production would be suspended. However, tighter environmental controls were also expected in other vanadium-producing regions (Argus Media group Metal-Pages, 2016b).

Pangang stopped selling vanadium slag to the spot market and was using it for its own vanadium production. Chengde Iron and Steel Group was reportedly also not selling vanadium slag and it resorted to importing slag from New Zealand to decrease costs (Argus Media group Metal-Pages, 2016c).

China-based VRB companies included Dalian Rongke Power Co. Ltd., Golden Energy Century Ltd., Golden Energy Fuel Corp., Pu Neng Energy, 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 the Shanghai municipal government (Shanghai Shen-Li High Tech Co., Ltd., undated). UniEnergy Technologies (Seattle, Washington) and Rongke Power were expected to deploy an 800-megawatthour vanadium flow battery on the Dalian Peninsula in northern China. The China National Energy Administration approved the application of the battery into the utility grid owing to its competitive price, lack of emissions, and operational flexibility (PR Newswire, 2016).

Czechia.—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 world's leading processors of VTM. The Vanady Tula facility, located 200 km south of Moscow, uses low-cost, highly efficient technology to process the vanadium slag produced by NTMK (EVRAZ plc, undated b). 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, 2017, p. 182).

Vanchem Vanadium Products Pty Ltd. (eMalahleni) stopped production in May 2015 after its raw material supplier, the Mapochs Mine, went into business rescue along with its owner, EVRAZ Highveld (Metal-Pages, 2015). However, at the end of 2015, Vanchem went into business rescue again when its raw material supply from the Mapochs Mine ended. Vanchem, part of Switzerland-based Duferco S.A., produced approximately 5,000 t/yr of vanadium products prior to being in business rescue. In 2016, EVRAZ Highveld decided to close the company completely, which could involve selling the company in one piece, selling parts of it, or selling off its assets (Argus Media group Metal-Pages, 2016d).

In 2016, Bushveld Minerals Ltd. agreed to purchase EVRAZ's 78.8% holding in Strategic Minerals Corp., which owns the Vametco vanadium mine and plant in Brits, North West Province. Vametco Alloys Ltd. produced 2,419 t of vanadium in 2015 in the form of vanadium nitride and vanadium oxide. Its plant has a capacity of 2,750 t/yr which could increase to 3,340 t/yr through some plant improvements (Argus Media group Metal-Pages, 2016a; Bushveld Minerals Ltd., 2016).

Bushveld Minerals was also developing its Mokopane vanadium project in Limpopo Province. The company announced it would be focused on the growing interest in the usage of VRBs. However, as of May 2016, Bushveld Minerals announced that $7.7 million would be needed to complete further technical studies, and with current market conditions, a strategic partner involvement did not appear forthcoming (Bushveld Minerals Ltd., 2016).

Glencore Xstrata plc (Baar, Switzerland) announced that its Rhovan vanadium facility, 30 km northwest of Brits, produced 9,570 t of V_2O_5 in 2016, a slight increase compared with 9,480 t of V_2O_5 produced in 2015 (Glencore Xstrata plc, 2017, p. 62).

Outlook

Continued production cuts, as well as the idling of vanadium and ferrovanadium operations in China and South Africa, resulted in continued lower exports in 2016. However, there was little indication of new supply from other countries, other than Brazil, to compensate for this loss. The closure of EVRAZ Highveld in South Africa has significantly reduced global supplies of vanadium feedstock. The tight availability of feedstock has affected the downstream market as well. The World Steel Association forecast global steel consumption to increase by 1.3% in 2017, following an increase of 1% in 2016 (World Steel Association, 2017). Because 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 aircraft.

In addition to growth from the steel sector, one area of potential growth continues to be in the energy storage market, specifically with VRBs. According to the REN21 Renewables 2016 Global Status Report, by yearend 2015, 173 countries had defined renewable energy targets (REN21, 2016, p. 20). Many countries are seeking to meet renewable energy targets by 2030 or earlier and VRB storage is proving to be a potential solution, 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)

	2012	2013	2014	2015	2016
United States:					
Production, ore and concentrate, recoverable vanadium[2]	106	591	--	--	--
Consumption, reported	3,960	3,980	4,070	3,930	3,830
Imports for consumption:					
Ferrovanadium	4,190	3,710	3,230	1,980 r	1,590
Vanadium pentoxide (anhydride)	1,640	2,040	3,410	2,870	2,460
Other oxides and hydroxides of vanadium	905	205	104	94	660
Ash and residues[3]	2,210	4,190	6,160	8,210 r	5,030
Exports:					
Ferrovanadium	337	299	253	122	400
Vanadium pentoxide (anhydride)	62	90	201	356	5
Other oxides and hydroxides of vanadium	305	407 r	350	100	81
Stocks, yearend:					
Ferrovanadium	104 r	93 r	100 r	96 r	98
Other[4]	56 r	73 r	70 r	70 r	70
World, production from ore, concentrate, slag	74,900	81,400 r	85,700 r	84,600 r	79,000 p

pPreliminary. rRevised. -- Zero.
[1]Table includes data available through August 10, 2017. Data are rounded to no more than three significant digits.
[2]Source: Energy Fuels Inc. website in 2012–13.
[3]Not from the manufacture of iron and steel.
[4]Includes vanadium-aluminum alloy, other vanadium alloys, vanadium metal, vanadium pentoxide, vanadates, chlorides, and other specialty chemicals.

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

(Kilograms of contained vanadium)

	2015	2016
End use:		
Steel:		
Carbon	743,000	718,000
Full alloy	1,460,000	1,460,000
High-strength low-alloy	W	W
Stainless and heat resisting	61,400	61,400
Tool	W	W
Total	2,270,000	2,240,000
Cast irons	W	W
Superalloys	9,450	10,400
Alloys (excluding steels and superalloys):		
Welding and alloy hard-facing rods and materials	W	W
Other[2]	W	W
Chemical and ceramic:		
Catalysts	W	W
Pigments	W	W
Miscellaneous and unspecified[3]	1,650,000	1,580,000
Grand total	3,930,000	3,830,000
Form:		
Ferrovanadium	3,090,000	3,000,000
Other[4]	836,000	830,000
Total	3,930,000	3,830,000

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified."
[1]Table includes data available through August 10, 2017. 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	
Country or locality	Quantity, gross weight (kilograms)	Value	Quantity, gross weight (kilograms)	Value
Imports for consumption:				
2015	204,000	$4,520,000	182,000	$3,450,000
2016:				
Belgium	1,000	33,100	--	--
China	140,000	2,370,000	32,900	540,000
Czechia	8	4,580	--	--
Germany	4,490	200,000	11,700	386,000
Netherlands	2,500	61,200	--	--
Russia	87,200	1,440,000	--	--
Tokelau	--	--	500	66,700
United Kingdom	4	7,310	279	44,200
Total	235,000	4,120,000	45,300	1,040,000
Exports:				
2015	229,000	6,440,000	5,200	354,000
2016:				
Australia	1,860	112,000	3,000	232,000
Belgium	10,800	216,000	--	--
Canada	--	--	294	7,730
France	2,020	77,800	278	10,700
Germany	546	21,100	694	32,100
Guatemala	12	6,940	--	--
India	337	13,000	--	--
Japan	--	--	12,000	253,000
Korea, Republic of	--	--	2,000	49,300
Malaysia	--	--	245	42,000
Mexico	--	--	100	4,200
Netherlands	19,800	313,000	--	--
Romania	12,300	316,000	--	--
Russia	24,200	507,000	--	--
Singapore	--	--	73	2,810
Spain	434	16,700	--	--
Switzerland	138	5,320	--	--
United Kingdom	22,800	600,000	30	6,600
Total	95,200	2,200,000	18,700	641,000

-- Zero.
[1]Table includes data available through August 10, 2017. 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]

Country or locality	Ferrovanadium		Vanadium pentoxide (anhydride)[2]		Other oxides and hydroxides of vanadium	
	Quantity (kilograms, V content)	Value	Quantity (kilograms, V content)	Value	Quantity (kilograms, V content)	Value
Imports for consumption:						
2015	1,980,000 r	$64,100,000 r	2,870,000	$32,800,000	93,700	$1,840,000
2016:						
Austria	906,000	15,900,000	--	--	109,000	1,410,000
Brazil	1,410	64,200	477,000	3,560,000	--	--
Canada	113,000	2,090,000	--	--	--	--
China	4,280	127,000	487,000	5,270,000	1,300	28,700
Colombia	1,640	34,300	--	--	--	--
Czechia	(3)	20,100,000	--	--	--	--
Germany	775	37,500	218,000	3,050,000	--	--
India	16,000	306,000	--	--	--	--
Japan	40,100	791,000	--	--	--	--
Korea, Republic of	241,000	3,720,000	59,100	453,000	--	--
Russia	259,000	4,290,000	--	--	--	--
Singapore	2,050	38,500	--	--	--	--
South Africa	--	--	949,000	8,940,000	550,000	8,570,000
Taiwan	6,120	277,000	274,000	4,090,000	--	--
United Kingdom	--	--	1	2,060	--	--
Total	1,590,000	47,800,000	2,460,000	25,400,000	660,000	10,000,000
Exports:						
2015	122,000	3,190,000	356,000	3,430,000	99,800	841,000
2016:						
Argentina	--	--	910	36,700	--	--
Belgium	8,080	118,000	--	--	--	--
Brazil	13,400	260,000	--	--	--	--
Canada	114,000	2,630,000	--	--	9,940	99,700
Germany	7,730	101,000	--	--	10,300	165,000
India	25,500	230,000	1,940	18,500	--	--
Korea, Republic of	7,350	243,000	--	--	--	--
Mexico	140,000	2,090,000	1,500	28,000	1,160	10,300
Netherlands	74,100	1,380,000	--	--	--	--
Paraguay	741	24,700	--	--	--	--
Peru	3,410	136,000	--	--	--	--
Spain	5,870	73,500	--	--	--	--
Thailand	--	--	800	24,700	--	--
Trinidad and Tobago	--	--	--	--	59,900	406,000
Total	400,000	7,280,000	5,150	108,000	81,300	681,000

[r]Revised. -- Zero.
[1]Table includes data available through August 10, 2017. Data are rounded to no more than three significant digits; may not add to totals shown.
[2]May include catalysts that contain vanadium pentoxide.
[3]Data suppressed according to U.S. Census Bureau; not included in "Total."

Source: U.S. Census Bureau.

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

Country or locality	2015 Quantity (kilograms, V content)	2015 Value	2016 Quantity (kilograms, V content)	2016 Value
Canada	4,660,000	$13,700,000	4,640,000	$7,530,000
Chile	--	--	5,050	65,900
France	1,150	12,800	--	--
Mexico	1,920,000 r	9,400,000 r	--	--
Netherlands	--	--	370,000	2,200,000
Russia	1,630,000	12,900,000	--	--
Switzerland	--	--	20,200	241,000
Total	8,210,000 r	36,000,000 r	5,030,000	10,000,000

rRevised. -- Zero.
1Table includes data available through August 10, 2017. Data are rounded to no more than three significant digits; may not add to totals shown.
2Includes Harmonized Tariff Schedule codes 2620.40.0030 and 2620.99.1000.

Source: U.S. Census Bureau.

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

Material and country or locality	2015 Quantity (kilograms, V content)	2015 Value	2016 Quantity (kilograms, V content)	2016 Value
Sulfates:				
Canada	--	--	2	$3,200
China	12,500	$134,000	5,990	73,500
Finland	--	--	4,000	28,000
Germany	--	--	1,900	13,000
Japan	93	4,340	100	2,540
Netherlands	44	3,620	--	--
Total	12,600	142,000	12,000	120,000
Vanadates:				
Austria	4,600	83,600	62,400	823,000
China	--	--	82,600	1,370,000
Germany	11,000	264,000 r	12,100	240,000
India	--	--	99	2,920
Japan	395	27,300	916	59,300
Korea, Republic of	--	--	8,630	138,000
Netherlands	13,000	148,000	1,040	26,100
South Africa	62,700	909,000	20,700	290,000
Spain	640	28,900	--	--
Sweden	2,610	19,700	--	--
Taiwan	74,000	756,000	118,000	1,330,000
United Kingdom	4,030	77,700	6,440	124,000
Total	173,000	2,310,000 r	313,000	4,400,000

rRevised. -- Zero.
1Table includes data available through August 10, 2017. Data are rounded to no more than three significant digits; may not add to totals shown.
2Comprises vanadium ore and miscellaneous vanadium chemicals.

Source: U.S. Census Bureau.

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

(Metric tons of contained vanadium)

Country or locality[3]	2012	2013	2014	2015	2016[p]
Brazil	-- [e]	-- [e]	1,030	5,800	8,000
China	40,000	45,000 [r]	48,000 [r]	45,000 [r]	45,000
Russia	14,856	14,400 [e]	15,100 [e]	16,000 [e]	16,000
South Africa	19,957	21,397	21,600	17,788 [r]	10,000
United States[4]	106	591	--	--	--
Total	74,900	81,400 [r]	85,700 [r]	84,600 [r]	79,000

[e]Estimated. [p]Preliminary. [r]Revised. -- Zero.

[1]Table includes data available through May 2, 2017. All data are reported unless otherwise noted. Totals, U.S. data, and estimated data are rounded to 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 was inadequate to make reliable estimates of output.

[3]Credited to the country of origin of the vanadiferous raw material. Production from ore, concentrate, and slag.

[4]In 2012 and 2013, Energy Fuels Inc. produced vanadium. Source: Energy Fuels Inc. website.

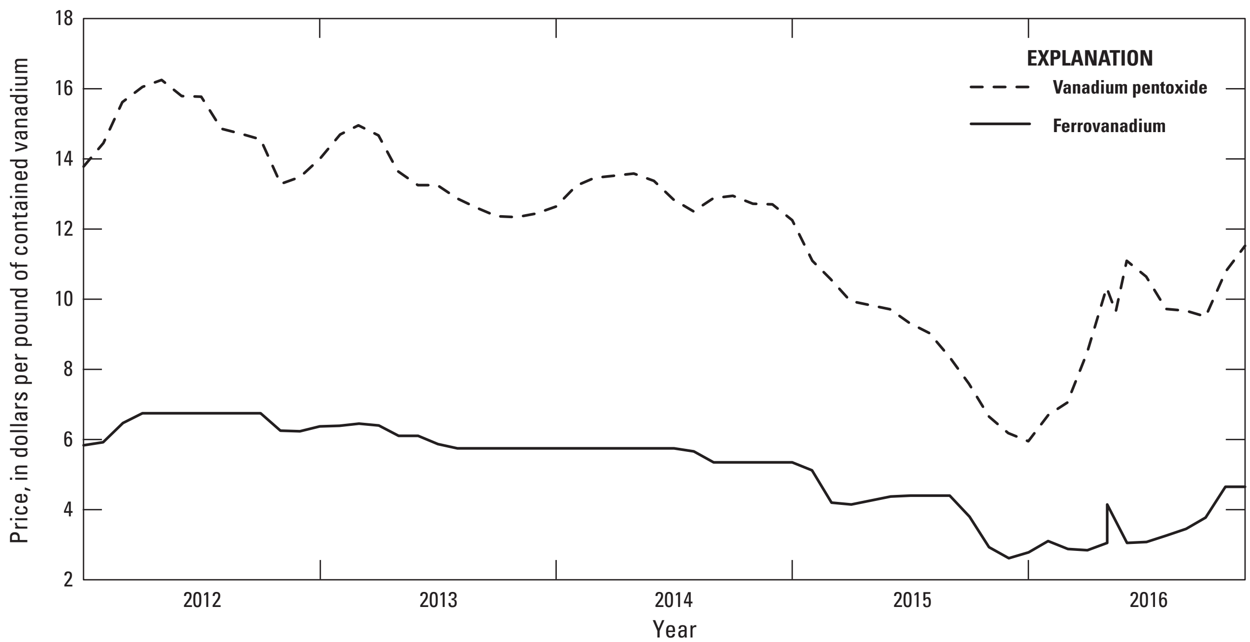

Figure 1. Average monthly prices for U.S. vanadium pentoxide and U.S. ferrovanadium from 2012 through 2016. Source CRU Group.