



# 2015 Minerals Yearbook

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## NIOBIUM [ADVANCE RELEASE]

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# NIBIUM

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In 2015, U.S. niobium apparent consumption (measured in contained niobium) was 7,080 metric tons (t), 29% less than that of 2014 (table 1). No domestic mine production of niobium ore was reported. Niobium content of world mine production of niobium mineral concentrates was 64,300 t, 6% less than that of 2014 (table 4). In 2015, the United States exported 1,430 t of niobium contained in niobium materials (29% more than that of 2014) and imported 8,520 t of niobium contained in niobium materials (23% less than that of 2014) (table 1). The leading end use of niobium was as an alloying element in high-strength low-alloy (HSLA) steel.

Because the United States has no niobium reserves, domestic supply has been a concern during every national military emergency since World War I. Materials for recycling and stocks are the only domestic supply sources of niobium.

Traded niobium materials included ferroniobium and niobium chemicals, metal, ores and concentrates, and scrap. Ferroniobium is the leading traded niobium material.

## Legislation and Government Programs

The U.S. Defense Logistics Agency Strategic Materials (DLA Strategic Materials), U.S. Department of Defense, did not designate niobium materials for disposal under its fiscal year 2016 Annual Materials Plans (Defense Logistics Agency Strategic Materials, 2015a); however, the DLA Strategic Materials designated a ceiling quantity of 105 t of ferroniobium for acquisition (Defense Logistics Agency Strategic Materials, 2015b).

The U.S. Department of Labor identified coltan, a niobium- and tantalum-containing ore, from Congo (Kinshasa) as a good produced by child labor or forced labor (U.S. Department of Labor, 2014, p. 4).

## Production

Globally, pyrochlore is the leading mineral mined for niobium. The leading marketable niobium materials are ferroniobium and niobium metal, ore, and oxide. In 2015, no domestic niobium mine production was reported.

NioCorp Developments Ltd.'s Elk Creek property was thought to be the only primary niobium deposit being developed in the United States (NioCorp Developments Ltd., 2015b, p. 5). In April, NioCorp filed an amended National Instrument 43-101 preliminary economic assessment on the Elk Creek niobium project in Nebraska. NioCorp planned to (1) extract ore by underground mining; (2) convert the ore to concentrate by grinding and flotation; (3) hydrometallurgically extract niobium pentoxide ( $\text{Nb}_2\text{O}_5$ ) from the concentrate by leaching, sulfation, purification, and precipitation; and (4) pyrometallurgically

produce ferroniobium by aluminothermic reduction. NioCorp reported, to a cutoff grade of 0.3%  $\text{Nb}_2\text{O}_5$ , indicated plus inferred resources of 180 million metric tons (Mt) containing 0.62%  $\text{Nb}_2\text{O}_5$  (NioCorp Developments Ltd., 2015a, p. 2-3, 5). NioCorp made an offtake agreement with ThyssenKrupp Metallurgical Products GmbH and CMC Comerals, a division of Commercial Metals Company, to annually purchase ferroniobium: ThyssenKrupp committed to purchase 3,750 t (about 50% of NioCorp's planned ferroniobium production) and CMC committed to purchase 1,875 t (about 25% of NioCorp's planned ferroniobium production) for an initial 10-year term, with an option to extend beyond that timeframe (NioCorp Developments Ltd., 2014, 2016).

## Consumption

Domestic consumption data for niobium materials were developed by the U.S. Geological Survey by means of the "Columbium (Niobium) and Tantalum," "Consolidated Consumers," and "Specialty Ferroalloys" surveys. For niobium materials, 1 consumer responded to the "Columbium (Niobium) and Tantalum" canvass, about 70 responded to the "Consolidated Consumers" canvass, and 1 responded to the "Specialty Ferroalloys" canvass.

Niobium ore typically was beneficiated to concentrates containing about 54%  $\text{Nb}_2\text{O}_5$ .  $\text{Nb}_2\text{O}_5$  was produced from the concentrate; ferroniobium or niobium metal, from  $\text{Nb}_2\text{O}_5$ . Ferroniobium, the leading commercial niobium-containing material, typically contained about 60% niobium and was consumed in the production of HSLA steel. Other uses included the production of niobium carbide and chemicals.

ATI Wah Chang, Global Advanced Metals (GAM), and H.C. Starck Inc. consumed niobium feed materials to produce intermediate niobium materials used in industrial manufacturing processes and products.

## Prices

Niobium materials were not openly traded. Purchase contracts were confidential between buyer and seller; however, traders declared the value of niobium materials that they imported or exported (table 1).

## Foreign Trade

Niobium material exports from and imports to the United States included ferroniobium and niobium chemicals, metal, ore, and oxide. Based on monetary value in 2015, U.S. exports of niobium-containing materials were about the same and imports of niobium materials decreased by 26% (table 3).

## World Industry Structure

Brazil and Canada were the leading producers of niobium mineral concentrates (table 4). The leading niobium ore and concentrate producers were Companhia Brasileira de Metalurgia e Mineração (CBMM) and Anglo American Brazil Ltd. (a subsidiary of Anglo American plc) in Brazil and Magris Resources Inc. at its Niobec Mine in Canada. The Tantalum-Niobium International Study Center reported annual niobium primary production based on a survey of its members. Niobium primary production from niobium concentrates and other concentrates containing more than 2% Nb<sub>2</sub>O<sub>5</sub> was estimated to have been about 68,000 t of contained niobium in 2015 (Tantalum-Niobium International Study Center, 2016).

Ecclestone (2015) reported that the top three leading niobium-producing companies were in the Western Hemisphere: Anglo American (Brazil), CBMM (Brazil), and Magris Resources (Canada). Niobium-containing ore is beneficiated and then processed to produce niobium oxide, which may subsequently be processed to produce ferroniobium or niobium metal. Ferroniobium is used in alloy steel, nonferrous alloys, and in niobium alloys. Niobium ore is mined in Brazil, Canada, China, and other countries. It is processed and used in progressively diverse locations (AVX Corp., 2015; ULVAC Inc., 2015).

## World Review

**Brazil.**—Grupo Minsur's subsidiary Mineracao Taboca S.A. temporarily halted production at its Pitinga Mine at the start of August owing to power supply problems and then resumed operations at a reduced rate. Water filtrations were found at the dike of the hydroelectric plant that provides energy to Pitinga, forcing the hydroelectric plant to work at one-half of its capacity (CRU Group, 2015). Niobium is a byproduct of tin production at Pitinga Mine.

Ferroniobium producers CBMM and Anglo American plc were 2 of only 4 out of 17 Associação Brasileira dos Produtores de Ferroligas e de Silício Metálico associates that survived electrical power price increases that resulted from the worst drought in 80 years. The price of electrical power increased to \$147.38 per megawatthour in March from \$25.80 per megawatthour, the price specified by contracts that expired in December 2014 (Assalve, 2015, p. 5–6; Metal Bulletin Magazine, 2015, p. 10).

**Canada.**—GéoMégA Resources Inc. reported 266.6 Mt of indicated plus inferred resources at 0.14% Nb<sub>2</sub>O<sub>5</sub> (Belzile Solutions Inc. and G Mining Services Inc., 2015, p. 1–10, 1–12). GéoMégA planned to optimize its separation technology process. Sarissa Resources Inc. reported that there is no NI 43–101-compliant current resource estimate for its Nemegosenda Lake niobium project. Sarissa planned to add historic exploration data to a current base and complete a detailed high-resolution magnetic gradient survey (Sarissa Resources Inc., 2015, p. 8, 16). Niobec Inc. announced that Magris Resources Inc. became its new official owner on January 22 (Niobec Inc., 2015). Magris Resources purchased Niobec Inc. for \$530 million (Niobec Inc., 2014).

**Estonia.**—Molycorp Silmet AS, a metals producer that specialized in the production of tantalum and niobium,

experienced a plastic pipe and construction waste fire. Silmet planned to make repairs to restore its lost production capacity (Gerden, 2015a).

**Kenya.**—Pacific Wildcat Resources Corp. (West Kelowna, British Columbia, Canada) explored for niobium and rare earths at Mrima Hill until 2013, when the Government of Kenya revoked the company's mining license. Pacific sought relief in the Kenyan court and tried to arbitrate a resolution through the World Bank (Wafula, 2015). Arbitrators were appointed in November (Pacific Wildcat Resources Corp., 2015).

**Malawi.**—Mkango Resources Ltd. explored for niobium and tantalum across the Thambani Massif in southern Malawi. Mkango took and assayed trench samples in the Chikoleka and Little Ngona River targets (Mkango Resources Ltd., 2015).

**Russia.**—Technoinvest Alliance planned to build a tantalum-niobium mining complex in the Zashihinskoe rare-earth metals field located in the Nizhneudinsk area of the Irkutsk region, Siberia. The mine would produce concentrate containing 4.4% tantalum and 44% niobium. The product was to go to Angarsk Electrolysis Chemical complex, which would produce 2,000 t/yr of Nb<sub>2</sub>O<sub>5</sub>. Technoinvest planned to start construction in 2016 and start production in 2018 (Gerden, 2015b). Wolfram Company CJSC planned to start ferroniobium production at its Unecha ferroalloys plant (Metal Bulletin Daily, 2015, p. 7).

**Tanzania.**—Cradle Resources Ltd. explored for niobium at Panda Hill and completed a prefeasibility study that identified 178 Mt of measured plus indicated plus inferred resources at an average grade of 0.50% Nb<sub>2</sub>O<sub>5</sub> (Cradle Resources Ltd., 2015, p. 3, 6). Cradle planned to complete a definitive feasibility study in 2016.

## Outlook

Currently operating niobium mines have adequate reserves. Potential new sources of niobium are typically associated with the production of other minerals with niobium as a byproduct. Niobium minerals are typically converted to ferroniobium and other products at the mine site. Most ferroniobium is used in HSLA steel. The quantity of niobium use in HSLA steel per quantity of HSLA steel production is greatest in developed countries, suggesting that there is potential for increasing niobium use in steel produced in developing nations (Roskill Information Services Ltd., 2013, p. 197–213). CBMM (Brazil) continued to be the leading niobium producer followed by Anglo American (Brazil) and Magris Resources (Canada). No significant change in production distribution is anticipated.

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TABLE 1  
SALIENT NIOBIUM STATISTICS<sup>1</sup>

		2011	2012	2013	2014	2015
<b>United States:</b>						
<b>Exports:</b>						
Gross quantity:						
Niobium ores and concentrates	metric tons	12	31	110	60	73
Synthetic concentrates <sup>2</sup>	do.	20	209	61	200	138
Tantalum ores and concentrates	do.	186	202	204	225	98
Niobium content:						
Niobium-containing ores and concentrates <sup>3</sup>	do.	<b>26</b>	<b>53</b>	<b>53</b>	<b>60</b>	<b>42</b>
Niobium metal	do.	338	332	382	1,050	1,390
Total exports, Nb content	do.	363	385	435	1,110 <sup>r</sup>	1,430
<b>Imports for consumption:</b>						
Gross quantity:						
Niobium ores and concentrates	do.	9	11	8	2	--
Synthetic concentrates <sup>2</sup>	do.	11	--	--	--	--
Tantalum ores and concentrates	do.	179	261	655	897	730
Niobium content:						
Niobium-containing ores and concentrates <sup>3</sup>	do.	23	32	75	101	82
Niobium metal <sup>4</sup>	do.	1,460	1,440	1,360	1,870	886
Niobium oxide <sup>e</sup>	do.	1,120	1,220	997	1,020	983
Ferroniobium <sup>e</sup>	do.	6,910	7,430	6,140	8,120	6,570
Total imports, Nb content	do.	9,520	10,100	8,580	11,100	8,520
<b>Reported consumption, Nb content:</b>						
Raw materials	do.	W	W	W	W	W
Ferroniobium and nickel niobium	do.	9,060	7,460	7,500	8,210	7,510
Apparent consumption, Nb content	do.	9,160	9,730	8,140	10,000 <sup>r</sup>	7,080
<b>Value, gross quantity:<sup>5</sup></b>						
Niobium ores and concentrates	dollars per kilogram	39.34	23.54	17.15 <sup>r</sup>	14.94	7.59
Niobium oxide	do.	37.69	44.43	43.47	37.04	36.19
Ferroniobium	do.	26.43	27.63	27.29	25.78 <sup>r</sup>	24.27
World, production of niobium concentrates, Nb content	metric tons	50,200 <sup>r</sup>	62,700 <sup>r</sup>	57,100 <sup>r</sup>	68,700 <sup>r</sup>	60,500 <sup>e</sup>

<sup>e</sup>Estimated. <sup>r</sup>Revised. do. Ditto. W Withheld to avoid disclosing company proprietary data. -- Zero.

<sup>1</sup>Data are rounded to no more than three significant digits, except values.

<sup>2</sup>Synthetic concentrates are produced from tin slag.

<sup>3</sup>Includes niobium and tantalum ores and concentrates and synthetic concentrates. Nb content of ore and concentrate is computed assuming 69.904% Nb in Nb<sub>2</sub>O<sub>5</sub>, 30.0% Nb<sub>2</sub>O<sub>5</sub> in niobium ores and concentrates, and 16.0% Nb<sub>2</sub>O<sub>5</sub> in synthetic concentrates and tantalum ores and concentrates.

<sup>4</sup>Includes niobium and articles made of niobium.

<sup>5</sup>Mass average value of imported plus exported materials.

TABLE 2  
 REPORTED CONSUMPTION, BY END USE, INDUSTRY STOCKS OF FERRONIUM AND  
 NICKEL NIOBIUM, AND GOVERNMENT STOCKS BY MATERIAL IN THE UNITED STATES<sup>1</sup>

(Metric tons of niobium content)

	2014	2015
End use:		
Steel:		
Carbon	1,680	1,280
Stainless and heat-resisting	918	712
Full alloy	(2)	(2)
High-strength low-alloy	757	800
Electric	(2)	(2)
Tool	(2)	(2)
Unspecified	3,159	3,078
Total	6,510	5,870
Superalloys	1,680	1,620
Alloys (excluding steels and superalloys)	23	20
Grand total	8,210	7,510
Stocks, December 31:		
Consumer	381	344
Producer <sup>3</sup>	W	W
Total	381	344
National Defense Stockpile, total uncommitted inventory by material:		
Niobium metal ingots	10.0	1.71

W Withheld to avoid disclosing company proprietary data.

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

<sup>2</sup>Included with "Steel, unspecified."

<sup>3</sup>Ferroniobium only.



TABLE 3  
U.S. FOREIGN TRADE IN NIOBIUM, BY CLASS<sup>1</sup>

HTS <sup>2</sup> code	Class	2014		2015		Principal destinations and sources in 2015 (gross quantity in kilograms and values in thousand dollars)
		Gross quantity (kilograms)	Value (thousands)	Gross quantity (kilograms)	Value (thousands)	
<b>Exports:</b>						
2615.90.3000	Synthetic concentrates	200,000 <sup>†</sup>	\$5,370 <sup>†</sup>	138,000	\$3,260	China 73,700, \$1,160; Germany 50,100, \$1,900; Hong Kong 12,100, \$201.
2615.90.6030	Niobium ores and concentrates	59,600	772	73,400	557	Germany 35,700, \$886; Estonia 30,900, \$120; United Kingdom 2,540, \$18.
2615.90.6060	Tantalum ores and concentrates <sup>3</sup>	225,000	5,940	98,200	4,860	Hong Kong 54,000, \$3,130; China 26,200, \$1,610; Brazil 18,000, \$123.
7202.93.0000	Ferroniobium	1,620,000 <sup>†</sup>	22,900 <sup>†</sup>	2,140,000	26,300	Canada 1,620,000, \$20,500; Mexico 495,000, \$5,450; Peru 15,800, \$174; Taiwan 10,900, \$119.
Total exports		XX	35,000 <sup>†</sup>	XX	35,000	
<b>Imports for consumption:</b>						
2615.90.6030	Niobium ores and concentrates	2,000	148	--	--	--
2615.90.6060	Tantalum ores and concentrates <sup>3</sup>	897,000	71,300	730,000	49,300	Rwanda, 302,000, \$16,600; Brazil 177,000, \$20,200; Australia 117,000, \$6,380; Congo (Kinshasa) 90,500, \$4,340; Tanzania 20,600, \$737; Congo (Brazzaville) 19,900, \$929.
2825.90.1500	Oxide	1,460,000	54,100 <sup>†</sup>	1,410,000	50,900	Brazil 664,000, \$25,600; Russia 403,000, \$12,600; Estonia 108,000, \$4,430; Thailand 125,000, \$3,900; China 88,300, \$3,360; Spain 12,000, \$498; Germany 5,560, \$471.
Total ores, concentrates, and oxides		XX	126,000	XX	100,000	
<b>Ferroniobium:</b>						
7202.93.4000	Silicon <0.4%	774,000	35,400	658,000	28,500	Brazil 473,000, \$21,200; Germany 170,000, \$6,950; Russia 9,200, \$240; Canada 3,000, \$65; Mexico 3,350, \$62.
7202.93.8000	Other	11,700,000	305,000	9,440,000	242,000	Brazil 7,110,000, \$178,000; Canada 2,320,000, \$64,400; Estonia 8,000, \$186; United Kingdom 7,150, \$143.
Total ferroniobium		12,500,000 <sup>†</sup>	341,000 <sup>†</sup>	10,100,000	271,000	
8112.92.4000	Unwrought, powders <sup>4</sup>	1,870,000	95,800	886,000	45,400	Brazil 808,000, \$39,700; Estonia 28,300, \$2,650; Germany 40,200, \$2,250; China 2,530, \$477; Russia 6,360, \$280; Kazakhstan 250, \$23.
Total imports		XX	563,000 <sup>†</sup>	XX	416,000	

<sup>†</sup>Revised. XX Not applicable. -- Zero.

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

<sup>2</sup>Harmonized Tariff Schedule of the United States.

<sup>3</sup>Tantalum ores and concentrates may contain niobium. To estimate Nb content, it was assumed that tantalum ores and concentrates contain 16.0% Nb<sub>2</sub>O<sub>5</sub> and the Nb content of Nb<sub>2</sub>O<sub>5</sub> is 69.904%.

<sup>4</sup>Niobium waste and scrap is included in 8112.92.0600 along with other materials. Niobium other than unwrought; waste and scrap; and powders is included in 8112.99.9000 along with other materials.

Sources: U.S. Census Bureau and U.S. Geological Survey.

TABLE 4  
 NIOBIUM: WORLD PRODUCTION OF MINERAL CONCENTRATES, BY COUNTRY<sup>1</sup>

(Kilograms, niobium content)<sup>2</sup>

Country <sup>3</sup>	2011	2012	2013	2014	2015 <sup>e</sup>
Brazil, Nb minerals <sup>4,5</sup>	45,198,000	57,471,000	51,497,000	62,055,000 <sup>r</sup>	54,000,000
Burundi	31,000 <sup>e</sup>	51,000 <sup>r</sup>	14,000	21,000 <sup>r</sup>	12,000
Canada, Nb minerals <sup>6</sup>	4,551,000	4,705,000	4,916,000	5,774,000 <sup>r</sup>	5,753,000 <sup>7</sup>
China	13,981 <sup>r</sup>	14,680 <sup>r</sup>	15,379 <sup>r</sup>	19,573 <sup>r</sup>	30,059 <sup>7</sup>
Congo (Kinshasa)	180,000 <sup>r</sup>	180,000 <sup>r</sup>	190,000 <sup>r</sup>	340,000 <sup>r</sup>	260,000
Ethiopia, tantalite	24,500	26,000 <sup>e</sup>	3,500 <sup>r</sup>	14,000 <sup>r</sup>	17,000
Kazakhstan	NA	43,000	44,000	72,000 <sup>r</sup>	96,900
Mozambique	10,000	21,000 <sup>r</sup>	11,000 <sup>r</sup>	5,700 <sup>r</sup>	4,800
Nigeria, columbite-tantalite	15,000 <sup>r</sup>	26,000 <sup>r</sup>	38,000 <sup>r</sup>	52,000 <sup>r</sup>	52,000
Rwanda, columbite-tantalite	180,000 <sup>r</sup>	190,000	360,000 <sup>r</sup>	350,000 <sup>r</sup>	250,000
Uganda	1 <sup>r</sup>	--	--	--	900
Total	50,200,000 <sup>r</sup>	62,700,000	57,100,000 <sup>r</sup>	68,700,000 <sup>r</sup>	60,500,000

<sup>e</sup>Estimated. <sup>r</sup>Revised. NA Not available. -- Zero.

<sup>1</sup>World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown. Includes data available through April 18, 2017. Figures for all countries represent marketable output.

<sup>2</sup>Content is quantity of metal contained in marketable niobium minerals produced. Nb<sub>2</sub>O<sub>5</sub> is 69.904% Nb.

<sup>3</sup>In addition to the countries listed, Australia, French Guiana, Malaysia, and Russia also produce or are thought to produce niobium mineral concentrates, but available information is inadequate to make reliable estimates of output.

<sup>4</sup>Includes columbite and pyrochlore.

<sup>5</sup>Reported in Nb<sub>2</sub>O<sub>5</sub> content by Brazil in Sumário Mineral, various years.

<sup>6</sup>Reported in Nb content by Canada in Mineral Production of Canada, by Province.

<sup>7</sup>Reported figure.

TABLE 5  
 FERRONIBIUM (FERROCOLUMBIUM): WORLD PRODUCTION, BY COUNTRY<sup>1</sup>

(Metric tons, niobium content)

Country <sup>2</sup>	2011	2012	2013	2014	2015 <sup>e</sup>
Brazil <sup>3</sup>	53,700	50,562	46,600	51,700 <sup>r</sup>	50,000
Canada <sup>4</sup>	4,550 <sup>r</sup>	4,710 <sup>r</sup>	492 <sup>r</sup>	5,770 <sup>r</sup>	5,760 <sup>5</sup>
Russia	420	420	360	360	400
Total	58,700	55,700	51,800 <sup>r</sup>	57,900 <sup>r</sup>	56,200

<sup>e</sup>Estimated. <sup>r</sup>Revised.

<sup>1</sup>Estimated data and totals are rounded to no more than three significant digits; may not add to totals shown. Includes data available through April 18, 2017.

<sup>2</sup>In addition to the countries listed, Austria, China, and Germany are thought to have produced ferroniobium (ferrocolumbium), but available information is inadequate to make reliable production estimates.

<sup>3</sup>Reported in Nb content by Brazil in Sumário Mineral, various years. Average grade is assumed to have been 65.0% Nb.

<sup>4</sup>As reported by Canada in Mineral Production of Canada, by Province, various years. All of mine production was assumed to have been converted to ferroniobium at an average grade of 65.0% Nb.

<sup>5</sup>Reported figure.